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A questioning of the Thermal Sensation Vote index based on questionnaire survey for real working environments

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Abstract

Throughout this paper, we present the results of the thermal comfort analysis in a real office using subjective data from questionnaires survey and experimental data from a thermal manikin prototype and a standardized measurement system was presented. The comparison between TSV of the questionnaires and the PMV of the Comfort Sense data showed a great dispersion for the TSV while the values of the PMV from the standardized system and from the thermal manikin were found to be close. The agreement between the thermal manikin data and the standardized system data should be related in our opinion to the possibility of having of a large scale distributed measurement system that reproduces both the global predicted thermal sensation of a real space but also gives the possibility of investigating local discomfort trough the local distributions of the equivalent temperature of the segments of the manikin. This kind of representation allows for instance the inspection of the uniformity of an environment.

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Keywords: Thermal comfort; thermal manikin; real environment assesement

1. Introduction

Indoor environment in a building must meet two requirements: to be comfortable and functional in accordance with the requirements of the occupants. The building must protect them from adverse external conditions and to provide a pleasant ambient and indoor air quality. Thermal comfort is a subjective term defined by a plurality of

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sensations and is secured by all factors influencing the thermal condition experienced by the occupant, therefore is difficult to give a universal definition of this concept. Human thermal comfort is sometimes defined as all conditions for which a person would not prefer a different environment [1]. Another definition proposed in the American standard ASHRAE 55 [2] explains thermal comfort as a subjective concept related to physical and psychological well-being in agreement with the environment.

Nomenclature

CS	Comfort Sense
mrt	mean radiant temperature
PMV	predicted mean vote
PPD	predicted percentage of dissatisfied
RH	relative humidity
t_{eq}	equivalent temperature
t_i	indoor air temperature
t_{OP}	operative temperature
TM	thermal manikin
TSV	thermal sensation vote

Given that humans are different, thermal comfort concept usually refers to a set of optimal parameters, for which the highest percentage possible of a group of people, feel comfortable about the environment [3]. There were many attempts during the three past decades of proposing different assessment methods of this complex concept which is thermal comfort. Several models and indexes are available and standardized nowadays, proposing a quantification of the thermal comfort for buildings and other occupied spaces [4-8]. In the same time, the majority of these models or indexes usually lead to wrong results and incorrect assessment of a thermal ambiance when the depending parameters are not within a relatively narrow range of values [9-11]. The studies conducted by Fanger more than 30 years ago are the basis for the two main standards [12, 13] that are currently used for assessing thermal comfort in all types of enclosures occupied by humans. Fanger’s studies, as well as many of the experimental investigations conducted afterwards, are based on real human subjects in standardized clothing and doing standardized activities, exposed to laboratory homogenous thermal environments. These studies proposed specific parameter ranges – named comfort zones - in which a large percentage of occupants of same sex, age, activity and clothing, will characterize the environment as acceptable. However, it is currently recognized that in buildings pure steady-state conditions are rarely encountered in practice, given the interactions between the building structure, the occupants, the climate conditions and the HVAC systems. On the other hand, there are several other parameters that are affecting the human perception of thermal comfort, but which are not taken into account in either of these models. After a thorough survey of the literature [14] our conclusion is that currently proposed models can be either too generalist or either too difficult to implement and judge. For instance, experimental campaigns show high discrepancies between numerical results and in situ evaluation [15] and furthermore even higher discrepancies between human subjects’ response and experiments using other methods of evaluation [16, 17]. The main questions that we are addressing in our review paper [14] are: Which is the “best” thermal comfort model? Are these models adapted to nowadays indoor evaluation methods, since they have not been updated for decades? Do we need extra evaluation or just a better implementation of existing models? What are the future perspectives for thermal comfort predicting?

We wanted to check by ourselves what is happening with several standardized methods and models in a real building working environment and in this paper we are proposing several comparisons and discussion of experimental data.

2. Experimental set-up

The experimental data and correlations that we are presenting in this paper were obtained in a real office environment from the Thermal-Hydraulic Systems Laboratory at the Faculty of Building Services of Technical