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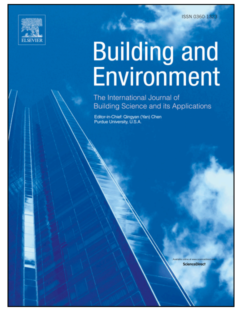

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Finite Panel Method for the simulation of wind-driven rain

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Abstract: In present numerical methods for the wind-driven rain (WDR) simulation, a large computational work for raindrop trajectories is required to obtain the distribution of the catch ratio because of the randomness of the initial conditions of the raindrops. A new method named Finite Panel Method (FPM) that is employed to acquire the catch ratio distribution is proposed to reduce the calculation amount and diminishes the randomness. In the FPM, raindrops ending in the corners of the panels which are divided on the surface are simulated, and then the distribution of catch ratio is acquired by a reconstruction method. As a demonstration, catch ratio results by FPM in typical flow fields are presented, including the case of the three-dimensional flow field of power-law velocity profile, and cases of the flow around two- and three-dimensional low-rise buildings. The FPM results are compared with these calculated by the classical method and literatures. The results indicate that FPM can reduce the calculation amount of raindrop trajectories with equivalent accuracy compared to the classical method.

Key words: wind-driven rain, catch ratio, numerical simulation, Finite Panel Method, reconstruction

1. Introduction

Studies of wind-driven rain (WDR) are important in the earth science, building science and meteorology [1]. Predictions of the WDR distribution can be used for the design of catchments, control of water loss and soil erosion, as well as guidance for agriculture and precaution against the forest fire [1]. In building science fields, the WDR influences the hygrothermal performance of building façades, and may cause surface soiling and mold growing, which affect the durability of walls [2]. Moreover, the wetting of building façades caused by WDR is also a boundary condition in building heat-air-moisture (HAM) transport models [3].

Two parameters utilized to quantify the amount of WDR are the specific catch ratio and catch ratio [4]. Measurements, semi-empirical methods and numerical methods are main approaches in building WDR researches. Blocken and Carmeliet [1] reviewed the application of these methods. Compared with measurements, numerical methods are easier to perform and consume less time. Besides, numerical methods are not confined to weather conditions, which are basic requirements for measurements. On the other hand, numerical methods can provide more accurate results compared with semi-empirical methods. Hence, numerical methods are widely used in building WDR researches.

Currently, numerical methods for WDR are based on the Euler-Lagrange model or the Euler-Euler model. The principle of the Euler-Lagrange model is to calculate the motion of discrete raindrops in continuous wind flow field. Early in 1970s, researches have been performed in simulating the raindrop trajectories in flow field around buildings [5]. In the early 1990s, Choi [6, 7] systematically proposed the numerical method for building WDR simulation based on the Euler-Lagrange model. This method is on the basis of steady flow field, and the raindrop

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