

Analyzing Green Building Technologies in Indian Vernacular Architecture: A Case Study of Kerala

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ABSTRACT: Green buildings have been a major boom in the society for past few years because such buildings focus on energy conservation and low-environmental impact design, which is the need of the hour. This paper tries to understand the influence and use of technologies that have been termed in the contemporary world as green building technologies in Indian vernacular architecture. This study aims at investigating the green technologies which are applied in the vernacular houses of Kerala which are built using local materials and traditional construction methods. These technologies were identified by studying and analysing the structure on the basis of their site planning, spatial organization, material specifications and building envelope specifications. Understanding how climatically and culturally responsive architecture of the past recognizes such technologies will help us to reinvent the link between the green buildings of the modern age and vernacular architecture of the past.

KEYWORDS: Green building technologies; Vernacular architecture; Typology; Occupant comfort; Kerala.

I. INTRODUCTION

We spent 90% of our time in building, either office or home. Energy used in commercial and residential buildings contributes to major share of total energy usage of a country. The percentage varies depending on the degree of electrification, level of urbanization, the amount of building area per person, the prevailing climatic conditions and the country's policies to promote energy efficiency. In residential sector the majority of energy is used for space heating or cooling and lighting and this depends not only on efficient of the systems but also the efficiency of the building in which they function.

Thus building design, technologies used and materials have a significant effect on the energy consumed for a selected set of end uses. The energy usage should be reduced; new technologies and renewable sources of energy should be used in order to meet the current demand and also make the resources available for future generations.

Green Building Technology

The office of federal environmental executive defines green buildings as the practice of increasing the efficiency with which buildings and their sites use energy, water and materials and reducing the building impacts on human health and environment through better siting, design, construction, operation, maintenance and removal ([Howe, 2010](#)).

As mentioned in [Fig 1](#), the five major areas of focus of green buildings are Site, Energy, Materials, Water and Occupant comfort. Green building technology refers to the techniques that are adopted in green buildings which adhere to the issues related to five major focus areas of green buildings namely Site, Energy, Materials, Water and Occupant comfort, and providing an environmental sensitive solution to the issues, and thus reducing the environmental impact of buildings ([Yuksek, 2013](#)).

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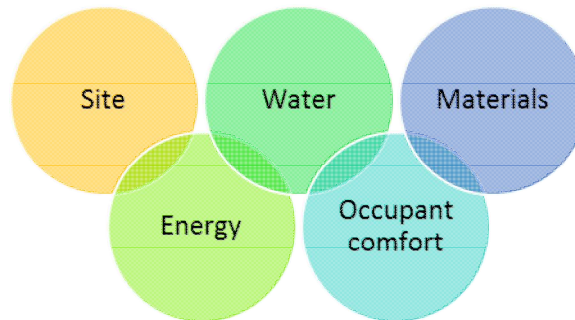


Fig 1. Guide to apply styles

Vernacular Architecture

Vernacular architecture is the style of architecture which takes into account all the needs and requirements of the residents, nature, construction materials and also mirrors the traditions and culture. (Sarkar, 2015).

Traditional building design takes the advantage of natural sources such as sun and wind to achieve comfort conditions within the building (Nguyen, 2011). The basic idea is to tap the available resources to provide comfort when and where required by close interaction with the dynamic conditions of the external environment. The study and analysis of vernacular architecture will give us an understanding on how architecture can act as a design response to the prevailing site condition, climate and culture.

II. TOPOGRAPHY AND CLIMATE OF KERALA

Kerala which spans between 8°18'N to 12°48'N latitude and 74°52'E to 72°22'E longitude has a warm and humid climate as per the National building code. Kerala which is on the south west coast of India lies between the Arabian sea on the west and Western Ghats on the east which makes it fall under the belt of monsoon zone, and experiences seasonal changes in solar radiation and wind direction. The predominant wind direction is from south-west to north east. The temperature of Kerala varies between 21 °C to 33 °C and relative humidity varies from 65% to 70%.

Kerala climate can be divided distinctly into two seasons, rainy season and non-rainy season. The rainy season which lasts about six months occurs due to south-west monsoon from June to August and north-east monsoon from October –November. The winters and summers come under non-rainy seasons.

Climate Considerations for Warm and Humid Climate

Major considerations for achieving thermal comfort in a warm and humid region like Kerala involves coping up issues such as:

- High humidity-Presence of excess moisture in the atmosphere
- Intense solar radiation
- High temperature
- Excess rainfall

This can be done by maximizing the improving the air circulation by providing fenestrations and courtyards and enhancing the stack effect, so that there is constant flow of air into the house and minimizing heat gain by providing appropriate shading devices for fenestrations as well as walls. The spatial organization and site planning should be done in such a way that the prevailing winds should never be obstructed and a continuous flow of air should be maintained. Organizing rooms according to their daytime use and locating them in appropriate positions would help to reduce heat gain.

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III. VERNACULAR ARCHITECTURE OF KERALA

Most of the traditional buildings in Kerala are built according to *Vaastushastra* and residential buildings are no exception. According to spatial and structural considerations the vernacular residential forms of Kerala can be categorized into four types namely rectangular I shaped shelter belonging to tribal people, Rectangular single-hall building (*Ekashala*) with Granary (*Ara*), Traditional courtyard house (*Nalukettu*), *Ekashala* with courtyard like extension.

Rectangular hall I shape shelter

This is the most commonly found vernacular residential building type in Kerala. This type is modified by repetition, extension and expansion. The house is divided into two zones inner and the outer zone. [Fig 2](#) shows that the inner zone houses the private spaces the outer zone is usually has a porch and sitting platform.



Fig 2. Rectangular hall I shaped shelter ([Widiastuti, 2013](#))

Rectangular Single-Hall Building (*Ekashala*) with Granary (*Ara*)

In this typology the granary (*Ara*) becomes the most significant addition. The major zoning consists of a veranda that becomes the outer zone and the inner core consists of granary (*Ara*), kitchen and other function rooms, refer the [Fig 3](#). Sometimes such houses are constructed as an annex to the main house.



Fig 3. *Ekashala* with *Ara* ([Widiastuti, 2013](#))

Traditional Courtyard House (*Nalukettu*)

This basic form of a Kerala courtyard house or *Nalukettu* is four blocks built around an open courtyard, the *nalukettu* house is shown in the [Fig 4](#). It could have a square or rectangular plan with high pitched roofs and the courtyard left open to bring in light and ventilation. The internal veranda and external veranda act as protection from rain and sun. The blocks and courtyard are laid out according to the rules of dimensions scales and proportions. Depending upon the size and importance of the family the *ettukettu* (eight blocks) and *pathinarukettu* (sixteen blocks) are made out of repeated modules of *nalukettu*.

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Fig 4. *Nalukettu* in Harripad ([Widiastuti](#), 2013)

Ekashala with courtyard like extension

This housing typology is a variation of *nalukettu* wherein the courtyard is smaller and acts as water cistern. In the [Fig 5](#), the courtyard acts as a transition space between the main building and the annex. This transition space is essential as to create a distinct demarcation between the public zone which is the main house and the private zone which is the annex.

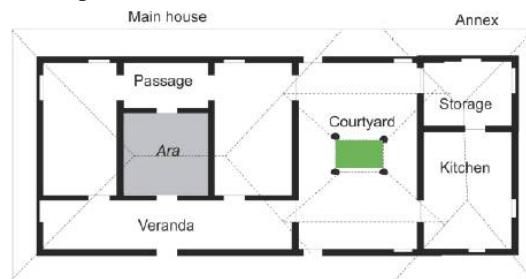


Fig 5. Christian Syrian House ([Widiastuti](#), 2013)

IV. ANALYSIS OF NALUKETTU USING GREEN BUILDING TECHNOLOGIES

From the four typologies of vernacular houses, the traditional courtyard house (*nalukettu*) in Alathur, Palakad (See [Fig 6](#)) is chosen and the various green building technologies used are categorized according to the following criteria:

- Site planning and spatial organization
- Materials specifications
- Building envelope specifications

Site Planning and Spatial Organization

Most of the *nalukettu* are located amidst a large expanse of land which is thickly vegetated. This allows for unobstructed air flow and the vegetation cover helps in reducing the insolation.

From the [Fig 7](#), Spatial planning of a *nalukettu* revolves around a central courtyard. The entrance usually from south or east and side. The rooms are sandwiched between two verandahs one exterior and one interior. The external verandah running along the building footprint acts as a buffer space reducing direct heat entry into the living spaces. The internal verandah which is the major circulation spine of the building acts as buffer space dissipating and

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distributing light and air coming from courtyard into the building. High plinths are provided to prevent moisture entering from ground.



Fig 6. Nalukettu in Alathur, Palakkad

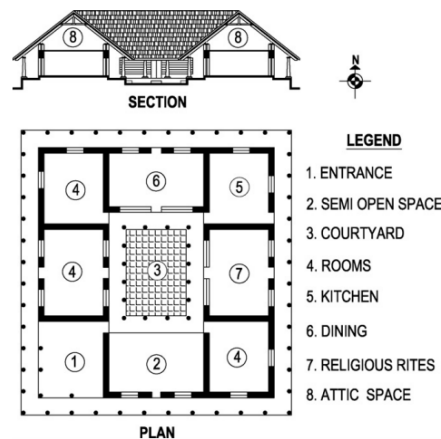


Fig 7. Typical plan and section of nalukettu (Diji, 2010)

The rooms which are used during day such the semi open space which functions as living room and the entrance which also functions as a drawing room are placed on the south east and southern side respectively to protect from harsh sunlight from the western side. It is easy to reduce solar heat gain on southern side by using nominal shading devices as the sun angle is high in south side. Since the prevailing wind direction is from South west to north east, kitchen is usually located at the north-east corner to avoid the spreading of hot air from kitchen to other spaces creating thermal imbalance.

Fig 8 explains that the courtyard being a microclimate modifier helps in retaining cool air. Since the heat gain in upper part of courtyard is more, the air in this part is warmer and lighter causing the air to move upwards thus developing a low pressure in courtyard. Due to the pressure difference in the courtyard and surroundings an air movement from induced from outside. This helps in maintaining constant air circulation within the building and thus helps in coping up with the humid conditions and enhancing thermal comfort. This will help in reducing energy consumption, because we the use of electrical appliances such as fans is reduced.

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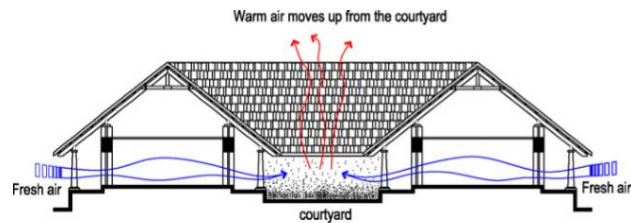


Fig 8. Air flow pattern in a nalukettu (Dili, 2010)

Materials

The materials used for construction vary across the different regions of Kerala. But the major materials used are laterite stone, granite stone for foundations, wood, clay roof tiles and bamboo. In Fig 9, the exposed laterite stone masonry is clearly illustrated in the typical Kerala house. All these materials are locally available thus they have low embodied energy due to its minimum transportation.



Fig 9. Exposed Laterite stone masonry



Fig 10. Unfinished granite stone flooring

In some cases lime mortar strengthened with vegetable juices is used for plastering. Mud mortar is used as a binding element and mud is used for making wall, clay tiles etc. Fig 10 shows that the Red oxide flooring is used for interiors and unfinished granite stone flooring for exteriors is used. The roughness of granite stone reduces reflectivity. These materials as per GRIHA code criteria comes under low environmental impact materials.

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Building envelope

Wall: Exposed laterite bricks having a rough surface are used for external walls as these have self-shading properties, refer [Fig 11](#) and thus reducing the radiation falling on them. The thermal mass of external wall is increased by using double layer of laterite masonry with a cavity in between that is filled with sand, this helps in insulating the interiors. This will help in reducing the cooling loads. Facades are painted with white or light colors to minimize the heat absorption.



Fig 11. Attic space

Roof: High pitched roofs and large roof overhangs are used to maximize pressure difference which in turn will maximize air flow. The pitched roof is provided with a roof beneath creating a large air space that acts as an attic providing an insulating layer against conduction on external heat through roof. This air space is provided with openings to which creates an escape route for hot air transferred down the tiled roof. Due to this the second roof remains cooler than the pitched roof above. These steeped roof and deep eaves helps in rainwater discharge as heavy rains is one of the important concerns.

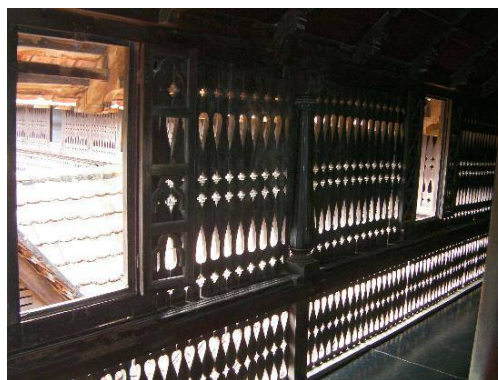


Fig 12. Wooden jaalis

Fenestration: In typical *nalukettu* cross ventilation is enhanced by provision of fenestrations on opposite walls. Various kinds of fenestrations are used ranging from typical two paned casement windows to wooden. [Fig 12](#) illustrates the wooden jaalis are arranged meticulously to cut off glare and bring in diffused light and improve air movement. These small perforations increase the velocity of air which passes through them and enhance the mild breeze outside and allows deeper penetration of air which is very essential for thermal comfort in warm and humid climate of Kerala. These also reduce solar heat gain as direct radiation is cut down.

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Side lighting and top lighting strategies are used to bring in daylight and in most of the cases northern side has more number of fenestrations to bring in glare free light. [Fig 13](#) shows the top lighting glass roof tiles are used in strategic places to bring in daylight thus reducing the energy used for artificial lighting.



Fig 13. Top lighting using glass roof tiles

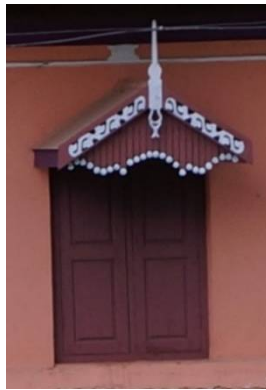


Fig 14. Shading devices for wall (left) and Shading device for window (right)

Side lighting strategies are effective only if the windows are open because the window panes are made of wood and daylight does not enter if the windows are closed. But this has an advantage that heat gain is reduced as glazed surfaces are bare minimum and this in turn reduces cooling load. Shading devices for windows as well as walls are used to cut down solar heat gain. [Fig 14](#) shows the eaves of the roofs projected to act as a shading device for the walls if verandahs are not being provided. And for windows two way sloping shading devices which is in sync with the roof form are provided. The closed plan also contributes to shading as the facades mutually shade each other reducing the radiation falling on the facades.

V. CONCLUSION

Understanding about the vernacular architecture of a particular region would give us an insight on how architecture can function in perfect harmony with nature. The climate responsive architecture helps in maintain indoor environmental quality and also provides us with some infallible methods and techniques of maintaining human comfort conditions. These techniques when integrated with current technologies can help in providing maximum comfort to occupants with minimum use of energy.

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