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Autor: Pircher, Heinz / Haas, Wernfried

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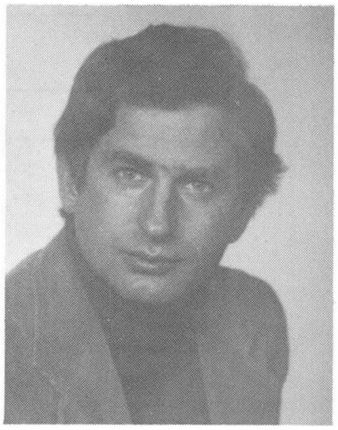
Integrated Program Systems for Mini- and Micro-Computers

Systèmes de programmes intégrés pour mini- et micro-ordinateurs

Integrierte Programmsysteme für Mini- ind Micro-Computer

Heinz PIRCHER
Civil Engineer
TDV
Graz, Austria



Heinz Pircher, born 1940, obtained his civil engineering degree at the TU Graz, Austria. After five years as an assistant at the «Institut für Stahlbau, Holzbau und Flächentragwerke» he founded TDV in 1970. He is active in the development of civil engineering software and its application in his own computing centre.

Wernfried HAAS
Physicist
TDV
Graz, Austria

Wernfried Haas, born in 1947, obtained his degree in technical physics in 1972 at the TU Graz. From 1972 to 1976 he worked there as an assistant in computer controlled measurements. He joined TDV in 1977 and has been working in the development of several FEM-codes and as a system analyst.

SUMMARY
The authors' opinion of the present state and the further development of civil engineering software is put into discussion. Of particular interest are micro-computers and their influence on future development. Examples demonstrate their universal applicability.

RESUME
L'opinion des auteurs concernant l'état actuel et les développements futurs de programmes pour ingénieurs est mis en discussion. L'apparition des micro-ordinateurs sur le marché et leur influence sur les développements futurs sont particulièrement intéressantes. Quelques exemples montrent l'application universelle de ce type d'ordinateurs.

ZUSAMMENFASSUNG
Die Meinung der Autoren zum momentanen Stand und zur weiteren Entwicklung von Bauingenieur-Software wird zur Diskussion gestellt. Von speziellem Interesse sind Micro-Computer und ihr Einfluss auf die zukünftige Entwicklung. Beispiele demonstrieren ihre universelle Anwendbarkeit.

1. INTRODUCTION

In European civil engineering, the majority of the planning work is done by "Civil Engineering bureaus". One can say that the typical size of such a bureau lies between 10 and 20 people. Only a few bureaus employ more than 50 people. The construction offices of the larger building companies are also of similar size.

All questions which concern the application and development of new working methods are therefore made with respect to the special situation concerning firms of this size. Only steel construction is an exception, because here a large part of the planning and construction work is done in large steel construction firms, which have different criteria for the introduction of new working methods.

One can be certain that the difference in average size between the two is partly responsible for the different path taken by steel construction firms in applying computer-methods to the one taken by the average civil engineering firm.

Many technical, economic and organizational reasons have moulded the present computer applications and the possibilities for further development.

2. TECHNICAL ASPECTS OF ENGINEERING SOFTWARE

Looking at the current situation of civil engineering software, we realize that structural analysis has been developed and that several software systems are already in practical use. The computer is also used for various dimensioning problems.

The latest and perhaps the last step in development is to also use the computer to produce all the drawings needed to build the structure. The slogan "CAD = Computer Aided Design" was first created by mechanical engineers and now even civil engineers think about a complete solution integrating structural analysis, dimensioning tasks and graphic modules. If one acknowledges "CAD" to be the aim of actual development then the term "CAD" should not be taken too simply, namely merely "graphic data processing". Everything such as using a computer to define the shape of a construction, to define its dimensions and to produce plans necessary to build it should be included.

Looking at the current situation one realises that for many applications software solutions are already in practical use:

2.1. Structural Analysis

Here, the use of computers is a matter of course.There are programs for all types of processors and the possibility to use these programs in a computing centre or on one's own computer. A further development will be the improvement of present programs. Basically all important problems have been solved.

An important point to mention is that today all complicated structural analysis problems, that are solved by computers, are supported by graphics. This is especially the case when using "Finite Element Method" programs. Today the checking of input values for complex structures is unthinkable without graphic support. The same applies for the representation of results.

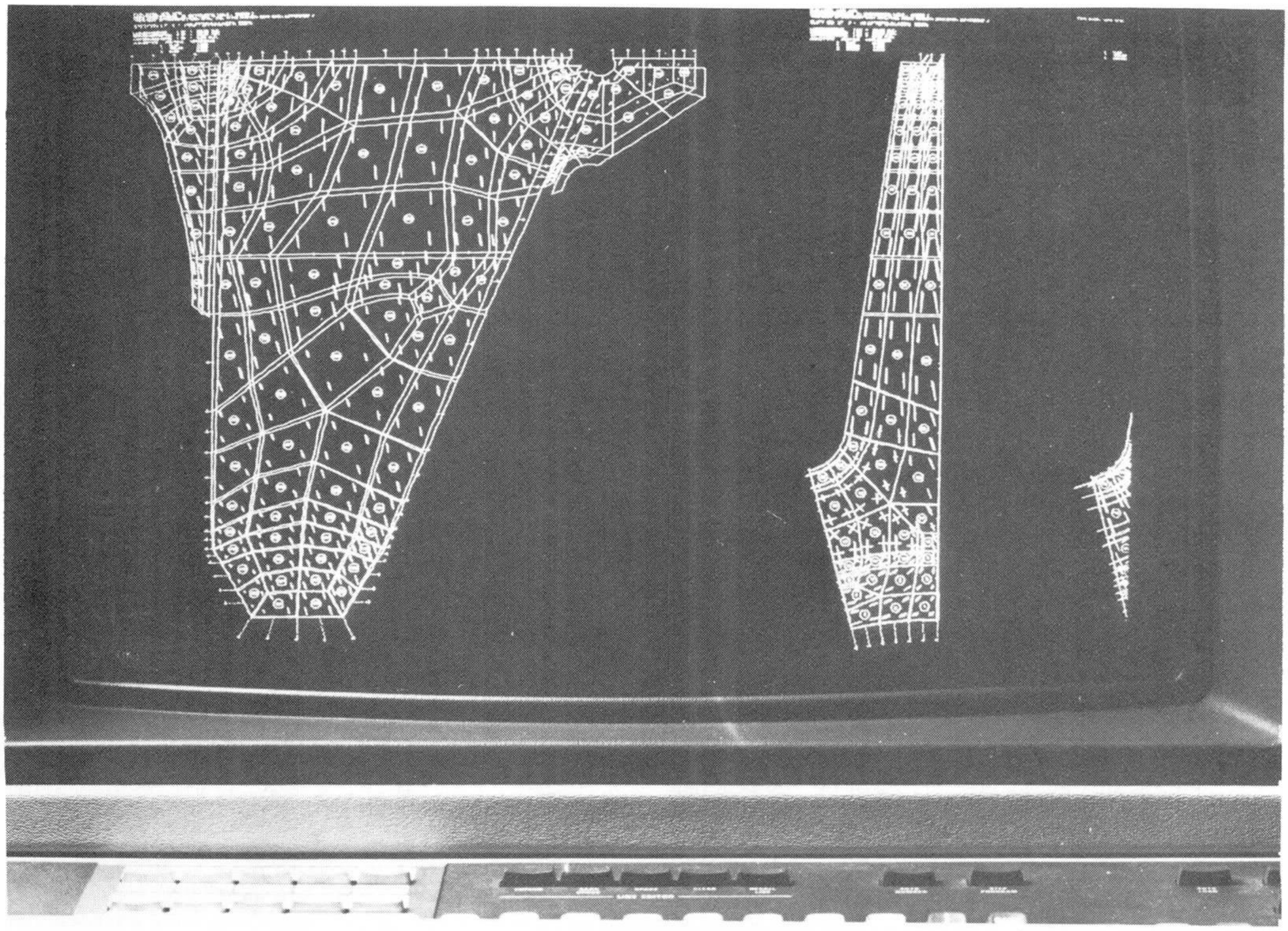


Fig. 1 Example of representation of results of a F.E.M. calculation

One can say with hindsight that the solution to this problem paves the way for a much broader use of these methods. The use of graphics for F.E.M. calculations was a major starting point for the CAD development.

It is noteworthy that today's F.E.M. programs with extensive interactive graphics for input control, element net generation and representation of results are also available in BASIC for desk top computers.

2.2. Reinforced Concrete

The dimensioning of the reinforcement and the production of the corresponding plans is the main work of many engineering bureaus. Programs to calculate the required reinforcement belong to the basic tools of every computer used in this field.

The "dimensioning programs" are often coupled to structural programs. For various constructional elements (beams, supports, slabs, etc), programs exist to draw the reinforcement plans, also coupled to simple dimensioning routines.

Furthermore it should be noted that this sort of solution is already available for very cheap computer systems.

What is missing is a general, comprehensive solution including statics, dimensioning and graphics in one integrated system.

The structural programs have been concepted in such a general way that the data from any structural system, or from any type of construction can be captured onto the computer system.

Even the dimensioning has been similarly comprehensively solved for all relevant construction elements. The next logical step would be towards the automatic drawing of a similar general solution and to connect this to an available structural analysis program. This is one of the most up-to-date-problems in software development in civil engineering.

These efforts are only successful, if a certain level of standardisation is achieved.

The traditional ideas of "how a plan should look like", differ and a rationalisation is only possible if all those active in this field agree. The programmer needs a final and precise algorithm !

A further problem is that drawing reinforcement plans is partly routine work for a computer and partly creative engineering; they are not separable. The many constructional details and definitions, which first become apparent during drawing, cannot be decided upon by the computer.

It is obviously very important to develope user-friendly dialogue-programs. The engineer makes his decisions and needs easy-to-use talking here about a model for computer supported work - as opposed to a completely automatic solution, which would only be possible in a few special cases.

2.3. Pre-stressed-concrete

In this field, there are highly development solutions available, especially for pre-stressed and prefabricated elements. The problems here are not very complex and programs already exist for cheap desk-top computers, which take care of all calculation and have either full or partial graphic support.

Program systems for the design of pre-stressed concrete bridges have been developed, which apart from calculationg all important values even include the ability to draw plans for the laying of the cables:

Definition and calculation of the stressing cable geometry and pre-stress-forces using all values for the stressing protocol, load case creep + shrinkage and all verifications required by design code, representation of the pre-stressing tendons in plan view and vertical section, and the production of a finished plan by bringing such views and cross sections together (see Fig. 2).

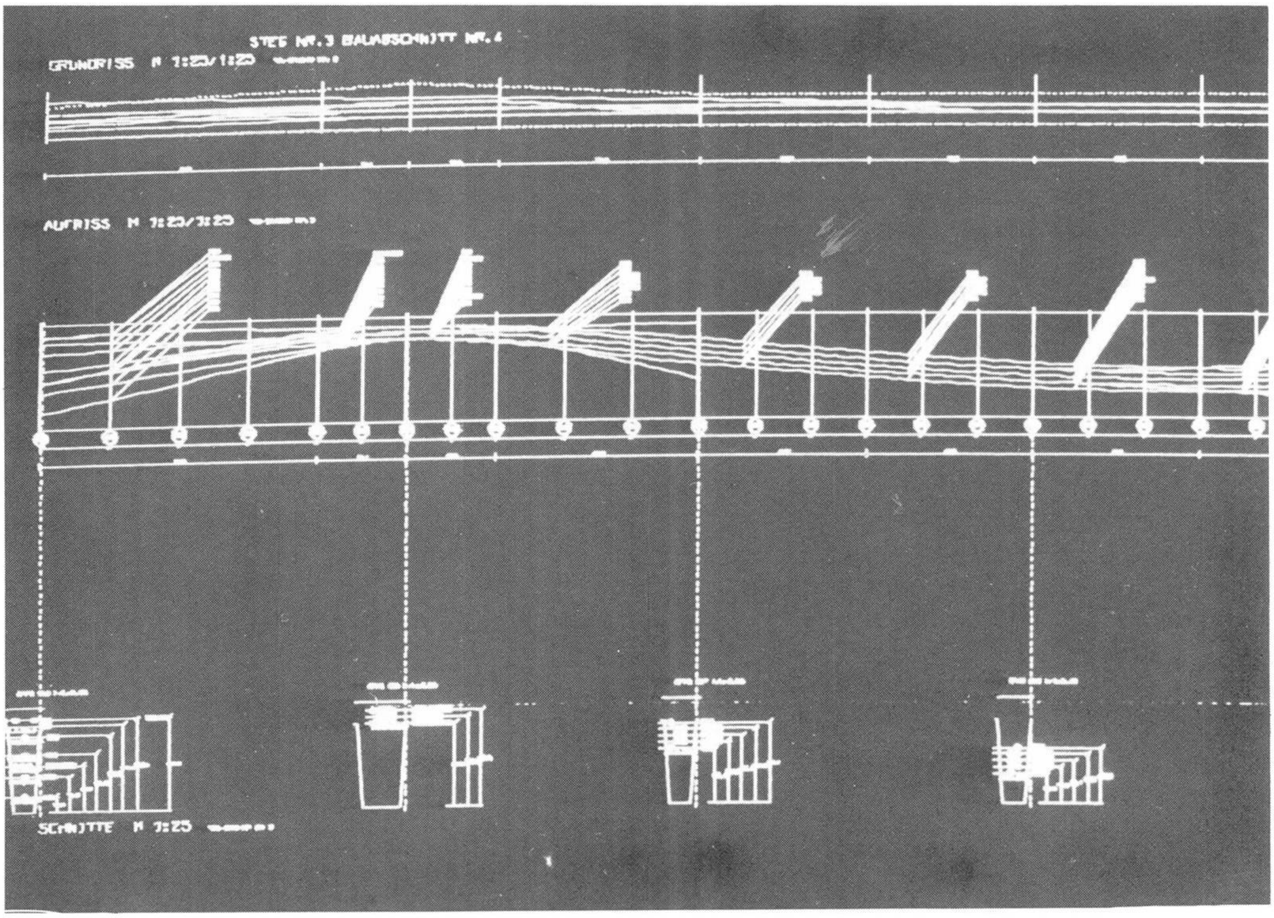


Fig. 2 Example of pre-stressing cable plan

The program package "Pre-stressed-concrete" is integrated into a program for structural analysis and the whole system is a good example of a complete solution for calculation, dimensioning and drawing.

Even in this case it is important when using the computer sensibly that the pre-programmed course supports the engineer but does not replace him. Therefore, great emphasis has been laid upon dialogue input and great care has been taken in programming the graphic representations.

The program is used by a great number of Austrian engineering bureaus and civil engineering firms. It is even used in computing centres as well as on private machines. It has also been sold to nameworthy engineering bureaus abroad (approx. 7Ø installations, approx. 5Ø in Austria).

There are two versions:

BASIC for desk-top computers (the performance is obviously limited by BASIC) and FORTRAN for mini-computers (this version also runs on all mainframes).

2.4. Steel construction

In steel construction, the main stress of actual development lies in the direction of computer aided design.

A problem seems to be that available program packages concentrate mainly on the drawing of plans. The coupling of data to structural analysis is problematic. Much work is still required to include into the overall program package constructive details (cross sectioning, profile choice, determination of connections) with all required calculations to achieve a general solution for calculations, construction and drawing of plans.

The dependency on standards plays an important role in the development of technical programs.

Since the design codes and "unwritten" working conventions differ so much from country to country, international cooperation is made difficult. This is awkward for programmers.

Program users find it difficult, if not impossible to use solutions developed in other countries and the programmer does not have access to foreign markets if he conforms only to local conventions.

3. ECONOMIC ASPECTS OF ENGINEERING SOFTWARE

At the beginning it was pointed out that the majority of potential and actual users have a certain size, ie. 10 to 20 people. The cost of computer applications must therefore be within reach of such firms.

In spite of the small size of firms there is a need for a complete solution including structural analysis, computer supported dimensioning and drawings like a C.A.D.-system.

When purchasing a computer system the costs have to be regarded: the initial cost of the system and the running costs (mainly maintenance and personnel). In order to estimate the initial costs, one must consider that integrated solutions are mainly a matter of proper data organisation. Only if results and constructional details are properly stored in a data base, can all the necessary data for structural analysis and drawings be efficiently extracted.

The computer must therefore be equipped with sufficient external memory. To guarantee fast access to the database, a powerful processor is required. In this way, costs quickly escalate up to 100.000,-- or 150.000,-- $. Yet, one still needs a powerful plotter (with sufficient paper size and quality) and a graphic terminal with good resolution.

The costs for graphic hardware lie between another 30.000,-- $ and 50.000,-- $.

Then, there is of course, the software. The initial cost of such software systems lies between 100.000,-- and 200.000,-- $. If it is not possible to reduce these costs, then this system will have to earn its user 5.000,-- $ a month, which for the majority of potential users is highly improbable.

From the programmers point of view, these development projects will last for many "man-years". To do this privately in one's own average sized engineering bureau would therefore only be possible in exceptional cases. A professional software house would need to sell approx. 50 program systems in 2 years to be able to keep the software price down to such a level, that the total cost (hardware + software) does not escalate too far.

These statements make it clear that with todays costs it is difficult to strike a balance between cost and usefulness if one wants to buy the complete C.A.D.-solution. This may be the explanation for the fact that a large part of structural analysis and CAD development is supported by the state.

4. FUTURE OUTLOOK

There are two ways out of this dilemma:

That the expected continuing fall in hardware costs in the coming years increases the circle of potential users to such an extent that software development costs can be better divided. Then the profitability of obtaining such a system will be easier proven. Please note, that the actual development of micro computers is a very important fact in this context and will therefore be dealt with in chapter 5.

Restriction of problems in order to take out only specific topics that are of real interest and concentration on practical points can reduce the hardware and software specifications so much that the profitability for user and producer is guaranteed.

The author has been tackling these problems for many years and has succeeded in implementing engineering software on mini- and even microcomputers. The special considerations necessary for such implementations will be explained in the next chapter.

5. MINI-MICROCOMPUTERS

5.1. What is a mini ?

The question: "What is a minicomputer ?" cannot be answered easily or fully. Some years ago, the answer would have been easier. At that time, a minicomputer was a digital computer with a word-length of 16 bits, preferrably used for process-controlling purposes in real-time applications.

The 16-bit word length restricted the addressable memory space to 64 KBytes. This meant that no program on a mini could exceed that magic limit. Some of the minicomputer soft- and hardware characteristics are given in the following table:

MINI	16 Bit word length 64 KB Addressable memory space fast floating point operations all peripheral devices electronics one generation younger than on mainframe low price compared to mainframe broad range of system-software available (from compilers to communications network software)
SUPERMINI	32 bit word length some MB addressable memory space price less than mainframe

MICRO

8 - 32 bit word length
more advanced electronics CPU = 1 chip
slower than mini
sometimes no floating point hardware
not so many peripherals
very cheap

To continue the history - very soon after minicomputers had appeared on the market their ability of solving technical problems economically was discovered.

Upto this time all the available FEM codes had been developed - mostly at the universities - on big mainframe computers. Of course, they were too expensive to be used in everyday engineering practice.

Since then, many people have started to use the FEM-method on mini-computers, but not only because they are cheaper.

There are also other good reasons for preferring a minicomputer to a mainframe:

- minicomputer are usually easier to use
- they have a more modern operating system which is better designed for
- interactive method of working
- easy file (data) handling
- it can be located where the engineer works,
- so he has direct access to all peripherals like printers, plotters, tapes, disks

Therefore, it seems that all these advantages of a mini-micro-computer outweigh its disadvantage of being slower than a mainframe. Very often, the high speed of the mainframe is lost anyway, when plots or printouts have to be sent to the user.

Of course, many tasks remain which have to be done preferrably on really big machines. But in my example I would like to show to what extend minicomputers can be used. A connection between intelligent terminals, decentral minicomputers and mainframes connected in a hierarchical tree structure seems to be a widely accepted concept.

5.2. Programming concepts

Due to the characteristics of a mini-computer, especially its address space restriction to 64 Kbytes, special programming strategies had to be devised for the implementation of FE-codes on them.

First of all, instead of one big software-system containing all possible element types and all thinkable algorithms a family of program modules has to be constructed. There, the number of available elements is reduced to those which offer good performance for a wide range of applications.

These different modules communicate with each other by means of disk files.

Secondly, an overlay structure as simple as possible has to be defined to use the available memory space as efficiently as possible.

As a result, the programs are disk i/o oriented. This could lead to machine dependent programming (Disk i/o is not standardized !).

But by special programming techniques where all i/o is put into special subroutines this problem can be solved. It is then very easy to include system subroutines in these subroutines, which make disk i/o very fast, compared to standard i/o speeds.

Consequently the algorithms have to be chosen, not only considering their incore efficiency, but sometimes mainly with regard to the number of i/o operations performed.

Of course, the concept has to be made so flexible that big memory can be used, when it is available. Think of the new generation of micros with a 16 bit CPU and an addressing capability of about 8 MBytes.

6. EXAMPLES

To illustrate our concept of technical programming, some examples will be presented in this section. It has to be pointed out that all these examples have been solved on very small computers.

In Fig. 3, results of a plate analysis are shown. The program used for this purpose runs on a basic programmable desktop-computer with 64 KBytes main memory and a floppy-disk capacity of approximately 512 KBytes. The cost for such a configuration is currently less than 316.000,-- $.

Fig. 4 shows the FE mesh for the analysis of a wheel of a generator. Cyclic symmetry has been taken into account for this system, comprising of about 350 shell elements.

In Fig. 5, the mesh for a 3-D analysis of an arch dam, approximately 200 m high, is shown. This problem too, has been solved on a mini-computer with 256 Kbyte of main memory, 20 Megabytes of disk space and of a price of about 45.000,-- $.

Finally, I would like to stress that all the software mentioned in this paper is already implemented, and functioning on modern 8-bit and 16-bit-micro-computer. We have excellent experience in using them. Naturally, there is a limit to what extent the small machine can solve the problem in acceptable time. Within this limitation the solution using micro computer is unbeatably cheap. Please note, that the arch dam (fig. 5) can also be analyzed using a micro computer during a single night.

All these experiences strengthen the opinion that the new generation micro computer can be a base for the development of complete CAD-Systems including everything needed for structural analysis, dimensioning and drawing of plans.

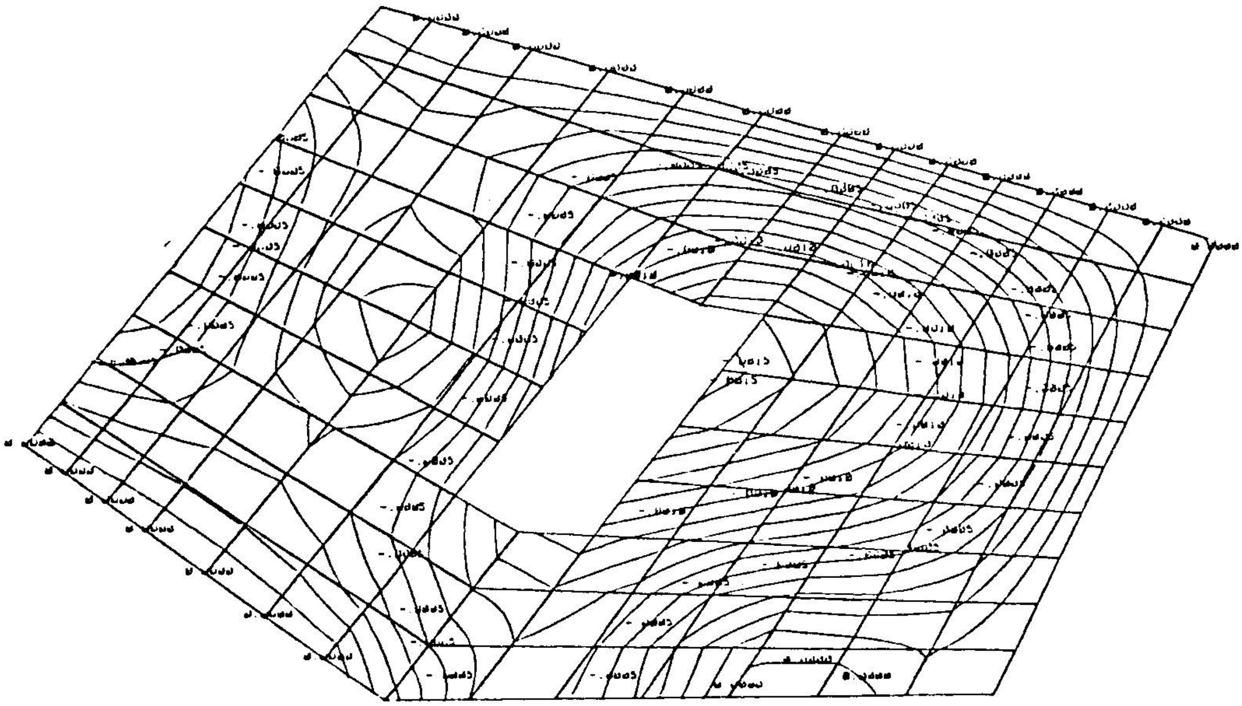
7. SUMMARY

In order to supply the engineers with cost-effective and easy usable computer support, it is proposed to concentrate future work on the following:

Specialized software solutions for special applications, as opposed to general, expensive and big software-packages.

Usage of cheap and efficient mini- and micro computers instead of centralized mainframes.

This concept has been followed in our company for more than ten years. It seems that nowadays - especially due to the advantage of the new generation micro computers - this concept is accepted by a wide group of scientists and engineers.



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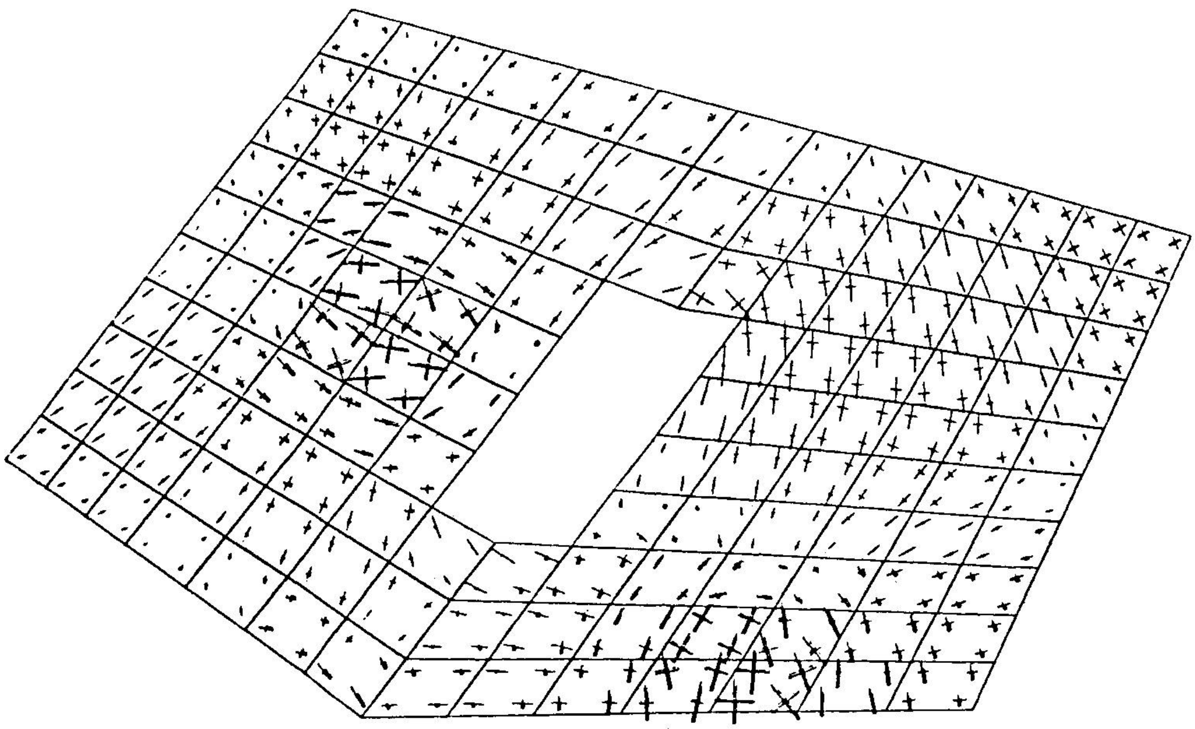

PRINCIPAL MOMENTS

Fig. 3

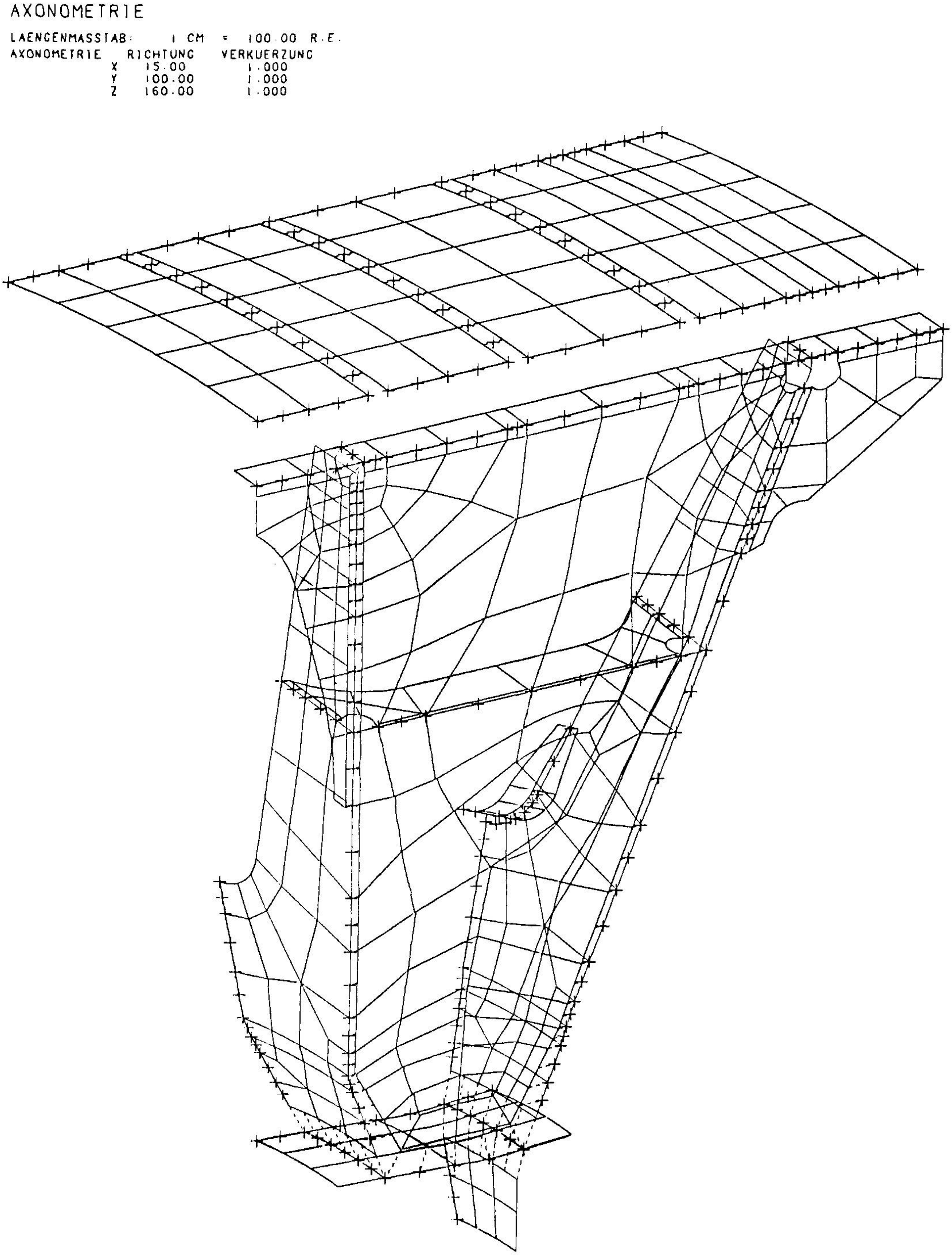
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Fig. 4

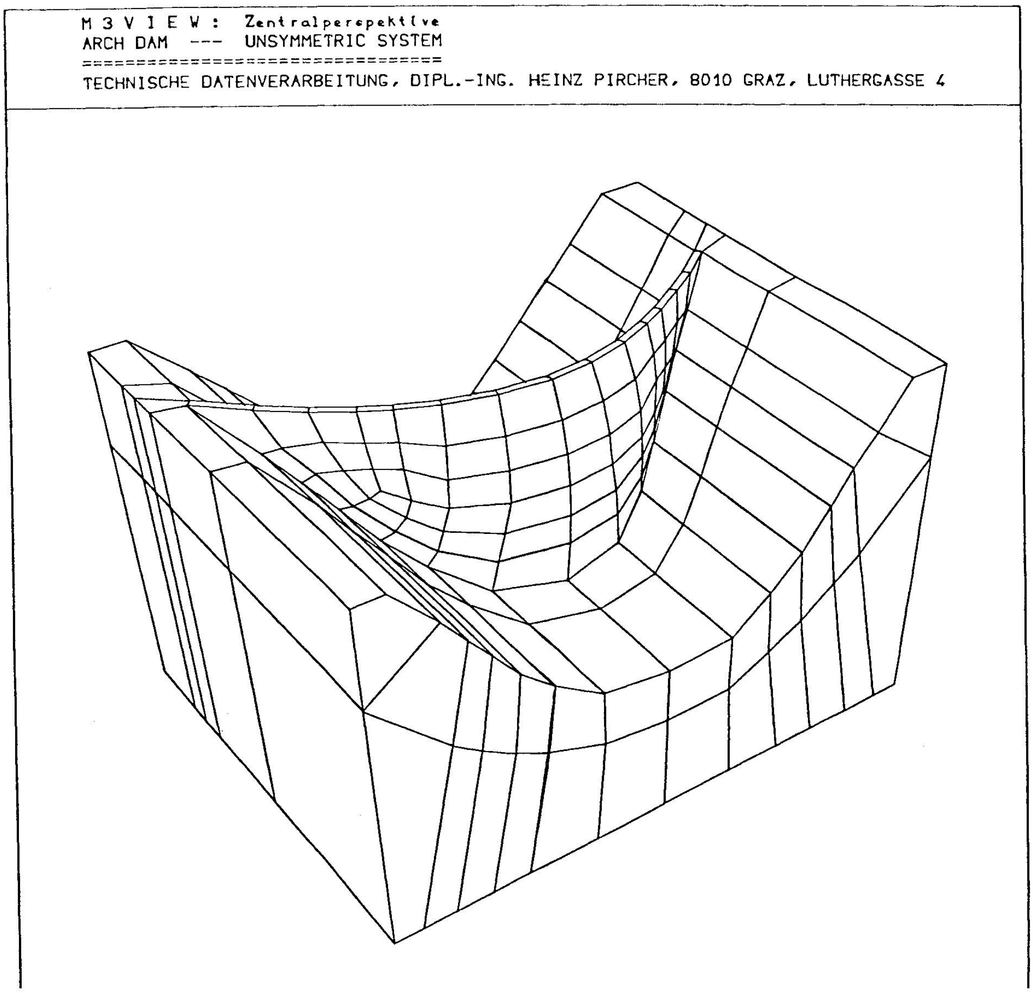
M 3 V I E W : Zentralperspektive
ARCH DAM --- UNSYMMETRIC SYSTEM
TECHNISCHE DATENVERARBEITUNG, DIPL.-ING. HEINZ PIRCHER, 8010 GRAZ, LUTHERGASSE 4

Fig. 5