Integration of structural health monitoring into bridge monitoring system in Brazil

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Summary

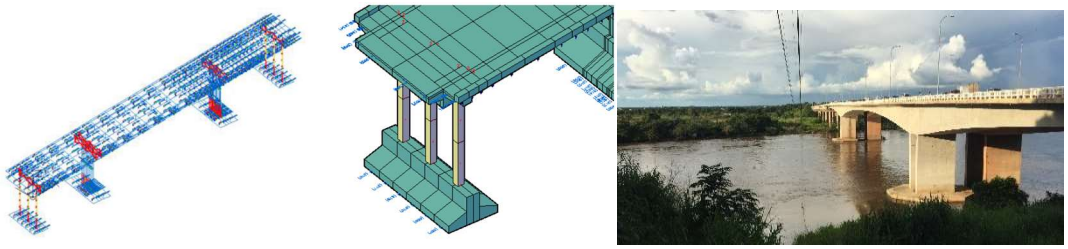
Bridges are structures integrated to roads with the objective of overcoming obstacles, thus contributing to the quality of life of people and the economy of the regions. They are generally built to achieve a useful life of at least 50 years. However, due to several factors, they present natural or accidental wear, more frequent than those predicted in the design phase. In order to keep these structures in operating conditions, their managers use the Bridge Management System - BMS, which, in most countries where they are located, are based on visual inspections and trials. In some bridges, with higher added costs, in addition to static and dynamic tests, the manager invests in Structural Health Monitoring - SHM, to monitor, in real time or not, the structure's behavior. In order to ascertain the existence of structural damage, it is common to use numerical models in finite elements properly calibrated to reproduce the measured structural response and the application, directly on the data from the monitoring, of machine learning algorithms borrowed from artificial intelligence. In this work, the SHM approach will be made, together, with numerical techniques, artificial intelligence and monitoring.

Given this scenario, the guiding motivation of this work is the possibility of allowing better identification and management of damage in bridges. Therefore, the objective of this thesis is to propose a solution for the integration between SHM and BMS. To demonstrate the potential of this integration, numerical models in finite elements were created, applied in two case studies, namely, Z24 Bridge in Switzerland (monitored for almost a year) and Itacaiúnas Bridge in Brazil (monitored in 2018 and 2021). In the Z24 Bridge, damage was introduced to assess the structure's behavior in a controlled manner, and Itacaiúnas Bridge currently presents excessive deformations in the deck.

Thus, the development of the thesis begins by surveying the current management and monitoring systems of bridges; the summary of the dynamic tests carried out in environmental vibration on the Itacaiúnas Bridge; the description of the process of experimental identification of the modal properties of the Itacaiúnas Bridge and of the Z24 Bridge (modal configurations, natural vibration frequencies and damping coefficients); and the description of the finite element numerical models of the bridges, calibrated using the results of the respective dynamic tests. Note that numerical modeling allowed quantitative assessments of the state of deterioration in damaged areas. In addition to these scientific contributions already generated in this study, it is expected, as additional contributions, the integration between finite element method and machine learning algorithms and SHM and BMS, whose research is still in progress a certain level, incipient, and the development of a monitoring and structural diagnosis procedure based on the aforementioned coupling paradigm; SHM-BIM integration for the immediate benefit of the Brazilian National Transportation Infrastructure Department - DNIT.

Keywords

Structural health monitoring, bridge management system, building information modeling, finite element model.



Left: Finite element model of the Z-24 Bridge; Right: Twin bridges over Itacaiúnas River in Marabá, Brazil.