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natural ventilation in the urban environment

ASSESSMENT AND DESIGN

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EDITORS Cristian Ghiaus and Francis Allard

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Edited by Cristian Ghiaus and Francis Allard

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List of Contributors and Reviewers

CONTRIBUTORS

Francis Allard (LEPTAB, Université de La Rochelle)
Manuela Almeida (IDMEC, University of Porto)
Patrice Blondeau (LEPTAB, Université de La Rochelle)
Chrissa Georgakis (University of Athens)
Mario Germano (LESO-PB, École Polytechnique Fédérale de Lausanne)
Cristian Ghiaus (LEPTAB, Université de La Rochelle)
Gérard Guarracino (Ecole Nationale des Travaux Publics de l'Etat ENTPE, URA CNRS)
Vlad Iordache (LEPTAB, Université de La Rochelle)
Eduardo Maldonado (IDMEC, University of Porto)
Fergus Nicol (LEARN, School of Architecture, London Metropolitan University)
Liam Roche (Building Research Establishment)
Claude-Alain Roulet (LESO-PB, Ecole Polytechnique Fédérale de Lausanne)
Mateos Santamouris (University of Athens)
John Shelton (LEARN, School of Architecture, London Metropolitan University)
John Solomon (LEARN, School of Architecture, London Metropolitan University)
Michael Wilson (LEARN, School of Architecture, London Metropolitan University)

REVIEWERS

Nicolas Heijmans (Belgian Building Research Institute) (Chapters 2, 7, 8, 10)
Liam Roche (Building Research Establishment) (Chapters 1, 2, 10)
Frank Tillemkamp (Axima AG Axima Lab) (Chapters 3, 4, 5, 6, 9, 10, 11)

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;
- Claude-Alain Roulet and Mario Germano, École Polytechnique Fédérale de Lausanne, Switzerland;
- Frank Tillenkamp and Joachim Borth, Axima Lab, Switzerland;
- Nicholas Heijmans, Belgian Building Research Institute, Belgium;
- Fergus Nicol and Michael Wilson, London Metropolitan University, UK;
- Eduardo Maldonado and Manuela Almeida, IDMEC, University of Porto, Portugal;
- 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 ² K/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 draught 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

Contents

<i>List of Figures and Tables</i>	<i>vii</i>
<i>List of Contributors and Reviewers</i>	<i>xiv</i>
<i>Foreword</i>	<i>xv</i>
<i>List of Acronyms and Abbreviations</i>	<i>xviii</i>
1 Energy in the Urban Built Environment: The Role of Natural Ventilation <i>Mat Santamouris</i>	1
2 The Role of Ventilation <i>Claude-Alain Roulet</i>	20
3 The Physics of Natural Ventilation <i>Cristian Ghiaus and Francis Allard</i>	36
4 Wind and Temperature in the Urban Environment <i>Chrissa Georgakis and Mat Santamouris</i>	81
5 Noise Level and Natural Ventilation Potential in Street Canyons <i>Michael Wilson, Fergus Nicol, John Solomon and John Shelton</i>	103
6 Outdoor–Indoor Pollutant Transfer <i>Cristian Ghiaus, Vlad Iordache, Francis Allard and Patrice Blondeau</i>	124
7 Strategies for Natural Ventilation <i>Cristian Ghiaus and Claude-Alain Roulet</i>	136
8 Specific Devices for Natural Ventilation <i>Claude-Alain Roulet and Cristian Ghiaus</i>	158
9 The Design of Optimal Openings <i>Manuela Almeida, Eduardo Maldonado, Mat Santamouris and Gérard Guarraçino</i>	168
10 Natural Ventilation Potential <i>Mario Germano, Cristian Ghiaus and Claude-Alain Roulet</i>	195

<i>vi</i>	<i>Natural Ventilation in the Urban Environment</i>	
11	Whole Life Costing of Ventilation Options <i>Cristian Ghiaus and Liam Roche</i>	228
	<i>Index</i>	238

List of Figures and Tables

FIGURES

1.1	Load curves for 1995 and 2020 in Spain	6
1.2	Energy expenditure as a percentage of income	8
1.3	Per capita energy consumption and share of energy spending in household budgets in Eastern Europe and Central Asia	9
1.4	Estimated burden of disease (DALYs) in India for selected major risk factors and diseases compared with major risk factors from indoor air pollution	12
1.5	Household fuel transition and possible contribution of natural ventilation	13
1.6	Average number of overheating hours and reduction percentage due to night ventilation for three different set-point temperatures	14
1.7	Average cooling load and reduction percentage due to night ventilation for three different set-point temperatures	15
1.8	Reduction of air change rate for single-sided and cross-ventilated buildings in ten urban canyons	16
2.1	Evolution of temperatures in a free-running building and its environment throughout the year (Northern hemisphere)	23
2.2	Heat lost by a sitting person placed in an isothermal environment	24
2.3	Relationship between the percentage of people who do not feel comfortable (PPD) and the mean vote (PMV)	25
2.4	Optimal operative temperatures for various clothing and activities	28
2.5	Effect of radiant temperature asymmetry at optimal operative temperature	29
2.6	Effect of a temperature difference between head and ankle	30
2.7	Minimum air temperature so that less than 10 per cent of people complain of draughts for various air velocities and turbulence intensities	31
2.8	(a) Observed and predicted indoor comfort temperatures from ASHRAE RP-884 database for air-conditioned buildings; (b) observed and predicted indoor comfort temperatures from RP-884 database for naturally ventilated buildings	32
2.9	Adaptive comfort models from 80 per cent and 90 per cent bands are acceptance intervals for the de Dear model	33

2.10	Ninety per cent accepted comfort ranges according to the adaptive comfort model and EN-ISO 7730 standard, assuming 1.2 met and adapted clothing (1 clo in winter and 0.5 clo in summer)	33
2.11	Airflow rates to control IAQ and thermal comfort	34
3.1	Fluid inside a volume V enclosed by the surface S ; at a point on the surface, where the unit outward normal is n , the stress is σ	41
3.2	Pressure force for an infinitesimal unit of volume	42
3.3	The motion of a fluid element, initially defined by the dashed figure, can be described as a combination of (a) translation, (b) rigid body rotation, (c) shear compression and (d) pure compression	42
3.4	The x_1 component of the viscous force acting on a fluid element of volume dx_1, dx_2, dx_3 consists of the viscous shear stresses τ_{12} and τ_{13} acting on the surfaces normal to the x_2 and x_3 axes and the viscous normal stress τ_{11} acting on the surfaces normal to the x_1 -axis	43
3.5	Heat flow in a room	52
3.6	Reynolds decomposition	55
3.7	Typical record of wind velocity near the ground	60
3.8	Coefficient of roughness, C_R , and reference roughness, $\lambda(x)$	64
3.9	Example of C_p distribution on a building	68
3.10	Stack effect	71
3.11	Gravitational flow through a vertical opening	74
3.12	Airflow through large openings (density gradient)	76
3.13	Network representation of a multi-zone building	77
4.1	Flow chart of the algorithm for estimating wind speed inside street canyons	87
4.2	Location of measurement points for wind speed	94
4.3	Data distribution in a box plot	94
4.4	Box plot of wind speed inside a deep and long street canyon when wind is perpendicular to the canyon axis: (a) $90^\circ \pm 15^\circ$; (b) $270^\circ \pm 15^\circ$	95
4.5	Box plot of wind speed inside a deep and long street canyon when wind blows parallel to the canyon axis: (a) $\pm 15^\circ$; (b) $180^\circ \pm 15^\circ$	96
4.6	Box plot of wind speed inside a deep and long street canyon when wind blows oblique to the canyon axis: (a) from east; (b) from south; (c) from west; (d) from north	97
4.7	Examples of validation of wind speed in street canyons: (a) Nicholson model; (b) Hotchkiss model	98
4.8	Box plots of temperature distribution in a street canyon: (a) vertical distribution in the centre of the canyon; (b) temperature of the walls	100
5.1	Three noise sources: the direct component, dc , the reverberant component, rc , and the background noise	109

5.2	Variation of the value of R^2 with changing assumptions about the location of the stream of traffic	111
5.3	Measured noise level L_{eq} (LEQ) (dB) against the predicted L_{eq} (LEQEST) (dB) ($R^2 = 0.75$)	112
5.4	Correlation between traffic intensity, n (vehicles per hour), and street width, W (m); $R^2 = 0.78$	113
5.5	Predicted noise levels in decibels (dB) with different street widths and heights above the street	113
5.6	Noise attenuation with height as a function of street width w (m)	114
5.7	Mean value of the noise attenuation for different values of the street width and the height above the street	115
5.8	Measured values of attenuation (DLEQ) (dB) plotted against calculated values using equations (5.9) and (5.10) (DLEQX) (dB) ($R^2 = 0.58$)	115
5.9	Variation of the maximum value of the attenuation, ΔL_{AeqH} , at the top of buildings bordering on an urban canyon, with the aspect ratio AR and the street width in metres	116
5.10	Predicted noise levels at different heights within the canyon (10m wide street, aspect ratio of 2.1)	118
5.11	Simulated contribution of balconies to reducing noise level at the surface of the building in five-storey buildings in street canyons	119
5.12	Contours of noise level at different heights above the street and at different street widths	121
6.1	Relationship between pollution and development: (a) particles and SO_2 pollution in relation to income; (b) estimated global annual deaths from indoor and outdoor pollution	126
6.2	The variation of indoor per outdoor ozone ratio as a function of (a) air changes per hour (CW = closed window; POW = partially opened window; OW = open window) and (b) outdoor concentration	127
6.3	Building classification according to permeability	128
6.4	Two types of multivariable models: (a) multiple regression; (b) fuzzy modelling	129
6.5	Ozone outdoor–indoor transfer: (a) I/O ratio; (b) precision; (c) degree of confidence	130
6.6	NO_2 outdoor–indoor transfer: (a) I/O ratio; (b) precision; (c) degree of confidence	131
6.7	Particle matter outdoor–indoor transfer	132
7.1	(a) Single-sided wind-driven ventilation; (b) air changes per hour calculated for a room of 2.7m in height with windows of 1.5m in height and a window area of 1/20 floor area	137
7.2	Wind-driven cross-ventilation: (a) pressure drops associated with wind-driven cross-ventilation; (b) Wind pressure differences for a rectangular, isolated building	138

7.3	Opening dimension and position can control night cooling of all levels of a multi-storey building	141
7.4	Stack pressure-driven natural ventilation: (a) pressure drops associated with buoyancy-driven stack ventilation; (b) pressure stack variation as a function of temperature difference and building height	142
7.5	Combined effects of wind and stack: (a) adding the effects of wind and stack; (b) opposite effects of wind and stack	143
7.6	Combined wind- and buoyancy-driven ventilation: (a) pressure drops; (b) total pressure as a function of wind velocity, temperature difference and building height	144
7.7	Mixed natural ventilation strategies in a single building in order to satisfy local and global ventilation needs	146
7.8	Queen's Building of De Montfort University, Leicester, UK	147
7.9	Top-down or balanced stack natural ventilation systems use high-level supply inlets to access less contaminated air and to place both inlet and outlets in higher wind velocity exposures	147
7.10	Passive downdraught evaporative cooling stack ventilation	150
7.11	Strategy for intensive night cooling	151
7.12	Effect of passive cooling through night ventilation on the LESO building, Switzerland	152
7.13	Views of the Building Research Establishment's Environmental Office of the Future building, showing the solar-assisted stack air ducts	155
7.14	Solar collector used as (a) ventilator and (b) heater	155
7.15	Media school: fan-assisted natural ventilation	156
8.1	Various types of operable windows	159
8.2	Combination of openings in a window	160
8.3	Louvers in a new building and in a renovated building	160
8.4	'Constant airflow' vent to be installed in a window frame	161
8.5	Moisture-controlled air inlets and outlets	161
8.6	Vent with acoustic attenuation	162
8.7	Three ways of installing stack ventilation ducts	162
8.8	The Yazd wind catcher in Iran	163
8.9	Windcatcher natural ventilation systems	164
8.10	Chimneys on the roof of the IVEG building in Hoboken (Belgium)	165
8.11	The glazed blades in the outer skin protect the Lausanne postal office from driving rain and allow large airflow rates	166
8.12	The double-skin façade of the Siemens building, Dortmund	167
9.1	The geometry of canyons	170
9.2	Flat façades	171
9.3	Façade with obstacles (solar shading)	171
9.4	Non flat façades	172
9.5	Façades with balconies	172
9.6	Façades with obstacles	173

9.7	Scenario for single-sided ventilation	174
9.8	Scenario for stack-induced situations	174
9.9	Building envelope and stack	175
9.10	COMIS chimney scheme	175
9.11	Plan of the Ermou apartments, Athens	176
9.12	Ermou office apartment building, Athens	177
9.13	Air exchange in zone 3 with cracks in opening 1	177
9.14	Air exchange in zone 2 with cracks in opening 1	178
9.15	Air exchange in zone 1 with cracks in opening 1	178
9.16	Influence of wind velocity for different temperature differences	179
9.17	Influence of temperature difference for different wind velocities	180
9.18	Influence of the width of the window for different wind velocities and temperature differences	180
9.19	Influence of the height of the top of the window for different wind velocities and temperature differences	181
9.20	Influence of the height of the opening bottom for different wind velocities and temperature differences	182
9.21	Influence of the useful area of the chimney	183
9.22	Influence of the chimney diameter	183
9.23	Influence of the height of the chimney for two chimney diameters	184
9.24	Influence of the temperature difference for two chimney diameters	184
9.25	Different types of windows	185
9.26	Influence of the height of the room	185
9.27	Influence of the window geometry and location for different volumes of the room	186
9.28	General outline of the model	187
9.29	Feed-forward neural network	188
9.30	Architecture of the model of calculating ACH for single-sided ventilation	188
9.31	Graphical interface to calculate ACH	189
9.32	Architecture of the model calculating the width of the window	190
9.33	Graphical interface to optimize the opening	190
9.34	Graphical interface to start the program	191
10.1	Wind field at 10m calculated by the LM model	197
10.2	Algorithm for assessing wind speed inside the canyon	198
10.3	Situations when $T_i > T_e$: (a) assisting wind force; (b) opposing wind force with upward flow; (c) opposing wind force with downward flow	201
10.4	Heating, ventilation and cooling domains	202
10.5	Natural ventilation potential graphs (Lausanne, Switzerland)	216
10.6	Degree-hours graphs (Lausanne, Switzerland)	217
10.7	Degree-hour distributions and inside-outside temperature difference ('stack effect') distributions	218