FATIGUE TEST OF MIG SPOT-WELDED JOINTS OF ALUMINIUM PLATES

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MIG spot welding excellently suits watertight connection between top sheets of aluminium trapezoidal-wave roof plates and cross ribs. These connections feasible from one side are stronger than riveted connections. Load capacity of these connections and effect of determining factors have been tested on a high number of specimens at the *Laboratory of the Department of Steel Structures, Technical University, Budapest.*

Test specimens

Material of specimens was the same as that of series-produced roof panels: AlMg 3 half-hard plates, in thicknesses $v = 1$ mm and 2 mm. Welding electrode was ∅ 1.6 mm AlMg 5 wire type ESAB OK AUTROD 18.15. The welding equipment was type BOC, involved a power source type SPR, of nearly horizontal characteristic, a wire feed unit type LYNX II/E, and an air-cooled welding torch type LT-4. Pure argon was used as shielding gas. For geometrical identity, specimens were welded on patterns. Two-spot welds were tested where the force direction was normal to the line connecting the spots. Figure 1 is the photo of a specimen, indicating essential dimensions. Fatigue specimens were made by applying welding characteristics resulting in the highest tensile forces in about 1500 specimens in previous static tests. These welding characteristics were:

welding current:	$I = 290$ to 300 A
welding voltage:	$V = 19.5$ to 20 V
welding time:	$t = 1$ sec
argon feed:	20 l/min.

Electrode length melted to make one spot amounted to about 145 mm. Copper washers were used in welding specimens.

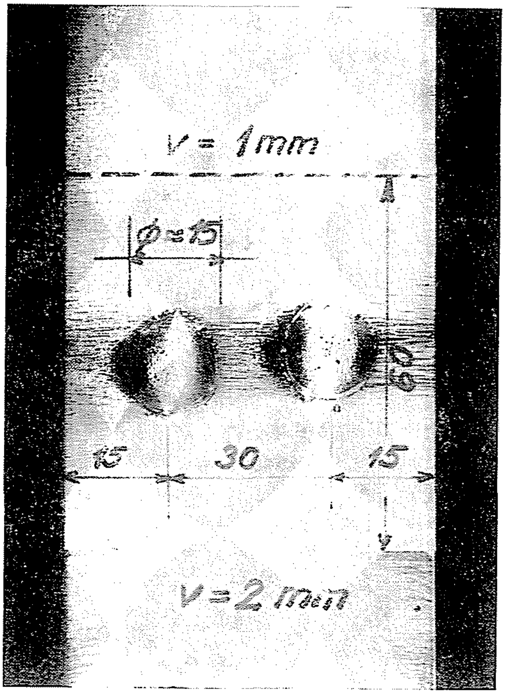


Fig. 1

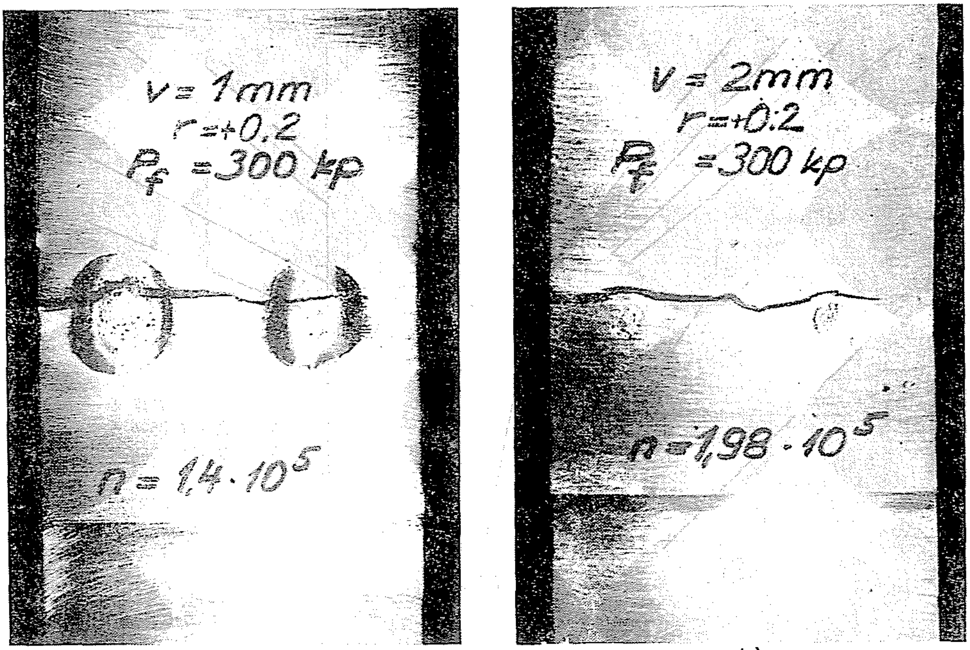
Fatigue tests

All the fatigue tests were carried out in a 5-ton axial-load hydraulic Losenhansen machine at frequencies of 1000 stress cycles per minute. Nine specimens were tested at each load level. Results are seen in Table 1. Static tensile test results on nine specimens have been tabulated, averaging 1230 kp. Ratio of lower to upper testing forces was

$$r = \frac{F_{\text{lower}}}{F_{\text{upper}}} = +0.6 \quad \text{and} \quad r = +0.2 \, .$$

Typical failures are seen in Figs 2; Fig. 2a presenting fatigue cracks in the top plate 1 mm thick, Fig. 2b that in the bottom plate 2 mm thick.

Results were processed in a computer type HP 9830A, applying the so-called simplified triple diagram [1] (Figs 3 and 4). This diagram yields strength distributions by transformation from endurance distributions using graphic plotting based on the theory of probabilities. F/N curves belonging to failure probabilities $p = 1\%$ and $p = 50\%$ in Fig. 5 have been constructed from computer-plotted triple diagrams. By convention, force values belonging to 2.10^6 repetitions may be considered as fatigue limits for the given connection.


v = 1 mm
r = +0.2
P_f = 300 kp
n = 1,4 · 10^5
v = 2 mm
r = +0.2
P_f = 300 kp
n = 1,98 · 10^5

a) b)

Fig.

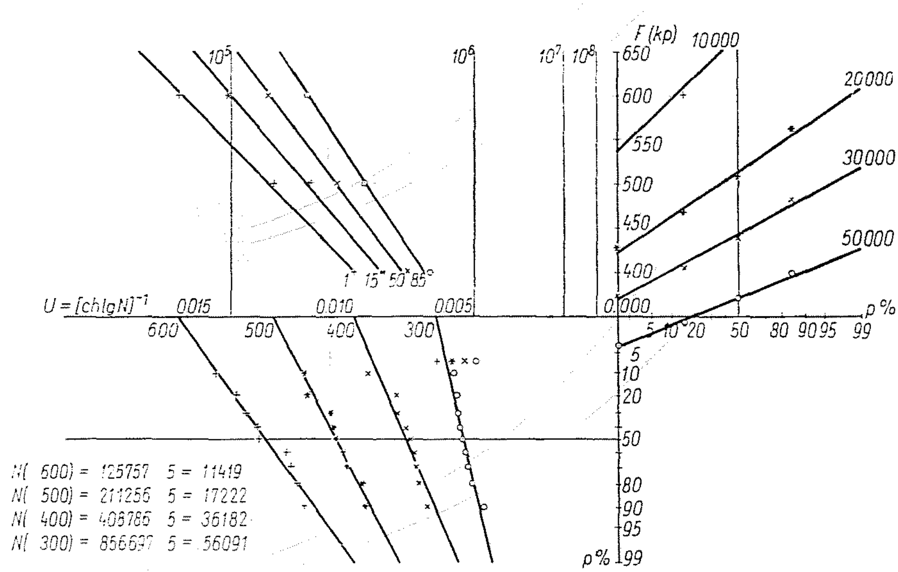

F (kp)
10000
20000
30000
50000
650
600
550
500
450
400
10^5
10^6
10^7
10^8
U = [ch lg N]$^{-1}$
0.015
0.010
0.005
0.000
600
500
400
300
5 10 20 50 80 90 95 99
p %
5
10
20
50
80
90
95
99
p %
N(600) = 125757 s = 11419
N(500) = 211256 s = 17222
N(400) = 408786 s = 36182
N(300) = 856697 s = 56091

Fig. 3

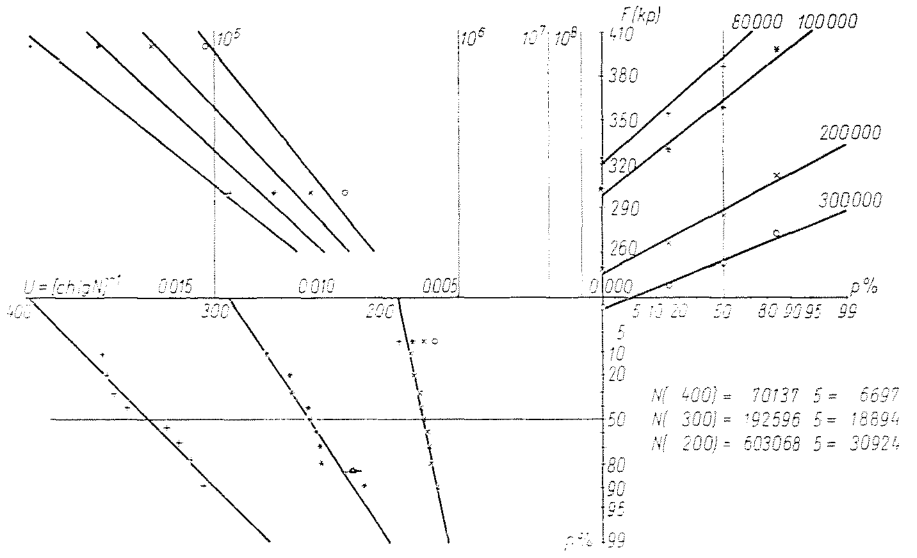

F (kp)
80000
100000
200000
300000
p %
$U = [ch \lg N]^{-1}$
0.015
0.010
0.005
0.000
N(400) = 70137 s = 6697
N(300) = 192596 s = 18894
N(200) = 603068 s = 30924

Fig. 4

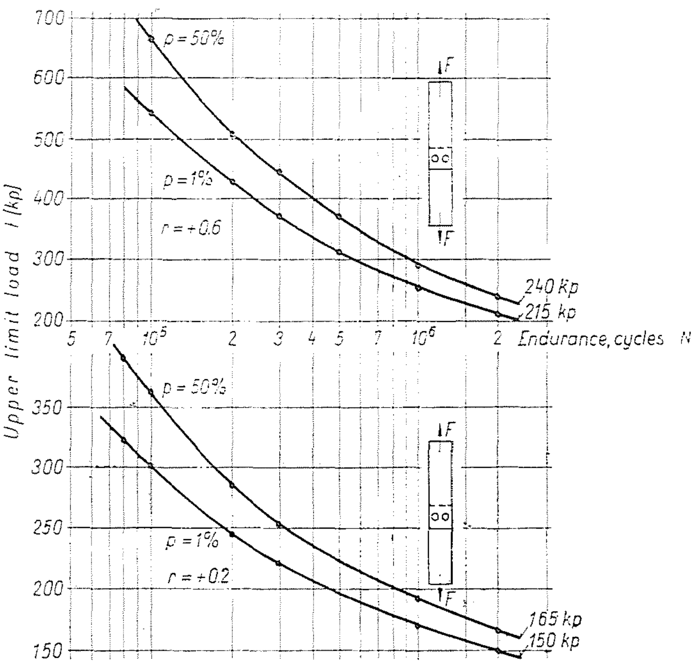

p = 50%
p = 1%
r = +0.6
240 kp
215 kp
Endurance, cycles N
Upper limit load l (kp)
r = +0.2
165 kp
150 kp

Fig. 5

Conclusions

Alternating loads produce important, abrupt decrease of the static strength. Already at the ratio $r = +0.6$ the fatigue limit is only 15 to 20% of the static load capacity, and with further decrease, e.g. at $r = +0.2$ tending to pulsating stresses, only 10 to 15% of the static load capacity persists. Wöhler diagrams of spot welded connections have no inflexion point, hence no horizontal asymptote. This fact is obvious also in the tests concerned. Parallel to the Department's tests, tests have also been made at the *Research Institute of Metallurgy* again on fatigue specimens made at the Department, of the same material and geometry, with the only difference that no washer was used in welding. Specimens were tested at 3000/min in an *Amsler* high-frequency machine, practically at $r = 0$. Tests were made by the so-called staircase method. Fatigue limit was 134 kp for 5.10^6 cycles and a failure probability $p = 50\%$, in good agreement with results at the Department.

Table 1

No.	F_{stat} [kp]	Endurance in an ordered sample $N_i \cdot 10^3$						
		$r = +0.6$				$r = +0.2$		
		F_{upper} [kp]				F_{upper} [kp]		
		300	400	500	600	200	300	400
1.	1270	737	280	163	92	508	140	50
2.	1160	763	367	167	104	530	166	56
3.	1080	780	373	202	111	582	168	57
4.	1120	800	410	206	119	583	191	59
5.	1330	832	430	209	120	601	193	63
6.	1410	861	447	224	145	630	203	77
7.	1230	911	457	230	150	647	208	82
8.	1140	960	470	267	156	660	210	88
9.	1340	1171	521	272	164	730	310	95

Summary

Fatigue tests have been made on specimens made from thin aluminium plates by consumed-electrode arc spot welding. Nine specimens have been tested in tension and pulsation at different stress levels each. "Endurance" section of Wöhler curves of the connections have been made by statistic evaluation.

References

1. MATOLCSY, M.: Triple Diagrams for Evaluating Fatigue Tests. (In Hungarian). Gép. Vol. 19 (1967) No. 3. p. 56—100.
2. McFALL, S. E.: Inert-Gas-Shielded Metal-Arc Spot Welding of Aluminium. Welding Journal, 12. 1960.

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