Reliability Assessment and Prediction using Monitoring Information

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Summary

The reliability and performance assessment of engineering structures by monitoring systems in its nature is a complex challenge, since not only a couple of physical quantities, such as material strength properties, environmental conditions, and local stresses but the comprehensive time dependent behavior of structures are of interest. This behavior has to be deducible by sensor readings and associated descriptive mechanical functions. In addition, the layout/design of monitoring systems and the monitored properties are accompanied by uncertainties. Nevertheless, down to the present, probabilistic-statistic principles are hardly involved in the design of monitoring systems and in the assessment of monitoring readings. However, such principles can significantly contribute in the optimization of location and number of sensors, and in the reduction and efficient assessment of recorded data. Therefore, the purpose of this paper is to present (a) stochastically analytical assessment methods usable for the adjustment of monitoring systems, (b) possibilities to merge visual inspection methods with monitoring methods, and (c) to present Bayesian strategies for the incorporation of past information from visual inspection results or from analytical prediction models in monitoring.

Keywords: Monitoring system; Bayesian updating; Optimization of number of sensor; Probabilistic-statistic principles

1. Introduction

In several areas, like medicine, chemistry, industrial production, monitoring systems (MS) already are highly represented. These MS serve for the quality control associated with production and the optimization of processes. In addition, monitoring supports also in design by testing as proposed in EN 1990, Annex D. The reliability and performance assessment of engineering structures by MS in its nature is a complex challenge, since not only a couple of physical quantities, such as material strength properties, environmental conditions, and local stresses are of interest but the comprehensive time dependent behavior of structures should be captured by the monitored information. The formulation of general rules for the layout of MS associated with engineering structures is hardly feasible because of the uniqueness of each structure and the diversity of sensors. Engineering knowledge and engineering risk based decisions related with the location and the grouping of sensors are claimed. Top-down approaches for the layout of MS are in sharp contrast to how structural health monitoring (SHM) is often utilized. At present monitoring is generally used as a bottom-up, diagnostic tool in response to an existing problem or defect or to conduct system

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identification by a finite element model [1]. In addition, top down approaches are also used to screen new construction methodologies as performed e.g., for the verification of a new composite technology applied on the Lehigh River Bridge SR-33. Nevertheless, down to the present, probabilistic-statistic principles are hardly involved in the design of MS and in the assessment of monitoring readings. However, such principles can significantly contribute in the optimization of location and number of sensors, and in the reduction of recorded data. Furthermore, probabilistic approaches associated with MS provide (a) access to the reliability based assessment of sensor readings, and (b) the incorporation of additional information e.g., from analytical prediction models and/or visual inspection e.g. by Bayesian theorem. Hence, the objectives of this paper are the presentation of (a) reliability based assessment and combinatory strategies for recorded sensor data and for data obtained by visual inspections, (b) concepts combining recorded sensor data with visual inspection data and data from degradation models, and (c) the Bayesian strategy for the incorporation of historical data. The proposed approaches partly are applied on the Lehigh River Bridge SR-33, a four-span continuous weathering steel deck truss.