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Tackling uncertainty in structural lifetime evaluations

Assessment of the impact of monitoring data and correlated input parameters on a prognosis

At present, investigation, rehabilitation and if necessary deconstruction and replacement of civil infrastructure are key challenges in structural engineering. Internationally, the number of bridges that show a critical state of preservation is growing while traffic loads, frequencies and freight amounts are still rising. Against the background of economic constraints authorities are challenged to decide on the right measures and order to take. Sound decisions rest on reliable data concerning structural health states and safely estimated residual lifetimes. Among experts it is widely accepted that estimated residual lifetimes must involve uncertainties from various domains like modelling assumptions, material data assessment, realistic traffic loads etc. [1]. Uncertainties reduce accuracies and thus reduce computed residual lifetimes. To overcome this burden, model updates, material testing, traffic census or at best monitoring of sensitive structural elements can be applied [2].

The contribution presents up-to-date methods and results of geometry assessments from laser scans, multi-copter overflights or mobile mapping, material testing, FE-model updates from test loadings on-site, data and video based traffic census, transient temperature constraint evaluations from climate data as well as strain monitoring of tendons at a large scale concrete bridge [3] (cf. Figure 1, top). The measures are stochastically evaluated to quantify potential gains even if correlation of model parameters is involved.

In probabilistic analysis, the residual fatigue lifetime of prestressed concrete bridges shows a high level of uncertainty in the prediction. This is shown on a holistic fatigue model of a reference bridge [2], considering the very different parameters like material stiffness, traffic loads or the geometry. For the reference structure the 90 %-interval of fatigue damage D ranges from 0.002 to 0.259. Correlation of the input is analyzed using a special sampling procedure for prescribed correlated input. Then, the results do no longer fit to a log-normal density function. Also the upper tale, which is relevant for fatigue lifetime, is just slightly affected by correlation.

A high scatter of the prediction can be reduced significantly by monitoring and on-site measurements. Here, the various measures are taken into account. That way, the probability of failure of the reference bridge could be reduced by almost two orders of magnitude.

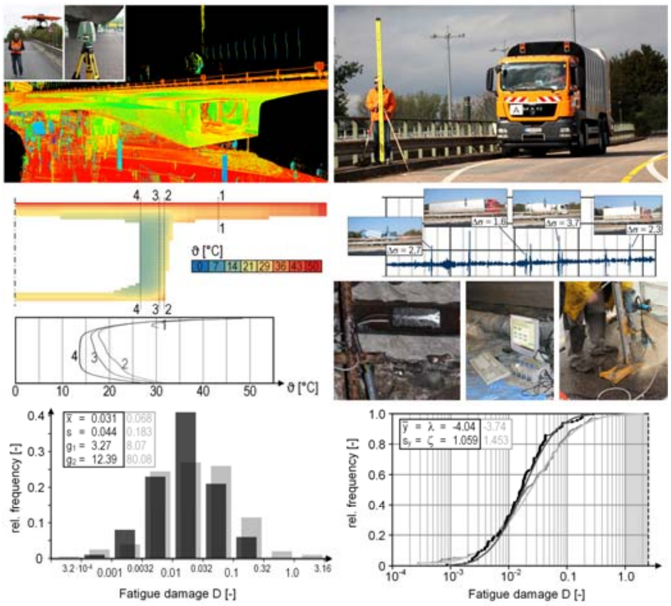

Figure 1: Collection of alternative monitoring and measurement techniques to improve the precision of lifetime prognoses with on-site data (top) and histograms of accumulated damage D (left) and associated discrete CDF's (right) in case of independent and improved input.

Bibliography

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