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A.R C. Technical Report

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The Influence of the Method of Stringer Attachment on the Buckling and Failure of Skin Panels with Square Top-Hat Stringers

An Abstract from the Thesis of E. E. Labram, D.C.Ae.,
prepared by K. H Griffin, B Sc ,
of the Department of Aircraft Design, College of Aeronautics

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THE COLLEGE OF AERONAUTICS

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DEPARTMENT OF AIRCRAFT DESIGN

The Influence of the Method of Stringer Attachment on the Buckling and Failure of Skin Panels with Square Top-Hat Stringers

An Abstract from the Thesis of E.E. LABRAM, D.C.Ae., prepared by K.H. GRIFFIN, B.Sc., of the Department of Aircraft Design.

SUMMARY

The results of experiments to find the buckling and failing loads of panels with riveted and glued stringers are given, and a comparison between the two methods of attachment is made. In the case of buckling stresses, a comparison is made with theoretical results. It is concluded that the glued panels show noticeably higher buckling and failing stresses, but that failures tend to be more extensive.

List of Symbols

h = height of stringer

b = pitch of stringers

t = skin thickness

t_s = stringer thickness

E_T = tangent modulus

f_b = buckling stress

f_o = $3.62\ E_T(\frac{t}{b})^2$

f_a = average stress in panel at failure

Introduction

This is a short account of the work done at the College of Aeronautics by E.E. Labram in preparation for his thesis for the Diploma of the College. The problem was to find the effect of stringer attachment on the buckling and failure of stringer-skin combinations.

A series of panels with square top-hat stringers was constructed having the following nominal parameters:
$t_s/t = 1.35, 1.02, 0.77$; $h/b = 0.146, 0.211, 0.271$.
Two complete sets covering this range were constructed, one having the components riveted and the other being bonded together with Redux.

Construction of Panels

These were manufactured by Messrs. Folland Aircraft Ltd. and were all of material D.T.D. 546; the bonding of the glued panels was carried out by Messrs. Aero Research Ltd. The dimensions of the panels are shown in Table I.

All stringers were of 18 s.w.g. material to the cross-section shown in Fig.1. The panels were each of length equal to four times the stringer pitch.

/ Method .....

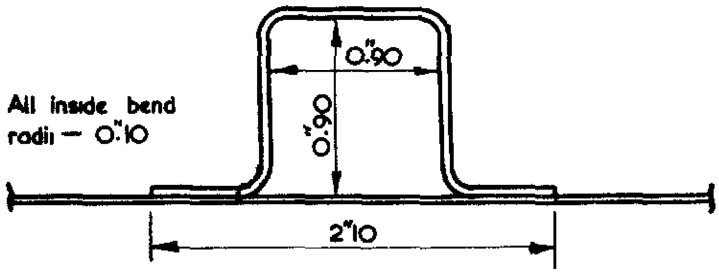


Fig. 1.

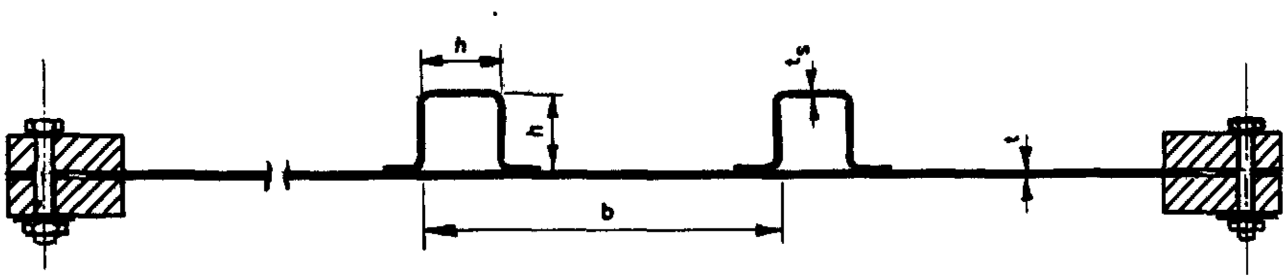


Fig. 2.

Method of Test

As constructed the panels had four skin bays and three stringers (Fig. 2). The edges of the two outer skin bays were clamped between wooden blocks to give a reasonable approximation to the support given by the adjacent stringer in a large panel.

Extensometers were mounted on the two outer stringers. The panels were cast in low melting-point alloy to a depth of about 1" at each end, and these ends were machined flat and parallel.

During test, readings were taken both of edge strain of the stringers and of buckle amplitude. The buckling stresses were obtained both from load-strain and (buckle amplitude)^2-strain curves. The latter method was in general fairly consistent with the former, but had rather larger scatter; so in this report only the values of f_b obtained from the load-strain

Results

The buckling stresses of the various panels are given in Table I, together with the buckling stress ratio f_b/f_o. This latter is plotted in Figs. 3 & 4 against h/b for the three values of t_s/t. Also in Figs 3 & 4 are the appropriate theoretical curves obtained by Hemp & Griffin in Ref.1. Average stress at failure is also given in Table I.

The relation between the results for the two types of attachment is what one would expect, the glued panels giving higher buckling and failing stresses. In Ref.1 it was assumed that the stringers were attached to the skin without flanges, and in such a manner that under buckling the sides of the stringers always remained perpendicular to the adjacent skin. Riveted flanges provide a more flexible type of attachment than the theoretical model, and thus one would expect riveted panels to achieve buckling stresses slightly below the theoretical. Glued flanges, however, add flexural rigidity to the bays of skin between the stringers and so the buckling stress should be raised, and these conclusions are supported by the experiments.

In the case $t_s/t = 0.77$, the increase in f_b/f_o for glued panels over riveted ones is 9% - 16%, while for $t_s/t = 1.02$ it is 12% - 20%.

For relatively thick glued stringers one would expect the flanges to exert a clamping effect on the skin, and in Fig.4 the dotted curve has been drawn on the assumption that the inter-stringer skin bays are clamped at the mid-flange lines. This seems to accord quite well with the experimental results ($t_s/t = 1.35$).

The increases in average stresses at failure for glued panels over riveted range from 9% - 29% for $t_s/t = 0.77$; from 7% - 28% for $t_s/t = 1.02$; from 27% - 45% for $t_s/t = 1.35$

It was found that the tendency was for the glued panels to show more extensive failures than those riveted. Normally the rivets failed over one or possibly two rivet pitches (rivet pitch = $\frac{3}{4}$").

/ The glued .....

The glued flanges tended to strip away from the skin on either side of the failure, this stripping occurring over lengths up to six inches; and in nearly all the cases where failure occurred near the end of a panel, the skin and stringers separated completely at that end.

Conclusions

The use of stringer skin combinations bonded together with adhesives such as Redux brings noticeable and worthwhile increases both in the buckling and failing stresses as compared with similar panels riveted together. This is especially true for panels where the skin is thinner than the stringer material.

However, the tests here recorded indicate that the failures of glued panels tend to be more extensive than those of riveted ones. Thus they are likely to show poorer load-carrying properties after failure.

Reference 1.

W.S. Hemp & K.H. Griffin. "The buckling in compression of panels with square top-hat section stringers."

College of Aeronautics Report No. 29.

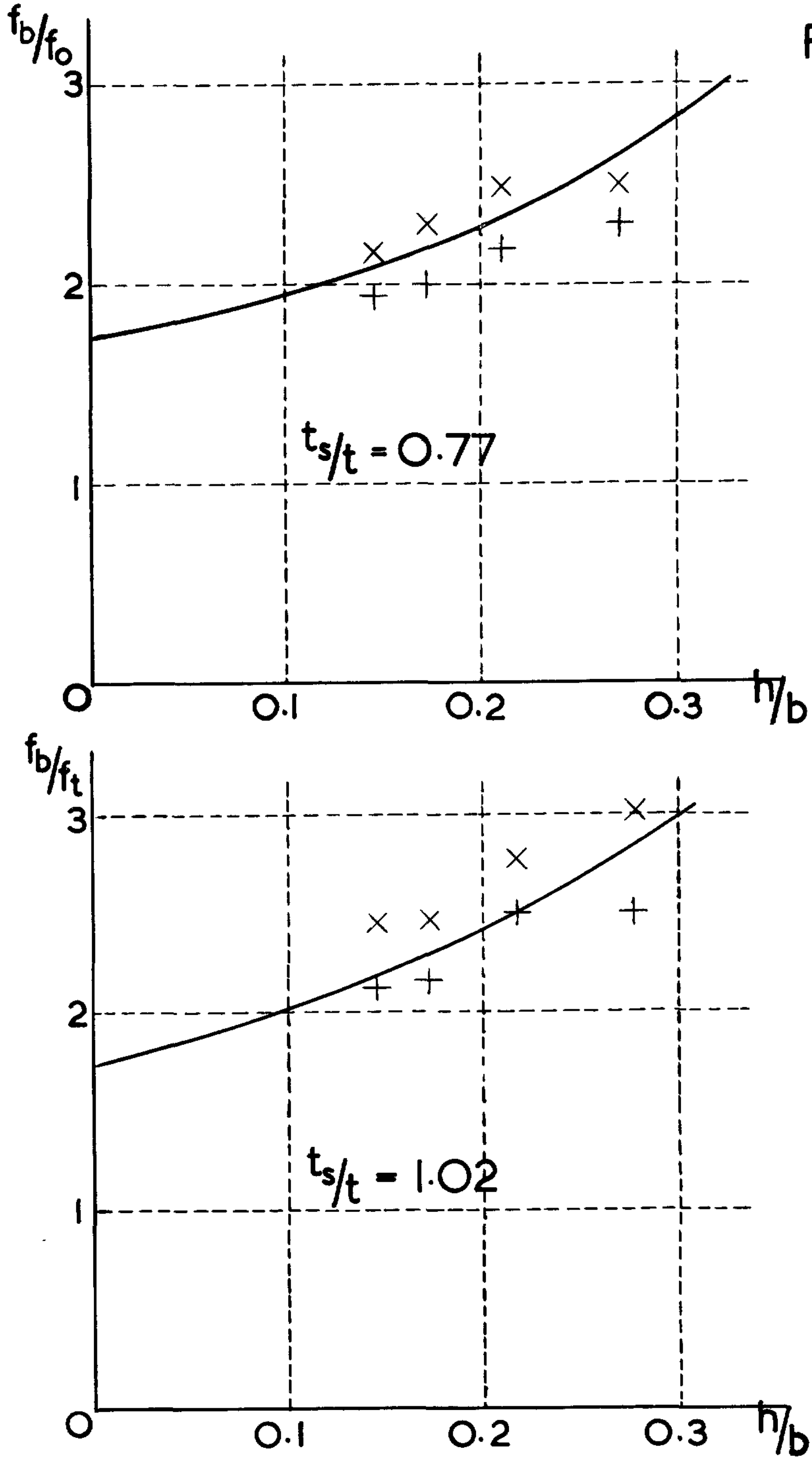
R. & M. 2635. June, 1949.

/ Table I ....

TABLE I

Nominal Skin Gauge	t_s/t (Actual)	Stringer pitch b	Panel width	h/b (Actual)	Attachment	f_b (lb/in^2)	f_b/f_o	f_a (lb/in^2)
16 swg	0.77	6.5"	24.7"	0.146	Redux Rivet	8500 7350	2.16 1.95	29200 26900
		5.5"	20.55"	0.172	Redux Rivet	12610 11000	2.30 2.00	33000 28300
		4.5"	16.6"	0.211	Redux Rivet	20500 17500	2.49 2.13	39800 33200
		3.5"	12.6"	0.271	Redux Rivet	33100 30200	2.51 2.31	45500 35300
18 swg	1.02	6.5"	24.7"	0.146	Redux Rivet	5500 4700	2.47 2.12	26400 24950
		5.5"	20.55"	0.172	Redux Rivet	7690 6400	2.50 2.14	34300 28400
		4.5"	16.6"	0.211	Redux Rivet	12900 11790	2.78 2.50	41000 28800
		3.5"	12.6"	0.271	Redux Rivet	21950 18900	3.02 2.50	43400 30700
20 swg	1.35	6.5"	24.7"	0.146	Redux Rivet	3820 2820	3.03 2.36	29700 22500
		5.5"	20.55"	0.172	Redux Rivet	6160 4060	3.38 2.30	32700 25900
		4.5"	16.6"	0.211	Redux Rivet	8900 6100	3.18 2.44	36600 25400
		3.5"	12.6"	0.271	Redux Rivet	20100 12100	5.02 2.82	41300 29000

Fig. 3.

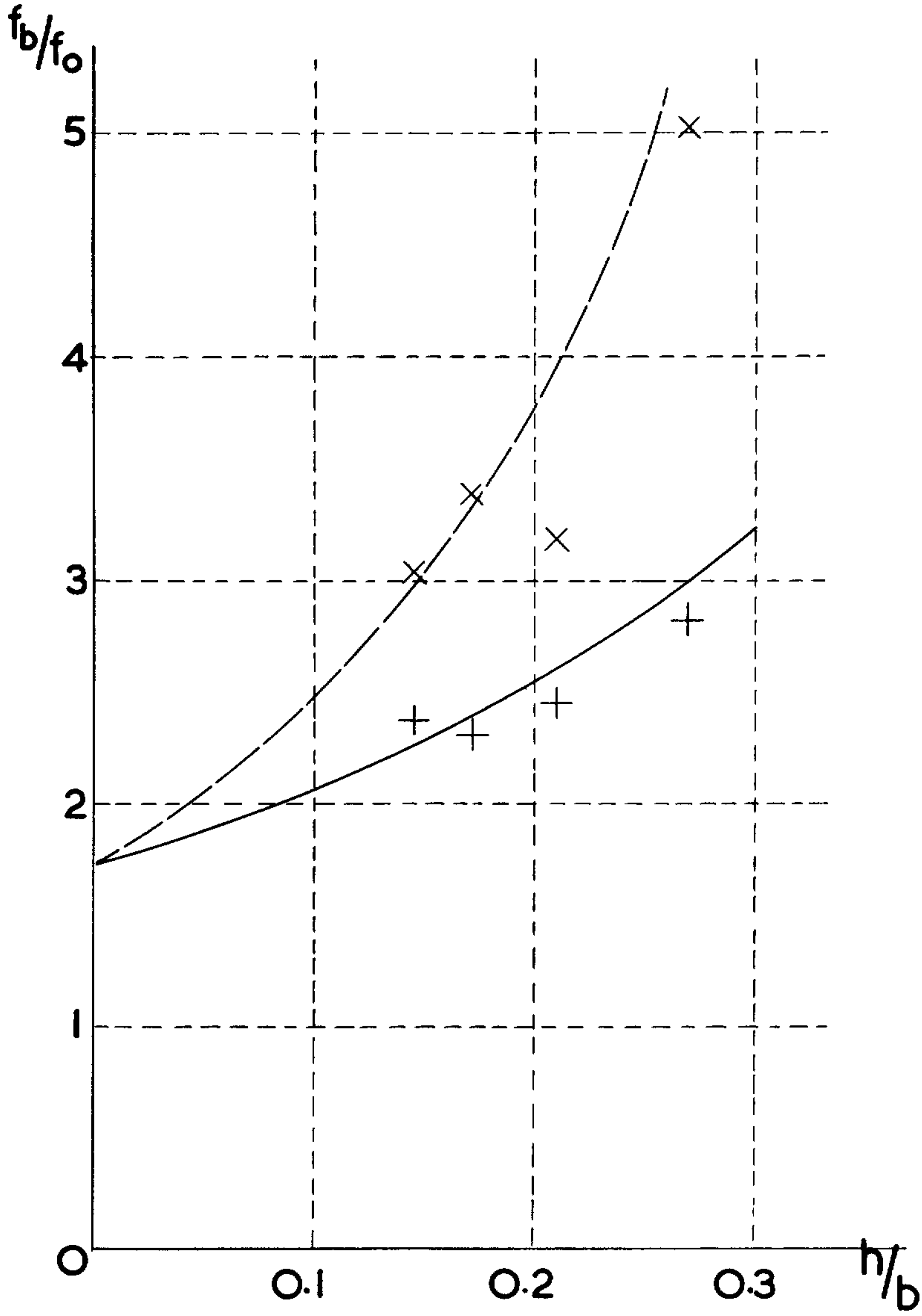


X Glued stringers

\+ Riveted stringers

Fig. 4.

f_b/f_o for $t_s/t = 1.35$



X- Glued stringers

+- Riveted stringers

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