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Combined thermal acceptability and air movement assessments in a hot humid climate

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ABSTRACT

In the ASHRAE comfort database [1], underpinning the North American naturally ventilated adaptive comfort standard [2], the mean indoor air velocity associated with 90% thermal acceptability was relatively low, rarely exceeding 0.3 m/s. *Post hoc* studies of this database showed that the main complaint related to air movement was a preference for 'more air movement' [3,4]. These observations suggest the potential to shift thermal acceptability to even higher operative temperature values, *if* higher air speeds are available. If that were the case, would it be reasonable to expect temperature and air movement acceptability levels at 90%? This paper focuses on this question and combines thermal and air movement acceptability percentages in order to assess occupants. Two field experiments took place in naturally ventilated buildings located on Brazil's North-East. The fundamental feature of this research design is the proximity of the indoor climate observations with corresponding comfort questionnaire responses from the occupants. Almost 90% thermal acceptability was found within the predictions of the ASHRAE adaptive comfort standard and yet occupants required 'more air velocity'. Minimum air velocity values were found in order to achieve 90% of *thermal and air movement acceptability*. From 24 to 27 °C the minimum air velocity for thermal and air movement acceptability is 0.4 m/s; from 27 to 29 °C is 0.41 −0.8 m/s, and from 29 to 31 °C is >0.81 m/s. These results highlight the necessity of combining thermal and air movement acceptability in order to assess occupants' perception of their indoor thermal environment in hot humid climates.

1. Introduction

Regulatory documents such as comfort standards are strategic in stimulating market acceptance of design approaches based on natural ventilation, as illustrated by the adaptive comfort models that are included in the North American and international comfort standard ASHRAE 55-2004 [2] and its European counterpart EN15251 2007 [5]. Based on an analysis of twenty thousand row data from buildings around the world, the RP-884 database found that indoor temperatures eliciting a minimum number of requests for warmer or cooler conditions were linked to the outdoor temperature at the time of the survey [1].

The approach adopted in the ASHRAE adaptive comfort standard was to define the indoor operative temperatures statistically associated with observed mean thermal sensation votes (TSV) of ±0.5 and ±0.85. According to Fanger's PMV/PPD model [6], these mean thermal sensation values corresponded with Predicted Percentages Dissatisfied of 20 and 10% respectively. By adopting the same PMV/PPD logic and applying it to observed thermal sensation models in the ASHRAE comfort database, it was possible to define 80% and 90% indoor thermal acceptability levels as a function of outdoor climate. The results were integrated into ASHRAE 55 [2] and have been applied and studied worldwide ever since [7,8]. China, Brazil and India are moving towards standards for naturally ventilated buildings [9–12]. Recent developments towards a Chinese thermal comfort standard highlight the interest in incorporating the adaptive model for naturally ventilated buildings [11]. There is an ongoing research project aiming to establish a database of occupant's comfort, thermal performance and energy consumption across commercial, office and public buildings in India [9]. Based on the research outcomes from this project, an India adaptive comfort standard is expected to be released [10].Apart from defining temperature limits, the regulatory documents surrounding indoor thermal comfort also specify limits for indoor air speed. Traditionally, air speed has been framed in terms of *maximum* permissible limits [13–15]. In cold and temperate

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