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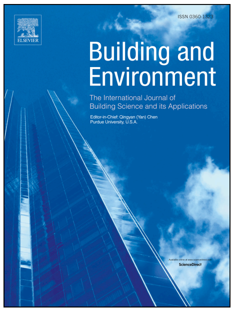

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Adaptive Thermal Comfort in the two college campuses of Salesian College, Darjeeling – Effect of difference in altitude

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ABSTRACT *Thermal comfort standards help building designers to provide good indoor climate as well as optimization of energy consumption in a building. Usually, Predicted Mean Vote (PMV) model which had its basis on the extensive climate chamber experiments is utilized to estimate the comfort condition for a building. However, the recent studies in the field of thermal comfort shows that the commonly used PMV model frequently underestimates and overestimates the thermal sensation in cooler and warmer condition in the real conditions leading to a more extreme set point temperature than required thus with higher energy consumption. This discrepancy in predicted and actual sensation was explained by the adaptive theory researches where the subjects have various adaptive opportunities to make themselves more comfortable than as predicted. However, the field survey based adaptive comfort standards depend upon several factors like the local climatic condition, ethnicity, etc. In this paper, we present the results of adaptive thermal comfort based field study conducted on two campuses of the same institution separated by altitude. A total of 1147 datasets were collected from 356 subjects with age group 18 – 29 years, most of whom were college students. We have discussed the variation of clothing insulation and thermal neutrality both with the altitude and with outdoor conditions. A wider range of indoor temperature for which the subjects voted neutral was seen especially on the lower side (12.5° - 32.3°C) in comparison to previous studies.*

Keywords – Altitude; Predicted Mean Vote; Thermal Sensation; Thermal Neutrality

1. INTRODUCTION

Building sector holds tremendous potential for conservation of energy as it consumes 48% of the total energy worldwide for its construction, operation and maintenance. And in India, providing thermal comfort indoors consumes about 48% of the energy used in this sector [1]. Thus a reduction of energy consumption in this sector even by a small fraction will lead to substantial savings considering the huge population of the country.

Naturally ventilated (NV) buildings as compared to air conditioned (AC) buildings consume lesser energy for its running throughout its lifespan. This happens so because they entirely depend upon fans and windows without any mechanical ventilation for providing thermal comfort to its occupants. Thermal comfort is defined as “that condition of mind which expresses satisfaction with the thermal environment” [2].

Two methods are generally used for thermal comfort models. First, the Fanger’s climate chamber based Predicted Mean Vote – Percentage Predicted Dissatisfied (PMV-PPD) model [3]. This method utilize the four indoor environmental variables, air temperature, mean radiant temperature, relative humidity, air velocity and two personal variables, clothing insulation and metabolic activity to calculate the PMV based comfort condition in a seven point scale. This model however being a laboratory based is unable to take care of various adaptive approaches the occupants take so as to make them-selves comfortable. This PMV model thus, frequently either underestimates the thermal sensation in cold conditions or overestimates in warm conditions [4]. This advices for a higher set point temperature for heating during cold conditions and lower set point temperature for cooling during warm conditions than would be otherwise required by the occupants, thereby leading to increased energy consumption.

In contrast, the adaptive principle states, “if a change occurs such as to produce discomfort, people react in ways which tend to restore their comfort” [5]. In actual indoor environment, occupants use different adaptive opportunities or approaches according to their own preference in order to obtain thermal comfort. Adaptations are (i) behavioral, which include change in the clothing pattern, opening and closing of windows, ventilators, etc; (ii) physiological, i.e. the acclimatization of an individual to the environmental condition; and (iii) psychological, which include the thermal expectation of the individual from the environment.

In India there are no thermal comfort standards. Two narrow ranges of temperatures, 23° - 26° C for summers and 21° - 23° C for winter are prescribed by the National Building Code (NBC) of India [6] irrespective of its wide geographic, climatic and ethic variations which affects adaptations and thereby thermal comfort. However recent adaptive thermal comfort based studies in Indian buildings in hot and humid climates showed comfort temperatures much