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Autor: Bengtsson, A. / Blom, H.

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Some Demands on a Suitable Civil Engineering Structural Program

Quelques demandes d'un propre programme de structure

Forderungen an zweckmâssige Datenprogramme auf dem Gebiet der Baustatik

A. BENGTSSON
Managing Director
Nordisk ADB
Stockholm, Sweden

H. BLOM
M. Sc. Eng.
Nordisk ADB
Stockholm, Sweden

Summary
Most of the general computer programs in structural engineering have been developed in order to analyse big complex structures. These programs can often not be used in a effective and profitable way for the simple problems which occure daily, because they don't have such facilities (technical and input/output) that can make the designer's work easier for this kind of problems.

Résumé
Presque tous les programmes généraux de structures sont developpés pour faire l' analyse des grandes structures. L'utilisation de ces programmes pour les problemes frequentes moins grandes ne sont pas efficace, parce que souvent ils n'ont pas des possibilités (techniques et "input/output") qui peuvent faciliter l' utilisation à l' ingenieur pour ces types des problemes.

Zusammenfassung
Viele der bisher entwickelten Datenprogramme auf dem Gebiet der Baustatik haben den Vorteil grosse und komplizierte Systeme berechnen zu können. Für die kleineren alltäglichen Probleme sind sie jedoch nicht effektiv und preisgünstig genug. Es besteht daher ein Bedürfnis an allgemeinen baustatischen Programmen mit vielen technischen Möglichkeiten, einer leichten Eingabe und einer einfachen Resultatdeutung, um die Arbeit des Ingenieurs zu erleichtern.

A time- and cost-estimation of an ordinary calculation, of the type and extent frequently occurring to most of the structural engineers, might look as follows:

1.	Conventional calculation by hand	10 h	$ 400
2.	Computer calculation		
	a) Computer costs		$ 4-10
	b) Input preparation	1 h	$ 40
	If knowledge and/or experience of methods and programs are insufficient the following costs may be added:		
	c) Study of manuals etc		$ 400-1000
	If a program has to be developed		
	d) Program cost		$ 4000-

The use of computers for the calculation of a multi-storey building, an arch-dam or an suspension bridge is today self-evident. The hypothetical example above indicates that it can be a very effective and cost-saving way also for the solving of the daily minor calculation problems. However, sometimes the economy of the method is doubtful - sometimes a downright catastrophe! It therefore might be worthful to consider if the designer, for whom the calculation only is a rather small part of the job, should perform the computer calculation himself or use a computer specialist. In order to use the computer efficiently without too many costly failures he must

- plan and perform his design task considering his powerful tool,
- have knowledge of the behavior of the structure to be able to define the calculation-model and evaluate the results,
- have experience and knowledge of the actual programs,
- have access to suitable hardware (computer, terminal, plotter etc.),
- have access to suitable programs, program-manuals and, in case of need, support by a program-expert.

Up to now most computer calculations have been carried out by a rather limited number of computer specialists. This will certainly also be the case in the future for more complicated calculations. However, the only way to reach a more extensive use, also for solving the daily occurring smaller problems, would be that the designer at least would prepare (control and correct) the input and evaluate the result himself. The prospect for this will of course be necessary education, but it will also put severe tests on the facilities of the programs used.

I will therefore here mention some of the demands which I think ought to be met. In doing so I will restrict myself to those facilities which the user will get in direct contact with, i.e. technical facilities and input and output. As regards the technical facilities I will restrict myself, for the sake of simplicity, to plane frames and static loads. A suitable structural civil engineering program should at least have the following facilities:

1. Generally

Linear theory is normally acceptable but at least the following non-linear facilities ought to be available

- cracked concrete (for calculated or given reinforcement),
- plastic hinges or mechanisms,
- friction and no-tension hinges and reactions,
- theory of second order including big deformations.

2. Regarding materials and geometry

- Arbitrary cross-sections also built up from different materials.
- Straight or curved elements.
- Arbitrary variation of cross-section along the elements.
- Hinge-elements and reactions defined as fixed, elastic or free.
- Excentrial connections between joints (nodal points) and elements, reactions or hinges.
- Facilities to handle infinite stiff elements (for instance a plate may be stiff in its own plane).

- General boundery conditions and cyclic symmetry etc.
- Orthotropie (dep. on material or geometry).

3. Regarding_loads

- Concentrated or distributed loads arbitrarily placed and directed.
- Temperature loads with varying intensity also over the cross-sections.
- Support settlements.
- Prestressing loads.
- Traffic loads.

4. Regarding_combination_of_structural_systems_and_loads

Most structural systems are loaded with a number of different load-cases. The designer is then normally not interested in the influence of each isolated load-case, but possible combinations of them giving optimal influences in the result points. In these combinations the character of the loads (dead, live, alternative etc.), the probability of the combination, the actual code etc. should be considered. Sometimes there is a need to combine results from different structural systems as for instance systems with symmetrical and antimerical boundary conditions or systems describing different phases in the building of a structure.

5. Regarding_results

The following type of results ought to be optional:

- Grossforces and/or stresses in arbitrary points on the elements for defined load-combinations or as envelopes over the result-points.
- Reaction forces for defined load-combinations or as envelopes over all reaction-points.
- Deformations in joints and arbitrary points on the elements for defined load-combinations or as envelopes in the deformation-points.
- Stability-factors.
- Influence-lines.
- Eigen-values and eigen-vectors.

6. Regarding input

- The structure for the input should be manageable and suitable not only for the preparation of data but also for the testing and correction.

- It should have facilities for an automated data generation (from data-banks, from a preprocessor or built-in procedures).

- Joint- and element-numbers as well as load-case names ought to be optional. A coupling between for instance the joint-numbers and the equation-order might course either an unfavorable bandwidth of the total stiffness-matrix or a renumbering of the joints if an extra joint is introduced.

- Input-data ought not to be loaded with unnecessary computer-based formalism.

7. Regarding checking facilities

- Formal and if possible also technical checks ought to be made of the program as early as possible.

- The program should not break off the input reading and checking as soon as a smaller error has been detected but should go on reading and checking as far as possible. Then of course the program must stop before calculation starts.

- Data-echo with a plain indication of detected errors must be delivered.

- Special check output such as a plot of the system and a table showing value and position of the resulting force for all load-cases can be very valuable.

8. Regarding output

- Each calculation ought to be delivered as a "closed" selfdefining calculation.

- The pages ought to have a standard format and they should be paginated.

- The numbers ought to be printed in decimal form (no E-format).

- Plotted results is often useful.

- Results should be saved in data-banks in such form that they can be available for other programs.

Conclusions

As far as I know no program is available which include all above mentioned facilities. The reason for this might be that most of the general programs have been developed for the calculation of rocket towers, reactor shells or other complicated constructions and not for the analyses of smaller bridges or similar problems. However, if we want that the designer, for whom the calculation of a certain type of constructions might be actual once a year, should be able to perform this calculation without having to study the manuals again and without doing unnecessary failures, then I think that all programs he uses should have a standardized structure of input, output, checking- and restart-facilities etc. I think it might be worthful if IABSE would initialize such a standardization.