SIMoNET Structural Integrity Monitoring Network

http://www.simonet.org.uk

Report on 22nd SIMoNET Meeting
"SIM for Infrastructure & Energy"

Held at UCL on November 11th 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. Monitoring for Structural Integrity Assurance and Demonstrating ALARP for Fixed Steel Jacket Platforms

David Sanderson
MMI Engineering

The load path redundancy enjoyed by the majority of fixed steel jacket platforms allows for the tolerance of member severance without an unacceptable loss of strength. This fact allows the wide application of Flooded Member Detection (FMD) which relies on a defect having gone through thickness and flooding a nominally dry member. Structural assurance for fixed jacket structures on the UKCS is typically demonstrated by calculating the probability that a structure exists in one of a number of damaged or undamaged conditions and then calculating the ultimate strength for each postulated condition. The return period of a storm to cause collapse of the structure from each condition is then obtained by reference to extreme value predictions of MetOcean conditions. At the moment, it is probably fair to say that it is considered best practice to adopt this approach considering the possibility of only one member failure at a time. However, recent HSE Guidance based on research suggests that as jackets are pushed towards and even beyond design life, the effects of stress redistribution and multiple member failures may significantly affect the predicted structural reliability and that this possibility should be addressed by operators. This paper discussed how global integrity monitoring methods such as Flooded Member Detection and Natural Frequency Response Monitoring could be used to assure integrity in an ageing fleet of platforms and presented a proposed method as to how the risks to persons on board (POB) can be demonstrated as ALARP.

2. Capabilities and Limitations of Electro-magnetic Techniques

Carl Hamer
Innospection

The principle of the Eddy Current Inspection method were described for detecting surface breaking cracks. Several practical applications in the aerospace and offshore sectors were outlined, with multiple sensors being used to inspect larger areas. The Saturation Low Frequency Eddy Current (SLOFEC) system was also described for corrosion screening of ferromagnetic objects. This technique had been used to inspect storage tanks of 30mm wall thickness, with a capability of detecting a 20% local reduction in wall thickness. An easy method for mapping corrosion severity was also described.

3. Ultrasonic wall thickness and crack monitoring at high temperatures (>500°C)

Fred Cegla
Imperial College London

Corrosion and erosion shorten the life of components that are used in the petrochemical industry. In order to mitigate the safety and financial risks posed by the degradation mechanisms, plant operators monitor wall thicknesses at regular inspection intervals. In high temperature locations inspections have to be carried out at plant shut downs because conventional ultrasonic sensors cannot withstand the high operating temperatures. The author and his team have developed a waveguide based high temperature thickness gauge for monitoring of wall thicknesses in high temperature areas. The waveguide allows the use of conventional transduction systems (max temp. 60°C) at one end and guides ultrasonic waves into the high temperature region where the inspection is to be carried out. Slender stainless steel waveguides allow a temperature drop of ~500-600°C per 200mm length to be sustained simply by natural convection cooling. This paper described the technical challenges that had to be overcome (dispersion and source/receiver characteristics) in order to implement this “acoustic cable”. A range of experimental results of thickness measurements on components of different thickness, and furnace tests at different temperatures were presented. An accelerated corrosion test that demonstrates the feasibility of the monitoring for corrosion was also presented, together with results from site trials. The technique has been further extended to the monitoring of thermal fatigue cracks in power station boiler outlet pipes by means of an array of ultrasonic waveguides. The defect monitoring concept was described and simulated results were presented for the operating envelope of the array. The effects of component geometry, array location and signal to noise ratios on measured defect size were investigated. Results show that the array is capable of measuring defects ranging from the size of an ultrasonic wavelength to half the thickness of the component to within ±0.2mm of the defect length. Experimental tests using a prototype array attached to a 30mm thick steel plate containing a 5mm deep and 0.3mm wide notch in a furnace at 550°C showed that monitoring at elevated temperatures is possible. A mean defect length of 5.09mm with standard deviation of 0.13mm was measured over a 2.5 weeks period. Further tests at even higher temperatures (up to 730°C) were used to accelerate creep in the attachment mechanism and showed that long-term exposure to temperatures at 550°C should not have a detrimental effect on the system.

4. Optical displacement monitoring of large structures

John Brewster
Imetrum

With our aging infrastructure and the need to monitor structures during majoring engineering works, there is a high demand coming from the civil engineering community for a simple to use system which provides accurate measurement data of the movement of large structures 24 x 7. Imetrum has developed an optical measurement system that embraces the need of the industry, which is simple to use, but provides large quantities of real time accurate date. Pattern recognition technology was a key method involving the use of optical measurements and video cameras. Measurements relative to a datum point allowed compensation for any camera movement. Applications of the technique to several bridges were described, together with comparison of the results with those from displacement sensors. The method has also been used for monitoring rail displacement and the effects of loading from individual axles and bogies could be seen. Other applications included monitoring of chimneys and dams.

5. Discussion Session
"The need for prioritisation of SIM research and future directions in light of the budget cuts"

John Sharp
Cranfield University

John Sharp and Brian Bell (Network Rail) outlined the current sources of research funding for SIM type activities. Given the likely reductions in funding it was explained that there was a need to prioritise on research topics and where possible collaborate with other parties. This also applied to client type research. Identifying gaps in knowledge was also important. Knowledge Transfer Networks (KTN's) could play an important part in this.

In the discussion there was support for collaboration, with for example an opportunity for several groups with interests in SIM (e.g. FESI, HOIS and SIMoNET) to develop a common voice and provide a pressure group for ensuring SIM type research continues.

The consequences of not doing research were also highlighted, with some expected asset lifetimes of up to 100 years. Regarding European funding, the Framework 7 programme appeared to remain free of cuts. It was important to be active at the stage that new programmes were being formulated. In this respect the benefit of being part of a Technology Platform was highlighted, several of which had interests in structural integrity (e.g. European Rail transport, aeronautics, wind energy). The EU programme also had funding routes for SMEs. Work was already starting on formulating the Framework 8 programme.

6. Residual life assessment of electricity pylons

Peter Carden
Lloyd's Register

The structural integrity assessment of a 220 kV overhead power line was described. The line comprises 70 towers over a distance of approximately 30 km, predominantly in a valley location. The line was originally constructed in the 1950's, approximately 50 years prior to the requested structural integrity assessment. The review established site-specific safety factors at the time of original design and construction accounting for the possible presence of the "Thomasstahl" steel. As part of a follow on programme of structural integrity assessment, an electricity transmission tower of a separate line located on top of a ridge was instrumented and its performance monitored for one year. Extremely large diurnal changes in the natural frequencies of the tower and unexpected bending of the leg members were observed and found to correlate with temperature. The changes in the performance of the tower were investigated numerically through analysis of the changes in tension of the conductors due to temperature and a finite element model of the tower. The bending strains induced in the legs were large enough to be important in the integrity assessment. The measured dynamic performance of the tower implies that a structural health monitoring paradigm based on modal parameter changes must be able to account for large shifts due to environmental variability.

7. Corrosion Detection and Large Datasets

Peter Haycock
SciSite

Electromagnetic techniques can provide useful additions to the portfolio of tools available to corrosion surveyors. However, even simple techniques can produce large datasets on moderate sized structures. New artificial neural network architecture has been developed which is well suited to the automated analysis of such data and similar time-series datasets. Examples of using the technique for corrosion detection on ferrous materials were described. It is a non-contact method offering fast measurements, needing limited training. It is also applicable to detection of corrosion in steel reinforced concrete. The technique was particularly useful for managing large datasets, using pattern recognition methods.

8. Wireless Sensing and the Railway Intelligent Infrastructure

Simon Maddison
Senceive

Senceive has been working with the UK rail industry deploying wireless sensing applications as part of Network Rail's Intelligent Infrastructure programme. This is focused on moving the organisation from a reactive to a predictive maintenance regime, with very hard targets of cost reduction. With such a huge and widely distributed set of assets, economical sensing is crucial to meeting this objective. Wireless in turn should be a key factor in making this a reality, by enabling rapid deployment, eliminating the cost and problem of wires, and also enabling comprehensive monitoring through the economical use of new low cost sensors. Simon Maddison reported on progress to date, and also gave some indications of the directions in which this can evolve.

Conclusion

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