Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 190 (2017) 575 – 580

Procedia Engineering

www.elsevier.com/locate/procedia

Structural and Physical Aspects of Construction Engineering

Wind-tunnel Simulation Of Thermally Unstable Atmospheric Flow In Complex Terrain

Stanislav Pospíšil[a,*], Sergey Kuznetsov[a], Hrvoje Kozmar[b], Vladimíra Michalcová[c]

[a]Institute of Theoretical and Applied Mechanics, Prosecká 76, 190 00 Prague, Czech Republic
[b]Department of Mechanics, Faculty of Civil Engineering, Technical University Ostrava, L. Poděště 1857, 182 00 Ostrava, Czech Republic
[c]Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb, Ivana Lučića 5, 10000 Zagreb, Croatia,

Abstract

The paper presents the characteristics of thermal effects in wind-tunnel simulations of the atmospheric boundary layer (ABL) flow developing above complex terrain. The differences and instable stratification effects between the windward and leeward sides of a hill model were investigated for different wind characteristics. Particularly, the buoyancy effects on the structure of the ABL simulation in a wide range of stability conditions expressed by Richardson number are studied.
© 2017 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
Peer-review under responsibility of the organizing committee of SPACE 2016

Keywords: Instable stratification; Wind Tunnel; Richardson number

1.Introduction

Wind climate influencing wind loads on buildings and other structures, as well as dispersion of pollutants from various surface is essentially determined by small-scale motions and processes occurring in the atmospheric boundary layer (ABL). It is usually assumed that the influence of heat convection on the wind loading can be disregarded. In such cases, logarithmic profiles prevail for wind speed, variances of the wind velocity components are essentially constant with height, and the wind velocity spectra have relatively simple properties. The limits to which these approximations are adequate depend on many factors such as roughness, heat flux, and height above the ground. In reality, the ABL nearly always has some vertical heat flux either in the form of sensible or latent heat. The larger the height, the more important convection becomes. Also, the strength of convection increases with vertical flux of heat (to which a moisture term must be added under hot, cold, humid conditions). Dependent on whether the heat flux is upward (unstable) or downward (stable), in addition to the mechanical production; turbulent

* Corresponding author. Tel.: +420 283880854 ; fax. +420 286882334
E-mail address: pospisil@itam.cas.cz

1877-7058 © 2017 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
Peer-review under responsibility of the organizing committee of SPACE 2016
doi:10.1016/j.proeng.2017.05.382

energy is either produced or dissipated. Consequently, the mean flows, as well as turbulence in the adiabatic surface layer, differ from those in the neutrally stratified surface layer and the modification of mean wind profile and fluctuation needs to be taken into account. For example, they play a major role in the pollutant diffusion problems in the real atmosphere, and often, the very hazardous environmental and wind-loading conditions are a direct result of those effects.

Nomenclature

g	[m/s2]	Acceleration of gravity
H	[m]	Height of the hill
Re	[-]	Reynolds number
Ri	[-]	Richardson number
T	[°C]	Temperature of the warm surface
T_o	[°C]	Reference temperature
Q	[kW]	Energy of the heating
u^*	[-]	Friction (shear) velocity
$V(z)$	[m/s]	Mean wind speed at height z
V_0	[m/s]	Reference wind velocity
x, y, z	[m]	Distance in longitudinal, lateral, and vertical direction
z_o	[m]	Aerodynamic surface-roughness length
z_s	[m]	Atmospheric surface layer with a height
β	[-]	Generalized wind profile exponent, $\beta=\beta(Ri)$
κ	[-]	Von Karman constant
Θ	[K]	Absolute temperature (Θ=T+273°C)

In [1], the measured vertical profiles are studied with respect to the modification of the logarithmic wind profiles. Several researchers have investigated in detail the wind flow over generic topographic terrain using various experimental techniques. The flow field over generic escarpments and conical hills were determined [2, 3] using CTA measurements. Surface pressure measurements and the flow visualizations [4], as well as CTA and Pitot tube measurements for isolated two-dimensional hills were performed in [5]. The rough estimates of the effect of a small hill on wind characteristics are presented analytically in [6]. CTA and PIV mixed measurements were performed in [7] for isolated valleys. Thermal effects on the airflow, building geometry and architecture as well as street canyon dimensions, have been mainly studied using wind-tunnel experiments [8, 9, 10] and numerical models [11, 12, 13] and fewer with full-scale or near full-scale experiments [14, 15, 16]. The mass transfer from street canyon surfaces by a naphthalene sublimation technique in a wind tunnel was investigated [17]. This technique was used to quantify scalar vertical fluxes out of a street canyon under neutral conditions. The convective transfer velocity from individual wall surfaces was evaluated in an urban canyon using a water evaporation technique [18].

The authors present the wind tunnel experiments focused on the low turbulent flows within the instable thermal stratification. The convective boundary layer is created with the convective turbulent natural flow developing as the complex ground model (hill) is warmed up, e.g., by the solar radiation. The flow is analyzed with respect to its stability expressed by the Richardson number (*Ri)*. The flow data are obtained using Particle Image Velocimetry (PIV) method and compared with the computational analysis for validation.

2.Wind tunnel experiments

Wind-tunnel experiments were carried out in the climatic wind tunnel (CWT) of the Institute of Theoretical and Applied Mechanics. This wind tunnel is designed to determine wind effects on structures, aero-elastic structural response, ABL modelling, and other civil, mechanical, and environmental engineering applications. It consists of an aerodynamic section, a climatic section, a fan section, and heating/cooling exchanger. The coordinate system is defined with x in the stream-wise direction, z in the wall-normal direction, and y in the span-wise direction.

Download English Version:

https://daneshyari.com/en/article/5027249

Download Persian Version:

https://daneshyari.com/article/5027249

Daneshyari.com