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RESTRICTED BULLETIN

DATA ON COMPRESSIVE STRENGTH OF FLAT PANELS WITH Z-SECTION STIFFENERS

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A comprehensive series of compression tests on skin-stiffener panels with Z-section stiffeners formed from flat sheet (see fig. 1) is being made in order to show the importance of the relative dimensions in determining the strength of the panels. The results obtained to date in this investigation are presented in this report.

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.

The stiffeners were attached to the sheet with machine-countersunk flush rivets of a new type. These rivets consisted of ordinary flathead rivets inserted from the stiffener side of the joint, the countersunk heads being formed in the driving of the rivets. The portion of the formed countersunk head which protruded above the skin surface after driving was removed with the flush-rivet milling tool described in reference 1. The rivets in any one stiffener were driven in a single operation on a Cincinnati press brake, as shown in figure 2. Rivets of this type have been found to be superior to the conventional flush rivets. (See reference 2.)

In all cases, the rivets were A17S-T aluminum alloy. The rivet spacings and rivet diameters used in the test specimens are given in terms of the skin thickness in the following table:

$\frac{t_w}{t_s}$	$\frac{\text{Rivet spacing}}{t_s}$	$\frac{\text{Rivet diameter}}{t_s}$
0.63	12.3	1.23
.80	12.3	1.54

The symbols t_w and t_s are defined in figure 1. The

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included angle of the countersunk head was 60° in all cases. The depth of countersink was three-fourths of the skin thickness.

As shown in figure 3, the specimens were tested with flat ends in the 1,200,000-pound-capacity testing machine in the NACA structures research laboratory. The loading head of this machine is laterally supported during tests by the heavy side columns of the machine in such a manner as not to affect the accuracy of load measurement. The ends of the specimen were ground flat and parallel in a planer specially adapted for this purpose, and the method of transfer of the specimen from the planer to the testing machine was such as to maintain this flatness and parallelism of the ends.

Test results.- The results obtained to date are presented in figures 4 and 5. The symbols used, with the exception of L, the specimen length, are defined in figure 1.

The main value of figures 4 and 5 lies in the actual data presented. These data enable the designer to study the effect of the various dimension ratios on the average stress at maximum load for the skin-stiffener combination. More complete studies of this nature will be possible when the present investigation is completed.

The following conclusions as to the effect of each of the dimension ratios can be drawn from the data of figures 4 and 5, if it is assumed in each case that the other ratios are held constant:

1. A Z-section stiffener with $b_F/b_W = 0.2$ is less efficient than one with $b_F/b_W = 0.3$ or 0.4. As there seems to be little difference between the average stresses at maximum load when $b_F/b_W = 0.3$ and when $b_F/b_W = 0.4$, it appears that further increase in this ratio will not increase the average stress developed. This deduction is borne out by a theoretical analysis based on the curve presented in figure 6 of reference 3.

2. The average stress at maximum load decreases 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.

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4. The average stress at maximum load increases slightly with increasing values of the ratio t_W/t_S.

5. The average stress at maximum load is almost independent of the ratio b_W/t_W within the range of values included in the present investigation.

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.

The countersunk rivets used to attach the stiffeners to the sheet in the panels of this investigation are not in general use in the aircraft industry. A few duplicate specimens were therefore made with commercial roundhead rivets. The results presented in the following table reveal that the average stress at maximum load was in every case greater for the panels with the new type of machine-countersunk flush rivets than for the panels with roundhead rivets:

Average stress at maximum load (lb/sq in.)	
New type flush rivets	Commercial roundhead rivets
33,190	31,270
34,010	33,150
23,360	21,300
22,800	21,850
29,370	28,320

Because of the small number of tests, it may not be justifiable to conclude that the new type of machine-countersunk flush rivet is alone responsible for this increase in strength. It is certainly justifiable, however, to conclude that these rivets are at least as good as the commercial roundhead rivets for attaching stiffeners to the skin within the range of proportions included in these tests.

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3. Stowell, Elbridge Z., and Lundquist, Eugene E.: Local Instability of Columns with I-, Z-, Channel, and Rectangular-Tube Sections. T.N. No. 743, NACA, 1939.

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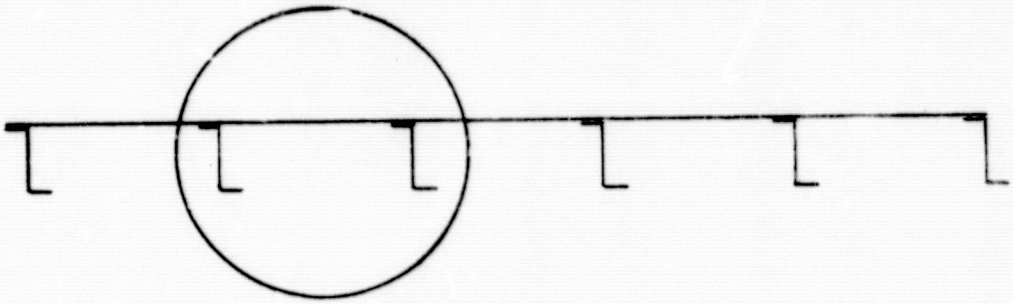

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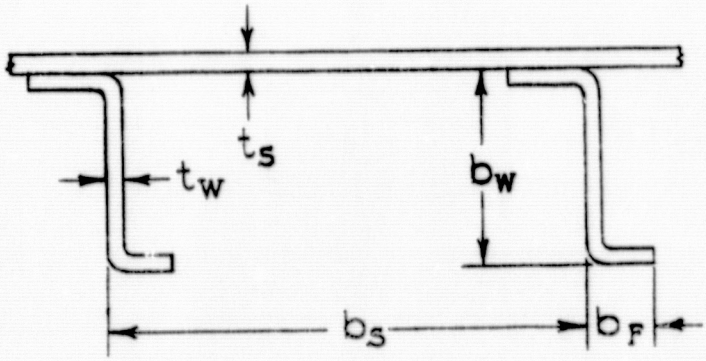

Figure 1.- Cross section of a test panel.

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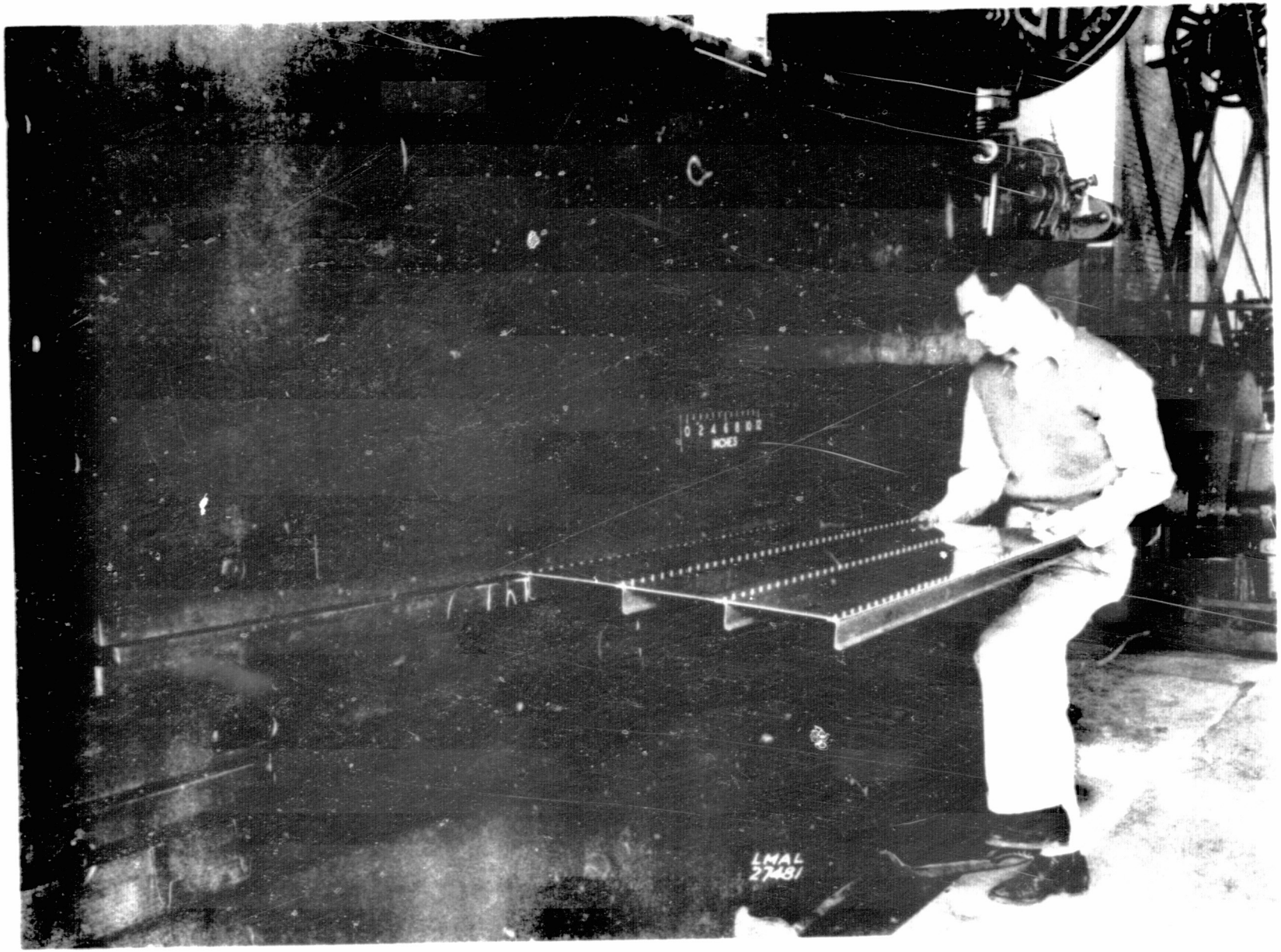

Figure 2.- Gang riveting of stiffeners to skin with Cincinnati press brake.

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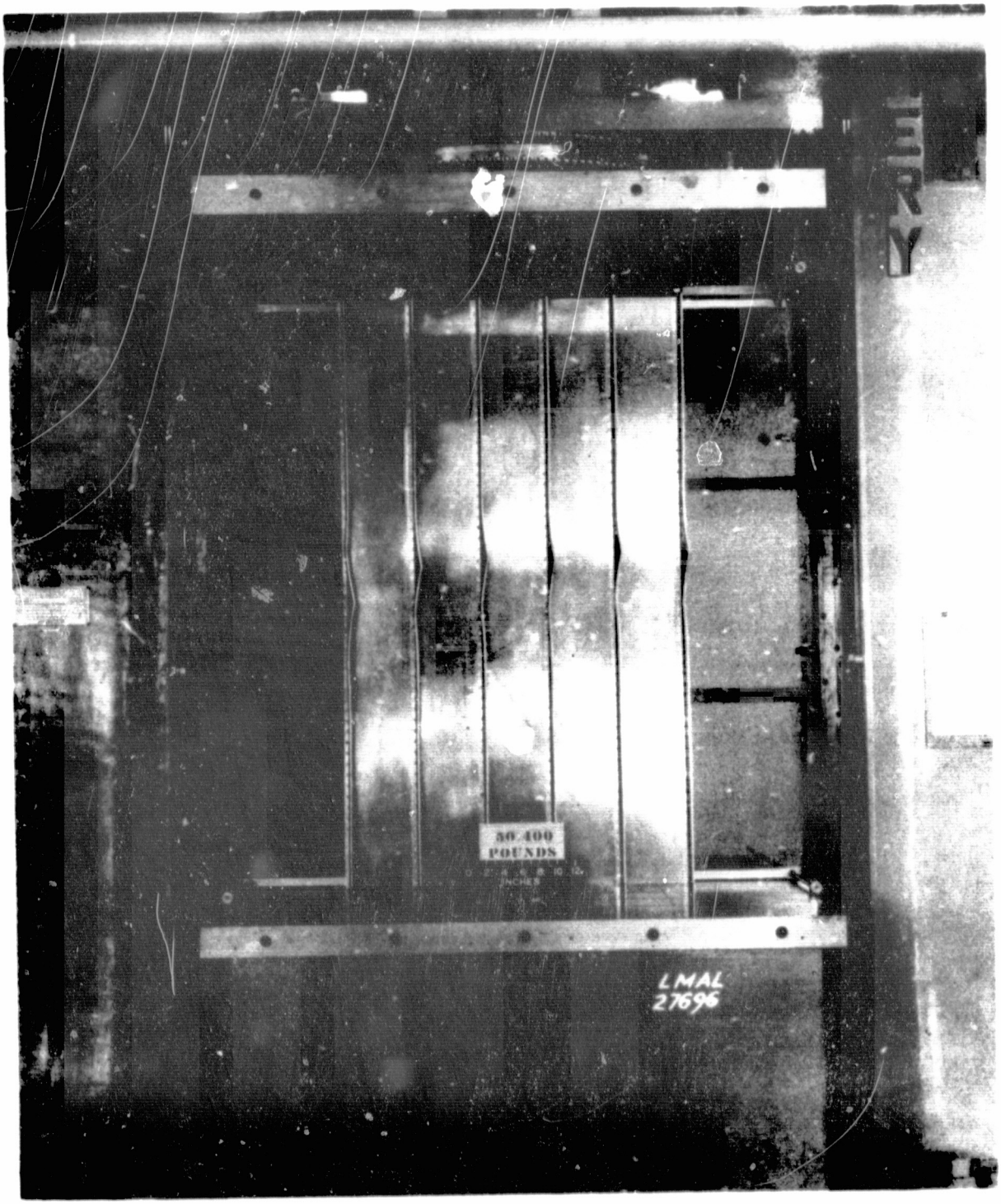

Figure 3.- Panel after failure in testing machine.

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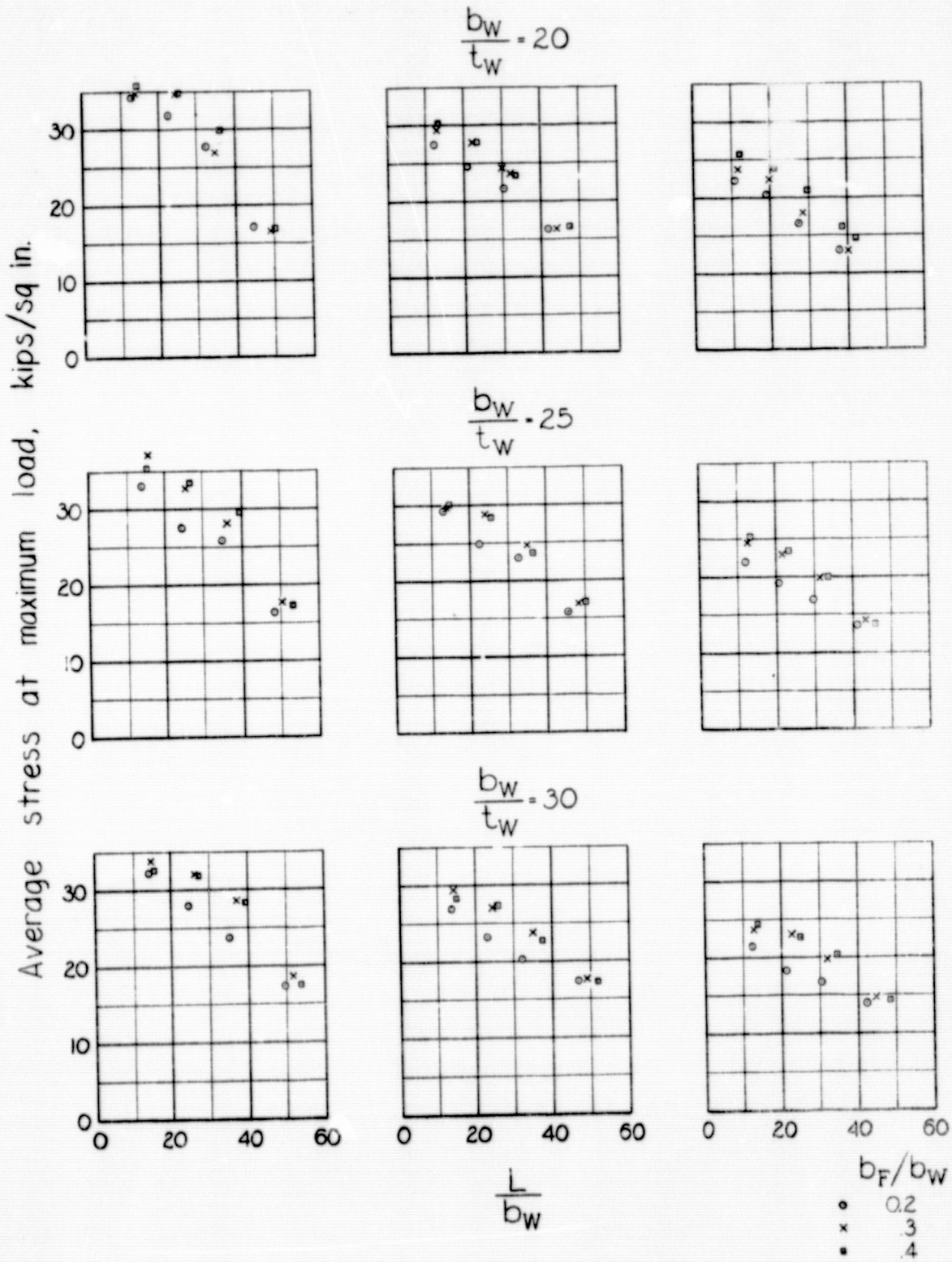

Figure 4.- Strength of test panels with Z-section stiffeners (t_w/t_s=0.80).

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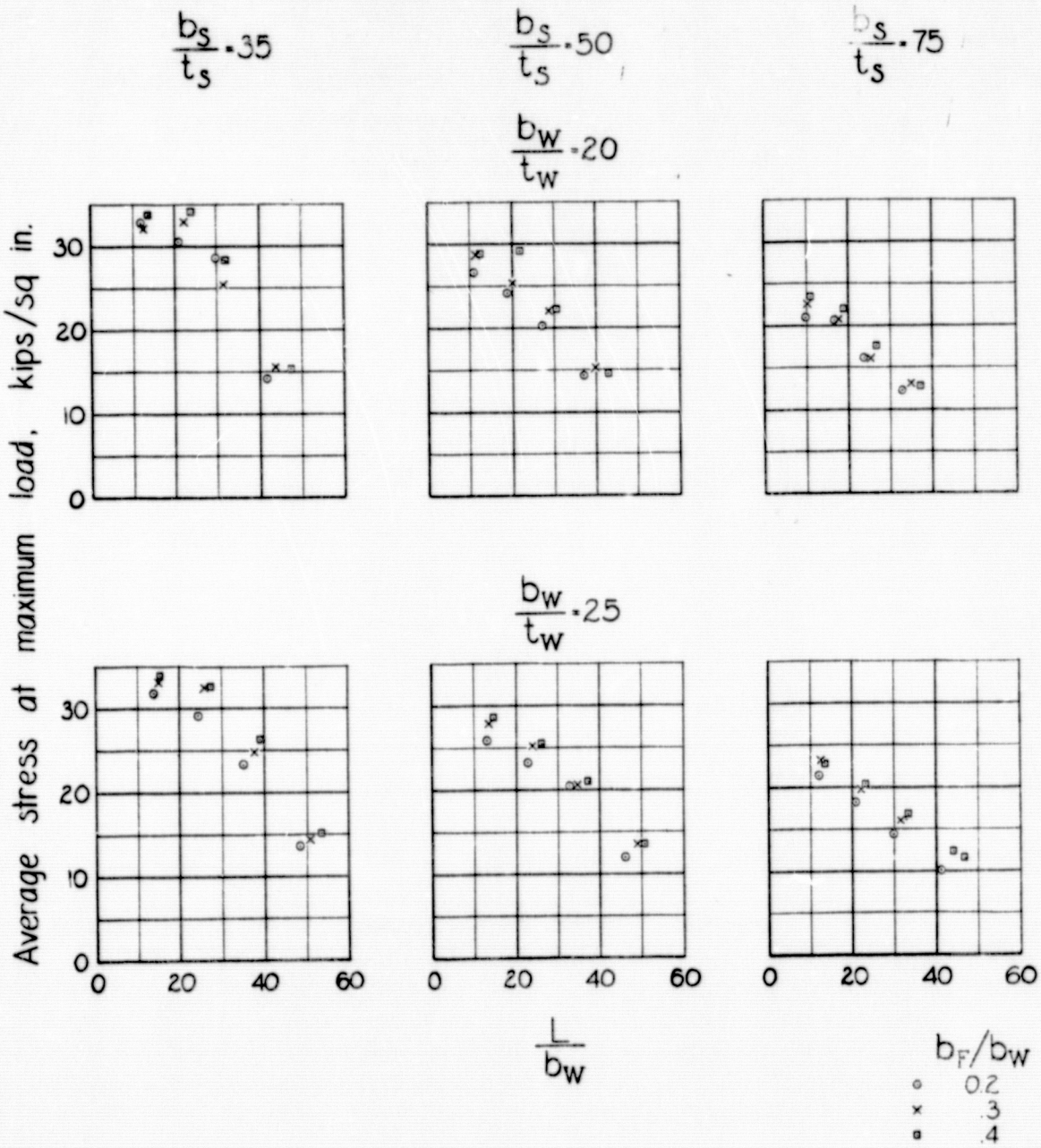

Figure 5.- Strength of test panels with Z-section stiffeners (t_w/t_s = 0.63).

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