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Journal of Wind Engineering
and Industrial Aerodynamics 93 (2005) 905–928

JOURNAL OF wind engineering AND industrial aerodynamics

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High-resolution wind-driven rain measurements on a low-rise building—experimental data for model development and model validation

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Received 27 September 2004; received in revised form 9 August 2005; accepted 9 September 2005
Available online 25 October 2005

Abstract

With the specific intention to provide experimental data for model development and model validation, a new measurement setup for wind, rain and wind-driven rain (WDR) has been designed and installed at the Laboratory of Building Physics (Katholieke Universiteit Leuven). This paper focuses on the new measurement setup and on the obtained measurement results. The CFD-based design and the installation of the measurement setup are outlined and samples of the database containing the wind, rain and high-resolution WDR measurements are provided and discussed. This paper also provides the link to a website from which the experimental WDR database can be downloaded. Finally, the use of these data to determine WDR coefficients and their use in WDR assessment are briefly addressed.
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Keywords: Wind-driven rain; Driving rain; Air flow; Raindrop; Building; Experimental database; Web file download; Validation; Numerical simulation; Coefficient; Guidelines

1. Introduction

Wind-driven rain (WDR) is an important boundary condition for the study of the hygrothermal performance and the durability of building facades and for their design.

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0167-6105/$ - see front matter © 2005 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jweia.2005.09.004

Nomenclature

E_{AW}	absolute adhesion-water-evaporation error (mm)
e_{AW}	relative adhesion-water-evaporation error ($e_{AW} = E_{AW}/S_{wdr}$) (dimensionless)
k	turbulent kinetic energy (m^2/s^2)
R_h	horizontal rainfall intensity (mm/h)
S_h	horizontal rainfall amount (mm)
S_{wdr}	wind-driven rain amount (mm)
U_2, U_4, U_6, U_{10}	reference wind speed at 2, 4, 6, 10 m height (m/s)
U, V, W	streamwise, vertical and lateral component of mean wind-velocity vector (m/s)
x, y, z	Cartesian co-ordinates (x = streamwise, y = vertical, z = lateral co-ordinate) (m)
y_0	aerodynamic roughness length (m)
Z	resultant horizontal wind-velocity vector (m/s)
α	wind-driven rain coefficient (s/m)
α_P	power-law exponent (dimensionless)
ε_{AW}	adhesion-water-evaporation error for the ratio S_{wdr}/S_h ($\varepsilon_{AW} \approx E_{AW}/S_h$) (dimensionless)
ε	turbulence dissipation rate (m^2/s^3)
θ	angle between wind direction and normal to the wall (°)
φ	wind direction (deg. from north)
IBL	internal boundary layer
HAM	heat–air–moisture
HAMTIE	Heat–Air–Moisture Transfer in highly Insulated building Envelope parts
RANS	Reynolds-Averaged Navier–Stokes equations
VLIET	VLaams Impulsprogramma voor EnergieTechnologie
WDR	wind-driven rain

Three categories of methods for quantifying WDR on building facades exist: (1) measurements, (2) semi-empirical models and (3) numerical simulation models that are based on Computational Fluid Dynamics (CFD). A review of these methods is provided in [1].

Since the first WDR measurements on building facades were conducted in 1937 by Holmgren in Trondheim, Norway [1], measurements have been the primary tool in WDR studies. They not only provide a direct indication of the amount of WDR falling onto different parts of a building facade but they are also essential for the development and the validation of semi-empirical models and numerical simulation models. Especially the vast increase of the use of CFD in WDR studies in the past 15 years (e.g. [1–10]) and the subsequent need for CFD model validation have strengthened the need for adequate experimental WDR databases. Although a large amount of measurements have been performed in the past, a review of the literature has pointed out that only very few of these have been published in a form that can be suitable for model development and model validation. This is believed to be the most important reason for the fact that the validation of CFD modeling of WDR is still lacking. Adequate experimental data should comprise

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