# LISTENING BRIEF

The cables with the system in place

Acoustic emission specialist Physical Acoustics Corporation is working with Hampton University and the Virginia Transportation Research Council in the USA on a new study to monitor the stay cables of a major bridge. The project on the Varina-Enon Bridge over the James River started last month *(April)*. The structure was opened in 1990 and carries six lanes of traffic over the river.

The study, which is being led by Hampton University in Virginia, will involve the short-term evaluation of bridge cables using acoustic emission sensors provided by Physical Acoustics Corporation. The Research Council, which is the research division of the Virginia Department of Transportation in partnership with the University of Virginia, in Charlottesville, will oversee the project on this bridge, which is owned by Virginia DOT.

The bridge's supporting cable stays are formed of steel strands made up of individual wires, and the study is intended to determine the condition of the strands by short-term monitoring. This is proposed to be carried out by the use of acoustic emission instrumentation on a single stay cable of the Varina-Enon Bridge during periods of both low traffic volumes (acoustically quiet) and high traffic volumes (acoustically noisy).

Engineers will conduct acoustic emission monitoring during high- and low-traffic volumes two times during the year, which is intended to account for summer and winter temperature extremes. In addition, this study will evaluate signature sounds and/or wire breaks that occurred during test periods. If cables are found to be acoustically inactive, the system can be moved to another bridge at the end of the monitoring period.

This study will enhance VDOT's ability to evaluate the health of this structure and to pinpoint regions that might require more in-depth inspections.

The degradation of civil infrastructure is an continuing problem, not only in terms of structural engineering but also in regards maintenance planning. One major dilemma for bridge owners is having the ability to detect the degradation of the structure, and carry out effective planning with regards to maintenance, repair, rehabilitation, or replacement. This difficulty increases when the structure becomes difficult to inspect due to access restrictions or discontinuities that cannot be seen visually. Despite these challenges, it has been shown that non-destructive testing and monitoring can help assess the condition of the bridge so that informed decisions regarding maintenance can be made.

To perform this study, acoustic emission sensors will be fixed to a single cable at

strategic locations and monitored for two and a half months during the winter period, followed by two and a half months during the summer period.

Acoustic emission testing and monitoring is one example of a non-destructive technique that has been used to help ensure the integrity and performance of bridges and other structures. It is recognised as a wide-area non-destructive monitoring technique that can detect changes in the structural integrity of materials caused by defects or discontinuities that become active during typical operating loads, high energy impact, overloading conditions or degradation of the material, such as corrosion for example. Thus acoustic emission is defined as the rapid release of energy in the form of a transient elastic stress wave generated by an acoustic source that can be detected and recorded by special acoustic emission instrumentation.

There are a range of different acoustic emission sources that can be detected in various materials. For metals, typical sources include crack initiation, crack propagation, fretting between crack faces or bolts, for example, movement of dislocations, slipping of bearings, and fracture. For composites, sources include matrix cracking, fibre breaks, fibre bundle fracture, debonding and delamination.

For concrete and prestressed concrete bridge structures, acoustic emission may be a result of crack initiation and/or growth, crack opening and closing (such as fretting/rubbing of crack faces and bolts), wire breaks and/or wire strand rupture. Acoustic emission has also been successfully used for monitoring bearings in swing and lift bridges, deterioration of reinforcing steel, concrete decks, and corrosion of substructure components.

In terms of visual inspection, only 31% of the combined surface area of the box girders is available for this type of construction as the top flanges of the box girders are covered by an asphalt overlay and being adjacent, the webs of the interior girders cannot be accessed.

Acoustic emission instrumentation consists of sensors, electronic signal processing and recording, digital hardware and software for recording, displaying and analysing the data. These tests used a Sensor Highway II for the collection of the data; the system contained

Equipment is portable and lightweight

16 acoustic emission channels with capability for simultaneous feature/waveform-based channels. This is a portable, lightweight system that is ideal for permanent or field testing and does not require an external power source for operation. Additionally this system can monitor a further 32 channels of strain gauges, LVDTs, weather station and so on, and it is connected via cellular modem. It was chosen for a steel bridge testing programme carried out by the FHWA in 2007. The cost of this system was less than US$100,000 and took just three days to set up. Linear location will be used to determine possible breaks, and it is being monitored by cellular modem.

The instrumentation used for the collection of the acoustic emission data employed PAC R.45I-AST sensors. The AST designation indicates that the sensor has an integrated auto sensor test capability, which allows the sensor to send a pulsing signal to verify that it is correctly coupled and check its performance at any time throughout testing. Additionally, the sensors are designed to be shielded against electromagnetic and radio frequency interference ■