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Computer Use in a Small U.K. Practice

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1. Introduction

Buro Happold is a small consulting engineering practice with its main office in Bath, England, where there are about 75 members of staff, and with small branch offices in New York, Sydney, Stuttgart, Kuwait, Riyadh and Hong Kong which together amount to another 25 members of staff. Structural engineering is the basic discipline but there is now a considerable amount of environmental physics and services engineering carried out. More than 50% of the work is overseas and the practice sees itself as an innovative one with a speciality in the design of large, often tensile, structures.

2. Equipment

The engineering computing facilities within Buro Happold are currently based upon Hewlett-Packard HP 9845 desktop computers. The principle features of these machines are:

(i) Integral processor, keyboard, VDU screen and thermal printer.
(ii) Single-user operation.
(iii) 500 Kbyte user memory, with programming exclusively in BASIC.

Computer "workstations" are configured as below to enable both analysis and draughting:

(i) HP 9845 computer
(ii) HP 9895 dual 8" disc drive (2.4 Mbytes)
(iii) HP 7580A plotter (A1 size)
(iv) Summagraphics digitizer board (A0 size).

Buro Happold currently have two such workstations in their Bath office, and one in their associated practice in Hong Kong.

In addition there is a third workstation in Bath which is primarily used for advanced analytic applications, and does not have a draughting capability. This system comprises

(i) HP 9845 computer
(ii) HP 9895 disc drive
(iii) Benson Electronics model 1201 plotter.

The computer-aided finance and management of the practice is separate from the engineering computers, and will shortly be updated and implemented as a Hewlett Packard HP 9836 computer.

The practice also has access to the computing facilities of Bath and City Universities.

3. Use of Computers in the Design Office

3.1 Linear Analysis

The common frame, turns and grillage analysis programmes are employed at both scheme and final design stages.

For the former case the numerical model is as coarse as reasonably possible, with approximate and generally conservative loadings applied. This is then suitable for numerical experimentation for differing member properties and arrangements. The aim here is to reinforce the desinger's physical understanding of the structure's response under load, and particular use will be made of graphic presentations of deflected shapes, etc.

At the final design stage the structural form has been confirmed, and detailed member forces are sought from a refined mathematical model subject to improved loadcare definitions.

3.2 Computer Drafting

At present the drafting programme is utilised at all stages of a project from the initial definition of grid lines through to final tender drawings. These are all for layout drawings; the system does not at present handle reinforcement or the taking off of quantities.

The main difficulty with such systems seems to occur at the final stages of a project when minor alterations to drawings may be necessary. Here the precision of a computer drawing is such that rather than, say, merely altering a dimension, the adjacent linework must all be redefined. This slower process leads to the current tendency to perform some minor adjustments by hand.

4. General Problems

There are a number of general problems associated with computers and their software, particularly that developed in-house.

We currently operate all our systems on floppy discs. These have a habit of becoming mislaid, and the updating of any programme involves modifications to each disc. This will hopefully be alleviated by networking and the use of centralised hard disc storage.

Maintenance of programmes, both correction of errors and inclusion of new features, is a time consuming process that usually rests upon the author of any particular programme. There is clearly a problem of continuity when the "key individual" moves on that may only be met by advanced planning. This must be considered when deciding between home development or external purchase of software.

The ability of computers to perform analytic tasks quickly and accurately should in theory enable engineers to put more effort into thinking about the design of a structure. Here there is no substitute for design experience and the ability to look critically at both a mathematical model and its ensuing results. The old adage of "garbage in, garbage out" is especially applicable, and no amount of detailed analysis will turn a bad design into a good design. It is important that a questioning use of computers is fostered in young engineers.

5. Software

Software has been developed in-house for structural engineering and draughting, with building services engineering programmes imported from outside.

5.1 Linear Structural Analysis

This includes all of the conventional 2 and 3 demensional frame and truss analysis programmes, and a plane stress finite element programme.

The analytic techniques behind these programmes are well known, so the reason behind the choice to develop in-house lies in the integration of the programme within the total design process. This is achieved by paying particular attention to the entry of data and presentation of results.

Extensive use is made of graphics for the verification of input and display of output. All output is in the form of titled A4 calculation sheets suitable for direct inclusion in calculation files. Comprehensive, self-documenting, archiving facilities which allow data to be saved and exchanged between programmes.

5.2 Drafting

The MAS-DRAW 2 drafting system was developed in-house specifically to suit the construction industry. Particular features of relevance are:

(i) User interaction is via menus or the digitiser board, thus the draftsman need not be familiar with the operation of the computer.
(ii) At all stages the user works with diagrams or drawings plotted to scale by the computer. This avoids the problems associated with abstract lists of numbers or VDU images.
(iii) The method of entering linework into the system is based upon conventional drawing techniques in which new linework is defined with respect to existing features.
(iv) All the linework relating to a subject is stored full size in a database. Several drawings of different scale and content may be derived from the same database. This assure consistency between the drawings, and any amendments will automatically be rejected in each drawing.

5.3 Non-linear Structural Analysis

Specialist non-linear analysis software has been developed in-house for the equilibrium from generation and load analysis of fabric and cable-net tensile structures. This software is also used for the direct generation of fabrication geometry.

These techniques have been extended by the inclusion of bending elements, to provide a full three-dimensional non-linear elastic/plastic collapse analysis capability.

6. Future Developments

The current trend in computer hardware is for increasing power at reduced cost, whilst the cost of development and support of applications software forms an ever increasing proportion of the total computing expenditure. With this in mind, computer manufacturers are abandoning their "insularity" and heading towards the state when different machines and their software will be compatible.

With these considerations in mind we have formulated a policy on computing development that we feel to be appropriate for a practice that is expanding both in size and scope of work. The keywords of this policy are flexibility and continuity. Flexibility of hardware and software within a planned environment should enable us to respond rapidly and efficiently to developing needs, whilst continuity should minimise the need to "re-invent the wheel" at regular intervals:

(i) Flexibility of hardware should be provided by a range of compatible computers of varying cost and power. Each should be able to operate as a single-user stand alone workstation and run a common set of application software. All equipment should have a local area network capability enabling the workstations and peripherals to be linked.

(ii) The key to flexibility in the availability and effective use of software lies in the adoption of an "industry standard operating system" such as UNIX. This will provide access to a range of standard languages and to external software written in these languages. In particular there should be significant reductions in hardware dependence of software.

To date structural engineering computing within Buro Happold has concentrated on analysis rather than design applications. Except for the specialist non-linear area it is likely that our current software and computing power will be adequate for most applications in the forseeable future.

The design of individual structural elements is well suited to low cost computers. These should permit quick assessment of design alternatives whilst maintaining a uniformity of calculation and presentation of results. A full range of design checks are offered as a matter of course. Only a limited amount of input data is required, and may be obtained from hand calculations or computer analysis. In the latter case it is an advantage that computerised analysis and design be separated by positive interaction by the engineer.

Beyond the immediate concerns of analysis, design and drafting, introduction of networked computer power should open up wider applications in the field of "information management". These relate to the more general management and control of the practice.