Zeitschrift: IABSE reports of the working commissions = Rapports des commissions de travail AIPC = IVBH Berichte der Arbeitskommissionen

Band: 31 (1978)

Artikel: Trends in computer management for structural engineering

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DOI: https://doi.org/10.5169/seals-24905

IABSE
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COLLOQUIUM on:
"INTERFACE BETWEEN COMPUTING AND DESIGN IN STRUCTURAL ENGINEERING"
August 30, 31 - September 1, 1978 - ISMES - BERGAMO (ITALY)

Trends in Computer Management for Structural Engineering

Développement de l'emploi de l'ordinateur en génie civil

Entwichlung des Einsatzes von Rechenalagen im Bauwesen

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Summary
After a brief mention of ENEL's design activities, the Author illustrates the criteria underlying the organization of ENEL's computer system for technical and scientific calculations. Finally, the problems associated with the recourse to a computer by a design office are discussed.

Résumé
L'auteur mentionne brièvement les activités de l' ENEL dans le domaine du projet et indique les critères de base d' après lesquels ENEL a organisé la structure des ordinateurs pour le calcul de projets techniques et scientifiques. Les problèmes découlant de l' emploi de l'ordinateur par un bureau d'ingenieur sont mis en évidence.

Zusammenfassung
Der Verfasser weist auf die Tätigkeiten von ENEL im Bereich der Konstruktion hin und erläutert die Grundlagen der organisatorischen Struktur des technisch-wissenschaftlichen Computersystems von ENEL.
Es werden Probleme behandelt, die sich beim Einsatz des Rechners durch ein Ingenierbüro stellen.

TRENDS IN COMPUTER MANAGEMENT FOR STRUCTURAL ENGINEERING

The condensation of the merits and faults of a coordinated system of computers employed for structural engineering or an outline of the optimal management policy in a short presentation is a very hard task for a general rapporteur because of the present multiform proliferation of a management criteria on one hand and because of the difficulty of making general statements when the most diverse structures are involved, without touching upon peculiar problems arising from the environment. By "environment", in this context we mean the machinery, the personnel available, and the organization of the executive unit involved. So, rather than relating on the various managerial trends in the area considered in this Colloquium, it may be more appropriate to give an outline of the approach adopted by ENEL with a few comments on some of the choices made in the past or envisaged for the future.

Within the scope of its terms of reference, ENEL, in addition to generating and distributing electricity, performs the design and research associated with electric energy generating, transformation and transmission plant. The design activities are carried out by the Milan and Rome Centers for Thermal and Nuclear Plant Design and Construction and by the Turin, Venice and Naples Centers for Hydro and Electric Plant Design and Construction. Research is carried out by a number of Centers that are specialized in different areas. In addition, for special studies and research, ENEL seeks the collaboration of external laboratories, such as ISMES or CISE.

The close relationships among the technical problems associated with plant design, construction and operation made it necessary for ENEL to set up a coordination service. For this purpose, an apposite Advisory Committee has been formed so that the design activities--for which the Engineering and Construction Division is responsible--will be coordinated with the technical-scientific activities of other Divisions, such as the Research Division, the Generation and Transmission Division, the Planning Division, the Distribution Division and the Office for Information Organization and Processing.

The Advisory Committee handles all the automatic technical-scientific calculations that are now considered desirable and often indispensable for the various design and research activities. In view of its coordinating function and of the need to meet the users' requirements with the means available, the Committee serves the purposes of:

- constituting the proper seat for an exchange of ideas and experiences among the Divisions that are interested in new computer applications for the solution of technical-scientific problems;
- facilitating a forecast of the required computer time;
- collaborating in the preparation of the processing equipment and for the actions to be taken to implement the approved programs;
- coordinating the efforts for the preparation of the programs so as to pinpoint any interactions between different projects and to expand the information system.

Quite a significant part of the design activities concerns structural engineering and call for calculations to determine the static and dynamic behaviour of the continuous and discrete structures in the design stage. The number and complexity of the structures to be built (barrage dams, underground powerhouses, nuclear reactor containment systems, turbogenerator pedestals, transmission line towers, etc.), the variety of loading and stressing conditions to be considered, the severity of the safety codes to be met and the need for flexibility in changing decisions already made call for a host of calculations that are often long and painstaking to be completed in a very short time. Therefore, the help that the designers will receive from recourse to the computer and automatic data processing is greater ad the complexity of the calculations increases even though this in turn entails a certain amount of difficulties which we shall mention later.

The powerful and sophisticated calculation methods available today, such as the finite-element method, allow even the most complex problems to be tackled and solved. Although the basic mathematics of these methods are now well establisched, their range of application is being expanded continuously;

for instance, we shall mention the application of the finite-element method to problems of fluid dynamics.

The use of these methods by the designers is a first step towards computers-assisted designing but, as we stated earlier, this poses a number of delicate and important problems, the successful solution of which is a prerequisite to the effectual application of the methods.

The main problem is a correct man-machine communication. On one hand, the designer must become familiar with the use of the computer without becoming a programmer, and he must be fully aware of the basic features, capabilities and limitations of the various computer processes in order to check the results from an engineering standpoint without being swamped by them or carried away by the computer. On the other hand, the calculation means, inclusive of hardware and software, should be rendered more flexible, simpler and easier to use. Because of the complexity of the mathematical and numerical methods required and of the computer utilization techniques, it is important--at least in the more challenging cases--that a close collaboration be established between the designer and the software specialist so that the combination of the two different, but complementary, professional efforts will allow computers to find their optimal location in the design process.

At any rate, it should be clear that in the symbiosis of the designer, the mathematician and the computer, the first should prevail as the only one who can assess the correctness of the results and thus the adequacy of the team as a whole.

At the present state of the art, the use of a computer for the calculation of structures encounters delicate problems from the very preparation of the data that are to describe the structures themselves. These problems entail long and toilsome checks to be sure that the calculations are performed on a model that corresponds to the real structure and to prevent the computer from putting out results for a structure that differs from the one conceived by the designer. All this means a painstaking check, often numerically and not graphically, of the data to be fed to the computer.

So, the computer has rid the designer of some calculation phases, but it has introduced others.

As a result, the adoption of a computer does not, in general, reduce the bulk of work for the designer, but only helps him to cope more efficiently with very complex problems and to perform the technical-economic optimization of the project more rapidly.

Within this general context there is the question of organization for the best utilization of the computer. In line of principle, this can be done in two ways;

(1) each design office can be equipped with persons and facilities of such capabilities as to meet all the processing requirements of that office;

(2) each design office can be connected by means of receiving terminals to a central computer, to which the software specialists are assigned.

Of course, there are numerous feasible arrangements between these two extremes.

The first decentralized arrangement presents the following advantages:

(a) greater speed in the performance of the work schedule as no priority order is to be established with other operative units;

(b) real-time assistance can be rendered by the software specialists to the designers in the use of the programs and computer;

(c) the software specialists acquire a better understanding of the requirements of the design office they belong to, and this alleviates the hand work, even though it may mean giving up sophisticated optimization of the computer work;

(d) maximum availability of the software-hardware on the spot as a result of the absence of more computers on line, telephone lines, interfaces etc.

The arguments against this arrangement, at least in the present state of the information techniques, are;

(a) the software is often quite complex and calls for very powerful computers that may not be utilized full time; in addition, the software implies maintenance problems and a flow of documents that would require more specialized personnel;

(b) a computer code is often used by more than one office, this could mean duplicating a code for several computers with an obvious waste of resource;

(c) the installation of a large computer in any office raises the problem of the management of the computer and of manning each office with specialist in order to ensure the most efficient use of the computer.

The arrangement adopted by ENEL is somewhere in between both as regards the hardware and as regards the software specialists.

We have decided to make a distinction between calculation programs of general interest to several design offices and particular programs of limited interest and complexity. For the former we use a centralized unit which develops the programs upon request from the design offices and runs the computer. For the latter we have decided to grant each design office complete autonomy. The configuration of the hardware selected for the calculation system thus consists in one or more large centralized computers to which each office has access through different types of terminals: from the simple teletyper to real "satellite" computers that are capable of performing simple calculations, such as are generally required to optimize the transmission of the input data and results with large computers. At any rate, the problem is complex and will certainly take a few years to reach an optimal solution.

Our main concern has been to have available a reliable means in order to avoid other adding problems with computer operation to the design problems. On the hand, the technology is evolving so rapidly both in the field of small- and medium-capacity computers and in the field of printing machines that it is possible that with time we shall take another approach, for instance a more decentralized arrangement, also because the experience acquired in the meantime by the individual design office with the use of computers will give sufficient assurance for their greater autonomy.

The installation of a decentralized computer network is undoubtedly one of the prospects that we are seriously considering for the future. For the moment, however, the techniques for the creation of such a network are still in a preliminary stage, hampered by both technical and commercial

difficulties of different nature, the discussion of which would take us far from the subject of this Colloquium.

I have given you a brief outline of the problems associated with the use of the computer system for structural calculations based on Enel's experience. I feel it is appropriate, however, to spend a few words on the "abuse" of computers, that is,having excessive reliance on their capabilities to get ideas and to make decisions. "To abuse" of the computer, at least in the field of structural calculations, means to confuse the designer's tasks with those of the computer. Starting in the sixties, the fast succession of more and more advanced computer generations has led to the illusory idea that "electronic brains" are capable of solving any task reserved for the human brain.

Although later experience has shown the limitations of computers in terms of creativity and ideas, I have a feeling that the illusion I mentioned previously will continue to dwell deep inside our subconsious, givingrise to confusions that may by dangerous, to say the least. It may be that in a more or less distant future, for instance with the advent of machines capable of understanding the meaning of the designer's ideas first as fast and as well as the human brain or of producing a design from them (that is, computers capable synthesis), the illusion will cease to be and we may have to review our present position of diffidence.

For the moment, however, at least to my knowledge, there are no computers capable of synthesis, and therefore any request for thoughts or creative ideas is, in my opinion, to be considered an abuse.

This statement, which may seem obvious but should be constantly borne in mind, is valid particularly for structural calculations where there are technical and organizational problems that are only apparently facilitated by the use of a computer. It will suffice, for instance,to recall the difficulties encountered when we want the computer to understand certain physical phenomena such as the soil-structure interactions with a degree of approximation comparable to the precision it is capable of achieving in the calculations.

There are, however, computers capable of performing uniformly even

very complex calculations that the designer can use to great advantage to verify his own ideas and creativity completely and systematically, and later to check the behaviour of the structures he designed. For instance, to check the consistency between the model data and the measurements taken on the built dam, or foundation soil or underground powerhouse, the computer is a most valuable tool.

To conclude, the computer is definitely an indispensable tool for an efficient and competitive design office. However, on the basis of my experience I feel that the use of a computer never has and never will lead to direct or immediate modifications in concept. Indirectly, it does offer a means to make a deeper structural analysis, and this is certainly very important to the designer in the design synthesis for which he is solely responsible. The best way to use this tool to the advantage of the designers is a matter of subjective judgment and susceptible of changes.