



Review

A Study on Thermal Performances of Historic Buildings – A Review

Ar. Supriya Mahesh Patil and Kasthurba A. K.
Department of Architecture, National Institute of Technology Calicut, Kerala, India
Corresponding author Email: patil-supriyam@gmail.com

Received: 06/01/2018

Revised: 17/02/2018

Accepted: 19/02/2018

Abstract: The thermal comfort conditions inside building are important criteria for the comfort of occupants. This comfort condition depends upon the various building design factors. To achieve an ideal thermal comfort condition proper control of climatic elements such as air temperature, humidity, and air movement through design is needed. Based on various research studies it is evident that traditional buildings are more climate responsive compared to the modern buildings. Thus the thermal performance evaluation of the traditional buildings is necessary to find out the micro climatic efficiency achieved by them. This paper reviews three different research studies undertaken based on this. A detailed analysis was carried out to derive suitable suggestions for thermal comfort conditions in buildings. It is found that the traditional architectural design and building techniques facilitate to achieve thermal comfort inside the buildings. Sometimes not only the techniques but materials also play an important role in the thermal comfort conditions. Some field measurements and

survey techniques can also help to formulate the thermal comfort conditions.

Keywords: Humidity, Micro Climate, Temperature, Thermal Comfort, Traditional Buildings

INTRODUCTION

Along with the evolution of the mankind, the evolution of the architecture also has taken place. This evolution is purely instinctive i.e. to cope up with climate and thermal comfort. The form, shape, material used in the building is totally climate responsive. Thus the buildings with such kind of techniques are having high thermal comfort for the occupants. The micro climatic conditions are modulated in such buildings and the main elements considered for the thermal comfort are temperature, humidity, air changes etc. the heritage buildings for many years are standing facing diverse climatic conditions. Solar radiation, wind direction along with temperature and humidity are responsible for the changes in internal climate of the structure as well as changes into the building envelop. Passive methods of achieving thermal comfort inside

the buildings are the best solution to provide a healthy and energy efficient indoor environment (Krishnan, et al., 2001). But nowadays unfortunately most of the buildings are designed without any consideration of the climate. Instead of the local materials cement concrete has gained the popularity as a major construction element. Therefore there is a need to study and analyze the thermal performance and micro level climatic conditions of the heritage buildings and to apply them into modern construction techniques. Three journal papers are selected for the review in the above area. These papers are discussed in detail in next section.

Methodology in the literature review:

Paper 1:

Study on the thermal performance of the Chinese traditional vernacular dwellings in Summer, Lin Borong, Tan Gang, Wang Peng, Song Ling, Zhu Yingxin, Zhai Guangkui.

This paper discusses about the thermal environment parameters of indoor and outdoor temperature of traditional traditional dwellings at Wannan area in summer. Some design principles of traditional traditional dwellings were revealed. The study was based on the field measurements of temperature, humidity, velocity and black ball temperature etc. The site was located near north latitude 30° and belongs to subtropical belt monsoon wet climate. Four traditional buildings and one modern building were selected for the study.

Comparison of the thermal performance between the traditional vernacular dwellings and the modern houses:

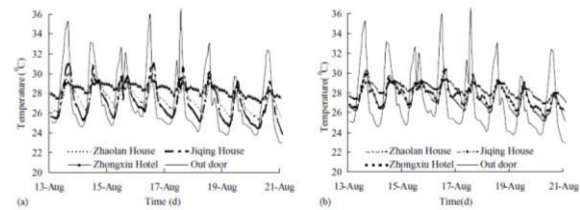


Figure: 1 Comparison of air temperature in different rooms of the residence [Lin Borong]

The above figure1 shows the graphs of temperature differences of one month in different rooms of the same building. From the results, it can be seen that the whole day mean temperatures of the two rooms of traditional buildings were 1.5°C lower than the modern house.

So it clearly shows that during the daytime the temperatures of traditional houses were not lower than those of modern houses.

Relationship between the shading and thermal insulation design and the indoor thermal environment:

It was very common that the roofs of the traditional dwellings were designed as a double-pitched raft and with an overhead double layer tiled structure, which was named Wang Brick by local people. The ceiling height of a traditional house, which was often above 6m, is usually higher than modern houses but the measured temperature distribution in vertical direction does not show a significant effect of the ceiling height. The maximum temperature differences were below 1.5°C . Also, if compared with the long-term measured hall temperature results, it can be concluded that the taller the hall, the higher its diurnal temperature. So it contradicts to the conclusion in literature that, the taller the ceiling height, the cooler is the room. So it can be concluded that sun shading and insulation should be considered firstly while designing. In summer season, the ventilation

of the room should be proper at daytime and to boost it at night with thermal pressure induced ventilation. All the climatic elements should be considered properly while designing any building.

Natural ventilation designs and the indoor thermal environment

At daytime, the outdoor air temperature is higher than the indoor air. So the thermal pressure ventilation cannot run efficiently in the whole building. On the other hand, the pressure-induced ventilation is also restrained at daytime because of the compact arrangement of the traditional dwellings. With limited natural ventilation the dwelling can get a relatively low temperature and its thermal environment is congenial. At night the effect of the thermal pressure ventilation is obvious when the outdoor air temperature is lower than indoor air. Thus, with the successive entering of cool air from outdoor, the room can get a satisfactory thermal environment. (Lin Borong et. al., 2004)

Paper 2: Thermal comfort study of Kerala traditional residential buildings based on questionnaire survey among occupants of traditional and modern buildings

A.S. Dili, M.A. Naseer, T. Zacharia Varghese

In this paper the thermal comfort analysis of the traditional residential buildings in Kerala was done. The analysis was done on the basis of questionnaire survey among the occupants of traditional residential buildings as well as modern residential buildings for three seasons viz, summer, winter and rainy season. The survey focused on the effect of factors which are affecting the thermal comfort inside the building. These factors were like temperature, humidity, air movement, thermal comfort etc. Separate graphs for responses for temperature, air

movement, humidity and thermal comfort were plotted for winter, summer and rainy seasons. And a comparative analysis was done. Also some experimental investigations which were already reported on Kerala traditional residential buildings were compared with the results obtained from the survey.

Results and analysis:

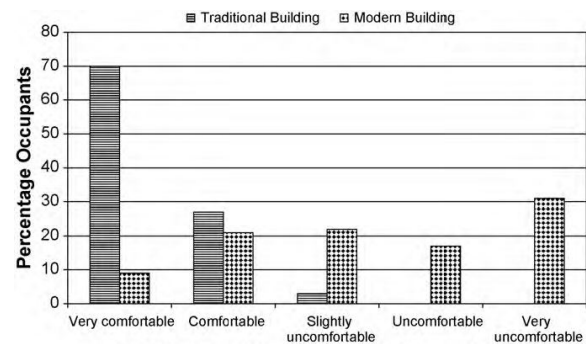


Figure: 2 Distribution of subjective response on overall thermal comfort [A.S. Dili]

From the above Figure 2 it can be observed that modern buildings are found to be uncomfortable and very uncomfortable whereas the traditional buildings fall under very comfortable, comfortable and slightly uncomfortable.

Similarly it was seen that while more than 50% of the residents of the traditional buildings voted for neutral condition in terms of temperature in summer, 30–35% people voted for the same in other two seasons. Most of the people in traditional houses feel that their dwellings are cooler in winter and summer, and are warmer in rainy season. The thermal characteristics of the Kerala traditional building envelope were playing a vital role in controlling the temperature. It can also be learned from the analysis that, the modern buildings were warmer in winter and rainy seasons and were hotter in summer (Dili et. al., 2010)

The best solution to create an energy efficient, healthy and comfortable indoor environment is to provide a passive system of ventilation in buildings. The adoption of techniques from traditional buildings is important to achieve thermal comfort indoors in a passive manner. The results of the survey at a glance reflect that the residents of the traditional houses of Kerala prefer to stay there because they are very comfortable to live in irrespective of the seasons.

Conclusion: The outcome of the survey and its analysis clearly indicate that traditional houses of Kerala were very comfortable to live in round the year irrespective of the season. The result also shows that the basic reason for discomfort was rise in temperature and humidity in atmosphere. And by providing highly insulating building envelop and proper and continuous air movement through building, the comfort conditions can be achieved. So it can be concluded that the modern buildings should be designed with the traditional techniques for maintaining thermal comfort conditions for the occupants inside the building.

Paper3:
Analysis of Historic Buildings in Terms of their Microclimatic and Thermal Comfort Performances “Example of Konya Slender Minaret Madrasah”
Enes Yasa, Guven Fidan and Mustafa Tosun

In this paper the analysis of thermal comfort and micro climatic performance was done by studying a building, Konya Slender Minaret Madrasah. According to the author the micro climatic elements like indoor air temperature, average surface temperature, air variation ratio, indoor relative humidity, illumination level and brightness were the factors needs to be considered for achieving

thermal comfort conditions inside the building. The analysis was done by using simulation. The simulation was applied on the system defined by the building using computational fluid dynamics (CFD) software based on the finite volume method. Simulation was used for analysis of temperature gradient, air velocity field for simplified model, perimeter walls, and splay windows and in coffered ceiling zone.

In order to achieve whether micro-air conditioning comfort state in a building or macro-air conditioning for a town, studies on effects of natural air conditioning not only on the shape of a building, but also on urban residential areas, residential buildings as well as on air flow inside and around buildings should be conducted by making use of Computational Fluid Dynamics (CFD) Simulations and Wind Tunnel Tests. Generally, the effect of shadowing on the required heating load during winter was more than its effect on decreasing the cooling load during summer. Thus, the sensitivity of the heating load towards the obtained solar radiation was higher than the sensitivity of the cooling load towards shadowy area. [Enes Yasa]

General Discussion

The building physics, energy performances and thermal comfortability related to the simulation model building was investigated in order to determine suitable characteristics of the mathematical model, and different alternative methods and potentials were discussed.

The effect of shadowing on the required heating load during winter was more than its effect on decreasing the cooling load during summer. Thus, the sensitivity of the heating load towards the obtained solar radiation was higher than the sensitivity of the cooling load towards shadowy area. We can therefore conclude that making solar radiation gain during winter was more critical (important)

than evading this during summer. In order to achieve whether micro-air conditioning comfort state in a building or macro-air conditioning for a town, studies on effects of natural air conditioning not only on the shape of a building, but also on urban residential areas, residential buildings as well as on air flow inside and around buildings should be conducted by making use of Computational Fluid Dynamics (CFD) Simulations and Wind Tunnel Tests.

Analysis and Discussion

Table 1 Comparative Analysis of the Review Papers

Paper	Type of building selected	Parameters under study	Type of study
Paper 1	Residential Traditional building	Temperature, humidity, velocity, black ball temp.	Field measurements and graphs and tables
Paper 2	Residential Traditional vs modern building	Temperature, humidity, air movement, thermal comfort	Questionnaire survey, field measurements
Paper 3	Religious heritage building	Temperature, velocity, wind flow, solar radiation	CFD simulation

Table 1 shows the comparative analysis of the three papers selected for the study. It can be revealed from the table that temperature, humidity, air movement and heat gain are the main parameters for the study of thermal comfort inside the heritage buildings. For the results it is needed to be collecting the data from actual field measurements. Some software's can also be useful for the analysis of the data.

Summary: From the above three reviewed papers it can be concluded that there is lack of awareness in using traditional methods of passive cooling and heating of building in

modern architectural practice. Proper use of building materials and construction techniques can help in improving microclimatic and thermal comfort performances. To calculate these parameters, actual field measurements and analysis of the same are necessary. Thermal insulation of materials, solar shading devices, structure of the building envelopes and roofs are identified as the major factors responsible for the thermal performance of the buildings. The area, shape, location and relative positioning of the courtyards and fenestrations plays also play significant role in thermal behaviour of the buildings.

REFERENCES:

Arvind Krishnan, Nick Baker, Simos Yannas S V Szokolay (2001) "Climate Responsive Architecture A Design Handbook for Energy Efficient Buildings", New Delhi, Tata Mcgraw Hill Publishing Co. Ltd.,

Lin Borong, Tan Gang, Wang Peng, Song Ling, Zhu Yingxin, ZhaiGuangkui (2004) "Study on the thermal performance of the Chinese traditional traditional dwellings in Summer", Energy and Buildings vol. 36, pp 73–79.

A.S. Dili, M.A. Naseer, T. Zacharia Varghese, (2010), "Thermal comfort study of Kerala traditional residential buildings based on questionnaire survey among occupants of traditional and modern buildings", Energy and Buildings vol. 42, pp 2139–2150.

Microclimatic and Thermal Comfort Performances-Example of Konya Slender Minaret Madrasah", Architectural Engineering Technology.