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Pedestrian comfort using clothing values and body temperatures

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Abstract

Outdoor human comfort in an urban environment may be affected by a wide range of weather and human factors. The paper describes a research study investigating the complex relationship between physical and psychological parameters on human comfort levels. The study determined that the air temperature and the wind speed have a clear influence on the human comfort level while the solar radiation and relative humidity do not show a strong relationship. The effects of adaptation were shown clearly using over 8000 data sets with clear differences between five European countries. The importance of adaptation was further shown by the low correlation values between comfort and certain meteorological parameters. It is suggested that the subjective parameter of human comfort level is not well suited to determine guidelines for the design of outdoor spaces. Controlled tests in a wind tunnel have shown that the skin temperature (forehead and hand) has the potential to be used as a surrogate for comfort. With respect to the climatic variations outlined in this paper, it was discovered that lower forehead temperatures resulted in lower comfort values nearly independent of the meteorological parameters. Therefore, in the current study it is found that the skin temperature may be used as an objective parameter to determine human outdoor comfort levels although further tests will be necessary.

Keywords: Pedestrian comfort; Climate; Urban environment; Outdoors; Clothing values; Body temperatures; Multi-variant regression

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1. Introduction

As the human comfort level can have a significant implication for the development of cities, it is essential to understand and evaluate comfort conditions in urban spaces. Traditionally, within the wind engineering community, comfort has been measured by assessing the mechanical comfort with respect to wind speed. Different criteria are used based on either the mean wind speed or on a kind of gust wind speed, both quoted with a probability of exceedence level. A range of different wind comfort criteria exist (e.g. Ratcliff and Peterka, 1990; Blocken and Carmeliet, 2004; Sanz-Andres and Cuerva, 2006), all of which aim to combine the different criteria to give a universally applicable single criterion. However, several investigators (e.g. Nikolopoulou and Lykoundis, 2006; Stathopoulos et al., 2004; Chun et al., 2004; Nikolopoulou and Steemers, 2003; Givoni et al., 2003; Nagara et al., 1996) have highlighted that the human comfort level depends not only on wind speed but also other meteorological parameters such as air temperature, relative humidity and solar radiation and subjective parameters such as human activity, clothing levels, age, origin etc. The studies by Nikolopoulou and Steemers (2003) and Nikolopoulou and Lykoundis (2006) have shown that not only the microclimatic parameters have an important influence on the human comfort level but also the adaptation of the people living in a certain area. They stated that only 50% of the variation between subjective and objective comfort evaluation can be attributed to physical properties. The idea of acclimatisation has also been raised by Stathopoulos et al. (2004) who investigated pedestrian comfort levels in downtown Montreal.

The importance of determining the climate value in the urban environment has recently been highlighted by the COST Action C14 working group 1 (Baker, 2004) which assessed urban wind problems and specifically looked at pedestrian wind comfort. They determined that there are a number of different approaches used in Europe and the rest of the world to classify tolerable and intolerable wind conditions in the urban environment. They concluded that not only the thermal effects such as air temperature, wind speed, solar radiation and humidity affect the overall comfort but also psychological parameters such as age and gender, type of activity, acclimatisation and personal expectations, to name but a few.

The Bureau of Meteorology in Australia (2006) provides a website describing the importance of determining the apparent temperature (AT) in order to assess the thermal stress and therefore the human comfort level. Wind speed, air temperature, air humidity and solar radiation are taken into account based on a mathematical model of an adult walking outdoors in the shade, as proposed by Steadman (1984). This model is an extension of the initial definition of AT developed in the late 1970s to measure thermal sensation indoors. Both the heat index and the wind chill index are provided by the Bureau of Meteorology (2006) for people to make an educated choice regarding their activity. This is only one example where human comfort is analysed in everyday life.

A slightly different approach has been taken in the area of human biometeorology where the focus is on the development of comprehensive heat budget models, which take all mechanisms of heat exchange into account. Input variables include air temperature, water vapour pressure, wind velocity, mean radiant temperature including solar radiation in addition to metabolic rate and clothing insulation (Jendritzky et al., 2002). The complex heat budget model forms the basis of the development of a Universal Thermal Climate Index (UTCI), which is the subject of the COST Action 730 (http://www.utci.org).