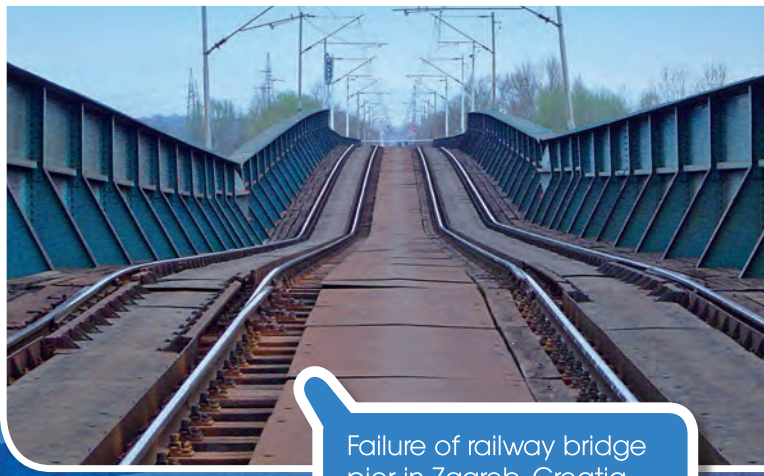
SMARTRAIL

JUNE 2013

Smart Maintenance and Analysis of Transport Infrastructure



Failure of railway bridge pier in Zagreb, Croatia (31st March 2009)

SEVENTH FRAMEWORK PROGRAMME

SMARTRAIL

The research leading to the results has received funding from the European Community's Seventh Framework Programme (FP7/2008-2013) under grant agreement no.285683

INTRODUCTION

The SMARTRAIL project brings together experts in the areas of highway and infrastructure research, SME's and railway authorities who are responsible for the safety of national infrastructure. The goal of the project is to reduce replacement costs, reduce delays and provide environmentally friendly maintenance solutions for ageing infrastructure networks.

The rail sector, as shown in the document RailRoute 2050, will become the sustainable backbone of the Single European Transport Area. In order to achieve this it has to increase its competitiveness and overcome limitations on existing infrastructure by:

- reducing the cost of maintenance
- increasing capacity & efficiency
- simultaneously improving resilience to climate change & extreme weather conditions

Tackling these challenges for continuous productivity improvements whilst traffic levels continue to grow is a demanding but powerful incentive to provide:

- innovative & practical solutions
- technological integration & adaptation of lessons learned
- solutions should be cost-effective and environmentally friendly

The SMARTRAIL project aligns with these aims together with those expressed in the EC's "Establishing a Single European Railway Area (Recast)".

The identification of the user requirements are the basis for the streamlining of the work in the work packages. The results of the SMARTRAIL project will be validated together with Infrastructure Managers (IMs) and regulators in terms of:

- benefit and relevance
- implementation
- cost reduction, performance improvement, safety improvement

Project **UPDATE**

The project is now at the half way point and this section looks at where the project is in terms of specific work packages and the views of the end user.

User view point: This has been achieved trough the member associations, EURNEX and FEHRL, the participation of the infrastructure managers as SMARTRAIL partners, excellent engagement with industry through technical events, workshops, one to one meetings and questionnaires. Progress is being made in meeting the customer objectives, however, before the results can be fully assessed, we recognise that a cost benefit analysis needs to be carried out for each proposal. The work on bridge scour, in particular, is very important, and this work along with the other packages will need to have guidelines for implementation prepared in order to ensure that the research is implemented.

Work Package **UPDATE**

Instrumented Smart Slope: The stability of a slope is provided by near surface suction. Rainfall can cause the formation of a wetting front, which reduces the suction and may cause failure. Typically, shallow slips emerge. A lot of measurable parameters, such as suction, rainfall intensity, soil strength or the slope angle can influence the probability of slips.

The data gathered from this experiment will give us valuable information on the advance of the wetting front and the rate of infiltration. Further by combining this information with the suction and moisture content measurements we will be able to more accurately determine the relationship between rainfall and decrease in shear strength. This will give us a clearly picture of the accuracies of existing formulae in predicting both infiltration and failure. In addition to this the data gathered from the experiment can be used to improve existing variable distributions and as a result increase the accuracy of current probabilistic assessments.

Rainfall induced slope failure in Ireland

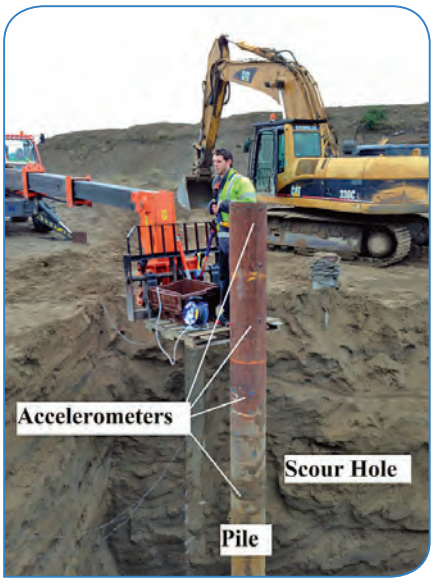
Assessment of bridges subject to scour

Scour is defined as the excavation and removal of material from the bed and banks of rivers as a result of the erosive action of flowing water. There are three main forms: general scour, which naturally occurs in river channels; contraction scour, which occurs as a direct result of the presence of a bridge reducing the cross-sectional area of a river and local scour, which affects bridge piers and abutments. Scour in rivers is often a combination of the three forms and has an adverse effect on the stability and safety of bridges located over waterways.

Customers require an improved system detection process to predict bridge scour failures in a better way. This requires moving from costly manual inspection to intelligent inspection supported by the use of experienced people on site with real data from non-intrusive broad spectrum followed by intrusive focused investigations.

Real-time monitoring is becoming a reality as sensors are becoming cheaper and remote logging is available to provide remote/active monitoring of high risk structures

Within SMARTRAIL methods to monitor the progression of scour depths by analyzing the change in natural frequency of bridge foundation piles are being developed. In order to correlate frequencies to scour depth, numeral models were developed that model the soil-structure interaction. With this information, a bridge owner only has to point to the value of observed frequency and obtain a depth of scour directly from this.



Scour vibration test
in action at UCD test site

New rehabilitation technologies to extend service life of existing railway infrastructure

Low-cost and environmentally friendly remediation measures are needed to extend the service life of this railway infrastructure. Especially in transition zones with abrupt changes in the rigidity. New rehabilitation methods should lead to a smooth transition between the different types of track structure. Within SMARTRAIL, existing tracks and transition zones have been supported with geotextiles, geogrids and anchoring in order to improve the track alignment and to smoothen the changes in stiffness. The goal is to develop and verify sustainable technologies for effective rehabilitation and strengthening of the infrastructure, in order to reduce maintenance costs and to extend the service life.

Instrumented rehabilitation of open track section

Drainage systems are critical to the optimal performance of a railway system. The influence of long-term saturation and contamination of ballast layers with mud and small aggregate (known as mucky spots) have a significant effect on ballast/track stiffness, and require significant remedial works. Methods to prevent the development of this contamination and in general controlling water ingress are investigated.

A Pilot section has been selected on the most heavily trafficked railway lines in Slovenia which enabled only a very short time for rehabilitation (6 hours). Approximately 50 cm of ballast was placed directly on the ground with embedded concrete sleepers. The main problem was the weak subgrade material, which has caused water and mud to be pumped into the ballast. Mud clugs in ballast layers caused a loss of strength and track misalignment. The section needed urgent rehabilitation. As part of the SMART RAIL project two rehabilitation sections were installed in May 2012, with geogrids and geotextiles, including reflecting strips for monitoring deformations. The project is ongoing, with continuous monitoring of the railway substructure behaviour.

Continuous monitoring at improved open track in Slovenia

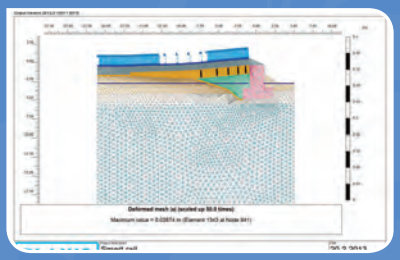
Pilot project Buna bridge in Croatia

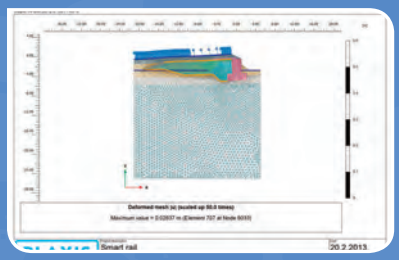
Buna bridge in Croatia was selected as a pilot project, since it is a good representation of the railway infrastructure in the Eastern European countries. It was originally designed in 1893, repaired in 1953, and in 2010 selected for the full replacement, as it reached the end of its service life. The pilot section within SMART RAIL project includes new rehabilitation methods for transition zones from both sides of the bridge. Transitions were designed in a way that both settlement and stiffness variations are smoothened in a reasonable way so that both safety and comfort of passing trains are not negatively affected at these locations.

Buna bridge 2012 before rehabilitation and 2013 during take out

Extensive geophysical and geotechnical investigation works were performed in March 2012.

Geotechnical and geophysical investigation on the location of Buna bridge





Modelling results of 2 different solutions for transition zones at the Buna bridge

The second part of the pilot project is focused on the rehabilitation of the steel bridge structure that was removed from the Buna bridge site. The structure of the old Buna bridge will be transported to the laboratory and used for the experimental assessment and development of the new rehabilitation methods. The tests will include the implementation of ultra-high performance fibre reinforced concrete into the prefabricated slabs, which can be quickly mounted and anchored to the steel structure, increasing the bearing capacity of the bridge. The rehabilitated structure will then be tested to destruction in the laboratory. This work is scheduled for May 2013.

Weigh-in-motion
The railway WIM system makes use of piezoelectric strain sensors for collecting measurement data. These sensors have been chosen as an alternative to standard strain gauges as their advantages including higher sensitivity and enhanced durability when encapsulated in polymer coating.

As part of the SMARTRAIL projects a piezo-based WIM system was mounted on a steel bridge on the on the Polish Rail network. The system has been subject to tests including validation with static weighing -and the first results are promising. A novel aspect of the work is the use of GSM protocols allowing remote monitoring and the presentation of the data on a web based platform. The WIM system mounted on a live railway bridge will provide real-time train loading data for a structural health monitoring system.

Sensor-equipped railway bridge in Poland

Life-cycle cost calculation tools
Currently a number of Infrastructure Managers utilize programs to determine life cycle costs e.g. OBB, DB Netz and Network Rail. These programs have differing inputs and so the results cannot be compared across borders. This issue was identified by the UIC Lasting Infrastructure Cost benchmarking exercise as critical for European infrastructure managers..

The Infrastructure Managers are looking for a LCC program which will enable them to prove to funders the benefits of using LCC when making investment decisions whilst also allowing comparison amongst Infrastructure Managers. In a number of countries the procurement regulations force the Infrastructure Manager to accept the lowest price for the particular task which is not necessarily the lowest price in terms of LCC e.g. in track renewals it has been proven that by paying for a better quality product at the start, maintenance costs are reduced over the lifetime of the element of infrastructure.

The model has already been developed and draft results of the LCA analyse shows that on a section in Slovenia the open track that remediation using geosynthetics wass more environmental friendly than the traditional form of construction without geosynthetics. The emission of the global $C0_2$ was lower because of reduced maintenance requirements for the section of open track.

Highlights from the upcoming period:
1. Prototype scale tests will be performed to assess the capability of the scour detection method developed by researchers at UCD to measure scour effects. The tests will consider shallow pad foundations as this foundation is used widely to support old railway bridges.

2. User friendly probabilistic analysis techniques which can be implemented by infrastructure managers will be published for the assessment of bridges (by AIT and RODIS) and for slopes (RODIS and UCD).

3. The Buna bridge will be transported to the heavy structures laboratory in IGH and remediated. Following this it will be tested to failure.

4. A number of dissemination events are planned including joint with the FP7 MAINLINE project in Paris on May 14th and 15th at the UIC headquarters. The two projects will also run a joint session on the morning of June 6th at the FIRM 2013 Conference in Brussels on Innovation for railway infrastructure.

SMARTRAIL Partners

Third parties

PROJECT RUNS FROM
01.09.2011 to 31.08.2014

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