Development of a comprehensive computerised bridge rating system

Development of a Comprehensive Computerised Bridge Rating System

Système informatique pour l'évaluation des ponts

Entwicklung eines umfassenden computerunterstützten Brückenbewertungssystems

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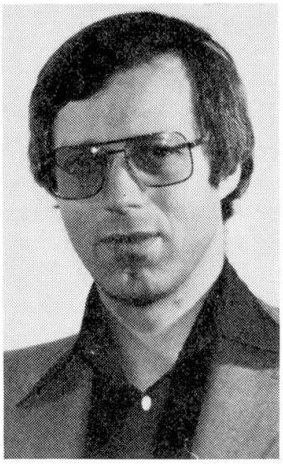

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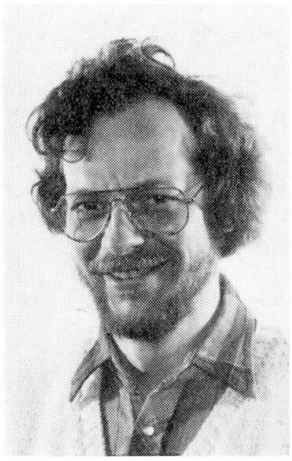

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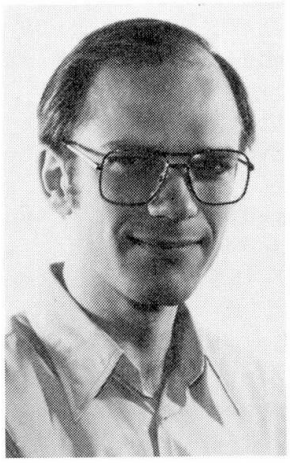

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SUMMARY

The accelerating deterioration of bridge structures cause major problems to bridge authorities all over the world. To establish priority of rehabilitation and replacements, and to manage special permits, all structures must be rated. When rating, the realistic load carrying capacity should be utilized, with due regard to the present physical state of the structure. In the contribution, the requirements to a comprehensive computerised rating and evaluation system are defined. Further, the practical approach to planning, development and maintenance of such a system under development in Denmark is described.

RESUME

La dégradation progressive de structures de ponts est un grave problème posé aux autorités, de tous les pays. Pour établir des programmes prioritaires de réparation et de reconstruction, ainsi que pour l'attribution de permis spéciaux, toutes les structures doivent être classées. Une telle classification doit être basée sur la capacité portante réelle en tenant compte de l'état physique actuel de la structure. La contribution définit les conditions à remplir par un système général de classification et d'évaluation de structures de ponts par ordinateur. De plus, elle décrit les méthodes pratiques de planification, d'établissement et d'entretien d'un tel système, en cours de réalisation au Danemark.

ZUSAMMENFASSUNG

Die zunehmende Zustandsverschlechterung von Brückenkonstruktionen verursacht erhebliche Probleme für die Brückenverwaltungen in aller Welt. Für alle Konstruktionen müssen Bewertungen geschaffen werden, um die Reihenfolge für Instandsetzung und Austausch festzusetzen und die Erteilung von LKW-Genehmigungen zu ermöglichen. Die Festsetzung der Belastungen muss aufgrund einer realistischen Traglastkapazität erfolgen unter Berücksichtigung des augenblicklichen Standes der Konstruktion. In diesem Beitrag wird ein umfassendes Computersystem für die Belastungs- und Bewertungsfestsetzung beschrieben. Weiter wird der praktische Vorgang bei Planung, Entwicklung und Unterhalt eines solchen Systems beschrieben, welches in Dänemark zur Zeit entwickelt wird.

1. INTRODUCTION

During the sixties and seventies the Danish highway network was rapidly developed to serve the increasing traffic demands, resulting from the economic and commercial progress.

This road construction, which as a backbone comprised a national divided highway system, has caused an unprecedented activity in bridge construction. The bridges vary from long span bridges in steel and concrete, crossing major waterways, to a significant amount of highway overpasses and underpasses, interchange bridges, etc.

The great majority of bridges applied the - at that time - rather new prestressed concrete technology which opened for new slender structural concepts and use of high strength concrete.

At that time most engineers were fully occupied by the planning and implementation of new construction activity, and little attention was paid to the durability problem. This for a good reason, as the reinforced concrete bridge - essentially built during the pre-world war construction boom in the thirties -had proven excellent and virtually maintenance free performance throughout their 20-40 year service life.

However, as the bridge inventory increased it was realized during the latter part of the seventies that the recently built concrete bridges suffered from rapid deterioration even after few years of service. The cause of this has been the subject of substantial research activity, and although this is still not concluded it is conclusive that changing traffic patterns (intensity and load), introduction of deicing salts, changing material characteristics (cement and aggregates), higher material strength utilization and less careful (accelerated) construction - and curing practice etc., are major contributory factors.

The drastically increasing obligation to highway administrations from increasing bridge inventory and accelerating deterioration simultaneously with further limited funding, imposes strict and selective management for max. benefit/cost ratio [1].

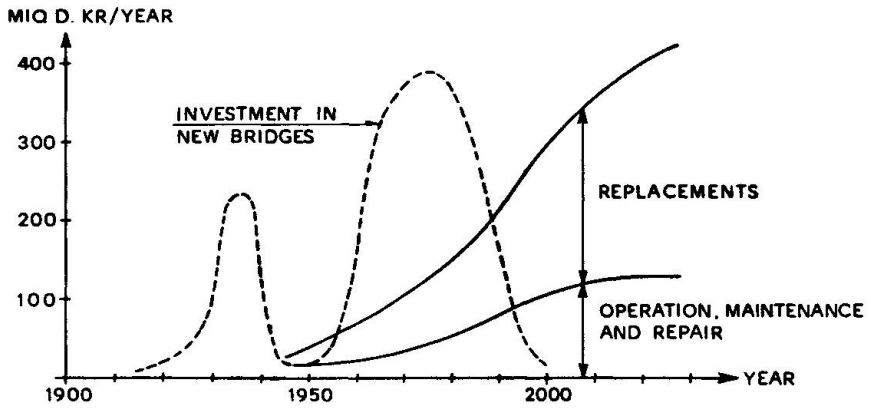

Fig. 1 Total yearly bridge investments and expenditures on the Danish national highway system [1].

In order to handle expenditures as indicated in Fig. 1, The Danish Road Directorate has started a methodical approach to an effective management system and Cowiconsult has been involved in this work.

2. BASIS FOR A COMPREHENSIVE COMPUTER SYSTEM

The increasing traffic intensity, in particular heavy transports, and a new traffic code with increased allowable vehicle/axle loads has required a complete rating of the existing Danish bridge inventory with respect to actual load carrying capacity. This has led to the development of a first generation of a computerised management system, as illustrated in Fig. 2. The system comprises databanks for storing general bridge data, reported deficiencies and data from inspections, in accordance with principles outlined in the OECD bridge inspection report [2]. Structures and vehicles are rated according to a matching standard system. Furthermore, special permits for exceptional vehicles can be issued either on the basis of the actual rating system or after supplementary structural analysis.

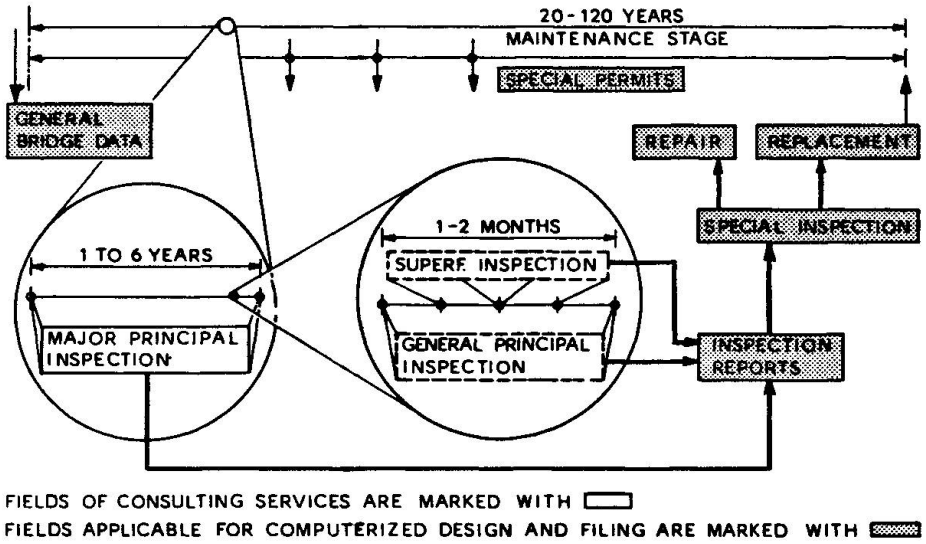

Fig. 2 Bridge maintenance system

However, due to the number of bridges to be classified/rated within a short period of time, only simplified methods on the safe side have been possible. A more accurate approach will be able to disclose a significant and realistic additional load carrying capacity, which - if documented - will permit higher ratings, and postponement of strengthening/replacement with optimum economic results.

Management of priorities for bridge repair, strengthening and rehabilitation, as well as the heavy transport road system and administration of special heavy transport permits are closely interrelated with structural analysis and design. Thus, it is natural to organize all requirements - which necessitates handling of large amounts of data - in a comprehensive computerised system based on a modern data base file.

Cowiconsult's existing bridge program library, used for the design and rating of more than 1,000,000 sq.m of bridges, and general programs from external sources will constitute the background and software for the system.

3. DEVELOPMENT OF THE COMPUTER SYSTEM

During planning and implementation of the computer system, existing bridge rating and evaluation facilities are incorporated. Thus, the following routines will be easily accessible and in most cases automatically processed:

- Standard rating of structures (inventory and operation rating)
- Standard rating of vehicles, i.e. ranking of an actual vehicle in a system of standardized vehicles used in rating of structures.
- Posting and special permit analyses of structures
- Evaluation of structurally deficient bridges, e.g. to investigate consequences of damage and risk of collapse
- Evaluation of effects of rehabilitation work (upgrading of structures)

The existing Danish bridge maintenance system leads to a considerable number of reports with a heavy flow of data during the lifetime of a bridge. Consequently, adequate updating facilities must be available in order to ensure that bridge data is always in accordance with the actual physical state of the object.

The most important part of the system will be comprehensive data base facilities enabling access to the latest information about each specific bridge. The information basically includes
- project data,
- data from inspection reports,
- information concerning repair of the bridge throughout its lifetime,
- information concerning standard ratings and heavy vehicle permits.

The project data is either original design data, or data produced by renewed structural analyses of existing bridges.

Facilities also feature reference to the DS, AASHTO, DIN and BS Standards, as well as most common construction material characteristics.

In order to manage the data efficiently and to minimize redundancy, the operation of existing bridge rating and design systems has been analysed. This work indicated that bridge data may be arranged into coherent, logical groups of data in a natural way. The following selected types indicate the principle:

- "Site information data": Any information directly related to the site. Such information is stored and updated independently. Several bridges may refer to the same site information. Typical site information comprises soils data, climatic data etc.
- "Loads": Frequently used international standard loads are stored and updated, as required
- "Materials": Library of materials and their characteristics corresponding to relevant codes including long term behaviour. Updating by introduction of results from new research is possible.
- "Geometry": Basic geometrical data for the actual bridge.
- "Statical models": Statical models covering all structural systems for each particular bridge during construction and final operational phases.

The database is divided into a total of 13 such groups of data. A specific piece of data is stored in a predestined logical part. Information is therefore retrieved from different parts of the database, as required.

Individually independent program modules carry out the dataprocessing in the system. The detailed requirements for these modules have been clarified from experience with other systems. Therefore, existing computer bridge programs in the firm have been decomposed into program routines whose abilities match the requirements of the program modules. To complete the system, several new program modules are being developed.

Design, rating, and evaluation programs for structural analyses include the following facilities:

- Composition from one or more structural materials
- Regard to effects from variation of material properties with time. The variation is either based on actual reports, theoretical work, or standards.
- Regard to all concepts of structural systems.
- Regard to influence of the construction process used.

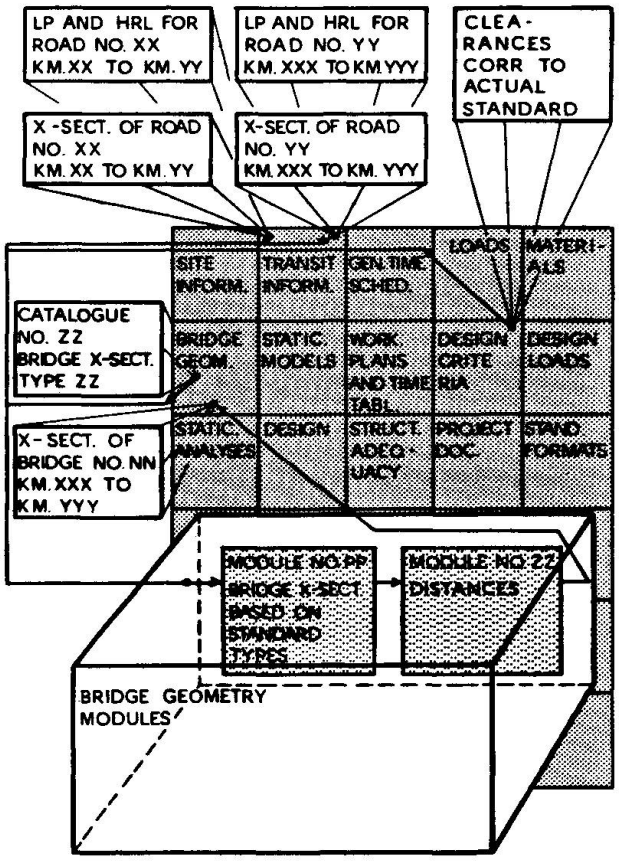

Fig. 3 Main Principles of the computer system

Furthermore, it will be possible to compare the feasibility of different rehabilitation projects in order to optimize the remaining life and costs of the structure.

Data is documented by using program modules and results may be printed in a standard format or as plotted construction drawings and bar schedules.

The above-mentioned structure may be illustrated by the dataflow in the system at a preliminary design stage, as indicated in fig. 3. Original road geometry data is combined with a proposed standardized cross section in a program module which then produces data describing the actual bridge cross section.

On completion, the Danish system will comprise facilities for rating, evaluation and design of the most common types of bridges in steel and concrete , whether cast-in-place, precast, segmentally constructed (balanced or span by span), or incrementally launched. The bridges may be simple span, continuous single or multiple frames and contain external members, e.g. cable stays.

The development work is now in progress, scheduled to be completed by end of 1983.

The programming language is standard FORTRAN 77, and the development is being carried out on a computer system comprising PRIME 550 and PRIME 850 computers.

4. MAINTENANCE AND FUTURE DEVELOPMENT

The modular concept of the computerised bridge rating system ensures that a continuous updating can take place in the future. Code revisions, new codes, as well as changed design procedures and other future bridge management requirements will be introduced as required by special staff, who will also provide the technical support - and back up services to external users.

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