Executive Summary

The Bridge Technical Committee (BTC) of the World Road Association (WRA) met on 16-17 October 2017 in Santiago, Chile, as part of the 2016 – 2019 research cycle. The BTC focused on bridge rehabilitation and maintenance methods. The WRA meeting was followed by the Second International Congress in Chile on 18-20 October 2017. The Congress focused on the design, construction and maintenance of bridges.

Background

There are three issues being examined by the BTC in the 2016 – 2019 research cycle:

- **Issue D.3.1:** Bridge design toward improved inspection and maintenance
  - ***Strategies:*** Undertake an evaluation and analysis of inspection and maintenance practices and plans developed to meet new codes and standards. Review of practices to include practical examples and case studies of successful and failed practices.
  - ***Outputs:*** Report reviewing, good and poor practices and proposal of general recommendations and guidance.
- **Issue D.3.2:** Technical and economic considerations of bridge rehabilitation methods
  - ***Strategies:*** Consideration and review of rehabilitation strategies (from no rehabilitation to major rehabilitation or rebuilding). Include factors such as: bridge life span, remaining life, residual value, rehabilitation cost, and replacement cost.
  - ***Outputs:*** Report with review and analysis of the experience of different countries. Compendium of best practices.
- **Issue D.3.3:** Inspections and damage assessment techniques
  - ***Strategies:*** Conduct a review of assessment techniques and evaluation models used to determining the reliability and safety of bridges.
  - ***Outputs:*** Report on the impact and outcomes of several damage assessment techniques and evaluation models.

I am part of the group working on issue D.3.2 (bridge rehabilitation methods).

Meeting outputs

During the meeting the group reviewed the draft report that was compiled after the Madrid meeting in April 2017. Since that meeting, additional questionnaire answers were received from the United States of America (USA), Chile, Japan, Norway, Korea and South Africa.

The response from Wisconsin, USA was interesting. It outlines a new Structures Asset Management System. The system features a decision support tool for prioritising and programming preventative maintenance and rehabilitation work on structures. It is similar to the decision support tools for road rehabilitation that are currently used in Australia. The software was developed in-house. It uses the inventory and condition data collected during inspections and applies their preservation policy, cost data and deterioration curves to produce a work program for the network. The system will be analysed in the final report of the BTC.

During the meeting, the Chilean member suggested using the Cost Action TU1406 (European Cooperation in Science and Technology) to assist with compiling the report. The TU1406 is a project for standardising the quality specifications for roadway bridges to a European level. The website is written in English and the technical reports are freely available (general website: http://www.tu1406.eu/).

Working Group 1 of Cost Action TU1406 wrote a comprehensive technical report in July 2016 on Performance Indicators for Roadway Bridges. The performance indicators cover technical, environmental, economic and social categories. At a network level, a bridge is prioritised by its importance in the network

operation. With 75% weighting to the bridge condition assessment criteria and 25% weighting to the bridge importance criteria [see Figure 18 below, from the TU1406 report].

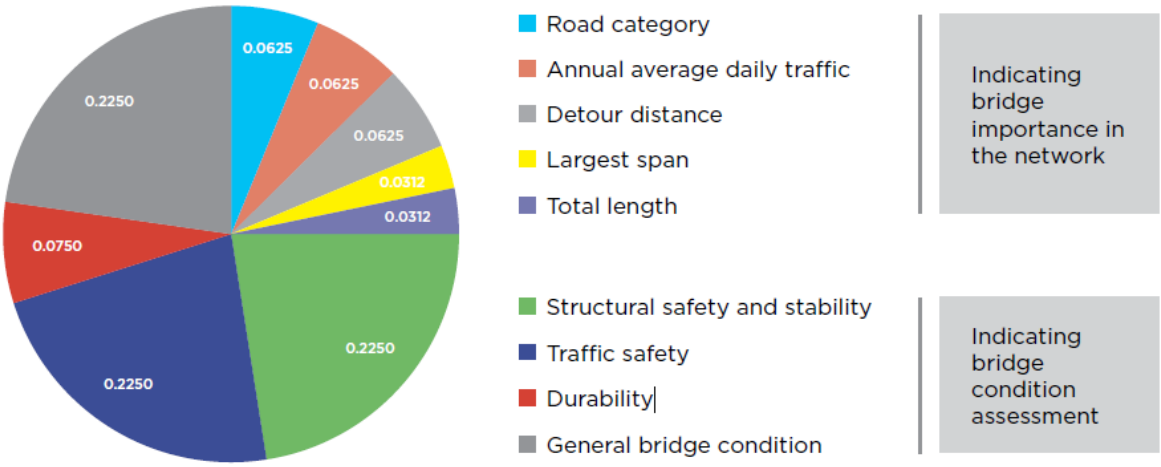

Fig. 18. Example of weight of performance criteria for priority repair ranking

http://www.tu1406.eu/working-groups/wg1-performance-indicators

Emerging issues

The issues to be analysed for the next four-year research cycle are currently being discussed. If there are any suggestions, I can submit them to the group for consideration.

Learnings for Australia and/or New Zealand

Throughout the meeting and bridge congress, there were a few recurrent themes regarding bridges:

- Emphasis on long-term monitoring of a structures health by measuring the reaction to live loads and natural events
- Adaption of structures for climate change challenges
- The use of drones for inspections
- The use of timber structures on secondary highways
- The adaption of structures to withstand seismic activity
- The redundancy of road networks to cope with natural disasters
  - This was a particular problem for Chile after the 2010 earthquakes. Chile is a very long and narrow country (about 4270km north to south and on average about 177km east to west). The earthquakes caused a number of complete structure failures that isolated whole communities because there were no alternative routes

Some of the topics raised at congress follow and may be of interest for further research. The presentations will be made available on the congress website by the end of 2017. The website is in Spanish, but a lot of the presentation papers will be provided in English. Information on the keynote lecturers is available now: http://www.acct.cl/?event=conferencia-de-puentes-chile-2017.

The first session of the congress included presentations of the research topics for the bridges group of the WRA from 2012 to 2015. The topics covered were:

- Risk analysis and risk management of bridges
- New repair and rehabilitation methods of bridges
- Estimation of load carrying capacity of bridges based on damage and deficiency

These reports are publicly available on the WRA website: https://www.piarc.org/en/knowledge-base/road-bridges/

One of the keynote lecturers in the conference was Dr Frangopol from the USA. Dr Frangopol is the President of the International Association for Bridge Maintenance and Safety (IABMAS) which formed a group in Australia in 2014 (http://www.iabmas-aust.org). Dr Frangopol' s session was focused on sustainability of bridges and bridge networks. He spoke about using asset management techniques to minimise the total lifetime maintenance cost of structures and the importance of sustaining structures by considering economic, environmental and social aspects.

Another keynote lecturer was Ian Buckle from the University of Nevada. Mr Buckle spoke about experimental studies on seismic performance of skewed bridges. Mr Buckle noted that field experts had long accepted that skewed bridges don't withstand seismic activity well, but that theory has taken time to catch up. Mr Buckle has done large-scale laboratory experiments to develop numerical models, and the results show reduced impacts where the support length of the span at the abutments is increased. More information on his research can be found at the university's website: https://www.unr.edu/cee/people/buckle

Some examples of extreme bridge design and construction conditions were discussed:

- Fly over at Mexico City Lake Zone by Campos e Matos, A. et al.
  - Large parts of Mexico City are built on the bed of ancient lakes that have been drained into canals and tunnels
  - The beds consist of approximately 50m depth of very soft clay
  - The ground level has sunk 8m in the last 100 years (approximately 40cm/year), and the differences in settlement depths cause most of the issues
  - The sinking is primarily due to the city draining water from the aquifers faster than it can be replaced
  - Need floating foundations for a 50-year bridge design life or the road and bridge levels will not match for long

Image from www.ecowatch.com showing differential settlement of a building in Mexico City.

- Nanay River Cable-Stayed Bridge, Iquitos, Peru by Lopez, J. et al
  - Being constructed in Iquitos City, which is situated in the great plains of the Amazon Basin

- The city can only be reached by river or air. With a population of 420,000 people, it is the largest city in the world that cannot be reached by road
- Materials used for concrete are very scarce, sources are 400km away by boat, therefore steel and precast elements are more economical, the main piles are concrete but are slender
- Bolted joints are required as welding is difficult due to the climatic conditions
- The total bridge length is 2157m
- Large deposits of very soft clay and organic soils meant the piles in the main cable stayed span needed to be 60m deep, 18 cast-in-place drilled shafts of 2m diameter were used for each of the main towers
- The towers for the 240m long central cable stayed span and are 80m high
- More information available through Google search

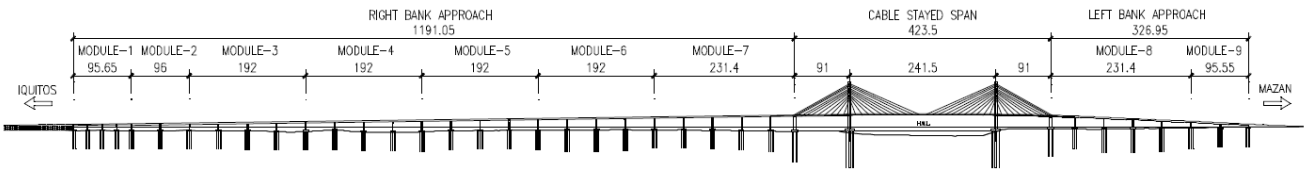

Figure 1. Nanay Bridge: Elevation View

Drawing from 'Design of the Nanay Bridge, Iquitos Peru' by Jack Lopez Acuna and Jack Lopez Jara.

The Australian IABMAS group will host the 9th International Conference on Bridge Maintenance, Safety and Management in Melbourne 2018. Website of the conference: http://iabmas2018.org/welcome.

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