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Synthesis and Conclusions

Synthèse et conclusions

Synthese und Schlussfolgerungen

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Several interesting points have emerged from the papers in the Preliminary Report and from the deliberations at this session. First of all it can be seen that work in Structural Optimization is being carried out at very many different technical levels. Some of the work which has been described can only be classified as purely theoretical research. Other papers have described attempts to apply some of the advanced methods of structural optimization to practical design problems. A few contributions have described purely practical approaches to structural optimum design which use none of the advanced methods now available.

This very wide range of papers demonstrates one common theme. As structural engineers we are all interested in designing better structures. The ultimate goal of any designer must surely be to produce the best possible design for a structure to fulfill prescribed tasks. We are all seeking the best solution and consequently our work itself is an optimum-seeking process.

There are probably many engineers today who believe that there is no necessity for designers to concern themselves with some of the complicated mathematical methods which have been developed for structural optimization. They will probably argue that a good designer with great experience will naturally produce good designs which are closely optimal, therefore there is no need to use complex numerical techniques. To these people I would like to say that fifteen years ago the same things were being said about the new computer-oriented analysis methods such as matrix methods and finite-element techniques. Now there are few projects which do not at some stage use computer-based analysis methods to verify the suitability of a design. The computer is now an established engineering tool and we should make maximum use of it to help in design. Some people seem to fear that the computer might take over entirely if it is allowed to enter into the design process thus reducing the designer to the status of a computer operator. This fear is totally irrational - the computer is merely a servant carrying out such tasks as are assigned to it. It has no intuition or innovative capacity and these are the essential attributes of a good engineer which cannot be reduced to mathematical form. In structural engineering the experience and skill of a designer will always be required. The increasing use of computers for optimum design can only add to the status of the designer by making his efforts consistently better.

It came as a pleasant surprise to me that IABSE had planned to run this structural optimization session at the Tokyo Congress. For the practicing engineer structural optimization is still largely a thing of the future. For twenty years structural optimization has been an area of intensive research and only recently, within the last five years or so, some of this research has begun to percolate through to practical design engineers in a useable form. Some of this practical work we have seen during this session but the overwhelming tone of the discussions and papers has been that of research. The topic is not yet sufficiently developed for large scale practical use in everyday structural design. More research is necessary and more practical applications need to be studied in detail. Structural optimization still remains a thing for the future but the signs are that this future is not now very far away.

I cannot comment in detail on all this session's papers so I will restrict myself to comments upon a few. Firstly a very important point was made by Professor Massonnet on behalf of Dr. Maquoi. The use of the correct problem model is essential in optimization if realistic results are to be obtained quickly. It is seldom stressed that structural optimization is a two stage process. Firstly, a real-world problem must be modelled in mathematical form and secondly this mathematical problem must be solved. Often the first stage is the more difficult and, as Dr. Maquoi suggests, it is vitally important to get the right relationship between the real-world structure and its mathematical idealisation.

Dr. Hartmann's paper demonstrates this point very well. He shows a design for an encastré beam which, although optimal, is a totally impracticable design. Here the idealisation is incorrect and constraints to ensure a practical solution should have been included but were omitted. Unfortunately he ascribes the impracticable design to the use of mathematical optimization methods - the second stage of the process - and suggests that because mathematical methods produced this crazy design they should be discarded in favour of random search techniques. The logic here is surely wrong. It is not the mathematical techniques which are incorrect but the idealisation of the practical design problem

The papers by Di Carlo and Selleri are both interesting and worthy of further study. Mixed penalty functions as described by Di Carlo are not new, of course, but the specific application is interesting, demonstrating the existence of local optima. The problem of how to find the global optimum from several possible local optima is still an area for future research. Selleri's paper on cable structures and the papers by Daiguji and Feder on cable-stayed, prestressed structures reflect a growing interest in design problems associated with cables and similar work has been done on these topics in the USA and Great Britain.

Several of the papers presented for this Theme have used Linear Programming either straightforwardly or as a sequential iterative technique for design problems. To those people meeting structural optimization for the first time it might possibly appear that Linear Programming is a very powerful, widely applicable method for many structural design problems. I would like to set the record straight by stating that this is not so. Linear programming is a very simple method to use and consequently it is frequently employed to try to solve problems for which it is unsuitable. I will not repeat my warning as given in the Introductory Report, but will merely say that Linear Programming frequently causes more computational problems than it solves when applied to non-linear problems. Most structural optimization problems are non-linear.

I hope this session has given some idea of the great interest which now exists Worldwide in Structural Optimization. The Japanese National Group of IABSE quite rightly recognised the important place which structural optimization is likely to hold in structural design in the future and they showed remarkable foresight in suggesting it as a Theme for this Congress. I believe that at future Congresses much more will be heard of structural optimization and that in years to come it will become an established structural design tool. IABSE will then deserve much credit for stimulating discussions and interest in this topic at their 10th Congress.