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COMPARATIVE INVESTIGATION OF TRADITIONAL AND MODERN PASSIVE DESIGN STRATEGIES TO REDUCE THE ENERGY USE IN RESIDENTIAL BUILDING OF WEST–MAHARASHTRA REGION

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Abstract

In India, traditional values as well as the timeless way of building compact residential environments is now threatened by new and foreign influences .These influences are incompatible with the climate of the country and traditional culture of its people. In the context of the worldwide concern for global warming and a need for reduced carbon emissions, increased energy efficiency, reduced waste and need for alternative sources of energy, this paper reviews passive design strategies that were used in the traditional buildings across India and assess their potential in modern design. This study offers a classification of vernacular environmental design traditions based on West Maharashtra climatic regions and a detailed study of thermal comfort in traditional and modern dwellings using environmental performance modeling. The results show that traditional passive techniques provide a high degree of comfort for a longer part of the day while potentially minimizing energy use. Some problems were identified specifically in West Maharashtra region in adopting the passive strategies to the present context. For example, there are limitations in the use of traditional building materials, such as earth, but suitable alternatives with similar properties can be readily adapted to the same effect. Sustainability in Indian settlements is static and is based on the living practices. India has got diversified climatic, topological and vast socio conditions due to which each region has its own unique identity with climate base responsive building designs and its knowledge in the form of vernacular architecture. This traditional wisdom of building human habitats is known to be tested by time for its sustainability in various settlements. This paper talks about West Maharashtra settlement , achieving sustainability through planning, orientation, materials and architectural practices evolved from long time due to socio, economic and environmental factors. Factors results in two levels i.e. macro and micro level. Macro level broadly focuses on planning & architecture aspects .Micro level describes art, architectural details and socio practice affecting built habitat. Trained designers of modern era have mostly ignored it .The study of passive design traditional strategies with local vernacular architecture and lessons about climate responsive planning, techniques can be helpful to generate an approach towards energy reduce and climate responsive building design in West Maharashtra corridor.

***Keywords**: Passive Design, sustainable Architecture ,tropical, vernacular, thermal comfort, Climate responsive design.*

Introduction:

For centuries, India has upheld a tradition of building with nature and it is only post independence that there has been a surge in a tactless following the so called 'global trend'. In an attempt to break free from the British rule of 200 years, independent India, instead of evolving on its traditional roots, started blindly following the trend in the west. The architecture of centuries of trial and error was abandoned in a moment.

Not only modernism but globalization as well has much influenced the Indian building industry. The last few decades have seen an incredible increase in the amount of mass housing and glass towers, in a climate where the sun is not an asset but an inconvenience. Tall apartment blocks, with concrete structure and thin filler walls, generously adorned with glazing and an array of air-conditioning units sticking out of the windows blot the landscape.

In West Maharashtra context, this study is an attempt to rediscover those vanishing passive design strategies that were the architectural statement of the West Maharashtra regions for centuries and served the purpose well and to see if they can be employed in the current architectural statement that completely lacks the empathy to environment. It should be emphasized that this study does not advocate reverting back to the traditional vernacular architecture of West Maharashtra , but to acknowledge the ingenious traditional architecture that was a result of centuries of trial and error to find that harmony with the forces of nature. It cannot be denied that the changed scenario does not permit one to go back to the traditional vernacular. The lifestyles, the needs of the people, the material use, and the aesthetic expectations have all changed and thus, need a different approach in residential design. But the passive design solutions that the traditional vernacular architecture offered cannot be ignored, considering the potential they offer. Hence, there arises a need to explore these traditional design strategies and reinterpret the knowledge of the past to suit the energy needs of the present and the future.

West Maharashtra Climate has a major effect on the performance of the building and its energy consumption. Reducing energy consumption, using natural resources and providing comfortable, healthier and sustainable living spaces are the aims of a climatically responsive sustainable building design strategies.

Sustainable design and construction strategies are of great importance now a days. One may say that sustainability was already a driving force in the past, exhibiting its validity through the different forms and techniques used. Therefore, from Vitruvius till today, problems and precautions in design and construction did not change fundamentally, although many developments have been seen in materials and technology.

Moreover, these developments may have had some negative effects. That is the reason why the building process should be discussed in a holistic way. In other words, climatically responsive design, selection of materials and building techniques must be evaluated together and the final product should perform well during its whole service life. Sustainability, which is presented as past decades in Maharastrian courtyard houses concept, has been in fact applied since long culture and was realized spontaneously in traditional architecture

When sustainable design and construction strategies of West Maharashtra traditional architecture are under scrutiny, then it is possible to observe how traditional buildings and settlements in this region were designed in harmony with the local cultural, topographical and climatic conditions and how their design and construction could be integrate in today's design practices.

This study is based on comparative investigation and research strategies, which has been carried out on passive building techniques used in the hot-dry areas West Maharashtra .The study first aims to show the similarities and the differences of the traditional housing principles in climate responsive design point of view. Secondly, contemporary buildings it aims to put forward the basic principles and their meaningful changes in usage that can be used for sustainable housing designs of the West Maharashtra region . In this study, design strategies in hot and dry climate were examined and modern and traditional houses were evaluated in terms of design strategies , such as selection of the area of the dwelling, distance between buildings, orientation, building envelope and building form ending with passive design principles.


Traditional to Contemporary transformation of house form.

Though the modelling analysis was limited to the effect of thermal mass, material properties and urban layout, and did not consider specifics of evaporative or ground-tempered cooling which is used in the regions as an aid to cooling; it nevertheless gives an inkling to the effect of passive strategies in the traditional buildings of West Maharashtra when compared with the modern construction of this region . It thus, points out to certain lessons that are to be learnt from vernacular architecture and which can be incorporated in modern architecture to make it more efficient energy responsive buildings . The comparative investigation of features and results from the modelling a analysis are presented in this article that can be deciphered from the analytical study and thermal analysis can be point out and how these can possibly be incorporated in Modern building design specifically West Maharashtra settlements and support residential region. Threshold and model analysis is a suggested mode of analysis as per research methodologies are concern.

Climate / Environment

Climate had a major effect on the performance of the traditional building architecture and its energy consumption in hot dry area of Iran. Lack of water and energy sources in these areas forced people to build their houses with some strategies based on minimum energy consumption. Heating and cooling usually use largest portion of energy in buildings. Therefore, builders tried

to use natural climatic strategies for coping with harsh conditions. These strategies include: layout orientation, distance between buildings, building orientation & form, climatic elements such as Varandah wind catchers, central courtyard, and so on.

The first aims to introduce these strategies and then, to categorize these characteristics at three levels

a) Macro scale

b) Medium scale

c) Micro scale

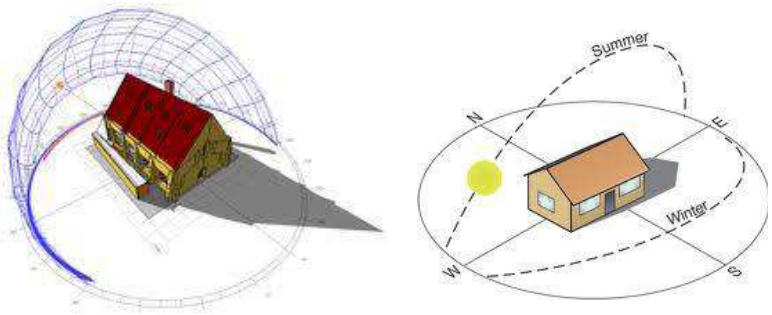
In addition, the mentioned strategies will be explained in their level of performance and the relevant elements in other levels. Furthermore, this aims to put forward basic principles and changes in their usage that may be of benefit in sustainable housing designs in the future. In this study, the cited design strategies will be examined and modern and traditional houses will be evaluated in terms of design criteria - such as, selection of the area, distance between buildings, orientation, building envelope and building form. Its a simplified evaluation and comparison of a traditional house with a contemporary house will be given.

The most important design parameters affecting indoor thermal comfort and energy conservation in building scale are distances between buildings, building form, building envelope design, self efficiency in building materials and optical and thermo-physical properties of the building envelope. Among these parameters, building envelope design, as it separates the outdoor and indoor environment, is the most important. All of these parameters are related to each other and the optimum values of each should be determined depending on the values of the others and their optimum combination should be determined according to the climatic characteristics of the West Maharashtra region.

Micro scale character-court being active element for ventilation.

Orientation and urban form:

The orientation in traditional residential planning was designed to take advantage of the prevailing wind direction and to minimize the solar insolation in the building. There is no reason why the same principles cannot be followed in modern day planning, even when using court planning. The house form in modern planning is dictated by the economic status and multilevel planning are finding preference as against the traditional linear layouts. Yet, considering the benefits of orienting to reduce insolation and increase wind movement in planning should be considered by designers. Building depth should also be kept within the limit required to provide good ventilation and lighting in different spaces.



Orientation of building inclined with sunpath diagram.

Typology (Courtyard / Non courtyard) :

The lack of space and the westernized design trend have steered house planners away from adapting the courtyard in house design, along with the changes in lifestyles of West Maharastrian people, such that they no longer require a semi-enclosed space to do household chores. The box-like design makes the modern house deeper than can be efficiently serviced by natural ventilation. The use of courtyard typology allowed for ventilation

through well-shaded openings and a store for cooler air from the night ventilation. But similar effect, to a lesser degree, cabe achieved by designing an multilevel court space with high-level ventilators and provision for night cooling.

Traditional non courtyard house typology.

Contemporary courtyard house typology.

Building form:

West Maharashtra region in a hot and dry climate, the most preferred house plan is one with a courtyard. In order to minimize the area affected by the solar radiation, compact forms are chosen. By arranging those forms with courtyards, shady areas can be obtained. In courtyards, with the help of water and plants for evaporative cooling, the floor temperature can be minimized

by the high walls surrounding the courtyard, shady areas can be obtained and the open areas can be used during the day. Channels for water poured out from the pool are important elements for

cooling. Water is often spread by channels to the floors of the courtyard and evaporative cooling from the surface of the courtyard floors which are made of porous stone contributes

to that effect. Courtyards are always on the ground floor and have different forms depending on the landscape of the house.

Evaporative cooling.

In West Maharastra regions with scarcity of water, this technique was limited for its want of water features or the requirement of keeping gunny bags or earthen pots wet, but with the advent of fine-spray sprinklers, the strategy can be successfully adapted much more efficiently in modern design by making passive water sprinkler systems in house by means of water curtains and wet landscapes.

Shading/Jali work windows.

Jali windows make a distinct aesthetic expression but are a concern for safety and pest control along with being expensive in both time and money.They can be designed to be used as the safety guards between the glass and pest screen shutters in a window, or more appropriately be used in high-level openings with pest screens. Alternatively, the use of louvers/blinds and tinted or heat-reflective windows instead of clear float glass windows will also help in increasing the efficiency of the windows. Shades must be designed to keep the solar insolation out while letting the light in, as such light shelves can be used for better performance of windows. Deep overhangs and verandahs are also loosing importance in design but are an efficient way of

shading windows as well as walls and reducing the sol-air temperature while providing a usable semi-enclosed space.

Traditional windows and jails character to ventilation & aesthetic.

Fenestration design.

Vernacular architecture features fenestration design variation in the different climate zones to either minimize solar gains or take advantage of the air movement, which is often ignored in the modern residential design and can be easily adapted to increase thermal comfort. The modern house has large glazed areas not well-shaded from the sun and oriented in all directions. The use of different types of openings for different purposes in a dwelling should be incorporated in design as per the climate requirement.

Building envelope:

Sustainability and energy efficiency are greatly affected by a building's skin. The amount of surface area, material choice and insulation strategies are key elements in buildings located in West Maharashtra region The buildings are built in cubic forms and architects tried to minimize the ratio of outdoor surfaces of buildings to the space required instead for habitation. Linear Court forms helped buildings to have a lower exposure to hot weather factors than more linear forms of building.

Layering of building with traditional brick walls , fenced window

Optical and thermo-physical properties of the building envelope:

In the hot and dry climatic areas in West Maharashtra in examples of traditional architecture, to benefit from the time lag of temperatures in the building envelope, materials with greater thermal mass have been chosen. These kinds of thermally massed envelope details are very convenient for continental climates, where the summers are very severe with high swings in daily temperature variations. This big thermal mass will slow down the heat transfer through the envelope and thus higher day-time temperatures will be reached indoors although outdoor air temperature is much lower and consequently more stable indoor thermal conditions will be provided. On the other hand this thermal mass, which has higher surface temperature on outer side will rapidly lose heating energy to the atmosphere via radiation at night to start the next day from a cooler level.


Contemporary building envelop verses traditional roofing layer.

Stack effect openings/wind towers.

Modern house design often ignores the principles of fenestration design for ventilation, focusing on providing large glazed areas for visual aesthetics. The traditional principles employed for increasing the wind movement in indoor spaces can be efficiently adapted to the current West Maharastra context, by providing high level trickle vents or atrium spaces with ventilators. The use of wind towers is discouraged also due to aesthetic concerns but a well-designed wind tower can add to the aesthetic expression and provide an efficient way to cool buildings. It can also be coupled with sprinklers to provide evaporative cooling, further enhancing the potential.

Traditional architects were obliged to rely on natural ventilation to render the inside condition of the buildings more pleasant.

The air trap was a common specific feature of architecture found in the majority of hit dry regions of West Maharashtra regions. Air traps were normally positioned in a suitable location in the house according to the size of the building, and the number of air traps that were necessary to cool the summer.


In old times and in traditional buildings in hot and dry West Maharashtra regions the air trap functioned like the present modern air conditioning system. Air trap is like a duct whose end is underground and the top is elevated above a specific height on the roof. At the upper outlet many small openers or ducts may be set. At the end of the air trap at the bottom of the door, often a pool is set whose water was provided by water ducts. The height of air trap, the number of openers and the location of the air traps depends on the location and orientation of building .

Traditional mangalore tile roofing with stag vent tile.

The air trap operates in response to the condition of the wind and sun radiation in the region. The inside and outside walls absorb a lot of temperature during daytime. As a result they cause a balance of temperature at night and bestow the attracted warmth to the cold night air. The thickness of the air trap walls and the dimension of the holes inside it are designed in a manner to allow enough heat to be transferred for better comfort. The light warm air inside the air trap ascends and is sucked away at the upper elevation. As a result cool air flows from windows and doors into the house and continues all night.

Contemporary stag window at roof top level as warm air oulet

The air trap operates according to the condition of the wind and sun radiation in the region. The inside and outside walls absorb a lot of temperature during daytime. As a result they cause a balance of temperature at night and bestow the attracted warmth to the cold night air. The wind catcher functions on several principles. They are built with their long ventilation shafts positioned to catch any hint of a passing breeze to channel down into the house. The interlinking rooms of old buildings were designed to circulate the air that fluted down the wind catchers.

raditional verses Contemporary techniques of vertical ducting.

Carved exposed surfaces/ Self shading ornamentation.

Traditional design took the benefit of carved wall surfaces to increase surface area for radiative loss and also to self-shade the wall. Some modern designs also use textured wall finishes or exposed brickwork in different courses to the same effect.

Roof design.

The thin concrete roof characteristic of the modern dwelling is the source of high solar gains and some traditional design principals can be successfully adapted to reduce the solar gains. The use of double roofs is an efficient way of reducing heat gains and can easily be incorporated in modern design. The use of earthen pots for insulation in traditional houses can also be adapted in modern design to reduce heat gains. The use of high roofs to facilitate stack effect should be incorporated in design to increase air movement. In the warm humid region, the use of a low thermal mass roof that reciprocates the external conditions is useful for the fact that it cools down faster in the night restoring the dwelling to comfort conditions. Although it also heats up faster, it might be beneficial to explore the use of movable insulation to prevent heat gain in the day but promote heat loss in the night.

Modern concrete roofing and traditional sloped mud tile roofing

Materials.

This is perhaps the most difficult aspect to adapt, as most traditional construction materials are outdated and unsuitable to current standards. But as demonstrated in the analysis, they have a profound effect on the thermal performance of the building and there is ample scope of improvement in the current envelope design specifications. The modern brick-concrete construction does not provide the long thermal lag, and the rapid cooling in the hot and humid climate. In the hot and dry zone, the heavy thermal mass of the walls and the roofs of the traditional house provides long thermal lag ideal for a climate with high diurnal range, keeping the house comfortable both in the day and the night while in the hot and humid zone, the high thermal mass of the walls provides some thermal lag while the thin roof allows the house to cool rapidly in the evenings to maintain comfort conditions. Materials having similar thermal properties as the traditional stone or mud walls can be found or composite walls made to perform similarly which find naturally in abundant. The use of cavity walls and insulation can be applied to the same effect.



Unique style of waffle slab with traditional filling materials

Use of vernacular materials such as stone , brick and wood is always one of the concerns in the architecture of West Maharastrian buildings. As an illustration, they used to use excavated foundation soil from river bed in order to make bricks. There are many examples like this which are incorporated in today's architectural concepts for sustainable building design .Vernacular material selection, compatibility, embodied energy, application of passive energy and design environmental strategies in waste and technology management concerning the impacts in the environment are all concepts that are part of sustainable building design .

Conclusion:

It can be concluded that the traditional passive strategies can be effectively adapted to modern design conditions and benefit the comfort conditions in dwellings. As perspective study from the thermal modelling, only through the effects of materials, orientation and shading, the traditional West Maharashtra dwelling are comfortable for 60–65% of the time as against the modern dwelling which is comfortable only for 35–40% of the time on an average hot day. Most of the design-based strategies are easy to adapt and the material-based strategies have alternative solutions that can be used to make the buildings more energy-efficient in the ways identified in this study. Further exploration is required to understand the other strategies apart from the thermal performance of materials, layout and shading; in order to fully comprehend the combined effect of these strategies. An exploration into finding different combination of these strategies in modern design might unravel a solution for a completely passive design approach in West Maharashtra region.

Climate responsive passive design strategies in hot and dry area of West Maharashta region were discussed in this paper through three levels.

In the first level orientation of buildings, form ,pattern of planning and traditional and contemporary settings of plan were considered as macro strategies. Review and development of these traditional residential patterns should be considered in hot and dry climate of West Maharashtra region.

Medium scale strategies cover building form, building envelop, self-efficiency in materials and optical and thermophysical properties of building envelop in this paper. Sustainable architecture force us to re-think what we do and synchronize traditional methods of construction and the use of domestic materials. Blending of traditional and contemporary building technology to enlish the comfort aspect.

Finally, micro scale strategies demonstrate some more relevant architectural design methods which are the same as contemporary passive systems. As an illustration, old wind-catchers have been developed into advanced passive cooling systems in recent time to develop natural method of wind cooling and channeling.

Consequently, consideration and development of the above passive strategies allow contemporary architects and designers to build contemporary architecture in a more sustainable, comfortable and self sufficient way. This comparative investigation of Traditional to modern passive strategies of energy reduce systems gets comprehensive and systematic approach of climate responsive panning for the future West Maharashtrian residential.

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