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# Passive control methods of Kerala traditional architecture for a comfortable indoor environment: Comparative investigation during various periods of rainy season

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ABSTRACT

The traditional architecture of Kerala, a state in India lying along its southwest coast, is known for its use of natural and passive methods for a comfortable indoor environment. Although there have been attempts to analyze the traditional architecture of Kerala, they were focused only on qualitative approach. An investigation was thus initiated by the authors to understand the passive environment control system of Kerala traditional architecture in providing better thermal comfort, by continuously monitoring thermal comfort parameters of a typical traditional residential building over a period of time. The inferences of the first phase of the investigation carried out during winter and summer seasons, lasting about half of the year have already been published. This paper illustrates the inferences of the second phase of the investigation that is carried out during the rainy season of the year. A comparative analysis with the results of the winter and summer periods is also incorporated. The investigation has revealed that, when the outside ambient temperature is below normal, the building system tries to maintain the indoor air temperature at a higher but comfortable level and when the outside temperature is above normal, the indoor is kept at a lower but comfortable level. It is found that a continuous gentle wind flow is maintained inside the building irrespective of the wind outside. The required level of thermal comfort is achieved by maintaining a balanced level of temperature and relative humidity along with a continuous and controlled airflow inside the building irrespective of seasons.



## 1. Introduction

Energy efficient and sustainable buildings have become the order of the day. This calls for a need to revisit the traditional buildings simply because they are time tested. Therefore, efforts have been made by many researchers worldwide to study the passive control methods of traditional architecture. These types of investigations were reported in Korea, Zambia and China in 1996 [1–4], followed by countries such as Japan, France etc., in the last few years [5–13]. Most of these studies have started with specific objectives to extract techniques to adopt in contemporary architecture and the results of such studies have now seen their application in modern buildings in Korea [14].

As a beginning in similar line, it is important to investigate the effectiveness of the passive environment control system of Kerala traditional residential architecture and identify its potential for contemporary application. Although there have been attempts to analyze the traditional architecture of Kerala, they were focused only on qualitative approach [15–18]. The effectiveness of any passive environment control system can only be established with a comprehensive analysis supported by field measurements of various comfort parameters in all seasons. A quantitative study was thus initiated by the authors by continuously monitoring the comfort parameters through various seasons. The results of the first phase of the investigation carried out during winter and summer seasons have already been published [19]. A qualitative analysis, discussing in detail about the passive concepts adopted and the materials used in traditional buildings of Kerala and the real need for such investigations for a climate responsive design for comfortable living in warm–humid climate was also reported in Ref. [20–22].

In Kerala, a number of traditional residential buildings have been demolished or modified, due to the change in the social setup, when joint families changed into nuclear families. However, a good number of buildings still exist with their original use or as holiday homes for tourist preserved in their original form and functional use. Residents as well as visitors prefer to stay in such buildings because they are very comfortable to live in for the former while it

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is a real experience for the latter. This also really emphasizes the need for such an investigation in the context of Kerala.

Extending from 8°18′ to 12°48′ N latitude and 74°52′ to 72°22′ E longitude, Kerala is on the southwest coast of India lying between the Arabian Sea on the West and the Western Ghats on the East. Kerala has a characteristic Warm–Humid climate because of its geographic settings. In effect, Kerala has only two predominant seasons – non-rainy and rainy seasons. Winter and summer come under the non-rainy season i.e., December to May. The rainy season lasts for the other half of the year (June–November) where heavy rainfall occurs due to South-West monsoon (locally known as *Edavapathi*) and North-East monsoon (locally known as *Thulavarsham*). Interestingly, it is observed that rainy season is the season with more fluctuations in the climatic parameters.

This paper is based on the second phase of the investigation carried out during the rainy season and can be considered as the second part of the paper already published [19]. A comparative analysis of the passive control methods of Kerala traditional architecture during various periods of rainy season for a comfortable indoor environment is thus illustrated. A comparative analysis with that of the results of the winter and summer periods is also incorporated.

## 2. Experimental investigation

### 2.1. Building description

Since the design of Kerala traditional residential building is based on a modular concept with four blocks built around an open courtyard strictly adhering to the ancient rules of geometrical grids, proportions and scale, the investigation is confined to a typical traditional residential building in a selected location.

The residential building selected for the study is located at Nilambur in the Malappuram district of the northern part of Kerala. The building (*Puthiya Kovilakam*) is nearly 300 years old. It has three rectangular courtyards in which one courtyard is surrounded by a double storeyed structure while the other two courtyards are surrounded by single storeyed structures. The internal space taken for the investigation is around the courtyard of 6 ft × 12 ft surrounded by double storeyed structures. The courtyard has an inward looking verandah of 3.5 ft in width. Two sides of the courtyard are semi open spaces that are used for living. The other two sides are provided with rooms having windows and doors opening to the courtyard. A figure showing plan and section of Nilambur Kovilakam with selected area for the study marked is shown in Fig. 1a [19,20].

### 2.2. Experiment setup

The authors have devised an instrument setup called Architectural Evaluation System (AES) with electronic sensors (to record temperature, relative humidity and air movement), data loggers (normal speed and high speed especially for wind sensors), memory module (to record data from all sensors) and a computer interface (to view and download data to the computer) to continuously record the comfort parameters over a period of time. A schematic representation of Architectural Evaluation System (AES) is shown elsewhere [20].

The sensors of the instrumentation setup (AES) have been calibrated and certified by India Meteorological Department (IMD) which is the authority to certify instruments related to climatic measurements in India.

In the second phase of the investigation, the authors have augmented the AES by employing a high speed data logger to record the air movement in every second. Additional RH sensors were also incorporated to the setup to study the variation of RH in different spaces.

High speed data logger was used to record the wind speed in every second to give a continuous plot of wind flow. In normal speed data logger the minimum interval that can be set is 5 min. So a parameter which is more fluctuating nature like wind flow shows only a discontinuous plot. This is because after a particular recording, the intensity or existence of wind in the consecutive recording will be totally independent of the previous recording. In the case of other parameters (temperature and RH), the variation even in 15 min is very less and shows a continuous plot which is helpful for critical analysis. However, wind flow plots in normal speed data logger are also essential to analyze the characteristics of wind flow for a longer period. This can be well appreciated from the wind flow plots given in the results section.

All parameters including air movement were recorded using normal speed data logger that was set to 15 min interval. With the introduction of high speed data logger, the air movement data were available for discontinuous plot as well as a continuous plot on graph for appropriate analysis.

### 2.3. Field measurements

Field data were collected using temperature sensors fixed at the bottom and top of courtyard, in the semi open space around the courtyard, in a bedroom adjacent to the courtyard and in the verandah. Ambient outdoor temperature was measured using a sensor enclosed in wooden Stevenson's screen located suitably. Sensors were located inside the building to record the air movement in the semi open space around the courtyard. Outdoor wind velocity was also recorded simultaneously. Relative humidity (RH) sensors were kept in the courtyard, in the semi open space and in the bedroom (Fig. 1b). Outside RH was recorded using a sensor located suitably.

Continuous data for a period from June 2009 to November 2009 were recorded with the windows kept open for unobstructed wind flow through various spaces within the building.

## 3. Results

It is observed that rainy season is the season with more fluctuations in the climatic parameters. Inorder to have a detailed comparative analysis, the rainy season has been divided into four periods such as days in the beginning of rainy season, days during normal rain, days during heavy rain and non-rainy days. The results of the four periods of rainy season are explained individually in the following sections initially. A detailed comparison and analysis of results are given at the end.

A 24 h time scale at an interval of 6 h is given in the *X* axes of Figs. 2–5. According to the climate of Kerala, the timings 00, 06, 12 and 18 stand for midnight, morning, noon and evening respectively.

The results obtained during various periods of rainy season are presented in Table 1. The results are further explained below with figures (Figs. 2–5) for a better understanding.

### 3.1. Days in the beginning of rainy season

The beginning period of rain after summer brings a drop of about 7° C in the maximum temperature and a drop of about 1 °C in the minimum temperature compared to summer. It is observed that the outdoor temperature has a diurnal variation of 7° C i.e., from 24° C to 31° C. The simultaneous indoor temperature was varying from 27° C to 29° C showing a diurnal variation of about 2° C only (Fig. 2a). The lower part of the courtyard is found to be cooler by about 2.5° C from the maximum outdoor temperature