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

Band: 31 (1978)

Artikel: Computer aided cheking of structural safety

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DOI: https://doi.org/10.5169/seals-24926

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

Computer Aided Checking of Strucuural Safety

Vérification de la securité des structures à l'aide de l'ordinateur

Rechnerunterstützte Standsicherheitsprüfung

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Summary

The procedure of auditing the calculations of inner forces and dimensions of building structures, which is usual in the German Federal Republic, is criticized. Instead of this procedure it is proposed to check the safety of a structure against failure by determining its bearing load considering the dimensions of its members as they will be constructed. Therefore designing engineers should be allowed to deliver data holders which contain detailed descriptions of all members of a structure in a standardized form instead of giving evidence of its safety by calculation. Auditing engineers should have software at their disposal which enables them to determine the bearing load from these data.

Résumé

La procédure de contrôle officielle des efforts et du dimensionnement des structures, utilisée dans la République Fédérale d'Allemagne, est critiquée. Au lieu de cette procédure, on propose de vérifier la stabilité d'une structure en dérivant ses charges de rupture de documents d'exécution. Par conséquence, on devrait permettre - à la place de la preuve de stabilité - de présenter pour vérification des supports de données qui contiennent la description de tous les éléments de construction dans une forme normalisée. Les bureaux de contrôl doivent disposer d' un système de programmes d' ordinateur, les rendant capables de dériver la charge de rupture sur la base de ces données.

Zusammenfassung

Das ist der Bundesrepublik Deutschland gebräuchliche Verfahren, die Schnittkraftermittlungs und Dimensionierungsberechnungen für Bauwerke amtlich zu prüfen, wird kritisiert. Statt dieses Vorgehens wird vorgeschlagen, die Standsicherheit durch Ermitteln der Traglasten aus den Ausführungsunterlagen zu bestätigen. Es sollte deshalb zulässig sein, an Stelle eines Standsicherheitsnachweises Datenträger zur Prüfung vorzulegen, die ausführungsreife Beschreibung aller Tragglieder in standardsierter Form enthalten. Prüfämter und Prüfingenieure sollten über Software verfügen, mit deren Hilfe sie die Traglasten der so beschriebenen Tragwerke ermitteln können.

In many countries the construction documents of building structures have to be audited before the erection of a building is licensed, in order to guarantee structural safety and thus to protect the public against the danger of a collapse.

Traditionally, together with the request for the building licence evidence of structural safety has to be given in a verificable manner, in order to facilitate the procedure of auditing.

Usually, for this purpose the designer presents the calculation by which he determined the inner forces of the structure and the dimensions of its members. He really could not be forced to do so. Instead of this he rather could determine the ultimate inner forces of each member, and then give evidence that the whole structure is able to bear ν times the working and dead load of the building, where ν is the safety coefficient.

The auditing officials or the consulting engineers to whom the licensing authority might delegate the auditing work have to check whether the evidence is complete and correct.

If, instead of a special evidence of structural safety, the designer presents his calculation of inner forces and dimensions, the auditor inevitably does not only check the results, but also the procedure of the designer's work. Thus his attention will be directed to the numerical correctness of the calculation and diverted from the real structural safety.

For this reason - in the German Federal Republic - more and more instructions for the adequate manner of calculating inner forces and of dimensioning have been incorporated into the official building codes. The designers working conditions have been affected and - at least partially - narrowed by these regulations.

When computers were introduced into structural design work it was generally presumed that furthermore calculations of inner forces and dimensioning should remain to be objects of auditing. In the "Preliminary guidelines for setting up and auditing electronic computations of structural safety" from 1966, which are still valid now, there is prescribed that the author has to indicate the structural model, upon which he bases his calculation, and to describe in detail the computer program which he uses.

Proposales of alternative procedures as "parallel calculation by use of an independant computer program" or "auditing by use of intermediate results" suggest the auditor to deal intensively with the designers assumptions and with the results of his calculation rather than with the designed structure.

Consequently there are continued efforts to standardize the procedures of structural design work in order to facilitate the auditing work. Demands like that for "computer adequate standardization"sometimes are based on the idea the whole procedure of dimensioning, the calculation of the inner forces included, obligatory should be prescribed for important, regular cases.

In three different respects this development appears to be disadvantageous to the individual engineer als well as to the whole profession:

a The creative energy of designing engineers is exhaustet more and more by observing the increasing amount of regulations.[+] They remain fixed to the analytical procedure of dimensioning, though the use of computers should have liberated them from mechanical computing work.

b The amount of documents necessary to give evidence of structural safety and therewith the expenditure of time and labour for auditing work is growing more and more. The difference between the designer's and the auditor's expenditures diminishes, while the charges for auditing calculations remain much lower then those for establishing them.

c It grows more and more difficult to make sure, that the auditing procedure is totally independent from the dimensioning one. Therefore, in spite of the increasing expenditure for auditing, the risk also increases, that serious deficiencies of a structure remain undetected.

These are the reasons for my proposal to disconnect the evidence of structural safety totally from the procedure of dimensioning.

The auditors should have computer programs to their disposal, by which they are able to determine the bearing loads of structures from the dates which they understand immediately from the construction documents. They should use these programs without to know the assumptions the designers had taken while dimensioning the structure.

The designers could be exempted from giving evidence of the safety of their structure in case they deliver to the licensing authority not only the construction documents but also data holders which contain detailed descriptions of all members of the structure in a standardized form.

If these data holders could also be used to produce drawings and other construction documents automatically, the expenditures of the designers as well as those of the auditors and even the total amount of paper which has to be interchanged between designing, auditing and constructing organizations could

[+] Alfred Mehmel warned already in 1965 structural designs would remain sums of observed regulations only.

be decreased.

In favour of the standardization of those data holders all efforts should be canceled, to standardize the procedure of dimensioning structures and proving structural safety. Existing regulations on these procedures should not be obligatory in case designer and auditor agree about the interchange of data holders.

The previous critical remarks and propositions are based on the problems, we actually have in the German Federal Republic. It would be of great interest to learn in the discussion, whether in other countries similar problems exist or not, and if more effective procedures of proving structural safety are practised.