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Adaptive thermal comfort in primary school classrooms: Creating and validating PMV-based comfort charts

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ABSTRACT

In this research the thermal comfort and thermal comfort parameters for children in primary school classrooms has been investigated. Actual thermal sensation and clothing insulation of children (age 9–11) in non-air-conditioned classrooms in three different schools in the Netherlands have been obtained. Results are available for a total of 24 days, covering winter, spring and summer conditions (year 2010). Questionnaires have been applied to obtain the actual thermal sensation and clothing insulation in the morning and afternoon of regular school days. In this period physical parameters (temperature, relative humidity, etc.) were recorded as well in order to derive the PMV.

The results show that children adapt clothing during the year from mean values around 0.9 clo in winter to 0.3 clo in summer, with the largest changes occurring in the mid-season. There is a small difference in clothing adaptation between male and female children, with the females showing more adaptation.

Comparison of the actual mean vote with the calculated PMV, based on the measured data, indicates a clear difference. The conclusion is that the PMV model does not predict the thermal sensation of these children accurately; it underestimates the mean thermal sensation up to 1.5 scale point.

When the actual thermal sensation votes are compared to comfort predictions based on adaptive temperature limits it shows that children prefer lower temperatures than predicted by these methods.
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1. Introduction

The Adaptive Temperature Limits (ATL) [1] method which is used in the Netherlands was developed for naturally ventilated office buildings. It shows the required operative temperatures as function of a weighted running mean of the exterior temperature; this is a very easy-to-understand representation of thermal comfort criteria. Another method to predict thermal comfort is Fanger's Predicted Mean Vote (PMV) [2]. Earlier research by van der Linden et al. [3] indicated that the PMV method, with correct input, can lead to similar predictions as the ATL method, for thermal comfort in a moderate climate like the Netherlands. With correct input is meant: sufficient detail on personal and environmental parameters. The advantage of the PMV method is that its input can be adjusted to the specific situation to be evaluated, so the range of buildings it can be applied to is broader.

In order to investigate this assumption, this research addresses thermal comfort evaluation for primary school classrooms in the Netherlands. The indoor environment in classrooms can have a large effect on comfort, health and learning performance [4]. The aim is to assess whether the PMV method can be used to improve accuracy of thermal comfort predictions for non-air-conditioned primary school class rooms when the input conditions more accurately represent realistic conditions as was assumed for naturally ventilated offices in [3]. Specific attention was given to the clothing insulation for children, and adaptation of clothing during the year.

Thermal comfort is defined by ASHRAE [5] as 'that condition of mind which expresses satisfaction with the thermal environment and is assessed by subjective evaluation'. The subjective evaluation of thermal comfort is influenced by the thermal environment and personal factors influencing the heat transfer with this environment, but also by psychological factors influencing the condition of mind directly. All these factors in thermal comfort can be altered by behavioural, physiological or psychological adaptation.

Many thermal comfort criteria and predictions are based on the PMV as introduced by Fanger [2] and presented in ISO 7730:2005 [6]. This comfort equation can be used to calculate the PMV. This predicted thermal sensation can be transferred to the predicted thermal

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