A Tool for Planning the Future of Regional Infrastructure

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Abstract

This paper introduces the risk-based approach to bridge management as implemented by the Department of Transportation of the Autonomous Province of Trento (APT). The APT Bridge Management System (BMS) [1] has been operational since 2004 and inspections have been carried out on the whole stock, including more than 1000 bridges. The data collected by adequately trained inspectors are gathered in a Data Base and are automatically analyzed by the system using a number of mathematical models. The APT-BMS is reliability-based and fully operative on the web, and includes (i) a Condition State (CS) assessment section, (ii) a reliability assessment section, and (iii) a prioritization section. CS is evaluated on the basis of a procedure that acknowledges the general rules of the AASHTO Commonly Recognized (CoRe) Standard Element System [2]. As for the safety level, normally the system conservatively estimates a prior reliability index for each bridge on the basis of the inspection data. When the condition of the bridge calls for a more detailed evaluation, its reliability is evaluated using multi-step procedures, where each step is more refined than the preceding one [3].

The prioritization approach adopted in APT-BMS is based on the following principle: priority is given to those actions that, given a certain budget, will minimize the risk due to a number of unacceptable events in the whole network in a specific time span (for example: in the next t_L=5 years). The definition of unacceptable event is an issue that concerns the owner, and is related to the management policy. A rigorous approach merits a formal definition of the statistical correlation between the occurrence of a failure and the occurrence of an unacceptable event, such as a casualty. Risk is defined as a measure of the magnitude of a hazard: the risk R_i associated with the E_i unacceptable event can be seen as the product of two factors:

$$R_i = P_{E_i} \cdot P_{X|E_i} \qquad (1)$$

where P_E is the probability of occurrence of the unacceptable event and $P_{X|E}$ is the magnitude of the expected damage if the event occurs.

The APT-BMS currently considers five sources of risk: failure of a principal element; failure of a secondary element; pile collapse due to scour; road accidents due to sub-standard guardrails; loss of life due to earthquake. The expected damage depends on the event considered and on the importance of the bridge, expressed for example in terms of its length and traffic. In the full length paper, the reader can find the detail of the models adopted for the four different risk factors, as well as the application to some specific case studies.

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Distributed by structurae

As a matter of example, in Figs. 1 and 2 the risk distribution of the whole stock of bridges is represented for sub-standard guardrails and earthquake. Each bridge is represented by a dot, the colour of which (green, yellow, orange and red) represents increasing risk values. The white dots that are present in the distribution associated with an accident due to sub-standard guardrails represent bridges on state highways for which guardrail data is not yet available. The risk associated with earthquake has very low values when compared to the risk for structural collapse and to the risk for scour: from 10^{-16}, which means an almost null damage, and 10^{-6}. The reason for this is that the Province of Trento is a region with low seismicity, except for its south-eastern portion. In addition, the bridge vulnerability is calculated without taking into account the condition state of its structural elements.

The risk associated with an accident due to sub-standard guardrails has likewise values around 10^{-16} when the guardrails comply with the Italian code, and values between 10^{-4} and 10^{-2} when they do not. These high risk values are due to the great number of accidents that occur every year in the Province of Trento due to sub-standard guardrails. The total risk is used by the system for planning maintenance actions: priority is given to bridges that have a lower ratio of risk over reconstruction cost.

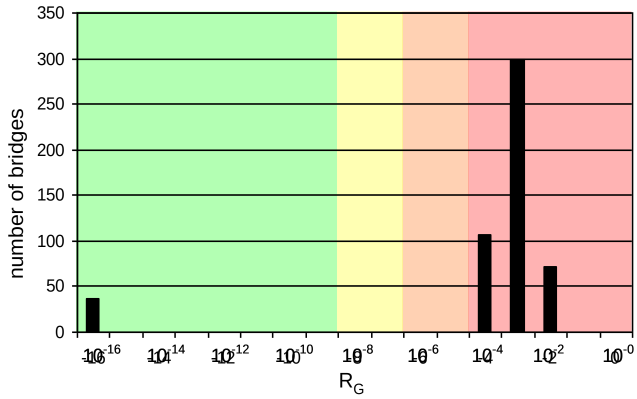

Fig. 1. Distribution of risk associated with an accident due to sub-standard guardrails.

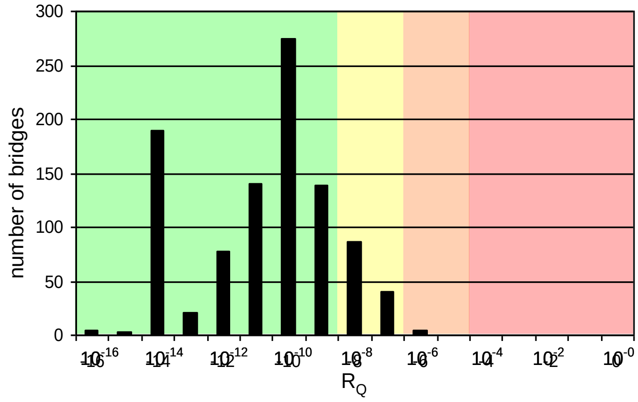

Fig. 2. Distribution of risk associated with earthquake.

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