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A REVIEW ON FILLET WELDED JOINTS

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***Abstract*: Several approaches exist for the fatigue strength assessment of welded joints. In addition to the traditional nominal stress approach, various approaches were developed using a local stress as fatigue parameter. Increasing the life cycle of welded joint is now a day's main concern of research. Many researchers have done different work and also developed different methods to measure the strength of welded joints. So, it is necessary to review welded joints parameters and methods. Here in this work review on different parameters of welded joint was reviewed and also concern about the methods used for detecting the life of the components.**

***Keywords*: Welding, joints, methods, process parameters and review**

1. Introduction

A weld is a homogeneous bond between two or more pieces of metal, where the strength of the welded joint exceeds the strength of the base pieces of metal. At the simplest level, welding involves the use of four components: the metals, a heat source, filler metal, and some kind of shield from the air. The metals are heated to their melting point while being shielded from the air, and then a filler metal is added to the heated area to produce a single piece of metal. It can be performed with or without filler metal and with or without pressure. There are several types of welding that are used today. Gas Metal Arc Welding (GMAW) or MIG, Gas Tungsten Arc Welding (GTAW) or TIG, Flux Core Arc Welding, and Stick Welding are the most common found types in industrial environments. Welding is distinct from lower temperature metal-joining techniques such as brazing and soldering, which do not melt the base metal. In addition to melting the base metal, a filler material is typically added to the joint to form a pool of molten material (the weld pool) that cools to form a joint that, based on weld configuration (butt, full penetration, fillet, etc.), can be stronger than the base material (parent metal). An intermittent fillet weld is one that is not continuous across a joint. These welds are portrayed as a set of two numbers to the right of the triangle instead of just one. The first number as mentioned earlier refers to the length of the weld. The second number, separated from the first by a "-", refers to the pitch. The pitch is a measurement from midpoint to midpoint of the intermittent welds. Intermittent welding is used when either a continuous weld is not necessary, or when a continuous weld threatens the joint by warping. In some cases intermittent welds are staggered on both sides of the joint. In this case, the notation of the two triangles aren't directly on top of each other. Instead, the side of the joint to receive the first weld will have a triangle further to the left than the following side's triangle notation.

2. Design of fillet weld

Fillet welds are broadly classified into side fillets and end fillets. When a connection with end fillet is loaded in tension, the weld develops high strength and the stress developed in the weld is equal to the value of the weld metal. But the ductility is minimal. On the other hand, when a specimen with side weld is loaded, the load axis is parallel to the weld axis. The weld is subjected to shear and the weld shear strength is limited to just about half the weld metal tensile strength. But ductility is considerably improved. For intermediate weld positions, the value of strength and ductility show intermediate values. In many cases, it is possible to use the simplified approach of average stresses in the weld throat. In order to apply this method, it is important to establish equilibrium with the applied load. Studies conducted on fillet welds have shown that the fillet weld shape is very important for end fillet welds.

3. Existing work

Many of the researchers have optimized the different process parameters of welding and fillet making preparation. Some of the previous work is concluded here.

Li et.al (2018) This paper studies under traffic loads, orthotropic steel bridge slabs suffer from an obvious fatigue problem. In particular, fatigue cracking of diaphragms seriously affects application and development of orthotropic bridge slabs. In the paper, based on cracking status quo of an orthotropic deck diaphragm of a large-span bridge, experimental tests were formulated to test stress distribution states of the diaphragm. **Pradana et.al (2017)** This paper presents two simplified procedures for the calculation of the Effective Notch Stress (ENS) on non-overlapping circular hollow section (CHS) K-joints. The proposed procedures aim to alleviate the modelling challenges associated with the traditional ENS calculation on joints with complex geometry, such as the CHS joints. **Shen et.al (2017)** This paper puts forward a kind of calculation method of estimating fatigue crack initiation life by considering welding residual stresses as initial stresses. The numerical method could be used to quantitatively analyse the influence of residual stresses on the cumulative fatigue damage. In order to gain the distribution of weld-induced residual stresses, the FE analyses as well as measurements were carried out. Based on critical plane approach, analysis of damage parameters was performed considering both welding residual stress and biaxial loads. **Vodzyk et.al (2016)** In this paper welded joints are subjected to cyclic operational conditions tend to fail due to fatigue failure. This type of failure can occur at a stress level below the yield strength of the material. Design to resist such failures and the early detection of the internal flaws are the basic components of the damage tolerance design philosophy, which have significant impact in terms of saving time, money and people's lives. **Yamada et.al (2015)** In this analysis, over 150,000 highway bridges exist in Japan and about 47 percent of the bridges will be over 50 years old in 2026.

The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) launched nation-wide projects to inspect and to establish maintenance plans. About one half of the highway bridges were steel bridges with concrete slabs. Due to heavy truck traffics being operated in or between industrial cities, some of which were illegally overloaded, severe deteriorations to concrete slabs and fatigue cracks in steel girders have been observed. Fatigue cracks in orthotropic steel decks were also found.

Rong et.al (2014) In the given review the orthotropic steel decks are used in beams and cable-supported bridges. Fatigue cracks of the vertical rib–deck welded joint have been found in some of the bridges. In this paper, the structural hot spot stress (SHSS) approach is applied to evaluate the rib–deck fatigue. Refined solid models are built using a multi-sub-model technique. Stress around the weld tip is analysed and effects of the weld profile, the weld toe radius and mesh size are discussed. The SHSS is analysed using the surface stress extrapolation method, the stress linearization method and the 1 mm stress method. **Tecchio et.al (2012)** This paper analyses the effect of fatigue is particularly relevant in steel bridges since the influence of traffic load cycles on serviceability limit stress values is very high if compared to relatively low dead weights. Orthotropic steel decks, directly subjected to traffic loads, are very sensitive to fatigue: in most cases, fatigue defects appear as cracks in the top plates, longitudinal ribs and the bracing of the deck. In this paper the case study of a 20 years old box girder bridge affected by fatigue problems is presented: the bridge has an orthotropic steel deck with three spans whose total length is 152m. **Meneghetti et.al (2012)** This paper deals with the local approach based on the Notch Stress Intensity Factors (NSIFs) to analyse the fatigue behaviour of welded joints. In transverse load carrying fillet-welded joints, failure may occur either at the toe or at the root, depending on the geometry. At the toe, due to the flank angles that are usually encountered in practice, mode I local stresses are singular, while mode II stresses are not. **Aygul et.al (2012)** In this analyses the fatigue life estimation of orthotropic steel bridge decks using the finite element method is most frequently associated with the application of the structural hot spot stress approach or the effective notch stress approach, rather than the traditional nominal stress approach.

Sim et.al (2012) This paper is about fatigue tests of full-scale orthotropic steel decks that were recently conducted to evaluate the fatigue performance of rib-to-deck partial joint-Penetration (PJP) groove welded joints. The test results indicated that rib-to-deck joints are more prone to fatigue cracks in the deck plate than in the rib wall. A shallower weld penetration (for example, an 80% PJP) also appeared to have a slightly higher fatigue resistance than a deeper one (for example, a 100% weld penetration). **Saiprasertkit et.al (2011)** This paper deals between base metal and weld deposit were studied. Low and high cycle fatigue tests were performed on specimens with five matching conditions and two sizes of incomplete penetration. Observation of the specimens revealed that crack propagation paths differ by low and high cycle loading conditions and that failure life was dominated by crack propagation. **Alam et.al (2009)** In this paper a simplified fatigue and fracture mechanics based assessment methods are widely used by the industry to determine the structural integrity significance of postulated cracks, manufacturing flaws, service-induced cracking or suspected degradation of engineering components under normal and abnormal service loads. **Sonsino et.al (2009)** In this analysis the structural durability of welded structures is determined by the interaction of different influencing parameters such as loading mode, spectrum shape, residual stresses and weld geometry among others. Examples from plant, offshore, transportation and automotive engineering show how these parameters influence the fatigue life and to what extent they are considered in design codes. **Baik et.al (2008)** In this analysis fatigue tests have been carried out on three types of non-load-carrying fillet welded joint subjected plate bending, such as single-side fillet welded joint, T-shaped fillet welded joint and cruciform fillet welded joint. Fatigue failure of each welded joint has been demonstrated. The test results show that fatigue crack forms flat semi-ellipse during crack propagation and propagates to about 80% of plate thickness before failure.

Gustafsson et.al (2006) In the present paper it is well known that the fatigue strength of welded joints decreases when plate thickness increases. This decrease in fatigue strength is known as the thickness effect. In many standards for fatigue design the thickness effect is taken into account for joints with plate thickness typically greater than 25 mm. Previous work has mainly been focused on joints with plate thickness between 12-200 mm. Less attention has been paid to thinner joints. Published investigations on joints with sheet thickness 2-12 mm show an increase of fatigue strength with decreasing sheet thickness. **Connor et.al (2006)** In the present review, the current fatigue design provisions the Bridge Design Specifications identify and classify the rib-to-web (rib-to-diaphragm) connections commonly utilized in steel orthotropic bridge decks where cut outs are used. The fatigue resistance of these details has been established through full-scale laboratory testing. This paper examines how the fatigue stress range was defined and determined during the testing which established the fatigue resistance of the details. **Huo et.al (2005)** This paper improves the fatigue performance of welded joints and structures significantly. This has been verified by many constant amplitude fatigue tests. However, there is the need to check their benefits for structures subjected to variable-amplitude loading. Therefore, fatigue tests were performed on fillet welded joints in 16Mn steel for three different conditions: as-welded, TIG dressed and after treatment by ultrasonic peening. **Livieri et.al (2005)** This paper studies the weld bead geometry cannot, by its nature, be precisely defined. Parameters such as bead shape and toe radius vary from joint to joint even in well-controlled manufacturing operations. In the present paper the weld toe region is modelled as a sharp, zero radius, V-shaped notch and the intensity of asymptotic stress distributions obeying Williams' solution are quantified by means of the Notch Stress Intensity Factors (NSIFs). **Atzori et.al (2002)** In the present paper decreasing the notch root ρ the theoretical stress concentration factor Kt increases and the fatigue limit of a notched component decreases. Below a given critical value for ρ, the fatigue limit is no longer controlled by Kt and the notch behaves like a crack of equal depth. In the welded joints the conventional welding procedures result in a small value of the weld toe and the weld root radius.

Taylor et.al (2002) This paper is concerned with the prediction of high-cycle fatigue behaviour in welded joints. Recently, we have developed some new approaches for predicting the effects of notches and other stress concentrations which have been successfully applied to solid parts, using stress data obtained from FEA. In the present work we consider the extension of the same theories to cover welded joints. Two basic constants are needed to characterise fatigue in the weld equivalent to the plain fatigue limit and crack propagation threshold in conventional materials. These parameters were obtained experimentally and used to predict test results for two different joint geometries: a T-shaped fillet weld and a butt weld. **Roy et.al (2001)** In this analysis enhancement in fatigue performance of welded joints by Ultrasonic Impact Treatment (UIT) was evaluated with large-scale rolled beam and built-up specimens having yield strength of 345 to 760 MPa. Eighteen rolled-beam specimens having welded details at cover plates and transverse stiffeners and eight built-up specimens having only transverse stiffener details were fatigue tested after treating the weld details by UIT. **Dong et.al (2001)** In this analysis a mesh-size insensitive structural stress definition is presented. The structural stress definition is consistent with elementary structural mechanics theory and provides an effective measure of a stress state that pertains to fatigue behaviour of welded joints in the form of both membrane and bending components. Numerical procedures for both solid models and shell or plate element models are presented to demonstrate the mesh-size insensitivity in extracting the structural stress parameter. Conventional finite element models can be directly used with the structural stress calculation as a post-processing procedure. **Dimitrakis et.al (2001)** This paper analyses both the experimental results and the analytical predictions of this study confirm that the poor fatigue performance of weldments with longitudinal attachments is due to poor weld quality which in turn leads to either a cold-lap or a very small weld toe radius. As well as to the combination of a very high 3-D stress concentration, and very high tensile residual stresses. **Haagensen et.al (1998)** This paper summarizes fatigue test on high strength steel specimens in the as-welded condition and specimens treated by ultrasonic impact treatment, TIG dressing and a combination of TIG dressing and ultrasonic impact treatment. Single lap joint specimens in 6 mm aluminium plate material were tested in the as-welded, hammer peened, needle peened and ground condition. **Wright et.al (1996)** This report is a follow up to demonstration of a new ultrasonic hammer peening technique (Ultrasonic Impact Treatment – UIT) held at the Federal Highway Administration's as some of the fillet welds on a welded plate girder in the laboratory with the ultrasonic equipment. Following treatment, fatigue test specimens were cut from the plate girder to study the fatigue behaviour of both treated and untreated weldments. Results indicate that the fatigue performance of the weldments was improved following the UIT treatment. **Vosikovsky et.al (1979)** In the present review, the effects of stress ratio on fatigue crack growth thresholds and low and intermediate fatigue crack growth r8tes are examined on steels with ferrite-pearlite and tempered martensite microstructure, tested in air.

Conclusion

Through literature survey it is found that the performance of welded joint depends on different parameters. It is found that performance of welding joints depends on different electrical parameters used during welding, fillet profiles make before doing weld, welding types and many other. When cyclic load is applied on the joint, the performance of joint degrades rapidly. So, it is necessary to review the welding process and different parameters on which its strength depends.

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