PERGAMON

Building and Environment 36 (2001) 673–680

BUILDING AND ENVIRONMENT

www.elsevier.com/locate/buildenv

Tools for quality control in simulation

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Abstract

This research examines the nature of environmental design information used by building designers.The goal is to identify commonality in the types of information that design tools should produce. It presumes that improving the use of design tools will lead to improved building performance. Through practitioner interviews, it investigates application of design decision support tools by building designers. It proposes a means of increasing designers' use of these tools. This proposal derives from observation that systematic quality assurance (QA) systems are seldom used with simulation-based tools. The proposal is a QA system comprising (a) a simulation veracity test akin to the Turing test of computer intelligence; (b) an internet database of building performance information; (c) post-analysis tools that define the reliability of design tool output. © 2001 Published by Elsevier Science Ltd.

Keywords: Commercial buildings; Residential buildings; Simulation; Energy; Daylight; Quality assurance; XML; Web technologies; Practitioner; User survey

1. Introduction

This research [1] asks: *what is the nature of the environmental design information sought by building designers?* It assumes that improved building performance is the goal of all designers. For the research, we interviewed users of building environmental design decision support tools. The goal was to identify whether common needs exist across different environmental design topics for particular types of tools and information.

All environmental design decision support tools are "simulations" of some imagined reality. These simulations can be charts of building performance versus window size in a solar house design handbook; an *R*-value calculation; a wind tunnel test; or use of a computer to predict the performance of a building.Complex computer programs like DOE2 [2] and RADIANCE [3] that are conventionally known as 'simulation' programs, are just more detailed, and potentially more realistic simulation tools.

2. The background

The premise is that architects need the environmental analysis skills to adapt the architectural *precedents* [4] they are encouraged to study. Using these precedent buildings in new locations requires more than a mere assertion that architecture has *profound significance* or *embodies timeless laws* [5]. [1] What they require is a systematic understanding of the relationship of those precedents to the environment — a numerate designer.

The research turns always to this one critical point: to what degree does the role of the architect in the building design team require analytical skills? The conventional notion [6] is of the architect as team leader. Building science researchers frequently conclude that a design approach compatible with these conventions [7] that is also to deliver quality environments should place central importance on *early design decision making*. Many spend long hours developing tools that they hope will improve the effectiveness of early design decisions [8].

3. The "experiment"

For the research project, we interviewed practitioners on use of a range of different design decision support tools. The interviews varied in delivery and question. Forty-six out of 130 New Zealand architects and designers in

[1] It is a telling commentary on the current situation that architects must now be convinced that it is no mean achievement to design buildings that function well, and that allow people to carry on their social life in a practical way [5].

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0360-1323/01/$ - see front matter
PII: S0360-1323(00)00059-7

workshops introducing concepts of passive solar house design returned a follow-up questionnaire. We interviewed architects in 16 of the 23 firms involved in wind-tunnel tests as part of the planning permission process for 51 high-rise buildings in Wellington. We also interviewed two architect clients of CBPR thermal and visual simulation services. Eighty practitioners in New Zealand responded to telephone or personal interviews about their use of energy efficiency design decision support tools. Twenty users of computer thermal-simulation programs in the USA responded to 'phone interviews'.

The interviews showed that all these different modes of simulation have problems that reduce the clarity of the relationship between prediction and reality. These problems fall into the following classes:

- model preparation time limits;
- no clear guidance as to the important features of a building that should be modelled well, and the features whose effect on predicted performance is insignificant,
- minimal quality assurance systems that allow the simulation user to ensure the relevance and accuracy of their recommendations,
- lack of performance guidelines for buildings that provide a basis for understanding the recommendations from the simulation,
- lack of tools for summarising and detecting patterns within the information overload that well-applied simulation can produce when exploring design scenarios.

3.1. Limited preparation time

Half the passive solar house design seminars were spent in lectures, the other half in workshops. Participants showed strong interest in learning the calculation techniques and the Rules of Thumb. When trying to prove to themselves that their designs would 'work', they used the calculations. This is in complete contradiction to the findings of the general survey of New Zealand practitioners' use of energy efficiency design tools. Their call was for tools that they could use with little effort. No client would apparently pay for the extra analysis time.

USA simulation program users' responses agree with researchers' conclusions [7] that the most important phase of the design process is the first so-called conceptual design phase. Participants in New Zealand and USA surveys did not comment directly on the time taken to use a simulation program. However, when asked to suggest improvements to simulation software many of the USA users said they wanted easier-to-use programs. The principal benefit was to reduce simulation time.

A very high proportion (79%) of the USA participants saw a high value in continued and expanded use of simulation in building design. None commented that simulation was better applied later in design.

Concerning "practical difficulties … in carrying out wind tunnel tests yourself", typical comments described the time this type of simulation takes away from the design process: "Not enough people in the office to spare someone for that time. Not confident to have done it efficiently and to have come out with a good report. … Is it necessary? Why can't others do it? … Design time is usually quite short, and anything adding to that is an obstacle". … Another aspect of time is the cost of doing a wind tunnel simulation. Comments on this aspect included: "Expensive, one *time*, models and analysis taken into account. *Time*, expertise, cost all have an effect — testing takes much longer than it should as a result of the lack of experience, wasting time, costing money while gaining experience, not economical or time efficient for developer". They argued for a simplification of the method. The implication was that simplification would produce quicker turnaround of applications in the Council approval process — a saving in time.

Time was the most significant aspect of any comments from architect clients about CBPR thermal and visual simulations. The architects suggested that the extra time required to consider fully the options put forward by the CBPR would have put them behind schedule. They could not afford to do this as they risked losing money at current low design fee levels. "[We] had limited funds, therefore we had to produce a design quickly to come within the fees we were being paid. [Because of the] minimum fee we weren't interested in pursuing alternatives unless we were paid for it".

3.2. Lack of guidance on which features are significant

The participants in the passive solar house seminars tried the "simulation" formulae provided in the manual [9] almost at random to sort out what worked. They did not behave as if they had any idea, even after the lectures, which building features would have the greatest effect. They did not try to find connections between the "Rules of thumb" and the calculations. Rules of thumb typically specify what size a building feature (window size, wall thickness, thermal storage) "should" be but they do not normally specify why.

The solution seems to be to produce simulation programs that are flexible. Designers would use them to explore the interaction of all parameters in a design. This type of simulation requires more time and resources than current programs. The highest priority is for simulation output to include a ranked list of the building parameters that affect performance the most.

When asked to describe the priorities they would set in establishing courses for new users of simulation, the USA simulation program users talked of teaching 'scepticism'. They wanted to imbue a distrust of the Black Box. They were trying to convey the importance of knowing what