BRITTLE FRACTURE BEHAVIOR OF WELDED WIDE PLATE WITH NON-CONTINUOUS STIFFNERS

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ABSTRACT

The purpose of this study was to assess the characteristics of the initiation of brittle fracture of welded joints used in high performance structures. Three types of the welded wide plate tests have been carried out and the brittle fracture transition temperature of the weldment of two kinds of structural steel(A131 and A537) were obtained. A preliminary study was made on the brittle fracture behavior of flawed welded joints with structurally stress concentration.

KEYWORDS

Brittle fracture, welded joint, wide plate test, stress concentration

INTRODUCTION

Welded joints used in high performance structures are subjected to severe working condition. Besides the structural high stress concentration, There is a strong possibility of superposition of various fracture parameters such as welding residual stress, weld defects, etc.. It may be more important to prevent the brittle fracture of welded joint for safty of welded structures

In order to avoid brittle fracture of a welded joint, it is necessary to select materials with adequate toughness for the operating conditions and examine all regions of a welded joint to determine the worst risk(Harrison, 1973). In general, the notched bar impact test used in toughness investigations can only be used to classify materials according to their impact energy when applying standard test conditions. However, the test is not suitable for defining material or component bahaviour under service conditions. Taking into cosideration such circumstances, in the present study three types of the welded wide plate tensile tests were carried out not only in order to determine the brittle fracture characteristics of the actual structural element but also to investigate a method for fracture assessment of welded joints in the structurally stress concentration regions

WELDED WIDE PLATE TEST PROCEDURE

The material for tests was 20mm thick structural steels of ASTM A131 and ASTM A537. Welding was by manual arc and butt joints were made. The mechanical properties of the material are given in Table 1 .

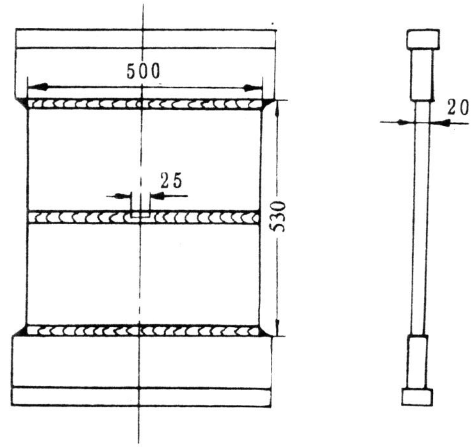
Table 1 Mechanical properties

Materials	Mechanical properties				
	σ_s (MPa)	σ_b (MPa)	ε_s ($\mu\varepsilon$)	φ(%)	δ(%)
A537–P.M	387.0	523.5	1880	74.9	26.0
A131–P.M	280.4	417.9	1362	78.3	29.0
A537–Joint	373.5	555.8	1815	67.8	29.3
A131–Joint	329.2	472.2	1660	74.1	34.6
A537–W.M	468.0	532.2		77.43	18.35
A131–W.M	468.0	526.4		77.43	18.31

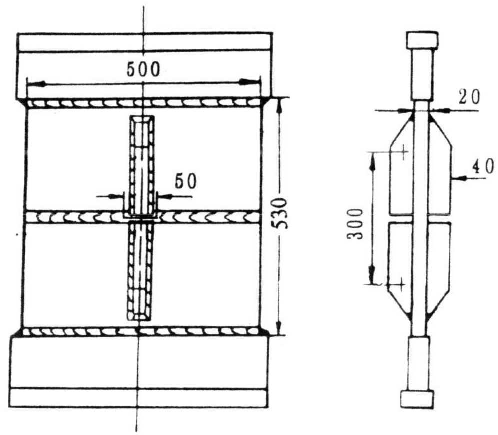
P.M–parent material W.M–weld metal

Fig. 1. indicates three types of welded wide plate tension test specimens. Fig. 1.(a) shows a standard welded wide plate test specimen with central through thickness defect. Fig. 1.(b) is a welded wide plate with a doubling vertical stiffner on both sides that are not continuous in the middle of the specimen. A notch is machined in the center of a non–continuous part. Type C specimen is base on the type B model in which a doubling transverse stiffener on both sides is introduced. Type B and C model specimen were used to examine the influence of stress concentration, residual stress and weld defect on the brittle fracture of welded structure.

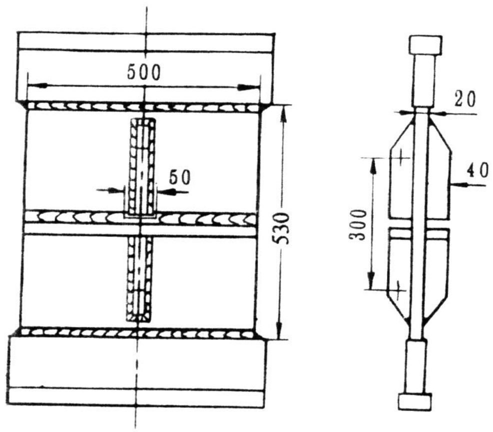
The tests were carried out with an axial–force load on a 12MN capacity tensile machine. During the tests, temperature was measured by a thermocouple situated at the mid–thickness of the plate. Tensile force and elongation and crack openning displacement(COD) were recorded. Extension strains to fracture were measured.



(a) Type A



(b) Type B



(c) Type C

Fig. 1. Welded wide plate test specimens.

TEST RESULS AND DISCUTIONS

The shape of the tensile test records conformed to the three cases is shown in Fig. 2. In the case of as–welded specimens, fracture strengths are of primary interest, and there are plotted against testing temperature in Fig. 3. The extensions trains to fracture have been plotted in Fig. 4. against temperature. The results of COD to fracture at different temperatures are shown in Fig. 5.

From the comparision of stress and strains to fracture for each test model, we can see that the temperature dependence of stress and strains to frature is shown elastic to plastic transition behavior, but there is a difference between the stress and strains to fracture transition temperature. Having the same weld metal for WWP specimens of A131 and A537, the stress to fracture transition temperature exhibited similar behavious. Owing to the different of overall ductility of A131 and A537 steels, the strain to fracture transition temperature for WWP of A537 steel is about 20 ° C higher than that of A131 steel. Due to the effect of stiffner and crack size the transition temperature of stress to fracture for type A model is about 30 ° C lower than that of type B and C. It is difficult to determine the transition temperature of elastic to plastic fracture in accordance with transition curve of stress or strain to fracture. On the other hand, in Fig. 5. the transition temperature of COD to fracture for all

WWP tests follows the same curve at different temperature. The transition temperature range is about −65 to −40 ° C. It is well known that a COD value corresponds to local material toghness. Thus, COD transition curve is more reasonable for design purpose than others.

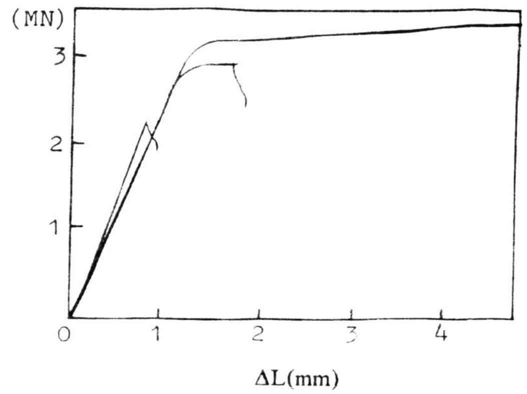


Fig. 2. Load and deformation.

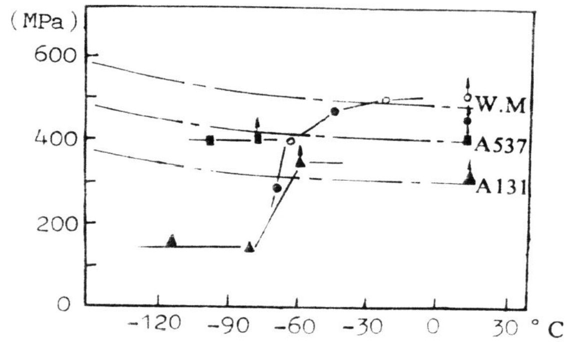


Fig. 3. Fracture stress and temperature.

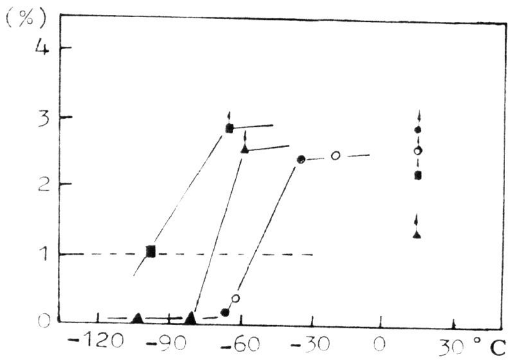
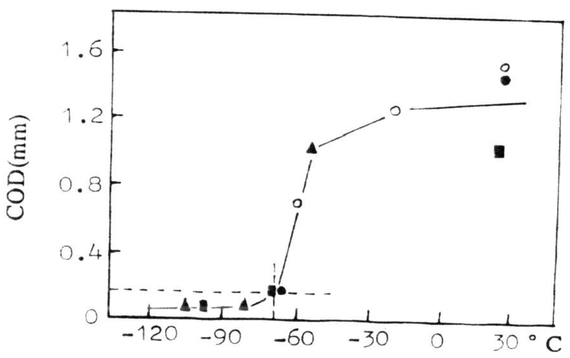


Fig. 4. Plastic deformation and temperature.



■-A131-A ●-A537-B ▲-A131-B ○-A537-C

Fig. 5. Critical COD and temperature.

In any welded joint it is unlikely that the properties of the weld metal will be exactly the same as those of the parant material. The two properties which dominate the performance of the joint will be the yield strength and fracture toughness of the

weld metal as compared to the parent material. The protection that a weld metal obtains by the fact that it usually overmatches the parent plate in yield strengh is well known. At a given applied stress level, an overmatching weld metal will be working at a lower value of the ratio applied to yield stress than the parent material. This means that the COD actually achieved in the overmatching weld metal will be lower than the parent material or undermaching weld metal. In this study the welded joint of A131 and A537 have the same overmaching weld metal, where the ratio of weld to parent yield stress are 1.67(A131) and 1.19(A537) respectively.

The test results show that because of the influence of stress concentration the crack in type B and C of WWP tension test opens more widely than that in a flat plate. Some related studies show that the COD behaviours in type B and C of WWP is closely approximated to those at the stress concentration region of welded structures. Thus it is feasible for assessing the fracture of welded joints with structurally stress concentration although such tests are very costly. The results show that the gross strain exceeds 2% for WWP specimens with size 50mm at a temperature of −40 °C and the COD values also indicate the high deformation capability of the weld metal.

CONCLUSIONS

It is concluded that the tension test of welded wide plate with non–continous stiffners is effective for assessing the brittle fracture of joints used in high performance structures. The effects of defect size, stress concentration and temperature on the fracture strength of welded joint are obtained by means of these tests. The results show that the COD transiton temperature curve is reasonable for design purpose.

REFERENCES

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