THE UNIVERSITY of NEW ORLEANS

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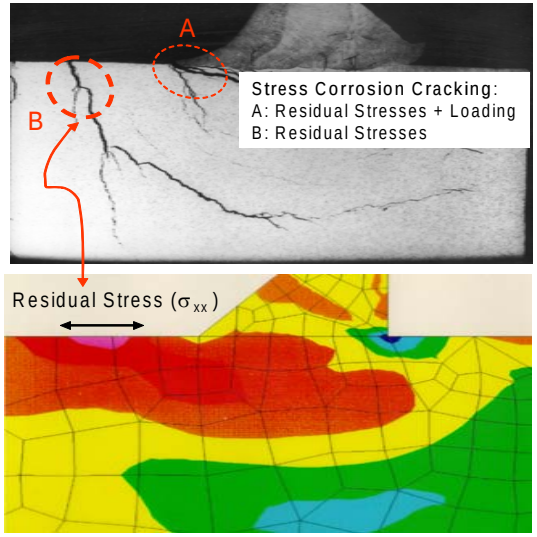
The Business of Innovation

Residual Stresses and Distortions in Welded Structures: Modeling, Analysis, and Mitigation

Oct. 13 - 14, 2008
Center for Advanced Marine Structures and Fabrication, University of New Orleans, LA



Example: Root Cause Analysis for a Real-World Stress Corrosion Cracking

About the Course

It is well known that welding-induced residual stresses and distortions can have significant impact on the manufacturability and structural integrity of welded components. This unique course is designed to:

- provide a critical assessment of "state of art" residual stress modeling, analysis, and measurement techniques
- demonstrate effective modeling and analysis procedures for various industrial applications
- train participants to define and solve day to day residual stress and distortion problems, e.g., how to effectively:
  - obtain engineering solutions using existing commercially available analysis techniques
  - mitigate residual stresses and distortions
  - incorporate residual stresses in fracture and fatigue assessment procedures

A bound volume of all course notes will be provided to all registered participants.

About the Instructor

The course will be taught by Dr. Pingsha Dong, Northrop Grumman Endowed Chair and Professor, School of Naval Architecture and Marine Engineering, University of New Orleans. Dr. Dong has published over 180 peer-reviewed papers in archive journals and major conference proceedings. He has lectured internationally as a keynote or invited speaker on fatigue/fracture of welded structures and advanced process computational modeling techniques for welding/joining processes. Over the last two decades, he has worked with many government agencies and industrial clients on residual stress and distortion related Dr. Dong has received numerous prestigious awards/recognitions, including IIW Paton Prize (2008), SNAME Helmer L. Hann Award, (2007), *R&D Magazine*'s R&D 100 Award (2006), *TIME Magazine*'s Math Innovator (2005), *Aviation Week and Space Technology*'s Aerospace Laurels Award (2004), SAE Henry Ford Award (2003), AWS R.D. Thomas Award, and ASME G.E.O Widera Literature Award (2002).

Course Content

Mon Oct. 13: 8:30am – 5pm

- Why should we be interested in residual stresses?
  - Weldability
  - Structural manufacturability
  - Structural integrity
- Residual stress/distortion development mechanisms
  - Necessary and sufficient conditions
    - Thermal stress
    - Simple thermo-plasticity descriptions for welding phenomena
  - A graphic solution technique for 1D problems
  - Some typical weld residual stress features
- Modeling requirements and procedures
  - Time and length scale considerations
  - What needs to be modeled?
  - What can be modeled today?
  - How to validate modeling results?
  - Proven residual stress analysis procedures
    - Welding heat flow solutions
      2D versus 3D modeling
      The most common mistake in 2D analysis
    - High temperature material behavior
      Proper constitutive model descriptions
      What needs to be considered?
      What can be ignored?
  - Proven distortion analysis procedures
    - Stable distortions
    - Unstable or buckling distortions
- Residual stresses in weld repairs
- Comments on residual stress measurements
  - Available techniques
  - Assumptions and limitations
  - Why measurements can be wrong!
  - How to interpret measurement results
  - How to devise an effective measurement plan
  - Some well-documented examples
- Residual stresses from other welding/joining processes
  - High energy beam processes (EB, Laser, etc)
  - Solid state processes, e.g., RSW, friction/inertia welding, friction stir welding, etc

5-6:30pm: Happy hour/Networking

Tues Oct. 14: 8am – 12pm

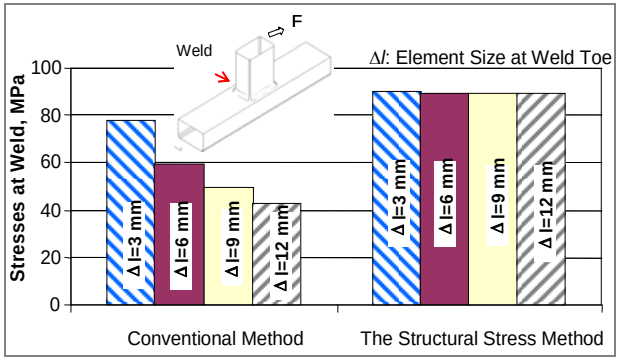
- Principles for mitigating residual stresses and distortions
  - In-process techniques, e.g., thermal and/or mechanical techniques, weld sequencing planning, fixturing, etc.
  - Post-process techniques, e.g., thermal and/or mechanical based stress improvement techniques (e.g., local peening, rolling, …) and conventional stress relief treatment (PWHT, Local PWHH, alternative stress improvement techniques, hydrotest, etc)
- Some well-documented real-world examples on residual stresses and distortions, and mitigation techniques
  - Aerospace and automotive
  - Petrochemical/power generation
  - Heavy equipment and offshore/marine structures
- Fracture mechanics treatment of residual stresses in fitness for service assessment
  - A length scale based characterization
  - Residual stress decomposition technique
  - A generalized parametric description adopted by the 2007 API 579/ASME FFS-1
  - The problem with J-integral calculation
  - Load- versus displacement-controlled conditions
  - Residual stress contributions to K
  - Treatment of residual stresses in fatigue/facture assessment
  - Real-world examples:
    - Fatigue evaluation of a hydro-formed tubular joint
    - Stress corrosion cracking analysis of a vessel weld
    - Life assessment of a repair weld in heater header
    - Buckling mitigation in light-weight panel structures
    - Residual stress effects in residual stress and PWHT induced creep damage; stress corrosion cracking evaluation; novel stress improvement techniques
- Summary and Q/A

THE UNIVERSITY of NEW ORLEANS

Battelle
The Business of Innovation

The Mesh-Insensitive Structural Stress Method for Fatigue Evaluation of Welded Structures

Oct. 14 - 15, 2008
Center for Advanced Marine Structures and Fabrication (CADSF), University of New Orleans, LA



Battelle Structural Stress (BSS) Method

A Battelle Joint Industry Project (JIP) was launched in 2001 to further refine and validate the Battelle mesh-insensitive structural stress (BSS) method (its commercial version is also referred to as the Verity® module in fe-safe™ distributed by Safe Technology). Since then, the structural stress method has not only been proven to be mesh-insensitive and robust, but has also been demonstrated as effective in collapsing thousands of well-documented fatigue tests from the literature into a single narrow band, referred to as the master S-N curve. One major objective in the on-going JIP is to facilitate the adoption of the BSS method by various Codes and Standards. A recent milestone along these lines was the adoption of the BSS method in the new 2007 ASME Div 2 and API 579/ASME FFS-1 Codes published in the summer of 2007. Bureau Veritas (BV) is currently leading the development of fatigue guidance incorporating the BSS method for use in offshore/marine structures.

As a part of the on-going Battelle JIP activities, an entry-level training course on the Battelle structural stress methodology is offered twice a year for both JIP II sponsors (free of charge for up to five representatives per sponsor) and non-JIP participants.

About the Course

This course will provide a unique opportunity for attendees to learn the details of the mesh-insensitive structural stress method for fatigue evaluation of welded structures, from its mechanics basis, numerical implementation to S-N data correlations and life predictions. Through this training course, participants will become familiar with some of the most important issues associated with fatigue of welded joints and existing design and analysis methods. Participants, with hands-on experiences gained during the training course, should be able to:

- Solve basic fatigue design problems
- Effectively interpret fatigue test data
- Perform computer-based fatigue life estimations for small-scale fatigue problems

A demo version of an automated structural stress post-processor and a bound volume of all course notes will be provided to all registered participants. It is desirable to have a laptop for effective participation in the hands-on exercises.

About the Instructor

The course will be taught by Dr. P. Dong, the lead developer of the mesh-insensitive structural stress method and Northrop Grumman Endowed Chair and Professor, School of Naval Architecture and Marine Engineering, University of New Orleans. Dr. Dong has published over 180 peer-reviewed papers in archive journals and major conference proceedings. He has lectured internationally as a keynote or invited speaker on fatigue/fracture of welded structures and advanced process computational modeling techniques for welding/joining processes. Over the last two decades, he has worked with many government agencies and industrial clients on residual stress and distortion related problems. Dr. Dong has received numerous prestigious awards/recognitions, including IIW Paton Prize (2008), SNAME Helmer L. Hann Award, (2007), *R&D Magazine*'s R&D 100 Award (2006), *TIME Magazine*'s Math Innovator (2005), *Aviation Week and Space Technology*'s Aerospace Laurels Award (2004), SAE Henry Ford Award (2003), AWS R.D. Thomas Award, and ASME G.E.O Widera Literature Award (2002).

Course Content

Tues Oct. 14, 1-5pm:

1. Fundamental aspects of weld fatigue
   - Some relevant terminologies and definitions
   - Unique fatigue features associated with welded joints
   - Conventional fatigue evaluation procedures
     - Key assumptions
     - Stress definitions and calculation procedures
     - Code-recommended S-N curves and assumptions
     - Unresolved critical issues
2. The Structural Stress (SS) Method – Part I
   - Requirements for an effective fatigue parameter
   - The structural stress definition
     - Weld toe and weld root failure modes
     - Mechanics basis
     - Numerical implementation
   - Simple calculation procedures
     - Shell/plate models
     - 2D and axisymmetric solid models
   - SS measurement techniques and validations
   - Comparison with other stress definitions
     - ASME stress classification method
     - Hot spot stress method, etc.

5-6:30pm: Happy hour/Networking

Weds Oct. 15, 8am-5pm:

3. The Structural Stress Method – Part II
   - Needs for a generalized SS procedure
   - SS procedure for arbitrarily curved weld in space
   - Formulation and numerical implementation
   - Mesh-insensitivity validations
   - Treatment of multi-axial stress state
   - Structural stress post-processor
   - Demo of SS Post-Processors
   - Hands-on session by course participants with pre-prepared examples run on their laptops
4. The Master S-N Curve Approach
   - How to consider thickness and loading mode effects?
     - Fracture mechanics consideration
     - SS-based K solution techniques
     - Two-stage crack growth model and validations
   - Formulation of the master S-N curve
   - Validations using a large amount of S-N data
   - Implications on fatigue testing and data interpretation
     - Failure definitions
     - Load-controlled versus displacement-controlled
5. SS Modeling and Fatigue Prediction Procedures
   - Structural stress calculations – do's and don'ts
   - Other weld types, e.g., spot welds, friction stir welds, etc
   - Treatment of weld root/throat failure
   - Life prediction examples
6. Additional Topics
   - Multi-axial and non-proportional loading
   - Low cycle fatigue and thermal fatigue
   - Solder fatigue in electronic packaging
   - Overview of the master S-N curve procedure in the new 2007 ASME Div 2 and API 579/ASME FFS-1
7. Summary and Q/A

Registration Form
UNO/Battelle Training Courses

1. Residual Stresses and Distortions in Welded Structures: *Modeling, Analysis, and Mitigation*, Oct. 13-14, 2008
2. The Mesh-Insensitive Structural Stress Method for Fatigue Evaluation of Welded Structures, Oct. 14-15, 2008

Both courses will be conducted at the UNO's Center for Advanced Marine Structures and Fabrication (CADSF) located at 5100 River Road (The four-floor UNO Building), Avondale, LA 70094

Please remit via fax or mail to:

Ms. Bonnie Bailey
Battelle, 505 King Avenue
Columbus, OH 43201-2693
Phone: 614-424-4388
Fax: 614-458-4388
Email: Baileyb@battelle.org

Attendee's Name: _____

Attendee's Title: _____

Company Name: _____ Citizenship: _____

Street Address/P.O. Box _____ City: _____ State: _____

Zip/Postal Code: _____ Country: _____Office Phone: _____

Office Fax: _____ E-mail address: _____

Make Checks payable to: Battelle Memorial Institute

Course Selection (Please mark those as appropriate)	**Registration Fee (USD)***			
	Prior to Sept. 29, 2008		**After Sept. 29, 2008**	
	On-Going Battelle Structural Stress JIP II Participant?			
	Yes	No	Yes	No
Course 1 only	$1,100	$1,600	$1,600	$2,000
Course 2 only	Free	$1,600	Free	$2,000
Registration for Both	$1,100	**$2,700**	$1,600	**$3,300**
TOTAL				

Amount: _____ (US Currency)

Charge by Credit Card: Charge to: [ ] VISA [ ] MasterCard [ ] American Express

Account Number _____ Exp. Date _____

_____ _____
Signature Date

UNO Negotiated Hotel (Please ask for UNO Discount) close to CADSF:

Hampton Inn & Suites ($119)
HAMPTON INN AND SUITES, 5150 Mounes Street, New Orleans, LA 70123
Phone: 504 733-5646, Fax: 504 733-5609
(Other hotels can also be found in the same area)

* 100% of the course fee will be charged for cancellations received after September 29. Attendance is limited to the first 40 registrants. Battelle reserves the right to limit admission.