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natural ventilation in the urban environment

ASSESSMENT AND DESIGN

EDITORS Cristian Ghiaus and Francis Allard

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Foreword

This book is the work of the teams involved in the European project 'URBVENT: Natural Ventilation in the Urban Environment', which has been carried out as part of the Fifth Research and Development Programme of the Directorate for Science, Research and Development of the European Commission. This project was coordinated by Francis Allard and Cristian Ghiaus from the University of La Rochelle, France. The assistance of Dr George Deschamps, the manager of the programme, and Professor Mordechai Sokolov, external expert of the European Commission, is highly appreciated.

The URBVENT project aimed to create a methodology, embedded in software, to assess the potential and feasibility of, and to design optimal openings for, natural ventilation in the urban environment, accessible to architects, designers and decision-makers. The methodology and the tools have been tested in three stages by the developers, the end-users and the project integrator. This book provides knowledge, tools and information on the efficient use of natural ventilation in urban buildings in order to decrease energy consumption for cooling purposes, increase indoor thermal comfort and improve indoor air quality.

The book includes contributions from the whole URBVENT consortium. The writing of each chapter followed the same philosophy as the project as a whole: drafting, reviewing and editing. The people involved in each process were different and each of their contributions are important.

The first chapter is an introduction, drafted by Mat Santamouris and reviewed by Liam Roche, presenting the importance of natural ventilation technologies for urban buildings in order to prove that, although it is not an energy 'machine', natural ventilation is an effective engine for progress and development.

Chapter 2, drafted by Claude-Alain Roulet and reviewed by Liam Roche and Nicholas Heijmans, describes the role of natural ventilation in indoor air quality, reduction of energy consumption and comfort.

Chapter 3, which was written by Cristian Ghiaus and Francis Allard, introduces the reader to the physics of natural ventilation. It is organized into three main sections: the basics of fluid dynamics, the atmospheric boundary layer and the modelling of air flows in buildings.

Chapters 4, 5 and 6 address the relationship between urban environment and natural ventilation. Reduced wind velocity, higher temperatures due to heat island effect, noise and pollution are considered as barriers to the application of natural ventilation in the urban environment. Models based on first-hand experience acquired within the URBVENT project and in a related project financed by the French government (the PRIMEQUAL programme) are presented.

Chapter 4, drafted by Chrissa Georgakis and Mat Santamouris and reviewed by Frank Tillenkamp, presents the wind and temperature in street canyons. It is based on experiments achieved in Athens.

Chapter 5 was written by Michael Wilson, Fergus Nicol, John Solomon and John Shelton and was reviewed by Frank Tillenkamp. The chapter explores the problem of noise reduction in street canyons. The results are derived from experiments carried out in the same streets as the wind and temperature measurements.

Chapter 6 provides information about outdoor–indoor pollution transfer as a function of building permeability and outdoor pollutant concentration. It was authored by Cristian Ghiaus, Vlad Iordache, Francis Allard and Patrice Blondeau, and Frank Tillenkamp carried out a review.

Chapter 7, drafted by Cristian Ghiaus and Claude-Alain Roulet and reviewed by Nicholas Heijmans, presents the strategies for natural ventilation and gives the order of magnitude for pressure difference and airflow rate.

Chapter 8 describes specific devices for the use of natural ventilation. Examples of the various technologies and some examples of their application are given: from operable windows to stacks, self-regulating vents and fan-assisted natural ventilation. Claude-Alain Roulet and Cristian Ghiaus are the authors of this chapter, and Nicholas Heijmans reviewed their work.

Chapter 9 was drafted by Manuela Almeida, Eduardo Maldonado, Mateo Santamouris and Gérard Guarracino, and describes the methodology used to obtain a database of airflow and air change rates as a function of ventilation strategy used (single-sided or stack-induced) and the position, form and dimensions of the openings. This database can be used as it is for finding the optimal opening for a known flow rate. Alternatively, a neuro-fuzzy model was developed to find the optimal opening when the ventilation strategy and airflow rate are given.

Chapter 10 introduces an original method for evaluating natural ventilation potential, which was developed as part of the URBVENT project by Mario Germano, Cristian Ghiaus and Claude-Alain Roulet. A review of the method and of the chapter was carried out by Frank Tillenkamp, Nicholas Heijmans and Liam Roche. The natural ventilation potential (NVP) is expressed by the probability of ensuring an acceptable indoor air quality using only natural ventilation. Ensuring an acceptable indoor air quality or cooling down the building structure using natural ventilation depends upon the site (outdoor air quality, temperature, wind, moisture and noise, urban structure, etc.) and upon the building (indoor pollutant, heat sources and stored heat, position and size of ventilation openings, orientation of building, internal air path distribution, etc.). The NVP cannot, therefore, be expressed as a single number. It is a multiple attribute variable – that is, a list of quantitative and qualitative characteristics of the site and of the building, based on available input data. It is, nevertheless, possible to decide, on the basis of these characteristics combined with the requirements, if a given building – or a room in a building – is likely to be sufficiently ventilated or not when natural ventilation is used. The method is based on two paradigm shifts. The first, applied to the site, is a qualitative comparison of existing experience representing the quantification and formalization of qualitative thinking. The second, applied to the building, is based on the concept of free-running temperature and uses a modifiable database to estimate the potential for cooling by ventilation and the possible role of stack-driven ventilation.

Chapter 11, drafted by Cristian Ghiaus and Liam Roche, presents an analysis of the whole-life costs of ventilation options.

This book is the result of common effort and contributions of the consortium of the URBVENT project. The participants in this project were:

- Francis Allard and Cristian Ghiaus, LEPTAB (Building Physics Laboratory), University of de La Rochelle, France;
- Mat Santamouris and Chrissa Georgakis, Group of Building Environmental Physics, University of Athens, Greece;
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- Frank Tillenkamp and Joachim Borth, Axima Lab, Switzerland;
- Nicholas Heijmans, Belgian Building Research Institute, Belgium;
- Fergus Nicol and Michael Wilson, London Metropolitan University, UK;
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- Gérard Guarracino, CNRS/LASH-ENTPE, France;
- Liam Roche, Philippa Westbury and Paul Littlefair, Building Research Establishment, UK.

We would also like to acknowledge the contribution of James Axley from Yale University, US, who provided comments and suggestions during his sabbatical year spent at the University of La Rochelle, France.

Cristian Ghiaus and Francis Allard
March 2005

List of Acronyms and Abbreviations

°C	degrees Celsius
ACH	air changes per hour
AR	aspect ratio
BBRI	Belgian Building Research Institute
BRE	Building Research Establishment (UK)
CFD	computational fluid dynamics
clo	Unit for the thermal resistance of clothing; 1 clo = 0.15 m^2K/W
cm	centimetre
CO	carbon monoxide
CO_2	carbon dioxide
Cal PX	California Power Exchange
CSTB	Centre Scientifique et Technique de Bâtiment
dB	decibel
DT	temperature difference between the outside and inside environment
ESDU	Engineering Sciences Data Unit
ETI	Hungarian Institute of Building Science
FAR	frontal aspect ratio
GNP	gross national product
GW	gigawatt
ha	hectare
HOPE	Health Optimization Protocol for Energy-Efficient Buildings project
HVAC	heating, ventilation and air conditioning
I/O	indoor–outdoor pollutant ratio
IAQ	indoor air quality
ISO	International Organization for Standardization
J	joule, unit of energy
K	Kelvin, unit of temperature
kg	kilogram
km	kilometre
km/h	kilometres per hour
LDC	less developed country
LM	Lokal-Modell
LPE	Swiss environment protection law
m	metre
m/s	metres per second

m^2	square metres
m^3	cubic metres
m^3/h	cubic metres per hour
met	unit of metabolism, 1 met = 58 W/m^2 body area
MeteoSwiss	Swiss Federal Office of Meteorology and Climatology
mm	millimetre
MW	megawatt
MWh	megawatt hour
NO_2	nitrogen dioxide
NPL	neutral pressure level
NVP	natural ventilation potential
O_3	ozone
OECD	Organisation for Economic Co-operation and Development
Pa	Pascal, unit of pressure
PAD	plan area density
PCP	passive cooling potential
PDEC	passive downdraught evaporative cooling
PM	particle matter
PMV	predicted mean vote
ppb	parts per billion
ppm	parts per million
RH	relative humidity
RbH	relative building height
s	second
SAR	side aspect ratio
SCATS	Smart Controls and Thermal Comfort
SO_2	sulphur dioxide
TWh	terawatt hour
toe	tonnes of oil equivalent
UK	United Kingdom
URBVENT	Natural Ventilation in the Urban Environment
US	United States
VOC	volatile organic component
W	Watt, unit of power
W/m^2	watt per square metre. For thermal comfort, the area is the body area
WHO	World Health Organization

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