Chapter 49

Mapping Ground Penetrating Radar Amplitudes Using Artificial Neural Network and Multiple Regression Analysis Methods

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ABSTRACT

Bridges are aging and deteriorating. Thus, the development of Bridge Management Systems (BMSs) became imperative nowadays. Condition assessment is one of the most critical and vital components of BMSs. Ground Penetrating Radar (GPR) is one of the non-destructive techniques (NDTs) that are used to evaluate the condition of bridge decks which are subjected to the rebar corrosion. The objective of the proposed method is to develop standardized amplitude scale for bridge decks based on a hybrid optimization-decision making model. Shuffled frog leaping algorithm is employed to compute the optimum thresholds. Then, polynomial regression and artificial neural network models are designed to predict the prioritizing index based on a set of multi-criteria decision-making methods. The weibull distribution is utilized to capture the stochastic nature of deterioration of concrete bridge decks. Lastly, a case study is presented to demonstrate the capabilities of the proposed method.

INTRODUCTION

Infrastructure systems are systems that support the prevailing of the society. Infrastructure systems are divided into: bridges, highways, dams, waste water systems, sewer water systems, etc. Existing infrastructure systems are continuing to age and deteriorate and at the same time, demands for better services are growing in response to the higher standards of health. As per Canada Infrastructure Report Card, 40% of infrastructure systems are in a "Good" condition, 40% of infrastructure systems within 20 years will be in "Fair" condition, 40% of infrastructure systems within 40 years will be in "Poor" condition, 40% of infrastructure systems within 60 years will be in "Very Poor" condition (Felio, 2016). Moreover, there is a significant increase in the risk of service disruption where one-third of the municipal infrastructure systems are either: fair, poor or very poor.

American Society of Civil Engineers (2017) stated that $3.32 trillion are needed to maintain the infrastructure in a good condition which corresponds to grade "B" in the United Sates. There is a funding gap of $1.44 trillion for funding the infrastructure in the United States. Grade "A" is exceptional, grade "B" is good, grade "C" is mediocre", grade "D" is poor, and grade "E" is failing. The national grade of America's infrastructure is "D+". The grade of bridges is "C+." The grade of roads is "D" while the grade of waste water systems is "D+".

Bridges are one of the vital elements of the infrastructure systems that are subjected to aggressive influences such as overloading, chloride ingress, cycles of the freeze and thaw, earthquakes, etc. Thus, they are more likely to deteriorate significantly. Based on the Canadian infrastructure report card, 17% of the bridges are in a "Very Good" condition, 57% of the bridges are in a "Good" condition, 22% of the bridges are in a "Fair" condition, 3% of the bridges are in a "Poor" condition, and 1% of the bridges are in a "Very Poor" condition (Felio, 2016). This means that 26% of the bridges were given either "Fair", "Poor" or "Very Poor "ratings.

There are two main reasons for the significant deterioration of bridges which are: the decrease in the public investment, and the high age of bridges. The investment in bridges is below the required level to maintain the age of bridges constant, whereas the age of bridges increased by 3.2 years from 21.3 years in 1985 to 24.5 years in 2007. Quebec has about 9,600 bridges and overpasses where 4,300 bridges are a part of the municipal network while 5,300 bridges are a part of the provincial network. 70% of the bridges in Quebec were constructed between the 1960s and 1980s. Consequently, there is a major challenge in order to maintain the aging bridges efficiently and effectively (Farzam et al., 2016). In the United States, 9.1% of the bridges were structurally deficient and 13.6% of the bridges were functionally obsolete in the United States. Therefore, $20.8 billion should be invested annually to remove the bridge deficient backlog by 2028. However, $12.8 billion are currently invested annually (American Society of Civil Engineers, 2017).

BRIDGE MANAGEMENT SYSTEMS

AASHTO defined Bridge Management System as "a system designed to optimize the use of available resources for inspection, maintenance, rehabilitation and replacement of bridges" (Abd Elkhalek et al., 2016).

The development of comprehensive and efficient Bridge Management Systems has become a fundamental imperative nowadays for three main reasons:

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