Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 113 (2017) 166 – 173

Energy Procedia

International Scientific Conference "Environmental and Climate Technologies", CONECT 2016, 12–14 October 2016, Riga, Latvia

Analysis of convective heat transfer at building facades in street canyons

Gabriele Battista*

Department of Engineering, University of Roma TRE, via della Vasca Navale 79, Rome – 00146, Italy

Abstract

The natural convection effects on the flow structures and the heat processes have been analysed in an urban canyon. Predictions of convective heat transfer are essential in building and environmental studies on urban heat islands and building energy performance. An important part of the heat exchange between buildings and the ambient surrounding is due to convective and radiative heat flows. An idealized 2D urban canyon with Height/Width (H/W) equal to 1 were evaluated. The aim of this study is to quantify the influence of different wind intensity to the convective heat transfer coefficient when the walls were heated.

Peer-review under responsibility of the scientific committee of the International Scientific Conference "Environmental and Climate Technologies".

Keywords: urban heat island; CFD; convective heat transfer coefficients; building; street canyon

1. Introduction

The rapid urbanization and economic growth of cities causes different worsening to human health regarding both thermal comfort and exposure to pollutant. In urban areas, the environmental is influenced by different causes: height of building, weight of roads, absence or presence of vegetation, pavement and building material, wind intensity and consequent natural ventilation and so on. In order to evaluate the thermal flow field depending on different variable, researches on urban areas are needed [1–8]. Frequently, the variation of urban thermal field leads to indirect energy efficiency effect. As a matter of facts, the increase of air temperature due to the urban heat island effect (UHI) [9] leads to an increase of building energy demand. Many studies are focused on the performance of building analyzing the efficiency of different building envelope and plants [10–22]. However, the rapid urbanization

* Corresponding author. Tel.: +39-06-5733-3289.
E-mail address: gabriele.battista@uniroma3.it

Peer-review under responsibility of the scientific committee of the International Scientific Conference "Environmental and Climate Technologies".
doi:10.1016/j.egypro.2017.04.048

can lead to the variation of urban fabric around the building taken into account. This fact leads to a modification of the environment thermo-fluid dynamic field and a consequent variation of the building and plant performances.

In order to reduce the thermal worsening, especially during the summer, the technique of urban heat island mitigation techniques can be used to reduce the temperature differences from urban and rural area. Often cool materials are the simplifier solution to this purpose [23–27].

Computational fluid dynamics (CFD) can be used to predict the thermal flow field inside urban areas, varying different conditions such as wind direction and intensity, solar radiation, geometrical layout, and so on.

In this paper the thermal flow field condition was analysed in an idealized urban canyon, defined as the space between building that line up continuously on both sides of the street [28]. Results on convective heat transfer coefficient at building façades are analysed depending on wind intensity and heated walls.

Nomenclature

U	velocity, m/s	T	air temperature, °C
u^*	friction velocity, m/s	T_a	ambient air temperature, °C,
y_0	roughness length, m	T_g	ground temperature, °C
κ	von Karman coefficient	U_{2H}	velocity at altitude of 2H, m/s
ε	turbulence dissipation rate, m^2/s^3	H	building height, m
k	turbulence kinetic energy, m^2/s^2	W	street width, m
Rb	bulk Richardson number	ΔTG	temperature difference between ground and air, °C
g	acceleration due to gravity, m/s^2	ΔTB	temp. difference between building walls and air, °C

2. Methodology

The work consists of the following steps, such as:

- Analysis of the Uehara wind tunnel experiment setup in order to validate the numerical model;
- Applying of the validated numerical model to the idealized urban canyon setup and comparison with the Uehara wind tunnel experiment;
- Analysis of the thermal flow field and the convective heat transfer coefficient at building façades in depending of wind intensity and heated walls.

3. Numerical model

The idealized 2D street canyon is shown in Fig. 1, where all the dimensions of the model domain are related to the building height H. The distances from the building and the domain boundary are made in according to the AIJ guidelines [29].

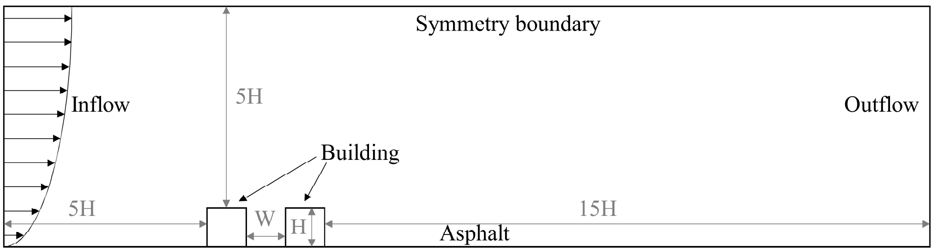

Fig. 1. Schematic diagram of the computational domain.