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Innovative sensing for infrastructure

Rail Bridge Monitoring – Stafford Area Improvement Programme

CSIC with Industry Partners Atkins, Laing O'Rourke, Network Rail and VolkerRail

The project

The £250m Stafford Area Improvements Programme will increase capacity on the West Coast Main Line near Crewe, allow for train speeds up to 100 mph (160 kph), and aims to both reduce congestion and improve maintainability. The main project works are scheduled for completion by winter 2016.

For this project, CSIC is implementing monitoring systems in two of the 11 new bridges being constructed as part of this major improvement programme. The first bridge is a pre-stressed concrete girder bridge and the other a steel composite girder bridge. The aim is to develop a robust, highly distributed and real-time fibre optic based bridge monitoring and data collection system.

The challenge

Traditionally, the asset management and maintenance of bridges has principally relied on data obtained through periodic visual inspections as a basis for establishing repair and maintenance programmes. With the advent of innovative and robust structural monitoring systems, smarter, more objective and reliable performance data can be collected from the beginning of a structure's life. Incorporating structural sensing technology into bridge components at the construction stage provides the opportunity for establishing a comprehensive performance baseline for future condition assessment, structural model updating, and constructive feedback based on comparisons between monitoring data and design assumptions.

The approach

CSIC has deployed two types of fibre optic monitoring systems, one distributed system based on Brillouin Optical Time Domain Reflectometry (BOTDR) and the other a point-based system using fibre Bragg gratings (FBG) capable of measuring changes in strain in real time. At present, more than 200 FBG sensors and over 600 metres of BOTDR sensor cables have been installed. These sensors have already provided some fundamental data that has been useful in determining static and dynamic load response, and will continue to feed analysis of the performance of the structures once the bridges are in use.

Now, even more advanced data analysis and visualisation techniques are being developed to provide engineers and researchers with an invaluable tool for understanding the actual structural behaviour of bridges.

Investigation is also underway into the load-deformation response of railway track beds utilising fibre optic sensing, dynamic laboratory testing and finite element modelling.

The benefits

The monitoring system is a resilient, easy-to-install and cost-effective alternative to more conventional systems. Fibre optic sensors present a number of advantages over more traditional instrumentation, including their size, non-ferrous non-corroding nature, longer life span and immunity to electromagnetic radiation.

This project represents the first time new bridges have been instrumented in such detail to understand their structural behaviour from the moment they are created. The evaluation of actual short-term pre-stress losses, the onset of composite action, and the real-time tracking of live train forces as they are transmitted through the various structural components will all be made possible using this sensor system.

It is anticipated that the findings of this work will provide valuable feedback for the design of future large scale infrastructure projects such as HS2 and could lead to more economic designs and more efficient asset management strategies.

CSIC's installed fibre-optic bridge monitoring systems will serve as long term demonstrators for this technology, showcasing the UK as a world leading innovator in civil infrastructure sensing.

The response

"We are very excited to be part of this project. The need for better, more accurate and configurable real-time monitoring of our assets is of vital importance for the industry. This is a very real step in the development of our understanding of this type of structure and will be extremely useful in the future, not only in terms of design, but also so that we can enhance our approach to maintenance planning and asset renewal."

Ruth Platt, Associate at Atkins

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