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No. 821

SOME COMPARATIVE TESTS OF PLAIN AND ALCLAD 24S-T SHEET

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Aluminum Company of America

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SUMMARY

Comparative data on the behavior of plain and alclad 24S-T sheet under several types of structural loading are presented. The results indicate that, as far as flexural stiffness and resistance to buckling are concerned, the effect of the soft protective coating on alclad sheet is equivalent to a reduction in thickness of about 7 percent. Differences in the stiffness and the buckling resistance of plain and alclad 24S-T sheet, or in the thickness requirements necessary to offset such differences, may be estimated on the basis of this reduced effective thickness. Although alclad sheet is much more sensitive to flexural permanent set than plain sheet because of the low elastic strength of the coating, differences in permanent-set characteristics have little bearing upon the relative load-carrying capacities of the two materials in structural applications.

INTRODUCTION

Because of its superior corrosion resistance, particularly where spot welding is used, alclad 24S-T is used more generally than plain 24S-T in aircraft construction. Although the sacrifice in tensile properties involved in the use of alclad rather than plain sheet is known, experimental data are needed to show the relative behavior of these materials under other common types of structural loadings. This report presents in condensed form the results of tests pertaining to the relative flexural stiffness, buckling resistance, permanent-set characteristics, and ultimate strengths of similar specimens of plain and alclad 24S-T sheet.

DESCRIPTION OF SPECIMENS AND PROCEDURE

Two thicknesses of material, nominally 0.064 inch and 0.250 inch, were obtained in plain and alclad 24S-T for these comparative tests. The different types of specimen used and the procedures followed may be described as follows:

1. Tensile and compressive property determinations were made on all lots of material for the direction parallel to that in which the materials were stressed in the structural tests. The tensile tests were all made on 1/2 inch wide, sheet-type specimens (reference 1); strains were measured over 2-inch gage lengths by means of a Templin autographic electrical extensometer. The compression tests on the 0.064-inch material were made on seven-piece packs (reference 2), 5/8 inch wide by 2 inches long; the tests on the 0.250-inch material were made on single 1-inch wide strips, 2.89 inches long. Compressive strains in all cases were determined by means of Huggenberger tensometers on 1/2-inch gage lengths.

2. Bending tests were made on 3-inch-wide strips from all lots of material in order to show differences in the flexural stiffness and permanent-set characteristics of single thicknesses of material. The tests were made in a 40,000-pound capacity Amsler hydraulic testing machine, using central concentrated loads on 6-inch and 8-inch spans. Bending deflections and permanent sets were measured at the center of the spans by means of a dial indicator graduated in thousandths of an inch.

3. Column tests were made on 1-inch-wide strips of the 0.250-inch material in lengths ranging from 2.89 to 28.9 inches, corresponding to effective slenderness ratios (KL/r) from about 20 to 200. These specimens were loaded to failure in a 40,000-pound capacity Amsler hydraulic testing machine, using fixed bearing heads.

4. Figure 1 shows the dimensions of the box beams fabricated from the 0.064-inch sheet. These specimens were all 40 inches long and each specimen was composed of two formed channel sections, 3 inches deep, to which cover sheets were riveted. Over-all widths of $2\frac{3}{4}$ and $4\frac{1}{2}$ inches were used in both materials to provide flanges having widely different buckling characteristics. Table I gives the essential section elements.

Bending tests were made on these specimens in a 40,000-pound capacity Amsler hydraulic testing machine, using a third-point loading on a 36-inch span. Deflections and permanent sets at the center of the span were measured by mirrored scales attached to the beams, midway between flanges, and fine wires stretched between the ends of the span. Flange stresses were measured in the middle third of the span by means of Huggenberger tensometers on gage lengths of 1 inch. On the specimens having over-all widths of $4\frac{1}{2}$ inches, the buckling characteristics of the compression flanges were also investigated by measuring deflections at 1-inch intervals along the longitudinal center line of the flanges. All specimens were loaded in increments to failure.

5. Figure 2 shows the dimensions of the stiffened flat-sheet panels fabricated from the 0.064-inch material. The specimens were all approximately $18\frac{1}{8}$ inches long and were each composed of four $1\frac{1}{4}$ by $1\frac{1}{4}$ by $\frac{1}{4}$-inch angles, riveted in pairs to the edges of a flat-sheet panel. In order to cover a wide range of buckling loads, specimens having widths of 2, 3, 4, and 6 inches between stiffeners were provided. Table II gives the essential section elements.

Edge compression tests were made on these specimens in a 300,000-pound capacity Amsler hydraulic-type testing machine, using fixed bearing heads fitted with leveling rings. Lateral deflection and permanent-set measurements were taken at 1-inch intervals along the longitudinal center line of the panels by means of a dial indicator, graduated in thousandths of an inch, used in conjunction with a reference frame fastened to the testing machine heads. Strains were measured on eighteen 2-inch gage lines at the center section of each panel by a Berry strain gage.

The procedure followed in these tests was to apply increments of load, measuring lateral deflections at each increment, until buckling of the sheet became apparent. From this point on, permanent-set readings were taken after each increasing load. Strain measurements were taken at a sufficient number of loads to indicate the distribution of stress before and after buckling of the sheet and to indicate the first yielding of the stiffeners. Each of these specimens was tested to failure of the complete panel.

DISCUSSION OF RESULTS

Tensile and Compressive Properties of Materials

Table III gives a summary of the tensile and the compressive properties for the materials used. Although there is considerable variation in properties for the different lots of material, all values are above the specified minimums for both plain and alclad 24S-T sheet; in fact, the properties for the 0.064-inch sheet are above those specified for this alloy in the RT condition (reference 3).

The ratios of the strengths obtained for the alclad to those for the plain materials are of interest in connection with the results obtained in the structural tests. It would simplify comparisons if the protective coatings of the alclad accounted for the only differences between the properties of the materials used but such was obviously not the case.

Bending Tests on Single Thicknesses of Sheet

Figure 3 shows the load-deflection and permanent-set curves obtained from bending tests on single thicknesses of each material. Two significant differences in behavior will be noted: (1) permanent sets were observed in the alclad specimens almost from the start of the tests, indicating stresses in the extreme fibers exceeding the elastic strength of the coating material; and (2) the deflections of the alclad specimens within the estimated elastic range of the core material were about 20 percent greater than indicated for the plain specimens of equal thickness.

Figure 3 shows that the difference in flexural stiffness found for the plain and the alclad specimens corresponds very closely to that computed, if only 93 percent of the thickness is assumed to be effective in the case of the alclad. Such a value of effective thickness does not seem unreasonable in view of the fact that protective coatings normally account for about 11 percent of the total thickness and it does not seem necessary to neglect their stiffening effect entirely. Because of the large ratios of width to thickness of specimen involved in these tests, the computed deflections shown in the figures were based on a modulus of elasticity equal to $E/(1 - \mu^2)$, where $E =$ 10,300,000 pounds per square inch and $\mu = 1/3$. Such a computation procedure was apparently not as justified for the 0.250-inch as for the 0.064-inch material, but this fact has no bearing upon the differences in the flexural stiffness observed for the two materials.

Column Tests on Single Thicknesses of Sheet

Figure 4 gives the results of the column tests on the 1-inch-wide strips of 0.250-inch sheet. As would be expected from the 20-percent difference in compressive yield strength of the plain and the alclad materials given in table III and the differences in flexural stiffness shown in figure 3, the column strengths of the alclad specimens were less than found for corresponding specimens of plain material. For comparative purposes, two computed column-strength curves are shown in figure 4; one is based on the compressive yield strengths of the materials (reference 4) and the other is based on values of tangent modulus used in the Euler equation for elastic buckling (reference 4). In the case of the plain material, the computed column-strength curve based on tangent moduli is in good agreement with measured values, while the more common straight-line relation gives values that are somewhat low in the range of intermediate effective slenderness ratios. The strengths of the alclad specimens were below those computed by either of the foregoing methods, except for low slenderness ratios, where the yield strength of the material was a predominant factor. Although neither of the two methods of computation has ever been suggested as being strictly applicable to alclad material, their principal weakness is that they do not take into account the influence of the coating material upon flexural stiffness.

Figure 5 shows the column strengths for the alclad specimens based on the assumption that only 93 percent of the full thickness was effective. The strengths indicated by the tests and the corresponding effective slenderness ratios are about 7 percent higher than shown for the same specimens in figure 4. From the good agreement found between these modified test results and the computed column-strength curve based on the same reduction in effective thickness, it appears that the column strength of single thicknesses of material may be estimated by the reduced-thickness method proposed.

Bending Tests on Box Beams

Figure 6 shows the load-deflection and the permanent-set curves obtained from the tests on the box beams fabricated from 0.064-inch sheet. Although permanent sets occurred earlier in the alclad specimens than in those of plain material and there was some difference in flexural stiffness, the influence of the alclad coating material was by no means as pronounced as found in the bending tests on single thicknesses of material. The explanation for this difference is that the flexural stiffness of built-up sections does not vary as the cube of the sheet thickness, as in the case of bending of a single thickness of material about its own centroidal axis, but varies approximately as the first power of the thickness.

For purposes of comparison, two sets of computed load-deflection relations have been shown in figure 6; one set is based upon the full thickness of the sheet elements, and the other is based upon a 93-percent effective sheet thickness. The procedure based on 93-percent thickness resulted in computed deflections about 7 percent greater than obtained using full thicknesses. In the bending tests on single-thickness specimens, it will be recalled, the same procedure resulted in a 20-percent difference in flexural stiffness. It appears from the good agreement obtained between measured and computed deflections that the use of the effective-thickness method for predicting the flexural stiffness of built-up alclad beams is as satisfactory as for predicting the behavior of this material under any of the other types of loading considered. Although load-stress data have not been included here, they were entirely consistent with the behavior indicated by the measured deflections.

Measurements of local buckling in the compression flanges of the $4\frac{1}{2}$-inch-wide beams indicated typical buckle patterns, although it was not possible to determine when buckling first occurred. It was evident, however, that buckling occurred earlier in the alclad than in the beam of plain material and that local permanent sets were first obtained in the alclad beam. A comparison of the measured deflections indicated that appreciable buckling did not occur in the compression flanges of either material for loads less than those computed as critical for an assumed condition of fixed edges (reference 5, p. 41). In the case of the alclad beam, an effective sheet thickness of 93 percent was used in the computation of flange buckling load.

Table IV gives a summary of the ultimate loads carried by the box beams with the corresponding maximum computed bending stresses or moduli of failure. Failure occurred in all cases by buckling of the compression flanges, as shown in figure 7. Although several rivets were broken in the $2\frac{3}{4}$-inch-wide specimen of plain 24S-T, there was no evidence of primary rivet failure.

From a comparison of the results given in tables III and IV, it may be seen that the modulus-of-failure values were all less than the compressive yield strengths of the materials; the differences are about 5 percent in the case of the $2\frac{3}{4}$-inch-wide specimens and 20 to 25 percent in the case of the $4\frac{1}{2}$-inch-wide specimens. These percentages, based on the elements of the full-beam sections, would not be altered by using an effective sheet thickness of 93 percent for the alclad specimens because both the modulus-of-failure values and the compressive yield strengths would be changed by the same amount. The moduli of failure were from 25 to more than 100 percent greater than the computed buckling strength of the flange sheets alone, assuming fixed edges at the line of rivets. The greatest differences were found, of course, in the widest specimens, where the influence of buckling was most pronounced. It is clear that the theoretical buckling strength of the flange sheets alone does not provide a satisfactory basis for predicting ultimate beam strengths, since failures obviously cannot occur until the resistance of the combined flange and web is exceeded. Table IV shows that a better estimate of ultimate load may be obtained by assuming failure to occur at a stress equal to the compressive yield strength of the material, acting on an assumed effective flange area after buckling (reference 5, p. 45). The predicted loads obtained by this method averaged within about 10 percent of the test values.

Table IV indicates that the ultimate strength of the $2\frac{3}{4}$-inch-wide alclad beam was about 83 percent of that developed by the corresponding specimen of plain material. The strength of the $4\frac{1}{2}$-inch-wide alclad specimen was 78 percent of that found for the corresponding plain specimen. These percentages correspond very closely to the tensile and the compressive yield-strength ratios given for the 0.064-inch plain and alclad sheet in table III.

Compression Tests on Stiffened Flat-Sheet Panels

Figure 8 shows typical load-deflection and permanent-set curves as well as buckle patterns for the stiffened flat panels of 0.064-inch sheet. It is clear that the alclad panels buckled at loads somewhat less than found for similar specimens of plain material and that the buckling loads and the number of waves in all buckle patterns increased with decreasing width of sheet between stiffeners. Permanent sets occurred in the alclad panels almost with the first evidence of buckling; whereas, in the plain specimens no evidence was obtained to show that permanent sets in any case resulted from excessive deflection of the sheet.

Figure 9 shows a set of average load-strain curves for the eighteen 2-inch gage lines located on the widest panels tested. The curves for all gage lines except 4 and 13 on the center line of the panels are approximately the same and are typical of those obtained for the corresponding gage lines in the panels of all other widths. Proportional limits in the vicinity of 60,000 to 80,000 pounds, corresponding to average computed stresses based on the gross area of 20,000 to 30,000 pounds per square inch, were indicated by the strains measured in the stiffeners. Strain readings taken on the stiffener angles after the application of loads of this magnitude clearly indicated permanent sets in all panels, regardless of width, so that any evidence of permanent buckling in the plain 24S-T sheet panels at these loads would appear to be the result of stiffener yielding rather than excessive sheet deflection. A comparison of the average strains measured on gage lines 4 and 13 with those measured at all other points indicates the extent to which sheet buckling influenced the distribution of load. Only in the case of the specimens having a clear width of 2 inches between stiffeners did the average load-strain curves indicate a uniform distribution of stress across the panels for the entire range of loads investigated.

The selection of critical buckling loads from load-deflection curves of the kind shown in figure 8 is obviously not a very exact procedure and buckling was arbitrarily assumed to occur at loads corresponding to the points of inflection estimated on the load-deflection curves. Such values, as has been found from similar tests of stiffened flat-sheet panels, should be in the vicinity of the critical loads determined by the Southwell method (reference 6) of plotting loads against ratios of load to deflection. The method proposed by Dunn (reference 7), of plotting loads against the squares of the deflections, is applicable to these data but gives critical loads consistently less than those indicated by the point of inflection. The point-of-inflection criterion gave buckling loads in fair agreement with the "break" or apparent point of buckling on the load-strain curves obtained for gage lines 4 and 13.

Table V gives a summary of estimated buckling loads for those cases in which sheet buckling occurred before general yielding of the entire panels. Although there may be some question about the magnitudes of the critical loads selected, the important observation to be made from these tests concerns the relative buckling resistances of the plain and alclad panels. As may be seen from the table, the ratios of buckling loads for the two materials ranged from 0.71 to 0.91. For purposes of comparison, theoretical buckling loads based upon a condition of fixed edges and assuming an effective sheet thickness of 93 percent for the alclad, are also included in the table. Considering the indefiniteness involved in the experimental determination of buckling loads, the agreement between observed and computed critical-load ratios for the two materials is reasonably satisfactory.

Figure 9 shows a typical comparison of average measured and computed stresses for several loads. Although strain measurements were limited to gage lines parallel to the direction of loading, it was assumed that the corresponding stresses might be determined by assuming a state of unidirectional stress. The curves indicate a reasonably uniform distribution of stress across the width of the panels for loads less than the buckling values. The average measured stresses, moreover, were in good agreement with those computed. For loads greater than the buckling values, the results indicate that the center portion of the sheet carried less than its share of the load.

Table VI gives a summary of the ultimate loads carried by the stiffened flat-sheet panels as well as the corresponding average compressive stresses based on both gross and net effective areas. Effective sheet thicknesses were not used for the alclad panels because the resulting effects on total areas were less than 1 percent.

Table VI also shows, for purposes of comparison, the computed column strengths of the different panels based on the net effective areas of the panels and the compressive yield strength of the stiffener material. These computed strengths range from 6 to 9 percent less than the test results based upon the net effective areas. Figure 10 shows the stiffened flat-sheet panels after failure.

CONCLUSION

It is concluded from these comparative tests of several different types of structural elements that the flexural stiffness and buckling resistance of alclad 24S-T sheet may be predicted in the same manner as for plain 24S-T sheet, provided that only 93 percent of the thickness of the alclad is assumed effective. Where material properties enter into such computations for alclad as, for example, in the derivation of a column formula based upon compressive yield strength, these properties should be increased by the ratio of the full thickness to the assumed effective thickness.

In order to obtain equal flexural stiffness and resistance to buckling in alclad and plain 24S-T sheet, it appears that the thickness of the alclad should be about 7 percent greater than that for the plain sheet. In cases where the tensile strength of the material rather than the flexural stiffness or the resistance to buckling governs structural behavior, however, alclad 24S-T sheet should be about 11 percent thicker than plain 24S-T sheet, based on present allowable strengths (reference 8).

The marked difference in flexural permanent-set characteristics of single thicknesses of plain and alclad 24S-T sheet reflects the low elastic strength of the alclad coating material but has little bearing upon the relative load-carrying capacities of the two materials in structural applications.

Although the tests described in this report were limited to samples of plain and alclad 24S-T sheet, it seems reasonable to conclude that about the same relative behavior would be found between plain and alclad 24S-RT and 17S-T sheet, in which alclad coatings of high-purity aluminum are used.

Aluminum Research Laboratories,
Aluminum Company of America,
New Kensington, Pa., June 13, 1941.

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TABLE I

Section Elements of Box Beams

Material	Sheet thickness (in.)	Over-all width (in.)	Over-all depth (in.)	Moment of inertia (in.^{4})	Section modulus[b] (in.^{3})
24S-T	0.065	2.76	3.14	1.43	0.93
Alclad 24S-T[a]	.063	2.74	3.13	1.37	.89
24S-T	.065	4.49	3.13	1.94	1.27
Alclad 24S-T[a]	.063	4.51	3.13	1.90	1.24

[a] Elements for alclad specimens based on full thickness of sheet.

[b] For stress at middle plane of flange sheet.

TABLE II

Section Elements of Stiffened Flat-Sheet Panels

Panel width between stiffeners (in.)	Sheet thickness, t (in.)		Gross area[a] (sq in.)		Computed effective area after sheet buckling[b] (sq in.)	
	Plain 24S-T	Alclad 24S-T	Plain 24S-T	Alclad 24S-T	Plain 24S-T	Alclad 24S-T
6	0.0660	0.0635	2.88	2.86	2.59	2.59
4	.0640	.0630	2.74	2.73	2.58	2.58
3	.0665	.0635	2.69	2.67	2.60	2.59
2	.0650	.0635	2.61	2.61	2.59	2.59

[a] Area of sheet plus area of four 1¼ by 1¼ by ¼ inch angles (2.32 sq in.).

[b] Effective widths of panel after buckling assumed equal to $\frac{5400t}{\sqrt{\text{Yield strength}}}$. (See reference 5, p. 45.)

TABLE III

Mechanical Properties of Material

Material	Nominal thickness (in.)	Tension			Compressive yield strength (Set=0.2 percent) C.Y.S. (lb/sq in.)	$\frac{\text{C.Y.S.}}{\text{T.Y.S.}}$	Ratios of strength $\frac{\text{Alclad 24S-T}}{\text{Plain 24S-T}}$		
		Yield strength (Set=0.2 percent) T.Y.S. (lb/sq in.)	Ultimate strength T.S. (lb/sq in.)	Elongation in 2 in. (percent)			T.Y.S.	C.Y.S.	T.S.
24S-T[a]	0.250	47,000	70,000	18.0	49,600	1.05	0.98	0.80	0.95
Alclad 24S-T	.250	45,900	66,300	20.5	39,500	.86			
24S-T	.064	62,700	77,100	17.0	46,500	.74	.78	.85	.85
Alclad 24S-T	.064	48,900	65,400	19.0	39,500	.81			
24S-T (angle)	.250	51,300	67,900	20.0	44,000	.86			

[a] Specimens cut normal to direction of rolling. For all other materials, specimens were cut parallel to direction of rolling.

TABLE IV

Ultimate Strengths of Box Beams

Material	Nominal beam width (in.)	Ultimate load (lb)	Modulus of failure (lb/sq in.) (a)	Computed buckling stress for flange sheet (lb/sq in.) (b)	Predicted ultimate load based on C.Y.S. and effective flange area (lb) (c)	Ratio of moduli of failure $\frac{\text{Alclad 24S-T}}{\text{Plain 24S-T}}$
24S-T	$2\frac{3}{4}$	6950	44,800	34,300	6350	0.83
Alclad 24S-T	$2\frac{3}{4}$	5520	37,100	30,100	5320	
24S-T	$4\frac{1}{2}$	7900	37,400	16,700	6640	.78
Alclad 24S-T	$4\frac{1}{2}$	6000	29,100	14,100	5570	

[a] Based on section elements given in table I.

[b] Computed using equivalent slenderness ratios in column formulas. (See reference 5, p. 41.) Fixed edges assumed at rivet lines. Effective thickness of 93 percent assumed for alclad sheet.

[c] See reference 5, p. 45, for determination of effective width.

TABLE V

Buckling Loads for Stiffened Flat-Sheet Panels Subjected to Edge Compression

Panel width between stif-feners (in.)	Buckling loads estimated from load-deflection curves (lb)			Buckling loads estimated from load-strain curves (lb)			Theoretical buckling loads for fixed edges (lb) (a)		
	Plain 24S-T	Alclad 24S-T	Alclad/Plain	Plain 24S-T	Alclad 24S-T	Alclad/Plain	Plain 24S-T	Alclad 24S-T	Alclad/Plain
6	27,000	20,000	0.74	28,000	20,000	0.71	22,600	18,000	0.80
4	44,000	40,000	.91	48,000	40,000	.83	45,800	38,200	.83
3	72,000	64,000	.89	-------	64,000	-----	74,800	62,000	.83
2	-------	-------	-----	-------	-------	-----	96,900	85,000	.88

[a] Computed using equivalent slenderness ratios in column formulas . (See reference 5, p. 41.) Effective thickness of 93 percent assumed for alclad sheet. Buckling loads based on gross areas for both plain and alclad panels.

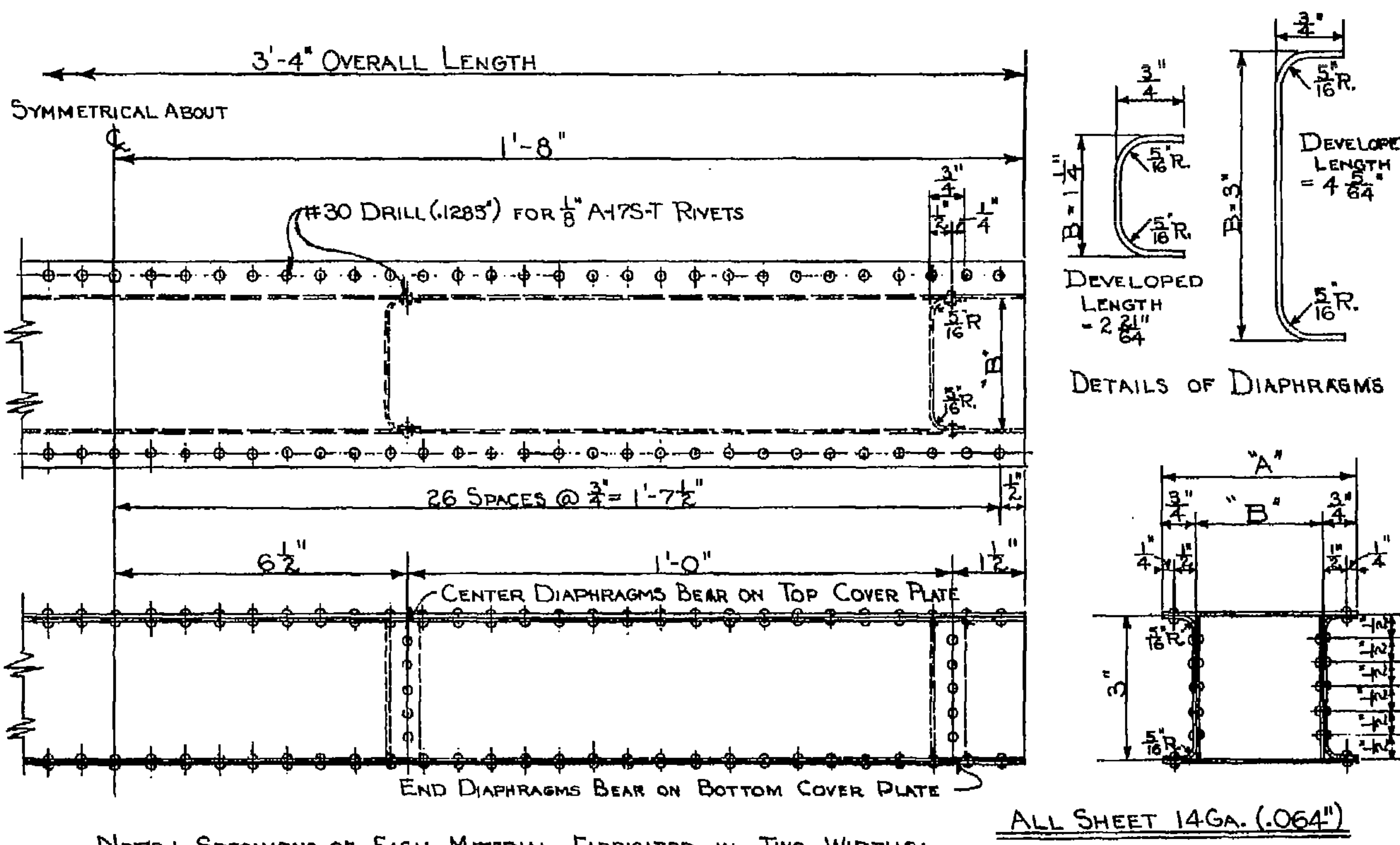
TABLE VI

Ultimate Strengths of Stiffened Flat-Sheet Panels Subjected to Edge Compression

Panel width between stiffeners (in.)	Ultimate load (lb)		Corresponding stresses (lb/sq in.) (a)				Computed column strength
			Gross area		Effective area after buckling		
	Plain 24S-T	Alclad 24S-T	Plain 24S-T	Alclad 24S-T	Plain 24S-T	Alclad 24S-T	(lb/sq in.) (b)
6	128,500	126,700	44,600	44,300	49,600	48,900	45,500
4	124,800	124,900	45,500	45,800	48,300	48,400	45,500
3	126,600	125,600	47,000	47,000	48,700	48,500	45,500
2	126,800	125,700	48,600	48,200	48,900	48,500	45,500

[a] Based on areas given in table II.

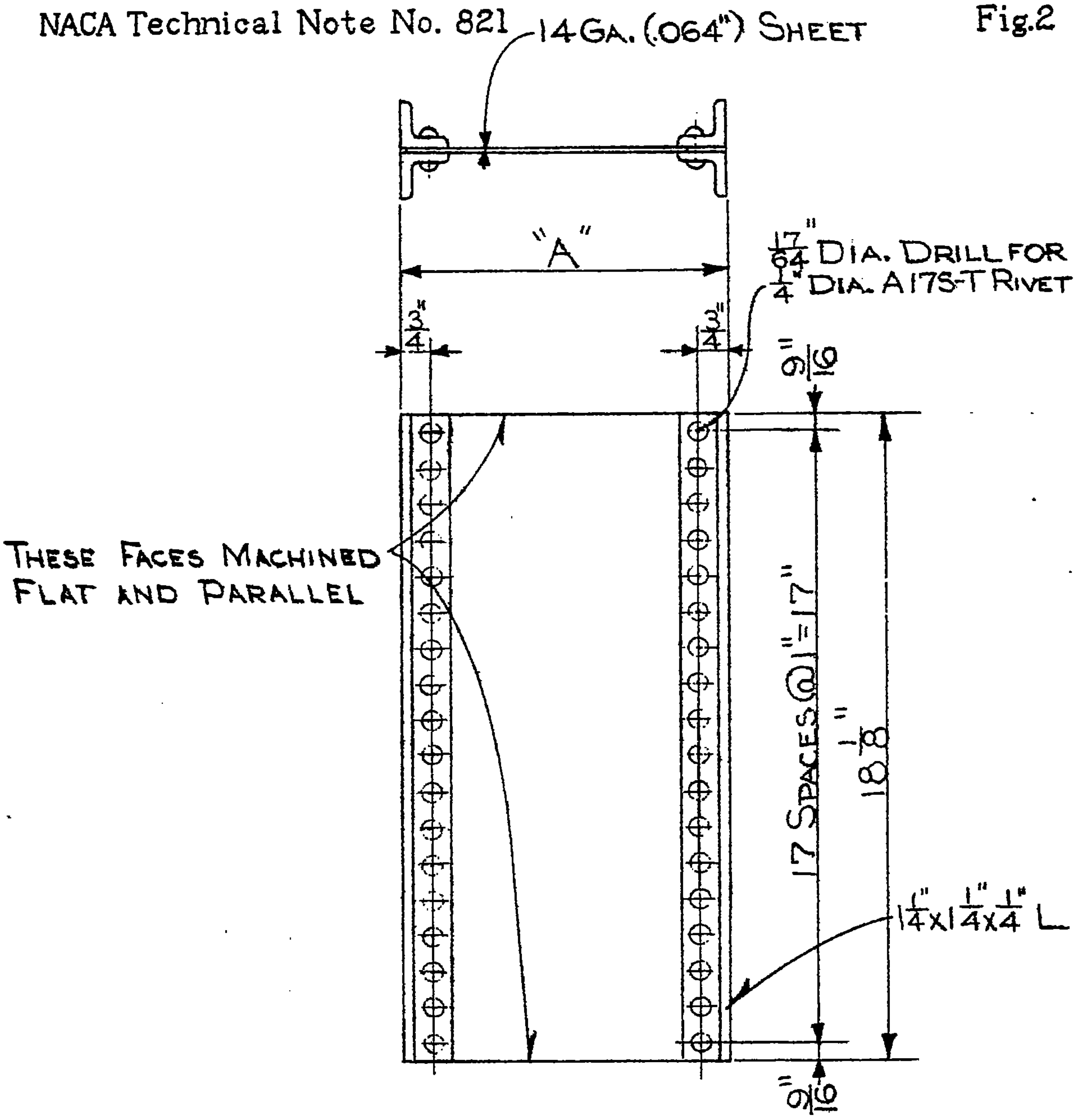
[b] Based on effective areas and compressive yield strength of stiffener material.



NOTE: SPECIMENS OF EACH MATERIAL FABRICATED IN TWO WIDTHS:-

A = 4 1/2", B = 3"
A = 2 3/4", B = 1 1/4"

FIGURE 1.- BOX BEAMS FOR COMPARISON OF PLAIN AND ALCLAD 24S-T SHEET



NOTE: SPECIMENS OF EACH SHEET MATERIAL FABRICATED
IN FOUR WIDTHS - A = 4 1/2", 5 1/2", 6 1/2", 8 1/2"
STIFFENER ANGLES 24S-T EXTRUDED ON ALL SPECIMENS

Figure 2.-
STIFFENED FLAT-SHEET PANELS FOR
COMPARISON OF PLAIN AND ALCLAD 24S-T SHEET

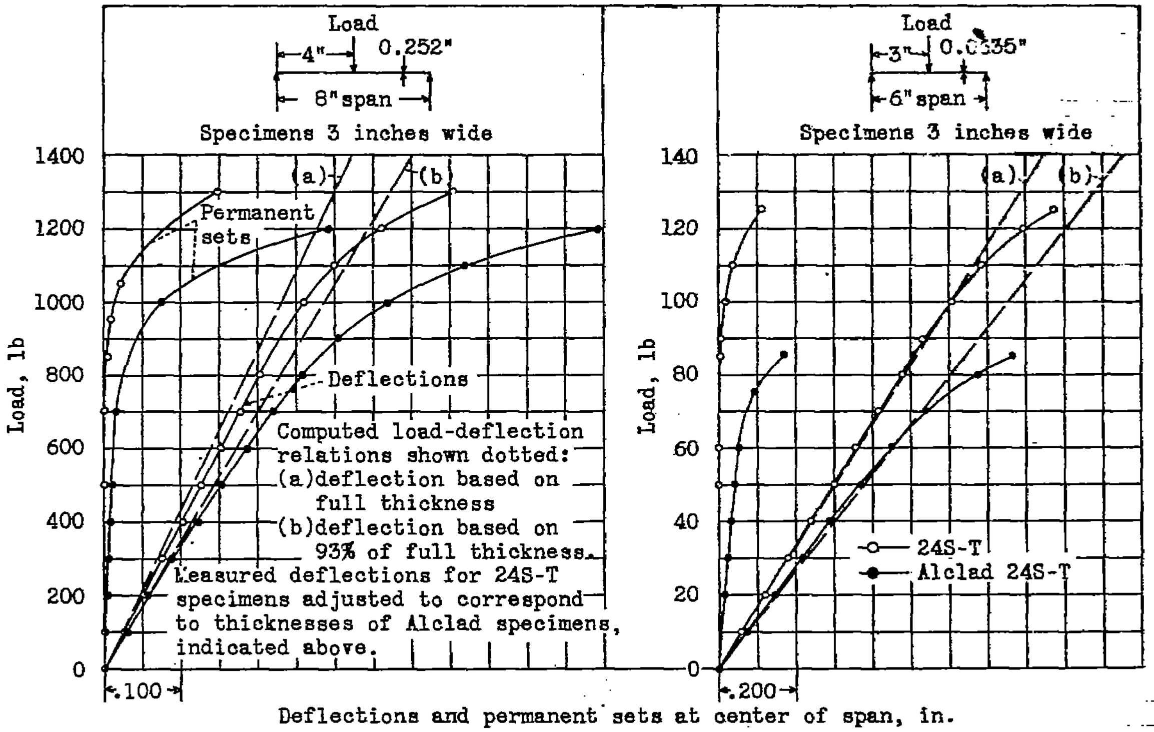


Figure 3.- Load-deflection and permanent set curves for single thicknesses of material.

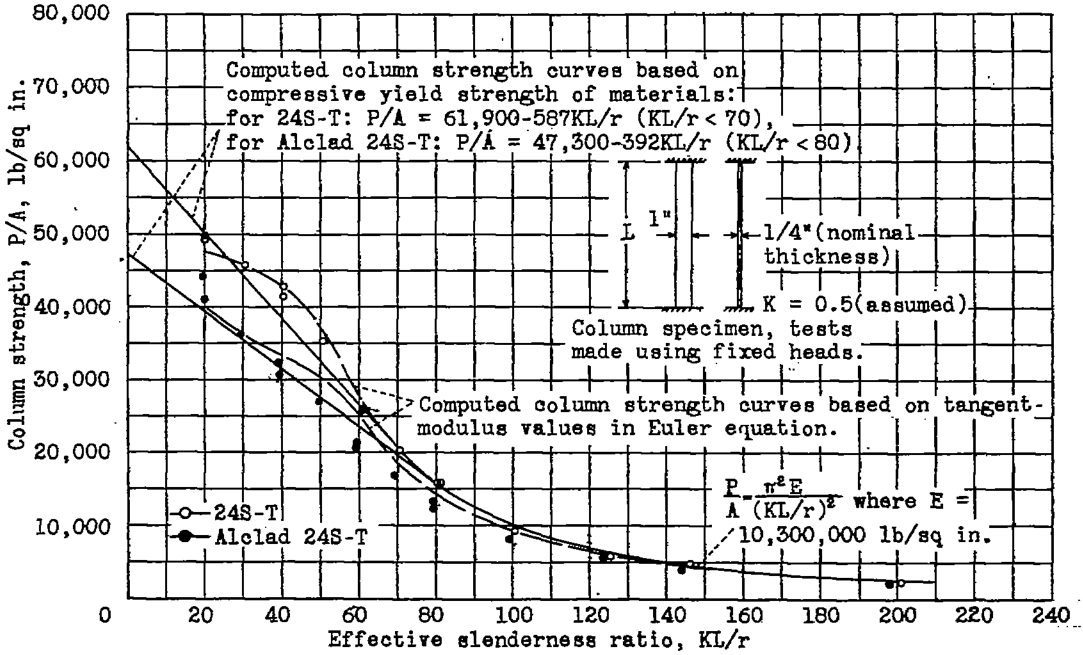


Figure 4.- Column strength of 1/4-inch sheet.

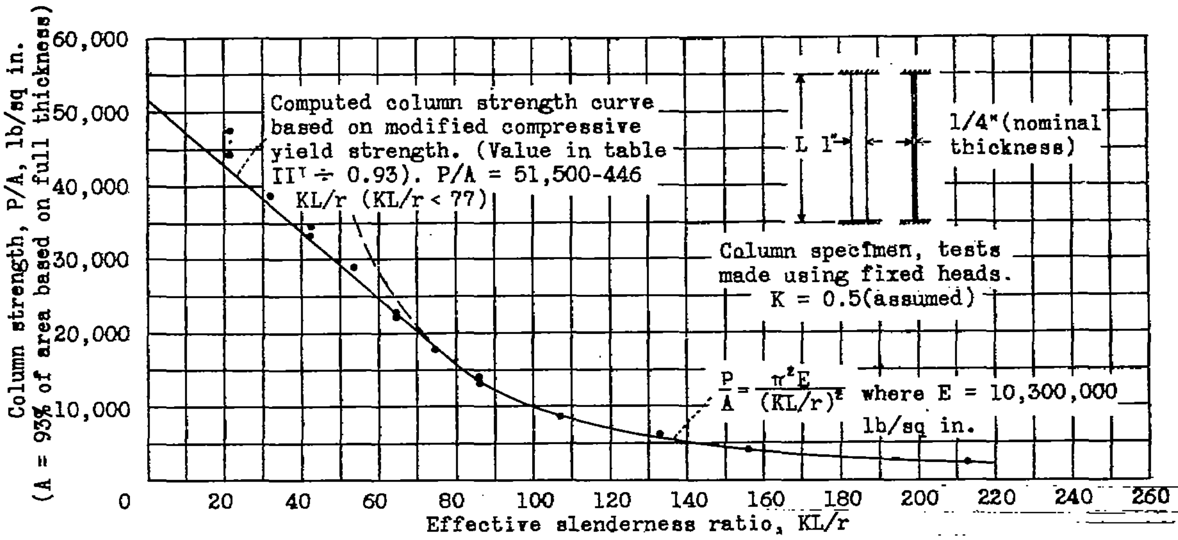


Figure 5.- Column strengths of 1/4-inch thick Alclad sheet based on 93 percent effective thickness. r = 93 percent of radius of gyration based on full thickness.

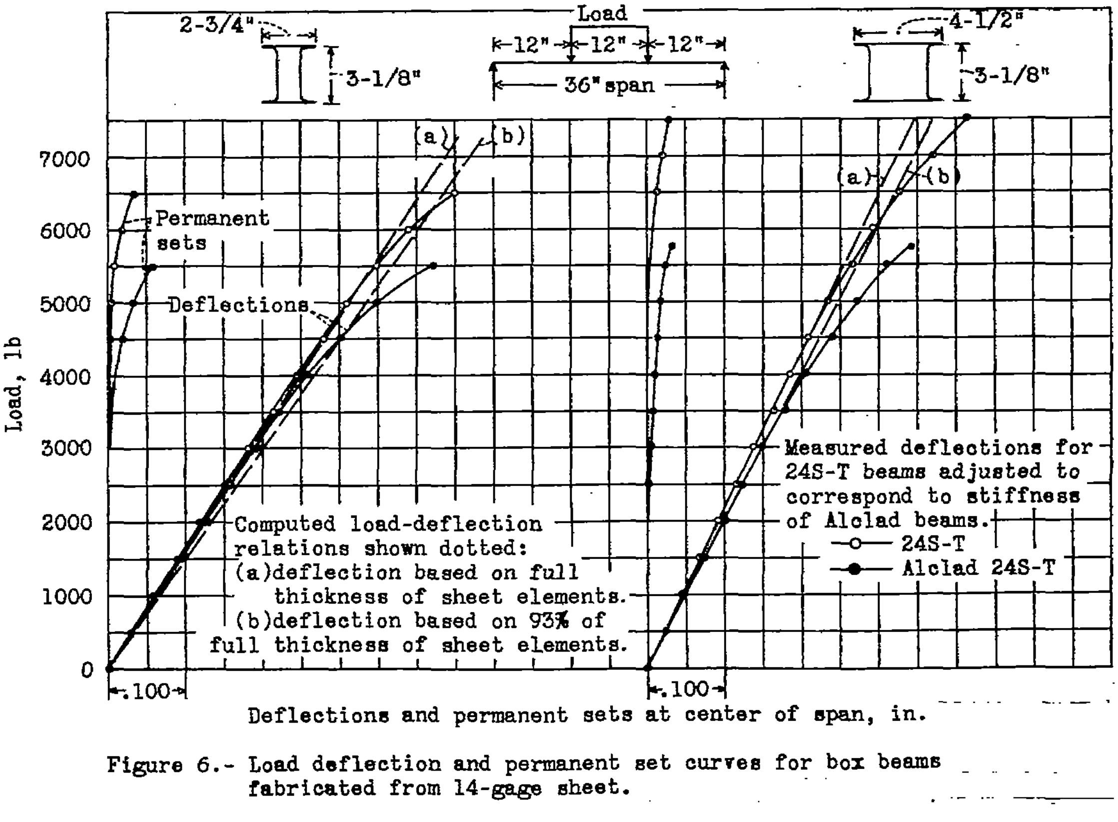


Figure 6.- Load deflection and permanent set curves for box beams fabricated from 14-gage sheet.

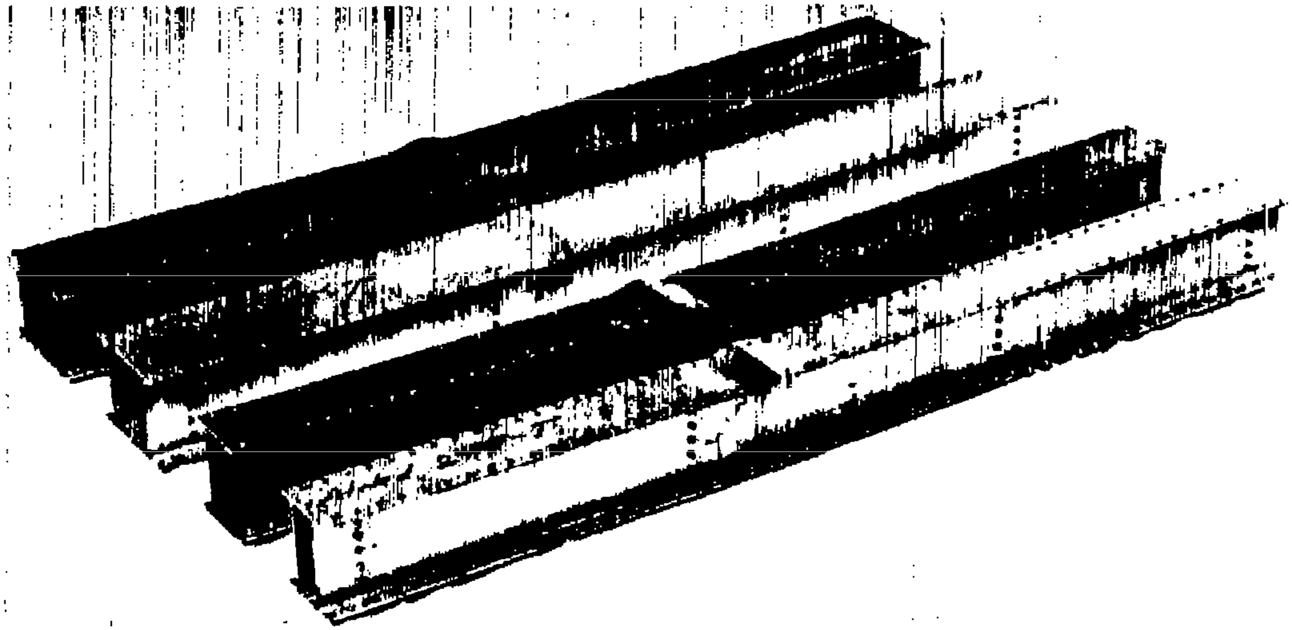


Figure 7.- Box beams after failure.

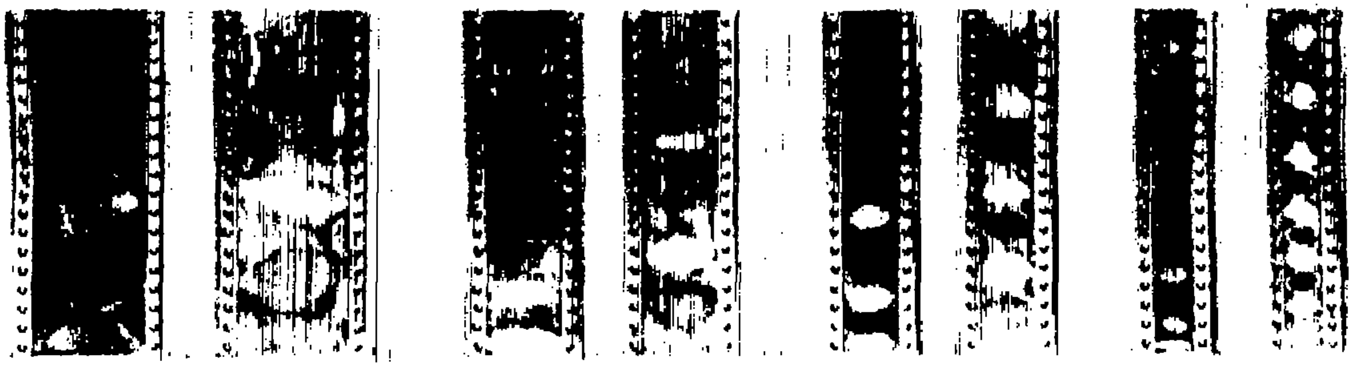


Figure 10.- Stiffened flat-sheet panels after failure.

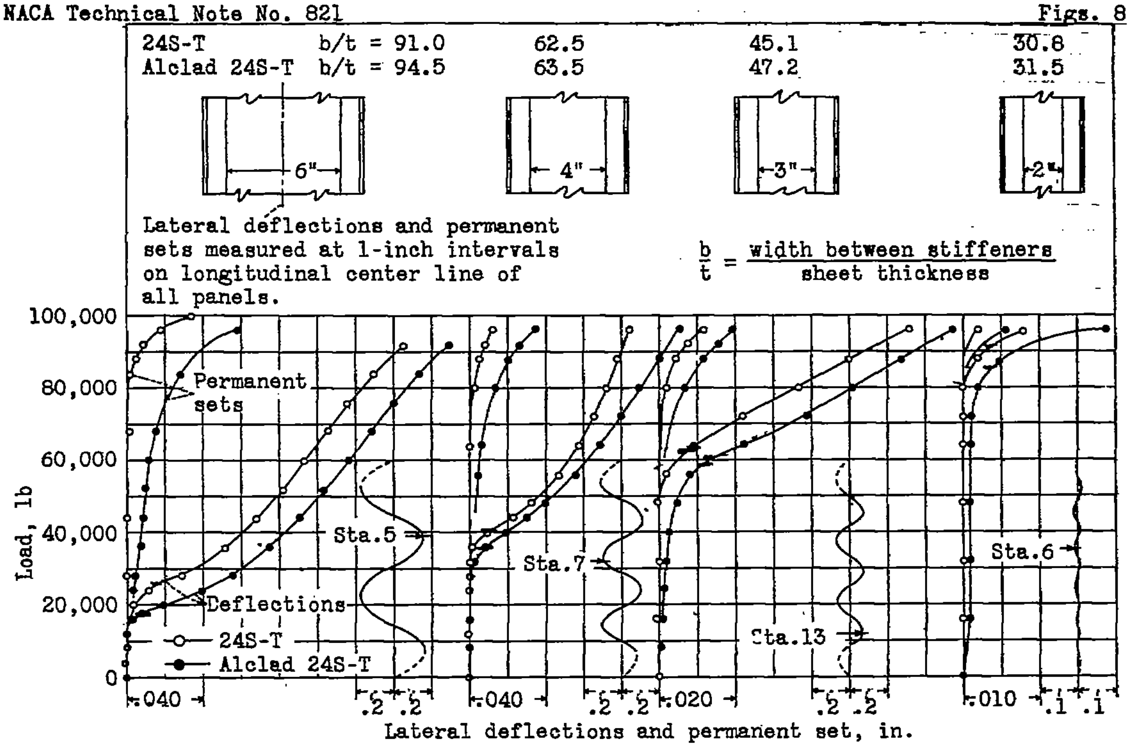


Figure 8.- Typical load deflection and permanent set curves for stiffened flat-sheet panels. Buckle patterns are shown for 96,000 pound load on 24S-T panels.

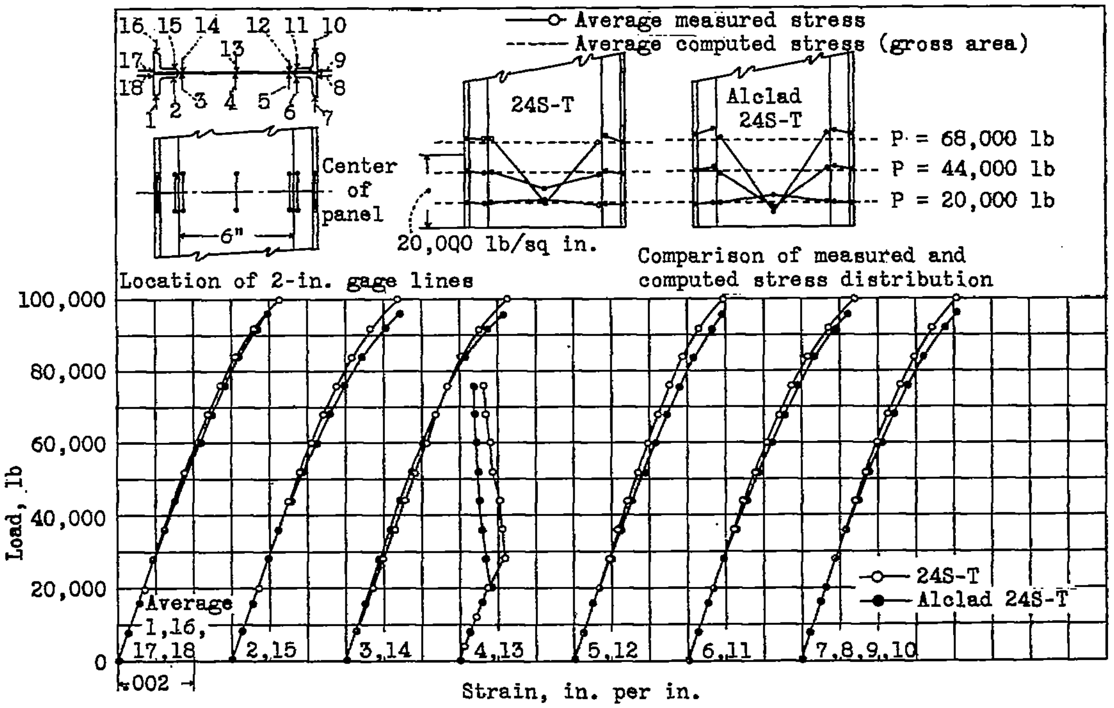


Figure 9.- Compressive load-strain curves and stress distribution in stiffened flat-sheet panels.

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ABSTRACT

Comparison tests on the behavior of plain and Alclad 24S-T sheet under several types of structural loadings indicate that as far as resistance to buckling is concerned, the soft protective coating on Alclad sheet is equivalent in a reduction in thickness of about 7%. Differences in stiffness and buckling resistance of plain and Alclad 24S-T sheet may be estimated on the basis of this reduced effective thickness. Alclad sheet is more sensitive to flexural permanent set than plain sheet; however, the differences in permanent set characteristics have [illegible] ring in structural application.

NOTE: Requests for [illegible] be addressed to N.A.C.A., Washington, D. C.

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