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COMPRESSIVE STRENGTH OF FLAT PANELS WITH Z-SECTION STIFFENERS

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SUMMARY

Compression tests were made on several series of flat panels with Z-section stiffeners, in which relative dimensions were varied individually. The test data presented show the effect of each dimension ratio on the buckling stress for the sheet and on the average stress at maximum load.

INTRODUCTION

Several series of compression tests have been made on panels with Z-section stiffeners formed from flat sheet (see fig. 1) to show the importance of relative dimensions in determining the strength of the panels. The average compressive stresses at maximum load and the buckling stresses for the sheet obtained in the investigation are presented in this report, which is an extension of reference 1 and which supersedes this reference.

SYMBOLS

b_A width of attachment flange

b_F width of outstanding flange

b_S spacing of stiffeners

b_W width of web

t_W thickness of stiffener

t_S	thickness of sheet
r_A	radius of bend between web and attachment flange
r_F	radius of bend between web and outstanding flange
L	length
c	end-fixity coefficient in Euler column formula
σ_{cr}	buckling stress of sheet
σ_{max}	average stress in panel at maximum load

TEST SPECIMENS

The specimens used in the tests were constructed of 24S-T aluminum alloy with the grain in both sheet and stiffeners parallel to the longitudinal axis of the stiffeners. Longitudinal stress-strain curves representative of the group of specimens for which the ratio t_W/t_S was 0.51 are presented in figure 2. Inasmuch as the investigation of which these tests are a part is still in progress, a complete set of stress-strain curves is not yet available.

The stiffeners for all panels were formed from sheet material 0.064 inch thick. From the value $t_W = 0.064$, the actual dimensions of any panel can be determined from the dimension ratios subsequently presented herein. A knowledge of the actual dimensions is not necessary, however, because the stresses that can be carried are established by the relative dimensions of a panel.

The stiffeners were attached to the sheet with machine-countersunk flush rivets driven by an NACA flush-riveting procedure. These rivets consisted of ordinary flat-head rivets inserted from the stiffener side of the joint, the countersunk heads being formed in the driving process. A flush-rivet milling tool of the type described in reference 2 was used to remove the portion of the formed countersunk head that protruded above the sheet surface after driving. The rivets in each stiffener were driven in a single operation on a Cincinnati press brake as shown in figure 3. Machine-countersunk rivets of this type have been found to be tighter than the conventional flush rivets. (See reference 3.) A number of tests were made to obtain a comparison between conventional round-head rivets and this new type of rivet when it is employed in the construction of stiffened panels. The results of these tests may be obtained from reference 1. The conclusion was that the new type of rivet is as strong as or stronger than conventional round-head rivets used for attaching stiffeners to the sheet within the range of proportions included in these tests.

In all panels, the rivets were A17S-T aluminum alloy. The included angle of the countersunk head was 60° and the depth of countersink was three-fourths of the sheet thickness. The rivet spacings and rivet diameters used in the test panels are given in terms of the sheet thickness in the following table:

$\frac{t_W}{t_S}$	$\frac{\text{Rivet spacing}}{t_S}$	$\frac{\text{Rivet diameter}}{t_S}$
0.51	10.0	1.50
.63	12.3	1.84
.79	12.3	1.56
1.00	11.7	1.95

METHOD OF TESTING

The specimens were tested with flat ends in the 1,200,000-pound-capacity testing machine in the NACA structures research laboratory in the manner shown in figure 4. The accuracy of load measurement for this machine was within one-half of 1 percent. The ends of the specimens were ground flat and parallel in a planer especially adapted for this purpose, and the method of alinement of the specimens in the testing machine was such as to maintain this flatness and parallelism of the ends.

RESULTS AND CONCLUSIONS

Because stresses are established by the relative rather than the absolute dimensions of the specimens, the results are presented in nondimensional form. Figures 5 to 8 and tables I to IV present test data that have been reduced to take into account the end fixity that existed in the tests. The fixity coefficient for similar specimens tested in the same testing machine has been found to be about 3.75, and that value was used in the reduction of the data. Two scales are given for the abscissas in figures 5 to 8 - one for a fixity coefficient $c = 1$, and the other for $c = 1.5$.

The data are adjusted to give stresses for panels that are sufficiently wide to be considered as having an equal number of stiffeners and bays. This adjustment was made, in the calculations of average stress at maximum load, by subtracting from the total area and the total load the area and the load for one stiffener; the load in a stiffener was obtained by extrapolation of the load-strain curve for the stiffener. The adjustment was in every case less than 4 percent of the stress.

The sheet-buckling load was obtained from the load-strain curve for the sheet and was taken to correspond to the point at which the compressive strain on one side of the sheet began to be reduced with increasing load. No correction for the number of stiffeners and bays was made in the calculation of buckling stress because the stress was assumed to be uniform until buckling occurred. The values of sheet-buckling stress given in figures 5 to 8 are the averages of the values shown for corresponding groups of panels in tables I to IV.

The important feature of tables I to IV and figures 5 to 8 is the presentation of the actual data, because these data enable the designer to study the effect of various dimension ratios on the average stress at maximum load and on the buckling stress for the sheet-stiffener combination.

The following conclusions as to the effect of each dimension ratio on the average stress at maximum load and on the buckling stress can be drawn from the data shown in the figures and tables, if it is assumed in each case that the other ratios are held constant.

1. The specimens having Z-section stiffeners with $b_F/b_W = 0.2$ developed less compressive stress at maximum load than those with $b_F/b_W = 0.3$, 0.4, or 0.5. Little change is noted in the average stress for the values of b_F/b_W above 0.3. Changes in the ratio b_F/b_W have no apparent effect on the buckling stress of the sheet.

2. The average stress at maximum load and the buckling stress of the sheet decrease with increasing values of the ratio b_S/t_S.

3. The average stress at maximum load decreases with increasing values of the ratio L/b_W over the range of values used. The tabulated data reveal no apparent effect of the ratio L/b_W on the buckling stress of the sheet over this range.

4. The average stress at maximum load increases with increasing values of the ratio t_W/t_S. Although the sheet-buckling stresses for panels with $t_W/t_S = 1.00$ were higher than for corresponding groups of panels with $t_W/t_S = 0.51$, the difference is not large and there appears to be no consistent trend over the range of values of t_W/t_S investigated.

5. Changes in the ratio b_W/t_W have little apparent effect on either the average stress at maximum load or the buckling stress of the sheet.

Some of the foregoing conclusions have been known to aircraft designers, but numerical values have not been available to establish the optimum proportions in a given design problem. This series of tests was made to supply some numerical data.

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REFERENCES

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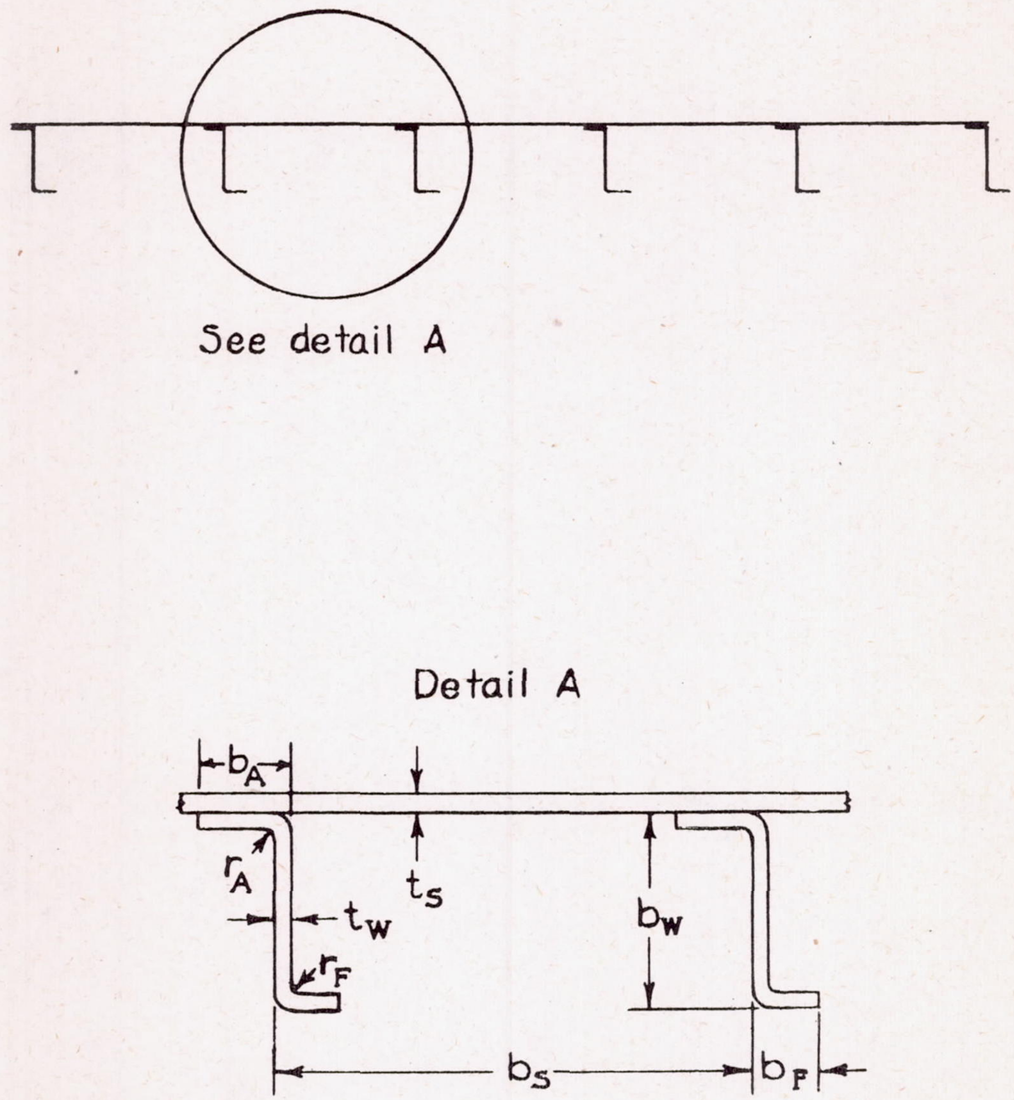

Figure 1.- Cross section of a test panel.

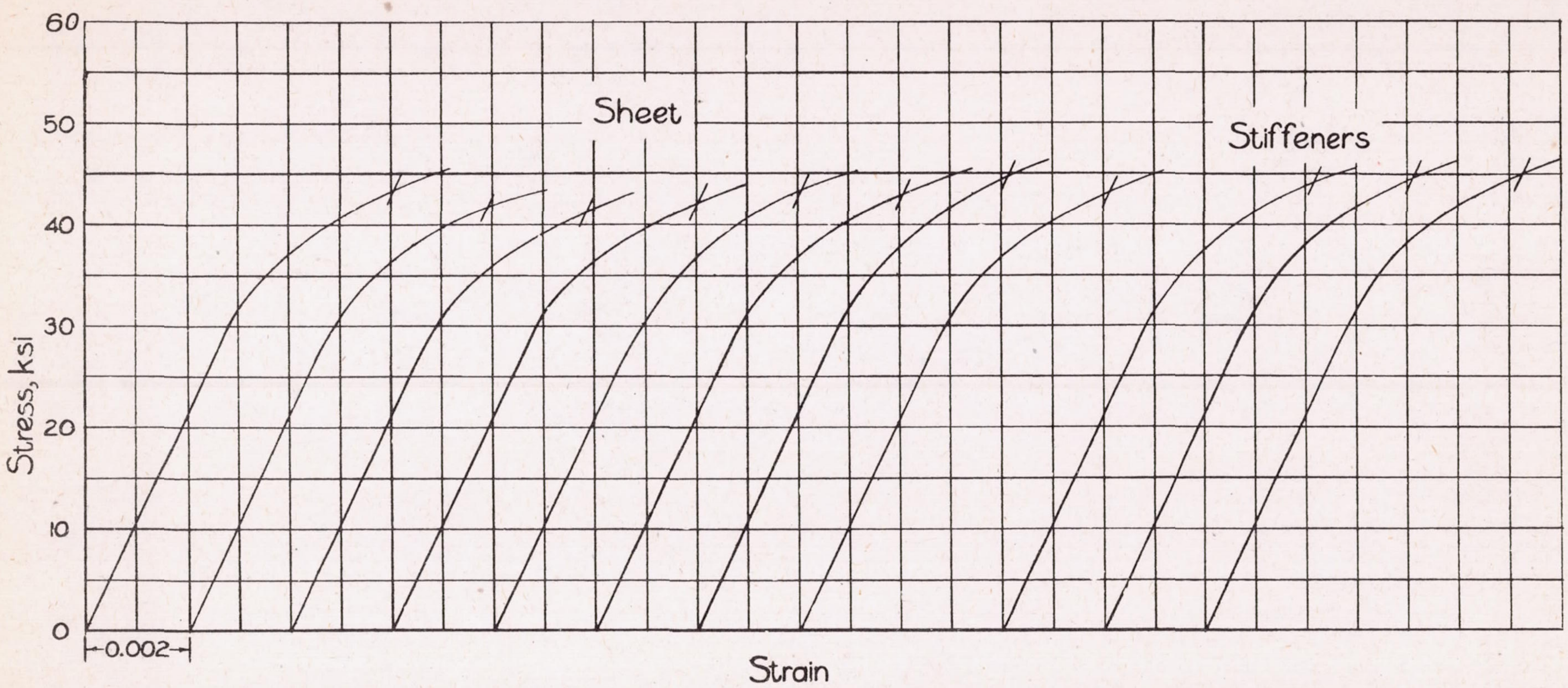

Figure 2.- Representative compression stress-strain curves for test panels with $t_W/t_S = 0.51$.

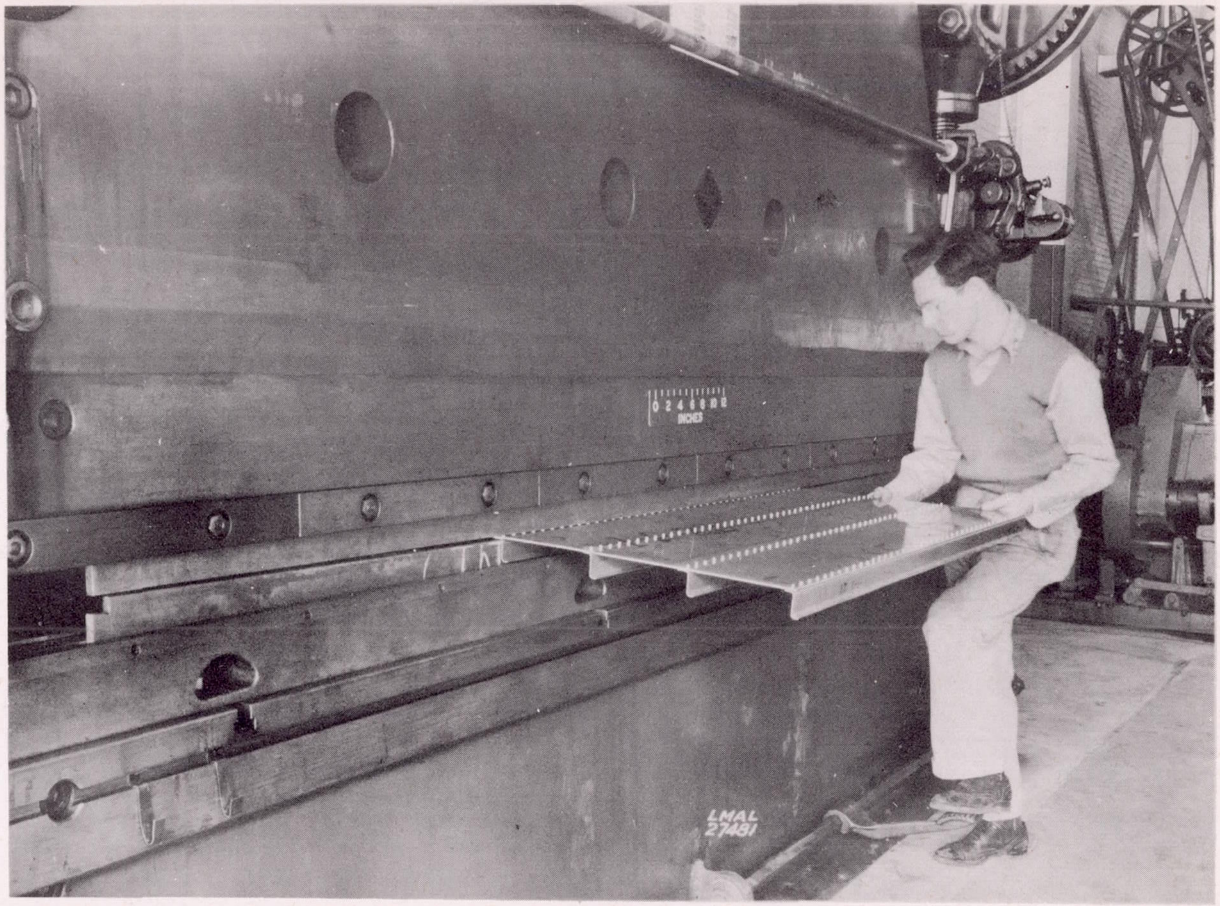

Figure 3.- Gang riveting of stiffeners to skin with Cincinnati press brake.

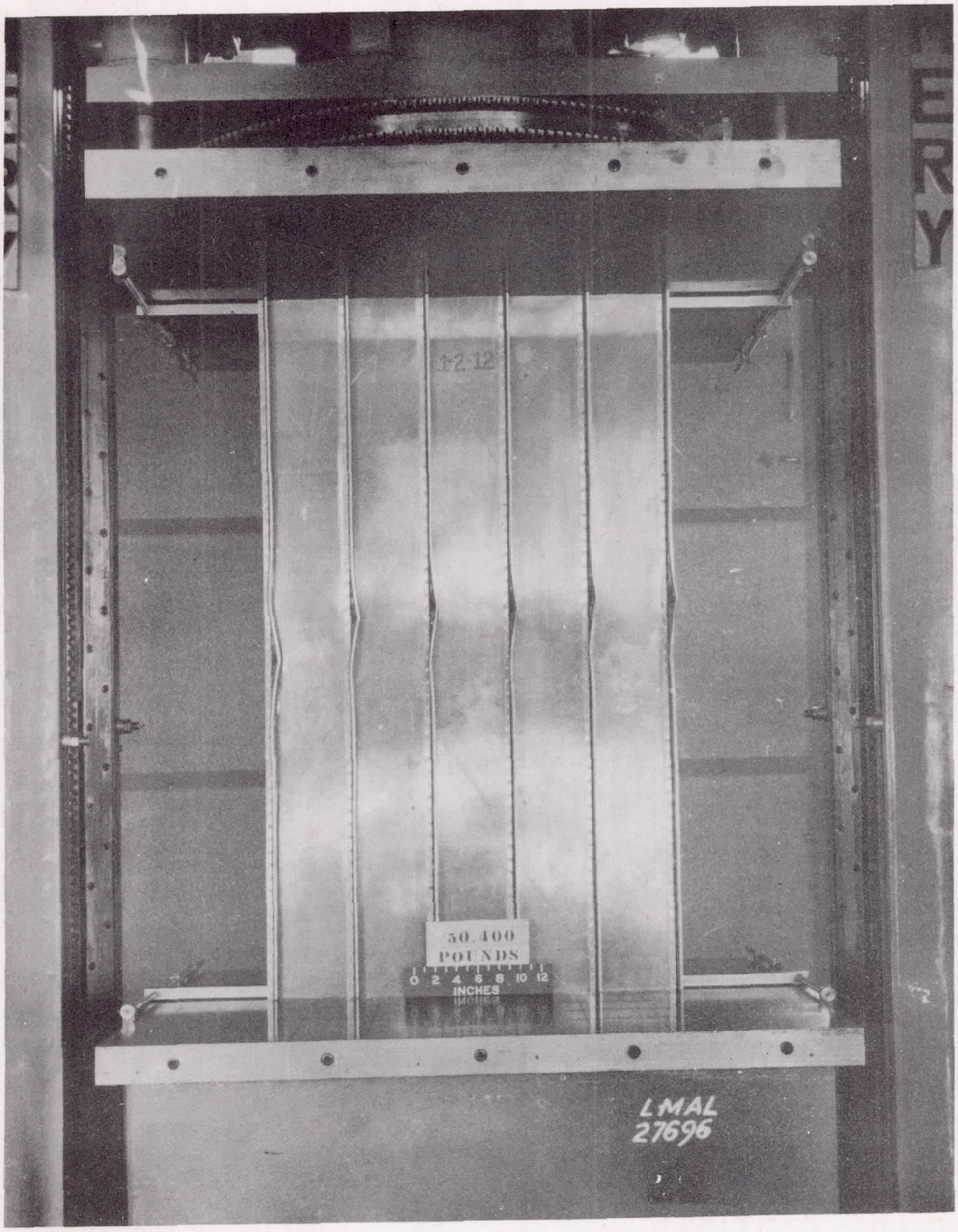

Figure 4.- Panel after failure in testing machine.

L-4499

TABLE I.- TEST DATA FOR PANELS WITH $t_W/t_S = 0.51$

$[c = 1]$

$\frac{b_W}{t_W}$	$\frac{b_F}{b_W}$	$\frac{b_S}{t_S} = 35$: $\frac{L}{b_W}$	σ_{cr} (ksi)	σ_{max} (ksi)	50: $\frac{L}{b_W}$	σ_{cr} (ksi)	σ_{max} (ksi)	75: $\frac{L}{b_W}$	σ_{cr} (ksi)	σ_{max} (ksi)
20	0.2	5.4	-----	29.9	4.8	16.8	24.7	4.0	-----	19.8
		9.5	-----	30.1	8.4	16.7	22.3	7.3	7.0	18.4
		13.5	-----	26.1	11.9	-----	20.4	10.4	6.4	16.0
		18.7	-----	15.4	16.8	-----	12.9	14.7	7.2	12.0
	0.3	5.7	-----	31.5	5.1	17.1	26.2	4.1	-----	22.4
		10.1	-----	30.6	9.0	16.6	24.0	7.8	7.4	18.4
		14.7	-----	25.6	12.9	17.6	21.9	11.2	7.1	16.5
		20.2	-----	14.9	18.1	-----	15.0	15.5	7.4	12.2
	0.4	6.0	-----	31.2	5.5	17.4	26.7	4.6	8.7	20.5
		10.8	-----	31.2	9.6	17.0	25.1	8.3	7.6	19.2
		15.1	-----	25.8	13.6	17.0	21.2	11.8	6.9	16.7
		21.4	-----	15.2	19.2	-----	14.6	16.4	7.7	12.0
	0.5	6.4	30.4	31.4	5.7	17.7	26.3	5.0	7.3	21.2
		11.2	-----	30.3	10.1	17.1	23.7	8.8	7.6	18.6
		15.9	-----	26.4	14.3	16.9	21.1	12.5	7.0	17.2
		22.6	-----	13.4	20.2	-----	15.0	16.5	7.0	13.3
25	0.2	5.8	-----	30.2	5.2	16.1	24.2	4.4	9.0	18.7
		10.2	-----	27.9	9.1	16.3	21.6	7.8	7.6	16.0
		14.4	-----	25.1	12.9	16.1	19.7	11.2	7.0	15.2
		20.0	-----	14.6	18.1	-----	12.4	15.4	6.9	11.2
	0.3	6.2	30.3	32.5	5.3	-----	25.2	4.9	7.4	21.0
		10.5	-----	31.7	9.8	17.2	24.7	8.4	7.3	18.6
		15.5	-----	26.6	13.8	17.6	20.8	11.9	7.7	16.5
		21.4	-----	16.8	19.5	-----	15.2	16.6	-----	13.7
	0.4	6.5	-----	30.9	5.7	15.9	25.9	5.1	6.6	21.0
		11.5	-----	31.2	10.2	16.2	24.0	8.8	7.6	19.4
		16.5	-----	26.9	14.5	17.9	22.2	12.5	7.8	17.5
		23.4	-----	13.4	22.0	-----	13.6	18.2	7.2	12.2
	0.5	6.9	-----	32.3	6.2	16.1	26.5	5.4	7.4	20.9
		11.8	-----	31.4	10.6	16.7	24.9	9.4	7.5	19.4
		17.0	-----	27.0	15.4	17.5	22.8	13.5	7.8	17.6
		23.7	-----	14.4	21.3	-----	15.9	18.6	8.2	12.8
30	0.2	6.1	-----	29.9	5.5	16.3	23.2	4.8	6.9	19.4
		10.6	-----	26.8	9.6	16.8	21.9	8.4	7.1	17.7
		15.2	-----	24.1	13.7	-----	18.4	11.4	7.2	15.0
		21.2	-----	16.0	19.3	-----	13.6	16.6	7.0	11.3
	0.3	6.4	30.5	31.4	5.9	17.3	25.6	5.1	7.4	20.0
		11.3	-----	30.7	10.2	17.6	24.3	9.0	7.3	18.9
		16.2	-----	27.0	14.6	17.6	22.6	12.6	7.3	16.4
		22.8	-----	16.8	20.1	-----	15.7	17.6	7.6	13.6
	0.4	6.9	-----	30.7	6.2	16.2	25.0	5.3	6.8	19.2
		11.9	-----	31.0	10.9	17.0	23.8	9.6	7.6	19.8
		16.9	-----	27.5	15.4	17.7	22.6	13.5	7.2	17.7
		23.8	-----	17.4	21.6	-----	16.4	18.8	7.8	13.4
	0.5	7.2	-----	31.1	6.5	16.7	25.5	5.8	7.8	20.6
		11.2	-----	30.3	11.5	16.8	24.4	10.0	8.7	19.8
		17.9	-----	27.5	16.0	16.9	23.0	14.3	7.2	17.0
		25.2	-----	17.5	22.3	-----	16.5	20.1	7.4	13.2

L-499

TABLE II.- TEST DATA FOR PANELS WITH t_W/t_S = 0.63

[c = 1]

$\frac{b_F}{b_W}$	$\frac{b_S}{t_S}$ = 35: $\frac{L}{b_W}$	σ_{cr} (ksi)	σ_{max} (ksi)	50: $\frac{L}{b_W}$	σ_{cr} (ksi)	σ_{max} (ksi)	75: $\frac{L}{b_W}$	σ_{cr} (ksi)	σ_{max} (ksi)	$\frac{b_W}{t_W}$
0.2	6.1	-----	32.6	5.4	17.4	26.0	4.8	8.9	20.4	20
	10.7	-----	30.3	9.6	15.6	23.6	8.4	8.2	20.2	
	15.2	-----	25.7	13.9	16.8	20.1	12.1	6.2	15.8	
	21.3	-----	14.3	19.3	-----	14.5	16.9	6.9	12.0	
0.3	6.5	29.4	32.0	5.9	15.9	28.2	5.1	-----	22.0	
	11.5	-----	32.8	10.3	16.0	25.0	8.9	6.9	20.2	
	16.2	-----	25.4	14.7	17.1	21.8	13.0	8.0	15.8	
	22.5	-----	15.6	20.4	-----	15.1	18.0	7.6	13.0	
0.4	6.9	-----	33.5	6.3	-----	28.3	5.5	7.8	22.7	
	12.1	-----	34.0	11.1	-----	25.8	9.6	-----	21.3	
	16.5	-----	28.3	15.5	16.5	22.2	13.8	7.3	17.2	
	24.3	-----	15.4	21.8	-----	14.5	19.2	7.7	12.5	
0.5	7.1	29.7	33.5	6.5	16.3	27.4	5.6	-----	22.4	
	12.4	-----	32.0	11.3	15.8	25.5	10.0	6.9	20.5	
	17.8	-----	29.4	16.3	16.8	22.9	14.4	7.0	18.5	
	24.6	-----	17.7	22.5	-----	16.3	20.1	7.7	13.9	
0.2	7.1	-----	31.7	6.7	15.7	25.5	6.1	7.3	20.9	25
	12.4	-----	29.0	11.7	16.8	22.7	10.6	7.6	17.8	
	17.9	-----	23.1	16.8	-----	20.2	15.5	7.5	14.1	
	25.1	-----	13.6	23.5	-----	11.9	21.2	7.7	10.0	
0.3	7.6	-----	33.1	7.1	18.0	27.4	6.5	7.9	22.7	
	13.3	-----	32.4	12.4	16.6	25.0	11.4	7.3	19.2	
	19.2	-----	24.7	17.8	15.8	20.6	16.3	8.2	15.6	
	26.3	-----	14.4	25.3	-----	13.5	----	-----	----	
0.4	8.0	-----	33.8	7.5	15.5	28.0	6.9	7.9	22.1	
	14.0	-----	32.4	13.4	16.4	25.0	11.9	7.9	19.8	
	20.0	-----	26.1	18.8	-----	20.4	17.1	7.9	16.4	
	27.5	-----	15.1	26.0	-----	13.5	24.2	8.0	11.3	
0.5	7.5	29.7	32.5	6.9	16.9	28.0	6.2	8.1	22.7	
	13.1	-----	30.9	12.2	16.1	26.2	10.5	7.3	20.9	
	18.5	-----	28.2	17.2	16.8	23.0	15.5	7.1	18.1	
	25.9	-----	17.4	23.5	-----	17.2	21.5	7.4	13.8	
0.2	6.6	29.6	31.2	6.2	-----	24.9	5.4	7.4	19.9	30
	11.4	-----	27.3	10.6	16.0	22.2	9.4	6.9	17.3	
	16.5	-----	23.5	15.4	17.0	20.3	13.8	8.1	16.9	
	22.8	-----	16.9	21.3	-----	15.2	19.0	7.6	13.1	
0.3	7.1	-----	30.7	6.6	16.4	26.1	5.8	-----	20.6	
	12.3	-----	29.9	11.4	16.2	24.9	10.2	7.2	19.6	
	17.6	-----	27.9	16.1	16.0	22.9	14.5	7.6	18.6	
	24.2	-----	17.9	22.6	-----	16.3	20.4	7.6	13.8	
0.4	7.4	-----	30.7	6.8	16.3	25.8	6.2	8.4	21.2	
	12.9	-----	31.4	12.0	17.8	26.9	10.8	7.5	21.0	
	18.1	-----	28.1	16.9	16.6	23.2	15.3	8.0	18.8	
	25.4	-----	18.5	23.8	-----	16.2	21.4	7.9	14.1	
0.5	7.8	-----	30.4	7.2	16.1	26.2	6.5	6.4	21.0	
	13.7	-----	29.1	12.7	15.8	24.0	11.4	8.3	20.2	
	19.3	-----	27.6	18.1	15.4	22.3	16.5	-----	18.0	
	27.0	-----	18.0	25.0	-----	17.1	22.6	7.0	14.2	

L-499

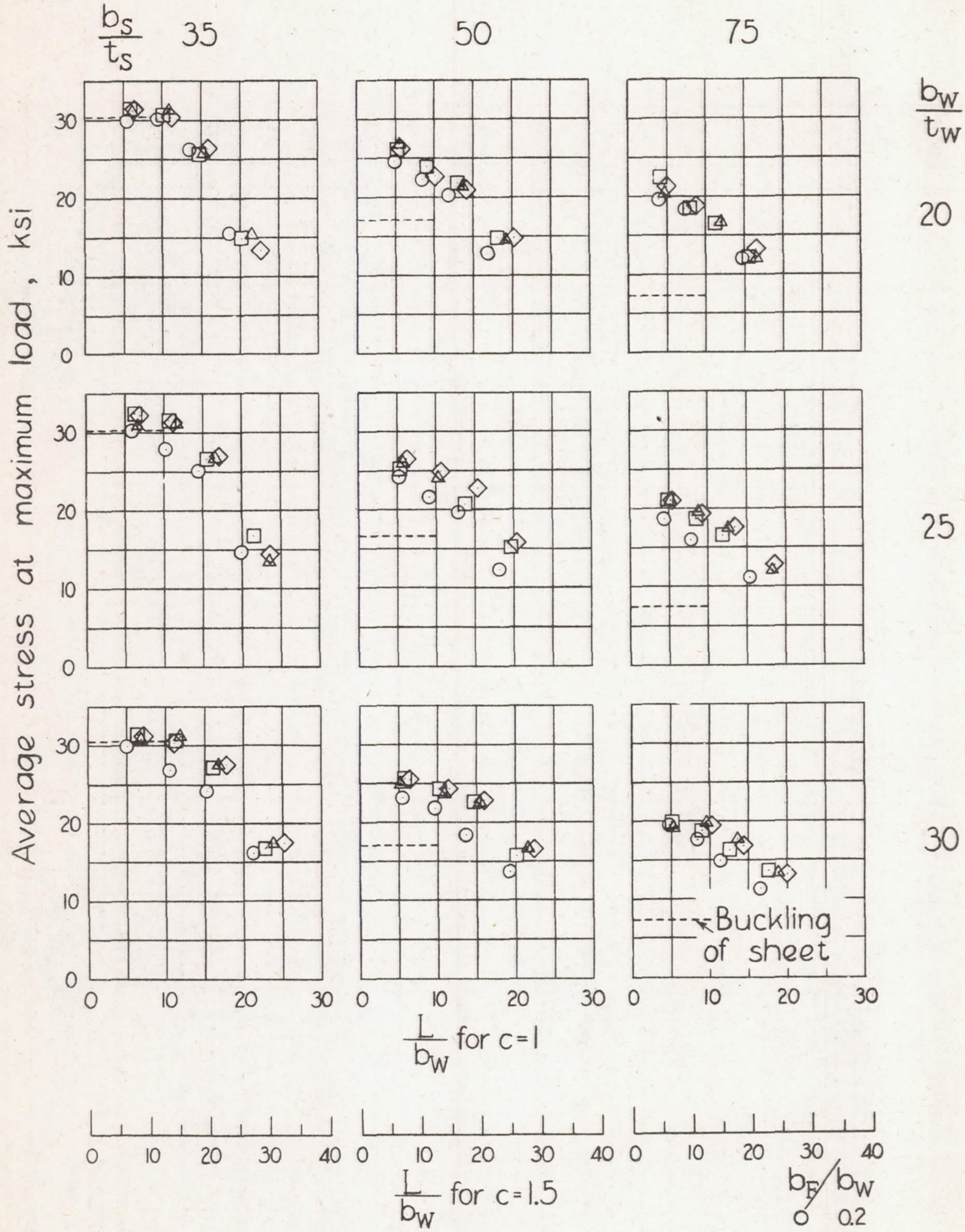

Figure 5.- Strength of test panels with Z-section stiffeners, $t_W/t_S = 0.51$ ($b_A/t_W = 11.4$, $r_A/t_W = 3$, $r_F/t_W = 4$).

L-499

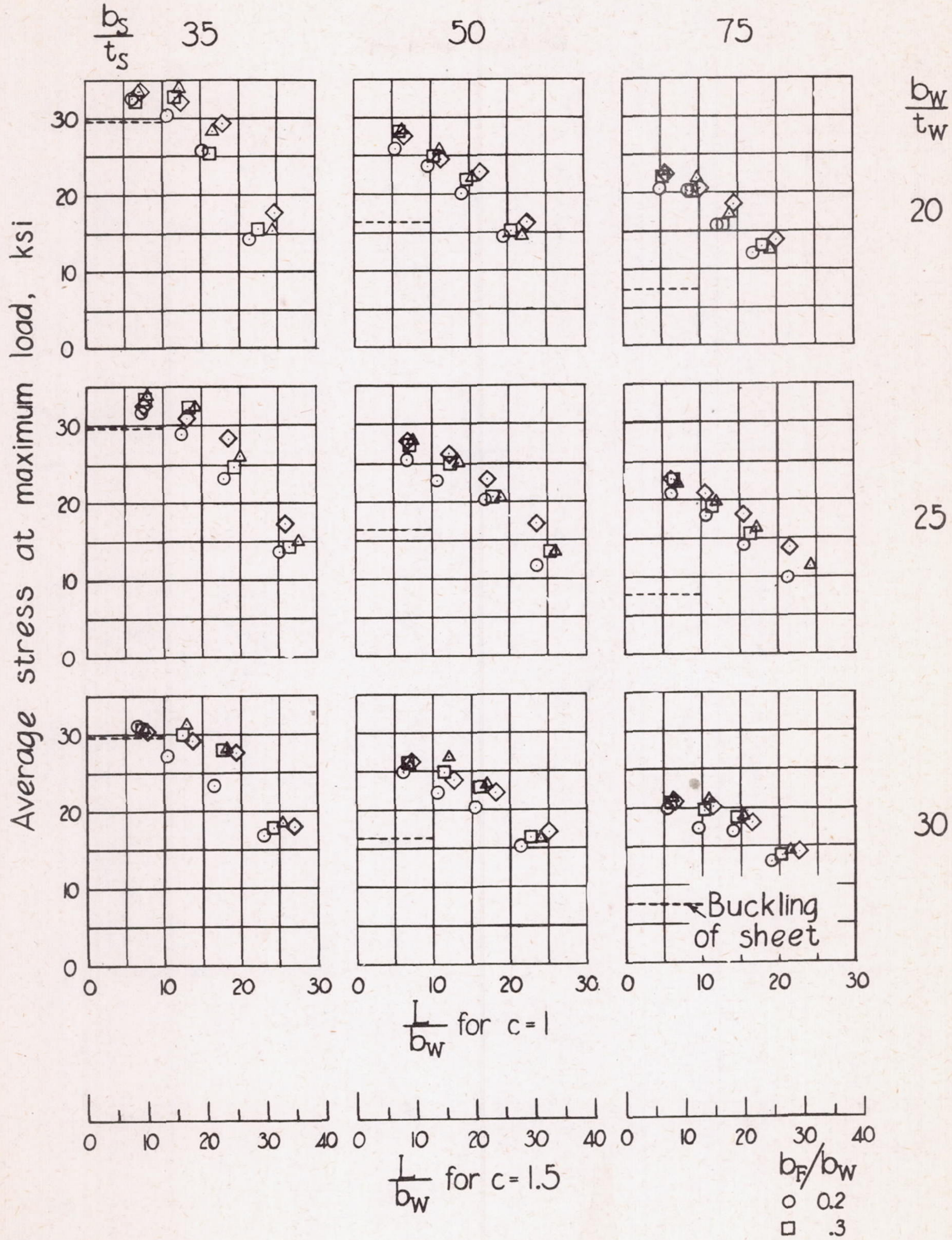

Figure 6.- Strength of test panels with Z-section stiffeners, $t_W/t_S = 0.63$ ($b_A/t_W = 10.9$, $r_A/t_W = 3$, $r_F/t_W = 4$).

L-499

TABLE III.- TEST DATA FOR PANELS WITH $t_W/t_S = 0.79$

$[c = 1]$

$\frac{b_W}{t_W}$	$\frac{b_F}{b_W}$	$\frac{b_S}{t_S} = 35$: $\frac{L}{b_W}$	σ_{cr} (ksi)	σ_{max} (ksi)	50: $\frac{L}{b_W}$	σ_{cr} (ksi)	σ_{max} (ksi)	75: $\frac{L}{b_W}$	σ_{cr} (ksi)	σ_{max} (ksi)
20	0.2	6.6	-----	34.1	6.2	18.7	26.9	5.6	7.4	21.3
		11.6	-----	31.8	10.8	18.8	24.1	9.8	7.9	19.8
		16.7	-----	27.7	15.5	17.5	21.5	14.1	8.4	16.1
		23.0	-----	16.9	21.5	-----	16.3	19.6	8.3	12.6
	0.3	7.0	-----	34.5	6.5	-----	28.7	5.9	9.6	22.9
		12.5	-----	34.4	11.5	20.5	27.2	10.2	8.7	21.7
		17.9	-----	26.9	16.5	18.9	23.4	14.6	8.8	17.4
		25.3	-----	16.5	22.7	-----	16.2	20.7	9.6	12.7
	0.4	7.4	27.4	35.7	6.9	16.9	29.6	6.2	9.7	24.7
		13.2	-----	34.6	12.1	19.0	27.2	10.8	9.1	23.1
		18.7	-----	29.7	17.3	18.7	23.2	15.2	8.6	20.4
		25.8	-----	16.8	24.5	-----	16.4	21.7	8.7	14.2
	0.5	7.6	-----	34.8	7.2	17.6	29.7	6.6	8.2	24.2
		13.3	31.6	33.7	12.3	18.8	28.5	11.3	9.3	22.3
		18.9	26.1	27.7	18.0	18.7	23.1	16.3	8.0	19.4
		26.6	-----	17.6	24.5	-----	16.4	22.5	8.4	13.3
25	0.2	7.1	-----	32.8	6.7	17.2	28.4	6.1	8.8	21.3
		12.5	-----	29.7	11.7	18.2	24.3	10.6	7.9	18.7
		18.0	-----	25.7	16.8	-----	22.8	15.2	9.2	16.6
		24.9	-----	16.2	23.4	-----	15.9	21.2	8.7	13.3
	0.3	7.6	28.3	37.0	7.1	-----	28.9	6.5	-----	23.6
		13.3	-----	32.6	12.3	-----	28.2	11.3	9.4	22.2
		18.7	-----	28.2	17.9	17.6	24.4	16.2	8.6	19.3
		26.0	-----	17.6	24.8	-----	16.9	22.6	9.2	13.8
	0.4	8.0	-----	35.2	7.5	14.4	29.2	6.8	10.1	24.4
		13.9	-----	33.3	13.2	18.6	27.8	12.0	7.9	22.6
		20.3	-----	29.3	18.7	-----	23.3	17.2	9.1	19.5
		27.4	-----	17.1	25.8	-----	17.0	23.8	8.2	13.4
	0.5	7.9	-----	33.2	7.5	18.5	28.5	6.9	8.8	23.6
		13.9	-----	33.8	13.3	-----	27.4	11.8	-----	22.9
		19.8	-----	27.9	18.8	17.4	23.5	17.0	7.9	19.9
		27.5	-----	17.7	26.7	-----	17.2	24.0	8.2	14.2
30	0.2	7.2	-----	32.0	6.8	19.2	25.3	6.3	9.0	20.8
		12.6	-----	27.7	11.9	20.1	22.7	10.9	8.6	17.8
		18.0	-----	23.6	16.6	-----	20.2	15.7	8.8	16.3
		25.4	-----	17.3	24.1	-----	17.3	21.8	8.9	13.7
	0.3	7.6	28.4	33.8	7.7	19.1	27.8	6.6	8.9	22.9
		13.5	-----	32.0	12.8	19.5	26.6	11.7	8.5	22.3
		19.1	-----	28.5	18.1	19.1	23.6	16.5	8.5	19.2
		26.5	-----	18.6	25.4	-----	17.6	23.2	7.9	14.4
	0.4	8.1	-----	32.5	7.6	18.6	27.6	7.1	9.0	23.6
		14.0	-----	31.7	13.3	20.1	26.8	12.5	9.0	21.6
		20.1	-----	28.2	19.3	18.4	22.6	17.8	8.8	19.7
		27.8	-----	17.5	26.5	-----	17.2	25.1	8.9	14.0
	0.5	8.0	-----	31.2	7.6	17.9	26.9	7.2	8.1	22.5
		14.1	-----	30.2	13.6	-----	25.0	12.7	8.8	20.9
		20.2	-----	26.5	19.5	-----	23.7	17.8	8.8	18.9
		28.6	-----	17.1	27.4	-----	16.5	25.4	8.1	14.8

L-4995

TABLE IV.- TEST DATA FOR PANELS WITH $t_W/t_S = 1.00$

[c = 1]

b_W/t_W	b_F/b_W	$b_S/t_S = 35$: L/b_W	σ_{cr} (ksi)	σ_{max} (ksi)	$b_S/t_S = 50$: L/b_W	σ_{cr} (ksi)	σ_{max} (ksi)	$b_S/t_S = 75$: L/b_W	σ_{cr} (ksi)	σ_{max} (ksi)
20	0.2	7.2	-----	33.8	6.8	19.5	27.6	6.3	8.3	22.2
		12.7	-----	30.4	12.1	19.7	26.9	10.9	9.2	19.9
		18.1	-----	26.7	17.1	20.6	22.3	15.6	9.0	17.4
		25.3	-----	16.8	24.0	-----	16.0	21.6	9.1	13.7
	0.3	7.6	-----	36.3	7.2	18.3	30.2	7.3	8.6	24.0
		13.1	-----	32.8	12.4	18.4	27.8	11.5	7.7	23.2
		18.9	-----	26.8	17.7	18.6	23.2	16.4	8.6	18.3
		24.8	-----	17.6	25.4	-----	18.5	23.2	8.6	14.6
	0.4	7.9	-----	36.7	7.4	18.8	31.6	7.0	9.7	25.9
		13.7	-----	33.7	12.9	18.0	29.1	12.3	8.4	23.8
		19.6	-----	27.3	18.8	17.5	24.1	17.5	8.3	20.1
		26.4	-----	17.5	25.8	-----	16.7	24.6	8.9	14.3
	0.5	8.3	33.0	36.1	8.0	20.0	32.0	7.2	9.0	26.1
		14.2	32.2	34.1	13.8	19.0	28.2	12.9	8.5	24.7
		20.4	-----	28.0	19.5	17.6	23.2	18.3	8.7	20.2
		28.5	-----	17.2	27.1	-----	16.5	25.5	9.2	14.8
25	0.2	7.4	-----	31.6	7.2	20.9	26.9	6.7	8.9	21.5
		12.9	-----	26.8	12.8	19.6	24.6	11.5	8.9	18.8
		19.1	-----	22.9	18.2	-----	21.2	16.8	9.1	18.0
		26.1	-----	17.3	24.7	-----	16.7	25.4	8.9	13.7
	0.3	7.8	-----	33.5	7.4	19.2	29.6	7.1	9.2	24.2
		13.9	-----	31.7	13.0	19.4	27.1	12.0	8.2	22.4
		19.3	-----	27.3	18.5	18.6	24.3	17.4	8.3	20.7
		26.9	-----	18.1	26.0	-----	17.2	24.4	9.2	14.7
	0.4	8.1	-----	35.4	7.8	18.4	31.0	7.2	7.5	25.8
		13.8	-----	31.8	13.7	19.9	27.7	12.5	8.8	24.1
		20.0	-----	28.7	19.1	-----	24.5	18.2	8.3	21.1
		27.1	-----	16.4	27.5	-----	18.0	24.6	-----	14.3
	0.5	8.3	32.7	35.3	8.1	19.5	30.8	7.7	8.6	25.5
		14.6	31.6	33.1	14.1	20.1	27.9	13.3	9.3	23.9
		20.6	-----	25.3	19.9	20.1	23.9	19.1	8.8	21.5
		28.7	-----	16.8	28.5	-----	17.5	26.3	9.5	14.1
30	0.2	7.6	-----	29.7	7.3	-----	26.0	6.9	8.8	21.3
		13.2	-----	25.5	12.8	-----	21.7	11.9	8.9	18.7
		18.7	-----	21.7	18.2	-----	19.9	17.1	8.9	16.1
		26.4	-----	16.8	25.2	-----	15.8	23.4	10.0	14.1
	0.3	8.0	-----	33.1	7.8	-----	28.2	7.4	8.6	23.9
		14.0	-----	29.4	13.4	-----	25.9	12.7	8.6	21.6
		19.9	-----	23.6	19.3	-----	23.3	18.3	8.6	19.6
		28.0	-----	15.0	26.6	-----	16.6	25.8	8.6	14.5
	0.4	8.4	32.4	33.3	8.2	18.9	29.0	7.6	8.0	24.2
		14.4	-----	31.6	14.0	17.8	27.5	13.4	8.8	22.8
		20.8	-----	23.8	20.2	-----	21.8	19.1	8.5	20.8
		28.9	-----	15.1	28.4	-----	16.6	26.6	8.4	14.8
	0.5	8.5	-----	32.7	8.3	20.0	28.1	8.1	9.5	24.0
		14.8	-----	30.1	14.7	19.3	26.3	14.0	8.8	22.4
		21.2	-----	26.0	20.8	-----	22.7	19.8	9.3	20.2
		29.4	-----	13.5	28.5	-----	16.1	27.7	8.4	14.1

L-499

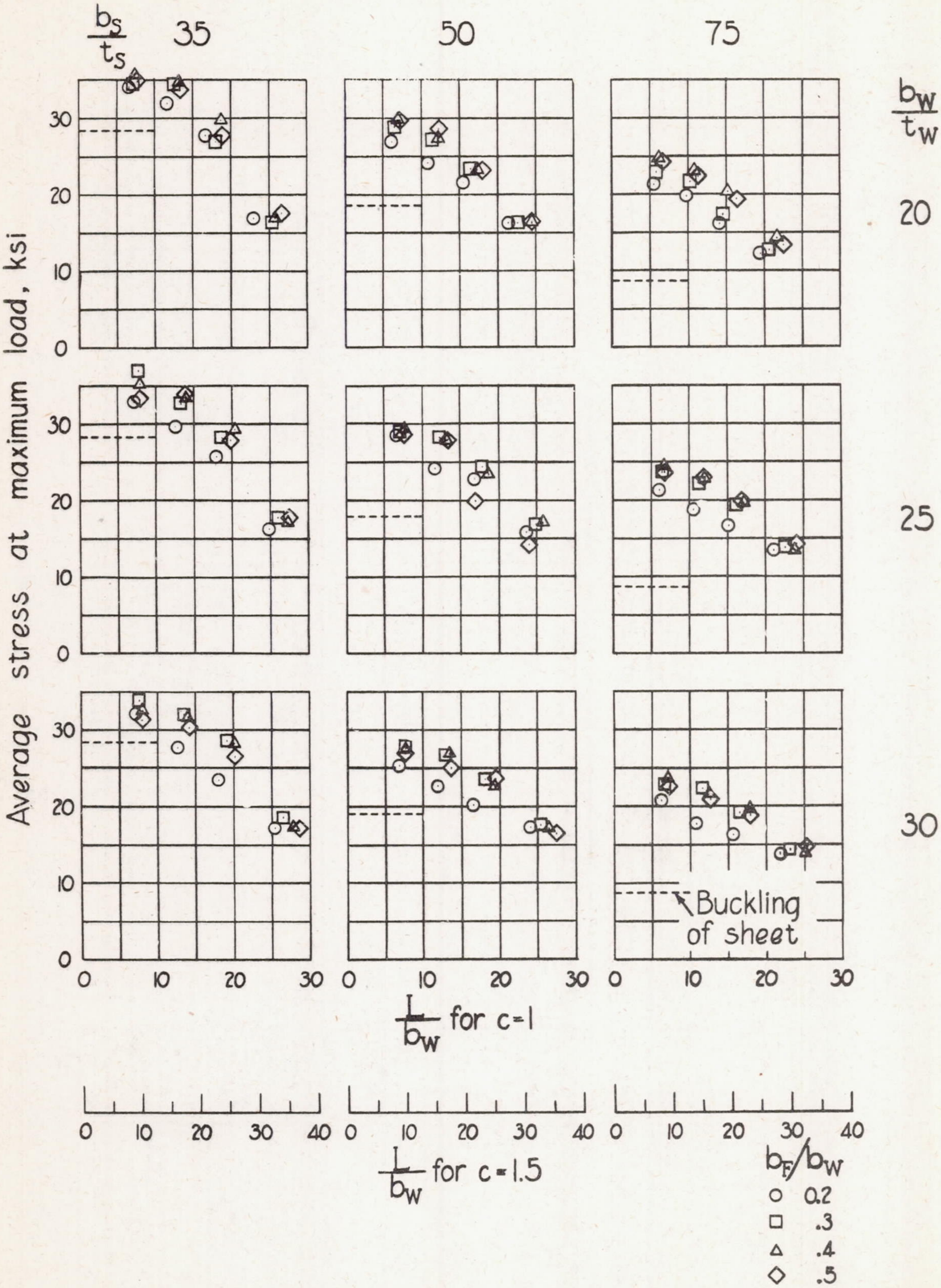

Figure 7.- Strength of test panels with Z-section stiffeners, $t_W/t_S = 0.79$ ($b_A/t_W = 9.8$, $r_A/t_W = 3$, $r_F/t_W = 4$).

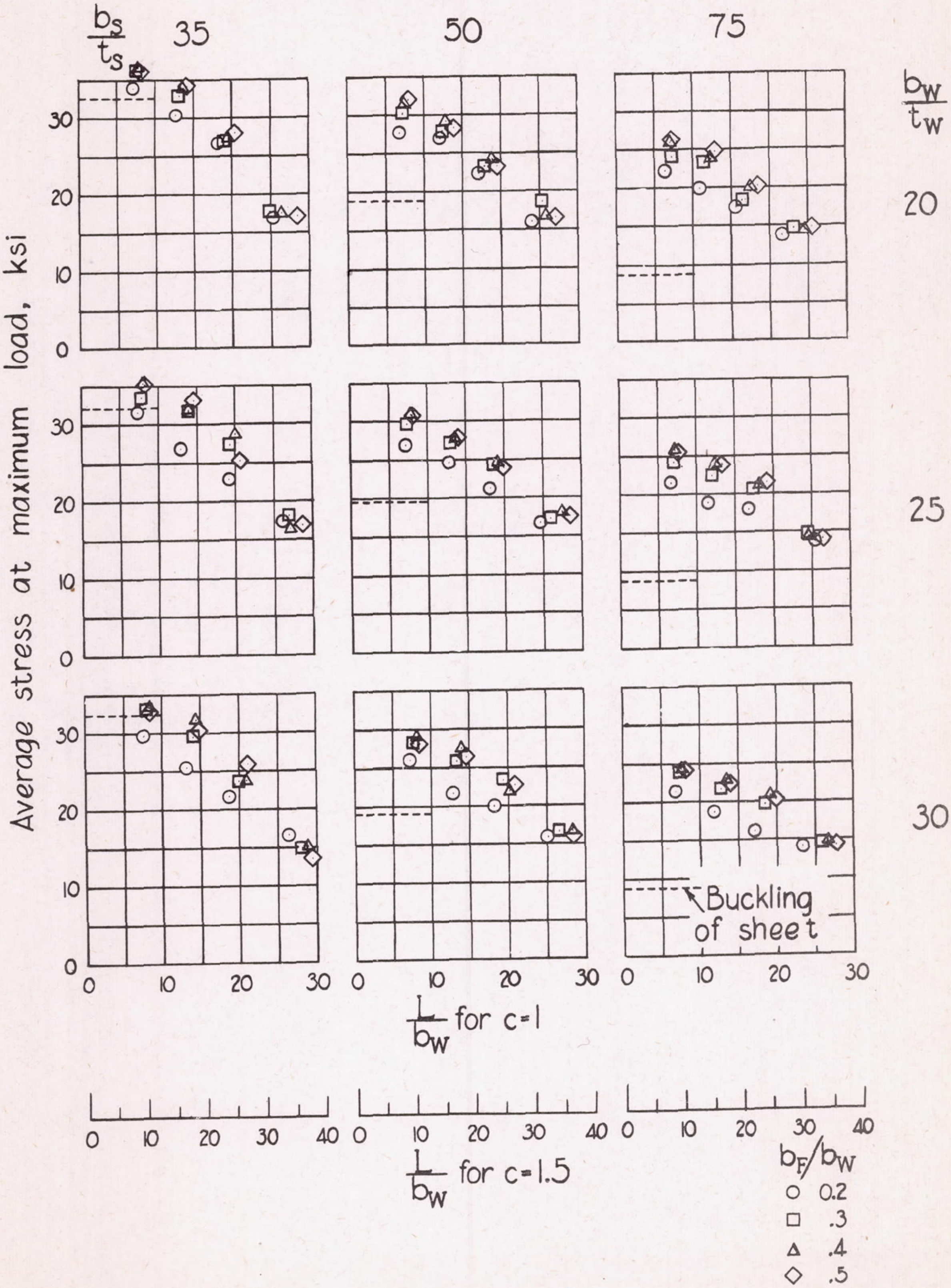

Figure 8.- Strength of test panels with Z-section stiffeners, $t_W/t_S = 1.00$ ($b_A/t_W = 8.6$, $r_A/t_W = 3$, $r_F/t_W = 4$).