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Data Bank System for the Maintenance of Highway Structures

Banque de données pour la gestion des ouvrages d'art

Datenbanksystem für die Erhaltung von Kunstbauten

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SUMMARY

The data bank management system permits the computerized registration of structures including checking and repair work, provides an effective means of control and monitoring by the responsible authorities and simplifies the work of checking the structures. It was developed as a joint project commissioned by the Swiss Federal Highways Department together with Canton Schwyz as pilot canton.

RÉSUMÉ

La banque de données permet de gérer par l'informatique les données relatives aux ouvrages d'art y compris les contrôles et les assainissements. Elle est un outil efficace de contrôle et de surveillance pour les autorités responsables et simplifie les inspections des ouvrages d'art. Le logiciel a été développé par un groupe de travail sous la direction de l'office suisse des routes en collaboration avec le canton de Schwyz pour le projet pilote.

ZUSAMMENFASSUNG

Das Datenbank-System ermöglicht die Erfassung von Kunstbauten mittels EDV inklusive Kontrollen und Sanierungsmassnahmen, unterstützt als wirkungsvolles Führungsmittel die Kontroll- und Ueberwachungsaufgabe der zuständigen Aufsichtsbehörden und erleichtert die Durchführung der Bauwerkskontrollen. Es wurde durch eine Arbeitsgemeinschaft unter Aufsicht des Schweizerischen Bundesamtes für Strassenbau zusammen mit dem Kanton Schwyz als Pilotkanton, entwickelt.

PROBLEM DESCRIPTION

A large part of the present Swiss highways system was constructed during the last 40 years. The maintenance of these highways presents the owners and those responsible for their upkeep with new problems particularly in connection with the numerous structures involved, there being altogether about 10,000 structures of which about 3,000 are bridges on the National Highways network alone. With the aid of a new data bank management system this maintenance work should in future be both simplified and unified.

The data bank for the maintenance of structures (structures data bank) serves the cantons as a practical tool and guide in the work of structural maintenance and helps the Federal Highways Department in its nationwide supervisory responsibilities. In order to include the specific wishes and needs of the cantons, Canton Schwyz was brought in and heavily involved in the development of the structures data bank.

Data exchange between the cantons and the Swiss Federation must be guaranteed despite different computer euqipment and greatly varying degrees of hardware installation. At the moment this data exchange will be carried out annually using diskettes as a storage medium. A proper data network system requires, in addition to the inevitable standardisation of data contents and data structures, also compatibility in the data administration systems.

CONCEPT

The data bank management system must be capable of running on mainframes, mini--computers and IBM compatible PC's both as single user and in a network configuration. For personal computers the following are the minimum requirements:

- main memory 1.5 MB
- fixed disk storage 40 MB
- floppy drives 1.2 MB

For the problem at hand only a data bank software of a relational type is feasible. The data is organized in the form of relations (a mathematical concept). In general, this can be visualised as two-dimensional tables. The special feature of the relational model is that the user data and the relations are strictly separated. In this way the system may be extended and the disadvantage of hierarchical models in which the access path is given in data is thus overcome. So also in the planning stage one can still accomodate unforeseen questions. The capability of running on various different computer systems and especially on PC's was the deciding factor in the choice of ORACLE as the data bank software.

Special demands are placed on the user comfort. In this respect ORACLE did not satisfy all the requirements. As a result ORACLE was enhanced to have a user guide and a user interface developed specifically for the structures data bank, which included screen formats in various colours and windowing.

Additional user-friendliness was achieved by the implementation of the following important aids:

- automation of the data saving, access and function selection
- extendable catalogs with expert knowledge
- standard access paths and corresponding lists for quick access
- automatic output of structural element specific checklists
- structural component generators

To achieve good maintenance characteristics the application parameters and all text with the exception of the free texts are kept in external lists. Particular significance in this respect was given to accomodating several official languages as is necessary in a country like Switzerland by having text-independent data storage. In working with the structures data bank each user can choose between the German, French, and Italian languages.

EXTERNAL DATA SCHEME

The external data scheme, Figure 1, shows, from the standpoint of the user, the structuring and view of the data, which is subdivided into object data and structural component data. With the component classes given in Figure 1 and 2 similar or related structural components are combined. These element or component classes, however, do not contain user data but the catalog information at the component level. When possible the data processing is supported by the catalog information with expert knowledge stored in the system.

Both object and structural component data refer to three different areas, namely

- description
- checking
- repair work

The history of the structure can be reconstructed out of the classified data. This has the advantage that the relationship of checking to repair work is clearly seen and later evaluations of all kinds of structural components with regard to durability and maintenance expenditures can be undertaken. A new description of this structural component is only added to the system if the component has been replaced or substantial structural changes, i.e. changes relevant to the description, have been made. If the complete structure (object) has been replaced or correspondingly rebuilt or changed, then a new object has to be defined.

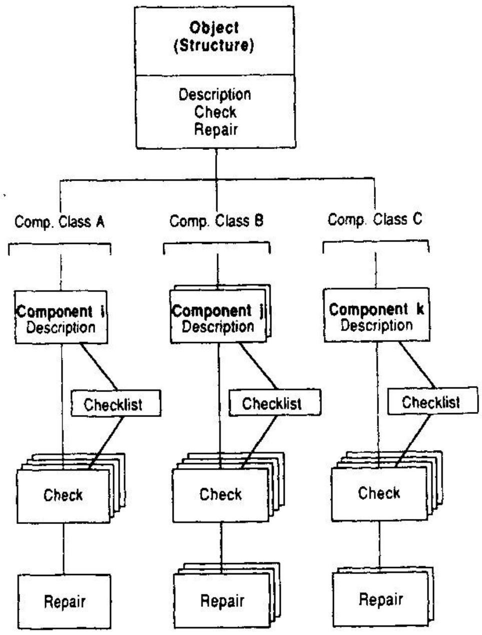

Fig. 1: External data scheme

Object data

The object data includes all data relevant to the whole structure. The description comprises at the object level, Figure 1, information concerning:

- reference systems
- basic data: object type, function
system, geometry
year of construction
participants
checking cycles
- documents: standards
construction documents

Each individual measure for checking and repair work ist anchored as follows:

- checking: type of checking, number
  year when checking carried out
  participants
  condition assessment

- repair work: repair number
  year of repair work
  participants

Apart from the time reference system (calendar year) the objects are linked with three further reference systems:

- hierarchical system (owner)
  country, canton
  object number

- operating system: those responsible for maintenance
  maintenance section

- axis system (highways etc.):
  for highways:
  highway key
  ref. point, kilometres
  position of axis
  restrictions on use

The object key is obtained from these reference systems by means of the hierarchical system. To each object or structure can be assigned a maintenance section with those responsible for maintenance as well as any axis, of which at least one has to be a highway axis with defined highway key (e.g. cantonal highway, national highway). The highway axis defines in this way the object position, with details of a reference point and kilometres. With the axis position the position is also given of the highway axis relative to the structure, and with the information on restrictions concerning use (geometry and loads) the data bank is also provided with the basic data on whether the structure is open to exceptional transport.

Thus far the following object types are implemented in the system:

- bridge
- gallery
- cut and cover tunnel
- culvert
- retaining structure
- protective structure

Structural component data

Each object or structure can be subdivided into a number of structural components, whereby each component is assigned to a particular (structural) element or component class, which enables similar or related structural components to be placed together.

Figure 2 shows the componet classes implemented thus far in the system. Here element classes connected with the bearing structure are distinguished from other element classes, which mainly involve structural components having high maintenance expenditure.

It would exceed the scope of this article to describe in detail all the element classes included in Figure 2 together with their corresponding structural components. Instead, it is more appropriate here to illustrate using the example of the structural component "i" of a bridge superstructure the main relationships between this structural component and its element class (Figure 3).

All user data is related basically to the structural component. The element class contains a selection of the stored catalog information with expert knowledge. In the data processing a corresponding catalog choice appears in the screen window. Depending on the case considered one or more details may be assigned to the structural component using keypress.

Component Class	Bridge	Other Structure
Foundations	□	–
Burried Structural Comp.	×	×
Abutments	×	–
Colums, Piers, Pylons	×	–
(Super) Structure	□	–
Bearing Structure	–	□
Bearings, Joints	×	×
Expansion Joints	×	×
Sealing	×	×
Surfacing (Pavement)	×	×
Safety Installations	×	×
Concrete-Surface Treatment	×	×
Carriageway Drainage	×	×
Installations	×	×

□ always × if existent

Fig. 2: Component classes

A furhter speciality of this system are the stored defects catalogs (Fig. 3), which are classified according to component classes and structural materials. After defining the structural materials the material--related defects are automatically selected, so that a component- and material--specific checklist is generated. It can be printed and it simplifies in this form the checking of the structural components on site. In addition, this checklist appears on the screen and aids the computer investigation of defects. For each structural component any combination of defects can be stored for arbitrarily chosen positions.

The evaluation of defects carried out for each position on a structural component is summerized to the level of object, in order to pass on relevant information to all those responsible.

The inclusion of the rapair measures is seen in Figure 3. If changes are made to a structural component, i.e. with replacement or reconstruction affecting the description, then this component has to be described once again.

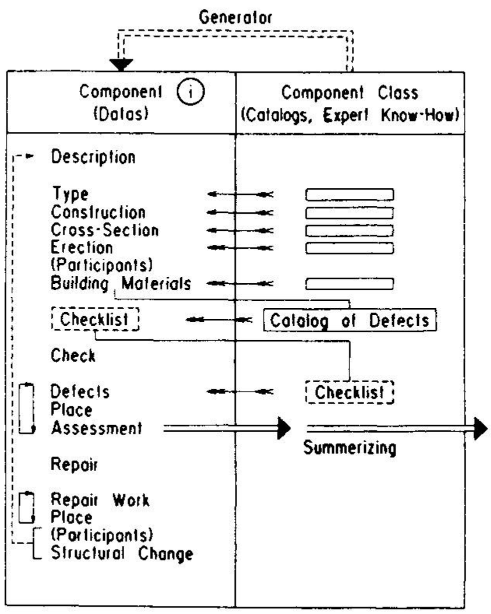

Fig. 3: Component of superstructure

CONCEPTIONAL DATA SCHEME

The conceptional data scheme differs from the external scheme in that it shows the structural relationships between data types, relations and catalog information. In designing the conceptional data scheme care was given to summarizing all user data in a few compact tables, in order to keep the question search time to a minimum. The development of the system architecture is based on the most up-to-date principles: user data, catalog information and relations in the data bank for the maintenance of highway structures are separate from each other.

FINAL REMARKS

The data bank management system described may be easily extended. Some extensions are already planned, whereas others are conceivable, such as a statistical evaluation of defects, assessment of structural types or repair measures, expert proposals for repair works and budget planning.

Data bank and expert systems will undoubtedly establish themselves in the future as additional instruments for the engineer. The meaningful and economic use of such systems, however, will be restricted to those who have a broad and fundamental technical knowledge. This and the ability to think in terms of structured and interrelated systems (networking) will be more important for the future user than special computer know-how.

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