SIMoNET Structural Integrity Monitoring Network

http://www.simonet.org.uk

Report on 21st SIMoNET Meeting
"SIM for Transport, Aerospace & Shipping"

Held at UCL on April 14th 2010

Introduction

Dr. Paul Fromme introduced the seminar, welcoming those attending and briefly describing the background to the SIMoNET network. Brief details of the presentations are given below.

1. In-Service Integrity Monitoring

Paul Faulkner
Tangent Technology

The speaker started by discussing the need for the short-term (small number of loading cycles, e.g. pressure tests) and long-term monitoring of large structures, which often consist of metallic and composite materials. Acoustic emission (AE) techniques can be performed with a limited number of sensors and have no requirement for special test conditions. Tangent Technology has developed a specialized AE system with Airbus and Lloyds Register and the speaker demonstrated a number of case studies in different industry sectors, such as aerospace, offshore & marine, refinery corrosion and pipeline monitoring, including:

a. Composite test panel with anisotropic material properties
b. AE sensors on waveguide for corrosion under insulation detection on hot pipeline
c. Accelerated tests using pressure cycles on a buried pipeline
d. Flight trials with Airbus and P3 Orion
e. Early detection of defects in aerospace trials

2. Modern analytical tools for the NDE of composites in aerospace and other industries

Brian Allen
QinetiQ

The next generation of civil aircraft need to meet new demands on operational and environmental costs which have given rise to the development of composite aircraft. This change has brought with it new challenges, not only in the design, but also the manufacture of aircraft. QinetiQ have worked with the leading aircraft manufacturers to develop enhanced imaging capabilities for the composite structures and is able to provide 3D image analysis of the structure providing an enhanced tool set for the inspection of aircraft for both build and also during service. The presentation showed examples of the imaging capability now available along with automatic inspection

techniques to reduce operator workload. Whilst ultrasound provides the most commonly used technology it is not always the most appropriate choice for all composites and examples of alternative technologies were covered.

3. SHM of offshore structures from measurements of global ambient motion

Andrew Hillis
University of Bath

Structural integrity management is key to the safe and economic operation of offshore structures. Presently, regular manual inspections are conducted. This is expensive, time consuming, often dangerous, and is prone to human error. The talk described preliminary research investigating the possibility of using non-linear analysis techniques to provide automatic early detection of damage in an offshore structure, using only measurements of global structural acceleration. The method was shown to be insensitive to normal operating parameter variations and to variations in wave excitation force, and demonstrated that very small changes in stiffness of individual structural members are detectable from measurements of global structural motion.

4. Acoustic Emission Testing (AET) Marine Applications

Marcus Cridland
American Bureau of Shipping

The speaker discussed some of the Acoustic Emission (AE) applications in the marine environment, giving an overview and background on AE monitoring. Transient and continuous AE monitoring with different signal levels depending on the type of application and damage was explained. Examples were given from hull monitoring systems for double hull CNG tankers and container ships. The testing of the AE technology in the marine environment, with the potential to target critical areas such as under deck corrosion, and the verification using ultrasonic testing and strain gauges was reported.

5. Discussion Session

John Sharp
Cranfield University

A report entitled “Structural Integrity Monitoring –Review and appraisal of current technologies for offshore applications” prepared by Atkins for HSE had a set of Requirements for Development of SI Monitoring Techniques. These were used to stimulate discussion on a number of topics, including:

a. Need for experienced and qualified operating personnel
b. Extended battery life
c. Reduction of background noise
d. Robust sensors
e. Wider applicability of current SI monitoring methods

The results led to an interesting discussion session, led by Prof. John Sharp.

6. Laser Shearography and Digital Image Correlation for Aerospace and Wind Energy Composites

Rob Wood
Dantec Dynamics

The methodology and application for the fast measurement of large areas using laser shearography and digital image correlation were explained by the speaker. Depending on the application, different systems can be used to apply the load for laser shearography, e.g., vacuum or heat. The system is well suited for composite and honeycomb materials and has been successfully used for a number of applications, such as wrinkles in turbine blades, rubber tile adhesion, jet engine inlets and RAF sentry radome. Digital image correlation can be used to quantify damage in the structure with a resolution down to 1 μm, but requires a natural or sprayed-on pattern to correlate 3D contours and displacements. Various examples were demonstrated, including tyre and wing deformation and helicopter windows.

7. Monitoring concrete structures by CMS

David R Andrews
Cambridge Ultrasonics

Concrete structures have been monitored using a distributed array of intelligent sensors. The network was controlled and monitored by a PC using CAN-bus communications. Each sensor injected ultrasonic chirps in a known pattern of a linear sweep in frequency chirp according to a schedule chosen by the operator and controlled by the PC. Echoes from the concrete were collected in digital form by each sensor. The range of ultrasound in concrete is typically 0.5m to 2.0 m. Echo signals were transferred to the PC where they were processed using matched filtering to de-convolute the chirp from the echoes before being archived. Processed chirps were submitted to an artificial neural network, one network for each sensor, to be classified as either representing good quality concrete or representative of significant structural change. Baysian conditional probability was used on the output of from each artificial neural network to compensate for how well each network had been trained. Probabilities of change after Baysian compensation were submitted to a CAD program after simple thresholding to show where on the structure change has been detected. Results in this form show where on the structure change has occurred. In addition, results from sensors are combined according to their location on structural components to give a probability of structural change for each component of the structure; this tree-like process of combining probabilities is continued to combine probabilities of ever larger assemblies until a probability of significant structural change for the entire structure is obtained.

The method does not depend upon capturing transient acoustic emission signals. Ultrasonic waves are mechanical waves and are intrinsically sensitive to the mechanical condition of the material through which they pass. In the case of concrete, ultrasonic waves are very sensitive to the existence of micro-cracks that are commonly created by: corrosion of steel forms in the concrete, overloading of the structure and various mechanisms of deterioration of concrete such as alkali silica

reaction cracks. Failure in concrete structure under load are always preceded by the creation of networks of micro-cracks. Results of evaluation tests in the technique have been performed by partners in a collaborative European R&D project and were described.

8. The ACFM Inspection Method for Underwater Inspection

Martin Lugg
TSC Inspection Systems

The speaker explained the ACFM methodology for the detection of surface breaking cracks and the achieved good sensitivity due to the uniform magnetic field of the probe. This technique can be applied through non-conducting coating, which is especially useful for underwater applications with marine growth. Different designs and application strategies for the underwater ROV inspection of straight welds and curved geometries were presented, including arrays and special designs to scan along the weld using a ROV manipulator in water depths up to several 100s of meters.

Conclusion

Professor Sharp closed the seminar, thanking those who had presented and those attending and reminded attendees of the next Simonet seminar in November of 2011.