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COLLOQUIUM on:  
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**Problems of Collaboration - Nationally and Internationally**  
Problèmes de collaboration, nationale et internationale  
Nationale und internationale Zusammenarbeitsprobleme

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**Summary**

Highway bridge design in Denmark is traditionally carried out by private consultants and although this practice has worked satisfactorily when design work was all craftsmanship, it may pose problems when design work becomes more industrialized through intensive use of computers. The article touches upon the problems involved in establishing collaboration and outlines some of the possible solutions.

**Résumé**

Au Danemark, les projets de ponts sont faits traditionnellement par des bureaux d'ingénieurs privés; bien que cette pratique fonctionne bien pour des projets étudiés de façon conventionnelle, elle pose des problèmes lorsque l'établissement de projets plus industrialisé, par exemple par usage intense d'ordinateurs. L'article rend compte des problèmes impliquées par l'établissement d'une collaboration et propose des solutions.

**Zusammenfassung**

Strassenbrücken in Dänemark sind herkömmlicherweise von privaten Firmen entworfen worden. Im grossen und ganzen hat dies zufriedenstellend funktioniert, besonders wenn die Projekte manuell ausgeführt worden sind. Es wird aber Probleme gegeben wenn die Projekte mehr industrialisiert durch intensiven Gebrauch von Computers ausgeführt werden. Der Beitrag wird die probleme mit der Entwicklung einer solchen Zusammenarbeit berühren und wird einige mögliche Lösungen erwähnen.

### 1. BRIDGE BUILDING IN DENMARK

Most bridge projects are carried out in Denmark by either the Road Directorate or the Danish State Railways each within their particular scope of activities.

The Road Directorate builds motorways bridges and important highway bridges, the design of which is traditionally entrusted to recognized consulting engineers.

The Danish State Railways of course build railway bridges - and are themselves preparing the projects for most of them.

In view hereof it would be reasonable - and advantageous to establish a cooperation within the field of Electronic Data Processing between the relatively few parties concerned with bridge design.

### 2. EDP PROGRAMS WITHIN BRIDGE ENGINEERING

An investigation has shown that, in fields of essential importance in regard to the calculation of supporting structures in bridges, EDP programs have been developed parallelly by several firms. On the other hand, the investigation has also shown that the firms have developed their particular programs in conformity with their specific fields of projects.

The programs referred to could be classified into the following main groups:

#### 2.1 Girders, Beams, and Slabs in Bridges

In respect to these structural members most engineering firms are in possession of relatively adequate software. The programs used solve, generally speaking, the same problems, although they may differ in certain respects. For example, some programs determine the extreme internal stresses and the deformations automatically, whereas other programs require repeated application.

Problems relating to prestressed structures are also treated in different manners, some programs thus determine the optimal location of the prestressed cables, and the optimization requires repeated runs.

## 2.2 Calculation of Rigid Frames

Several engineering firms possess software covering such structures. It is not quite clear whether or not all the programs determine automatically the extreme internal stresses and the deformations. The scope of the programs corresponds, on the whole, apparently to the scope covered by the more comprehensive standard programs commonly available.

## 2.3 Foundation and Soil Mechanics

In this field the similarity of the developed programs is, apparently, less remarkable than in the cases referred to above. The programs referred to cover, combined, the essential geotechnical problems mentioned in the following:- Piled foundations, direct foundations, retaining walls, stability of slopes.

## 2.4 Utility Programs for Calculation of Bridge Structures

All of the firms subjected to investigation possess such utility programs - typically programs for calculation of cross section coefficients and for nonsymmetrical bending.

## 2.5 Other Programs

In addition to the programs referred to in the preceding, there are certain programs which are found to represent a rather advanced stage of development. By way of examples the following could be mentioned:- Calculation of the geometry of bridge structures, slabs, transversal distribution of forces in bridges, influence diagrams for suspension bridges, and finite element programs, and also programs for the calculations required in connection with the cantilever method of construction.

The firms possessing their own EDP installation have relatively small computers. The general impression obtained by the investigation is that the software referred to covers very essential parts of the statics relating to bridge structures, as seen from the point of view of bridge design practice.

The Road Directorate is observing new methods and systems intended for calculation of bridge structures, which are already utilized - or are being developed - in other countries.

The purpose is to find such methods and implements as could - when they approach reasonable levels of utility - be procured, by the Road Directorate, and made available for the purpose of designing bridges.

Principal importance has been attached to interactive methods which, like in computer-aided-design, provide the designer with better possibilities of early arrival of satisfactory projects, so that the efforts could be concentrated on more promising solutions.

### 3. PROPOSAL FOR EDP COOPERATION

In recent years developments have advanced at an extraordinary rate in regard to utilization of EDP within the fields of statics and dynamics. In the same period the cost of engineering assistance have increased while the cost of EDP running-time had declined.

Seeing that these trends is assumed to continue in future - and at an accelerating rate, the advantage obtainable by using EDP in design activities will be steadily increasing.

There are in Denmark, in fact, only few public institutions and consulting engineers that embark upon bridge projects. A concentration of the relatively modest resources must therefore be recommendable, in such a manner that concentrated joint efforts could be attained, and the cost of the design phase as well as of the construction works could, in turn, be reduced.

Within the Road Directorate it is considered that such cooperation could be established between: The Road Directorate, The Danish State Railways, The Technical University of Denmark, and the consulting engineering firms.

Following a series of negotiations it appeared that the consulting engineers are not inclined for such cooperation. - Economic cooperation between consulting engineers will be a new and extraneous feature, for consulting engineers that traditionally, adopt a rather conservative attitude. Some consulting engineers tend to assume - erroneously - that development of programs, as such, constitutes in fact an engineering effort, and therefore, the development of programs is considered to be a feature of competition. The consulting engineers want to keep the development of new software within their own organization, and to be in a position to have the programs developed run by their own computers. This because such production runs make it financially possible for the consulting engineers to possess their own EDP facilities - which is considered necessary with a view for further development and improvement of the technical capacity in general.

These points of view collide with the Road Directorate's basic ideas in regard to such cooperation. Moreover, it is considered unacceptable that the development of EDP procedures depend on the particular EDP installations possessed by the consulting engineers. These installations are today of a limited capacity, and would consequently involve limitation of the possibilities of developing more comprehensive software systems. The use of the software already developed in other countries would also be restricted. The object of such cooperation could not be to ensure satisfactory financial results of the consultants operating their own EDP installations. Direct access to an EDP installation is clearly of considerable value to a design office. But such access could easily be established via terminals.

#### 4. AN ALTERNATIVE

A usable alternative is to let control of the development of EDP software for the purpose of bridge designers to be entrusted with the Road Directorate, Danish State Railways, exclusively. This implies, of course, that

these two departments undertake the full financing of such development and they overcome the obstacles of cooperation with the consulting engineers. The part of the consulting engineers in the cooperation will change so that, instead of participating in the financing and control, they contribute only through an advisory body, where they assist in connection with the use and maintenance of the developed software.

Such alternative can not, in reality, be said to be of very radical change as compared with the original proposal, but it reflects, of course, a realization of the difficulties in smoothening the conflicts in the interrelations between "employer and consultant" to attain cooperation without reserve.

Employers on their part see, of course, their advantage in being in a position to lay down the principles of the forthcoming development, in such a manner that it could be adapted to the policy planned in regard to Electronic Data Processing. At the same time, however, there is an obligation to keep step with rapidly accelerating international developments.

A natural prerequisite of the outlined alternative is a close cooperation with the consulting engineers, which - notwithstanding that all essential decisions are to be made by the Road Directorate and the State Railways - are supposed to cooperate in connection with the development and the application of any planned software in accordance with the guidelines that might at any time be laid down by the two departments..

#### 5.A THIRD ALTERNATIVE

A group of professors at the Technical University of Denmark have taken the initiative for the establishment of an EDP Institute, and for the nomination of an ADP Committee (Automatic Data Processing covering Dynamic and Statics, used for calculation of structures). The committee was nominated in June, 1976, by the Danish Academy of Technical Sciences.

The ADP committee has the following composition:

- 1 employer representative,
- 2 representatives of consulting engineers,
- 2 representatives of other institutes, and
- 2 representatives of the Technical University.

### 5.1 Objects

The objects of the committee is promotion of the development of technical and scientific procedures in dynamics and statics, as used for calculation purposes, and based on automatic data processing.

The committee shall promote the establishment of facilities permitting engineers practising calculation, using Electronic Data Processing, within the fields of statics, dynamics, and continua to get access to a series of selected, well-documented programs, adapted to circumstance in Denmark, and to obtain instruction in the use of such programs.

The committee shall be in charge of development and testing of programs for design etc., of structures, primarily through utilization of, and in cooperation with, existing public and private EDP-centres, and in close consultation with the Technical University of Denmark and the institutes under the Danish Academy of Technical Sciences.

The committee shall investigate, moreover, whether it will be necessary, on a long-term basis, to commence development of possibilities for technical scientific development activities within the fields mentioned in the preceding, and the committee shall submit its recommendations in regards to the matter to the Danish Academy of Technical Sciences.

### 5.2 Financing

The financial basis for the work to be done by the ADP Committee should be obtained through earnings through the Committee's activities, or through means which might be made available by other sources for the promotion of research and commercial activities.



In respect of any liabilities incurred by the ADP committee, any such liability shall be limited to the value of the capital and property possessed by the Committee specifically in its capacity of ADP Committee. Any operating profit shall be used solely for promotion of the Committee's object.

### 5.3 Scope of Activities

- 1) The ADP Committee may undertake requisitioned work, provided that it comprises an appropriate measure of technical/scientific development work.
- 2) Such ADP committee activities as are financed through foundations shall be made available to the public.
- 3) The ADP Committee shall not undertake any activities that might inflict unfair competition on any established commercial activities.

The Road Directorate awaits this initiative, since we think it might be too extensive, with a too scientific view, and touches too little on the day to day problems of bridge construction.

## 6. CONCLUSION

This was a short resumé of the collaboration forms the Road Directorate in Denmark has worked with since 1974, and some of the problems we have recognized. The first two collaboration forms does not seem to have any promising possibilities, the third alternative is just established, and it is too early to estimate its future.

Since the Road Directorate has limited resources we are essentially referred to the benefit that other major countries might contribute. This is why the Road Directorate investigate which new methods and systems for designing of new bridge structures by mean of EDP, there either are beeing used or are under development in other countries. The aim is to find a solution for the future, which, when it reaches a feasible level, can be purchased by the Road Directorate and be at the disposal for the consulting engineers for the purpose of bridge design.

The main purpose should be placed on the interactive systems, which like the computer-aided-design increases the consultants possibilities to make good projects.

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