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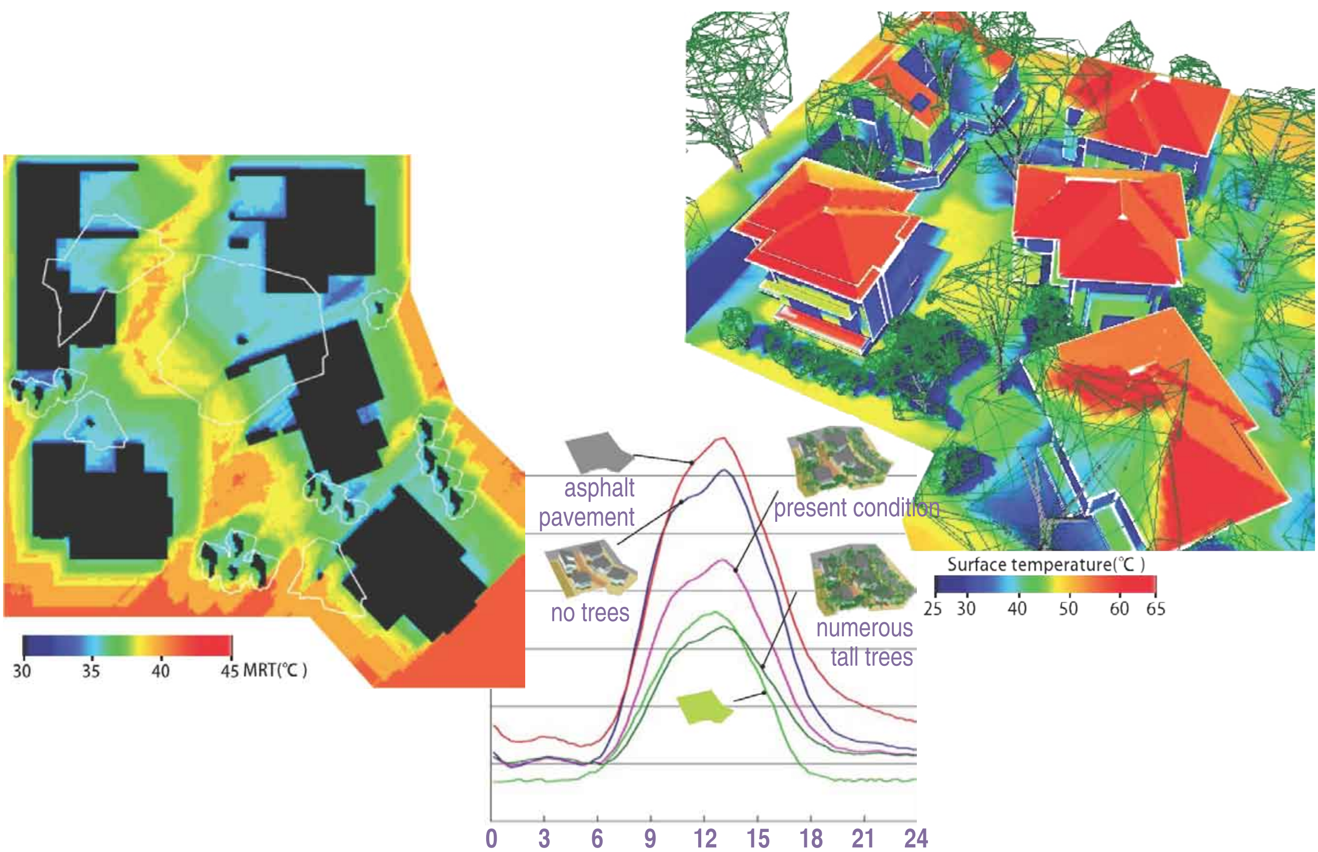

Inside:

- IBPSA launches the Journal of Building Performance Simulation
- Call for Abstracts and key dates for BS'09
- Articles on floor cooling capacity in an airport, the effects of leakages in roofs with ventilated air layers, and the development of a support tool for outdoor environmental design
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The newsletter of the International Building Performance Simulation Association ISSN 1993-8586

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President's message

IBPSA Members and Friends,

Welcome to this issue of IBPSA News. We are delighted to announce the launch and call for papers of the Journal of Building Performance Simulation (JBPS). - the official scientific journal of IBPSA.

The JBPS complements IBPSA's website at www.ibpsa.org which offers masses of information (e.g., all previous Newsletters and more than 1500 papers from the 10 international IBPSA conferences spanning two decades are freely downloadable) and the twice-a-year Newsletter that you are reading now.

It may also be of interest to you to know that at the last Board of Directors meeting IBPSA established five standing committees, which are, in alphabetic order:

- Conference Development - headed by Ian Beausoleil-Morrison
- Honours and Awards - headed by Lori McElroy
- Membership Development - headed by Jonathan Wright
- Newsletter Activities - headed by Larry Degelman
- Website Activities - headed by Roberto Lamberts

A future issue of the Newsletter will contain information about the membership and the mandates of these committees. In the meantime, if you would like to become involved as a volunteer on any of them, please make contact.

What else is on the horizon? In the very near future you will receive your ballot for election of a new board of directors. In a separate voting procedure you will be asked about some by-laws revisions. The annual meeting of the board is scheduled for October. If there is anything you would like the board to address please don't hesitate to contact us.

In this Newsletter, you will find that many of the regional affiliates and other organizations have building simulation events planned for the near future. One of the main ones will be Building Simulation 2009 in Glasgow. The organizers guarantee Scottish humor and weather and promise that IBPSA's 11th international conference will be fun and memorable. I suggest starting to make your plans!

Best wishes,

Jan Hensen

The International Building Performance Simulation Association (IBPSA) exists to advance and promote the science of building performance simulation in order to improve the design, construction, operation and maintenance of new and existing buildings worldwide.

Ian Beausoleil-Morrison &
Jan Hensen
Co-editors
Journal of Building Performance Simulation
www.informaworld.com/jbps

IBPSA launches the Journal of Building Performance Simulation

We are very pleased that after a five year preparation period we are now able to announce that the inaugural issue of the Journal of Building Performance Simulation (JBPS) — the official scientific journal of IBPSA — has been published. We think that it is very nice that the journal became a fact shortly after the 20th anniversary of IBPSA.

IBPSA takes a leading role in the promotion and development of building simulation technology and provides a forum for researchers, developers and practitioners to review building performance simulation developments, facilitate evaluation, encourage the appropriate and correct use of software programs, address standardization, accelerate integration and technology transfer. In addition to IBPSA's ongoing activities such as conferences, website and newsletter, the JBPS will be a key element in IBPSA's strategy to achieve this aim.

The JBPS is an international refereed scientific journal, publishing only articles of the highest quality that are original, cutting-edge, well-researched and of significance to the international community. The journal also publishes original review papers and researched case studies of international significance. The JBPS aims at being a reference and a powerful tool to all those professionally active and/or interested in the methods and applications of building performance simulation.

The journal provides authors with fast publication and dissemination of their research to a wide audience in both print and online at the dedicated journal homepage **www.informaworld.com/jbps**. Readers will benefit from access to 'online early' articles at the journal homepage and the ability to sign up for table of contents alerting (including RSS feeds) when new articles and issues are published (see **www.informaworld.com/alerts**).

We would like to take this opportunity to express our sincere thanks and deep gratitude to many colleagues and organizations (too many to name here) for their full support of the journal. We are particularly grateful to all the members of the IBPSA Board of Directors and the Editorial Board for their encouragement and commitment.

Finally we thank the publisher, Taylor & Francis, for sharing our vision and making the journal a reality. In this respect, we particularly wish to thank Meloney Bartlett, Rachel Moore, Elizabeth Thompson, Sophie Caples and Kayoko Ikeshiro for their wonderful support without which this journal would not have been established.

We look forward to welcoming you as readers and authors of this exciting high-quality new scientific journal. There is a Call for Papers flyer at the end of this *ibpsa*News.

Building Simulation 2009
University of Strathclyde
Glasgow, Scotland
27th – 30th July 2009

www.bs2009.org.uk

BS'09: Call for Abstracts

IBPSA will hold its 11th biennial international conference, the leading international conference in building performance simulation, in summer 2009 at the University of Strathclyde in Glasgow. Glasgow, Scotland's largest city, has an unrivalled choice of museums, theatres, parks, science centre and shopping, set within some of the finest Victorian architecture in Europe. In addition, Glasgow has a worldwide reputation as a welcoming city and is firmly established and experienced as a major centre for conferences and international events.

The conference organizers are seeking high quality papers and will limit the number of peer-reviewed oral presentations. Submissions will therefore be rigorously peer-reviewed. Simulation-based papers on the following themes are welcomed:

1 advances in building physics
2 human aspects of the indoor environment
3 building services
4 commissioning and operation
5 energy capture and conversion
6 advances in applications
7 validation and calibration
8 software issues
9 simulation in design practice
10 regulation/code compliance
11 application day case studies

Abstracts should be in plain text and no more than 500 words. They should describe clearly the research objectives and new knowledge arising from the research.

One day of the conference will be devoted to practical applications, focusing particularly on simulation in practice with illustrative case studies. A limited number of additional papers are invited in order to enable practitioners to demonstrate the benefits flowing from the recent upsurge in the use of simulation in building design. If you wish to contribute such a paper, please ensure it is marked as an application day case study in the abstract submission.

The key dates are:

Abstracts due	1 September 2008
Abstract acceptance	1 November 2008
Full papers due	1 February 2009
Paper reviews provided to authors	1 April 2009
Deadline for revised paper	15 April 2009
Deadline for final formatted papers	22 April 2009
Final acceptance notification	1 May 2009
Deadline for conference pre-registration	15 May 2009
BS '09 Conference	27-30 July 2009

Accommodation, both convenient hotels and student apartments, can be booked through the conference website **www.bs2009.org.uk**. There is more information about Glasgow, the University of Strathclyde, the accommodation, the accompanying persons' programme, technical tours and other aspects of the conference on the website and in the conference flyer at the end of this *ibpsa*News.

Student support will again be available — details will be announced later on the website.

We look forward to welcoming you to Glasgow and are sure you will enjoy the experience.

Expansion of IBPSA in India

IBPSA may spread its wings in India. Like-minded individuals including researchers, educators and professionals from CEPT University, Ahmedabad and elsewhere are in process of forming a new organisation with the objectives of promoting and strengthening building performance simulation practice, research and education in India. Amongst other activities planned, IBPSA India will host an interactive web site and an email discussion group to increase interaction amongst its members.

The establishment of IBPSA India will be supported by a grant from the US Department of Energy to promote energy efficiency and to develop building simulation capabilities in the sub-continent. CEPT University invites all to get involved in establishment of IBPSA India with inputs and constructive suggestions.

For details and inputs please contact:

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Forthcoming events calendar

Date(s)	Event	Information
2008		
23-24 April 2008	**DesignBuilder & EnergyPlus training workshops** Sydney, New South Wales, Australia	www.designbuilder.com.au/services.html
29-30 April 2008	**ACDM: Adaptive Computing in Design & Manufacture** Bristol, UK	www.ad-comtech.co.uk/ACDM08
29 April-1 May 2008	**Micro-Cogen 2008: Micro-Cogeneration Technologies and Applications** Ottawa, Canada	www.nrcan-rncan.gc.ca/es/etb/cetc/cetc01/htmldocs/Events/cogen_2008/index_e.htm
14-16 May 2008	**I3CON: Industrialised, Integrated, Intelligent Construction** Loughborough, UK	www.i3con.org
20-22 May 2008	**eSIM 2008** Québec City, Canada	www.eSim.ca
5 June 2008	**Computer Aided Building Physical Modeling** ***IBPSA Slovakia Conference*** Bratislava, Slovakia	www.cab.sk/cerc
16-18 June 2008	**NSB: Nordic Symposium on Building Physics 2008** Copenhagen, Denmark	www.nsb2008.org
21-25 June 2008	**ASHRAE conference** Salt Lake City, USA	www.ashrae.org
23-25 June 2008	**DCC: Design, Computing + Cognition** Atlanta, USA	http://mason.gmu.edu/~jgero/conferences/dcc08
2-4 July 2008	**EG-ICE: European Group for Intelligent Computing in Engineering** Plymouth, UK	www.eg-ice-plymouth.org
7-10 July 2008	**DDSS: Design & Decision Support Systems in Architecture & Urban Planning** Eindhoven, Netherlands	http://2008.ddss.nl
14-16 July 2008	**COBEE: 1st International Conference on Building Energy & Environment** Dalian, China	http://bechtelrh.colorado.edu/ceae/cobee

30 July-1 August 2008	**SimBuild 2008** Berkeley, USA	**www.ibpsa.us/simbuild2008**
17-22 August 2008	**Indoor Air** Copenhagen, Denmark	**www.indoorair2008.org**
20-22 August 2008	**Canadian Solar Buildings Conference** Fredericton, Canada	**www.solarbuildings.ca/en/conference**
8-10 September 2008	**BauSIM 2008** Kassel, Germany	**http://bausim.ibpsa-germany.org**
7-10 October 2008	**EuroSun 2008** Lisbon, Portugal	**http://eurosun2008.org**
9 October 2008	**IBPSA-NVL** Eindhoven, Netherlands	**www.ibpsa-nvl.org**
14-16 October 2008	**AIVC conference** Kyoto, Japan	**www.aivc2008.jp**
16-18 October 2008	**ICCCBE + INCITE: 12th International Conference on Civil & Building Engineering + 2008 International Conference on Information Technology in Construction** Beijing, China	**http://icccbe2008.civil.tsinghua.edu.cn**
20-21 October 2008	**ICEBO: International Conference for Enhanced Building Operations** Berlin, Germany	**http://buildingcommissioning.wordpress.com/2007/12/20/icebo-2008-conference-berlin**
22-24 October 2008	**PLEA conference** Dublin, Ireland	**www.plea2008.org**
29-31 October 2008	**BPS: Building Physics Symposium** Leuven, Belgium	**www.kuleuven.be/bwf/projects/BPS2008**
6-7 November 2008	**IBPSA France conference 2008** Lyon, France	**http://conference2008.ibpsa-france.net**
19-21 November 2008	**GreenBuild 2008** Boston, USA	**www.greenbuildexpo.org**
26-28 November 2008	**ANZAScA Conference** Newcastle, Australia	**www.newcastle.edu.au/anzasca2008**
2009		
24-28 January 2009	**ASHRAE** Chicago, USA	**www.ashrae.org**
14-19 June 2009	**SASBE: 3rd CIB International Conference on Smart & Sustainable Building Environments** Delft, Netherlands	**www.sasbe2009.com/index.html**

15-18 June 2009	**IBPC: 4th International Building Physics Conference** Istanbul, Turkey	**www.ibpc4istanbul.itu.edu.tr**
20-24 June 2009	**ASHRAE** Louisville, Kentucky, USA	**www.ashrae.org**
27-30 July 2009	**Building Simulation 2009** Glasgow, Scotland, UK	**www.bs2009.org.uk**
8-10 September 2009	**BauSim 2009** (Preliminary announcement - no information yet on website)	**http://ibpsa.inf.bauwesen.tu-muenchen.de/index.php/IBPSA-Germany**

21-22 May 2008
Québec, Canada
www.esim.ca

eSim 2008

IBPSA Canada

The biennial conference of IBPSA-Canada will bring together professionals, academics and students interested in building performance simulation issues and applications. It is being hosted by l'École d'architecture de l'Université Laval in Québec City, in collaboration with the National Research Council of Canada, and will be held in Québec City, Canada on 21 and 22 May 2008 (pre-conference workshops 20 May 2008).

L'École d'architecture is located within the fortifications of the historic district of Québec City. The nearby Musée de la civilisation, located in the city's old port district — well-known for its hotels and restaurants — will serve as the main conference venue (**www.mcq.org**). 2008 will be a landmark year for Québec as the city will be celebrating the 400th anniversary of its founding in 1608. Although most celebrations will be held from June to August, the end of May is expected to be a festive — and busy — time of year in this part of the city (**www.monquebec2008.com**).

Please visit the conference web site **www.esim.ca** for more information.

The themes for the conference are:

- Recent developments for modelling the physical processes relevant to buildings (thermal, air flow, moisture, lighting)
- Algorithms for modelling conventional and innovative HVAC systems
- Methods for modelling the whole-building performance, including integrated resource management, renewable energy sources and combined heating, cooling and power generation
- Building simulation software development and quality control approaches
- Use of building simulation tools in code compliance and incentive programmes
- Moving simulation into practice. Case studies of innovative simulation approaches
- Validation of building simulation software
- User interface and software interoperability issues
- Architectural and engineering data visualization and animation
- Optimization approaches in building design.

5 June 2008
Bratislava, Slovakia
www.cab.sk/cerc

Computer Aided Building Physical Modeling

IBPSA Slovakia

Computer aided simulation of building performance is increasingly widely used by building physicists and HVAC professionals, but it is still neglected by architects and designers in the initial phases of the building design, when the most important decisions are made. The main aim of this conference is to reduce this neglect by increasing understanding between designers and building physicists.

A second ambition is to encourage information exchange between professionals active in this field in the Central European Region by helping them to get to know each other better and to find new ways to cooperate. The conference will therefore be more an opportunity for informal discussions than a series of presentations.

Themes will include:

- Heat, air and moisture transfer in the building envelope
- Energy performance and energy efficiency
- Durability, sustainability and reliability
- Indoor environment - indoor-air quality, acoustics, lighting
- Promotion and education

The conference is being organised jointly by the Slovak University of Technology in Bratislava, the Slovak IBPSA branch and the Slovak Society for the Technique of Environment.

We would like to extend a cordial invitation to all professionals in the Central European Region active in the areas of building physics, HVAC, building design, management, development and last but not least the representatives of the state and local administrations, science and research to attend this event. Further information is available from the conference website **www.cab.sk/cerc**.

16-18 June 2008
NSB 2008
Copenhagen, Denmark
www.nsb2008.org

Nordic Symposium on Building Physics 2008

NSB 2008, the 8th Nordic Symposium on Building Physics, will be held in Copenhagen on 16-18 June 2008. Its themes will be research results on

- Energy performance
- Hygrothermal performance/moisture
- Air transport

It will cover heat, air and moisture transfer in building materials, building envelopes and whole buildings, with special emphasis on models, experiments and practice.

Further information is available from the conference website **www.nsb2008.org**.

30 July - 01 August 2008
University of California, Berkeley, California, USA
www.ibpsa.us/simbuild2008

SimBuild 2008
IBPSA USA

IBPSA-USA will hold its third national conference from 30 July to 01 August 2008 on the campus of the University of California at Berkeley. The format will be broadly similar to SimBuild 2004 at the University of Colorado, Boulder and SimBuild 2006 at MIT, except that there will be more time allocated to invited presentations and structured discussions on key topics of current interest. Training workshops by various software vendors are being scheduled for the Monday and Tuesday preceding the conference - further details may be found later on the IBPSA-USA web site

The Berkeley Tower

The conference organizers are limiting the number of peer-reviewed oral presentations in order to maintain a high level of quality in the papers, and submissions will be rigorously peer-reviewed. Conference themes include system or component modeling, simulation algorithm development, CFD applications, IAQ, acoustics, energy, lighting, life safety, weather, city-scale environmental simulations, and case studies that exhibit in-depth use of simulation software.

The meeting is open to all, world-wide. Being near San Francisco, Berkeley is a convenient destination for travelers from major cities in the U.S. and in many other countries. U.C. Berkeley is the oldest campus of the University of California system, which also operates the well-known Lawrence Berkeley National Laboratory, the Lawrence Hall of Science, the Space Sciences Laboratory, and the U.C. Botanical Garden. The city of Berkeley contains a variety of neighborhoods with diverse character and excellent restaurants. The "Bay Area" is full of visitor attractions accessible within 20 minutes, such as the city of San Francisco, scenic mountains, and rich architecture (including the Marin Civic Center by Frank Lloyd Wright). Numerous wineries are within one hour travel to the Napa and Sonoma valleys, where wine-tasting tours are available.

Napa Valley

The S. F. Pyramid

The conference registration fees are:

Full registration	$400
Student registration	$200

Conference housing will be offered on campus in dormitories and in nearby hotels. Single- and double-occupancy dormitory rooms will range in price from about $39 to $68 per night. Student bursaries will again be available.

For more information, please visit the IBPSA US website at **www.ibpsa.us/simbuild2008**.

8-10 September 2008
Kassel, Germany
http://bausim.ibpsa-germany.org

BauSIM 2008

BauSIM 2008
IBPSA Germany

IBPSA Germany's second local biennial conference will be held in Kassel, Germany on September 8-10, 2008 at the University of Kassel. The main focus will be on sustainable and energy efficient building design.

BauSIM2008 brings together practitioners, researchers and developers working in the field of building performance simulation and related applications.

The deadline for submitting abstracts is April 18, 2008. A number of selected contributions will be published in Bauphysik, one of Ernst&Sohn's journals.

For more information, please visit the conference website at http://bausim.ibpsa-germany.org.

6-7 November 2008
Lyon, France
http://conference2008.ibpsa-france.net

IBPSA France conference 2008
IBPSA France

IBPSA France's 2008 conference will be held at the Centre de Thermique de Lyon, France on 6-7 November 2008. The conference themes are:

- Building physics, including the transport of heat, moisture and air
- Heating, ventilation and air conditioning systems
- Renewable energy, energy storage, and CHP
- Thermal and visual comfort
- Air quality
- Control systems
- Recent developments in simulation, including user interfaces and methods for validation and calibration
- Optimisation and error correction
- Simulation case studies
- Energy-efficient building

Information about booking and other issues is available from the conference website at **http://conference2008.ibpsa-france.net**.

14-19 June 2009
Delft, Netherlands
www.sasbe2009.com/index.html

3rd CIB International Conference on Smart & Sustainable Building Environments
CIB

Are climate change and the depletion of natural resources a problem? Perhaps. We prefer to see them as the ultimate opportunity to do things right, the lever to propel sustainable development. We invite everyone to join us in presenting solutions rather than problems at SASBE2009.

Striving for efficiency has delivered performances close to 100%, but not in sustainability. We need to do things differently. Effectiveness before efficiency, creativity before directives.

The emphasis at SASBE conferences is on an integrated approach via different disciplines and different scales. SASBE2009 focuses on smart solutions for the built environment in a changing climate. It supports a positive approach that uses climate change and limited resources as a stimulus for better planning, design and construction, and the development of smart, clean and effective technologies, cradle to cradle.

Follow the example of a succession of great people who put sustainability on the political agenda and present the world with your own solutions at SASBE2009. Submit your paper, come to Delft from 15 to 19 June 2009 and join us in making the built environment a pleasant place for everyone.

Software news

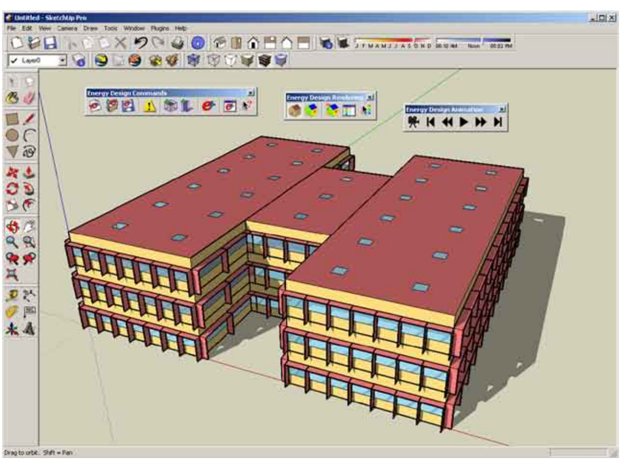
EnergyPlus Energy Design Plugin for Google SketchUp public beta release

Peter Ellis, NREL

DOE and NREL are pleased to announce the public beta release of the Energy Design Plugin—an EnergyPlus plugin for Google SketchUp. This can be downloaded for free from the EnergyPlus web site at **www.energyplus.gov/energy_design_plugin.html.**

The plugin makes it easy to create and edit the building geometry in your EnergyPlus input files. The plugin also allows you to launch EnergyPlus simulations and view the results without leaving SketchUp.

Designed to integrate seamlessly with the SketchUp environment, the plugin allows you to use the standard SketchUp tools to create and edit EnergyPlus zones and surfaces.



You can explore your EnergyPlus input files by using all of the native SketchUp 3D capabilities to view the geometry from any vantage point, apply different rendering styles, and perform accurate shadowing studies. The plugin allows you to mix EnergyPlus simulation content with decorative content such as background images, landscaping, people, and architectural finish details—all within the same SketchUp model.

The plugin adds the building energy simulation capabilities of EnergyPlus to the SketchUp environment. You can launch an EnergyPlus simulation of the model you are working on and view the results without leaving SketchUp.

Highlights of the beta version of the Energy Design Plugin include:

- The ability to create and edit EnergyPlus zones and surfaces
- The ability to launch EnergyPlus and view the results without leaving SketchUp

This plugin makes it easier to work with EnergyPlus. However, expertise in using EnergyPlus at the text level is highly recommended for performing successful and accurate simulations. The beta version of the plugin does not yet handle all critical input objects. Some editing of the input file will usually be required outside of SketchUp.

EnergyPlus version 2.2 now available

Dru Crawley, DOE

The latest release of the EnergyPlus building energy simulation program, Version 2.2, became available in early April. Key new features include a dual-setpoint humidistat, enhanced economizer controls, greater flexibility in specifying internal gains (i.e., people, lights, equipment) and ventilation/infiltration, a microturbine electric generator model, and upgrades to the equivalent one-diode PV model. We have updated and extended capabilities throughout the existing building envelope, daylighting, and HVAC equipment and systems portions of the program. The set of example input files now includes full-blown models of typical new construction (drawn from the DOE Commercial Benchmarks project).

Other new EnergyPlus features include:

DATA SETS

- Electronic enthalpy air-side economizer curves
- Microturbine electric generators

INPUT

- Design days now allow scheduled input for Beam and Diffuse Solar values
- Design days allow users to select periods from weather files to be used in design/sizing calculations

DAYLIGHTING

- Reference point Illuminance levels calculated by DElight now included in standard output variables

ZONE MODEL

- Internal gains can now be entered in intensity:
  - People can be entered as number of people, people/floor area or vice versa (area/person)
  - Lighting can be entered as total Watts, Watts/floor area or Watts/person
- Equipment (electric, gas, other) can be entered as Watts, Watts/floor area or Watts/person

NATURAL AND MECHANICAL VENTILATION

- Outside Air Controller now allows boosted air flow rates for high humidity control. A schedule may also be used to operate the outside air economizer based on a time-of-day schedule. Each of these features is also included in the controller for the stand-alone energy recovery ventilator.
- Infiltration can be entered as total volume, volume/floor area, volume/exterior surface area, or air changes per hour
- Ventilation, mixing and cross mixing can be entered as total volume, volume/floor area, volume/person, or air changes/hour

- Airflow network model now includes more coil types, including water cooling, water heating, detailed flat water cooling, multimode DX cooling, and multispeed cooling and heating
- Multiple infiltration and ventilation objects now allowed in each zone, and the temperature control limits for the ventilation object can now be scheduled (instead of constant)

HVAC

- Dual-setpoint humidistat with deadband now available
- Water heater volume and capacity can be autosized.
- Supply air fan operating mode (continuous versus cycling) can now be scheduled based on time-of-day for window air conditioner, packaged terminal heat pump and water-to-air heat pump
- New economizer controls added to Controller:Outside Air and Controller:Stand Alone ERV objects. New controls include Dew Point Temperature limit and Electronic (Variable) Enthalpy limit
- DX System (DXSystem:Airloop object) now allows cool-reheat dehumidification control type

ON-SITE ENERGY SUPPLY

- New operating scheme for electric generators to follow thermal loads
- New microturbine electric generator model
- Upgraded equivalent one-diode PV model to include options for BIPV and inverter

ENVIRONMENTAL IMPACTS

- Environmental emissions can now be scheduled for all fuel types

OUTPUT

- New detailed reports on Internal Gains (People, Lights, Equipment) as well as Simple Air Flow (Infiltration, Ventilation, Mixing, Cross Mixing) in the .EIO file
- New report variables for summed zone load components
- Added additional column in internal heat gains reporting that shows the sum of gains/floor area

UTILITIES

- Many enhancements in the IDF Editor and HVAC Diagramming tools

DOCUMENTATION AND GUIDES

- Input/Output Reference and Engineering Reference updated and extended for all new features and updates. Total documentation now exceeds 3700 pages

Improved warning messages to assist users, along with many other enhancements and speed improvements throughout. EnergyPlus v2.2 and more information about its new features are available at no cost from the EnergyPlus web site **www.energyplus.gov**.

Building Energy Tools Directory

Dru Crawley, DOE

The web-based Building Energy Tools Directory at **www.energytoolsdirectory.gov** contains information on more than 350 building-related software tools from more than 20 countries around the world. Haven't visited lately? Since October 2007, more than 10 new tools have been added. For each tool in the directory, a short description is provided along with information about technical expertise required, users, audience, input, output, validation, computer platforms, programming language, strengths, weaknesses, technical contact, availability and cost. A link is also provided for directly translating the web pages into more than 8 languages.

If you know of a tool (yours?) that isn't in the directory, send the information shown here: **www.energytoolsdirectory.gov/submit.cfm** in an email message to Dru Crawley at **Drury.Crawley@ee.doe.gov**.

NUMERICAL EVALUATION ON FLOOR COOLING CAPACITY IN AN AIRPORT

Bing Yu[1,3], J.P. Ruchti[1] and P.G. Luscuere[1,2]

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ABSTRACT

In the modern architectural design, large space open area is widely used, for example, atrium, airport, open office, etc. Radiation heat transfer provides better indoor thermal comfort and makes it possible to apply high temperature cooling and low temperature heating. This will lead to high energy efficiency. Water carrying radiation systems, e.g. cooling ceiling and floor heating system, become an applicable solution for a good indoor climate design.

The floor cooling is less effective than floor heating and can provide usually limited cooling capacity. In order to make a good design of floor cooling system, a theoretic method is described and the numerical evaluation of the cooling capacity is done. The influence parameters for the capacity, for example the distance between pipes, the length of one loop, the water flow rate and the supply water temperature, etc, have been analysed. It can be used for the correct estimation during the design phase.

KEYWORDS

Floor cooling, Capacity, Numerical evaluation, Airport

INTRODUCTION

Large space with open area is widely used in the modern architectural design, to realize such as atrium and halls. Especially, there is a lot of large open space in the airport. In the past, a lower ceiling will be placed to hide all the technical installations, such as pipes, ducts, cables, etc. Nowadays, steel structure is increasing popular. This means a very high roof in the space. Traditional conditioning method with hundred percent of air is not efficient in this situation.

Floor heating works perfect for the large floor area in the airport. Radiation heat transfer provides better indoor thermal comfort. In order to make use of the existed floor heating system, the concept of floor cooling is logically raised. It is supposed to work with supplied chilled water. Some of the airports, such as Suvarnabhumi airport, the new Bangkok International Airport, Thailand and the International Airport of Jeddah, Saudi Arabia applied floor cooling system to condition the indoor climate.

A previous research (Nisson, 1997) shows radiant floor piping can be used to cool a house, but it is only appropriate for dry climates. The floor temperature is held at 20°C by using either a small cooling machine (chiller) connected to the floor piping or the steady 13°C temperature of the ground by means of an earth loop. In most climates, the cool floor can be used to supplement or replace standard ducted air systems. However, in humid climates, problems with over-cooling the floor could lead to wet slippery surfaces and fungus growth.

Argiriou et al (2005) applied TRNSYS program to study the performance of a building with Absorption Heat Pump with floor heating/cooling system. The research was focussed on the application as well and used standard model of floor cooling which is integrated in TRNSYS. A validation on the floor cooling model with test chamber was done and a conclusion was drawn that the TYPE 160 module that was used in order to assess the performance of the total system seems to have systematically underestimated the particular experimental results.

Another researches look at the application of floor cooling system in the residential building as well (Hamada, et al. 2001, Lim, et al. 2003, Lim, et al. 2006).

Normally, floor heating will generate a good temperature gradient vertically because the warmer air will flow upwards. In certain application, floor will be used for both heating and cooling purpose due to the large space, e.g. at airport. The floor cooling will less effective than floor heating and can provide usually limited cooling capacity. This is due to the cold air will stay lower and close to the floor and therefore, the convective heat transfer is weaker than floor heating. This can be proved from the data of heat transfer coefficient for horizontal plate as well (ASHRAE handbook, 2005).

In this study, the authors build up the physical and mathematical model for the hall of Eindhoven airport. Based on the conservation equations, a simulation model is built with Matlab. The influences with the total length, distance between rows, supply water temperature, thermal radiation and water flow rate are analyzed by simulation.

A preliminary design proposal with a floor coling system is chosen as the reference. This has been evaluated and better solution is presented.

MODELING

A typical hydronic radiant floor system is usually placing the water pipe beneath the finished floor or screed floor. The pipe layer is shown in the Figure 1.

Figure 1. Example layout of hydronic radiant floor system (picture from Econosto)

For the application at Eindhoven airport, a preliminary concept is proposed with the section view as Figure 2. This is a system which the pipes are placed above the prefab board and then filling sand concrete above them.

The water pipe is installed inside the concrete layer of 80mm thickness. The centre of the pipe is (47+12) = 59mm below the floor.

Outside long diameter of the pipe is 24mm. The inner diameter is 19mm.

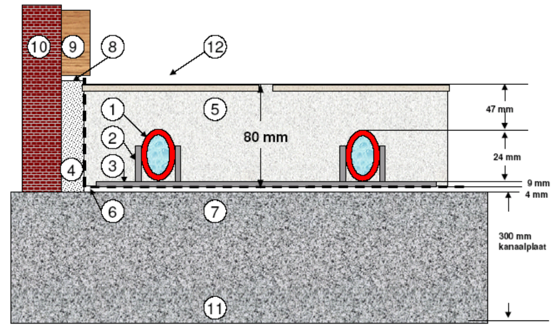


Figure 2. Floor cooling system

The heat transfer process occurs with the floor cooling system will involve several aspects: heat conductivity within the concrete floor; heat convection with the surrounding air; radiation from the floor to the other surfaces; and solar load falling on the floor surface.

The general scheme of the floor piping system is shown as Figure 3. The pipes are placed under the concrete layer with certain distance between different lines.

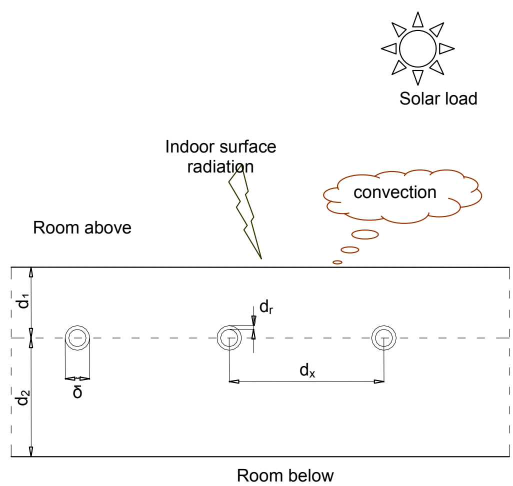
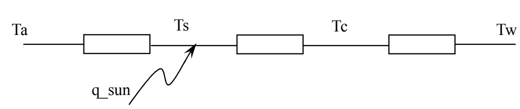


Figure 3. Scheme of the floor piping system with related to the surrounding

Energy conservation:



$$\dot{q}_c = \alpha_t (T_a - T_s) + \dot{q}_{sun} = U_t (T_s - \overline{T}_w) \qquad (1)$$

$$\alpha_t = 0.7(T_a - T_s)^{0.33} + 4\sigma\varepsilon C_r (T_s + 273.15)^3 \qquad (2)$$

$$U_t = (\frac{d_1}{\lambda_b} + R_w + R_r + R_z + R_x)^{-1} \quad (3)$$

$$T_s - \overline{T}_w = \frac{T_{wo} - T_{wi}}{\ln\left(\frac{T_s - T_{wi}}{T_s - T_{wo}}\right)} \quad (4)$$

$$T_{wo} = T_{wi} + (T_s - T_{wi})(1 - e^{-\frac{U_t A}{\dot{m} c_p}}) \quad (5)$$

Cr is the correction factor to correct the influence of the surrounding objects. In this study, Cr is chosen 0.85. If much furniture or fixed structure with surfaces is placed nearby the floor, the surface temperature will have big deviation from the air temperature and the Cr will be decreased. If large atrium is applied, Cr should be increased.

Total heat transfer coefficient analysis on distributed pipes

It is assumed that the distributed pipes will be simplified as a continuous functioning (concrete core) layer.

According to the theory by Koschenz and Lehmann (2000), the total heat resistance from the water supply temperature to the concrete core layer includes four items:

– Rx is the heat resistance which is supposed the whole plane of the concrete core is the same as the surface temperature of the register

– Rw is the heat resistance from the water to the inner surface of the register

– Rr is the heat resistance due to the conductivity of the wall of register

– Rz is the heat resistance due to the inconsistent temperature of the water in the register

$$R_t = R_x + R_w + R_r + R_z \quad (6)$$

Where

$$R_x = \frac{d_x \ln(\frac{d_x}{\pi\delta})}{2\pi\lambda_b} \quad (7)$$

This equation is a simplified version when $d_1/d_x > 0.3, d_2/d_x > 0.3$ and $\delta/d_x < 0.2$ .For most situation, these conditions are met.

$$R_w = \frac{d_x}{\alpha_w(\delta - 2d_r)\pi} \quad (8)$$

$$R_r = \frac{d_x \ln(\frac{\delta}{\delta - 2d_r})}{2\lambda_r \pi} \quad (9)$$

$$R_z = \frac{1}{2\dot{m}_{sp} c} \quad (10)$$

Heat transfer coefficient

[ASHRAE Handbook, 2005 Fundamentals] Convection from horizontal plates facing downward when heated (or upward when cooled) is a special case. Because the hot air is above the colder air, theoretically no convection should occur. Some convection is caused, however, by secondary influences such as temperature differences on the edges of the plate. As an approximation, a coefficient of somewhat less than half the coefficient for a heated horizontal plate facing upward can be used.

For large space floor cooling,

$$h = 0.7(\Delta t)^{0.33} \quad (11)$$

For force convection,

$$Nu = \frac{hl}{\lambda} = 0.037 \,\mathrm{Re}^{0.8}\, \mathrm{Pr}^{0.6} \quad (12)$$

SIMULATION CONDITIONS

The room temperature is 25°C and outside temperature is 30°C. Water supply temperature is 16°C.

The required cooling capacity of the floor pipe system is 25W/m^2.

A preliminary design has been proposed as:

- Length of one pipe: 180m
- The distance between center of the neighbor pipes: 30cm
- Water flow rate: 194 l/h

ANALYSIS AND DISCUSSION

Evaluation of the preliminary design

According to the information above, the following results will be achieved.

For the condition of no movement (no passenger), the natural convection will be applied based on the equation (1). The released cooling capacity is approximate 17W/m^2 and the return water temperature is about 20°C.

For the condition of 0.25m/s movement (some passengers walk relaxedly inside the airport), the released cooling capacity is about 18W/m^2 and the return water temperature is about 20.2°C;

For the condition of 0.5m/s movement (passengers keep moving), the released cooling capacity is about 19W/m^2 and the return water temperature is about 20.5°C.

Possible adaptations

Several adaptations can be chosen to improve the cooling capacity released from the floor piping system.

- Modification of the length of one loop;
- Modification of the water flow rate;
- Modification of the distance between the center of neighbor pipes;
- Change of the supply water temperature.

The following figures show the results with one variable and the rest keep the same as the preliminary design. Every adaptation will show for three type of movement above the floor.

Influence of length

The length of one pipe will influence the cooling capacity from the hydronic radiant floor system. The longer the length of one pipe is, the higher the water return temperature is and therefore, the mean temperature difference between air and water is smaller. It is clearly shown in the Figure 4 and 5 for the change of cooling capacity and water return temperature.

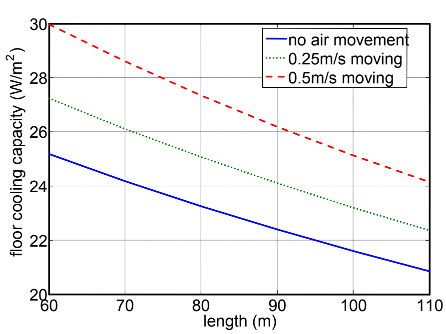


Figure 4. Variation of cooling capacity for different length of one pipe

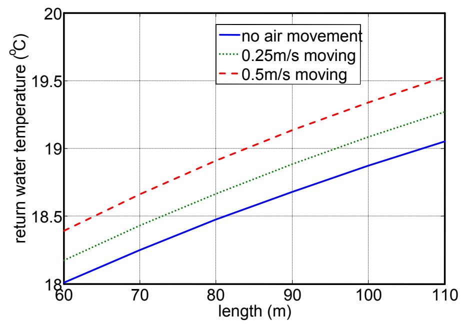


Figure 5. Variation of return water temperature for different length of one pipe

From the above shown results, it is clear that the length of the pipe should be decreased to 60 ~ 100m to get a 25W/m^2 cooling capacity for different movement condition.

Influence of water flow rate

The water flow rate will influence both the thermal performance and the hydraulic system. Higher water flow rate will lead to a higher cooling capacity. This can be found from the result of Figure 6. However, attention should be paid for a higher water flow rate because this might require a too large pump and therefore, it is not cost effective.

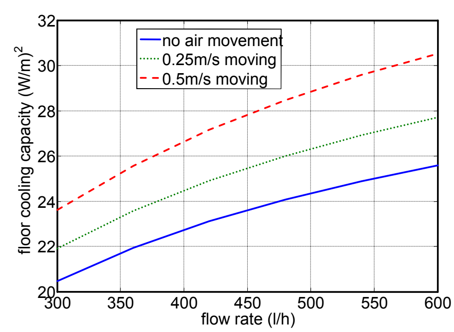


Figure 6. Variation of cooling capacity for different water flow rate

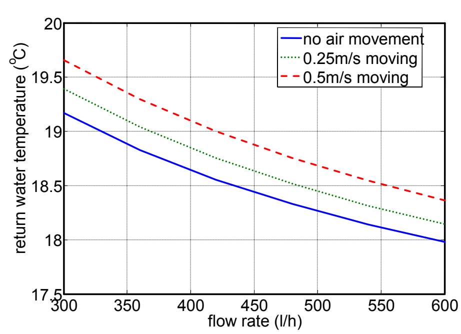


Figure 7. Variation of water return temperature for different water flow rate

From the above shown results, it is clear that the water flow rate should be increased to 540 ~ 340l/h to get a 25W/m^2 cooling capacity for different movement condition. This is about 1.7 ~ 3 times of the preliminary design.

Influence of distance between neighbor pipes

The distributed characteristic of the pipes will generate non-homogeneous temperature distribution horizontally. Figure 8 shows a result from CFD (Computational Fluid Dynamics) on one section along the pipe of floor cooling system. It can be clearly seen that the temperature increases circularly around the pipe and interferes with each other. If the distance between pipes changes, the homogeneous of the temperature at a horizontal level changes as well.

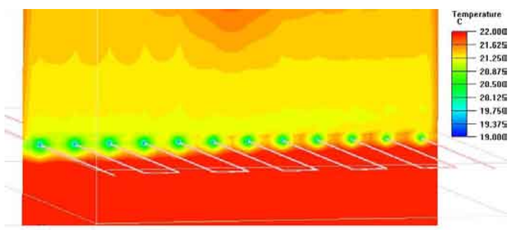


Figure 8. Section view of the temperature distribution along the pipe of floor cooling (an example)

The h.o.h (heart of heart) represents the distance between the centers of the neighbor pipes. It can be seen that the cooling capacity increases when the h.o.h decreases. And this will lead to the decrease of the water return temperature (Figure 10).

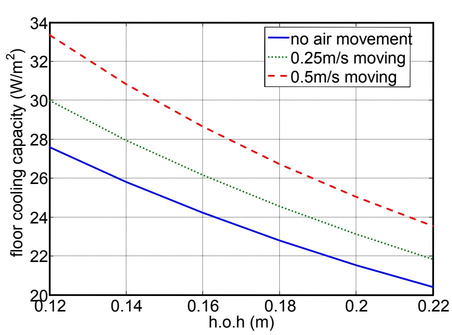


Figure 9. Variation of cooling capacity for different distance between neighbor pipes

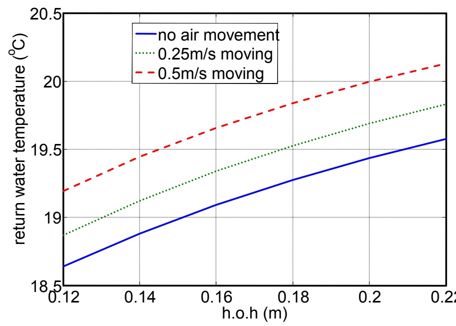


Figure 10. Variation of water return temperature for different distance between neighbor pipes

From the above shown results, it is clear that the distance between the pipes should be decreased to 0.15 ~ 0.2m to get a 25W/m^2 cooling capacity for different movement condition.

Influence of water supply temperature

Water supply temperature will influence the cooling capacity as well. When the supply temperature decreases, the temperature difference between the room air and the water will become bigger and therefore, more cooling capacity can be released to the room. This is almost a linear process (Figure 11). And the water return temperature will decrease following the trend as the supply temperature (Figure 12).

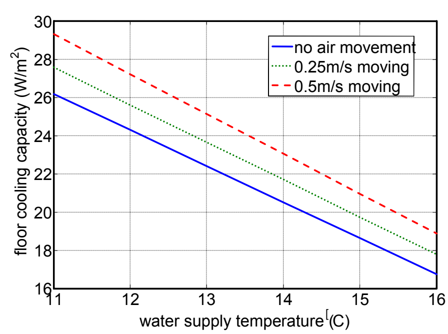


Figure 11. Variation of cooling capacity for different water supply temperature

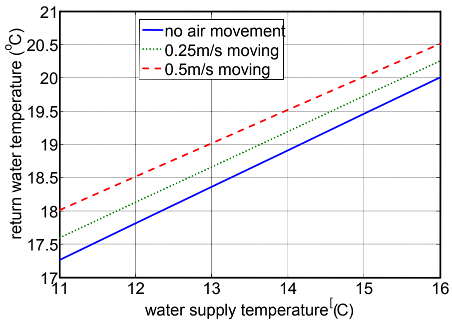


Figure 12. Variation of water return temperature for different water supply temperature

From the above shown results, it is clear that the water supply temperature should be decreased to 11.6 ~ 13.1°C to get a 25W/m^2 cooling capacity for different movement condition.

Influence of the solar radiation

The solar radiation falls on the floor will increase the cooling demand to the water pipe (therefore the central cooling machine) but release less cooling capacity to the air. This is because the solar radiation will be absorbed by the surface of floor and transferred quickly to the hydronic system. The water return temperature will be higher than the situation of no solar radiation. The mean temperature difference will be smaller and leads to less effective cooling capacity to the surrounding air.

Influence of radiation correction factor Cr

Cr is a correction factor to involve the effect of the temperature distribution of the surrounding surfaces. To explain it in a simple way, when most surfaces are far away from the cooling floor, Cr is closer to 1. In case, many surfaces are closer to the floor, e.g. much furniture stand above the floor, Cr is smaller than 1.

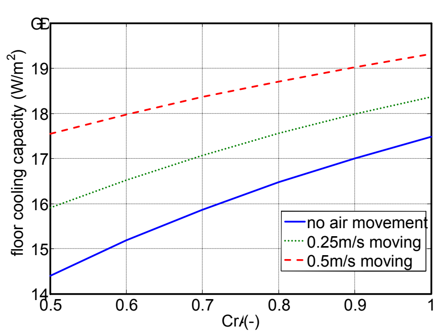


Figure 13. Variation of cooling capacity for different correction factor Cr

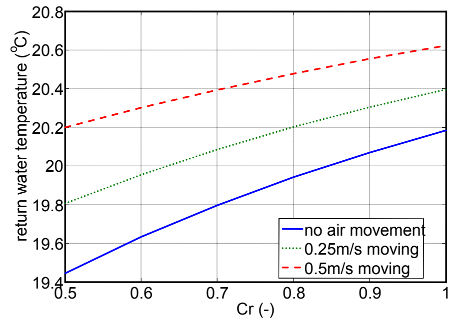


Figure 14. Variation of water return temperature for different correction factor Cr

From the above figures, it can be seen that Cr will correct a little bit on the cooling capacity but not dramatically. The change from 0.5 to 1 of Cr will lead to about 9% variation on the cooling capacity.

Influence of the movement

From Figure 4 to 14, all the results indicate the influence of the movement above the floor. It is clear that the moving of the passengers will give a positive effect to release more cooling capacity. In practice, when a lot of people are moving, more cooling is required. It happens barely that no movement occurs when the cooling is required.

CONCLUSIONS

The analytical model for the floor cooling system of the Eindhoven airport is built based on the conservation equations.

The preliminary design has been simulated and could not be able to deliver 25W/m^2 cooling capacity as expected from floor piping system.

Several parameters can be adapted to improve the cooling capacity:

- Modification of the length of one loop;
- Modification of the water flow rate;
- Modification of the distance between pipes (h.o.h);
- Change of the supply water temperature.

The influence from the above parameter as well as the other factors such as solar radiation and the movement of the passengers has been discussed. The introduced correction factor Cr has been analyzed and the result shows that Cr will lead to a bit change on cooling capacity but not dramatically.

It is possible to optimize all the parameters with the simulation model if an object such as total cost is defined.

NOMENCLATURES

q	Heat flux
α_t	Total heat transfer coefficient
T	Temperature
U_t	Total heat transfer coefficient of distributed pipes
σ	Stephen-Boltzmann constant
ε	Black body coefficient
δ	Diameter of pipe
R	Thermal resistance
d	Thickness; distance
λ	Thermal conductivity
A	Area
m	Mass flow rate
h	Heat transfer coefficient
Cp	Thermal capacity
Cr	Correction factor
Δt	Temperature different
Nu	Nusselt number
Re	Renolds number
Pr	Prandtl number

Subscriptions:

c	cooling
a	air
s	surface
w	water
i	inlet
o	outlet

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THE EFFECTS OF LEAKAGES IN ROOFS WITH VENTILATED AIR LAYERS - A CFD APPROACH

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ABSTRACT

The following paper is focused on hygrothermal behaviour of roofs with ventilated air layers subjected to air leakages in their internal decks (the internal partial construction located below the ventilated air layer). Possibilities of CFD modelling of such constructions are discussed in the first part of the paper including the problem of introduction of water vapour diffusion into calculation. A brief comparison of results from CFD analysis and from calculation based on a technical standard is also included. The main part of the paper includes a case study concerning various effects of leakages in three basic types of ventilated roofs. General conclusion discussing the significance of leakages is included in the final part of the paper.

KEYWORDS

CFD analysis, ventilated roofs, leakages, heat and moisture transfer, condensation risk

INTRODUCTION

Roofs with air layers ventilated by external air used to be recommended frequently as optimal roof constructions for buildings with moist internal microclimate in the past decades. Their incidence nowadays is not so large but they are still being built – and often still in the cases of swimming pools and similar buildings with complicated operation.

The hygrothermal behaviour of these constructions is strongly dependent on the tightness of the internal partial construction separating the ventilated air layer from interior. If this “internal deck” is sufficiently impermeable, the water vapour transport to the ventilated air layer is reduced and the air ventilation ensures that any remaining water vapour transferred into the construction is safely ventilated away without condensation. On the other hand, any leakage or crack in this part of the roof construction can lead to serious damages caused by the condensation on the upper cold deck (during the winter period with low external temperatures).

Calculation procedures for the assessment of ventilated roof constructions, which can be found in some technical standards (e.g. CSI 2005) generally do not consider the effects of local leakages and cracks. These simple calculation models are based on air pressure, heat and moisture balance equations in the air channel with transverse heat and water vapour flows. The solution is typically derived with the assumption that all the flows have two-dimensional characteristic only (Figure 1) and that these transport processes can be separated one from another and solved sequentially – starting from the solution of air pressure balance equation and ending with the solution of moisture balance equation. Theory for these simple models can be found for example in Hagentoft (2001).

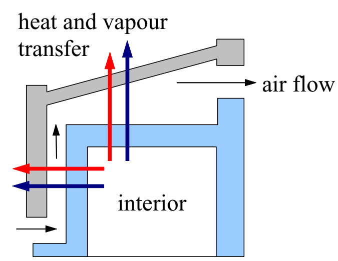

Figure 1 Simple model of a ventilated layer

The effects of leakages were not actually so important in the past when the thermal resistances of the internal decks were usually considerably lower than they are nowadays. The air layers were due to that fact warmer and the condensation risk in the cold winter days was not so high. Contemporary ventilated roofs with high thermal resistances are in much more condensation risk and should be preferably evaluated by means of more advanced calculation procedures such as computational fluid dynamics (CFD) modelling – especially in the cases of spatially complicated roofs.

The objective of this paper is to present the possibilities of this calculation technique for the modelling of hygrothermal behaviour of ventilated roof constructions - including the effects of various leakages in their internal decks. However, the use of CFD approach for this purpose brings also some problems, which should be discussed first.

WATER VAPOUR DIFFUSION IN CFD

The possibilities of CFD modelling are generally very extensive. On the other hand, the time necessary for the calculation can be quite long and sometimes even unacceptable for the common design practice.

In the case of sloping roof constructions, the desirable simplification of the calculation model (which leads to faster calculation) is hardly reachable because all the sloping layers must be modelled – and that results in high number of unknown values.

Nevertheless, far more important problem is the fact that CFD programs generally do not calculate the water vapour diffusion through the building constructions (or in more general terms: through materials). The modelling of water vapour condensation and evaporation is usually also limited to some basic cases (e.g. condensation or evaporation over the surface of a planar region with known, constant surface humidity). Interstitial water vapour condensation in building constructions is also typically excluded from CFD calculations.

These drawbacks can be bypassed in various ways – usually depending on the software being used. Various researchers already dealt with the most important problem – the modelling of water vapour diffusion – and presented some interesting solutions. One of the most motivating was the idea of replacing the materials being exposed to water vapour diffusion by "immobile fluids" with known water vapour diffusion coefficients (Mortensen et alt. 2005). Unfortunately, such idea is not applicable to all CFD programs. The other possibility, which is more generally usable, is to model the water vapour flow rate through the internal deck by means of a planar source of moisture. This source should be placed on the external surface of the internal deck and its capacity should be calculated, which is not so simple because the water vapour flow rate depends also on the unknown values of air temperature and humidity in the ventilated air layer. Not all CFD programs offer satisfying procedures how to handle this problem. For example, there is a possibility to enter the moisture source as a linear source in the commonly used CFD program Flovent 6.1 (FLOMERICS 2005) but the built-in equation for this type of source is too simple:

$$g_d = \beta \cdot (x_s - x_a) \qquad (1).$$

Equation (1) assumes that the temperature and relative humidity on the surface of the moisture source is constant, which means that the user can enter the water vapour content of air x_s as known input value. This is sufficiently correct in cases when the moisture source is connected to a large mass with high thermal inertia (e.g. water pool). The case of the ventilated roof is different because temperature and relative humidity vary over the surface of the roof's internal deck, and therefore the water vapour flow rate (or the capacity of the moisture source) should be calculated from general equation

$$g_d = \frac{p_i - p_a}{Z_{pI}} \qquad (2),$$

which can be also expressed using the water vapour contents of air as

$$g_d = \frac{R_{H_2O}}{Z_{pI}} \left(x_i T_i \rho_i - x_a T_a \rho_a \right) \qquad (3).$$

Subscripts i and a stand for the internal air and for the air in the ventilated air layer respectively. Comparing equations (1) and (3), one can see that the temperature dependence is missing in equation (1) (dependence on the air density can be neglected in common tasks due to its minor influence). Fortunately, this difficulty is not fundamental in many cases. If one accepts results with a certain safety margin, it is possible to calculate the water vapour flow rate from equation (2) with the initial assumption that the air in the ventilated air layer has the properties of the external air. Such assumption leads to higher resulting water vapour content of air in the ventilated air layer, which is quite acceptable if the results are used mainly to check the quality of the roof design.

Results that are more exact can be obtained by means of iteration with the water vapour flow rate calculated in one step after another using the results (temperature and relative humidity of the air in the ventilated layer) from previous steps. The convergence of this process is quite rapid even for the roofs with low diffusion resistance of the internal deck situated above moist internal environment. Figure 2 shows results of iteration for a simple ventilated roof with U-value of the internal deck 0.13 W/(m^{2}K) and low equivalent diffusion thickness s_d of 4.5 m (Figure 3). The following boundary conditions were considered: air volume flow of 0,019 m^3/s in the ventilated air layer, outdoor air temperature -15 ˚C and relative humidity 84 %, indoor air temperature 20 ˚C and relative humidity 90 %. All results were obtained by means of 3D calculation using LVEL k-ε turbulence model with total number of 261 000 grid cells.

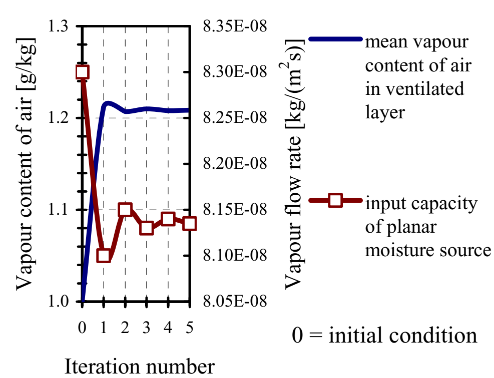

Figure 2 Iteration results for the test case

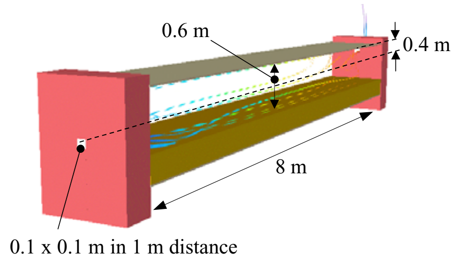

Figure 3 Simple ventilated flat roof

The last thing to mention is that equation (2) is valid only when no condensation occurs in the internal deck - but this condition can be usually satisfied with no major problems.

STANDARD AND CFD ANALYSES

Interesting issue is a comparison between the results of CFD analysis and the results of commonly used simple procedures from technical standards. This comparison is highly important mainly for building design practitioners who are usually familiar only with the standard methods accepting them as a verified tool for the evaluation of ventilated roofs.

The correspondences and differences between both approaches can be clearly shown on the basic type of ventilated roof (Figure 4). The hygrothermal behaviour of this roof depends mainly on thermal and diffusion resistances of its internal deck, on vertical distance between openings and on the wind velocity.

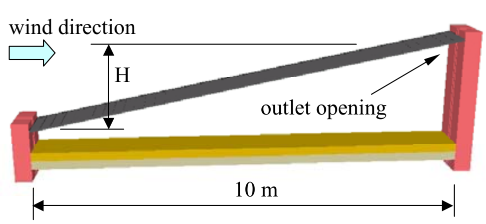

Figure 4 Basic type of a ventilated roof

In the parametric study, both geometry of the ventilated air layer and the size of openings (0.1 x 0.1 m in the distance of 1 m) were considerer the same for all test cases. Boundary conditions were also identical (internal air: 21 °C and 50 %, external air: -15 °C and 84 %). Thermal transmittance of the internal deck was variable as well as the vertical distance between openings. Both openings were taken as completely open and resistance-free in order to avoid the differences due to different modelling of air flow resistances.

The temperature and relative humidity of air in the centre of outlet were studied. The first compared method was CFD analysis (FLOMERICS 2005) using 3D LVEL k-ε turbulence model with total number of 278 000 grid cells. The second analysed method was standard simple calculation based on CSI 2005. The results are summarised in Table 1. It is apparent that in most cases the standard procedure gives less positive, more "secure" results with higher relative humidity of air (note especially the cases with calm external air). On the other hand, the results of the standard method are more optimistic for higher wind velocities (2 m/s and above). The best agreement between both compared methods can be found for the wind velocity around 1 m/s. It is worth a note that very similar results can be obtained also for other basic types of ventilated roofs (Svoboda 2006).

The differences in results are caused by the fact that the standard procedure does not take into account the air flow in the ventilated layer in all its complexity, including for example the heat conduction through walls (Figure 5).

The spatial distribution of water vapour content of air is also worth a brief mention. Figure 6 shows that the humidity field in the ventilated air layer is dependent on the wind velocity in the same way as the temperature field (Figure 5). However, the scale on Figure 6 indicates that the differences among various values of water vapour content of air in the ventilated layer are almost negligible. Besides, the water vapour content of air in all parts of the ventilated layer is

Table 1 Results of comparative calculation (CFD versus standard procedure)

VERTICAL DISTANCE (INLET/OUTLET)	U-VALUE OF THE INTERNAL DECK	WIND VELOCITY	TEMPERATURE OF AIR AT THE OUTLET		RELATIVE HUMIDITY OF AIR AT THE OUTLET	
H	*U*	*v*	*θ* [°C]		*φ* [%]	
[m]	[W/(m².K)]	[m/s]	CFD	CSI	CFD	CSI
1.0	0.4	0.0	-6.6	-10.1	48	51
		1.0	-10.5	-10.4	58	58
		2.0	-11.8	-11.1	65	61
	0.2	0.0	-9.5	-12.2	64	73
		1.0	-11.9	-12.4	67	70
		2.0	-13.1	-12.8	72	71
	0.1	0.0	-11.1	-13.5	71	85
		1.0	-13.1	-13.6	74	78
		2.0	-13.8	-13.8	76	78
2.0	0.4	0.0	-8.3	-10.2	53	58
		1.0	-10.9	-10.5	60	60
		2.0	-12.2	-11.1	67	61
	0.2	0.0	-10.3	-12.2	63	71
		1.0	-12.3	-12.4	69	70
		2.0	-13.2	-12.8	73	71
	0.1	0.0	-11.5	-13.5	69	81
		1.0	-13.4	-13.6	76	78

		2.0	-14.0	-13.8	78	78

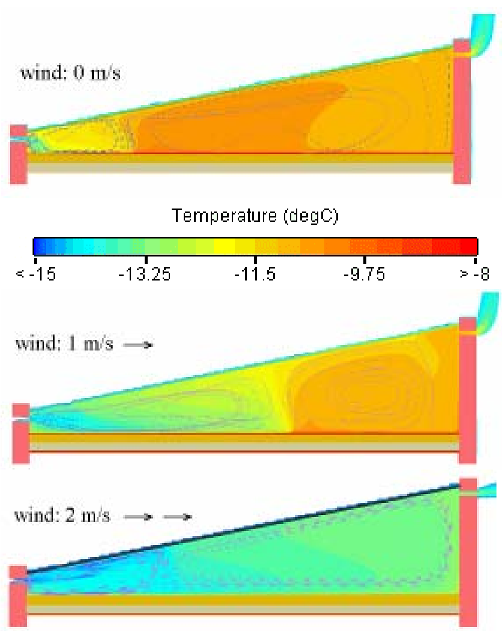

Figure 5 Temperature field and air flow paths in the ventilated layer of the roof with vertical distance between openings H=2 m and U-value of the internal deck 0.2 W/(m^2·K)

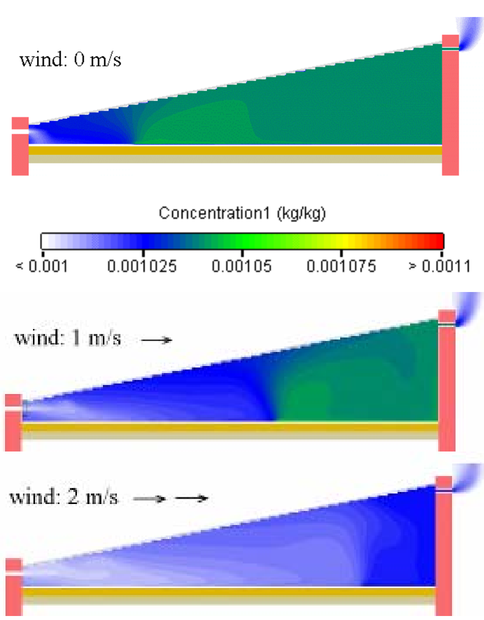

Figure 6 Field of water vapour content of air in the ventilated layer of the same roof as on Figure 5

only slightly above 1 g/kg which is the value corresponding to the water vapour content of the external air. This fact is one of the signs of a proper design of the chosen model roof.

The water vapour content of air in the ventilated layer would be significantly higher in the case of insufficiently ventilated air layer and/or permeable internal deck. Leakages in roofs are particularly important and deserve a deeper investigation.

EFFECTS OF LEAKAGES

Leakages with their influence on the overall hygrothermal behaviour of building constructions are subject of many recent studies (Wahlgren 2002, Serkitjis et alt. 2002, Ge and Fazio 2004, Ciucasu et alt. 2005, Svoboda 2006). Most of these studies deal with the thermal effects of leakages but that does not mean that the influence of leakages on the moisture distribution is less essential. On the contrary, because the air flow is able to transport high amounts of water vapour through the construction and this can subsequently induce interstitial condensation with very high condensation rates in the periods with low external temperature. This can even lead to serious damage of such permeable and/or leaky construction.

In the case of flat roofs with ventilated air layers, leakages usually cause heavy local condensation on the internal side of the upper deck (part of the roof with waterproof membrane situated above the ventilated air layer). The condensate can even freeze to this surface creating ice coatings, sometimes with local "stalactites". These ice layers often melt away quite quickly during warmer days and this usually means that all the water drops down in droplets to the thermal insulation and occasionally even through it to the internal surface of the roof. If the external temperature is higher (slightly above 0 °C) the condensate is not transformed to ice but falls down in droplets right away if its amount is sufficient. Such effects have been recognised as the cause of failures of many roofs.

SIMULATION: A CASE STUDY

Numerical analysis of hygrothermal effects of the leakages in ventilated roofs must be based on a complex model taking into account three-dimensional heat, air and moisture transfer. CFD modelling is a suitable tool for this purpose (although it has still some drawbacks like already discussed modelling of water vapour diffusion). The following case study shows the influence of various leakages on the hygrothermal behaviour of three basic types of ventilated flat roofs (Figure 7). All results were calculated by means of CFD software Flovent 6.1 (FLOMERICS 2005) for the following boundary and other conditions and model settings:

- external air temperature -15 °C and relative humidity 84 %;
- internal air temperature 28 °C and relative humidity 70 % (e.g. swimming pool);

- surface thermal resistances 0,04 m^2K/W (external surface) and 0,10 m^2K/W (internal surface);

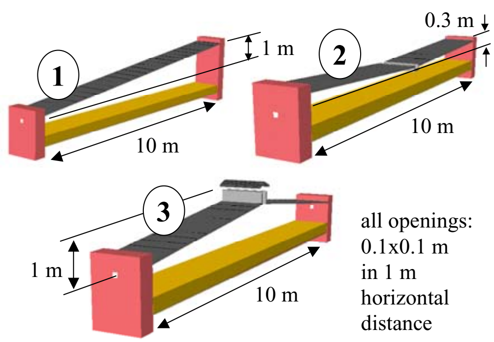

Figure 7 Three types of analysed roofs

- internal (lower) deck with thermal transmittance $U = 0.13$ W/(m^2K) and equivalent diffusion thickness $s_d = 85$ m;
- external (upper) deck with thermal transmittance $U = 4.10$ W/(m^2K) and equivalent diffusion thickness $s_d = 250$ m;
- area of openings to the ventilated air layer 2 x 0.01 m^2 (inlet and outlet) in the distance of 1 m;
- ventilated air layer with no partitions;
- 3D calculation with LVEL k-ε turbulence model;
- calculation models with total number of grid cells from 280 000 up to 850 000 (typical calculation times ranged from 50 to 220 minutes).

The boundary conditions described above were applied to all calculation models according to Figure 8. The capacity of planar moisture source was derived from equation (2) as $5.7 \cdot 10^{-9}$ kg/(m^2.s).

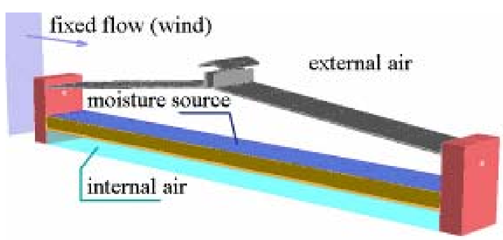

Figure 8 Location of boundary conditions

The mean values of air temperature and water vapour content of air in the ventilated air layer were registered during all calculations as well as the air temperature and water vapour content of air in the centre of the internal face of outlet.

Relative humidity of the air was derived subsequently from these values. Such simple approach is usable without inaccuracies for the cases with relative humidity lower than 100 %. However, it was also necessary to proceed in the same way in the cases with the air saturated by water vapour. When this happens in the real ventilated roof, the water vapour condensates on most surfaces located in the ventilated air layer. Due to this condensation, the water vapour content of air is never higher than the value corresponding to the relative humidity of 100 % for the given temperature. Unfortunately, such complex process is still impossible to simulate in most CFD software packages. Typical result from a CFD analysis is a spatial field of water vapour content of air calculated without the effects of condensation. Therefore, the final values of water vapour content can be higher than it is possible (they can indicate higher relative humidity than 100 %). Nevertheless, if the purpose of the calculation is just verification of design correctness, such "minor" inaccuracies can be neglected as far as the exact calculated value of water vapour content is not the main issue.

The following states of operation were analysed:

- completely impermeable internal deck;
- internal deck with small leakages regularly distributed over its area;
- internal deck with one single leakage located either near inlet or centre or outlet.

Table 2 Results of the case study

CASE	MEAN VALUES IN THE VENTILATED AIR LAYER			VALUES IN THE CENTRE OF THE OUTLET		
	θ_{am} [˚C]	x_{am} [g/kg]	φ_{am} [%]	θ_a [˚C]	x_a [g/kg]	φ_a [%]
Roof 1 : no wind effect						
A	-10.50	1.004	58.6	-9.53	1.005	54.3
B	-10.42	1.034	59.9	-9.48	1.042	56.1
C	-10.16	1.344	76.3	-9.46	1.351	72.6
D	-10.15	1.455	82.5	-9.23	1.473	77.7
E	-10.36	1.382	79.7	-9.04	1.567	81.4
Roof 2 : no wind effect						
A	-9.77	1.012	55.7	-7.73	1.014	47.6
B	-9.69	1.081	59.1	-7.61	1.104	51.3
C	-7.95	3.097	100	-7.17	3.691	100
D	-7.70	3.154	100	-6.80	3.721	100
E	-8.96	2.271	100	-5.00	3.904	100
Roof 3 : no wind effect						
A	-11.92	1.002	65.5	-11.49	1.002	63.2
B	-11.84	1.066	69.2	-11.41	1.071	67.2
C	-10.88	1.755	100	-10.73	1.796	100
D	-10.79	1.762	100	-10.65	1.853	100
E	-11.52	1.313	83.0	-9.08	2.243	100

Key: A = impermeable internal deck
B = regularly distributed small leakages
C = one leakage located either 2 m from inlet (roofs 1 and 2) or 1 m from inlet (roof 3)
D = one leakage located between inlet and outlet

E = one leakage located either 1 m from outlet (roofs 1 and 2) or under it (roof 3).

The area of leakages was taken as 0.005 % from the total area of the internal deck in all cases. This percentage had been chosen as realistic low value in order to simulate the leakage area usually observed on existing roofs. All leakages were modelled as holes with planar flow resistances corresponding to 70 % of open space. The rule of minimum number of 4 grid cells in the horizontal section through the holes was applied to all models.

Results of the case study for the assumption of calm external air are presented in Table 2. Temperature fields and distributions of water vapour content of air for the model roof no. 3 can be seen on Figures 9 and 10. Interesting issue is the wind effect, which can be explored in Table 3 and on Figures 11 and 12. The area of the upper deck threatened by the surface condensation is also worth attention (Figure 13).

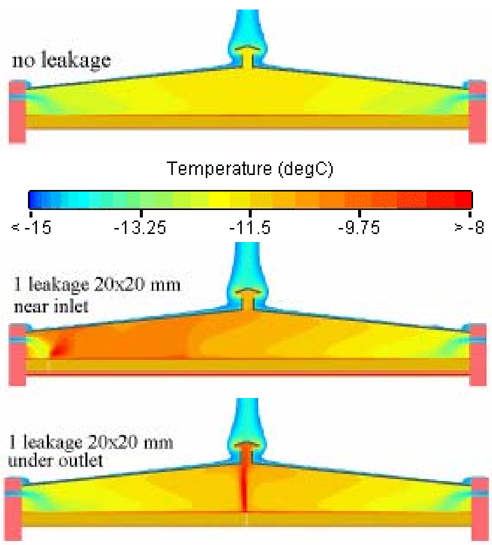

Figure 9 Temperature field in the ventilated layer of the model roof no. 3

ANALYSIS OF RESULTS

Several conclusions can be derived from the results:

- any leakage in the internal deck of the ventilated roof leads to higher temperature and relative humidity of air in the roof's ventilated layer;
- high number of very small leakages is not so dangerous as one single hole of the same area;
- striking hygrothermal effects can be observed even for small local leakages with cross-section 20 x 20 mm and less;
- position of local leakages has significant effect: mean relative humidity of air in the ventilated layer is generally the highest if the leakage is located in the centre of the distance between inlet and outlet;
- water vapour content of air reaches its peak when the single local leakage is situated near the outlet because in this case the water vapour does not have

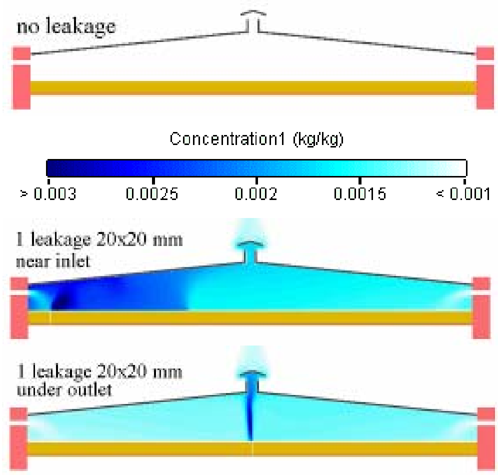

Figure 10 Distribution of water vapour content of air in the ventilated layer of the model roof no. 3

opportunity to disperse more regularly around the ventilated layer;

- better ventilation does not necessarily mean safer roof: higher air flow rate in the ventilated layer usually leads to greater pressure difference between interior and the ventilated layer (with underpressure in the ventilated layer) and this results in higher heat and water vapour transfer through the leakages (or in other words: in higher exfiltration); another reason is the fact that more ventilated air layer is also colder and is able to absorb less water vapour before saturisation (compare results for Roof 1 and Roof 3 in Table 2);
- however, the worst case is usually a flat roof with very low air flow rate (Roof 2): higher mean air temperature is not sufficient safety factor to avoid massive condensation risk on the whole surface of the upper deck if the roof's internal deck is not perfectly impermeable (Figure 13);
- wind effect is usually positive: water vapour content of air in the ventilated layer is reduced as well as relative humidity of air in spite of lower mean air temperature (the decrease of water vapour content is more influential);

Table 3 Results for Roof 3 subjected to wind

CASE	MEAN VALUES IN THE VENTILATED AIR LAYER			VALUES IN THE CENTRE OF THE OUTLET		
	θ_{am} [°C]	x_{am} [g/kg]	φ_{am} [%]	θ_a [°C]	x_a [g/kg]	φ_a [%]

Roof 3 : wind 1 m/s						
B	-13,43	1,031	76.1	-13.09	1.031	74.0
C	-12.49	1.424	97.3	-12.42	1.430	97.2
D	-12.48	1.433	97.9	-12.25	1.435	96.2
E	-12.80	1.233	86.4	-12.36	1.446	97.8

Key: see Table 2

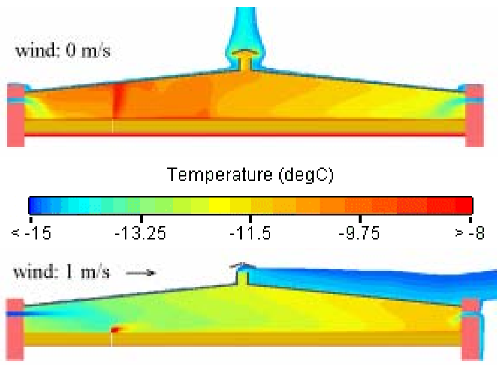

Figure 11 Temperature field in the model roof no. 3 – illustration of wind effect

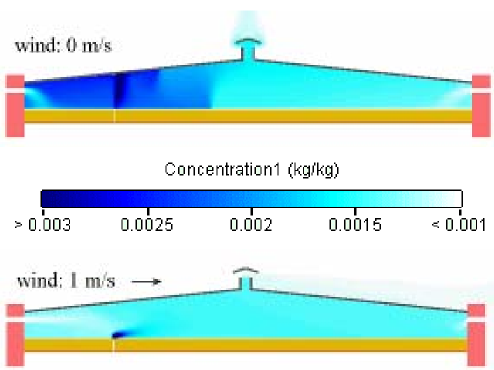

Figure 12 Field of water vapour content of air in the model roof no. 3 – illustration of wind effect

- area of the roof's upper deck subjected to high condensation risk depends on the position of the local leakage: this area is generally larger if the vertical distance between the upper deck and the leakage is low (which usually happens if the leakage is located near the inlet); the surface area threatened by the condensation is also significantly influenced by the circular characteristic of the air flow in the ventilated layer (compare Figure 5 and Figure 13).

CONCLUSION

The air-tightness of the internal deck is a factor of high importance for every ventilated roof. Any leakage can lead to air infiltration or exfiltration and subsequently to significant modifications in the temperature and relative humidity fields. The results of such deformations in the temperature and water vapour distribution include not only increase of the heat loss but in the case of air exfiltration also substantial increase of the water vapour condensation risk. The final effects can be very severe, especially in specific conditions (e.g. in buildings with moist internal microclimates) as presented here. Higher moisture transport through the permeable construction can easily lead to surprisingly rapid damage beyond all design assumptions. Maximum air-tightness of the vapour barrier and other airtight layers is therefore almost obligatory.

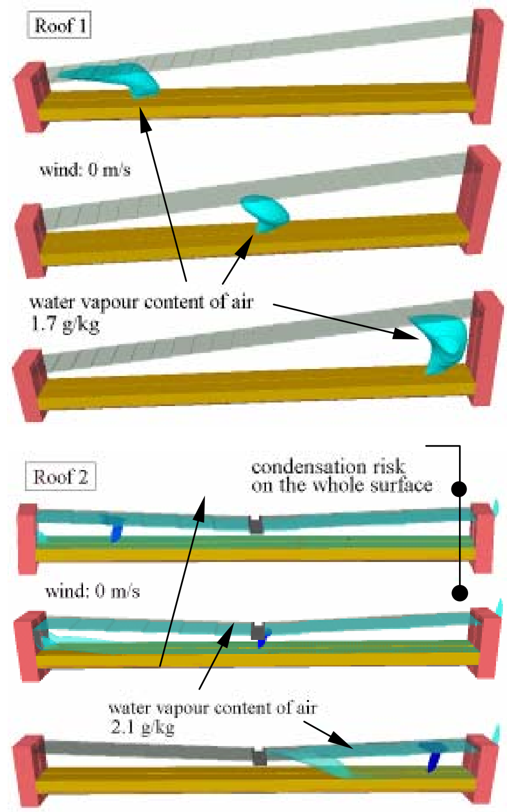

Figure 13 Iso-surfaces indicating high condensation risk on the internal surface of the upper deck

Numerical evaluation of permeable and/or leaky ventilated roofs is the task, which cannot be accomplished using common simple procedures from technical standards. One possibility how to solve such problems is to use sophisticated CFD software tools. In spite of some difficulties regarding especially the introduction of water vapour diffusion into CFD calculation, contemporary CFD programs are able to simulate complex transfer processes in ventilated roofs. Their use in the roof design is particularly appropriate in the cases of spatially complicated roofs.

ACKNOWLEDGMENT

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NOMENCLATURE

g_d water vapour flow rate [kg/(m²·s)]

p partial water vapour pressure in air [Pa]

R_{H2O} gas constant of water vapour [J/(kg·K)]

T thermodynamic temperature [K]

U thermal transmittance [W/(m²·K)]

v wind velocity [m/s]

x water vapour content of air [kg/kg]

Z_{pI} diffusion resistance of the internal deck [m/s],

β vapour boundary transfer coefficient [kg/(m²·s)]

φ relative humidity [%]

θ temperature [°C]

ρ air density [kg/m³]

substripts:

a air in the ventilated air layer

i internal air

m mean value

s external surface of the internal deck

Development of support tool for outdoor thermal environmental design of urban/building using numerical analysis

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ABSTRACT

The purpose of this study is to develop a thermal design tool for architectural designer by combining a heat balance simulation for urban surfaces, including buildings, the ground and greenery, with a 3D-CAD. This tool is constructed by improving the previous simulation model, which uses the Geographic Information System for the input data. The simulation algorithm is improved so as to predict the surface temperature distribution of urban blocks while taking into account the actual design of the outdoor space using the 3D-CAD system. A pre-post processing system using all-purpose 3D-CAD software is developed. The results obtained by applying this simulation tool to an area of detached houses reveals that the tool is able to simulate the effects of building shape, materials, and tree shade on the surface temperature distribution, as well as the MRT and HIP, which are evaluation indexes of the urban thermal environment.

KEYWORDS

Thermal environment, Surface temperature,Environmental design tool, Numerical simulation, 3D-CAD

1. INTRODUCTION

Urban Heat Island Phenomena is an urban environmental problem that is attracting public attention in Japan. Under such circumstances, the central government of Japan adopted the Heat Island Countermeasure Scheme in March of 2004. Consequently, both the central government and local governments are now considering the introduction of heat island mitigation policies when promoting urban regeneration. Urban development and building design considering the urban thermal environment has become of interest. Architectural designers would then be able to evaluate proposed designs on not only the architectural design, but also on the design's thermal impact.

In recent years, the availability of numerical simulation tools for evaluating the urban thermal environment that can be implemented using personal computers has increased gradually. For example, ENVI-met (Bruse M, Fleer H. 1998)(Anon), provided as freeware on the web, is a three-dimensional microclimate model, based on computational fluid dynamics (CFD), designed to simulate micro scale interactions between urban surfaces, vegetation and the atmosphere in an urban environment.

In the present study, we develop a thermal design tool for use in planning outdoor spaces by combining a heat balance simulation for urban surfaces, including buildings, the ground and greenery, with a 3D-CAD system implemented on a personal computer.

2. OUTLINE OF SIMULATION TOOL DEVELOPMENT THAT INCORPORATES A 3D-CAD SYSTEM

2.1 Concepts of the support tool

The three followings are important features of developing the thermal design tool of thermal environment for architectural designers.

i) The simulation tool allow to predict a thermal influence of the buildings designed by designers

An outdoor surface temperature is dependent upon spatial forms and materials such as outdoor object shapes, building and ground materials and a tree's crown. If the tool allows to reproduce the outdoor spatial forms and to predict thermal impact, Designers are able to evaluate proposed designs on not only the architectural design, but also on the design's thermal impact.

ii) The input and pre-processing method using the 3D-CAD system and the GUI.

It is important to build the interface for designer in order to integrate environmental simulations into architectural design and urban planning in practical business, at present, no environmental design tools that use 3D-CAD systems. The input and pre-processing method using the 3D-CAD system is developed. It can connect the design parameters such as building shape, material, tree, and the calculation parameters of heat transfer analysis such as coefficient of thermal conductivity and volumetrically specific heat

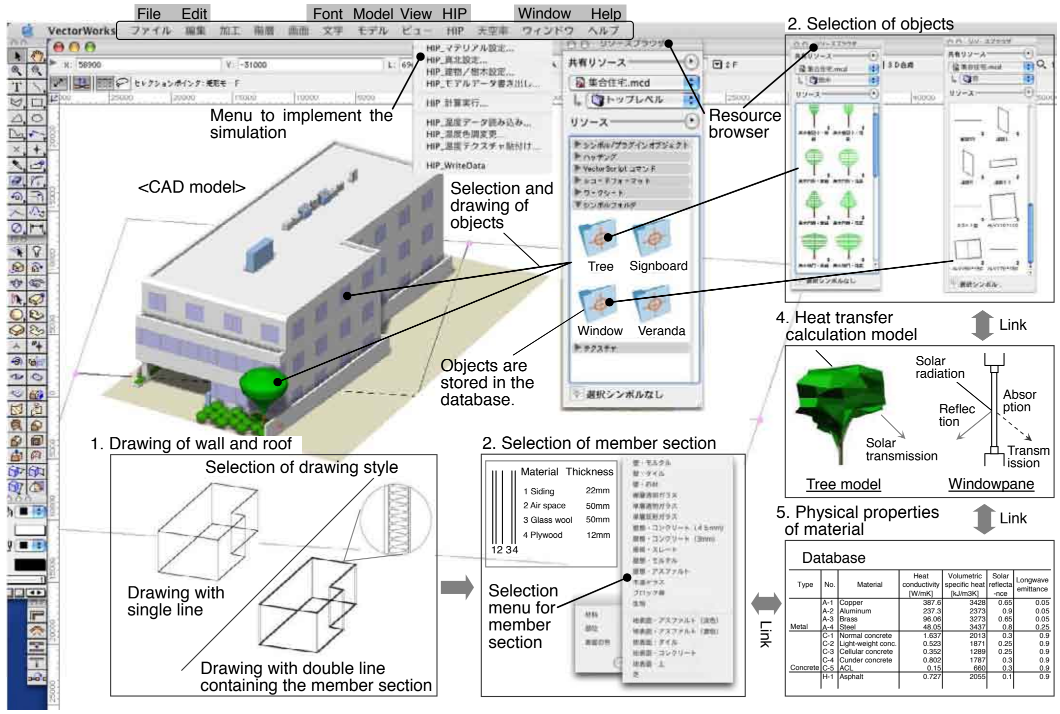

Figure.1 Input and pre-processing method using the CAD software interface

iii) Visually expressing the results of the calculations This allow the designer to understand and evaluate the effects of spatial forms and materials on the outdoor surface temperature.

2.2. Assessment of the requirements for development of the simulation system

This simulation model is mainly constructed by heat transfer calculation models, which are generally used for thermal environment simulations, following the fundamental formula of surface heat balance. The fundamental algorithm of this simulation model was then constructed in the previous study (Iino A, Hoyano A. 1998) by the authors group, using measured data obtained by airborne remote sensing, so that the present paper focuses on the following two important aspects. One is the simulation algorithm to realize the heat balance calculation in an outdoor space having a detailed spatial geometry, and the other is an integration method of heat balance simulation with a 3D-CAD system for use as a practical tool. The prediction of local air temperature and humidity will be considered in a future study, whereas the present study deals with the prediction of the surface temperature distribution.

In the previous simulation model (Iino A, Hoyano A. 1998), the building geometry is simply modeled by entering the building height information into the 2D-plan data derived from GIS data. In addition, input and output processes are based on manual operation, depending on the experience and specialty of the user. In order to improve the previous system to predict the surface temperature distribution using the all-purpose 3D-CAD, the following features should be examined in developing the simulation tool:

(1) The input and pre-processing method using the CAD system and the GUI.

(2)The database linking the design parameters and the parameters for the heat transfer calculation

(3) The simulation algorithm is improved to further reduce the calculation time and PC memory required for the simulation, allowing the system to be run on a personal computer.

(4) Establishment of the simulation parameters and the system

(5) A method for visually expressing the results of the calculations via 3D-CAD.

3. INTEGRATION OF THE SIMULATION MODEL WITH THE 3D-CAD SYSTEM

3.1. Input and pre-processing method using the 3D-CAD system

In order to develop a simulation tool for designers, the input and pre-processing method of this tool are developed using the features of the CAD system and the GUI. Figure 1 illustrates the input and pre-processing method using the CAD software interface. Buildings and trees are drawn using 3D objects. The drawing line style is selected as either single line or double line containing the building member section. The important parameters for reproducing the shapes of trees are height, width, crown shape, and height under the crown. Ground cover is drawn using 2D objects. Users can input or select component materials and building members, such as walls, roofs and veranda, with the aid of various dialog boxes and databases.

The following data are stored in the "Spatial Component Database": (a) Buildings: building structures, building members, and component materials (b) Trees: species (c) Ground: ground cover and its inner component.

The parameters for the heat transfer calculation, including the physical properties of materials and the heat transfer calculation models, are then automatically selected and determined from the aforementioned parameters and the following databases. The physical properties of materials are stored in a "Material Database". Objects that require specific modeling of heat transfer, for example rooftop lawns and water-permeable pavement, are also included in the “Heat Transfer Calculation Model Database”.

3.2. Method of generating the 3D-mesh model for calculation

The CAD models generated by the above process are then transformed into a 3D-voxel mesh model that includes the calculation parameters required for heat transfer analysis. Figure 2 illustrates a schematic diagram of the conversion method. The 3D-CAD model is sectioned horizontally at a certain height, and a horizontal section of the CAD model is then generated. The 2D figure data of the section is then transformed into mesh data. This process is repeated automatically from the bottom to the top of the CAD model at an interval of the mesh size. Consequently, the 3D-voxel mesh model is completed. The calculation point is set for all of the meshes, and the calculation parameters (component materials, normal direction of the mesh surface, etc.) input during the aforementioned process are automatically stored in the 3D-mesh model. Tree mesh models are also generated by the same process.

3.3. Heat balance calculation method reproducing spatial geometry

The heat balance calculation for predicting the surface temperature of each mesh is performed as described below. In the developed calculation method, the heat balance on the external surfaces is simulated using a high-resolution voxel mesh model generated by the above method. The applied mesh size is determined in Section 4.2. Figure 3 shows a schematic illustration

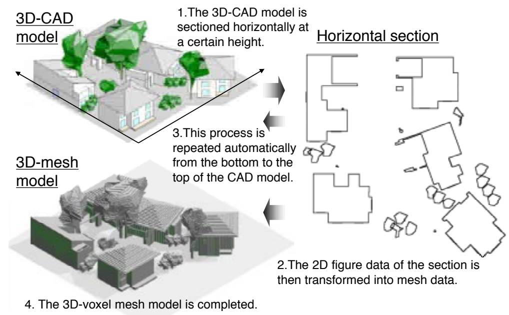

Figure.2 Schimatic diagram of the mesh model generation

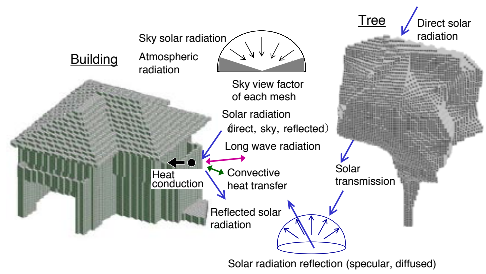

Figure.3 Schematic diagram of the heat balance calculation method

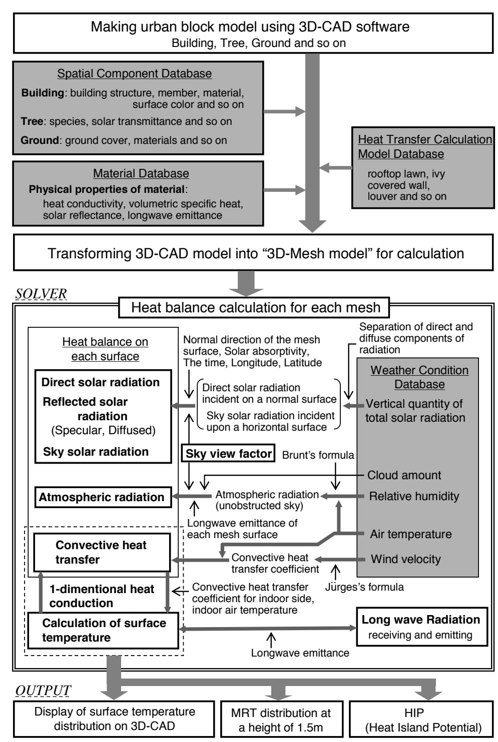

Figure.4 The flow chart of this simulation tool

of the mesh models and the heat balance calculation method. Figure 4 shows a flow chart depicting the various components and processes involved in this tool. The fundamental formula of the heat balance calculation is shown in the following formula (1):

$$q = a_{su}\left(cos\theta \cdot I_{DR} + \Phi_{sky} I_{SR} + I_{RR}\right) + \epsilon_s \Phi_{sky} \sigma T_a^4 \left(a + b\sqrt{e}\right) + \epsilon_s \sum_{i=1}^{n} \epsilon_i \Phi_i \sigma T_i^4 - \epsilon_s \sigma T_s^4 + \alpha_c \left(T_a - T_s\right) \quad (1)$$

q : Amount of heat conduction into surface [W/m^2]
T : Temperature [K]
a_{su} : Solar absorptivity
θ : Incidence angle of direct solar radiation [rad]
I_{DR} : Amount of direct solar radiation [W/m^2]
Φ : Shap modulus [sky : sky factor]
I_{SR} : Amount of sky solar radiation [W/m^2]
I_{RR} : Amount of reflected solar radiation [W/m^2]
ε : Longwave emittance
σ : Stefan Boltzmann constant [W/m^{2}K^4]
a,b : Constant on Brunt's formula
e : Water vapor pressure near the ground [Pa]
α_c : Convective heat transfer coefficient [W/m^{2}K]
s(subscript) : Surface
a(subscript) : Atmosphere
n(subscript) : The total number of objects which emit long wave radiation

Convective heat transfer is calculated under the assumption that there is no distribution of air temperature and wind velocity in the subject urban canopy. This approximation is established under the low-wind-velocity condition. The computer performance-based calculation, which excludes CFD, is realized by this approximation. The convective heat transfer coefficient is estimated by the Jurges formula.

One-dimensional heat conduction in each spatial component is simulated, using calculated heat balance data, as the boundary condition for external surface. The boundary conditions for inner side of the surface are the indoor air temperature for the building and the underground temperature for the ground. The backward-difference method is used for the calculation of the unsteady static heat conduction. One running simulation runs for five days in order to obtain a periodic steady-state solution with initial conditions of periodic weather data. The calculation results of surface temperature for the 5th day are used as the output.

This simulation tool evaluates the impact of a proposed building or urban block on the urban thermal environment by two indices based on surface temperature. One index is the Mean Radiant Temperature (MRT) for evaluating the radiative effect on thermal comfort, and the other is the Heat Island Potential (HIP) (Iino A, Hoyano A. 1998), which indicates the total sensible heat from the entire surface of the urban block being analyzed. HIP is expressed as the measure of a temperature, and is calculated by the following Formula (2):

$$HIP = \frac{\int_{AllSurface} \left(T_s - T_a\right) dS}{A} \quad (2)$$

HIP : Heat Island Potential[°C]
T_s : Surface Temperature of each mesh [°C]
T_a : Air Temperature (derived from weather condition data) [°C]
A : Plane area of the urban block[m^2]
dS : Area of each mesh[m^2]

3.4. Post-processing method on the 3D-CAD system

The mesh data of the surface temperature calculation results are converted into surface texture data, and the textures are visually projected onto the 3D-CAD model generated in the pre-process. This allows the user to understand and evaluate the effects of spatial geometry and materials on the outdoor surface temperature from almost any viewpoint, including a bird's-eye view and axonometric projections.

4. Establishment of the simulation parameters and the system

4.1. Optimum mesh size investigation

This subsection describes the results obtained from the mesh size optimization experiments. A small mesh size is necessary in order accurately reproduce detailed spatial components such as eaves, verandas, and the shape of tree crown. On the other hand, a small mesh size significantly increases the calculation load. Therefore, mesh size optimization was conducted.

A building with a small and complex spatial geometry is appropriate for the examination of the mesh dependence, so that a detached house having verandas and eaves was chosen as the building model for the present examination.

The direct solar radiation quantity was calculated for several different mesh size models. Figure 5 shows the relationship between the applied mesh size and the calculation time. The mesh size was varied between 0.1 m and 1.0 m. This figure shows that detailed spatial forms, such as eaves and a wing wall, cannot be sufficiently reproduced when a 1.0 m mesh is applied. The calculation time for the 0.2 m mesh is approximately the same as that for the 0.5 m mesh. Although the 0.1 m mesh results in an accurate reproduction of the building details, the calculation time is long. Therefore, the 0.2 m mesh is suitable for use in the simulation of subjects having detailed spatial geometry. This size allows for fast simulation while accurately reproducing detailed outdoor spatial geometry.

4.2. Optimum number of tracers in the multi-tracing simulation

The increase in the number of tracers in the multi-tracing simulation used in the estimation of the sky view factor and radiative heat transfer causes the growth of the calculation load, so that the optimum number should be determined for practical use. In this section, we examine the relationship between the number of tracers in the multi-tracing simulation and the calculation accuracy using the sky view factor, which is significant with respect to outdoor heat balance, as the evaluation standard index.

The urban block model used in this examination is an apartment housing area model in a substantial urban area in Tokyo (Fig.6). The Root Mean Square Error (RMSE) index is used for this investigation of calculation accuracy (Formula (3)). The maximum number of tracers for calculating the RMSE, as the standard, is over 63,000.

The relationship between the number of tracers and the RMSE index of the sky view factor for the whole of the ground is shown in Fig. 7. As the number of tracers increases, the value of the RMSE decreases sharply. However the difference in the RMSE is small when using over approximately 500 tracers. When 524 tracers are applied, the RMSE value is less than 1%. The image in Fig. 7 shows the simulation result for the sky view factor distribution on the ground using 524 tracers. A clear distribution of the sky view factor is calculated. This result confirms that for this multi-tracing simulation the suitable number of tracers is more than 500.

5. SIMULATION TOOL APPLICATIONS

5.1. Application to actual urban block

This tool is intended to be applied to architectural design and urban planning at the urban block level. This section describes the application of this tool to actual urban block in Tokyo. Figure 8 depicts the CAD model of the subject urban block, and Fig. 9 depicts the surface temperature calculation results for the urban block.

The calculation time for this subject area, which includes high-rise buildings, was approximately 7 hours using a PC (Macintosh Power Mac G4: 1.25 GHz, Memory: 1 Gbyte). The calculation time for the residential area considered in the next subsection was approximately one hour.

The effect of high-rise buildings on the surface temperature distribution of the surrounding area is clearly illustrated by Fig. 10. This output also shows that the component materials used in the block greatly

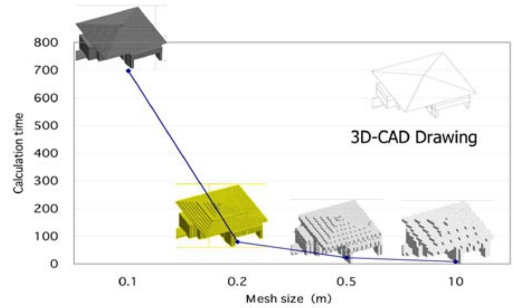

Figure.5 Relationship between the applied mesh size and the calculation time

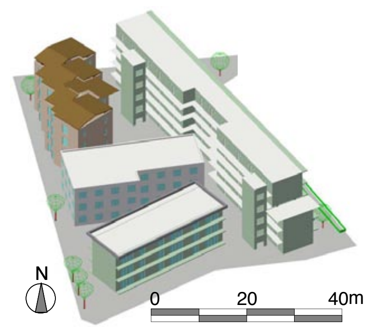

Figure.6 Apartment housing model

$$\mathrm{RMSE} = \sqrt{\frac{\sum_{n=1}^{N}(sf_e - sf_{63180})^2}{N}} \qquad (3)$$

sf_e : Sky view factor using the maximum number of tracer
sf_{63180} : Sky view factor using the each tracer number
N : The number of mesh
RMSE : Calculation error index (Root Mean Square Error)

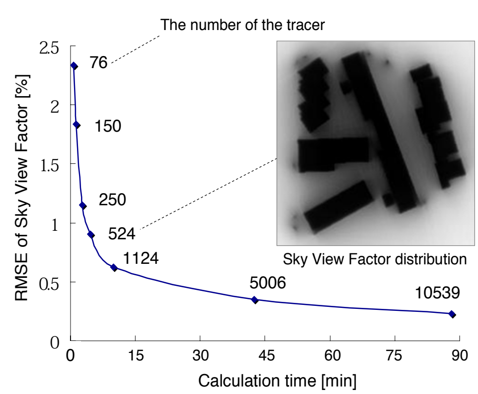

Figure.7 Relationship between the number of tracer and RMSE of Sky View Factor

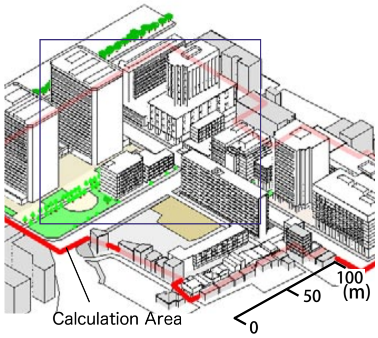

Figure.8 CAD model of the actual uraban blocks for calculation

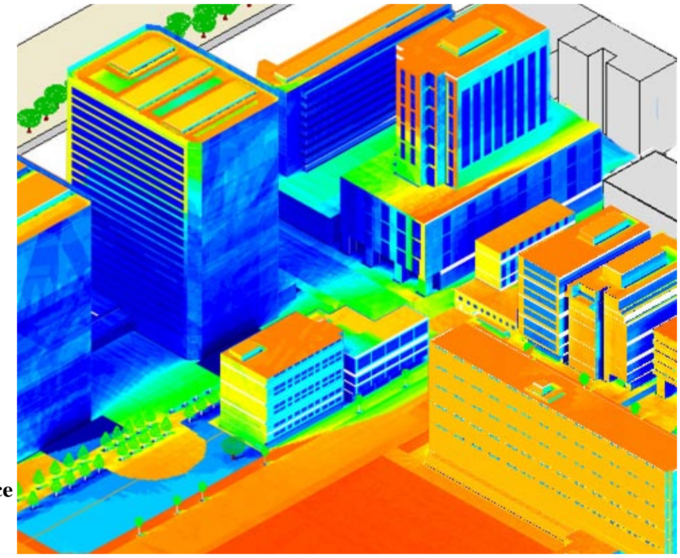

Figure.9 Bird's-eye view of the surface temperature distribution (Clear sky day in summer, 12:00)

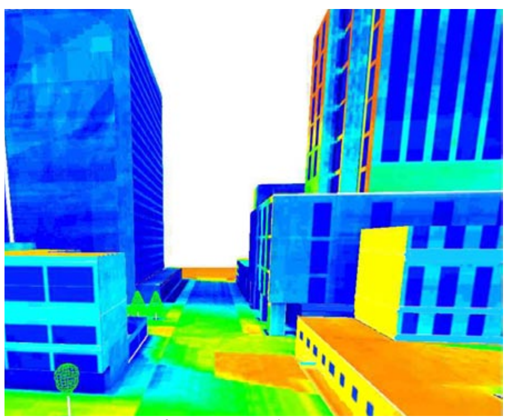

Figure.10 Perspective depiction of the surface temperature distribution(Clear sky day in summer, 12:00)

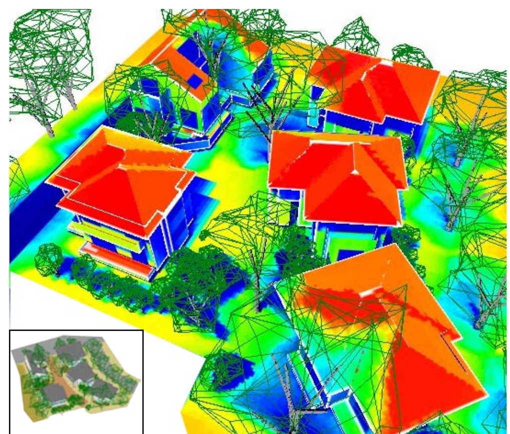

Figure.11 Simulation results of the surface temperature of the residential area (Clear sky day in summer, 12:00)

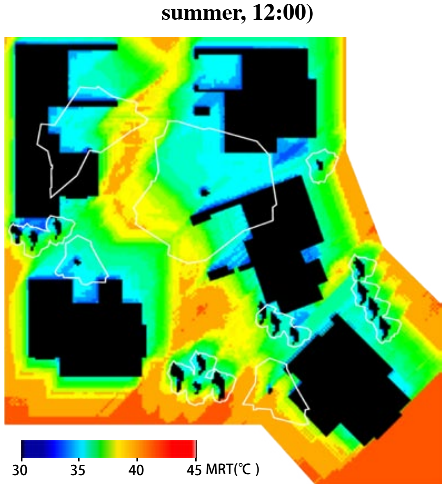

Figure.12 MRT distribution at a height of 1.5m (Clear sky day in summer, 12:00)

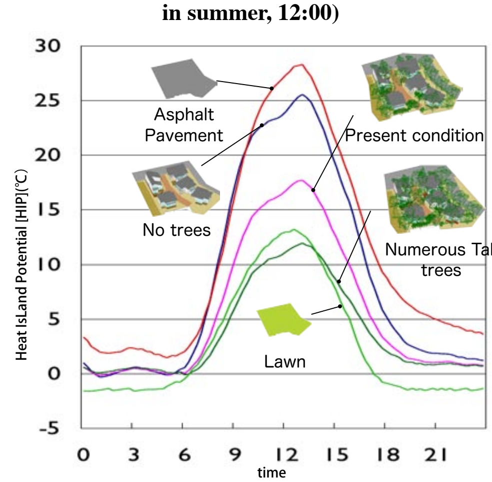

Figure.13 Diurnal variation of HIP

affect the surface temperature distribution.

5.2. Application to the evaluation of the effect of planting tall trees

In order to confirm the applicability of this simulation tool for the purpose of thermal design of outdoor spaces, this tool was applied to an area containing detached houses surrounded by numerous trees with leafy canopies.

Figures 11 shows a bird's-eye view of the surface temperature distribution depicted in the 3D-CAD model, as well as a perspective depiction of surface temperature distributions. The effect of shade from the tall trees results in numerous surfaces having temperatures that are approximately equivalent to the ambient air temperature.

Figure 12 depicts the MRT distribution at a height of 1.5 m. The MRT under the tall trees is 32°C, which is approximately 10°C lower than that observed in areas exposed to a solar radiation.

Figure 13 shows the diurnal variation of the HIP. The calculation was performed for three different scenarios, which differ with respect to the number and position of trees. This figure indicates that the HIP drops markedly due to the presence of tall trees.

These results reveal that the tool is able to simulate the effects of building shapes, materials and trees shade on the surface temperature distribution, and the MRT and HIP indexes. Therefore, this simulation tool has been demonstrated to be useful in evaluating the impact of a proposed design on the urban thermal environment by using the results of surface temperature.

6. CONCLUSION

This paper details the development of a simulation tool that will enable the user to virtually predict and evaluate the effect of building and urban block designs on the thermal environment of an area using a 3D-CAD software. In order to allow for prediction taking into account detailed outdoor spatial geometry and to allow the system to be put into practical use, the following features were examined and incorporated into this simulation tool: the input and pre-processing method using the CAD system and the GUI, the database linking the design parameters and the parameters for the heat transfer calculation, the simulation algorithm is improved to further reduce the calculation time and PC memory required for the simulation, allowing the system to be run on a personal computer, Establishment of the simulation parameters and the system and a method for visually expressing the results of the calculations via 3D-CAD.

The results of the application of this simulation tool in an area of detached houses confirms that the simulation tool is able to simulate the effects of spatial geometry and materials existing in the outdoor space, including the effect of shading by tall trees, on the surface temperatures and evaluation indexes of urban thermal environments.

The examination using a broader range of examples of urban areas will be conducted in a future study. Future research will focus on the introduction of a latent heat calculation model to evaluate the influence of rainfall and evaporative cooling. In addition, this system will be combined with CFD in order to predict the air flow and air temperature distribution in an area.

ACKNOWLEDGEMENTS

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News from IBPSA affiliates

IBPSA affiliates are asked to submit a report to the IBPSA Board each year to keep Board members informed about their activities and membership. These are much more detailed than the summary reports we have previously included in *ibpsa*NEWS. Affiliates have been asked to make their latest annual report available through their web sites, and in future we plan to include only selected news from affiliates — in this issue, from IBPSA Poland. News about other affiliates is available from their websites:

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IBPSA Scotland (no web site yet)		**Lori McElroy**
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IBPSA Poland

9th Indoor Air Quality in Poland conference – 2007

The Institute of Heating and Ventilation at Warsaw University of Technology has organised "Indoor Air Quality in Poland" conferences every two years since 1989. These aim to present and review the latest research results in indoor climate, air quality and solutions for healthy buildings.

30 papers were presented at the latest conference, held on November 23-25, 2007, in six plenary sessions. The invited speakers represented a wide range of disciplines from medicine to architecture and engineering.

On the last day of the conference there was a special session on the use of building simulation techniques in research on the indoor environment. Five papers were presented, addressing daylight utilization and visual comfort, energy systems in office buildings, fire and smoke distribution, and wind flow and thermal comfort in low-energy buildings. All the papers presented will be published as a monograph in "Air Quality" in 2007.

The Conference was once more a great success. For IBPSA Poland, it was the first opportunity after the funding meeting in 2007 to become known as a scientific association. The next conference, the 10th, is planned for November 2009.

Special Issue of "Energia i Budynek" by IBPSA-Poland

"Energia i Budynek" is the newly established official journal of Energy Auditors Association in Poland. It is intended that one issue each year should be devoted to the application of energy simulation in building practice. The first of these special issues, edited jointly by the journal's Scientific Committe and IBPSA Poland, was published in December 2007 (No. 09/2007).

Eleven papers were included, from seven different research institutions in Poland. These were all of the highest scientific quality and addressed practical applications, with a special focus on methods for calculation of energy demand for the purpose of implementation of Energy Performance Directive in Poland. Topics included energy conservation, indoor climate, HVAC systems and sustainable building. More information is available at: http://www.energiaibudynek.pl.

IBPSA Sustaining Members

Sustaining members of IBPSA are those individuals or organizations that provide financial support to IBPSA at the level of US$500 or more per year. To learn about sustaining membership, please contact one of the IBPSA officers shown in this newsletter.

	US - DOE **United States Department of Energy** **1985-2009**
	American Society of Heating, Refrigerating & Air-Conditioning Engineers **2003-2009**
rehva	**REHVA** **Federation of European Heating & Air-Conditioning Associations** **2003-2009**
	IEA - ECBDS **International Energy Agency - Energy Conservation in Buildings & Community Systems** **2005-2009**
清華大學 Tsinghua University	**Tsinghua University** **2007-2009**
HVAC&R	**China HVAC&R Society** **2007-2009**

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For additional information about IBPSA, please visit the Association's web site at www.ibpsa.org. For information on joining, contact your nearest regional affiliate.

IBPSA's mailing list has recently been consolidated into another listserver known as BLDG-SIM, which is a mailing list for users of building energy simulation programs worldwide, including weather data and other software support resources.

To subscribe to BLDG-SIM, to unsubscribe or to change your subscriber details, use the online forms at http://lists.onebuilding.org/listinfo.cgi/bldg-sim-onebuilding.org.

To post a message to all members, send email to bldg-sim@lists.onebuilding.org.

The BLDG-SIM list is provided by GARD Analytics. If you have any questions, please contact the list owner Jason Glazer at jglazer@gard.com or +1 847 698 5686.

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1994-1997 (4 years) Joe Clarke, Scotland

1998-1999 (2 years) Larry Degelman, USA

2000-2001 (2 years) Roger Pelletret, France

2002-2005 (4 years) Jeff Spitler, USA

Privileges and Obligations of IBPSA Members and Affiliates

All members are encouraged and entitled to take part in the activities of IBPSA, subject to constitutional or special provisions by the management of IBPSA. The aims of the activities are to disseminate information and aid the progress of IBPSA's efforts and image.

All members have the right to participate in meetings of IBPSA, but the right to vote is subject to the provisions for voting as contained in the present By-Laws. Members holding their membership through an Affiliate are not eligible to vote if the Affiliate has not submitted its membership roster to the Secretary of IBPSA. Affiliates, therefore, need to keep their membership rosters up to date and communicate them to the Secretary.

All members joining IBPSA must undertake to observe the IBPSA constitution and By-Laws and all obligations arising from them. They must also accept the obligation to contribute to the accomplishment of the activities of IBPSA according to their particular competence.

Any member may submit any communication for consideration at a General or Special Meeting of IBPSA or the Board of Directors. The Board will indicate its decision on the proposals within a reasonable timeframe that allows for an IBPSA Board meeting, either in person or by e-mail.

Affiliates are entitled to appoint one representative to the Board and take part in activities of IBPSA. Affiliates, upon joining IBPSA, must undertake to observe the IBPSA constitution and By-Laws and all obligations arising from them. Special obligations of Affiliates include annual notification to the Secretary of IBPSA of the following items:

1. the name of the Affiliate's board representative
2. the Affiliate's membership roster
3. reports of meetings and/or conferences held by the Affiliate, and
4. other information or reports requested by the Board.

Resignation and Termination

Affiliates wishing to terminate their affiliation may do so at any time subject to 90 days notice. Notice of termination must be transmitted in writing to the Secretary. If all communications from an Affiliate to the Board have ceased for a period of two years prior to any Board meeting, that Affiliate will be considered to have resigned.

Building Simulation 2009

University of Strathclyde, Glasgow
27th – 30th July

11th International Building Performance Simulation Association Conference and Exhibition

www.bs2009.org.uk

Welcome to Glasgow

Day	Am	Pm	Evening
Monday 27/07/09	Registration opens	Formal opening conference, keynote speeches.	Civic Reception Glasgow City Chambers
Tuesday 28/07/09			City tour (walking)
Wednesday 29/07/09	Main conference: plenary and parallel sessions, poster sessions and exhibitor displays. (Accompanying persons' tours)		Conference Dinner Barony Hall – University of Strathclyde
Thursday 30/07/09			Conference close Board Meeting
Friday 31/07/09	Technical tours and training courses		

Glasgow: Scotland with style™

We are delighted that The University of Strathclyde in Glasgow has been selected to host the 11th International Building Performance Simulation Association Conference and Exhibition in 2009.

With regard to Architecture and Engineering Design, the city has a longstanding reputation for innovative design and invention and has three Universities that include two schools of architecture, and a reputation for engineering that is second to none. In particular, over the past thirty years, Scotland has built up a strong reputation in the field of simulation research, development and technology transfer, through commercial and academic channels. Through IBPSA Scotland, and the University of Strathclyde, this knowledge and technology transfer work is developing rapidly and industry interest is growing, and so it is fitting that the conference should take place at Strathclyde.

As Scotland's largest city, Glasgow offers direct access from over 13 European cities and 5 transatlantic destinations. In addition there are 52 return flights per day from London. The city is well served by three airports: Glasgow International Airport is 10 minutes drive from the centre with a regular bus service, Glasgow Prestwick Airport is 23 miles south west of the city with a direct rail link (journey time 30 minutes) and Edinburgh Airport is located 45 minutes (35 miles) from Glasgow city centre.

Culturally, Glasgow has an unrivalled choice of museums, theatres, parks, science centre and shopping, set within some of the finest Victorian architecture in Europe. In addition, Glasgow has a worldwide reputation as a welcoming city and is firmly established and experienced as a major centre for conferences and international events.

Within a 30 minute drive from the city centre, visitors can experience the beautiful scenery of the lochs, mountains and castles of Scotland and the historic capital city of Scotland, Edinburgh is less than one hour away. This allows us to offer many interesting options for accompanying persons' programmes and technical tours – from the 'Whisky Trail' to the best golf courses in the world, to the much publicised Scottish Parliament building, designed by the late Spanish architect, Enric Miralles.

Conference Topics

Papers will be sought in the following areas:

1. **Advances in building physics:** heat, air, moisture, radiation and sound transfer modelling relating to building structure and systems.
2. **Human aspects:** comfort (acoustic, visual and thermal), health, productivity, indoor air quality, interaction with control systems.
3. **Building services:** lighting, heating, ventilation, air-conditioning, fire/smoke control, cold and hot water supply.
4. **Commissioning and operation:** building energy management, building control and optimisation, fault detection and diagnostics, and condition monitoring.
5. **Energy capture and generation:** modelling of renewable energy devices/ systems, thermal storage (including phase change materials), decentralised generation (e.g. CHP, district heating and cooling).
6. **Advances in application:** use in building codes and regulations, modelling of novel designs, risk management, simulation use in policy formation and strategic planning.
7. **Validation and calibration:** novel methods, applications and user certification.
8. **Software issues:** interoperability, teaching, user interface design, open source initiatives and internet based services.
9. **Simulation in design practice:** high quality case studies of modelling used in design.

University of Strathclyde

The University of Strathclyde was founded in Scotland in 1796 (as the Royal College of Engineering), to make higher education available to all, and to combine excellence with relevance. In fulfilling this mission in today's world it aims to:

Contribute to the advancement of the knowledge society, to social cohesion and to the quality of life in Scotland, and in the wider national and global community;

Generate, through excellence in research and scholarship, new ideas, knowledge and skills to create opportunities for individuals and society;

Provide high-quality education to all of its students, regardless of background, inspiring them to develop to the full their abilities, and creating outstanding professional and creative people;

Offer the opportunities for all staff to develop their full potential, and contribute fully to the achievement of the University's Vision.

Strathclyde is one of the top UK universities, blending tradition with a dynamic, progressive approach to teaching and learning.

Accommodation

Accommodation will be offered on campus at the University and in a number of top class hotels within 15 minutes walking distance of the conference venue.

The University of Strathclyde has its own campus village in the heart of the city with over 1000 rooms on site and a further 500 within close walking distance, mainly in the fashionable Merchant City. All student accommodation has access to an advanced computer and information network 24 hours a day and every study bedroom has full network access.

Currently we are holding rooms in the following hotels all within 15 minutes walk from the city centre campus. Further details are available on the conference website.

Accommodation	Star rating
Millennium Hotel	4
Holiday Inn Theatreland	4
Express by Holiday Inn Theatreland	3
Premier Travel Inn George Street	3
Express by Holiday Inn Riverside	3
University of Strathclyde	En suite

Conference Location

The conference will be held in the John Anderson Building on the University campus in the centre of Glasgow. The main auditorium seats 450 people, and there are adjacent lecture rooms for parallel sessions, and space for poster and exhibition displays.

Organising Committee

Conference Chair: Lori McElroy
Co-Chair: Paul Strachan
Industry Liaison: Joe Clarke
Software demo/training courses: Jon Hand
Sponsorship/ exhibitions: Jeremy Cockroft
Website: Kim Jaemin and Nick Kelly
Secretarial support/ Accompanying persons' programme: Kathleen Whyte
Conference Support: ESRU and Sust.

Scientific Executive Committee

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Co-chair: Nick Kelly

Members
Fried Augenbroe, Ian Beausoleil-Morrison, Michael Donn, Jan Hensen, Roberto Lamberts, Jeff Spitler, Terry Williamson, Harunori Yoshida, Yingxin Zhu

Scientific Committee

The Scientific Executive Committee will nominate approximately 150 international reviewers.

Conference Theme

The conference theme is to promote the use of computer based simulation of the built environment in research and practice. Conference topics may be addressed at different levels: from single systems through buildings to urban and regional scale models, and at different stages of building life cycle: from concept design through building commissioning and operation to demolition.

Exhibition

The Anderson cluster includes various exhibition spaces that can be used for commercial exhibits and software demonstrations. This will provide excellent opportunities for any institution or company to promote their simulation services or products.

Accompanying Persons' Programme

A varied program will be arranged for accompanying persons drawing from Scotland's rich historical and contemporary culture. Example tours could include:

- Glasgow's galleries and museums including the Lighthouse, the Burrell Collection, Gallery of Modern Art, the People's Palace, Glasgow Science Centre and Kelvingrove Museum and Art Gallery;
- Edinburgh Castle;
- Visit to a crystal factory;
- Stirling Castle, Wallace monument and the site of the Battle of Bannockburn;
- Dumgoyne whisky distillery, (tour and whisky tasting!);
- and of course shopping in the best shopping centre in the UK outside of London.

We are confident that we can offer an experience of Scotland that is second to none.

Technical Tours

Many local businesses use simulation as an integral part of the design process. The technical tour will focus on two iconic buildings that took advantage of this in their design:

- The Scottish Parliament Building in Edinburgh (designed by Spanish architect Enric Miralles);
- A visit to the Lighthouse – Glasgow's Centre for Architecture and the City (designed in 1895 by Charles Rennie Mackintosh).

Dates

The conference will be held from the 27th to the 30th July 2009.

Deadline for submission of Abstracts	1 September 2008
Notification of abstract acceptance	1 November 2008
Deadline for full paper	1 February 2009
Notification of paper review	1 April 2009
Deadline for revised paper	15 April 2009
Deadline for final formatted papers	22 April 2009
Final acceptance notification	1 May 2009
Deadline for conference pre-registration	15 May 2009
Conference	27-30 July 2009

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