ROLE OF SOLAR PASSIVE TECHNIQUES IN VERNACULAR HOUSES IN WEST-BENGAL IN INDIA

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Abstract—The Human settlements are known as best example to describe civilization. The growth of vernacular settlement is affected by a particular type of religion, social value, climate and availability of building materials in local area. Vernacular settlements vary in nature in different regions of the world. Study of different building forms indicates the traditional techniques by local unskilled masons, craftsmen and skilled artisans. This gives a symbolic identity to the particular region with its unique vernacular style. Thus, vernacular architecture is also called as an architecture without an architect.

The paper is elaborated on the basis of case studies of settlements in the Coastal region of west-bengal with special reference to rural communities in ancient townships. It has evolved over generations with the available building materials, climatic conditions and local craftsmanship. However, some beautiful examples of vernacular architecture are still found all over the coastal region with the finest examples being concentrated in the historical town which are nearby.These vernacular dwellings provided with various passive solar techniques including natural cooling systems and are more comfortable compared to the contemporary buildings in today's context.

This paper discusses different passive techniques that have been used in the vernacular buildings in order to achieve comfort particularly during summer. It has been observed that vernacular houses are more energy efficient and perform better than the contemporary house in providing comfort level in indoor conditions.

Keywords: Vernacular settlements, climate responsive design, traditional and contemporary house, chiley kota(mud roof), bari, bhita (houses)..

1. INTRODUCTION

The term vernacular is derived from the Latin word vernaculus, meaning "domestic, native, and indigenous";. It tends to evolve overtime to reflect the environmental, cultural and historical context in which it exists and is influenced by a great range of different aspects of human behavior and environment, leading to different building forms. Our ancestors have survived, sheltering themselves in the vernacular buildings which have been experimented through the ages. Now, there is an enquiry into vernacular, building in search of passive techniques for thermal comfort if some climates, masonry and mud have been utilized as one of the simplest and most effective ways of reducing building heating and cooling loads with its relatively low cost technique. Such decline in building envelop heat gain combined with optimized material configuration and proper amount of thermal insulation in the building envelop could help to decrease the building's cooling and heating energy demands and building related carbon dioxide emission into environment.



Coastal West-Bengal comes under warm humid climate zone. The people in this climate have well utilized the air currents for minimizing the effects of heat and humidity by using the local building materials and designing appropriate building form. For generations, these dwellings have provided comfortable life conditions. Form, pattern, elements and spaces rendered image ability and provide, character and distinct identity to the particular area. As this provides better thermal comfort with indigenous passive solar techniques, there is a need to study the construction technology used in those vernacular buildings.

2. VERNACULAR ARCHITECTURE OF COASTAL WEST-BENGAL

The vernacular architecture of coastal Bengal evolved over generations with the available building materials and local craftsmanship. Vernacular architecture is influenced by a great range of different aspects of human behavior and environment, leading to differing building forms due to climate of the region, culture and availability of building materials. One of the most significant influences on vernacular architecture is the climate of the area in which the building is constructed. Buildings in warm climates, by contrast, tend to be constructed of lighter materials and allow significant cross ventilation. The way of life of building occupants, and the way they use their shelters, has great influence on building forms. The size of family units of different users, food habits and cultural considerations will affect the layout and size of dwellings. Culture also has a great influence on the appearance of vernacular buildings, as occupants often decorate buildings in accordance with local customs and beliefs. The availability of building materials also affects the vernacular architecture of a particular region. Vernacular, almost by definition, is sustainable, and will not exhaust the local resources. Areas rich in trees and rice production use thatch roof, wood and bamboo as building material. The housing pattern in coastal Bengal falls into two major types: linear and clustered.

3. FACTORS INFLUENCING VERNACULAR ARCHITECTURE OF WEST-BENGAL

3.1 Geography and Climate

West-Bengal extends from 17°-49'N to 22°-34'N latitude and from 81°-29'E to 8T-29'E longitude on the eastern coast of India. The winter is very pleasant in Coastal Bengal. However the summer and rainy seasons allowed the local people to construct different forms of vernacular housing to protect them from natural disasters like flood and cyclone and heat waves.

3.2 Local Building Materials

The main factor influencing is related to the availability of local building materials which includes twigs, leaves, thatch, country tile, Mangalore tiles for roofing materials. Similarly twigs/leaves, mud, stone for walls. The materials used for construction are indigenous and locally available.

3.3 Construction Technology

In the simple village houses there are some very sophisticated design arrangements like sloped thatch roof with Attu (Mud ceiling with bamboo/timber rafter) and Kadi Baraga Roof. The Kadi (timber beam) and Baraga (timber rafter) applied for flat roof construction.

4. DESIGN CHARACTERISTICS

•Space

Space design has evolved over time as per the need from single unit to double unit and multiple units separated by enclosed courtyard. The orientation of the buildings was mostly chosen on the basis of topography, solar movement and wind direction. Design features have been mostly influenced by the local skill and craftsmanship.



A typical vernacular house consists of a common verandah, small room for cattle, entrance room (Bata Ghara) and other rooms arranged around the courtyard. It does not include toilet which is located at the back side of the house.

Organizational Pattern

Where high land is not available, earth obtained from excavating ponds or channels is raised into a mound about 2 to 3 metres high depending on the surrounding water level, on which a homestead or bari is established. A bari often begins with an individual household and incrementally develops into a settlement of several ghors (dwelling units and ancillary structures) of intergenerational households belonging to a joint or extended family. The settlement is organic in nature i.e. free flowing. Most of the people live near their farmland. The village is thus a settlement area, surrounded by paddy fields and made up of several small linear settlements, each of these comprises two or more subdivisions as per different caste groups, and accordingly manifests a variety of living patterns in their house forms.

There are vast open spaces in the front and backside of the building. The front side is used as gardens and the back sides have gardens and paddy fields. The external garden is a comfortable place in the morning and evening. The trees provide shade and the lower shrubs channel, cool breeze for natural ventilation in the building. The approach road is very narrow.



• Type of House

In Coastal Bengal, three types of houses (ghara) are commonly found..

- Gacher ghor house made of wood
- Basher ghor –house made of bamboo

• Tiner ghor- house made of tin.

Based on roof, houses are classified as-

- Narar- chani or chaal (roof)-roof of straw(khord)
- Tiner chani-roof of tin.
- Patar chani/ chaal-roof of big leaves
- Choner-chaal- roof of big grass.

Mud used for the construction of such houses is of soft type known as atel mati.Bamboo stick is an important element of mud-house.The agriculturists and higher castes have houses with rectangular ground plan with rooms along all the sides (bhita-ghara), leaving an open space (courtyard) at the center. Mud walls with a gabled roof of thatch made of paddy stalks were common. The more affluent had double-ceiling houses (dutala ghar) with the inner ceiling of mud plaster supported by wooden or bamboo planks. This construction made it fire proof and insulated against the summer heat and winter chill. Poor people had houses with mud walls and straw thatched gable roofs, without enclosed courtyards or double ceilings. As per the socio economic status of inhabitant, there are two types of Vernacular dwellings such as Chala house (Thatch roof and mud wall) and Pucca House (Thatch roof / pucca roof and stone wall) in which there is a courtyard in the center and rooms are arranged around the courtyard with verandah.

2. •Plan form

People in coastal Bengal live in large families. In the typical housing, there is a long verandah connecting all the rooms which permits social gathering as well as the storage of paddy.

A comparatively large house, of a middle class family, comprises alignment of rooms on four sides (choumata)) arranged around an inner courtyard known as utthan (courtyard) with separate cattle shed outside. In most of the day and night time people use this courtyard for different works and for social interaction. The Central courtyard is a very sensible place for different activities.



In summer "Courtyard effect" takes place keeping the adjacent rooms cool. In winters people sit in the courtyard in day time. The place is also used for various religious activities and festivals and also for cooking, drying of fire wood, crop etc.

2. Building Envelope

To make the building climate responsive, several basic techniques are used such as steep roofs to protect against the thrust of the wind and high plinth to protect against floods are used. The thatch roof is generally projected beyond the walls to provide additional shelter from rain and one side of the roof is often extended four to five feet beyond the wall and supported by stone pillars to form verandah.

5. EXAMPLES OF VERNACULAR AND CONTEMPORARY BUILDINGS

Case study-1: Vernacular Residential Building at Barhammpore, West- Bengal



After raising land, this homestead begins on the mound with a main dwelling unit (boshoth ghor). Ancillary structures such as kitchens (ranna ghor),granaries (gola ghor) and cowsheds (goyal ghor) are built gradually over time around a central open space, and thus begin to define the courtyard



The word ghor literally means 'room', indicating that the individual units are perceived actually as rooms with specific functions and not really as buildings; the Bari consisting of several ghors around a courtyard is considered the unit of home. The main ghor is usually a well-built structure on the homestead and the ancillary structures tend to be semipermanent and built of perishable materials. The materials used in the Building are stone wall, (sloping roof with mud ceiling with bamboo/timber rafter) and Plain cement floor. Architectural Design features The special feature of the design is bhita



(Mud ceiling with bamboo/timber rafter). Due to porosity of the (Mud Ceiling) built on bamboo or wooden frames; hot air goes out, keeping the building cool in summers and also aids in fire protection. Mud, on account of its easy availability, good insulation and binding properties has been extensively used. This vernacular Attu ceiling whose peculiar form is a characteristic of this part of BENGAL proved to be a distinct identity for the area. High plinths are provided to protect the building from rain and flood and also for proper storm water drainage from the courtyard. Verandahs with projected roof on front and rear are to protect the wall from sun and rain. Generally,the height of plinth is kept as 2'-4'.



Light and wind i.e. alo-batas is major factor that is considered well in advance. Attic space of traditional house in Bengal is

locally known as upper space. Upper space is the most common feature of all types of the traditional houses in Bangladesh, which plays a vital role in thermal environment of the living space(Rumana, 2007). Upper space design came from the user demand. In the post monsoon periods, people accumulated a huge amount of paddy, wheat, beans, etc at a time. So people need a huge storage space and the upper space serves this purpose.

6. CASE STUDY-2: VERNACULAR RESIDENTIAL BUILDING AT SUNDARBAN, WEST- BENGAL

Entry into the compound from the outside is through gaps between units. The surroundings are extensively planted

with trees along the boundary and strengthen the introverted layout. Traditionally, the courtyard is an activity space, accommodating various household activities, drying clothes and other items such as condiments, working, winnowing and husking rice receiving guests, etc. The court yard serves a function even it in some cases, only as reception or circulation space. Such courtyards are in rural homesteads their surface consists of bare, beaten earth. Courtyard appears as principally cultural design element. The social and cultural meaning of the traditional courtyard has been stripped. Traditional houses follow a courtyard concept. A group of separate units surround an open space and thus define the courtyard.



Each unit is essentially a one or two roomed structure accommodating different functions such as dwelling units for extended family members, kitchens and granaries. Toilets and outhouses such as cowsheds are located on the periphery of the homestead. The layout is introverted, that is, the units face away from the outside and are accessed through the courtyard



7. INFERENCES OF CASE STUDIES

The coolness of vernacular buildings during summer is very satisfactory without the use of modern building technology. All buildings have been designed in rows and are not exposed to the sun due to front and rear verandah and the internal courtyard. It prevents heat but it also keeps hot winds out while ensuring movement of cooler air through the buildings and open areas. Measured temperatures in the vernacular buildings in two locations showed that the indoor temperature in the day was 8°C lower than the outdoor temperature. The users of these building did not show any sign of discomfort during summer.



8. OBSERVATIONS OF THE CASE STUDY

The comfort temperature has been compared with the inside and outside temperature. It has been observed that, vernacular building with mud/stone wall, and thatch roof with baash ceiling and aathchala roof provide comfortable inside temperature compared to the building with AC sheet and RCC roof with the same proportiort of opening for ventilation. However courtyard has not been designed in contemporary building. Energy consumption was very low because occupants did not use equipment which consumes much energy. However in case study 3 indoor temperature in the day was 5°C lower than the outdoor temperature and higher than the maximum limit of comfort. The users of these building feel discomfort during summer..

9. CONCLUSION

The vernacular dwellings are the unconscious expressions of people's culture. With the passage of time the vernacular buildings of coastal Bengal are vanishing due to change in functional requirements. Many of the new constructions do not blends well to the local environment and social context which otherwise cause serious damage to the environment and social status of the people of this region. Negligence towards nature ,the cost of maintenance and acute shortage of skilled craftsmen are also responsible for the loss of rich architectural tradition of the region. However the vernacular buildings are climate responsive compared to the contemporary buildings.

The study of vernacular architecture is very much essential in the present context. The Vernacular architecture is a better option for rural people of Bengal by using low cost, low energy and locally available building materials and indigenous techniques. This paper comes to the conclusion that the vernacular architecture which is the outcome of man's interaction with nature should not be disturbed.



The construction techniques which have been scientifically proved successful for thermal comfort by the use of locally available material should be encouraged. The craftsmen and their traditional and vocational skills also need rejuvenation, while analysing and improvising them through advance contemporary technical knowhow. Finally the importance of vernacular passive climate sensitive and sustainable design, as well as its awareness of regional environmental and material concerns, demands a fresh look, as it pertains to the practice of contemporary climate responsive and energy efficient buildings.

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