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Critical Size of Fillet Welds in High Strength Steel Joints

Taille critique des cordons d'angle dans les joints en acier à haute résistance

Kritische Grösse von Kehlnähten bei Verbindungen aus hochfestem Stahl

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SUMMARY
Joints built up with fillet welds and submitted to fatigue can fail either by plate fracture or by weld fracture. The first mode gives higher fatigue resistance. It takes place with welds bigger than a "critical size". Tests on high strength steels indicate that, for longitudinal welds, the statical calculation is always safe, while for transverse welds, the initial size is found to be higher than for mild steel.

RESUME
Les joints soudés par cordons d'angle sollicités en fatigue peuvent se rompre soit dans les plats assemblés, soit dans les cordons de soudure. Le premier mode donne des résistances plus élevées. Il est obtenu pour des dimensions de cordon supérieures à une "taille critique". Dans les aciers à haute limite élastique, le calcul statique du cordon donne des dimensions supérieures à cette taille critique, pour les joints longitudinaux; dans les joints transversaux, la taille critique est trouvée plus élevée que pour les aciers doux.

ZUSAMMENFASSUNG
Ermüdungsbeanspruchte Kehlnahtstösse brechen entweder im Grundmaterial oder im Schweissgut. Der Bruch im Grundmaterial ergibt eine höhere Ermüdungsfestigkeit und erfolgt ab einer bestimmten kritischen Grösse der Schweissnaht. Bei hochfesten Stählen ergibt die statische Bemessung Längsnähte, die die kritische Grösse übertreffen und somit auf der sicheren Seite liegen. Für Quernähte bei Normalstahl werden grössere kritische Abmessungen gefunden.

1. INTRODUCTION

Joints built up with fillet welds loaded by fatigue can fail either by weld fracture ot by plate fracture. Fig. 1 and 2. The latter mode gives higher fatigue resistances, so that it is interesting to know where the frontier is between the two modes. To this frontier corresponds a "critical" size of welds. Several works |1||2||3||4| tackles this problem for relatively mild steel. We complete these works by a study on high strength steels, with a yield stress of about 700 N/mm^2 .

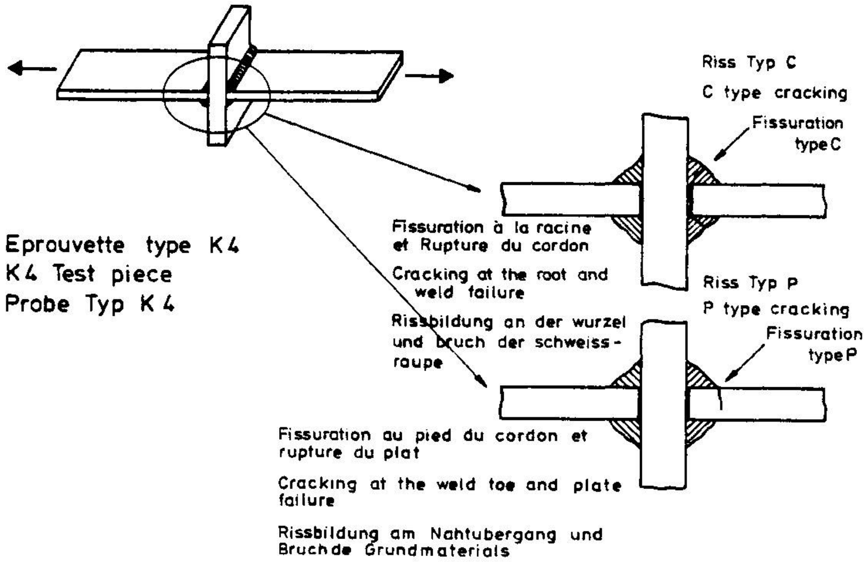


Figure 1

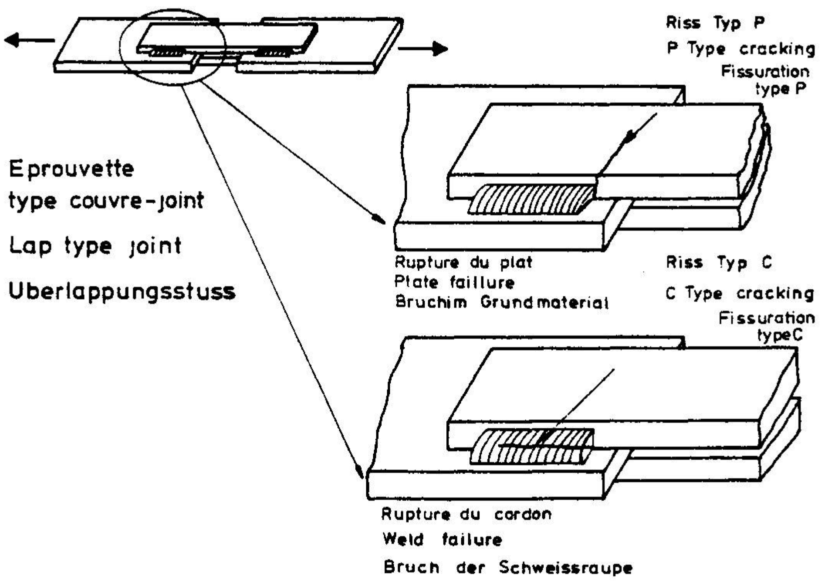


Figure 2.

2. DESCRIPTION OF TEST PIECES AND TESTING PROCEDURE.

For transverse welds the only parameter of the study is the thickness a of the weld. The general dimensions of the test pieces are defined on Fig. 3. The dimensions "a" are defined on the basis of a previous work |2|. If we refer to

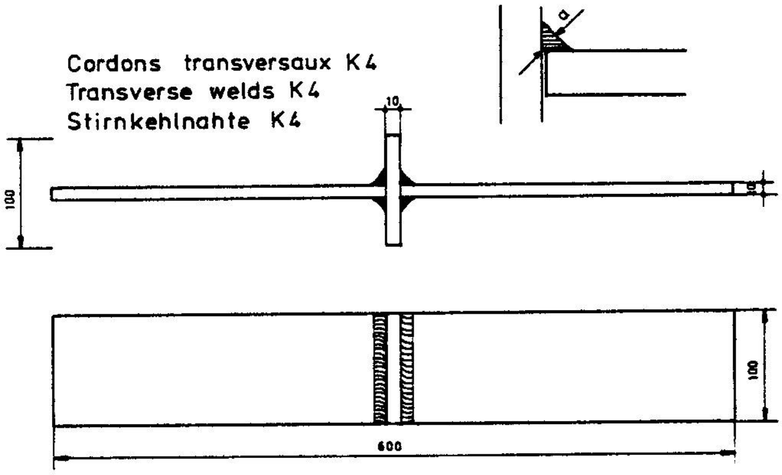


Figure 3

fig. 4, we have, for V = 0,9 T, a_{crit} = 6,4 mm.

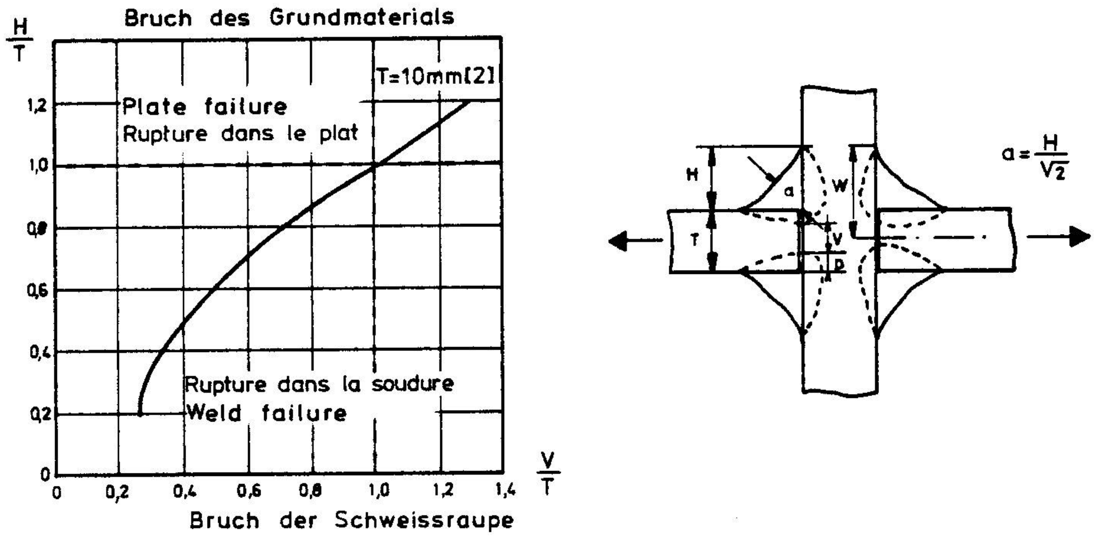


Figure 4

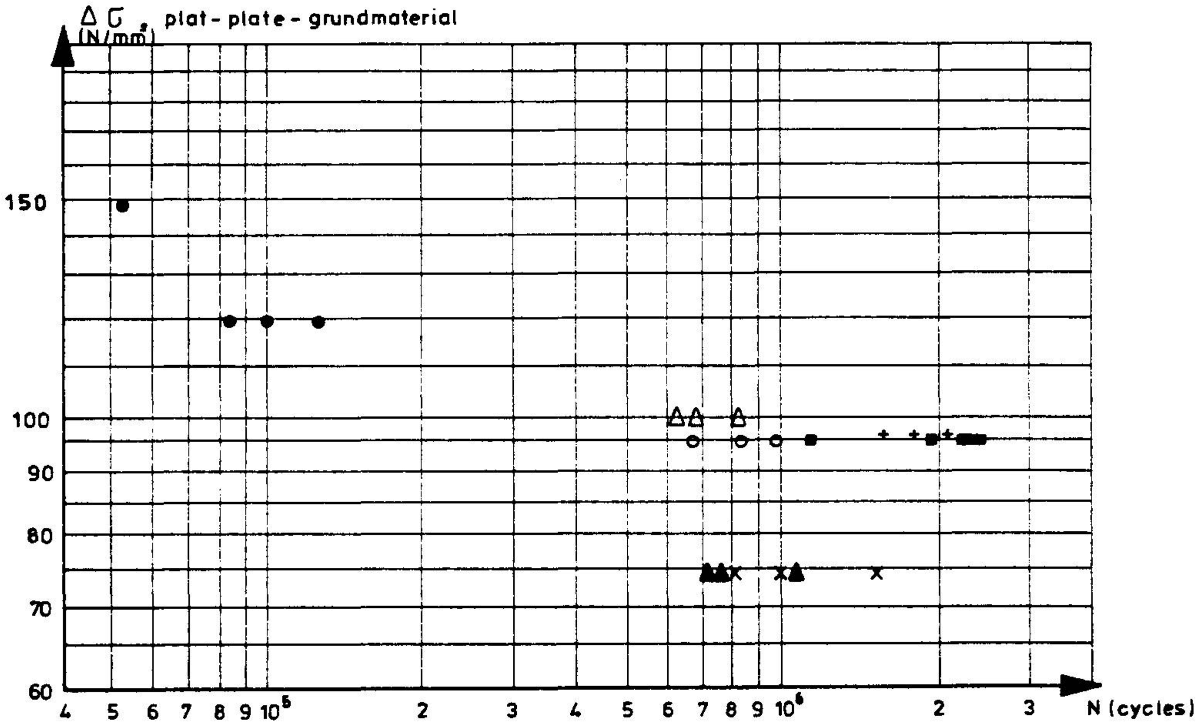
For our test pieces, a ranges from 5 to 12 mm. As a comparison, the necessary size for equal resistance of the joint ant the assembled plates, under static loads, is a = 7,5 mm.

No existing literature was found for defining the critical size of longitudinal fillet weld. We used the following procedure : a first serie having the critical size defined above is welded and tested. The dimensions of the next series are defined on the basis of the results of the first serie.

The fatigue tests are constant amplitude tests, with S_{max} of about 300 $N/_{mm}2$, $R = \frac{S_{min}}{S_{max}}$ of about 0,6 and a frequency of 4 Hz.

3. RESULTS OF TEST ON TRANSVERSE WELDS.

Test results are presented on fig. 5. It can be seen that there is a continuous increase of fatigue resistance with the size of welds and no discontinuity when the failure mode changes. The critical size is found of about 10 to 12 mm, which is significantly higher than 7,5 mm.



Eprouvette type k4-AE 700
K4 type joint - Fe E 700
Kreuzstoss K4-Stahl F_e E 700

	a (mm)
●	5
▲	5,5
x	6
Δ	7
o	8
+	10
■	12

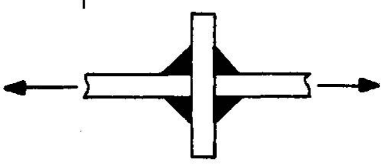


Fig. 5.

Weld failures cannot be characterized by the only stress in the plate, because it is also dependent on the size of the internal. "defect" defined by $\frac{V}{2H + T}$ (see Fig. 6). We present the test results in a diagramm taking V H and T into account on Figure 6. A significant difference of about 40 % is confirmed. A comparaison with test results from the literature

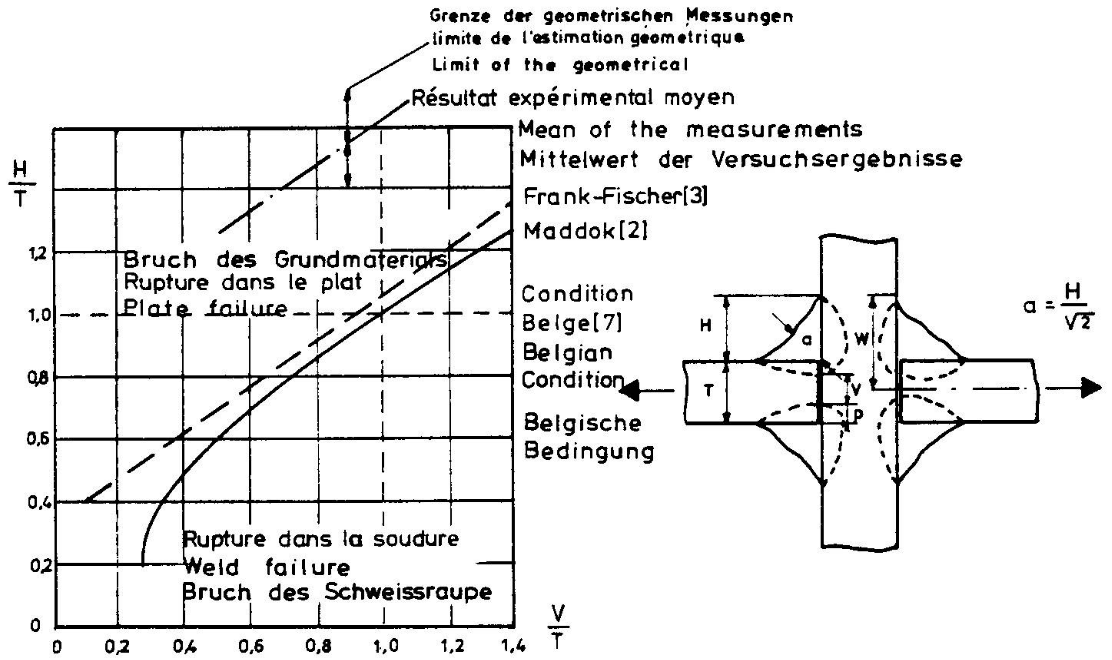


Figure 6.

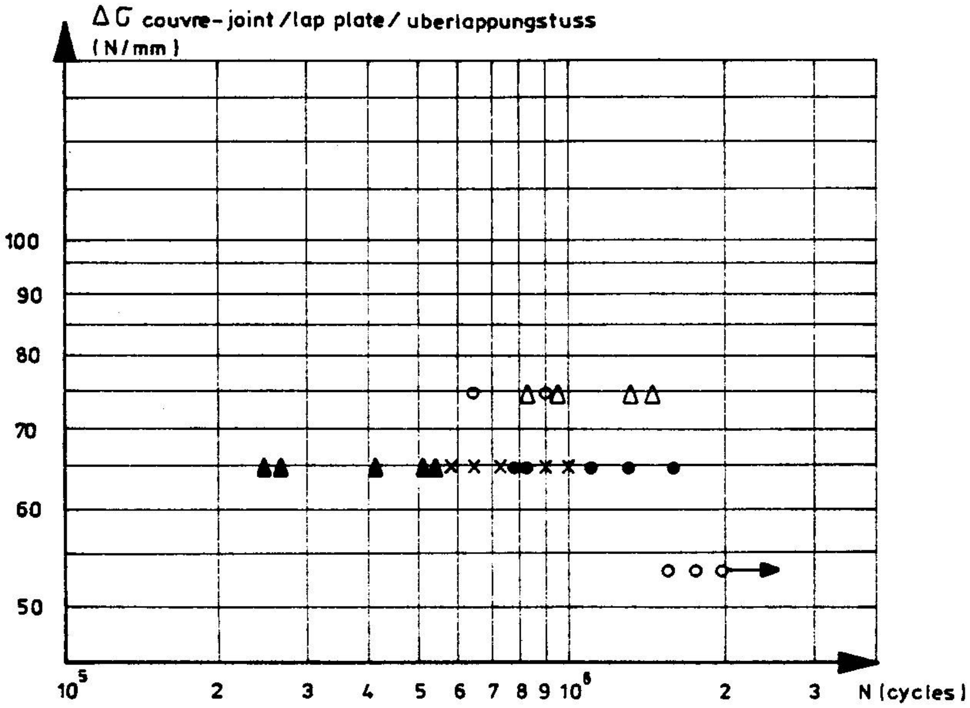
shows that it is mainly caused by the relatively low fatigue resistance in the weld failure case. One explanation for those low results could be the high mean stress applied, though 250 N/mm^2 is not so high for a high strength steel.

However, as a result of the continuous rise in fatigue resistance with the weld size, independantly of the failure mode, the lack of security generated by a classical computation of the weld size is relatively minor for welds having an "a" greater than 1,2 time the critical size.

4. RESULTS OF TESTS ON LONGITUDINAL WELDS.

Test results are presented on Fig. 7.

It can be seen that there is no real discontinuity when shifting from one failure mode to the other ; the fatigue resistance increases with the weld size when a weld failure is observed, but it is found quite independant of the weld size, when there is a lap failure.



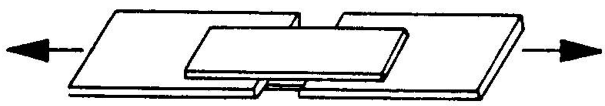
Eprouvette type couvre-joint

lap plate joint

Uberlappungstuss

	a mm	l mm	s mm²
▲	5	30	150
x	5	40	200
●	5	50	250
o	6	50	300
Δ	7	50	350

Figure 7.



As explained above, the critical size of welds is found by a step procedure. The critical area of one weld is found equal to approximately 200 mm^2 while if we design the joint for the equal resistance of the lap plates and the welds, the necessary dimension is found equal to 433 mm^2.

It is concluded that, for longitudinal loaded fillet welds in high strength steel joints, the static design ensures a plate failure under fatigue loads so that, for high strength steel joints, the critical size of longitudinal welds has no importance in the computation.

5. ACKNOLEDGMENTS.

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