

Evaluation of Thermal Comfort of a Green Building: A Case Study

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ABSTRACT: Thermal comfort is a condition of mind that expresses satisfaction with the thermal environment and the same depends on wind velocity, relative humidity, surface temperature, activity level, clothing level etc. This work discusses the evaluation of thermal comfort of a green building during the post monsoon season (October 2016 to December 2016) with respect to the parameters namely temperature, wind velocity, relative humidity and intensity of light. It was found that the surface temperature is more for the rooms located on the south eastern side compared to that of rooms located on the northern side. Average outside relative humidity differs from the indoor humidity by 7%. This is mainly due to the design and orientation of the building. The application of double wall had considerable effect on the wall temperature. From the study it is concluded that the orientation, design and material selection are the key factors which determines the thermal comfort of the building under study.

KEYWORDS: Thermal comfort, Green building, Environmental factors, Wind velocity, Temperature, Intensity of light, Relative humidity.

I. INTRODUCTION

Thermal comfort is important for health and well-being and the lack of thermal comfort causes stress among building occupants. As per International Standard ISO 7730 thermal comfort is defined as: 'that condition of mind which expresses satisfaction with the thermal environment'. The U.S. EPA says "Green building is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction. This practice expands and complements the classical building design concerns of economy, utility, durability, and comfort. Green building is also known as a sustainable or high performance building. "Green buildings are designed in such a way to reduce overall impact on environment and human health by: reducing trash, pollution and degradation of environment, efficiently using energy, water and other resources, protecting occupant health. Green buildings may be designed to be responsive to regional climate, and use less active strategies to help provide an acceptable range of thermal comfort through the seasons. Passive solar heating will maximize the warming benefit of the sun in heating season. Passive cooling will use proper shading and natural ventilation to reduce indoor temperatures, and provide air movement to increase comfort. Passively cooled buildings will be set up to maximize outdoor air intake at night, when it is cool. Thermal comfort depends on both environmental factors and personal factors. Environmental factors include temperature, air velocity, relative humidity etc. and personal factors include clothing, metabolic rate and well being.

Climate plays an important role in the performance of the building and its energy consumption. Energy consumption can be reduced with the use of natural resources and by providing comfortable, healthier and sustainable living spaces. As per the National Building Code of India (NBC), India is divided into five climatic zones namely hot-dry, warm-humid, composite, temperate, and cold, as shown in figure 1[1]. The climate in Kerala is warm- humid based on the climatic zone of India. In Kerala the main monsoon is North East monsoon or post monsoon (October to December)

and the second one is the South west monsoon (June to September) which contributes about 60% and 20% of the total annual rainfall respectively [2].

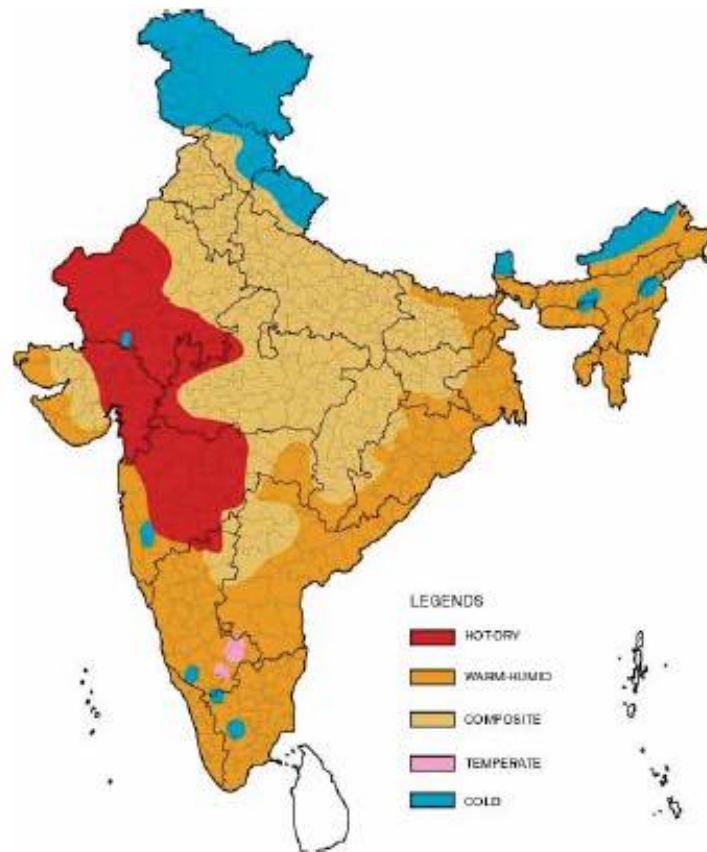


Fig. 1: Climate zone map of India

Amitava Sarkar et al., [3] conducted a study on the impact of opaque building envelope components on thermal and energy performance of houses in the lower western Himalayans and found out that the use of thermal mass in wall and roof construction can maintain indoor thermal comfort during winter and summer months in composite climate.

S.S. Chandel et al., [4] did a study on performance assessment of a passive solar building for thermal comfort and energy saving in a hilly terrain of India. They found out that the space heating, cooling and mechanical ventilation loads and total annual energy consumption are reduced due to passive solar design features in the building.

Amitava Sarkar et al., [5] studied the thermal performance design criteria for bio-climatic architecture in Himachal Pradesh. An appropriate architectural design criteria for present day buildings located in lower Himachal Pradesh was suggested by quantitative and qualitative comparison of thermal performances of traditional and modern residential buildings through field-survey.

S.H. Ibrahim et al., [6] made a study on the thermal comfort conditions in the Masjid Al-Muttaqin located in Kota Samarahan, Sarawak. They found out that although the air velocity in the mosque is acceptable, due to the influence of high air temperature, thermal comfort is not achieved. A retrofit design by adding new materials and installing insulations on the existing roof were proposed and the results showed that there is significant improvement of thermal comfort inside the mosque.

II. STUDY AREA

The study area selected is the green building of Energy Management Centre (EMC), Trivandrum, Kerala. The study area is located at Sreekariyam ($8^{\circ} 54' 58''$ E latitude, $76^{\circ} 9' 09''$ N longitude) in Trivandrum district, the capital city of Kerala. It has a total built up area of 4030.73 sq.m. The city of Trivandrum has 'warm and humid' climate as per the Indian climate classification based on National Building Code. The study area is shown in figure 2.



Fig. 2: Study Area

The main features of Green building of Energy Management Centre are:

1. The building is constructed using brick and cement having high fly ash content.
2. Rainwater harvesting is done using two ponds.
3. The building is oriented in the north south direction. Maximum windows on north and south direction help to utilize the daylight effectively and reduce solar radiation.
4. Provision of double wall helps to reduce the indoor wall temperature
5. Application of white paint with high Solar Reflectance Index (SRI) at the roof of the building helps in keeping the building cool.
6. Solar panels installed at the top of the building helps to reduce the consumption of electricity.
7. The building is provided with air vents and turbo ventilation which helps in removing the hot air inside the building.
8. The central courtyard is an added advantage of the building.
9. Energy efficient lights and fan such as LED and super fans are used in the building.
10. A large number of bamboo species are planted near the building which act as a green wall and reduces the air pollution.
11. The corridors are designed in such a way that physically challenged people can also walk easily.

Some of the key features of the study area mentioned above are shown in figure 3.



Fig 3 a) Terrace painted with white paint having high SRI Fig. 3 b) Corridor



Fig. 3: c) Turbo ventilation

Fig. 3: d) Solar panels

Fig. 3: Some key features of EMC

III. METHODOLOGY

In India, few studies on thermal performance and thermal comfort of residential buildings and office buildings are reported till date [1]. In this study, the field-survey was conducted at green building of Energy Management Centre during the period October 2016 to December 2016. The following parameters namely interior and exterior wall temperature, wind velocity, intensity of light and relative humidity were measured to evaluate the thermal comfort of the building. Weekly measurement of all the parameters were carried out during both afternoon and forenoon sections. One room each in all the four direction on both the floors were selected for the study. In addition to that measurements were taken at reception, library, toilet, corridor and roof. The instruments used for measuring the said parameters are given in table 1 and the same are shown in figure 4 respectively.

Table 1: List of Instruments used

SI .No	PARAMETERS	INSTRUMENT USED
1	Wall temperature	Infrared thermometer
2	Wind velocity	Anemometer
3	Intensity of light	Lux meter
4	Relative humidity	Hygrometer

The hand-held calibrated digital instruments were placed at a height of 0.9 m from finished floor level, positioned at a distance of 1m from both the side walls and at the centre of the rooms. Minimum 5 to 7 days were spent in each month during post monsoon season to collect indoor environmental data from the green building.



a) Infrared Thermometer

b) Anemometer



c) Lux meter

d) Hygrometer

Fig. 4: Instruments used in the study

The wet and dry bulb temperature measured using hygrometer were used to calculate relative humidity from the psychrometric chart. A psychrometric chart presents physical and thermal properties of moist air in a graphical form. The measured values were compared with that of standard values. The effect of double wall on wall temperature was also measured.

IV. RESULTS AND DISCUSSION

Wall temperature

The outside wall temperature varied between 28.9 ° C on the northern side and 35.7° C on the south eastern side. Maximum inside wall temperature was on the eastern side with a value of 31.5° C and minimum temperature was observed at northern side which is about 28.1° C. Wall temperature was more during the afternoon than in the morning. Use of wall and roof insulation will help to reduce the wall temperature and to maintain indoor condition comfortable for large duration of time in a naturally ventilated building.

Intensity of light

The design of windows is very crucial for intensity of light inside a room. Intensity of light at various types of rooms were measured and compared with the standard given in National Building Code (NBC), 2005, Part 8, Section 1[1]. Light intensity at various rooms except those at the eastern side meets the NBC Standards. It mainly occurs when the climate is cloudy.

Wind velocity

Wind velocity was low inside the building except at northern side. People use ceiling fan to adjust to the indoor office environment.

Relative Humidity

Indoor relative humidity was low when compared with outdoor relative humidity. Outdoor relative humidity differed by 6 % when compared with indoor relative humidity. Air vents provided will help in cooling of the rooms by releasing the warm air.

Effect of double wall on wall temperature

When comparing the temperature of double wall with that of normal wall, there is a temperature difference of 0.8° C. Application of double wall will also provide good result in maintaining indoor thermal condition comfortable for the occupants.

V. CONCLUSION

In this study, an attempt has been made to determine the thermal comfort of a green building with respect to wall temperature, wind velocity, intensity of light and relative humidity. Intensity of light in almost all the rooms meets the National Building Code, 2005 Standards. This is because the building is designed in such a way that it takes the full advantage of natural light. The effective utilization of the windows by the occupants also enhances the energy efficiency of the building. Interior wall temperature was about 2° C less than that of the exterior wall temperature. The application of double wall had considerable effect on the thermal comfort of the building. Indoor relative humidity was

lower than that of the outdoor relative humidity. This is mainly due to the presence of courtyard with green plants which keeps the building cool.

ACKNOWLEDGEMENT

The authors wish to thank the Department of Civil Engineering, College of Engineering Trivandrum and Energy Management Centre, Trivandrum for providing necessary infrastructure for carrying out the study.

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