

Chapter 3

Digital Simulation for the Outdoor Thermal Comfort Assessment

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ABSTRACT

Creating a successful public outdoor space for the city people is significantly affected by the sensation of thermal comfort, which is influenced by the local microclimate. With the increase in the complexity of the urban environment and the excessive change in the climate, there is a great need to quantitatively assess the thermal comfort in outdoor spaces to help designers and decision makers to establish the optimum scenario from the first stages of design. The traditional methods of assessment have been criticized for dependency on people's subjective perceptions and responses to different thermal environments. This chapter aims to explore the potentials and limitations of the "Digital Simulation" as one of the methods that allow objective assessment. This chapter tackles several related issues and discusses researchers' recent attempts and contributions, which would help the readers to understand the pros and cons of using the digital simulation method in outdoor thermal comfort assessment and proposes possible solutions for several challenges.

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INTRODUCTION

Since the middle of the 20th century, creating a socially successful public outdoor space for city people has been considered a significant goal in urban design. One of the most important factors that significantly affect the outdoor spaces is outdoor microclimate, especially for pedestrians. The pedestrians using the outdoor spaces are exposed directly to all of the environmental elements; such as sun and shade, humidity and dry climate, changes in wind speed, etc. In fact, the people's decision of whether to use the outdoor space or not depends much on their sensation of thermal comfort, which is affected by the local microclimate (Chen & Ng, 2012).

In the global context with the aggravation of environmentally harmful practices that have led to the phenomenon of global warming, ensuring the outdoor thermal comfort is essential to improve the urban quality and livability. The outdoor space design should contribute to improving the local microclimate, especially in hot weather countries, which are suffering because of the continuous temperature rise. The cooling capacity of greenery, trees, and multi-building strategies are used to reduce air temperature. Therefore, enhancing the thermal comfort sensation and controls electrical energy consumption is also needed. Thus, designing appropriate urban open spaces is essential to enhance the people sensation of thermal comfort, to reduce the urban energy consumption and to develop the quality of the outdoor environment (Tariq & Arch, 2014).

Providing people with the sensation of outdoor thermal comfort is a complicated issue with multi-layers of concern that have to be studied in depth. There is a great need to assess the thermal comfort in outdoor spaces to help designers and decision makers to establish the optimum scenario from the first stages of design (Chen & Ng, 2012).

THE ASSESSMENT OF OUTDOOR THERMAL COMFORT

The assessment of thermal comfort is a multi-dimensional process. In order to understand the nature of the assessment process of the outdoor thermal comfort (OTC) concerning the thermoregulation aspect, two main methods of assessments are explained; Steady-state and Non-steady-state assessment methods.

First, *the Steady-state assessment method* is based on the assumption that the biometeorological data are reliable indices to describe human thermal comfort. The researchers who have adopted this assumption develop numerical solutions governing the thermoregulation with the human level of comfort.

Predicted Mean Vote Index (PMV), Predicted Percentage Dissatisfied Index (PPD), and the Physiological Equivalent Temperature (PET), are the most widely used steady-state assessment methods. Those methods are the quantitative prediction and analytical tools of people's thermal response to the local thermal environment that can be easily understood and interpreted. However, the main problem of the steady-state methods is that those methods are not flexible with the dynamic aspects of the course of human thermal adaptation due to the fact that the steady-state methods are based on thermoregulation, which is constructed for a passive state.

The Non-steady-state assessment methods can provide detailed investigations of the human thermal adaptation dynamics, but the *Non-steady-state assessment methods* do not have internationally accepted indices as in the steady-state methods. Those assessment methods depend on other indicators such as human skin temperature, sweating rate, and skin blood flow. Those Non-Steady-state indicators are hard to be monitored especially in the outdoor environment. In addition, these indicators require the

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