ISSN 2347 - 3983
Volume 11. No.6, June 2023
International Journal of Emerging Trends in Engineering Research
Available Online at http://www.warse.org/IJETER/static/pdf/file/ijeter061162023.pdf
https://doi.org/10.30534/ijeter/2023/061162023

# Climate Responsive Architecture in Warm Humid Climate - A Case of South Kanara Manor houses

**Dr. Lekha S Hegde**
Professor, BMS College of Architecture, Bull Temple Road, (affiliated to Visvesvaraya Technological University), Bangalore, India
[1]lekhashegde@gmail.com

Received Date: April 25, 2023 Accepted Date: May 21, 2023 Published Date : June 07, 2023

**ABSTRACT**
Thermal comfort is of utmost importance in an indoor environment. If people are living or working in unfavourable environments, the work efficiency is considerably affected. Hence it is the job of an Architect to design comfortable indoors.

Warm humid climatic zones are prevalent within 15º to 30º north and south of equator. The main characteristic of this climatic zone is there is very little seasonal variation, humidity is more than 50% (RH) and precipitation is also very high. South Kanara is along the Konkan coast in the state of Karnataka, under the warm humid climatic zone. The main challenge in designing in warm humid climatic zone is the temperature and humidity are high throughout the year and people indoors are not comfortable most part of the year. Hence, they have to depend on active cooling systems.

Vernacular structures which are specific to a climatic zone have come up after lot of experimentation with the use of locally available materials and techniques. Vernacular structures which are climate responsive architecture incorporate passive design strategies. Thermal comfort is achieved by appropriate orientation of the building, optimum size and orientation of the fenestration, adapt design of surrounding landscape feature, appropriate use of materials in construction of the building, enhanced wind movement in the interior by good planning, cutting down solar radiation entering into the interiors.

This article explains in detail the passive strategies to be adopted in warm humid climatic zone

Giving an insight into the climate responsive design strategies adopted in the vernacular structures of south Kanara manor houses.

**Key words**:Thermal comfort, Climate responsive design, Warm humid climatic zone, vernacular structures & passive design strategies

## 1. INTRODUCTION

Energy consumption in buildings and buildings construction sectors is on the rise. According to international energy agency these two sectors contribute to 30% of total global final energy consumption. in developing countries, energy demand from buildings and buildings construction continues to rise due to residential and commercial lighting, appliances, heating and cooling. The goal of climate-responsive design is to create a comfortable interior while reducing the building's reliance on artificial energy. There is a record global surge in energy demand post pandemic. Hence design of climate responsive structures is appropriate to combat energy crisis. Vernacular construction incorporated the sustainable practices and were built to utilise less energy to construct and maintain as compared to the conventional construction. Here in this article an investigation into the climate responsive design strategies used in the vernacular structures designed in the warm humid climatic zone is carried out.

## 2. CLIMATE RESPONSIVE DESIGN

Climate responsive design helps to reduce environmental impacts and provide for human wellbeing, this uses passive control system than the active systems. Since building built on the philosophy of climate design considers holistic environmental design it is appropriate to study the vernacular/ traditional buildings and their environment. These buildings have emerged after experimenting for thousands of years to come up with the appropriate material and techniques of climate responsive design.[1]

The site, context and the climate provide both opportunities and limitations for design especially in tropical zones other aspects influencing the built form are program, economics, and client aspirations. Climate responsive design is the way in which the built form has evolved for the comfort of the inhabitants.

### 2.1 STAGES IN CLIMATIC INVESTIGATION

Olgay suggested a way of assessing beneficial features of climate through analytical investigation of climate. This form of investigation and analysis is the bioclimatic design. This involves the interpretation of climatic data of any particular location in relation to the human comfort.[2]

Stage 1: information on seasonal and daily climatic data. This involves collecting macroclimatic data of the zone in which

the building is located. Data of air temperature and humidity around the year is collected.
Climatic data collection of

1. Temperature
2. Humidity
3. Rainfall
4. Solar radiation
5. Sunshine hours
6. Wind direction & velocity
7. Sun path, sun angles, site shading & shadows
8. Rain exposure & water run off

Stage 2: Analyze the climatic data with respect to thermal comfort standards
Investigation of the bioclimatic chart reveals the following information
The climatic data of the location as taken in stage 1 can be compared to the zone comfort defined by the bioclimatic chart
Strategies suggested if the climate exceeds or is below the comfort zone.
Stage 3: Propose strategies either heating or cooling based on analysis- climate modification strategies:
The strategies for extending the comfort zone using both human and building related factors are:

1. Overheating
2. Use of air flow improves the efficiency of cooling the body and removes heat from the indoors
3. Use of thermal mass can be used to store heat and cool during periods of low temperatures and cool air during hotter periods
4. This form of comparative analysis is available in a number of computer programs like DA Sketch Pad and ARCHIPAK

**Table 1:** Stages of climate investigations after Lippsmeier [3]

| Stage 1 | Stage 2 | Stage 3 |
|---|---|---|
| **Climatic data collection** | **Bioclimatic analysis** | **Selection of climate modification strategies** |
| Temperature Humidity Solar radiation Sunshine hours Wind velocity & direction Rainfall | Assessment of the climatic data with respect to the thermal comfort | Cooling strategies through airflow, thermal mass, and evaporation |

All three stages of climatic investigation and data collected for each stage is listed in table 1.

## 3. WARM AND HUMID CLIMATE

Warm climates are found near the equator receive high levels of solar radiation and have high humidity percentage. Very less seasonal variation, high rainfall is received during the year.

Lippsmeier, defines two zones-
Mountainous zone, here altitude affects climate
Maritime zone, here ocean/ sea affects climate

### 3.1 CLIMATE OF SOUTH KANARA

South Kanara region is along the west coast Indian South peninsula & is classified as warm humid climatic zone. The extent of area is as shown in figure 1. It receives the very high annual rainfall, the second highest in India. The average rainfall is around 3000mm/year. The daytime maximum temperatures are between 30 to 38 º Celsius for most part of the year. Monsoon season is from June to October bring torrential rains from southwest. The predominant winds are from the south- west direction & the rains are also received from the same direction. Thermal comfort indoors can be achieved by effectively allowing good ventilation.

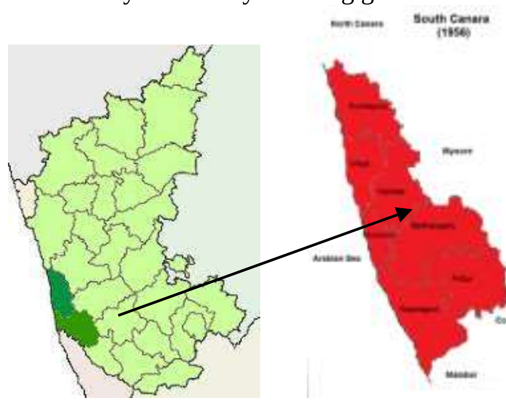


**Figure 1**-Map showing state of Karnataka and the South Kanara Region

## 4. VERNACULAR STRUCTURES

The vernacular buildings in this climatic zone are primarily built from readily available natural resources such as hard wood timber, clay, and stones. According to Watson and Bentley (2007), at least till 19th century most buildings had to be constructed using locally available materials due to limitations in transportation means. Vernacular is derived from the Latin word vernaculus meaning domestic or indigenous. Vernacular architecture is building without Architects [4]. The materials used in the vernacular buildings significantly contribute to the unique character and is worthy of being maintained and conserved. The buildings are constructed to provide protection from extreme climate, discomfort, and other sources of danger.
According to Jamaludin et al (2015) a sustainable building in one which is designed to harmonize with local climate, immediate context, tradition, and culture. These vernacular structures have been built as a result of many iterations in design, material and construction techniques [5]. The challenge is to balance the positive and negative aspects of climate to achieve efficient use of resources few designers draw on models from the past like the vernacular architecture, others go for simulation modelling approach. Vernacular architecture focuses more on daylighting, thermal responses, and natural ventilation [6]. The influencing factors of vernacular buildings are as listed in figure 2.

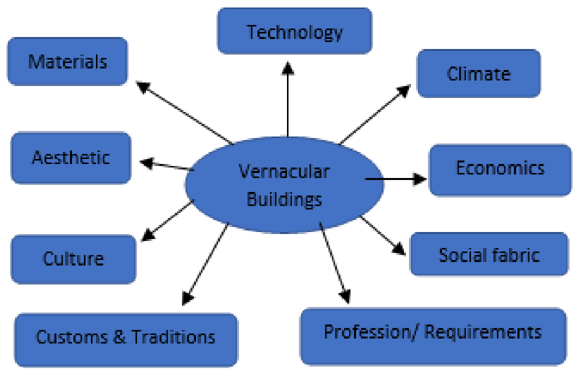


**Figure 2:** Influencing factors of vernacular buildings

## 5. PASSIVE METHODS OF COOLING- SUITABLE IN WARM HUMID CLIMATE

**Table 2:** Climatic strategies for building form & fabric in warm humid climatic zone [7]-

| | Type | Requirement |
|---|---|---|
| 1 | Materials | Lightweight materials preferred |
| 2 | Plan shape | Linear plan to maximize cross ventilation<br>Linear plans give ample daylight |
| 3 | Sections | Open section to encourage stack ventilation |
| 4 | Orientation | Shorter side facing east and west to reduce solar gain windows facing prevailing wind direction to facilitate cross ventilation during summer |
| 5 | Landscape | Use of canopy to shade the building but allow breeze |
| 6 | Verandas | To provide rain and sun protection to external walls |
| 7 | Courtyards | To provide light and ventilation<br>Diffused light let indoors and reduces glare |
| 8 | Roof | Light colored roof to reflect solar radiation |
| 9 | Building envelope/ Walls | Avoid windows to the east and west direction |

All the passive methos of cooling suitable in warm humid climate are listed in the table 2 above.

## 6. MANOR HOUSES OF SOUTH KANARA

South Canara is the coastal belt of Karnataka. This forms a part of the Konkan belt, which has similar kind of architecture and food habits starting from Kerala, Karnataka, Goa and Maharashtra. It has a warm humid climate. It is the land mass along the edge of Arabian sea and the western ghats.

The vernacular houses of this region are set in the center of huge farmlands. Hence houses are in isolation without any cluster formation and the neighboring structures are further away and not within the vicinity. This facilitates uninterrupted air movement, and the surrounding landscape comprises of coconut and areacanut trees, which have a very high canopy which doesn't interrupt the wind movement.

### 6.1 MATERIALS USED IN CONSTRUCTION

Main structure is between the roof and the ground, and the wall is made up of the locally available materials from the surroundings. Usually, the soil and laterite blocks were used for construction. Wooden frame with wooden mullions arranged in horizontal, vertical, and diagonal directions were extensively used in these vernacular buildings. These natural materials have very less thermal mass hence would minimize heat transfer into the indoors during the daytime. The use of these materials with high porosities will improve air movement in the building [11].

Air movement is of utmost importance in tropical climatic zones to reduce indoor temperatures and to provide comfort to the occupants. In the modern context the walling material is usually brick & concrete, which have high thermal capacity and will take a long time to release the heat received during the daytime. Hence this has resulted in dependency on services such as fans & air conditioning.

Another character of vernacular buildings is the open and fluid interior spaces, which encourages air flow through the building. Living spaces are large uninterrupted and open with wooden jaalis and very few furniture such as chairs, tables and beds which maximizes air flow within. The materials used in all building components of vernacular structures of manor houses are listed in table 3.

**Table 3:** Materials used for construction and thickness in Vernacular structures

| Building component | Thickness | Material used |
|---|---|---|
| Roof | - | Mangalore tiled roofing with rafters and battens of wood. |
| Wall | 30 cm | Mud walls with lime plaster / cement plaster |
| Floor | - | Red oxide flooring |

### 6.2 PLAN SHAPE

Vernacular buildings here are usually separated and arranged around courtyards for free flow of air. Rooms are usually single row with access from open verandahs/ corridors of courtyards. Usually, the main living areas are facing north, in order to receive good daylight and usually the outdoor living areas are also north facing. Figure 3 gives a typical plan of manor house.

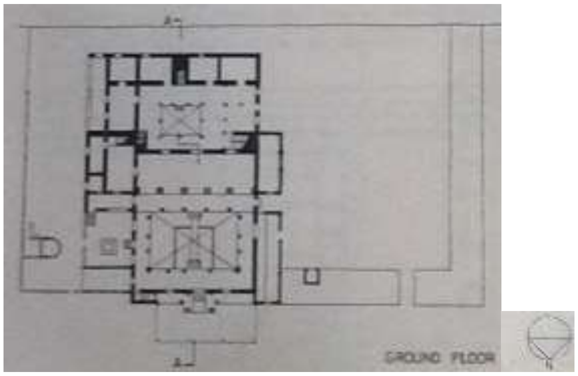


**Figure 3:** Ground floor plan of the vernacular house

### 6.3 SECTIONS

Due to pitched roof, the volume of all interiors is large, which further facilitates stack effect and improves ventilation in the interiors. Figure 4 shows typical section of manor house.

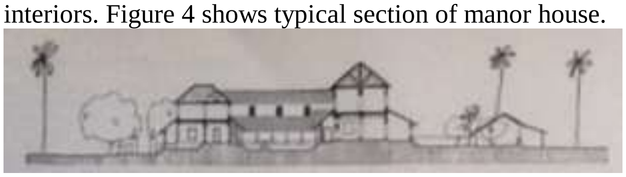

**Figure 4:** Section of the vernacular house

### 6.4 ORIENTATION

In tropical climates orientation of buildings in relation to prevailing wind direction is beneficial. In warm humid climate the building needs to be oriented to receive cool breeze during the summer months- appropriate materials need to be selected for the building envelope. Orientation of the building will determine the amount of solar radiation received and in turn affects the inhabitant's comfort.

The study in tropical climates by La Roche et al (2001) found that buildings must avoid having large openings in the east and west elevation, where they receive about twice the amount of radiation as compared to the north and south façade (elevation). The orientation of buildings in the tropical climate has a maximum exposure to breeze and limited exposure to direct sun [8]

### 6.5 SURRONDING LANDSCAPE

**Figures 5 & 6-:**Surroundings & setting of the vernacular house

The surrounding context is very important and has to be addressed during the process of design. The outdoor area surrounded by a garden of non-reflective landscaped surface and the outdoor area shaded with the grass cover rather than paving. Trees and shrubs will cool the air passing into the building. Site planning in terms of obstruction/ vegetation positioning with respect to openings. Figure 5 & 6 shows the surrounding landscape features.

### 6.6 VERANDAS

Verandahs are present all around the courtyards, which act as the transition space from the outside to the inside. Figure 7 shows the surrounding verandahs around the courtyard of manor house.

**Figure 7:** Ariel view of a Vernacular residence [9]

### 6.7 COURTYARDS

Courtyards of different sizes are used for various activities and are an integral part of the building. Courtyards facilitate better air movement in the interiors. Typical features of courtyard in manor house shown in figure 8.

**Figure 8-:**COURTYARD IN THE VERNACULAR HOUSE

### 6.8 ROOF

Roof is a building component which provides protection from wind, precipitation, and thermal forces. Roof is one of the most important elements, roof should always be designed with regard to the climatic conditions. Roof is required to withstand heavy rainfall to quickly drain off the rainwater. Throughout the tropical climates, people have traditionally combined roofs of different slopes in the same building [10] [11].

In warm humid climate, the buildings have surplus heat, and the roof plays an important role in reducing solar heat gain during the day and also promoting cooling at night. Hence in warm humid climate the roof geometry and the material used become utmost important [12]. Figure 9 shows the typical roof profile of the manor house.

The pitched roof having an inclination of up to 23 degrees with the horizontal. If the inclination of the roof is much more then chances of these individual Mangalore tiles sliding off the battens is more. The roof profile creates a high attic space in the building. Apart from good storage the attic facilitates air circulation and reduces the heat gain from the roof. The roof plays a significant role in reducing the heat build-up.

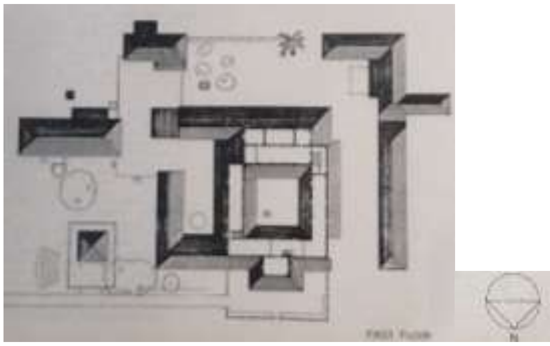

**Figure 9:** Roof plan of the vernacular house

Another climate responsive features of the roofs in the tropical zone are the wide overhangs. These overhangs are important in tropical climates to protect the majority of the walls and openings (both doors and windows) from sunlight and rain. These eaves and usually covered by fascia board, which are ornamental and decorated. Keeping the eaves away from the wall helps to protect the building from heavy downpours and usually installed with end gutters to reduce the splashing of rainwater

For covering of these sloping roofs, Mangalore tiles are used. Typically, these are a part of Spanish and Italian architectural styles, the tiles were first introduced in India in 1860 by German missionary. These tiles are manufactured from hard laterite clay. These double tiled roofs are thin, and it will not burden the weight of houses on the slender stilts, its thickness reduced its heat absorption and reradiation capacity and if damaged can be easily removed and replaced and has environmentally friendly qualities

Air movement is uninterrupted because of huge living rooms with only intermediate columns to support the roof. Most of the living spaces are kept open from the sill level onwards to facilitate good air movement. The space near the staircases become especially breezy during the afternoons due to the huge volume. The false ceiling made of wood for the bedrooms, keeps the indoors cool. The living rooms where the false ceiling is not provided, double tiling of Mangalore tiles is provided to give good thermal insulation. The courtyard in addition facilitates better air movement.

## 7. CONCLUSION

Climate investigation will give an insight into the possible passive strategies which are feasible in that climatic zone. The effectiveness of climate responsive architecture is evident in lessened costs of utilities and maintenance. A poorly designed structure which doesn`t consider environmental or vernacular factors can ultimately cost the occupant. We are now living in times of rapid technological advancement. Digital technologies have given rise to faster construction and increasingly complex designs. Many architects are investing time and resources to decode the world of vernacular architecture so as to come up with sustainable solutions. The contemporary structures have to take forward the learning from these vernacular buildings, discourage use of active cooling systems and utilize minimum energy and so to merge traditional outlooks with modern techniques [13] [14]. Many architects have turned to vernacular philosophies as the solution to sustainability.

## REFERENCES

[1] Arvind Kishan, Baker & Szokolay, Climate Responsive Architecture, Tata McGraw Hill, 2002.

[2] Olgyay, Victor, Design with Climate: Bioclimatic Approach to Architectural regionalism- New and expanded edition, 2015, Princeton University

[3] Riley Mike, Cotgrave Alison & Farragher Michael, Building Design, Construction and Performance in tropical climates, 2018, Routledge, Taylor and Francis group, London and New York.

[4] Watson GB & Bently I, Identity by Design, 2007, Routledge Taylor and Francis group, London and New York.

[5] Hussein, H. and Jamaludin, A.A. (2015) POE of Bioclimatic Design Building towards Promoting Sustainable Living. Procedia—Social and Behavioral Sciences, 168, 280-288

[6] Hyde, Richard and Wood, Peter, 2000 Climate Responsive Design A Study of Buildings in Moderate and Hot Humid Climates, Taylor & Francis, London, ISBN9781315024905

[7] Koenigsberger, Ingersoll, Szokolay, Mayhew. Manual of Tropical Housing and Building Climatic Design, Orient Longman Private Limited; 2003

[8] La Roche, P., Quiros, C., Bravo, G., Gonzalez, E. & Machado, M. (2001). Keeping cool: Principles to avoid overheating in buildings in S. V. Szokolay (Ed.), PLEA notes, Passive and low energy architecture international: Design tools and techniques. New South Wales: Research, Consulting and Communications (RC&C).

[9] "Vernacular Architecture of South Kanara and Sustainability", International Journal of Emerging Technologies and Innovative Research (www.jetir.org), ISSN:2349-5162, Vol.6, Issue 6, page no.275-278, June 2019, Available: http://www.jetir.org/papers/JETIR1907G84.pdf

[10] Report on South Kanara Manor house by Dr. K S Anathakrishna and Dr. RP Deshmukh, Dept. of Architecture, Manipal Institute of Technology

[11] Brown GZ, DeKay M. Sun, wind and light – architectural design strategies, 2nd Ed., John Wiley and Sons Inc., New York; 2001

[12] Mili Majumdar (Editor); Energy Efficient Buildings in India; The Energy and Resources Institute, TERI, 2009

[13] Oliver P. Encyclopedia of vernacular architecture of the world, Cambridge university press; 1998

[14] Krishna, A. and Rewatkar, K. (2006). The relevance of heritage architecture in today's context., Journal of Indian Institute of Architects, 71 (8).