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Fatigue strength of transverse butt welds in steel plate under axial loading

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THE PREPARATION OF THIS DATA ITEM

The work on this particular Data Item was monitored and guided by the Stress Analysis and Strength of Components Committee. This Committee first met in 1964 and now has the following membership:

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Dr J. Spence	—	University of Strathclyde
Prof. C.E. Turner	—	Imperial College of Science and Technology.

The construction and subsequent development of the Data Item was undertaken by

Mr R.P. Sharp	—	Engineer.

The person with overall responsibility for the work in this subject area is Mr M.E. Grayley, Head of Strength Analysis Group.

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FATIGUE STRENGTH OF TRANSVERSE BUTT WELDS IN STEEL PLATE UNDER AXIAL LOADING

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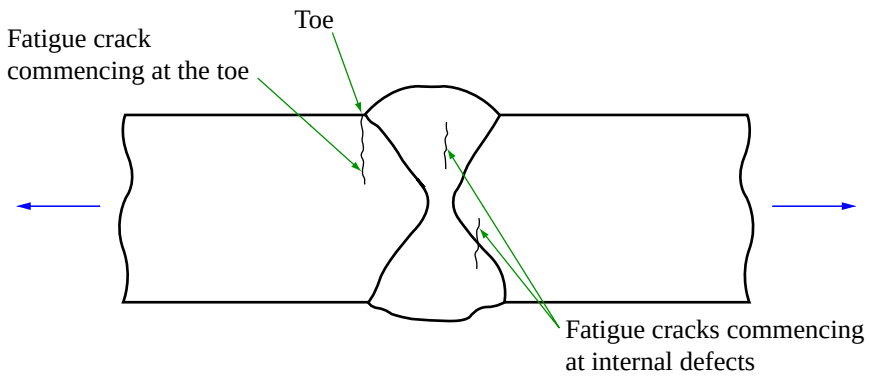
1. NOTATION

N	endurance		
R	stress ratio $= \dfrac{S_m - S_a}{S_m + S_a} = S_{min}/S_{max}$		
S_a	alternating stress (half range) in loaded plate	N/m^2	lbf/in^2
S_m	mean stress in loaded plate	N/m^2	lbf/in^2
S_{min}	minimum stress in loaded plate	N/m^2	lbf/in^2
S_{max}	maximum stress in loaded plate	N/m^2	lbf/in^2

Both SI and British units are quoted.

2. NOTES

This Item provides data on the as-welded fatigue strength of transverse butt welds in steel plate under axial loading. The type of joint for which data are presented is illustrated in Sketch 2.1.



Sketch 2.1 Transverse butt weld showing types of failure

The joints were manufactured from plates between 6 mm and 50 mm thick prepared prior to welding with either square, single or double V or U weld preparation, as illustrated in Sketch 2.2, and welded from both sides. (Sealing runs were used in the case of single V or U weld preparation.) The welding methods employed were either submerged arc welding or arc welding with flux covered electrodes. Root runs were

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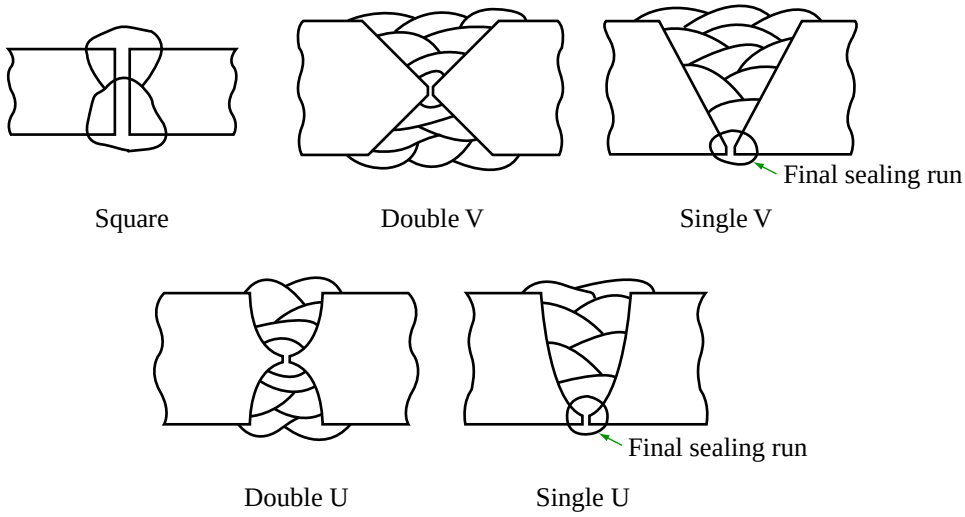
backchipped except where backchipping was purposely incomplete to produce specific defect types and sizes that may arise from poor welding techniques that can occur in ordinary production. There was insufficient information to assess the effects of backchipping.



Sketch 2.2 Showing the types of weld preparation used for transverse butt joints

Failure may occur by the initiation and propagation of fatigue cracks from either the transition region at the toe of the weld bead or from weld defects arising from the welding process. Data for toe failures relate to specimens in the as-welded condition with the weld reinforcement intact and data for weld defect failures relate to specimens in the as-welded condition with the weld reinforcement either intact or machined flush to the plate surface.

Data for welds failing from the weld toe are given in Figures 1 and 2 and relate to tests carried out with fully tensile loading cycles and zero mean stress respectively. Figure 3 gives data for fatigue failures that started at weld defects. The distribution of the data in Figure 1 about the mean strength line was found to be sensibly Normal and statistical analysis has led to the confidence limits shown on the figure. The inner limits give bounds within which there is 95 per cent confidence that 95 per cent of the population will fall and the outer limits give bounds within which there is 99 per cent confidence that 99 per cent of the population will fall. These lines are also shown in Figures 2 and 3 for the purpose of comparison. The data in Figure 3 were not analysed statistically as, due to the large number of factors affecting fatigue strength, the distribution of data follows no acceptable form for analysis but it can be seen that the scatter is within the same range as the data in Figure 1. Figure 4 shows the reduction in fatigue strength with reduction in cross-sectional area due to various types of weld defect.

3. FACTORS AFFECTING THE FATIGUE STRENGTH

This section discusses the effects of residual stress, mean stress, joint size, weld bead shape and weld defects on the fatigue performance of the type of joint for which data are provided.

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