PASSIVE ARCHITECTURAL TECHNIQUES FOR ACHIEVING COMFORT IN HOT AND DRY CLIMATE

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ABSTRACT

The architecture of region is an expression of development of culture, social and economic values of a community and impact of geographical and climatic conditions. Climate plays a vital role and is considered for contextual planning of spaces. India is divided in various climatic zones. Design in Hot and dry climate, should resist heat gain and promote heat loss. Use of vernacular and passive architectural techniques is the solution to harsh features of hot and dry climate.

Passive Architectural techniques are most sustainable solution for shaping architecture of hot and dry region.

The knowledge of Passive materials and technique is passed on one generation to other with working in groups and oral communication. Knowledge of materials and their use with architectural innovation will direct to better sustainable eco-friendly development of the region.

Keywords: Climate, Hot and Dry climate, Vernacular Architecture, Passive techniques, sustainability

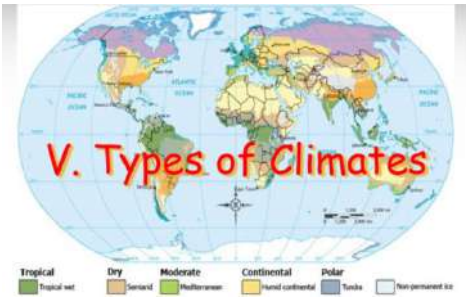
INTRODUCTION:

Climate refers to long patterns and average of weather conditions in a particular region. It encompasses factors like temperature, humidity, wind patterns and precipitation over an extended period, typically decades to million of years. Climate is different from weather, which refers to short term atmospheric conditions. Changes in climate can have significant impacts on ecosystems, agriculture and human societies.

A climate is classified as micro and macro climates. Micro climate is specific climate of a small, localized area. Macro climate is the overall climate of the larger region. Macro climate is about details and macro climate is more about the general trends and patterns.

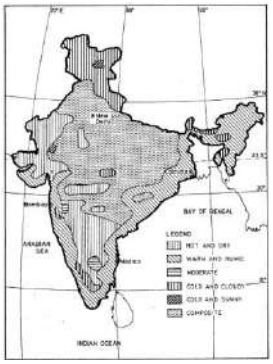
CLIMATIC ZONES OF WORLD

The most well-known classification of climates was introduced by a German Russian climatologist Wladimir K ppen in 1884. He divided the climates into five main types: Tropical, Dry, Moderate Continental and Polar.



CLIMATIC ZONES OF INDIA

India is divided into six climatic zones, namely, hot and dry, warm and humid, moderate, cold and cloudy, cold and sunny, and composite. (Bansal & Minke, 1988)



This research paper focus only on hot and dry climate. Climatic conditions of Hot and Dry climate are as follows.

SKY CONDITIONS

- A generally clear sky.
- As the sky is clear at night, the heat absorbed by the ground during the day is quickly dissipated to the atmosphere.
- Hence, the air is much cooler at night than during the day.

SOLAR RADIATION

- Intense solar radiation.
- The ground and the surroundings of this region are heated up very quickly during day time.
- It is imperative to control solar radiation and movement of hot winds.
- High solar radiation causing an uncomfortable glare is typical of feature of this zone.

DIURNAL VARIATION

- The diurnal variation in temperature is quite high more than 10^{o}C.

AIR TEMPERATURE

- Summer:
  Day: Mean maximum temperature is between 40 and 45^{o}C.
  Night: Mean minimum temperature is between 20 and 30^{o}C.
- Winter:
  Day: Mean maximum temperature is between 5 & 25^{o}C.
  Night: Mean minimum between 0 & 10^{o}C.

HUMIDITY

- Relative humidity is generally very low, ranging from 25 to 40 % due to low vegetation and surface water bodies

PRECIPITATION

- Less rainfall- the annual precipitation being less than 500 mm.

WIND

- Hot winds blow during the day in summers and sand storms are also experienced.
- Night is usually cool and pleasant.

VEGETATION

- Sparse vegetation comprising cactus, thorny trees and bushes.
- A typical hot and dry region is usually flat with sandy or rocky ground conditions.

Some key features and Design strategies typically employed in hot and dry climate are:

1. **Resist heat gain:**

- Decrease exposed surface area
- Increase thermal resistance
- Increase thermal capacity(time lag)
- Increase buffer spaces
- Decrease air exchange rate (ventilation during day time)
- Increase shading
- Increase surface reflectivity

2. Promote Heat loss:

- Ventilation of spaces
- Increase air exchange rate(ventilation during night time)
- Increase humidity levels

3. Use of Vernacular Architecture Techniques:

Vernacular architecture the use of local materials and knowledge, usually without the supervision of professional architects. It's specific for specific region. Vernacular architecture reflects the environment, culture and historical context in which it exists. It has been always raw, unrefined.

The use of local materials with consideration to local climate and participation of the people leads to a holistic design approach.(Ar.Laurie Baker)

Factors influencing vernacular Architecture of a region are Culture, Materials and climate.In India, Rajasthan is the region with hot and dry climate. Rajasthan has a wide range of climate that varies from extremely arid to humid. The humid zone spans the southeast and east.
Some of the Architectural materials and techniques used in rajasthan are follows

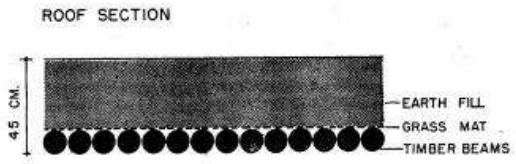


Fig. 8. Construction of the roof of Nathmalji's Haveli

A typical section of earth fill roof

Use of Jharojha and jali

Main elements are as below:Designing more than one courtyard,Stimulating Heatloss,Small windows,cross ventilation,Use of traditional shading elements,Textured walls,Thick slabs and walls.

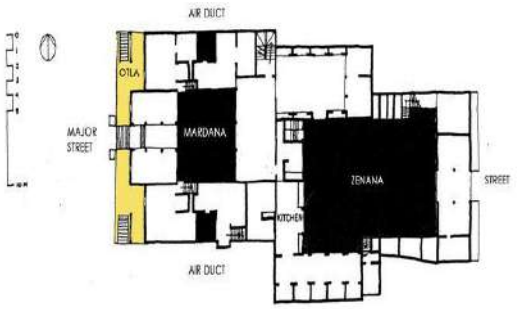


FIG: Ground Floor Plan of Nathmalji Haveli.

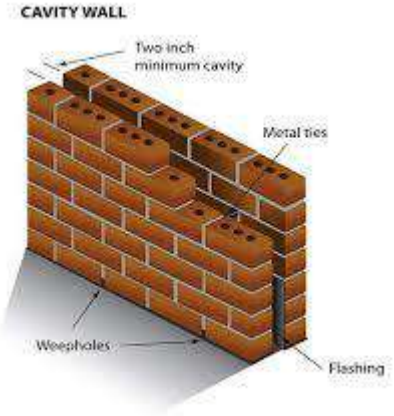
Use of air ducts and courtyards

Vernacular methods adopted for cooling effect in Rajasthan.

- Use of Clay and sand with water, cow dung and bajra waste.
- Construction of ceiling with kejri wood.
- Two or three layers of bushes at outer side of roof.

- Use of perforated brick wall.
- Use of hallow clay block and compressed straw blocks.
- Use of filler slab and brick jail.

- Use of Cavity Wall



4. Use of passive cooling Techniques: in this paper we are focusing on physical manifestation in design for adopting passive cooling techniques.

PASSIVE ARCHITECTURE

Buildings designed to ensure living comfort without the need for additional heating or cooling systems are referred to as "passive buildings." These structures are designed to be highly energy-efficient and make the most of natural resources to maintain a comfortable indoor climate.

AIM OF THE STUDY

The research will be carried to analyse the Elements of passive architecture techniques for hot and dry climate, in reference to contemporary context.

OBJECT OF THE STUDY

- To study and understand the design concepts used in hot and dry climate.
- To study and understand the Passive Architecture design strategies.
- To study and understand the Passive Architecture materials.

PHYSICAL MANIFESTATION OF PASSIVE TECHNIQUES FOR HOT AND DRY CLIMATE:

Passive Architectural techniques in hot and dry climate aim to maximize energy efficiency and comfort while minimizing the need for active cooling systems like air conditioning. These techniques take advantage of local climate conditions to reduce heat gain and improve indoor comfort. Here are some common passive architectural techniques for hot and dry climate.

1. Orientation of building: The orientation of building in hot and dry climate is planned to maximize energy efficiency and comfort. Longest side of building should face south. This helps in minimizing direct sun exposure to east and west sides of the buildings, as they can be extremely hot during day.

2. Shape of Building: Compact building shape with a minimal surface area to volume ratio. This reduces the exterior surface area and thus, minimise heat gain and loss.

3. Insulation: Proper insulation is necessary to prevent heat transfer through walls and the roof. High quality insulation helps keep indoor spaces cooler during the day and warmer at night.

4. Airlocks: Airlocks are used to maintain controlled conditions by preventing the outside air from directly entering the climate controlled spaces. They provide a buffer zone to minimize the transfer of solar heat. Airlocks control temperature, humidity, dust and contaminant mitigation, Airlocks help in reducing loads on air conditioners and cooling systems. Thus increase energy efficiency of buildings.

5. Shading: passive and mechanical shading techniques can be adopted to protect building from intense heat. Overhangs, cantilevers, pergolas, plantation of deciduous trees that provide sheds in summers but allow sunlight to pass through them in winters when the leaves fall.
While designing in a hot and dry climate, it is important to place shading devices to prevent the excessive heat directly penetrating the façade. Devices like visors can be provided on the roof, offering protection to the façade from extreme radiations and thus maintaining a comfortable temperature in the interiors.
The curtain wall system of Al Bahar in Abu Dhabi consists of hi-tech sunscreens that are controlled via a management system to provide maximum heat protection for the facade.

6. Openings: Minimizing the number of openings on the east and west sides of buildings to reduce heat gain from various sun angles. if windows have to be necessarily provided ,then use of shading devices or reflective coatings to restrict harsh sun heat has to be provided.

7. Cross-Ventilation: Natural cross ventilation can be provided in building design by providing windows and openings on opposite sides of the building. This will allow passage of cool breeze through the building, helping to cool indoor spaces.

8. Courtyards: Courtyards in hot and dry climates are provided to make outdoor spaces more comfortable and functional. Courtyards are used to create shaded and ventilated spaces within building envelope as temperatures are high and humidity is low, courtyards provide ample of shaded areas with use of pergolas, canopies and tall trees. Water body like fountains, ponds and shallow pools can be provided in courtyard. The evaporation of water can help cool the surrounding areas and create pleasant microclimate.

9. Reflective Roofing: Passive solar design: strategically placement of thermal mass and well insulated windows.

10. Ventilated roof: Ventilated or cool roof with an air gap between the roofing materials and the roof deck can help dissipate heat and keep the building cooler.

11. Thermal Mass: Incorporate thermal mass elements like stone or concrete walls. This can store heat during the day and release it during cooler evenings.

12. Colour Palette: Colour choices should create a comfortable and visually

appealing .Earthy tones like warm browns, terracotta and sandy beige will compliment the natural landscape and provide a sense of warmth. Light and cool neutrals like pale gray, soft blues help in creating a sense of calm and balance with hot and dry climate. White and off white can reflect sunlight and keep spaces cooler. Desert tones like deep rust, deep reds create a sense of warmth. Cool blues and pale greens remind of water, and nature thus creates soothing effect.
White walls are preferred in the exteriors as they reflect heat, given their high reflection ratio. Cool colours are chosen in interiors for their adaptability to temperatures. Mediterranean houses act as an example for this feature as well.

Mediterranean House © divisare

13. Reflective roofing: Reflective Roofing has high solar reflectance properties. They reduce the amount of heat absorbed by the roof and helps in reducing indoor temperatures. This leads to cost savings on air conditioning and cooling systems. It helps in minimizing heat island effect.

14. Wind breaks: Use natural or man-made wind breaks like walls or vegetation to reduce impact of strong winds, heat and dryness.

15. Sustainable Design: Implement sustainable design like rainwater harvesting systems, solar panels, and efficient irrigation systems to reduce environment impact and resource usage.

16. Micro Climatic Consideration: Considering local climatic conditions such as prevailing wind patterns, vegetations, water bodies and contours.

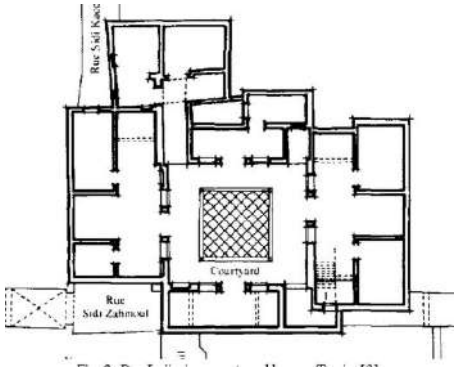
17. Materials: Materials with high thermal mass like adobe, concrete or stone should be used in building design. These materials can absorb heat during day and release it slowly at night, helping to stabilize indoor temperature. Materials used in construction in hot and dry climate should be selected on basis of heat resistance, durability and low water absorption.

Adobe bricks are made from natural materials like clay, sand and straw. They have excellent thermal mass properties. Rammed earth constructions provide excellent insulation properties. Concrete can with stand extreme heat and dry conditions. Natural stone such as sandstone or limestone can with stand harsh climate and maintain structural integrity. Ceramic tiles are best choice for flooring and wall coverings, as they are durable, low water absorption and ability to reflect sunlight. Polycarbonate and fibreglass are often used for roofing and shading structures, the provide shade while allowing diffused light to penetrate.PVC and Vinyl are often used for outdoor applications like fencing and pergolas. They are resistant to UV radiation and require minimal maintenance.

18. Plant selection: choose native and drought resistant plants for landscaping. Xeriscaping principles can be used. Shade

19. Cloth: They help to provide shade in outdoor spaces and are made from durable materials like HDPE (High density polyethylene)

20. Lobbies, balconies and verandas: These spaces help in cross ventilation and, when covered with pergola and plants, can act as cooling systems helping in reducing the temperature of the interiors when connected.
The houses that are built in a hot and dry climate to sustain extreme temperatures have a central patio around where other spaces are designed in a layout.



Traditional Arabic house plan ©semantic scholar

21. Wind Tower: Wind towers are also known as wind catchers. It is used to harness natural vegetation and cool indoor spaces. It operates on the principle of natural ventilation. They capture and direct the prevailing winds into buildings, creating a flow of air that helps cool the interior spaces.

As the wind passes through the tower, it accelerates and creates a lower pressure zones. This can result in a cooling effect as the air inside the tower is drawn upwards creating a natural drift. The movement of the air helps in dissipating heat and maintaining a more comfortable indoor temperature.

22.**Evaporative cooling**: It is an effective and energy efficient method of cooling in hot and dry climate. The process takes advantage of the natural evaporation of water to cool the air. It is suitable for regions with low humidity where air has the capacity to absorb more moisture. When water evaporates it absorb heat from the surrounding air, causing a drop in temperature.

Conclusion:

Energy Efficient-Passive Architecture techniques consume less energy as compared to traditional air conditioning systems.

Cost effective-Passive techniques are cost effective, thus beneficial to common people.

Environmentally Friendly: As natural elements are used thus it is environmentally friends.

Less maintenance: As all techniques are contextual thus less or no maintenance.

Principles of vernacular architecture and passive techniques can be applied to modern architecture and offer improved adaptation to a particular climate.

This materials and techniques help in increasing comfort of users and decrease in cost, labour and time. Thus architects and engineers should promote maximum use of passive techniques especially in hot and dry climate.

Reference:

- http://www.springer.com/us/book/9789048188932 View project
- https://link.springer.com/article/10.1007/s10668-014-9545-6
- www.berkeleyprizecompetition.org/endowment/the-reserve?id=3191
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