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Report

Activity of the Commission XIII

“FATIGUE BEHAVIOUR OF WELDED COMPONENTS AND STRUCTURES”

of the International Institute of Welding (IIW)

2007 IIW Annual Assembly (Dubrovnik & Cavtat, Croatia)
July 1 - 6, 2007

1. 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 activities of Commission XIII include:

- 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 H-P. Lieurade (France).

The Commission XIII has a few so-called Working Groups:

1. Working Group 1: Fatigue Testing and Evaluation of Data for Design, Chairman: open, acting chairman Gary Marquis (Finland)

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2. Working Group 2: Techniques for Improving the Fatigue Strength of Welded Joints, Chairman: P J Haagensen (Norway).
2. Working Group 3: Hot Spot Stress Method in Fatigue Analysis of Welded Components, Chairman: W. Fricke (Germany).
4. Working Group 4: The Influence of Weld Defects in Fatigue Loaded Structures, Chairman: H-P Lieurade (France).
5. Working Group 5: Repair of Fatigue-Loaded Welded Structures, Chairman: C Miki (Japan).
6. Joint Working Group XIII/XV: Fatigue Design Rules, Chairman: A Hobbacher (Germany).
7. Joint Working Group X/XIII/XV: Residual Stress and Distortion Prediction, Chairman: J. Janosch (France).

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).

2. Meeting of the Commission XIII at the 60th Annual Assembly of the IIW, Dubrovnik&Cavtat, Croatia, July 1-6, 2007. Participation of the Canadian Delegation.

The main Commission XIII meetings were scheduled on July 2-4, 2007. Working Groups meetings were also held on July 1 and July 5, 2007.

The following are the list of main topics and documents presented at the 2007 Commission meetings:

1. REPORTS OF WORK IN PROGRESS IN VARIOUS COUNTRIES

XIII-2167-07 Work in progress in Japan related to fatigue of welded structures by C. Miki

XIII-2168-07 Work in progress on fatigue strength of welded joints in the Nordic countries by J. Samuelsson, P. J. Haagenen, H. Agerskov and G. Marquis

XIII-2183-07 Work in progress in France related to fatigue of welded components and structures by H.P. Lieurade, I. Huther, F. Lefebvre, and A. Galtier

2. FATIGUE LIFE IMPROVEMENT METHODS

XIII-2179-07 Annual Report of WG2 on 'Techniques for improving the fatigue strength of welded joints' by P. J. Haagenen

XIII-2154-07 Fatigue behaviour of welded high strength steels after high frequency mechanical postweld treatments by I.Weich, H.Eslami, T.Ummenhofer, K.Dilger,Th.Nitschke-Pagel

XIII-2155-07 Fatigue behavior of welded joints of AISI 316l stainless steel including the effect of hammer peening at weld toe, for thin walled exhaust tubes used in gas turbines of military ships by C.M. Branco and V. Infante

XIII-2156-07 Improving the fatigue strength of toe ground welds at the ends of longitudinal attachments by S. J. Maddox

XIII-2170-07 Fatigue improvement of weld repaired crane runway girder by ultrasonic impact treatment by T. Tominaga, K. Matsuoka, Y. Sato and T. Suzuki

XIII-2173-07 Industrial application of ultrasonic peening for fatigue life improvement of welded elements and structures by Y. Kudryavtsev and J. Kleiman

XIII-2180-07 On identify in UIT preparation for comparative testing and field application by E. S. Statnikov, V. Y. Korostel and A. D. Manelik

3. FATIGUE TESTING AND EVALUATION OF FATIGUE DATA

XIII-2188-07 Annual Report of Working Group 1 on 'Fatigue testing and evaluation of data for design' by A. Galtier and M Huther.

XIII-2161-07 Development of a new fatigue testing machine and some fatigue tests for plate bending by K. Yamada, S. Ya, B. Baik, A. Torii, T. Ojio and S. Yamada

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XIII-2164-07 Full size fatigue tests of the orthotropic steel deck system by H. Suganuma and C. Miki

XIII-2182-07 The use of ultrasound to accelerate fatigue testing during assessment of the UIT effectiveness by E. S. Statnikov and V. Y. Korostel

XIII-2195-07 6" pipes P. J. Haagensen

XIII-2196-07 30" pipes P. J. Haagensen

4. WELD QUALITY AND FATIGUE

XIII-2189-07 'Annual Report of Working Group 4 on 'Influence of weld defects in fatigue-loaded structures' by H-P.Lieurade

XIII-2163-07 Study on improvement of fatigue strength of welded joints in bridges by new functional structural steel plates N.Konda, M.Nishio, K.Onishi, K.Arimochi, H.Nagaki, T.Yamano, H.Morishita, S.Takaba and O.Yasuda

XIII-2175-07 Fatigue strength and weld defect assessment of cruciform joints fabricated with different welding processes by Z. Barsoum and B. Jonsson

XIII-2177-07 Simplified assessment of weld quality for fatigue loaded cruciform joints by T. Nykänen, G. Marquis and T. Björk

XIII-2184-07 Effect of weld quality and postweld improvement techniques on the fatigue resistance of extra high strength steels by H.P. Lieurade, I. Huther, F. Lefebvre

5. REPAIR, RETROFITTING AND MONITORING OF WELDED STRUCTURES

XIII-2165-07 Annual report 2007 of Commission XIII Working Group WG5 Retrofitting engineering for steel bridge structures by C. Miki and T. Konishi

XIII-2152-07 Correlation of phased array inspection and fatigue performance of FSW joints by S. Caravaca, C. R. Bird, K. Beamish and S. J. Maddox

XIII-2194-07 Application of fatigue sensors for assessing the service damage of a welded structure by M. Bousseau

6. RESIDUAL STRESS AND DISTORTION

XIII-2190-07 (XV-1242-07) Annual Report of JWG X/XIII/XV on 'Residual stress and distortion prediction' by J.J.Janosch

XIII-2169-07 (X-1620-07) Numerical analysis of weld distortion considering phase transformation effects by Y. Mikami

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XIII-2171-07 (XV-1255-07) Influence of welding residual stresses and notch effect on fatigue data for welded joints and components by M. Kassner and J. Krebs

XIII-2172-07 Residual stresses from welding, prediction by FEA and verification by measurements and fatigue tests by J. L. Hansen, A. V. Hansen, H. Agerskov and J. Bjørnbak-Hansen

XIII-2153-07 Residual stresses and near surface material condition of welded high strength steels after high frequency mechanical postweld treatments by I. Weich, H. Eslami, T. Ummerhofer, K. Dilger, Th. Nitschke-Pagel

7. DESIGN OF WELDED TUBULAR STRUCTURES

XIII-2186-07 (XV-1237-07) Annual Report of Sub-Commission XV-E: 'Welded joints in tubular structures' by X-L. Zhao

XIII-2159-07 (XV-1259-07) Stress concentration factors at welds in tubular sections and pipelines by I. Lotsberg and P. A. Holth

XV-1256-07 (XIII-2191-07) Ductility and ultimate strength of cold-formed rectangular hollow structural section welded joints in arctic conditions by T. Björk

8. FATIGUE ASSESSMENT AND DESIGN

XIII-2185-07 (XV-1243-07) Annual Report of Joint Working Group XIII/XV on 'Fatigue design rules' by A Hobbacher

IIW-1823-07 (XIII-2151-07/XV-1254-07) Recommendations for fatigue design of welded joints and components by A Hobbacher

XIII-2158-07 (XV-1250-07) Assessment of multiaxial spectrum loading of welded steel and aluminum joints by modified equivalent stress and Gough-Pollard algorithms by C.M. Sonsino and J. Wiebesiek

XIII-2176-07 (XV-1257-07) Proposal to initiate the development IIW recommendations for the design of laser and laser hybrid welded joints for load bearing structures by T. Björk, G. Marquis and V. Kujanpää

XIII-2192-07 (X-1616-07) Probabilistic fatigue analysis of a pipe under thermal mixing by I. Varfolomeyev and D. Siegele

XIII 2193-07 (X-1622-07) Estimation of fitness for service of a structure presenting a fatigue crack using two software packages by M. Bousseau

XIII-2162-07 Fatigue strength evaluation formula for cruciform welded joints failing from weld roots under bi-axial loading by T. Mori and M. Myoken

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XIII-2160-07 Low cycle fatigue assessment for welded joints based on local strain approach by K. Tateshi, T. Hanji and T. Chen

XIII-2197-07 (X-1629-07) Fatigue crack propagation and fracture analysis of aerospace Al-alloy flat panels with laser beam welded stringers and clips by M. Koçak, B. Petrovski and V. Uz

XIII-2174-07 Influence of parent metal strength on the fatigue strength of parent material with machined and thermally cut edges by J.-O. Sperle

9. STRESS ANALYSIS

XIII-2187-07 (XV-1240-07) Annual Report of Working Groups XIII-3 and XV-10 on ‘Stress analysis’ by W. Fricke

XIII-2166-07 (XV-1253-07) Local stress analysis and fatigue assessment of bracket toes based on measured weld profile by W. Fricke and A. Kahl

XIII-2181-07 (XV-1258-07) Thickness effect in mesh-insensitive structural stress by H. Kyuba

XIII-2157-07 (XV-1249-07) Fatigue design values for welded joints of the wrought magnesium alloy az31 (ISO-mgai3zn1) according to the nominal, structural and notch stress concepts in comparison to welded steel and aluminum connections by C.M. Sonsino and H. Hanselka

The Canadian delegation presented the technical document on improvement treatments: IIW Document XIII-2173-07 **“Industrial application of ultrasonic peening for fatigue life improvement of welded elements and structures”** (presenter - Dr. Yuri Kudryavtsev, Integrity Testing Laboratory Inc., Markham, Ontario). One of the new and promising processes for effective fatigue life improvement of welded elements and structures -Ultrasonic Peening (UP) is considered in this document.

During the different stages of its development the UP process was also known as ultrasonic treatment (UT), ultrasonic impact treatment (UIT), ultrasonic impact peening (UIP). The beneficial effect of UP is achieved mainly by relieving of harmful tensile residual stresses (RS) and introducing of compressive RS into surface layers of metals and alloys, decreasing of stress concentration in weld toe zones and enhancement of mechanical properties of the surface layers of the material. The fatigue testing of welded specimens showed that: a) the UP is the most efficient improvement treatment as compared with traditional techniques such as grinding, TIG-dressing, heat treatment, shot peening and hammer peening, b) the application of UP for treatment of welded elements of existing (not new) structures provides, practically, the same increase in fatigue life of welded elements that could be achieved by treatment after/during construction.

The developed technology and computerized complex for UP was successfully applied for increasing of the fatigue life of welded elements, elimination of distortions caused by welding

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and other technological processes, residual stress relieving, increasing of the hardness of the surface of materials and surface nanocrystallization. The areas/industries where the UP was applied successfully include: Railway and Highway Bridges, Construction and Stamping Equipment, Shipbuilding, Mining, Automotive and Aerospace. The examples of industrial application of UP for fatigue life improvement of welded elements of highway and railway bridges, stamping and mining equipment are also considered in this document.

The UP technology and equipment were developed by ITL Inc.(Canada) jointly with the partners from Ukraine. The ITL Inc. is the exclusive representative of the UP technology and equipment in the North American and world markets.

Canadian representatives took part in the discussion of the updated version of the IIW Recommendations on fatigue design and application of the improvement treatments. The UP technology is included in the list of most effective fatigue life improvement techniques in the IIW Recommendations on Fatigue Design.

On the behalf of Canadian Delegation the ITL also presented the paper “**Fatigue of Welded Elements: Residual Stress and Improvement Treatments**” at the IIW Conference Welding&Materials, July 5-6, 2007, Cavtat, Croatia. The main stages of residual stress management are considered in this paper. A number of new engineering tools such as ultrasonic computerized complex for residual stress measurement, software for analysis of the effect of residual stresses on the fatigue life of welded elements as well as a new technology and, based on it, compact system for beneficial redistribution of residual stresses by ultrasonic peening are introduced. Examples of industrial applications of the developed engineering tools for residual stress analysis and fatigue life improvement of welded elements and structures and are discussed.

3. Future meetings of the Commission XIII: Graz, Ausria, July 6-11, 2008. Participation of the Canadian Delegation.

Taking into account the discussions at the meetings of Commission XIII in Dubrovnik&Cavtat, Croatia and leading role of Canada in development and industrial application of the new and promising fatigue life improvement technique ITL will prepare and present on behalf of Canadian Delegation at least one IIW Document and a paper for 2008 IIW Conference in the area of fatigue improvement, safety and reliability of Welded Components.

The ITL Inc. is planning also to take part at the intermediate meeting of Commission XIII (Cambridge, UK, March 10-11, 2007).

4. Conclusions

1. The 60th 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 with the presentation of IIW Documents, presenting papers at the IIW conferences, incorporation

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of the results of R&D in the drafts of international standards and codes provides the leading position for Canada in the field of design, manufacturing, maintenance and repair of welded elements and structures with enhanced fatigue performance.

3. It is planned to present a number of IIW Documents by Canadian Delegation through the Commission XIII in 2008-2010 to affect the drafts of international standards and codes on fatigue design and improvement treatments of welded elements and structures by Ultrasonic Peening with the goal to strengthen the Canadian position in the field of manufacturing of welded structures with enhanced fatigue behavior.

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