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Abstract

The submitted dissertation is focused on aging large reinforced concrete structures, for which carbonation-induced corrosion is the main degradation factor. This degradation phenomenon causes significant economic losses to the operators of these structures such as cooling towers. Due to large variability of basic variables, the degradation process needs to be described by probabilistic models, preferably using data from in-situ surveys. It is then possible to predict the time development of areas with damaged concrete cover and to optimise structural surveys and maintenance. The application of the developed probabilistic framework is illustrated by the case study of cooling towers in power plants. The presented investigations show that the choice of the model for carbonation ingress is an important decision in the probabilistic reliability analysis of service life of cooling towers. The complex carbonation ingress model presented in the fib Model Code provides the basis for the identifying the most influential basic variables. In the dissertation, the model is optimised for practical applications in service life assessments of cooling towers. The sensitivity analysis reveals that the important basic variables are the inverse carbonation resistance of concrete, relative humidity of the ambient air and weather function parameters. Available measurements confirm that only crude estimates of inverse carbonation resistance of concrete can be obtained from in-situ concrete compressive strength. This is why it is recommended to describe carbonation ingress on the basis of measurements. Two limit states seem to be most important for practice and are thus investigated in detail. Initiation limit state (ILS) is related to the corrosion initiation and is used to assess conditions of the structure since the subsequent corrosion propagation and crack development is associated with large uncertainties. Serviceability limit state (SLS) related to the time to spalling of concrete cover can then be well verified by visual surveys or inspected by drones. The case study demonstrates that the developed probabilistic model updated by measurements can well predict the degradation progress of the outer shaft of cooling towers during their lifetime as verified by the comparison with in-situ observations. The probabilistic analysis reveals that the assessments according to the current engineering practice are governed by the criteria for the ILS only. Further, the currently used criteria for the SLS of spalling are shown to be inadequately low. Required harmonisation of the ILS and SLS criteria can be supported by using the proposed probabilistic model. Within future research, it is recommended to further investigate the effect of protective coatings on carbonation ingress and improve modelling of environmental effects including the effects of rain, wind, and freeze-thaw effects. Important is also to specify a limiting value of crack width above which the corrosion progress may significantly accelerate and the long-term environmental effects may become more important. It is expected that the proposed probabilistic framework for the assessment of large reinforced concrete structures will support applications of the probabilistic approaches in practice. Their wider use will inevitably be accompanied by systematic collection of relevant data that will make it possible to consistently describe associated uncertainties and avoid unnecessary conservativism frequently present in deterministic assessments. In a wider perspective, the proposed framework can be adapted for assessments of other large concrete structures such as bridges, tunnels, retaining walls etc.