

ASSESSMENT OF BRIDGES REGISTERED AS INDUSTRIAL HERITAGE

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ABSTRACT

Methods for the reliability assessment of the 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. Cost optimisation is proposed to estimate target reliability levels considering cultural, societal and economic consequences of failure or malfunction of a bridge. The developed procedure is applied in assessment of a reinforced concrete road bridge.

It appears that reliability assessment of the bridges registered as industrial heritage can be based on probabilistic methods. Target reliability levels seem to be primarily dependent on costs of safety measures and consequences of failure including loss of the cultural heritage value. Obtained experience indicates that future applications of the cost optimisation in practice should be based on carefully formulated objective functions, well assessed costs, specified reference period and the discount rate.

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REFERENCES

1. TICCIH, 2003 *'The Nizhny Tagil Charter for the Industrial Heritage'*, Nizhny Tagil: The International Committee for the Conservation of the Industrial Heritage, p. 6.
2. COST 345, 2004 *'Procedures Required for the Assessment of Highway Structures'*, Final Report, Reports of Working Groups 1-6 COST 345.
3. ISO 13822, 2003 *'Bases for design of structures - Assessment of existing structures'*, Geneva, Switzerland: ISO TC98/SC2, p. 35.
4. EN 1990, 2002 *'Eurocode - Basis of structural design'*, Brussels: CEN, p. 87.
5. EN 1991-2, 2003 *'Eurocode 1: Actions on structures - Part 2: Traffic loads on bridges'*, Brussels: CEN.
6. ISO 2394, 1998 *'General principles on reliability for structures'*, Geneva, Switzerland: ISO, p. 73.
7. ALLEN, D.E., 1993 *'Safety Criteria for the Evaluation of Existing Structures'*, *In Proceedings IABSE Colloquium on Remaining Structural Capacity*.
8. SCHUEREMANS, L. & VAN GEMERT, D., 2004 *'Assessing the safety of existing structures: reliability based assessment framework, examples and application'*, *Journal of Civil Engineering and Management*, X(2), Vilnius: Technika, p. 131-141.
9. FRAGNER, B., 2010 *'Přístupy k záchraně průmyslového dědictví v České republice (Approaches to protection of the industrial heritage in the Czech Republic - in Czech)'*, *Stavebnictví*, IV(01/2010), p. 16-18.
10. STEWART, M.G., ROSOWSKY, D.V. & VAL, D.V., 2001 *'Reliability-based bridge assessment using risk-ranking decision analysis'*, *Struct.Saf.*, 23(4), p. 397-405.
11. RACKWITZ, R., 1997 *'A Concept for Deriving Partial Safety Factors for Time-variant Reliability'*, *In Proc. ESREL' 97, Advances in Safety and Reliability*, Pergamon, p. 1295-1305.
12. RAFIQ, M.I., CHRYSANTHOPOULOS, M.K. & ONOUFRIOU, T., 2004 *'Performance updating of concrete bridges using proactive health monitoring methods'*, *Reliability Engineering & System Safety*, 86(3), p. 247-256.
13. SÝKORA, M., 2008 *'Prediction of a remaining working life of existing bridges'*, *In Proc. 3rd Int. Conf. Reliability, safety and diagnostics of transport structures and means 2008*, Pardubice: University of Pardubice, p. 360-369.
14. VU, K.A.T. & STEWART, M.G., 2000 *'Structural reliability of concrete bridges including improved chloride-induced corrosion models'*, *Structural Safety*, 22(4), p. 313-333.

15. HOLICKÝ, M., MARKOVÁ, J. & SÝKORA, M., 2008 'Partial factors for assessment of existing reinforced concrete bridges', *In Proc. 6th Int. Probab. Workshop*, Darmstadt: TU Darmstadt, p. 117-132.
16. HANSWILLE, G. & SEDLACEK, G., 2007 'Background report - Traffic loads on road bridges, Basis of the load models, in EN 1991-2 and DIN - Report 101', Draft Nov. 2007 p. 29.
17. VON SCHOLTEN, C., ENEVOLDSEN, I., ARNBJERG-NIELSEN, T. et al., 2004 'Reliability-Based Classification of the Load Carrying Capacity of Existing Bridges, Report 291', Road Directorate, Ministry of Transport, Denmark.
18. TRBOJEVIC, V.M., 2009 'Another look at risk and structural reliability criteria', *Struct.Saf.*, 31(3), p. 245-250.
19. ANG, A.H.S. & DE LEON, D., 1997 'Determination of optimal target reliabilities for design and upgrading of structures', *Struct.Saf.*, 19(1), p. 91-103.
20. ONOUFRIOU, T. & FRANGOPOL, D.M., 2002 'Reliability-based inspection optimization of complex structures: a brief retrospective', *Comput.Struct.*, 80(12), p. 1133-1144.
21. RACKWITZ, R. & STREICHER, H., 2002 'Optimization and target reliabilities', *In JCSS Workshop on Code Calibration*, Zurich: Joint Committee on Structural Safety, p. 28.
22. RACKWITZ, R., LENTZ, A. & FABER, M., 2005 'Socio-economically sustainable civil engineering infrastructures by optimization', *Struct.Saf.*, 27(3), p. 187-229.
23. HOLICKÝ, M., 2009 'Probabilistic risk optimization of road tunnels', *Struct.Saf.*, 31(3), p. 260-266.
24. LEE, K., CHO, H. & CHA, C., 2006 'Life-cycle cost-effective optimum design of steel bridges considering environmental stressors', *Eng.Struct.*, 28(9), p. 1252-1265.
25. JCSS, 2006 'JCSS Probabilistic Model Code', Zurich: Joint Committee on Structural Safety.
26. ISO 13822, 2008 'Bases for design of structures – Assessment of existing structures. Annex I Heritage structures', Geneva, Switzerland: TC98/SC2/WG6, p. 10.
27. SANZ, J.Á., HERRERO, L.C. & BEDATE, A., 2003 'Contingent Valuation and Semiparametric Methods: A Case Study of the National Museum of Sculpture in Valladolid, Spain', *Journal of Cultural Economics*, 27(3-4), p. 241-257.
28. BEDATE, A., HERRERO, L.C. & SANZ, J.Á., 2004 'Economic valuation of the cultural heritage: application to four case studies in Spain', *Journal of Cultural Heritage*, 5(1), p. 101-111.
29. LOURENCO, P.B., 2002 'Computations on historic masonry structures', *Prog. Struct. Engng Mater.*, 4(3), p. 301-319.
30. EN 1992-1-1, 2004 'Design of concrete structures - Part 1-1: General rules and rules for buildings', Brussels: CEN.