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Some Organizational Aspects on Computing in Structural Design in Finland

Utilisation de l'ordinateur pour le projet de structures. Quelques aspects de l'organisation en Finlande

Anwendung des Computers im Bauentwurf. Organisatorische Aspetke in Finnland

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Summary

The paper is based on the existing conditions in structural design in Finland. After a short historic description of the use of computers in structural design the most significant demands of the authorities are explained. Then the process of computing, difficulties in communication and the education of EDP orientated structural engineers are discussed. Finally, the cost trend of EDP and the influence of today' s economic situation are examined and the main points of the tariff policy are described.

Résumé

L'article présente la situation actuelle en Finlande, en matière d' utilisation de l'ordinateur pour le projet de structures. Après un bref historique, on présente les besoins les plus significatifs des autorités, puis les procédés de programmation, les difficultés de communication, et l'éducation des ingénieurs civils, spécialistes de l' ordinateur. On examine la tendance des coûts d'utilisation de l'ordinateur dans la situation économique actuelle et les points essentiels des tarifs appliqués.

Zusammenfassung

Es wird über die heutige Lage in Bauingenieurwesen in Finnland berichtet. Nach einer kurzen historischen Einleitung der Anwendung des Computers für die Berechnung von Trakwerken, werden die wichtigsten Wünsche der Behörden erläutert. Das Computerverfahren, die Kommunikations-Schwierigkeiten und die Ausbildung von Bauingenieuren, welche mit Computern arbeiten, werden beschrieben. Die Entwicklung der EDV-Kosten, die heutige Wirtschaftslage werden untersucht und die hauptsächlichsten Punkte der Tarif-Politik erklärt.

1. THE HISTORY AND FUTURE OF THE EDP IN STRUCTURAL DESIGN

The use of the digital computer as a generally available (that is, commercially produced) tool is less than 30 years old. Its first applications were in science and engineering. Its early users took a rather restricted view of its capabilities. It was put to work composing lengthy numerical tables and performing other prosaic calculations [1].

In Finland the first computers were introduced about 20 years ago. However, their real productivity could not be utilized until a few years later. As far as the structural design is concerned 1966 is a note-worthy year. At that time a common software centre called TEKLA was founded by a group of leading Finnish engineering consultants to create a common EDP agency and software-house on commercial basis. Considering the needs of the owners, the aim was to specialize TEKLA in EDP applications for structural and civil engineering planning activities. In long range, the main goal was to create ample resources, by means of which a continuous development of specialized program software would become possible. This denotes how early the importance of computers and applicable software was understood by structural engineers.

Remote computing was started in 1970 by five computer marketers or service bureaus, who began to sell time sharing and/or remote batch service. The most important computers used were really large ones like the GE 600. So the developing of advanced program systems was possible from the very beginning.

The lack of software produced a problem as opposed to hardware, which could be imported within a few months. To remove this drawback several teams were gathered under TEKLA's wings to make recommendations for the development of software for various civil engineering branches. Because of the common problems and as a result of the team work, programs of high quality were to be expected. The aim was reached in this respect. A satisfactory program library was soon via terminals placed at common disposal. As a consequence of this a wider adoption of desk top calculators and mini computers was delayed in Finland and has not reached large use.

Interest towards graphic output service and the use of plotters arose about three years ago. Today practical results are seen especially in the field of urban planning where maps are drawn and highway lines or street cross sections etc. are designed using these methods. In the field of structural engineering the checking of FEM (finite element method) mesh models, e.g., can be mentioned.

The plotting of final drawings has not yet reached wider use although some good results have been achieved by some building and bridge construction engineering firms.

The future seems to be rather clear. In an engineering company there will be an intelligent mini/midi-computer with discs and graphic display and perhaps with a digitizer too. This can act as a terminal via a common data communication net to a larger computer with sufficient capacity and, e.g., with common data bases. The amount of "turn key" systems which include all necessary software and hardware in one total price, will probably increase. How distant we are today from this picture of the future is hard to say, especially since the economic situation is discouraging and difficult to predict.

2. THE DEMANDS OF AUTHORITIES AND OTHER CLIENTS

As a matter of fact no rules exist for presenting computer results in Finland. In the beginning, in fact, the more results one gave to a client the happier he was. But naturally the glory and the all-mightiness of computers did not last very long time. People began to understand that computer results can include errors although the output layout is excellent.

There are mainly three reasons which a few years ago, made some governmental authorities create general rules for computer calculations used in their projects, namely

- the enormous amount of paper to be stored,
- the meaninglessness of computer results with incomplete input data, output explanation etc. and
- the lack of exact documentation of the computation especially when approximative methods (for instance FEM) are used.

As an example the demands for bridge calculations of The National Board of Public Roads and Waterways, which is the highest authority for road bridges in Finland, are listed below:

1. General arrangement of the computation. Presentation of
   - what shall be calculated,
   - which program shall be used.
2. Description of the basis of the program including references.
3. Reliability of the program (does not concern generally accepted library programs). Description of the

- testing,
- qualification,
- accuracy.

4. Presentation of the results within the design calculations:
   - design model for the analysis and the main assumptions,
   - input data and its calculation,
   - load positions or equivalent data (preferably with figures),
   - input data sheets,
   - output data sheets for the dimensioning parts of the structure. These shall be detached from the rest of the sheets, numbered and given intermediary titles,
   - summary of the results in a tabular and graphic form (bending moments, shear forces, torsional moments, deflections etc.),
   - control calculation by another method for the significant parts of the structure and comparison of the results.

At present a project led by The Association of Finnish Civil Engineers is aimed at the standardization of design calculations. This project will also deal with the presentation of computer results and the following principles are put forth at this stage:

- the name, developer and maintainer of the program must be mentioned,
- an explanation of how the program works and its reliability must be given,
- the authorities may ask for the program documentation, source program and test computations to satisfy themselves of the reliability of the program and the actual calculation,
- for the data check information about the units, sign conventions, numberings, simplifications, structural model, support and loading conditions and the interpretation of the results must be given,
- the output should be in A4 size,
- all input data printed by the computer must be presented,
- the output presented should be as short as possible but clear and manually completed if necessary,
- the most important results must be checked using some simple manual method.

The opinion that all programs should be approved by some organization was also brought forth, but this was, however, found impossible. Thus the common programs can be used quite freely, but new programs require some kind of checking by the authorities. In any case the total responsibility for the calculation methods and the accuracy of the results is with the designer.

The checking of computer calculations is much more difficult than that of visual calculations made by hand, because the progress of the calculation can no more be easily followed or checked with simple comparing calculations. This applies to conventional methods as well as to FEM [2].

3. THE PROGRESS OF THE CALCULATIONS

The use of EDP consists of two main factors, the hardware and the software. In respect to disposal four different ways of using hardware can be distinguished:
- external aid in the form of computational consultation is used with no personal contact to the hardware or the software,
- input data sheets are filled and the results are interpreted personally, but the computation itself is carried out in an external data service centre,
- the whole calculation is personally carried out using a remote terminal in own rooms,
- the calculation is carried out using an own computer.

The available software can belong to
- the importer of the computer,
- an external data service centre or
- the user himself.

The progress of a calculation is to some extent dependant on the combination of these two factors.

Structural designers have from the very beginning actively used EDP and that is why pure computational consultation newer played an important role in Finland. Hence this case does not need to be discussed any further. The same applies to the combination in which external software is used in an own computer. If a company possesses a computer of its own, it usually develops the necessary software or aquires it by bargain. Leasing is not frequently used. Of the remaining combinations the most common ones are the following:
- the calculation is carried out in an external data centre with its programs,
- a remote terminal and external programs are used,
- a remote terminal and own programs are used,
- an own computer and own programs are used.

Figure 1 shows the computation procedure of an ordinary structural design. The procedure resolves itself into two parts depending upon whether the computing is carried out by personal computer operation or with the aid of a data centre.

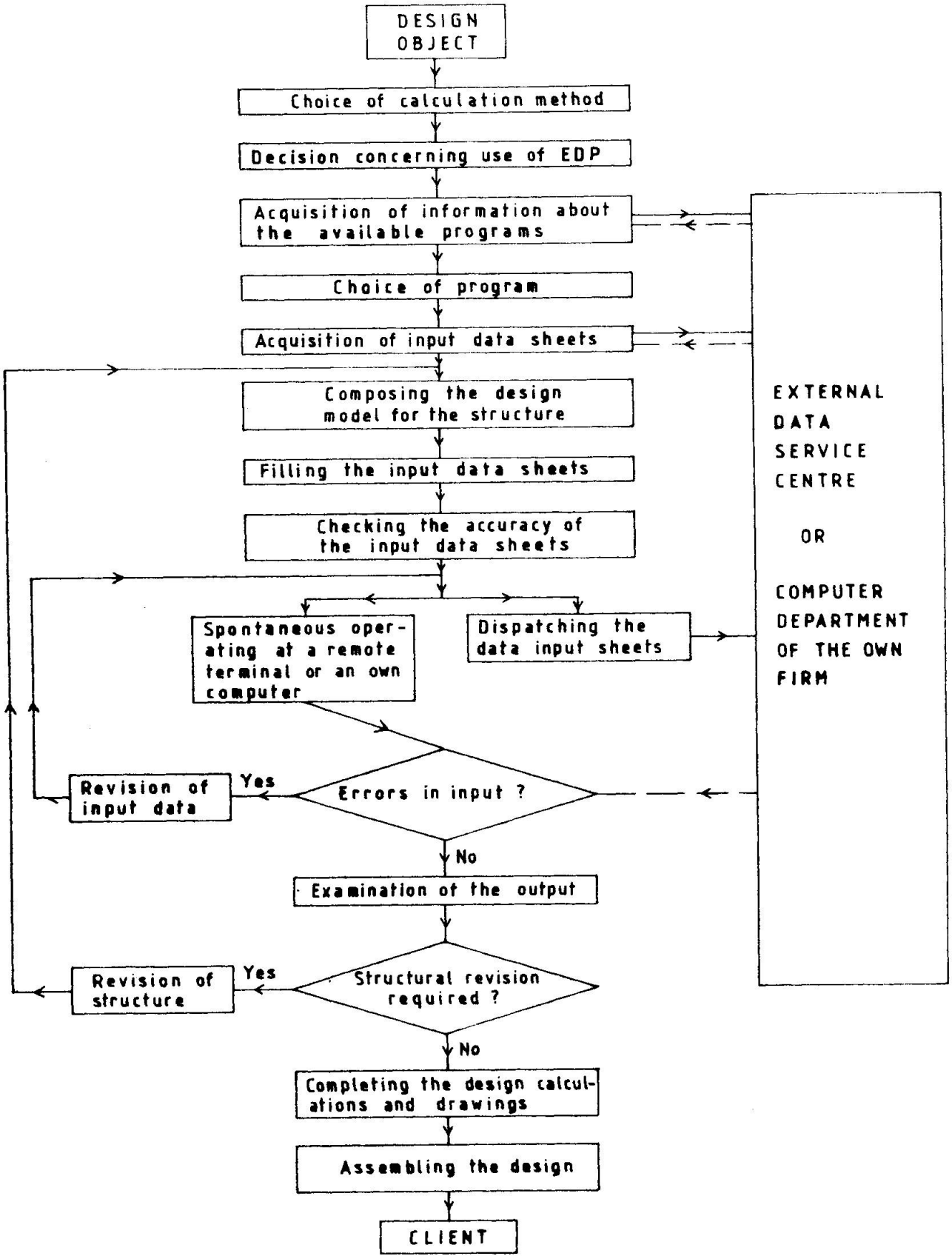

Fig. 1 Computation procedure in structural design with or without personally operating the computer.

If the computation is carried out self-actingly, i.e., by the designing engineer himself at a computer or a remote terminal, the results are received without delay and the structure can be modified at the same time. Further, if the computing is done with an own computer whose fixed expenses do not tax one computing too heavily, the input data does not need to be so carefully checked as in the case when an external data service centre is used. The modifying of the design object is also cheaper. The use of a data service centre, the computer department of the own firm, a remote terminal or a desk calculator has only a minor effect upon the computing procedure.

4. DIFFICULTIES IN COMMUNICATION

In the field of structural engineering, the most significant communication difficulties in using the computer in general from the technical point of view lie in the relation between the computer expert and the client. This, however, does not cause any serious trouble in practice, since the designer represents the client in this situation. The client is often not interested in how his structure is calculated or designed, but he is more keen on the final result. There are only a few clients in Finland, mainly state organizations and the largest cities or industrial companies, who possess expertise, structural engineers, that a computor expert may come into personal contact with.

In practice there are sometimes minor difficulties between the designer and the computer expert - and now we do not need to think only about money. This is due to the fact that the designer is not a highly qualified computer expert and the computer expert is not a designer. To become well acquainted with one field means almost unavoidably less knowledge of another. For the designer it is absolutely necessary to know at least on which base the program he is using is built, which its limitations are, and its possibilities. This information he can get only from the computer expert. The difficulty lies in the fact, that very often even the expert does not know all that, since the program has been produced by someone else, maybe another structural expert. This kind of situation makes the designer loose confidence in EDP. Fortunately this does not seem to disturb just graduated young engineers, who without criticism accept any text printed by a computer as the absolute and final truth.

The deepest gap does not lie between persons working in different sections of the whole system, but between the designer and the computer or a remote terminal

connected to it. To utilize this device beneficially calls for extra endeavour on the part of the designer and very often in his spare time. Especially older engineers, who were not trained to use computers in school, may feel this threshold too high to exceed. Hence the use of computers is minimized and the difficulties in communication do not decrease.

In some cases the designer communicates with an external computer expert as little as possible. This is due to the fact that the communication itself causes too high expenses to the designer and he does not see enough benefit in it. Even the lack of time may be the reason. This kind of decrease in communication is not dangerous if the computing itself is cheap. On the other hand the computer expert may have a similar intention, especially when he has to work on a fixed price basis.

The communication itself does not guarantee that a computation is correct. For instance a large slab bridge was to be designed a few years ago. The designing engineer was in close contact with a qualified EDP consulting firm with the aim to make the structural calculations with its library program. In spite of the collaboration of these two experts, the impact factor of the loads was forgotten and the whole computing lost its validity. Although a recomputing was allowed on a lower charge, the expenses of the designer became rather high. In this case there was much more communication between the designer and the EDP expert than usually, but nevertheless surprising difficulties arose.

In Finland serious difficulties in communication between various sections have been avoided because of TEKLA, whose experts possess experience both in structural design and the EDP. Since 1966 it has developed a great number of programs with reliable testing and clear documentation for various kinds of structures. These programs are commonly used by most engineering firms, by state and municipal organizations. The difficulties have been avoided, because a set of programs built up basicly in the same way has been generally available.

5. EDUCATION

The most ideal combination would be a structural engineer specialized in EDP. Besides the broad field of civil engineering, a person of this kind should know the most common programming languages, system design, programming technique, documentation and the use of various data processors. It is said that it is easier

first to become a structural engineer and then an EDP expert. This has also been considered reasonable in the education of new engineers in universities and technical institutes. Much attention is paid to civil engineering subjects and only the basic knowledge in EDP is given. Final education in the latter subject is left to the person himself, his employer, data service centres, computer importers and various engineering societies. Most of these arrange courses on varying levels, but only on a commercial basis.

In the technical universities the education given to civil engineering students in computing consists of compulsory and optional courses. The students of various departments are taught these subjects unitedly in connection with the teaching of the fundamentals of mathematics and natural sciences. The compulsory courses include fundamentals of data processing, time-sharing, BASIC and FORTRAN programming, the structure and function of data processing systems, data systems and their design, practical applications of a computer and the fundamentals of the influence of the EDP upon society. The most popular of the optional courses are those which deal with newer programming technics, the execution and organizing of practical programming and symbolic machine languages. Some of the courses are taught as televion courses and all of them include plenty of practical exercise in a laboratory. The final skill to use a computer is reached at the end of the studies. When examining a whole structure with a computer for the diploma work, the student faces the same situation he will meet later in his work.

6. THE COSTS AND TARIFF POLICY

The cost trend follows rather much the trend of the whole world. The hardware costs are continuously going down and the software costs are rising. Because of the global communication networks, the prices must be on an international level. However, as far as the software is concerned, Finalnd is sometimes considered to be so remote that nominal margin costs can be applied.

Because of national codes and the demands of the authorities, some software must be developed in the own country. Because there are only 4,7 million Finns, the development costs are distributed between very few companies. Thus the costs are rather high. To improve the profitability both import and export of software is found necessary.

When comparing EDP costs with those of manual work one can see that the gap is widening all the time in favour of EDP. Design costs usually being 2...6 % of

the total costs of a project, the costs of EDP are a maximum of 10 % of the design costs. Hence, it is not worth saving in EDP costs. Or let us put it another way. When doubling EDP costs, the total costs would rise only 0,5 %. The decrease of other costs would certainly be more, maybe ten times that.

At present the economic situation is depressed in all parts of the western countries. This also affects the use of computers. No one is willing to invest in own hardware and software. Companies are more eager to put their people to work with their own existing facilities to avoid extra external costs. Manual work is whenever possible used to reach this aim. On the other hand, engineers have more time to study new alternatives, which again brings them back to their toy - the computer.

For the charge of EDP costs of a design project there are general rules published by The Finnish Association of Consulting Firms SKOL [3]. They are based upon the fact that the charge should cover both the direct and indirect EDP costs of the consultant. The direct costs are of
- expenses paid to a data service centre,
- hardware costs of the consultant,
- file costs for the actual project,
- program royalties and
- time used for punching and operating.

The indirect costs are of
- the space needed for the hardware,
- the telephone and on-line costs,
- cards, tapes, cartridges, forms, papers etc. and
- other indirect costs (documentation, setting out of rules, information, file maintenance, service, acquisition of materials, accounting, development, education and a share of the expenses for administration, general office outlay, profit, capital cost etc.).

The compensation for the EDP costs paid to the consultant can be determined in two alternative ways. It can be based upon the performance or the real EDP costs. In the former case the charge should cover all the EDP costs including or excluding punching. In the latter case the charge of an external data service centre is increased with 30 % to cover general expenses and the program royalties are charged separately. In case the consultant uses data service of his own, the charge is based upon the following costs:
- computer costs charged by the data centre for time sharing,
- hardware costs of the consultant,

- 75...100 % of the costs of the two above points as general expenses,
- file costs for the actual project,
- program royalties and
- the time used by various employees.

When the charge is based upon the time used for various operations, the charge for the computer can be based for instance upon the CPU-time.

7. CONCLUSIONS

The demands of national codes and authorities limit the use of highly specialized foreign software. Therefore, a large set of programs for structural engineering have been developed and maid generally available on commercial basis. For the charge of EDP costs common rules exist and they can be applied as well for the services of a data centre as for the use of an own computer.

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