Bridgemon Newsletter – Ljubljana / Delft / Warsaw / Claro / Dublin – November 2014

Issue 3

BRIDGEMON

# Bridgemon Newsletter

## About the BridgeMon Project

CAPACITIES

BridgeMon is a research project funded under the *Research for the Benefit of SMEs (Small and Medium Size Enterprises)* scheme of the 7th Framework Programme of the European Commission (http://ec.europa.eu/research).

Many of the world's bridges are old and need to be periodically repaired or replaced. But premature replacement wastes money and non-renewable carbon-intensive resources such as concrete and steel. BridgeMon was led by four SMEs from Slovenia, the Netherlands, Poland and Switzerland who, with the help of research providers from Ireland and Slovenia, were working to extend the lives of existing bridges. They were developing bridge monitoring technologies to prove that many bridges are safe and can be kept in service for longer, thus ensuring more sustainable road asset management.

## BridgeMon Project Successfully Completed

The end of November 2014 sees the completion of the BridgeMon project. The project has lasted for two years and has led to the development of a number of significant improvements in the technologies and services which are available for carrying out detailed monitoring of bridges. The capability of Bridge Weigh-in-Motion (WIM) technology to collect accurate information on traffic loading has been enhanced, with the SiWIM® system achieving class A(5) accuracy for gross weights. This represents a significant advancement in the field of Bridge-WIM, and provides evidence that Bridge-WIM technology can compete amongst the most accurate WIM technologies in the world.

A detailed monitoring campaign in the Netherlands has demonstrated how the *'virtual monitoring'* technique can be used to estimate fatigue damage in steel bridges. In this case, Bridge-WIM technology was combined with a detailed finite element model of the structure which allowed an investigation into the remaining fatigue life of the bridge.

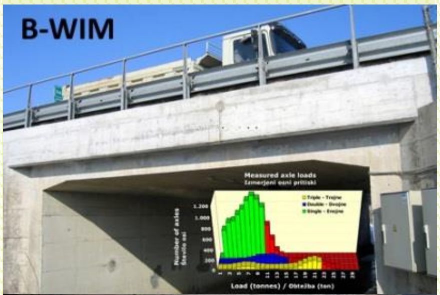
Finally, the Bridge-WIM technique was applied to a railway bridge in Poland in a format suitable for calculating train weights. Combining this with newly developed algorithms for identifying damage to railway bridges allows information to be obtained on the loading on a bridge along with any damage that may occur.

BridgeMon has been a great success and the results should allow the SMEs and bridge owners to avail of the latest technologies for monitoring bridges.

*(Peter Favai, Cestel – BridgeMon coordinator)*

## In this issue






## Slovene Workshop

The Slovene workshop took place on November 25 at ZAG in Ljubljana. It included a visit to the nearby culvert bridge, which had been used for testing within the Bridgemon project.

Apart from the project members five participants attended representing three Cestel's key stakeholders: the National Roads Agency, the Motorways Company of the Republic of Slovenia and the police. All workshop attendees were already familiar with the SiWIM® system as Cestel have been providing WIM data to road operators for over a decade. They also have strong cooperation with the police as part of the pre-selection process for weight enforcement. In a lively discussion it was pointed out that the improvements achieved during BridgeMon will allow permanent long-term installations of the SiWIM® system which had previously only been suitable for 1-week to 1-month portable ones.

## Next Activities

These are the coming activities with **BridgeMon** attendance:

- December 2014: National Seminar on the Renovation of Steel Bridges, Delft, the Netherlands
- April 2015: 12th Slovenian Road and Transportation Congress, Portorož, Slovenia
- May 2015: Bridge Weigh-in-Motion (BWIM) workshop, Winnipeg, Canada
- July 2015: 6th International Conference on Mechanics and Materials Design, Azores, Portugal

# Accuracy Class A(5) Achieved with SiWIM®

One of the key objectives of the BridgeMon project was to achieve a step change in accuracy and long term stability of the SiWIM® bridge weigh-in-motion system. SiWIM® has been used for over a decade for short-term, up to 1-month measurements in many countries around Europe, but an improvement was needed to become even more successful. Thus, testing of various approaches was carried out using numerical modelling and in-field measurements on three different bridges in Slovenia. The most successful approaches were implemented in an updated version of the software.

Free-of-Axle Detector installation, which does not require any action on the pavement, is one of the key advantages of the SiWIM® system. Improvements in axle detection algorithms and instrumentation strategies showed that the updated SiWIM® system only missed 3 of the 542 axles crossing a 20-m beam-and-slab bridge 3 of the 778 axles crossing a 6-m culvert.

A vast number of other enhancements were implemented within the system with updated algorithms for calculating the bridge influence line, calculation of vehicle weights, temperature/velocity calibration and improved approaches for quality assurance of measurements.

All improvements were verified by comparing the SiWIM® results with the results of static weighing which was carried out by the police. Results of 178 freight vehicles measured over a period of 15 months on a 6-m culvert showed an improvement of *four accuracy classes* from class E(35) to class C(15). Despite this remarkable improvement better accuracy could not have been achieved due to bad pavement condition. The pavement was shown to be uneven, with a bump at the entry to the bridge. This demonstrated the importance of selecting a bridge with a smooth road profile.

Results of 122 freight vehicles from the 20-m beam-and-slab bridge were considerably better. The improved version of SiWIM® showed an increase in accuracy from D+(20) to B(10), representing an improvement of two accuracy classes. Even more promisingly, it was shown that when the lighter vehicles, which are of less interest from a traffic monitoring perspective, were omitted from the accuracy classification, the system was capable of achieving **accuracy class A(5)** for gross weights. This is extremely rare in WIM technology and represents a huge advancement in the field of Bridge-WIM, particularly considering that the results were achieved over 6-months long monitoring period.

The work carried out in WP1 of the BridgeMon project has lead to considerable improvements in the accuracy of the SiWIM® system and should improve the ability of Cestel to compete with other WIM technologies in the field of traffic load monitoring.

(Aleš Žnidarič, ZAG, *Robert Corbally – ROD-IS*)

# Case Study in Extending the Life of a Bridge - Fatigue Experiment in the Netherlands

The second work package of BridgeMon, WP2, aimed to develop a technique to accurately monitor the traffic loading on a bridge and calculate the remaining fatigue life. The ability to obtain such information on loading and resistance will assist bridge owners in making better founded and more economic life-cycle maintenance decisions.

A Structural Health Monitoring (SHM) system was combined with measurements of the actual traffic loading on the bridge to facilitate more realistic fatigue damage calculations. The SHM system used the '*virtual monitoring*' concept which '*virtually*' monitors the parts of the bridge that are not monitored directly, through simulations using a calibrated Finite Element (FE) model.

The overall goal of WP2 of the BridgeMon project was to test a Structural Health Monitoring system that utilises traffic loading measurements, and the virtual monitoring concept, on a steel bridge in the Netherlands. A cable stayed bridge was selected for testing, one part of which was instrumented with the SiWIM® Bridge-WIM system to collected traffic information. Additional strain gauges were installed on the main cable-stayed portion of the structure. Using information gained on-site and in the design drawings, a detailed Finite Element (FE) model of the bridge was developed. The information from the two measurement systems was used to calibrate and validate this numerical model of the bridge. The calibrated FE model of the bridge was then used to assess the level of fatigue damage at critical locations. This virtual monitoring concept allows a fatigue damage calculation to be carried out for any location on the bridge, without the requirement for the installation of sensors at every specific location.

Fatigue assessment requires an accurate estimation of lifetime traffic load. Given the cost involved in monitoring a bridge for its lifetime, traffic measurements are generally only collected for a limited period of time. In this study a month of traffic measurements, collected by the SiWIM® system, were used to simulate traffic flow scenarios based on the observed patterns in the measured traffic. Using this so-called "scenario modelling", accurate projections of traffic flow can be simulated by examining the nature of the actual traffic at the chosen site. This approach is extremely useful for carrying out a fatigue calculation, as accurate site-specific traffic loading can be simulated for the duration of the service life of the bridge.

The combination of a validated numerical model of the bridge and the actual traffic loading allowed a detailed prediction of the present fatigue damage of the bridge and an estimate of the remaining fatigue life. The comparison between damage resulting from scenario modelling versus the EuroCode load model clearly indicated that the EuroCode Load model is excessively conservative and using the virtual monitoring method which is site-specific, can facilitate maintenance optimisation and lifecycle cost reductions through avoidance of unnecessary repair and/or replacement on serviceable bridge structures. This approach provides bridge owners/managers with an important decision making tool when deciding on possible future rehabilitation/renovation strategies.

*(Donya Hajializadeh, ROD-IS)*

## Dutch Workshop

The Dutch workshop took place on November 18, 2014, at Rijkswaterstaat WNZ office in Rotterdam. Apart from the project members, 8 participants attended, representing the Ministry of transport and water management, City of Rotterdam and ProRail, the Dutch railway company.

The entire content of the BridgeMon project was covered, with the focus on the measurements and analysis carried out as part of WP2. The participants appreciated the open and detailed discussion on the possibilities of the BridgeMon approach. In particular, the fact that the presentations also showed the problems that were encountered and the things that are not possible yet, increased the credibility of the results that were presented.

Although the Dutch railways are already well covered with other railway WIM technologies, it was agreed to organise a follow up meeting will with Prorail to discuss the possibilities of having a pilot project in the Netherlands with the railway Bridge-WIM application of SiWIM®. Discussions have started with RWS on possible developments and applications of structural health assessment of other bridges on the Dutch highway network.

*(Hans van Loo, CornerStone)*

## Polish Workshop

The Polish workshop took place on November 6 at the General Directorate of Polish Railways in Warsaw.

The participants included six experts from the Polish Railways, of whom five were bridge inspectors and one was an expert from the Automation section. The workshop was conducted in Polish, with consecutive translations of the presentations held in English.

Lively discussion followed the presentations that focused primarily on how the Polish Railways could benefit from the Railway Bridge WIM system and bridge assessment. As a conclusion, it was agreed that Adaptronica would present a proposal to Polish Railways regarding bridge monitoring systems combining weigh-in-motion and structural health monitoring.

*(Przemyslaw Kolakowski, Adaptronica)*

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http://www.linkedin.com/groups/BridgeMon-5033238

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# Railway Bridge WIM and SHM

While the Bridge-WIM approach has been successfuly used to monitor traffic loading on road bridges, the technology was not available for monitoring train weights on railway bridges. BridgeMon has developed the first commercially available railway Bridge-WIM system for the Polish SME, Adaptronica. In addition, algorithms for detecting damage which may occur to the bridge have also been developed. These can be combined with the railway Bridge-WIM technology to provide a useful tool for managers of railway bridges.

In order to test the accuracy of the railway Bridge-WIM system, sensors were installed on a truss bridge in Poland and measurements were carried out during the passage of a number of trains.

A number of challenges had to be overcome to successfully apply the technology to railway bridges and the standard Bridge-WIM algorithms were adapted accordingly. Four trains were weighed in a nearby railway yard, allowing the accuracy of the Bridge-WIM calculations to be assessed. The final results showed that carriage weights were accurately calculated and in nearly all cases were within 5% of their actual values.

Finally, a number of different algorithms for detecting damage were tested using a detailed numerical model which allowed for the dynamic interaction of the train, the track, the ballast and the bridge. These simulations, coupled with measurements from the bridge, showed that it is possible to identify when the bridge has become damaged, depending on the extent and location of damage.

*(Robert Corbally, ROD-IS)*

For the latest information visit **bridgemon.fehrl.org**

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