Study on outdoor thermal comfort of urban microclimate in the urban street in a hot subtropical area of China

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With the rapid development of urbanization and the ever-increasing scale of city, coupled with the influence of human activities, causing many urban climate problems. Among them, the urban heat island (UHI) effect is the most significant factor causing the severe thermal environment in the city and seriously affects the health and thermal comfort of residents. As a basic component unit of urban outdoor environment, the research and improvement of thermal environment of city street have significant influence to improve the urban thermal environment quality. The relationship among microclimate, thermal sensation, and human behavior is expected to provide guidance for urban outdoor space design and planning practice. Given this, the paper aimed at a better understanding of outdoor thermal comfort in the urban street in a hot subtropical area of China. This study counted the number of people staying at the street, recorded physical measurements, collected questionnaire surveys to determine the thermal comfort of the street and simulated which type of urban canyon have the most suitable thermal environment. Special emphasis is placed on a human bio-meteorological assessment of these microclimates by using the physiologically equivalent temperature (PET). Afterwards, the investigation was carried out by using the three-dimensional numerical model ENVI-met, which simulated the microclimatic changes within urban environments in a high spatial and temporal resolution. Model calculations were run for a typical summer day in Hangzhou, China (30°16′N, 120°12′E), a region characterized by a hot and humid climate. Symmetrical urban canyons, with various height-to-width ratios (i.e. H/W=0.5, 1 and 2) and different solar orientations (i.e. E–W, N–S, NE–SW and NW–SE), have been studied.

Questionnaire about pedestrian's perceptions about the outdoor thermal environment indicate that the 90% acceptable PET range affected by the local climate and thermal adaptation is 18.2–30.8°C. The result of simulation show that Deep canyons have lower air temperatures and offer more favorable thermal condition for pedestrians during summer because of lower level of exposure to the sun. The PET in wide canyons (H/W=0.5) are 10°C higher than the one in narrow canyons(H/W=2). E–W oriented streets experience the worst thermal condition during the day. In fact, E–W oriented streets suffer from a prolonged period of solar exposure during the summer compared with N–S oriented streets. Combined street orientation with aspect ratio, the N-S axis streets can improve the thermal environment inside the streets by adjusting the aspect ratio of the streets, and the thermal conditions of the N-S street with an aspect ratio of 0.5 to 1 is the best. This study also indicated that the effect of canyon orientation is more perceptible in high H/W canyons than low ones. In the streets design of future cities, integrated with the research results of urban microclimates, the thermal environment of streets can be made more comfortable.

Key words: microclimate, thermal comfort, street aspect ratio, street orientation, PET

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