

## A Semi-Markov Chain-Based Model for the Prediction of Deterioration of Concrete Bridges in Quebec

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**Abstract :** Infrastructure systems are crucial to every aspect of life on Earth. Existing Infrastructure is subjected to degradation while the demands are growing for a better infrastructure system in response to the high standards of safety, health, population growth, and environmental protection. Bridges play a crucial role in urban transportation networks. Moreover, they are subjected to high level of deterioration because of the variable traffic loading, extreme weather conditions, cycles of freeze and thaw, etc. The development of Bridge Management Systems (BMSs) has become a fundamental imperative nowadays especially in the large transportation networks due to the huge variance between the need for maintenance actions, and the available funds to perform such actions. Deterioration models represent a very important aspect for the effective use of BMSs. This paper presents a probabilistic time-based model that is capable of predicting the condition ratings of the concrete bridge decks along its service life. The deterioration process of the concrete bridge decks is modeled using semi-Markov process. One of the main challenges of the Markov Chain Decision Process (MCDP) is the construction of the transition probability matrix. Yet, the proposed model overcomes this issue by modeling the sojourn times based on some probability density functions. The sojourn times of each condition state are fitted to probability density functions based on some goodness of fit tests such as Kolmogorov-Smirnov test, Anderson Darling, and chi-squared test. The parameters of the probability density functions are obtained using maximum likelihood estimation (MLE). The condition ratings obtained from the Ministry of Transportation in Quebec (MTQ) are utilized as a database to construct the deterioration model. Finally, a comparison is conducted between the Markov Chain and semi-Markov chain to select the most feasible prediction model.

**Keywords :** bridge management system, bridge decks, deterioration model, Semi-Markov chain, sojourn times, maximum likelihood estimation

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