

FATIGUE STRENGTH OF TRANSVERSE FILLET WELDED JOINTS AND ATTACHMENTS IN STEELS UNDER BENDING LOADING

1. NOTATION

b	depth of penetration at weld root (see Sketches 3.1a to 3.1e)	m	in
N	endurance (number of load cycles)		
P	load applied to joint (see Sketch 2.1)	N	lbf
R	stress ratio = S_{min}/S_{max}		
S_a	nominal alternating extreme fibre stress (half range) in loaded plate	N/m ²	lbf/in ²
S_m	mean extreme fibre stress in loaded plate	N/m ²	lbf/in ²
S_{max}	nominal maximum extreme fibre stress in loaded plate	N/m ²	lbf/in ²
S_{min}	nominal minimum extreme fibre stress in loaded plate	N/m ²	lbf/in ²
s	weld leg length on loaded plate (see Sketches 3.1a to 3.1e)	m	in
t	nominal thickness of plate (see Sketches 3.1a to 3.1e)	m	in

Both SI and British units are quoted.

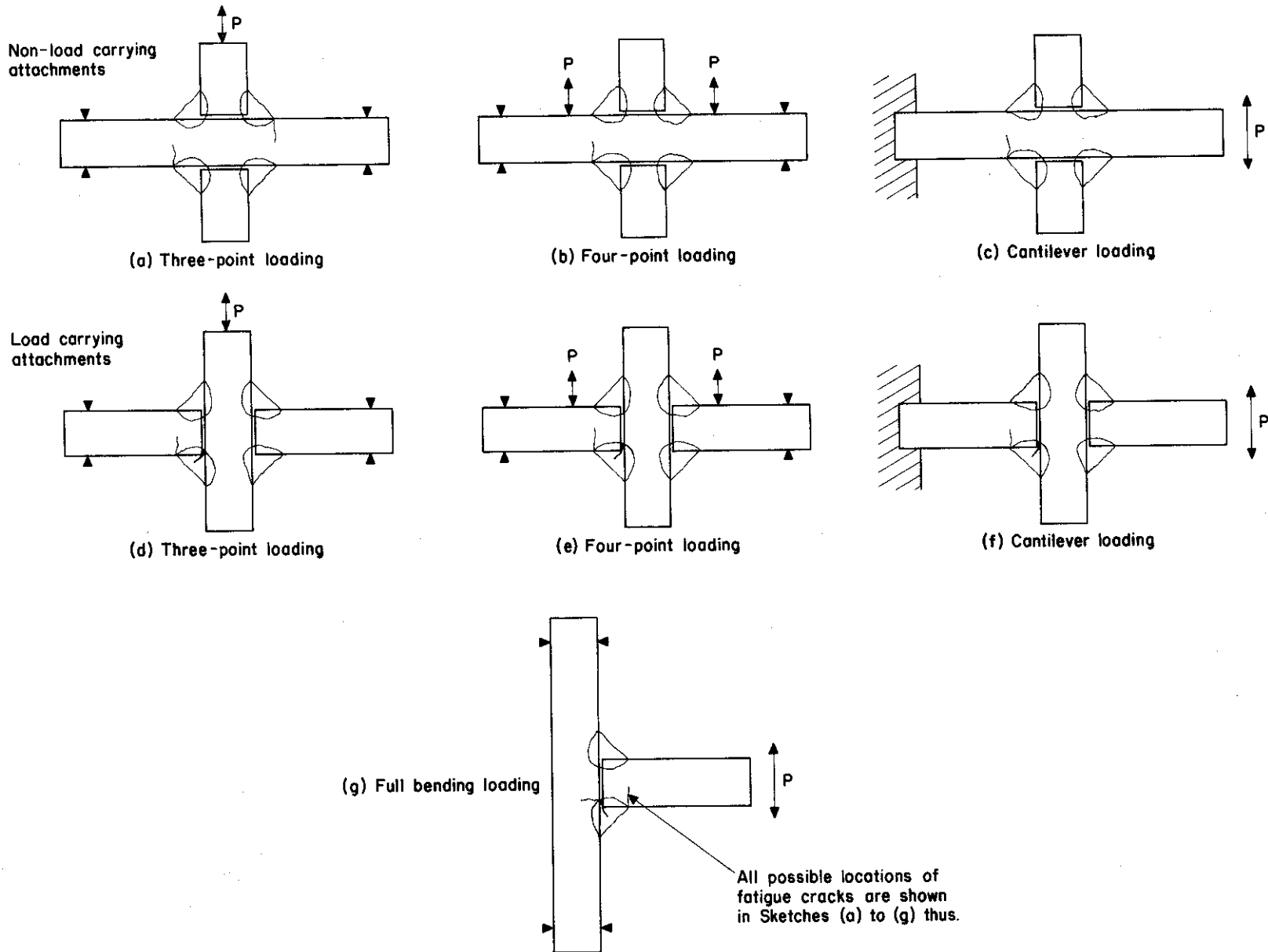
2. PRESENTATION OF DATA

This Item provides data on the as-welded and ground fatigue strength of transverse fillet welded joints and attachments in flat steel plate subjected to bending. The data are based upon the nominal extreme fibre stress range in the plane of the weld toe in the loaded plate, that is the plate(s) that experiences the bending moment.

The Item gives data for joints failing from the weld toe by initiation of fatigue cracks at small defects in the transition region between plate and weld materials and the subsequent propagation of these cracks through the loaded plate transverse to the direction of stress. The data are for both non-load-carrying and load-carrying joints, that is joints failing through the continuous plate or the attachment respectively. For joints in which failure commenced from locations other than the weld toe, for example non-load-carrying welds failing from the crack-like defect caused by unfused land through the weld throat, the nominal extreme fibre stress range at the weld toe was also used in presenting the data, irrespective of where the failure commenced.

This Item provides data on joints and attachments of the types shown schematically in Sketch 2.1. The sketch shows both the attachments and continuous plates as being of the same thickness and this was the case for the majority of joints tested. The remainder of the data was for cases in which the attachment was thinner than the continuous plate. Attachments in some non-load-carrying joints were on one side of the continuous plate only and in a few cases more than one attachment was welded to one side of the continuous plate.

Issued October 1978
With Amendment A, February 1982



Sketch 2.1 Illustrating the types of joint covered by this Item

Figure 1 gives data for toe failures in all the joints shown in Sketch 2.1. The data are split into three groups corresponding to plate thicknesses of 10 to 19 mm, 20 to 29 mm, and 30 to 39 mm. A family of lines is drawn through these data for various plate thicknesses. For cases of toe failure no significant difference between data for non-load-carrying and load-carrying welds was found. Figure 2 shows the relationship between the parameters $2s/t$, $2b/t$ and the location of failure. Figure 3 gives data obtained under four-point bending load for joints having the weld toes ground. Figure 4 gives a comparison of data for joints under bending loading and data for similar joints under axial loading. This figure covers both toe and root failures.

3. FACTORS AFFECTING FATIGUE STRENGTH

This section discusses the effects of residual stress and mean stress, joint size, weld leg length, depth of penetration and of grinding the weld on the fatigue performance of the types of joint for which data are presented.

3.1 Residual Stress and Mean Stress

The as-welded fatigue strength of welded joints is usually independent of the applied mean stress. This is because as-welded joints contain a highly localised system of residual stresses, which result from the constraints applied during cooling of the weld, and the high stress concentration that exists at the toe of the weld.

These residual stresses will be tensile in the toe region of the plate surface and compressive in the centre of the plate. If these stresses are such that the applied stresses cause yielding at the weld toe then the actual stress experienced by the material at the toe of the weld bead will vary from the yield stress to the yield stress less the stress range, see Item No. 75016. Thus, application of high alternating and/or mean stress, magnified by the stress concentration at the toe of the weld bead and any residual stress, will give a yield limited condition. However, if the mean stress and stress range are low, or if the stress concentration is low, this yield limited condition may not apply. In the absence of positive assurance that the residual stresses and/or the stress concentration at the toe are insufficient to cause yielding it ought to be assumed that this yield limited condition prevails.

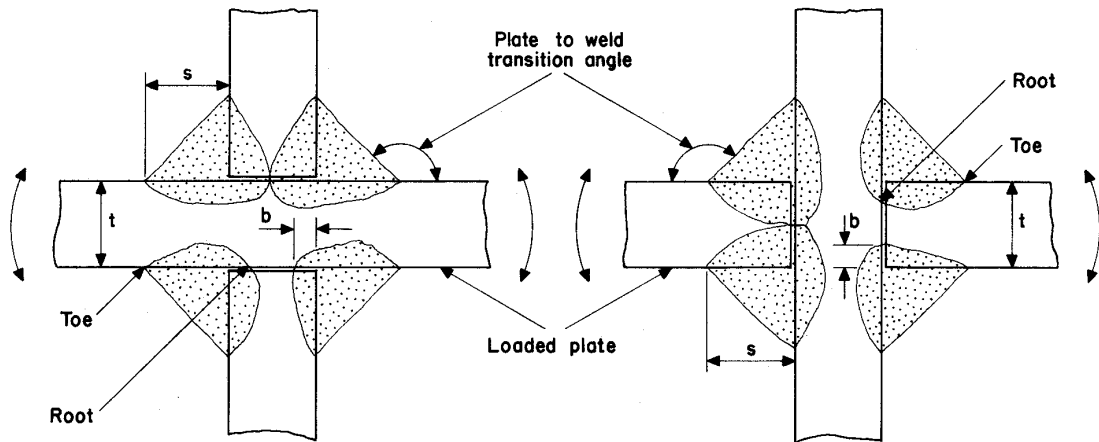
In thin plates, say less than 10 mm thick, the temperature in the plate during welding may be reasonably uniform through the plate thickness and the resulting residual stresses in the direction of loading are likely to be small (although in a wide plate the stress along the weld may be high). In thicker plates the temperature differences through the thickness will be more pronounced leading to higher residual stresses in the region of the weld. (A similar effect occurs if the plate is wide, that is if the length of the weld is long, as a result of lateral strain setting up a complementary strain across the joint.)

3.2 Joint Size

Size effect is shown in Figure 1 by a series of curves plotted on the data for toe failures identified by plate thickness, that is thicknesses from 10 to 19 mm, 20 to 29 mm and 30 to 39 mm. These lines were derived in Reference 12 from the derivations given in Section 4. Size effect can also be seen in the data for joints having the weld toes ground, see Figure 3. Size effect is thought to be largely due to four factors; residual stress, stress gradient, statistical probability of defects and stress concentration effects.

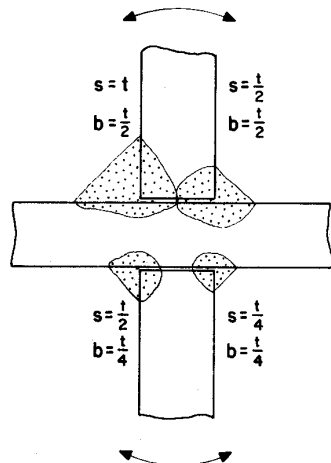
3.2.1 Residual stress in relation to size

The magnitude of residual stresses in welded joints is dependent upon joint size, see Section 3.1; therefore it would be expected that large joints exhibit a low fatigue strength and show no variations in fatigue strength with change in mean stress whereas thinner joints exhibit a higher fatigue strength and show mean stress effects, especially at the lower stress ranges.

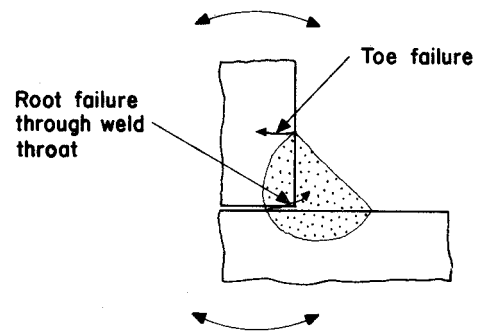


Sketch 3.1a Non-load-carrying transverse fillet welded joint showing basic notation

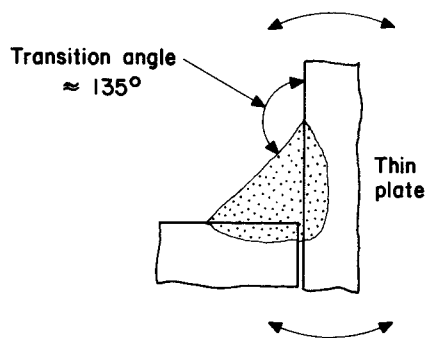
Sketch 3.1b Load-carrying transverse fillet welded joint showing basic notation



Sketch 3.1c Partial and full penetration welds in load-carrying transverse fillet welded joints. Notation as in Sketches 2.2a and 2.2b



Sketch 3.1d Illustrating the two basic modes of failure found in load-carrying transverse fillet welded joints under bending loading



Sketch 3.1e Showing the change in transition angle likely to occur in full penetration non-load-carrying welds as plate thickness is increased (Section 3.2.4)

