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Material and structural destruction of concrete elements in the industrial environment

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Abstract

A brief review of selected models which are currently used to describe the service life of structural systems, especially made of concrete is presented, taking into account influences and processes that cause material destruction and decrease in structural durability of such elements. There are also mentioned the models, verified experimentally in laboratories on simple samples, that can lead to define remaining (residual) service life of deteriorated RC structures. This is of great importance for proper planning and execution of repair works for degraded structural elements to maintain their further functionality. Finally, some examples of real assessment of condition, causes of deterioration and methods of repair of concrete structural elements deteriorated by the influence of industrial environment aggressive agents are presented.

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Keywords: Concrete structures, durability, service life, industrial environment, deterioration.

1. Short review of models predicting structure's service life

There exist a lot of models defining the process of exploitation and maintenance (including renovation and repair) of engineering structures during their service life. The widest presentation of models and methods of life-cycle performance of structural systems were presented in the last years, for example, by Gulvanessian [1], Sabation et al. [2], Frangopol & Soliman [3] or Czarnecki et al. [4]. Exhausted review on recent concrete durability studies is

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also presented by Tang et al. [5]. In case of concrete or reinforced concrete structures all these models are nowadays included, in general assumptions, the requirements and principles, based on European Standard EN 1504 [6] and its national equivalent codes as well as in many guide books [7].

Frangopol & Soliman [3] presented two simple graphics of structure's performance taking into consideration the effects of gradual deterioration and sudden damage (Fig. 1) as well as the effect of different maintenance procedures that can be applied (Fig. 2). In Fig. 1 it can be seen that structural systems deteriorate gradually with time (due to effects such as natural material deterioration), whereas extreme events may cause a sudden drop in the performance, id. failure. The results of various maintenance procedures on the performance of a deteriorating structure are shown in Fig. 2. It is very important to define when and what level of maintenance should be introduced. However, it is a difficult task to decide what type of maintenance should be performed and it can be answered through the life-cycle management techniques [3].

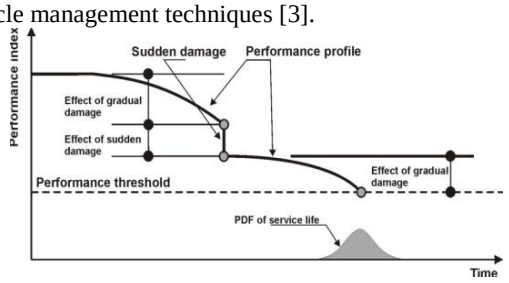

Fig. 1. Effect of gradual damage and sudden damage on the structural performance [3].

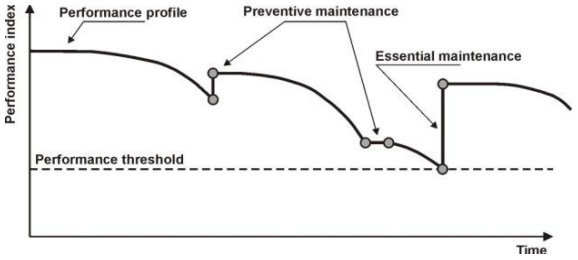

Fig. 2. Effect of two main types of maintenance on the structural performance [3].

Czarnecki et al. [4], based on the standard EN 1504 [7], presented and widely discussed the material factors of failure and methods of repair of concrete structures. Summarizing they underlined the importance of synergy between protection and repair of structures and strategy of their maintenance (Fig. 3).

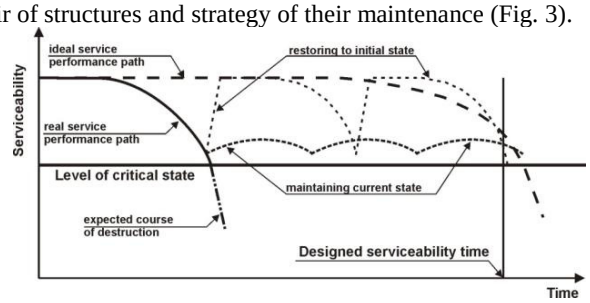

Fig. 3. Repair cycles during structure's service life with different strategies of structural management [4].

Length of service life of concrete structures depends on many factors, starting from design procedures, passing through material used for construction, quality of workmanship, and finishing at factors causing concrete and reinforcement degradation. Several deterioration models dedicated to concrete structures were invented and are used to predict a service life.

The conceptual model of steel reinforcement deterioration, which was initially proposed by Tuutti [8], is the basis for nowadays assessments of the decline in service life of concrete structures. This model describes two stages of deterioration mechanism of concrete structures:

- *the initiation phase* when there is no visible structural or material destruction but some aggressive environmental media can pass the existing protective barrier,
- *the propagation phase* when the degradation starts and several deterioration mechanism progresses, as for example, reinforcement corrosion process.