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A risk analysis for asset management considering climate change

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Abstract

This paper presents an optimization framework for highway infrastructure elements that integrates risk profiles (for infrastructures) and economic aspects. One main goal is to assess the necessary additional effort to satisfy performance constraints under different scenarios of climate change. In order to be easily deployable by national road administrations (NRAs), this framework is built in such a way that it can be embedded into asset management systems that include an inventory of the asset, inspection strategies (to report element conditions and safety defects) and decision-making for funds allocation. Using the inventory of the asset and condition assessment as input, the method aims to determine some degradation profiles for bridge components, retaining walls and steep embankments. The method to determine the degradation process is detailed so that any infrastructure manager can determine their own deterioration processes based on the inventory and condition assessment of their stock. Combining degradation of highway infrastructures with a risk analysis, this paper presents an optimization framework to determine optimal management strategies.

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Keywords: risk analysis; optimization; condition rating; highway infrastructures

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1. Introduction

Several road infrastructures built in Europe during the 1960s and the 1970s are now in need of repairs or can no longer adequately serve the road user. As infrastructure deterioration caused by heavy traffic and an aggressive environment becomes increasingly significant, this results in a higher frequency of repairs and higher costs to maintain the required service life performance of road infrastructure. In a context of climate change under scare capital resources (PIARC 2008, 2011, 2012a,b), the need for risk-based assessments to prioritize risk and optimize budgets/resources for maximized service life performance of road infrastructure is increasingly urgent. This paper aims at presenting an overall approach which considers some performance aspects in the decision process for ageing structures (such as structural degradation, increasing loads, and natural hazards, translated into risk profiles).

The proposed framework is summarized in Fig. 1. Module M1 is concerned with degradation modelling and considers ageing, traffic volume and environmental conditions as potential factors in the degradation process, Module M2 considers an integrated risk analysis, and finally Module M3 considers maintenance strategy optimization.

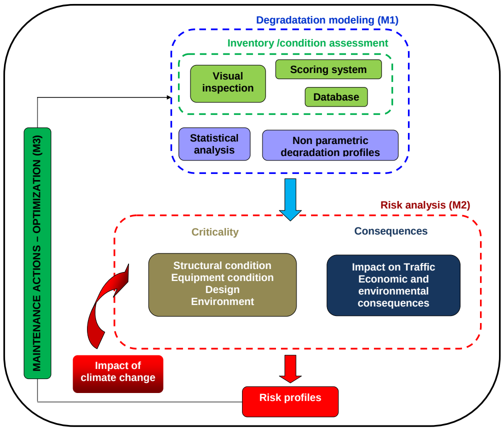

Fig. 1. Proposed risk-management framework.

This framework, developed in the project RE-GEN (Risk assEssment of aGEing iNfrastructure) funded through the CEDR Transnational Road Research Programme Call 2013 "Ageing Infrastructure", includes (a) the modelling of vulnerability considering climate change, (b) traffic effect forecasting, (c) risk profiling and (d) risk management and decision tools. The objective of this project is to provide Road Owners/Managers with best practice tools and methodologies for risk assessment of critical infrastructure elements, such as bridges, retaining structures and steep embankments. The output of the RE-GEN project should be a risk modelling tool, which will consider risk from a variety of perspectives, e.g. safety risk, financial risk, operational risk, commercial risk and reputational risk, considering both the current situation and the challenges posed by projected traffic growth, climate change and limited funding.

This paper, which focuses on climate change and impact in the determination of optimal strategies, is organized as follows. The methodology to model degradation due to the ageing process (Module 1 in Fig. 1) is described in section 2. Using the inventory of the asset and condition assessment as input, the method aims to determine some degradation profiles for bridge components, retaining walls and steep embankments depending on the age of the infrastructure, traffic volume or environmental conditions. Section 3 details the risk analysis (module 2 in Fig. 1), based on the degradation model which also includes potential effects of climate change and traffic growth. Once the degradation profiles are determined, they are used to characterize how the vulnerability of infrastructures evolves with time. Different types of hazards are then considered (including the potential impact of climate change) and risk is defined as a joint measure of hazards, vulnerability and consequences of failure. The two following failure modes are considered in this paper: (i) loss of serviceability (minor structural failure or equipment failures that need some