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Invited Lecture

Probabilistic Service Life Prediction of Concrete Structures

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Summary

For structures exposed to damaging environments the structural performance must be considered as time-dependent, mainly because of the progressive deterioration of the mechanical properties of materials which makes the structural system less able to withstand the applied actions. Therefore, the verification of the structural performance should be performed not only at the initial time of construction, when the structure is fully intact, but also during the whole expected service lifetime by taking into account the effects induced by unavoidable sources of mechanical damage and by eventual maintenance interventions.

At present, the assessment of the lifetime structural performance with respect to chemical-physical damage phenomena is based on simple criteria associated with strict environmental classifications. As an example, for concrete structures such criteria introduce threshold values for concrete cover, water-cement ratio, amount and typology of cement, and others, to limit the effects of structural damage induced by carbonation of concrete and corrosion of reinforcement. However, a durable design cannot be based only on such indirect evaluations of the effects of structural damage, but needs to take into account the global effects of the local damage phenomena on the overall performance of the structure.

Based on these premises, the aim of this lecture is to present a novel approach to lifetime assessment of concrete structures subjected to the diffusive attack from external aggressive agents. In the proposed approach the diffusion process is modeled by using cellular automata and the mechanical damage coupled to diffusion is evaluated by introducing proper material degradation laws. Since the rate of mass diffusion usually depends on the stress state, the interaction between the diffusion process and the mechanical behavior of the damaged structure is also taken into account by a specific modeling of the stochastic effects in the mass transfer. In addition, to consider the unavoidable sources of uncertainty involved in the problem, the randomness of the main structural parameters, including material properties, geometrical parameters, area and location of the reinforcement, material diffusivity and damage rates, is taken into account by using a Monte Carlo simulation. The results of this simulation are used to compute the time-variant reliability with respect to proper measures of structural performance, as well as to predict the corresponding remaining service life which can be assured without maintenance interventions. Moreover, it is shown how the results of the lifetime reliability analysis can be also used to select, among different maintenance scenarios, the most economical rehabilitation strategy leading to a prescribed target value of the structural service life. The effectiveness of the proposed methodology is finally shown through the application to arch and cable-stayed bridges.

References

F. Biondini, F. Bontempi, P.G. Malerba, D.M. Frangopol. Cellular Automata Approach to Durability Analysis of Concrete Structures. ASCE *Journal of Structural Engineering*, **130**(11), 2004, 1724-1737.

F. Biondini, F. Bontempi, P.G. Malerba, D.M. Frangopol. Probabilistic Service Life Assessment and Maintenance Planning of Concrete Structures. ASCE *Journal of Structural Engineering*, **132**(5), 2006, 810-825.

F. Biondini, D.M. Frangopol, P.G. Malerba. Time-variant Performance of the Certosa Cable-stayed Bridge. *Structural Engineering International*, **16**(3), 2006, 235-244.