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Monitoring of Railway Bridges in Poland

Surveillance des ponts de chemins de fer en Pologne

Kontrolle der Bahnbrücken in Polen

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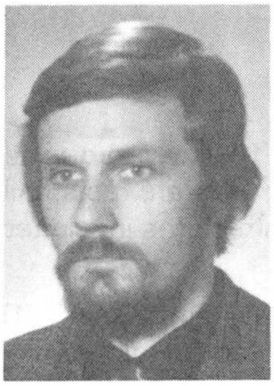

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SUMMARY

New computer-aided system of bridge condition monitoring has been implemented by Polish railway administration. Main elements of the system, such as bridge inspection, condition rating, computer software, inspector training, are presented in the paper.

RÉSUMÉ

Aidé par l'ordinateur, un nouvel système d'évaluation et de contrôle est introduit par l'administration des chemins de fer polonais. Les principaux éléments du système, tel qu'inspections de ponts, estimation de l'état des ponts, programmation, instruction pour les inspecteurs, sont présentés dans cet article.

ZUSAMMENFASSUNG

Das neue rechnerisch unterstützende Beurteilungs- und Kontrollsystem des Brückenzustandes wird von der polnischen Bahnverwaltung eingeführt. Im vorliegenden Aufsatz werden die Grundelemente des Systems, sowie die Brückeninspektion, die Zustandsbeurteilung, die Computerprogramme und die Inspektorsausbildung, dargestellt.

1. INTRODUCTION

Polish State Railway (PKP) is one of the biggest railway companies in Europe. In 1993 PKP transported 530 million passengers what gives fourth place in Europe and 213 thousand tons of goods - second place in Europe. Railway infrastructure of PKP is third in Europe: 23.250 km of railway lines (48.000 km of trucks), 1.050 square km of area (0.33 % of Poland), 34.000 civil structures (about 10.000 bridges).

Condition of bridges and other civil structures can be described by following data:

- 65 % of structures is more than 80 years old,
- only 1 % of structures is less than 10 years old,
- weighted mean of civil structures age is about 90 years,
- during last 25 year's maintenance funds were less than 20 % of needs.

2. BRIDGE MONITORING SYSTEM

2.1 General remarks

Taking into account large needs in bridge maintenance PKP decided in 1994 to reorganise the management system and to form new units - Bridge Divisions. New units are responsible for management and maintenance of all bridges and other railway civil structures in allotted areas.

Simultaneously to the reorganisation, the Railway Bridge Management System "SMOK" [1], has been elaborated as computer-aided management system. One of the most important parts of the RBMS "SMOK" is a uniform bridge monitoring system that consists of:

- system of inspections,
- system of bridge condition rating,
- computer system for data storage and processing,
- training system for bridge inspectors.

2.2 Bridge inspections

Bridge inspections are the most important part of the monitoring system because they are source of information on a real condition of the structures. In Poland five levels of railway bridge inspections are distinguished in the monitoring system. Characteristics of the inspections are presented in Table 1.

2.3 Bridge condition rating

Condition of railway bridges is evaluated taking into account two aspects:

- ***technical condition*** - defined as conformity between designed and current technical parameters (properties) of the structure,
- ***serviceability*** - defined as conformity between current service parameters of the structure and service parameters (speed limit, load capacity, clearance) required by the railway network.

Technical condition and serviceability of the bridge are evaluated in the 6-level scale, from 5 (full conformity between current and required parameters) to 0 (serious damages of the structure, bridge out of use).

No	Name	Frequency	Executor	Type
1.	General overview	every day	truck inspector	visual inspection
2.	Current inspection	3 months	bridge inspector	visual inspection
3.	Basic inspection	1 year	bridge inspector	visual inspection & simple tests
4.	Detailed inspection	5 years	division inspector & bridge inspector	visual inspection & advanced tests
5.	Special inspection	if any needs	consultants & division/bridge inspector	high-tech tests, proof loads, etc.

Table 1 Bridge inspections

Technical condition is evaluated separately for 10 main elements of the bridge, divided into 4 groups according to an importance of the elements:

- group 1: 1.1. supports, 1.2. main girders, 1.3. deck, 1.4. bearings;
- group 2: 2.1. waterproofing, 2.2. drainage, 2.3. accessories;
- group 3: 3.1. approaches, 3.2. non-bridge installations;
- group 4: 4.1. underpass.

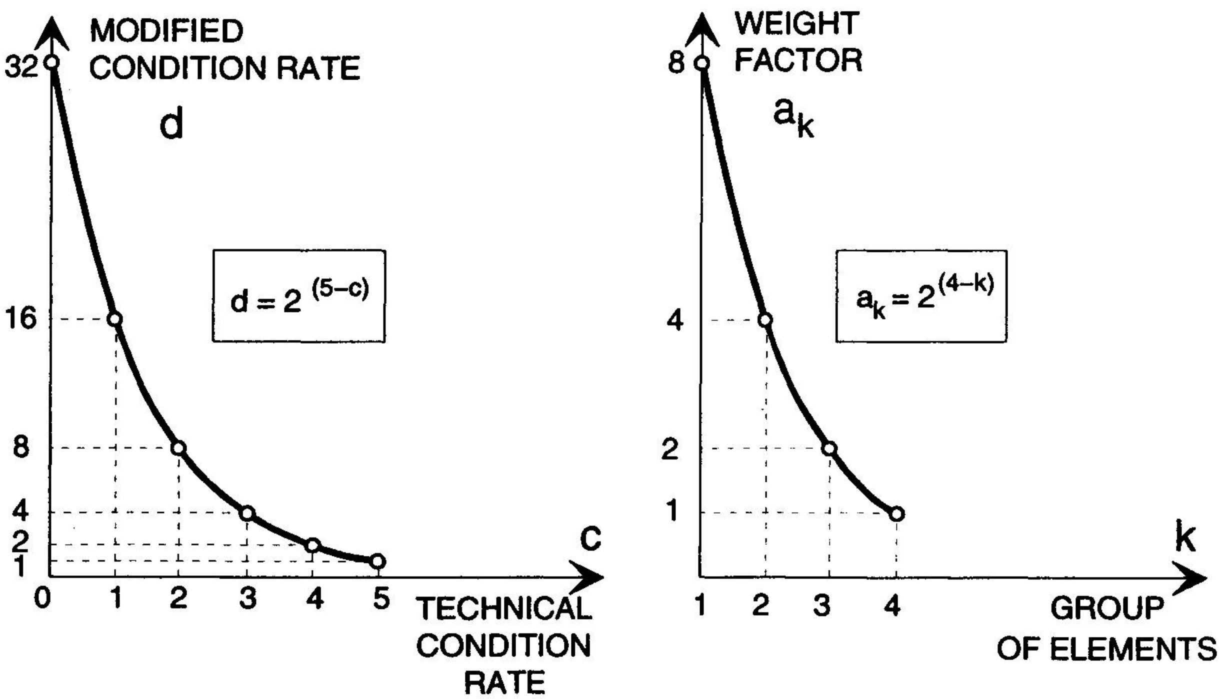

Fig. 1 Modification of technical condition rate [2]

Technical condition of the whole structure is calculated on the basis of element condition as:

(1) **B**ridge **SA**fety index (**BSA** index)

$$BSA = min\ (c_{11}, c_{12}, c_{13}, c_{14}) \qquad (1)$$

where c_{ik} is the technical condition rate of element *"i"* in the group *"k"*;

(2) **B**ridge **T**echnical **C**ondition index (**BTC** index) calculated by means of the WRAM method [2] in the following steps:

- calculation of modified rate d_{ik} for each evaluated element *"i"* in each group of elements *"k"* (Fig.1a),
- on the basis of an arithmetic mean of d_{ik} for each group *"k"* is calculated weighted rate of technical condition for the group c_k,
- BTC index for the whole structure is calculated as a weighted mean of c_k for all groups of elements

$$BTC = \sum_{k=1}^{4} a_k \times c_k \bigg/ \sum_{k=1}^{4} c_k \qquad (2)$$

where a_k is the weight for the group *"k"* (Fig. 1b). Values of both indices (BSA and BTC) are in the range 0 to 5.

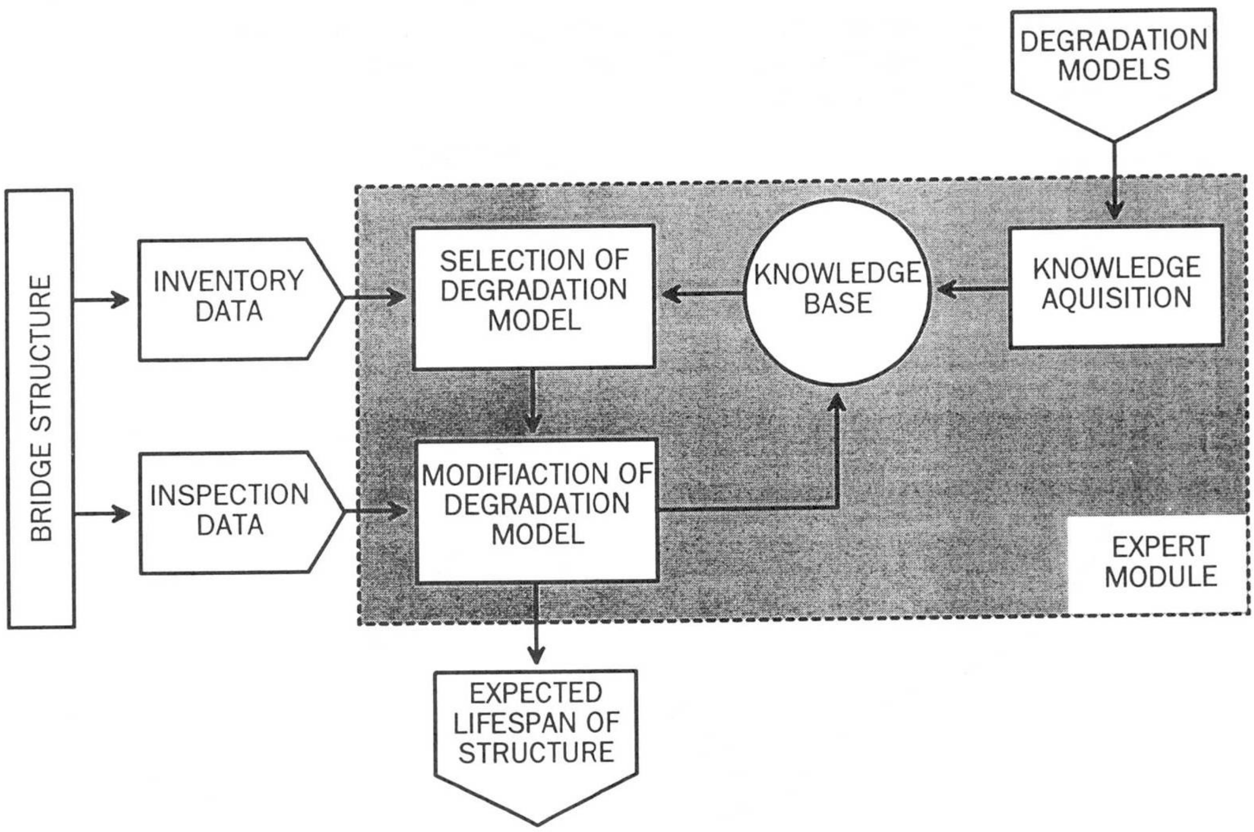

Fig.2 Expert module in computer system

Serviceability of the structure is represented by the Bridge **SE**rviceability index (**BSE** index). BSE index is calculated like BSA index as a weighted mean of serviceability rates for service parameters: speed limit, load capacity, clearance, etc.

2.4 Computer system

Bridge monitoring is aided by computer system, part of the "SMOK" system. Prediction of bridge condition and service life is supported by expert module (Fig. 2). This part of the system is based on fuzzy logic and neural network technique [3], [4].

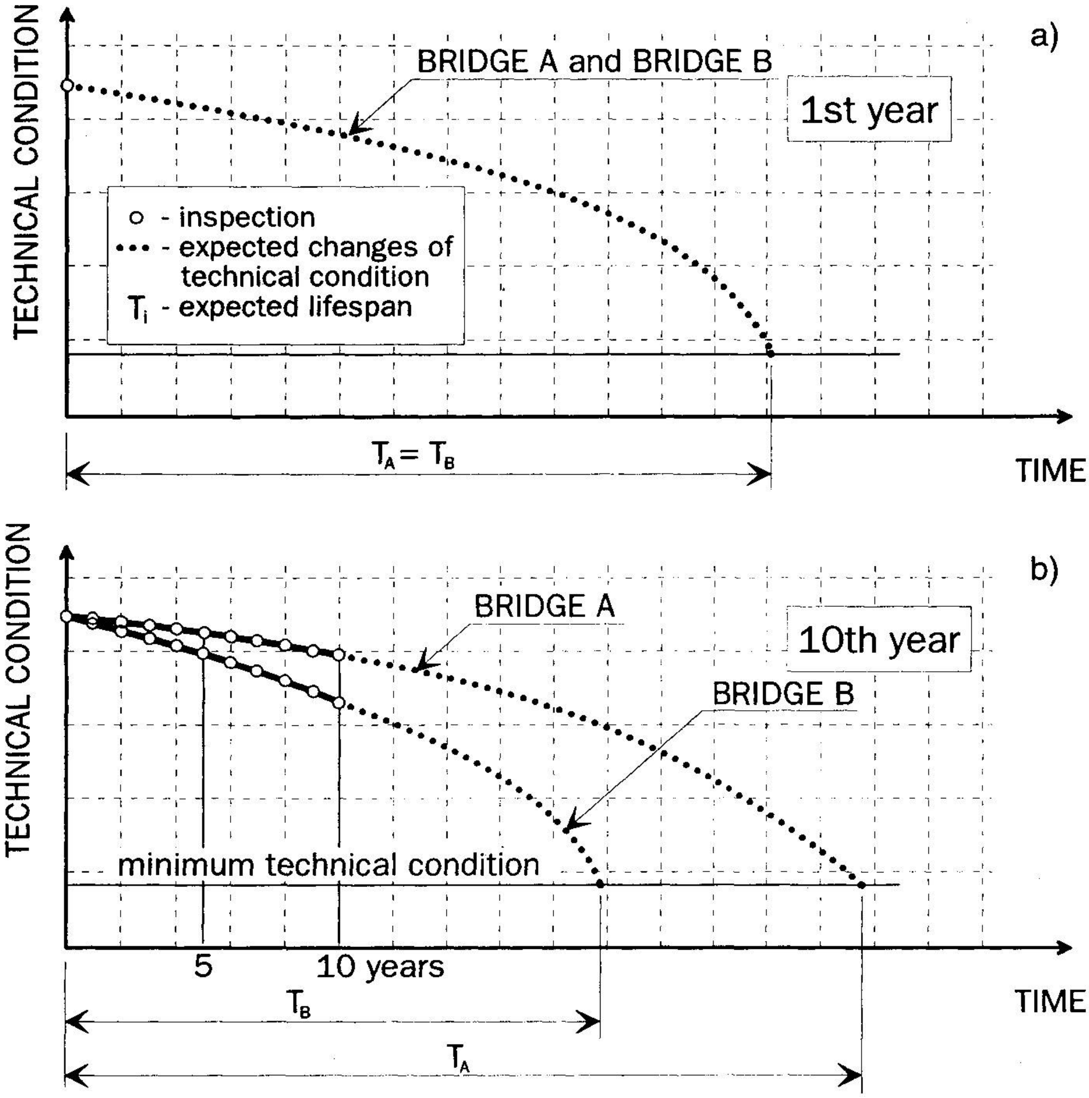

Fig. 3 Self-modification of deterioration model

For various types of bridges special deterioration models are elaborated. Proper model for each bridge is selected (see Fig. 2) taking into account inventory data such as: material, construction, age, etc. During implementation of the system (first year) for all bridges of the same type there is applied the same deterioration model (Fig. 3a). Considering bridge condition evaluated by inspection's, deterioration model will be modified in the next years and individual model for each structure will be created (Fig. 4b).Such individualisation enables very exact prediction of bridge condition and lifespan.

2.5 Bridge inspectors training

Bridge inspectors (about 200 in the entire country) play very important part in the monitoring system and they should be trained permanently. In the training system there are two phases distinguished:

(1) training during system implementation (2-3 weeks courses): "Bridge inventory", "Evaluation of bridge condition and maintenance planning", "Economic aspects of bridge management";

(2) training after implementation of the system - 2 or 3-day meetings once a year.

3. CONCLUSIONS

The railway bridge monitoring system is designed and developed at Wrocław Technical University (WTU) for the Polish State Railway (PKP). The conceptual design study was prepared in 1993 and now the system is being implemented.

New computer-aided system of bridge condition monitoring should give more efficient allocation of limited maintenance funds. It is estimated that profits from the system should cover its costs within 1-2 years.

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