THE BENEFITS OF USING COMPUTER AIDED DESIGN

In response to recent criticism of computer aided design (RIBAJ 10/77), Professor Tom Maver* has assembled evidence of the experience of six users to show that it can give significant benefits in design quality and efficiency and has enormous future potential.

Design – arguably the highest endeavour to which man and woman can aspire – can be defined as making explicit, proposals for a change from some existing state to some future state which more closely approximates to man and womankind’s concept of the ideal. Central to the activity of design is the concept of modelling future reality; to Bronowski, the single most significant step in the ascent of man was the creation of the cave paintings – graphic models of the future reality to be faced by the young men of the tribe. Around the year 2 800 BC the master builders changed the face of architectural design by the introduction of design drawings – models of future built form; it is difficult to imagine the practice of architecture in the 1970’s without the aid of design drawings.

During the last 5 000 years, however, there has been a curious lack of development of the modelling techniques: the models of future reality have remained prescriptive, dealing statically with the visual characteristics of the design. More curious still is the reactionary resistance to the current development of a new generation of models capable of being predictive, and of dealing diagrammatically with the functional and visual characteristics of the design. As a response to Nigel Cross’s article ‘Problems and threats of computer-aided design’ (RIBAJ 10/77), the experiences of a few design offices currently using and developing the new generation of models have been collated in this article.

The aim in selecting these offices has been to exemplify the variety of application areas in both the public and private sectors. Three of the offices - the Scottish Special Housing Association, the GMW Partnership and the Oxford Regional Health Authority - have acquired hardware especially for CAAD/CABD work; Cheshi County Council and Strathclyde Region Council use existing but appropriate machines with occasional use of add-on bureaux; the Common Services Agency of the Scottish Health Service use its own terminal equipment connected, necessary by telephone to a bureau.

The application areas – on which the contributions focus – though not necessarily representing the total commitment of the respective offices – are:

*CCC Brief development with particular reference to accommodation schedule applying to schools.

*CSA Layout appraisal and visualisation to development control plan stage, applying to hospitals.

*ORHA Layout appraisal and production documentation, applied to Oxford hospitals.

*SSHA Layout and site appraisal and production documentation applied to housing.

Common Services Agency: The floor plans of alternative design schemes are input to the program PHASE at the graphics computer terminal by means of a cursor and menu of commands.

Common Services Agency: The output from the program PHASE be displayed graphically which allows the cost-performance attributes of current scheme to be compared with earlier design hypotheses.

Common Services Agency: As a supplement to the measurable cost/performance attributes the program PHASE automatically allows perspective views from any chosen viewpoint.

GMW Partnership: Typical core detail of a multi-storey office building produced by GMWP using the RUCAPS drafting system.
GMWP Drafting, scheduling, visualisation and management, applied to various building types.

SRC Energy studies and their relation to design, applied to various building types.

Cheshire County Council
In Cheshire County Council Department of Architecture the computer is not utilised exclusively as a CAAD or CABD facility but rather as a tool which can aid the Department as a whole during the design, management and maintenance processes. Computing facilities are used in a variety of ways but the type of usage can be considered to fall into two broad categories. The first category is the user specifies and designs a system which will perform the routine, repetitive calculations which form a measurable or major part of the user's job. The benefits of this type of development can usually be assessed in terms of speed of service, increased quality of service, or finance. Cheshire applications of this type which have been developed to date, or are in the course of development, include:
- Calculation of limits/cost plans for buildings in a building program
- Manpower resource/fee calculations
- Fuel tariff checking
- Formula price adjustments for variation in quality of services
- Maintenance expenditure control
- Time sheet analysis
- Other applications fall into what can be described as an "enabling" category. That is, they permit a new area of enquiry to be opened up by assisting a development group in processing a mass of data. Cheshire applications in this category include:
- Cheshire Fuel Monitoring system
- Space scheduling using the program ECOPE 1

Worthy of further description is the utilisation of program ECOPE 1. The program is intended for use by the design team in the preparation of a schedule, or schedules of accommodation. This could form the basis of a brief for a new school or alternatively be used in the processes of design and feasibility for extensions or adaptations to meet a future educational organisation. The program has been used in Cheshire to assist in the development of a system for secondary school building performance appraisal. It is thus a tool for decision-making which will allow more effective use of building stock, and by implication, promote the development of improved briefing techniques. The research team collected and processed analysis data from a sample of ten Cheshire schools and used this data as constraint information in modelling hypothetical comprehensive schools with members of the college's advisory staff.

ECOLE 1 was used to translate the data into what in Cheshire is called an activity demand for space, which can be set against existing buildings in order to determine how far a school building can meet the requirements of a future pattern of usage. Its value to the research team can be summarised as follows:
- The research team can be a highly qualified group of people and computer programs such as ECOPE 1, can produce a mass of output in an acceptable period, thus utilising a great deal of data without employing research assistants.
- As a rough estimate the team has calculated that up to three man years of manual calculation would have been required to produce information of equivalent quality to the computer-aided output.
- The cost of running ECOPE 1 has not been directly calculated but is contained within a total computing bill of £5000 during the period when it was executed.

The appraisal system is an on-going service to the client department. This service is being maintained by professional staff with the support of computer data files.

Potential benefits are great compared to the financial investment in ECOPE 1. There are approximately seventy secondary schools in Cheshire and the appraisal process has been applied to over half that number of schools for one reason or another. In this context the investment in the program is seen as a fairly small scale commitment which does not prejudice any future course of action by the Department of Architecture as a whole.

The appraisal system as a whole allows the architect to be involved in proposals for development of a school building before production of the client brief. It enables appraisal and design processes to be initiated in such a way that the architect participates in the development of a design team brief and in this sense increases the involvement of the architect, with an anticipated improvement in quality. In summary, it is apparent that the program has been of direct benefit to the research team in developing the system and of indirect benefit to the design team in improving the quality of design proposals.

Scottish Health Service
The set of computer programs known as PHASE 2 - design appraisal aids specifically developed for use at the early stages (RIBA Stages C, D, E) had been in use in the Health Service in Scotland since 1973. The software is used at the strategic level of whole hospital design - the point where the first decisions that determine building form, principles of circulation, supply and disposal, services distribution, phasing, etc. are taken. The programs rely on the design team to develop alternative design solutions, from which the program then presents the best solution or solutions so that subsequent decisions can be made in fuller knowledge of their consequences over a range of design criteria. Program input consists of the geometry of the building form, site characteristics, constructional requirements, activity patterns, current cost and energy rates. Program output, a comparative assessment of the cost and performance characteristics of a given scheme, is stored in a detailed and structured form as records of the programs have been developed for interactive use by those with no previous computing experience.

Use of the software has been made on the following schemes. Firstly, primarily as tests of the software, on the design of a 700 bed DHG for West Lothian and on the design of the 866 bed Motherwell DHG (subsequently re-briefed as a phased development). Secondly, use of the design aids was made by the Scottish Health Service, Common Services Agency, Building Division, on the 'in-house' production of a development control plan for the West Fife DHG (a two phase scheme of 2400 beds).

Here, and this is typical of the mode of working, several variations/developments of each of these three basic alternative design strategies were appraised (a dozen or so schemes in total); the design team proposing a possible building form, making an appraisal of the scheme, and in the event the program output, from intuition and from past experience then making modifications to the building form, and re-appraising; this cycle being repeated until the most satisfactory solution is identified. Similar research was also carried out for the Borders DGH (in this case a scheme being done executively by outside consultants in association with the Building Division).

It can be argued that the Scottish Health Service has its greatest pay-off at this early design stage and the use made of the programs has demonstrated that it is possible to undertake the investigation of design options, in a rigorous and logical manner. This design stage where previous manual techniques have proved impossibly tedious. The programs have been used for reasonable cost (approx. £1500 in the case of West Fife, paid for by the client) by the appointed design teams with little specialist assistance.

In a situation where it is not possible to develop high quality software experiments that can demonstrate the advantages, or disadvantages, of any new method of design working, the proof of the pudding must be in the eating. After some five years experience of works on major projects, the effectiveness of the design aids the Building Division continues to encourage the use of the software on major new projects, done both in-house and executively, as the design aids have proved to be effective in terms of allowing the investigation of more design options, easy and cost-effective to use and easy to integrate with existing methods of working.

Oxford Regional Health Authority
In any of the arguments about the benefits or otherwise of Computer Aided Design (CAD), what does not seem to have been realised is that CAD enables a different design strategy to become possible, particularly in hospitals. The major difficulty in hospital design is that of solving the complex design problems in the face of the voluminous information which the solution generates.

The major obstacle to achieving competence in design is not a lack of resources but the difficulty of coping with the mass of data in the design process where they are likely to be most effective. The traditional difficulty has been the need to allocate a major proportion of resources to the mass task of preparing contract documentation which in itself is not a design but a translation process. Consequently, in the absence of adequate and effective design resources at the early design stage, when inventiveness and intuition are at their peak, the solution is confined to being an amateur one. If aircraft were designed in this way, they would crash on take-off.

The objective therefore of the Oxford approach is to shift the mass of design documentation to design. This achieves superior solutions, arising from rigorous investigation of many alternatives and sub-alternatives. Documentation is reduced to its rightful place as an automated by-product of the design process.

OXSYS*3, the computer system used by the Oxford Regional Health Authority, is basically a computing framework into which programs are integrated and which enables the attainment of this objective. Using pre-defined building and services elements and components, the OXSYS
The immediate objective of speed and accuracy saves money. Instead of being forced by financial exigencies to reduce the variety of design — a situation which was rapidly overtaking the SSHA — they are now in a position to have every house different without unacceptable delays in time.

The superstructure package has only recently gone into production for most of the SSHA's range of houses. There is already, however, clear evidence of the advantages. For example, four new house types were required in a hurry for a scheme at Hamilton. Only sketch plans were available. Within a working week a team of four was able to provide full contract documentation — drawings and bill of quantities — for the houses and gables in brick construction. Documentation for the scheme in no-fines reinforcement drawings — still an unsolved process.

The site layout package is not yet in full production but its use as a test on a site in Bo'ness highlighted its benefits. Two alternative layouts were being considered — one with garages in blocks and one with garages at each house. It was appreciated that the latter would be more expensive although more desirable. Instead of being directed to proceed with the cheaper scheme and not waste money on investigating a possibility likely to prove too expensive, the SSHA was able to demonstrate the actual costs involved in both schemes. In this example, the extra money absorbed in the higher amenity scheme was found to be less than feared and the better layout was adopted.

At present the GABLES programs are being used to quantify, and illustrate if required, the gable and mutual wall configurations for most SSHA houses, providing, in conjunction with the HOUSE DESIGN package, complete superstructure BO information, for everything above DPC Level. When fully implemented the site layout will quantify substructure, roads, drainage and all external works.

In conclusion, the SSHA has already found that CAAD can offer more freedom to design within the constraints imposed on the Association by the machine, more opportunities and facilities to examine designs in depth with much faster and more accurate translation of these designs into contract documentation.

**GMW Partnership**

Based on their own experience, GMWP believe that, particularly in these financial depressed times in the building industry, the only way to introduce computer aided design techniques (or anything in the private sector) is to prove beyond doubt that they are cheaper than manual methods for the purchaser, and give the purchaser's client a better service.

The range of applications currently operating in GMWP includes:

- **Drafting**: Drafting is carried out by the designers and draughtsmen who would otherwise be responsible for the work if done manually. The system is completely graphic and instantaneous interactive so that it is easy to learn and natural to use in the production environment. Currently the system running daily on 2 installations in UK and one in Brussels.

- **Scheduling**: Scheduling is carried out at ten levels which are complementary.

- **Schedules of quantity** are derived automatically from the computer aided drafting database (with or without costs).

- **Fully detailed schedules** are produced from pro-formas filled in at the drafting board; the data is key in and edited at the terminus, then sorted, updated and printed by GMWP's own software.

**3-D Visualisation**

The ability to look...
schemes in 3-D for design and presentation work is an important facility for any design office. GMWP uses the powerful AUTOPROD package for all such visualisations, which include perspective, isometric and axonometric projections with or without hidden line suppression. The designer is able to preview the projections on the screen before selecting those he wishes to have drawn on the plotter.

Management
Contracts management is a major part of the activities of any practice; GMWP uses an in-house CPA program to compare projected against achieved performance, both on site and in its own office. The monitoring of workload resources is a continuing exercise for the success of any practice; the data collated for this computer application also provides the accounts with information for all internal costings, projections, ledgers and preparation of client bills.

Strathclyde Regional Council
The Strathclyde Regional Council's Department of Architectural and Related Services actively pursues a Computer Assisted Design Policy. Particular interest is shown in the field of Environmental Engineering where use and development has advanced in three main areas:
(a) Everyday design tools for calculating heat losses, assessing radiator sizes and quantities, calculating heating system pipe sizes and determining regulation valve settings. Programs for illumination and glare calculations are used together with programs for point to point illumination calculations for both point and linear sources.
(b) Occasional full-scale appraisal of the dynamic thermal behaviour of new or existing buildings, involving load estimation and optimal plant operating strategies.
(c) The use of computer analysis for energy conservation where norms can be generated and automatically compared with actual usage, with graphical output. Electricity tariffs can automatically be compared and best selections made for each building. Under development is a billing verification system considerably reducing existing manual systems.

Taken together, these applications have dramatically reduced the time taken to carry out design operations by traditional manual methods and have the added advantage that the output is standardised in format and can extend the experience range of the designer by allowing option checking.

The growing need to define clearly the building envelopes and systems for minimum energy consumption cannot be handled by traditional calculation methods. A total analysis and review is necessary before any best option can be attempted. Thus a meaningful energy conservation program can only be undertaken with a suitable data base from which to glean information to establish a correct program. For all these operations a computer is desirable if not essential.

Summary
The "problems and threats" conjured up by Nigel Cross (from five-year-old literature and a four-year-old half day experiment involving a second year architectural student), however reassuring to the more reactionary sections of the profession, are in little evidence in the foregoing examples of current practice. Significant design quality and efficiency are already being enjoyed; more importantly, the potential for development of these early and tentative aids to design decision-making and management is virtually limitless. The promise is of a wide range of readily accessible, easily usable and inexpensive design aids which will allow the design team, with the participation of users, to explore the formal and functional attributes of a wide range of design alternatives in the search for "that future state which most closely approximates to man and womankind's concept of the ideal". The challenge is to make these promises come good, by investment of the profession's rich design skills in the specification, construction and testing of the new generation of design models - the seeds of future built environments.

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References

A Really Universal Computer-Aided Production System (RUCAPS, for short)
Recognising that, whatever advantages computer aided design may have, progress will remain slow if the necessary hardware is not easily available. GMW Computers Ltd have combined new computer equipment technology and their own expertise in C.A.D. to produce a package which is ideally suited to the needs of the design team.
Known as RUCAPS, its main advantage is that lease-purchasing of the computer hardware and GMW's software produce a situation where, during the leasing period, the annual payment is less than the cost saving. Thus, any size of practice can finance the introduction of computer aids in a means of increasing efficiency and profitability.

Programs are designed for use by the person who has to solve the problem. For example, a designer generates and selects a perspective, or a draughtsman creates a working drawing. Existing staff can easily be trained to handle the systems without supervision by computer specialists. Indeed, the cost-effectiveness of the system derives from the direct conversation between designer and computer. For further information contact GMW Computers Ltd, 18 Manchester Square, London W1 M GAY.

Above right: perspective drawing using the "Autopro" program and the plotter, showing "hidden lines suppression" on the right
1 Digitiser board 2 Digitiser pen 3 Visual display unit 4 Light pen 5 Computer processor and controller 6 Two cartridge discs 7 Drum plotter (RSI) 8 Keyboard and printer