PREDICTION OF FATIGUE LIFE IN FILLET WELDED JOINTS INCLUDING GEOMETRY EFFECTS

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INTRODUCTION

Fatigue life in welded joints is dependent on geometry effects. The existing fatigue design curves in welded joints do not take into account this effect and therefore very conservative results can be obtained when design data for bigger thicknesses is used (1,2,3).

The purpose of this work is to assess the fatigue behaviour of non-load carrying cruciform joints in terms of thickness, loading mode and weld shape. The emphasis of the results is in the low to intermediate thickness range in order to draw more definite conclusions about any improvement in fatigue life to be incorporated in the design codes.

RESULTS

The prediction of fatigue life was made using Paris law. The appropriate stress intensity factor solutions were obtained using either the weight function method or the J-integral formulation. A comparison of the results obtained by these two methods was carried out, which revealed that for cracks propagating from the weld toe and through the plate thickness the weight function method is sufficiently accurate for an adequate determination of the stress intensity.

Semi-elliptical cracks were assumed in the calculation taking the crack-aspect ratio values obtained in the experimental results in the fatigue tests carried out in these types of joints. The stresses and displacements at the crack propagation line were calculated with a 2DFE isoparametric program. Figs. 1 a), b) show the basic mesh type and the geometrical variables studied in this work.

The equation for stress intensity was the Raju and Newman formulation for semi-elliptical cracks with correction factors for the proximity of the crack at the free surface to the thickness and width directions. Monitoring of crack shape and growth was done in some specimens using an ACPD technique. The experimental and predicted crack-aspect ratios along the plate thickness were compared as were the experimental and predicted curves of crack length against number of cycles; good agreement was obtained.

The size effect was taken into account by the parameter ℓ/B (toe to toe

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distance over the main plate thickness) and also by the thickness. The weld shape was quantified by the radius of curvature at the weld toe, ρ. Four values of ρ/B were assumed in the analysis: 0, 1/12, 3/12 and the semicircular contour.

The theoretical results showed that for ρ/B values less than 3/12 both for bending and tension in the main plate the fatigue strength decreased with increasing values of ℓ/B up to a value of ℓ/B close to 1.2. For greater ℓ/B values the the fatigue strength is independent of ℓ/B. However when the weld contour is semi-circular, fatigue strength does not depend on ℓ/B at least for the range of values studied in this investigation. A similar trend was obtained when the main plate thickness was increased keeping the ℓ/B value constant. The fatigue strength increased with increasing values of the ratio ρ/B, but this effect was more pronounced for thickness values below 12 mm.

Fatigue tests were carried out on fillet welded specimens in bending and tension with main plate thickness values of 4, 6, 12 and 20 mm. Some of the S-N curves are plotted in Fig.2 and good agreement can be observed between the experimental and predicted results. It is also seen that fatigue strength is lower in tension than in bending and decreases when the main plate thickness increases.

REFERENCES

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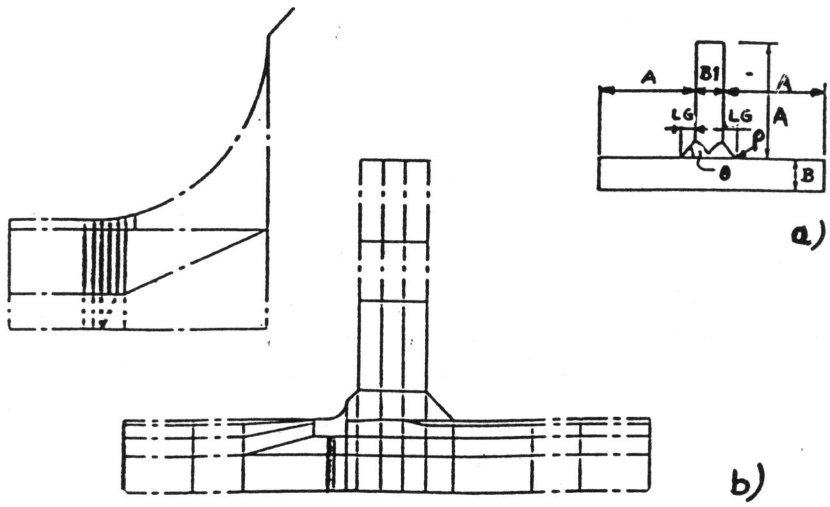

Figure 1-a) Geometrical variables of the welded joint; b) FE mesh type.

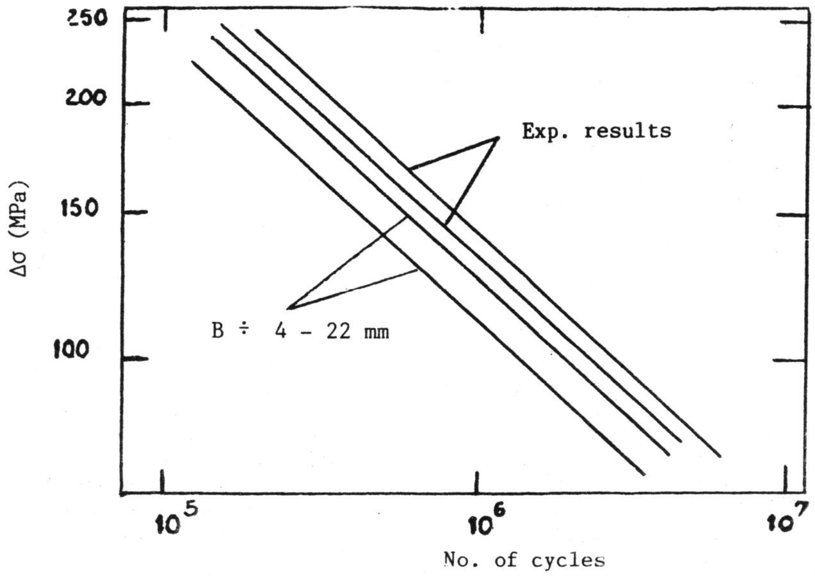

Figure 2 - Typical S-N curves showing influence of loading mode and thickness. a_i = 0.15 mm. ρ = 2 mm.