STIMULATING SIMULATION

Computer tools in building services

The application of computer tools in construction is set for a revolution as integrated software packages come close to fruition. But there are barriers to the increased use of electronic design tools, notably worries over validation, the skills needed both in the design studio and on site and the quality assurance issues of correctly defining product elements and the design criteria. Over the next three articles, we examine the potential for using integrated computer design tools. To begin, Paul Ruyssevelt and David Batholomew discuss the use of computer models with more traditional design methods.

Reality bytes

Back in January 1995, an International Energy Agency (IEA) study threw doubt on the validity of computer simulation models[1,2]. Three years on and there is no sign that supporters of computer simulation have lost their enthusiasm, but neither has it become routine design practice.

Few would question that accurate simulation makes it possible to design better buildings. The doubt has always been whether 'validation' – comparing models with reality – is the acid test. Since 1995, modellers have largely won the technical argument, and the forthcoming CIBSE *Application Manual* on energy and environmental modelling (and, possibly, the next edition of the CIBSE *Guide*) will give modelling an unmistakable seal of approval.

But will that be enough to encourage designers to use modelling more widely? After all, little has really changed. The basic accuracy of programs is much the same now as it was during the IEA study[3], and at least one of the programs in that study could have produced equally good results 15 years ago.

If accuracy is not the key issue for designers, what is? Could 'validation' studies have been looking at the wrong things? Or does designers' scepticism arise from entirely different factors? Are they Luddites, or actually very wise?

With support from the DETR's Partners in Technology programme, a fresh look has been taken at the case for modelling, why the profession has been so reluctant to take it up and what needs to be done to settle the argument between modellers and traditionalists.

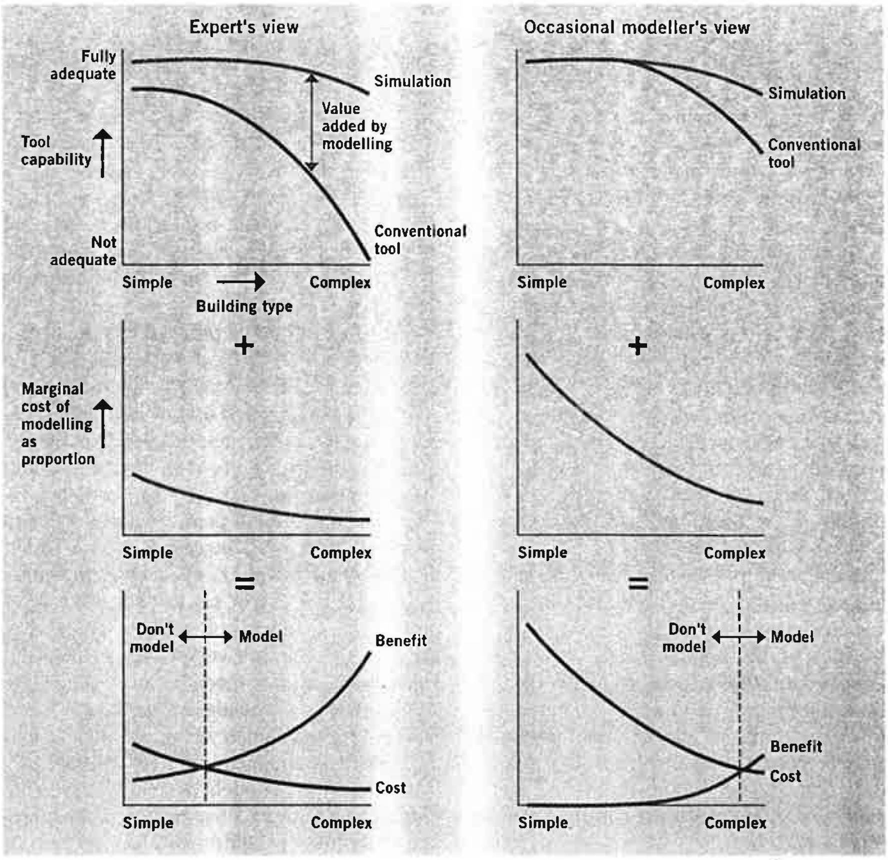

FIGURE 1: Enthusiasts believe modelling can add significant value in a wide range of situations, and is affordable or even profitable. Sceptics doubt that it can add much value, and see it as expensive.

To do this, we drew on our own experience, discussed the issues with other expert modellers and with model developers and vendors, looked at experience in other fields where modelling is used, and interviewed respected architects and building services engineers who do not use models (or only use them occasionally).

The IEA project and other building validation studies attempted to discover whether computer programs can reproduce the physical behaviour of simple structures. They certainly helped to reveal errors and limitations in the software and were undoubtedly a valuable part of the model development process. However, they give no direct evidence of whether modelling leads to better design solutions than conventional methods like CIBSE *Guide* procedures, let alone how much better the solutions are, or whether the improvement is worth the extra design cost.

Put another way, building model validation has concerned itself with the ability to capture natural processes (to represent physical processes such as conduction, radiation and heat storage) and to reproduce natural patterns (to predict correctly how internal temperature reacts to sunshine, for example), and it has ignored the ability to serve a practical purpose (to lead to better design decisions). A new approach to validation is urgently needed, focusing on validity defined as usefulness.

It is not actually necessary for a model to capture natural processes or to reproduce natural patterns particularly well in order to be useful. CIBSE *Guide* methods are highly simplified models that are typically rather poor in these respects – they would not show up at all well against simulation models in IEA-type validation exercises – but nevertheless experience shows that they usually lead to good designs. Their 'validity defined as usefulness' is clearly good.

There is much anecdotal evidence that simulation models can do better still. Leading design practices have used them for years, and the decision to dispense with air conditioning in a number of recent (successful) buildings would have been unacceptably risky without reassurance from simulation. However, no systematic attempt to establish where simulation is advantageous is known, or to assess the performance improvement it can offer. Without this, it is entirely legitimate for designers to be suspicious of modelling.

In-depth interviews with designers seem to support this analysis. Few doubt that modelling works and that it can be valuable in addressing design problems that they perceive to be beyond the scope of conventional tools like CIBSE *Guide* methods. What non-modellers and occasional modellers doubt is that there are many design problems like this, and that modelling can help them find significantly better design solutions than conventional methods.

Interviews with practitioners confirmed that doubts are not typically rooted in serious distrust of models' ability to represent building behaviour – that is, in their technical capability or their validity (as conventionally defined). Some certainly approach model predictions with a degree of scepticism, but they are conscious of approximations and limitations in CIBSE *Guide* calculations as well.

Most people accept that modelling is fundamentally a more powerful technique, but doubt that this superiority in the representation of physical processes can be translated into better design. Their doubts appear to arise almost entirely from a lack of positive evidence.

The question of cost

The surprise from the interviews with engineers and architects was the importance of cost in designers' propensity to use models. Indeed, it may be the biggest inhibition to modelling.

Practitioners' perception of cost is a complex and largely subjective function of the practice's size, the nature of its client base and work, the background of the staff, their technical conservatism, their attitude to commercial risk, the capital costs of computers, software, training and quality assurance, the revenue costs of staff time and external consultancy, the visibility of the various costs (which depends, for example, on accounting practices) and the extent to which costs can be passed on to clients. Perceived costs vary widely, and may be very different from an 'objective' estimate made by an outsider.

No attempt was made to disentangle these influences in the interviews, but a clear and consistent picture of the main issues emerged. Most occasional modellers clearly see modelling as an additional cost in design, an outgoing that reduces their profits.

This contrasts with regular modellers, who believe it increases profits, either through sales of specialist consultancy services, as a chargeable addition to design services or as a marketing tool.

In practices without an in-house modelling capability, capital items – especially software and training courses – were clearly dominant in the interviewees' perceptions of cost. Labour costs were generally a lesser concern, even though 'objective' analysis would show them to be a larger part of the lifetime cost of a modelling facility.

The value of modelling

Typically, the difference between enthusiasts and sceptics is not a different interpretation of IEA-type validation results, which most designers see as irrelevant. Rather, it is that enthusiasts believe modelling can add significant value in design in a wide range of situations, and is affordable (or even profitable). Sceptics doubt that it can add much value, and see it as expensive (figure 1).

The two steps that would do most to establish modelling as a normal part of good practice are cheaper programs, backed up by well-designed and affordable training and support, and convincing direct evidence of the value that modelling can add in design.

Practices can overcome the capital cost barrier by using public-domain programs like SERI-RES (a thermal simulation) and RADIANCE (lighting visualisation). There are difficulties in this (notably the lack of support), but public domain programs offer an excellent way to try out modelling without significant capital investment.

Such programs usually have fewer capabilities than commercial programs and their user interfaces look old-fashioned in a Windows 95 world, but the best are technically excellent: SERI-RES, for example, performed very well in the IEA tests.

Starting with public domain software allows investment in a modern commercial program to be deferred until it is clear that the

VALIDATION EXERCISES

A new round of validation collaboration between the BRE and Electricité de France (EdF) has recently started with the focus on validation in real buildings, *writes Foroutan Parand.* These include the BRE test houses with simulated occupancy, and an unoccupied office room at the BRE. The first set of results is expected in March '98.

The first BRE/EdF validation exercise showed that the modelling of heaters was a source of discrepancy between predictions and measurements. This issue is being investigated in a DETR Partners in Technology project involving EDSL (developer of TAS), the Energy Monitoring Company (EMC), the EdF and the BRE.

Tests have been carried out in the EMC's Test Cell 3000. These are being used to develop new models for heaters to be incorporated in the programs involved – Clim2000, TAS and 3TC – and tested with new data sets collected next winter.

As part of the BRE/EdF validation exercise, a validation database has been developed by De Monfort University which contains the description of a number of high quality datasets for comparative and empirical tests, including some of those discussed. The validation database has recently been made available as an Internet resource (http://cig.bre.co.uk).

A new IEA validation, Task 22 under the Solar Heating and Cooling Implementation Agreement, is also underway. The Empirical Validation Subtask of the IEA Task 22 will use some of the data gathered under the BRE/EdF validation exercises as well as data being collected in EdF test houses in France to test a number of programs.

Under another subtask of IEA 22, the idea of BESTEST is being used to develop a set of benchmarks for testing plant models within simulation programs.

Foroutan Parand PhD is head of the Centre for Construction IT at the Building Research Establishment Ltd.

practice benefits from an in-house modelling capability.

There is little that practices can do themselves to get evidence that modelling has 'validity defined by usefulness', that it adds value in design. *Building Services Journal* may pursue this next year in a follow-up to the PROBE projects, tracing the history of buildings that were designed with modelling support to discover how it influenced individual design decisions, and what these contributed to the overall success of the buildings.

David Bartholomew is principal of David Bartholomew Associates. Dr Paul Ruyssevelt is associate director with HGa Consulting Engineers.

References

[1]Bunn R, 'Tower of Babel or the Promised Land', *Building Services Journal*, 1/95.
[2]'Testing time', *Building Services Journal*, 1/95.
[3]Lomas K, Eppel H, Martin C and Bloomfield D, 'Empirical validation of thermal building simulation programs using room test data: Volume 1' (Final report of IEA Annex 21: *Calculation of energy and environmental performance of buildings*, 1994.

If you were involved in the design of a building that demonstrates the value of modelling and would like to participate in this project, contact Paul Ruyssevelt at HGa Consulting Engineers on 01793 814756.

Cool running

Computer simulation is reckoned to model reality with acceptable accuracy, but how does it perform in practice, and can a client as demanding as Marks & Spencer be convinced?

BY GARRY PALMER

The design of chilled food halls is a three-way balancing act between the comfort of shoppers, the presentation of produce and the efficient preservation of goods. All these factors are in continual conflict, the resolution of which requires careful and detailed design.

In food halls there can be no physical boundary between the occupied zone and the chilled cabinets, although each has a very different environmental requirement. In terms of customer comfort, food halls often have very low average air temperatures and significant vertical temperature differentials. This can lead to increased cabinet running costs or, occasionally, conflict with store hvac systems.

Micro-climate models

A programme of computational fluid dynamics (cfd) projects on chilled food halls has been carried out by Oscar Faber Applied Research for Marks & Spencer.

The projects began with the modelling of a prototype chilled cabinet, the aim being to improve the performance of a conventional cabinet, particularly its energy use and temperature control (figures 1 and 2).

This entailed the detailed simulation of the cabinet's components such as an examination of the supply jet design to refine its direction and length of throw, which dictates the air curtain's performance. Other areas of investigation included the return air grille design,

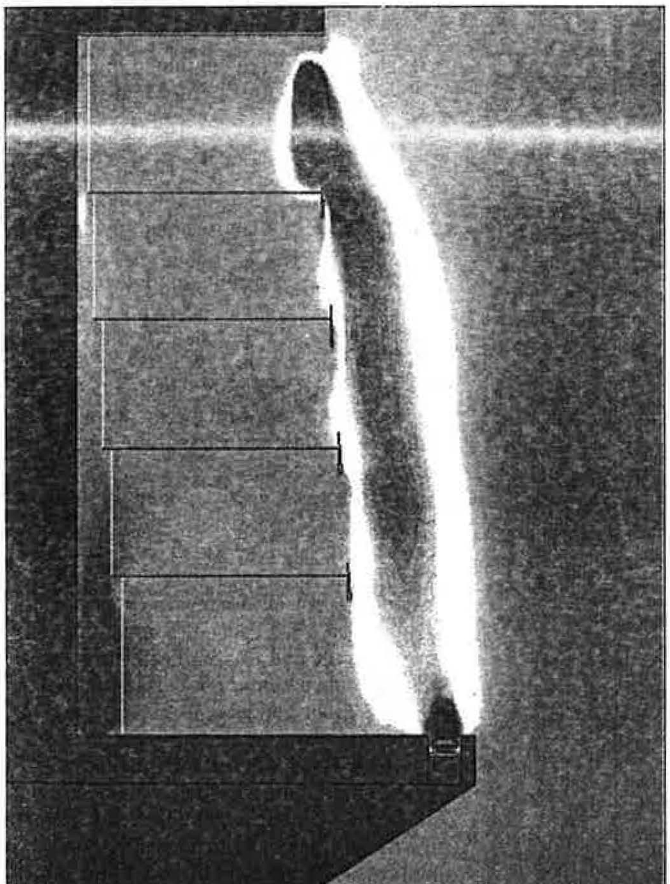

FIGURE 1: Air curtain design – section through chilled cabinet showing air vertical velocity.

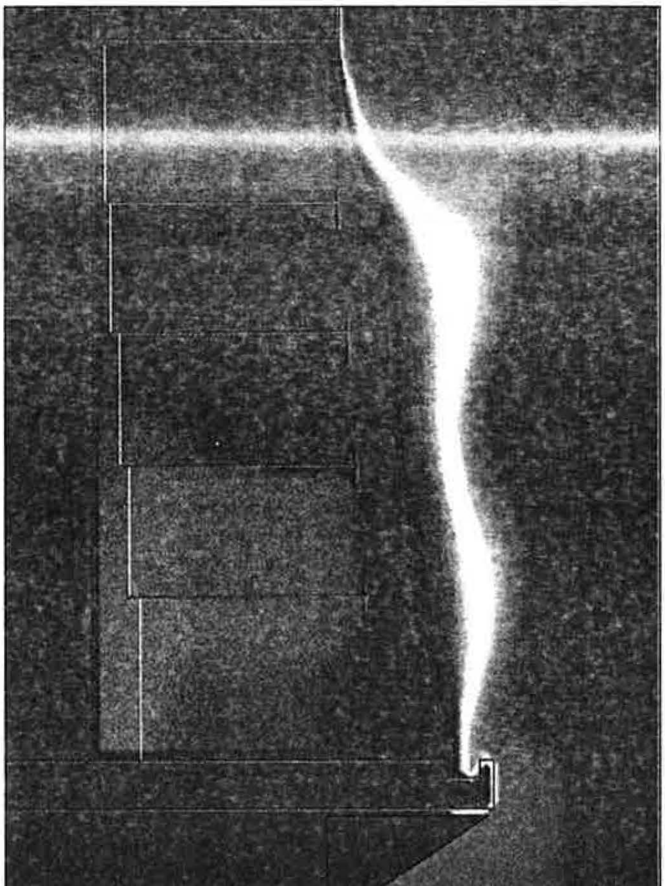

FIGURE 2: Cabinet design – section through chilled cabinet showing air temperature.