Zeitschrift: IABSE congress report = Rapport du congrès AIPC = IVBH Kongressbericht

Band: 13 (1988)

Artikel: Integrated bridge design and analysis system

Autor: Soerensen, Kaj A. / Andersen, Georg B. / Jakobsen, Peder F.

DOI: https://doi.org/10.5169/seals-12986

Integrated Bridge Design and Analysis System

Programme intégré pour la conception et l'analyse de ponts

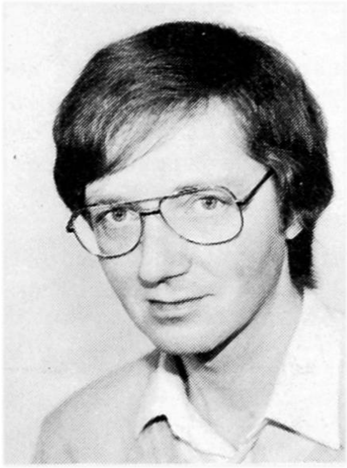
Integriertes Brückenplanungs- und Berechnungssystem

Kaj. A. SOERENSEN
Civil Engineer
Cowiconsult
Virum, Denmark

Georg B. ANDERSEN
Civil Engineer
Cowiconsult
Virum, Denmark

Peder F. JAKOBSEN
Mechanical Engineer
Cowiconsult
Virum, Denmark

Kaj A. Soerensen, born 1939, gained his M.Sc. in civil engineering and his Ph.D. at the Technical University of Denmark. He joined Cowiconsult in 1978 as head of the Research and Development Department. He has been in charge of the development of IBDAS since 1983.



Georg B. Andersen, born 1952, gained his M.Sc. in civil engineering at the Technical University of Denmark and his Ph.D. at Aalborg University Centre. He joined Cowiconsult's Research and Development Department in 1979 as a specialist in structural engineering and computers. He has worked as system designer in the development of IBDAS since 1983.

Peder F. Jakobsen, born 1956, gained his M.Sc. in mechanical engineering at the Technical University of Denmark. He joined Cowiconsult's Bridge Department in 1981. He has been working on the development of IBDAS since 1983.

SUMMARY
This paper briefly describes the structure, function and capabilities of a newly developed, fully integrated bridge design and analysis system based on three dimensional parametric solid modelling.

RÉSUMÉ
Cet article donne un apercu sommaire de la composition, du fonctionnement et de la capacité d'un programme intégré et nouvellement développé, basé sur la modélisation paramétrique tridimentionnelle et utilisé pour la conception et l'analyse de ponts.

ZUSAMMENFASSUNG
Der vorliegende Artikel beschreibt in kurzer Form Aufbau, Funktion und Kapazität von einem neuentwickelten, integrierten Brückenplanungs- und Berechnungssystem, das auf dreidimensionaler parametrischer Modellierung basiert.

1. INTRODUCTION

IBDAS is a fully integrated bridge design and analysis system based on three dimensional parametric solid modelling.

It has been developed by the authors of this paper and financed jointly by Cowiconsult and the Development Foundation under the Danish Ministry of Industry.

IBDAS has been developed primarily for the integrated design of reinforced and prestressed concrete bridges and the calculation of permissible loads on existing reinforced and prestressed concrete bridges with regard to the bridges' current condition.

At the same time the system can also be used for the design of steel and composite bridges and for the design of structures in general.

IBDAS has been programmed in standard FORTRAN 77 and has been implemented on the VAX/VMS operating system. The program comprises approximately 170.000 lines of code of which 75.000 lines are executable and consists of a database module and application modules for statical analyses, geometrical analyses, optimization, drawing generation and report generation.

The simplified system diagram in Fig. 1 shows the component parts of the program whose function and capabilities are briefly described in this paper.

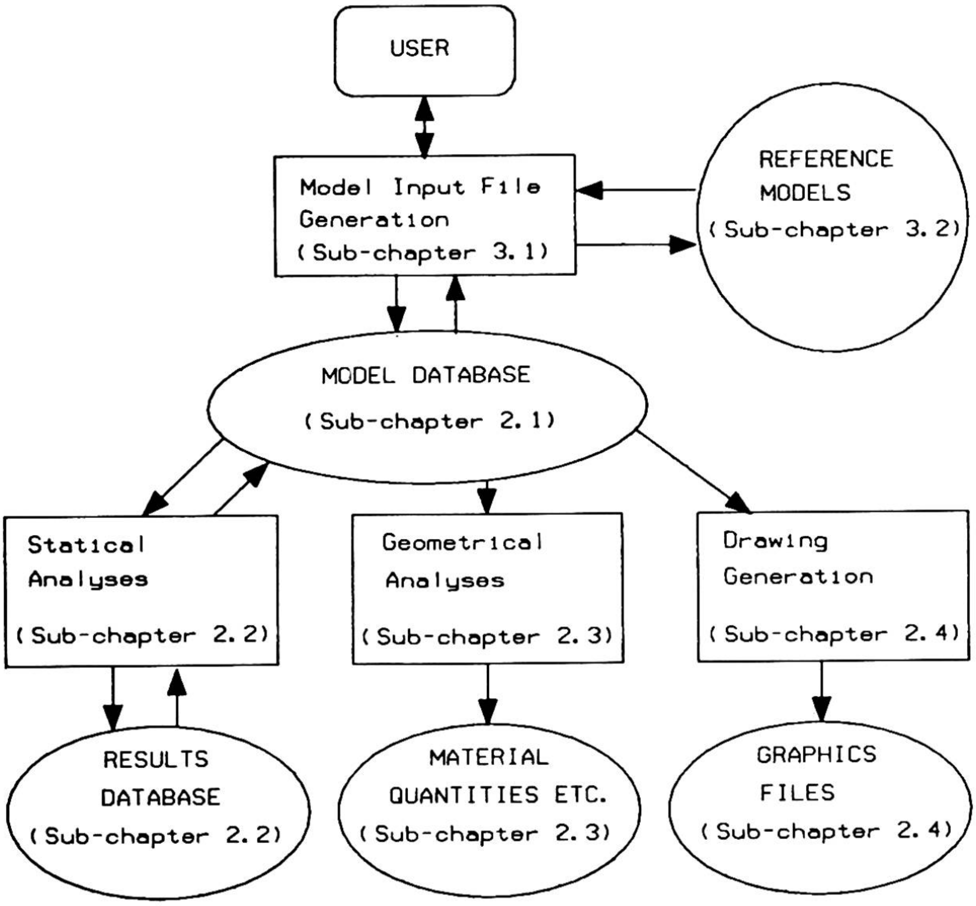


Fig. 1 Simplified system diagram

2. INTEGRATED LOGICAL DESIGN WITH IBDAS

2.1 Model Database

A user defined model database constitutes, in an actual design situation, the common integrated basis for the production of drawings and written documentation as well as statical and geometrical analyses.

The model database is built up as a sequential system of data entity definitions (points, curves, surfaces, volumes, etc.). The definition of each data entity in the sequence of definitions can logically refer to previously defined entities. This enables an automatic update of secondary data entities after any user defined changes to primary data entities.

For example, the model database for a bridge design task will normally first of all contain definitions of the overpassing and underpassing roads (alternatively railways or waterways).

Fig. 2 shows a simple example of such a defined road system.

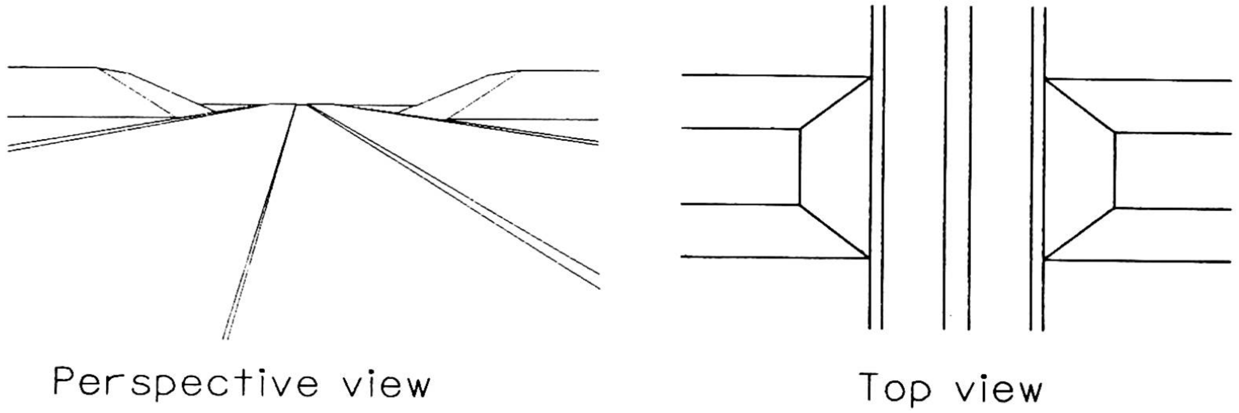


Fig. 2 Road system

Secondly, the model database will contain geometrical and material definitions of the actual bridge type, where geometrical definitions logically refer to the previously defined road systems.

Fig. 3 shows a simple bridge defined logically in relation to the previously defined road system.

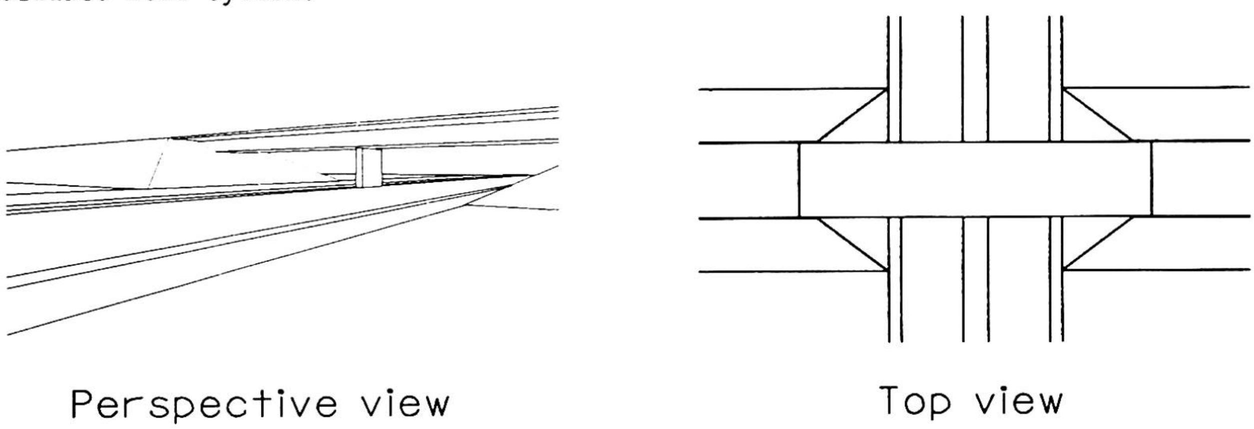


Fig. 3 Simple bridge defined in relation to road system

Fig. 4 shows the result of the automatic consequence update of the bridge definition after changing the road system.

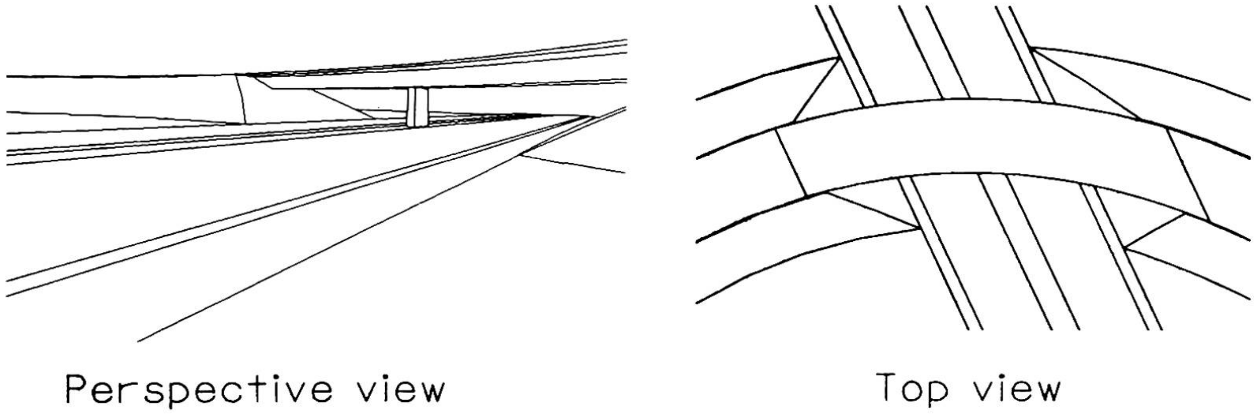


Fig. 4 Automatic update of bridge after changing the road system

The rest of the model database's component parts, i.e. definitions of reinforcement, statical analysis models, loads, construction processes, drawings, written documentation, etc., will similarly update automatically when defined logically in relation to previously defined data entities.

2.2 Statical Analyses

Statical analyses are carried out by the statical analysis module, which operates directly on the model database where actual analysis models, building processes, loads and load combinations, and design criteria are defined.

Fig. 5 shows an example of a finite element model, which has been logically defined in relation to the bridge definition illustrated in Figs. 3 and 4.

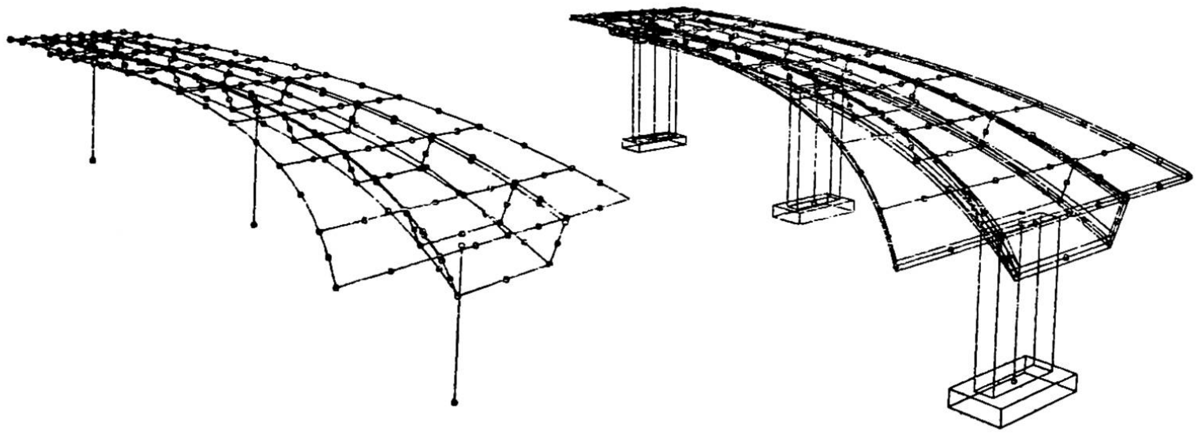


Fig. 5 Finite element model

The analyses may comprise load effect analyses, statical verification and dimensioning.

The load effect analyses may be construction process analyses, where the accumulated effects of dead loads, temporary supports, pre-stressing, shrinkage, creep and relaxation etc. are calculated, or service load analyses where extreme effects of traffic, wind and temperature loads are calculated.

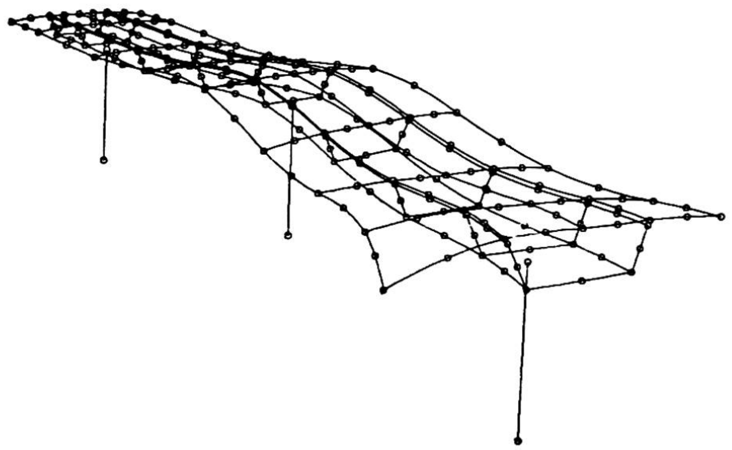


Fig. 6 shows a result (deflection corresponding to uniform distributed load) from a simple load effect analysis carried out with the analysis model shown in Fig. 5.

The calculated load effects are stored in a results database. The verification analysis and dimensioning programs subsequently operate on this database in combination with the model database.

Fig. 6 Deflection corresponding to uniform distributed load

2.3 Geometrical Analysis

Written geometrically based project documentation as, for instance, material quantities, bending schedules and setting out data tables, are generated by the geometrical analysis module, which operates directly on the model database where the required geometrical project documentation is defined logically in relation to the geometrical and material definitions of the actual bridge type.

2.4 Drawing Generation

The drawings are built up as organized collections of 3-D pictures, fully dimensioned 2-D pictures, and text blocks.

They are generated as graphics files by the drawing module which operates directly on the model database where the required drawings are defined in relation to the geometrical and material definitions of the actual bridge type.

All the figures in this paper are examples of drawings produced by the drawing module.

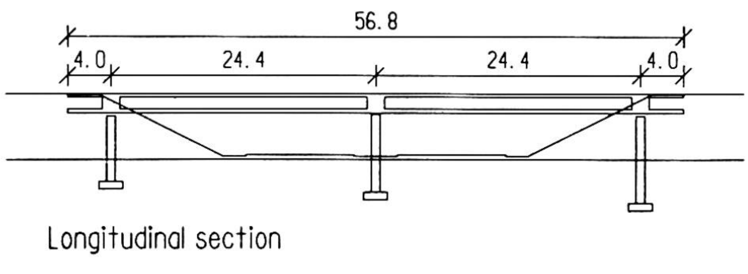


Fig. 7 Drawing

Fig. 7 shows a simple example of a drawing, which has been defined logically in relation to the bridge definition illustrated in Figs. 3 and 4 and the road system shown in Fig. 2.

The drawing module consists og a general part and special interfaces to external graphics systems. In the first version of IBDAS an interface to the Intergraph IGDS graphics system has been implemented.

3. DEFINITION OF IBDAS MODEL DATABASES

3.1 Model Input Files

A model database is generated by the database module by compiling and linking a model input file.

The model input file is a readable text file which constitutes the user's task definition.

It is built up interactively with the help of a text editor and written in the IBDAS model definition language.

This language has been developed on the basis of a comprehensive analysis of the work processes and data which structural design entails. It is a high level language which enables logical and parametric descriptions of design objects, statical and geometrical analyses as well as drawings and written design documentation.

Creating a model input file may be done stepwise and recursively with a degree of detail which at each step corresponds to the user's actual requirements. Defined coordinate systems, geometrical elements, design objects, etc. can be visualized in their entirety or selectively at any stage during the creation of model input files.

3.2 Reference Models

The user may use previously defined models as parametric or fixed reference models during the creation of an actual model input file.

These models are then included logically as part definition in the actual task definition.

When a previously defined model is used as a fixed reference model, it is maintained as an individual model database and operates as the same fixed part definition wherever it is used in the task definition.

On the other hand, when a previously defined model is used as a parametric reference model, data entities in the reference model may be substituted by corresponding data entities defined in the actual, higher-level, model input file. In this way parametric reference models are able to adapt to the specific requirements of the actual task. Parametric reference models are linked together with the actual, higher-level, model input file and are then included as integral parts of the corresponding model database.

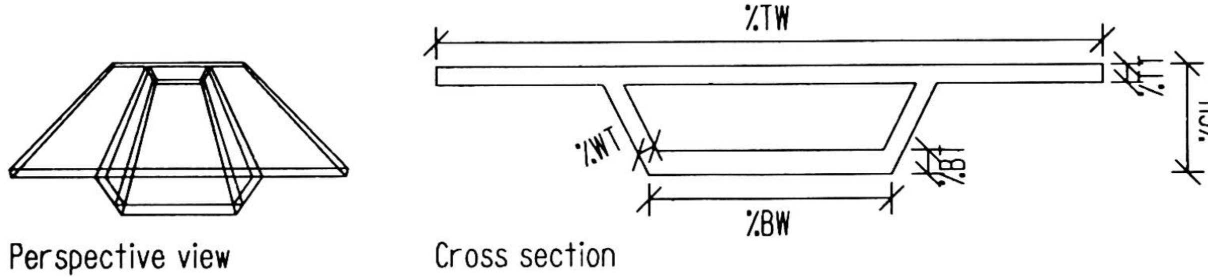


Fig. 8 Simple parametric girder model

Fig. 8 shows a graphical representation of the model which has been used as parametric reference model for the superstructure in the model of the simple bridges shown in Figs. 3 to 7.

Models which are used as reference models are themselves able to use reference models. This means that different kinds of tasks may be defined individually as a multi-level structure of reference models with optimum use of standard models, which have been defined once and for all.