



Probabilistic Reliability Assessment of Industrial Heritage Bridges

Miroslav SYKORA

Researcher
Czech Technical University
in Prague, Czech Republic
miroslav.sykora@klok.cvut.cz

Miroslav Sykora, born 1977,
received his Ph.D. degree from
Klokner Institute, Czech
Technical University in Prague.

Milan HOLICKY

Deputy director
Czech Technical University
in Prague, Czech Republic
milan.holicky@klok.cvut.cz

Milan Holicky, born 1943,
Professor at Czech Technical
University in Prague.

Jana MARKOVA

Researcher
Czech Technical University
in Prague, Czech Republic
jana.markova@klok.cvut.cz

Jana Markova, born 1955, Assoc.
Prof., involved in reliability
analyses and risk assessments of
structures.

Summary

Methods for reliability assessment of bridges registered as industrial heritage are developed taking into account principles of EN 1990, ISO 13822 and ISO 2394. A proposed probabilistic procedure allows for consideration of new information obtained from inspections or monitoring and satisfactory past performance. Application of general principles is illustrated in the assessment of a reinforced concrete road bridge. The study reveals that reliability assessment of bridges registered as industrial heritage can be based on probabilistic methods. Modelling of degradation processes seems to be a key issue of the reliability analysis.

Keywords: industrial heritage; bridges; reliability assessment; probabilistic methods.

1. Introduction

A number of industrial buildings and bridges has been registered as industrial cultural heritage. Such structures are mostly of a significant architectural, historic, technological, social, or scientific value. For instance about 350 bridges are included in the Czech Register of the Industrial Heritage.

Qualified decisions concerning existing bridges should be based on available information on actual resistances, loadings, unfavourable environmental effects and potential consequences of bridge malfunctioning. One of the most important parts of the decision making is the assessment of structural reliability. It is recognised that simplified conservative procedures based on the design methods applied for new structures may lead to expensive interventions. Relevant uncertainties in the description of actual conditions of existing bridges including deterioration processes are to be considered in the reliability assessment. In accordance with ISO 13822 [1] these uncertainties may be effectively taken into account by probabilistic methods. The paper is aimed at the development of methods applicable to the reliability assessment of industrial heritage bridges considering principles of the European (EN) and international (ISO) standards.

2. Reliability assessment

Many existing bridges do not fulfil requirements of present codes of practice including recently nationally implemented Eurocodes. Minimisation of construction interventions is required in rehabilitation, but sufficient reliability should also be guaranteed. Decisions about adequate construction interventions should be based on the complex assessment of a structure considering actual material properties, use and environmental conditions. The following aspects should be taken into account:

- social and cultural aspects: loss of cultural and heritage values;
- economic aspects: additional costs of measures to increase reliability of an existing bridge in comparison with a new bridge, decommissioning costs;
- principles of the sustainable development: waste reduction and recycling of materials;
- lack of information for the assessment: commonly, testing of the mechanical properties of materials is difficult, expensive, but also very important.

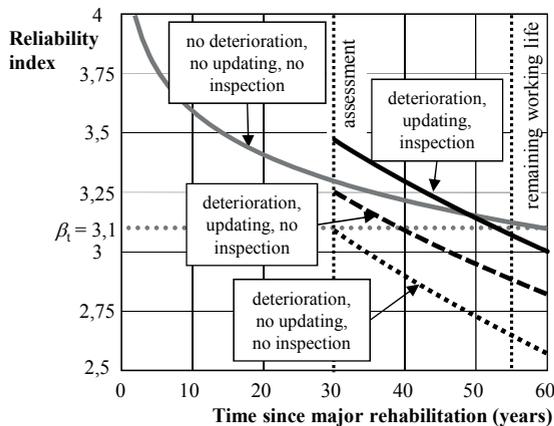


Fig. 1: Variation of the reliability index with time

ISO 13822 [1] and EN 1990 [2] a general probabilistic procedure is thus proposed to improve the reliability assessment, describe better the uncertainties, and allow for inclusion of results of inspections, testing and consideration of the satisfactory past performance of a bridge. The following aspects are discussed in the full paper:

- time-variant reliability (description of traffic loads and degradation processes);
- probabilistic updating using information from inspections, tests, survival of load etc.;
- appropriate target reliability levels.

3. Numerical example

The proposed procedure is applied in the example of reliability assessment of a reinforced concrete road bridge. Results of this probabilistic reliability analysis are indicated in Fig. 1. It appears that the reliability index updated considering satisfactory past performance increases above the assumed target level $\beta_t = 3,1$ when the results of inspection are taken into account (black solid curve).

4. Conclusions

Methods for reliability assessment of bridges registered as industrial heritage are developed taking into account principles of Eurocodes and ISO standards. The proposed probabilistic procedure allows for consideration of new information obtained from inspections or monitoring and satisfactory past performance. It is demonstrated that probabilistic methods can be applied to describe uncertainties and take into account results of inspections and satisfactory past performance.

Acknowledgements

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References

- [1] ISO 13822, *Bases for design of structures - Assessment of existing structures*, Geneva, Switzerland: ISO TC98/SC2, 2003, pp. 35.
- [2] EN 1990, *Eurocode - Basis of structural design*, Brussels: CEN, 2002, pp. 87.

Significant uncertainties related to actual material properties and structural conditions usually need to be considered in the assessment. In design codes a limited number of safety factors is intended to cover all possible design situations. Therefore, verifications based on deterministic design procedures may be too conservative. Application of commonly used design procedures may thus lead to expensive repairs and loss of the cultural and heritage value. It follows that use of deterministic design procedures may not be an appropriate approach.

It has been recognised that the assessment of existing structures is a structure-specific task that is difficult to codify. In accordance with