

FESI Workshop: Developments in Engineering Structural Integrity

Round Table Discussion: Notes

Chair: Dr Brian Tomkins

Panel: Prof Peter Flewitt (Magnox North Ltd and Bristol University)
Dr Phil Heyes (Health and Safety Laboratories)
Dr Iain Le May (Metallurgical Consulting Services, Canada)
Mr Keith Wright (Rolls-Royce plc)

Following Dr Brian Tomkins' introduction, Prof Peter Flewitt opened the Round Table Discussion by thanking all concerned for their excellent presentations. Prof Flewitt drew attention to a theme which had emerged from the day's workshop presentations: an emphasis on the need for an integrated approach when assessing the safe and economic operation of plant. Prof Flewitt referred to Mr Andy Holt's discussion of his HSE experience in a regulator's view of assessment tools and their application, which highlighted the need for organisations to achieve a balance between a robust safety culture and the economic drivers of their business competitiveness. Another recurring theme noted by Prof Flewitt was the requirement for a system of structured feedback with regard to emergent problems identified during the assessment process, and he suggested that FESI could have a role in the dissemination of learning derived from this source.

Prof Flewitt challenged the audience to consider the maturity of the discipline of Structural Integrity (SI): Was it their perception that the workshop had covered the full range of SI challenges existing within their organisations, or were there yet other issues to be addressed? What were the specific issues concerning their organisations' safety culture? Where are the audience's organisations positioned in terms of their safety culture?

Prof Flewitt went on to say that mechanistic and microstructural understanding needs to be enhanced in order to underpin failure-avoidance practices and that, overall, the success rate of failure avoidance needs to be improved. In general the engineering and technological communities are good at explaining failures but less able to predict overall of components and structures, hence the need for appropriate safety factors in codes and procedures

Mr Holt responded that mechanistic modelling did indeed increase understanding and he emphasised, as he had in his presentation, how important it is that SI and industry codes should not be 'blindly applied' in organisations. He identified one positive outcome of improved mechanistic understanding as the increase in operators' confidence in their tools, and another as the accumulation of accurate information about the residual stresses in welds and in the practice of welding, both for assessment and in design. Mr Holt went on to say that SI is a strong 'supporting leg' for safety models.

Mr Keith Wright summarised Rolls Royce's perspective on Structural Integrity, which is awarded a high priority within the organisation. He went on to comment that Design Codes (e.g. ASMEIII) assume that structures are defect-free but, to demonstrate a higher level of reliability ('incredibility of failure') than can be claimed from code compliance alone, then there is a need for defect tolerance assessments via the R6 failure avoidance procedure in the structural integrity assessment. The UK is investing in the next

generation of nuclear submarines and the requirements of a modern standards safety case have led to a significant investment in terms of R&D expenditure. The design of the vessels needs to include a design of welds for reduced residual stresses and Rolls-Royce is working in partnership with Serco to be able to deliver this. The investment in SI is in excess of £10m per annum which includes research on various issues including environmental effects. Environmental fatigue evaluations, using some of the latest design curves with a dependency on strain rate amongst others, suggest increases in fatigue usage factors of x15 to x20 but this has not been reproduced in real plant operation. Hence the support to the need identified in Prof Andrew Sherry's presentation, Fracture Mechanics-Based Methodologies, to investigate the behaviour of real materials containing real defects under real loading conditions, and the need for the testing of representative component features. He also pointed out that design codes such as ASMEIII included design by analysis methodologies based on 1960s technologies. There is much work to be done to update the codes and their acceptance criteria in particular for application to 3D finite element models

Mr Holt commented that different industries have different perspectives and hierarchies of needs. While SI is a high priority at Rolls Royce and the nuclear industry in general, it is, unfortunately is not regarded as important at a senior level in other organisations. Mr Holt emphasised that SI must be seen as a vibrant community and not given mere lip service. It is not HSE's role as a regulator to prescribe to organisations, but it is the job of industry and academic bodies to decide where SI goes from here. HSE supports industry in a manner consistent with its remit and has produced pamphlets intended to disseminate the HSE's learning on various topics including RBI, and it pump primes projects such as PANI 1, 2 & 3, discussed in Mr Bernard McGrath's presentation, Non-Destructive Examination.

Dr Phil Heyes commented that risks do not remain static, and that risk must be assessed as "low as reasonably practical for today". Dr Heyes referred to the mining industry, which still uses codes developed in the 1950s although these have not been reassessed to take into account the numerous developments in practice and technologies.

Dr Iain Le May addressed the need to use tested techniques such as metallography in fracture mechanics and to tie these techniques in with inspection procedures. A further issue for the industry is, he said, the tolerance assumed in industry codes for 'no defects'; not only is this impossible to achieve, but codes continue to specify this although it is clear that in reality there can be no such thing. This ambiguity can have significant implications, one instance of which being when failures lead to legal interventions. Dr Le May cited two legal cases on which he had consulted, where complications arose from the inadequate wording of codes. He suggested that codes and standards must be much more considered in their phraseology and need to be more specific to retain their relevance. He commented further that while RBI itself cannot assure risk avoidance, it has a role in risk reduction.

Mr Holt reiterated the message from his presentation: organisations must apply SI for "the right reasons".

Dr Le May raised two further issues; namely that 1, in industry there is only a limited time window in which inspections can take place, and as an outcome the reality is that not all defects can be discovered or will be identified, and 2, there is a need to maintain and keep proper records so they can be referred to later.

Dr Heyes agreed that there is a need for inspection records to be accurate, and added that he had witnessed instances where inspection records had contained fictitious information.

Dr Le May commented that he had seen cases where inaccurate inspection records had been carried forward without amendment and were thus useless in the identification of subsequent problems.

Prof Flewitt threw a question open to the floor: Why are probabilistic methodologies not, apparently, being developed? These were stated 20 years or so ago but there seems little connect activity,

Dr Isabel Hadley, TWI, responded that she was not aware of any developments, but confirmed that there is a need research in this area. She mentioned that a deficiency in assessment methodology is because there is no lower threshold for measurement, as in, for example, fracture toughness, where there is no lower band. Dr Hadley also emphasised the need to acquire the correct input data for use in these assessments. At present such data are limited.

Dr Tomkins introduced a philosophical discussion regarding the nature of engineering: in the past assessment factors had been dependent on and derived from 'expert opinion' and experience from within the industry, and assessment methodologies reflected this. Now, however, there is a need for quantitative and mechanistic methodologies, and meanwhile NDE and other analyses must be much more rigorous. Traditionally, engineers tended to focus on and work within specific industry sectors and thus accumulated a broad experience base; latterly this was supplemented with technical underpinning. However, now the industry is increasingly technology-driven and there is a need for sound scientific knowledge.

Dr Heyes commented that this appeared to be the case in the railway industry, where it seems that aspects of SI are considered to be covered, by and large, by the experiential knowledge of employees.

Dr Tomkins indicated that he saw a need for the engineering industry to find mechanisms for sharing their learning across all sectors.

Dr Le May commented that there is also a need for quantitative methods of data collection, and he questioned the quality of materials available today: What are their properties? How reliable are they? He stated that there is a constant worry about getting materials with the right properties for purpose, and noted that inferior products are sometimes passed by quality control but these are often for an organisation's export market.

Dr Heyes suggested that it would be appropriate for FESI to run an SI workshop which drew in all industry sectors, so that their experiences could be exchanged and shared. He indicated that the HSE has spent some £40m on pump-priming and other activities and, although not intended to solve industry's problems as that is not HSE's role, the focus was on assisting an improvement in performance. Dr Heyes raised two further concerns; 1, the role of 'human factors' in NDT because of the variability of the inspectors' performance, and 2, how it would be possible to raise the quality of human performance.

Mr Bernard McGrath, Serco, responded, that when his project team canvassed NDT vendors, the biggest issue identified was the lack of information from clients. He suggested that there is an urgent need to improve communications between practitioners and clients.

Prof Chris Scruby, Imperial College, London, raised a further issue which will impact assessment: demographics. Current NDT inspectors will not be around in ten years time. Low-cost, automated assessment techniques are currently being researched to good purpose but, he noted, the continued development of high-end solutions will raise standards across the board. Ultimately, solutions will be determined by market size because of the cost implications.

Dr Heyes asked if a way of addressing the 'human factors' issues in assessment might be by having an accreditation scheme for inspectors, and wondered if there are any courses which currently offer such accreditation.

Dr Tomkins responded that, historically, this was not a component of engineering courses.

Prof John Yates, Sheffield University, commented that this is a supply and demand issue, and that in general the level of awareness is not high. He noted that there are two issues to be considered: 1, there are very few home students with the necessary funding, and 2, what should the educational focus of SI be - what should its content be, and how would it be assessed? Exams may not be a realistic means of assessment.

Dr Tomkins noted that there is a need for a much better connection between industry and education.

Dr Hadley offered that the Open University has available a module in SI, but that it probably does not exist at graduate or post-graduate levels.

Prof Flewitt noted that a Structural Integrity course must be truly multi-disciplinary, and include an NDT side. While conservatism should be built in, it is still necessary to determine the correct level of conservatism.

Mr Wright, Rolls-Royce, pointed out that the University of Strathclyde is involved in hosting a new series of Structural Integrity webinars that covers all the elements of the SI field. Rolls-Royce has recently made use of this.

Dr Tomkins reverted to discussion of the proposed FESI cross-sectoral industry workshop: Would there be a demand? What should the course structure be?

Mr Wright commented that there is a difficulty in finding graduates with experience in Engineering Critical Assessments. (It is a term used in BS7910 for a fracture assessment.)

Dr Tomkins asked where consultancy personnel come from?

Dr Phil Horrocks, ESR Technology, replied that in his experience they are difficult to find, and his organisation is constantly seeking to locate suitable personnel.

Dr Tomkins related how useful he continued to find Prof Michael Burdekin's 20-year old notes on SI and the range of issues they covered, and wondered if they could be used as the basis for a customised SI course.

Dr Horrocks commented that there is a perception that SI will be applied in-service, whereas most companies don't carry out maintenance in-service, and this acts as a barrier to the application of SI.

Dr Tomkins replied that this barrier to SI is being eroded. There are OEMs at design base, and the growth of consultancy and technology support has aided with SI participation.

Andrew Wasylyk, a PhD Student delegate from Manchester University, described the SI perspective from his viewpoint as a recent graduate. He drew attention to the need to raise awareness of SI within universities: What do graduates either see or know of SI? Where can they go to find out about research and job opportunities? Moreover, what would an SI engineer actually do? What would the job entail? He suggested that there is a need for the SI community, and FESI, to connect with under-graduates and recent graduates.

Prof Chris Scruby commented that while available funding is mainly directed at ESRC, they will sometimes lend an ear to industry. There are, however, schemes such as the four-year EngDoc award, an alternative to the traditional PhD, which is aimed at post-graduates who wish to pursue a career in industry. EngDoc opportunities exist in Manchester and Birmingham Universities. EngDoc centres are attempting to provide some of the outcomes discussed around the table; however, these centres are not increasing in number and someone must lobby for this to happen. Prof Scruby suggested that this might be a task for captains of industry, as they will need to address the skill shortage which will result from a shortfall of suitably qualified personnel for industry.

Dr Tomkins regretted that the time allocated for the Round Table Discussion had expired. He noted that the discussion indicated that there is potential for a number of publishing opportunities for FESI, including the development of practical handbooks and manuals. He encouraged those present to liaise with FESI, who would appreciate the audience's input and suggestions. He reminded the audience that FESI is a not-for-profit organisation owned by its members, and therefore all profits are fed back into the organisation for its benefit.

Prof Flewitt commented in closing that FESI has a role in addressing the key issues raised and in disseminating learning about them to the wider community involved in SI.

Dr Tomkins agreed, with the caveat that it is not FESI's role to launch a new journal.

Dr Le May noted that FESI could add value to its activities by providing updated references to SI drawn from various existing journals and conference proceedings.

Dr Tomkins encouraged everyone present to send information on these and the other issues raised during the day to Mr Poul Gosney at FESI. He asked delegates to note that the FESI website at www.fesi.org.uk is becoming increasingly interactive and could provide a useful resource.

Prof Flewitt closed the Round Table Discussion with a reminder that the FESI Conference, **Engineering Structural Integrity Assessment: Present Goals – Future Challenges**, will take place in Manchester on May 19 and 20, 2009. He added that, in the light of the remarks about student participation and the need for their raised awareness of SI, as many students as possible should be encouraged not only to attend the conference **BUT** also submit papers. As an incentive, he confirmed that there is a cash prize to be

awarded to the best student paper/presentation at the conference and that the Conference Organising Committee was still accepting Abstracts. For all Conference information go to the FESI website.

Finally he said that the notes of this discussion would be recorded and made available to all attendees.

Elisabeth Decker
Metellurgical Consulting Services Ltd, Canada

Programme

09:15 Registration & Coffee

09:45 **Introduction – Where are the challenges coming from?**

Dr Brian Tomkins – FESI
Andrew Holt – HSE

10:25 **Current Structural Integrity Assessment Procedures – BS 7910, R6, FITNET and API 579**

Dr Isabel Hadley - TWI

11:05 **Non-Destructive Examination – what are we doing to improve input data for methodologies**

Bernard McGrath – Serco
Prof Chris Scruby – RCNDE/Imperial College

11:45 **Fracture Mechanics-based Methodologies – identifying weaknesses and challenges**

Prof Andrew Sherry – University of Manchester
John Sharples - Serco

12:30 – 13:30 Lunch

13:30 **Residual Stress – accommodation in assessment methodologies**

Prof Phil Withers – University of Manchester
Steve Bate - Serco

14:10 **Risk Based Methodologies/Life Management**

Dr Phil Horrocks – ESR Technology

14:50 **Corrosion – management and mitigation of corrosion, particularly in the chemical and process industries**

Pauline Parker - ABB

15:30 Refreshments

15:45 **Round Table Discussion – Chaired by Dr Brian Tomkins**

Panel members will include: Prof Peter Flewitt FEng, Magnox Electric; Dr Phil Heyes, HSL; Prof Iain Le May, MCS Ltd; Keith Wright, Rolls-Royce

16:30 Close