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**The Responsibility for Electronic Calculations**  
**La responsabilité pour les calculs exécutés par l'ordinateur**  
**Die Verantwortung für elektronische Rechnungen**

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**Summary**

The designer is full responsible for electronic calculations as he usually was for manual calculations. He has to check the results of the calculation which is possible due to equilibrium and compatibility costs. As even for tested programs sometimes hidden errors exist testing and checking of the program itself is not enough for judgment of the correctness of a calculation.

**Résumé**

Le projeteur est aussi bien responsable des calculs exécutés par l'ordinateur que par lui-même. Le contrôle d'un calcul doit inclure les conditions d'équilibre et de déformation. Les programmes éprouvés peuvent toujours contenir des erreurs cachées; il n'est donc pas suffisant de se contenter d'un test, ou d'un contrôle du programme pour une appréciation définitive du calcul.

**Zusammenfassung**

Die Verantwortung für elektronische Rechnungen liegt wie für manuelle Rechnungen beim Entwerfer. Die Überprüfung einer Rechnung muss die Ergebnisse erfassen, was mit Gleichgewichts - und Verformungs - kontrollen fast immer möglich ist. Da auch bei getesteten Programmen versteckte Fehler existieren können, kann der Programmtest und die Programmüberprüfung nicht für die endgültige Beurteilung der Berechnung ausreichen.

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When designing buildings it was the usual way that the responsibility for the calculation was at the designer, even when some detail calculation was done by auxiliary designer. The man in charge of the job was able to overlook the whole calculation and therefore no difficulties in checking such calculation arose. By simple formulas it could be checked that all assumptions are reasonable and when usual methods were used detail checking of figures could be left to auxiliary personal.

In some way methods of checking calculations have changed since computers are used and new problems arise about the responsibility for the total design. Due to my experience the designer should be responsible for the calculation. He must find a way to check the calculation of the computer to be able to take the responsibility. For further remarks there is no special difference if the computer center belongs to the same firm as the designer, or if the computer center is an own firm and is calculating on a commercial base.

Some of the remarks which follow will be valued not only for checking calculations of a computer but also for checking of programs during their development.

All input data should be systematically printed to give the possibility for calculating the same problems manually or with other programs. Additionally, preferably intermediate results should be printed to allow checks on random sampling such figures for a equilibrium or compatibility tests. Sometimes, for well known programs, such checks are enough to proof the credibility of the results. Usually such controll calculations are even simple, when the program uses a very complicated procedure. As an example, even the results of a large system of equations can be checked by multiplication of one single line of this system. The total equilibrium of a complicated structure calculated by finite elements usually is also not difficult to check. Naturally some labour has to be invested.

Praxis shows that a too strict demand for such checks would especially hinder the development of new procedures. The following way gives as well for the computer center as for the designer a good economy on their cooperation.

Naturally some confidence and reliance between both of them is needed. The programmer has to give a very exact description of the methods he uses and he must show the limits of these methods and has to show the sensitivity against defaults and small changes in input data. Programs should be safe in an economic way against failure in use, when this seems possible. Today, the security against machine failures is nearly 100%. The printed calculation should give, additional to input data and intermediate results, the final results and also dimensions if the program is not designed to work dimensionless.

As usually such calculations need to be copied very often calculation sheets should be signed in a way that they cannot be confused with calculations of similar kind or even with nearly the same input data at the same day. A very good way is to print the date and time of the beginning of the calculation on every sheet.

Everybody who has to do with computer calculation will remember the case, that programs, which have been tested some years ago and which seemed to be correct due to the experience of hundreds of calculations, show bad results after years when input data are in a special constellation. The mistake is due to the fact that there is a large number of logical ways through the program and it is impossible to test all of them during testing a program. Nobody should therefore make the computer center or the programmer too much responsible for the consequences of such wrong calculations. A computer center working on a commercial base should deliver a new calculation without additional costs if the mistake is due to a wrong program. But the responsibility for technical consequences must be with the designer.

We must therefore insist on the fact that testing a program does not give us the security that the calculations are correct. There must be at least some check of the results to be safe.

As said before, for a lot of problems the printing of intermediate results allows a manual check at least on a random base. For more complicated problems as there are Eigen-value problems the printing of the matrix and the printing not only of the Eigen-value but also of the Eigen-solution were a valuable help. Even programs which are

proofed since years can give wrong results due to changing in the compilers for new installed machines.

When there are calculations of extremely large extension the responsible designer will be compelled to check such calculations with tests or in comparison with results of another program. As there are sometimes - especially for difficult problems - no other programs available a second calculation with the same program but with the input data made according to the drawings by another person will give safety against errors.

When making compatibility tests for the deflections it should be noted that for manual calculations the virtual forces can act at any chosen statically determinate system and therefore such a check is very easily done.

Most of these ideas have been fixed in "Allgemeine Richtlinien für die Vorlage und Prüfung von statischen Berechnungen mit programm-gesteuerten Rechenanlagen (elektronische Berechnungen)" which have been edited by the Österreichischen Stahlbauverband in 1967. These recommendations give at least a good guidance for checking of electronic calculations and should be published to experts.