Computer aided design—the need for sophisticated data handling

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The Paper makes a sound case for automated data-handling methods and presents stimulating ideas on the direction that design procedures will tend to move with advances in computer technology.

62. The Authors' attempt to look to the near future is to be applauded, but the systems which they propose are too unmanageable to be of commercial value without refinement; computer methods and equipment are not yet sufficiently easy to use to make them attractive to engineers. The Authors recognize this in § 29 where it is stated that computer languages must be dictated by the users, not by the system. Likewise, equipment must match user needs more closely than at present.

63. Current computer aided design methods are well reviewed in §§ 5–12 but it should be remembered that engineers are only slowly accepting computer aided design to those levels. To reach beyond them, techniques which are easier to use must be developed. The use of terminals (§ 18) will allow the designer to obtain data, particularly intermediate data, quickly, but this requires training and continuing use if a reasonable operator performance is to be maintained. Improvements are therefore needed to current terminal systems.

64. We question that the facility listed in § 19 (*c*) needs to be an on-line computer databank facility. Other methods such as microfilm off-line to a computer should be adequate.

65. The facility to intervene at intermediate design stages is essential but need not be carried out on-line. The batch process permits this and may indeed be economically advantageous and preferable since the designer will have time to make decisions which would be the poorer if they were hasty.

66. The dialogue between the user and the computer described in § 37 onwards and shown in Fig. 5 is an elementary one and present day terminals render such conversations prone to error because of the inability of the average engineer to reply in the time scale permitted by sophisticated computer programs, and by the lack of familiarity of engineers with keyboards and keying-in rules.

67. No doubt databanks will be built up on computers, particularly for estimating purposes. The design process will become more computer based but it need not be assumed that all the items shown in Fig. 2 will be contained in a computer-based databank. Some may be there temporarily during certain phases of a project in the work areas shown in Fig. 4.

68. The procedures shown in Fig. 6 are undoubtedly possible but we wonder if the complexity of the problem and the constant need to up-date programs and databanks will not render the concept uneconomic, except for a sharing consortium.

69. To us, the last sentence of § 59 is crucial insofar as engineers and other specialists will not use advanced computer aided design methods such as the Authors propose until improvements are made to computer equipment and systems so that they are easier to use. Engineers should press manufacturers and software developers to design systems that they find usable and will want to use.

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The digital electronic computer has, as the Authors have outlined, caused a revolution in the understanding of structural behaviour because of the powerful new methods

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of structural analysis, epitomized by finite elements, that are now in general use. It is not only for complex problems that the computer is useful; considerable savings in effort and gain in accuracy can be achieved using computers for repetitive work even if the calculations are straightforward.

71. The Authors have described a method by which the power of a computer could be harnessed in the day to day work of a design office. Clearly if a computer could be used effectively for such work there is a strong likelihood that more economic designs could be produced more quickly and for less cost; however, we believe that unless at least one of these advantages is achieved, and in particular the cost criterion, there is little justification in using a computer. The Authors have made little attempt to assess the costs and the value of their data handling scheme or to point out where savings could be achieved by its use. In particular on the critical question of cost we feel that the use of the sophisticated hardware and software described in the text, that are needed to store and retrieve details of codes of practice and previous designs, must result in costs which far exceed those of present design methods. Would the Authors give their views on this?

72. We are interested in the example of the crane design and analysis system as we have been studying, what is in many ways a similar problem, namely the design of highway bridges by computer. We have worked on the principle that the greatest economic return for computer effort can be achieved by using the computer to produce, starting from the minimum input data, optimum designs of the standard bread and butter structures. Computer programs have been written in connexion with this work; these produce a better (more fully analysed) design in a shorter time and at lower cost than traditional hand methods. We consider each bridge as made up of a set of (standard) components: typically, deck, pier and abutments. The engineer describes his trial design for the component to the computer including details of the material that he wishes to use. The computer computes the loadings and section properties according to the relevant codes of practice and analyses this design. Should any sections be overstressed according to the codes it makes suitable modifications to the trial design and repeats the analysis. When the design is satisfactory the computer prints out details of the final shape and stresses. Work is in hand to extend the programs to produce a bill of quantities and reinforcement schedules based on standard reinforcement patterns for each component. Experience has shown that a bridge pier can be designed in less than one pound's worth of computer time with perhaps an additional half hour required for data preparation. The program suite is described more fully elsewhere.[20]

73. It might be felt that the need for the engineer to select his own trial design is a weakness of our system. However, as the initial design of a bridge is based jointly on aesthetics and previous experience it is vital to allow freedom of choice. Should the computer show that the design is considerably understressed the engineer may rethink his initial design and try again.

74. On the question of whether there is a need for a data handling system for storing details of completed designs we disagree with the Authors. We contend that a set of drawings must be produced for use during the construction of any design and its subsequent maintenance. This is true whatever the design is for, as a set of drawings is the primary, and often only, means of communication between the designer and the builder and we foresee no change here. These drawings are normally readily available to the designer; in our opinion a simple indexing system is adequate for identifying similar designs.

Messrs Vine-Lott, Smethurst and Thompson

We agree with the remarks made by **Mr Blayney** and **Mr Lane** on the need for improvements in terminals, computer equipment and systems so as to make it easier for designers to use computers. However, it is unrealistic to expect all the adjustments to be made by the computer industry. The designer must also play his part if methods are

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to be developed which will enable the designer to produce better designs in a shorter time and at a lower cost.[21]

76. We concluded that the needs of the designer were best served by an on-line terminal based system which provided both calculating and information handling capabilities and which could also be used to prepare input data for processing on suitable general purpose computers using approved programs. Stress analysis, particularly by the finite element method, is best done on a large matrix handling computer. There is no logical reason why one large central machine should not carry out all such processing.

77. Information on standard components and improved erection procedures must be made readily available to designers if they are to be persuaded not to specify sub-optimal solutions.[22] If full advantage is to be taken of the latest developments in materials and methods then it must be made as easy as possible for the designer to find information and to relate it to the problem in hand. Catalogues, indexes, microfilm, and on-line terminals all have a role to play. In our opinion on-line terminal orientated databanking is the only available technique that provides the facilities needed to store, retrieve and transform information needed for design, analysis, detailing, billing, estimating, construction and control.

78. The procedures shown in Fig. 6 were developed from current manual methods. Many designs are developed by a group sitting round a table. The individual members of the group then return to their own offices to carry out any necessary analysis for reporting to the next meeting. We have added a terminal and a databanking facility to ease the problems of defining a design and so that individual members can later select the information required to aid them in their analysis and report their comments for consideration by the other members of the group. Whether or not organizations will develop the facilities for a group to carry out any necessary analysis on-line in a design studio will depend on the benefits and the demand.[23]

79. **Mr Jones** and **Dr Bellamy** have referred to costs. We agree that the introduction of the computer and of information storage and retrieval facilities to design requires a considerable capital investment with an increase in fixed costs and a reduction in variable costs. Development, documentation and testing of a computer program represent an investment that must be recovered over a series of designs. Whether or not this results in a general increase in design costs or the cost of the product depends on circumstances. In the crane industry design is carried out by the manufacturer and an increase in design costs can be offset against savings in materials or manufacturing costs. This does not, in general, apply in civil engineering and any consultant considering the introduction of computers would be well advised to establish suitable cost control systems first.[24] He will then be in a better position to find a balance between capital investment, design costs and project costs.[25, 26]

80. We are interested to read of the work of the West Riding County Council. We referred to the building up of a design from standard components in § 14 and to the use of information stored by the computer in § 58. We agree that the use of computers for the production of optimum designs from minimum input data generally results in the development of better designs more quickly and cheaply. There is a considerable difference between storing details of standard components and worthwhile procedures and storing details of completed designs (§ 74). Performance reports on completed designs are of considerable value in forecasting future maintenance costs and should be accessible to the designer. Details of completed designs may be needed only for record purposes.

81. Drawings are important but they are not the only means of communication between the designer and the builder. Specifications, bills of quantities, schedules, reports, minutes, verbal statements and previous designs are also used. Two thousand drawings per project are not unusual and many offices handle 500 projects a year. We doubt whether simple indexing systems are adequate for locating working drawings let alone similar designs by different authorities at different times.

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