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Pedestrian level winds and outdoor human comfort

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Abstract

Outdoor human comfort in an urban climate may be affected by a wide range of parameters, including wind speed, air temperature, relative humidity, solar radiation, air quality, human activity, clothing level, age, etc. Several criteria have been developed in the wind engineering community for evaluating only the wind-induced mechanical forces on the human body and the resulting pedestrian comfort and safety. There are significant differences among the criteria used by various countries and institutions to establish threshold values for tolerable and unacceptable wind conditions even if a single parameter, such as the wind speed is used as criterion. These differences range from the speed averaging period (mean or gust) and its probability of exceedance (frequency of occurrence) to the evaluation of its magnitude (experimental or computational). The paper addresses the progress made towards the computational evaluation of pedestrian level winds. All existing criteria for wind and thermal comfort are absolute criteria, which specify the threshold values or comfort ranges for respective weather parameters. The paper will outline an approach towards the establishment of an overall comfort index taking into account, in addition to wind speed, the temperature and relative humidity in the area.

Keywords: Comfort; Design; Pedestrians; Wind

1. Introduction

The quality of open urban spaces has received a lot of attention in recent years. There is a broad recognition that microclimatic conditions contribute to the quality of life in cities, both from the economic as well as from the social viewpoint. Consequently, universities

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and other research organizations, municipal and other government forms, as well as construction and architectural companies have expressed significant interest and allocated resources to examine microclimatic conditions, particularly the effect of wind, on the outdoor human comfort. In Europe, a 3-year EU-funded project with surveys carried out at different open spaces has just finished after completing approximately 10,000 interviews, which will eventually be uploaded on the internet (http://alpha.cres.gr/ruros). The project aims to produce an urban design tool that provides architects, engineers, urban planners and other decision makers with means to assess effectively the construction of new buildings and the development of cities from the economic, psycho-physiological and sociological perspective of human comfort.

Work has also been carried out within the auspices of the European Action C14 dealing with *Impact of Wind and Storm on City Life and Built Environment,* with a working group interested in the effects of wind on pedestrians, their assessment and comparisons, as well as the parameters they influence human comfort and its evaluation. Results have appeared in the 2002 Workshop in Nantes, e.g. Westbury et al. (2002) and in the International Conference in Urban Wind Engineering and Building Aerodynamics organized by Von Karman Institute for Fluid Dynamics in May 2004. In addition, the American Society of Civil Engineers (ASCE) has put out a pertinent state-of-the-art document (ASCE, 2003), which was developed with input from the European Action C14. The paper will address the experimental and computational evaluations of the wind on people in the urban environment and will focus on the state-of-the-art of the development of human outdoor comfort criteria by considering a wide range of parameters, including wind speed, air temperature, relative humidity, solar radiation, air quality, human activity, clothing level, age and the like.

2. Experimental and computational evaluations

The flows around buildings even in simple surrounding environments, let alone in complex urban settings are still extremely difficult to predict by computational methods. However, the testing of scale models in a boundary layer wind tunnel capable of simulating the mean-velocity profile and turbulence of the natural wind has been shown to be a very effective method of prediction by comparison with respective full-scale data. The wind-tunnel model typically includes all buildings in the surrounding landscape; thus, their effect is automatically included. Both existing conditions and those with the new building(s) in place can be readily measured, thus allowing the impact of the new building(s) to be identified. Furthermore, the effects of changes to the building itself, or to landscaping, can also be studied, particularly where undesirable wind conditions are found. A typical set up of a wind-tunnel model in a boundary-layer wind tunnel is illustrated in Fig. 1. The building itself and the model of its surroundings are mounted on the wind-tunnel turntable, which can be rotated to allow various wind directions to be simulated. Typical model scales for large buildings are in the range of 1:200–1:500. Larger scales have been used for smaller buildings. The model of surroundings enables the complex flows created by other buildings near the study building to be automatically included in the tests. However, it is also essential to create a proper simulation of the natural wind approaching the modeled area. The requirements for modeling the natural wind in a wind tunnel are described in the ASCE Manual of Practice (ASCE, 1999). In typical wind tunnel tests, the airflow speed above the boundary layer is in the range 10–30 m/s.