Acoustic Emission Inspection for Bridge Applications

Introduction

Acoustic Emission (AE) is a technology based on the detection of high frequency transient elastic waves, generated by the release of energy from localized sources within a material. AE has the ability to detect active defects, leaks and active corrosion under the right operating loads and environmental conditions. The high frequency sound produced by one of these events propagates through the structure where it can be detected by surface mounted sensors. The real-time data that is collected allows the user to detect these internal noise sources, isolate their location and characterize the different sources.

MISTRAS Group's Products & Systems division, Physical Acoustic Corp. has successfully demonstrated the use of AE Inspection for bridges around the U.S. for a variety of designs and structures.

Current Condition

Since there are a variety of bridge designs, there are a variety of bridge problems that relate to the structural integrity of the bridge or one of its components. For the different bridge designs, (dead load, live loads and the operating environment) contribute to the growth of defects and degradation of the structural material that is there to support the loads.

AE has been used to detect, locate and assess structural problems associated with a variety of bridge designs. A summary of several of our success stories follows.

Application Solutions

(A) Retrofits, Stop Drill Holes and Fatigue Crack Arrester Plates:

Retrofit devices installed by bridge owners on existing structures have to be periodically examined in order to determine if they have arrested the growth of cracks and defects. We have demonstrated that AE technology is very effective for evaluating these retrofits. This has been accomplished by temporarily removing the retrofits and monitoring during normal traffic loading. The areas with the known cracks are instrumented and monitored with AE during normal traffic loading. The retrofits are loosely replaced and monitored again and finally, the retrofits were tightened and monitored for a third time. By using source location and guard sensors, AE was able to show that the known cracks were active with no retrofits in place and loose retrofits.

Figure A1: Box beam instrumented for AE monitoring.

When the retrofits were replaced and tightened, there were no locatable emissions indicating that the retrofit was doing the job that it was designed for.

A box beam (Figure A1) was instrumented and monitored with AE for two hours during normal traffic loading. The beam contained cracks in the longitudinal weld such as the surface breaking crack shown in Figure A2. Retrofits (repairs) of the cracks include grinding, drill stop holes and peening of the cracks.

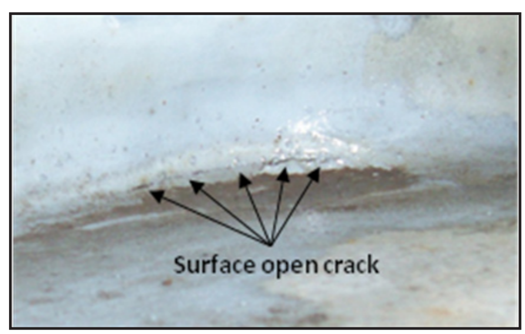

Figure A2: Surface breaking crack in the box beam.

Results for one area that was ground are shown in Figure A3. Linear location of the AE data is shown in the graph below the photograph of the area that was ground. Over the two hours of monitoring, only six events were located with none corresponding to the area that was ground.

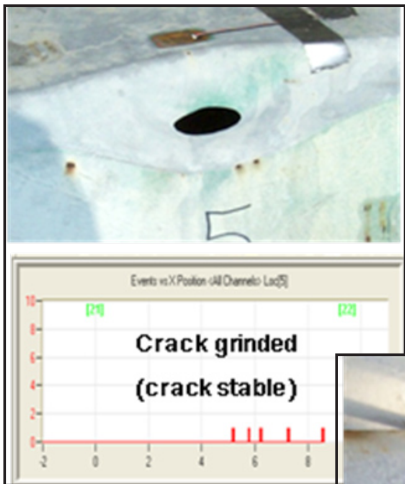

Figure A3: Photo and AE results from ground crack.

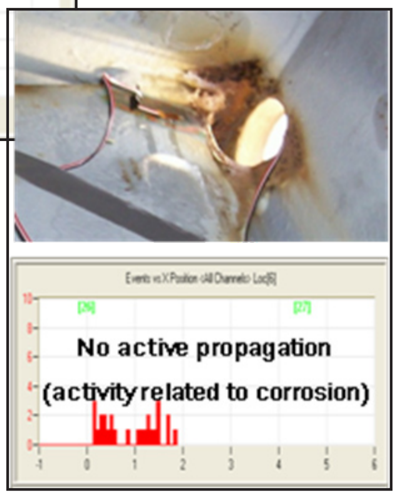

Figure A4: Photo and AE results from the stop drill hole.

In another example, a stop drill hole was used to arrest the growth of a crack. AE was used to monitor this area with the results shown in Figure A4. The active corrosion around the stop drill hole was detected but there were no emissions from the original crack.

To examine the active corrosion, a one inch stop drill hole was located at the tip of a crack in order to arrest the crack growth. This area was instrumented with AE and monitored during normal traffic loading. The results of this monitoring indicate that there were no emissions originating on or near the stop drill hole, confirming that the hole had arrested the crack growth.

(B) AE as a Screening Tool for Prioritizing Repairs

The Pocket AE™ computerized hand-held Acoustic Emission system (Figure B1), has been used to screen existing cracks on bridges for identifying and ranking each location from worst to best. In some cases where cracks were found in unexpected locations, representative locations from adjacent stringers were also checked (though no surface crack was detected) to see if there was any possible subsurface cracks.

Figure B1: Pocket AE.

(C) Suspension Cables

Suspension cables consist of tens of thousands of strands of metal wire strung back and forth from one anchorage to another. Over the course of time, individual strands can break and eventually impact the loading carrying ability of the suspension cable. As a result, AE systems have been developed to continuously monitor these cables and detect, count and locate these wire breaks. One system has been in place on the East Coast of the US since 2001 remotely supplying data through the internet. For additional information on monitoring of the M48 Severn Suspension Bridge in South Wales, UK (Figure C1), please contact our headquarters in Princeton Junction, NJ.

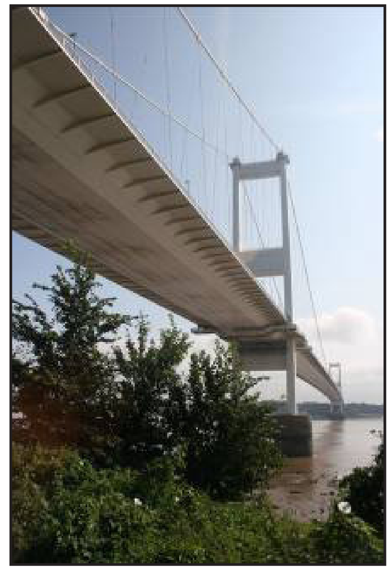

Figure C1: Severn Bridge

(D) Cable-Stayed Bridges

A cable-stayed bridge located in Brazil was suffering from failures in the cable-stay supports as a result of corrosion. This bridge (shown in Figure D1) is located over a salt marsh and experiences heavy traffic loading as well as steady breezes and warm temperatures.

Figure D1: Cable-stayed bridge in Brazil.

Three cables were randomly selected for monitoring with AE. Each cable was instrumented with two sensors in a linear array with one sensor mounted on the support and the other 5 meters away on the cable.

The cables were monitored for 24 hours with the most active cable producing over 6500 AE signals. Location analysis for this cable produced 30 events in the exact location as shown in Figure D2. This location corresponds exactly to the area of previously failures as shown in Figure D3.

Figure D2: Linear location results for 24 hours of AE monitoring.

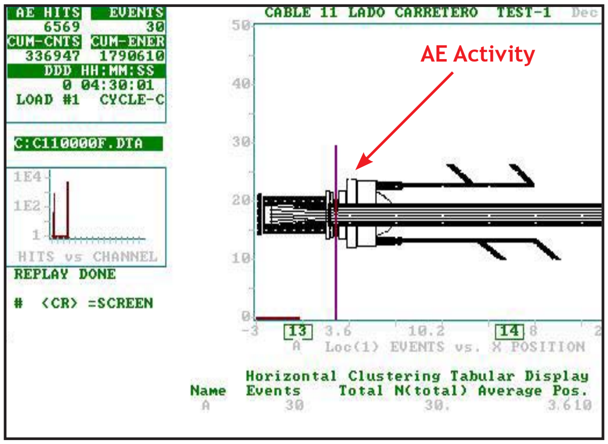

Figure D3: Failure site of cable-stay support - note multiple strand failures.

(E) Continuous Crack Monitoring for Box Beams

Motorway trails in the UK led to the detection of an active AE source located in a box beam. It was located below the end of a diagonal bracing connection at the bottom of the flange. Continuous monitoring of this crack-like defect produced AE events that could be located using source location algorithms. The results are shown in Figure E1 indicating a 250 mm long defect.

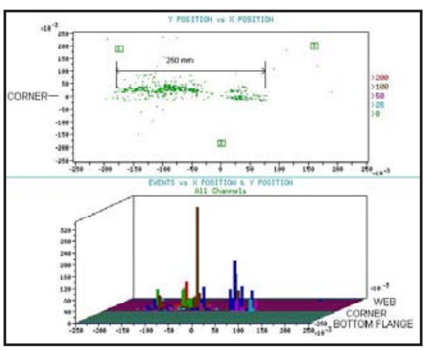

Figure E1: Planar location of crack-like defect in a box beam.

(F) Bascule Bridges:

There is one example of a bascule bridge (see Figure F1) that was producing audible sounds when it was operated. The non-moving structure was instrumented with AE sensors and monitored during operation.

Figure F1: Bascule bridge that was monitored with AE during operation

The bridge was opened and closed several times until sufficient data was collected. Location analysis was used to isolate the source of the sound which proved to be an area where there was interference between the moving and nonmoving parts of the bridge.

(G) Monitoring of Post/Pre-tensioned Concrete Girders

We worked with a university on the testing of two adjacent concrete box beam girders that were removed from a section of bridge that failed in December of 2006. Each beam was monitored with AE during cyclic loading up to failure. While AE could easily pick out cracking and fretting in the concrete, the major interest was the detection of rupturing prestressing strand in the reinforcement (see Figure G1).

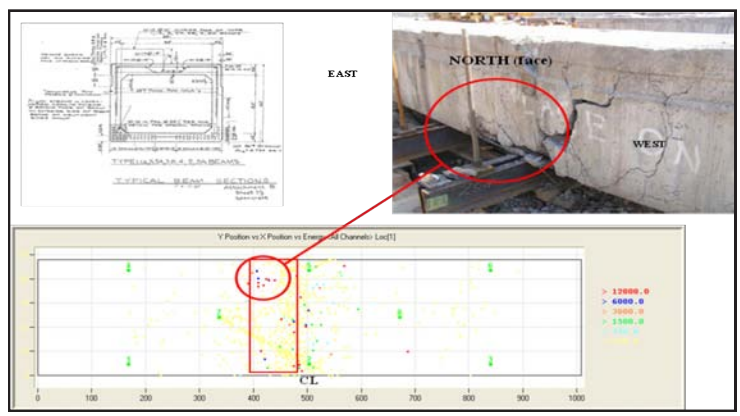

Figure G1: Location of AE events shows rupturing of prestressing strand.

For assistance or additional information, please contact our Princeton Junction headquarters.

195 Clarksville Road, Princeton Junction, NJ 08550 USA
Phone: (609) 716-4000 • Fax: (609) 716-0706
Email: sales.systems@mistrasgroup.com • www.mistrasgroup.com