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STUDY OF TRADITIONAL BUILDING MATERIALS; ITS POTENTIAL FOR GREEN AND SUSTAINABLE DEVELOPMENT: A CASE STUDY OF TRADITIONAL HOUSE IN WARDHA REGION

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Abstract : At present the demand of sustainable lifestyle is no longer a matter of personal choice and construction industry sector has now been regulated for the purpose of implementing measures that improve the infrastructures for environmental behaviour. In contradiction the traditional architecture of India in the respective region reflects biodiversity, wide culture followed by rich traditions. Each region has its own vernacular language evolved organically overtimes and derived from its climatic conditions, utilizing locally available materials, history, lifestyle, reflecting skilful art and craftsmanship of the local people. The traditional house of India is not only a shelter but a place giving a feel of security, a locus of family and community life, an expression of identity and cultural continuity. It gives a sense of place and time. It is a product of long and complex evolutionary process. Hence there is a strong relationship between traditional architecture and the social, economic and environmental conditions of a region thus contribute to the sustainability parameters of the respective region.

The construction technologies in traditional architecture in the region have changed according to the climatic condition and availability of local resources which include type of soil, vegetation pattern, flora n fauna, etc. This paper develops a co-relation between traditional building materials which has a potential for sustainable development of the respective region. This paper focuses on mud construction technology as green building material and includes the study of thermal performance and human comfort in traditional house located at Wardha.

Key words **- Traditional house, Green Building Material, Sustainable Development, Thermal performance**

I. INTRODUCTION

The Traditional Architecture of India reflects biodiversity, wide culture followed by rich traditions. Each region has its own vernacular language evolved organically overtimes and derived from its climatic conditions, utilizing locally available materials, history, lifestyle, reflecting skilful art and craftsmanship of the local people. The traditional Architecture of India has potential because of the material used and construction technology applied by the people considering the environmental behaviour of the region. The major factor of Traditional architecture is the use of local material. Use of local material enhances sustainability and ecological supporting parameters in the building; it has the benefit of reducing significantly environmental impacts of the region.

India is well known for its topographical diversity, different climatic conditions and biodiversity. This biodiversity forms a rich resource for different materials used in building industry. The material resource sets challenges for the craftsman to evolve different construction techniques which are suitable in the climatic condition of the respective region. There are many such appropriate construction technologies which are evolved from the available resources in different regions of India which fulfill the criteria of sustainability and if they are used over the conventional construction technology using building material baked bricks, steel, cement RCC etc. contributes towards sustainable development of the region.

Sustainability is the condition or state which would allow the continued existence of homo sapiens, and provide a safe, healthy and productive life in harmony with nature and local cultural and spiritual values. Sustainable development is then the kind of development we need to pursue in order to achieve the state of sustainability. It is a continuous process of maintaining a dynamic balance between the demands of people for equity, prosperity and quality of life, and what is ecologically possible. Sustainable construction means that the principles of sustainable development are applied to the comprehensive construction cycle from the extraction and beneficiation of raw materials, through the planning, design and construction of buildings and infrastructure, until their final deconstruction and management of the resultant waste. It is a holistic process aiming to restore and

maintain harmony between the natural and built environments, while creating settlements that affirm human dignity and encourage economic equity.

Sustainability can be achieved in three different angles

i) Environmental: - Proper management of available resources, waste reduction low carbon emissions, use of renewable energy and eco-friendly materials, suitable to the respective climatic condition etc.

ii) Social:-This will integrate all the factors such as ethnic, religious, economic, health etc .i.e. Quality of life, uplift local skill, impact on local communities etc.

iii) Economic: - It should be cost effective, create new market opportunities etc.

II. THE PHYSIOLOGICAL HUMAN RESPONSE TO CLIMATE AND ARCHITECTURE-

Shelter, with food, is one of mainstays of human life on Earth. The nature of shelter required largely depends on the conditions of the environment, with the climate providing one base that determines the type needed. Primitive peoples of the world primitive in the technological and preliterate sense using the limited resources at hand often developed shelters that were in harmony with the climatic conditions under which they lived. Although it is clear that climate does impact many aspects of human life and activities the ideas of climatic determinism are not acceptable. However, the human body does react to changes in the surrounding atmosphere, and shivering and sweating provide two ways in which the body reacts to extreme temperatures. Bio climatological indexes, such as the wind chill index and the heat index, have been developed to measure the impacts of combined atmospheric elements on people. The nature of traditional primitive constructed shelters largely depends on the prevailing climates. Modern structures are not always designed with climate, with resulting increased energy costs for heating and cooling.

There exist a relationship between basic climatic factors and building requirement. The climatic factors which directly influence human health and comfort and the stability and durability of buildings are important for the conception of buildings that mainly serve to protect people. It is for this reason that the traditional building method in each zone offers an inexhaustible reservoir for research into suitable architectural and structural measures for regulating climate by means of the selective use of factors of the climate. The factors which are influence by the climatic condition of the respective region and are major design criteria of the built environment are shown in Fig. no.1

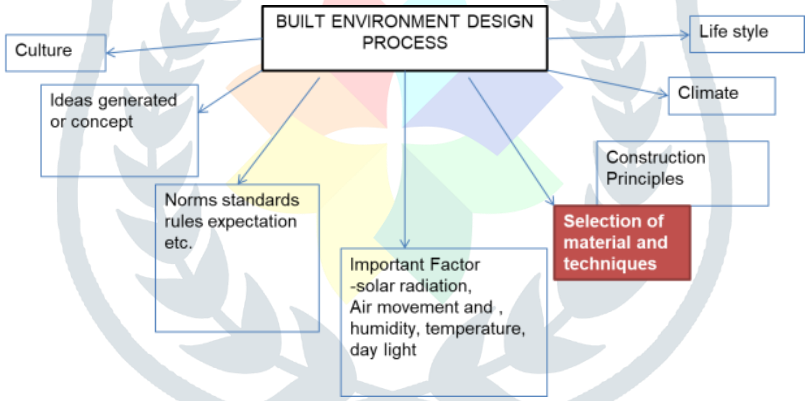


Fig. no. 1. - Criteria for designing built environment

III. TRADITIONAL ARCHITECTURE AND SUSTAINABLE CONSTRUCTION TECHNOLOGIES

Traditional architecture is a category of architecture based on localized needs and construction materials, and reflecting local traditions. Vernacular architecture tends to evolve over time to reflect the environmental, cultural, technological, and historical context in which it exists. The vernacular construction technologies in the region have changed according to the climatic conditions, socioeconomic class and availability of local resources which include type of soil, vegetation pattern for use of agricultural waste. According to Paul Oliver, "Vernacular architecture comprises the dwellings and other buildings of the people. Related to their environmental contexts and available resources they are customarily owner or community-built, utilizing traditional technologies. All forms of vernacular architecture are built to meet specific needs, accommodating the values, economies and ways of life of the cultures that produce them".

Over many centuries, examples of building design and construction technique have been developed in all climatic zones, bringing forth structures that provide more or less comfortable living conditions without the use of sophisticated technical devices. Most designers in the past were familiar with the climate in which they were building. They were also aware of ways by which they could benefit from certain climatic features, and overcome those that are less favourable, merely by means of appropriate building shape, location, and orientation and construction technique.

Traditional Architecture in India generally exhibits considerable ingenuity in the use of locally available materials and techniques to produce buildings that are well adapted to the local climate. Many such proven methods have been ignored in the

design of modern buildings, which consequently need special means for heating and cooling, invariably incurring high costs for equipment and energy inputs. For example, this can illustrate in the context of Rajasthan, a hot and dry region in North-West of India. The climate is characterized by high day time temperatures and uncomfortably low night temperatures. The solution best suited to such wide temperature fluctuations is to delay the entry of heat into the building, such that it reaches the interior when it is least bothersome. The inhabitants of this area achieve this desired thermal performance by using thick walls and materials of high thermal capacity, such as mud and stone. In warm and humid climate, the diurnal temperature variations are small so that materials of low heat storage capacity are more appropriate. Therefore, people construct their houses with lighter materials, such as palm leaves and twigs, allowing air to circulate, avoiding stagnant humid air and providing comfort by evaporative cooling.

Thus, there is availability of wide range of resources that is materials which support constructions and develop different construction technologies in various regions of India. It evolves to accommodate not only innovations in construction technologies, but also shift in social structures. The technology innovated from available resources can lead to sustainability. There are many such innovative construction technologies which are evolved from the available resources in different regions of India which fulfil the criteria of sustainability; and if they are used over the conventional construction technology using building material baked bricks, steel, cement RCC, etc., contributes towards Sustainable Development of conditions.

IV. SUSTAINABLE CONSTRUCTION AND TRADITIONAL BUILDING MATERIALS

At present the demand for a **more sustainable way of building** is no longer a matter of personal choice, and the sector has been now regulated for the purpose of implementing measures that improve the infrastructures´ and buildings´ environmental behaviour. Sustainable construction is defined as "the creation and responsible management of a healthy built environment based on resource efficient and ecological principles". A **sustainable construction** takes account of the use of resources that are energy and natural resources and their environmental impact, while fulfilling the criteria of sustainable architecture the major decision is selection of **environmentally-friendly materials also known as green building materials.** The comprehensive construction cycle starts from the process of extraction and beneficiation of the raw materials, through planning, design, and construction on site of building and infrastructure and ends with their final deconstruction and management of final resultant wastes. The use of less processed and local materials for construction reduces embodied energy and grey energy. The green building materials consumes low embodied energy material, reduces induced energy, grey energy and operational energy thus they have low environmental impact. Embodied energy is the sum of all energy inputs for manufacturing, all transportation human resources etc. Transportation plays a major role here so, if a material can be sourced locally, it can reduce the embodied energy and a carbon footprint which is quite sustainable.The building material selected should be **durable, reusable or recyclable, include recyclable materials** in their composition and have to be procured from local resources of the building context. These materials can **be mud/** soil, wood, cork, bamboo, straw, sawdust, etc. and construction technique developed should respond to local climatic condition.

Traditional green material-The natural materials such as mud, stone, wood, crop residue such as straw, wool, fibres – hemp, cork and clay present the traditional construction material. Traditional (natural) building materials used as structural materials as load bearing construction such as wood, stone, rammed earth, straw bales, clay bricks, etc., insulation materials used are sheep wool, fibers - hemp, cork, etc., complementary materials – mud, cow dung slurry, realization of plastering, painting, flooring - clay, cork, cowdung slurry etc. A preliminary study of traditional green materials is as follows:

(i) Stone is one of the major construction materials. It is a highly durable, low maintenance building material with high thermal mass. It is versatile, available in many shapes, sizes, colours and textures, and can be used for floors, walls, arches and roofs. Stone blends well with the natural landscape, and can easily be recycled for other building purposes.

(ii) Wood is the oldest material used by humans for constructional purposes, after stone. Despite its complex chemical nature, wood has excellent properties which lend it to human use. It is readily and economically available, easily machinable, and amenable to fabrication into an infinite variety of sizes and shapes using simple on-site or off-site building techniques, exceptionally strong relative to its weigh, a good heat and electrical insulator and is a renewable and biodegradable resource. In construction industry, straw occurs most frequently in the form of straw bales which are used either as infill cladding for wood framed buildings or as load-bearing construction, which can transfer load on the roof, without adding any supporting structures. It is also possible straw used as thermal insulation of roofs, but the best with it already foreseen in the design of the building.

(iii) Mud is an appropriate and oldest natural building material. It consists of a mixture of clay, sand, and dust. It may also contain coarser particles (gravel) or organic material. The most common way to use clay in the construction is in the form of clay bricks or clay in the form of ramming. In addition, it presents the filling of half-timbered construction and wood framed construction or as a clay plaster. Each of traditional construction material is characterized by physical properties that determine its use in construction sector. The natural materials are the most common use as thermal insulating material. Fig. no. 2 indicates the application of mud as green material in traditional architecture as well as contemporary architecture.

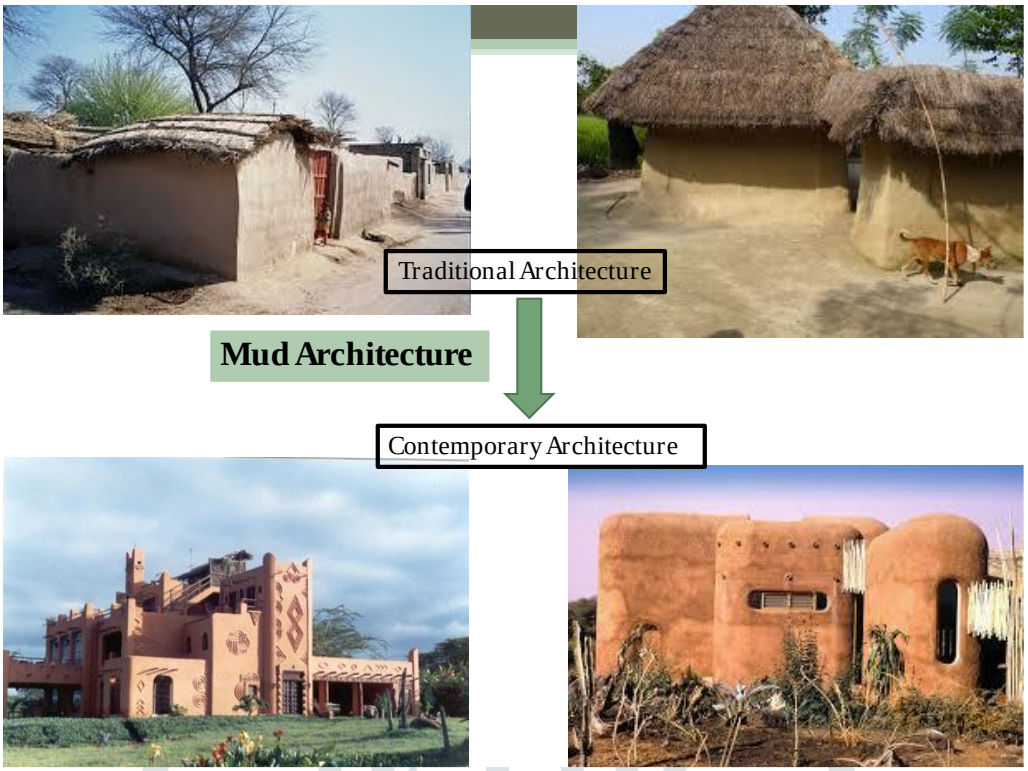


Fig. no. 2 Application of mud as green building material.

There are five major types of earth wall construction:-Wattle and daub, Puddled clay and cob, Rammed earth, Adobe or sundried bricks, Compacted soil blocks. Mud, stone, and fibrous plants are the most basic reinforcement materials. People all over the world have used these three materials together to build structures to suit their local weather conditions. The proportion of each building material used leads to different construction technique. The building materials proportion factor is usually related with the type of the soil. The larger quantum of stabilized mud and undressed stone is usually meant using the *cob/adobe* construction technique, while lesser quantum of soil with a major framework of plants is usually associated with *sod /*wattle and daub construction technique in the building. The other main ingredients include more or less sand/gravel and straw/grasses. *Rammed earth* is used in both traditional and contemporary buildings for walling technique, constructed by compacting mud between planks by hand operated tools or in contemporary architecture by means of mechanical pneumatic compressors are used. Mud is good thermal insulator; it helps in achieving thermal comfort. A house built with mud tends to be naturally cool in the summer heat and warm in cold weather. These buildings have remained habitable for hundreds of years.

Mud, as a building material has the following advantages and disadvantages;

- It is cheap, and in most parts of the world, it is readily one reason why it is so widely used.
- It provides excellent heat insulation, so inside a mud building is cooler in summer and hotter in winter than a building made with steel and concrete.
- It is strong in compression (i.e. difficult to squash) and so makes good walls. But mud also has some serious disadvantages:
- It is eroded easily by water, which makes its use difficult in areas with high rainfall or possibilities of flooding.
- It has a low tensile strength (i.e. is easy to pull apart), which means mud roofs are difficult to make.
- It is susceptible to mechanical damage. Rodents can easily make holes in mud walls and under the floor, or thieves can ding their way into the house.
- Mud does not grip wood properly, so gaps often develop around wooden doors and windows in mud walls. Consequently mud houses often have few openings and are badly ventilated. Where walls are made of reinforced mud, wattle plastered with mud, or sun-dried mud bricks, this problem is not so severe.
- Mud soaks up water and becomes heavy. Consequently, wooden beam supporting a mud roof begin to sag, the mud cracks and the mud cracks and the roof starts leaking. To reduce sagging of beams, many villagers have built very narrow rooms, but these rooms tend to leak in heavy rains and are less functional in context of modern lifestyle.

4.1 Case Study of Traditional Architecture in Vidarbha region-

Study of Vidarbha region

Vidarbha is the central part of India. (Fig.no. 3) Vidarbha region lies between Latitude: 21°12.575’ North Longitude: 79°14.203’ East in the eastern part of Maharashtra state. It consists of 11 districts. (Fig. no. 4) According to the rainfall condition, Vidarbha region is sub divided into three zones (Fig.no. 5)

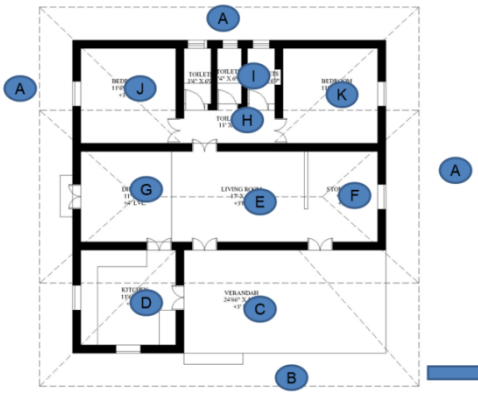
(Fig.no.3)

(Fig.no.4)

(Fig.no.5)

. The rainfall condition in Vidarbha region is Gondia, Bhandara and part of Chandrapur majorly Tadoba forest area lies in high rainfall zone. Nagpur, Wardha, Yavatmal, Washim and part of Chandrapur lies in moderate rainfall zone and Amravati, Buldhana, Akola lies in Assured rainfall zone. The construction techniques which are identified in the respective region use locally available resources, agricultural waste and traditional skills.The crop pattern varies according to varied rainfall conditions.

The observations of traditional buildings notified many attractive features of design typically suited to the climatic condition of Vidarbha region in Maharashtra. The selected case study is a 7 years old residential building type located at Aamgaon, Near Selu, Wardha, Maharashtra central part of India. The parameter for selection of case study is application of sustainable building materials in traditional architecture of composite climatic region. The spatial arrangement of the building is shown in Fig.no. 6



S.No.	Details
A	Adjacent farm land
B	Front area of house
C	Veranda
D	Kitchen
E	Living room
F	Dinning
G	Store
H	Bedroom 1
I	Bedroom 2
J	Toilet
K	Passage

Fig. no. 6: Ground floor plan and view of building
(Spatial arrangement of typical traditional house located at Selu Dist. Wardha.)

The height of structure is 5.50m. (18 feet). The building materials used are mud, Shahabad stone , mud flooring, mud plaster wood, country tile for roofing. The construction is single storied load bearing structure using vernacular construction techniques for

- Foundation Ashlar masonry and random rubble masonry in basalt stone is observed. For Ashlar masonry well-dressed basalt stone is used .Trench of about 0.75m. are dug out but it vary depending on the quality of work and the soil. The trench is filled up with stone masonry mud & lime mortar up to the plinth level.
- Structural framework is of timber members
- Walling techniques adobe wall and cob wall in processed white soil can be seen in the built structure. The wall thickness varies from 0.75m -0.45m, tapered walls the thickness of the wall reduces as the height of the wall increases. Adobe wall-A homogeneous mixture of dung, wheat straw and mud in water in the ratio of 1:1:3 is left to ferment for a period of 7 days. The wall is then sculptured out of the mixture in layers of 0.30m. to 0.45m.The subsequent layers are constructed only after the earlier layer has dried off. Cob wall- White soil & locally available stone are used in cob wall construction.
- Plastering- The wall is finished by plastering in two layers, a mixture of cow dung and mud in the ratio 1:2 is applied in a 0.05m. Thick layer. On the top of this layer cow dung mixed with water is applied after the first has dried.
- Mud Flooring- The floor is constructed after the walls are completed. The area to be floored is first filled with mud. This wetted mud is then pressed and finished with hygienic layer of cow dung.
- Timber floor with Mud flooring for flat floor level
- The basic formwork is created of timber post and beams. These carved timber post of 0.15x0.15m.are placed at a maximum distance of 2.4m.The primary timber roof beam between the timber posts forms a main structural support .The secondary timber beams spanning between post are placed at distance 0 .60m c/c are then topped with another course of timber planks laid edge to edge, spanning the distance between two consecutive secondary beam. This is then topped with a 0.12m. thick layer of processed white soil finished with cow dung slurry.
- Pitch roof supported by timber truss and country tile as well as Mangalore tile roofing are used.
- Lintel and door window openings are made of timber. More openings provided in East, North and South Direction of size-**0.75 x 1, 1.2 x 1.8;** only Minimum openings with high lintels provided in west direction. Cross and Stack type of ventilation provided for heat loss.

The above analysis of traditional building is to be proved with the help of material analysis for that the thermal performance of material (thermal mass) is done by recording inside and outside temperature of building. To prove the Mud is good thermal insulator and it helps in achieving thermal comfort in the building. A house built with mud tends to be naturally cool in the summer heat and warm in cold weather. These buildings have remained habitable for hundreds of years.

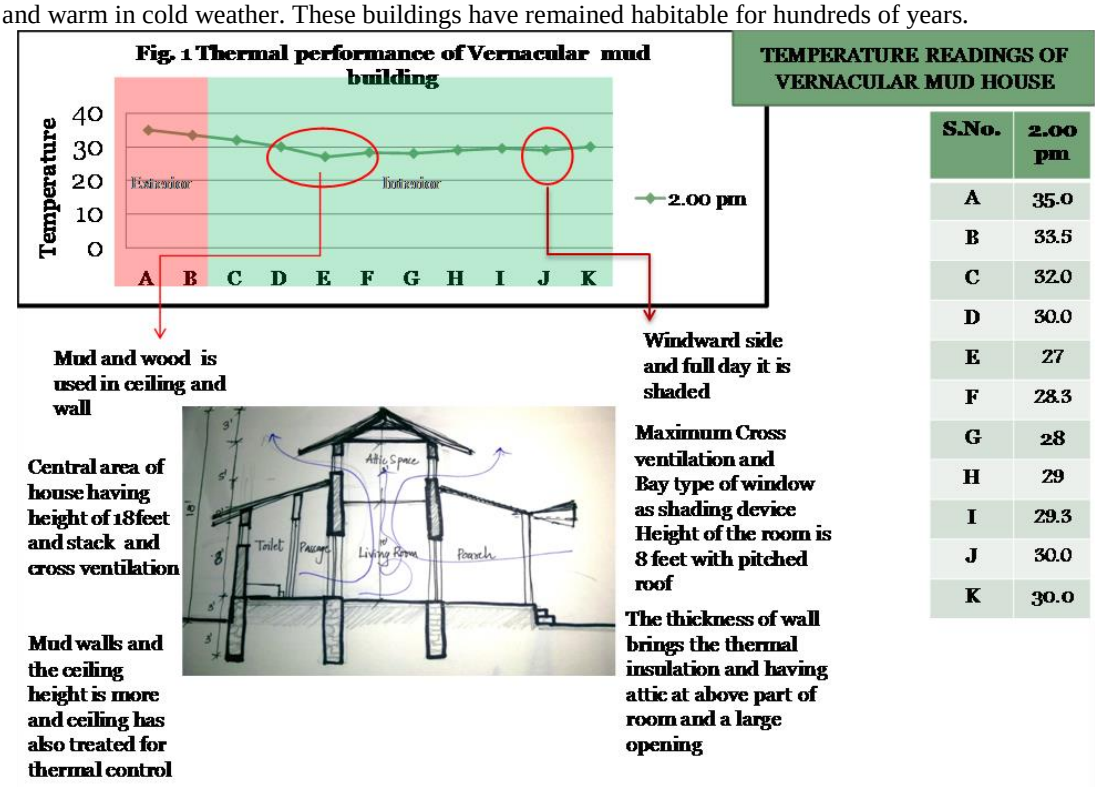


Fig. no. 7: Analysis of Temperature fluctuations for thermal performance of construction technology and material of traditional building

The above graph is used to study the thermal behaviour of building in summer season. In the block plan Fig.No. 6 the exterior and interior areas are marked to record the temperature. Then the temperature readings are plotted on the graph in sequential manner to analyse the temperature differences or fluctuation from exterior (marked as red zone) to interior spaces (marked as green zone) as shown in activity. It is observed from the readings plotted on the graph that, there is 2 to 3 degree Celsius fall in temperature from outside to inside ambient temperature. Thus proved that, because of design strategies adopted, height of the structures, material used and the construction technology applied to the building to achieve the thermal comfort inside the building for the habitable living conditions.

FINDINGS –

- The Traditional Architecture in the respective zones of Vidarbha region is a reflection of social values and climatic pattern using available resources and creating identity of the region.
- The Vernacular construction technique in Vidarbha region uses locally available resources and addresses the local needs with minimum embodied energy and grey energy as the transportation of the material is negligible.
- The building material used is biodegradable and recyclable.
- The construction techniques adopted are indigenous and transfer its knowledge from one generation to other through skills.
- The mud wall has thermal insulating properties which help in maintaining indoor comfort conditions.

The findings of the present study have established the role and need of integrating thermal performance evaluation approach for a building envelope in design stage. It has also been established that a compact planning, with maximum openings, appropriate shading and material use for building envelop has better thermal performance.

CONCLUSION- Environmentally-friendly materials or green building materials are those which are locally processed with low embodied energy, reducing transportation energy and operational energy, for low environmental impact have been observed. The traditional architecture by virtue of its characteristics helps in maintaining the ecological balance and contributes to the sustainable development of the region. High-mass building materials can offer significant energy benefits in exterior walls. The benefit may be primarily in the shifting of peak load conditions or in an actual reduction in overall heat gain or loss. These benefits are highly dependent upon where the building is located, how it is designed, and how it is operated. How we should give credit—in terms of energy performance—for high-mass building materials is still very much open for debate. Until standardized procedures for determining the regional significance of the mass effect are widely applied, there will likely be continued confusion and continued exaggeration regarding the energy benefits of thermal mass.

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