Engineering a Sustainable Built Environment

BUILDING SIMULATION GROUP

NEWSLETTER

Issue 2
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STUDENT PRIZE

Rongweixin Chen's CIBSE BSG 2013 Student Prize winning entry

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Anna Menezes on CIBSE TM54
2014 CIBSE BSG Student Prize

Community Centre at the North West Cambridge Development
Image courtesy of AECOM

Foreword by the Group's Chairman

This Group was established five years ago with the aim of supporting good practice on, and informing CIBSE members of the role of building modelling and simulation in building services design

This is the second Newsletter since the Building Simulation Group decided in 2013 to publish this information highlight on the Group's activities. In this edition, three major recent activities of the Group and its members are highlighted: a summary of the topic for the Group's 2013 Prize for Best MSc Dissertation by the Prize winner Rongweixin Chen; an announcement for the 2014 Student Prize; and highlights of CIBSE TM54 by one of its authors Anna Menezes.

Since the last Newsletter, the Group has organised a successful seminar on the "Design and Simulation for Zero Carbon Buildings" which focused on new approaches to design concepts of buildings and systems within the constraints of zero carbon buildings (ZCB). Seminar topics included thermal and ventilation performance, energy storage, the application of renewable energy systems to buildings and the anticipated performance of ZCB.

Another seminar was jointly organised with the CIBSE Natural Ventilation Group called "Modelling Air Movement: CFD Simulation vs. Experimental Methods". This very successful seminar explored current practices to modelling air movement within the built environment; focusing on the accuracy of predicting air movement by different methods and the advantages and limitations of each. The presentations from these two and previous seminars are available at the Group's website for downloading.

The Group also sponsored the IBPSA-England Building Simulation and Optimization Conference which took place at University College London on the 23rd and 24th June 2014. At this Conference the Group organized the Workshop on Advances in Building Simulation which included presentations from EDSL, Ansys, CD-Adapco and Design Builder. We are also planning new seminars in the near future which will be announced shortly.

The completely revised AM11, which was a major task for the Group over the last three years or more, is currently undergoing publication. We look forward to more participation of CIBSE members in the Group's future activities.

Prof. Hazim Awbi
BSG Chairman
chairman@cibsebsg.org

Next CIBSE BSG Event to examine Building Information Modelling

It is proposed to hold the next Group's seminar on the topic "Linking the Building Design Performance with BIM". This is scheduled for November 2014. The Group is seeking professionals experienced in this area to give presentations at the proposed seminar. Interested parties are asked to contact Sahm Sawaf, the Group's Events Secretary (email: s.sawaf@pgr.reading.ac.uk), to register their interests.

Call for Articles

The CIBSE BSG are seeking articles or case studies for submission to appear in this newsletter. If you have some news or a good example of how building simulation has improved and aided building design, please contact the editor Darren Coppins at editor@cibsebsg.org

Building Simulation Group Prize for Best MSc Dissertation

The Building Simulation Group supports and encourages the application of advanced building simulation tools for building and system design with the aim of achieving best performance, reliability and energy efficiency. In 2012 the Group initiated an annual prize open to postgraduate students from UK and overseas universities who undertake a research project at Master's level or equivalent which includes a major element involving the application of building simulation tools in research. The aim is to encourage the use of, and innovation in, building simulation techniques for research and development.

The 2013 £1,000 prize for 'Simulation of Ventilation in Buildings' has been awarded to Rongweixin Chen from the University of Cambridge. His entry is summarised in the adjacent article

This year's award will focus on projects involving the application and development of advanced simulation techniques and/or software for predicting the performance of buildings and environmental control systems. Expressions of Interest have been received and invitations for full applications will be announced soon. The winning project will be announced towards the end of 2014.

2013 Student Award: Innovative Natural Ventilation for Summer Cooling

The 2013 Student Award was won by Rongweixin Chen with his work titled 'A conceptional case study of an innovative natural ventilation strategy for Summer Cooling' ***Rengweixin Chen*** *provides a summary of his work below.*

The main hall of the project titled 'The Nursery and Community Centre for North West Cambridge' is proposed to be ventilated by using an innovative natural ventilation strategy: air is distributed from an adjacent air intake wall via underground tubes and a labyrinth to the main hall. A study was conducted to analyse the effectiveness of the proposed ventilation strategy by using three methods: (1) manual calculations based on mathematical models; (2) multizone airflow network (AFN) models; (3) models coupling AFN and Computational Fluid Dynamics (CFD) analysis. Moreover, a full CFD analysis, which couples external domain and internal domain, is conducted to support the reliability of the results of the coupling of AFN and CFD.

The first method is based on the mathematical model

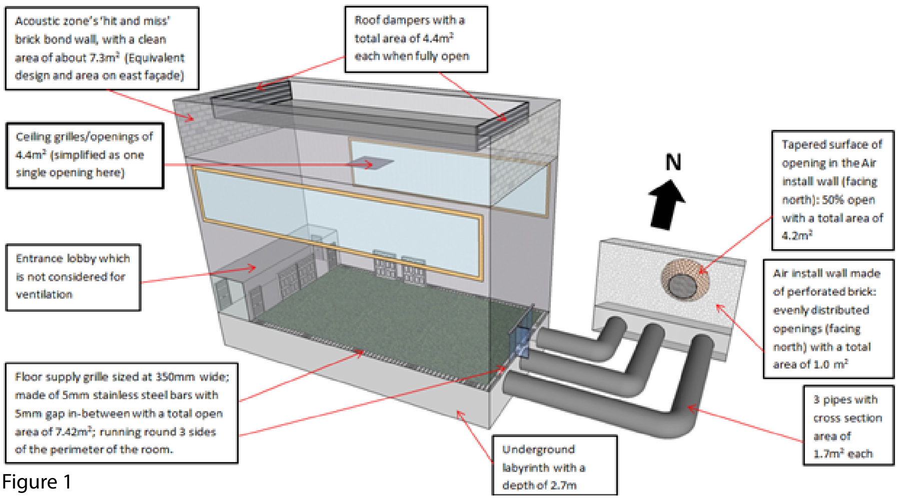

Figure 1

which was originally developed by Linden et al. (1990) and was improved by Hunt and Linden (2001). The model describes the stable stratification within a tall zone produced by displacement ventilation and internal heat sources. Major Limitations of the model are that they do not consider radiant power of heat sources, solar radiation and heat transfer through walls. Moreover, it may only be applicable to the case that internal heat sources are of low-density, since the models are only valid when plumes produced by internal heat sources do not interact.

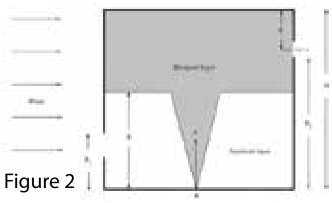
Figure 2

The second method, an AFN model uses the building energy simulation tool, ESP-r. When using AFN modelling for natural ventilation analysis, a building is modelled as a collection of nodes representing rooms or sub-rooms (i.e. sub-zones partitioned off from a room). These nodes are linked to each other or external nodes (which include envelope wind-pressure boundary conditions) via components (i.e. cracks, openings or doors) to indicate distributed flow paths. A basic feature of AFN modelling is the conservation of zone mass flow. This is achieved in ESP-r simulations through a customized Newton-Raphson approach in which iterative calculations modify nodal pressures until the mass residual meets certain criteria (Hand, 2011). Figure 3 illustrates the AFN model of the building for ESP-r simulations, where the main hall is divided into ten AFN zones.

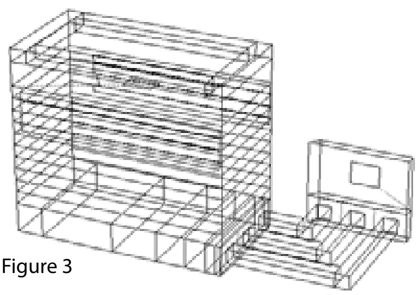
Figure 3

The third method is coupling AFN and CFD analysis. In ESP-r, one airflow network zone node can be treated as a CFD domain, and the CFD module can also be conflated with the thermal simulation facility. Hence, ESP-r is capable of explicitly simulating the performance of the CFD zone by obtaining thermal boundary conditions of building envelope from the thermal simulation domain and the initial incoming/outgoing air flow details by coupling with the AFN domain. In this case, the main hall as a whole is treated as a CFD domain. Furthermore, a full CFD analysis, which couples external domain and internal domain, is conducted to support the reliability of the results of the coupling of AFN and CFD.

The results show that the ventilation strategy could eliminate or largely relieve the threat of overheating. The cool

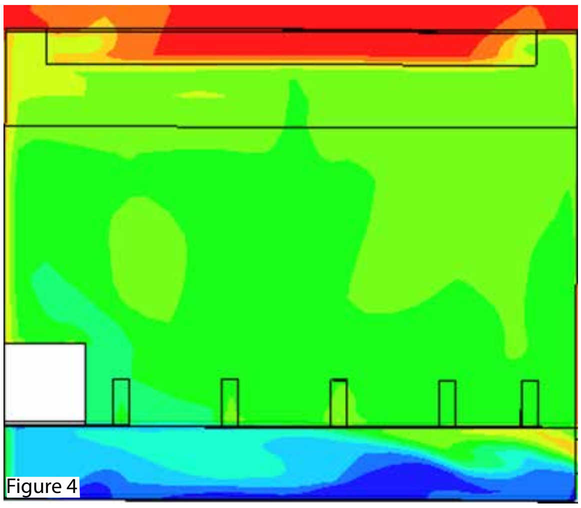
Figure 4

labyrinth, whose air temperature can be several degrees lower than ambient, may play an important role in the ventilation system. Among the three analysis methods, the first method, namely manual calculations based on mathematical models, is less applicable here compared to the second (AFN models) and the third method (models coupling AFN and CFD analysis). Between the latter two, the third method is capable of providing more information than the second method. The results of the coupling of AFN and CFD are to some extent verified by the full CFD analysis. It worth noting that the full CFD analysis may be more accurate in analysing such a problem, but it requires significant computational time.

References

Hand, J. (2011). The ESP-r cookbook: Strategies for Deploying Virtual Representations of the Built Environment. University of Strathclyde, Glasgow.

Hunt, G. R. and Linden, P. F. (2001). Steady-state flows in an enclosure ventilated by buoyancy forces assisted by wind. J. Fluid Mech. 426, 355–386.

Linden, P. F., Lane-Serff, G. F. and Smeed, D. A. (1990). Emptying filling boxes: the fluid mechanics of natural ventilation. J. Fluid Mech. 212, 300–335.

The actual design of the Community Centre at The North West Cambridge Development has been undertaken by MUMA Architects and URS. MUMA supported Rengweixin Chen in undertaking his studies. This article and images has been publised with permission of North West Cambridge Development.

CIBSE TM54 by co-author Anna Menezes

The operational energy use of buildings is typically far higher than anticipated and comparisons such as the one illustrated in Figure 1 are becoming more common. This 'performance gap' can be attributed to an array of issues, surrounding both modeling practices and operational performance. In general, design stage estimates tend to be unrealistically low, excluding several sources of energy use, whilst actual energy performance is often unnecessarily high. However, the overall problem could be interpreted as an inability of current modelling practices to represent realistic use and operation of buildings in addition to a lack of feedback regarding actual performance. The reality is, the likely operational energy performance is rarely considered at the design stage, with focus being mainly on modeling to demonstrate compliance with Building Regulations. With these issues in mind, CIBSE has recently published new guidance aimed at helping designers evaluate the operational energy performance of buildings at the design stage (CIBSE TM54).

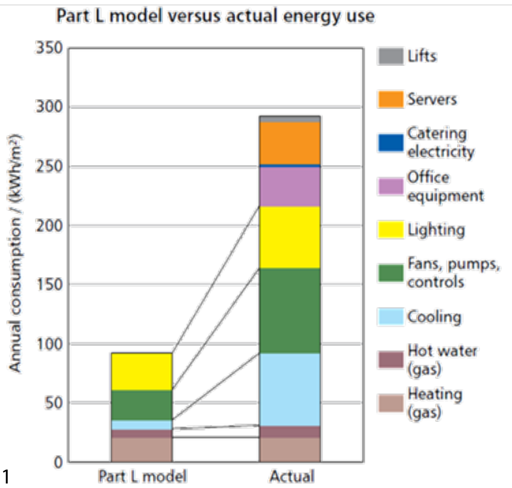

Figure 1

The new guidance explains the problem with compliance models and sets out a methodology for evaluating operational energy use at the design stage. The methodology is built on some key principles to ensure that the estimates are a more accurate reflection of likely operational performance. These include:

- calculating and including all of the energy uses in the building, such as small power, catering, server rooms etc
- estimating energy use for heating, cooling, fans and pumps, using more realistic occupancy duration and density, and assumptions about the inputs
- having a dialogue between the designers and all the prospective occupants about likely operating hours and energy management regimes
- carrying out a comparison against existing energy use benchmarks to ensure that the results are within a range of likely outcomes
- presenting the results as a range with a high and low energy use scenario to help show that there is uncertainty about predicting energy use.

Figure 2 (top right) illustrates the results from the original Part L (compliance) model and actual operational energy for the same case study building shown in Figure 1, but it also includes the estimate based on the principles set out in the guide (labelled 'TM54 Estimate').

The graph shows that the calculations based on TM54 provide a much closer estimate of actual energy use, compared to the original Part L model. The TM54 estimate bar also includes a range of results to reflect the uncertainty of the result and the different operating scenarios for the building (shown by the black error bar).

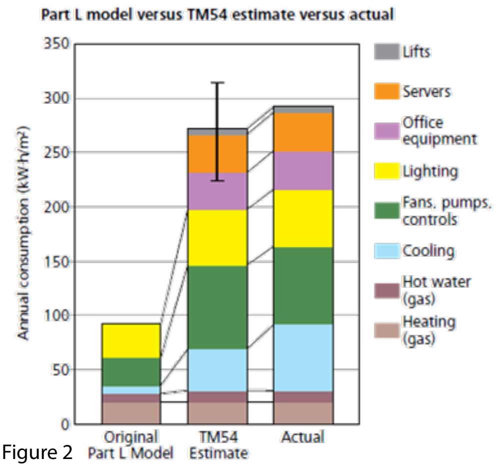

Figure 2

The guidance also emphasises the importance of communicating in ranges rather than absolute estimates, recommending that a number of different scenarios be considered in the estimation of operational energy use. It also provides examples of how to present the results by using different scenarios to reflect the level of uncertainty of the estimates.

The results of all the calculations, the sensitivity analysis and the range of scenarios can be presented as simple graphs showing the overall results (Figure below right). In this example, the high-end scenario is calculated by increasing the run-hours of the plant and equipment, the low end scenario is a well-managed building with plant operating hours closely matched to occupied hours. The mid-range scenario is the best estimate of energy use, based on the run-hour estimates from the prospective occupants and the most reasonable assumptions for controls and management regimes. The worst case scenario assumes a poorly managed building with extended run hours and above-average internal heat gains.

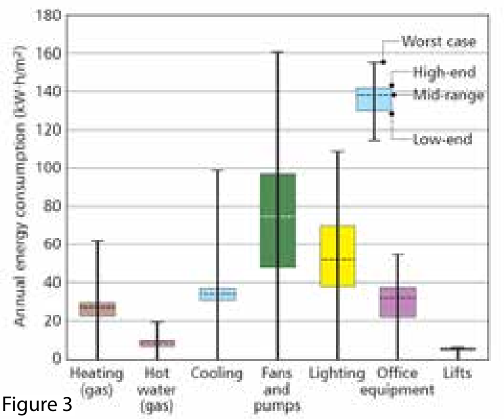

Figure 3

As well as enabling designers to estimate energy use more accurately, these results will highlight any areas where actual energy use may be higher than a typical building, allowing this to be considered at the design stage.

The objective of the new guidance is to provide building designers and owners with clear guidance on how to evaluate operational energy use more fully, and accurately, at the design stage and ultimately help to close the gap between expected and actual performance. The document can be downloaded from the Knowledge Portal and is free for CIBSE members.

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Co-author of the CIBSE TM54 Technical Memorandum