Performance simulation for better building design

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This thematic issue contains twelve papers that address recent advancements in the field of simulation of building behavior. The papers represent a selection of papers presented at the IBPSA 2003 conference which was held from 11–14 August 2003 in Eindhoven. The conference which was run under the theme "Simulation for better building design", was the 8th conference in a series of double blind peer reviewed conferences hosted by IBPSA (International Building Performance Simulation Association) since 1989 when the first conference was organized in Vancouver (1989). Since then, Nice (1991), Adelaide (1993), Madison (1995), Prague (1997), Kyoto (1999), Rio de Janeiro (2001) and Eindhoven (2003) have followed. The next, Building Simulation 05 conference, will be held in Montreal. IBPSA provides a forum for researchers, developers and practitioners to foster new developments, encourage the development and proliferation of software programs throughout the industry, address standardization, accelerate integration and promote technology transfer.

Over the past two decades the building simulation discipline has matured into a field that offers unique expertise, methods and tools for building performance evaluation. It draws its underlying theories from diverse disciplines, mainly from physics, mathematics, material science, biophysics, human behavioral, environmental and computational sciences. The theoretical challenges are bountiful when one recognizes that the physical state of a building is the result of the complex interaction of a very large set of physical components. The integration of these interactions in one behavioral simulation poses major modeling and computational challenges. Its ability to deal with the resulting complexity of scale and diversity of component interactions has gained building simulation a uniquely recognized role in the prediction, assessment and verification of building performance. The building simulation discipline is continuously evolving and maturing and improvements are continuously taking place in model robustness and fidelity. As a result the discussion has shifted from the old agenda that focused on software features to a new agenda that focuses on the effectiveness of and team based control over simulation tools in building life cycle processes.

The papers in this issue extend the knowledge base in the general areas addressed above and apply building simulation in various novel fields. This thematic issue offers different perspectives on these issues and deals with the next generation of building performance simulation, recognizing the need for the management of the simulation process as an element in the larger management processes executed in the architectural and engineering office. The agenda in that field is driven by the need to increase effectiveness, speed, quality assurance, and users’ productivity. An important aspect is the integration of simulation software applications with other design applications.

Different interaction paradigms with building performance information and dynamic control paradigms are emerging. They will change the way that building simulation is incorporated in decision making, during all stages of design, from inception through operation and use. Taking this one step further, it will become common place to interact with the world around us through simulation models that are executed in the background. One will be able to interrogate this simulation model about the consequences of the proposed system intervention one is about to make. This is just one manifestation of ‘invisible’ and ubiquitous simulation on which some papers offer deeper reflections. It is expected that new developments will radically influence the way that simulation is performed and its outputs used in design evolution and post occupancy decision making. Apart from this shift from simulation of phenomena to design decision making, there are a number of major trends that appear from the papers in this issue, such as the shift from the need for “raw number crunching” to the need for support of the “process of simulation”, and from “tool integration” to the “process of collaboration”.

In spite of the fact that these trends are receiving increasing attention there is no escaping the fact the building simulation discipline still has some distance to travel to bridge the traditional “divide”, caused by the asymmetric ignorance between the design and engineering disciplines in the building industry. Many aspirations remain to be achieved, such as the support for rapid evaluation of alternative designs, better adaptation of simulation tools to decision making processes, and team support of incremental design strategies. Quality assurance procedures and better management of the inherent uncertainties in the inputs and modeling assumptions in simulation are two other areas where more progress is needed.

195 papers were presented during the BS03 conference, twelve of which have been selected for inclusion in expanded
and improved form in the thematic issue before you. The twelve papers constitute an interesting cross section of the development of the field and may be viewed as road sign to what lies ahead.

The first three papers deal with various design support issues. Augenbroe’s paper describes the Design Analysis Integration (DAI)-initiative which aims to steer towards new solutions for design analysis integration that may overcome the limitations of current data-centric interoperability approaches. This paper reports on the first phase of the development, which has produced a first-generation ‘workbench’ prototype for managing a process driven design analysis dialogue.

The paper by De Wilde and Van der Voorden addresses the integration of building simulation tools and building design. This problem has been narrowed down to computational support for one specific type of building design decision: the selection and integration of one or more energy saving building components like solar walls, advanced glazing systems, sunspaces and photovoltaic arrays into a given building design.

The first paper by Clarke et al. describes the application of a building simulation program to construct a decision-support tool for use by Scottish policy makers. It is argued that the generic nature of the tool renders it suitable to support the cumulative roll-out of upgrade measures in the long term, both within and outside the UK. The tool is then used to appraise the impact of the upgrade measures that might be applied to the Scottish housing stock.

Then follow two papers related to the urban climate. The paper by Takahashi et al. investigates the characteristics of heat flow in urban areas, and describes a model which can be used to investigate the effect of additional green on roofs and ground in order to mitigate urban heat island effects and to improve the urban thermal environment at street level.

Tanimoto et al.’s paper describes another tool for evaluation urban heat island effects. This paper describes the objectives and fundamental methods underlying the tool, as well as the structure and numerical techniques of the software.

The next two papers deal with energy storage. The paper by Heim and Clarke describes the numerical modeling and thermal simulation of phase-change material in a whole building energy simulation environment.

Ihm et al.’s paper deals with the integration of ice based thermal storage systems in another whole building energy simulation environment.

The next four papers address a mix of issues. Mardaljevic’s paper describes a new image-based technique to quantify the effectiveness of shading devices, which is founded on predictions of direct solar irradiation using hourly meteorological data for a full year. The technique produces numerical output, as well as synoptic images that reveal the spatial and temporal variation of solar irradiation.

The paper by Saelens et al. draws the attention to the importance of a correct modeling of the inlet temperature of naturally and mechanically ventilated multiple-skin facades. The paper presents experimental and sensitivity analysis results, and uses an integrated whole building energy simulation to indicate the importance of a correct inlet temperature on the energy performance.

A second paper by Clarke et al. describes possible roles for simulation support in e-services. It is about the establishment of an infrastructure which enables the development of a range of new energy, environment and health-related services for people in their homes and workplaces using the Internet and making use of building modeling and simulation.

Westphal and Lamberts present in their paper a methodology to analyze the thermal Loads of non-residential buildings based on simplified weather data. The methodology showed good results for cases with low mass envelope but revealed limitation to represent thermal inertia influence on the annual cooling and heating loads.

Finally the paper by Henninger et al. discusses analytical and comparative testing of an integrated whole building energy simulation software in terms of its heating, ventilating and air-conditioning equipment models. The paper demonstrates the use of the Building Energy Simulation Test and Diagnostic Method for Heating, Ventilating, and Air-Conditioning Equipment Models (HVAC BESTEST) which was published in 2002. The authors state that these tests proved to be very useful in debugging and verifying air-conditioning equipment models and algorithms. The paper summarizes the difficulties encountered and the benefits gained in applying these quality assurance tests.

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