LIFE CYCLE ASSESSMENT MODELS OF MAINTENANCE FOR CONCRETE BRIDGES ELEMENTS

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The problem statement. The durability problem of bridges today are very important for Ukraine. These days we state that the average life of reinforced concrete superstructure of Ukrainian bridges does not exceed 45-50 years [5]. According to the data of regional maintenance organizations, the number of bridges whose condition does not correspond to the normal maintenance conditions, require major repairs or reconstruction, in 1996 it was 220, as of 01.01.2001, the number of such bridges increased to 330, and as of 01.01.2004 there were already 428. Currently, 90-95% of reinforced concrete superstructure of bridges have been defects in concrete and steel reinforcement, which reduce durability and load carrying capacity.

The reasons for reducing the expected resource are at all stages of the buildings life cycle. The low technical condition and low durability of reinforced concrete bridges are explained, first of all, by low quality of building works and the lack of maintenance.

Therefore, the central goal of this work is to analyze and systematize models for the life cycle assessment of reinforced concrete elements in use.

Classification of models. As part of research, somewhat conditional, models of life-cycle assessment are classified in three groups (Fig. 1):

- deterministic models;
- stochastic models;
- combined models.

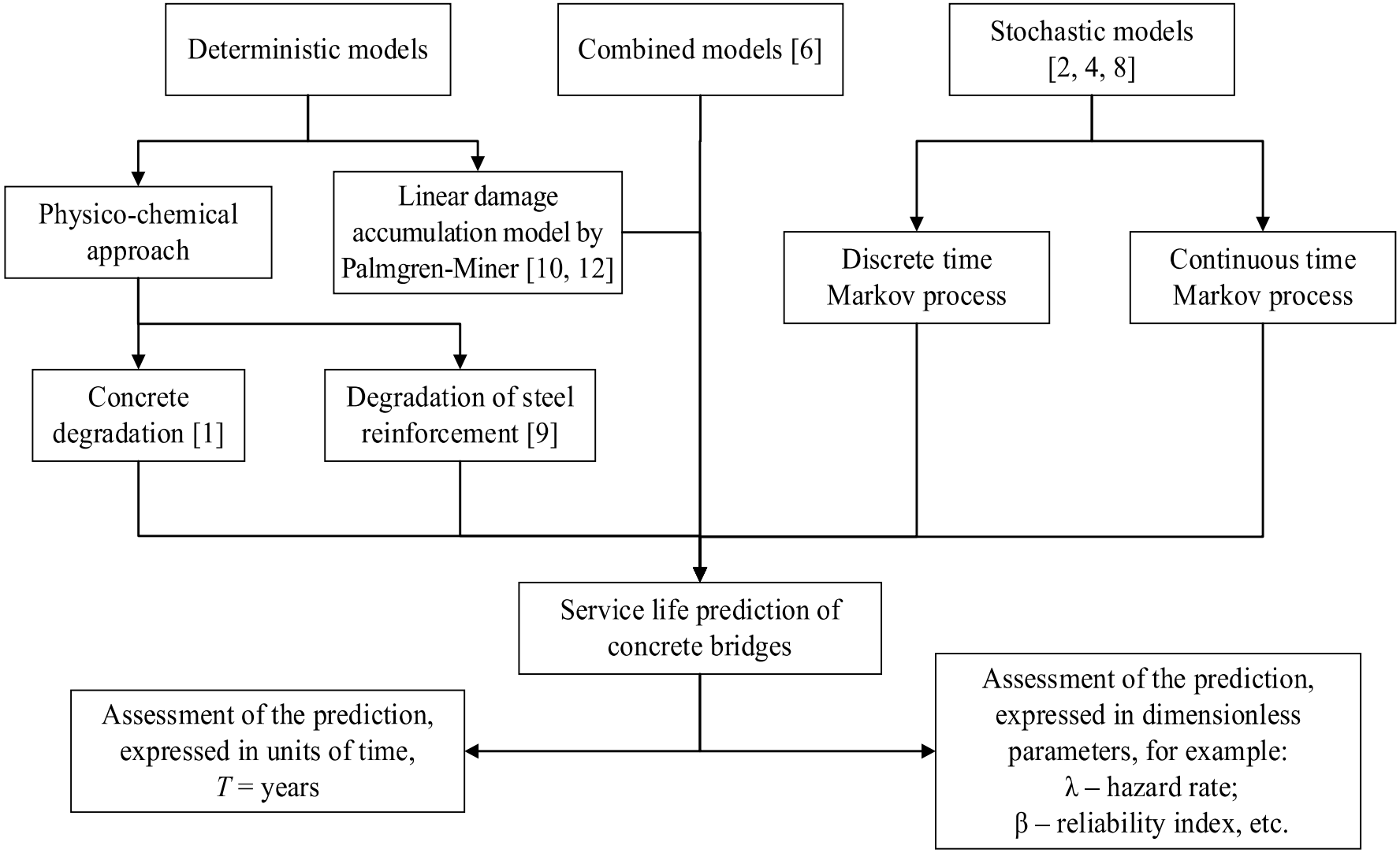

Figure 1 – Classification models of prediction durability for concrete highway bridges elements

Deterministic models – the most simple to predict the technical condition of the bridge elements. These models are based on statistical, usually nonlinear, regression of data analysis to determine the degradation rate. Another approach to developing a deterministic model is based on the physical and mechanical aspects of material degradation under the influence of external loads and environmental effect.

Stochastic models represent the process of deteriorating technical condition of the bridge elements over time, as the concept is functionally linked with reliability. The stochastic phenomenological models of accumulation and damage prediction considered here are based on the theory of Markov chains.

Combined models – built on the physics principles of degradation reinforced concrete in combination with probabilistic aspects of the process.

Then, in more detail, consider only the most common models.

Deterministic models. The models are based on the general laws of the analytical theory of gas diffusion. Models based on the study of the degradation rate, depending on the time of carbonization and saturation with chlorides of the protective concrete layer [1] become quite widespread. In these models it is postulated that intense corrosion of the armature begins after carbonization or full saturation with chlorides of the protective concrete layer. The degradation processes are described by the well-known equation of the first and second laws of Adolf Fick (1855).

Linear damage accumulation model by Palmgren-Miner. In the construction mechanics, since the 1950's, a model of damage accumulation was known as the "the Palmgren-Miner linear cumulative damage rule", which uses the principle of linear superposition [10, 12].

Stochastic models. The phenomenological stochastic models describing the accumulation of damage, as a process whose evolution in time is determined by probabilistic laws, became a significant alternative to deterministic models in the last 30-40 years. Stochastic phenomenological models of accumulation and damage prediction are based on the theory of Markov chains. Let us consider the construction elements deterioration model, which is described by the Markov discrete process with continuous time (the so-called Markov chain). Such a model the most commonly used.

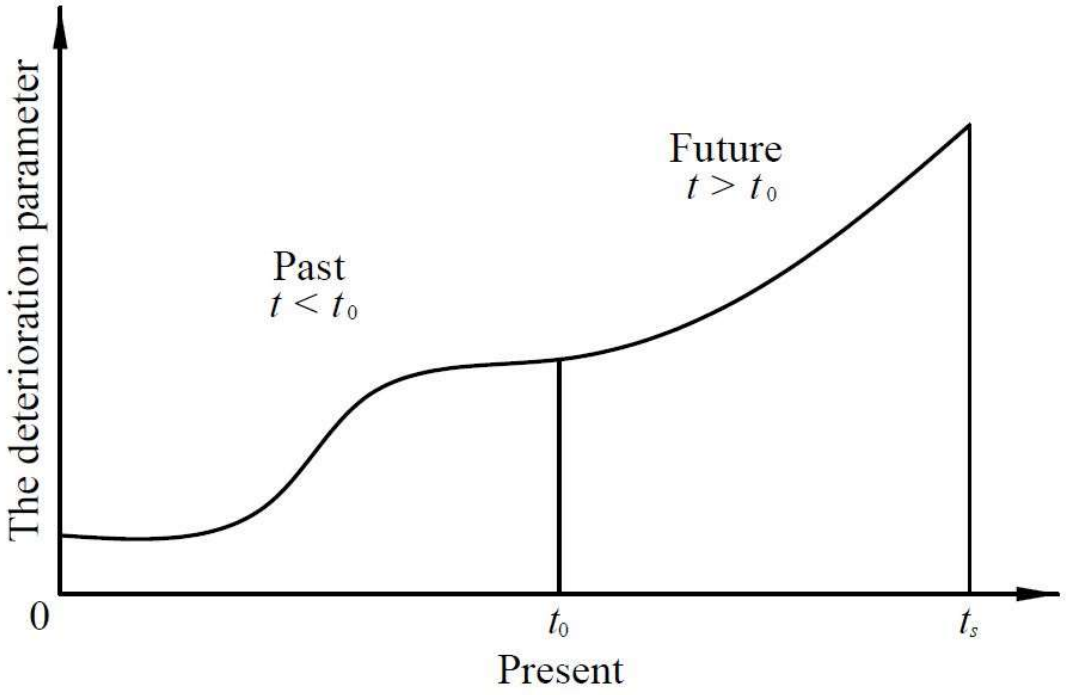

Figure 2 – Dependence "past"-"future"

Modeling by the Markov process means that for any time t_0, the probability of each state of the system in the future (for $t > t_0$) depends only on its current state and does not depend on the behavior of the system in the past (for $t < t_0$) Fig. 2. In other words, the distribution of the Markov process at the time t can be expressed by the distribution at a prior moment of time, regardless of the history of the process.

Summary. The analysis of publications aimed at systematization of life cycle assessment models of maintenance for concrete bridges elements has revealed, first of all, the socio-economic significance problem of the assessment and prediction technical condition of highway bridges.

The analysis of life cycle assessment models for reinforced concrete bridges elements had shown that the stochastic models of the Markov chains today are the most promising, universal integral apparatus for describing the gradual destruction of the structures elements [3, 7]. Most automated bridge management system (BMS) in the world are based on Markov models [11, 14]. The Markov model of damage accumulation is the theoretical basis for the software of the well-known integrated bridge management system Pontis [13, 14].

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