EDGEWISE COMPRESSIVE STRENGTH OF PANELS AND FLATWISE FLEXURAL STRENGTH OF STRIPS OF SANDWICH CONSTRUCTIONS

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EDGEWISE COMPRESSIVE STRENGTH OF PANELS AND FLATWISE FLEXURAL STRENGTH OF STRIPS OF SANDWICH CONSTRUCTION[1]

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Summary

An experimental investigation was conducted to determine the behavior of sandwich constructions having facings of both equal and unequal thickness on cores of expanded-type honeycomb construction, and as simply supported flat panels loaded in edgewise compression and as strips loaded in flatwise flexure under two concentrated loads. Analyses of the test data showed that the behavior of these sandwich constructions could be predicted by use of appropriate theories.

Introduction

Expanding interest in the structural use of sandwich construction because of its high stiffness-weight and strength-weight ratios has resulted in the derivation of theoretical analyses to describe the behavior of such constructions subjected to various types of loading. In the interest of further substantiation of these theories and of possibly arriving at appropriate design criteria, the work reported was done at the Forest Products Laboratory. Panels of the various sandwich constructions were furnished by the cooperating concern.

The work covered by this report has been divided into two parts. The first part concerns the testing and analysis of flat panels of sandwich construction under edgewise compressive loads. The second part considers the testing and analysis of flat sandwich strips subjected to flexure.

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Experimental work was done to determine the buckling load and the maximum load of flat panels of sandwich constructions loaded in uniform edgewise compression. The edges of the panels were simply supported insofar as practicable.

Materials

The sandwich constructions were of every possible combination of 0.020-, 0.040-, and 0.064-inch facings of clad 24-ST aluminum sheets on 5/8-inch-thick cores of either 4- or 8-ounce phenol-resin-impregnated cotton cloth formed to a honeycomb of 7/16-inch cell size. The 4- and 8-ounce cores had densities of 4.2 and 8.9 pounds per cubic foot, respectively. Facings were bonded to the cores with a high-temperature-setting modified phenol-polyvinyl butyral adhesive.

Two panels, 110 inches long and 48 inches wide, were made of each construction. The aluminum facings were placed so that the direction of rolling was parallel to the long dimension of the panel. The core material was placed so that the continuous direction of the cloth was parallel to the long dimension of the panel. Three square panels, one 47 inches, one 37-1/2 inches, and one 19-3/4 inches in size were cut from each large panel. Smaller coupons for determining the moduli of rigidity of the cores were also cut from each large panel. The square panels were prepared for testing by bonding 1-inch strips of 0.032-inch-thick aluminum to each facing at the loaded ends to prevent local facing failures. These strips were bonded with a contact-pressure, room-temperature-setting epichlorohydrin resin-base adhesive that had been developed at the Forest Products Laboratory for the Bureau of Aeronautics, U. S. Navy.

Testing

The square sandwich panels were tested in edgewise compression in the apparatus shown in figure 1. The ends of the panel were loaded through flat steel bars. The vertical edges were simply supported in narrow, adjustable slots. A detailed sketch of these edge supports is shown in figure 2. Panels calculated to fail at loads less than 100,000 pounds were tested in a hydraulic testing machine. Stronger panels were tested in a mechanically operated testing machine of larger capacity. The loads were applied at a free-head travel of the movable head of the testing machine of approximately 0.02 inch per minute. Strains at the panel center and in a direction parallel to the direction of the applied load were measured on each facing by means of metalectric strain gages.

Small strips of sandwich constructions cut from the same large panels as were the compression specimens were tested in bending under center loading over a relatively short span to determine the moduli of rigidity of the core materials. Strips were cut both parallel and perpendicular to the long dimension of the large panel so that the modulus could be measured both parallel and perpendicular to the continuous direction of the cloth of the core. The method used to calculate the moduli of rigidity is given in the appendix to this report. Values of the moduli are given in table 1.

Results of Tests

Approximately 60 percent of the compression panels exhibited definite buckling. Many of these panels showed large buckles, but the stiffer one did not have much of a buckled appearance. The exact determination of the buckling loads was made by observing the load-strain curves. The buckling load was that load at which one of the facing strains began to decrease. An illustration of this is given in figure 3. The facing stresses at buckling for the various panels are given in table 1.

Behavior after buckling was characterized by increasing deflection of the buckled surface and finally resulted in failure by crimping, often near one end of the panel. There was usually not much increase in load at failure compared to the buckling load. This is shown by the graph of figure 4, in which the facing stress at failure is compared with the stress at buckling. The stresses were obtained by dividing the load by loaded area of the facings. The greatest panel load was approximately 20 percent larger than the buckling load of that panel. Maximum facing stresses for all the panels are given in table 1.

Analysis and Discussion of Test Results

The behavior of the edgewise compression specimens suggested a comparison of the experimental buckling stresses with stresses computed by means of formulas obtained from a theoretical analysis[3] of the compressive buckling of sandwich construction. Although buckling was not evident in many of the specimens tested, the failure was sudden and of the same type as for specimens that definitely did buckle, and since it thus indicated buckling, the buckling stresses were computed for all specimens.

The facing stresses for sandwich-panel buckling for constructions having isotropic facings on orthotropic cores, with all edges simply supported, are given by:[3]

$$p_f = \frac{\pi^2 f_1 f_2 (h + c)^2 b^2 E \left(1 + \frac{n^2 a^2}{b^2}\right)^2}{4\lambda a^4 (f_1 + f_2)^2 n^2 \left[1 + \frac{\pi^2 c f_1 f_2}{a^2 \lambda (f_1 + f_2)} \left(\frac{E}{G_a} + \frac{n^2 a^2 E}{b^2 G_b}\right)\right]} \qquad (1)$$

[3] This analysis was obtained from equations 1, 11, and B11 of Forest Products Laboratory Rept. No. 1583-B, "Compressive Buckling of Sandwich Panels Having Facings of Unequal Thickness," by W. S. Ericksen and H. W. March. Nov. 1950.

where p_f = facing stress

f_1, f_2 = facing thicknesses

h = total sandwich thickness

c = core thickness

a = panel width (loaded edge)

b = panel length

n = number of half waves in buckled form n = 1, 2, 3,......
Note: "n" is chosen so that p_f is minimum

E = facing modulus of elasticity

λ = 0.91

G_a = core shear modulus associated with shear in the direction of dimension "a"

G_b = core shear modulus associated with shear in the direction of dimension "b"

In order to determine stresses greater than the proportional limit value the tangent modulus E_T was used in equation 1. The condition then remained that the modulus must be compatible with the stress. This was easily accomplished by taking the reciprocal of equation 1 and multiplying by the Young's modulus. The resulting expression is:

$$\frac{E}{p_f} = Q\,\frac{E}{E_T} + U \qquad (2)$$

where

$$Q = \frac{4\lambda\, a^4\,(f_1 + f_2)^2\, n^2}{\pi^2\, f_1 f_2\, b^2\,(h + c)^2 \left(1 + \frac{n^2a^2}{b^2}\right)^2}$$

$$U = \frac{4ca^2\,(f_1 + f_2)\left(\frac{n^2a^2}{b^2} + \frac{G_b}{G_a}\right) n^2 E}{b^2\,(h + c)^2 \left(1 + \frac{n^2a^2}{b^2}\right) G_b}$$

E = Young's modulus of facings
E_T = tangent modulus

Expression 2 was solved graphically by placing a straight line of slope Q and ordinate intercept U on a reciprocal stress-modulus curve. The point of intersection of the straight line with the curve gave the appropriate value of $\frac{E}{p_f}$, which was then divided into the Young's modulus to obtain the facing stress at panel buckling. A reciprocal stress-modulus curve and an example of its application are given in figure 5.

Facing stresses at the panel buckling loads were theoretically computed by using equation 2 for the various constructions tested. Values of n were chosen so that the stress was a minimum, and it was found that for the panels tested n = 1 always gave the minimum stress. The computed stresses are given in table 1. A graphical comparison of the computed stresses with the test buckling stresses is made in figure 6. The maximum test stresses were compared with the computed buckling stresses for panels that did not exhibit definite buckling.

The comparison made in figure 6 shows that, on the average, the test panels buckled at stresses somewhat greater (approximately 15 percent) than were theoretically computed. The buckling stress obtained from the tests was no doubt influenced by the end conditions of the specimen. These ends were flat rather than simply supported, and buckling stresses greater than the computed values would therefore be expected. Figure 6 shows that there was considerable scatter of the individual test points, approximately ± 30 percent, from theoretical values. This scatter is not unreasonable for the stability type of behavior.

Conclusions

The theoretical analysis employed yields reasonable estimates of the buckling stresses of simply supported flat panels of sandwich construction under edgewise compression.

The strength of flat sandwich panels under edgewise compression loads may be considered to be the buckling load.

Flatwise Flexural Strengths of Strips of Sandwich Construction

Flexure tests were conducted by loading flat sandwich strips with two symmetrical, concentrated loads. The greater part of the work was done on relatively long specimens chosen so as to fail in the facings rather than in the core.

Materials

The strips of sandwich construction were of every possible combination of of 0.020-, 0.040-, and 0.064-inch facings of clad 24-ST aluminum sheets on each of the following 1-inch-thick honeycomb cores placed so that the continuous direction of the sheet material of the core was parallel and also perpendicular to the span.

(1) 4-ounce phenol-resin-impregnated cotton cloth formed to 7/16-inch cell size; density of 4.2 pounds per cubic foot.

(2) 8-ounce phenol-resin-impregnated cotton cloth formed to 7/16-inch cell size; density of 8.9 pounds per cubic foot.

(3) 3-mil 3SH aluminum sheet formed to 3/8-inch cell size; density of 4.2 pounds per cubic foot.

(4) 5-mil 3SH aluminum sheet formed to 3/8-inch cell size; density of 6.5 pounds per cubic foot.

(5) 2-mil 3SH aluminum sheet formed to 1/4-inch cell size; density of 4.2 pounds per cubic foot.

(6) 4-mil 3SH aluminum sheet formed to 1/4-inch cell size; density of 7.5 pounds per cubic foot.

Facings were bonded to the cores with a high-temperature-setting phenol-polyvinyl butyral adhesive.

Large panels of these constructions were furnished, and flexure specimens 2 inches wide were cut from them with a metal-cutting band saw. Additional specimens were cut of constructions that have unequal facings so that tests could be made with the thin facing in compression and also in tension.

Testing

The flexure specimens were loaded at two points, each 2 inches from the midspan point. The loading points had a radius of approximately 1/16 inch in contact with a 1/8-inch-thick piece of birch plywood extending 1/2 inch from each side of the load point. The plywood was placed between the loaded facing and the load point to eliminate failures due to highly concentrated stresses. The specimens were supported at the reactions on plates separated by rollers. The total thickness of the rollers and plates was approximately 1/2 inch. The lower plate was free to tilt on the knife-edge reaction support. Central deflections were measured by observing the movement of a scale, reading to 0.01 inch, suspended on a pin at the center of the core with respect to a fine wire stretched from pins placed at the core center at the reactions. The wire was held taut by means of a stretched rubber band at one end. The angle of slope of the beam at one reaction was measured by observing the tilt of a protractor that was fastened to the bottom surface of the reaction plate.

Tests were first made on constructions having the thickest facings on short spans (12 in.) for all core materials in order to obtain the core shearing strengths. Long specimens were then designed to fail in the facings if possible.

Results of Tests

A total of 200 tests were made. Of this number 36 were short so as to insure shearing failure in the core. The remaining specimens were longer and should have failed in the compression or tension facing. Of these remaining specimens 35 percent of them failed in the compression facing, 17 percent in the tension facing, 10 percent in shear in the core, and 38 percent failed in the bond between the facing and core. The construction descriptions, together with maximum loads, deflections, end slopes, and types of failure are given in table 2. The maximum moment is also given. This was computed from the formula:

$$M = \frac{Pka}{2} + \frac{P\Delta}{2} \tan \theta \qquad (3)$$

where M = maximum moment

P = total load

ka = distance from reaction to load point

Δ = midspan deflection

θ = slope of beam at reaction

The derivation of expression 3 may be seen by referring to sketch A of figure 7.

It was observed that the compression facing failures begun by the facing dimpling into the open cells of the honeycomb cores. This dimpling grew so prominent that the entire core pattern was visible over the central portion of the specimen. Final failure usually occurred by sudden separation of the facing from the core.

Tension facing failures occurred only in specimens having tension facings thinner than compression facings. The failure was sudden and usually broke straight across the specimen and was always located between the load points. The midspan deflection at failure was usually 3 to 6 times greater at tension failure than for compression failure of the same construction with the thin facing in compression.

Shear failures in the cores occurred suddenly and were evidenced by buckling of the honeycomb cell walls, followed by a crimping appearance of the sandwich at the point of severest failure.

Bond failures occurred by sudden separation of the facings from the core. Usually this separation extended from a load point to the adjacent reaction. Occasionally there was some core failure in conjunction with the bond failure, although it was not apparent as to whether the core failure occurred with or immediately after the bond failure. Approximately one-half of the bond failures occurred at core shear stresses far less than the shearing strengths of the cores.

Analysis and Discussion of Test Results

The following analysis and discussion is divided into two parts, first, the failure of facings, and second, the failure of cores and bonds.

A tabulation was made of the maximum moments that caused compression or tension facing failures. It was noticed that the moment necessary to cause compression failure could be segregated into parts representing sandwich cores of different honeycomb cell size. Values of the moments are given for the different cell sizes in table 3. Average facing stresses were computed by using the formula:

$$p_f = \frac{2M}{f_{1,2}\,(h + c)} \qquad (4)$$

where p_f = average facing stress

M = moment

f = facing thickness

h = total sandwich thickness

c = core thickness

This formula was obtained by equating the moment, M, to the couple formed by the facing forces, F, acting at a distance $\frac{h + c}{2}$ apart (fig. 7, B).

A comparison of the facing stresses given in table 3 shows that for compression failures these stresses increase as the core cell size decreases and as the facing thickness increases, and that for tension failures the stresses are approximately the same regardless of core cell size or of facing thickness. The tension facings failed at an average stress of 63,200 pounds per square inch as compared to a tensile strength of 24-ST clad aluminum of 64,000 pounds per square inch.[4] Since it was observed that the compression facings showed dimpling into the honeycomb core cells, the compressive stress at dimpling was calculated by the formula:[5]

[4] This value was given in the booklet, "Alcoa Aluminum and Its Alloys," by Aluminum Company of America.

[5] Norris, C. B., and Kommers, W. J. Short-column Compressive Strength of Sandwich Constructions as Affected by the Size of the Cells of Honeycomb-core Materials. Forest Products Laboratory Rept. No. 1817, Aug. 1950.

$$p_f = \frac{1}{3} E_R \left(\frac{f_1}{R}\right)^{3/2} \tag{5}$$

where p_f = facing stress at dimpling

E_R = reduced facing modulus

f_1 = compression facing thickness

R = radius of circle inscribed in core cell

This formula was simpler to use at stresses greater than the proportional limit by inverting it and multiplying both sides by the Young's modulus; then

$$\frac{E}{p_f} = 3.33 \left(\frac{R}{f_1}\right)^{3/2} \frac{E}{E_R} \tag{6}$$

where E = Young's modulus of the facing material.

Equation (6) was solved graphically by use of a reciprocal stress-modulus curve. A curve for the facings tested is given in figure 5.

Theoretical dimpling stresses for the compression facings were computed for the various cell sizes by using equation (6) and the graph of figure 5. A comparison was made by plotting the experimental stresses versus the computed values in figure 8. The experimental values agreed with ± 12 percent of the computed values.

Core failures and bond failures of sandwich beams in flexure are essentially shear failures. Therefore the core shearing stresses were computed for specimens failing in shear or bond by using the formula:

$$\tau = \frac{P}{h + c} \tag{7}$$

where τ = shearing stress

P = total load supported by the beam

h = total sandwich thickness

c = core thickness

The values obtained are given in table 2. The core shear stress developed at shear or bond failure is plotted versus the shear strength of the appropriate core, as obtained by testing short specimens with thick facings, in figure 9. The points on this figure show that shearing failures occurred in some of the longer specimens at stresses of approximately 75 percent of the shearing-strength values. This seemed to be independent of facing thickness, as can be observed by comparing values in table 2. Since the core material may have been of changeable quality, the comparison should not be made, but the strength of the core would probably be an average of values obtained for all spans.

Half of the bond failures occurred at core shearing stresses within approximately 30 percent of the core shear strengths. The remaining bond failures occurred at much lower stresses, one as low as 10 percent of the core shear strength.

The low-strength bond failures were probably due to defects that might easily occur during the experimental manufacture of sandwich panels. A more rigid control of processes, such as would be necessary for quantity production, would help considerably to produce consistently good-quality panels.

Conclusions

The following conclusions preclude the possibility of failures due to low bond strengths or defects.

Tension facing failures of sandwich construction occur at the tensile strength of the facing.

Compression facing failures of sandwich constructions having honeycomb cores occur at the stress at which the facing buckles into the cells.

Shearing failures occur at the shear strength of the core material.

The preceding conclusions combined with ordinary design considerations for beams enable the designer to predict the behavior of loaded beams of sandwich construction.

Appendix

Method for Determining Core Moduli of Rigidity

The deflection of a strip of sandwich construction in flexure results from the combined action of bending moments and shearing forces. The deflection caused by bending moments varies as the cube of the span length and the deflection caused by shear varies linearly as the span length; therefore, the shearing deflection will be a greater percentage of the total deflection if the span length is shortened. Theoretical formulas have been derived for the bending and the shearing deflections.[6] By solving these formulas for the shear modulus of the core material, the results of tests on a centrally loaded beam may be used to calculate this core modulus. The formula is given by:

$$G = \frac{Pac}{2\Delta h(h + c)b\left[1 - \frac{Pa^3}{48\Delta D}\right]} \qquad \text{(A1)}$$

where G = core shear modulus

P = central concentrated load

a = span length

c = core thickness

Δ = central deflection at load P

h = total sandwich thickness

b = width of sandwich

$$D = \frac{bf_1f_2(h + c)^2 E}{4(h - c)\lambda}$$

$f_{1,2}$ = facing thicknesses

E = facing modulus of elasticity

$\lambda = 0.91$

The value of $\frac{Pa^3}{48\Delta D}$ was kept less than 0.60 by shortening the span if necessary.

[6] March, H. W., and Smith, C. B. "Flexural Rigidity of a Rectangular Strip of Sandwich Construction." Forest Products Laboratory Rept. No. 1505, 1949.

Table 1.--Results of tests of sandwich panels in edgewise compression[1]

Panel No.	Facing thickness f_1	Facing thickness f_2	Total thickness h	Width a	Length b	Shear moduli G_b	Shear moduli G_a	Weight of cloth in core	Test facing stresses: Buckling stress p_{cr}	Test facing stresses: Maximum stress p_{max}	Computed buckling stress
	In.	In.	In.	In.	In.	P.s.i.	P.s.i.	Oz.	P.s.i.	P.s.i.	P.s.i.
C 1a	0.020	0.020	0.672	46.5	46.5	5,660	2,820	4	21,800	26,200	18,500
b	.020	.020	.673	46.5	46.5	5,980	2,580	4	22,300	26,400	18,200
C 2a	.020	.020	.671	37.0	37.0	5,660	2,820	4	20,000	20,700	26,500
b	.020	.020	.671	37.0	37.0	5,980	2,580	4	31,300	33,400	26,200
C 3a	.020	.020	.671	19.5	19.5	5,660	2,820	4	....	41,300	36,800
b	.020	.020	.670	19.5	19.5	5,980	2,580	4	....	40,200	36,500
C 4a	.020	.020	.665	46.5	46.5	10,190	4,380	8	21,200	25,900	18,900
b	.020	.020	.672	46.5	46.5	10,460	4,960	8	21,800	27,300	19,400
C 5a	.020	.020	.662	37.0	37.0	10,190	4,380	8	31,300	34,500	27,300
b	.020	.020	.674	37.0	37.0	10,460	4,960	8	....	29,200	27,900
C 6a	.020	.020	.664	19.5	19.5	10,190	4,380	8	....	42,400	37,700
b	.020	.020	.672	19.5	19.5	10,460	4,960	8	....	42,200	38,200
C 7a	.040	.040	.711	46.5	46.5	6,390	2,540	4	20,200	22,300	16,600
b	.040	.040	.716	46.5	46.5	6,960	2,110	4	19,100	22,300	16,400
C 8a	.040	.040	.713	37.0	37.0	6,390	2,540	4	23,000	23,000	23,000
b	.040	.040	.709	37.0	37.0	6,960	2,110	4	....	27,000	21,700
C 9a	.040	.040	.711	19.5	19.5	6,390	2,540	4	....	35,400	34,000
b	.040	.040	.712	19.5	19.5	6,960	2,110	4	....	32,400	33,300
C10a	.040	.040	.711	46.5	46.5	8,670	4,120	8	20,700	23,700	18,100
b	.040	.040	.711	46.5	46.5	10,390	4,990	8	19,100	22,600	18,900
C11a	.040	.040	.710	37.0	37.0	8,670	4,120	8	25,300	27,900	25,800
b	.040	.040	.713	37.0	37.0	10,390	4,990	8	28,000	30,000	27,000
C12a	.040	.040	.711	19.5	19.5	8,670	4,120	8	....	37,900	36,400
b	.040	.040	.714	19.5	19.5	10,390	4,990	8	....	31,200	37,200
C13a	.064	.064	.759	46.5	46.5	6,490	2,720	4	17,300	20,400	15,900
b	.064	.064	.759	46.5	46.5	6,630	2,460	4	17,300	19,400	15,600
C14a	.064	.064	.758	37.0	37.0	6,490	2,720	4	22,100	23,400	20,700
b	.064	.064	.758	37.0	37.0	6,630	2,460	4	....	25,500	20,100
C15a	.064	.064	.758	19.5	19.5	6,490	2,720	4	....	25,500	31,200
b	.064	.064	.759	19.5	19.5	6,630	2,460	4	....	25,400	30,600
C16a	.064	.064	.758	46.5	46.5	9,820	4,510	8	19,900	22,600	18,100
b	.064	.064	.755	46.5	46.5	10,010	4,490	8	20,200	22,600	18,200
C17a	.064	.064	.758	37.0	37.0	9,820	4,510	8	23,300	24,200	24,700
b	.064	.064	.754	37.0	37.0	10,010	4,490	8	25,800	28,200	24,900
C18a	.064	.064	.757	19.5	19.5	9,820	4,510	8	31,500	32,100	35,300
b	.064	.064	.758	19.5	19.5	10,010	4,490	8	....	22,800	35,300

Sheet 1 of 2

Table 1.--Results of tests of sandwich panels in edgewise compression[1] (Continued)

Panel No.	Facing thickness f_1	Facing thickness f_2	Total thickness h	Width a	Length b	Shear moduli G_b	Shear moduli G_a	Weight of cloth in core	Test facing stresses: Buckling stress P_{cr}	Test facing stresses: Maximum stress P_{max}	Computed buckling stress
	In.	In.	In.	In.	In.	P.s.i.	P.s.i.	Oz.	P.s.i.	P.s.i.	P.s.i.
C19a	0.020	0.040	0.688	46.5	46.5	6,260	2,350	4	21,300	23,900	15,500
b	.020	.040	.684	46.5	46.5	6,610	2,570	4	18,400	21,000	15,600
C20a	.020	.040	.691	37.0	37.0	6,260	2,350	4	16,400	18,500	22,100
b	.020	.040	.683	37.0	37.0	6,610	2,570	4	28,000	29,300	22,100
C21a	.020	.040	.689	19.5	19.5	6,260	2,350	4	....	39,100	34,200
b	.020	.040	.698	19.5	19.5	6,610	2,570	4	....	37,100	35,000
C22a	.020	.040	.691	46.5	46.5	10,140	4,750	8	23,700	26,500	17,200
b	.020	.040	.690	46.5	46.5	10,180	4,420	8	19,800	22,500	17,100
C23a	.020	.040	.693	37.0	37.0	10,140	4,750	8	....	27,700	25,800
b	.020	.040	.692	37.0	37.0	10,180	4,420	8	29,300	31,900	25,400
C24a	.020	.040	.694	19.5	19.5	10,140	4,750	8	....	40,800	36,800
b	.020	.040	.709	19.5	19.5	10,180	4,420	8	....	37,600	37,000
C25a	.040	.064	.730	46.5	46.5	6,360	2,930	4	15,500	17,800	15,700
b	.040	.064	.726	46.5	46.5	5,370	2,930	4	15,900	17,000	15,300
C26a	.040	.064	.729	37.0	37.0	6,360	2,930	4	....	17,400	21,400
b	.040	.064	.727	37.0	37.0	5,370	2,930	4	18,500	19,500	20,800
C27a	.040	.064	.730	19.5	19.5	6,360	2,930	4	....	28,100	32,800
b	.040	.064	.729	19.5	19.5	5,370	2,930	4	....	30,000	32,300
C28a	.040	.064	.734	46.5	46.5	9,950	4,770	8	18,000	21,200	17,800
b	.040	.064	.732	46.5	46.5	9,350	4,660	8	16,800	20,200	17,610
C29a	.040	.064	.734	37.0	37.0	9,950	4,770	8	28,200	30,100	25,300
b	.040	.064	.730	37.0	37.0	9,350	4,660	8	27,100	28,600	24,700
C30a	.040	.064	.735	19.5	19.5	9,950	4,770	8	....	29,500	36,000
b	.040	.064	.732	19.5	19.5	9,350	4,660	8	....	37,800	35,700
C31a	.020	.064	.709	46.5	46.5	6,260	2,490	4	16,700	19,300	12,800
b	.020	.064	.712	46.5	46.5	5,890	2,480	4	15,200	17,400	12,800
C32a	.020	.064	.709	37.0	37.0	6,260	2,490	4	19,000	24,100	17,900
b	.020	.064	.710	37.0	37.0	5,890	2,480	4	22,200	23,600	17,900
C33a	.020	.064	.709	19.5	19.5	6,260	2,490	4	....	34,100	31,600
b	.020	.064	.712	19.5	19.5	5,890	2,480	4	36,100	36,700	31,500
C34a	.020	.064	.709	46.5	46.5	10,850	4,720	8	15,700	17,500	14,100
b	.020	.064	.711	46.5	46.5	10,930	5,470	8	15,700	18,000	14,400
C35a	.020	.064	.708	37.0	37.0	10,850	4,720	8	22,200	24,700	20,700
b	.020	.064	.708	37.0	37.0	10,930	5,470	8	24,100	26,200	20,900
C36a	.020	.064	.709	19.5	19.5	10,850	4,720	8	....	30,000	34,500
b	.020	.064	.694	19.5	19.5	10,930	5,470	8	....	37,600	34,200

[1] Facings of 24 ST clad aluminum, cores of impregnated-cotton-cloth 7/16-inch-cell-size honeycomb.

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Table 2.--Results of flexure tests of sandwich constructions having facings of 24 ST clad aluminum. Loads applied 2 inches each side of midspan

Specimen No.	Thickness: Compression facing f_1	Thickness: Tension facing f_2	Thickness: Total h	Span a	Maximum: Load per inch width P	Maximum: Center deflection Δ	Maximum: Slope at reaction θ	Maximum: Moment per inch width M	Failure	Maximum core shear stress τ^1
	In.	In.	In.	In.	Lb.	In.	Deg.	In.-lb.		P.s.i.
Core: 4-ounce cotton-cloth honeycomb; parallel to span										
B 1a	0.020	0.020	1.036	18	219	0.38	3.0	768	Compression	
b	.020	.020	1.032	18	205	.36	3.0	711	do	
B 4a	.020	.040	1.057	18	212	.28	2.0	739	do	
b	.020	.040	1.052	18	216	.31	3.5	755	do	
c	.040	.020	1.052	18	324	.79	5.5	1,143	Shear	158
d	.040	.020	1.048	18	309	.70	5.0	1,091	do	151
B 5a	.020	.064	1.090	18	222	.29	2.0	774	Compression	
b	.020	.064	1.084	18	221	.27	2.0	763	do	
c	.064	.020	1.077	18	293	.47	2.5	1,024	Shear	141
d	.064	.020	1.080	18	256	.35	2.0	897	do	123
B 3a	.064	.064	1.124	12	310				do	146
b	.064	.064	1.126	12	322				do	151
c	.064	.064	1.125	12	305				do	143
Core: 4-ounce cotton-cloth honeycomb; perpendicular to span										
B 1a	.020	.020	1.041	20	120	.36	2.0	478	Shear	59
B 3a	.064	.064	1.126	12	145				do	68
b	.064	.064	1.130	12	170				do	80
c	.064	.064	1.130	12	160				do	75
Core: 8-ounce cotton-cloth honeycomb; parallel to span										
B 7a	.020	.020	1.055	12	382	.18	2.0	766	Compression	
b	.020	.020	1.060	12	389	.20	4.5	778	do	
B 8a	.040	.040	1,095	20	372	.45	3.5	1,498	Bond	178
b	.040	.040	1.095	20	470	.64	4.5	1,901	do	224
B 9a	.064	.064	1.138	28	529	1.30	5.5	3,204	do	246
b	.064	.064	1.142	28	559	1.35	6.5	3,372	do	261
B10a	.020	.040	1.064	20	227	.35	2.5	912	Compression	
b	.020	.040	1.064	20	215	.32	2.5	862	do	
c	.040	.020	1.068	20	305	1.59	11.5	1,270	Tension	
d	.040	.020	1.072	20	309	1.75	12.0	1,289	do	
B11a	.020	.064	1.090	28	130	.46	2.5	785	Compression	
b	.020	.064	1.098	28	135	.47	2.5	821	do	
c	.064	.020	1.093	28	208	1.90	9.5	1,287	Tension	
d	.064	.020	1.097	28	218	2.79	14.5	1,389	do	
B12a	.040	.064	1.120	25	435	1.02	6.0	2,279	Compression	
b	.040	.064	1.120	25	416	.93	5.0	2,212	do	
c	.064	.040	1.120	25	494	1.58	14.5	2,678	Bond	233
d	.064	.040	1.123	25	489	2.19	12.0	2,685	do	230

Table 2.--Results of flexure tests of sandwich constructions having facings of 24 ST clad aluminum. Loads applied 2 inches each side of midspan (Continued)

Specimen No.	Thickness: Compression facing	Thickness: Tension facing	Thickness: Total	Span	Maximum: Load per inch width	Maximum: Center deflection	Maximum: Slope at reaction	Maximum: Moment per inch width	Failure	Maximum core shear stress
	f_1	f_2	h	a	P	Δ	θ	M		τ^1
	In.	In.	In.	In.	Lb.	In.	Deg.	In.-lb.		P.s.i.
Core: 8-ounce cotton-cloth honeycomb; parallel to span (Continued)										
B 9a	0.064	0.064	1.127	12	622	....	....	....	Shear	292
b	.064	.064	1.126	12	565	....	....	....	....do.....	266
c	.064	.064	1.122	12	600	....	....	....	....do.....	282
Core: 8-ounce cotton-cloth honeycomb; perpendicular to span										
B 7a	.020	.020	1.053	12	222	0.20	1.5	447	Compression	....
b	.020	.020	1.045	12	200	.15	1.5	402	....do.....	....
B 8a	.040	.040	1.086	20	260	.43	2.5	1,046	Bond	124
b	.040	.040	1.093	20	265	.45	2.5	1,064	....do.....	127
B 9a	.064	.064	1.132	28	242	.67	2.0	1,449	....do.....	113
b	.064	.064	1.136	28	210	.49	1.5	1,261	....do.....	98
B10a	.020	.040	1.063	20	181	.43	3.0	727	Compression	....
b	.020	.040	1.067	20	192	.48	4.0	774	....do.....	....
c	.040	.020	1.070	20	204	.45	2.0	819	Bond	98
d	.040	.020	1.073	20	202	.43	2.5	802	....do.....	98
B11a	.020	.064	1.087	25	155	.45	2.0	812	Compression	....
b	.020	.064	1.090	25	153	.42	2.0	805	....do.....	....
c	.064	.020	1.087	25	228	2.64	14.0	1,272	Tension	....
d	.064	.020	1.092	25	222	2.14	11.5	1,215	....do.....	....
B12a	.040	.064	1.113	28	236	.67	3.5	1,417	Bond	112
b	.040	.064	1.113	28	270	.90	4.0	1,626	....do.....	128
c	.064	.040	1.113	28	265	.88	3.5	1,599	....do.....	125
d	.064	.040	1.117	28	253	.77	3.0	1,517	....do.....	119
B 9a	.064	.064	1.123	12	350	....	....	....	Shear	164
b	.064	.064	1.123	12	330	....	....	....	....do.....	155
c	.064	.064	1.120	12	360	....	....	....	....do.....	170
Core: Aluminum honeycomb, 3/8-inch cell size of 0.003 inch 3SH foil; parallel to span										
B13a	.020	.020	1.039	12	334	.13	2.0	666	Compression	....
b	.020	.020	1.046	12	410	.13	2.0	820	....do.....	....
B14a	.040	.040	1.090	20	395	.31	2.0	1,586	Bond	189
b	.040	.040	1.092	20	193	.18	1.5	772	....do.....	92
B15a	.064	.064	1.133	28	385	.53	3.5	2,352	....do.....	181
b	.064	.064	1.138	28	337	.42	3.0	2,078	....do.....	158
B16a	.020	.040	1.058	20	222	.37	2.0	882	Compression	....
b	.020	.040	1.062	20	214	.30	2.5	859	....do.....	....
c	.040	.020	1.064	20	303	1.40	9.0	1,246	Tension	....
d	.040	.020	1.067	20	293	1.10	8.0	1,194	....do.....	....

Table 2.--Results of flexure tests of sandwich constructions having facings of 24 ST clad aluminum. Loads applied 2 inches each side of midspan (Continued)

Specimen No.	Thickness: Compression facing	Thickness: Tension facing	Thickness: Total	Span	Maximum: Load per inch width	Maximum: Center deflection	Maximum: Slope at reaction	Maximum: Moment per inch width	Failure	Maximum core shear stress
	f_1	f_2	h	a	P	Δ	θ	M		τ^1
	In.	In.	In.	In.	Lb.	In.	Deg.	In.-lb.		P.s.i.
Core: Aluminum honeycomb, 3/8-inch cell size of 0.003 inch 3SH foil; parallel to span (Continued)										
B17a	0.020	0.064	1.083	25	150	0.29	2.0	796	Compression	....
b	.020	.064	1.084	25	150	.31	2.0	795	....do....	....
c	.064	.020	1.086	25	235	1.76	10.0	1,289	Tension	....
d	.064	.020	1.087	25	180	.36	2.5	1,218	Bond	86
B18a	.040	.064	1.103	25	406	.86	5.0	2,158	....do.....	193
b	.040	.064	1.108	25	400	.79	4.5	2,116	....do.....	190
c	.064	.040	1.110	25	385	.51	3.5	2,033	....do.....	182
d	.064	.040	1.115	25	320	.39	2.5	1,687	....do.....	152
B15a	.064	.064	1.119	12	502	....	....	....	Shear	237
b	.064	.064	1.121	12	505	....	....	....	....do.....	238
c	.064	.064	1.122	12	455	....	....	....	....do.....	214
Core: Aluminum honeycomb, 3/8-inch cell size of 0.003 inch 3SH foil; perpendicular to span										
B15a	.064	.064	1.124	12	205	....	....	....	Shear	96
b	.064	.064	1.124	12	280	....	....	....	....do.....	132
c	.064	.064	1.126	12	252	....	....	....	....do.....	118
Core: Aluminum honeycomb, 3/8-inch cell size of 0.005 inch 3SH foil; parallel to span										
B19a	.020	.020	1.038	12	430	.20	2.5	864	Compression	....
b	.020	.020	1.032	12	395	.18	2.0	785	....do....	....
B20a	.040	.040	1.082	20	582	1.69	13.0	2,436	Bond	280
b	.040	.040	1.086	20	584	1.77	13.0	2,452	Compression	....
B21a	.064	.064	1.150	28	275	.34	2.0	1,681	Bond	128
b	.064	.064	1.148	28	328	.41	2.5	2,000	....do.....	153
B22a	.020	.040	1.059	20	207	.39	3.5	830	Compression	....
b	.020	.040	1.062	20	217	.39	3.0	870	....do....	....
c	.040	.020	1.065	20	289	1.44	10.0	1,190	Tension	....
d	.040	.020	1.067	20	282	1.12	7.5	1,146	....do....	....
B23a	.020	.064	1.080	28	159	.61	3.5	958	Compression	....
b	.020	.064	1.080	28	152	.55	3.0	914	....do....	....
c	.064	.020	1.078	28	196	1.97	10.0	1,219	Tension	....
d	.064	.020	1.080	28	201	2.11	11.5	1,257	....do....	....
B24a	.040	.064	1.107	25	445	1.06	5.5	2,364	Compression	....
b	.040	.064	1.108	25	460	1.29	8.0	2,494	....do....	....
c	.064	.040	1.112	25	498	2.63	15.5	2,807	Tension	....
d	.064	.040	1.115	25	350	.41	3.0	1,846	Bond	166
B21a	.064	.064	1.145	12	950	....	....	....	Shear	442
b	.064	.064	1.141	12	685	....	....	....	....do.....	320
c	.064	.064	1.146	12	720	....	....	....	....do.....	336

Table 2.--Results of flexure tests of sandwich constructions having facings of 24 ST clad aluminum. Loads applied 2 inches each side of midspan (Continued)

Specimen No.	Thickness: Compression facing	Thickness: Tension facing	Thickness: Total	Span	Maximum: Load per inch width	Maximum: Center deflection	Maximum: Slope at reaction	Maximum: Moment per inch width	Failure	Maximum core shear stress
	f_1	f_2	h	a	P	Δ	θ	M		τ
	In.	In.	In.	In.	Lb.	In.	Deg.	In.-lb.		P.s.i.
Core: Aluminum honeycomb, 3/8-inch cell size of 0.005 inch 3SH foil; perpendicular to span										
B19a	0.020	0.020	1.042	12	320	0.13	1.5	640	Bond	157
b	.020	.020	1.036	12	171	.07	1.0	344	Compression	....
B20a	.040	.040	1.077	20	342	.32	2.5	1,360	Bond	165
b	.040	.040	1.078	20	280	.24	1.5	1,119	....do.....	135
B21a	.064	.064	1.150	28	197	.28	1.5	1,198	....do.....	92
b	.064	.064	1.147	28	330	.48	2.5	2,006	....do.....	153
B22a	.020	.040	1.058	20	197	.28	3.0	790	Compression	....
b	.020	.040	1.056	20	190	.25	1.5	761	....do.....	....
c	.040	.020	1.059	20	270	1.54	11.5	1,120	Tension	....
d	.040	.020	1.061	20	264	1.34	10.0	1,086	....do.....	....
B23a	.020	.064	1.078	25	140	.30	2.0	737	Bond	68
b	.020	.064	1.080	25	160	.38	2.0	842	Compression	....
c	.064	.020	1.080	25	218	2.35	13.0	1,205	Tension	....
d	.064	.020	1.079	25	211	1.66	9.5	1,146	....do.....	....
B24a	.040	.064	1.104	28	355	.83	4.5	2,145	Bond	168
b	.040	.064	1.106	28	360	.86	5.0	2,166	....do.....	171
c	.064	.040	1.107	28	396	2.09	11.0	2,469	....do.....	188
d	.064	.040	1.112	28	375	1.37	7.5	2,292	....do.....	178
B21a	.064	.064	1.145	12	320	....	....	....	Shear	149
b	.064	.064	1.147	12	330	....	....	....	....do.....	154
c	.064	.064	1.149	12	385	....	....	....	....do.....	179
Core: Aluminum honeycomb, 1/4-inch cell size of 0.002 inch 3SH foil; parallel to span										
B25a	.020	.020	1.033	12	418	.17	3.0	842	Compression	....
b	.020	.020	1.032	12	432	.22	3.0	874	....do.....	....
B26a	.040	.040	1.078	20	452	.41	3.0	1,815	Shear	....
b	.040	.040	1.080	20	460	.46	3.5	1,844	Bond	221
B27a	.064	.064	1.112	28	438	.65	3.5	2,666	....do.....	208
b	.064	.064	1.114	28	432	.64	4.0	2,655	....do.....	204
B28a	.020	.040	1.049	20	245	.41	4.0	986	Compression	....
b	.020	.040	1.050	20	244	.47	3.5	978	....do.....	....
c	.040	.020	1.052	20	288	1.24	10.0	1,186	Tension	....
d	.040	.020	1.055	20	290	1.43	10.0	1,197	....do.....	....
B29a	.020	.064	1.076	25	200	.66	4.0	1,065	Compression	....
b	.020	.064	1.077	25	199	.64	4.0	1,055	....do.....	....
c	.064	.020	1.080	25	249	2.56	14.5	1,399	Tension	....
d	.020	.064	1.083	25	203	.65	4.0	1,077	Compression	....

Table 2.--Results of flexure tests of sandwich constructions having facings of 24 ST clad aluminum. Loads applied 2 inches each side of midspan (Continued)

Specimen No.	Thickness: Compression facing	Thickness: Tension facing	Thickness: Total	Span	Maximum: Load per inch width	Maximum: Center deflection	Maximum: Slope at reaction	Maximum: Moment per inch width	Failure	Maximum core shear stress
	f_1	f_2	h	a	P	Δ	θ	M		τ^1
	In.	In.	In.	In.	Lb.	In.	Deg.	In.-lb.		P.s.i.
Core: Aluminum honeycomb, 1/4-inch cell size of 0.002 inch 3SH foil; parallel to span (Continued)										
B30a	0.040	0.064	1.094	25	380	0.65	4.0	2,014	Bond	182
b	.040	.064	1.098	25	405	.83	5.0	2,157	do	193
c	.064	.040	1.100	25	451	1.10	6.5	2,414	do	215
d	.064	.040	1.104	25	405	.54	3.0	2,149	do	192
B27a	.064	.064	1.121	12	465				Shear	219
b	.064	.064	1.124	12	455				do	214
c	.064	.064	1.127	12	475				do	222
Core: Aluminum honeycomb, 1/4-inch cell size of 0.002 inch 3SH foil; perpendicular to span										
B25a	.020	.020	1.027	18	210	.22	2.0	730	Shear	103
b	.020	.020	1.030	18	196	.26	2.0	683	do	97
B28a	.020	.040	1.042	18	180	.19	1.5	626	do	88
b	.020	.040	1.041	18	179	.19	1.5	630	do	88
c	.040	.020	1.045	18	214	.22	1.5	743	do	104
d	.040	.020	1.043	18	178	.19	1.5	622	do	87
B29a	.020	.064	1.074	18	188	.17	1.5	650	do	91
b	.020	.064	1.070	18	196	.18	1.5	678	do	95
c	.064	.020	1.065	18	198	.18	1.5	686	do	96
d	.064	.020	1.067	18	189	.18	1.5	658	do	92
B27a	.064	.064	1.133	12	245				do	115
b	.064	.064	1.136	12	270				do	126
c	.064	.064	1.139	12	300				do	140
Core: Aluminum honeycomb, 1/4-inch cell size of 0.004 inch 3SH foil; parallel to span										
B31a	.020	.020	1.052	12	402	.15	2.0	805	Bond	196
b	.020	.020	1.048	12	470	.25	3.0	944	Compression	
B32a	.040	.040	1.085	20	225	.23	1.0	908	Bond	108
b	.040	.040	1.090	20	92	.09	.5	367	do	44
B33a	.064	.064	1.136	28	591	1.70	4.0	3,551	do	277
b	.064	.064	1.140	28	418	.48	3.5	2,463	do	195
B34a	.020	.040	1.061	20	298	.77	5.5	1,206	Compression	
b	.020	.040	1.064	20	287	.61	5.0	1,159	do	
c	.040	.020	1.064	20	322	1.18	9.5	1,322	Tension	
d	.040	.020	1.068	20	300	.83	7.0	1,218	Bond	145
B35a	.020	.064	1.075	28	178	1.00	7.5	1,091	Compression	
b	.020	.064	1.076	28	172	.85	10.5	1,065	do	
c	.064	.020	1.083	28	195	1.85	15.0	1,231	Tension	
d	.064	.020	1.087	28	203	2.40	4.0	1,251	do	

Table 2.--Results of flexure tests of sandwich constructions having facings of 24 ST clad aluminum. Loads applied 2 inches each side of midspan (Continued)

Specimen No.	Thickness: Compression facing	Thickness: Tension facing	Thickness: Total	Span	Maximum: Load per inch width	Maximum: Center deflection	Maximum: Slope at reaction	Maximum: Moment per inch width	Failure	Maximum core shear stress
	f_1	f_2	h	a	P	Δ	θ	M		τ[1]
	In.	In.	In.	In.	Lb.	In.	Deg.	In.-lb.		P.s.i.
Core: Aluminum honeycomb, 1/4-inch cell size of 0.004 inch 3SH foil; parallel to span (Continued)										
B36a	0.040	0.064	1.105	28	432	2.03	11.5	2,704	Compression	....
b	.040	.064	1.106	28	431	1.98	11.0	2,696	....do.....	....
c	.064	.040	1.107	28	416	3.35	18.5	2,760	Tension	....
d	.064	.040	1.108	28	416	3.53	19.0	2,776	....do.....	....
B33a	.064	.064	1.148	12	980	....	....	....	Shear	456
b	.064	.064	1.148	12	825	....	....	....	....do.....	384
c	.064	.064	1.149	12	930	....	....	....	....do.....	432
Core: Aluminum honeycomb, 1/4-inch cell size of 0.004 inch 3SH foil; perpendicular to span										
B31a	.020	.020	1.043	12	345	.13	1.5	681	Compression	....
b	.020	.020	1.046	12	379	.16	2.0	762	Bond	185
B32a	.040	.040	1.093	20	257	.22	1.5	1,037	....do.....	123
b	.040	.040	1.096	20	100	.07	.5	401	....do.....	48
B33a	.064	.064	1.134	28	397	.57	3.5	2,379	....do.....	186
b	.064	.064	1.136	28	160	.22	1.0	956	....do.....	75
B34a	.020	.040	1.060	20	247	.41	3.5	996	Compression	....
b	.020	.040	1.065	20	198	.25	2.0	794	Bond	96
c	.040	.020	1.065	20	256	.63	5.0	1,034	....do.....	124
d	.040	.020	1.066	20	188	.27	2.5	753	....do.....	91
B35a	.020	.064	1.070	25	182	.59	3.0	969	Compression	....
b	.020	.064	1.075	25	189	.65	4.0	998	....do.....	....
c	.064	.020	1.078	25	220	2.86	16.0	1,250	Tension	....
d	.064	.020	1.082	25	192	.98	5.0	1,017	Shear	92
B36a	.040	.064	1.106	25	392	.84	4.5	2,096	Bond	186
b	.040	.064	1.110	25	388	.80	4.5	2,062	....do.....	184
c	.064	.040	1.110	25	415	.85	4.5	2,121	....do.....	197
d	.064	.040	1.113	25	148	.18	1.5	741	....do.....	70
B33a	.064	.064	1.146	12	485	....	....	....	Shear	226
b	.064	.064	1.150	12	480	....	....	....	....do.....	223
c	.064	.064	1.153	12	450	....	....	....	....do.....	209

[1] $\tau = \frac{P}{h + c}$

Z M 87259 F

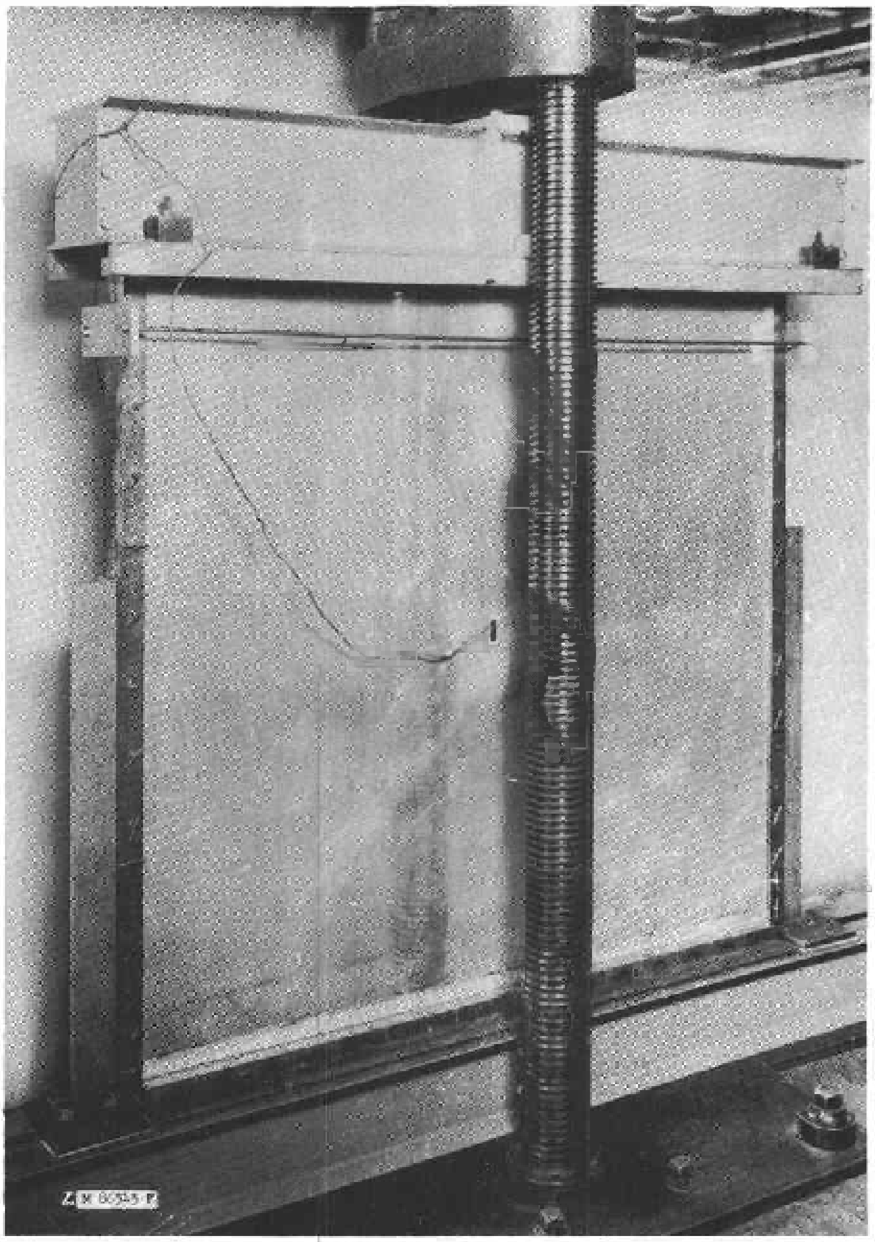
Table 3.--Maximum moments causing compression or tension failure of sandwich flexure specimens

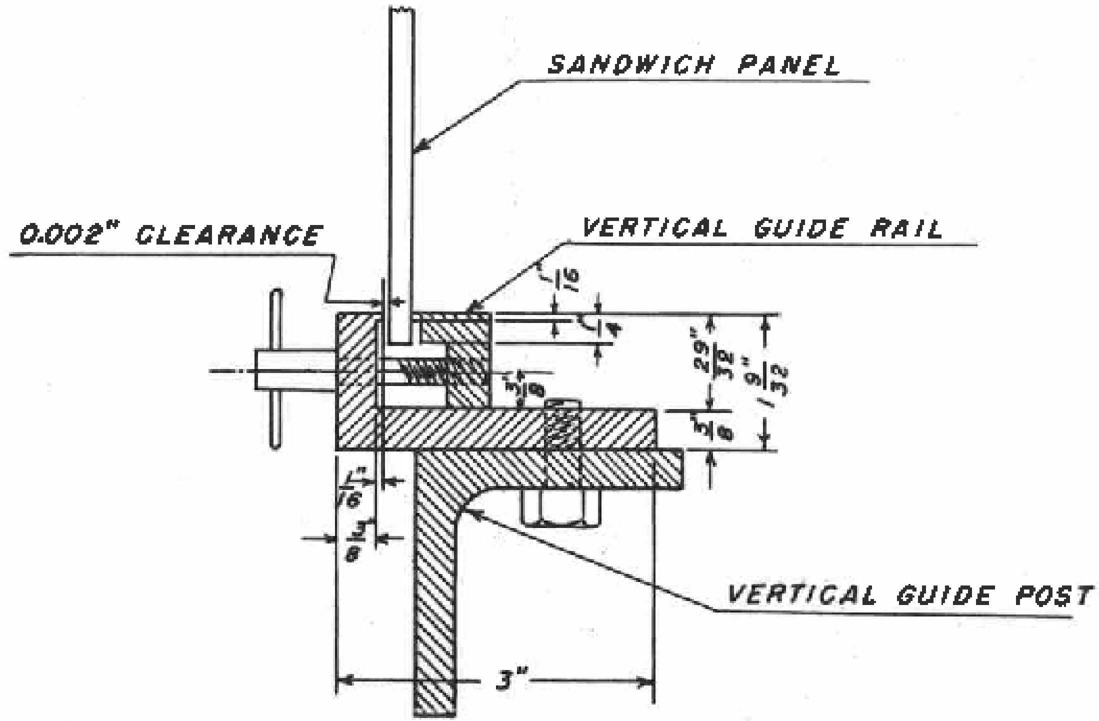
Maximum moment[1] for compression failure						Maximum moment[1] for tension failure					
Cores of 7/16-inch cells		Cores of 3/8-inch cells		Cores of 1/4-inch cells		Cores of 7/16-inch cells		Cores of 3/8-inch cells		Cores of 1/4-inch cells	
f_1=0.020 inch	f_1=0.040 inch	f_1=0.020 inch	f_1=0.040 inch	f_1=0.020 inch	f_1=0.040 inch	f_2=0.020 inch	f_2=0.040 inch	f_2=0.020 inch	f_2=0.040 inch	f_2=0.020 inch	f_2=0.040 inch
In.-lb.	In.-lb.	In.-lb.	In.-lb.	In.-lb.	In.-lb.	In.-lb.	In.-lb.	In.-lb.	In.-lb.	In.-lb.	In.-lb.
768	2,279	666	2,452	842	2,704	1,270	....	1,246	2,807	1,186	2,760
711	2,212	820	2,364	872	2,696	1,289	....	1,194	....	1,197	2,776
739	....	882	2,494	986	....	1,287	....	1,289	....	1,399	....
755	....	859	....	978	....	1,389	....	1,190	....	1,322	....
774	....	796	....	1,065	....	1,272	....	1,146	....	1,231	....
763	....	795	....	1,055	....	1,215	....	1,219	....	1,251	....
766	....	864	....	1,077	....	....	....	1,257	....	1,250	....
778	....	785	....	944	....	....	....	1,120	....	....	....
912	....	830	....	1,206	....	....	....	1,086	....	....	....
862	....	870	....	1,159	....	....	....	1,205	....	....	....
785	....	958	....	1,091	....	....	....	1,146	....	....	....
821	....	914	....	1,065	....	....	....	....	....	....	....
447	....	344	....	681	....	....	....	....	....	....	....
402	....	790	....	996	....	....	....	....	....	....	....
727	....	761	....	969	....	....	....	....	....	....	....
774	....	842	....	998	....	....	....	....	....	....	....
812	....	....	....	....	....	....	....	....	....	....	....
805	....	....	....	....	....	....	....	....	....	....	....
Average Moments											
745	2,246	798	2,437	1,000	2,700	1,287	....	1,190	2,807	1,260	2,770
Average Stresses[2]											
36,200	54,000	38,700	58,500	48,500	65,000	62,500	....	58,000	67,500	61,000	66,500

[1]This is moment per inch of width.

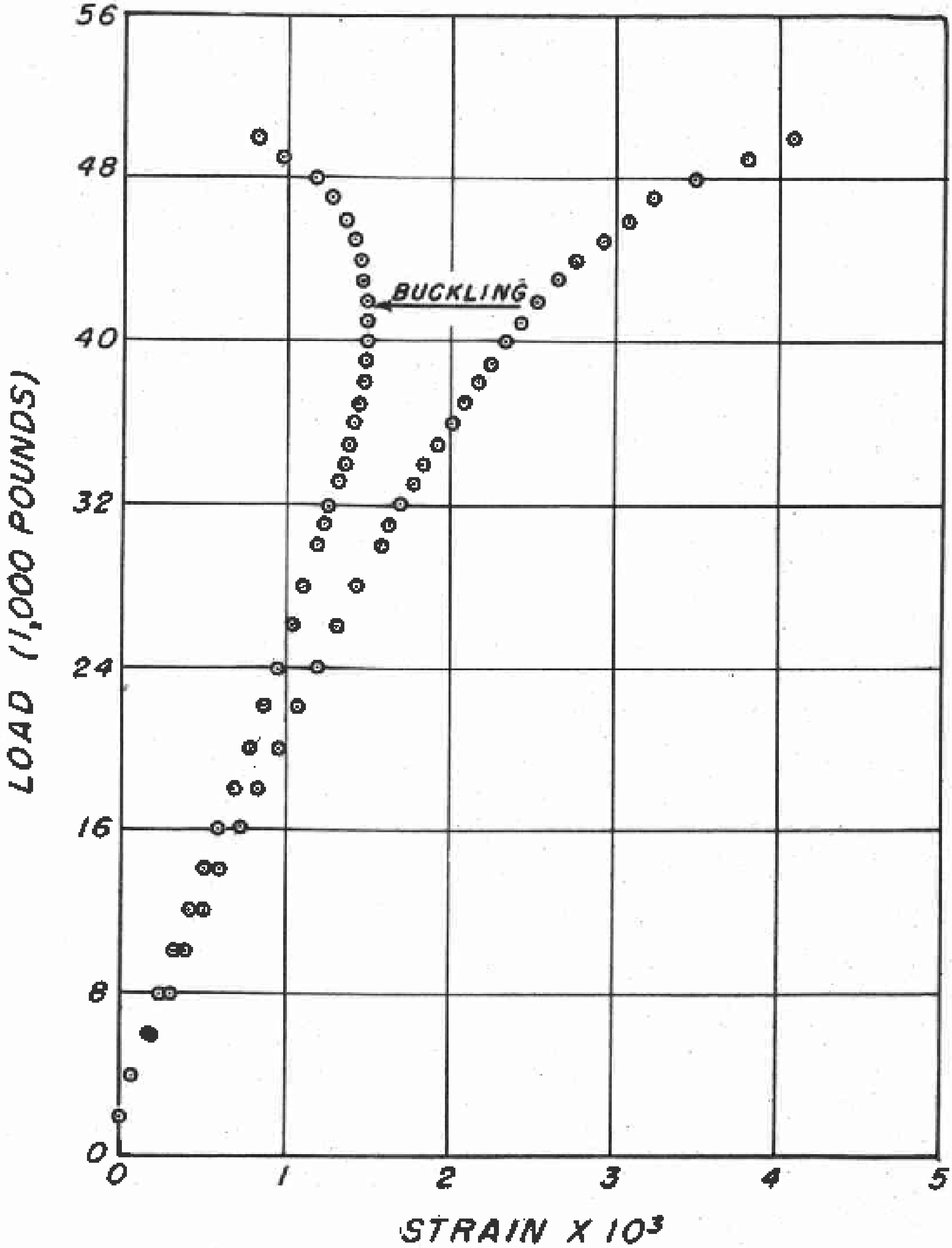
[2]Computed from $p_f = \frac{2M}{f_{1,2}(h + c)}$.

Z M 87260 F

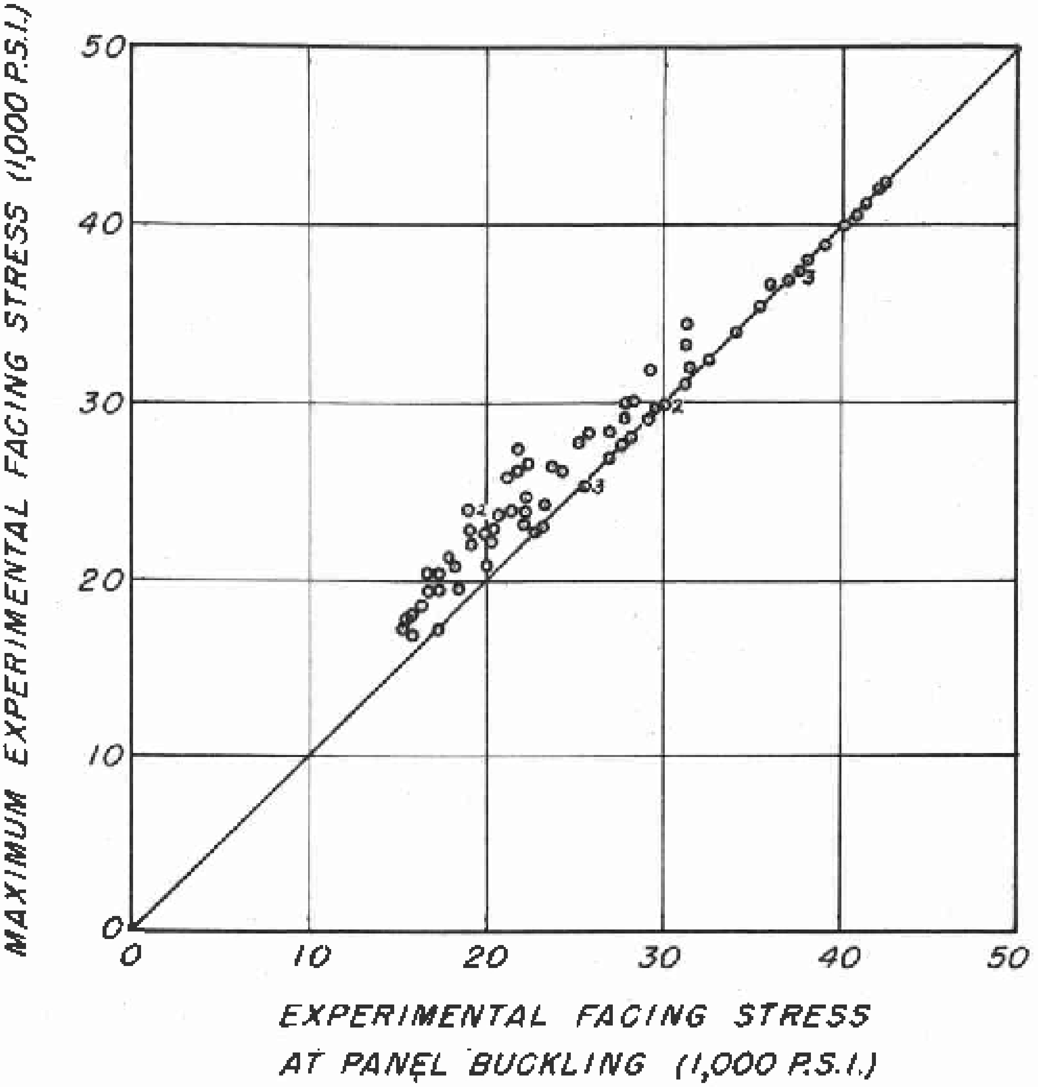



SANDWICH PANEL
0.002" CLEARANCE
VERTICAL GUIDE RAIL
VERTICAL GUIDE POST
3"

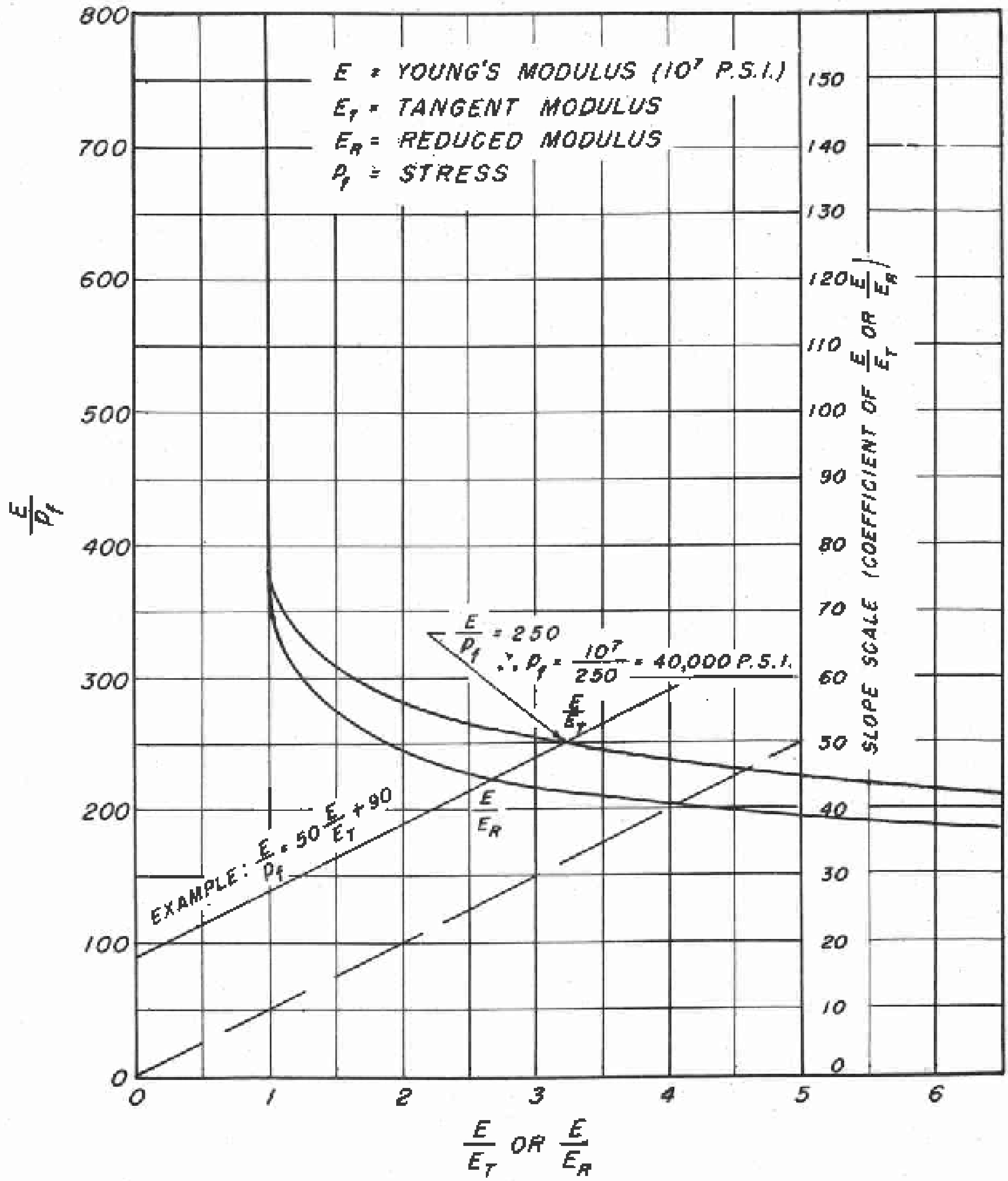
Z M 87244 F


56
48
40
32
24
16
8
0
LOAD (1,000 POUNDS)
BUCKLING
0
1
2
3
4
5
STRAIN X 10³

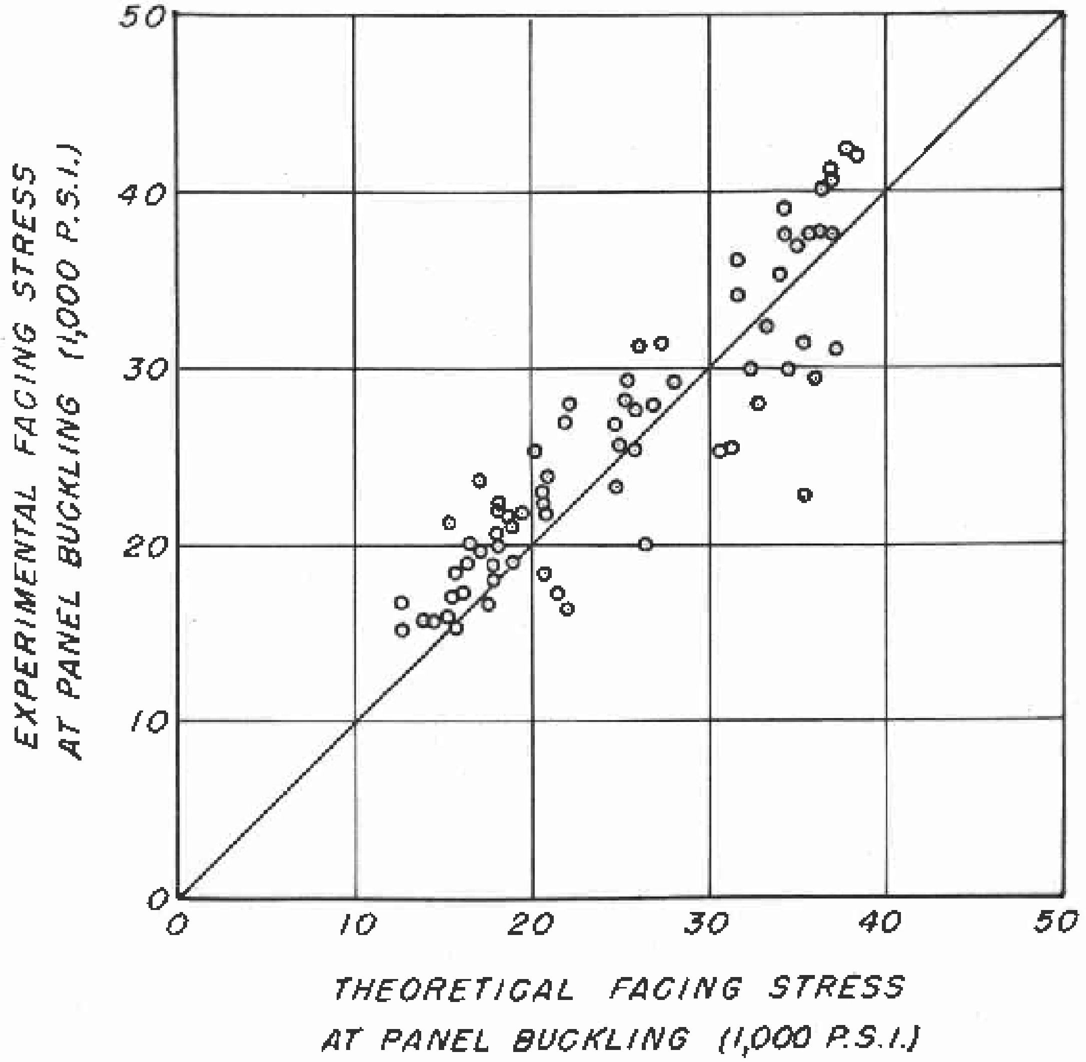
Z M 87245 F


MAXIMUM EXPERIMENTAL FACING STRESS (1,000 P.S.I.)
50
40
30
20
10
0
0
10
20
30
40
50
EXPERIMENTAL FACING STRESS
AT PANEL BUCKLING (1,000 P.S.I.)

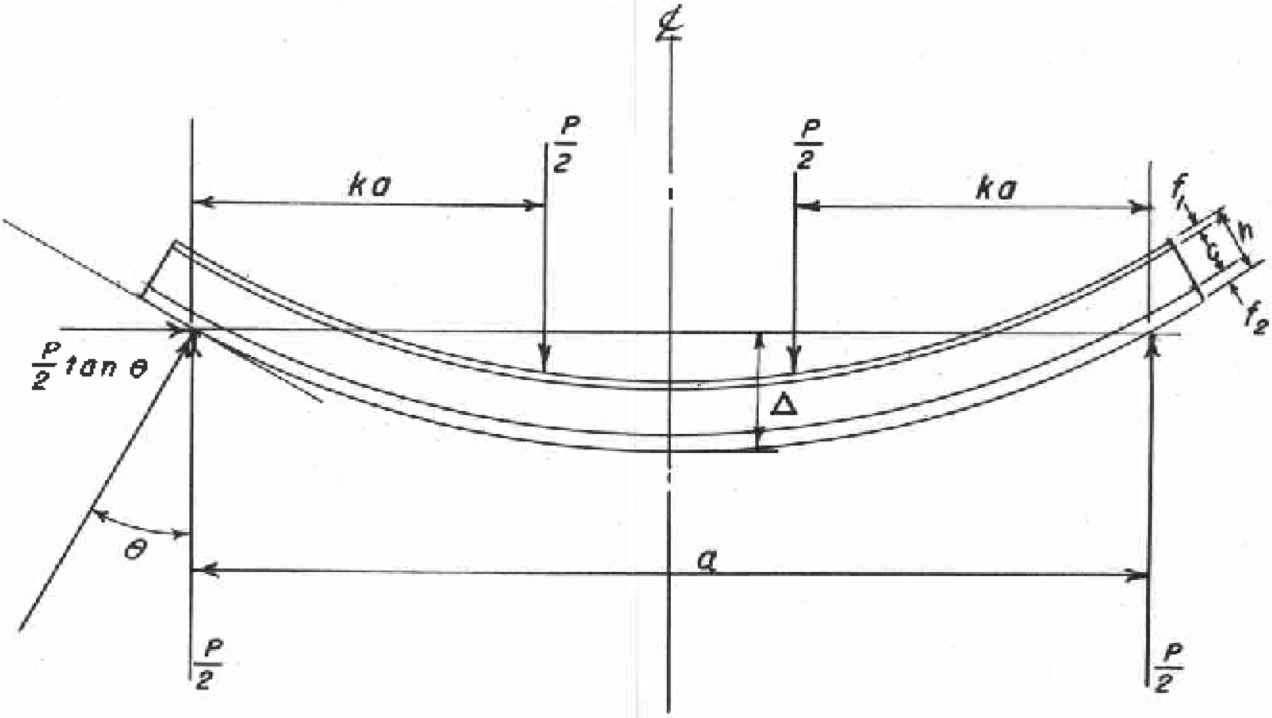
Z M 87246 F


E = YOUNG'S MODULUS (10^7 P.S.I.)
E_T = TANGENT MODULUS
E_R = REDUCED MODULUS
p_f = STRESS
$\frac{E}{p_f}$ = 250 ∴ $p_f = \frac{10^7}{250}$ = 40,000 P.S.I.
EXAMPLE: $\frac{E}{p_f} = 50\frac{E}{E_T} + 90$
$\frac{E}{E_T}$
$\frac{E}{E_R}$
$\frac{E}{p_f}$
SLOPE SCALE (COEFFICIENT OF $\frac{E}{E_T}$ OR $\frac{E}{E_R}$)
$\frac{E}{E_T}$ OR $\frac{E}{E_R}$
0
100
200
300
400
500
600
700
800
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
1
2
3
4
5
6

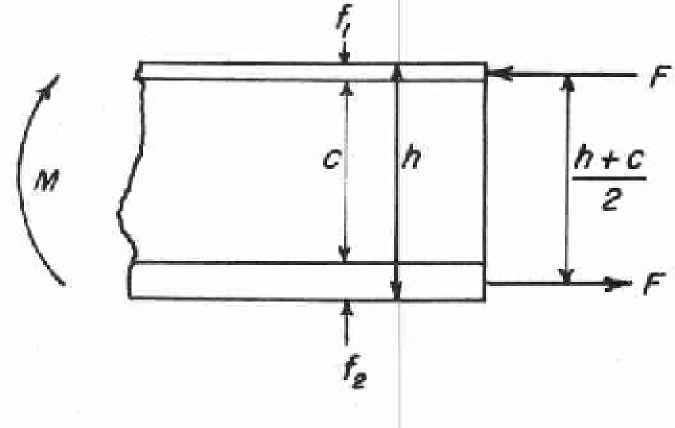
Z M 87247 F


EXPERIMENTAL FACING STRESS AT PANEL BUCKLING (1,000 P.S.I.)
THEORETICAL FACING STRESS AT PANEL BUCKLING (1,000 P.S.I.)
0
10
20
30
40
50

Z M 87248 F

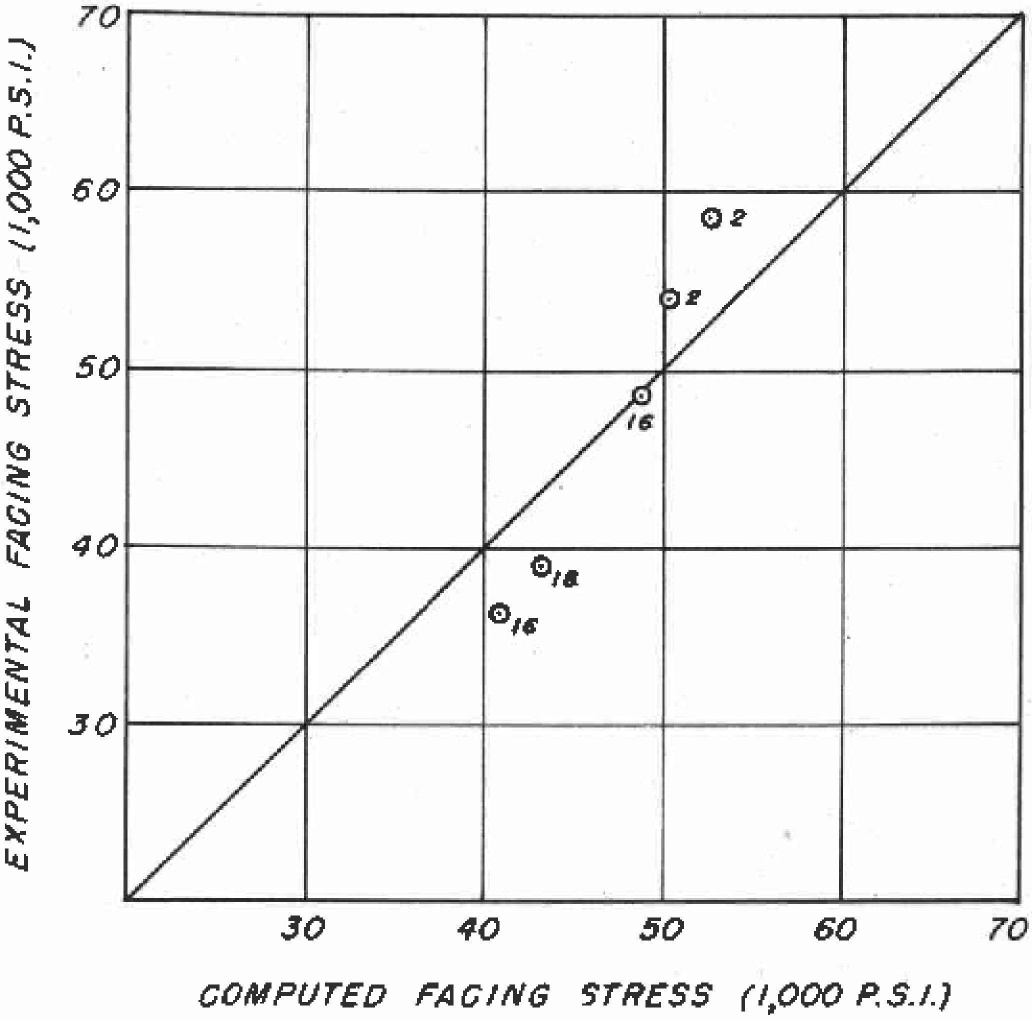


A

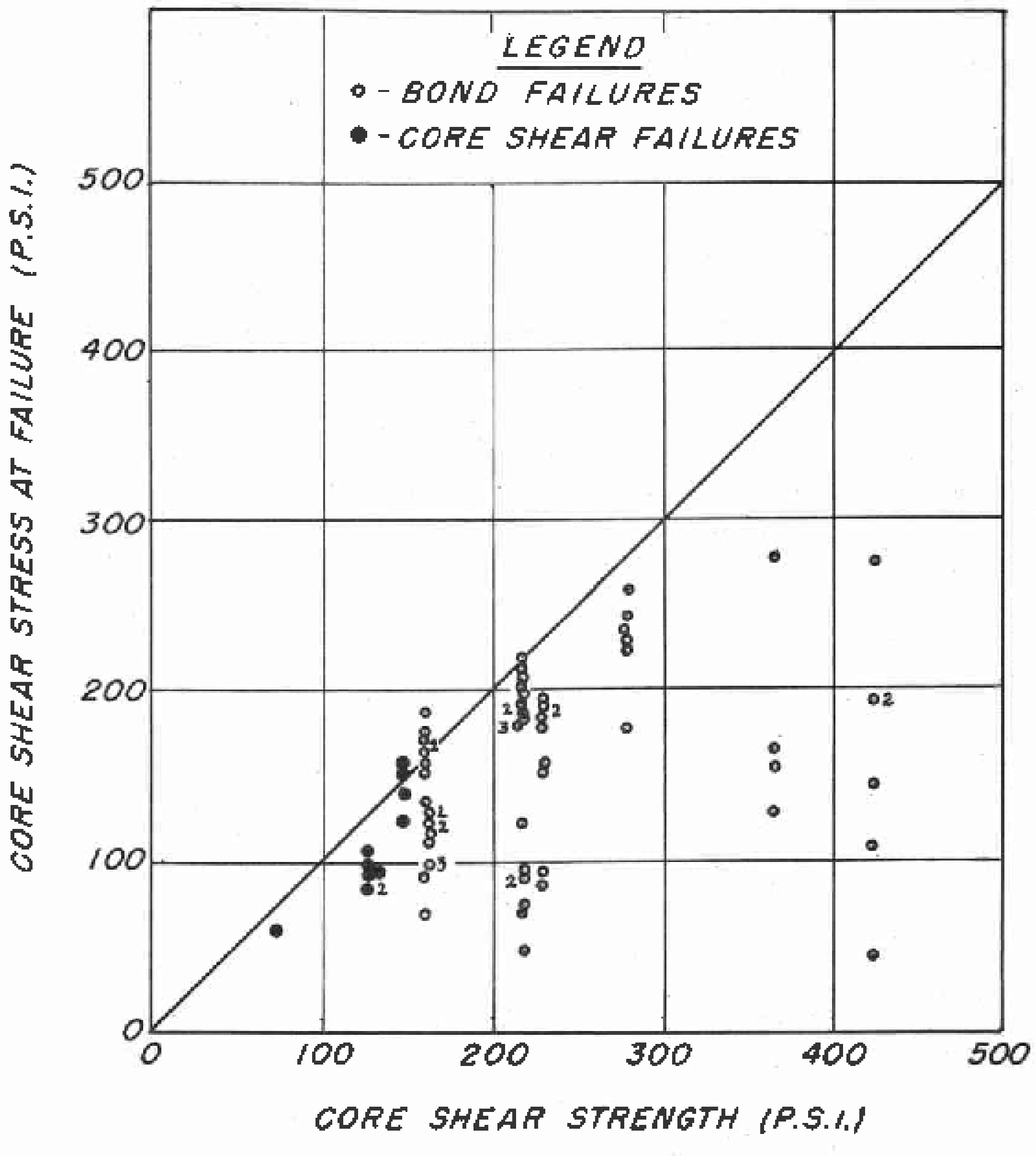


B

Z M 87249 F


70
60
50
40
30
EXPERIMENTAL FACING STRESS (1,000 P.S.I.)
2
2
16
18
16
30
40
50
60
70
COMPUTED FACING STRESS (1,000 P.S.I.)

Z M 87250 F



(DETERMINED BY FLEXURE TESTS OF SHORT SPECIMENS HAVING THICK FACINGS)

Z M 87251 F