

Seminar on Structural Integrity

The BSSM (www.BSSM.org) organised a one-day seminar on Structural Integrity at the University of Sheffield on 19th May 2004. The meeting was co-sponsored by IOP Stress and Vibration Group. The purpose of the seminar was to update and inform researchers, academics and industrialists on current 'hot' current topics in Structural Integrity Assessment. The speakers represented the most of the engineering areas, permitting discussion in a multi-disciplinary context. There were 20 delegates at the seminar representing a wide range of industries such as Beru F1 Systems, BAE Systems, Moog Controls, LDS Test and Measurement Ltd, Corus R&T, Capita, Roch Services, HSL and Mecon Ltd. The seminar was chaired by Dr Rachel Tomlinson from the University of Sheffield and Dr Janice Barton the University of Southampton.

Proceedings commenced with Professor Christian Boller from the University of Sheffield who presented an overview presentation entitled, "Structural Integrity: can more information help?" Christian's presentation was based around aircraft applications and considered a variety of techniques for assessing the fatigue life components. He described in the fracture mechanics approaches used to design damage tolerant structures. Then the talk moved on to cover the major airframe test with examples cited from Boeing, Airbus and Eurofighter. Christian concluded his talk by discussing load monitoring techniques in the context of diagnostics/prognostics and introduced some novel sensing approaches.

The second speaker, Mr Phil Cole from Physical Acoustics Ltd, also discussed aircraft monitoring. However, he concentrated on a particular monitoring technique, namely Acoustic Emission (AE). Phil's talk was appropriately entitled, "Listening and how it keeps things flying". He started his talk by describing the AE monitoring of the F111 aircraft and compared AE to NDE. The presentation moved on to describe the role of AE in the proof pressure testing of the VC10 ageing aircraft fleet, which are now used primarily for refuelling. Then he described the role of AE in full-scale static tests on Saab JAS-39 Gripen and discussed AE measurement versus strain gauges on composite structures. The AE proved invaluable as it detected the onset damage and allowed the damaging load to be identified. Phil described some work on the Ariana Spelda structure that is made from a combination of aluminium honeycomb and very thin carbon skins. Then he covered DC-XA VTOL space vehicle technology demonstrator for which PAC are involved in developing the in-service structural health monitoring systems. He also described the use of AE to monitor the condition of a helicopter gearbox. He concluded with a look into the possible future applications and prospects for acoustic emission.

The third speaker of the day moved away from the aircraft industry to discuss integrity aspects of the London Underground infrastructure. Dr Stuart Moy from the University of Southampton's talk was entitled "Three case studies of the use of carbon fibre composites for strengthening metallic structures on the London Underground". The first case study examined a bridge strengthened by ultra-high modulus carbon fibre plates bonded directly to the bottom flange of secondary beams of the bridge in service. He described how the technique was validated in the laboratory prior to the installation, and identified maximum slip allowed in the adhesive during the on-site cure. The second case study was a brick-lined vent shaft strengthened by cast iron. Ground movement had loaded the cast iron struts. The struts were strengthened under pre-load by applying carbon fibre composite using a vacuum assisted resin infusion process. Stuart described an experimental/FEA validation programme and as well as the challenges of applying the strengthening in-situ. The third case study covered the feasibility of using CFRP beams to reinforce cast iron girders and the brick arches in a 150 year old tunnel structure. Stuart gave a detailed description of a laboratory based test programme to identify the failure modes of the proposed structure.

The fourth speaker was Dr Xiang Zhong from Cranfield University. Her presentation returned to the aircraft industry and was entitled, "Delamination and Damage Tolerance of Aircraft Composite Structures". Xiang started her presentation by describing the advantages and limitations of the use of composites in aircraft structures. The talk concentrated on high velocity impact damage and defined a strategy for establishing damage extent in residual strength assessment. An aircraft wing box was used as a test structure. Xiang described the mechanisms that will cause damage propagation and structural failure. She and demonstrated that very low energy impact can cause significant delamination by visualising subsurface damage regions using ultrasound c-scan techniques. This data was then used in damage maps to show how the aircraft industry makes quantitative interpretations of damage. Xiang also showed an alternative technique using a fracture mechanics approach to make better interpretations of damage severity. Compression after impact was identified as a key factor in damage evolution and the presentation moved on to discuss this in two case studies: thick and thin stiffened panels. Data obtained from FE modelling was described along with experimental data. Xiang then described some remedies to prevent delamination including transverse stitching and z-pinning.

The final presentation of the second session was by Professor Bill Dover from UCL NDE Centre and TSC Inspection Systems Ltd on, "Structural Integrity monitoring for offshore inspection systems". Bill started his talk by introducing the TSC Stress Probe, which is a non-contacting device based on the piezomagnetism. The device can measure cyclic stress in a continuous recording mode. It has also been used to measure residual stress. Bill then described how the stress probe was

used to monitor in-service stresses of clamp bolts used in the Claymore platform. The technique was approved by Bureau Veritas and trialed in 1998 on a ROV. Bill then described a laboratory based validation programme that established the stability of the sensor in a structural monitoring context. An application of the use of the probe in chain monitoring was described in detail, discussing the complex stresses developed in the chain link and how a specially designed probe could measure the stresses in the chain links under both static and cyclic loading. Another application of offshore risers manufactured from composite materials was described. The non-magnetic characteristic of composite was overcome by using a metal patch. Bill described some full scale laboratory tests that demonstrated excellent agreement between the stress probe and readings obtained from strain gauges.

The first presentation of the afternoon was by Dr Bill Geary of the Health and Safety Laboratory. The talk was entitled, "Failures of pressure systems – HSL experience". Bill started his presentation by presenting some examples of serious failures and their consequence. He presented some interesting work on a sea water cooling system where a combination of surface embrittlement, high residual stress and stress corrosion cracking caused the failure. Bill then moved on to discuss pipework incidents in chemical plants and in gas mains supplies. Offshore piping was also discussed in terms of under insulation corrosion. Some examples of gas pressure vessel failure were presented where poor welding of support legs was the source of failure. Items such as double skinned vessels, tyres and small butane cartridges were also discussed.

The final speaker of the day was Dr Stuart Hillmansen of Imperial College, who presented work entitled, "Recent structural integrity failures in railway systems". Stuart is part of the Railway Research Group, based at Imperial College and led by Professor Rod Smith. The presentation commenced with a description of the track and vehicle dynamics in terms of a complex mathematical model. Stuart defined the ingredients for a successful structural integrity assessment as evaluation of input loads, understanding the structural response, relating this to material behaviour and understood defect tolerance. The first incident that Stuart described was at Eschede caused by a broken wheel. The reasons for failure were discussed and simple hand calculations showed that extremely high stresses were developed in the wheel rim. The next accident was at Rickerscote and occurred because of mid span axle failure. Stuart described a new technique for the intelligent measurement of the in-service axle strains. Stuart then moved on to discuss the derailment at Sandy caused by a fractured wheel. Finally Start discussed the Hatfield incident and the derailment at Southall East.

Rachel Tomlinson took delegates on a tour of the extensive structural integrity facilities available at the University of Sheffield.

Copies of the presentations are available on a CD at a cost of £15 plus VAT. For further details contact Sally Cryer at BSSM sally.cryer@bssm.org