



Healthy Buildings 2003

Energy-Efficient Healthy Buildings

Proceedings of ISIAQ 7th International Conference

7th – 11th December 2003
Singapore

Editors

Tham Kwok Wai

Chandra Sekhar

David Cheong

Jointly Organised by



Department of Building
National University of Singapore

and



International Society of Indoor Air Quality and
Climate (ISIAQ)

Sponsored by



U.S. Environmental
Protection Agency
(USEPA)



Your Essential Connection
American Industrial
Hygiene (AIHA)

Volume 2

The papers in this book comprise the proceedings of **Healthy Buildings 2003**. They reflect the authors' opinions and are published as presented without change, in the interests of timely dissemination. Their inclusion in this publication does not necessarily constitute endorsement by the editors, the sponsors or the organisers.

ISBN: 981-04-9974-4

Copyright and Reprint Permission

All rights reserved. This book, or parts thereof, may not be reproduced in any form or by any means, electronic or mechanical, including photocopying, recording or any information storage and retrieval system now known or to be invented, without written permission from the organiser.

All rights reserved. © 2003 by National University of Singapore

CRC and Printed by Stallion Press, Email: sales@stallionpress.com

Foreword

The Healthy Buildings conference is, for the first time, convened outside its traditional European-American circuit, and signifies the international recognition that healthy buildings and indoor environments are as much needed and desired in the developed and developing worlds, across all climatic regions. In the aftermath of the first emergence of Severe Acute Respiratory Syndrome (SARS), issues of environmental quality and control have become much more pertinent and important. In an unprecedented way, the linkage between health and environmental quality on the “consumer end” of the chain, and the policies, management and technologies on the “supply end” has been highlighted and articulated beyond the usual platforms of scientific publications to popular media. This presents HB2003, the 7th International Conference in tropical Singapore, as a unique opportunity for scientists, practitioners and policy makers to convene, discuss and share their latest findings and thinking on healthy buildings.

HB2003 continues the excellent work achieved by its predecessors in recognizing emergent issues and focusing on developing practical solutions based on rigorous scientific explorations and information. In recognising the importance, relevance and challenges of both IAQ and energy globally over the past four decades, the thrust of HB2003 is towards Energy-Efficient Healthy Buildings. Keynote addresses provide the state-of-the-art reviews and insights along the following five conference themes:

- Theme 1 : Science of Indoor Air Quality (IAQ) parameters
- Theme 2 : Materials, systems and technologies for healthy buildings
- Theme 3 : IAQ and human response
- Theme 4 : Practice and implementation issues in creating healthy buildings
- Theme 5 : Issues of healthy buildings and energy efficiency in the developing countries

Almost 400 papers from 45 countries documenting the research, thinking, innovative solutions and technologies for the achievement and sustenance of energy-efficient healthy buildings are published in three volumes of proceedings that are organised according to the five themes of the conference. Whilst 40% of the papers presented at HB2003 relate to the study of fundamental issues of indoor contaminants including thermal comfort aspects in THEME 1, 27% of the papers provide an insight into practical solutions across different climatic conditions in THEME 2. Environmental health related studies that impact upon occupant perception and work performance constitute 17% of the papers and are presented in THEME 3. Considerations from practitioners’ viewpoint are addressed in another 14% of the papers in THEME 4. The perspectives of the developing world are presented in a small number of papers in THEME 5.

All the technical papers published in HB2003 proceedings are presented as either ORAL or POSTER mode. To facilitate maximum interaction among authors and delegates, about half the total number of papers is presented as POSTERS, which are displayed throughout the duration of the conference. The poster papers are briefly introduced following oral presentations in a particular theme in each of the 55 parallel sessions that are spread across four days of the conference. Additionally, the technical sessions also incorporate six ISIAQ Task Force Workshops and a special SARS workshop.

A summary of the deliberations at the various Technical Sessions will be consolidated and made available to all delegates (by email) as a Post-Conference document and will also be uploaded on the conference website: www.hb2003.org

Tham Kwok Wai
Chandra Sekhar
David Cheong

Organising Committee

Organising Committee

Tham KW, *President*
Sekhar SC, *Technical chair*
David Cheong KW, *Technical chair*
Wong NH, *Treasurer*
Chan P, *Secretary*
Yap HM, *Member*
Tan ST, *Logistics*

Local Advisory Committee

Bong TY	Lee SE
Cheong HF	Ofori G
Chew YT	Ooi PL
Chou SK	Sze G
Goh KT	Tan TC
Kam F	Wong WC
Lam KP	

Local Scientific Committee

Chan P	Ng TP
Cheong KWD	Rajasekhar B
Foo SC	Seah D
Jayamaha L	Sekhar SC
Lai A	Sun D
Lee A	Tan F
Lee EL	Teh KJ
Lee HK	Tham KW
Lee SE	Wong NH
Ng EH	Wong R
Ng KC	Yap C

Conference Secretariat

Integrated Meetings Specialist Pte Ltd
1122A Serangoon Road, Singapore 328206
Tel: (65) 6295 5790 Fax: (65) 6295 5792
Email: ims@inmeet.com.sg

International Scientific Committee

Allard F, France
Awbi HB, UK
Axley J, USA
Barakat S, Canada
Bencko V, Czech Republic
Berglund B, Sweden
Bluyssen P, The Netherlands
Bojic M, Yugoslavia
Bornehag C-G, Sweden
Broadbent C, Australia
Brohus H, Denmark
Chan D, China (HKSAR)
Chung KS, South Korea
Clausen G, Denmark
Croome DC, UK
Da Silva MCG, Portugal
De Aquino RFN, Brazil
Dingle P, Australia
Fang L, Denmark
Fisk W, USA
Flatheim G, Norway
Godish T, USA
Gunnarsen L, Denmark
Gupta AB, India
Hagstrom K, Finland
Hayter R, USA

Ikeda K, Japan
Jaakkola J, Finland
Jensen O, Denmark
Johannesson G, Sweden
Kannan KS, Malaysia
Khalil E, Egypt
Khattar MK, USA
Kimura K, Japan
Knudsen H, Denmark
Korkin V, Russia
Kosonen R, Finland
Krishan A, India
Kulic E, Bosnia and Herzegovina
Li A, China
Li Y, China (HKSAR)
Liddament M, UK
Luxton RE, Australia
Maiya P, India
Melikov A, Denmark
Mendell MJ, USA
Mizielinski B, Poland
Moschandreas D, USA
Nazaroff W, USA
Nevalainen A, Finland
Nielsen P, Denmark
Novak P, Slovenia

Pejtersen J, Denmark
Persily A, USA
Popielek Z, Poland
Rane MV, India
Rodriguez ES, Spain
Saarela K, Finland
Salthammer T, Germany
Sandberg M, Sweden
Scartezzini JL, Switzerland
Shao L, UK
Shaw CY, Canada
Sherman M, USA
Shyu RY, Taiwan
Smith K, USA
Sowa J, Poland
Spengler J, USA
Steimle F, Germany
Tam LM, China (MSAR)
Toftum J, Denmark
Valbjorn O, Denmark
Wargocki P, Denmark
Wibulswas P, Thailand
Wolkoff P, Denmark
Wyon D, Denmark
Yoshino H, Japan
Yoshizawa S, Japan

International Coordinators

Agarwal RS, India
Banhidi L, Hungary
Boschi N, USA
Chow T T, China (HKSAR)
Cochet C, France
Fanger PO, Denmark
Fernandes EO, Portugal
Girman JR, USA
Haghighat F, Canada
Jantunen M, Finland
Levin H, USA
Lindvall T, Sweden
Maroni M, Italy

Matthews EH, South Africa
Mayer E, Germany
Morawska L, Australia
Murakami S, Japan
Murthy SS, India
Nathanson T, Canada
Olesen BW, Germany
Petras D, Slovakia
Pickering A, UK
Raw GJ, UK
Roulet C-A, Switzerland
Schwela D, Switzerland
Seifert B, Germany

Seppanen O, Finland
Shaughnessy R, USA
Su J, Taiwan
Sundell J, Denmark
Tanabe S, Japan
Tiffany J, USA
Todorovic B, Serbia
Weschler CJ, USA
White JH, Canada
Zhang G Q, China
Zhao R, China

Acknowledgements

Sponsored by:

U.S. Environmental Protection Agency
Lifa Air Ltd
Halton OY
American Industrial Hygiene Association
Innova AirTech Instruments A/S

Supported by:

American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)
Association of Consulting Engineers Singapore (ACES)
Australian Institute of Refrigerating, Air-conditioning and Heating (AIRAH)
Building and Construction Authority, Singapore (BCA)
Chartered Institution of Building Services Engineers (CIBSE)
Federation of European Heating and Air-conditioning Associations (REHVA)
Institution of Engineers Singapore (IES)
International Academy of Indoor Air Sciences (IAIAS)
International Council for Research and Innovation in Building and Construction (CIB)
Ministry of Health, Singapore (MOH)
National Environment Agency, Singapore (NEA)
Society of Heating, Air-Conditioning and Sanitary Engineers of Japan (SHASE)
The Finnish Society of HVAC Engineers (FINVAC)

Exhibitors

Dantec Dynamics A/S
GETC Asia Pte Ltd
Lee Hung Scientific Pte Ltd
MycoMeter ApS
Setsco Services Pte Ltd

Brief Contents for Volume 1

KEYNOTES

1A) CHEMICAL POLLUTANTS

1B) MICROBIALS

1C) THERMAL COMFORT (Continued to Volume 2)

Brief Contents for Volume 3

3A) HEALTH EFFECT & SBS SYMPTOMS

3B) OTHER INDOOR AIR POLLUTANTS

3C) COST EFFECTS AND BENEFITS OF GOOD IAQ

4A) SPECIFICATION, DESIGN, CONSTRUCTION, COMMISSIONING,
OPERATION AND MAINTENANCE

4B) IAQ STANDARDS & GUIDELINES

4C) POLICY & LEGAL ISSUES

4D) SURVEYS & CASE STUDIES

5A) STATUS-QUO ASSESSMENT

5B) SOLUTIONS FOR HEALTHY BUILDINGS

Contents for Volume 2

	Page
Foreword	iii
Organising Committee	iv
International Scientific Committee	v
International Coordinators	vi
Acknowledgements	vii
Brief Contents for Volume 1 and Volume 3	viii
 1C) THERMAL COMFORT	
Thermal Comfort in Office Buildings With Underfloor Air Supply—Quantitative and Qualitative Analysis	1
<i>Brenda C. C. Leite, Arlindo Tribess</i>	
The Impact of the Warmth Thermal Sensation into Non-Air-Conditioned and Naturally Ventilated Office Environments of Tertiary Refurbished Buildings in Tropical Climate	7
<i>Teresa Cristina F. de Queiroz Gaudin, Leopoldo Eurico Gonçalves Bastos</i>	
Evaluation on Thermal Comfort of Electric Heating Films System in Residential Building ..	13
<i>Xiaojun Ma, Xiaowei Xu, Shuie Wan, Kejin He</i>	
Numerical Calculation of Angle Factor and Effective Radiation Area for Humans and Animals Using Hemi-Cube Method	19
<i>Shinsuke Watanabe, Shin-ichi Tanabe</i>	
Thermal Comfort Requirements from Hot Humid and Hot-Dry Regions	25
<i>Saeed A. R. Saeed</i>	
The Adaptive Approach to Thermal Comfort: From Models to Solutions	30
<i>Ida Fato, Cecilia Chiancarella</i>	
The Effects of Direct and Indirect Air Flow on Thermal Comfort	36
<i>Ju-Youn Lee, Sim-won Chin, Chung Baik-young</i>	
A Thermal Comfort Study on Displacement Ventilation in the Tropics	42
<i>W. J. Yu, K. W. D. Cheong, Risto Kosonen, Yong Heng Xie, H. C. Leow</i>	
Thermal and Airflow Behaviour of Buildings—Model Reduction	48
<i>Thierry Berthomieu, Harry Boyer</i>	
An Experimental Study on the Comfort Zone in a Radiant Floor Heating System	54
<i>KwangSeop Chung, YongKyu Baik, MinKwan Cho, DongWon Yoon, HyunWoo Lee</i>	
Thermal Comfort in an Evaporatively Cooled Building: Effect of Exterior Wall Orientation and Exposure	61
<i>D. A. Hindoliya, S. C. Mullick</i>	

An Adaptive Thermal Comfort Approach in Air-Conditioned Buildings in the Tropical Hot-and-Humid Climates	67
<i>F. Tan, R. Kosonen</i>	
Modelling of Thermal Comfort in Spaces With Radiant Heating	73
<i>Karel Kabele, Zuzana Veverková</i>	
Periodic Heat Transfer Analysis—An Analytical Tool in Modelling of Non Air Conditioned Multi-Zone Buildings	79
<i>Vijay Majali, B. N. Prasad, A. K. Bhat</i>	
Thermal Characteristics of a Partition Air Supply System at a Personal Task Area	86
<i>Kybum Jeong</i>	
Subjective Response to the Thermal Comfort in Heated Dwellings	92
<i>Dusan Petras, Jana Sabikova</i>	

1D) PARTICULATE MATTER

Ultrafine and Fine Particles, VOC and Odour Emissions From Dusty Air Filters	98
<i>Marko Hyttinen, Pasi Yli-Pirilä, Marko Björkroth, Pertti Pasanen, Taisto Raunemaa, Pentti Kalliokoski</i>	
Indoor Air Quality in Two Different Office Buildings—Part 2: Indoor and Outdoor Airborne Particulate Levels and Air Filtration	104
<i>A. Ginestet, Bénédicte Ribot, Michel Henninot, Dominique Pugnet</i>	
IAQ Assessment in a Large School of Arts—Worker Exposure to Fine Particulate Matter and VOCs	111
<i>Pasi Yli-Pirilä, J. Nuutinen, Taisto Raunemaa</i>	
An Eulerian Model for Particle Deposition Under Electrostatic and Turbulence Condition ..	117
<i>Chen Fangzhi, Simon C.M. Yu, Alvin C.K. Lai</i>	
A Pilot Study on the Effect of Indoor Particle Sources on Indoor Particle Concentration in Residential Houses	123
<i>Congrong He, Lidia Morawska, Jane Hitchins, Dale Gilbert</i>	
Particle Collection Efficiency of Sorbent Tubes	129
<i>M. Jamriska, Erik Uhde</i>	
Ultrafine and Fine Particle Formation in a Naturally Ventilated Office as a Result of Reactions Between Ozone and Scented Products	134
<i>J. Toftum, F. van Dijken</i>	
Characterization of Particulate Matter in the Tropics	140
<i>Abhishek Gupta, K.W.D. Cheong, Wong Nyuk Hien</i>	
Particulate Matters in School Environments: Assessing the Effectiveness of a Low Allergen School	147
<i>Guicheng Zhang, Krassi Rumchev, Andy H. Lee, Jeffery Spickett</i>	
A Review of Modelling Particle Deposition	153
<i>Chen Fangzhi, Alvin C. K. Lai</i>	
When to Open Windows—A Concept of Balance-point Outdoor Concentration of Particles .	159
<i>Yuguo Li, Zhengdong Chen</i>	
Monitoring Pollutants in Occupied Spaces	165
<i>John Currie, Graham Capper</i>	
Indoor Air Pollution and Respiratory Health of the Peoples in Beijing: A Community-Based Pilot Study	170
<i>Xiao-chuan Pan, Linggu Wang, Lihua Wang, Xiaobin Jin</i>	
A Preliminary Study of Respirable Suspended Particulate Level in Taxi Transport Interchanges in Hong Kong	176
<i>Lu Wei-zhen, Wang Xie-kang</i>	

Transport of Fungal Spores and Particles Through a Building Structure	182
<i>M. Airaksinen, Pertti Pasanen, Jarek Kurnitski, Olli Seppänen</i>	
Impact of Ventilation Strategies on Particle Deposition in a Test Chamber	188
<i>Jérôme Bouilly, Marc Abadie, Karim Limam, Francis Allard</i>	
Indoor and Outdoor Measurements of Ultra Fine Particles In A Medium-Size and Large City	194
<i>U. Matson, L. E. Ekberg</i>	
VOC and Fine Particles in a Newly Renovated Building—A Case Study	200
<i>E. Uhde, G. A. Ayoko, L. Morawska</i>	
Modelling of Indoor Concentrations of Ultra Fine Particles Based on Laboratory Measurements	205
<i>Alireza Afshari, Lars Ekberg, Uve Matson</i>	
Relationship Between Indoor/Outdoor Concentrations of Particles: A Critical Review	212
<i>L. Morawska, Congrong He</i>	
Estimated Fine Particulate Matter Exposure Reduction Potential for Urban Population Using State of the Art Building Envelopes and Ventilation Systems: Example, Helsinki Finland	219
<i>Otto O. Hänninen, Matti J. Jantunen</i>	

2A) CLIMATE SPECIFIC DESIGN

A Parametric Study of Traditional Housing Prototypes From the Middle East	225
<i>I.A. Meir, I. Gilead, T. Runsheng, J. Mackenzie Bennett, S.C. Roaf</i>	
Environmentally Responsive Building Design	231
<i>Caimin McCabe</i>	
Architecture: In Quest for a Sustainable Future	237
<i>Arvind Krishan</i>	
Energy Optimization Through Thermal Zoning—The Outer Skin	243
<i>P. Mendonça, Luis Bragança</i>	
Climatic Maps for Natural Energy and Passive Cooling Methods Utilization in Thailand ...	249
<i>Athasit Jittawikul, Ikuo Saito, Osamu Ishihara</i>	
Influence of the Degradation of Building Components on Thermal Comfort	256
<i>F. Re Cecconi, P. Iacono</i>	
Moisture Control in Cold Climates—The Report of ISIAQ Task Force IX	262
<i>Ulla Haverinen, Tom Follin, Aino Nevalainen</i>	

2B) BUILDING TYPES

A Questionnaire Survey of Special Old Age Nursing Homes and Elderly Health Care Facilities in Japan	266
<i>Shintaro Yokoyama, Masaki Yoshioka, Satoshi Koguchi, Koji Hataya, Koichi Ikeda, Yasuhiro Hamada, Makoto Nakamura, Hideki Kubota</i>	
Statistical Analysis of Parameters Influencing the Relationship between Outdoor and Indoor Air Quality	272
<i>O. Poupard, Patrice Blondeau, Vlad Iordache, Francis Allard</i>	
The Indoor Climate in Historic Buildings Without Mechanical Ventilation Systems	278
<i>Morten Ryhl-Svendsen, Tim Padfield, Victoria A. Smith, Franco De Santis</i>	
Human Exposure to Particulate and Gaseous Pollutants in a Bar	284
<i>J. I. Currie, Graham Capper</i>	
Air Quality in Polish Schools—Pupils' Self Estimation	290
<i>J. Sowa, Barbara Ignar Golinowska</i>	

2C) VENTILATION

The Variation of Ventilation Performance in Relation to Change in Workstation Location in a Ventilated Room	296
<i>Y. Cho, H. B. Awbi, M. Marchetti</i>	
Post-Occupancy Monitoring of Windcatchers for Summer Ventilation in the UK	302
<i>A.A. Elmualim, H.B. Awbi</i>	
The Ups and Downs of Airflow in Building Ventilation	308
<i>Yuguo Li</i>	
Influence of the Jet Initial Inclination Angle on the Performace of an Air Curtain Device ...	314
<i>L. P. C. Neto, Manuel Carlos Gameiro Silva</i>	
The Verifying Concept for the Cleanliness of HVAC Systems	321
<i>V. Asikainen, R. Holopainen, A. Majanen, O. Seppänen, A. Seppälä, T. Jalonen, P. Pasanen</i>	
A Statistical Approach to the Evaluation of the Maximum Velocity Within the Occupied Zone	327
<i>Kim Hagström</i>	
Air Change Rates in Multi-Family Residential Buildings in Northern Portugal	333
<i>Manuel Pinto, Carl-Axel Boman, Hans Stymne, Vasco Peixoto de Freitas</i>	
Influence of Geometry of Thermal Manikins on Room Airflow	339
<i>Claus Topp, Peter Hesselholt, Mikkel Roed Trier, Peter V. Nielsen</i>	
The Impact of a Personalized Ventilation System on Indoor Air Quality at Different Level of Room Air Temperature	345
<i>Jianrong Yang, Jan Kaczmarczyk, Arsen Melikov, P.Ole Fanger</i>	
Ventilation and IAQ Performance of a Typical Split-System Air-Conditioning Unit in a Residential Apartment in Singapore	351
<i>S.C. Sekhar, Lim Weng Keong</i>	
Influence of Geometry of Thermal Manikins on Concentration Distribution and Personal Exposure	357
<i>Claus Topp, Peter Hesselholt, Mikkel Roed Trier, Peter V. Nielsen</i>	
Deflection Ventilation—A Conceptual Introduction	363
<i>Z. Lin, T. T. Chow, Y. Li</i>	
Experimental and Numerical VOC Concentration Field Analysis From Flooring Material in a Ventilated Room	370
<i>Ake Ahima Akoua, Bernard Collignan, François Maupetit, Olivier Ramalho</i>	
The Capability of a Needle Heat Exchanger to Prevent Moisture and Microbial Damage of the Fine Filter	376
<i>R. Halonen, H. Kokotti, L. Kujanpää, T. Kesikuru, M. Reiman</i>	
Indoor Air Quality and Airflow Distribution as a New Factor in Surgical Operating Theatres: A new Hypothesis	382
<i>Ramiz Kameel, Essam Eldin Khalil</i>	
Use of a Sensory Irritation Potential Index to Characterize Improvement of Indoor Air Quality in French Schools by Ventilation	388
<i>C. Mandin, R. Meininghaus, A. Cicolella</i>	
A Study of Demand-Controlled Ventilation (DCV) and Constant Air Volume (CAV) Systems ..	392
<i>Mohsen Soleimani-Mohseni</i>	
Tracer Gas Measurement of Airflow Rates in Rooms With Several Air-Handling Units	398
<i>C.A. Roulet, M.S. Zuraimi, S.C. Sekhar</i>	
Relative Influence of Boundary Conditions on the Indoor Air Quality of a Displacement Ventilated Room	404
<i>Henrik Brohus</i>	

Distribution of Room Air Contaminant Concentrations as a Function of Ventilation and Air Cooling—A Numerical Investigation	410
<i>Andrei Damian, Patrice Blondeau, Francis Allard</i>	
The Influence on Ventilation Efficiency in Typical Dwelling With Floor-Based Displacement Ventilation	416
<i>Nien-Tsu Chen, Yen-Yi Li, Po-Cheng Chou, Che-Ming Chiang</i>	
Presumption Experiment of Supply Rate Fulfilment Using Tracer Gas—Verification on the Cylinder house	422
<i>Masaki Tajima, Takao Sawachi, Hironao Seto, Hitoshi Takeda</i>	
Effect of Ventilation on Mould Growth in a Japanese Bathroom	428
<i>Yoshihiro Aizawa, Keiko Abe</i>	
Application of Active Stack System to Enhance Natural Ventilation in High-rise Residential Buildings	434
<i>Priyadarsini, R., K.W. Cheong, N.H. Wong</i>	
A Breath of Fresh Air (Natural Ventilation Strategies for Indoor Air Quality)	440
<i>Stuart Fishman</i>	
The Impact of a Uniformly Distributed Thermal Load on Mixed Flow	444
<i>Ingo Gores</i>	
Personalized Ventilation: Experimental Apparatus to Evaluate High Induction Air Terminal Devices	452
<i>P. Gori, L. Grossi, A. Vallati</i>	
Mixing and Displacement Ventilation Compared in Classrooms; Distribution of Particles, Cat Allergen and CO₂	458
<i>M. Mattsson, Greta Smedje, Leif Holmquist, O. Vesterberg, Robert Wålinder</i>	
Experimental Study on Unsteady Air Terminal	465
<i>S.F. Sun, Rongyi Ding, Rongyi Zhao, Weiquan Xu</i>	
Effects of Naturally Ventilated Double Skin Walls on Indoor Thermal Environment	471
<i>J.G. Tsutsumi, Morinobu Shingaki, Ryoki Arakawa, Ryo Nakamatsu</i>	
Passive Parallel VOCS and Ventilation Rate Sampler	475
<i>Yumiko Okuizumi, Kazukiyo Kumagai, Minoru Fujii, Hiroshi Yoshino, Naohide Shinohara, Atsushi Mizukoshi, Yukio Yanagisawa</i>	
Permeation of Tracer Gases Through Building Materials—Consequences for Ventilation Measurements with Tracer Gas Techniques	480
<i>Peter Hansson, Hans Stymne, Anette Valfridsson</i>	
Performance of Personalized Ventilation in a Room With an Underfloor Air Distribution System: Transport of Contaminants Between Occupants	486
<i>R. Cermak, Arsen K. Melikov</i>	
Design Methods for Air Distribution Systems and Comparison between Mixing Ventilation and Displacement Ventilation	492
<i>Peter V. Nielsen, Tine S. Larsen, Claus Topp</i>	
Air Quality of Kitchens in Jaipur City due to the Use of LPG as a Cooking Fuel: Part I—Role of Exhaust Fan in Dissipating the Pollution Generated	498
<i>Tarun P. Gupta, A. B. Gupta, Renu Jain, Virendra Singh</i>	
Methods and Methodological Tools for the Elaboration of Natural Ventilation Strategy	504
<i>Yasmine Mansouri, Francis Allard</i>	
The Retrofit of Respiratory Isolation Rooms for Tuberculosis Patients in Taiwan	510
<i>H.T. Loong, M.J. Wang, C.L. Chen, R.J. Shyu</i>	
Potential Economical Benefits of Balancing Airflows in an Office Building	516
<i>Marianna Tuomainen, Juha Smolander, Pirjo A. Korhonen, Lari Eskola, Olli Seppänen</i>	

Indoor Air Quality on Displacement Ventilation in the Tropics—A Chamber Study	522
<i>Y.H. Xie, K.W.D. Cheong, Risto Kosonen, Weijiang Yu, H.C. Leow</i>	
Improvements of ADPI and Ventilation Effectiveness of a Classroom by a Dedicated Outdoor Air System	528
<i>Hwataik Han, Yong-Il Kwon, Kyung-Hwan Kim, Gi-Seop Lee, Ho-Seon Choi, Gam-Gue Lee</i>	
Applying Tracer Gas Technique For Measurements in Air Handling Units With Large Recirculation Ratio	535
<i>C.A. Roulet, M.S. Zuraimi</i>	
The Use of CFD Simulations for the Assessment and Improvement of a Natural-Ventilated Hospital Building	541
<i>Alex Lee, Poh Hee Joo, George Xu Xiang Guo, Kurichi Kumar, Andrew Meier</i>	
Development of an Extraction Equipment for Preventing the Transmission of Contaminant Exhaled Air	548
<i>K.W. Mui Horace, W.T. Chan Daniel, K.C. Law Leo</i>	
CFD Simulation of Airflow Characteristics of Swirling Floor Diffusers	556
<i>H.T. Xu, J.L. Niu</i>	
 2D) CONTROL STRATEGIES	
A Study of Static and Dynamic Feed-Forward in Temperature Control of Buildings	562
<i>Mohsen Soleimani-Mohseni, Bertil Thomas</i>	
Survey of Indoor Air Quality in Three Swimming Pools	568
<i>Pasi Yli-Pirilä, Taipo Jauhiainen, Liisa Kujanpää, Arja Hirvonen, Raimo Halonen, Marjut Reiman, Helmi Kokotti, Taisto Raunemaa</i>	
Comparison of Occupancy Detection Algorithms, Methods of Signals Filtration and Types of Requirements Expression for CO₂-based DCV Systems	574
<i>J. Sowa</i>	
Evaluation of Gas-Phase Air Cleaning Devices—Full-Scale Chamber Test Methods and Results	580
<i>Wenhao Chen, Jianshun Zhang, James Smith, Zhibin Zhang</i>	
Capture Efficiency of Combustion Gases From Gas Fired Cooking-Stoves—Implications For Exposure to Nitrogen Dioxide in Homes	586
<i>Hans Stymne</i>	
Impact of Airflow Interaction on Inhaled Air Quality and Transport of Contaminants in Rooms With Personalized and Total Volume Ventilation	592
<i>A.K. Melikov, R. Cermak, O. Kovar, L. Forejt</i>	
Fuzzy Controllers for HVAC-VAV Systems to Maintain IAQ	598
<i>S. Sweet Annie Grace, D. Mohan Lal, Sharmeela</i>	
Fuzzy Logic Based Controller for Elevator System in Buildings	604
<i>Milind Mantravadi, Vishal Garg</i>	
A Personal Air Purifier for Schoolchildren	610
<i>Kazukiyo Kumagai, Kazuhide Ito, Kiyoshi Takahara, Mikio Hashida, Huaipeng Tang, Yukio Yanagisawa</i>	
Natural Products as Antifungal Agents in Carpets	616
<i>Chie Inumaru, Neil Zimmerman, Charles Woloshuk, James McGlothlin, Herman Cember</i>	
A Study on Effective Ventilation Strategy to Remove Pollutant in an Isolation Room of a Hospital	621
<i>K.W.D. Cheong, S.Y. Phua</i>	
Energy Efficient Duct Design and Control of VAV Systems: Where is the Fan Energy Savings?	628
<i>I. Khoo, M. Cook</i>	

2E) ENERGY EFFICIENCY

Can We Achieve Energy Efficiency and Good IAQ in Buildings?	634
<i>Lal Jayamaha</i>	
Potential IAQ and Energy Benefits Achievable with Personalized Air Supply	640
<i>J. L. Niu</i>	
An Introduction of Independent Humidity Control System Using Liquid Desiccant Air Conditioner	646
<i>Zhen Li, Yi Jiang, Xiao Yang Chen, Xiaohua Liu</i>	
Heat and Mass Transfer Analysis of Cross-Flow Heat Exchanger for Energy Recovery from Exhaust Air	653
<i>S. Anisimov, J. Zuchowicki</i>	
Architectural and Economical Implications in Consumption of Electricity on the Housing Sector in Arid Zones: The Mexicali Case in Mexico	659
<i>R. A. Romero, José Diego Morales</i>	
Energy Analysis of the Thermal Comfort	665
<i>M. Prek, V. Butala</i>	
Energy Efficient Air-Conditioning and Air Distribution System for Improved Indoor Air Quality	671
<i>S.C. Sekhar, C.R. Uma Maheswaran, K.W. Tham, David Cheong</i>	
Evaluation of Potential Possibility of Energy Efficiency in Residential Buildings	675
<i>B. Petrov, I. Puikévica-Puikévskā, N. Zeltinsh</i>	
Measures to Conserve Cooling and Heating Load Using a Pulse Ventilation System and Adsorbent Materials	681
<i>Minoru Fujii, Kazukiyo Kumagai, Naohide Shinohara, Junko Kawahara, Yumiko Okuizumi, Yasuro Katsuyama, Yukio Yanagisawa</i>	
Energy Efficiency Potential of Personalised Ventilation System in the Tropics	686
<i>S.C. Sekhar, Gong Nan, C.R. Uma Maheswaran, K.W.D. Cheong, K.W. Tham, Arsen Melikov, P.O. Fanger, D.P. Wyon</i>	
A Design Oriented Indexing System for Energy Use and Indoor Climate	692
<i>Erik Bjørn, Henrik Brohus</i>	
Energy Conservation for Operation Theaters by Secondary Return Air System	698
<i>S.C. Hu, Y.C. Chuang, Fu-Wen Hsiao</i>	

2F) INNOVATIVE TECHNOLOGIES & SOLUTIONS

Visual Comfort of New Window Systems for Office Buildings	703
<i>E. Mochizuki, T. Iwata, D. Itoh, N. Oba, M. Hirayama</i>	
Effect of Glass Transition Temperature on Volatile Emissions From Vinyl Flooring	709
<i>John C. Little, Steven S. Cox, Alfred T. Hodgson</i>	
Self-Regenerating Liquid Desiccant–Vapor Compression Hybrid Air Conditioning System	713
<i>P. Rajendra Prasad, B. Shaji Mohan, M.P. Maiya</i>	
Comparison of Two IAQ Calculation Methods	719
<i>W. Brad M. Stanley, Christopher O. Muller</i>	
Task AC Unit Operating Rate Prediction in Office	725
<i>Tatsuo Nobe, Shin-ichi Tanabe, Yumie Tomioka</i>	
Penetration of Degradation Products From Adhesive Into Concrete	731
<i>Anders Sjöberg</i>	
Efficient Dynamic Thermal Modelling Using CFD	737
<i>Shini Somarathne, Mark Seymour, Maria Kolokotroni</i>	

Optimisation of the Indoor Thermal Comfort in Private Houses Using Advanced Turbulent Models	743
<i>Peter Tibaut, Leopold Škerget</i>	
Definition of an Environmental Performance Evaluation System	750
<i>Eliana Cangelli, Iginia Plantamura</i>	
Healthy Bathroom–Bathrooms of the Future	757
<i>Gen Fujii</i>	
Development of Passive Flux Sampler (PFS) for Measurement of Formaldehyde Emission Rates	763
<i>Naohide Shinohara, Minoru Fujii, Akihiro Yamasaki, Kazukiyo Kumagai, Shinji Gishi, Yukio Yanagisawa</i>	
A Novel Technique For Measuring Moisture in Constructions and Application Examples ...	770
<i>Jukka Voutilainen, Juho Partanen, Tuomo Reiniaho, Eero Tommila, Raimo Sepponen</i>	
The Influence of the Capture Jet on the Efficiency of the Ventilated Ceiling in Commercial Kitchen	776
<i>Risto Kosonen, Panu Mustakallio</i>	
Overall Assessment Tool for Sustainable Office Building Design Towards Consistence Information and Knowledge Structure Needed For Innovative Design	782
<i>A. Abusada</i>	
Development of an Advanced Supply Air Filter	788
<i>I. Kulmala, A. Taipale, K. Heinonen, T. Jalonen, V. Mäkipää</i>	
The Effect of Water Floor on the Indoor Climate Control in Passive Solar House	794
<i>Yuji Hori, Nobuyuki Sunaga, Zhejun Xian</i>	
Exploration of CFD Models for Personalized Ventilation Air Terminal Devices	800
<i>Gong Nan, S.C. Sekhar, K.W.D. Cheong, K.W. Tham</i>	
High Speed Monitoring of Ethylene Oxide at the Sterilization Unit	806
<i>Josef Rieder, Iris Schuellner, Hartmann Raifer, Florian Bodrogi</i>	
Implementation of Triple Layer Façade in Singapore	810
<i>Haico Schepers, Russell Cole, Neil Johnson</i>	
Development of Contamination Testing Protocol for Ventilation System Components	814
<i>Riina Alén</i>	
European Testing Programme Investigating the Operation of an Innovative Ventilation System for Houses in Temperate Climates	820
<i>M. McEvoy, R. Southall</i>	
Preliminary Findings of a Pilot Study of Personalized Ventilation in Hot and Humid Climate ..	825
<i>S.C. Sekhar, Gong Nan, C.R. Uma Maheswaran, K.W.D. Cheong, K.W. Tham, Arsen Melikov, P.O. Fanger</i>	
Considerations in the Formulation of a Mathematical Model for a Newly Developed Compartmented Cooling Coil	831
<i>C.R. Uma Maheswaran, S.C. Sekhar, K.W. Tham</i>	
Performance Evaluation of an Air Cleaner Using Sorption Effect and its Life Cycle Inventory Analysis	837
<i>Hiroshi Matsumoto, Goro Okamura</i>	
A Pilot Study on Use of Hot Water in a Bathtub as a Heat Resource for Floor Heating	844
<i>Naoshi Kakitsuba, Mizoguchi Tadashi, Amagai Seiichirou</i>	
New Air Terminal Devices with High Efficiency for Personalized Ventilation Application ...	850
<i>Z. Bolashikov, L. Nikolaev, A. Melikov, J. Kaczmarczyk, P.O. Fanger</i>	
New Method to Measure Stored VOC in Concrete	856
<i>Anders Sjöberg, Claes Engström</i>	