Reliability of structure with respect to different phase of degradation

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During the exploitation of engineering structures a gradual degradation of the loading capacity takes place. The degradation process depends on many factors such as the type of the structure itself: it is different for the case of a bridge and for the case of building, the material of which the structure is made, the type of the load acting on the structure and on the environmental surrounding of the structure. Many phenomena such as: the structure aging, material fatigue, rheological changes in material or corrosion of the steel and reinforced concrete structures can take place. At this point, some question appear: how all this phenomena can be taken into account in the procedure of estimation the structure reliability? Often in the degradation process a few phases can be distinguished. Therefore, in the reliability calculations one should take into account the fact in which phase of degradation the analyzed structure is. A typical example of multiphase degradation process is the chloride corrosion of a reinforced concrete structure. According to the criterion of estimating the structure state the following phases can be distinguished [Thoft-Christensen]: propagation of the chloride ions through the concrete cover layer, corrosion of the reinforcement, cracking of the cover, spalling of the concrete cover. So, in reliability analysis a two, three or multi-phase model of structure degradation can be applied.

In the presented paper a general approach for reliability estimation in the case where the degradation process runs in a few different phases will be given. In such a case the structure reliability is a function of time. For example, for the three phase model of the degradation the probability of

failure $p_f(t)$ is given by the formula

$$p_f(t) = p_{f_1}(t) \left[1 - F_{t_1}(t)\right] + \int\limits_0^t p_{f_2}(t - \tau)\, f_{t_1}(\tau) \left[1 - F_{t_2}(\tau)\right] d\tau$$

$$+ \int\limits_0^t \int\limits_{\tau_1}^t p_{f_3}(t - \tau_2)\, f_{t_1}(\tau_1)\, f_{t_2}(\tau_2)\, d\tau_1\, d\tau_2,$$

where $p_{f_1}(t)$, $p_{f_2}(t)$, $p_{f_3}(t)$ are the probabilities of failure in the first, second and third phase of structure degradation, $F_{t_1}(t)$, $F_{t_2}(t)$ and $f_{t_1}(t)$, $f_{t_2}(t)$ are the cumulative distribution functions and the probability density functions of the time moment in which the structure degradation goes from the first phase to the second one and from the second phase to the third one, respectively.

As an example of proposed approach the reliability of a reinforced concrete structure in which the reinforcement is corroding due to the chloride corrosion and of a corroding steel structure will be calculated.

References

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