Fatigue Strength Of Welded Structures Second Edition Woodhead Publishing Series In Welding And Other Joining Technologies

The weld toe is a primary source of fatigue cracking because of the severity of the stress concentration it produces. Weld toe improvement can increase the fatigue strength of new structures significantly. It can also be used to repair or upgrade existing structures. However, in practice there have been wide variations in the actual improvements in fatigue strength achieved. Based on an extensive testing programme organised by the IIW, this report reviews the main methods for weld toe improvement to increase fatigue strength: burr grinding, TIG dressing and hammer and needle peening. The report provides specifications for the practical use of each method, including equipment, weld preparation and operation. It also offers guidance on inspection, quality control and training as well as assessments of fatigue strength and thickness effects possible with each technique. IIW recommendations on methods for improving the fatigue strength of welded joints will allow a more consistent use of these methods and more predictable increases in fatigue strength. Provides specifications for the practical use of each weld toe method, including equipment, weld preparation and operation Offers guidance on inspection, quality control and training, as well as assessments of fatigue strength and thickness effects possible with each technique This report will allow a more consistent use of these methods and more predictable increases in fatigue strength

Fatigue design and analysis of steel and composite bridges is generally based on the notion of the nominal stress using the classified S-N curves with corresponding fatigue classes for typical details. Such an approach can yield an unrealistic estimation of the load effects for structure components because of an ever increasing number of structural details and loading situations resulting in a limited number of possible treatable design cases. The advanced failure methods have been developed to enable an accurate estimation of the load effects for the fatigue strength of welded steel structures, in cases where the nominal stress is hard to estimate because of geometric and loading complexities or in cases where there is no classified detail that is suitable to be compared with. The overall objective of this study is to evaluate the applicability and reliability of the common fatigue life assessment methods using the finite element method. The failure methods considered are the nominal stress, hot spot stress and effective notch stress method. A number of frequently used bridge details have been evaluated for the purpose of comparing the equivalency between these methods.

This report is the result of a major study on the influence of both main plate thickness and of attachment size on the fatigue strength of joints with transverse non-load-carrying fillet welds. In particular, it defines the extent to which the size of the attachment might influence the thickness effect in such joints. Through a whole range of different tests, the study confirms that the present thickness effect correction for certain types of joint is too severe.

Recommendations of IIW Joint Working Group XIII - XV

Application of the Local Approach to the Fatigue Strength Assessment of Welded Structures in Ships

IIW-2006-09

Improving the Fatigue Life of High Strength Steel Welded Structures by Post Weld Treatments and Specific Filler Material (FATWELDHSS)

IIW Recommendations for the Fatigue Assessment of Welded Structures By Notch Stress Analysis

Analysis of Welded Structures: Residual Stresses, Distortion, and their Consequences encompasses several topics related to design and fabrication of welded structures, particularly residual stresses and distortion, as well as their consequences. This book first introduces the subject by presenting the advantages and disadvantages of welded structures, as well as the historical overview of the topic and predicted trends. Then, this text considers residual stresses, heat flow, distortion, fracture toughness, and brittle and fatigue fractures of weldments. This selection concludes by discussing the effects of distortion and residual stresses on buckling strength of welded structures and effects of weld defects on service behavior. This book also provides supplementary discussions on some related and selected subjects. This text will be invaluable to metallurgists, welders, and students of metallurgy and welding.

This report introduces definitions of the terminology relevant to stress determination for fatigue analysis of welded components. The various stress concentrations, stress categories and fatigue analysis methods are defined. Fatigue analysis methods considered are nominal stress, hot spot stress, notch stress, notch strain and fracture mechanics approaches. The report also contains comprehensive recommendations concerning the application of finite element methods and experimental methods for stress determination. It is intended for fatigue design of common welded structures, such as cranes, excavators, vehicle frames, bridges, ship hulls, offshore structures etc. fabricated from materials at least 3mm thick. In general, attention is focused on weld details which give rise to fatigue cracking from the surface, notably from the weld toe.

This volume contains the edited version of lectures and selected research contributions presented at the NATO ADVANCED STUDY INSTITUTE on ADVANCES IN FATIGUE SCIENCE AND TECHNOLOGY. held in Alvor. Portugal, 4th to 15th of April 1988. and organized by CEMUL - Center of Mechanics and Materials of The Technical University of Lisbon. The Institute was attended by 101 participants, including 15 lecturers. from 14 countries. The participants were leading scientists and engineers from universities, research institutions and industry. and also Ph.D~ students. Some participants presented papers during the Institute reporting the state-of-art of their research projects. All the sessions wel'e very active and quite extensive discussions on scientific aspects took place during the Institute. The Advanced Study Institute provided a forum for interaction among eminent scientists and engineers. from different schools of thought and young researchers. The Institute addressed the foundations and current state of the art of essential aspects related to fatigue science and technology, namely: Short Cracks, Metallurgical Aspects, Environmental Fatigue, Threshold Behaviour, Notch Behaviour.

Creep and Fatigue Interactions at High Temperature, Multiaxial Fatigue, Low Cycle Fatigue, Methodology of Fatigue Testing, Variable Amplitude Fatigue, Fatigue of Advanced Materials. Elastic-Plastic Fatigue, and several engineering applications such as welded joints, energy systems, offshore structures, automotive industry, machine and engine components. This book is organized in three parts: Part I: Fundamentals of Fatigue Part II: Engineering Applications Part III: Research Contributions The research contributions covered most of the areas referred above.

Recommendations for Fatigue Design of Welded Joints and Components

Analysis of Welded Structures

Fatigue Assessment of Welded Joints by Local Approaches

Flaws

Fatigue Design of Marine Structures

This report table of contents include: Expressing Endurance Limit; Endurance Limit of Welds and Welded Joints; Processes (Other Than Gas and Metallic Arc); Correlation of Fatigue With Other Physical Properties; Influence of Defects; Mechanical Treatment; Welding Technique; Fatigue Tests of Weld Elements; Thermal Treatment; Carbon Content; Alloys; Corrosion Fatigue; Methods of Design; Repeated Impact; Rail Joints; Creep; Boilers; Tests of Welded Structures; Riveting and Welding; Bridges; Vibrations; Tubes.

Studies the effects of various weld geometry parameters, residual stresses and the combined axial and bending loadings on the fatigue behaviour of butt-welded steel joints. Presents ways of improving the fatigue strength. Simulates the effect of the induced surface compressive residual stresses on the welded joints (for the improvement of the fatigue life). Explains the phenomenon of large scatter band associated with fatigue tests results. Suggests a new procedure for performing and evaluating the fatigue tests.

Avoiding or controlling fatigue damage is a major issue in thedesign and inspection of welded structures subjected to dynamicloading. Life predictions are usually used for safe life analysis,i.e. for verifying that it is very unlikely that fatigue damagewill occur during the target service life of a structure. Damagetolerance analysis is used for predicting the behavior of a fatiguecrack and for planning of in-service scheduled inspections. Itshould be a high probability that any cracks appearing are detectedand repaired before they become critical. In both safe lifeanalysis and the damage tolerance analysis there may be largeuncertainties involved that have to be treated in a logical andconsistent manner by stochastic modeling. This book focuses on fatigue life predictions and damage toleranceanalysis of welded joints and is divided into three parts. Thefirst part outlines the common practice used for safe life anddamage tolerance analysis with reference to rules and regulations.The second part emphasises stochastic modeling and decision-makingunder uncertainty, while the final part is devoted to recentadvances within fatigue research on welded joints. Industrialexamples that are included are mainly dealing with offshore steelstructures. Spreadsheets which accompany the book give the readerthe possibility for hands-on experience of fatigue lifepredictions, crack growth analysis and inspection planning. Assuch, these different areas will be of use to engineers andresearchers.

A Comparative Study

The Fatigue Strength of Transverse Fillet Welded Joints

Fracture and Fatigue of Welded Joints and Structures

Fatigue Strength of Welded Structures

Advances in Fatigue Science and Technology

This book of recommendations presents an overview of High

Frequency Mechanical Impact (HFMI) techniques existing today in the market and their proper procedures, quality assurance measures and documentation. Due to differences in HFMI tools and the wide variety of potential applications, certain details of proper treatments and quantitative quality control measures are presented generally. An example of procedure specification as a quality assurance measure is given in the Appendix. Moreover, the book presents procedures for the fatigue life assessment of HFMI-improved welded joints based on nominal stress, structural hot spot stress and effective notch stress. It also considers the extra benefit that has been experimentally observed for HFMI-treated high-strength steels. The recommendations offer proposals on the effect of loading conditions like high mean stress fatigue cycles, variable amplitude loading and large amplitude/low cycle fatigue cycles. Special considerations for low stress concentration welded joints are also given. In order to demonstrate the use of the guideline, the book provides several fatigue assessment examples.

The notch stress approach for fatigue assessment of welded joints is based on the highest elastic stress at the weld toe or root. In order to avoid arbitrary or infinite stress results, a rounded shape with a reference radius instead of the actual sharp toe or root is usually assumed. IIW recommendations for the fatigue assessment of welded structures by notch stress analysis reviews different proposals for reference radii together with associated S-N curves. Detailed recommendations are given for the numerical analysis of notch stress by the finite or boundary element method. Several aspects are discussed, such as the structural weakening by keyhole-shaped notches and the consideration of multiaxial stress states. Appropriate S-N curves are presented for the assessment of the fatigue strength of different materials. Finally, four examples illustrate the application of the approach as well as the variety of structures which can be analysed and the range of results that can be obtained from different models. Provides detailed recommendations for the number analysis of notch stress by the finite or boundary element method Discusses structural weakening by keyhole-shaped notches and the consideration of multiaxial stress states Provides four comprehensive examples, illustrating the variety of structures which can be analysed and the range of results that can be obtained from different models

The key to avoidance of fatigue, which is the main cause of service failures, is good design. In the case of welded joints, which are particularly susceptible to fatigue, design rules are available. However, their effective use requires a good understanding of fatigue and an appreciation of problems concerned with their practical application. Fatigue strength of welded structures has incorporates up-to-date design rules with high academic standards whilst still achieving a practical approach to the subject. The book presents design recommendations which are based largely on those contained in recent British standards and explains how they are applied in practice. Attention is also focused on the relevant aspects of fatigue in welded joints which are not yet incorporated in codes thus providing a comprehensive aid for engineers concerned with the design or assessment of welded components or structures. Background information is given on the fatigue lives of welded joints which will enable the engineer or student to appreciate why there is such a contrast between welded and unwelded parts, why some welded joints perform better than others and how joints can be selected to optimise fatigue performance.

Residual Stresses, Distortion, and Their Consequences

Cumulative Damage of Welded Joints

Bibliography on the Fatigue of Welded Structures

Fatigue Strength of Welded Connections in Round Bar Steel Structures

Designer’s Guide to the Structural Hot-Spot Stress Approach

This book presents guidelines on quantitative and qualitative measures of the geometric features and imperfections of welds to ensure that it meets the fatigue strength requirements laid out in the recommendations of the IIW (International Institute of Welding). Welds that satisfy these quality criteria can be assessed in accordance with existing IIW recommendations based on nominal stress, structural stress, notch stress or linear fracture mechanics. Further, the book defines more restrictive acceptance criteria based on weld geometry features and imperfections with increased fatigue strength. Fatigue strength for these welds is defined as S-N curves expressed in terms of nominal applied stress or hot spot stress. Where appropriate, reference is made to existing quality systems for welds.In addition to the acceptance criteria and fatigue assessment curves, the book also provides guidance on their inspection and quality control. The successful implementation of these methods depends on adequate training for operators and inspectors alike. As such, the publication of the present IIW Recommendations is intended to encourage the production of appropriate training aids and guidelines for educating, training and certifying operators and inspectors.

The failure of any welded joint is at best inconvenient and at worst can lead to catastrophic accidents. Fracture and fatigue of welded joints and structures analyses the processes and causes of fracture and fatigue, focusing on how the failure of welded joints and structures can be predicted and minimised in the design process. Part one concentrates on analysing fracture of welded joints and structures, with chapters on constraint-based fracture mechanics for predicting joint failure, fracture assessment methods and the use of fracture mechanics in the fatigue analysis of welded joints. In part two, the emphasis shifts to fatigue, and chapters focus on a variety of aspects of fatigue analysis including assessment of local stresses in welded joints, fatigue design rules for welded structures, k-nodes for offshore structures and modelling residual stresses in predicting the service life of structures. With its distinguished editor and international team of contributors, Fracture and fatigue of welded joints and structures is an essential reference for mechanical, structural and welding engineers, as well as those in the academic sector with a research interest in the field. Analyses the processes and causes of fracture and fatigue, focusing predicting and minimising the failure of welded joints in the design process Assesses the fracture of welded joints and structure featuring constraint-based fracture mechanics for predicting joint failure Explores specific considerations in fatigue analysis including the assessment of local stresses in welded joints and fatigue design rules for welded structures

This book provides background and guidance on the use of the structural hot-spot stress approach to fatigue analysis. The book also offers Design S-N curves for use with the structural hot-spot stress for a range of weld details, and presents parametric formulas for calculating stress increases due to misalignment and structural discontinuities. Highlighting the extension to structures fabricated from plates and non-tubular sections. The structural hot-spot stress approach focuses on cases of potential fatigue cracking from the weld toe and it has been in use for many years in tubular joints. Following an explanation of the structural hot-spot stress, its definition and its relevance to fatigue, the book describes methods for its determination. It considers stress determination from both finite element analysis and strain gauge measurements, and emphasizes the use of finite element stress analysis, providing guidance on the choice of element type and size for use with either solid or shell elements. Lastly, it illustrates the use of the recommendations in four case studies involving the fatigue assessment of welded structures using the structural hot-spot stress

Designer's Guide

Fatigue Testing of Weldments

Techniques for Improving the Fatigue Strength of Welded Structures

Structural Hot-Spot Stress Approach to Fatigue Analysis of Welded Components

Fatigue is a mechanism of failure which involves the formation and growth of cracks under the action of repeated stresses. Ultimately, a crack may propagate to such an extent that total fracture of the member may occur. To avoid fatigue it is essential to design the structure with inherent fatigue strength. However, fatigue strength for variable amplitude loading is not a constant material property and any calculations are necessarily built on a number of assumptions. Cumulative damage of welded joints explores the wealth of research in this important field and its implications for the design and manufacture of welded components. After an Introduction, chapter two introduces the constant amplitude database, which contains results obtained in test conditions and which forms the basis of the basic S-N curves for various types of joint. Chapter three discusses the influence of residual stresses which can have a marked effect on fatigue behaviour. Chapter four explores variable amplitude loading and the problem of how information from laboratory tests, obtained under constant amplitude conditions, can be applied to the design of structures for service conditions. This problem is further investigated in the next chapter which is devoted to two and three level load testing. Chapters six, seven and eight look at the influence that the variety of variable loading spectra can have on fatigue strength, whether narrow or wide band loading or cycles of small stress range. Taking all of this knowledge, chapter nine discusses structure designs. Cumulative damage of welded joints is a comprehensive source of invaluable information for welding engineers, supervisors, inspection personnel and designers. It will also be of great interest for academics working in the fields of structural and mechanical engineering. Covers the wealth of research in the field of fatigue strength and its role in the design and manufacture of welded components Invaluable reference source for welding engineers, supervisors, inspection personnel and designers

These recommendations present general methods for the assessment of fatigue damage in welded components, which may affect the limit states of a structure, such as ultimate limit state and serviceability limited state. Fatigue resistance data is given for welded components made of wrought or extruded products of ferritic/pearlitic or banitic structural steels up to fy = 700 Mpa and of aluminium alloys commonly used for welded structures.

"The title covers conditions for fatigue, detail design, nature of the stress variation, corrosion fatigue, high tensile steels, possible improvements in fatigue strength, effect of defects on fatigue strength, typical service failures, and design data."

Fatigue Analysis of Welded Structures Using the Finite Element Method

Residual Stress-Based Fatigue Design of Welded Structures

IIW Recommendations for the HFMI Treatment

Fatigue Strength of Welded Joints and Fatigue Strength of Welded Joints: A Review of the Literature to July 1, 1936

Fatigue of Welded Structures

This book provides a basis for the design and analysis of welded components that are subjected to fluctuating forces, to avoid failure by fatigue. It is also a valuable resource for those on boards or commissions who are establishing fatigue design codes. For maximum benefit, readers should already have a working knowledge of the basics of fatigue and fracture mechanics. The purpose of designing a structure taking into consideration the limit state for fatigue damage is to ensure that the performance is satisfactory during the design life and that the survival probability is acceptable. The latter is achieved by the use of appropriate partial safety factors. This document has been prepared as the result of an initiative by Commissions XIII and XV of the International Institute of Welding (IIW).

An English version of a sucessful German book. Both traditional and modern concepts are described.

Fatigue design concepts for welded structures generally consider residual stresses as a factor affecting the mean stress influence. Residual stresses are mostly interpreted as mean stresses. In addition, high tensile residual stresses are conservatively assumed, resulting in maximum effective load stresses from fatigue loading in the order of the yield strength. The consequence of this is that additional static load stresses may have no influence on the resulting fatigue strength because the local effective mean stress (residual stresses and load mean stresses) is always high. The related evaluation concepts neither distinguish between different steel grades nor between different origins and amounts of possible residual stresses in welded joints. The real magnitude of existing residual stresses is also usually not considered, because in practice, usually no explicit knowledge of the residual stresses at critical sites of a construction is available because residual stress measurements are not state of the art in welding practice. For an explicit consideration of residual stresses in design concepts, the sign, the initial amount, and especially the amount of the residual stresses after a load induced relaxation must be considered. Therefore, the steel grade and the condition of the material are of great importance, as well as the local stress condition influenced by welding-induced notch geometry. The article shall give an overview about the state of the art of consideration of residual stresses in fatigue design concepts for welded structures and the background of their development. Finally, a new approach shall offer a possibility for an enhanced consideration of residual stresses in design concepts based on the explicit knowledge about the effective residual stresses that can actually be observed with different measurement concepts.

IIW Recommendations On Methods for Improving the Fatigue Strength of Welded Joints

Fatigue Analysis of Welded Components

For Improving the Fatigue Strength of Welded Joints

A Method for Obtaining Conservative S-N Data for Welded Structures

Design and Analysis of Fatigue Resistant Welded Structures

Fatigue Strength of Welded StructuresWoodhead Publishing

A method of fatigue testing is proposed to simulate the behavior of large-sized welded structures having high tensile residual stresses by means of ordinary small width specimens containing a low level of residual stresses. The method involves the varying of the stress range from test to test while always maintaining the maximum stress at the yield strength of base metal. The results obtained by the proposed method agreed with those for slit welded joints containing high tensile residual stresses fatigued at constant amplitude at a stress ratio of zero. However, the fatigue strength of small width welded specimens as determined by the proposed method was lower than that obtained by the conventional method at a stress ratio of zero. It is emphasized that the proposed method is effective in obtaining conservative S-N data to be used for design of welded structures, where local fluctuating stresses were considered to pulsate downwards from tensile yield strength regardless of the applied stress ratio. It was also found that in the presence of a high tensile residual stress the grinding of the toe of welds which contain no undercut was not effective in improving the fatigue strength of welded joints.

Local approaches to fatigue assessment are used to predict the structural durability of welded joints, to optimise their design and to evaluate unforeseen joint failures. This standard work provides a systematic survey of the principles and practical applications of the various methods. It covers the hot spot structural stress approach to fatigue in general, the notch stress and notch strain approach to crack initiation and the fracture mechanics approach to crack propagation. Seam-welded and spot-welded joints in structural steels and aluminium alloys are also considered. This completely reworked second edition takes into account the tremendous progress in understanding and applying local approaches which has been achieved in the last decade. It is a standard reference for designers, structural analysts and testing engineers who are responsible for the fatigue-resistant in-service behaviour of welded structures. Completely reworked second edition of a standard work providing a systematic survey of the principles and practical applications of the various methods Covers the hot spot structural stress approach to fatigue in general, the notch stress and notch strain approach to crack initiation and the fracture mechanics approach to crack propagation. Written by a distinguished team of authors

The Influence of Residual Stresses on the Fatigue Strength of Welded Steel Structures

Stress Determination for Fatigue Analysis of Welded Components

IIW-2142-110

A Study of the Influence of Joint Geometry

Fatigue Design of Welded Joints and Components

Fatigue Design of Marine Structures provides students and professionals with a theoretical and practical background for fatigue design of marine structures including sailing ships, offshore structures for oil and gas production, and other welded structures subject to dynamic loading such as wind turbine structures. Industry expert Inge Lotsberg brings more than forty years of experience in design and standards-setting to this comprehensive guide to the basics of fatigue design of welded structures. Topics covered include laboratory testing, S-N data, different materials, different environments, stress concentrations, residual stresses, acceptance criteria, non-destructive testing, improvement methods, probability of failure, bolted connections, grouted connections, and fracture mechanics. Featuring twenty chapters, three hundred diagrams, forty-seven example calculations, and resources for further study, Fatigue Design of Marine Structures is intended as the complete reference work for study and practice.

This report provides background and guidance on the use of the structural hot spot stress approach to the fatigue design of welded components and structures. It complements the IIW recommendations for 'Fatigue Design of Welded Joints and Components' and extends the information provided in the IIW recommendations on 'Stress Determination for Fatigue Analysis of Welded Components'. This approach is applicable to cases of potential fatigue cracking from the

weld toe. It has been in use for many years in the context of tubular joints. The present report concentrates on its extension to structures fabricated from plates and non-tubular sections. Following an explanation of the structural hot spot stress, its definition and its relevance to fatigue, the authors describe methods for its determination. Stress determination from both finite element analysis and strain gauge measurements is considered. Parametric formulae for calculating stress increases due to misalignment and structural discontinuities are also presented. Special attention is paid to the use of finite element stress analysis and guidance is given on the choice of element type and size for use with either solid or shell elements. Design S-N curves for use with the structural hot spot stress are presented for a range of weld details. Finally, practical application of the recommendations is illustrated in two case studies involving the fatigue assessment of welded structures using the structural hot spot stress approach. Provides practical guidance on the application of the structural hot-spot stress approach Discusses stress determination from both finite element analysis and strain gauge measurements Practical application of the recommendations is illustrated in two case studies

The objective of the FATWELDHSS project was to study post-weld treatment techniques and their effect on the fatigue life of MAG welded attachments in High Strength Steel (HSS). Fatigue cracks in steel structures often occur at welded joints, where stress concentrations due to the joint geometry and tensile residual stresses are relatively high. Fatigue life improvement techniques, which rely on improving the stress field and/or the surface geometry around the welded joints, are generally known to be beneficial. Therefore, within the framework of this project, the following were examined: diode laser weld toe re-melting; High Frequency Mechanical Impact (HFMI) treatment; Low Transformation Temperature (LTT) filler wires Laser diode re-melting was used to improve the surface profile at the weld toe and thus reduce stress concentrations. HFMI treatment involving high frequency hammering of the weld toe is another technique that can produce a smooth weld toe profile but, more significantly, which also can introduce compressive residual stresses. Lastly, two new LTT filler wires were developed within the project as these can decrease or even remove tensile residual stresses resulting from weld zone shrinkage. An extensive fatigue testing programme was set up to establish the levels of improvement in the fatigue lives of the welded attachments achieved by application of the selected improvement techniques. Furthermore, two industrial demonstrators were selected that could show the project achievements in terms of facilitating the introduction of high strength steels by overcoming the limitations posed by the fatigue properties of the welded joints. In addition, modelling tools were developed to predict the residual stresses at the welded joint. Finally, practical guidelines were developed for enhancing the fatigue strength of HSS welded structures.

Fatigue strength of welded connections in round bar steel structures

Advanced Modelling of the Fatigue of Butt-welded Structures

IIW Guidelines on Weld Quality in Relationship to Fatigue Strength

One of a Series of Articles on the Application of Welding ...

Fatigue strength of welded ship structures