Finnish Project Level Bridge Management System

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ABSTRACT

The Finnish Bridge Management System (BMS) consists of two different parts: the Network Level BMS and the Project Level BMS.

The Project Level BMS, which deals primarily with individual bridges, uses the recommendations and goals from the network level to decide on the repair measures in individual repair projects to create repair and reconstruction programmes. The project level system is the key tool for everyday bridge repair planning in the road districts. The system helps the bridge engineer to plan and schedule the repair projects for individual bridges based on the recommendations and the damage data in the database.

The system works with repair and reconstruction programmes. In connection to these programmes different alternative studies and profitability calculations can be made. For example, analyses concerning bridge structural parts and bridges remnant life will be available.

A ranking system is used when picking out the bridges which need either repair and rehabilitation or reconstruction measures. An index describing the repair needs of individual bridges was taken in use for the purpose of arranging the bridges in an urgency order in the work programme. This repair index is a function of a bridge structural part's estimated condition, damage class and the repair urgency class. The programme is prepared so that the condition target can be reached by following the given repair recommendations.

BACKGROUND

The Finnish National Road Administration (Finnra) maintains today (1 January 1999) 10,686 bridges and 2,763 culverts (span length ≥ 2.00 m) with a total length of 315 km, a total deck area of 3.16 million m^2 and an estimated replacement value of 18 billion Finnish marks (3 billion Euros).

Finnra started the bridge management system development in 1986. At that time, the first computerised Bridge Register was running since 1979, but it only contained administrative and structural data, which was not adequate for bridge management. The first production version of the totally renewed Bridge Register, which also contained inspection, damage and repair data, was taken in use in 1990.

A computer-based network level bridge management system was designed to assist in high level bridge policy, long-term planning and programming of investments both in the Central Administration of Finnra and its nine road districts (1). The Network Level BMS has run as a prototype since 1996 (2).

In 1996 an expert seminar was held, where the basic principles of the much awaited project level bridge management system were decided upon (3). The Project Level BMS was taken into use by the bridge engineers in the nine road districts by the end of April 1998.

The Elements of the Bridge Management System

The whole bridge management system is based on a thorough bridge inspection and condition evaluation. The damages and deterioration detected during the inspections, their exact location and extent are recorded. Also, information on the effect of the damages on bridge bearing capacity, on repair urgency class and the inspector's proposals for repair measure and their costs are described and recorded (4).

All this information is stored in the bridge database together with bridge structural, administrative and traffic data. Also historical data and information on previous repairs and costs are gathered for further research and bridge age behaviour modelling.

The elements of the bridge management system are described in Figure 1.

The Network Level BMS consists of two parts: the long-term module to find the ideal optimal condition distribution for the bridge stock and the short-term module to find out how to get the bridge stock from the present condition distribution to the optimal distribution. The short-term analysis provides an economically optimal way to reach the long-term optimum condition distribution during the next few years. There are separate short-term solutions for each coming year. Each short-term solution represents a step towards the long-term optimum.

The Project Level BMS, which deals primarily with individual bridges, uses the recommendations and goals from the network level to decide on the repair measures in individual repair projects to create repair and reconstruction programmes. The project

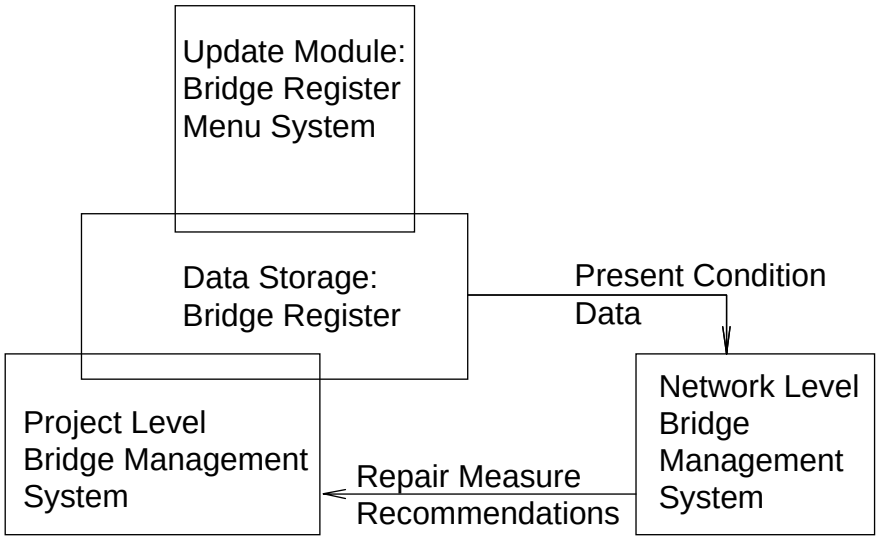

Figure 1: The connections between the elements of the bridge management system.

level system is the key tool for everyday bridge repair planning in the road districts. The system helps the bridge engineer to plan and schedule the repair projects for individual bridges based on the recommendations and the damage data in the database.

Maintenance Goal Setting

The road districts are responsible for maintenance, repair and rehabilitation (MR & R) of bridges. The Central Administration of Finnra allocates funds to the road districts for MR & R of roads and bridges based on the overall goals for road keeping and on network level analyses. The Central Administration also sets bridge stock MR & R preservation and functionality goals for the districts.

The districts' planning and steering units compile various analyses of MR & R needs. The projects are then prioritised to reach the goals set by the Central Administration. The districts use the project level bridge management system to determine the schedule and budget for the various bridge projects. The process is presented in the bridge management schema in Figure 2.

Structure of the Project Level BMS

Repair and Reconstruction Programmes

The repair and reconstruction programmes are the central concept of the Project Level BMS. The programmes are produced for a period of six years using repair indexes to find the bridges in need of repair or reconstruction. The length of the period was chosen to

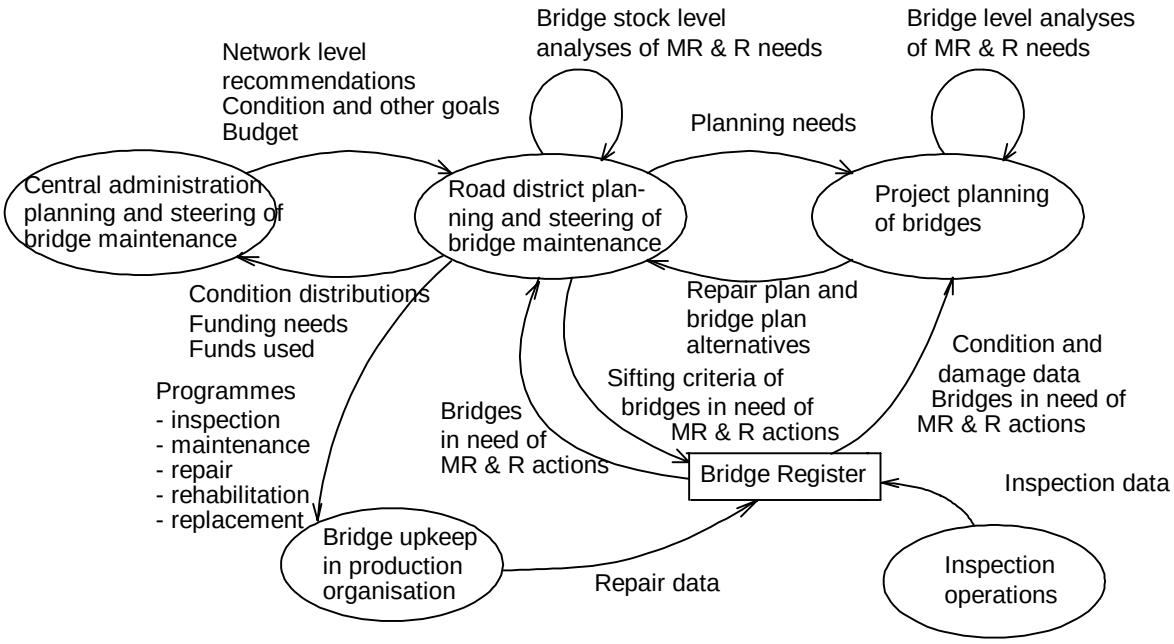

Figure 2: Bridge maintenance processes in Finnra (5).

correspond to the time span of Finnra's operation and economic plan. For budgetary reasons bridges that are to be repaired are treated separately from bridges that will be rehabilitated or reconstructed.

The new version of the project level system also includes a life-cycle cost analysis. In connection to the repair and reconstruction programmes different alternative studies and profitability calculations can be made. For example, analyses concerning structural parts and remaining life of the bridge will be available. Thus, the most advantageous repair measures for an individual bridge will be identified.

Repair Index

An index describing the repair needs of individual bridges was taken in use on the project level to arrange the bridges in an urgency order in the work programme. The programme is prepared so that the condition target can be reached following the given repair recommendations. This repair index (RI) is a function of the structural parts estimated condition (EC), damage class (DC) and the repair urgency class (UC). All these measures are given by the bridge inspector and stored in the database. The index describes the repair needs of the bridges: the greater the index value the greater the need of repair.

A score is calculated for every registered damage. The most serious damage, with a maximum score, will be taken as such, while the scores of other damages are multiplied by a reduction factor γ. The final number of points, the repair index RI, is the sum of scores derived in this way, Equation (1):

$$RI = Max_i\,(EC_i * DC_i * UC_i) + \gamma\,[\Sigma_{j,\, j \neq jmax}(EC_j * DC_j * UC)_j] \qquad (1)$$

Figure 3 describes the repair index distribution of the bridge stock in Finland at the beginning of 1998. The repair and reconstruction indexes are not intended to describe the condition of the bridge. The indexes are solely used to prioritise individual bridges when composing the repair and rehabilitation programmes for the following years.

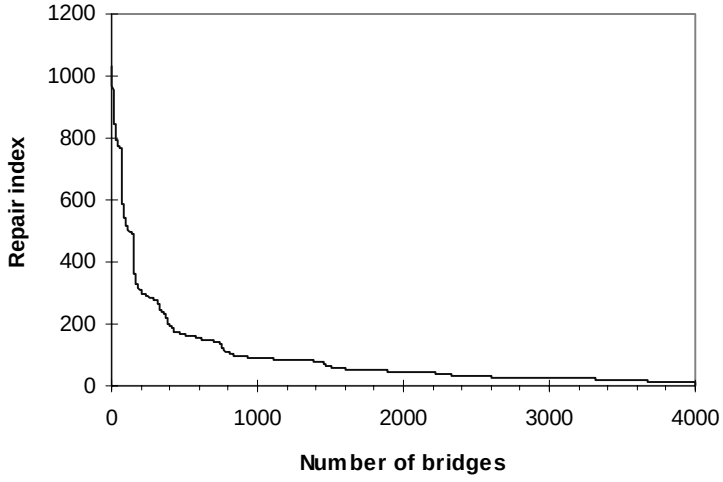

Figure 3: The repair index distribution of the bridge stock.

To keep the safety of the bridges on a satisfactory level, the maintenance goals and the given budget should reach a repair index level, where the condition of the parts of the bridge structure equals 1 (quite good), damage class 4 (serious damage) and the repair urgency class 1 (must be repaired during the next year). This value of RI represents a limit over which a bridge must be considered as potentially needing a repair quickly.

Rehabilitation and Reconstruction Index

The rehabilitation and reconstruction index is used to identify bridges that have functional deficiencies like narrowness or inadequate load carrying capacity, or bridges that have reached the end of their economical and functional life. Several factors and bridge properties result in the sum of points that describes the necessity of rehabilitating or replacing the bridge with a new one, like:

- Estimated conditions of superstructure and substructure
- Bearing capacity class
- Bridge age
- Vertical clearances
- Width of the bridge compared with the road width
- Bridge area

Efficiency Analyses of the Work Programmes

Condition predictions and efficiency analyses are needed when combining repair and reconstruction needs in an annual work programme. The life-cycle analysis gives the bridge engineer the possibility to compare the effects of different management strategies on the remaining economical and functional life of the bridge. The estimated condition can be calculated for individual bridges or a group of bridges. The life-cycle analysis will be implemented in the new version of the Project Level BMS.

Reports on the efficiency of the chosen work programmes are available in the first version of the Project Level BMS. The efficiency of the planned work programme can be evaluated based on condition predictions for the chosen bridge population. The condition prediction is reported as a yearly condition distribution by the main structural parts. The development of the repair index is included. Today the predictions are made for six years using simple default rules and values for deterioration.

A repair planning module is included, too. The user can input and update the repair and rehabilitation measures and the costs of repairs which already were carried out or will be realised in the future.

Deterioration Models

The first version of the project level bridge management system uses deterioration models of the structural parts as informative deterioration curves only. The curves can be used to assist the user when estimating the repair needs of a bridge. They are the result of research made by The Research Centre of Finland VTT when developing the age behaviour models for the network level bridge management system. An example is shown in Figure 4.

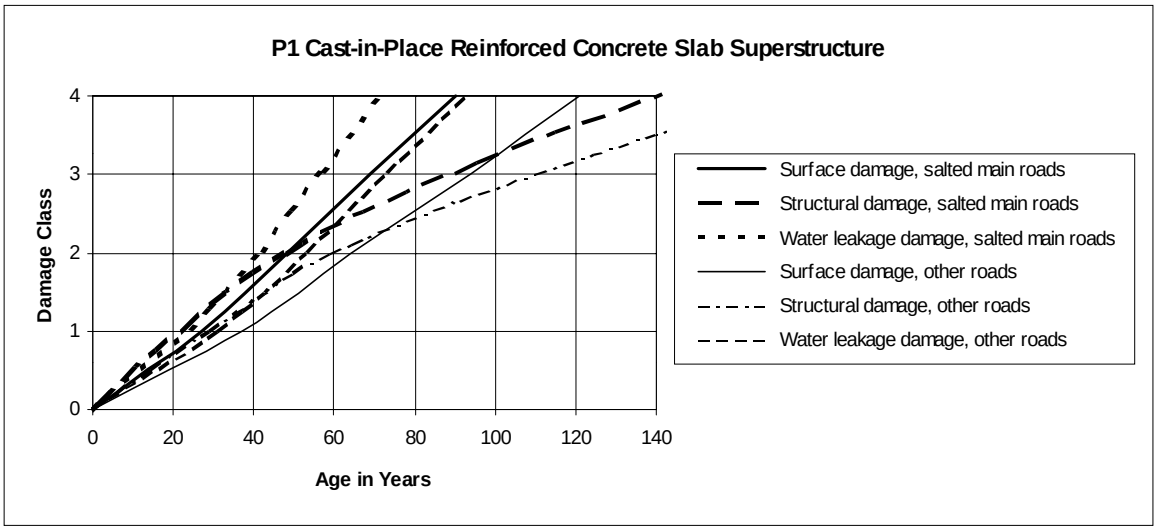

Figure 4: The age behaviour models for a group of structural parts in the BMS (6).

The age behaviour models for individual bridges are developed using the information from the network level models and from investigations and inspection data from a group of 120 reference bridges (7). The models will be implemented in the new version of the Project Level BMS together with a life cycle analysis.

Assessment and Further Development

The use of the Project Level BMS has shown that the available condition and damage data must be improved and completed. This will not be too difficult because the project level bridge management system design and implementation has motivated the end users that participated in the development work. The improvement of data quality is emphasised in the newly revised inspection training.

Ways to improve the repair and reconstruction indexes are being investigated. An importance factor for structural elements will probably be added to the repair index to grade the relative seriousness of a specific damage compared with damages to other elements of the bridge.

The Finnish bridge management system, i.e., the Bridge Register, the Network Level BMS and the Project Level BMS, together make up a comprehensive tool. To develop it further means that still much effort must be put into the age behaviour research of bridges. The quality of the models needs to be improved on the network level (8) and new models need to be created on the project level.

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