CoA Note No. 50

THE COLLEGE OF AERONAUTICS

CRANFIELD

DOUBLE SHEAR STRENGTH OF B.S. L.69 SNAP HEAD RIVETS IN L.72 AND L.73 ALUMINIUM ALLOY SHEET

by

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JULY, 1956.

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The double shear strength of B.S. L.69 snap head rivets in L.72 and L.73 aluminium alloy sheet

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SUMMARY

A limited series of tests has been carried out on single and double shear riveted joints using L.69 (D.T.D.327) snap head rivets and L.72 (D.T.D.610) and L.73 (D.T.D. 546) sheets. The specimens were similar to those used by the Royal Aeronautical Establishment (ref.1), the double shear specimens being essentially two single shear specimens placed back to back.

In each case the 1 per cent, 2 per cent and ultimate strengths were found, the single shear values being in agreement with the equivalent R.A.E. tests (ref. 2).

It was found that at high bearing stresses the permissible shear stress in the double shear joint falls below that of the single shear joint having the same nominal bearing stress. This reduction of permissible shear stress was found to increase with joint extension and to be independent of the sheet materials tested. Design curves are given.

MEP

SYMBOLS

A area of one rivet

d diameter of rivet

K_{10} ratio of the permissible shear stress of the double shear joint compared with that of the equivalent single shear joint, corresponding to r_{10}

K_{20} ratio of the permissible shear stress of the double shear joint compared with that of the equivalent single shear joint, corresponding to r_{20}

K_R ratio of the permissible shear stress of the double shear joint compared with that of the equivalent single shear joint, corresponding to R

r_{10} 1 per cent proof strength of joint, defined as that corresponding to a joint extension of 2 per cent of one rivet diameter

r_{20} 2 per cent proof strength of joint, defined as that corresponding to a joint extension of 4 per cent of one rivet diameter

R ultimate strength of joint

t sheet thickness of one plate of single shear joint, and one outer plate or half the centre plate of the double shear joint (see Figure 1).

The 'equivalent' single shear joint is that having the same value of A/dt or t/d as the double shear joint.

Introduction

The development[1] by the Royal Aircraft Establishment of an improved method of testing the strength of riveted joints, has led to a systematic investigation of the subject. The joints considered include a wide variety of rivet and sheet materials and types of rivet. In all cases the 1 per cent, 2 per cent and ultimate strengths of the joint have been estimated, but the work has been limited to the case of rivets in single shear.

It has long been known that the permissible shear stress of a joint in double shear tends to fall below that of the equivalent single shear joint, especially as the bearing stress becomes large. The extent of this loss in strength, especially in the proof cases, is not immediately apparent, and accordingly it was decided to initiate a series of tests on double shear riveted joints.

Tests

Full details of the specimens tested appear in Figure 1. In all cases both the single and double shear joints were tested. The single shear specimen is identical to that used by the R.A.E.[1] The double shear joint is essentially two single shear specimens placed back to back, it being assumed that a joint having equal total thicknesses of sheet is the worst case.

The specimens were loaded in tension, the extension over the rivets being measured. The 1 per cent proof load is defined as that corresponding to a joint extension of 2 per cent of one rivet diameter, whilst the 2 per cent proof load is defined as that corresponding to a joint extension of 4 per cent of one rivet diameter. These proof loads were obtained by using the 'permanent set' technique.

For all the specimens the nominal shear and bearing stresses corresponding to the 1 per cent, 2 per cent and ultimate loads were calculated. The nominal rivet diameter and actual sheet thickness were used for this purpose.

Results

The results are presented in Figures 2 to 7 as the variation of shear stress with bearing stress for each load case. In all cases a mean line has been drawn through the experimental values. Comparison of the single shear results for the L.73 (D.T.D. 546) material with those obtained by the R.A.E.[2] indicates good agreement. The only difference is a slightly lower 1 per cent proof value in the present tests.

It is of interest to note the way in which the mean line turns back on itself for high values of A/dt in the ultimate case, Figure 4.

The double shear results are similar in form to the single shear curves except that in the ultimate case there is no doubling back of the mean line. This difference is explained by consideration of the nature of the failure of the joints. The straight initial portion of the single shear curve represents a shear failure of the rivets. The curved portion corresponds to the onset of rivet and sheet bearing failure. The final straight portion is failure by the tearing of the sheet over the rivet heads due to the offset of the applied load. For the double shear specimens the type of failure is similar except for the last stage. Since the load is not offset there is a less tendency for the sheet to tear over the rivet heads, and hence bearing of the rivets and sheet is the main cause of failure.

As this difference between single and double shear joints will not necessarily occur in actual structures a 'design' curve has been estimated to bring the double shear results in line with the single shear values.

The ratios of the permissible shear stress sustained by the double compared with the single shear joints, as a function of the parameter t/d are given in Figure 8. These curves indicate that, with the exception of the ultimate case, the ratio is independent of the sheet materials tested. Use of the 'design' curve overcomes this exception and final curves appear in Figure 9.

It will be seen that the loss in shear stress of the double shear joint, whilst present for values of t/d less than 0.4, is not very great. This loss increases with increase of joint extension.

Conclusions

The permissible shear stress of a double shear joint is less than that of the equivalent single shear joint for values of t/d less than 0.4.

The ratio of loss in shear stress is independent of the materials tested, and increases with increase of joint extension. For values of t/d less than 0.4 the design curves, Figure 9, should be used.

References

1. Ripley, E.L. — Strength of B.S.L.37 Snaphead Rivets in D.T.D.546 Aluminium Alloy Sheet. R.A.E. Tech. Note Structures 104, July, 1952.

2. Henwood, M.J., Ripley, E.L. — Strength of B.S.L.57 Snaphead Rivets in D.T.D.546 Aluminium Alloy Sheet. R.A.E. Tech. Note Structures 141, January, 1955.

TABLE I

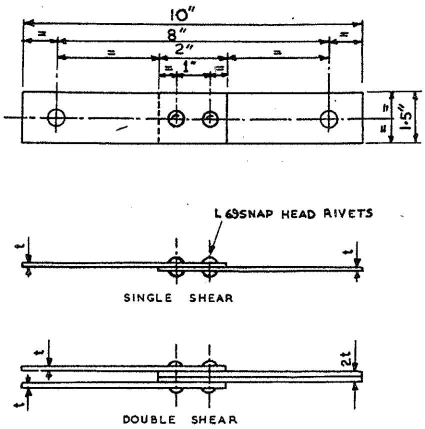
Experimental Results for L.72 Aluminium Alloy Sheet

Rivet Dia. ins.-d	Nom. Thick-ness	Actual Thick-ness ins.-t	Single Shear			Double Shear		
			r_{10} lbs	r_{20} lbs	R lbs	r_{10} lbs	r_{20} lbs	R lbs
1/8	10 G	0.130	700	780	834	1150	1350	1564
	12 G	0.104	670	720	820	1470	1580	1728
	14 G	0.085	670	780	807	1360	1510	1660
	16 G	0.063	730	800	896	1530	1650	1725
	18 G	0.048	704	764	834	1400	1486	1622
	20 G	0.036	665	715	817	1360	1430	1622
	22 G	0.028	520	584	766	1150	1225	1416
	24 G	0.023	465	520	650	1000	1030	1360
5/32	24 G	0.023	628	682	736	1252	1336	1383
3/16	16 G	0.063	1320	1420	1720	2820	3010	3390
	18 G	0.048	1190	1330	1642	2480	2650	3050
	20 G	0.036	1130	1230	1430	2050	2170	2570
	22 G	0.029	800	860	892	1670	1790	2164

TABLE II

Experimental Results for L.73 Aluminium Alloy Sheet

Rivet Dia. ins.-d	Nom. Thick-ness	Actual Thick-ness ins.-t	Single Shear			Double Shear		
			r_{10} lbs	r_{20} lbs	R lbs	r_{10} lbs	r_{20} lbs	R lbs
1/8	10 G	0.125	650	708	812	1270	1400	1634
	12 G	0.104	670	727	818	1388	1470	1640
	14 G	0.082	680	730	804	1350	1450	1618
	16 G	0.064	800	838	892	1420	1500	1674
	18 G	0.051	670	720	770	1330	1400	1620
	20 G	0.037	600	630	766	1380	1410	1652
	22 G	0.029	570	600	743	1250	1320	1360
	24 G	0.023	490	550	644	1060	1100	1130
5/32	24 G	0.022	656	732	867	1340	1380	1524
	26 G	0.019	619	648	653	1088	1190	1282
3/16	16 G	0.065	1340	1450	1644	2800	2980	3290
	18 G	0.051	1360	1460	1684	2540	2720	3180
	20 G	0.036	1170	1260	1456	2290	2390	2540
	22 G	0.029	960	1050	1108	1860	1980	2178
	24 G	0.023	843	898	930	1544	1684	1906



MATERIAL	RIVET DIAMETER	SHEET GAUGE-t
L 72	1/8"	10 12 14 16 18 20 22 24
	5/32"	24
	3/16"	16 18 20 22
L 73	1/8"	10 12 14 16 18 20 22 24
	5/32"	24 26
	3/16"	16 18 20 22 24

DETAILS OF SPECIMENS

FIG. 1

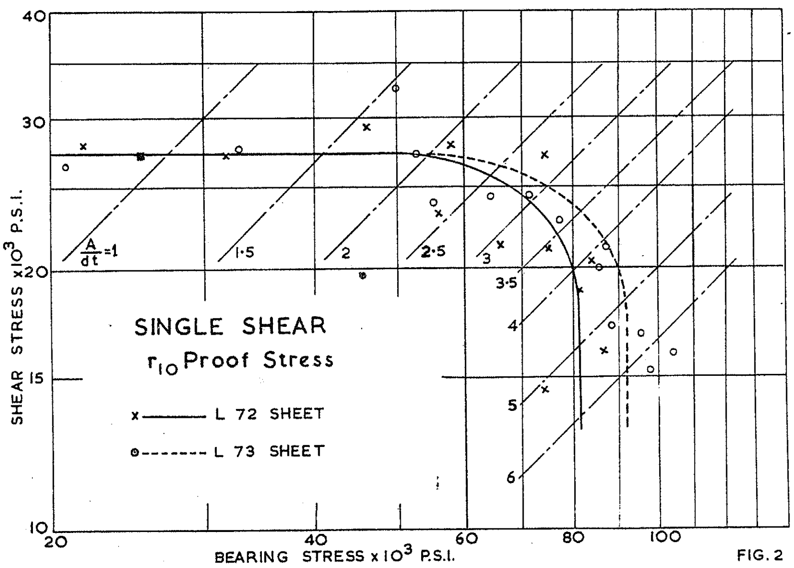


FIG. 2

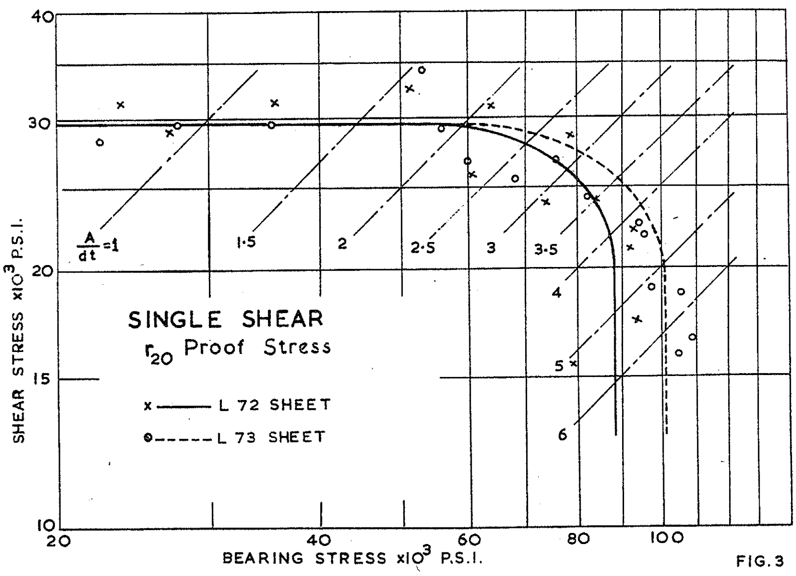


FIG. 3

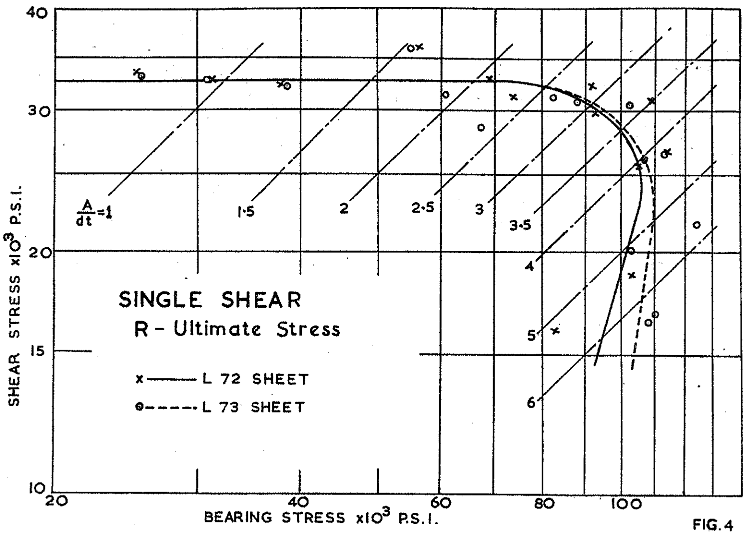


FIG. 4

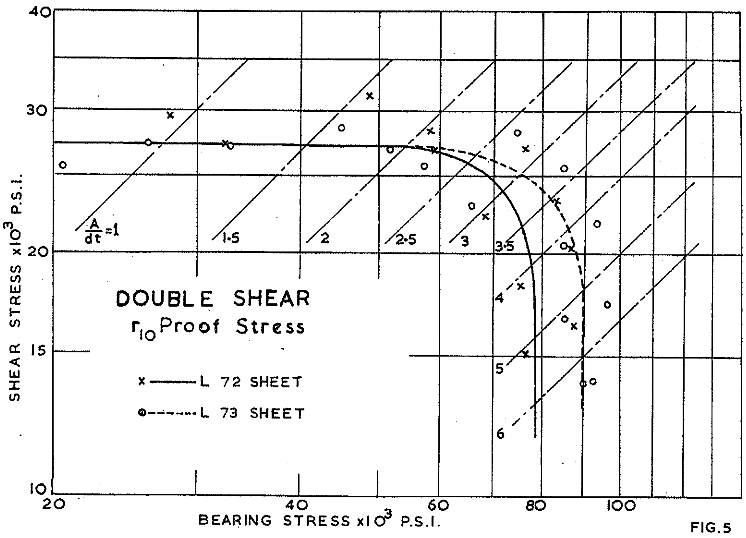


FIG. 5

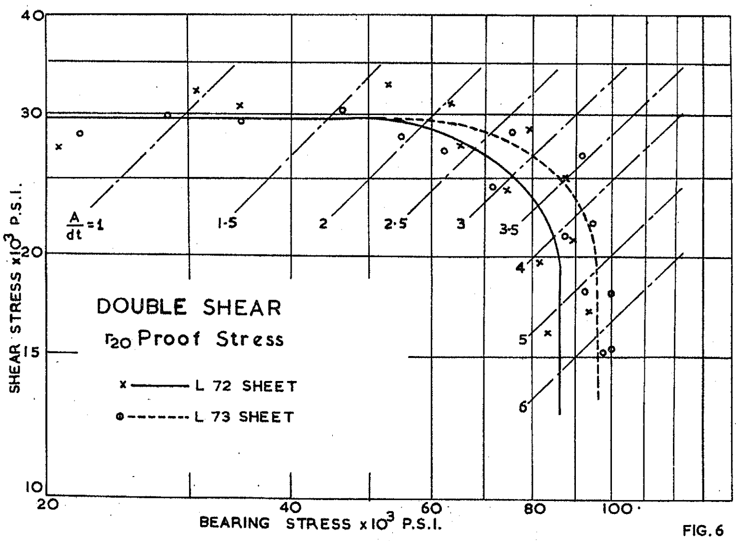


FIG. 6

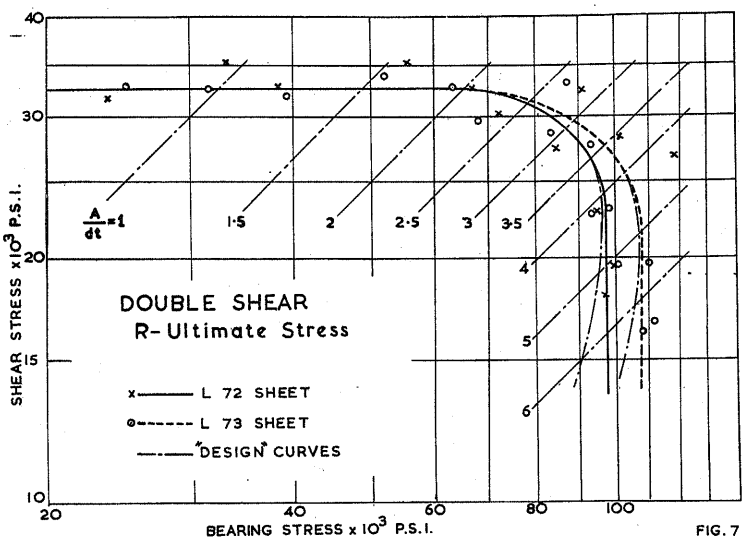
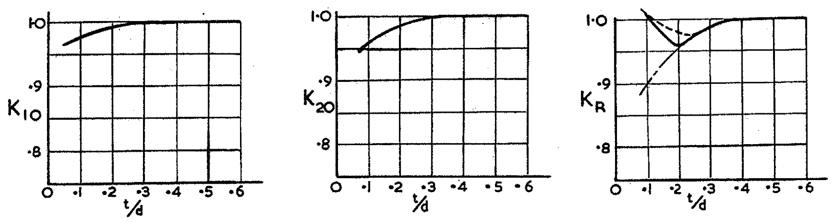


FIG. 7



K_{10} 1% PROOF RATIO

K_{20} 2% PROOF RATIO

K_R ULTIMATE RATIO

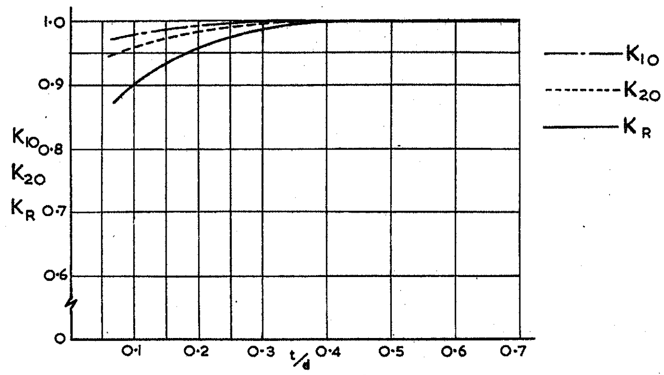
—— L 72 SHEET

----- L 73 SHEET

—·— "DESIGN" CURVE

RATIO OF DOUBLE TO SINGLE SHEAR STRESS

FIG. 8



DOUBLE SHEAR-DESIGN CURVES

FIG. 9