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Thermal comfort study of Kerala traditional residential buildings based on questionnaire survey among occupants of traditional and modern buildings

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ABSTRACT

Thermal comfort studies on traditional residential buildings of Kerala that is known for its use of natural and passive methods for a comfortable indoor environment, are under progress. Scientific analyses of the environmental parameters determining thermal comfort have already been reported. Similar studies on modern residential buildings are underway. In order to compare the results of the scientific analysis with the user responses from the residents of traditional as well as modern residential buildings, a questionnaire survey was conducted during various seasons such as winter, summer and monsoon. A questionnaire was prepared in detail to understand the effect of factors which affect thermal comfort such as temperature, humidity and air flow in the evaluation of thermal comfort. This paper is based on the compilation of responses from the conducted survey. A comparison of the study results with that of scientific analysis already reported is also incorporated at the end of this paper. This study further confirms that Kerala traditional residential buildings are very effective in providing comfortable indoor environment irrespective of various seasons.

1. Introduction

Passive methods of achieving thermal comfort inside the buildings are the best solution to provide a healthy and energy efficient indoor environment [1–4]. This is of supreme importance for buildings in the tropics where mechanical systems with high energy consumption are used to condition the indoor environment for thermal comfort [5]. The people are forced to depend on such systems because, majority of the buildings are designed without giving adequate importance to passive methods for controlling the indoor environment. In many cases, failure to provide the required thermal conditions has resulted in discomfort, ill health and productivity loss. Presently, there is a constant need to evaluate the thermal conditions of the indoor environments to learn further and proceed with the research in passive design [6–10].

Kerala, a state in India located in the southwest coast, falls in the warm-humid climatic zone according to Bureau of Indian Standards [11]. The presence of high amount of moisture in the atmosphere, due to its geographical setting, for major part of the year causes thermal discomfort as there is less evaporation, resulting in sweating. This becomes more acute in summer when the air temperature and relative humidity become higher.

Studies on passive methods of achieving thermal comfort in buildings are under progress in the form of extracting methods and techniques from traditional buildings in various countries [12–19]. In India, such studies have been reported recently from the North-East part where the climate is composite in nature [20–22]. The authors have conducted an investigation of traditional architecture in the context of Kerala, where the climate is warm-humid, to understand the passive environment control system. Quantitative analyses based on continuous recording and evaluation of thermal comfort parameters in traditional buildings has already been published [23–29].

A questionnaire based survey on the residents of the traditional and modern residential buildings was required to compare with the results obtained from the quantitative analyses. Thus a questionnaire survey was conducted among the residents of traditional and modern buildings through various seasons to assess the subjective response of thermal comfort. The study was conducted during various seasons such as winter, summer and rainy period of monsoon season.

The questionnaire was prepared in detail to understand the effect of factors which affect thermal comfort such as temperature, humidity and air flow in the evaluation of thermal comfort. Respondents from age groups ranging from 20 to 70 years, with more or less equal representation from either sex were selected for the survey. A Summary of Experimental Investigations already Reported on Kerala Traditional Residential Buildings is included in this paper.

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A comparative analysis of the outcome of the survey with the scientific studies already reported is also incorporated. This paper also explores a comparison of thermal comfort between traditional and modern buildings through various seasons.

2. Methods

2.1. Selection of people

The survey was conducted among the selected people from selected families of both traditional and modern buildings of Kerala. Fifty families each living in traditional and modern building were selected for the survey. A total number of 200 people each from traditional and modern houses were selected for the study with an average of four members from each family.

The traditional houses of about 200–300 years of age, built according to the ancient principles were selected for the survey. The basic module of traditional residential building of Kerala is known as *nalukettu* with four blocks built around an open courtyard. They are generally rectangular or square in plan with blocks topped with a sloping roof on all four sides while the courtyard is left open to the sky for letting air and light inside. There is an internal verandah around the courtyard for protection from rain and sun.

The roofs have steep slopes up to almost 45 degrees and are topped with clay tiles on wooden framework with gaps provided in between tiles to enhance ventilation and to allow the warm air to escape. Further, ventilators are provided for the ventilation of attic spaces that are formed by the wooden false ceiling (*tattu*) provided for the room spaces. This roof encloses a large insulated air space keeping the lower areas cooler. A detailed description on the traditional residential buildings of Kerala and its typical layout are given elsewhere [27].

Modern buildings of less than 20 years of age were selected for the survey. Modern buildings of Kerala do not have any common design principles nor do they follow a common architectural style. Most of the buildings are constructed with brick masonry walls plastered with cement mortar and topped with RCC roof. The roofs are either flat or sloping at different angles. Window openings are provided all around the buildings and they are extensively covered with glass paneled shutters.

The buildings, both traditional and modern, were selected from various parts of Kerala irrespective of the micro level variations in climate and topography. A detailed description on the topography and climate of Kerala are given elsewhere [27].

People with sensible mind and keen observation skill on thermal comfort were selected for the survey. They were briefed about the scope of the survey, and were given sufficient input before the conduct of the survey on how to respond to the questionnaire.

2.2. Preparation of questionnaire

The questionnaire for the survey was prepared to obtain the subjective responses from the respondents on various thermal comfort parameters such as temperature, humidity and air flow along with a response on overall thermal comfort. The selection and gradation of components in the questionnaire was done by a detailed review of literature in the respective field [30–38]. The residents were asked to evaluate the environment in a condition when they are not using any of the aid – mechanical or otherwise – to improve or modify the indoor environment.

The questionnaire was prepared both in English and Malayalam (regional language of Kerala) for easy conduct of the survey. Also, it was reproduced in three different colours – light blue, pink and light green – for the surveys conducted during winter, summer and rainy season respectively. The questionnaire prepared for the investigation is given in Appendix A at the end.

2.3. Survey methodology

The survey was conducted with the help of many interested people in this field. They were educated in detail about the relevance and objectives of the survey by the authors. The different components of the questionnaire, its meaning and the gradation were also explained in advance.

The survey was conducted in the peak of each season simultaneously in different locations i.e. during the first week of January 2009 (winter peak), last week of April 2009 (summer peak) and last week of July 2009 (monsoon peak).

3. Results and analysis

The subjective responses, on various thermal comfort parameters and that on the overall thermal comfort, obtained from the questionnaire survey conducted during various seasons are illustrated below. The analysis and interpretation of the results obtained from the survey is provided at the end of this section. An average vote for overall thermal comfort in an annual basis is also illustrated.

3.1. Winter season

Fig. 1 shows the distribution of subjective response on temperature in winter season. While about 35% of the residents of traditional buildings voted for neutral temperature, only 26% of the residents of modern buildings voted for the same. Also, while 25% of the residents of traditional buildings voted for slightly warm temperature, 37% of the residents of modern buildings voted for the same. 19% of the residents of modern buildings believe that their buildings are warm in winter while 8% believe that it is hot. When 32% of the residents of the traditional buildings believe that their buildings are slightly cool, only 10% of the modern building residents believe the same. It is evident from the Fig. 1 that, while the votes from people of traditional buildings are balanced around the neutral condition, the same of modern buildings shows a tendency towards warm condition.

The distribution of subjective response on humidity in winter season is shown in Fig. 2. From this figure, it is clear that, around 50% of the people in the traditional and modern buildings believe that their dwellings are neutral in terms of humidity in winter season. While about 31% of the residents of traditional buildings voted for slightly dry, 36% of the residents of modern buildings voted for the same. Less than 5% of people in both the buildings believe that their buildings are humid in winter season. Also, less than 10% of people

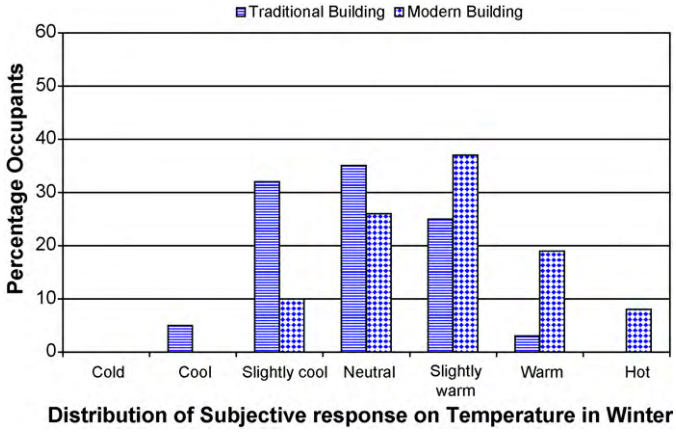

Fig. 1. Distribution of subjective response on temperature in winter season.