INFORMATION TECHNOLOGY AND BUILDING PERFORMANCE

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ABSTRACT

The quality of the built environment depends critically on the concept of sustainability and, in particular, on designs which are energy efficient and environmentally friendly. This paper gives an account of the successful application of computer-based simulations of the physical environment made available to architects through an Energy Design Advisory Service and used parametrically within a research project carried out jointly with a design and build company. It goes on to indicate how emerging multi-media technology can be used to provide an explanation, particularly to those who are technically unsophisticated, of the complexity of the way in which design decisions impact upon the energy efficiency and environmental friendliness of buildings.

1. THE IMPORTANCE OF SUSTAINABLE ARCHITECTURE

In the majority of developed or developing countries throughout the world, building is one of the largest single industrial sectors, accounting for up to 8% of the Gross Domestic Product and employing, directly or indirectly, 8% of the working population.

Yet despite its scale and importance in the national and regional economy, the building industry is under-developed and dis-aggregated. In the UK for instance, only 6% of contracting firms employ 7 or more people; 50% of architectural practices employ 2 or fewer professionals. The research and development budget of the industry is a meagre 1/2% of turnover. The professional education provision is highly fragmented and

Continuing Profession Development opportunities are very limited. Overall the labour force is poorly qualified.

This has a serious consequence for the quality of the built environment. Conservative estimates suggest that remedial treatment of building defects costs the UK upwards of £1,000 million per annum (excluding normal maintenance): some 50% of these defects, it is judged, could have been obviated by better design. In a high proportion of post-war buildings, energy consumption is profligate; UK Department of Energy figures suggest a potential saving of up to 50% through better design of new buildings and 25% through appropriate design intervention in the existing stock.

There is broad agreement amongst key institutions in the UK industry - the National Contractors Group, the Construction Industry Council, the Latham Committee - that an improved and more integrated provision in education and training and an increased investment in research and development would yield major benefits both in the competitive edge of professional practices and contracting firms, but also in the quality of the built environment.

The concept which is gaining currency in education and in research is that of sustainability.

Quite clearly, the Information Technologies have a major role to play in securing higher degrees of sustainability in our buildings and our cities and, indeed, a significant effort has been invested in the development of applications software relevant to sustainability but very little of this work is widely reported: the number of papers published in the CAAD Futures Conference series, which could reasonably be considered relevant to the issue of sustainability, is depressingly small.

The purpose this paper is to give greater emphasis to the successful application of information technology - particularly computer-based simulation and multimedia - in the service of energy conscious, environmentally friendly building design.

2. LARGE SCALE SIMULATION

Over the last decade the Architecture and Building Aids Computer Unit, Strathclyde (ABACUS) has developed three inter-related first principles models to simulated the physical environment in buildings:

ESP: Environmental Systems Performance [2] which models all heat and mass flow-paths and flow-path interactions within the building and between the building and the heating/cooling plant and its control system. Output, in the form of time-related graphs give the designer an insight into how design decisions on building shape, construction, fenestration and plant-control, impact upon energy consumption and comfort quality.

DIM: Digital Illumination Model [3] entails the tracking of light vectors as they inter-reflect between the surfaces of building interiors from any number and type of windows and luminaires. Output can be digital (luminance levels) or full colour graphics.

SAX: Sound Advice Xpert [1] uses the same computational approach as ESP and DIM in tracking sound energy as it reverberates within building interiors Work is continuing on the output modules of SAX.

2.1 Energy Design Advisory Service

The research team considered that it was not sufficient simply to generate a prototype implementation of the coding for each model but that it was necessary also to investigate the validity and useability of the software in the context of live design projects. The problem, however, was the reluctance of architectural practices to invest the effort in climbing the steep learning curve towards competent usage of the models.

The way forward, after much negotiation, was to bring into existence an Energy Design Advisory Service, financed by the UK Department of Energy and offered through the Royal Incorporation of Architects in Scotland, to RIAS members and their clients [4].

Since its inception EDAS in Scotland has been an outstanding success dealing annually with around 120 initial consultations and around 30 full computer-based modelling consultations.

Over the period of its operation, the efficiency of the design advice offered by EDAS in Scotland was closely, and independently, monitored. The conclusion was that the financial investment in software development and in subsidy to EDAS clients has yielded a return through savings in energy consumption which is at least an order of magnitude greater; this huge financial benefit is measured only in terms of the cases dealt with by EDAS and does not take account of the improvements in energy efficiency which the architectural clients of EDAS will carry forward, through improved understanding of the issues of energy conscious design, to subsequent design commissions.

The success of EDAS in Scotland encouraged the Department of Trade and Industry to extend the scheme to 4 regions in the UK. To date EDAS in the UK has generated around over 500 case studies which provide a rich source of information for teachers

and practitioners of architecture. The total savings in energy are evaluated at £6 million.

2.2. Teaching Company Scheme

The second opportunity which ABACUS sought to explore the useability of the software packages was through a Teaching Company Scheme (TCS) financed by the UK Science and Engineering Research Council which brought the research team into close R+D collaboration with a 'design and build' company. GA Construction had a declared commitment to 'quality' in design and build, with a particular concern for energy conscious design. The TCS presented the opportunity to work with ABACUS over a two year period in an effort to establish "what are the life-cycle costs/benefit from energy conscious design and construction and how can improved quality be marketed".

The project was carried out in five overlapping phases:

i) establishment of the basic physical principles which determine the energy behaviour of buildings.
ii) analyses of case material drawn from EDAS.
iii) establishment from the case material of the main design parameters of form and fabric which are likely to impact on energy consumption.
iv) simulation, using the ESP computer model, of the predicted impact of these design parameters in two main building types.
v) evaluation of the life-cycle costs, energy consumption and production of pollutants relating to each design variant.

The core activity of the project was the application of the ESP programme to a wide range of parametric variations on two main building types and the subsequent costs-in-

use analyses of each case. The incontrovertible conclusion - which matched perfectly with the prime concerns of responsible building client organisations - was the paradigm that:

> "good (computer-aided) design, without costing any more over the life-cycle of the building, can reduce energy consumption and, therefore, the associated harmful levels of atmospheric and stratospheric pollution, by a full 50%.

3 MULTIMEDIA EXPLANATION

The palpable benefits of the consultancy offered by the innovatory Energy Design Advisory Service and the conclusive outcome of the collaborative research conducted through the Teaching Company Scheme gave the researchers in ABACUS immense satisfaction in the knowledge that the CAD software had, indeed, brought about substantively and significantly improved quality in the built environment.

There remained the doubt, however, that the benefits were enjoyed predominantly if not exclusively only by the clients of EDAS and those people in GA Construction who were actively involved in the collaborative project. By great good fortune the Managing Director of GA, was sufficiently enamoured of the outcome of the collaborative endeavour to risk a further modest investment to produce what is, in the authors view, an outstandingly powerful multi-media presentation "GA and the Environment" [5] which not only reports on the joint research and development but offers a clear and cogent exploration of the principles which underlie energy-conscious building design.

"GA and the Environment" readily offers the user multilayed information on energy-efficient, environmentally friendly design under six broad headings.

Building and the Environment

Basic Principles

Responsive Building design

Building Performance Prediction

Case Studies

Benefits

The section in Case Studies will shortly be fully populated by up to 100 examples of energy-efficient, environmentally friendly design solutions generated by EDAS. The intention is to communicate - in a graphical mode which architects find acceptable - the complexity of the design issues which underpin sustainable, and substantiable, architecture.

At the same time efforts are underway to provide multi-media interfaces to the three simulation packages (ESP, DIM and SAX) in an endeavour to make them more widely usable in architectural practice.

4 CONCLUSION

It is quite clear that in the late 80's and early 90's there has been a widening gulf between the sophistication of first principles computer based models of the physical behaviour of buildings which affects sustainability and the competence of architects and engineers to take advantage of them.

This paper has attempted to celebrate the importance of computer simulation and to show that multi-media technology can provide the means to interpret, explain and even encourage participation by architects in sustainable architecture.

5 BIBLIOGRAPHY

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