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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. All papers are devoted to the better description, modeling and simulation of physical transport flows in buildings such as the flow of energy and matter as well as radiative transport phenomena such as light and sound. Applications of such studies deal with the simulation of energy conservation and storage systems, dynamic control systems for smart building technologies, optimal performance of heating and cooling devices, visual and acoustic comfort, smoke and fire safety, distribution of air borne contaminants, the growth of molds, and others. 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 based on a neutral language and shared representation.

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 from 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.

Bazjanac's paper inspects the claim that interoperable software enables seamless exchange of data among different compliant applications, in particular from the perspective that this should increase the quality of building energy simulation. The simultaneous interaction of multiple design and simulation tools is discussed as the key step towards increasing quality. The paper discusses the new IFC HVAC extension schemata that are included in the latest release of the IFC data model (IFC2x2) and the new functionalities and industry processes it supports. It describes an example of an interoperable software environment, and discusses possible gains from interoperable simulation, and shows opportunities and discusses some of the current limitations.

The paper by Fujii and Tanimoto reports on an exciting application of mixed, or hybrid, simulation. It describes a method of simulating the interaction between physical environment and human action. The approach pairs a building simulation model with a model for action simulation, and adds a procedure to mediate the two models. The underlying motive of the research is to describe and simulate environmentally symbiotic actions and codify the knowledge and beliefs that people should acquire to perform such actions. The authors recognize that it might not (always) be possible to identify humans as occupants with modeled desires, beliefs, and intentions, but the proposed model provides an interesting method to reason about the connection between environment and human action.

Glaser et. al.'s paper introduces a new interaction paradigm for lighting simulation data, focusing on the use of work plane illuminance charts to quickly assess office lighting requirements. The authors introduce a user-interface that allows interaction with the general audience. They show two systems for integrated lighting design and analysis—LightSketch and Scythe + Sew. Both systems allow for rapid and extensive exploration of a range of issues in lighting design, based on an algebra that operates on illuminance information.

The paper by Liu and Yoshino presents a method to solve moisture condensation problems by using a computational fluid dynamic (CFD) tool. The paper shows the development of a surface condensation component that was added to a 3D transient CFD model. Calibration in a test chamber indicates that there is a good agreement between the experimental results and the model predictions. The simulation shows good agreement with the effect of local airflow distribution on condensation risk. The model may be used to generate recommendations for the best placement of diffusers to avoid condensation risks.

Mahdavi's paper was presented at BS03 as keynote address. The author presents a view that puts the plethora of models used for the codification of buildings, and the process that take place in and around them, in a broader context. The paper presents four variations not so much "on", but rather "around" the theme of computational building models. This is done with the aim to address the range and effectiveness of model application towards supporting the design and operation of more habitable and sustainable built environments.

Manabe et. al's paper is a contribution to the further development of thermal comfort models. It describes the radiation environment of the human body by a 3D human body model, which allows shape factor calculations between the human body and its solid and "other" (e.g. other people) surroundings. Results are visualized by VRML, directly indicating the influence of thermal radiation on thermal comfort.

The paper by Park et. al. shows the development of occupant responsive optimal control of smart façade systems. The control can be implemented as a smart controller that operates a motorized venetian blind system and ventilation openings. The study uses a simulation model of smart façade systems with an embedded optimization routine that optimizes energy, daylighting and comfort performance. The control module allows occupant interaction via the Web where an occupant can choose from a set of predefined modes or set his or her own preferred mode. Results indicate that the proposed occupant responsive optimal control can lead to significant improvements in energy conservation.

The paper by Sahlin et. al. makes the observation that traditional monolithic simulation codes are still in dominance over simulators based on symbolic equations in a more general modeling and simulation language. It goes on to observe that the IDA tool has become the first wide spread thermal building performance simulator based on a new more expressive simulation language. Important lessons were learned and the paper shares some of them, in particular regarding general program structure, GUI design, and a variable time step differential-algebraic (DAE) solver.

Shimoda et. al's paper introduces a simulation model that predicts end-use energy consumption in residential sectors. The assumption is that the annual energy consumption of a residence can be predicted based on knowledge of the occupants' living activities, weather data and energy efficiencies of appliances and the residence. Results for Osaka city are compared with statistical data, and the effects of energy efficiency standards and urban heat island phenomena are examined using the model.

In their paper, Suter and Mahdavi describe a representation framework that supports performance analysis during schematic and detailed design. It is based on two co-existing building representations that include sufficient information for a range of performance analysis tasks. It is explained how automated, bi-directional mappings can maintain the consistency between the two representations, i.e. between the sheet-type representation, and a solid-type representation. It is discussed how model manipulation is supported by spatial partitioning techniques and how this technique may be used in performance-based design practice.

Wetter and Wright describe in their paper that solving optimization problems for building design and control often needs to be performed on cost functions that are discontinuous, limiting the type of optimization algorithms that are adequate for the task. The authors investigate how applicable direct search, stochastic, and gradient-based optimization algorithms are for solving such optimization problems. They do this by comparing the performance of these algorithms in minimizing cost functions with different levels of smoothness. The outcomes are a significant aid in the choice of suitable methods for optimization studies.

The paper by Zhai and Chen deals with the integration of building energy simulation and CFD programs. The paper discusses the methods used to determine convective heat transfer at interior surfaces of the building envelope, which is the key linkage between the two types of simulation programs. It is found that the size of the first grid near a wall in CFD is crucial for the correct prediction of the convective heat. Through numerical experiments, the paper suggests a universal first grid sizes for different types of flow. The investigation leads to important guidelines for use of CFD on whole building scale.

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