
# Life Cycle Management of Railway Bridges

Professor Tommy Chan is the project leader of a research project funded by CRC for Rail Innovation, which brings together a number of researchers from different universities and industry partners to develop an effective bridge management system for life cycle management of railway bridges and also facilitates the application of structural health monitoring for bridge management.

## Background:

Safety, serviceability and durability of a network of bridges are dependent on timely identifying those bridges which need repair, assessing their condition, predicting their future condition, developing strategies and plans for repair and/or maintenance and taking appropriate actions accordingly. Due to the scarcity of resources, a bridge management system (BMS) is required to fulfil the above tasks. The current BMSs needed to continually improve and become more reliable as development in knowledge and technology provides us with better tools every day. Each country or agency including Australia develops or improves its own BMS to better suit their own conditions. An innovative model of BMS uses the state of the art mathematical models, new structural evaluation analysis and systems, and new technologies. A reliable BMS enhances the reliability, availability, maintainability and safety of a network of bridges.

## Project Summary:

In the Life Cycle Management of Railway Bridges (LCMRB) project, the prioritization of maintenance and repair works is carried out considering structural details and structural components, and non-structural factors. The synthetic rating focuses on structural components and details. It is carried out based on the probability and consequences of failure and considering the current and future conditions of bridges and their components. In the developed method as the vulnerability of different components towards different loadings including train, earthquake, flood, wind, collision loads, and environmental factors are different, different ratings are calculated and assigned to each component of each bridge.

The evaluation of the current structural condition of bridges is conducted based on the data collected through inspection, and structural analysis. As the safety and its strict rules and regulations are the issue for structural condition evaluation, the structural analysis is incorporated in the synthetic rating method. To identify the contribution of different loads and environment factors towards bridge deterioration risk and hazard assessment available in design standards and analytic hierarchy process (AHP) are used in the method. The future condition of components are predicted using probabilistic method (e.g. Markov Chain) by the researchers at the University of Wollongong and incorporated to the synthetic rating method. The synthetic rating procedures (SRP) introduce the criteria for determining the deadlines for taking actions including inspection, repair and maintenance and structural analysis. The engineers and managers use the criteria to make decisions on the condition of the components and the bridge at different stages.


To maintain the practicality of the synthetic rating method to be applied to a network of thousands of bridges, the structural analysis is restricted to be performed only a few times over the lifetime of bridges. The results of any time that the structural condition of the components will be reassessed by inspectors to identify the criticality of the condition of bridges and their components. The weighing factors are defined to be the demand by capacity ratios of components subjected to different loads at both safety and serviceability levels. The second method introduced in the synthetic rating method for calculating the weighting factors and the associated criticality of the components are based on the measured responses (e.g. strain, deflection, and vibration) of the bridges components using sensors. The usage of sensors from an installed SHM system provides continual online information about the structural condition of the components at both safety and serviceability levels.

### Benefits:

The method can communicate with different stakeholders and experts using different types of descriptive and/or technical information. The advantage of the synthetic rating method is that its outputs will be more reliable over time by quantifying the contribution of more factors towards bridge deterioration and incorporating them in the synthetic rating equations. By recording more data about the condition of components overtime or continually measuring the responses of bridges through SHM systems, the future condition of components and bridges will be more reliably predicted and the output of the synthetic rating method that will be used for the estimation of the life-cycle cost will be more reliable. The above mentioned improvements in structural condition evaluation and rating reduce the subjectivity of the current rating methods used in practice and enhance the efficiency of the usage of resources and improve the safety and serviceability of bridges within their lifespan.

### KEY COLLABORATORS

- Queensland University of Technology
- Central Queensland University
- University of Wollongong
- Monash University

### INDUSTRY PARTNERS

- V/line Corporation
- Australian Rail Track Cooperation Ltd
- TasRail
- Rio Tinto Group
- Kiwirail Holdings Ltd

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CRC Rail Innovation

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### Outcomes:

A software which could assist authorities in allocating limited resources to protect existing infrastructure investments by ensuring safety while assuring the quality of the maintenance work has been developed.

### Selected Publications:

1. Aflatooni, M., Chan, T. H. T., & Thambiratnam, D. P. (2014). Synthetic rating procedures for rating railway bridges. J. Bridge Eng., 19(12). doi: 10.1061/(ASCE)BE.1943-5592.0000623
2. Aflatooni, M., Chan, T. H. T., & Thambiratnam, D. P. (2015a). Condition Monitoring and Rating of Bridge Components in a Rail or Road Network by Using SHM Systems within SRP. SMM, 2, No.3(2015), 199-211. doi: 10.12989/smm.2015.2.3.199
3. Aflatooni, M., Chan, T. H. T., & Thambiratnam, D. P. (2015b). A New Look at the Restrictions on the Speed and Magnitude of Train Loads for Bridge Management. Structural Engineering and Mechanics, 53(1), 89-104.
4. Aflatooni, M., Chan, T. H. T., Thambiratnam, D. P., & Thilakarathna, I. (2013). Synthetic rating system for railway bridge management. Journal of Civil Structural Health Monitoring, 3(2), 81-91. doi: 10.1007/s13349-013-0035-6
5. Aflatooni, M. (2015). Synthetic Rating System for Railway Bridge Management. (PhD Thesis), Queensland University of Technology.