



## ***Report***

*On*

### **The Activity of Commission XIII**

#### **“FATIGUE BEHAVIOUR OF WELDED COMPONENTS AND STRUCTURES”**

#### **of the International Institute of Welding (IIW)**

2013 IIW Annual Assembly (Essen-Germany)  
September 10 - 17, 2013

### **I. IIW Commission XIII and its Activity**

Commission XIII “Fatigue Behavior of Welded Components and Structures” is one of the well-organized and most active Commissions at the International Institute of Welding (IIW). Commission XIII usually meets twice a year including its Working Group meetings. The main Commission meetings are held at the Annual Assemblies of the IIW typically in summer time in different countries. The, so-called Intermediate meetings, are held in different countries, typically in February-March. The average daily attendance of the main meeting is around 35-40 people from 20-25 countries. The attendance at the Intermediate meetings is usually 15-20 attendees from 8-10 countries.

The main meetings that last two half-days and one full day, take the usual conference format, with papers and documents that are circulated in advance being presented by the authors and discussed by the Commission. All documents are made available on the IIW web site before the meetings and authorized users could download them.

The mandate of Commission XIII includes:

- To collect and present to the Commission documents on fatigue of welded components and structures;
- To collect and present information on service fatigue failures;
- To provide summaries of recent and current research work being carried out in the field of fatigue of welded components and structures, etc.

At present the Officers of Commission are: Chairman – G. Marquis (Finland), Vice Chairmen - C. Miki (Japan) and Prof Ken MacDonalds

Organization of Commission XIII.

Prof. Gary Marquis from Aalto University, Finland was re-elected for a third (final) term as commission chairman at the Annual Assembly in 2012.

Prof Ken MacDonald started as Commission Vice-Chairman at the 2010 Assembly in Istanbul.

Commission XIII has the following working groups and working group chairmen:

- Working group 1 Fatigue testing and evaluation of data for design - Dr. Guy Parmentier (France)
- Working group 2 Techniques for improving the fatigue strength of welded components and structures - Prof Z. Barsoum (Sweden)
- Working group 3 Stress analysis - Prof. Wolfgang Fricke (Germany)
- Working group 4 The influence of weld imperfections on fatigue strength - Mr. Bertil Jonsson (Sweden)
- Working group 5 Life extension of welded structures by repair, retrofitting and structural monitoring - Prof. Takeshi Mori (Japan)
- Working group 6 The influence of residual stress on fatigue - Dr. Thomas Nitschke-Pagel (Germany)
- Joint working group XIII/XV Fatigue design rules- Prof. Adolph Hobbacher (Germany)

The Working Groups also have meetings on a regular basis.

The long term actions of Commission XIII include:

- Extend the classification system to include a wider range of joint types and welding processes (Joint Working Group XIII/XV).
- Establish design methods for dealing with complex loading (e.g. multi-axial fatigue, rotating, principal stresses, combined loading), in particular the definition of the correct stress term to use (Joint Working Group XIII/XV).
- Complete final editing of Recommendations on the use of improvement methods and the hot-spot stress design approach (Editorial Groups from WG2 and WG3 respectively).
- Review the classification system to take more account of welded joint dimensions and fatigue loading conditions, with perhaps special new rules if a hot spot stress approach proves to be generally applicable (Joint Working Group XIII/XV, Working Group 3).
- Establish a closer link between fatigue strength and weld quality in order to allow scope for the use of increased design stresses related to welding method and quality. Liaise with Commission V with regard to NDT aspects (Working Group 4).
- Review IIW Fitness-for-Purpose document acceptance criteria of weld defects in the light of recent Commission XIII documents (e.g. XIII-1888-01) (Working Group 4).
- Critically review cumulative damage methods, including the validity of Miner's rule and the treatment of low stresses in the spectrum, with a view to providing a design method which is safe, but not unduly so, for all relevant service load spectra (Joint Working Group XIII/XV).
- Extend the number of case studies of service fatigue failures for inclusion in the IIW web site (French Delegation).
- Provide case studies of examples of repair of fatigue-loaded structures (Working Group 5).

- Review methods and commercial software for performing fatigue design or fatigue life prediction calculations (Working Group 4).
- Produce Commission XIII standard format for the presentation of fatigue test results.
- Produce recommendations on the statistical analysis of fatigue data (Working Group 1).

## **II. Meeting of the Commission XIII at the 66<sup>th</sup> Annual Assembly of the IIW, Essen, Germany, September 10 – 17, 2013. Participation of the Canadian Delegation.**

The main meetings of Commission XIII were scheduled on September 11 - 14, 2013.

### **1. REVIEW OF COMMISSION XIII ACTIVITIES**

The following are the list of main topics and documents presented at the 2011 Commission XIII meetings:

#### **COMMISSION XIII Working Group meetings**

##### **Wednesday, September 11<sup>th</sup>**

Prof. G. Parmentier, France the chair of the working group WG1 “Fatigue testing and evaluation of data for design” gave an overview of the activities in the group in the past year.

Prof. T. Nitschke-Pagel, Germany, presented an update on the activities of the working group WG6 “Residual stress effects in fatigue”

The working group WG3 “Stress analysis” meeting was conducted jointly with the XV-WG10 and was chaired by Prof. W. Fricke who presented the latest updates in the activities of the group.

The meeting of the working group WG5 “Life extension of welded structures by repair, retrofitting and structural monitoring” was chaired by Prof. T. Mori, Japan

The meeting of the Joint Working Groups XIII/XV “Fatigue design rules” chaired by Prof. A. Hobbacher, Germany, discussed the latest additions and changes to the document.

##### **Sunday, September 15<sup>th</sup>**

Two meetings were held on Sunday, September 15, as follows:

A session of the working group WG2 “Techniques for improving the fatigue strength of welded components and structures” was conducted with Dr M. Stoschka chairing the session.

And a meeting of the working group WG4 “Effects of weld imperfections on fatigue strength and SC Qual” was held in the afternoon with Dr. B. Jonsson and Dr. K. Middeldorf chairing it.

The main meetings of commission XIII took place on Thursday, September 12<sup>th</sup>. Prof. G. Marquis chaired the session at which a number of items were discussed like appointment of a drafting committee, review of the list of delegates, review of the membership list and Commission XIII Annual Report and the approval of agenda. In addition, the draft minutes from 2012 Annual Assembly in Denver (prepared by Remes, I. Lillemae and G. Marquis) were discussed and approved (Doc. XIII-2449-12H).

The Chairman's report was delivered by Prof. G. Marquis (Doc.XIII-2470-13).

## **2. WORK IN PROGRESS**

A report was presented by Prof. T. Mori, Japan on work in progress on fatigue strength of welded joints in Japan (Document XIII-2496-13 2013)

The next few sections will outline the sessions held by different groups of Commission XIII at which technical papers on various subjects were presented.

## **3. REPAIR, RETROFITTING AND MONITORING OF WELDED STRUCTURES**

Four papers were presented in this section as follows:

- a. Annual report 2013 of Commission XIII Working Group WG5 by T. Mori (Document XIII-2466-13)
- b. Effective suppressing method of fatigue crack extension by threaded stud by M. Mouri (Document XIII-2492-13)
- c. Fatigue crack detection by the use of ultrasonic echo height change with crack opening by H. Shirahata (Document XIII-2506-13)
- d. Retrofitting Engineering for Fatigue Damaged Steel Structures (version 2013) by Ch. Miki (Document XIII-2284r2-13)

## **4. FATIGUE TESTING AND EVALUATION**

Seven documents were presented in this session as follows:

- a. Annual report 2013 of Commission XIII Working Group WG1 G. Parmentier (Document XIII-2462-13)
- b. Low-cycle fatigue behavior of a welded web frame corner in ship structures by W. Fricke, N. Friedrich, L. Musumeci, H. Paetzold (Document XIII-2486-13)
- c. Experimental Investigations on Fatigue Damage of Ship Structures caused by Whipping Stresses W. Fricke, H. Paetzold (Document XIII-2487-13)
- d. Fatigue Strength of Cruciform Fillet Welded Joint with Undercut by T. MoriI (Document XIII-2493-13)

- e. Effect of overloads on the fatigue life of spot welded sheets by T. Bruder (Document XIII-2459-13)
- f. Analytical and Experimental Study on the Thickness Effect on Fatigue Strength --- Structural Model Test by N. Yamamoto, M. Mouri, T. Okada, and T. Mori (Document XIII-2498-13)
- g. An experimental study on the fatigue performance of new type pipe K-joints using cover plate by K. Yokozeki (Document XIII-2507-13)

A general discussion of future needs, developments, additions, etc. with respect to fatigue testing and statistical analysis of fatigue data for design was held at the end of the session.

## **5 . RESIDUAL STRESS AND DISTORTION**

Seven documents were presented in this session as follows:

- a. Annual report 2013 of Commission XIII Working Group WG6 Th. Nitschke-Pagel, (Document XIII- 2467-13)
- b. Welding Residual Stress Behavior under Multiaxial Fatigue Loading by M. Farajian, Th. Nitschke-Pagel, (Document XIII-2477-13)
- c. Residual stresses in steel plates with longitudinal fillet welded gussets by J. Hensel and Th. Nitschke-Pagel (Document XIII-2478-13)
- d. Study of the Influence of material and welding modeling on the residual stresses in longitudinal stiffeners by H. Nied and D. Siegele (Document XIII-2479-13)
- e. Influence of the deformation intensity on the fatigue strength of aluminium welds with different mechanical surface treatments by H. Eslami, K. Dilger and Th.Nitschke-Pagel (Document XIII-2483-13)
- f. 3-D FE Welding Residual stress simulation of dissimilar metal welds in penetration nozzles of nuclear reactors, by H-Y. Bae, C-Y Oh, J-S, Kim, Y-J Kim, J-S Kim, S-H Lee and C-Y Park, (Document X-1744-13)
- g. Influence of low ambient temperatures on the residual stress generation in fatigue loaded GMAW-welded Structures by J. Klassen, K. Dilger and Th. Nitschke-Pagel (Document XIII-2484-13)

A discussion of future needs with respect to evaluation of residual stresses and post-weld relieving technique approaches was held after the session.

## **6 . ASSESSMENT AND DESIGN**

Seven documents were presented in this session as follows:

- a. Annual report 2013 of Joint Working Group XIII / XV Fatigue design by A. Hobbacher (Document XIII-2461-13)
- b. Final report of the IIW round robin fracture mechanics exercise by A. Hobbacher (Document XIII-2476-13)

- c. Multiaxial fatigue evaluation of laser beam-welded magnesium joints according to IIW-fatigue design Recommendations by N. Exel and C.M. Sonsino (Document XIII-2457-13)
- d. Designing welded joints against variable amplitude multiaxial fatigue loading by Susmel (Document XIII-2502-13)
- e. Mechanical high-cycle fatigue phenomena predicted by a crystal plasticity FE-simulation by S. Tsutsumi, N. Yamato, K. Gotoh and F. Dunne (Document X-1739-13)
- f. Fatigue Life and Crack Growth Assessment for Welded Longitudinal Stiffeners by I. Varfolomeev, S. Moroz, D. Siegele (Document XIII-2489-13)
- g. IIW Recommendations for fatigue design of welded joints and components by A. Hobbacher (Document XIII-2460-13)

Discussion on the presented papers and action plan for future IIW Recommendations for fatigue design of welded joints and components was continued after the presentations

## 7. STRESS ANALYSIS

Before the technical session started a visit of IIW President, Secretariat and Welding in the World Editors to Commissions X, XIII and XV took place. Seven documents were presented in this session as follows:

- a. Annual report 2013 of Commission XIII Working Group WG3 and XV – WG 10 Stress Analysis by W. Fricke (Document XIII-2464-13)
- b. Granjon C Prize: Fatigue strength assessment of load carrying cruciform joints in low and high cycle region based on effective notch concept by K. Saiprasertkit (Document XIII-2456-13)
- c. Comparison of different methods for fatigue assessment of vibrating welded structures by Mettänen, H., Björk, T. and Nykänen, T. (Document XIII-2474-13)
- d. FEA shell element model for seam weld enhanced structural stress analysis by D. Turlier, P Klein and F. Berard (Document XIII-2482-13)
- e. Fatigue predictions of welded joints and the effective notch stress concept by J. Schjive (Document XIII-2485-13)
- f. Influencing factors on fatigue strength of welded thin plates based on structural stress assessment H. Remes, W. Fricke (Document XIII-2490-13)
- g. Improved fatigue assessment of welded joints by the stress averaging approach according to Neuber by J. Baumgartner (Document XIII-2504-13)

## 8. WELD QUALITY

Five documents were presented in this session as follows:

- a. Annual report 2013 of Commission XIII Working Group WG4 by B. Jonsson (Document XIII-2465-13)

- b. Effect of weaving technique on the fatigue strength of transverse loaded fillet welds made of ultra-high strength steel by Skriko, T., Björk, T. and Nykänen, T. (Document XIII-2473-13)
- c. Fatigue Strength of Flange-Gusset Welded Joints with Radius Transition by K. Kinoshita (Document XIII-2491-13)
- d. Cost savings using different post welding treatments on an I-beam subject to fatigue load by K. Jármai, H. Pahlke and J. Farkas (Document XIII-2499-13)
- e. Draft: IIW guidelines on weld quality in relationship to fatigue strength by B. Jonsson (Document XIII-2301r3-13)

After the presentations a discussion and action plan for future IIW recommendations on fatigue performance classes with respect to defects and weld geometry evolved.

## 9. FATIGUE LIFE IMPROVEMENT METHODS

Twelve overviews and reports were presented during the meeting of this group as follows:

- a. Annual report 2013 of Commission XIII Working Group WG2 by Z. Barsoum (Document XIII-2463-13)
- b. Use of martensitic stainless steel welding consumable to substantially improve the fatigue strength of low alloy steel welded structures by F. Scandella, N. Cavallin, P. Gressel, J. Houas, L. Jubin, F. Lefbvre, I. Huther (Document XIII-2481-13)
- c. Residual Stress Engineering by Low Transformation Temperature Alloys – State of the Art and Recent Developments by A. Kromm, J. Dixneit and Th. Kannengiesser (Document XIII-2510-13)
- d. Experimental verification of HFMI treatment of large structures by H. Yildirim, G. Marquis, B. Jonsson, S. Yang (Document XIII-2488-13)
- e. Experimental observations of HFMI treated joints subjected to high R-ratios and Variable amplitude Loading by E. Mikkola, M. Doré, G. Marquis and M. Khurshid (Document XIII-2480-13)
- f. Fatigue testing data of HFMI-treated joints – Verification of existing design recommendations with regard to increased plate thickness and fatigue preloading by P. Weidner and T. Ummenhofer (Document XIII-2500-13)
- g. Study of a Method for Estimating the Fatigue Strength of Welded Joints Improved by UIT H. Shimanuki (Document XIII-2495-13)
- h. Fatigue life improvement of welded doubling plates by grinding and ultrasonic peening by I. Lotsberg, A. Fjeldstad, M. R. Helsem and N. Oma (Document XIII-2505-13)
- i. Thickness Effect on Fatigue Strength of Welded Joint Improved by Post Weld Treatment by T. Iwata (Document XIII-2494-13)
- j. Fatigue strength assessment of HFMI-treated butt welds using the effective notch stress method by H. Yildirim (Document XIII-2475-13)
- k. Residual stress measurements and fatigue testing of butt welds subjected to peening treatments by B. Ahmad, M. E. Fitzpatrick, D. Howarth, H. Polezhayeva, J. Przydatek and A. Robinson (Document XIII-2497-13)

1. Fatigue Strength Improvement by Hammer Peening Treatment -verification from plastic deformation, residual stress and fatigue crack propagation rate by M. Tai and Ch. Miki (Document XIII-2501-13)

At the end of the meeting a discussion was held on the future developments and additions to the guidelines for fatigue strength improvement techniques for welded structures

### **III. The Canadian Delegation Contribution to the IIW Assembly.**

The Canadian delegation presented briefly a technical document at the meeting related to the new development of the Ultrasonic Technology for underwater use. Dr. J. Kleiman presentation entitled “Underwater Stress Relieve and Fatigue Improvement by Ultrasonic Peening” introduced first results of a study conducted to evaluate the efficiency of new technology and equipment for underwater ultrasonic peening (UUP) of welded elements that was developed for underwater treatment of welds and welded structures.

In the design of the underwater UP instrument specially selected anti-corrosion materials are used. The underwater UP instrument can be used for treatment of welds at depths up to 30 meters or, if required, with certain modifications, even deeper. Acoustic pump principle is used in the originally developed system for water cooling of the transducer. The developed UP system allows for improvement treatments at four different power levels and is using replaceable working heads that come in various configurations with variable numbers of pins, depending on the application. The results of the fatigue testing showed that the UUP provides significant fatigue improvement of welded elements similar to what is observed for UP in air. The fatigue life of welded samples increased under the action of UUP 3-5 times depending on the level of applied stresses.

A full paper with results of testing will be prepared and presented at the next IIW meeting in Korea in 2014.

### **IV. Future meetings of the Commission XIII: Participation of the Canadian Delegation.**

Taking into account the discussions at the meetings of Commission XIII in Essen and the leading role of Canada in development and industrial application of the new and promising fatigue life improvement techniques and residual stress measurement instrumentation, Sintec is planning to prepare and present on behalf of Canadian Delegation 2-3 IIW Documents and papers for 2014 IIW Conference to be held in Korea in the areas of fatigue improvement, safety and reliability of welded components and in residual stress measurements using the advanced system UltraMARS<sup>®</sup>

Sintec is planning also to take part at the intermediate meeting of Commission XIII to be held in March 2014 (the dates and exact place to be confirmed).

### **V. Conclusions**

1. The 66<sup>th</sup> Annual Assembly of IIW confirmed that Commission XIII “Fatigue Behavior of Welded Components and Structures” is one of the well-organized and most active units



of the International Institute of Welding. The technical documents produced by Commission XIII are recognized by world welding community.

2. Participation of Canadian Delegation in the work of Commission XIII, incorporation of the results of R&D in the drafts of international standards and codes provides a leading position for Canada in the field of design, manufacturing, maintenance and repair of welded elements and structures with enhanced fatigue performance and in measurement of residual and applied stresses in welded elements and structures. .
3. It is planned to present a number of IIW Documents by Canadian Delegation through Commission XIII in 20014-2017 to affect the drafts of international standards and codes on fatigue design and improvement treatments of welded elements and structures by Ultrasonic Peening and on measurement of residual and applied stresses using the non-destructive ultrasonic method with the goal to strengthen the Canadian position in the field of manufacturing of welded structures with enhanced fatigue behavior.

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