



## Thermal performance study and evaluation of comfort temperatures in vernacular buildings of North-East India

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### ABSTRACT

Solar passive techniques are being used in vernacular buildings throughout the world. Researchers have done extensive study on thermal performance of vernacular buildings in the different parts of the world. Vernacular architecture of North-Eastern India represents the principle of climate-responsive architecture, which still lacks experimental validation and quantitative analysis. Thermal comfort not only makes the occupants comfortable but also governs energy consumption in the building. Detailed field studies on thermal performances of typical traditional vernacular dwellings in different bioclimatic zones have been undertaken. This field study includes detailed survey of 150 vernacular dwellings, field tests and thermal sensation vote of 300 occupants on ASHRAE thermal sensation scale. Field test includes measurement of temperature, humidity, illumination level and building design parameters. Thermal performances of these vernacular dwellings were evaluated for winter, pre-summer, summer/monsoon and pre-winter months of the year 2008. This evaluation is based on 'adaptive approach', which is the outcome of the field studies and is now part of ASHRAE standard 55/2004 for predicting comfortable temperature of naturally ventilated buildings. This study also tried to find out the range of comfort temperature in these vernacular buildings for different season of the year. It has been found that these vernacular dwellings perform quite satisfactorily except in the winter months and the occupants feel comfortable in a wider range of temperature.

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### 1. Introduction

Vernacular buildings are the structures built by local people using locally available material and affordable technology to deal with the local and day-to-day needs [1]. The design of vernacular buildings is the outcome of the traditional knowledge based on trial and error approach. This type of architecture addresses the local climate constraints and shows maximum adaptability and flexibility. This provides uniqueness to these vernacular architectures and is often used as a symbol to represent a particular community or cultural setup [2]. Bioclimatism integrates the micro-climate and architecture to human thermal comfort conditions [1,3]. Recent studies on vernacular buildings conclude that bioclimatism is an integral part of vernacular architecture and a deciding parameter towards achieving sustainability of modern architecture [2,4]. Building sector in developing countries accounts for one-third of total energy consumption and consumes more than half of the electricity consumption [5]. Now climate-responsive building

design has become a necessity to meet this increasing energy demand.

In recent years number of studies have been carried out on climate oriented building design to enhance thermal comfort conditions in living space and at the same time to reduce both the embodied and operational energy consumption [2]. But the results reported in these studies often deviate from the actual scenario [6–8]. This discrepancy arises because most of the available thermal comfort standards are suited for air-conditioned buildings [9]. The situation leads to difficulty in estimating the thermal environments due to lack of adequate field experiments and long-term data collection [10]. In naturally ventilated buildings the occupants' ability to modify the indoor environment is limited. An uncomfortable indoor environment might not be possible to control only by passive means because of different socio-economic background and climatic condition. However, people living in naturally ventilated buildings are likely to be more tolerant [11–13].

The vernacular dwellings of North-East India represent the principle of climate oriented architecture [1]. These are naturally ventilated buildings and are in accordance with traditional lifestyles. Socio-economic background and traditional lifestyles have considerable effect on occupants' thermal comfort perception.

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However, no study has been done on thermal performance of these buildings. A study on thermal performance of these vernacular houses has become a necessity. For bioclimatic building design, one must have site specific design data like comfort temperature range, wind speed and direction, topography, outdoor maximum and minimum temperatures, rainfall, solar radiation, etc. Present research work has been carried out to find the thermal performance of the traditional vernacular houses of the region quantitatively. 'Adaptive approach' method is used to evaluate the thermal performance of these vernacular buildings. This 'adaptive approach' is the outcome of field studies and is now the part of ASHRAE standard 55/2004 and ISO 7730 for predicting comfortable temperatures of naturally ventilated buildings [14–18]. The primary data were collected in the vernacular buildings of all the three bioclimatic zones of the region. In each bioclimatic zone, one house was selected for carrying out long-term measurements [1]. Predictive formulae based on outdoor and indoor climate data are used to evaluate the thermal performance of these buildings. The research work also includes questionnaire based comfort survey. Finally the results are used to define the comfort temperature range in these vernacular buildings for different seasons of a year.

## 2. Vernacular architecture of North-East India

North-East India is classified into three bioclimatic zones: warm and humid climate, cool and humid climate and cold and cloudy climate [4]. Entire North-East India has more than 50 ethnic groups which have distinct cultural and social setup. All the houses have provisions to satisfy their cultural and social needs. Most of the houses of the region are constructed in direct response to the climatic constrains [1]. The entire region experiences heavy rainfall, so all vernacular houses have steeply inclined and extended roofs. Houses of each climatic zone are distinct in its built form [1]. Building materials and their processing is also different in each climatic zone. Houses in warm and humid climate zone are open structures with courtyard. Courtyard serves socio-cultural needs and provides support to day-to-day activity of the occupants. It also serves as a collector of cool air at night and a source of shade in the daytime. Houses are provided with sufficient number of windows and doors for proper ventilation. Baked bricks, mud, wood, cane and bamboo are the main building materials. False ceiling

arrangements are present in most of the houses to minimize the heat gain during daytime [1]. In cool and humid climate zone urban and rural built forms are different from each other. For rural houses, courtyard is an integral part of every house plan but in urban houses it is not so common. Building materials for rural vernacular houses are of processed mud, bamboo (sandwiched between two layers of processed mud), cane, and wood. For urban houses processed mud and bamboo are replaced by backed bricks and cement. Vernacular houses in cold and cloudy zone are compact and have minimum surface to volume ratio [1]. This helps in increasing the heat gain in daytime and minimizes the heat loss during night. Almost all the houses are constructed of stone chips, rock slabs, wood, cane and bamboo. Houses are constructed on the south side of slopes to receive maximum solar radiation. All building materials used to construct the vernacular houses are available locally. This provides an edge on environmental front as less energy is involved in processing and transportation and henceforth minimal environmental degradation [1]. Selection of vernacular houses for long-term monitoring is based on common building plan and functionality. These houses layout designs are still very popular and are widely constructed. Vernacular house considered for monitoring in warm and humid climate zone is constructed in the year 1990, for cool and humid zone in the year 1992 and for cold and cloudy zone in the year 1993. Figs. 1–3 represent the selected houses' photographs in the different bioclimatic zone, respectively. Fig. 4 represents the wall construction techniques in the different climatic zones.

## 3. Methodology

Vernacular houses of North-East India across the three bioclimatic zones are widely varied in its built forms and functionality. These vernacular houses are still very popular and are being constructed as they fit well into the socio-cultural setup. No serious study has been done so far related to thermal performance of these vernacular houses. Through this study we have tried to assess the thermal performance of these vernacular houses in all the seasons of a year, the comfort status of occupants living in these vernacular houses, comfort temperature range and neutral temperature. We also tried to explore the different behavioral adaptations of occupants that influence the thermal comfort perception in indoor environment.



Fig. 1. House selected for long-term monitoring (warm and humid climate).

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