01 Apr 1981

Web crippling and combined web crippling and bending of steel decks

Wei-Wen Yu
Missouri University of Science and Technology, wwy4@mst.edu

CIVIL ENGINEERING STUDY 81-2

STRUCTURAL SERIES

WEB CRIPPLING AND COMBINED WEB CRIPPLING AND BENDING OF STEEL DECKS

by

Wei-Wen Yu
Project Director

A Research Project Sponsored by American Iron and Steel Institute
Steel Deck Institute and H. H. Robertson Company

April 1981

Department of Civil Engineering

University of Missouri-Rolla

Rolla, Missouri

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

I. INTRODUCTION

A. General

During the period of October 1968 through September 1980, the 1968 Edition of the AISI Specification was used for the design of steel deck webs that could withstand web crippling and combined web crippling and bending.[1] The design formulas used to prevent web crippling were developed primarily on the basis of tests conducted in the 1940's and 1950's at Cornell University.[2-4]

Recently, new types of cold-formed steel sections have been developed and used in building construction. The use of unusual geometric configurations has complicated the design of such members. In order to develop new design criteria, additional studies of the crippling strength of beam webs have been made in several countries.[5-22]

Since 1973, a research project on a study of beam webs has been carried out at the University of Missouri-Rolla (UMR) under the sponsorship of American Iron and Steel Institute. Based on the available test data obtained from research at Cornell and tests recently conducted at UMR, modified AISI design formulas for web crippling have been proposed in Ref. 21. Because these modified formulas are based on the test data of channels, I-beams, and hat sections having vertical webs with relatively small R/t and N/t ratios, these proposed design provisions may or may not be fully suitable for the design of steel decks when they have inclined webs with large R/t and/or large N/t ratios. In addition, various types of embossments and indentations are usually formed in the webs of the steel decks to be used for composite slabs. These deformations may affect the web crippling strength of steel decks. For this reason, a research project was initiated in 1979 at the University of Missouri-Rolla to study the web crippling strength of steel decks. This project was cosponsored by Steel Deck Institute, American Iron and Steel Institute, and H. H. Robertson Company.

B. Purpose of Investigation

The objectives of the investigation were (1) to establish experimentally the web crippling strength of a selected group of steel decks, (2) to determine the effect of bending on web crippling load, and (3) to demonstrate the validity of the proposed design formulas for preventing web crippling of steel decks.

C. Scope of Investigation

In order to achieve the first objective mentioned above, a total of 84 web crippling tests of steel decks were conducted at the University of Missouri-Rolla during the period of September 1979 through March 1980. During these tests, 40 specimens were subjected to interior one-flange loading, and the remaining 44 specimens were subjected to end one-flange loading. Details of the first phase of the experimental study are presented in Articles II and III of this report. Comparisons between the test data and predicted web crippling loads are also included in these two articles.

In the second phase of the study, 56 specimens having relatively long spans were tested as simple beams and continuous beams to determine the effect of bending on the web crippling strength of steel decks. The test data have been used to determine the validity of the AISI interaction formulas that are used for the design of steel beams subjected to combined web crippling and bending. Details of the second phase of the study are presented in Articles IV and V.

Finally, the recommendations for future research are discussed in Article VI.

II. EXPERIMENTAL STUDY OF WEB CRIPPLING STRENGTH OF STEEL DECKS SUBJECTED TO INTERIOR ONE-FLANGE LOADING (IOF SERIES)

Since September 1979, 40 web crippling tests have been conducted for interior one-flange loading. The test specimens used in this experimental study were fabricated from steel decks received from five manufacturing companies. Figure 1 shows the type of test used in this part of the investigation.

The following discussions deal with the preparation of the test specimens, the tesing of the specimens, the results of the tests, and evaluation of the test data.

A. Preparation of Test Specimens

Nine different types of steel decks were used in the tests of web crippling strength for interior one-flange loading. Figure 2 shows the cross-sectional configurations of the steel decks used. The actually measured dimensions of the test specimens are presented in Table 1. All symbols used in this table are defined in Fig. 3. Table 2 lists the following design parameters for the steel deck specimens:

Design Parameter	Range
Web inclination angle, Θ	48.1 - 90.0 degrees
R/t ratio	3.05 - 7.24
h/t ratio	46.65 - 107.43
N/t ratio	63.40 - 208.80
N/h ratio	0.94 - 3.17
Yield point, F_y	39.3 - 49.9 ksi

Prior to testing, the tension flange of the steel decks was braced by two 1/8x3/4 inch rectangular bars along the inside edge of the end bearing plates. Self-tapping screws (#12 x 14 x 3/4 Tek Screws) were used for connectors.

B. Testing of Specimens

(a) Tensile Coupon Tests

The mechanical properties of the steels used for the test specimens were established by standard tensile coupon tests. All the coupons were tested in a 150,000-lb Tinius Olsen universal testing machine. Table 3 lists the test data on yield point, ultimate tensile strength, and elongation measured from 2-inch gage length. Each value is the average of four coupon tests.

(b) Testing of Deck Specimens

For the 40 web crippling tests of interior one-flange loading, 38 specimens were tested in the 150,000-lb Tinius Olsen universal testing machine. Only two wide specimens (IOF-19A and IOF-19B) were tested in the 8-foot wide, 9-foot high, and 21-foot long loading frame located in UMR's Engineering Research Laboratory.

(i) Test Setup

Each specimen was tested as a simply supported beam by using two large bearing plates (N_2) at both ends and a small bearing plate (N_1) under the concentrated load applied at midspan as shown in Fig. 4. The clear distance between the bearing plates was equal to approximately 1.5h, where h is the width measured along the plane of the web. The minimum distance of 1.5h between bearing plates was chosen to eliminate the effect of a two-flange loading action. The same criteria were used previously for the Cornell and UMR tests.[3,21]

Figures 5 and 6 show the test setup used in this phase of the experimental study.

(ii) Test Procedure

During the tests, the specimens were loaded continuously to the estimated allowable design load, beyond which an increment of 20% of the estimated allowable design load was added to each specimen following a waiting period of five minutes. All specimens were tested to failure. The maximum load at failure was recorded for evaluation of the test data.

C. Results of Tests

The results of 40 web crippling tests of steel decks subjected to interior one-flange loading are presented in Tables 4 and 5. In these two tables, $(P)_{test}$ is the total failure load for web crippling under the concentrated load, and $(M)_{test}$ is the bending moment computed from the load $(P)_{test}$ and the actual span length.

Typical failure modes for web crippling of steel decks subjected to interior one-flange loading are shown in Figs. 7 and 8.

D. Evaluation of Test Data

The results of the 40 steel deck tests have been carefully evaluated and compared with the predicted ultimate web crippling loads and the ultimate bending moments determined on the basis of the 1968 Edition of the AISI Specification[1] and the 1980 Edition of the AISI Specification.[23] Details of these comparisons are given below.

(a) Comparison of the Experimental Web Crippling Loads and the Predicted Loads Determined on the Basis of Addendum No.2 of the 1968 AISI Specification

In Table 4, the predicted ultimate web crippling loads, $(P_u)_{comp}$, for interior one-flange loading were calculated from the following equations:

(i) $R/t \leq 1$

$$(P_u)_{comp/web} = 1.85 \{t^2 [305 + 2.30(N/t) - 0.009(N/t)(h/t) - 0.5(h/t)]x[1.22 - 0.22(F_y/33)] (F_y/33)\} \sin\theta \quad (1)$$

(ii) $1 < R/t \leq 4$

$$(P_u)_{comp/web} = \text{Eq. (1)} \times [1.06 - 0.06(R/t)] \quad (2)$$

where
- t = web thickness, in.
- N = actual length of bearing, except that in the above formulas the value of N is not to be taken for a value greated than h, in.
- h = clear distance between flanges measured along the plane of the web, in.
- F_y = yield point, ksi
- R = inside bend radius, in.
- θ = web inclination angle, degree.

It should be noted that in Eqs. (1) and (2), $(P_u)_{comp/web}$ is the predicted ultimate load per web in kips. For this reason, the predicted ultimate web crippling load per specimen is computed as follows:

$$(P_u)_{comp}/\text{specimen} = (\text{Number of Webs})(P_u)_{comp/web}$$

With regard to the predicted ultimate bending moments, the following considerations were given to the computations of $(M_u)_{comp}$:

(1) The value $(M_{u1})_{comp}$ was calculated from the yield point of steel and the section modulus based on the effective width of the compression flange determined in accordance with Section 2.3.1.1 of the AISI Specification and the full area of the tension flange and webs.

(2) The value $(M_{u2})_{comp}$ was calculated from the yield point of steel and the section modulus based on shear lag consideration (i.e., the section modulus was based on the effective widths of both compression and tension flanges in accordance with Section 2.3.5 of the AISI Specification) and the full area of the webs.

(3) The value $(M_{u3})_{comp}$ was calculated from the section modulus based on the full area of the tension flange and webs combined with the effective width of the compression flange determined on the basis of Section 2.3.1.1 of the AISI Specification with $f = F_{bw}$ or $0.60\ F_y$, whichever was smaller. The stress used for computing the ultimate bending moment was either $1.67F_{bw}$ or F_y, whichever was less, where F_{bw} is the allowable stress for webs subject to bending stress. It was computed by using Eq. (3):

$$F_{bw} = \frac{520,000}{(h/t)^2} \qquad (3)$$

Also included in Table 4 are the $(M)_{test}/(M_u)_{comp}$ and $(P)_{test}/(P_u)_{comp}$ ratios, in which $(M_u)_{comp}$ is the smallest value of $(M_{u1})_{comp}$, $(M_{u2})_{comp}$, and $(M_{u3})_{comp}$. The correlation between the test results and the following interaction formula[1] is shown graphically in Fig. 9.

$$\frac{(P)_{test}}{(P_u)_{comp}} + \frac{(M)_{test}}{(M_u)_{comp}} = 1.3 \tag{4}$$

It should be noted that only four test points are shown in Fig. 9 because for other specimens, the R/t ratio exceeds the AISI limit of 4. As listed in Table 4, the mean value of A/1.3 ratios is 1.707. This high mean value and Fig. 9 indicate that the design provisions included in the 1968 Edition of the AISI Specification are very conservative for the design of these four test specimens. This possibly is because in calculating the predicted web crippling load acccording to the 1968 AISI Specification the bearing length, N, was taken to be not more than h. In addition, the test specimens exhibited a considerable postbuckling strength.

(b) Comparison of the Experimental Web Crippling Loads and the Predicted Loads Determined on the Basis of the 1980 Edition of the AISI Specification[23]

In comparing the experimental and the predicted loads determined on the basis of the 1980 Edition of the AISI Specification, the predicted ultimate web crippling loads for interior one-flange loading, $(P_u')_{comp}$, as given in Table 5, were computed from the following equations (Equation 3.5.1-3 of Ref. 23):

(i) $N/t \leq 60$

$$(P_u')_{comp/web} = 1.85 \{t^2 k C_1 C_2 C_\Theta [291 - 0.40(h/t)] \times [1 + 0.007 (N/t)]\} \tag{5}$$

(ii) $N/t > 60$

$$(P_u')_{comp/web} = 1.85 \{t^2 k C_1 C_2 C_\theta [291 - 0.40(h/t)] \times [0.75 + 0.011(N/t)]\} \quad (6)$$

where $k = F_y/33$

$C_1 = (1.22 - 0.22k)$

$C_2 = [1.06 - 0.06(R/t)] \leq 1.0$

$C_\theta = 0.7 + 0.3(\theta/90)^2$

θ = angle between web and bearing surface, degree

N = actual length of bearing, in., except that the N/t ratio shall not exceed 210 and the N/h ratio shall not exceed 3.5

R = inside bend radius, in., except that R shall not be greater than 7t for steel decks.

As far as the predicted ultimate bending moments are concerned, the values of $(M_{u1})_{comp}$ and $(M_{u2})_{comp}$ are the same as those listed in Table 4. The value $(M_{u3}')_{comp}$ was computed from the section modulus based on the full area of the tension flange and webs combined with the effective width of the compression flange. The latter was determined on the basis of Section 2.3.1.1 of the AISI Specification with $f = 0.60\ F_y$ or F_{bw}, whichever was smaller. In the calculation, the value of F_{bw} was determined by using Eq. 3.4.2-1 of Ref. 23:

$$F_{bw} = [1.21 - 0.00034\ (h/t)\ \sqrt{F_y}\ ](0.60F_y) \leq 0.60\ F_y \quad (7)$$

The ratios of $(M)_{test}/(M_u')_{comp}$ and $(P)_{test}/(P_u')_{comp}$ are presented in Table 5. The correlation between the test results and the interaction formula given in Eq. (8) is shown graphically in Fig. 10.

$$1.07 \frac{(P)_{test}}{(P_u')_{comp}} + \frac{(M)_{test}}{(M_u')_{comp}} = 1.42 \qquad (8)$$

It should be noted that Eq. (8) is the basic interaction formula used to develop the AISI design formula (Eq. 3.5.2-1 of Ref. 23) for beams having single, unreinforced webs subjected to combined bending and web crippling.[21] Therefore, Fig. 10 indicates the validity of the AISI design formulas for single span steel decks subjected to combined bending and web crippling.

Unlike Fig. 9, a total of 40 test points are shown in Fig. 10.* This is because in the 1980 Edition of the AISI Specification, the limit of the R/t ratio was extended from 4 to 7. The mean value of the B/1.42 ratios is 1.188 as given in Table 5. This mean value and Fig. 10 indicate the improvement of the AISI design equations for web crippling and combined web crippling and bending as compared with the 1968 Edition of the AISI Specification.

If the shear lag consideration is neglected (i.e., the value of $(M_u')_{comp}$ is either $(M_{u1})_{comp}$ or $(M_{u3}')_{comp}$, whichever is less), the correlation between the test results and the interaction formula can be shown as in Fig. 11. It can be seen that Eq. 8 may be used for the combined web crippling and bending of steel decks used for single span tests having relatively short span lengths. It should be noted that this equation is conservative for steel decks with flat webs.

---

*For Specimens IOF-2A, 2B, 9A, 9B, 10A, and 10B, the R/t ratios are slightly larger than 7. See Table 2.

(c) Effect of Intermittent, Longitudinal Embossments and Indentations on Web Crippling Strength

The effect of intermittent, longitudinal embossments and indentations on web crippling strength can be observed by comparing the test results of several specimens. As listed in Tables 1 and 2, the material properties and dimensions of Specimens Nos. 1,2,5, and 6 are practically identical with Specimens Nos. 9,10,11, and 12, except that for the composite decks (Specimens Nos. 9,10,11, and 12) the embossments and indentations as shown in Fig. 12 were used in the inclined webs. These deformations may reduce the web crippling strength of steel decks according to the size and arrangement of the embossments. Table 6 presents a comparison of the test results for eight different specimens subjected to interior one-flange loading. It seems to indicate that for the type and arrangement of embossments used in this comparison, the reduction of web crippling strength occasioned by the longitudinal embossments is within 10%.

E. Summary

A total of 40 web crippling tests were conducted for interior one-flange loading. Even though short span lengths were used in the tests, a considerable amount of bending moment was developed for most of the specimens.

The test results were carefully reviewed and evaluated. Comparisons between a limited number of test data and the equations used for combined bending and web crippling indicate that the R/t ratios of most of the steel decks used in this study exceeded the AISI limit included in the 1968 Edition of the Specification and that the 1980 Edition of the AISI Specification can be used for the design of steel decks. It has been noted that the AISI design provisions are conservative for steel decks having flat webs.

A comparison of the test data obtained for several specimens indicates that for the panels used in the tests, the web crippling load is slightly affected by the intermittent, longitudinal embossments and indentations formed in the webs. More tests should be conducted in this area for a detailed study.

III. EXPERIMENTAL STUDY OF WEB CRIPPLING STRENGTH OF STEEL DECKS SUBJECTED TO END ONE-FLANGE LOADING (EOF SERIES)

During the period of September 1979 through March 1980, 44 web crippling tests were conducted for steel decks subjected to end one-flange loading. Figure 13 illustrates the type of tests used in this phase of investigation. The test specimens used in the experimental study were fabricated from the same steel decks used in the web crippling study for interior one-flange loading that were reported on in Article II.

The preparation of test specimens, the testing of the specimens, the results of the tests, and evaluation of the test data are discussed in the following sections.

A. Preparation of Test Specimens

As in the tests for interior one-flange loading, nine different types of steel decks were used in the web crippling tests for the end one-flange loading condition. The cross-sectional configurations of the steel decks are the same as those shown in Fig. 2, except that specimens Nos. EOF-13, EOF-14, EOF-15, and EOF-16 were tested in an inverted position. This test setup was used to eliminate the effect of continuous longitudinal stiffeners on the web crippling strength at both ends.

The actually measured dimensions of the test specimens are presented in Table 7. All symbols used in Table 7 are defined in Fig. 3. Table 7 presents the design parameters for the steel decks used for end one-flange loading. The ranges of design parameters are similar to those listed on page 4.

Prior to testing, the tension flange of the steel deck specimens was braced by two 1/8 x 3/4 inch rectangular bars along the inside edge of the end bearing plates. In addition, a short piece of the same steel deck was attached to the central portion of the specimen to prevent premature failure of the deck at the location of the applied concentrated loads. This type of reinforcement was used for all tests, except for specimens EOF-13, EOF-14, EOF-15, and EOF-16 with continuous longitudinal stiffeners.

B. Testing of Deck Specimens

All specimens were tested in the 150,000-lb Tinius Olsen universal testing machine. The test setup and procedure are described in the subsequent sections.

(a) Test Setup

Each specimen was tested as a simple beam as shown in Fig. 14. Two large bearing plates were used under the applied concentrated loads, and two small bearing plates were placed under the specimen at both end supports. The clear distance between the bearing plates was approximately 1.5h. Figures 15 and 16 show the test setup used for the experimental study of end failure.

(b) Test Procedure

The procedure used for the web crippling tests of steel decks subjected to end one-flange loading is the same as that used for the interior one-flange loading. For details, see Article II.B.b.ii.

C. Results of Tests

The results of 40 web crippling tests of steel decks subjected to end one-flange loading are presented in Table 8. The value of the $(P_u)_{test}$ is the total load applied to the specimen at failure, in kips.

Typical failure modes for the web crippling of steel decks subjected to end one-flange loading are shown in Figs. 17 and 18.

D. Evaluation of Test Data

The results of 44 steel deck tests have been carefully evaluated and compared with the ultimate web crippling loads computed on the basis of the 1968 Edition of the AISI Specification [1] and the 1980 Edition of the AISI Specification. [23] The equations used to determine the predicted ultimate web crippling loads are given in the following sections.

(a) Comparison of the Experimental Web Crippling Loads and the Predicted Loads Determined on the Basis of the 1968 AISI Specification

In Table 8, the predicted ultimate web loads for end one-flange loading were calculated from the following equations, whichever was applicable:

(i) $R/t \leq 1$

$$(P_u)_{comp/web} = 1.85\,\{t^2[98 + 4.20(N/t) - 0.022(N/t)(h/t) + 0.011(h/t)] \times [1.33 - 0.33(F_y/33)] (F_y/33)\}\sin\theta \quad (9)$$

(ii) $1 < R/t \leq 4$

$$(P_u)_{comp/web} = \text{Eq. (9)} \times [1.15 - 0.15(R/t)] \quad (10)$$

All the symbols have been defined previously.

In view of the fact that Eqs. (9) and (10) deal with the predicted ultimate web crippling load for one web at each end support, the predicted total ultimate load applied to an entire specimen was computed as follows:

$(P_u)_{comp}$/specimen = 2(Number of Webs)$(P_u)_{comp/web}$

Also listed in Table 8 are the ratios of $(P_u)_{test}/(P_u)_{comp}$. Because most of the steel decks had R/t ratios larger than 4, only six test results could be used for this comparison.

(b) Comparison of the Experimental Web Crippling Loads and the Predicted Loads Determined on the Basis of the 1980 Edition of the AISI Specification.[23]

In comparing the experimental data and the predicted loads determined on the basis of the 1980 Edition of the AISI Specification, the predicted ultimate web crippling loads for end one-flange loading were computed from the following equations:

(i) Beams with Stiffened Flanges (AISI Eq. 3.5.1-1)

$$(P_u')_{comp}/\text{web} = 1.85\ \{t^2kC_3C_4C_\theta[179 - 0.33(h/t)] \times [1 + 0.01(N/t)]\} \quad (11)$$

(ii) Beams with Unstiffened Flanges (AISI Eq. 3.5.1-2)

$N/t \leq 60$,

$$(P_u')_{comp}/\text{web} = 1.85\ \{t^2kC_3C_4C_\theta[117 - 0.15(h/t)] \times [1 + 0.01(N/t)]\} \quad (12)$$

$N/t > 60$,

$$(P_u')_{comp}/\text{web} = 1.85\ \{t^2kC_3C_4C_\Theta[117 - 0.15(h/t)] \times [0.71 + 0.015(N/t)]\} \quad (13)$$

where $k = F_y/33$

$C_3 = (1.33 - 0.33k)$

$C_4 = [1.15 - 0.15(R/t)] \leq 1.0$ but not less than 0.5

$C_\theta = 0.7 + 0.3(\theta/90)^2$

θ = angle between web and bearing surface, degree

N = actual length of bearing, in., except that the N/t ratio shall not exceed 210 and the N/h ratio shall not exceed 3.5

R = inside bend radius, in., except that R shall not be greater than 7t for steel decks.

Consequently, the predicted total ultimate load applied to each specimen was determined as:

$(P_u')_{comp}$/specimen = 2(Number of Webs)$(P_u')_{comp/web}$*

The ratios of $(P_u)_{test}/(P_u')_{comp}$ for 36 specimens were calculated and are listed in Table 8. For two specimens, the R/t ratios slightly exceeded the revised limiting value of 7. Figure 19 shows the relationship between the computed C_4 and the R/t ratio. It can be seen that the lower limit of 0.5 for C_4 is justified. The larger scatter is due to the fact that many parameters concerning the deformed webs are not included in the design formulas.

A study of the ratios of $(P_u)_{test}/(P_u)_{comp}$ indicates that the 1968 AISI Specification is slightly conservative for the design of steel deck webs as far as the web crippling at end support is concerned. This is possibly due to the available postbuckling strength of steel deck webs. The 1980 Edition of the AISI Specification based on a previous study of channels and hat sections gives a conservative design except for Specimens EOF-13 and EOF-14. The low failure loads for these specimens were probably caused by the use of intermittent, longitudinal embossments in the webs.

In order to study the effect of support conditions on end failure,

---

*Specimens Nos. 1 through 16 had 4 webs all connected to stiffened flanges; Specimens Nos. 17 and 18 had 2 webs connected to unstiffened flanges; Specimens Nos. 19 and 20 had 6 webs connected to stiffened flanges and 2 webs connected to unstiffened flanges.

Specimens EOF-5C and EOF-5D were supported by two W shapes as shown in Fig. 20. No connections were used at the ends of the specimens. Figure 21 shows the failure mode of the steel decks tested. The total failure load per specimen is given in Table 10. In addition, Specimens EOF-5E and EOF-5F were spot welded to two end bearing plates by Mac-Fab Products, Inc. (Fig. 22). Three bolts were used to connect these bearing plates to support beams as shown in Fig. 23. For this case, the failure mode of the steel decks is shown in Fig. 24 under the failure load given in Table 10.

A comparison of the total failure load given in Table 10 indicates that when the steel decks are placed on support beams with or without connections, the steel deck webs can actually resist a larger load than that obtained from simple beam tests for which the bearing plate is allowed to rotate. For design parameters see Table 9.

(c) Effect of Intermittent, Longitudinal Embossments and Indentations on Web Crippling Strength

In order to determine the effect of intermittent, longitudinal embossments on the web crippling strength of the steel decks subjected to end one-flange loading, the test results of Specimen Nos. 1, 2, 5, 6, 9, 10, 11, and 12 were compared and are presented in Table 11. This comparison seems to indicate that for the case of end one-flange loading, the effect of longitudinal embossments on the web crippling strength is slightly larger than that for the case of interior one-flange loading. However, the reductions of failure loads for most of the test specimens are within 10%.

E. Summary

A total of 44 web crippling tests were conducted for the end one-flange loading condition. The test results were compared with the predicted loads computed by using the 1968 AISI Specification and the 1980 Edition of the Specification. The effect of a support condition on end failure was also studied briefly.

Several pilot tests showed that usually end web crippling is not a problem, because without any web reinforcement, steel deck specimens failed prematurely in the central portion of the specimens rather than at the end support even though the span length was kept very short and the bearing plate under the load was much wider than the end bearing plate.

IV. EXPERIMENTAL STUDY OF COMBINED WEB CRIPPLING AND BENDING: SIMPLE BEAM TESTS (BC SERIES)

Simple beam and continuous beam tests have been conducted for the purpose of studying the interaction between web crippling and bending of steel decks. Since March 1980, 24 long span steel decks have been tested as simple beams, and 32 long span steel decks have been tested as continuous beams. This Article deals only with the simple beam tests. The continuous beam tests are described in Article V.

The following discussions cover the preparation of test specimens, the testing of the specimens, the results of the tests, and evaluation of the test data obtained from the simple beam tests.

A. Preparation of Test Specimens

Seven different types of steel decks were used in the study of combined web crippling and bending. Figure 25 shows the cross-sectional configurations of the steel decks used in the long span simple beam tests. The measured dimensions of the test specimens are given in Tables 12 and 13. It should be noted that the steel decks listed in Table 12 were used without end connections in 16 simple beam tests, and those listed in Table 13 were used with end connections in eight simple beam tests. The symbols used in both tables are defined in Fig. 3.

The design parameters for the steel decks are presented in Tables 14 and 15. The following summary covers the ranges of design parameters employed in this investigation.

Design Parameter	Range
Web inclination angle, θ	48.9 - 90 degrees
R/t ratio	3.20 - 7.12
h/t ratio	54.15 - 107.85
N/t ratio	85.39 - 202.39
N/h ratio	1.00 - 2.68
Yield point, F_y	39.3 - 51.0 ksi

Before the steel decks without end connections were tested, the tension flange of the deck was braced by 1/8 x 3/4 inch rectangular bars along the inside edge of the end bearing plates. For the simple beams with end connections, a rectangular bar was fastened at the midspan of each specimen to brace the tension flange. Self-tapping screws (#12 x 14 x 3/4 Tek Screws) were used for connectors.

For the specimens with end connections, four foil strain gages were placed on the bottom face of the tension and compression flanges at the midspan. The arrangement of strain gages is shown in Fig. 26.

B. Testing of Specimens

(a) Tensile Coupon Tests

The mechanical properties of the steels used for the test specimens were determined by standard tensile coupon tests. All the coupons were tested in a 150,000-lb Tinius Olsen universal testing machine. Table 16 is a list of the test data on yield point, ultimate tensile strength, and elongation measured from a 2-in. gage length. Each value is the average of four coupon tests. The listed mechanical properties were used for the long span simple beams with end connections and the continuous beams. The mechanical properties listed in Table 3 were used for the simple beams without end connections.

(b) Testing of Deck Specimens

The test setup and test procedure used for the long span simple beam tests are the same as those used for the interior one-flange loading described in Article II.

(i) Test Setup

Each specimen was tested in a 150,000-lb Tinius Olsen testing machine on which two wide flange sections and tubular members were used as support beams. Before a specimen was tested, large bearing plates (N_2) were placed at both ends of the specimen, and a small bearing plate (N_1) was placed under the concentrated load applied at the midspan of the deck. Figure 27 shows the test setup used for long span simple beams without end connections. For this case, both ends of the specimen were free to rotate. Prior to testing, a dial gage was placed under the specimen at the midspan for measuring the deflection.

The test setup used for single span beams with end connections is shown in Fig. 28. At both ends of each two-foot wide test specimen, three 1/4-in. diameter bolts with 1/2-in. diameter washers were used to connect the steel deck to the bearing plates and the tubular members, which were fastened to support beams through three 7/8-in. diameter bolts. For the one-foot wide steel deck, only two bolts were used at each end of the test specimen. This type of end connection simulates the actual field conditions. Prior to testing, a dial gage was placed under the specimen at the midspan for measuring the deflection. Strain gages were connected to a data acquisition system for recording the test data. Figures 29(a) and 29(b) show the actual test setup used for single span beams with end connections.

(ii) Test Procedure

During the tests, the specimens were loaded continuously to the estimated allowable design load. Beyond this, an increment of approximate 20% of the estimated allowable design load was added to each specimen after a waiting period of five minutes. All the specimens were tested to failure. The ultimate failure load was recorded for each test.

During the tests of the single span beams with end connections, strain gage readings were usually taken at every 20% of the estimated design loads. In addition, the deflection at the midspan was recorded for every load increment.

C. Results of Tests

The results of 24 single span beam tests of steel decks subjected to combined bending and web crippling are presented in Tables 17 to 20. In these four tables, $(P)_{test}$ is the total ultimate load at failure. The value of $(M)_{test}$ is the bending moment computed from the load $(P)_{test}$ and the actual span length, i.e.,

$$(M)_{test} = 1/4\ (P)_{test}\ (L)$$

Typical failure modes at the midspan of the specimen are shown in Figs. 30 and 31.

The midspan deflections and strain gage readings are presented in Tables A1 and A4 respectively of the Appendix. Figures A1 to A8 of the Appendix show the load-deflection curves for single span beam tests. The tensile and compressive stresses developed under various loads are shown in Figs. A41 to A48.

D. Evaluation of Test Data

The results of the 24 steel deck tests have been carefully evaluated and compared with the predictions on the basis of the 1968 AISI Specification with Addendum No. 2[1] and the 1980 Edition of the AISI Specification.[23] Details of these comparisons are given below.

(a) Comparison of the Experimental Data and the Predictions on the Basis of Addendum No. 2 of the 1968 AISI Specification[1]

The predicted ultimate web crippling loads, $(P_u)_{comp}$, for interior one-flange loading presented in Tables 17 and 18 were calculated from either Eq. (1) or (2) whichever was applicable.

It should be noted that in Eqs. (1) and (2), $(P_u)_{comp/web}$ is the predicted ultimate load per web in kips. For this reason, the predicted ultimate web crippling load per specimen as given in Tables 17 and 18 was computed by multiplying the number of webs by $(P_u)_{comp/web}$.

With regard to the predicted ultimate bending moments, the same considerations used in Article II for the IOF series were applied to the computation of $(M_u)_{comp}$.

Also included in Tables 17 and 18 are the $(M)_{test}/(M_u)_{comp}$ and $(P)_{test}/(P_u)_{comp}$ ratios in which $(M_u)_{comp}$ is the smallest value of $(M_{u1})_{comp}$, $(M_{u2})_{comp}$, and $(M_{u3})_{comp}$. The correlation between the test results and Eq. (4) is shown graphically in Fig. 32. It should be noted that only two test points are shown in this figure, because for other specimens, the R/t ratio exceeds the AISI limit of 4. In Table 17, the mean value of A/1.3 ratios is 1.365 with a coefficient of variation of 0.020. This indicates that the 1968 AISI design provisions are conservative for the design of these two test specimens, because the test specimens exhibited a considerable postbuckling strength. However, it should also be noted that these two specimens are specially made hat sections. They are not the normally used steel decks.

(b) Comparison of the Experimental Data and the Predictions on the Basis of the 1980 Edition of the AISI Specification[23]

In comparing the experimental data and the predicted loads determined on the basis of the 1980 Edition of the AISI Specification,[23] the predicted ultimate web crippling loads for interior one-flange loading, $(P_u')_{comp}$, as given in Tables 19 and 20, were computed from either Eq. (5) or Eq. (6), whichever was applicable.

As far as the predicted ultimate bending moments are concerned, the values of $(M_{u1})_{comp}$ and $(M_{u2})_{comp}$ are the same as those listed in Tables 17 and 18. The value $(M_{u3}')_{comp}$ was computed from the section modulus based on the full width of the tension flange and the effective width of the compression flange determined on the basis of Section 2.3.1.1 of the 1980 AISI Specification with $f = 0.60\ F_y$ or F_{bw}, whichever was smaller. In the calculation, the value of F_{bw} was determined by using Eq. (7).

The ratios of $(M)_{test}/(M_u')_{comp}$ and $(P)_{test}/(P_u')_{comp}$ are presented in Tables 19 and 20. The correlations between the test results and the interaction formula given in Eq. (8) are shown graphically in Figs. 33 and 34.

Figure 33 shows that for the simple beams without end connections, only the results of five tests (BC-1A,1B,13A,17A, and 17B) can be used for a comparison with the interaction formula included in the 1980 Edition of the AISI Specification. The mean value of the B/1.42 ratios given in

Table 19 for these five tests is 1.076 with a coefficient of variation of 0.112. For other tests, the interaction formula is not applicable because the $(P)_{test}/(P_u')_{comp}$ ratio is less than 0.393, which is the lower limit of $(P)_{test}/(P_u')_{comp}$ when Eq. (8) is used. This figure also shows that for four test specimens having embossments in their webs (BC-9A, 9B, 12A, and 12B), the margin of safety is considerably lower than that for other specimens having flat webs. The ratios of $(M)_{test}/(M_u')_{comp}$ and $(P)_{test}/(P_u')_{comp}$ for these tests are presented in Table 19.

Because the cross-sectional configurations of the test specimens, the mechanical properties of the steels, and the test procedure used for the short span tests for interior one-flange loading discussed previously in Article II are practically the same as those used for the relatively long span simple beam tests reported herein, a comparison of Fig. 11 and Fig. 33 is in order. From these two figures, it can be seen that, in general, the relatively long span simple beam tests give a lower safety factor than the corresponding tests in which the short span specimens were used. This is apparently attributed to the large deflection of the long span specimens that causes an uneven distribution of pressure under the bearing plate at midspan.

In order to determine the effect of end connections on the load carrying capacity of the steel decks, eight additional tests were conducted. The setup for these tests is shown in Fig. 28. For these tests, 1/4-in. diameter bolts with 1/2-in. diameter washers were installed at both ends of each specimen to connect the deck to the bearing plates. The test results and the computed data are given in Table 20 and shown graphically in Fig. 34. Because the $(P)_{test}/(P_u')_{comp}$ ratio was less than 0.393 for these eight tests, the interaction formula for the combination of bending and web crippling could not be used for the purpose of comparison. On the basis of the $(M)_{test}/(M_u')_{comp}$ ratios listed in Tables 19 and 20 for specimen Nos. 2, 12, 16, and 19, it can be seen that the end restraints usually improved the load carrying capacities of steel decks from about 7 to 12%. However, the increases of the moment ratios for specimen No. 16 are more than 20%. The low $(M)_{test}/(M_u')_{comp}$ ratios for specimen Nos. 12C and 12D seem to confirm the need for a refined design formula for predicting the ultimate bending moment for composite decks. Of course, this is not an easy task because of the unlimited variations in dimensions and arrangements of embossments in webs.

E. Summary

A total of 24 single span beam tests were conducted on steel decks having flat webs and webs with embossments to study the interaction between bending and web crippling. Among these tests, 16 specimens were tested without end connections, and the remaining eight decks were tested with bolted connections fastened at both ends of each specimen. The purpose of this phase of the investigation was to determine the validity of the 1968 AISI design criteria and the 1980 Edition of the AISI Specification for steel decks subjected to combined bending and web crippling.

The test results were carefully reviewed and evaluated. A comparison between the test data and the equations used for combined bending and web crippling indicates that the R/t ratios of most of the steel decks used in this experimental study exceeded the previous AISI limit of 4.0. As a result, it is not possible to use these data for determining the validity of the 1968 AISI design criteria for combined bending and web crippling.

As far as the 1980 Edition of the AISI Specification is concerned, a comparison between the tested and the computed data indicates that the newly revised equations are adequate for steel decks having flat webs provided that the decks are properly connected to support beams. For steel decks having embossments in their webs, refined design formulas are needed for bending, web crippling, and a combination thereof.

V. EXPERIMENTAL STUDY OF COMBINED WEB CRIPPLING AND BENDING: CONTINUOUS BEAM TESTS (CB SERIES)

Steel decks are often used as multispan continuous beams to support uniform loads. The interaction between bending and web crippling at interior supports and the ultimate strength of continuous beams were investigated in this phase of the study.

A total of 32 continuous beam tests of steel decks were conducted in UMR's Engineering Research Laboratory during the period of May through July 1980.

A. Preparation of Test Specimens

Seven different types of steel decks were used for the continuous beam tests. Figure 35 shows the cross-sectional configurations of the steel decks used in this program. The measured dimensions of the 32 test specimens are given in Table 21. All symbols are defined in Fig. 3.

The design parameters for the steel decks are presented in Table 22. The ranges of the design parameters are listed below:

Design Parameter	Range
Web inclination angle, θ	46.7 - 74.6 degrees
R/t ratio	4.38 - 6.99
h/t ratio	47.06 - 109.69
N/t ratio	64.50 - 210.28
N/h ratio	0.95 - 3.09
Yield point, F_y	44.2 - 51.0 ksi

At the interior support, which is the location of maximum negative moment, four foil strain gages were mounted on the top surface of the tension and compression flanges of each specimen. See Fig. 36 for the arrangement of strain gages. For a few specimens, additional strain gages were mounted on the top and bottom flanges of the specimens at the end support and/or at the location of maximum positive moment.

B. Testing of Specimens

(a) Tensile Coupon Tests

The mechanical properties of the steels used in the continuous beam tests were established by standard tensile coupon tests. The test data are listed in Table 16.

(b) Testing of Deck Specimens

The steel deck specimens were tested in a vacuum loading apparatus, which consists of a 9-foot wide, 2-foot high, and 30-foot long chamber connected to a pump and a data acquisition system. Figure 37a is a photograph of the loading system. For the plan and side view of the uniform loading apparatus, see Fig. 37b. Of the 32 specimens tested, 28 were tested as two-span continuous beams, and the remaining four (CB-3A, CB-3B, CB-4A, and CB-4B) were tested as three-span continuous beams.

(i) Test Setup

The test setup for the continuous beam tests is shown in Fig. 38. Figures 39a and 39b show the top views for the three-span and two-span continuous beam tests respectively. Under each specimen, two large bearing plates (N_2) were used at both end supports, and a small bearing plate (N_1) was used at the interior support as shown in Fig. 38.

Each specimen was connected to all the bearing plates by 1/4-in. diameter bolts with 1/2-in. diameter washers at an approximate transverse spacing of 12 inches. Before being tested, the chamber was covered by a 0.006-in. thick natural polyethylene film, which was tightly sealed along all the edges.

Specimen Nos. 1 through 6, 9 through 12, 19, and 20 were tested in a normal position. In order to eliminate the effect of a continuous longitudinal stiffener on the interaction between bending and web crippling, Specimen Nos. 13 through 16 were tested in an inverted position. For these specimens, two rectangular strips were used to connect the top flanges over the interior support. See Figs. 35 and 42.

(ii) Test Procedure

During the tests, the specimens were loaded continuously with a uniform load up to the estimated allowable design load. Beyond this, an increment of approximately 10 to 20% of the estimated design load was added to the specimen after a waiting period of five minutes. The pressure and the corresponding strain gage readings were shown on the screen of a data acquisition system. At every 20% of the estimated design load, the midspan deflection was measured with a level. In addition, the applied uniform load and strain gage readings were recorded.

All the specimens were tested to failure. The ultimate failure load was recorded for each test.

C. Results of Tests

The results of 32 continuous beam tests are presented in Table 23. In this table, $(w)_{test}$ is the ultimate uniform load per specimen in kips per linear foot measured along the span length, and $(P)_{test}$ is the maximum load in kips computed from the following equations:

(a) For two-span continuous beams

$$(P)_{test} = 1.25(w)_{test}(L), \text{ kips} \qquad (14)$$

(b) For three-span continuous beams

$$(P)_{test} = 1.1\ (w)_{test}(L), \text{ kips} \qquad (15)$$

in which L is the span length in feet.

The values of $(M)_{test}$ were computed from the ultimate load by using the following equations:

(a) For two-span continuous beams

$$(M)_{test} = 0.125\ (w)_{test}\ (L)^2\ (12), \text{ in-kips} \qquad (16)$$

(b) For three-span continuous beams,

$$(M)_{test} = 0.1\ (w)_{test}\ (L)^2\ (12), \text{ in-kips} \qquad (17)$$

The failure modes for the different types of steel decks are shown in Figs. 40 through 43. During the tests, the bottom flange and the inclined web usually buckled within a small precentage of the failure load. However, the postbuckling strength of the specimen over the interior support permitted a moment redistribution for the continuous beam. Consequently, it was possible to develop a considerable positive bending moment in the middle portion of the span. Figures 40 through 43 show a different type of failure pattern as compared with the simple beam tests.

D. Evaluation of Test Data

The results of the 32 continuous beam tests have been evaluated and compared with the 1980 Edition of the AISI Specification. No attempt has been made to compare the test data with the 1968 AISI design criteria, because the R/t ratios exceeded 4.0.

The predicted ultimate web crippling load per specimen given in Table 23 was computed by using the following equation:

$$(P_u')_{comp/specimen} = (\text{Number of webs})\ (P_u')_{comp/web}$$

where $(P_u')_{comp/web}$ is the predicted ultimate web crippling load per web, in kips. It was computed by using either Eq. (5) or (6), whichever was applicable. The predicted moments, $(M_{u1})_{comp}$ and $(M_{u3}')_{comp}$, are the same as those described in Article II. It should be noted that the requirement for shear lag is not applicable for the continuous beam tests because of the uniform loading.

The ratios of $(M)_{test}/(M_u')_{comp}$ and $(P)_{test}/(P_u')_{comp}$ are given in Table 23. All the B/1.42 ratios exceed 1.0 and range from 1.029 to 2.337. These high B/1.42 ratios indicate that the interaction formula (Eq. (8)) for combined bending and web crippling is very conservative for multiweb steel decks having inclined webs when they are used as continuous beams.

A comparison between the test data and the predicted moments and web crippling loads is shown graphically in Fig. 44.

The midspan deflections and the strain gage readings are listed in Tables A2, A3, A5,and A6 of the Appendix. Also included in the Appendix are Figs. A9 to A40 for load-deflection curves and Figs. A49 to A80 for the stresses computed from the strain gage readings.

E. <u>Summary</u>

A total of 28 steel deck specimens were tested as two-span continuous beams, and four specimens were tested as three-span continuous beams. A comparison of the limited test data and the interaction formula (Eq. 8) for combined bending and web crippling indicates that Eq.(8) is very conservative for the multiweb steel decks used as continuous beams. This can be attributed to the different postbuckling behavior of the steel decks over the interior support and the moment redistribution that occured in the continuous beams.

In view of the fact that the above preliminary conclusion is based on the results of a limited number of tests, additional study is necessary in order to develop a refined design method for multiweb sections that are to be used as continuous beams. The future program should include a study of the ultimate strength of steel decks as affected by the inclination angle of the web, the dimensions and arrangement of the embossments, and other design parameters. The development of an exact design method for this particular case is beyond the scope of this phase of the investigation.

VI. RECOMMENDATIONS FOR FUTURE RESEARCH

Since September 1979, web crippling and combined web crippling and bending of steel decks have been studied at the University of Missouri-Rolla. This study has dealt with (a) the web crippling strength of a selected group of steel decks, (b) the effect of bending on web crippling load, and (c) the validity of the 1968 AISI design formulas and the 1980 Edition of the AISI Specification. Research results based on the testing of 84 short span steel decks and 56 long span specimens are presented in this report.

This study has been limited to the scope of the investigation outlined in the research proposal submitted to the sponsors. Even though some of the research findings have been used to develop the revised design provisions included in the 1980 Edition of the AISI Specification, many questions on web crippling and combined bending and web crippling have not been answered by the results of the present investigation.[24] This is particularly true for steel decks used as continuous beams.

It is therefore suggested that this research project be continued in the future. The future research may include the following activities:

1. Determining the bending strength of steel decks having embossed webs.
2. Using the multispan condition to study further the combined bending and web crippling of steel decks having embossed webs.
3. Determining the ultimate load carrying capacity of rectangular decks, hat sections, tubular members, channels, and Z-sections that are to be used as continuous beams.

4. Analyzing continuous beams by considering the interaction between web crippling and bending over the interior support with a moment redistribution in the beam.
5. Developing design criteria.

ACKNOWLEDGMENTS

The research work reported herein was conducted at the Department of Civil Engineering of the University of Missouri-Rolla under the cosponsorship of Steel Deck Institute, American Iron and Steel Institute, and H. H. Robertson Company.

The financial assistance granted by the sponsors and the technical guidance provided by the members of the Joint AISI/SDI/HHR Task Group on Bending and Web Crippling and Subcommittee 12 of the AISI Advisory Group on the Specification for the Design of Cold-Formed Steel Structural Members (Messrs. R. E. Albrecht, E. D. Branson, D. S. Ellifritt, R. W. Haussler, R. B. Heagler, L. W. Ife, A. L. Johnson, D. L. Johnson, T. J. McCabe, W. E. Mueller, T. B. Pekoz, G. D. Ratliff,Jr., T. G. Ryan, and R. M. Schuster) are gratefully acknowledged.

The test specimens used in this experimental study were donated by Consolidated Systems Inc., Epic Metals Corporation, Mac-Fab Products Co., H. H. Robertson, and United Steel Deck. Appreciation is expressed to Mac-Fab Products Company for preparing some of the test specimens.

Thanks are extended to Messrs. K. Haas, D. L. Foster, and J. A. Tucker, staff of the Department of Civil Engineering, for their help in developing the vacuum loading system and in preparing the test specimens. Appreciation is expressed to Messrs. J. A. Volker, M. A. Herr, P. Sritalapat, S. Sucharit, A. Z. Soudani, and Y. Z. Huang for testing the specimens. Thanks are also due to Messrs. B. Supornsilaphachai, P. Sritalapat, Y. Z. Huang, and W. A. Chambers for their assistance in evaluating the test data. Messrs. J. Shelby and J. Franklin have also helped in some of the experimental work.

Special thanks are extended to Mrs. DeAnne Larson and Mrs. Catherine McLaughlin for typing this final report and progress reports.

BIBLIOGRAPHY

1. American Iron and Steel Institute, "Specification for the Design of Cold-Formed Steel Structural Members," 1968 Edition with Addendum No. 1, 1970 and Addendum No. 2, 1977.

2. Winter, G., "Commentary on the 1968 Edition of the Specification for the Design of Cold-Formed Steel Structural Members," American Iron and Steel Institute, 1970.

3. Winter, G., and Pian, R.H.J., "Crushing Strength of Thin Steel Webs," Cornell Bulletin No. 35, Part I, 1946.

4. Zetlin, Lev, "Elastic Instability of Flat Plates Subjected to Partial Edge Loads," Journal of the Structural Division, ASCE Proceedings, Vol. 81, September 1955.

5. White, R.N., and Cottingham, W.S., "Stability of Plates Under Partial Edge Loadings," Journal of Engineering Mechanics Division, ASCE Proceedings, Vol. 88, No. EM5, October 1962.

6. Bagchi, D.K., and Rockey, K.C., "A Note on the Buckling of a Plate Girder Web Due to Partial Edge Loadings," International Association for Bridge and Structural Engineering, Final Report, September 1968.

7. Rockey, K.C., and Bagchi, D.K., "Buckling of Plate Girder Webs Under Partial Edge Loadings," International Journal of Mechanical Science, Pergamon Press, Vol. 12, 1970.

8. Rockey, K.C., and El-gaaly, M.A., "Ultimate Strength of Plates when Subjected to In-Plane Patch Loading," International Association for Bridge and Structural Engineering, Proceedings of the Seminar on Design of Plate and Box Girders for Ultimate Strength, 1971.

9. Rockey, K.C., El-gaaly, M.A., and Bagchi, D.K., "Failure of Thin Walled Members Under Patch Loading," Journal of Structural Division, ASCE Proceedings, Vol 98, No. ST12, December 1972.

10. Rockey. K.C., and El-gaaly, M.A., "Stability of Load Bearing Trapezoidal Diaphragms," International Association for Bridge and Structural Engineering, Publications, Vol. 32-II, 1972.

11. El-gaaly, M.A., and Rockey, K.C., "Ultimate Strength of Thin-Walled Members Under Patch Loading and Bending," Current Research and Design Trends, Proceedings of the Second Specialty Conference on Cold-Formed Steel Structures, University of Missouri-Rolla, October 1973.

12. Rockey, K. C. and El-gaaly, M.A., "Ultimate Strength of Plates when Subjected to In-Plane Patch Loading," International Association for Bridge and Structural Engineering, Colloquium on Design of Plate and Box Girders for Ultimate Strength, held in London, England, in March 1971, published July 1972.

13. Baehre, R., "Sheet Metal Panels for Use in Building Construction-Recent Research Projects in Sweden," Proceedings of the Third International Specialty Conference on Cold-Formed Steel Structures, University of Missouri-Rolla, Nov. 24-25, 1975.

14. European Convention for Constructional Steel Work Committee 17-Cold-Formed Thin-Walled Sheet Steel in Building, "Stressed Skin Design," Draft of European Recommendation, May 1975, (Rolf Baehre, Chairman of Committee 17).

15. Bergfelt, A., and Hovik, J., "Shear Failure and Local Web Crippling in Thin-Walled Plate Girders," Chalmers University of Technology, Sweden, 1970.

16. Bergfelt, A., "Patch Loading on a Slender Web," Chalmers University of Technology, Sweden, 1979.

17. Hoglund, T., "Design of Trapezoidal Sheeting Provided with Stiffeners in the Flanges and Webs," Stockholm, 1978.

18. NAHB Research Foundations, Inc., "Tests of United States Steel Super-C Steel Joists for Interaction of Bending and Web Crippling," CR-785B, 1972.

19. Ratliff, G. D., "Interaction of Concentrated Loads and Bending in C-Shaped Beams," Proceedings of the Third Specialty Conference on Cold-Formed Steel Structures, University of Missouri-Rolla, November 24-25, 1975.

20. Khan, M.Z., Johns, K.C., and Hayman, B., "Buckling of Plates with Partially Loaded Edges," Journal of the Structural Division, ASCE Proceedings, Vol. 103, No. ST3, March 1973.

21. Hetrakul, N., and Yu, W.W., "Webs for Cold-Formed Steel Flexural Members--Structural Behavior of Beam Webs Subjected to Web Crippling and a Combination of Web Crippling and Bending," Final Report, University of Missouri-Rolla, June 1978.

22. Hetrakul, N., and Yu, W.W., "Cold-Formed Steel I-Beams Subjected to Combined Bending and Web Crippling," Thin-Walled Structures (J. Rhodes and A.C. Walker, editors), International Conference on Thin-Walled Structures, University of Strathclyde, Glasgow, Scotland, April 1979.

23. American Iron and Steel Institute, "Specification for the Design of Cold-Formed Steel Structural Members," 1980 Edition.

24. Ryan, T.G., "Considerations for Evaluating Web Crippling and Combined Web Crippling and Bending of Cold-Formed Steel Members," April 2, 1980 (Committee Correspondence).

TABLE 1a

Dimensions of Steel Deck Specimens used for Web Crippling Tests

Interior One-Flange Loading

Specimen No.	No. of Ribs per Specimen	No. of Webs per Specimen	No. of Top Stiffener	No. of Bottom Stiffener	Type of Sidelap	Cross-Section Dimensions (in.)						
						T	D	D_T	D_B	D_E	W_1	W_2
IOF-1A	2	4	1	1	1	0.0299	1.990	0.305	0.300	-	0.670	1.350
IOF-1B	2	4	1	1	1	0.0294	1.985	0.290	0.305	-	0.660	1.370
IOF-2A	2	4	1	1	1	0.0290	2.025	0.310	0.280	-	0.760	1.315
IOF-2B	2	4	1	1	1	0.0294	2.025	0.315	0.290	-	0.840	1.285
IOF-3A	2	4	1	1	1	0.0463	2.010	0.310	0.320	-	0.790	1.290
IOF-3B	2	4	1	1	1	0.0441	2.010	0.315	0.330	-	0.910	1.290
IOF-4A	2	4	1	1	1	0.0452	2.055	0.375	0.330	-	0.970	1.300
IOF-4B	2	4	1	1	1	0.0451	2.050	0.350	0.330	-	0.760	1.320
IOF-5A	2	4	1	1	1	0.0302	3.015	0.310	0.300	-	0.890	1.435
IOF-5B	2	4	1	1	1	0.0303	3.030	0.305	0.295	-	0.980	1.265
IOF-6A	2	4	1	1	1	0.0302	3.040	0.305	0.290	-	1.050	1.295
IOF-6B	2	4	1	1	1	0.0296	3.060	0.310	0.300	-	0.900	1.355
IOF-7A	2	4	1	1	1	0.0463	3.080	0.330	0.350	-	0.950	1.325
IOF-7B	2	4	1	1	1	0.0470	3.080	0.330	0.350	-	0.950	1.325
IOF-8A	2	4	1	1	1	0.0470	3.010	0.350	0.315	-	0.910	1.350
IOF-8B	2	4	1	1	1	0.0469	3.010	0.305	0.315	-	0.950	1.410
IOF-9A	2	4	1	1	1	0.0298	2.035	0.320	0.305	-	0.820	1.290
IOF-9B	2	4	1	1	1	0.0297	1.990	0.315	0.300	-	0.870	1.305
IOF-10A	2	4	1	1	1	0.0299	2.030	0.315	0.305	-	0.810	1.270
IOF-10B	2	4	1	1	1	0.0296	1.985	0.315	0.310	-	0.850	1.300

TABLE 1a (Cont'd)

Dimensions of Steel Deck Specimens used for Web Crippling Tests

Interior One-Flange Loading

Specimen No.	No. of Ribs per Specimen	No. of Webs per Specimen	No. of Top Stiffener	No. of Bottom Stiffener	Type of Sidelap	Cross-Section Dimensions (in.)						
						T	D	D_T	D_B	D_E	W_1	W_2
IOF-11A	2	4	1	1	1	0.0309	2.970	0.305	0.300	-	0.970	1.410
IOF-11B	2	4	1	1	1	0.0313	3.060	0.295	0.300	-	0.970	1.270
IOF-12A	2	4	1	1	1	0.0305	3.090	0.295	0.290	-	0.990	1.270
IOF-12B	2	4	1	1	1	0.0311	3.040	0.300	0.290	-	1.000	1.310
IOF-13A	2	4	2	1	1	0.0337	2.003	0.305	0.310	-	0.850	1.400
IOF-13B	2	4	2	1	1	0.0333	2.020	0.315	0.300	-	0.660	1.420
IOF-14A	2	4	2	1	1	0.0336	2.010	0.300	0.310	-	0.840	1.460
IOF-14B	2	4	2	1	1	0.0334	2.020	0.290	0.300	-	0.830	1.350
IOF-15A	2	4	1	-	1	0.0352	3.070	0.300	-	-	0.830	1.400
IOF-15B	2	4	1	-	1	0.0349	3.090	0.300	-	-	0.760	1.380
IOF-16A	2	4	1	-	1	0.0353	3.040	0.301	-	-	0.720	1.410
IOF-16B	2	4	1	-	1	0.0351	3.030	0.300	-	-	0.800	1.360
IOF-17A	1	2	-	-	1	0.0293	3.030	-	-	-	1.880	0.219
IOF-17B	1	2	-	-	1	0.0292	3.020	-	-	-	1.860	0.219
IOF-18A	1	2	-	-	1	0.0288	3.030	-	-	-	1.900	0.213
IOF-18B	1	2	-	-	1	0.0295	3.020	-	-	-	1.910	0.210
IOF-19A	5	10	-	-	2	0.0286	1.890	-	-	-	0.600	0.793
IOF-19B	5	10	-	-	2	0.0285	1.890	-	-	-	0.600	0.793
IOF-20A	4	8	-	-	1	0.0284	1.890	-	-	-	0.590	0.760
IOF-20B	4	8	-	-	1	0.0286	1.890	-	-	-	0.590	0.760

Note: For definitions of symbols, see Figs. 3 and 4.

TABLE 1b

Dimensions of Steel Deck Specimens used for Web Crippling Tests

Interior One-Flange Loading

Specimen No.	Cross-Section Dimensions (in.)											
	W_3	W_4	W_5	W_6	W_7	W_8	W_9	W_{10}	W_{11}	W_{12}	S_1	S_2
IOF-1A	1.670	0.520	0.260	-	1.700	0.520	0.280	0.920	-	-	-	-
IOF-1B	1.690	0.490	0.310	-	1.655	0.530	0.290	0.920	-	-	-	-
IOF-2A	1.700	0.505	0.280	-	1.660	0.530	0.280	0.880	-	-	-	-
IOF-2B	1.685	0.530	0.300	-	1.665	0.525	0.300	0.870	-	-	-	-
IOF-3A	1.675	0.510	0.320	-	1.715	0.480	0.320	0.850	-	-	-	-
IOF-3B	1.675	0.520	0.330	-	1.720	0.480	0.330	0.850	-	-	-	-
IOF-4A	1.690	0.520	0.310	-	1.680	0.520	0.300	0.940	-	-	-	-
IOF-4B	1.670	0.490	0.310	-	1.695	0.535	0.270	0.880	-	-	-	-
IOF-5A	1.680	0.490	0.320	-	1.635	0.510	0.320	1.030	-	-	-	-
IOF-5B	1.755	0.470	0.290	-	1.630	0.475	0.350	1.000	-	-	-	-
IOF-6A	1.680	0.500	0.320	-	1.685	0.500	0.290	1.040	-	-	-	-
IOF-6B	1.700	0.510	0.300	-	1.685	0.475	0.350	1.040	-	-	-	-
IOF-7A	1.690	0.500	0.320	-	1.655	0.525	0.300	1.120	-	-	-	-
IOF-7B	1.690	0.500	0.320	-	1.655	0.525	0.300	1.120	-	-	-	-
IOF-8A	1.730	0.495	0.290	-	1.650	0.485	0.370	1.050	-	-	-	-
IOF-8B	1.715	0.475	0.310	-	1.680	0.505	0.290	0.960	-	-	-	-
IOF-9A	1.680	0.475	0.390	-	1.750	0.455	0.340	1.020	-	-	-	-
IOF-9B	1.710	0.455	0.350	-	1.735	0.470	0.320	0.910	-	-	-	-
IOF-10A	1.705	0.525	0.300	-	1.675	0.530	0.280	0.910	-	-	-	-
IOF-10B	1.680	0.505	0.330	-	1.675	0.515	0.320	0.840	-	-	-	-

TABLE 1b (Cont'd)

Dimensions of Steel Deck Specimens used for Web Crippling Tests

Interior One-Flange Loading

Specimen No.	Cross-Section Dimensions (in.)											
	W_3	W_4	W_5	W_6	W_7	W_8	W_9	W_{10}	W_{11}	W_{12}	S_1	S_2
IOF-11A	1.680	0.490	0.320	-	1.635	0.510	0.350	1.010	-	-	-	-
IOF-11B	1.680	0.500	0.310	-	1.640	0.500	0.310	1.010	-	-	-	-
Iof-12A	1.680	0.515	0.290	-	1.700	0.480	0.360	1.020	-	-	-	-
IOF-12B	1.675	0.510	0.320	-	1.670	0.475	0.370	1.010	-	-	-	-
IOF-13A	0.990	0.430	-	0.930	1.890	0.420	-	0.850	-	-	-	-
IOF-13B	1.050	0.430	-	1.020	1.750	0.400	-	0.700	-	-	-	-
IOF-14A	0.990	0.410	-	0.975	1.910	0.405	-	0.800	-	-	-	-
IOF-14B	1.050	0.410	-	1.060	1.900	0.390	-	0.850	-	-	-	-
IOF-15A	1.855	0.410	-	-	4.650	-	-	0.800	-	-	-	-
IOF-15B	1.850	0.410	-	-	4.620	-	-	0.900	-	-	-	-
IOF-16A	1.830	0.410	-	-	4.680	-	-	0.750	-	-	-	-
IOF-16B	1.840	0.410	-	-	4.680	-	-	0.820	-	-	-	-
IOF-17A	7.940	-	-	-	-	-	-	1.950	-	-	-	-
IOF-17B	7.790	-	-	-	-	-	-	1.900	-	-	-	-
IOF-18A	7.910	-	-	-	-	-	-	1.970	-	-	-	-
IOF-18B	7.930	-	-	-	-	-	-	1.900	-	-	-	-
IOF-19A	3.240	-	-	-	1.210	-	-	1.200	-	-	-	0.350
IOF-19B	3.240	-	-	-	1.210	-	-	1.200	-	-	-	0.350
IOF-20A	3.275	-	-	-	1.300	-	-	0.600	-	-	-	-
IOF-20B	3.275	-	-	-	1.300	-	-	0.600	-	-	-	-

Note: For definitions of symbols, see Figs. 3 and 4.

TABLE 1c

Dimensions of Steel Deck Specimens used for Web Crippling Tests
Interior One-Flange Loading

Specimen No.	Cross-Section Dimensions (in.)									Web Inclination (degree)	Overall Width (in.)	Overall Length (in.)
	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	h			
IOF-1A	0.200	0.200	0.210	0.280	0.210	0.250	-	-	2.21	60.7	20.99	28.44
IOF-1B	0.200	0.200	0.210	0.280	0.210	0.250	-	-	2.22	60.2	21.06	28.44
IOF-2A	0.210	0.210	0.220	0.280	0.220	0.280	-	-	2.22	62.4	20.94	35.44
IOF-2B	0.210	0.210	0.220	0.280	0.220	0.280	-	-	2.20	63.2	20.99	35.44
IOF-3A	0.210	0.200	0.210	0.230	0.200	0.240	-	-	2.16	62.7	20.89	28.44
IOF-3B	0.210	0.200	0.210	0.230	0.200	0.240	-	-	2.16	62.7	21.09	28.44
IOF-4A	0.210	0.210	0.220	0.250	0.210	0.250	-	-	2.20	63.2	21.27	35.44
IOF-4B	0.210	0.210	0.220	0.250	0.210	0.250	-	-	2.21	62.7	20.91	35.44
IOF-5A	0.220	0.200	0.210	0.250	0.210	0.240	-	-	3.16	69.4	21.59	33.96
IOF-5B	0.200	0.200	0.210	0.250	0.210	0.230	-	-	3.11	72.4	21.08	33.96
IOF-6A	0.200	0.200	0.200	0.260	0.210	0.260	-	-	3.13	71.9	21.29	40.96
IOF-6B	0.200	0.200	0.200	0.260	0.210	0.260	-	-	3.18	70.9	21.47	40.96
IOF-7A	0.210	0.190	0.200	0.260	0.210	0.230	-	-	3.15	71.7	21.43	33.96
IOF-7B	0.210	0.190	0.200	0.260	0.210	0.230	-	-	3.14	71.7	21.43	33.96
IOF-8A	0.200	0.210	0.220	0.250	0.210	0.240	-	-	3.09	70.9	21.48	40.96
IOF-8B	0.200	0.210	0.220	0.250	0.210	0.240	-	-	3.11	69.8	21.59	40.96
IOF-9A	0.200	0.210	0.210	0.260	0.220	0.230	-	-	2.22	63.0	21.15	28.44
IOF-9B	0.200	0.210	0.210	0.260	0.220	0.230	-	-	2.19	62.0	21.09	28.44
IOF-10A	0.210	0.210	0.220	0.260	0.210	0.250	-	-	2.20	63.7	21.01	35.44
IOF-10B	0.210	0.210	0.220	0.260	0.210	0.250	-	-	2.18	62.3	20.99	35.44

TABLE 1c (Cont'd)

Dimensions of Steel Deck Specimens used for Web Crippling Tests
Interior One-Flange Loading

Specimen No.	Cross-Section Dimensions (in.)									Web Inclination (degree)	Overall Width (in.)	Overall Length (in.)
	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	h			
IOF-11A	0.210	0.200	0.210	0.250	0.210	0.230	-	-	3.10	70.5	21.49	34.05
IOF-11B	0.210	0.200	0.210	0.250	0.210	0.240	-	-	3.13	74.3	21.02	33.98
IOF-12A	0.200	0.200	0.200	0.260	0.210	0.260	-	-	3.11	70.5	21.30	41.12
IOF-12B	0.200	0.200	0.200	0.260	0.210	0.260	-	-	3.13	75.0	21.25	40.87
IOF-13A	0.130	0.170	0.190	0.190	0.190	0.190	-	-	1.93	50.3	21.52	30.24
IOF-13B	0.130	0.180	0.190	0.190	0.190	0.190	-	-	1.92	49.1	21.58	30.24
IOF-14A	0.130	0.170	0.190	0.190	0.190	0.190	-	-	1.94	48.1	21.49	37.24
IOF-14B	0.130	0.190	0.190	0.190	0.190	0.190	-	-	1.83	50.4	21.51	37.24
IOF-15A	0.130	0.190	0.190	0.190	-	-	-	-	2.78	65.4	21.22	34.86
IOF-15B	0.130	0.188	0.190	0.190	-	-	-	-	2.79	66.0	21.10	34.86
IOF-16A	0.130	0.198	0.190	0.190	-	-	-	-	2.78	65.3	21.30	41.86
IOF-16B	0.130	0.190	0.190	0.190	-	-	-	-	2.70	65.1	21.21	41.86
IOF-17A	0.095	0.095	-	-	-	-	-	-	2.97	90.0	12.21	33.00
IOF-17B	0.095	0.095	-	-	-	-	-	-	2.96	90.0	11.99	33.00
IOF-18A	0.092	0.092	-	-	-	-	-	-	2.97	90.0	12.21	40.00
IOF-18B	0.090	0.090	-	-	-	-	-	-	2.96	90.0	12.16	40.00
IOF-19A	0.135	0.135	-	-	-	-	0.135	-	1.92	72.9	30.17	27.78
IOF-19B	0.135	0.135	-	-	-	-	0.135	-	1.92	72.9	30.17	27.78
IOF-20A	0.126	0.126	-	-	-	-	-	-	1.91	73.5	24.27	34.78
IOF-20B	0.126	0.126	-	-	-	-	-	-	1.91	73.5	24.27	34.78

Notes: For definitions of symbols, see Figs. 3 and 4.
For most of the test specimens, sidelaps were cut from the steel panels. Therefore, the overall width of test specimens may differ considerably from the nominal width shown in Fig. 2.

TABLE 2

Design Parameters for Steel Deck Specimens

Interior One-Flange Loading

Specimen No.	Thickness t (in.)	Inside Bend Radius R_2 (in.)	Web Width h (in.)	Bearing Length Under Load N_1 (in.)	Bearing Length at Support N_2 (in.)	Web Inclination θ (degree)	R_2/t	h/t	N_1/t	N_1/h	Yield Point F_y (ksi)	Span Length (in.)
IOF-1A	0.0299	0.20	2.21	2.98	5.93	60.7	6.69	73.91	99.67	1.35	43.3	15.66
IOF-1B	0.0294	0.20	2.22	2.98	5.93	60.2	6.80	75.51	101.36	1.34	43.3	15.66
IOF-2A	0.0290	0.21	2.22	5.93	7.86	62.4	7.24	76.55	204.48	2.67	43.3	20.75
IOF-2B	0.0294	0.21	2.20	5.93	7.86	63.2	7.14	74.83	201.70	2.70	43.3	20.75
IOF-3A	0.0463	0.20	2.16	2.98	5.93	62.7	4.32	46.65	64.36	1.38	42.9	15.66
IOF-3B	0.0441	0.20	2.16	2.98	5.93	62.7	4.54	48.98	67.57	1.38	42.9	15.66
IOF-4A	0.0452	0.21	2.20	5.93	7.86	63.2	4.65	48.67	131.20	2.70	42.9	20.75
IOF-4B	0.0451	0.21	2.21	5.93	7.86	62.7	4.66	49.00	131.49	2.68	42.9	20.75
IOF-5A	0.0302	0.20	3.16	2.98	5.93	69.4	6.62	104.64	98.68	0.94	48.1	18.45
IOF-5B	0.0303	0.20	3.11	2.98	5.93	72.4	6.60	102.64	98.35	0.96	48.1	18.45
IOF-6A	0.0302	0.20	3.13	5.93	7.86	71.9	6.62	103.64	196.36	1.89	48.1	23.42
IOF-6B	0.0296	0.20	3.18	5.93	7.86	70.9	6.76	107.43	200.34	1.86	48.1	23.42
IOF-7A	0.0463	0.19	3.15	2.98	5.93	71.7	4.10	68.03	64.36	0.95	41.2	18.42
IOF-7B	0.0470	0.19	3.14	2.98	5.93	71.7	4.04	66.81	63.40	0.95	41.2	18.42
IOF-8A	0.0470	0.21	3.09	5.93	7.86	70.9	4.47	65.74	126.17	1.92	41.2	23.42
IOF-8B	0.0469	0.21	3.11	5.93	7.86	69.8	4.48	66.31	126.44	1.91	41.2	23.42
IOF-9A	0.0298	0.21	2.22	2.98	5.93	63.0	7.05	74.50	100.00	1.34	42.9	15.66
IOF-9B	0.0297	0.21	2.19	2.98	5.93	62.0	7.07	73.74	100.34	1.36	42.9	15.66

TABLE 2 (Cont'd)

Design Parameters for Steel Deck Specimens

Interior One-Flange Loading

Specimen No.	Thickness t (in.)	Inside Bend Radius R_2 (in.)	Web Width h (in.)	Bearing Length Under Load N_1 (in.)	Bearing Length at Support N_2 (in.)	Web Inclination θ (degree)	R_2/t	h/t	N_1/t	N_1/h	Yield Point F_y (ksi)	Span Length (in.)
IOF-10A	0.0299	0.210	2.20	5.93	7.86	63.6	7.02	73.58	198.33	2.70	42.9	20.69
IOF-10B	0.0296	0.210	2.18	5.93	7.86	62.3	7.10	73.65	200.34	2.72	42.9	20.69
IOF-11A	0.0309	0.200	3.10	2.98	5.93	70.5	6.47	100.32	96.44	0.96	46.1	18.15
IOF-11B	0.0313	0.200	3.13	2.98	5.93	74.3	6.39	100.00	95.21	0.95	46.1	18.30
IOF-12A	0.0305	0.200	3.11	5.93	7.86	70.5	6.56	101.97	194.43	1.91	46.1	23.12
IOF-12B	0.0311	0.200	3.13	5.93	7.86	75.0	6.43	100.64	190.68	1.89	46.1	23.18
IOF-13A	0.0337	0.170	1.89	2.98	5.93	50.3	4.93	56.08	88.43	1.58	39.3	14.85
IOF-13B	0.0333	0.180	1.92	2.98	5.93	49.1	5.50	57.66	89.49	1.55	39.3	14.85
IOF-14A	0.0336	0.170	1.94	5.93	7.86	48.1	5.12	57.74	176.49	3.06	39.3	19.85
IOF-14B	0.0334	0.190	1.87	5.93	7.86	50.4	5.54	55.99	177.55	3.17	39.3	19.85
IOF-15A	0.0352	0.190	2.78	2.98	5.93	65.4	5.40	78.98	84.66	1.07	42.1	17.25
IOF-15B	0.0349	0.188	2.79	2.98	5.93	66.0	5.39	79.94	85.39	1.07	42.1	17.25
IOF-16A	0.0353	0.198	2.78	5.93	7.86	65.3	5.61	78.75	167.99	2.13	42.1	22.55
IOF-16B	0.0351	0.190	2.70	5.93	7.86	65.1	5.41	76.92	168.95	2.20	42.1	22.55
IOF-17A	0.0293	0.095	2.97	2.98	5.93	90.0	3.24	101.37	101.71	1.00	49.9	17.88
IOF-17B	0.0292	0.095	2.96	2.98	5.93	90.0	3.25	101.37	102.06	1.01	49.9	17.88
IOF-18A	0.0288	0.092	2.97	5.93	7.86	90.0	3.19	103.13	205.90	2.00	49.9	22.85
IOF-18B	0.0295	0.090	2.96	5.93	7.86	90.0	3.05	100.34	201.02	2.00	49.9	22.85

TABLE 2 (Cont'd)

Design Parameters for Steel Deck Specimens

Interior One-Flange Loading

Specimen No.	Thickness t (in.)	Inside Bend Radius R_2 (in.)	Web Width h (in.)	Bearing Length Under Load N_1 (in.)	Bearing Length at Support N_2 (in.)	Web Inclination θ (degree)	R_2/t	h/t	N_1/t	N_1/h	Yield Point F_y (ksi)	Span Length (in.)
IOF-19A	0.0286	0.135	1.92	2.98	5.93	72.9	4.72	67.13	104.20	1.55	41.2	14.70
IOF-19B	0.0285	0.135	1.92	2.98	5.93	72.9	4.74	67.37	104.56	1.55	41.2	14.70
IOF-20A	0.0284	0.126	1.91	5.93	7.86	73.5	4.44	67.25	208.80	3.10	41.2	19.76
IOF-20B	0.0286	0.126	1.91	5.93	7.86	73.5	4.41	66.78	207.34	3.10	41.2	19.76

Notes: 1. For definitions of symbols, see Figs. 3 and 4.

2. For specimens Nos. IOF-13, IOF-14, IOF-15, and IOF-16, the h value is measured as shown in Fig. 3c.

TABLE 3

Tested Mechanical Properties of Steels
Used for Steel Deck Specimens

Tensile Coupon No.	F_y (ksi)	F_u (ksi)	Elongation* (percent)
1	43.3	54.2	31.0
2	42.9	53.5	34.0
3	48.1	57.2	34.3
4	41.2	53.5	34.5
5	42.9	52.3	29.5
6	39.3	49.9	42.7
7	42.1	49.6	39.0
8	49.9	55.9	27.0
9	41.2	52.0	34.3
10	46.1	56.1	35.0

* 2-inch gage length.

TABLE 4

Comparison of the Tested and Computed Results for Interior One-Flange Loading

Based on Addendum No. 2 of the 1968 Edition of the AISI Specification(1)

Specimen No.	Test Data per Specimen		Computed Data per Specimen				$\frac{(M)_{test}}{(M_u)_{comp}}$	$\frac{(P)_{test}}{(P_u)_{comp}}$	$\frac{A^*}{1.3}$
	$(P)_{test}$ (kips)	$(M)_{test}$ (in-kips)	$(P_u)_{comp}$ (kips)	$(M_{u1})_{comp}$ (in-kips)	$(M_{u2})_{comp}$ (in-kips)	$(M_{u3})_{comp}$ (in-kips)			
IOF-1A	2.050	8.026	N/A**	20.011	13.938	20.011	0.576	N/A**	N/A**
IOF-1B	2.020	7.908	N/A	19.458	13.633	19.458	0.580	N/A	N/A
IOF-2A	2.352	12.201	N/A	19.796	15.433	19.796	0.791	N/A	N/A
IOF-2B	2.304	11.952	N/A	20.243	15.673	20.243	0.763	N/A	N/A
IOF-3A	5.250	20.554	N/A	31.550	21.395	31.550	0.961	N/A	N/A
IOF-3B	4.975	19.477	N/A	30.547	20.583	30.547	0.946	N/A	N/A
IOF-4A	5.690	29.517	N/A	32.457	24.254	32.457	1.217	N/A	N/A
IOF-4B	5.520	28.635	N/A	31.508	23.625	31.508	1.212	N/A	N/A
IOF-5A	2.545	11.739	N/A	38.822	29.701	38.822	0.395	N/A	N/A
IOF-5B	2.543	11.730	N/A	39.019	30.046	39.019	0.390	N/A	N/A
IOF-6A	3.125	18.297	N/A	39.826	33.027	39.826	0.554	N/A	N/A
IOF-6B	3.060	17.916	N/A	38.906	32.368	38.906	0.554	N/A	N/A
IOF-7A	5.825	26.824	N/A	54.216	39.884	54.216	0.673	N/A	N/A
IOF-7B	5.900	27.170	N/A	55.054	40.470	55.054	0.671	N/A	N/A
IOF-8A	7.225	42.302	N/A	52.781	42.507	52.781	0.995	N/A	N/A
IOF-8B	7.180	42.039	N/A	52.655	42.467	52.655	0.990	N/A	N/A
IOF-9A	2.000	7.830	N/A	20.913	14.479	20.912	0.541	N/A	N/A
IOF-9B	1.973	7.724	N/A	20.101	13.988	20.101	0.552	N/A	N/A

TABLE 4 (Cont'd)

Comparison of the Tested and Computed Results for Interior One-Flange Loading

Based on Addendum No. 2 of the 1968 Edition of the AISI Specification(1)

Specimen No.	Test Data per Specimen		Computed Data per Specimen						
	$(P)_{test}$ (kips)	$(M)_{test}$ (in-kips)	$(P_u)_{comp}$ (kips)	$(M_{u1})_{comp}$ (in-kips)	$(M_{u2})_{comp}$ (in-kips)	$(M_{u3})_{comp}$ (in-kips)	$\frac{(M)_{test}}{(M_u)_{comp}}$	$\frac{(P)_{test}}{(P_u)_{comp}}$	$\frac{A^*}{1.3}$
IOF-10A	2.392	12.373	N/A**	20.520	15.817	20.520	0.782	N/A**	N/A**
IOF-10B	2.420	12.517	N/A	19.692	15.158	19.692	0.826	N/A	N/A
IOF-11A	2.342	10.627	N/A	37.647	28.445	37.647	0.374	N/A	N/A
IOF-11B	2.460	11.255	N/A	39.476	29.990	39.476	0.375	N/A	N/A
IOF-12A	2.900	16.762	N/A	39.357	32.456	39.357	0.517	N/A	N/A
IOF-12B	2.920	16.921	N/A	39.168	32.302	39.168	0.524	N/A	N/A
IOF-13A	2.655	9.857	N/A	21.565	14.773	21.565	0.667	N/A	N/A
IOF-13B	2.660	9.875	N/A	20.239	14.235	20.239	0.694	N/A	N/A
IOF-14A	3.025	15.012	N/A	21.561	16.423	21.561	0.914	N/A	N/A
IOF-14B	3.100	15.384	N/A	21.666	16.523	21.666	0.931	N/A	N/A
IOF-15A	3.000	12.938	N/A	41.337	32.388	41.337	0.400	N/A	N/A
IOF-15B	3.085	13.304	N/A	41.287	32.419	41.387	0.410	N/A	N/A
IOF-16A	3.875	21.845	N/A	40.985	34.740	40.985	0.629	N/A	N/A
IOF-16B	3.750	21.141	N/A	39.993	33.845	39.993	0.625	N/A	N/A
IOF-17A	2.158	9.646	1.457	12.149	17.083	12.149	0.794	1.481	1.750
IOF-17B	2.120	9.476	1.446	12.002	16.829	12.002	0.790	1.466	1.735
IOF-18A	2.223	12.699	1.917	11.868	18.155	11.868	1.070	1.160	1.715
IOF-18B	2.210	12.625	2.030	12.172	18.396	12.172	1.037	1.089	1.635

TABLE 4 (Cont'd)

Comparison of the Tested and Computed Results for Interior One-Flange Loading

Based on Addendum No. 2 of the 1968 Edition of the AISI Specification[1]

Specimen No.	Test Data per Specimen		Computed Data per Specimen				$\frac{(M)_{test}}{(M_u)_{comp}}$	$\frac{(P)_{test}}{(P_u)_{comp}}$	$\frac{A^*}{1.3}$
	$(P)_{test}$ (kips)	$(M)_{test}$ (in-kips)	$(P_u)_{comp}$ (kips)	$(M_{u1})_{comp}$ (in-kips)	$(M_{u2})_{comp}$ (in-kips)	$(M_{u3})_{comp}$ (in-kips)			
IOF-19A	4.392	16.141	N/A	22.888	23.074	22.888	0.705	N/A	N/A
IOF-19B	4.392	16.141	N/A	22.775	22.996	22.775	0.709	N/A	N/A
IOF-20A	4.250	20.995	N/A	17.794	18.956	17.794	1.180	N/A	N/A
IOF-20B	4.440	21.736	N/A	17.933	19.086	17.933	1.212	N/A	N/A

* $A = (P)_{test}/(P_u)_{comp} + (M)_{test}/(M_u)_{comp}$

** R/t > 4

Mean Value 1.707

Coefficient of Variation 0.030

TABLE 5

Comparison of the Tested and Computed Results for Interior One-Flange Loading Based on the 1980 Edition of the AISI Specification[23]

Specimen No.	Test Data per Specimen		Computed Data per Specimen				$\frac{(M)_{test}}{(M'_u)_{comp}}$	$\frac{(P)_{test}}{(P'_u)_{comp}}$	$\frac{B^*}{1.42}$
	$(P)_{test}$ (kips)	$(M)_{test}$ (in-kips)	$(P'_u)_{comp}$ (kips)	$(M_{u1})_{comp}$ (in-kips)	$(M_{u2})_{comp}$ (in-kips)	$(M'_{u3})_{comp}$ (in-kips)			
IOF-1A	2.050	8.026	**2.160**	20.011	13.938	20.011	0.576	**0.949**	1.121
IOF-1B	2.020	7.908	**2.076**	19.458	13.633	19.458	0.580	**0.973**	**1.142**
IOF-2A	2.352	12.201	**3.157****	19.796	15.433	19.796	0.791	**0.745**	**1.118**
IOF-2B	2.304	11.952	**3.263****	20.243	15.673	20.243	0.763	**0.706**	**1.069**
IOF-3A	5.250	20.554	5.198	31.550	21.395	31.550	0.961	1.010	1.438
IOF-3B	4.975	19.477	4.735	30.547	20.583	30.547	0.946	1.051	1.458
IOF-4A	5.690	29.517	7.281	32.457	24.254	32.457	1.217	0.782	1.446
IOF-4B	5.520	28.635	7.228	31.508	23.625	31.508	1.212	0.764	1.429
IOF-5A	2.545	11.739	**2.366**	38.822	29.701	38.822	0.395	**1.076**	**1.089**
IOF-5B	2.543	11.730	**2.432**	39.019	30.046	39.019	0.390	**1.046**	**1.063**
IOF-6A	3.125	18.297	**3.818**	39.826	33.027	39.826	0.554	**0.818**	**1.007**
IOF-6B	3.060	17.916	**3.636**	38.906	32.368	38.906	0.554	**0.842**	**1.024**
IOF-7A	5.825	26.824	5.236	54.216	39.884	54.216	0.673	1.113	1.312
IOF-7B	5.900	27.170	5.389	55.054	40.470	55.054	0.671	1.095	1.298
IOF-8A	7.225	42.302	7.704	52.781	42.507	52.781	0.995	0.938	1.408
IOF-8B	7.180	42.039	7.618	52.655	42.467	52.655	0.990	0.943	1.407
IOF-9A	2.000	7.830	**2.091****	20.912	14.479	20.912	0.541	**0.956**	**1.102**
IOF-9B	1.973	7.724	**2.068****	20.101	13.988	20.101	0.552	**0.954**	**1.108**

TABLE 5 (Cont'd)

Comparison of the Tested and Computed Results for Interior One-Flange Loading Based on the 1980 Edition of the AISI Specification[23]

Specimen No.	Test Data per Specimen		Computed Data per Specimen				$\frac{(M)_{test}}{(M'_u)_{comp}}$	$\frac{(P)_{test}}{(P'_u)_{comp}}$	$\frac{B^*}{1.42}$
	$(P)_{test}$ (kips)	$(M)_{test}$ (in-kips)	$(P'_u)_{comp}$ (kips)	$(M_{u1})_{comp}$ (in-kips)	$(M_{u2})_{comp}$ (in-kips)	$(M'_{u3})_{comp}$ (in-kips)			
IOF-10A	2.392	12.373	3.365**	20.520	15.817	20.520	0.782	0.711	1.087
IOF-10B	2.420	12.517	3.275**	19.692	15.158	19.692	0.826	0.739	1.138
IOF-11A	2.342	10.627	2.424	37.647	28.445	37.647	0.374	0.966	0.991
IOF-11B	2.460	11.255	2.537	39.476	29.990	39.476	0.375	0.970	0.995
IOF-12A	2.900	16.762	3.799	39.357	32.456	39.357	0.517	0.763	0.939
IOF-12B	2.920	16.921	3.932	39.168	32.303	39.168	0.524	0.743	0.929
IOF-13A	2.655	9.857	2.666	21.565	14.773	21.565	0.667	0.996	1.220
IOF-13B	2.660	9.875	2.538	20.239	14.235	20.239	0.694	1.048	1.278
IOF-14A	3.025	15.012	4.110	21.561	16.423	21.561	0.914	0.736	1.198
IOF-14B	3.100	15.384	3.938	21.666	16.523	21.666	0.931	0.787	1.249
IOF-15A	3.000	12.938	3.041	41.337	32.388	41.337	0.400	0.987	1.025
IOF-15B	3.085	13.304	3.011	41.287	32.419	41.287	0.410	1.024	1.061
IOF-16A	3.875	21.845	4.652	40.985	34.740	40.985	0.629	0.833	1.071
IOF-16B	3.750	21.141	4.701	39.993	33.845	39.993	0.625	0.798	1.041
IOF-17A	2.158	9.646	1.734	12.149	17.083	11.840	0.815	1.244	1.511
IOF-17B	2.120	9.476	1.725	12.002	16.829	11.697	0.810	1.229	1.497
IOF-18A	2.223	12.699	2.709	11.868	18.155	11.524	1.102	0.821	1.394
IOF-18B	2.210	12.625	2.832	12.172	18.396	11.887	1.062	0.780	1.336

TABLE 5 (Cont'd)

Comparison of the Tested and Computed Results for Interior One-Flange Loading Based on the 1980 Edition of the AISI Specification[23]

Specimen No.	Test Data per Specimen: $(P)_{test}$ (kips)	Test Data per Specimen: $(M)_{test}$ (in-kips)	Computed Data per Specimen: $(P'_u)_{comp}$ (kips)	Computed Data per Specimen: $(M_{u1})_{comp}$ (in-kips)	Computed Data per Specimen: $(M_{u2})_{comp}$ (in-kips)	Computed Data per Specimen: $(M'_{u3})_{comp}$ (in-kips)	$\frac{(M)_{test}}{(M'_u)_{comp}}$	$\frac{(P)_{test}}{(P'_u)_{comp}}$	$\frac{B^*}{1.42}$
IOF-19A	4.392	16.141	6.262	22.888	23.074	22.888	0.705	0.701	1.025
IOF-19B	4.392	16.141	6.221	22.775	22.996	22.775	0.709	0.706	1.031
IOF-20A	4.250	20.995	8.152	17.794	18.956	17.794	1.180	0.521	1.224
IOF-20B	4.400	21.736	8.249	17.933	19.086	17.933	1.212	0.533	1.256
							Mean Value		1.188
							Coefficient of Variation		0.144

* $B = 1.07(P)_{test}/(P'_u)_{comp} + (M)_{test}/(M'_u)_{comp}$

** The R/t ratio exceeds 7 slightly.

TABLE 6

Effect of Longitudinal Embossments on Web Crippling Strength, Interior One-Flange Loading

Specimens Having Flat Webs			Specimens Having Deformed Webs			(7)	(8)
(1) Specimen No.	(2) $(P)_{test}$* (kips)	(3) B/1.42*	(4) Specimen No.	(5) $(P)_{test}$* (kips)	(6) B/1.42*	$\frac{Col.5}{Col.2}$	$\frac{Col.6}{Col.3}$
IOF - 1	2.035	1.132	IOF - 9	1.987	1.105	0.98	0.98
IOF - 2	2.328	1.094	IOF -10	2.406	1.113	1.03	1.02
IOF - 5	2.544	1.076	IOF -11	2.401	0.993	0.94	0.92
IOF - 6	3.093	1.016	IOF -12	2.910	0.934	0.94	0.92

* The individual value given in this table is the average of Tests A and B

TABLE 7

Design Parameters for Steel Deck Specimens

End One-Flange Loading

Specimen No.	Thickness t (in.)	Inside Bend Radius R_1 (in.)	Web Width h (in.)	Bearing Length at Support N_1 (in.)	Bearing Length Under Load N_2 (in.)	Web Inclination θ (degree)	R_1/t	h/t	N_1/t	N_1/h	Yield Point F_y (ksi)	Span Length (in.)
EOF-1A	0.0292	0.20	2.23	2.98	5.93	62.4	6.85	76.37	102.06	1.34	43.3	26.02
EOF-1B	0.0293	0.20	2.22	2.98	5.93	61.6	6.83	75.77	101.71	1.34	43.3	26.02
EOF-2A	0.0301	0.21	2.21	5.93	7.86	62.1	6.98	73.42	197.01	2.68	43.3	33.27
EOF-2B	0.0296	0.21	2.23	5.93	7.86	62.7	7.09	75.34	200.34	2.66	43.3	33.27
EOF-3A	0.0442	0.20	2.18	2.98	5.93	63.7	4.52	49.32	67.42	1.37	42.9	26.02
EOF-3B	0.0447	0.20	2.18	2.98	5.93	63.0	4.47	48.77	66.67	1.37	42.9	26.02
EOF-4A	0.0472	0.21	2.22	5.93	7.86	64.4	4.45	47.03	125.64	2.67	42.9	33.07
EOF-4B	0.0471	0.21	2.21	5.93	7.86	64.5	4.46	46.92	125.90	2.68	42.9	33.07
EOF-5A	0.0311	0.20	3.16	2.98	5.93	69.5	6.43	101.61	95.82	0.94	48.1	30.77
EOF-5B	0.0317	0.20	3.17	2.98	5.93	70.0	6.31	100.00	94.01	0.94	48.1	30.77
EOF-6A	0.0293	0.20	3.10	5.93	7.86	70.5	6.83	105.80	202.39	1.91	48.1	37.82
EOF-6B	0.0294	0.20	3.15	5.93	7.86	70.0	6.80	107.14	201.70	1.88	48.1	37.82
EOF-7A	0.0488	0.19	3.10	2.98	5.93	71.3	3.89	63.52	61.07	0.96	41.2	30.82
EOF-7B	0.0479	0.19	3.12	2.98	5.93	72.2	3.97	65.14	62.21	0.96	41.2	30.82
EOF-8A	0.0460	0.21	3.09	5.93	7.86	71.3	4.57	67.17	128.91	1.92	41.2	37.87
EOF-8B	0.0480	0.21	3.05	5.93	7.86	71.3	4.38	63.54	123.54	1.94	41.2	37.87
EOF-9A	0.0310	0.21	2.20	2.98	5.93	74.5	6.77	70.97	96.13	1.35	42.9	26.02
EOF-9B	0.0310	0.21	2.20	2.98	5.93	73.7	6.77	70.97	96.13	1.35	42.9	26.02
EOF-10A	0.0295	0.21	2.22	5.93	7.86	64.0	7.12	75.25	201.02	2.67	42.9	33.07
EOF-10B	0.0303	0.21	2.20	5.93	7.86	62.6	6.93	72.61	195.71	2.70	42.9	33.07
EOF-11A	0.0307	0.20	3.14	2.98	5.93	70.5	6.51	102.28	97.07	0.95	46.1	30.75
EOF-11B	0.0308	0.20	3.14	2.98	5.93	70.8	6.49	101.95	96.75	0.95	46.1	30.78

TABLE 7 (Cont'd)

Design Parameters for Steel Deck Specimens

End One-Flange Loading

Specimen No.	Thickness t (in.)	Inside Bend Radius R_1 (in.)	Web Width h (in.)	Bearing Length at Support N_1 (in.)	Bearing Length Under Load N_2 (in.)	Web Inclination θ (degree)	R_1/t	h/t	N_1/t	N_1/h	Yield Point F_y (ksi)	Span Length (in.)
EOF-12A	0.0305	0.20	3.13	5.93	7.86	70.0	6.56	102.62	194.43	1.89	46.1	37.80
EOF-12B	0.0311	0.20	3.10	5.93	7.86	70.2	6.43	99.68	190.68	1.91	46.1	37.79
EOF-13A	0.0351	0.17	1.92	2.98	5.93	50.3	4.84	54.70	84.90	1.55	39.3	27.72
EOF-13B	0.0343	0.18	1.90	2.98	5.93	49.1	5.25	55.39	86.88	1.57	39.3	27.72
EOF-14A	0.0350	0.17	1.93	5.93	7.86	48.1	4.86	55.14	169.43	3.07	39.3	34.77
EOF-14B	0.0345	0.19	1.81	5.93	7.86	50.4	5.51	52.46	171.88	3.28	39.3	34.77
EOF-15A	0.0369	0.19	2.78	2.98	5.93	65.4	5.15	75.34	80.76	1.07	42.1	31.57
EOF-15B	0.0363	0.19	2.79	2.98	5.93	66.0	5.23	76.86	82.09	1.07	42.1	31.57
EOF-16A	0.0361	0.20	2.78	5.93	7.86	65.3	5.54	77.01	164.27	2.13	42.1	38.62
EOF-16B	0.0365	0.19	2.70	5.93	7.86	65.1	5.21	73.97	162.47	2.20	42.1	38.62
EOF-17A	0.0293	0.10	3.01	2.98	5.93	92.0	3.41	102.73	101.71	0.99	49.9	30.02
EOF-17B	0.0296	0.10	3.02	2.98	5.93	91.3	3.38	102.03	100.68	0.99	49.9	30.02
EOF-18A	0.0286	0.09	3.02	5.93	7.86	90.8	3.15	105.59	207.34	1.96	49.9	37.07
EOF-18B	0.0288	0.09	2.98	5.93	7.86	90.1	3.13	103.47	205.90	1.99	49.9	37.07
EOF-19A	0.0288	0.14	1.94	2.98	5.93	75.9	4.86	67.36	103.47	1.54	41.2	25.52
EOF-19B	0.0287	0.14	1.90	2.98	5.93	75.1	4.88	66.20	103.83	1.57	41.2	25.52
EOF-20A	0.0286	0.13	1.88	5.93	7.86	74.3	4.54	65.73	207.34	3.15	41.2	32.57
EOF-20B	0.0284	0.13	1.94	5.93	7.86	75.1	4.58	68.31	208.80	3.06	41.2	32.57

Note: For Specimens Nos. EOF-13, EOF-14, EOF-15, and EOF-16, the inside bend radius R_2 was used for computing the R/t ratio because the specimens were tested in inverted position.

TABLE 8

Comparison of the Tested and Computed Results for End One-Flange Loading Based on the 1968 and 1980 Editions of the AISI Specification

Specimen No.	Test Data per Specimen	Computed Data per Specimen		$\frac{(P_u)_{test}}{(P_u)_{comp}}$	$\frac{(P_u)_{test}}{(P_u')_{comp}}$
	$(P_u)_{test}$ (kips)	1968 AISI Spec $(P_u)_{comp}$	1980 AISI Spec. $(P_u')_{comp}$		
EOF-1A	3.807	N/A*	1.964	N/A*	1.938
EOF-1B	3.845	N/A	1.968	N/A	1.954
EOF-2A	4.705	N/A	3.092	N/A	1.522
EOF-2B	4.625	N/A	N/A**	N/A	N/A**
EOF-3A	9.500	N/A	3.947	N/A	2.407
EOF-3B	9.605	N/A	4.007	N/A	2.397
EOF-4A	9.950	N/A	6.137	N/A	1.621
EOF-4B	9.788	N/A	6.123	N/A	1.599
EOF-5A	3.180	N/A	2.235	N/A	1.423
EOF-5B	3.265	N/A	2.315	N/A	1.410
EOF-6A	4.825	N/A	3.062	N/A	1.576
EOF-6B	4.850	N/A	3.058	N/A	1.586
EOF-7A	8.018	5.819	5.204	1.378	1.541
EOF-7B	8.025	5.536	4.952	1.450	1.620
EOF-8A	11.463	N/A	5.776	N/A	1.984
EOF-8B	11.260	N/A	6.188	N/A	1.820
EOF-9A	3.530	N/A	2.320	N/A	1.522
EOF-9B	3.815	N/A	2.308	N/A	1.653

* R/t > 4   ** R/t > 7

TABLE 8 (Cont'd)

Comparison of the Tested and Computed Results for End One-Flange Loading Based on the 1968 and 1980 Editions of the AISI Specification

Specimen No.	Test Data per Specimen	Computed Data per Specimen		$\frac{(P_u)_{test}}{(P_u)_{comp}}$	$\frac{(P_u)_{test}}{(P_u')_{comp}}$
	$(P_u)_{test}$ (kips)	1968 AISI Spec $(P_u)_{comp}$	1980 AISI Spec. $(P_u')_{comp}$		
EOF-10A	4.325	N/A*	N/A**	N/A*	N/A**
EOF-10B	4.470	N/A	3.118	N/A	1.434
EOF-11A	2.925	N/A	2.159	N/A	1.355
EOF-11B	2.925	N/A	2.175	N/A	1.345
EOF-12A	3.910	N/A	3.183	N/A	1.228
EOF-12B	4.150	N/A	3.293	N/A	1.260
EOF-13A	2.275	N/A	2.421	N/A	0.940
EOF-13B	2.410	N/A	2.320	N/A	1.039
EOF-14A	2.745	N/A	3.480	N/A	0.789
EOF-14B	2.475	N/A	3.468	N/A	0.714
EOF-15A	3.280	N/A	2.814	N/A	1.166
EOF-15B	3.075	N/A	2.744	N/A	1.121
EOF-16A	4.000	N/A	3.935	N/A	1.017
EOF-16B	4.150	N/A	4.017	N/A	1.033
EOF-17A	1.988	1.500	1.524	1.326	1.304
EOF-17B	2.135	1.539	1.553	1.387	1.374
EOF-18A	2.735	2.504	2.321	1.092	1.178
EOF-18B	2.725	2.587	2.354	1.053	1.158

TABLE 8 (Cont'd)

Comparison of the Tested and Computed Results for End One-Flange Loading
Based on the 1968 and 1980 Editions of the AISI Specification

Specimen No.	Test Data per Specimen $(P_u)_{test}$ (kips)	Computed Data per Specimen 1968 AISI Spec $(P_u)_{comp}$	Computed Data per Specimen 1980 AISI Spec. $(P_u')_{comp}$	$\frac{(P_u)_{test}}{(P_u)_{comp}}$	$\frac{(P_u)_{test}}{(P_u')_{comp}}$
EOF-19A	6.575	N/A	3.869	N/A	1.699
EOF-19B	6.055	N/A	3.840	N/A	1.577
EOF-20A	7.875	Failure occurred under interior bearing plates,			
EOF-20B	7.105	not at end supports.			
Mean Value				1.281	1.453
Coefficient of Variation				0.130	0.266

TABLE 9

Design Parameters for Steel Deck Specimens

End One-Flange Loading

Specimen No.	Thickness t (in.)	Inside Bend Radius R_1 (in.)	Web Width h (in.)	Bearing Length at Support N_1 (in.)	Bearing Length Under Load N_2 (in.)	Web Inclination θ (degree)	R_1/t	h/t	N_1/t	N_1/h	Yield Point F_y (ksi)	Span Length (in.)
EOF-5A	0.0311	0.20	3.16	2.98	5.93	69.5	6.43	101.61	95.82	0.94	48.1	30.77
EOF-5B	0.0317	0.20	3.17	2.98	5.93	70.0	6.31	100.00	94.01	0.94	48.1	30.77
EOF-5C	0.0300	0.20	3.15	2.98	5.93	71.5	6.67	105.00	99.33	0.95	48.1	30.77
EOF-5D	0.0300	0.20	3.15	2.98	5.93	70.3	6.67	105.00	99.33	0.95	48.1	30.77
EOF-5E	0.0303	0.20	3.13	2.98	5.93	71.3	6.60	103.30	98.35	0.95	48.1	30.77
EOF-5F	0.0301	0.20	3.15	2.98	5.93	72.0	6.64	104.65	99.00	0.95	48.1	30.77

TABLE 10

Effect of Support Condition on End Failure

End One-Flange Loading

Specimen No.	Support Condition	Connection Condition	Total Failure Load per Specimen (kips)	Remarks
EOF-5A EOF-5B	Rotation of end bearing plate is not prevented	No connections are used at ends of specimen	3.180 3.265	See Figs. 15 and 16
EOF-5C EOF-5D	Rotation of end bearing plate is prevented	No connections are used at ends of specimen	4.250 4.250	See Figs. 20 and 21
EOF-5E EOF-5F	Rotation of end bearing plate is prevented	Specimens are welded to end bearing plates	4.275 4.125	See Figs. 23 and 24

TABLE 11

Effect of Longitudinal Embossments on Web Crippling Strength, End One-Flange Loading

Specimens Having Flat Webs		Specimens Having Deformed Webs		
(1) Specimen No.	(2) $(P_u)_{test}$* (kips)	(3) Specimen No.	(4) $(P_u)_{test}$* (kips)	$\frac{\text{Col. 4}}{\text{Col. 2}}$
EOF - 1	3.826	EOF - 9	3.673	0.96
EOF - 2	4.665	EOF - 10	4.398	0.94
EOF - 5	3.223	EOF - 11	2.925	0.91
EOF - 6	4.838	EOF - 12	4.030	0.83

* The individual value given in this table is the average of Tests A and B

TABLE 12a

Dimensions of Steel Deck Specimens Used for Combined Bending-Web Crippling Tests

Simple Beam Tests Without End Connections

Specimen No.	No. of Ribs per Specimen	No. of Webs per Specimen	No. of Top Stiffener	No. of Bottom Stiffener	Type of Sidelap	Cross-Section Dimensions (in.)						
						T	D	D_T	D_B	D_E	W_1	W_2
BC - 1A	2	4	1	1	1	0.0297	2.000	0.303	0.300	-	0.670	1.350
BC - 1B	2	4	1	1	1	0.0298	1.993	0.295	0.305	-	0.660	1.370
BC - 2A	2	4	1	1	1	0.0300	2.013	0.305	0.280	-	0.760	1.315
BC - 2B	2	4	1	1	1	0.0299	2.013	0.308	0.290	-	0.840	1.285
BC - 9A	2	4	1	1	1	0.0295	2.018	0.310	0.305	-	0.820	1.290
BC - 9B	2	4	1	1	1	0.0297	1.970	0.318	0.300	-	0.870	1.305
BC - 12A	2	4	1	1	1	0.0308	3.070	0.283	0.290	-	0.990	1.270
BC - 12B	2	4	1	1	1	0.0305	3.005	0.280	0.290	-	1.000	1.310
BC - 13A	2	4	2	1	1	0.0349	2.002	0.303	0.310	-	0.850	1.413
BC - 13B	2	4	2	1	1	0.0348	2.005	0.303	0.300	-	0.660	1.441
BC - 16A	2	4	1	-	1	0.0356	3.020	0.296	-	-	0.720	1.410
BC - 16B	2	4	1	-	1	0.0357	3.015	0.295	-	-	0.800	1.360
BC - 17A	1	2	-	-	1	0.0297	3.020	-	-	-	1.880	0.219
BC - 17B	1	2	-	-	1	0.0292	3.000	-	-	-	1.860	0.219
BC - 19A	4	8	-	-	1	0.0290	1.920	-	-	-	0.600	0.793
BC - 19B	4	8	-	-	1	0.0284	1.935	-	-	-	0.600	0.793

Notes: 1. For definitions of symbols, see Fig. 3.

2. Specimens Nos. 1, 2, 17 and 19 have flat webs. Other specimens have embossments in their webs.

TABLE 12b

Dimensions of Steel Deck Specimens Used for Combined Bending-Web Crippling Tests
Simple Beam Tests Without End Connections

Specimen No.	Cross-Section Dimensions (in.)											
	W_3	W_4	W_5	W_6	W_7	W_8	W_9	W_{10}	W_{11}	W_{12}	S_1	S_2
BC - 1A	1.670	0.520	0.260	-	1.700	0.520	0.280	0.920	-	-	-	-
BC - 1B	1.690	0.490	0.310	-	1.655	0.530	0.290	0.920	-	-	-	-
BC - 2A	1.700	0.505	0.280	-	1.660	0.530	0.280	0.880	-	-	-	-
BC - 2B	1.685	0.530	0.300	-	1.665	0.525	0.300	0.870	-	-	-	-
BC - 9A	1.680	0.475	0.390	-	1.750	0.455	0.340	1.020	-	-	-	-
BC - 9B	1.710	0.455	0.350	-	1.735	0.470	0.320	0.910	-	-	-	-
BC - 12A	1.680	0.515	0.290	-	1.700	0.480	0.360	1.020	-	-	-	-
BC - 12B	1.675	0.510	0.320	-	1.670	0.475	0.370	1.010	-	-	-	-
BC - 13A	0.977	0.430	-	0.930	1.890	0.420	-	0.850	-	-	-	-
BC - 13B	1.029	0.430	-	1.020	1.750	0.400	-	0.700	-	-	-	-
BC - 16A	1.830	0.410	-	-	4.680	-	-	0.750	-	-	-	-
BC - 16B	1.840	0.410	-	-	4.680	-	-	0.820	-	-	-	-
BC - 17A	7.940	-	-	-	-	-	-	1.950	-	-	-	-
BC - 17B	7.790	-	-	-	-	-	-	1.900	-	-	-	-
BC - 19A	3.240	-	-	-	1.210	-	-	1.200	-	-	-	0.350
BC - 19B	3.240	-	-	-	1.210	-	-	1.200	-	-	-	0.350

TABLE 12c

Dimensions of Steel Deck Specimens Used for Combined Bending-Web Crippling Tests
Simple Beam Tests Without End Connections

Specimen No.	Cross-Section Dimensions (in.)									Web Inclination (degree)	Overall Width (in.)	Overall Length (in.)
	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	h			
BC - 1A	0.200	0.200	0.210	0.280	0.210	0.250	-	-	2.21	60.9	20.990	77.88
BC - 1B	0.200	0.200	0.210	0.280	0.210	0.250	-	-	2.22	60.3	21.060	77.88
BC - 2A	0.210	0.210	0.220	0.280	0.220	0.280	-	-	2.22	62.3	20.940	80.00
BC - 2B	0.210	0.210	0.220	0.280	0.220	0.280	-	-	2.20	63.0	20.990	80.00
BC - 9A	0.200	0.210	0.210	0.260	0.220	0.230	-	-	2.22	62.8	21.150	78.00
BC - 9B	0.200	0.210	0.210	0.260	0.220	0.230	-	-	2.19	61.8	21.090	78.00
BC - 12A	0.200	0.200	0.200	0.260	0.210	0.260	-	-	3.11	72.6	23.810	92.00
BC - 12B	0.200	0.200	0.200	0.260	0.210	0.260	-	-	3.13	71.4	23.970	92.00
BC - 13A	0.130	0.170	0.190	0.190	0.190	0.190	-	-	1.89	49.4	19.460	72.00
BC - 13B	0.130	0.180	0.190	0.190	0.190	0.190	-	-	1.92	48.9	19.300	71.63
BC - 16A	0.130	0.198	0.190	0.190	-	-	-	-	2.78	64.6	20.750	92.00
BC - 16B	0.130	0.190	0.190	0.190	-	-	-	-	2.70	65.5	20.740	92.00
BC - 17A	0.095	0.095	-	-	-	-	-	-	2.97	90.0	12.208	59.63
BC - 17B	0.095	0.095	-	-	-	-	-	-	2.96	90.0	11.988	60.00
BC - 19A	0.135	0.135	-	-	-	-	0.135	-	1.92	73.2	24.734	72.50
BC - 19B	0.135	0.135	-	-	-	-	0.135	-	1.92	73.3	24.734	72.00

TABLE 13a

Dimensions of Steel Deck Specimens Used for Combined Bending-Web Crippling Tests

Single Span Beam Tests With End Connections

Specimen No.	No. of Ribs per Specimen	No. of Webs per Specimen	No. of Top Stiffener	No. of Bottom Stiffener	Type of Sidelap	Cross - Section Dimensions (in.)						
						T	D	D_T	D_B	D_E	W_1	W_2
BC- 2C	2	4	1	1	1	0.0310	2.030	0.300	0.300	-	0.730	1.300
BC- 2D	2	4	1	1	1	0.0303	2.030	0.300	0.300	-	0.660	1.300
BC- 12C	2	4	1	1	1	0.0293	3.020	0.300	0.280	-	1.000	1.280
BC- 12D	2	4	1	1	1	0.0294	3.020	0.300	0.280	-	0.940	1.280
BC- 16C	1	2	1	-	1	0.0354	3.040	0.310	-	-	0.800	1.390
BC- 16D	1	2	1	-	1	0.0360	3.040	0.310	-	-	0.800	1.390
BC- 19C	4	8	-	-	1	0.0290	1.910	-	-	-	0.640	0.740
BC- 19D	4	8	-	-	1	0.0280	1.910	-	-	-	0.540	0.740

Notes: 1. For definitions of symbols, see Figs. 3.

2. Specimens Nos. 2 and 19 have flat webs. Other specimens have embossments in their webs.

TABLE 13b

Dimensions of Steel Deck Specimens Used for Combined Bending-Web Crippling Tests

Single Span Beam Tests With End Connections

Specimen No.	Cross - Section Dimensions (in.)											
	W_3	W_4	W_5	W_6	W_7	W_8	W_9	W_{10}	W_{11}	W_{12}	S_1	S_2
BC - 2C	1.690	0.510	0.310	-	1.670	0.525	0.290	0.720	-	-	-	-
BC - 2D	1.690	0.510	0.310	-	1.670	0.525	0.290	0.660	-	-	-	-
BC - 12C	1.700	0.520	0.310	-	1.700	0.520	0.310	1.000	-	-	-	-
BC - 12D	1.700	0.520	0.310	-	1.700	0.520	0.310	0.940	-	-	-	-
BC - 16C	1.830	0.410	-	-	-	-	-	0.880	-	-	-	-
BC - 16D	1.830	0.410	-	-	-	-	-	0.880	-	-	-	-
BC - 19C	3.210	-	-	-	1.300	-	-	0.640	-	-	-	-
BC - 19D	3.210	-	-	-	1.300	-	-	0.550	-	-	-	-

TABLE 13c

Dimensions of Steel Deck Specimens Used for Combined Bending-Web Crippling Tests

Single Span Beam Tests With End Connections

Specimen No.	Cross-Section Dimensions (in.)									Web Inclination (degree)	Overall Width (in.)	Overall Length (in.)
	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	h			
BC - 2C	0.205	0.205	0.215	0.280	0.215	0.265	-	-	2.18	62.7	20.75	79.94
BC - 2D	0.205	0.205	0.215	0.280	0.215	0.265	-	-	2.18	62.7	20.62	79.81
BC - 12C	0.200	0.200	0.210	0.250	0.220	0.250	-	-	3.11	69.7	21.37	91.88
BC - 12D	0.200	0.200	0.210	0.250	0.220	0.250	-	-	3.11	69.7	21.25	92.00
BC - 16C	0.130	0.195	0.190	0.190	-	-	-	-	2.80	65.2	9.63	91.75
BC - 16D	0.130	0.195	0.190	0.190	-	-	-	-	2.80	65.2	9.25	91.75
BC - 19C	0.130	0.130	-	-	-	-	-	-	1.91	74.5	23.94	71.88
BC - 19D	0.130	0.130	-	-	-	-	-	-	1.91	74.5	23.75	71.75

TABLE 14

Design Parameters for Steel Deck Specimens used for Combined Bending-Web Crippling Tests
Simple Beam Tests Without End Connections

Specimen No.	Thickness t (in.)	Inside Bend Radius R_2 (in.)	Computed Web Width h (in.)	Bearing Length Under Load N_1 (in.)	Bearing Length at Support N_2 (in.)	Computed Web Inclination θ (degree)	R_2/t	h/t	N_1/t	N_1/h	Yield Point F_y (ksi)	Span Length (in.)
BC - 1A	0.0297	0.200	2.22	2.98	5.93	60.9	6.73	74.75	100.34	1.35	43.3	71.95
BC - 1B	0.0298	0.200	2.23	2.98	5.93	60.3	6.71	74.83	100.00	1.34	43.3	71.95
BC - 2A	0.0300	0.210	2.21	5.93	7.86	62.3	7.00	73.67	197.67	2.67	43.3	72.14
BC - 2B	0.0299	0.210	2.19	5.93	7.86	63.0	7.02	73.24	198.33	2.70	43.3	72.14
BC - 9A	0.0295	0.210	2.20	2.98	5.93	62.8	7.12	74.58	101.02	1.34	42.9	72.07
BC - 9B	0.0297	0.210	2.17	2.98	5.93	61.8	7.07	73.06	100.34	1.36	42.9	72.07
BC - 12A	0.0308	0.200	3.15	5.93	7.86	72.6	6.49	102.27	192.53	1.91	46.1	84.14
BC - 12B	0.0305	0.200	3.11	5.93	7.86	71.4	6.56	101.97	194.43	1.89	46.1	85.09
BC - 13A	0.0349	0.170	1.89	2.98	5.93	49.4	4.87	54.15	85.39	1.58	39.3	66.07
BC - 13B	0.0348	0.180	1.91	2.98	5.93	48.9	5.17	54.89	85.63	1.55	39.3	65.70
BC - 16A	0.0356	0.198	2.71	5.93	7.86	64.6	5.56	76.12	166.57	2.13	42.1	85.09
BC - 16B	0.0357	0.190	2.69	5.93	7.86	65.5	5.32	75.35	166.11	2.20	42.1	85.09
BC - 17A	0.0297	0.095	2.96	2.98	5.93	90.0	3.20	99.66	100.34	1.00	49.9	53.70
BC - 17B	0.0292	0.095	2.94	2.98	5.93	90.0	3.25	100.68	102.05	1.01	49.9	54.07
BC - 19A	0.0290	0.135	1.95	2.98	5.93	73.2	4.66	67.24	102.76	1.55	41.2	66.57
BC - 19B	0.0284	0.135	1.96	2.98	5.93	73.3	4.75	69.01	104.93	1.55	41.2	66.07

TABLE 15

Design Parameters for Steel Deck Specimens used for Combined Bending-Web Crippling Tests
Single Span Beam Tests With End Connections

Specimen No.	Thickness t (in.)	Inside Bend Radius R_2 (in.)	Computed Web Width h (in.)	Bearing Length Under Load N_1 (in.)	Bearing Length at Support N_2 (in.)	Computed Web Inclination θ (degree)	R_2/t	h/t	N_1/t	N_1/h	Yield Point F_y (ksi)	Span Length (in.)
BC - 2C	0.0310	0.205	2.21	5.93	7.86	62.7	6.61	71.29	191.29	2.68	48.2	72.08
BC - 2D	0.0303	0.205	2.22	5.93	7.86	62.7	6.77	73.27	195.71	2.67	48.2	71.95
BC - 12C	0.0293	0.200	3.16	5.93	7.86	69.7	6.83	107.85	202.39	1.88	51.0	84.02
BC - 12D	0.0294	0.200	3.16	5.93	7.86	69.7	6.80	107.48	201.70	1.88	51.0	84.14
BC - 16C	0.0354	0.195	2.72	5.93	7.86	65.2	5.51	76.84	167.51	2.18	45.5	83.89
BC - 16D	0.0360	0.195	2.72	5.93	7.86	65.2	5.42	75.56	164.72	2.18	45.5	83.89
BC - 19C	0.0290	0.130	1.92	2.98	5.93	74.5	4.48	66.21	102.76	1.55	44.2	65.95
BC - 19D	0.0280	0.130	1.92	2.98	5.93	74.5	4.64	68.57	106.43	1.55	44.2	65.82

TABLE 16

Tested Mechanical Properties of Steels Used for Long Span Simple Beam Tests with End Connections and Continuous Beam Tests

Tensile Coupon No.	F_y (ksi)	F_u (ksi)	Elongation* (percent)
11	48.2	61.7	20.3
12	44.9	50.7	33.3
13	50.4	59.0	28.4
14	51.0	58.3	29.8
15	46.4	50.6	38.4
16	45.5	51.6	37.2
17	44.2	53.0	32.0

* 2-in. gage length

TABLE 17

Comparison of the Tested and Computed Results for Combined Bending-Web Crippling
Based on Addendum No.2 of the 1968 Edition of the AISI Specification
(Simple Beam Tests Without End Connections)

Specimen No.	Test Data per Specimen		Computed Data per Specimen				$\frac{(M)_{test}}{(M_u)_{comp}}$	$\frac{(P)_{test}}{(P_u)_{comp}}$	$\frac{A^*}{1.3}$
	$(P)_{test}$ (kips)	$(M)_{test}$ (in-kips)	$(P_u)_{comp}$ (kips)	$(M_{u1})_{comp}$ (in-kips)	$(M_{u2})_{comp}$ (in-kips)	$(M_{u3})_{comp}$ (in-kips)			
BC - 1A	0.973	17.502	N/A**	19.999	20.059	19.999	0.875	N/A**	N/A**
BC - 1B	0.975	17.538	N/A	19.828	19.916	19.828	0.885	N/A	N/A
BC - 2A	1.020	18.396	N/A	20.365	20.464	20.365	0.903	N/A	N/A
BC - 2B	1.017	18.342	N/A	20.460	20.528	20.460	0.897	N/A	N/A
BC - 9A	0.795	14.324	N/A	20.489	20.559	20.489	0.699	N/A	N/A
BC - 9B	0.790	14.234	N/A	19.846	19.942	19.846	0.717	N/A	N/A
BC - 12A	1.218	25.621	N/A	40.647	41.018	40.647	0.630	N/A	N/A
BC - 12B	1.219	25.931	N/A	38.983	39.401	38.983	0.665	N/A	N/A
BC - 13A	1.250	20.647	N/A	21.953	21.437	21.953	0.963	N/A	N/A
BC - 13B	1.073	17.624	N/A	20.629	20.246	20.629	0.870	N/A	N/A
BC - 16A	1.646	35.015	N/A	39.978	40.876	39.978	0.876	N/A	N/A
BC - 16B	1.690	35.951	N/A	40.524	41.457	40.524	0.887	N/A	N/A
BC - 17A	0.995	13.358	1.502	12.317	22.536	12.317	1.085	0.663	1.344
BC - 17B	0.985	13.315	1.446	11.887	21.772	11.887	1.120	0.681	1.386
BC - 19A	1.072	17.841	N/A	19.118	21.442	19.118	0.933	N/A	N/A
BC - 19B	1.083	17.888	N/A	18.754	21.231	18.754	0.954	N/A	N/A

Mean Value 1.365

Coeffieient of Variation 0.020

* $A = (P)_{test}/(P_u)_{comp} + (M)_{test}/(M_u)_{comp}$

** The design formula for web crippling is not applicable because the R/t ratio exceeds 4.0.

TABLE 18

Comparison of the Tested and Computed Results for Combined Bending-Web Crippling
Based on Addendum No. 2 of the 1968 Edition of the AISI Specification
(Single Span Beam Tests With End Connections)

Specimen No.	Test Data Per Specimen		Computed Data Per Specimen				$\frac{(M)_{test}}{(M_u)_{comp}}$	$\frac{(P)_{test}}{(P_u)_{comp}}$	$\frac{A^*}{1.3}$
	$(P)_{test}$ (kips)	$(M)_{test}$ (in-kips)	$(P_u)_{comp}$ (kips)	$(M_{u1})_{comp}$ (in-kips)	$(M_{u2})_{comp}$ (in-kips)	$(M_{u3})_{comp}$ (in-kips)			
BC - 2C	1.170	21.083	N/A*	23.168	23.256	23.168	0.910	N/A**	N/A**
BC - 2D	1.202	21.621	N/A	22.312	22.415	22.312	0.969	N/A	N/A
BC - 12C	1.400	29.407	N/A	39.247	40.580	39.247	0.749	N/A	N/A
BC - 12D	1.405	29.554	N/A	38.957	40.262	38.957	0.759	N/A	N/A
BC - 16C	0.867	18.183	N/A	16.162	16.454	16.162	1.125	N/A	N/A
BC - 16D	0.872	18.288	N/A	16.455	16.730	16.455	1.111	N/A	N/A
BC - 19C	1.200	19.785	N/A	19.851	22.211	19.851	0.997	N/A	N/A
BC - 19D	1.180	19.417	N/A	18.807	21.083	18.807	1.032	N/A	N/A

* $A = (P)_{test}/(P_u)_{comp} + (M)_{test}/(M_u)_{comp}$

** The design formula is not applicable beacuse the R/t ratio exceeds 4.

TABLE 19

Comparison of the Tested and Computed Results for Combined Bending-Web Crippling Based on the 1980 Edition of the AISI Specification[23]
(Simple Beam Tests Without End Connections)

Specimen No.	Test Data per Specimen		Computed Data per Specimen				$\frac{(M)_{test}}{(M'_u)_{comp}}$	$\frac{(P)_{test}}{(P'_u)_{comp}}$	$\frac{B^*}{1.42}$
	$(P)_{test}$ (kips)	$(M)_{test}$ (in-kips)	$(P'_u)_{comp}$ (kips)	$(M_{u1})_{comp}$ (in-kips)	$(M_{u2})_{comp}$ (in-kips)	$(M'_{u3})_{comp}$ (in-kips)			
BC-1A	0.973	17.502	2.130	19.999	20.059	19.999	0.875	0.457	0.961
BC-1B	0.975	17.538	2.138	19.828	19.917	19.828	0.885	0.456	0.967
BC-2A	1.020	18.396	3.382	20.365	20.464	20.365	0.903	0.302	N/A**
BC-2B	1.017	18.342	3.376	20.460	20.528	20.460	0.897	0.301	N/A
BC-9A	0.795	14.324	2.044	20.489	20.559	20.489	0.699	0.389	N/A
BC-9B	0.790	14.234	2.067	19.846	19.942	19.846	0.717	0.382	N/A
BC-12A	1.218	25.621	3.876	40.647	41.018	40.647	0.630	0.314	N/A
BC-12B	1.219	25.931	3.783	38.983	39.401	38.983	0.665	0.322	N/A
BC-13A	1.250	20.647	2.851	21.953	21.437	21.953	0.963	0.439	1.009
BC-13B	1.073	17.624	2.763	20.629	20.246	20.629	0.870	0.388	N/A
BC-16A	1.646	35.015	4.721	39.978	40.876	39.978	0.876	0.349	N/A
BC-16B	1.690	35.951	4.862	40.524	41.457	40.524	0.887	0.348	N/A
BC-17A	0.995	13.358	1.778	12.317	22.536	12.045	1.109	0.560	1.203
BC-17B	0.985	13.315	1.727	11.887	21.772	11.600	1.148	0.571	1.238
BC-19A	1.072	17.841	5.142	19.118	21.442	19.118	0.933	0.209	N/A
BC-19B	1.083	17.888	4.946	18.754	21.231	18.754	0.954	0.219	N/A
								Mean Value	1.076
								Coefficient of Variation	0.112

* $B = 1.07\,(P)_{test}/(P'_u)_{comp} + (M)_{test}/(M_u)_{comp}$

** The interaction formula is not applicable because the $(P)_{test}/(P'_u)_{comp}$ ratio is less than 0.393.

TABLE 20

Comparison of the Tested and Computed Results for Combined Bending-Web Crippling Based on the 1980 Edition of the AISI Specification[23]

(Single Span Beam Tests With End Connections)

Specimen No.	Test Data per Specimen		Computed Data per specimen				$\frac{(M)_{test}}{(M'_u)_{comp}}$	$\frac{(P)_{test}}{(P'_u)_{comp}}$	$\frac{B^*}{1.42}$
	$(P)_{test}$ (kips)	$(M)_{test}$ (in.-kips)	$(P'_u)_{comp}$ (kips)	$(M_{u1})_{comp}$ (in.-kips)	$(M_{u2})_{comp}$ (in.-kips)	$(M_{u3})_{comp}$ (in.-kips)			
BC - 2C	1.170	21.083	3.946	23.168	23.256	23.168	0.910	0.297	N/A**
BC - 2D	1.202	21.621	3.771	22.312	22.415	22.312	0.969	0.319	N/A
BC - 12C	1.400	29.407	3.672	39.247	40.580	39.247	0.749	0.381	N/A
BC - 12D	1.405	29.554	3.697	38.957	40.262	38.957	0.759	0.380	N/A
BC - 16C	0.867	18.183	2.487	16.162	16.454	16.162	1.125	0.349	N/A
BC - 16D	0.872	18.288	2.566	16.455	16.730	16.455	1.111	0.340	N/A
BC - 19C	1.200	19.785	5.523	19.851	22.211	19.851	0.997	0.217	N/A
BC - 19D	1.180	19.417	5.176	18.807	21.083	18.807	1.032	0.228	N/A

* $B = 1.07\ (P)_{test}/(P'_u)_{comp} + (M)_{test}/(M_u)_{comp}$

** The interaction formula is not applicable because the $(P)_{test}/(P'_u)_{comp}$ ratio is less than 0.393.

TABLE 21a

Dimensions of Steel Deck Specimens used for Continuous Beam Tests

Specimen No.	No. of Spans	No. of Webs per Specimen	No. of Top Stiffener	No. of Bottom Stiffener	Type of Sidelap	Cross - Section Dimensions (in.)						
						T	D	D_T	D_B	D_E	W_1	W_2
CB - 1A	2	4	1	1	3	0.0297	2.020	0.300	0.300	1.020	2.090	1.300
CB - 1B	2	4	1	1	3	0.0301	2.020	0.300	0.300	1.020	2.090	1.300
CB - 2A	2	4	1	1	3	0.0300	2.020	0.300	0.300	1.020	2.090	1.300
CB - 2B	2	4	1	1	3	0.0295	2.020	0.300	0.300	1.020	2.090	1.300
CB - 3A	3	4	1	1	3	0.0462	2.070	0.310	0.300	1.050	2.090	1.280
CB - 3B	3	4	1	1	3	0.0461	2.050	0.310	0.300	1.020	2.100	1.300
CB - 4A	3	4	1	1	3	0.0461	2.060	0.310	0.300	1.040	2.100	1.290
CB - 4B	3	4	1	1	3	0.0459	2.040	0.300	0.300	1.060	2.100	1.240
CB - 5A	2	4	1	1	3	0.0297	3.060	0.300	0.300	0.970	2.100	1.220
CB - 5B	2	4	1	1	3	0.0300	3.050	0.300	0.300	1.000	2.100	1.260
CB - 6A	2	4	1	1	3	0.0286	2.970	0.280	0.280	0.970	2.100	1.280
CB - 6B	2	4	1	1	3	0.0303	3.050	0.270	0.270	0.970	2.100	1.280
CB - 9A	2	4	1	1	3	0.0304	2.000	0.300	0.317	-	2.100	1.230
CB - 9B	2	4	1	1	3	0.0304	1.970	0.300	0.317	-	2.070	1.330
CB - 10A	2	4	1	1	3	0.0303	2.060	0.300	0.317	-	2.030	1.200
CB - 10B	2	4	1	1	3	0.0294	2.080	0.300	0.310	-	2.120	1.280
CB - 11A	2	4	1	1	3	0.0289	3.080	0.270	0.270	1.000	2.100	1.280
CB - 11B	2	4	1	1	3	0.0290	3.060	0.270	0.280	1.000	2.100	1.280

TABLE 21a (cont'd)

Dimensions of Steel Deck Specimens used for continuous Beam Tests

Specimen No.	No. of Spans	No. of Webs per Specimen	No. of Top Stiffener	No. of Bottom Stiffener	Type of Sidelap	Cross - Section Dimensions (in.)						
						T	D	D_T	D_B	D_E	W_1	W_2
CB - 12A	2	4	1	1	3	0.0287	3.050	0.270	0.270	1.000	2.100	1.280
CB - 12B	2	4	1	1	3	0.0303	3.050	0.270	0.270	1.000	2.100	1.280
CB - 13A	2	4	2	1	3	0.0358	2.000	0.305	0.310	0.330	1.640	1.500
CB - 13B	2	4	2	1	3	0.0359	2.000	0.305	0.310	0.330	1.640	1.500
CB - 14A	2	4	2	1	3	0.0360	1.970	0.315	0.320	0.310	1.640	1.500
CB - 14B	2	4	2	1	3	0.0359	1.970	0.315	0.320	0.310	1.640	1.500
CB - 15A	2	4	1	-	3	0.0358	3.020	0.300	-	0.430	3.500	1.390
CB - 15B	2	4	1	-	3	0.0356	3.020	0.300	-	0.430	3.500	1.390
CB - 16A	2	4	1	-	3	0.0358	3.020	0.300	-	0.430	3.500	1.390
CB - 16B	2	4	1	-	3	0.0358	3.020	0.300	-	0.430	3.500	1.390
CB - 19A	2	8	-	-	1	0.0297	1.910	-	-	-	0.520	0.740
CB - 19B	2	8	-	-	1	0.0285	1.910	-	-	-	0.470	0.740
CB - 20A	2	8	-	-	1	0.0286	1.910	-	-	-	0.420	0.740
CB - 20B	2	8	-	-	1	0.0282	1.910	-	-	-	0.470	0.740

Notes: 1. For definitions of symbols, see Figs. 3 and 38.

2. Specimens 1, 2, 3, 4, 5, 6, 19 and 20 have flat webs. Other specimens have embossments in their webs.

TABLE 21b

Dimensions of Steel Deck Specimens used for Continuous Beam Tests

Specimen No.	Cross - Section Dimensions (in.)											
	W_3	W_4	W_5	W_6	W_7	W_8	W_9	W_{10}	W_{11}	W_{12}	S_1	S_2
CB - 1A	1.690	0.510	0.310	-	1.670	0.525	0.290	2.080	0.470	-	0.600	0.900
CB - 1B	1.690	0.510	0.310	-	1.670	0.525	0.290	2.080	0.470	-	0.600	0.900
CB - 2A	1.690	0.510	0.310	-	1.670	0.525	0.290	2.080	0.470	-	0.600	0.900
CB - 2B	1.690	0.510	0.310	-	1.670	0.525	0.290	2.080	0.470	-	0.600	0.900
CB - 3A	1.700	0.510	0.310	-	1.720	0.500	0.300	2.060	0.400	-	0.550	0.900
CB - 3B	1.720	0.510	0.310	-	1.710	0.510	0.300	2.120	0.420	-	0.650	0.900
CB - 4A	1.710	0.510	0.310	-	1.720	0.510	0.300	2.090	0.410	-	0.550	0.900
CB - 4B	1.710	0.510	0.310	-	1.710	0.510	0.300	2.120	0.460	-	0.520	1.150
CB - 5A	1.680	0.520	0.310	-	1.680	0.520	0.310	2.150	0.400	-	0.800	0.900
CB - 5B	1.680	0.520	0.310	-	1.680	0.520	0.310	2.190	0.400	-	0.600	0.900
CB - 6A	1.700	0.520	0.310	-	1.700	0.520	0.310	2.180	0.400	-	0.600	0.900
CB - 6B	1.700	0.520	0.310	-	1.700	0.520	0.310	2.180	0.400	-	0.600	0.900
CB - 9A	1.710	0.460	0.380	-	1.725	0.480	0.380	2.080	0.500	-	0.683	0.670
CB - 9B	1.730	0.450	0.380	-	1.680	0.480	0.380	2.000	0.500	-	0.680	0.680
CB - 10A	1.730	0.470	0.350	-	1.720	0.480	0.350	2.100	0.500	-	0.725	0.750
CB - 10B	1.710	0.475	0.350	-	1.720	0.480	0.350	2.100	0.500	-	0.725	0.750
CB - 11A	1.700	0.520	0.310	-	1.700	0.520	0.310	2.180	0.400	-	0.600	0.900
CB - 11B	1.700	0.520	0.310	-	1.700	0.520	0.310	2.180	0.400	-	0.600	0.900

TABLE 21b (cont'd)

Dimensions of Steel Deck Specimens used for Continuous Beam Tests

Specimen No.	Cross - Section Dimensions (in.)											
	W_3	W_4	W_5	W_6	W_7	W_8	W_9	W_{10}	W_{11}	W_{12}	S_1	S_2
CB - 12A	1.700	0.520	0.310	-	1.700	0.520	0.310	2.180	0.400	-	0.600	0.900
CB - 12B	1.700	0.520	0.310	-	1.700	0.520	0.310	2.180	0.400	-	0.600	0.900
CB - 13A	1.020	0.420	-	1.000	1.890	0.405	-	1.900	0.400	-	0.375	0.300
CB - 13B	1.020	0.420	-	1.000	1.890	0.405	-	1.900	0.400	-	0.375	0.300
CB - 14A	1.020	0.420	-	1.000	1.890	0.405	-	1.900	0.400	-	0.375	0.300
CB - 14B	1.020	0.420	-	1.000	1.890	0.405	-	1.900	0.400	-	0.375	0.300
CB - 15A	1.850	0.410	-	-	4.650	-	-	1.640	0.200	-	0.450	0.400
CB - 15B	1.850	0.410	-	-	4.650	-	-	1.640	0.200	-	0.450	0.400
CB - 16A	1.835	0.410	-	-	4.650	-	-	1.640	0.200	-	0.450	0.400
CB - 16B	1.835	0.410	-	-	4.650	-	-	1.640	0.200	-	0.450	0.400
CB - 19A	3.210	-	-	-	1.300	-	-	0.520	-	-	-	-
CB - 19B	3.210	-	-	-	1.300	-	-	0.470	-	-	-	-
CB - 20A	3.210	-	-	-	1.300	-	-	0.420	-	-	-	-
CB - 20B	3.210	-	-	-	1.300	-	-	0.470	-	-	-	-

TABLE 21c

Dimensions of Steel Deck Specimens used for Continuous Beam Tests

Specimen No.	Cross - Section Dimensions (in.)									Web Inclination (degree)	Overall Width (in.)	Overall Length (in.)
	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	h			
CB - 1A	0.205	0.205	0.215	0.280	0.215	0.265	0.200	0.120	2.21	62.6	24.63	144.0
CB - 1B	0.205	0.205	0.215	0.280	0.215	0.265	0.200	0.120	2.21	62.6	24.50	144.0
CB - 2A	0.205	0.205	0.215	0.280	0.215	0.265	0.200	0.120	2.21	62.6	24.50	144.0
CB - 2B	0.205	0.205	0.215	0.280	0.215	0.265	0.200	0.120	2.21	62.6	24.50	144.0
CB - 3A	0.210	0.200	0.210	0.280	0.200	0.265	0.180	0.120	2.16	63.8	24.75	288.0
CB - 3B	0.210	0.200	0.210	0.230	0.200	0.240	0.180	0.120	2.16	63.0	24.75	288.0
CB - 4A	0.210	0.200	0.210	0.230	0.200	0.240	0.180	0.120	2.22	63.4	24.75	288.0
CB - 4B	0.210	0.200	0.210	0.230	0.200	0.240	0.180	0.120	2.22	64.5	24.75	288.0
CB - 5A	0.200	0.200	0.220	0.230	0.220	0.240	0.150	0.120	3.12	73.5	25.00	192.0
CB - 5B	0.200	0.200	0.220	0.250	0.220	0.250	0.150	0.120	3.15	72.6	25.00	192.0
CB - 6A	0.200	0.200	0.220	0.250	0.220	0.250	0.150	0.120	3.12	71.7	25.00	192.0
CB - 6B	0.200	0.200	0.220	0.250	0.220	0.250	0.150	0.120	3.12	72.3	25.00	192.0
CB - 9A	0.190	0.210	0.220	0.250	0.235	0.220	0.233	0.167	2.07	-	24.63	144.0
CB - 9B	0.230	0.220	0.240	0.220	0.230	0.220	0.230	0.167	2.02	-	24.50	144.0
CB - 10A	0.200	0.210	0.230	0.240	0.230	0.220	0.220	0.167	2.06	-	24.63	144.0
CB - 10B	0.208	0.210	0.220	0.220	0.220	0.210	0.200	0.167	2.02	-	24.63	143.9
CB - 11A	0.200	0.200	0.220	0.250	0.220	0.250	0.150	0.120	3.11	72.4	25.00	192.0
CB - 11B	0.200	0.200	0.220	0.250	0.220	0.250	0.150	0.120	3.12	72.4	25.00	192.0

TABLE 21c (cont'd)

Dimensions of Steel Deck Specimens used for Continuous Beam Tests

Specimen No.	Cross - Section Dimensions (in.)									Web Inclination (degree)	Overall Width (in.)	Overall Length (in.)
	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	h			
CB - 12A	0.200	0.200	0.220	0.250	0.220	0.250	0.150	0.120	3.14	72.3	25.00	192.0
CB - 12B	0.200	0.200	0.200	0.250	0.220	0.250	0.150	0.120	3.15	72.3	25.00	192.0
CB - 13A	0.130	0.180	0.190	0.190	0.190	0.190	0.180	0.180	1.95	47.4	24.30	144.0
CB - 13B	0.130	0.180	0.190	0.190	0.190	0.190	0.180	0.180	1.95	47.4	24.30	144.0
CB - 14A	0.130	0.180	0.190	0.190	0.190	0.190	0.180	0.180	1.95	46.7	24.3	144.0
CB - 14B	0.130	0.180	0.190	0.190	0.190	0.190	0.180	0.180	1.95	46.7	24.3	144.0
CB - 15A	0.130	0.190	0.190	0.190	-	-	0.180	0.180	2.78	64.9	24.6	168.0
CB - 15B	0.130	0.190	0.190	0.190	-	-	0.180	0.180	2.78	64.9	24.5	168.0
CB - 16A	0.130	0.190	0.190	0.190	-	-	0.180	0.180	2.78	64.9	24.4	168.0
CB - 16B	0.130	0.190	0.190	0.190	-	-	0.180	0.180	2.78	64.9	24.5	168.0
CB - 19A	0.130	0.130	-	-	-	-	-	-	1.91	74.6	23.7	144.3
CB - 19B	0.130	0.130	-	-	-	-	-	-	1.91	74.6	23.6	144.3
CB - 20A	0.130	0.130	-	-	-	-	-	-	1.91	74.6	23.5	144.3
CB - 20B	0.130	0.130	-	-	-	-	-	-	1.91	74.6	23.6	144.3

TABLE 22

Design Parameters for Steel Deck Specimens used for Combined Bending-Web Crippling Tests

Continuous Beam Tests

Specimen No.	Thickness t (in.)	Inside* Bend Radius R_1 (in.)	Computed Web Width h (in.)	Bearing Length Inter. Support N_1 (in.)	Bearing Length End Support N_2 (in.)	Computed Web Inclination θ (degrees)	R_1/t	h/t	N_1/t	N_1/h	Yield Point F_y (ksi)	Span Length (in.)
CB - 1A	0.0297	0.205	2.21	2.98	5.93	62.6	6.90	74.41	100.34	1.35	48.2	69.04
CB - 1B	0.0301	0.205	2.21	2.98	5.93	62.6	6.81	73.42	99.00	1.35	48.2	69.04
CB - 2A	0.0300	0.205	2.21	5.93	7.86	62.6	6.83	73.67	197.67	2.68	48.2	68.07
CB - 2B	0.0295	0.205	2.21	5.93	7.86	62.6	6.95	74.92	201.02	2.68	48.2	68.07
CB - 3A**	0.0462	0.210	2.20	2.98	5.93	63.8	4.55	47.62	64.50	1.35	44.9	94.02
CB - 3B**	0.0461	0.210	2.20	2.98	5.93	63.0	4.56	47.72	64.64	1.35	44.9	94.02
CB - 4A**	0.0461	0.210	2.20	5.93	7.86	63.4	4.56	47.72	128.63	2.70	44.9	93.38
CB - 4B**	0.0459	0.210	2.16	5.93	7.86	64.5	4.58	47.06	129.19	2.75	44.9	93.38
CB - 5A	0.0297	0.200	3.13	2.98	5.93	73.5	6.73	105.39	100.34	0.95	50.4	93.04
CB - 5B	0.0300	0.200	3.13	2.98	5.93	72.6	6.67	104.33	99.33	0.95	50.4	93.04
CB - 6A	0.0286	0.200	3.07	5.93	7.86	71.7	6.99	107.34	207.34	1.93	50.4	92.07
CB - 6B	0.0303	0.200	3.14	5.93	7.86	72.3	6.60	103.63	195.71	1.89	50.4	92.07
CB - 9A	0.0304	0.190	2.16	2.98	5.93	64.0	6.25	71.05	98.03	1.38	46.0	68.00
CB - 9B	0.0304	0.230	2.17	2.98	5.93	61.7	7.57	71.38	98.03	1.37	46.0	68.00
CB - 10A	0.0303	0.200	2.19	5.93	7.86	65.7	6.60	72.28	195.71	2.71	46.0	68.00
CB - 10B	0.0294	0.208	2.25	5.93	7.86	64.0	7.07	76.53	201.70	2.64	46.0	68.00
CB - 11A	0.0289	0.200	3.17	2.98	5.93	72.4	6.92	109.69	103.11	0.94	51.0	93.04
CB - 11B	0.0290	0.200	3.15	2.98	5.93	72.3	6.90	109.57	102.76	0.95	51.0	93.04

TABLE 22 (cont'd)

Design Parameters for Steel Deck Specimens used for Combined Bending-Web Crippling Tests

Continuous Beam Tests

Specimen No.	Thickness t (in.)	Inside* Bend Radius R_1 (in.)	Computed Web Width h (in.)	Bearing Length Inter. Support N_1 (in.)	Bearing Length End Support N_2 (in.)	Computed Web Inclination θ (degree)	R_1/t	h/t	N_1/t	N_1/h	Yield Point F_y (ksi)	Span Length (in.)
CB - 12A	0.0287	0.200	3.14	5.93	7.86	72.3	6.97	109.41	206.62	1.89	51.0	92.07
CB - 12B	0.0303	0.200	3.14	5.93	7.86	72.3	6.60	103.63	195.71	1.89	51.0	92.07
CB - 13A	0.0358	0.180	1.94	2.98	5.93	47.4	5.03	54.19	83.24	1.54	46.4	69.04
CB - 13B	0.0359	0.180	1.94	2.98	5.93	47.4	5.01	54.04	83.01	1.54	46.4	69.04
CB - 14A	0.0360	0.180	1.92	5.93	7.86	46.7	5.00	53.33	164.72	3.09	46.4	68.07
CB - 14B	0.0359	0.190	1.92	5.93	7.86	46.7	5.01	53.48	165.18	3.09	46.4	68.07
CB - 15A	0.0358	0.190	2.70	2.98	5.93	64.9	5.31	75.42	83.24	1.10	45.5	81.04
CB - 15B	0.0356	0.190	2.70	2.98	5.93	64.9	5.34	75.84	83.71	1.10	45.5	81.04
CB - 16A	0.0358	0.190	2.70	5.93	7.86	64.9	5.31	75.42	165.64	2.20	45.5	80.07
CB - 16B	0.0358	0.190	2.70	5.93	7.86	64.9	5.31	75.42	165.64	2.20	45.5	80.07
CB - 19A	0.0297	0.130	1.92	2.98	5.93	74.6	4.38	64.65	100.34	1.55	44.2	69.19
CB - 19B	0.0285	0.130	1.92	2.98	5.93	74.5	4.56	67.37	104.56	1.55	44.2	69.19
CB - 20A	0.0286	0.130	1.92	5.93	7.86	74.5	4.55	67.13	207.34	3.09	44.2	68.22
CB - 20B	0.0282	0.130	1.92	5.93	7.86	74.5	4.61	68.09	210.28	3.09	44.2	68.22

* Use R_2 for CB-13, 14, 15 and 16.

** Specimen Nos. 3A, 3B, 4A and 4B were tested as three-span continuous beams. Other specimens were tested as two-span continuous beams.

TABLE 23

Comparison of the Tested and Computed Results for Combined Bending-Web Crippling
Based on the 1980 Edition of the AISI Specification[23]
Continuous Beam Tests

Specimen No.	Test Data per Specimen			Computed Data per Specimen			$\frac{(M)_{test}}{(M'_u)_{comp}}$	$\frac{(P)_{test}}{(P'_u)_{comp}}$	$\frac{B^*}{1.42}$
	$(w)_{test}$ (kips/ft)	$(P)_{test}$ (kips)	$(M)_{test}$ (in.-kips)	$(P'_u)_{comp}$ (kips)	$(M'_{u1})_{comp}$ (in.-kips)	$(M'_{u3})_{comp}$ (in.-kips)			
CB - 1A	0.564	4.056	28.00	2.275	26.00	26.00	1.077	1.783	2.102
CB - 1B	0.582	4.186	28.90	2.341	26.46	26.46	1.092	1.788	2.116
CB - 2A	0.613	4.347	29.59	3.696	26.34	26.34	1.123	1.176	1.677
CB - 2B	0.637	4.517	30.75	3.573	25.77	25.77	1.193	1.264	1.793
CB - 3A	0.619	5.335	45.60	5.276	44.14	44.14	1.033	1.011	1.489
CB - 3B	0.639	5.507	47.07	5.233	43.78	43.78	1.075	1.052	1.550
CB - 4A	0.722	6.180	52.46	7.785	43.94	43.94	1.194	0.794	1.439
CB - 4B	0.720	6.163	52.32	7.782	43.38	43.38	1.206	0.792	1.446
CB - 5A	0.479	4.642	43.19	2.411	46.99	45.30	0.953	1.926	2.122
CB - 5B	0.460	4.458	41.48	2.452	47.16	45.56	0.910	1.818	2.011
CB - 6A	0.498	4.776	43.97	3.528	42.98	41.27	1.065	1.354	1.770
CB - 6B	0.515	4.939	45.47	3.967	47.97	46.42	0.980	1.245	1.628
CB - 9A	0.620	4.390	29.85	2.308	24.87	24.87	1.200	1.902	2.278
CB - 9B	0.613	4.361	29.65	2.209	24.36	24.56	1.207	1.974	2.337
CB - 10A	0.679	4.811	32.72	3.668	25.85	25.85	1.266	1.312	1.880
CB - 10B	0.657	4.651	31.63	3.407	25.06	25.06	1.262	1.365	1.917
CB - 11A	0.396	3.838	35.71	2.268	46.12	44.00	0.812	1.693	1.848
CB - 11B	0.413	4.003	37.24	2.286	45.93	43.92	0.848	1.751	1.917

TABLE 23 (cont'd)

Comparison of the Tested and Computed Results for Combined Bending-Web Crippling Based on the 1980 Edition of the AISI Specification[23]

Continuous Beam Tests

Specimen No.	Test Data per Specimen			Computed Data per Specimen			$\frac{(M)_{test}}{(M'_u)_{comp}}$	$\frac{(P)_{test}}{(P'_u)_{comp}}$	$\frac{B^*}{1.42}$
	$(w)_{test}$ (kips/ft)	$(P)_{test}$ (kips)	$(M)_{test}$ (in.-kips)	$(P'_u)_{comp}$ (kips)	$(M_{u1})_{comp}$ (in.-kips)	$(M'_{u3})_{comp}$ (in.-kips)			
CB - 12A	0.438	4.201	38.68	3.575	45.12	43.06	0.898	1.175	1.518
CB - 12B	0.431	4.134	38.06	3.996	48.38	46.76	0.814	1.035	1.353
CB - 13A	0.490	3.524	24.33	3.248	35.53	35.53	0.685	1.085	1.300
CB - 13B	0.462	3.323	22.94	3.265	35.63	35.63	0.644	1.018	1.221
CB - 14A	0.508	3.602	24.52	5.064	35.01	35.01	0.700	0.711	1.029
CB - 14B	0.571	4.049	27.56	5.039	34.91	34.91	0.789	0.804	1.161
CB - 15A	0.482	4.069	32.97	3.319	49.50	49.50	0.666	1.226	1.393
CB - 15B	0.492	4.153	33.66	3.282	49.14	49.14	0.685	1.266	1.436
CB - 16A	0.490	4.087	32.72	5.134	49.50	49.50	0.661	0.756	1.035
CB - 16B	0.533	4.446	35.60	5.134	49.50	49.50	0.719	0.866	1.159
CB - 19A	0.508	3.661	25.33	5.770	20.95	20.95	1.209	0.634	1.329
CB - 19B	0.494	3.560	24.63	5.348	19.73	19.73	1.248	0.666	1.381
CB - 20A	0.544	3.866	26.37	8.619	19.61	19.61	1.345	0.449	1.286
CB - 20B	0.570	4.051	27.63	8.415	19.48	19.48	1.418	0.481	1.361

Mean Value 1.603

Coefficient of Variation 0.228

* $B = 1.07\,(P)_{test}/(P'_u)_{comp} + (M)_{test}/(M'_u)_{comp}$

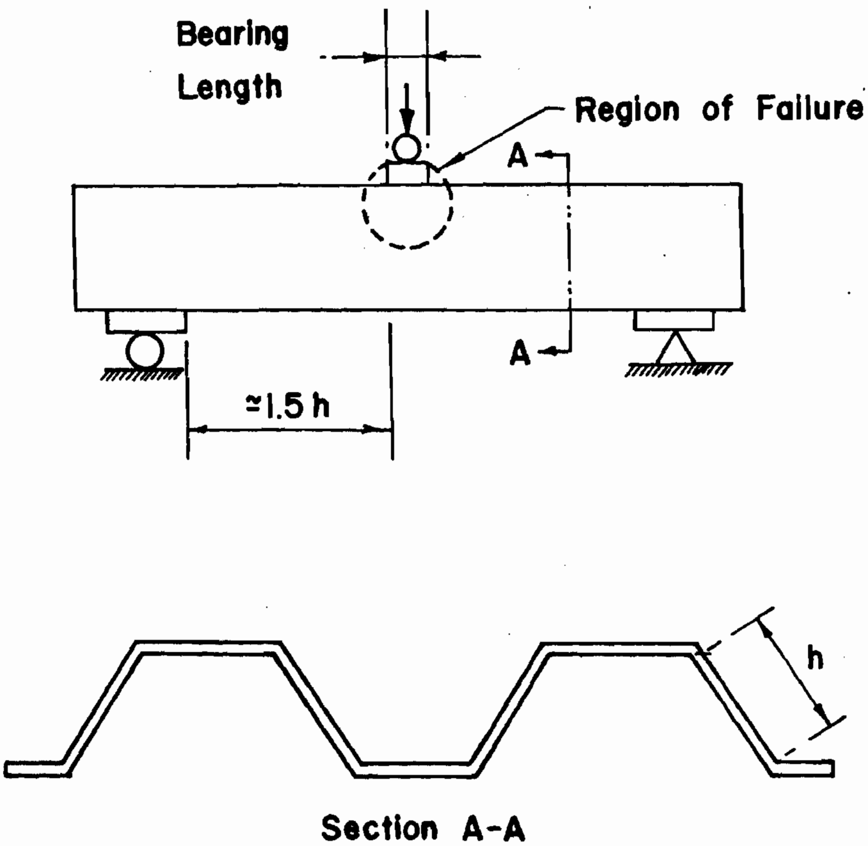
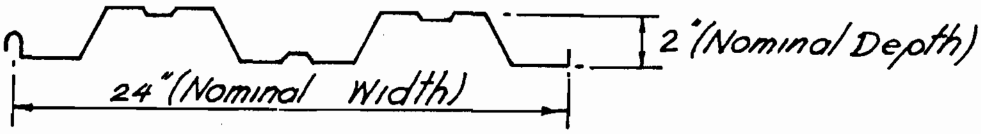
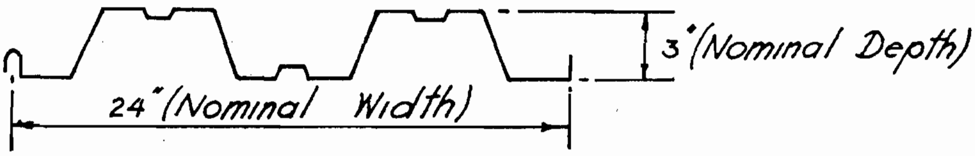


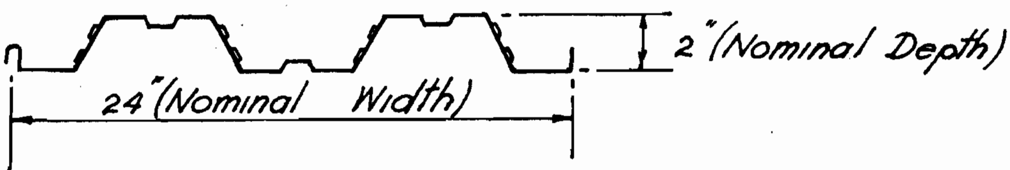
Fig. 1 Simple Beam Test Used for Interior One-Flange Loading



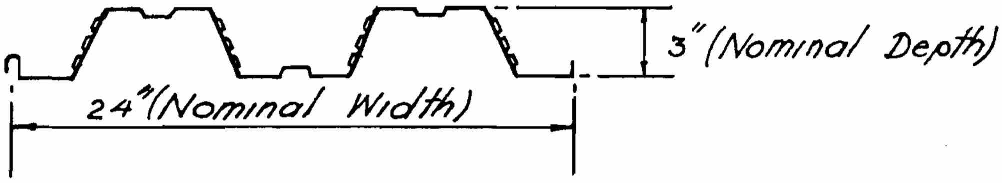
(a) Specimens 1A, 1B, 2A, 2B (Nominal t = 0.0295 in.)
Specimens 3A, 3B, 4A, 4B (Nominal t = 0.0474 in.)



(b) Specimens 5A, 5B, 6A, 6B (Nominal t = 0.0295 in.)
Specimens 7A, 7B, 8A, 8B (Nominal t = 0.0474 in.)

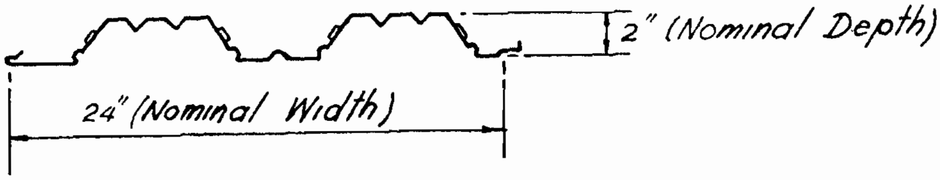


(c) Specimens 9A, 9B, 10A, 10B (Nominal t = 0.0295 in.)

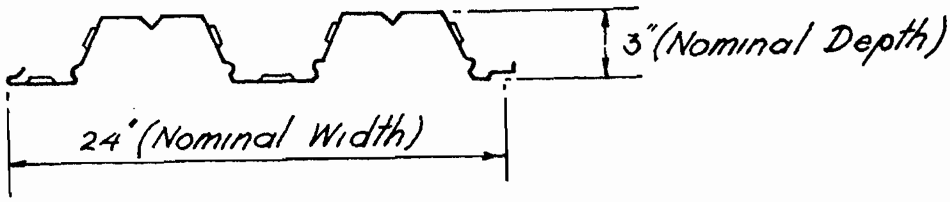


(d) Specimens 11A, 11B, 12A, 12B (Nominal t = 0.0295 in.)

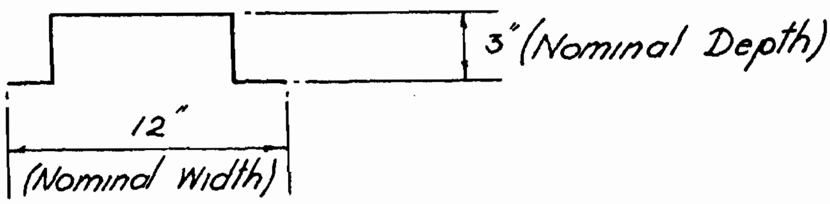
Fig. 2 Cross-Sectional Configurations of Steel Decks (IOF Series)



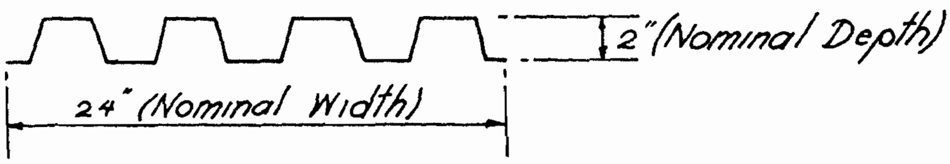
(e) Specimens 13A, 13B, 14A, 14B (Nominal t = 0.0358 in.)



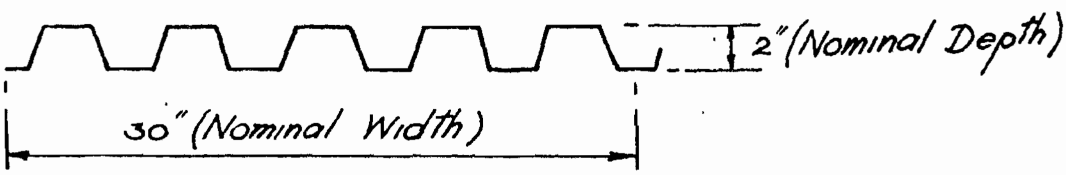
(f) Specimens 15A, 15B, 16A, 16B (Nominal t = 0.0358 in.)



(g) Specimens 17A, 17B, 18A, 18B (Nominal t = 0.0295 in.)



(h) Specimens 20A, 20B (Nominal t = 0.0295 in.)
(cut from the 30 in. wide panels)



(i) Specimens 19A, 19B (Nominal t = 0.0295 in.)

Fig. 2 Cross-Sectional Configurations of Steel Decks (Continued)

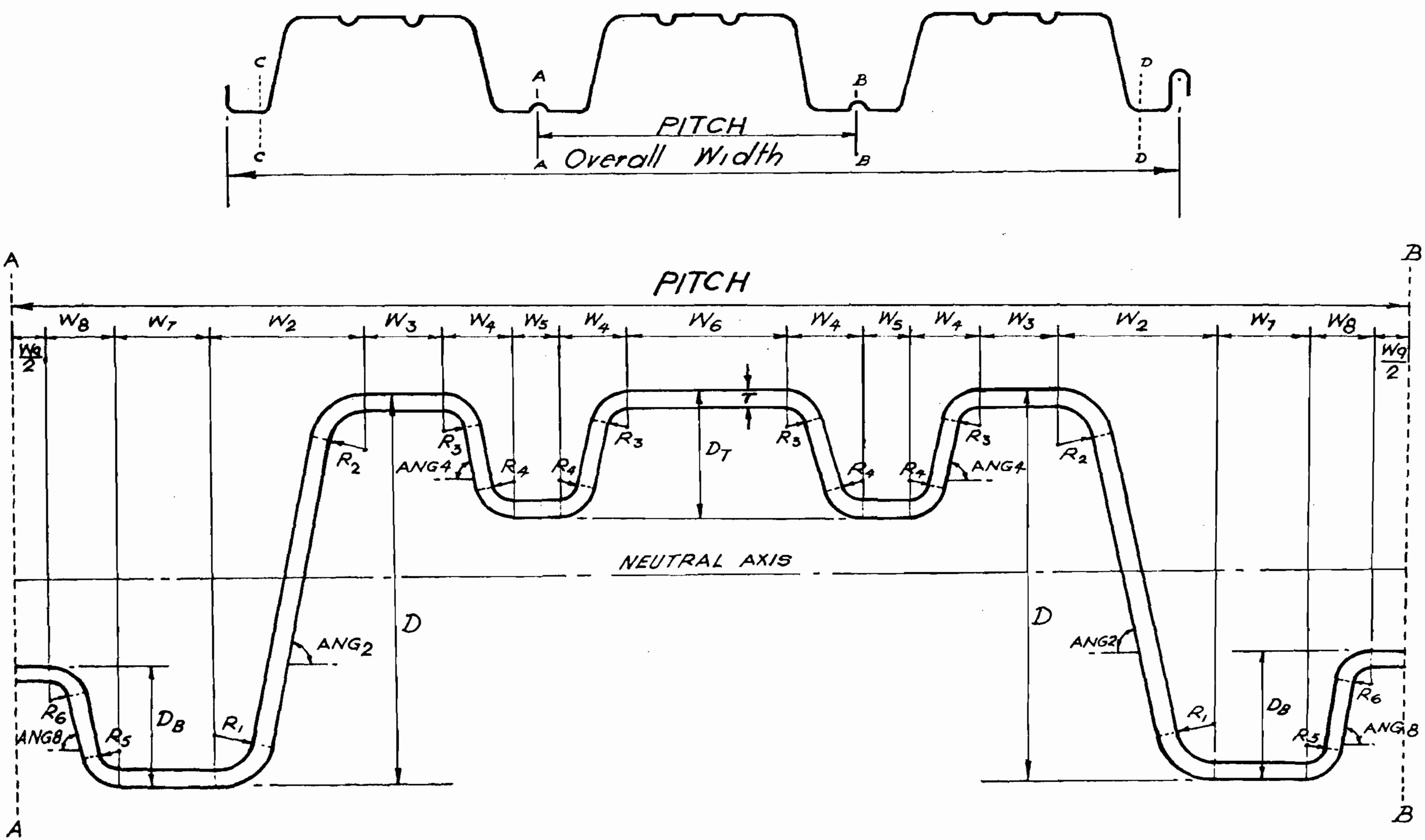


Fig. 3a Dimensions of Test Specimens
(For sidelaps, see Fig. 3b; for Specimens
Nos. 13, 14, 15, and 16,
See Fig. 3c for additional dimensions.)

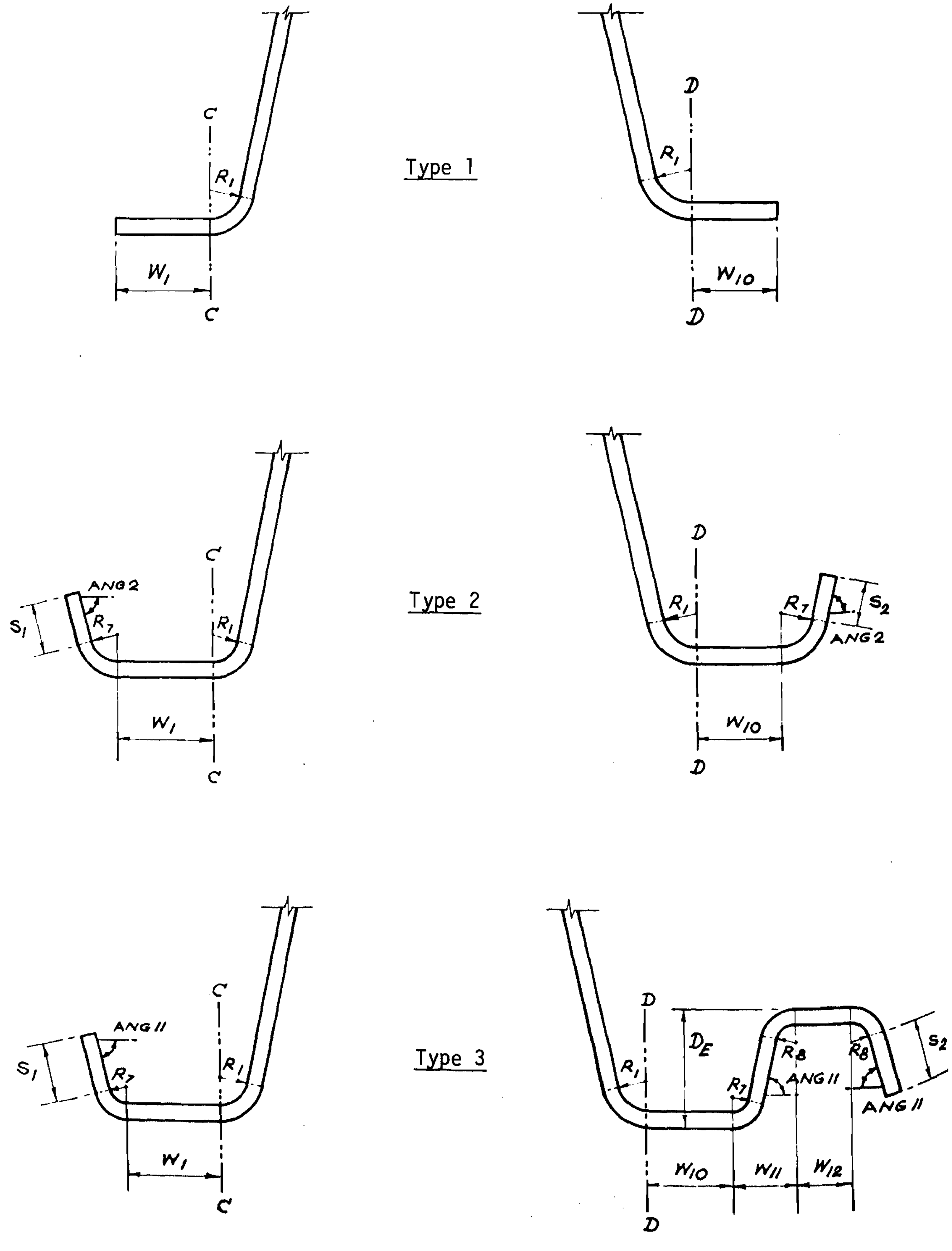


Fig. 3b Types of Sidelaps

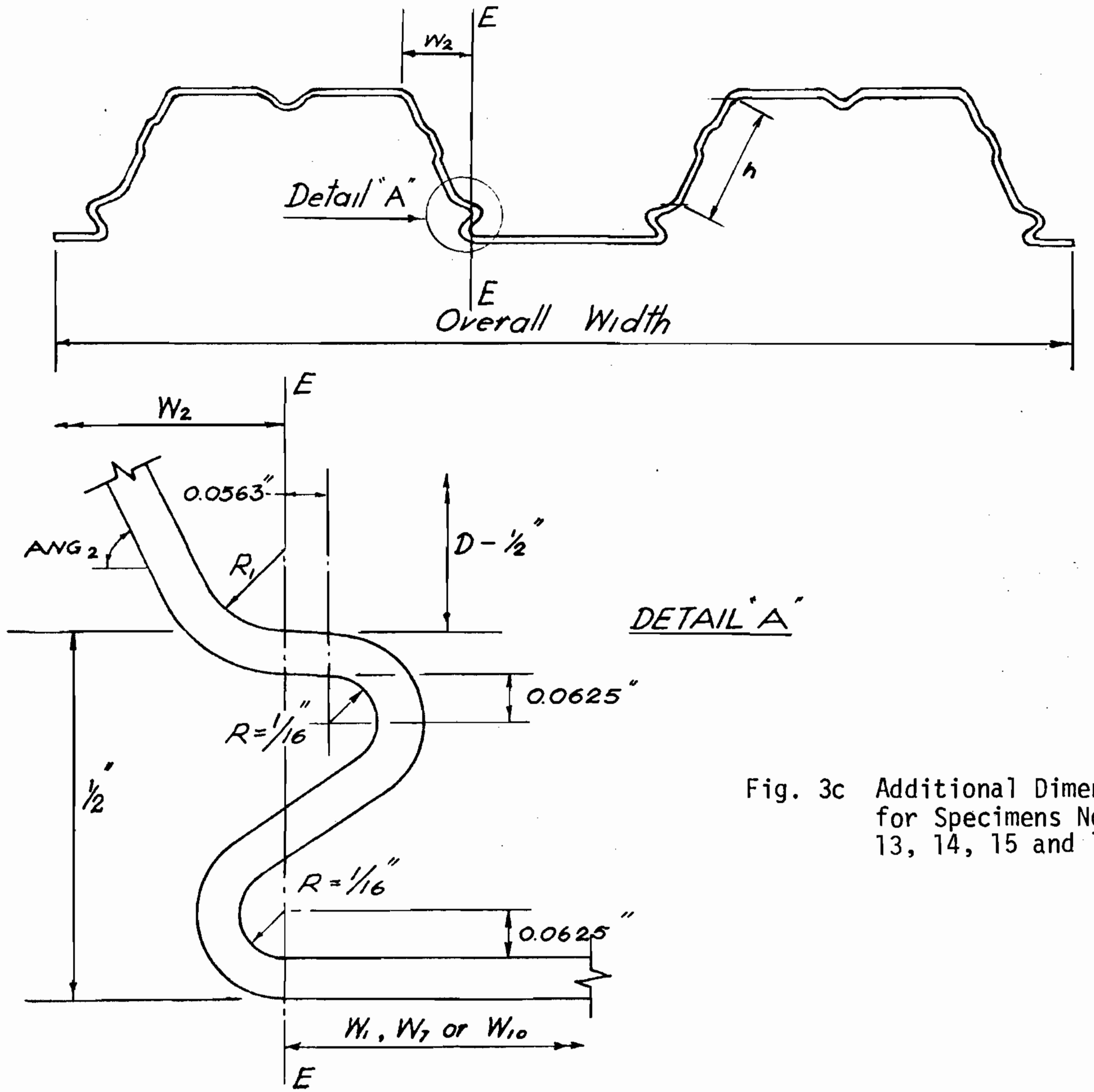


Fig. 3c Additional Dimensions for Specimens Nos. 13, 14, 15 and 16

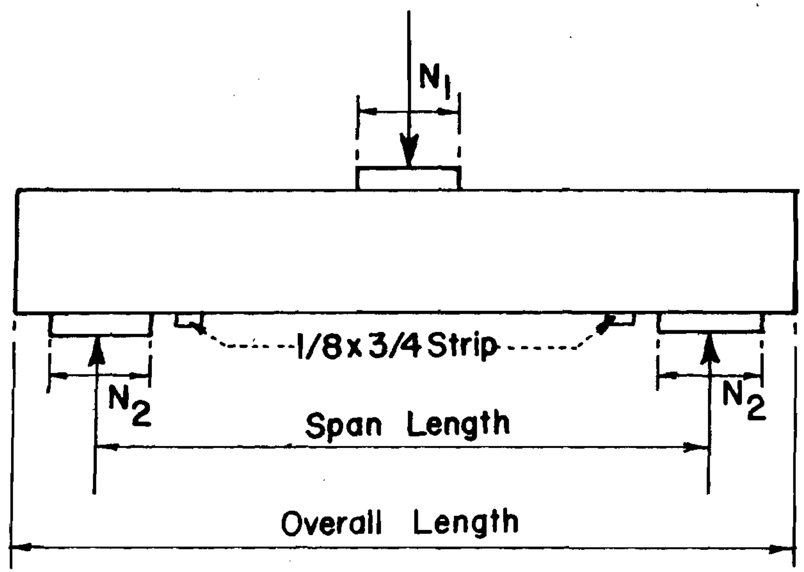


Fig. 4 Test Setup used for Interior One-Flange Loading

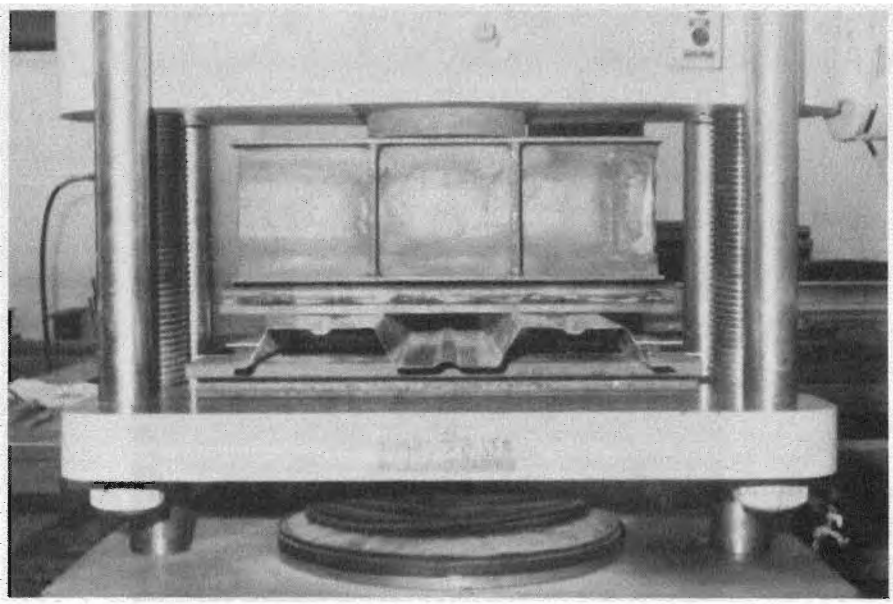


Fig. 5 Photograph Showing the Test Setup
Used for Interior One-Flange Loading

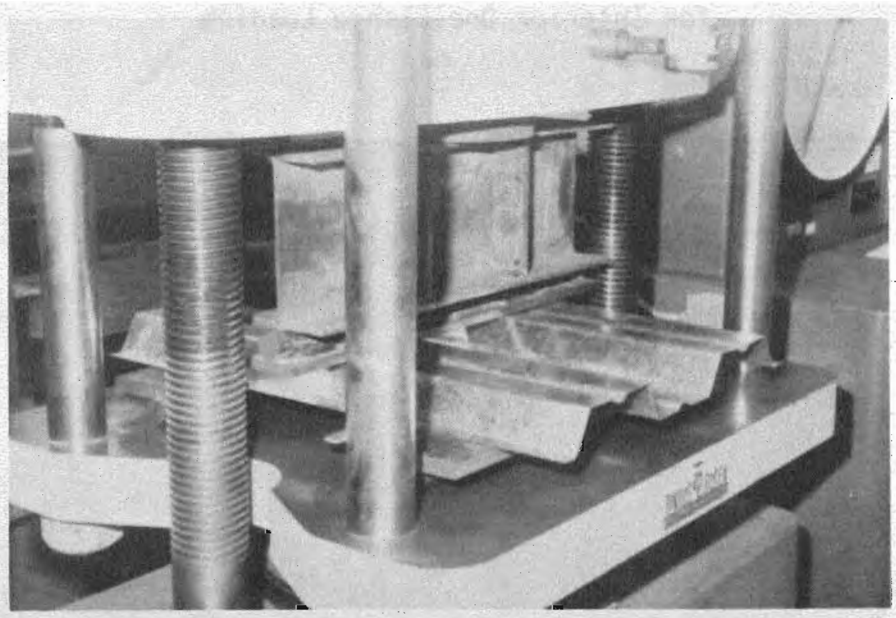


Fig. 6 Photograph Showing the Test Setup
Used for Interior One-Flange Loading

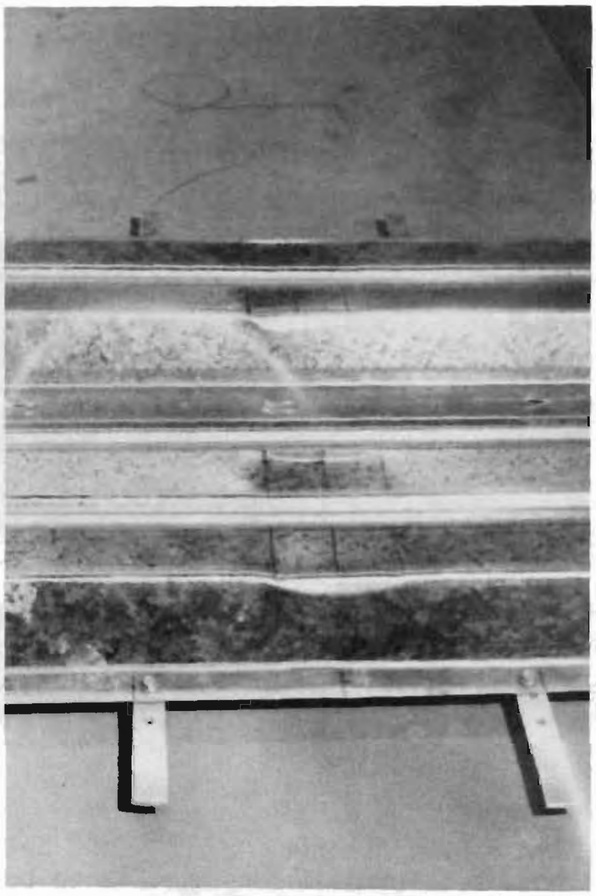


Fig. 7 Photgraph Showing the Typical Failure Mode for Interior One-Flange Loading

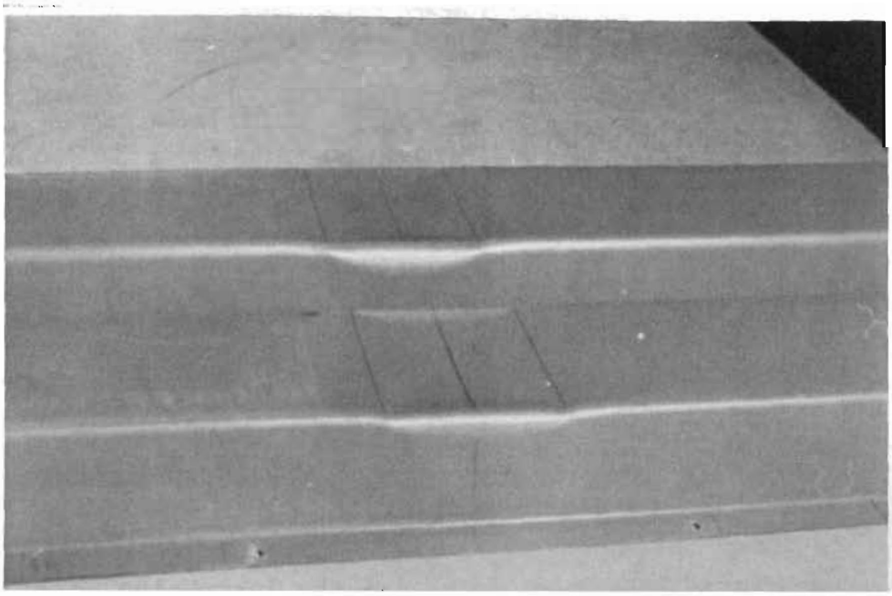


Fig. 8 Photgraph Showing the Typical Failure Mode for Interior One-Flange Loading

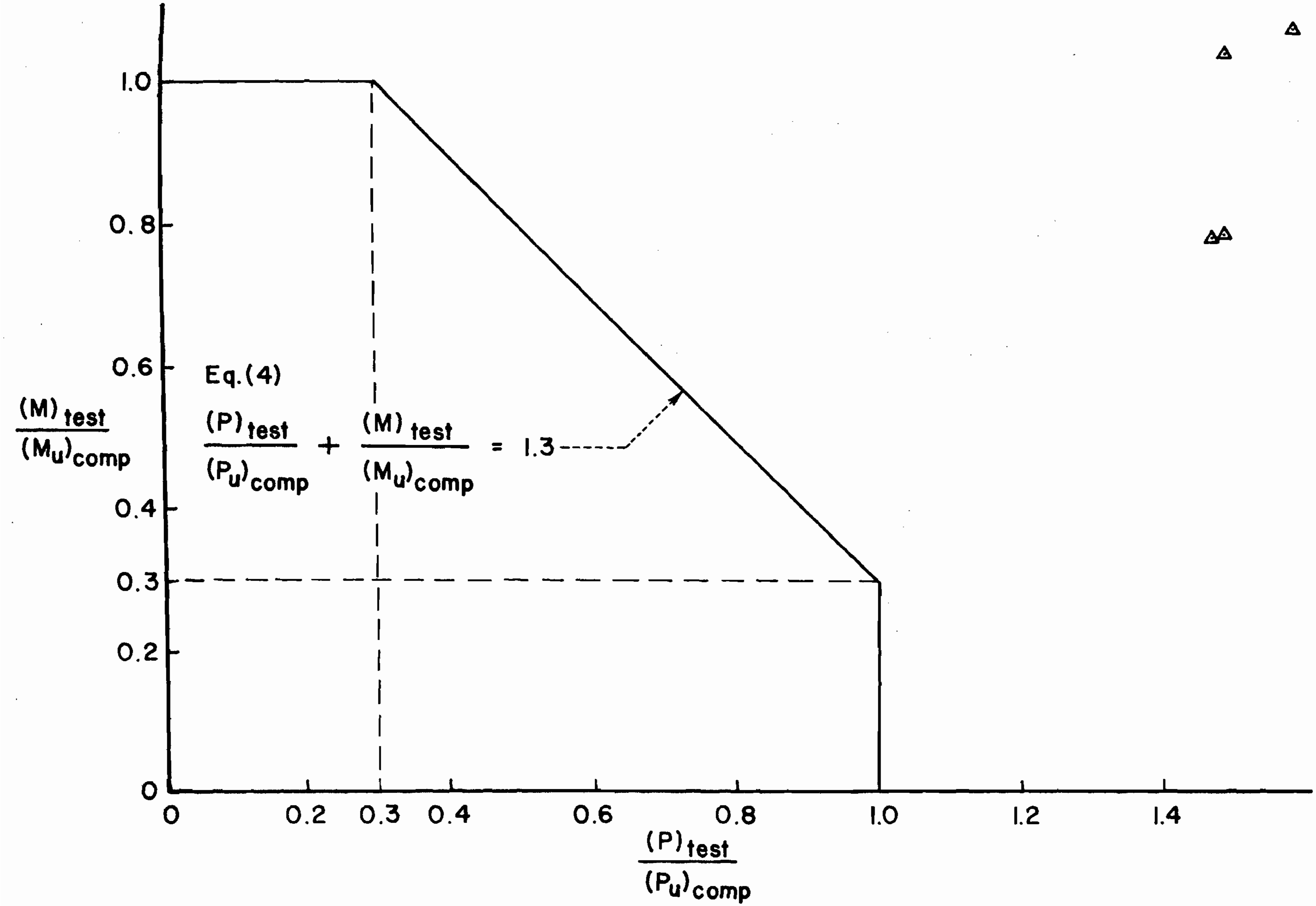


Fig. 9 Correlation Between the Test Results on Interior One-Flange Loading and the Interaction Formula Used for the 1968 AISI Specification (Shear Lag is considered)

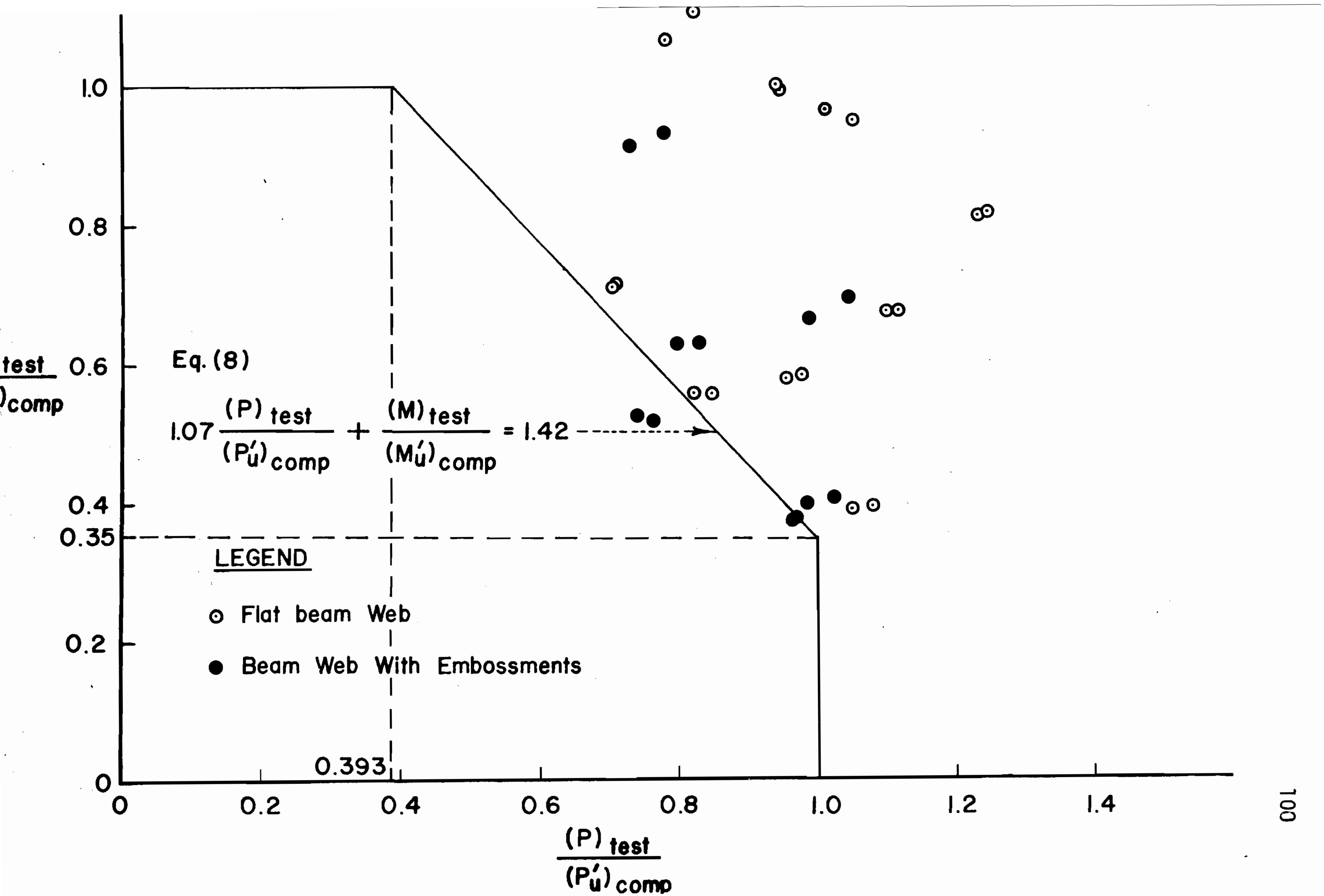


Fig. 10 Correlation Between the Test Results on Interior One-Flange Loading and the Interaction Formula Used for the 1980 Edition of the AISI Specification (Shear Lag is considered)

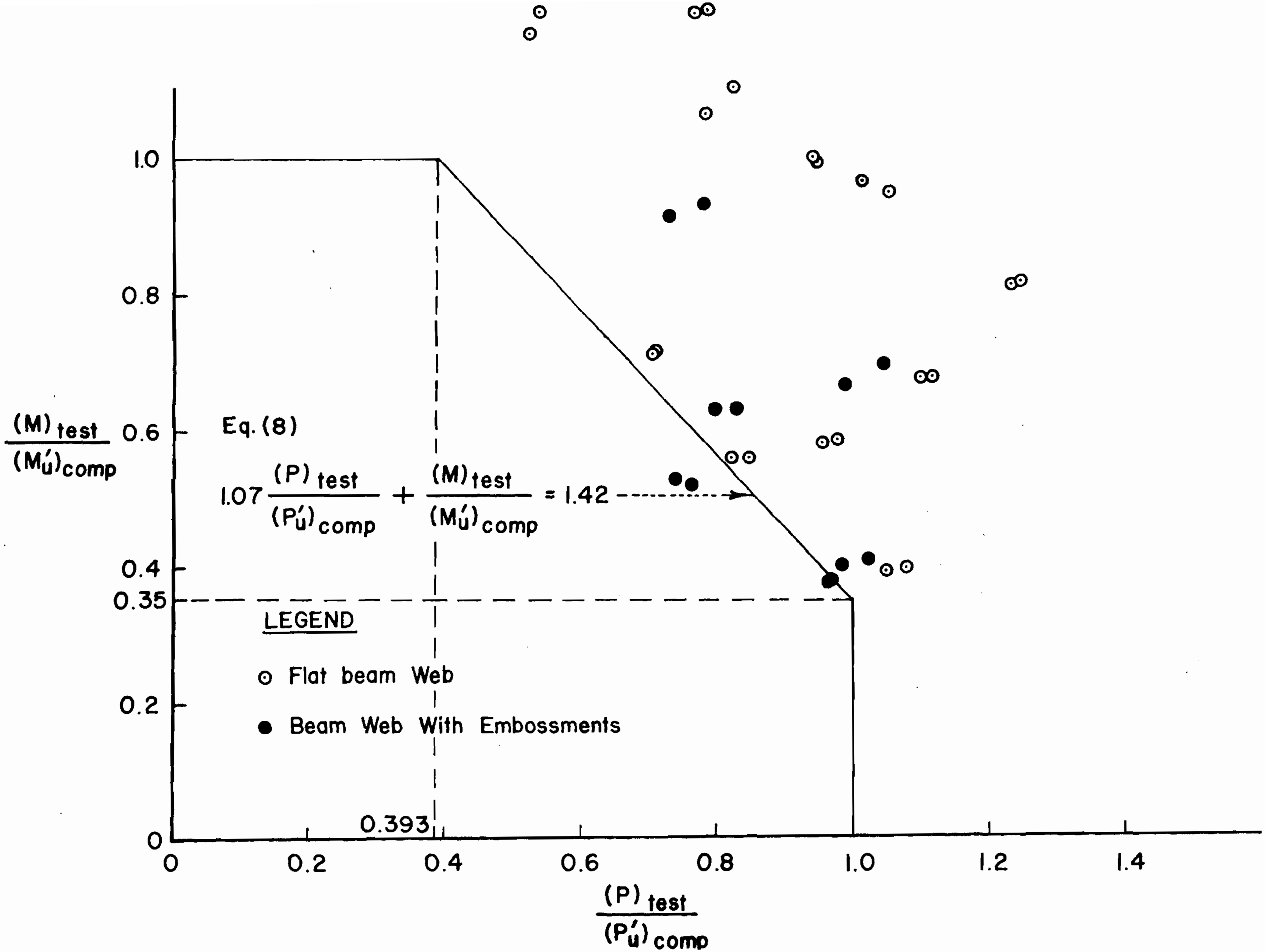


Fig. 10 Correlation Between the Test Results on Interior One-Flange Loading and the Interaction Formula Used for the 1980 Edition of the AISI Specification (Shear Lag is considered)

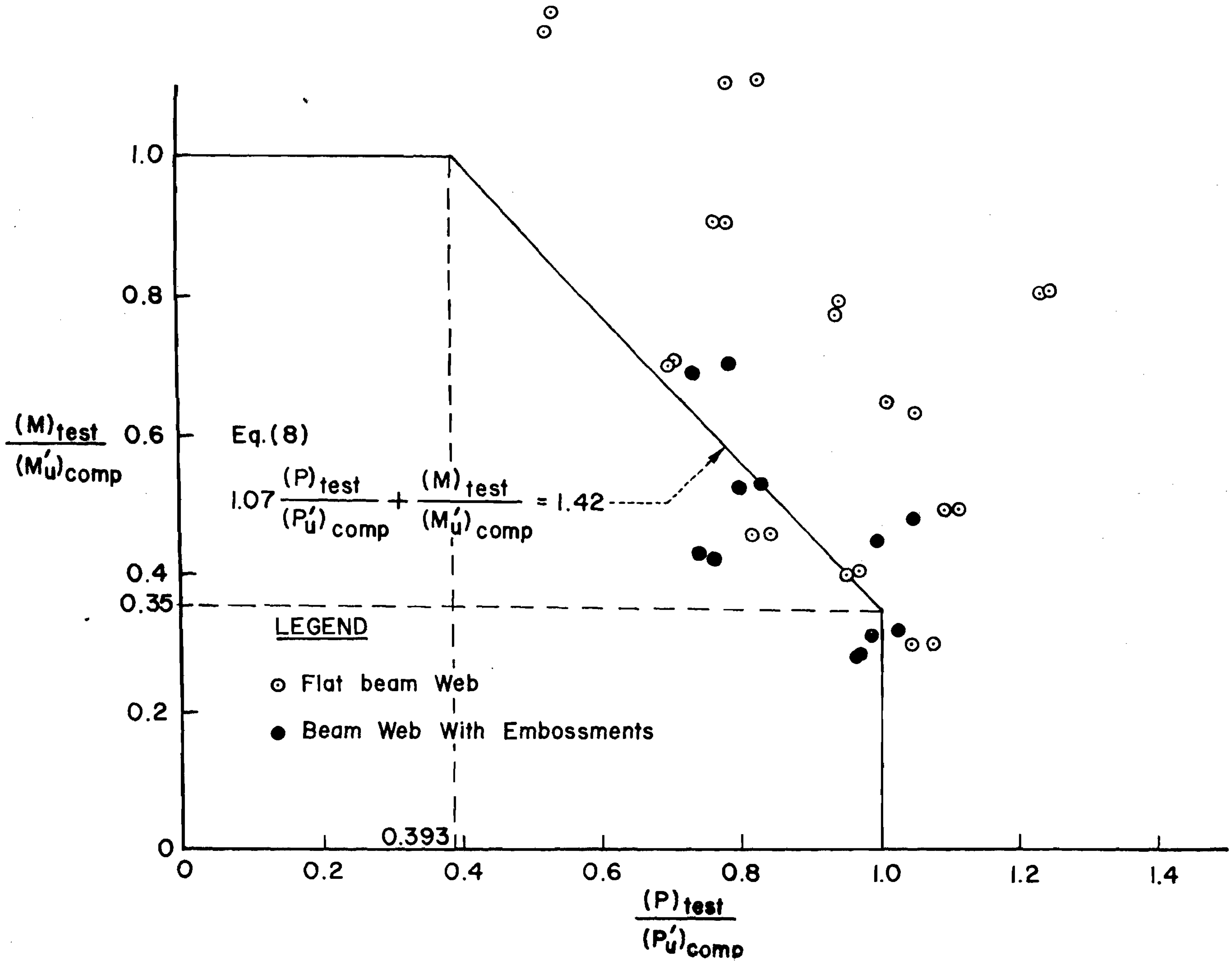


Fig. 11 Correlation Between the Test Results on Interior One-Flange Loading and the Interaction Formula Used for the 1980 Edition of the AISI Specification (Shear Lag is neglected)

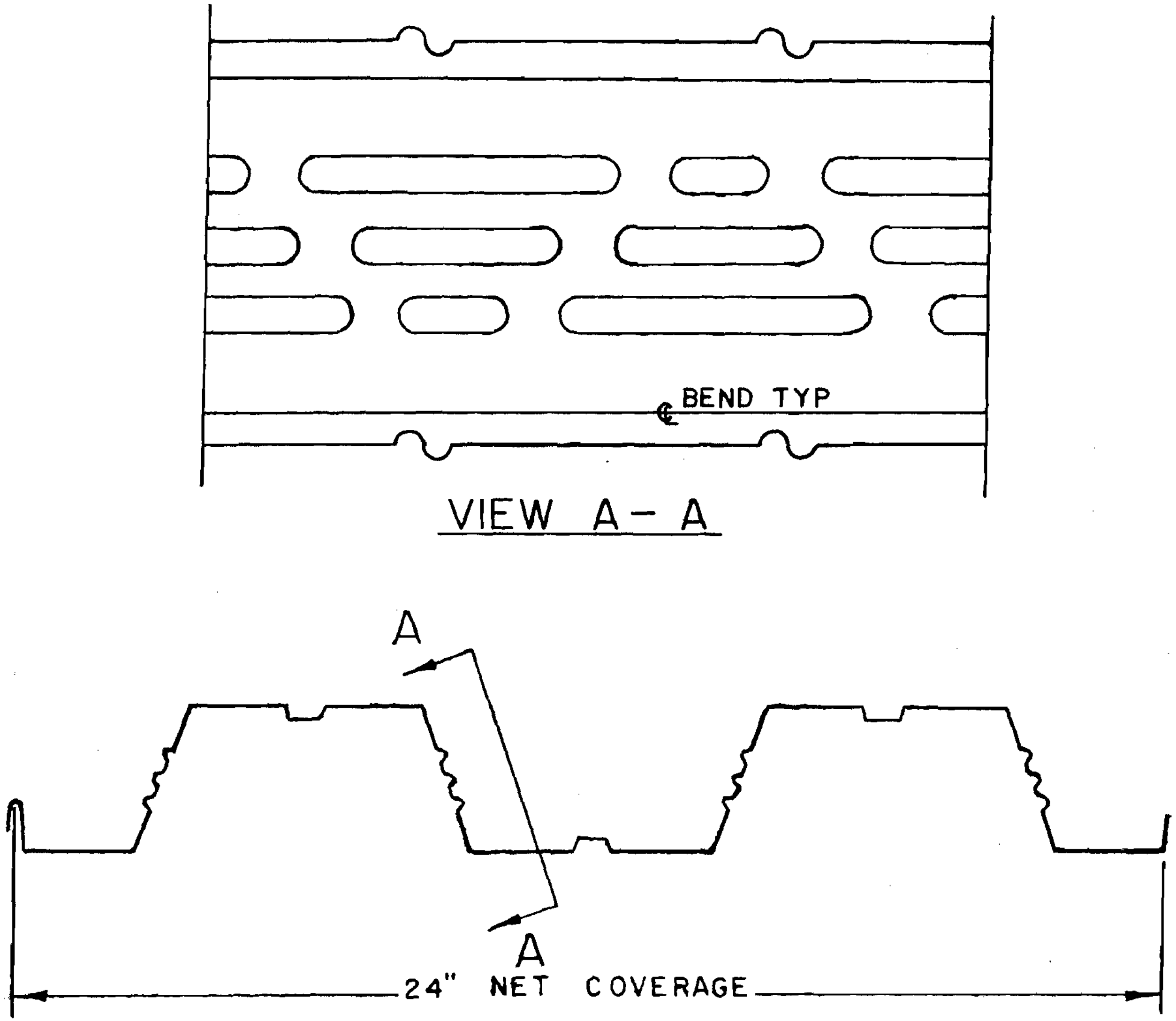


Fig. 12 Arrangement of Embossments in the Webs of Specimens Nos. 9, 10, 11, and 12

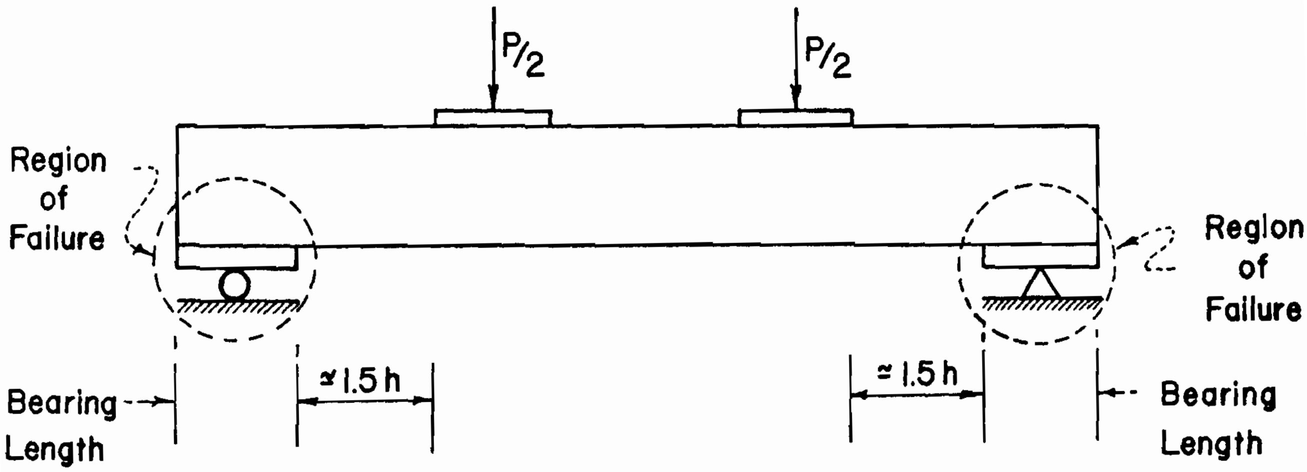


Fig. 13 Simple Beam Test Used for End One-Flange Loading

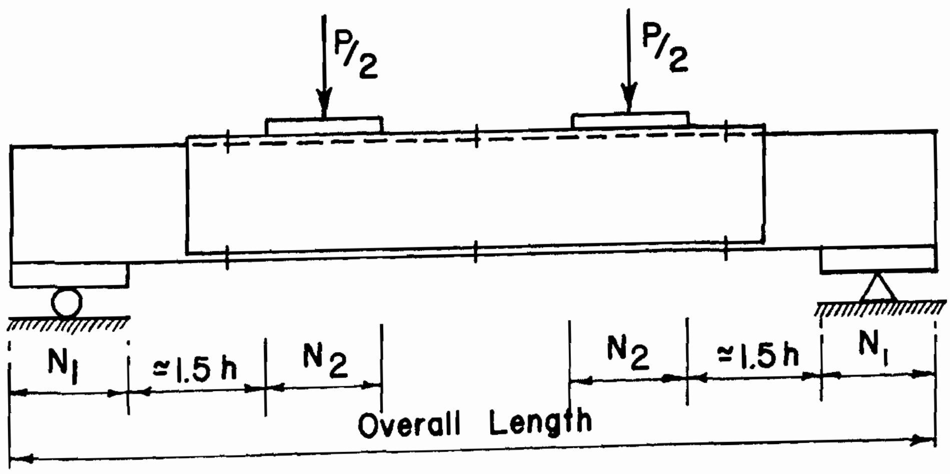


Fig. 14 Test Setup Used for End One-Flange Loading

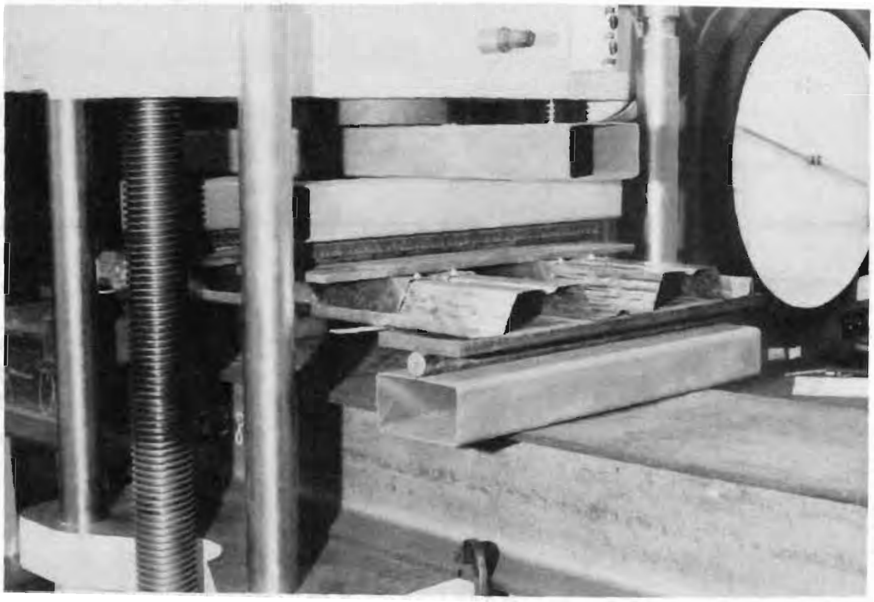


Fig. 15. Photograph Showing the Test Setup Used for End One-Flange Loading

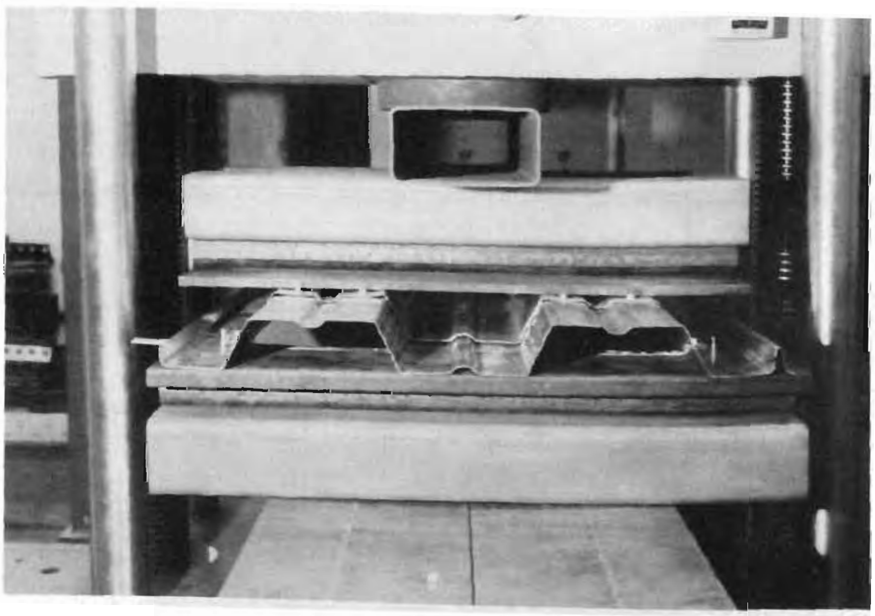


Fig. 16 Photgraph Showing the Test Setup Used for End One-Flange Loading

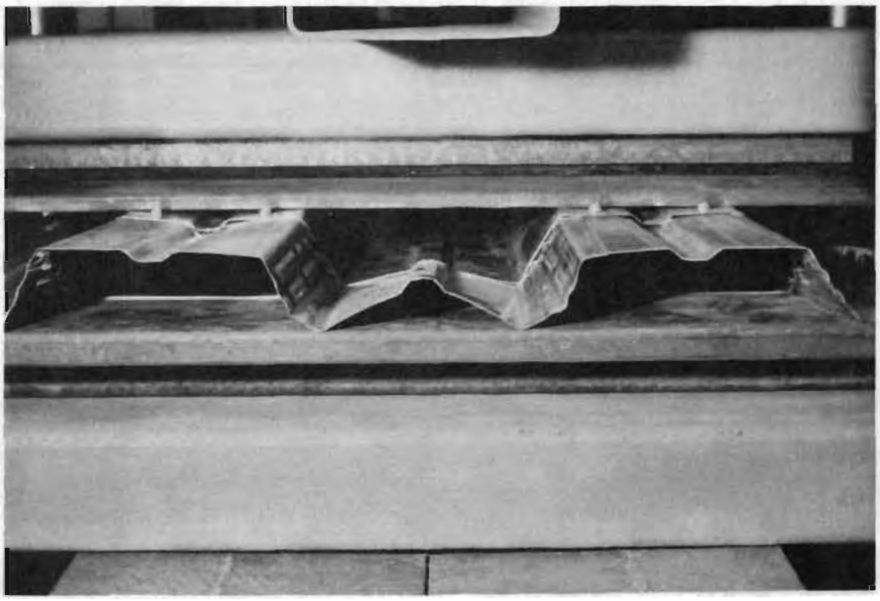


Fig.17 Photograph Showing the Typical Failure Mode for End One-Flange Loading

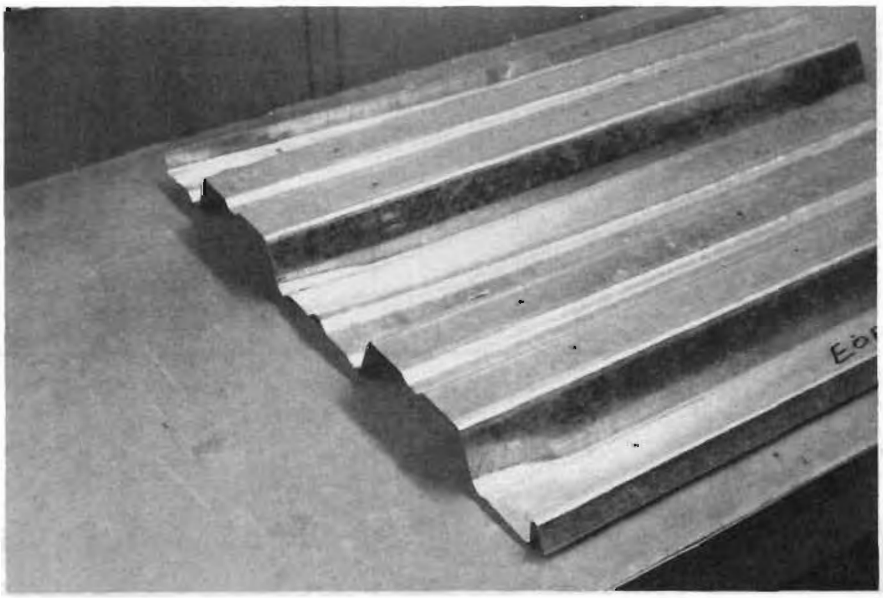


Fig. 18 Photgraph Showing the Typical Failure Mode for End One-Flange Loading

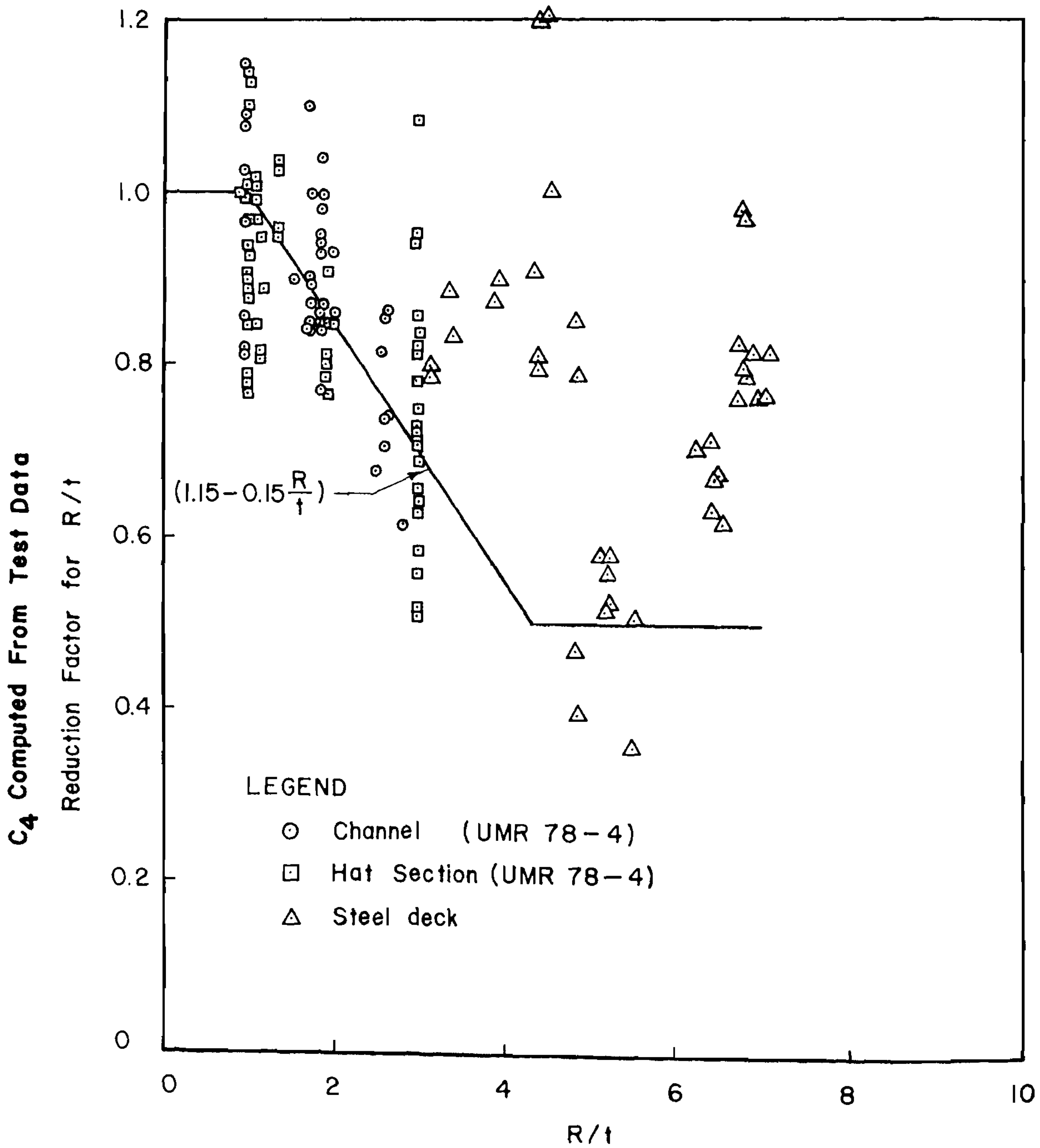


Fig. 19 Relationship Between the Computed C_4 and R/t Ratio

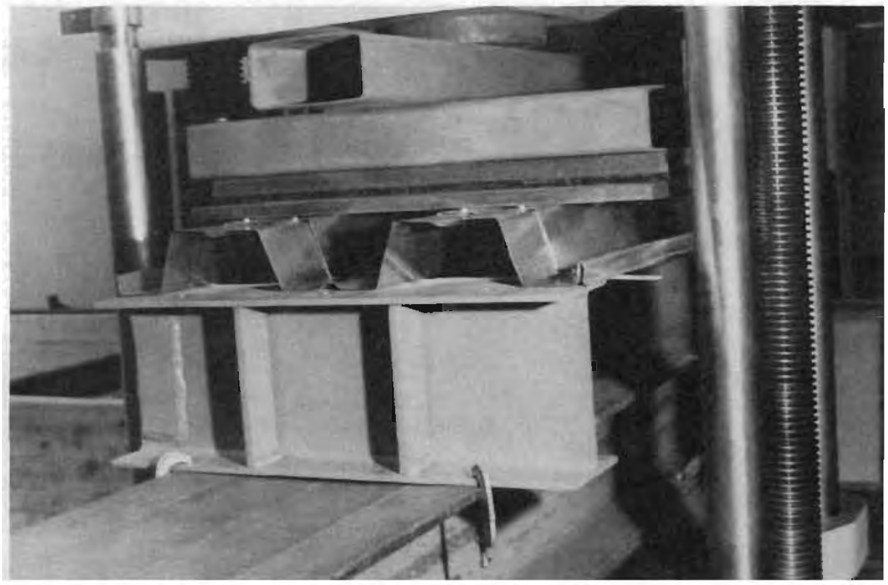


Fig. 20 Test Setup for End One-Flange Loading, EOF-5C and EOF-5D (Steel Panel is Supported by W Shapes at Both Ends Without Any Connection)

Fig. 21 End Failure for Steel Panels Using the Test Setup Shown Above

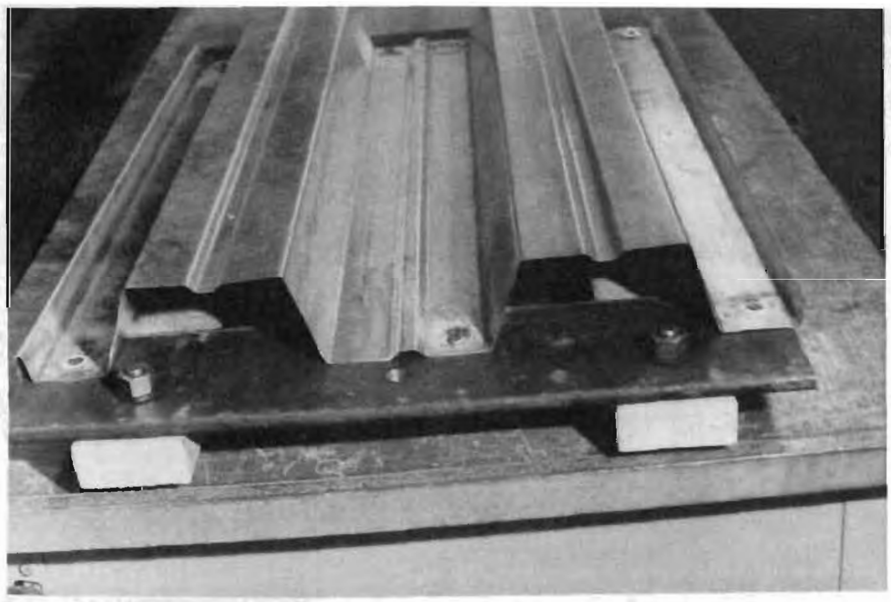


Fig. 22 Steel Panel is Welded to Bearing Plates at Both Ends (EOF-5E and EOF-5F)

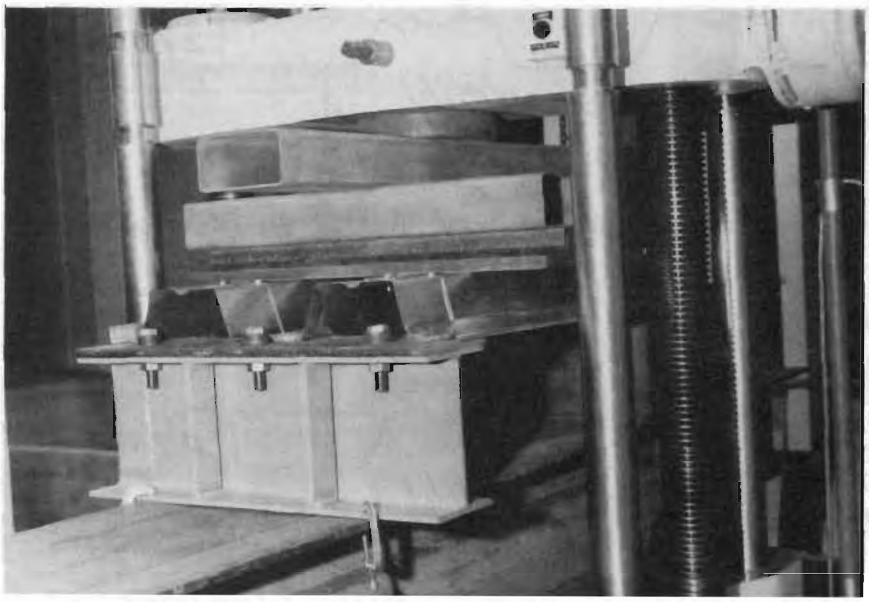


Fig. 23 Test Setup for End One-Flange Loading, EOF-5E and EOF-5F (Steel Panel is Welded to End Bearing Plates, Which are Connected to Support Beams by Using Bolts)

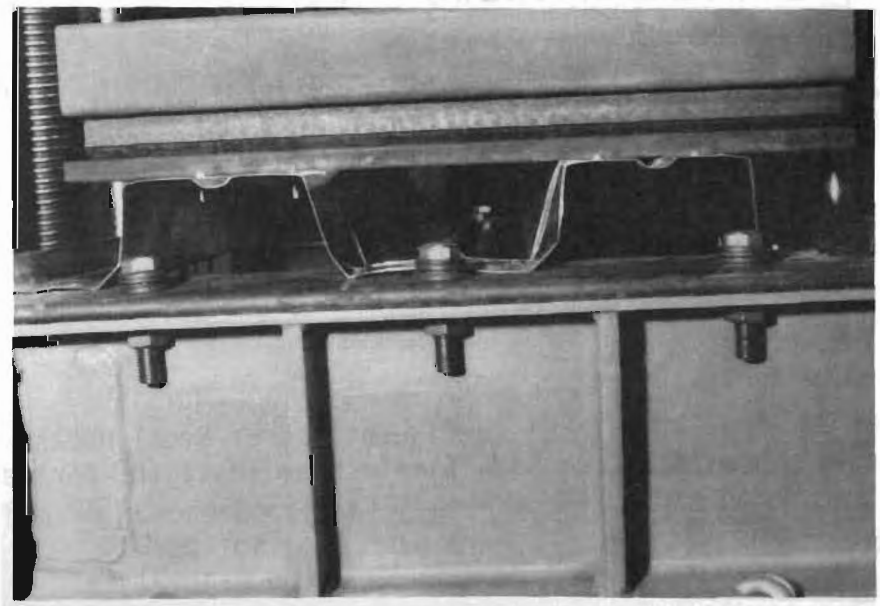
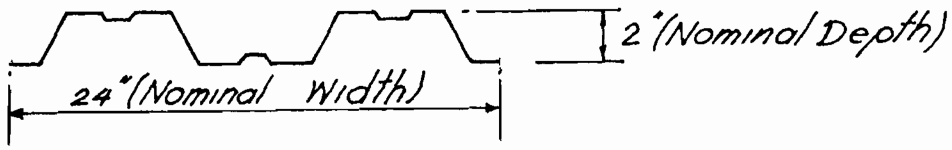
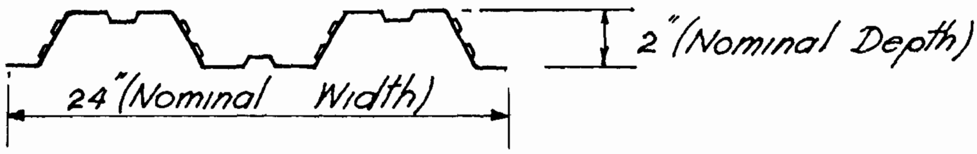


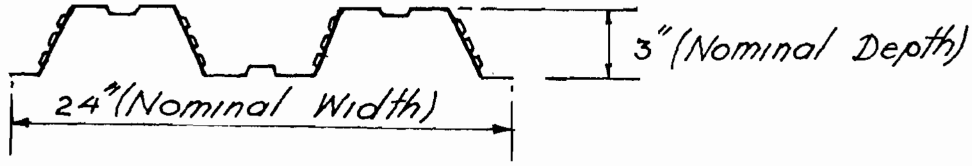
Fig. 24 End Failure for Steel Panels Using the Test Setup Shown Above



(a) Specimens 1A, 1B, 2A, 2B, 2C, 2D (Nominal t = 0.0295 in.)

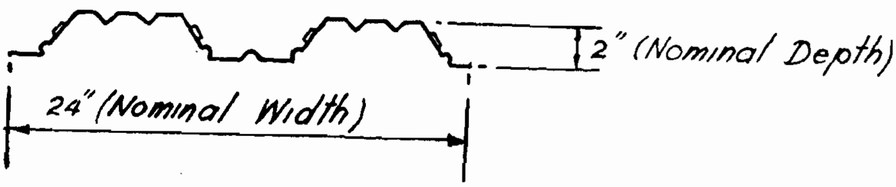


(b) Specimens 9A, 9B (Nominal t = 0.0295 in.)

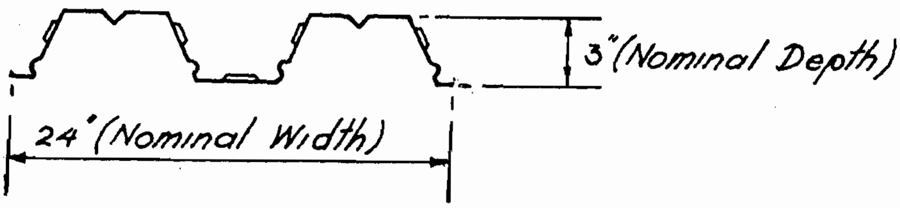


(c) Specimens 12A, 12B, 12C, 12D (Nominal t = 0.0295 in.)

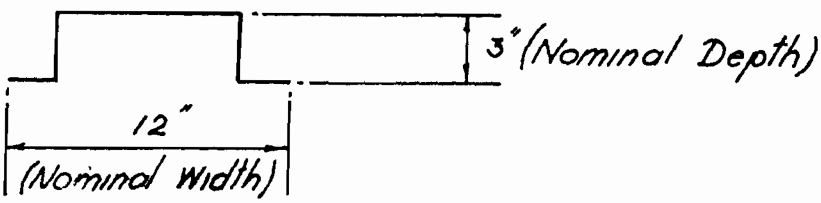
Fig. 25 Cross-Sectional Configurations of Steel Decks Used for Long Span Simple Beam Tests (BC Series)



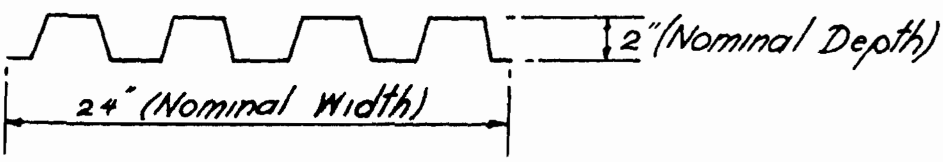
(d) Specimens 13A, 13B (Nominal t = 0.0358 in.)



(e) Specimens 16A, 16B, 16C, 16D (Nominal t = 0.0358 in.)



(f) Specimens 17A, 17B (Nominal t = 0.0295 in.)



(g) Specimens 19A, 19B, 19C, 19D (Nominal t = 0.0295 in.)
(cut from the 30 in. wide panels)

Fig.25 Cross-Sectional Configurations of Steel Decks Used for Long Span Simple Beam Tests (BC Series) (Continued)

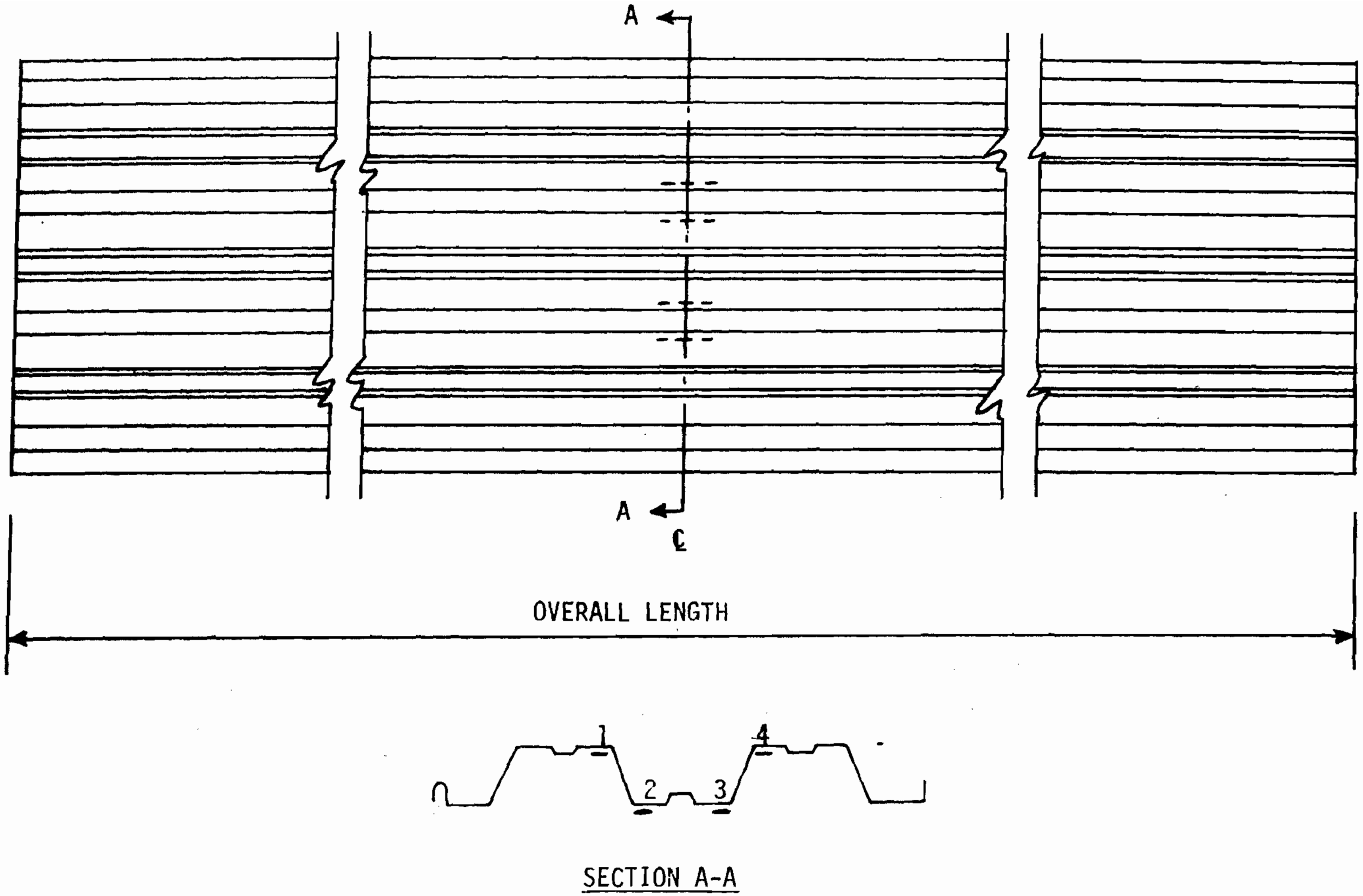


Fig. 26 Arrangement of Strain Gages Used for Single Span Test Specimens with End Connections (Specimens Nos. 2C, 2D, 12C, 12D, 16C, 16D, 19C and 19D)

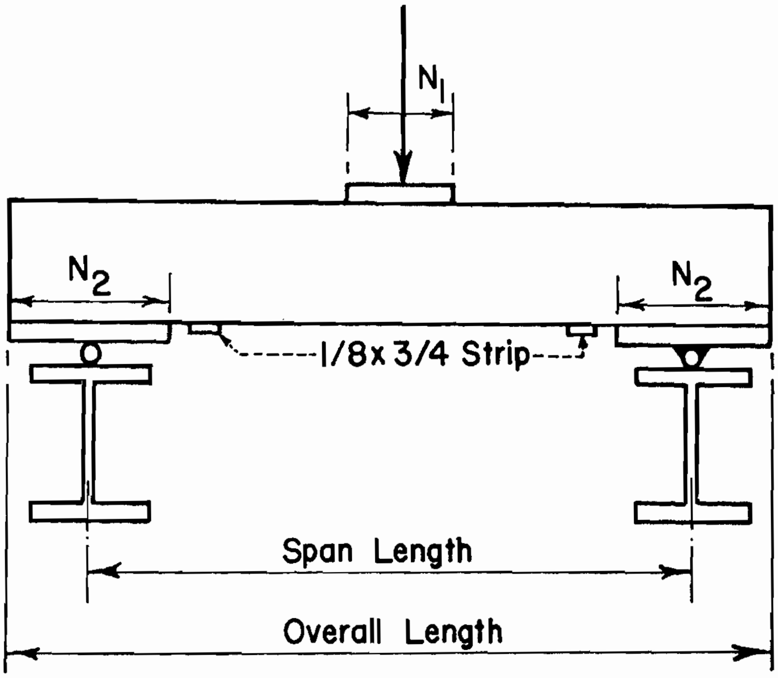


Fig.27 Test Setup Used for Long Span Simple Beams Without End Connections

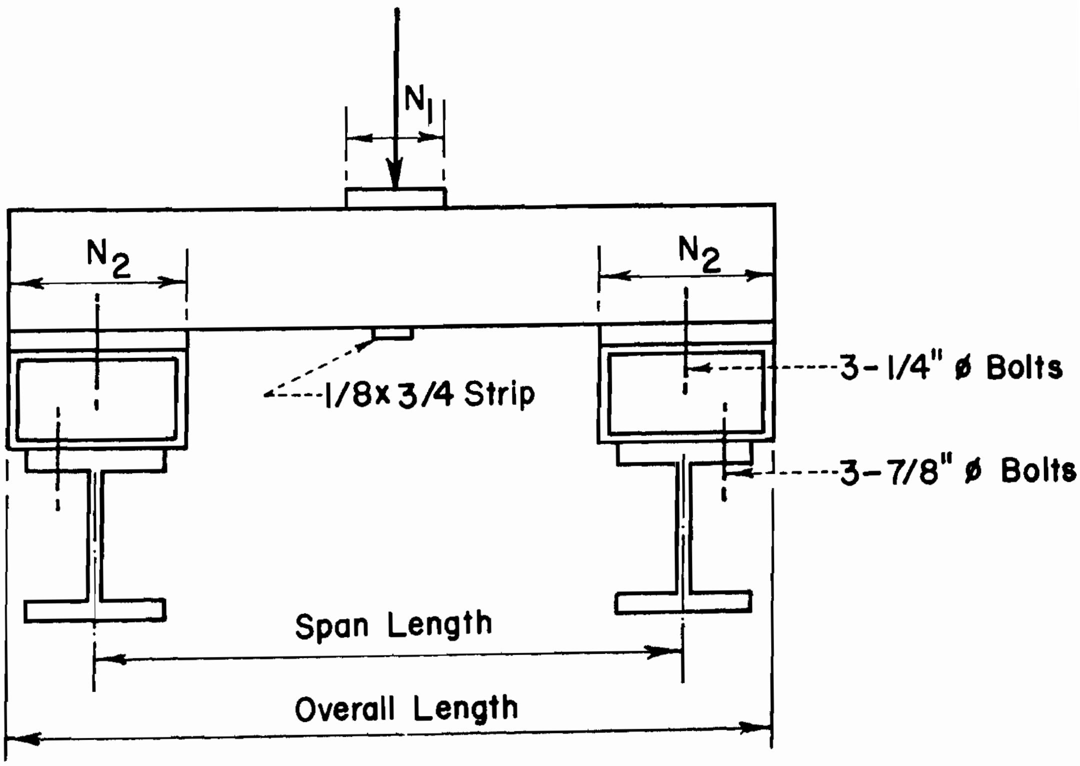


Fig.28 Test Setup Used for Single Span Beams With End Connections

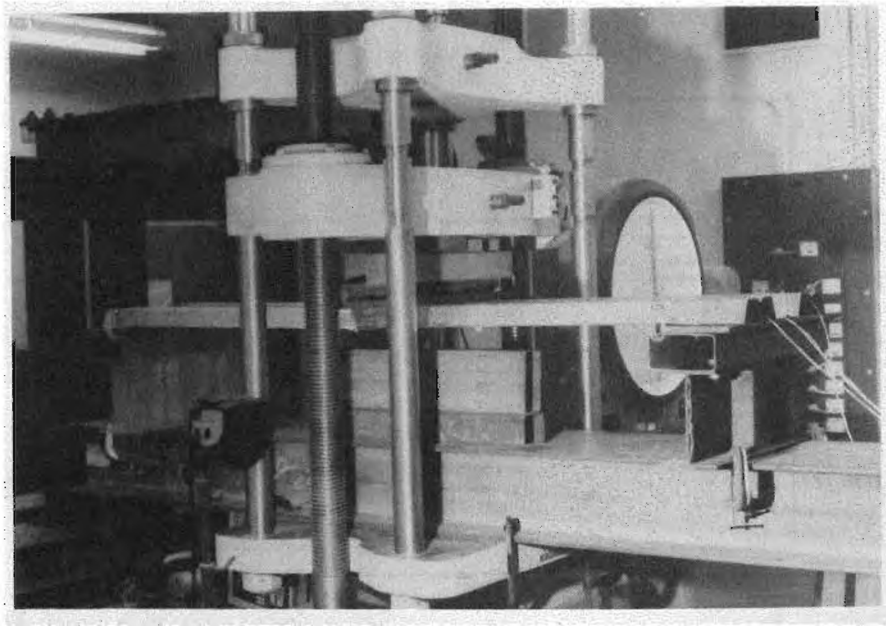


Fig. 29a Photograph Showing the Test Setup Used for Single Span Beams With End Connections

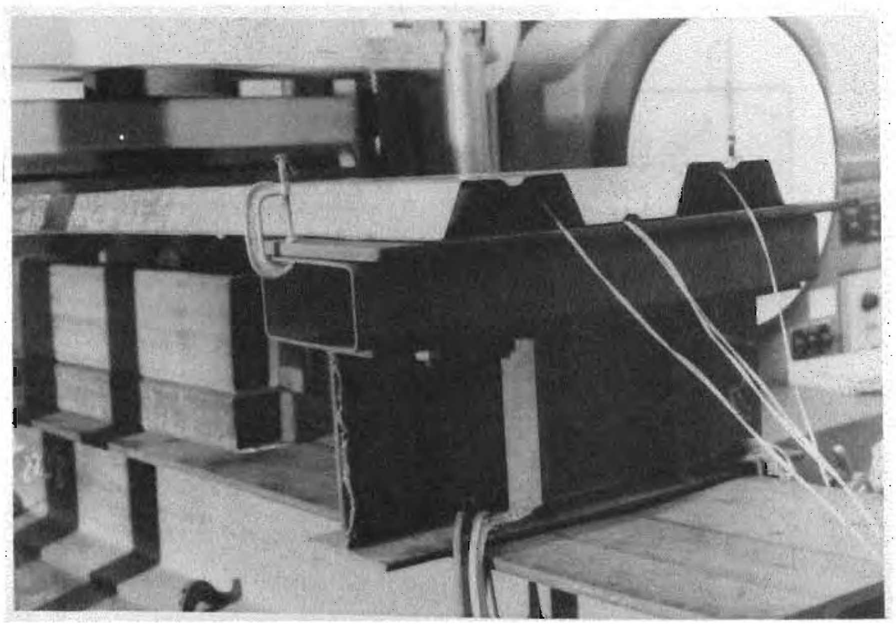


Fig. 29b Photograph Showing the Test Setup Used for Single Span Beams With End Connections

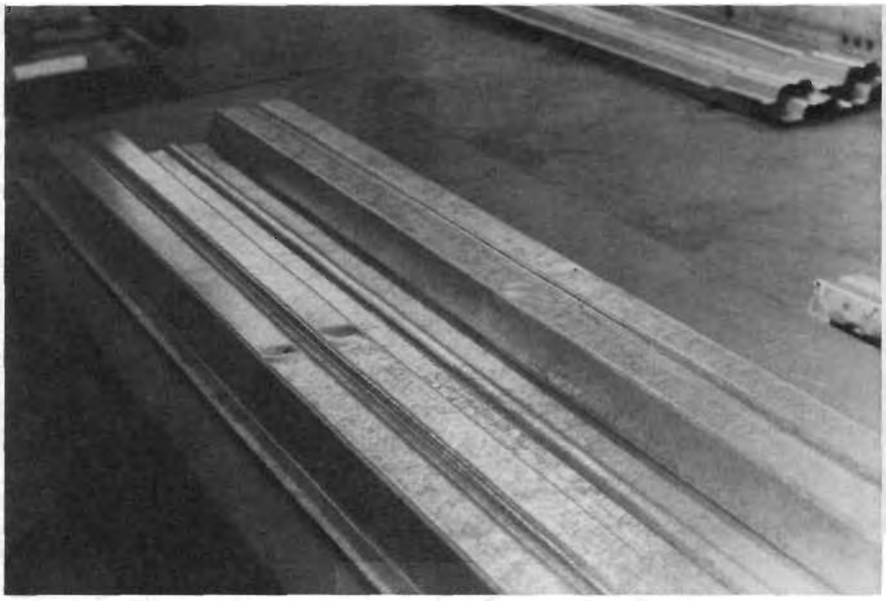


Fig. 30a Typical Failure Mode for Steel Decks Having Flat Webs (BC Series)

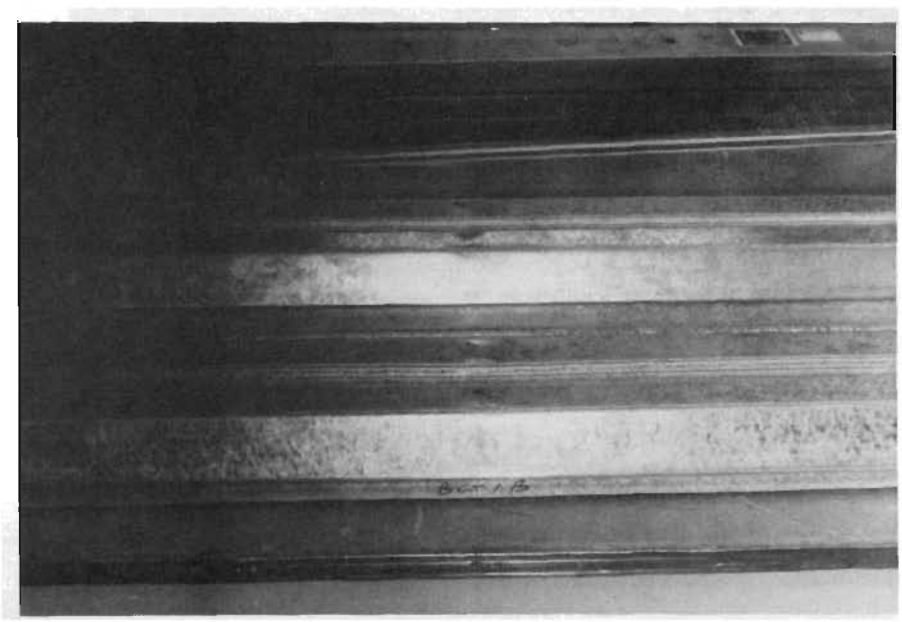


Fig. 30b Typical Failure Mode for Steel Decks Having Flat Webs (BC Series)

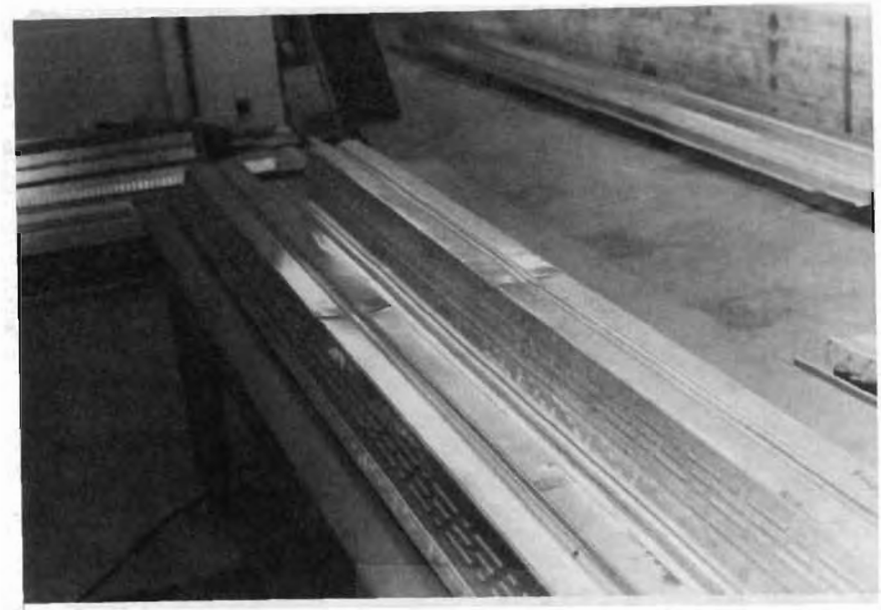


Fig. 31a Typical Failure Mode for Steel Decks Having Embossments in Their Webs (BC Series)

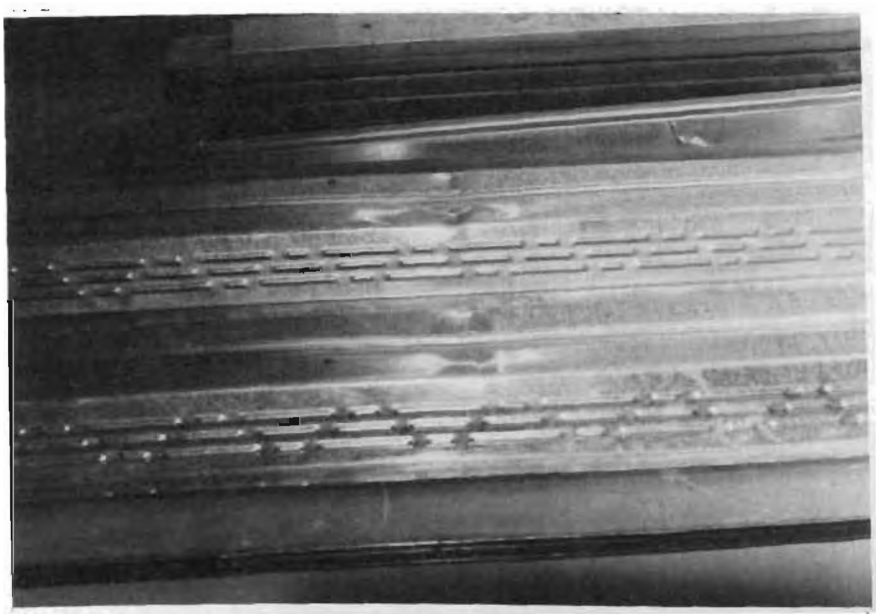


Fig. 31b Typical Failure Mode for Steel Decks Having Embossments in Their Webs (BC Series)

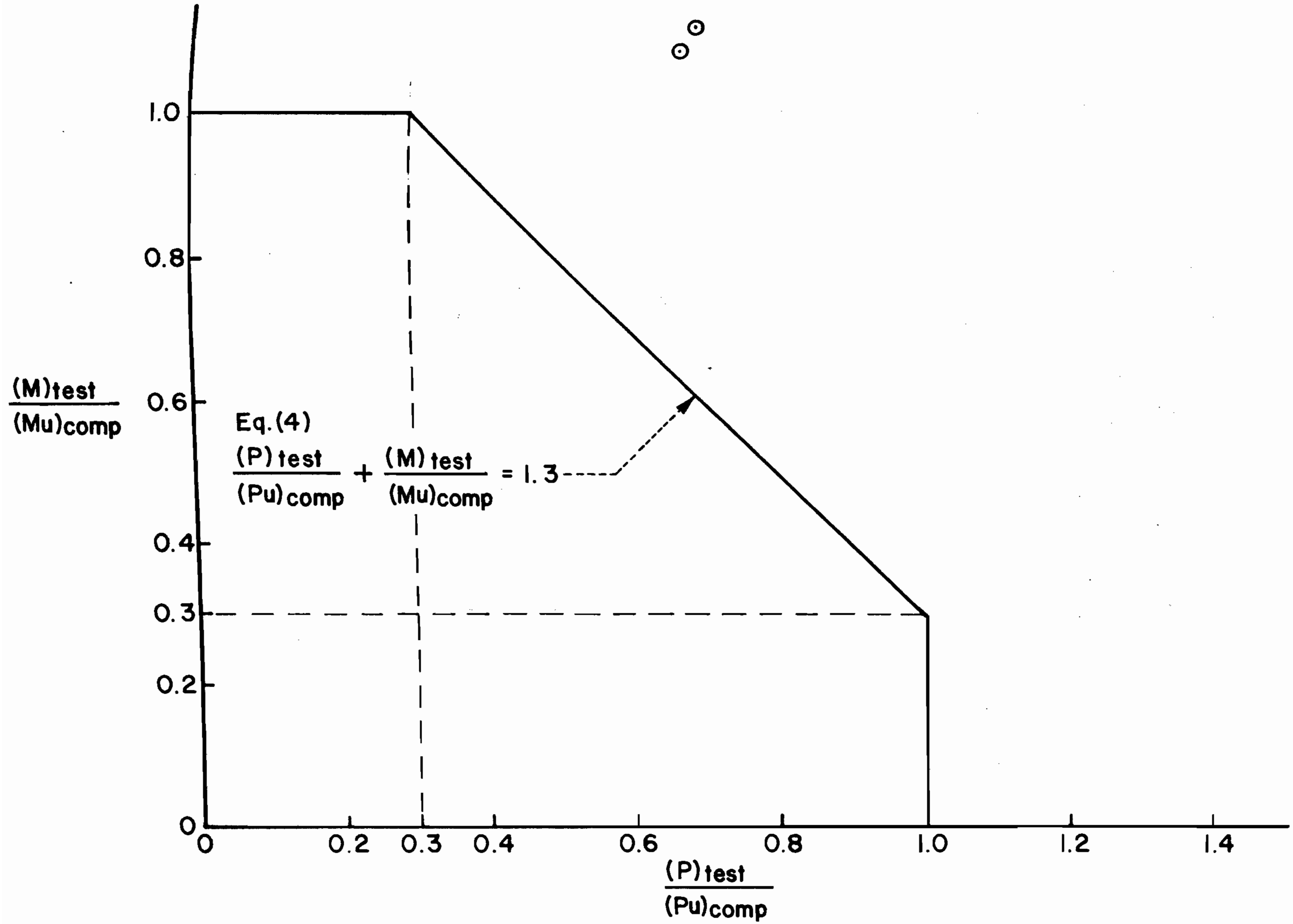


Fig. 32 Correlation Between the Test Results on Combined Bending and Web Crippling (Simple Beam Tests without End Connections) and the Interaction Formula Used for the 1968 AISI Specification

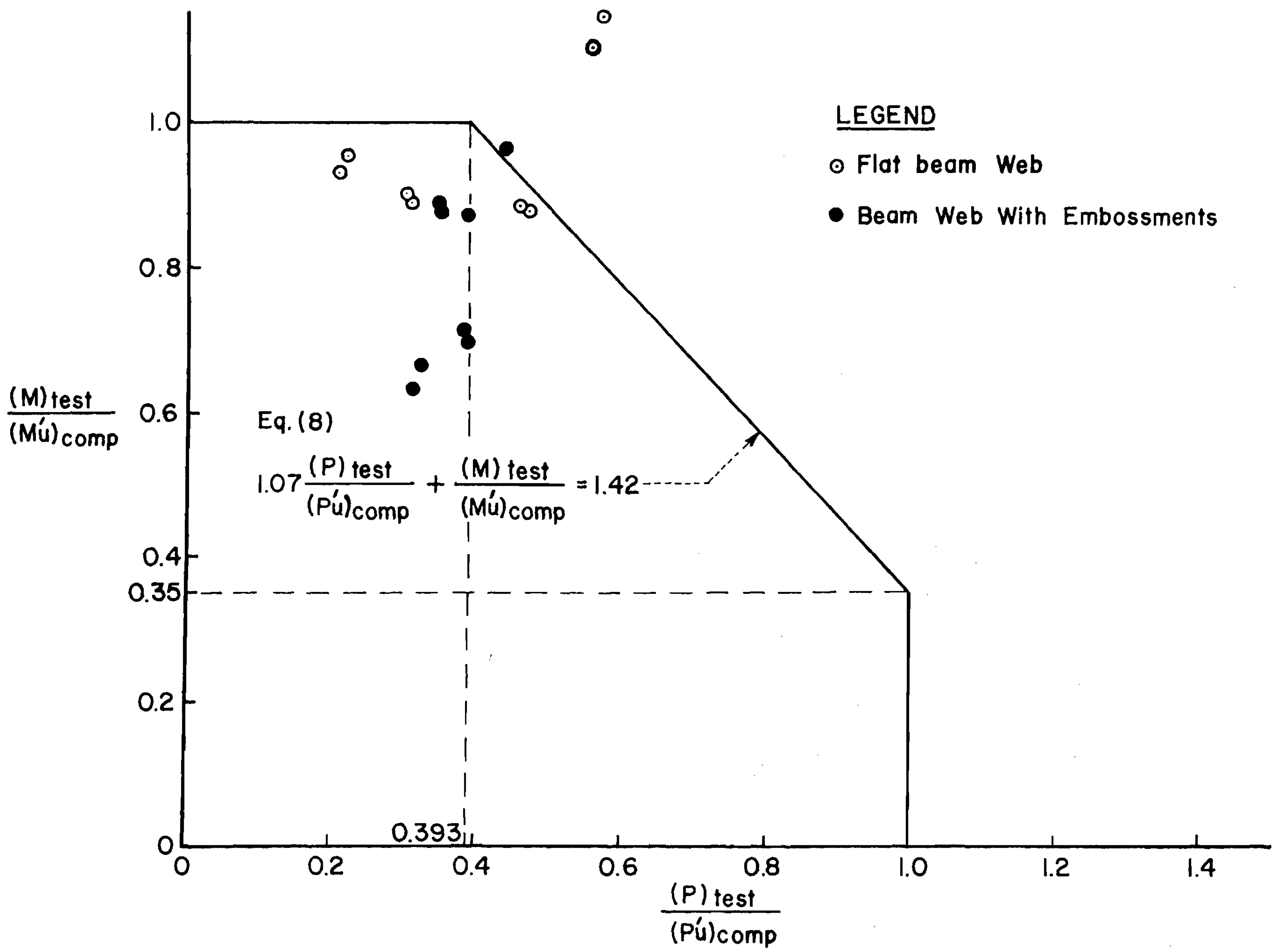


Fig. 33 Correlation Between the Test Results on Combined Bending and Web Crippling (Simple Beam Tests Without End Connections) and the Interaction Formula Used for the 1980 Edition of the AISI Specification

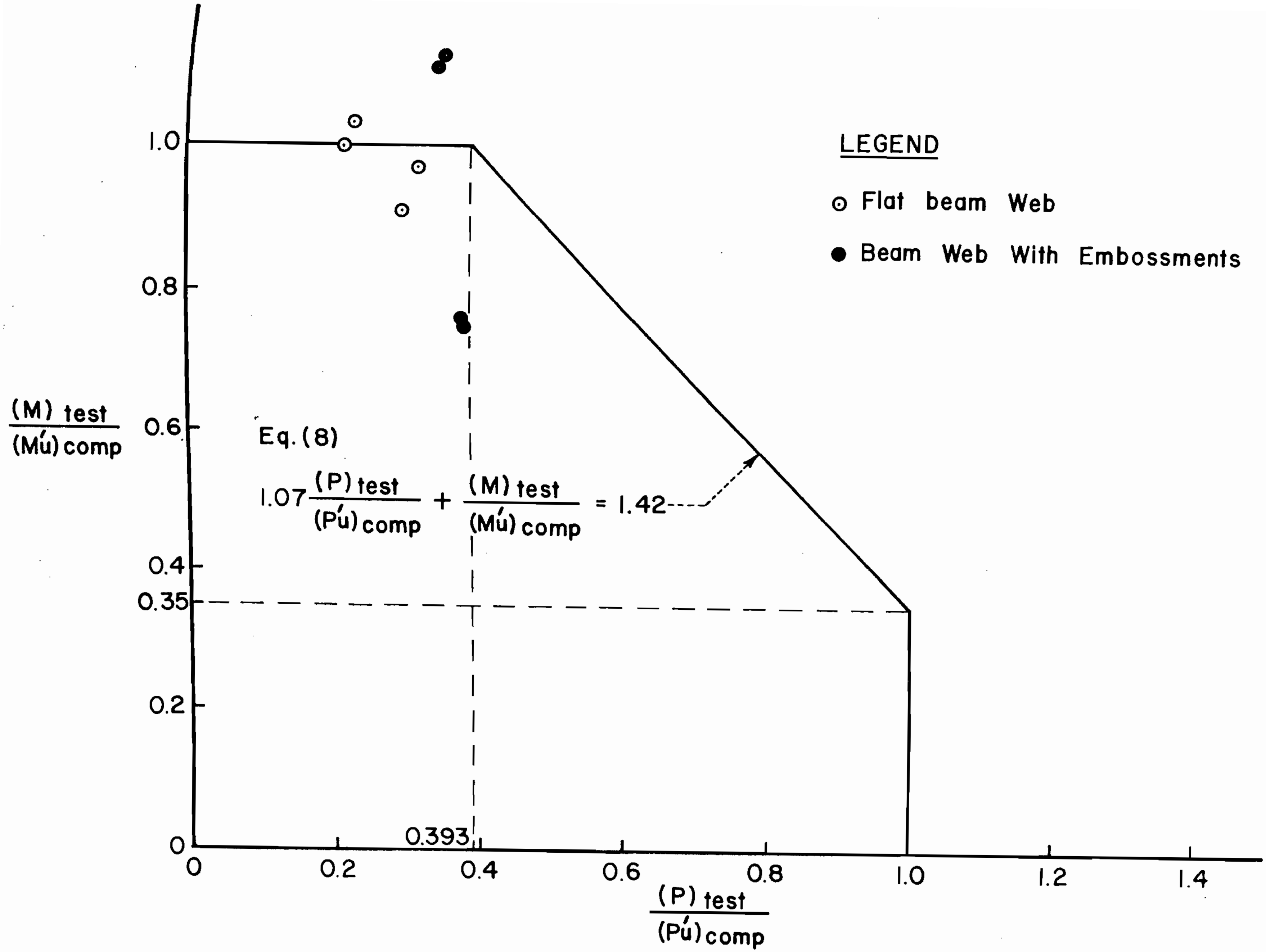
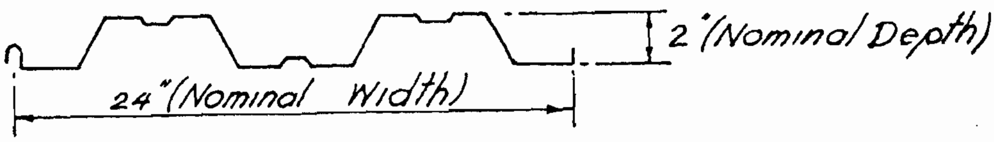
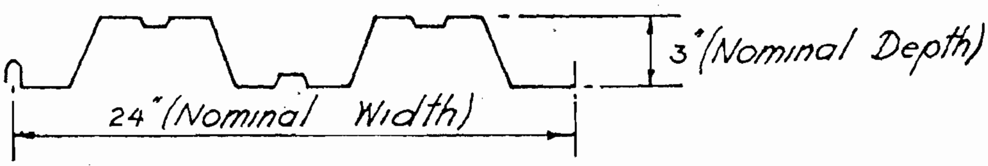


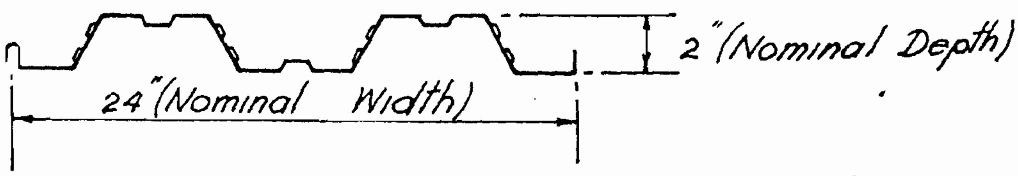
Fig. 34 Corrleation Between the Test Results on Combined Bending and Web Crippling (Single Span Beam Tests With End Connections) and the Interaction Formula Used for the 1980 Edition of the AISI Specification



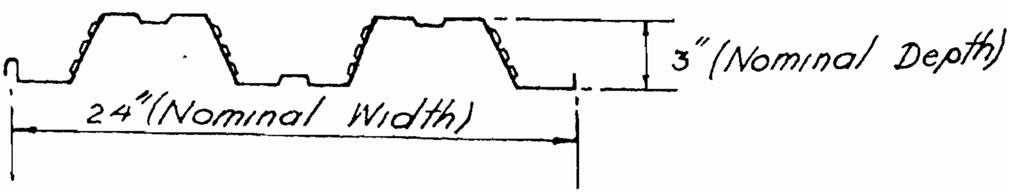
(a) Specimens 1A, 1B, 2A, 2B (Nominal t = 0.0295 in.)
Specimens 3A, 3B, 4A, 4B (Nominal t = 0.0474 in.)



(b) Specimens 5A, 5B, 6A, 6B (Nominal t = 0.0295 in.)

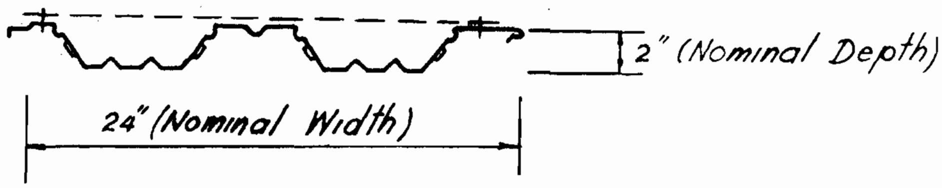


(c) Specimens 9A, 9B, 10A, 10B (Nominal t = 0.0295 in.)

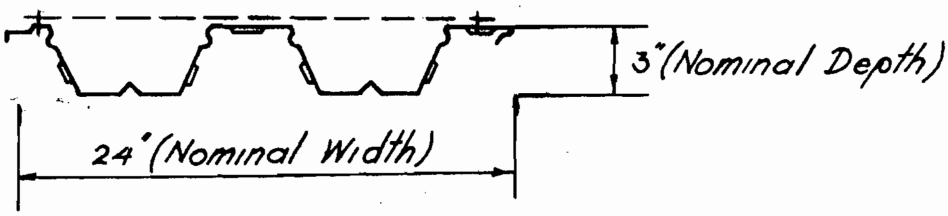


(d) Specimens 11A, 11B, 12A, 12B (Nominal t = 0.0295 in.)

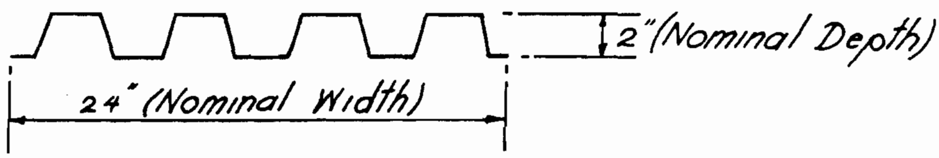
Fig. 35 Cross-Sectional Dimensions of Steel Decks used for Continuous Beam Tests (CB - Series)



(e) Specimens 13A, 13B, 14A, 14B (Nominal t = 0.0358 in.)



(f) Specimens 15A, 15B, 16A, 16B (Nominal t = 0.0358 in.)



(g) Specimens 19A, 19B, 20A, 20B(Nominal t = 0.0295. in.)
(cut from the 30 in. wide panels)

Fig. 35 Cross-Sectional Dimensions of Steel Decks used for Continuous Beam Tests (CB - Series) (cont'd)

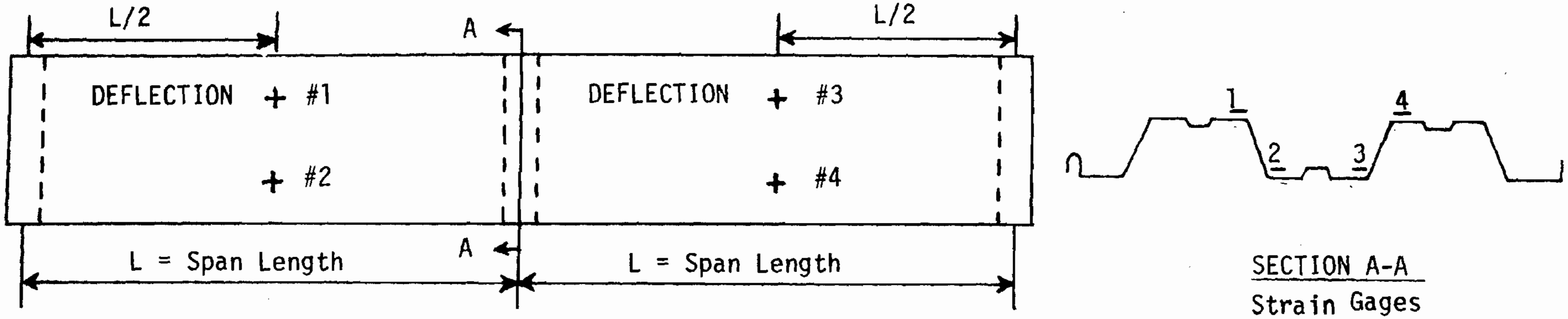


Fig. 36a Location of Strain Gages and Deflection Measurements for Two-Span Continuous Beams

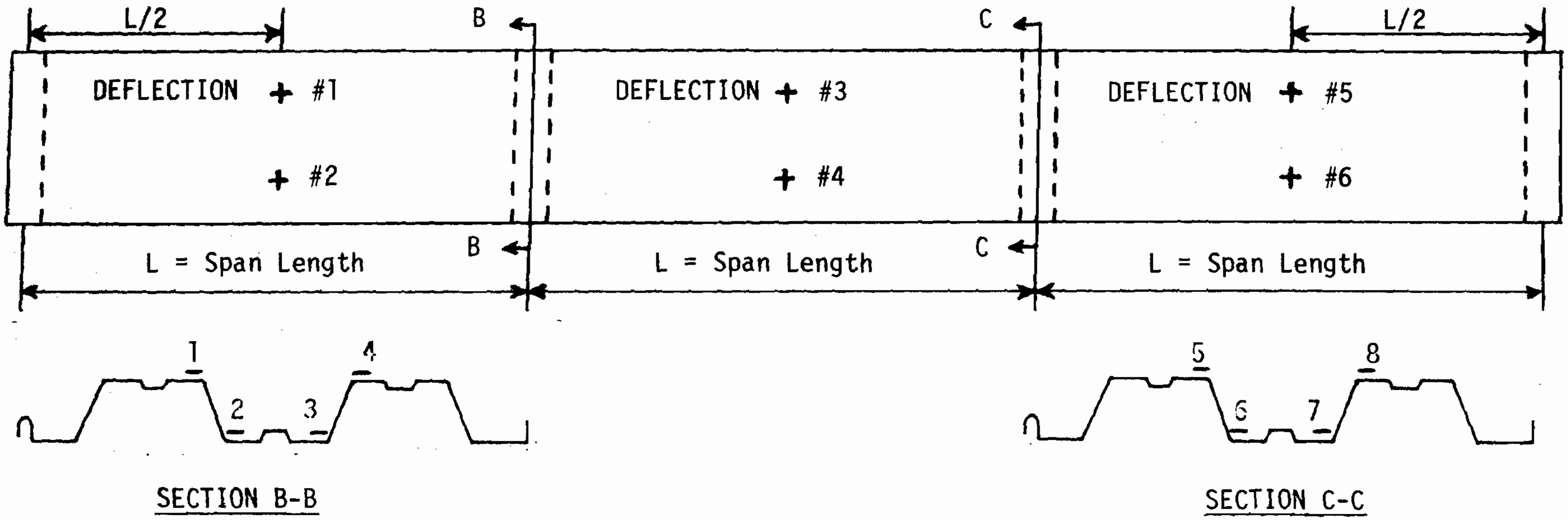


Fig. 36b Location of Strain Gages and Deflection Measurements for Three-Span Continuous Beams

Fig. 37a Uniform Loading Apparatus Used for Continuous Beam Tests

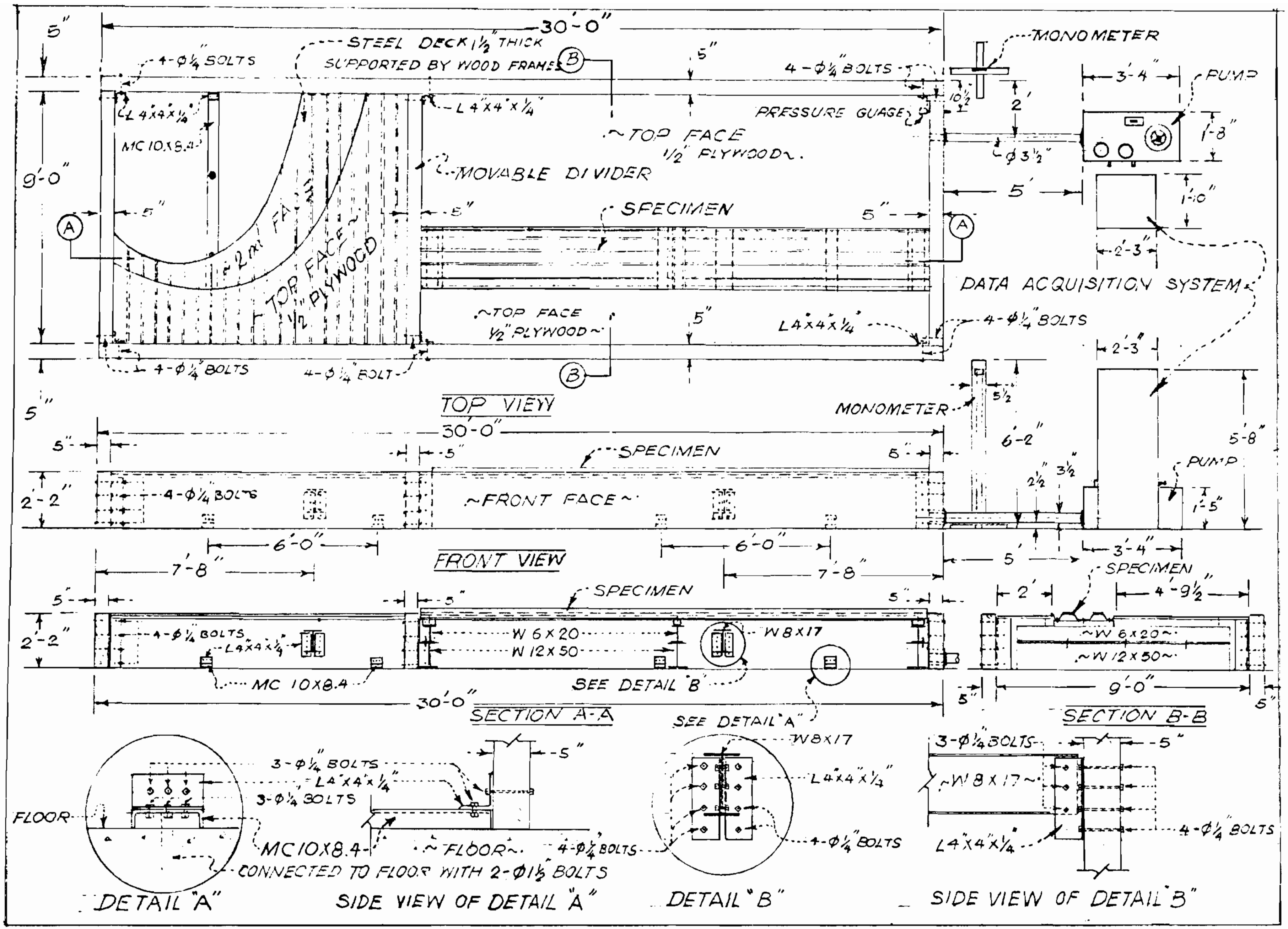


Fig. 37b Uniform Loading Apparatus Used for Continuous Beam Tests

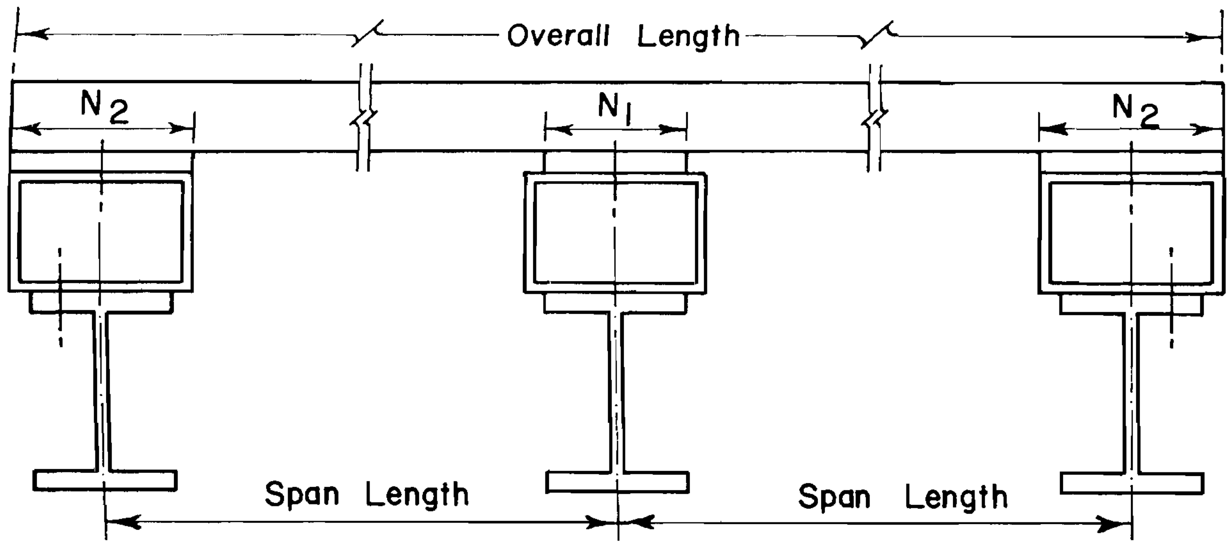


Fig. 38a Test Setup for Two-Span Continuous Beam Tests

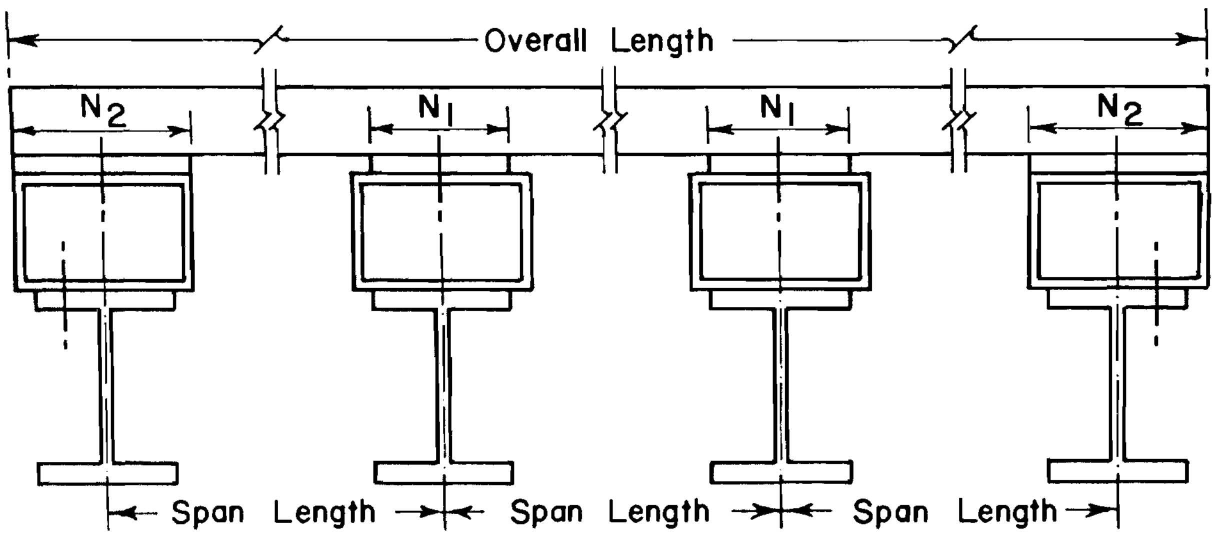


Fig. 38b Test Setup for Three-Span Continuous Beam Tests (Specimen Nos. 3 and 4)

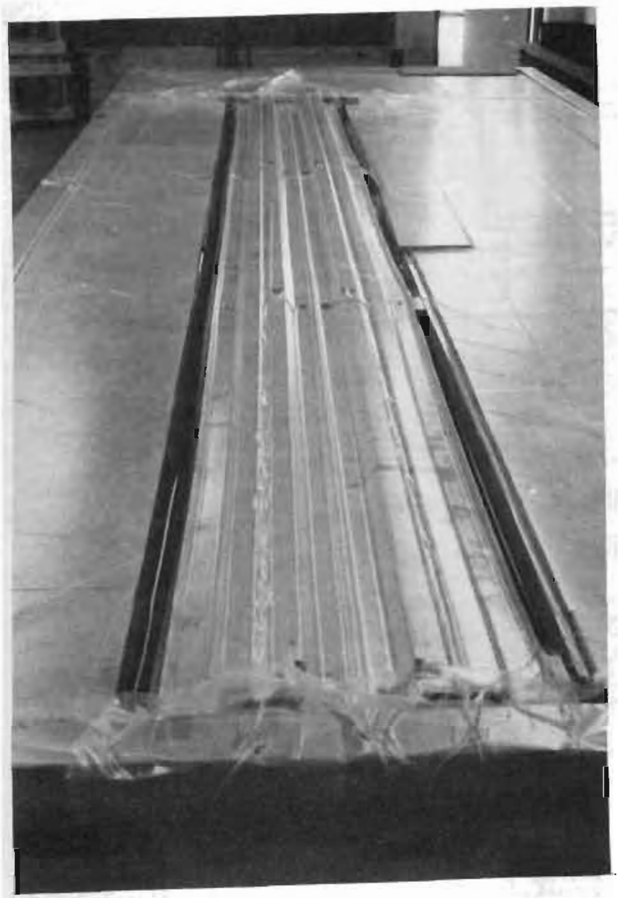


Fig. 39a Photograph Showing the Test Setup for Three-Span Continuous Beam Tests

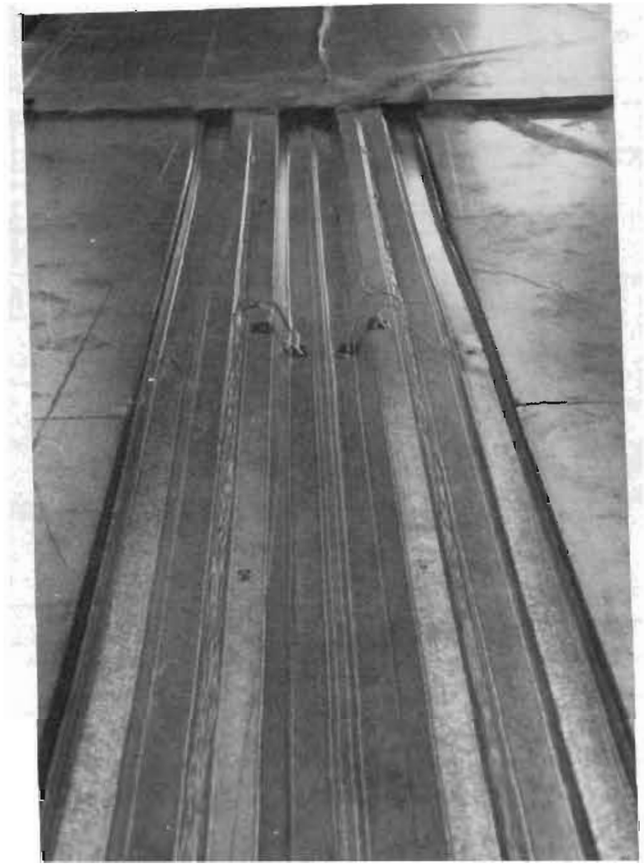


Fig. 39b Photograph Showing the Test Setup for Two-Span Continuous Beam Tests

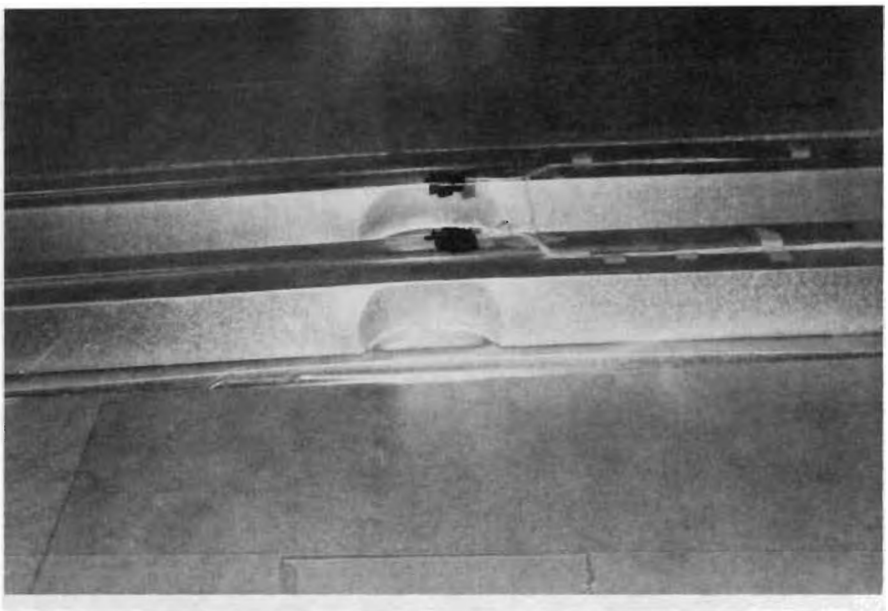


Fig. 40a Typical Failure Mode at the Interior Support of Continuous Beams for Steel Decks Having Flat Webs.

Fig. 40b Typical Failure Mode at the Interior Support of Continuous Beams for Steel Decks Having Flat Webs.

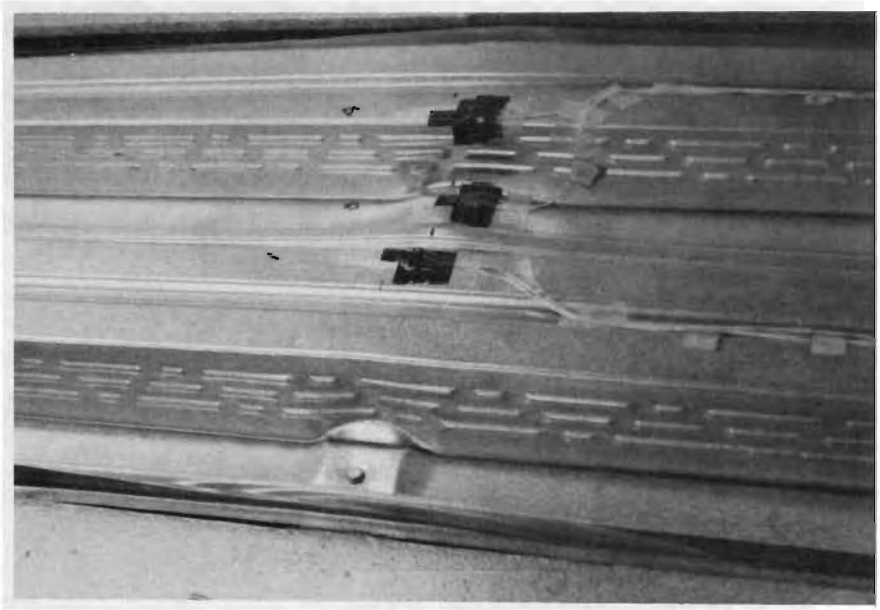


Fig. 41a Typical Failure Mode at the Interior Support of Continuous Beams for Steel Decks Having Embossed Webs

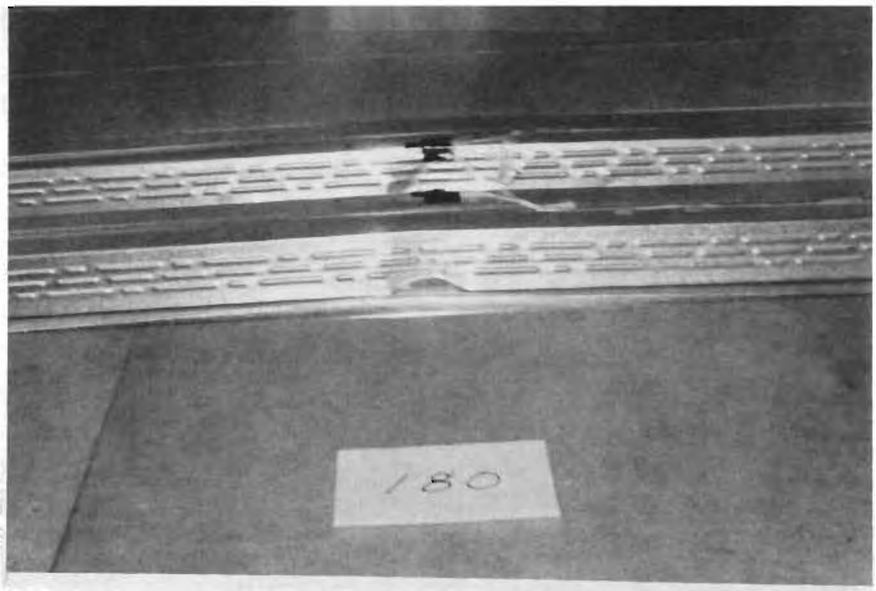


Fig. 41b Typical Failure Mode at the Interior Support of Continuous Beams for Steel Decks Having Embossed Webs

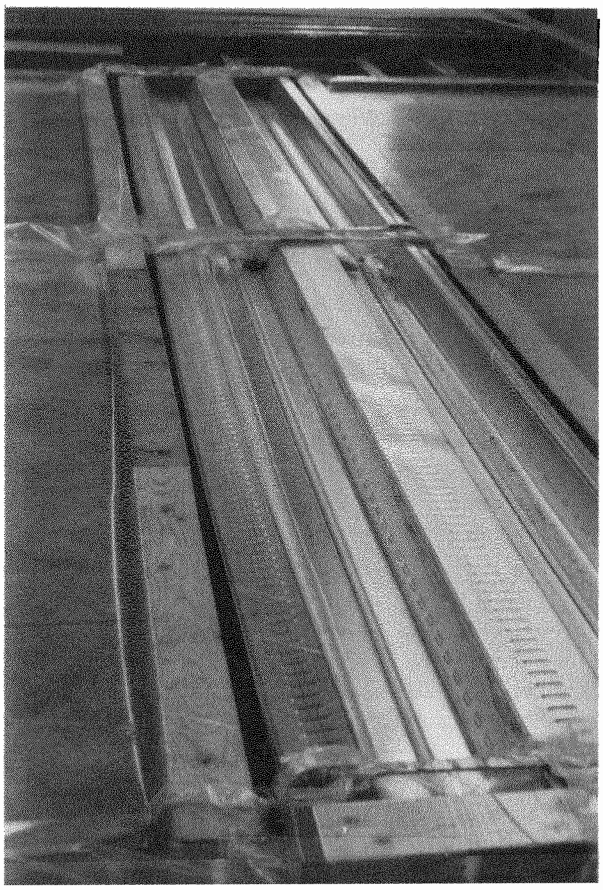


Fig. 42a Photograph Showing the Test Setup for Inverted Steel Decks (Specimens Nos. 13, 14, 15, and 16).

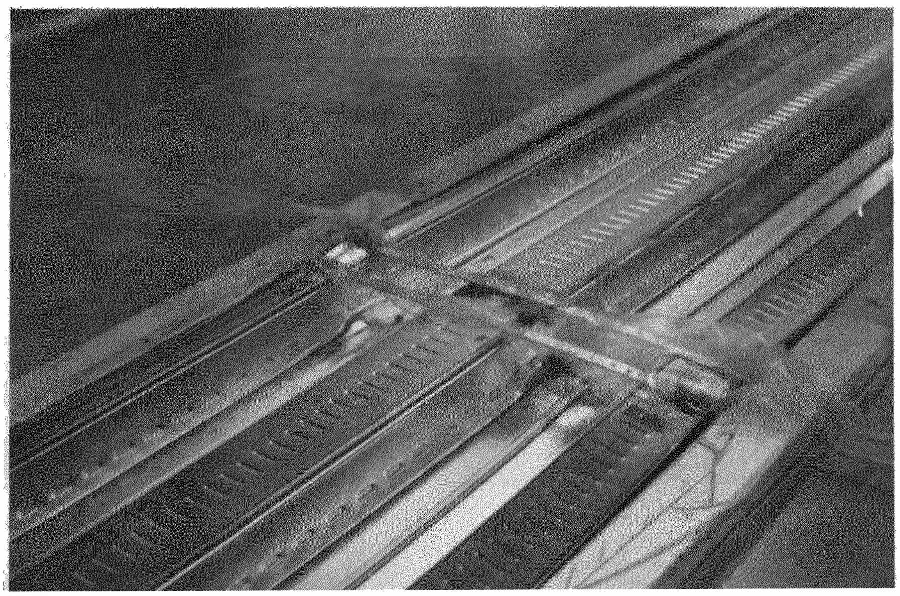


Fig. 42b Typical Failure Mode at the Interior Support of Continuous Beams for Steel Decks Tested in an Inverted Position.

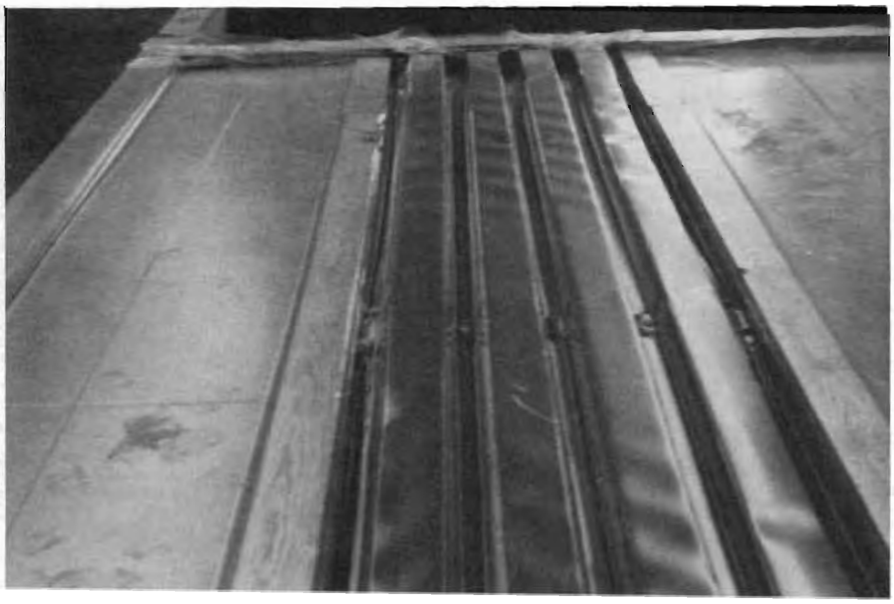


Fig. 43a Typical Failure Mode for Roof Deck

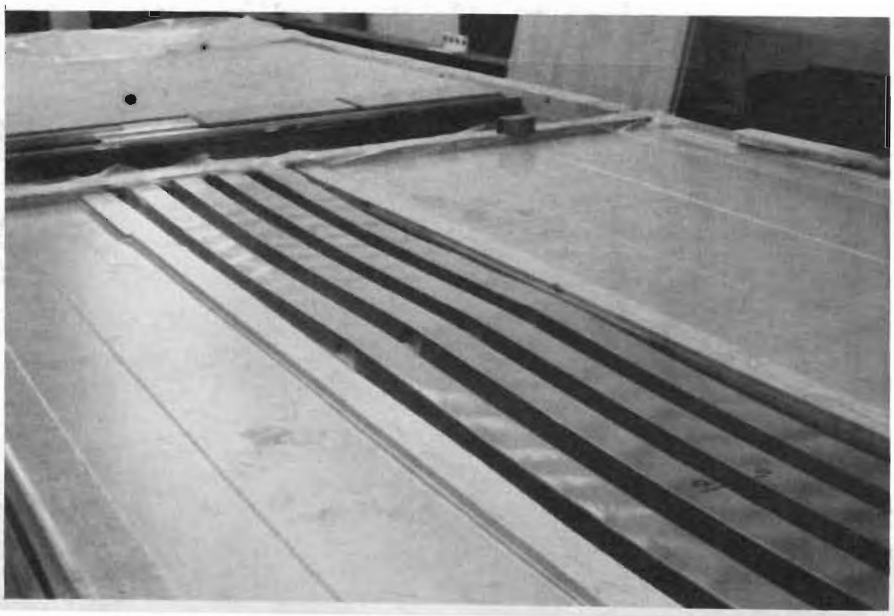


Fig. 43b Typical Failure Mode for Roof Deck

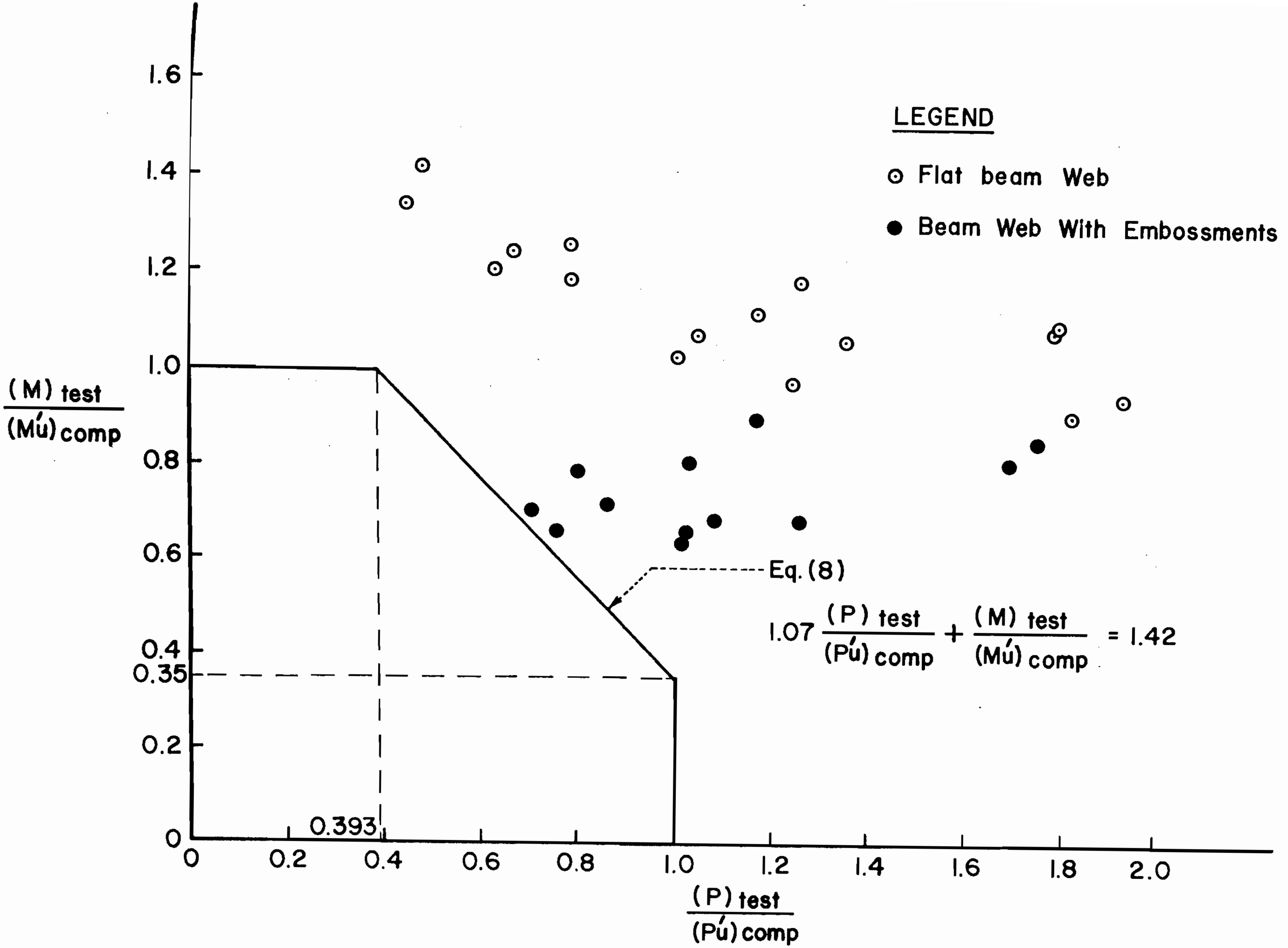


Fig. 44 Correlation Between the Results of Continuous Beam Tests of Steel Decks and the Interaction Formula Used for the 1980 Edition of the AISI Specification.

APPENDIX

TABLE A1

Mid-Span Deflection of Steel Deck Specimens
Single Span Beams Used for Combined Bending-Web Crippling Tests

Specimen No.	Applied Load (kips)	Mid-Span Deflection (in.)	Specimen No.	Applied Load (kips)	Mid-Span Deflection (in.)
BC - 1A	0.250	0.155	BC - 2D (cont'd)	0.720	0.287
	0.500	0.300		0.840	0.333
	0.750	0.445		0.960	0.386
	0.973	0.625		1.080	0.440
				1.200	0.514
BC - 1B	0.125	0.080		1.202	0.554
	0.250	0.154			
	0.375	0.225	BC - 9A	0.113	0.149
	0.500	0.299		0.225	0.241
	0.600	0.355		0.338	0.335
	0.700	0.415		0.450	0.418
	0.800	0.474		0.540	0.481
	0.900	0.542		0.630	0.552
	0.975	0.663		0.720	0.627
				0.795	0.797
BC - 2A	0.150	0.095			
	0.300	0.180	BC - 9B	0.200	0.201
	0.450	0.264		0.400	0.355
	0.600	0.348		0.600	0.501
	0.720	0.417		0.790	0.810
	0.840	0.488			
	0.960	0.578	BC - 12A	0.200	0.085
	1.020	0.698		0.400	0.171
				0.600	0.256
BC - 2B	0.150	0.090		0.800	0.339
	0.300	0.176		0.960	0.408
	0.450	0.260		1.120	0.486
	0.600	0.342		1.218	0.602
	0.720	0.413			
	0.840	0.484	BC - 12B	0.200	0.085
	0.960	0.571		0.400	0.169
	1.017	0.672		0.600	0.250
				0.800	0.331
BC - 2C	0.150	0.065		0.960	0.400
	0.300	0.129		1.120	0.474
	0.450	0.191		1.219	0.558
	0.600	0.252			
	0.720	0.303	BC - 12C	0.200	0.069
	0.840	0.354		0.400	0.135
	0.960	0.408		0.600	0.203
	1.080	0.468		0.800	0.272
	1.170	0.577		0.960	0.327
				1.120	0.385
BC - 2D	0.150	0.063		1.280	0.450
	0.300	0.122		1.400	0.541
	0.450	0.182			
	0.600	0.239			

TABLE A1 (Cont'd)

Mid-Span Deflection of Steel Deck Specimens
Single Span Beams Used for Combined Bending-Web Crippling Tests

Specimen No.	Applied Load (kips)	Mid-Span Deflection (in)	Specimen No.	Applied Load (kips)	Mid-Span Deflection (in)
BC - 12D	0.200	0.064	BC - 16C	0.115	0.075
	0.400	0.129		0.230	0.135
	0.600	0.195		0.345	0.202
	0.800	0.263		0.460	0.279
	0.960	0.318		0.550	0.332
	1.120	0.373		0.640	0.398
	1.280	0.437		0.730	0.470
	1.405	0.585		0.820	0.558
				0.867	0.689
BC - 13A	0.150	0.072			
	0.300	0.130	BC - 16D	0.115	0.068
	0.450	0.187		0.230	0.133
	0.600	0.241		0.345	0.199
	0.720	0.290		0.460	0.275
	0.840	0.332		0.550	0.331
	0.960	0.383		0.640	0.398
	1.080	0.442		0.730	0.470
	1.200	0.512		0.820	0.563
	1.250	0.630		0.872	0.673
BC - 13B	0.150	0.096	BC - 17A	0.150	0.095
	0.300	0.152		0.300	0.170
	0.450	0.205		0.450	0.241
	0.600	0.258		0.600	0.311
	0.720	0.306		0.720	0.367
	0.840	0.346		0.840	0.425
	0.960	0.397		0.960	0.495
	1.080	0.449		0.995	0.562
	1.200	0.500			
	1.350	0.670	BC - 17B	0.150	0.099
				0.300	0.177
BC - 16A	0.300	0.118		0.450	0.249
	0.600	0.218		0.600	0.322
	0.900	0.318		0.720	0.382
	1.200	0.418		0.840	0.440
	1.440	0.502		0.960	0.510
	1.646	0.608		0.985	0.550
BC - 16B	0.225	0.087	BC - 19A	0.230	0.107
	0.450	0.167		0.460	0.219
	0.675	0.243		0.690	0.342
	0.900	0.319		0.920	0.503
	1.080	0.383		1.072	0.816
	1.260	0.441			
	1.440	0.504			
	1.620	0.579			
	1.690	0.630			

TABLE A1-(Cont'd)

Mid-Span Deflection of Steel Deck Specimens
Single Span Beams Used for Combined Bending-Web Crippling Tests

Specimen No.	Applied Load (kips)	Mid-Span Deflection (in)	Specimen No.	Applied Load (kips)	Mid-Span Deflection (in)
BC - 19B	0.150	0.068	BC - 19C (cont'd)	0.840	0.324
	0.300	0.138		0.960	0.382
	0.450	0.209		1.080	0.454
	0.600	0.284		1.200	0.583
	0.720	0.353		1.200	0.690
	0.840	0.430			
	0.960	0.521	BC - 19D	0.150	0.058
	1.080	0.714		0.300	0.114
	1.083	0.791		0.450	0.171
				0.600	0.230
BC - 19C	0.150	0.054		0.720	0.280
	0.300	0.109		0.840	0.335
	0.450	0.165		0.960	0.393
	0.600	0.221		1.080	0.465
	0.720	0.271		1.180	0.614

TABLE A2

Mid-Span Deflection of Steel Deck Specimens
Two-Span Continuous Beam Tests

Specimen No.	Applied Uniform Load (psf)	Mid-Span Deflection (in.) #1	#2	#3	#4
CB - 1A	25	0.13	0.18	0.15	0.19
	50	0.17	0.22	0.17	0.23
	75	0.19	0.25	0.21	0.27
	100	0.22	0.28	0.25	0.29
	125	0.23	0.32	0.26	0.33
	150	0.27	0.35	0.29	0.37
	175	0.29	0.38	0.32	0.39
	200	0.33	0.42	0.36	0.44
	225	0.43	0.56	0.50	0.57
	235	0.52	0.63	0.57	0.64
	245	0.56	0.66	0.63	0.69
	255	0.60	0.72	0.65	0.75
CB - 1B	25	0.12	0.19	0.12	0.16
	50	0.16	0.20	0.15	0.20
	75	0.18	0.24	0.19	0.23
	100	0.22	0.27	0.23	0.26
	125	0.23	0.30	0.25	0.30
	150	0.27	0.33	0.27	0.33
	175	0.29	0.36	0.31	0.37
	200	0.33	0.40	0.34	0.39
	225	0.39	0.48	0.39	0.48
CB - 2A	25	0.07	0.09	0.12	0.10
	50	0.13	0.14	0.13	0.15
	75	0.15	0.19	0.19	0.19
	100	0.19	0.24	0.22	0.23
	125	0.24	0.27	0.25	0.29
	150	0.26	0.32	0.30	0.33
	175	0.30	0.36	0.37	0.36
	200	0.34	0.40	0.38	0.40
	225	0.39	0.45	0.42	0.48
	250	0.43	0.54	0.46	0.49
	255	0.44	0.54	0.50	0.54
	260	0.41	0.55	0.47	0.59
	265	0.48	0.55	0.48	0.56
	270	0.48	0.57	0.48	0.56
	275	0.50	0.60	0.51	0.56
	280	0.53	0.61	0.51	0.58
	285	0.65	0.70	0.53	0.61
	290	0.55	0.65	0.58	0.66
	295	0.59	0.66	0.59	0.76

TABLE A2 (Cont'd)

Mid-Span Deflection of Steel Deck Specimens
Two-Span Continuous Beam Tests

Specimen No.	Applied Uniform Load (psf)	Mid-Span Deflection (in.)			
		#1	#2	#3	#4
CB - 2B	25	0.11	0.14	0.10	0.14
	50	0.12	0.18	0.14	0.18
	75	0.16	0.23	0.16	0.21
	100	0.21	0.26	0.19	0.25
	125	0.22	0.29	0.20	0.28
	150	0.25	0.33	0.24	0.31
	175	0.28	0.36	0.26	0.34
	200	0.31	0.39	0.29	0.36
	225	0.32	0.42	0.31	0.40
	250	0.35	0.46	0.34	0.44
	255	0.35	0.47	0.34	0.45
	260	0.36	0.48	0.35	0.46
	265	0.36	0.49	0.35	0.46
	270	0.37	0.50	0.36	0.47
	275	0.38	0.51	0.37	0.48
	280	0.38	0.53	0.37	0.49
	285	0.39	0.54	0.39	0.50
CB - 5A	25	0.05	0.06	0.07	0.06
	50	0.10	0.09	0.10	0.10
	75	0.15	0.13	0.15	0.15
	100	0.21	0.19	0.20	0.22
	125	0.41	0.40	0.40	0.45
	140	0.48	0.48	0.48	0.52
	150	0.53	0.52	0.53	0.57
	160	0.58	0.57	0.57	0.62
CB - 5B	25	0.06	0.05	0.07	0.07
	50	0.10	0.10	0.12	0.11
	75	0.15	0.15	0.17	0.16
	100	0.20	0.23	0.22	0.22
	125	0.39	0.35	0.39	0.39
	140	0.50	0.50	0.49	0.50
	150	0.54	0.55	0.54	0.56
	160	0.59	0.60	0.59	0.60
	170	0.66	0.63	0.64	0.64
	180	0.69	0.67	0.69	0.70
CB - 6A	25	0.05	0.05	0.05	0.06
	50	0.10	0.11	0.11	0.10
	75	0.13	0.14	0.14	0.12
	100	0.18	0.19	0.18	0.16
	125	0.23	0.24	0.23	0.22
	150	0.39	0.43	0.39	0.39
	160	0.44	0.49	0.45	0.46
	170	0.51	0.55	0.51	0.52
	180	0.55	0.58	0.56	0.57

TABLE A2 (Cont'd)

Mid-Span Deflection of Steel Deck Specimens
Two-Span Continuous Beam Tests

Specimen No.	Applied Uniform Load (psf)	Mid-Span Deflection (in) #1	#2	#3	#4
CB - 6B	25	0.07	0.07	0.06	0.06
	50	0.11	0.11	0.11	0.11
	75	0.16	0.16	0.16	0.15
	100	0.20	0.19	0.20	0.19
	125	0.24	0.24	0.25	0.24
	150	0.32	0.31	0.30	0.32
	160	0.46	0.46	0.42	0.47
	170	0.53	0.51	0.49	0.54
	180	0.57	0.54	0.53	0.57
	190	0.62	0.60	0.58	0.63
	200	0.67	0.64	0.62	0.67
CB - 9A	25	0.11	0.04	0.10	0.03
	50	0.15	0.08	0.15	0.11
	75	0.20	0.09	0.19	0.11
	100	0.23	0.10	0.23	0.11
	125	0.25	0.18	0.23	0.15
	150	0.29	0.20	0.25	0.20
	175	0.33	0.24	0.27	0.23
CB - 9B	25	0.13	0.06	0.08	0.03
	50	0.16	0.11	0.13	0.08
	75	0.20	0.14	0.17	0.10
	100	0.23	0.17	0.19	0.14
	125	0.31	0.20	0.21	0.16
	150	0.32	0.24	0.23	0.20
	175	0.36	0.27	0.26	0.22
	200	0.40	0.34	0.30	0.31
	210	0.44	0.39	0.32	0.34
	220	0.46	0.44	0.34	0.39
	230	0.48	0.50	0.41	0.46
	240	0.50	0.54	0.45	0.48
	250	0.53	0.57	0.48	0.52
	260	0.55	0.61	0.53	0.56
	270	0.58	0.64	0.55	0.59
	280	0.63	0.68	0.61	0.63
CB - 10A	25	0.17	0.11	0.15	0.09
	50	0.22	0.15	0.23	0.10
	75	0.29	0.17	0.26	0.12
	100	0.30	0.22	0.30	0.15
	125	0.33	0.25	0.31	0.20
	140	0.35	0.28	0.33	0.23
	150	0.38	0.30	0.34	0.24
	160	0.39	0.31	0.37	0.27
	170	0.42	0.33	0.38	0.29

TABLE A2 (Cont'd)

Mid-Span Deflection of Steel Deck Specimens
Two-Span Continuous Beam Tests

Specimen No.	Applied Uniform Load (psf)	Mid-Span Deflection (in.)			
		#1	#2	#3	#4
CB - 10B	25	0.19	0.11	0.18	0.09
	50	0.25	0.16	0.22	0.14
	75	0.25	0.18	0.26	0.21
	100	0.27	0.19	0.30	0.22
	125	0.29	0.24	0.35	0.28
	150	0.37	0.30	0.36	0.29
	175	0.41	0.32	0.38	0.29
	200	0.46	0.36	0.41	0.30
CB - 11A	25	0.05	0.04	0.07	0.09
	50	0.11	0.09	0.12	0.12
	75	0.16	0.14	0.18	0.18
	100	0.21	0.19	0.23	0.24
	125	0.44	0.40	0.42	0.42
	140	0.49	0.50	0.51	0.50
	150	0.58	0.51	0.55	0.55
	160	0.61	0.63	0.61	0.61
	170	0.67	0.63	0.63	0.66
CB - 11B	25	0.03	0.04	0.06	0.05
	50	0.07	0.08	0.12	0.11
	75	0.13	0.12	0.17	0.17
	100	0.19	0.18	0.23	0.22
	125	0.33	0.34	0.37	0.36
	140	0.44	0.44	0.49	0.48
	150	0.51	0.50	0.55	0.52
	160	0.54	0.55	0.59	0.58
CB - 12A	25	0.06	0.08	0.06	0.07
	50	0.11	0.13	0.10	0.12
	75	0.16	0.16	0.15	0.16
	100	0.19	0.20	0.19	0.20
	125	0.24	0.25	0.23	0.25
	140	0.28	0.28	0.27	0.29
	150	0.31	0.30	0.29	0.31
	160	0.40	0.46	0.39	0.46
	170	0.50	0.54	0.48	0.56
	180	0.58	0.60	0.56	0.62
CB - 12B	25	0.07	0.08	0.08	0.09
	50	0.12	0.13	0.14	0.16
	75	0.17	0.18	0.19	0.20
	100	0.23	0.24	0.25	0.25
	125	0.27	0.28	0.30	0.30
	140	0.31	0.32	0.33	0.35
	150	0.37	0.39	0.38	0.40

TABLE A2 (Cont'd)

Mid-Span Deflection of Steel Deck Specimens
Two-Span Continuous Beam Tests

Specimen No.	Applied Uniform Load (psf)	Mid-Span Deflection (in.)			
		#1	#2	#3	#4
	160	0.44	0.48	0.45	0.49
	170	0.52	0.55	0.52	0.57
	180	0.59	0.61	0.58	0.64
CB - 13A	30	0.08	0.07	0.06	0.10
	60	0.12	0.09	0.12	0.11
	90	0.14	0.13	0.14	0.14
	120	0.15	0.16	0.18	0.17
	150	0.21	0.23	0.23	0.21
	180	0.26	0.28	0.28	0.26
	210	0.38	0.40	0.41	0.37
CB - 13B	30	0.08	0.07	0.10	0.06
	60	0.12	0.11	0.10	0.12
	90	0.14	0.13	0.15	0.14
	120	0.17	0.15	0.18	0.17
	150	0.19	0.19	0.20	0.20
	180	0.22	0.25	0.24	0.23
	210	0.28	0.30	0.30	0.29
CB - 14A	30	0.10	0.13	0.07	0.07
	60	0.15	0.18	0.11	0.12
	90	0.17	0.21	0.16	0.16
	120	0.20	0.24	0.17	0.18
	150	0.23	0.27	0.20	0.20
	180	0.26	0.30	0.25	0.23
	210	0.29	0.34	0.32	0.29
	230	0.32	0.37	0.32	0.32
	250	0.35	0.39	0.35	0.36
CB - 14B	30	0.10	0.08	0.08	0.10
	60	0.14	0.11	0.10	0.11
	90	0.17	0.15	0.13	0.15
	120	0.18	0.18	0.18	0.16
	150	0.22	0.20	0.20	0.20
	180	0.24	0.24	0.23	0.22
	210	0.28	0.29	0.29	0.27
	230	0.31	0.31	0.31	0.30
	240	0.32	0.32	0.32	0.31
	250	0.33	0.33	0.33	0.33
CB - 15A	30	0.01	0.03	0.05	0.07
	60	0.05	0.06	0.10	0.09
	90	0.07	0.10	0.13	0.10
	120	0.09	0.13	0.17	0.12
	150	0.11	0.21	0.26	0.18

TABLE A2 (Cont'd.)

Mid-Span Deflection of Steel Deck Specimens
Two-Span Continuous Beam Tests

Specimen No.	Applied Uniform Load (psf)	Mid-Span Deflection (in.)			
		#1	#2	#3	#4
CB - 15B	30	0.04	0.04	0.06	0.05
	60	0.07	0.07	0.09	0.09
	90	0.10	0.10	0.12	0.11
	120	0.11	0.12	0.14	0.14
	150	0.12	0.15	0.15	0.17
	180	0.29	0.35	0.32	0.38
CB - 16A	30	0.07	0.07	0.07	0.06
	60	0.11	0.12	0.09	0.08
	90	0.13	0.15	0.11	0.11
	120	0.16	0.19	0.14	0.13
	150	0.17	0.22	0.17	0.17
	180	0.21	0.25	0.18	0.20
	210	0.27	0.42	0.28	0.36
CB - 16B	30	0.05	0.03	0.09	0.06
	60	0.09	0.08	0.12	0.12
	90	0.12	0.10	0.15	0.16
	120	0.13	0.13	0.18	0.19
	150	0.14	0.14	0.20	0.22
	180	0.15	0.17	0.22	0.24
	210	0.20	0.21	0.25	0.28
CB - 19A	20	0.09	0.09	0.09	0.09
	40	0.14	0.12	0.13	0.13
	60	0.17	0.17	0.16	0.17
	80	0.19	0.19	0.19	0.20
	100	0.22	0.20	0.21	0.22
	120	0.25	0.23	0.25	0.26
	140	0.27	0.27	0.29	0.29
	160	0.29	0.29	0.31	0.31
	180	0.34	0.31	0.33	0.34
	200	0.37	0.36	0.39	0.39
	220	0.42	0.39	0.43	0.42
CB - 19B	20	0.11	0.10	0.10	0.11
	40	0.15	0.14	0.14	0.15
	60	0.18	0.17	0.19	0.20
	80	0.21	0.20	0.22	0.22
	100	0.24	0.22	0.25	0.26
	120	0.26	0.25	0.28	0.29
	140	0.28	0.27	0.31	0.31
	160	0.30	0.30	0.34	0.34
	180	0.34	0.31	0.39	0.39
	200	0.37	0.34	0.42	0.42
	220	0.42	0.40	0.47	0.46

TABLE A2 (Cont'd)

Mid-Span Deflection of Steel Deck Specimens
Two-Span Continuous Beam Tests

Specimen No.	Applied Uniform Load (psf)	Mid-Span Deflection (in)			
		#1	#2	#3	#4
CB - 20A	20	0.07	0.08	0.08	0.09
	40	0.12	0.12	0.10	0.10
	60	0.16	0.15	0.13	0.13
	80	0.19	0.19	0.16	0.17
	100	0.22	0.21	0.18	0.19
	120	0.26	0.25	0.21	0.22
	140	0.28	0.28	0.24	0.25
	160	0.31	0.31	0.27	0.27
	180	0.36	0.34	0.30	0.30
	200	0.38	0.38	0.31	0.32
CB - 20B	20	0.04	0.06	0.06	0.06
	40	0.08	0.10	0.09	0.09
	60	0.11	0.14	0.12	0.12
	80	0.15	0.16	0.15	0.15
	100	0.18	0.21	0.18	0.18
	120	0.22	0.23	0.19	0.22
	140	0.24	0.25	0.23	0.26
	160	0.27	0.27	0.26	0.29
	180	0.29	0.29	0.28	0.30
	200	0.32	0.34	0.31	0.36
	220	0.34	0.36	0.35	0.39
	230	0.35	0.37	0.37	0.40
	240	0.37	0.38	0.38	0.41
	250	0.40	0.41	0.40	0.42

Note: See Fig. 36a for the location of deflection measurements.

TABLE A3

Mid-Span Deflection of Steel Deck Specimens
Three-Span Continuous Beam Tests

Specimen No.	Applied Uniform Load (psf)	Mid-Span Deflection (in)					
		#1	#2	#3	#4	#5	#6
CB - 3A	20	0.11	0.08	0.05	0.04	0.08	0.07
	40	0.18	0.15	0.08	0.06	0.15	0.14
	60	0.24	0.21	0.10	0.08	0.21	0.20
	80	0.29	0.26	0.11	0.10	0.27	0.26
	100	0.35	0.31	0.14	0.12	0.33	0.31
	120	0.41	0.35	0.16	0.14	0.37	0.36
	140	0.46	0.41	0.18	0.15	0.43	0.41
	160	0.51	0.46	0.20	0.16	0.48	0.45
	180	0.54	0.50	0.22	0.17	0.54	0.48
	200	0.59	0.56	0.24	0.19	0.58	0.54
	220	0.65	0.62	0.25	0.19	0.65	0.59
	240	0.68	0.70	0.28	0.21	0.71	0.66
	260	1.03	1.09	0.77	0.65	1.02	0.97
CB - 3B	20	0.10	0.09	0.10	0.06	0.12	0.10
	40	0.19	0.16	0.15	0.10	0.18	0.16
	60	0.26	0.23	0.17	0.11	0.24	0.22
	80	0.30	0.28	0.19	0.12	0.29	0.27
	100	0.35	0.31	0.20	0.13	0.36	0.32
	120	0.40	0.37	0.22	0.14	0.40	0.35
	140	0.45	0.42	0.25	0.16	0.46	0.40
	160	0.49	0.46	0.27	0.18	0.49	0.45
	180	0.54	0.50	0.29	0.18	0.55	0.50
	200	0.57	0.56	0.30	0.20	0.58	0.56
	220	0.63	0.60	0.32	0.22	0.64	0.62
	240	0.67	0.67	0.37	0.23	0.69	0.67
	260	0.74	0.77	0.41	0.25	0.75	0.77
CB - 4A	20	0.12	0.09	0.09	0.05	0.10	0.09
	40	0.16	0.17	0.12	0.09	0.18	0.16
	60	0.24	0.24	0.15	0.11	0.24	0.22
	80	0.29	0.29	0.16	0.12	0.29	0.26
	100	0.35	0.35	0.17	0.13	0.35	0.31
	120	0.40	0.39	0.20	0.14	0.39	0.36
	140	0.45	0.41	0.21	0.15	0.44	0.40
	160	0.51	0.47	0.23	0.17	0.49	0.46
	180	0.54	0.51	0.25	0.19	0.55	0.51
	200	0.58	0.56	0.27	0.20	0.58	0.56
	220	0.62	0.59	0.28	0.22	0.63	0.60
	240	0.67	0.66	0.31	0.24	0.68	0.64
	260	0.73	0.68	0.33	0.25	0.73	0.71
	280	0.78	0.71	0.36	0.29	0.79	0.76
	300	0.85	0.78	0.38	0.30	0.84	0.82
CB - 4B	20	0.10	0.10	0.07	0.10	0.10	0.11
	40	0.17	0.18	0.10	0.14	0.15	0.17
	60	0.23	0.25	0.12	0.16	0.20	0.23

TABLE A3 (Cont'd)

Mid-Span Deflection of Steel Deck Specimens
Three-Span Continuous Beam Tests

Specimen No	Applied Uniform Load (psf)	Mid-Span Deflection (in)					
		#1	#2	#3	#4	#5	#6
CB - 4B (cont'd)	80	0.28	0.30	0.15	0.18	0.25	0.27
	100	0.34	0.37	0.16	0.20	0.29	0.32
	120	0.38	0.40	0.17	0.22	0.32	0.36
	140	0.43	0.45	0.20	0.25	0.36	0.41
	160	0.47	0.50	0.22	0.27	0.41	0.44
	180	0.51	0.54	0.24	0.28	0.44	0.47
	200	0.54	0.58	0.25	0.31	0.48	0.51
	220	0.58	0.62	0.27	0.34	0.51	0.54
	240	0.62	0.67	0.30	0.37	0.56	0.58
	260	0.68	0.72	0.32	0.39	0.59	0.63

Note: See Fig. 36b for the location of deflection measurements.

TABLE A4

Strain Gage Rendings for Steel Deck Specimens
Single Span Beams Used for Combined Bending-Web Crippling Tests

Specimen No.	Applied Load (kips)	Strain Gage Reading (micro in./in.)*			
		#1	#2	#3	#4
BC - 2C	0.150	-164	170	139	-132
	0.300	-328	343	285	-277
	0.450	-500	510	441	-437
	0.600	-687	681	602	-591
	0.720	-850	821	737	-731
	0.840	-1015	970	882	-873
	0.960	-1195	1124	1035	-1027
	1.080	-1461	1308	1221	-1191
	1.170 Failure Load	-2590	1555	1526	-1376
BC - 2D	0.150	-152	151	133	-130
	0.300	-290	300	274	-269
	0.450	-437	458	420	-415
	0.600	-593	612	569	-564
	0.720	-725	742	696	-690
	0.840	-870	879	832	-824
	0.960	-1030	1022	971	-962
	1.080	-1220	1180	1130	-1123
	1.200	-1413	1393	1360	-1375
	1.202 Failure Load	-1383	1421	1389	-1375
BC - 12C	0.200	-157	158	151	-145
	0.400	-320	317	300	-283
	0.600	-492	478	457	-429
	0.800	-682	642	625	-586
	0.960	-859	771	762	-711
	1.120	-1050	910	911	-840
	1.280	-1242	1074	1079	-965
	1.400 Failure Load	-1428	1254	1335	-891
BC - 12D	0.200	-74	94	209	-197
	0.400	-200	228	374	-341
	0.600	-337	377	554	-496
	0.800	-482	532	738	-650
	0.960	-610	666	890	-773
	1.120	-742	801	1038	-835
	1.280	-889	955	1201	-951
	1.405 Failure Load	-1225	1272	1381	-744

* Negative sign indicates compressive strain.
See page 112 for the location of strain gages.

TABLE A4 (Cont'd)

Strain Gage Rendings for Steel Deck Specimens
Single Span Beams Used for Combined Bending-Web Crippling Tests

Specimen No.	Applied Load (kips)	Strain Gage Reading (micro in./in.)*			
		#1	#2	#3	#4
BC - 16C	0.115	127	-68	-227	260
	0.230	286	-193	-350	419
	0.345	474	-274	-481	598
	0.460	702	-416	-622	808
	0.550	847	-504	-720	940
	0.640	1030	-582	-836	1091
	0.730	1225	-687	-960	1253
	0.820	1449	-899	-1075	1438
	0.867 Failure Load	1681	-1130	-1070	1431
BC - 16D	0.115	176	-127	-122	177
	0.230	354	-247	-250	357
	0.345	530	-366	-382	536
	0.460	733	-505	-537	741
	0.550	891	-613	-656	887
	0.640	1048	-734	-783	1034
	0.730	1216	-862	-913	1188
	0.820	1389	-1007	-1062	1418
	0.872 Failure Load	1406	-1133	-1303	1662
BC - 19C	0.150	-124	159	154	-107
	0.300	-264	331	324	-278
	0.450	-421	515	506	-469
	0.600	-572	688	677	-623
	0.720	-715	842	826	-786
	0.840	-874	1025	990	-961
	0.960	-1026	1259	1202	-1149
	1.080	-1195	1606	1500	-1414
	1.200	-1431	2505	2420	-1960
	1.200 Failure Load	-1532	2729	2583	-2193
BC - 19D	0.150	-116	151	167	-48
	0.300	-261	326	348	-162
	0.450	-406	505	540	-305
	0.600	-562	686	734	-469
	0.720	-688	825	889	-645
	0.840	-822	1006	1095	-817
	0.960	-981	1257	1351	-1019
	1.080	-1191	1654	1721	-1281
	1.180 Failure Load	-1581	2613	2947	-1755

* Negative sign indicates compressive strain.
See page 112 for the location of strain gages.

TABLE A 5

Strain Gage Readings for Steel Deck Specimens
Two-Span Continuous Beam Tests

Specimen No.	Uniform Load (psf)	Strain Gage Reading (micro in./in.)*			
		#1	#2	#3	#4
CB - 1A	25	57	56	98	-138
	50	196	-107	-113	15
	75	348	-245	-303	189
	100	487	-396	-477	329
	125	634	-569	-676	504
	150	779	-744	-892	681
	175	938	-940	-1093	855
	200	1136	-1208	-1306	1068
	225	1548	-3794	-869	1532
	235	1647	-3279	-457	1718
	245	1797	-3158	-347	1833
	255	1938	-3110	-338	1958
	265	2107	-3043	-300	2124
	275	2280	-3001	-277	2312
	285	Failure Load			
CB - 1B	25	-110	+80	+176	+55
	50	+41	-99	-44	+186
	75	+192	-269	-229	+325
	100	+347	-500	-437	+466
	125	+504	-735	-669	+607
	150	+663	-949	-923	+753
	175	+829	-1187	-1232	+911
	200	+1018	-1508	-1657	+1099
	225	+1304	-1669	-3116	+1431
	235	+1469	-1241	-3541	+1686
	245	+1633	-932	-2645	+1810
	255	+1738	-864	-2443	+1915
	265	+1848	-820	-2307	+2014
	275	+1972	-794	-2219	+2127
	285	Failure Load			
CB - 2A	25	-33	96	20	7
	50	-139	-56	-112	133
	75	-63	-200	-250	269
	100	-57	-350	-400	394
	125	81	-500	-555	531
	150	207	-647	-712	671
	175	302	-815	-883	810
	200	433	-980	-1051	958

* Negative sign indicates compressive strain
See page 122 for the location of strain gages.

TABLE A5 (Cont'd)

Strain Gage Readings for Steel Deck Specimens
Two-Span Continuous Beam Tests

Specimen No.	Uniform Load (psf)	Strain Gage Reading (micro in./in.)*			
		#1	#2	#3	#4
CB - 2A (cont'd)	225	567	-1198	-1270	1130
	250	719	-1490	-1497	1307
	260	826	-1824	-1607	1415
	270	882	-1990	-1679	1479
	280	969	-2328	-1786	1574
	290	1080	-2870	-2207	1695
	300	1152	-6732	-1384	1440
	300	Failure Load			
CB - 2B	+25	-87	+79	+73	+73
	+50	+58	-103	-61	+203
	+75	+194	-238	-179	+328
	+100	+323	-369	-312	+449
	+125	+459	-504	-449	+571
	+150	+602	-649	-595	+696
	+175	+742	-783	-734	+820
	+200	+890	-925	-887	+950
	+225	+1044	-1079	-1052	+1076
	+250	+1212	-1223	-1205	+1215
	+260	+1285	-1276	-1275	+1278
	+270	+1368	-1347	-1374	+1352
	+280	+1455	-1408	-1499	+1447
	+290	+1576	-1480	-1701	+1531
	+300	+1688	-1761	-2197	+1659
	+310	+1562	-950	-4574	+1749
	+312	Failure Load			
CB - 5A	25	172	-285	-194	155
	50	307	-597	-413	281
	75	431	-1060	-733	400
	100	514	-1990	-1175	497
	125	877	-4793	-186	692
	140	1081	-4525	-51	929
	150	1210	-4428	5	1057
	160	1382	-4248	54	1220
	170	1530	-4132	78	1374
	180	1682	-3974	101	1522
	190	1827	-3846	111	1657
	200	1989	-3716	118	1809
	210	2187	-3569	122	1952

* Negative sign indicates compressive strain.
See page 122 for the location of strain gages.

TABLE A5 (Cont'd)

Strain Gage Readings for Steel Deck Specimens
Two-Span Continuous Beam Tests

Specimen No.	Uniform Load (psf)	Strain Gage Reading (micro in./in.)*			
		#1	#2	#3	#4
CB - 5A (cont'd)	220	2419	-3477	121	2103
	230	2736	-3380	125	2281
	230	Failure Load			
CB - 5B	25	159	-230	-57	182
	50	278	-470	-361	335
	75	386	-749	-699	466
	100	492	-1189	-1349	565
	125	723	-449	-4345	779
	140	980	-359	-4240	923
	150	1088	-328	-4164	1021
	160	1237	-280	-4025	1169
	170	1392	-231	-3816	1303
	180	1513	-209	-3696	1415
	190	1671	-188	-3516	1554
	200	1797	-163	-3393	1671
	210	1919	-134	-3259	1780
	220	----	286	-4564	----
	221	Failure Load			
CB - 6A	25	145	-259	-147	98
	50	287	-523	-280	195
	75	420	-783	-444	281
	100	550	-1087	-615	369
	125	665	-1587	-896	440
	150	770	-2452	-1474	469
	160	587	-3549	-794	274
	170	589	-3502	-763	307
	180	623	-3606	-769	349
	190	698	-3612	-804	403
	200	809	-3623	-764	459
	210	889	-3625	-772	515
	220	964	-3609	-654	577
	230	1038	-3619	-626	641
	239	Failure Load			
CB - 6B	25	159	-375	-95	135
	50	294	-616	-271	263
	75	427	-863	-433	386
	100	560	-1051	-616	509
	125	678	-1273	-837	616

* Negative sign indicates compressive strain.
See page 122 for the location of strain gages.

TABLE A5 (Cont'd)

Strain Gage Readings for Steel Deck Specimens
Two-Span Continuous Beam Tests

Specimen No.	Uniform Load (psf)	Strain Gage Reading (micro in./in.)*			
		#1	#2	#3	#4
CB - 6B (cont'd)	150	775	-1826	-1336	711
	160	611	-2827	-783	568
	170	602	-2904	-699	597
	180	632	-2949	-682	627
	190	697	-2982	-583	690
	200	757	-2984	-512	753
	210	830	-2978	-441	823
	220	903	-2988	-401	898
	230	992	-2987	-347	976
	240	1077	-2967	-295	1041
	247	Failure Load			
CB - 9A	25	-70	+56	+33	-3
	50	22	-75	-27	-3
	75	154	-272	-225	--
	100	278	-444	-517	--
	125	412	-581	-825	--
	150	528	-695	-1041	--
	175	651	-784	-1432	--
	200	794	-947	-1787	--
	210	883	-1020	--	--
	220	979	-866	--	--
	230	1059	-735	--	--
	240	1112	-728	--	--
	250	1169	-696	--	--
	260	1209	-683	--	--
	270	1238	-660	--	--
	280	1281	-687	--	--
	290	1318	-731	--	--
	300	1366	-782	--	--
	302	Failure Load			
CB - 9B	25	-60	20	68	157
	50	20	-144	-90	307
	75	149	-312	-244	453
	100	270	-392	-385	598
	125	390	-508	-519	744
	150	508	-637	-679	881
	175	622	-787	-933	1052
	200	757	-1035	-1899	1317
	210	834	-1061	-1752	1446
	220	930	-1024	--	1525

* Negative sign indicates compressive strain.
See page 122 for the location of strain gages.

TABLE A5 (Cont'd)

Strain Gage Readings for Steel Deck Specimens
Two-Span Continuous Beam Tests

Specimen No.	Uniform Load (psf)	Strain Gage Reading (micro in./in.)*			
		#1	#2	#3	#4
CB - 9B (cont'd)	230	1001	-1001	--	1592
	240	1074	-945	--	1716
	250	1124	-940	--	1862
	260	1162	-906	--	2016
	270	1209	-809	--	2193
	280	1260	-788	--	2359
	290	1326	-810	--	2603
	300	8111	-353	--	13794
	300	Failure Load			
CB - 10A	25	-83	77	6	126
	50	7	4	-71	262
	75	123	-83	-223	393
	100	236	-207	-361	517
	125	346	-342	-520	640
	140	416	-415	-609	720
	150	456	-468	-671	763
	160	501	-530	-745	817
	170	541	-578	-812	872
	180	585	-642	-890	931
	190	626	-699	-965	978
	200	670	-761	-1049	1035
	210	711	-820	-1130	1087
	220	749	-882	-1217	1136
	230	800	-968	-1351	1211
	240	840	-1029	-1438	1266
	250	887	-1119	-1566	1336
	260	933	-1227	-1735	1409
	270	982	-1356	-1951	1487
	280	1034	-1477	-2298	1584
	290	1085	-1559	-2802	1696
	300	1144	-1471	-3403	1874
	310	1133	-1559	-3687	1979
	320	929	-1774	-2888	2009
	330	834	-2002	-2660	1912
	331	Failure Load			
CB - 10B	25	-20	-9	18	108
	50	115	-143	-124	243
	75	238	-308	-296	374
	100	360	-444	-454	509

* Negative sign indicates compressive strain
See page 122 for the location of strain gages.

TABLE A5 (Cont'd)

Strain Gage Readings for Steel Deck Specimens
Two-Span Continuous Beam Tests

Specimen No.	Uniform Load (psf)	Strain Gage Reading (micro in./in.)*			
		#1	#2	#3	#4
CB - 10B (cont'd)	125	482	-617	-588	643
	150	594	-785	-725	775
	175	710	-957	-900	913
	200	820	-1115	-1067	1037
	210	871	-1177	-1172	1109
	220	917	-1244	-1299	1172
	230	967	-1316	-1503	1247
	240	1015	-1379	-1708	1323
	250	1065	-1441	-1965	1407
	260	1120	-1510	-2303	1501
	270	1174	-1626	-2508	1600
	280	1203	-1844	-2861	1681
	290	1138	-2001	-3017	1731
	300	1042	-2054	-3315	1757
	310	916	-2019	--	1711
	320	Failure Load			
CB - 11A	25	178	-170	-192	141
	50	339	-657	-313	297
	75	493	-1291	-415	437
	100	660	-2290	-651	596
	125	972	-5117	-566	1086
	140	1003	-4837	-442	1333
	150	1042	-4710	-377	1495
	160	1108	-4612	-308	1650
	170	1168	-4488	-243	1770
	180	1250	-4440	-207	1893
	190	1346	-4363	-145	1983
	190	Failure Load			
CB - 11B	25	167	-279	-207	169
	50	332	-158	-432	326
	75	497	-273	-569	492
	100	669	-990	-765	664
	125	928	-3148	-24	948
	140	897	-3244	252	1160
	150	950	-3123	356	1294
	160	1021	-2979	446	1408
	170	1107	-2816	502	1536
	180	1192	-2694	535	1653
	190	1277	-2583	557	1751
	198	Failure Load			

* Negative sign indicates compressive strain.
See page 122 for the location of strain gages.

TABLE A5 (Cont'd)

Strain Gage Readings for Steel Deck Specimens
Two-Span Continuous Beam Tests

Specimen No.	Uniform Load (psf)	Strain Gage Reading (micro in./in.)*			
		#1	#2	#3	#4
CB - 12A	25	144	-194	-139	141
	50	285	-387	-251	283
	75	421	-679	-392	407
	100	555	-1011	-564	537
	125	688	-1502	-786	675
	140	757	-1946	-992	768
	150	810	-2402	-1546	848
	160	794	-3909	-4724	793
	170	598	-4088	-1640	809
	180	463	-4179	-1297	913
	190	399	-4229	-1163	1012
	200	334	-4235	-1047	1127
	210	284	-4205	-8080	1259
	210	Failure Load			
CB - 12B	25	204	-309	-106	147
	50	361	-552	-275	306
	75	517	-798	-442	465
	100	669	-1103	-600	609
	125	826	-1564	-783	748
	140	937	-2051	-929	827
	150	1042	-2525	-1218	893
	160	1109	-3893	-833	882
	170	1071	-4138	-685	950
	180	1014	-4214	-616	986
	190	990	-4286	-523	1052
	200	1013	-4301	-380	1115
	207	Failure Load			
CB - 13A	30	+72	-23	132	-270
	60	-60	32	265	-490
	90	-217	184	393	-697
	120	-382	289	521	-945
	150	-790	395	672	-1515
	180	-1156	506	758	-2329
	210	-3048	378	381	-2589
	230	-1267	-178	110	-1729
	240	-888	-252	72	-1594
	242	Failure Load			

* Negative sign indicates compressive strain.
See page 122 for the location of strain gages.

TABLE A5 (Cont'd)

Strain Gage Readings for Steel Deck Specimens
Two-Span Continuous Beam Tests

Specimen No.	Uniform Load (psf)	Strain Gage Reading (micro in./in.)*			
		#1	#2	#3	#4
CB - 14A	30	-111	109	0	-34
	60	-187	223	102	-127
	90	-278	329	196	-219
	120	-385	436	278	-305
	150	-495	552	372	-403
	180	-606	664	471	-510
	210	-783	840	587	-1042
	230	-827	919	663	-1235
	250	-977	1029	758	-1626
	251	Failure Load			
CB - 15A	30	-191	166	105	-152
	60	-365	289	181	-291
	90	-554	422	263	-454
	120	-728	544	334	-586
	150	-1031	674	422	-1069
	180	+434	282	--	--
	235	Failure Load			
CB - 15B	30	-136	89	152	-211
	60	-249	180	271	-364
	90	-383	268	387	-505
	120	-524	349	500	-621
	150	-677	430	591	-778
	180	-295	272	491	965
	210	-5	-83	197	1602
	220	-24	-129	175	1663
	230	-51	-210	134	1656
	240	-59	-239	127	1626
	241	Failure Load			
CB - 16A	30	-45	56	135	-128
	60	-153	157	248	-250
	90	-247	250	358	-343
	120	-342	344	471	-435
	150	-442	424	576	-523
	180	-558	514	679	-632

* Negative sign indicates compressive strain.
See page 122 for the location of strain gages.

TABLE A5 (Cont'd)

Strain Gage Readings for Steel Deck Specimens
Two-Span Continuous Beam Tests

Specimen No.	Uniform Load (psf)	Strain Gage REading (micro in./in.)*			
		#1	#2	#3	#4
CB - 16A (cont'd)	210	-1179	585	361	-407
	230	97	-291	-52	461
	240	227	-348	-85	506
	241	Failure Load			
CB - 16B	30	-5	1	153	-142
	60	-132	82	254	-257
	90	-249	169	364	-373
	120	-354	254	473	-496
	150	-444	337	582	-626
	180	-558	417	701	-781
	210	-681	489	808	-948
	230	-640	-68	150	226
	240	-428	-162	103	312
	250	-114	-320	5	430
	261	Failure Load			
CB - 19B	20	19	-19	-2	31
	40	109	-149	-147	104
	60	177	-267	-246	183
	80	249	-402	-579	275
	100	318	-504	-762	357
	120	395	-605	-888	435
	140	475	-703	-965	512
	160	572	-863	-1042	598
	180	691	-1081	-1137	691
	200	806	-1288	-1309	784
	220	973	-1447	-1505	903
	230	1273	-1443	-1296	1151
	240	1526	-1381	-1199	1407
	251	Failure Load			
CB - 20B	+20	+61	-52	+66	--
	+40	+132	-126	+142	--
	+60	+196	-222	+233	--
	+80	+258	-332	+315	--
	+100	+317	-443	+390	--
	+120	+385	-547	+468	--
	+140	+455	-657	+545	--
	+160	+525	-759	+618	--

* Negative sign indicates compressive strain.
See page 122 for the location of strain gages.

TABLE A5 (Cont'd)

Strain Gage Readings for Steel Deck Specimens
Two-Span Continuous Beam Tests

Specimen No.	Uniform Load (psf)	Strain Gage Reading (micro in./in.)*			
		#1	#2	#3	#4
CB - 20B (cont'd)	+180	+599	-877	+706	--
	+200	+670	-988	+782	--
	+220	+743	-1150	+870	--
	+230	+780	-1230	+917	--
	+240	+814	-1347	+970	--
	+250	+848	-1446	+1024	--
	+260	+870	-1555	+1068	--
	+270	+891	-1676	+1104	--
	+280	+903	-1754	+1106	--
	+290	Failure Load			

* Negative sign indicates compressive strain.
See page 122 for the location of strain gages.

TABLE A 6

Strain Gage Readings for Steel Deck Specimens
Three-Span Continuous Beam Tests

Specimen No.	Uniform Load (psf)	Strain Gage Reading (micro in./in.)*							
		#1	#2	#3	#4	#5	#6	#7	#8
CB - 3A	20	127	-160	112	87	51	-72	-67	137
	40	233	-276	59	171	155	-218	-219	230
	60	343	-397	-35	271	282	-376	-376	329
	80	442	-515	-132	369	386	-456	-510	422
	100	551	-603	-241	474	498	-541	-656	528
	120	662	-715	-354	574	604	-635	-812	629
	140	770	-819	-459	658	694	-715	-946	711
	160	879	-934	-569	748	790	-818	-1096	797
	180	993	-1098	-658	816	900	-947	-1266	903
	200	1107	-1260	-772	890	987	-1073	-1444	998
	220	1238	-1432	-910	960	1075	-1213	-1681	1108
	240	1385	-1616	-1095	1067	1145	-1353	-2020	1227
	260	1648	-1877	-1490	1222	1286	-1572	-2628	1553
	270	2858	-1298	-2583	1724	2750	-1981	-6888	5546
	280	2942	-1286	-4661	1815	2855	-1981	-7019	5801
	290	3115	-1163	-4770	1870	3044	-1821	-7149	6945
	300	Failure Load							
CB - 3B	20	5	13	-214		19	-20	-334	190
	40	90	-79	-252		71	-88	-441	323
	60	190	-204	-320		179	-231	-487	445
	80	289	-326	-406		278	-377	-542	539
	100	386	-445	-502		371	-493	-699	627
	120	482	-570	-621		462	-617	-811	716
	140	582	-692	-775		565	-747	-933	818
	160	681	-774	-934		654	-866	-1056	900
	180	783	-848	-1116		739	-992	-1196	978
	200	880	-930	-1285		823	-1115	-1335	1064
	220	985	-1038	-1507		911	-1256	-1513	1161
	240	1097	-1208	-1828		1005	-1415	-1764	1263
	260	1286	-1536	-2738		1148	-1677	-2439	1441
	270	1369	-1654	-3181		1210	-1785	-2763	1525
	280	1534	-1943	-4390		1332	-2010	-3887	1761
	290	3004	-1426	-10894		2541	-2005	-15640	4155
	300	3234	-1366	-11399		2756	-1963	-16095	4580
	310	Failure Load							
CB - 4A	20	17	-2	-206	162	18	-18	-154	125
	40	61	-62	-299	282	103	-122	-244	186
	60	150	-189	-418	392	189	-229	-354	262

* Negative sign indicates compressive strain.
See page 122 for the location of strain gages.

TABLE A6 (Cont'd)

Strain Gage Readings for Steel Deck Specimens
Three-Span Continuous Beam Tests

Specimen No.	Uniform Load (psf)	Strain Gage Reading (micro in./in.)*							
		#1	#2	#3	#4	#5	#6	#7	#8
CB - 4A (cont'd)	80	242	-304	-524	481	259	-314	-442	324
	100	338	-443	-662	584	340	-414	-551	400
	120	435	-592	-800	690	424	-516	-661	472
	140	524	-713	-906	772	490	-604	-753	527
	160	620	-835	-1010	883	573	-709	-865	600
	180	716	-947	-1107	987	659	-814	-981	676
	200	806	-1065	-1211	1084	734	-918	-1083	744
	220	901	-1185	-1321	1190	823	-1038	-1221	825
	240	987	-1322	-1433	1285	899	-1156	-1347	888
	260	1075	-1476	-1561	1393	985	-1295	-1503	956
	280	1173	-1656	-1716	1521	1088	-1456	-1724	1039
	300	1272	-1816	-1886	1638	1193	-1625	-2001	1126
	320	1410	-2051	-2230	1809	1342	-1714	-2656	1238
	330	1558	-2234	-3096	1916	1548	-1828	-4526	1365
	340	1129	-1961	-3997	1787	1509	-1694	-5348	1304
	350	1334	-1879	-4543	1713	1456	-1596	-5469	1233
	350	Failure Load							
CB - 4B	20	4	1	-108	144	5	1	154	146
	40	96	-102	-204	216	21	-29	-246	268
	60	179	-202	-292	283	96	-139	-400	366
	80	256	-303	-385	350	176	-264	-520	455
	100	336	-410	-480	421	262	-402	-641	548
	120	412	-513	-571	485	338	-519	-757	636
	140	490	-622	-664	549	413	-630	-874	715
	160*	567	-733	-761	607	484	-741	-986	789
	180	648	-863	-879	670	558	-874	-1118	870
	200	723	-998	-995	727	625	-1005	-1242	942
	220	800	-1130	-1121	801	702	-1149	-1383	1026
	240	869	-1278	-1279	865	764	-1297	-1548	1100
	260	952	-1494	-1797	954	825	-1481	-1820	1176
	270	1001	-1616	-2223	1006	861	-1579	-2005	1222
	280	1051	-1726	-2532	1058	897	-1666	-2163	1268
	290	1115	-1912	-2832	1139	950	-1812	-2429	1344
	300	1195	-2110	-3216	1225	1004	-1992	-2772	1415
	310	1236	-2460	-4349	1255	1136	-2397	-3695	1594
	320	1166	-2367	-4499	1142	1233	-2514	-5571	1662
	330	1094	-2293	-4466	1075	1060	-2290	-5698	1487
	340	1047	-2242	-4427	1037	975	-2090	-5756	1416
	349	Failure Load							

* Negative sign indicates compression strian.
See page 122 for the location of strain gages.

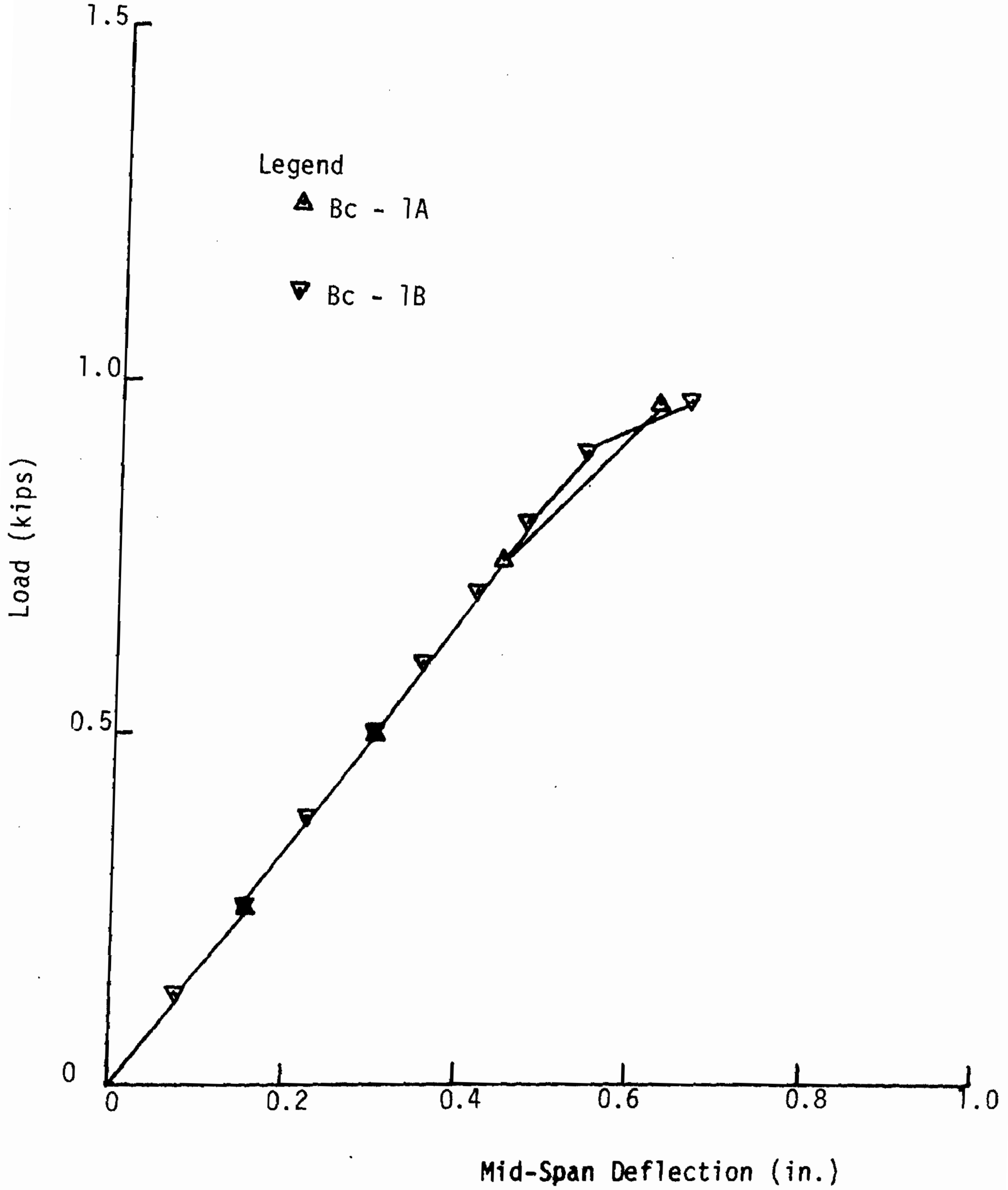


Fig. A1 Mid-Span Deflection of Steel Deck Specimens Nos. BC-1A and BC-1B

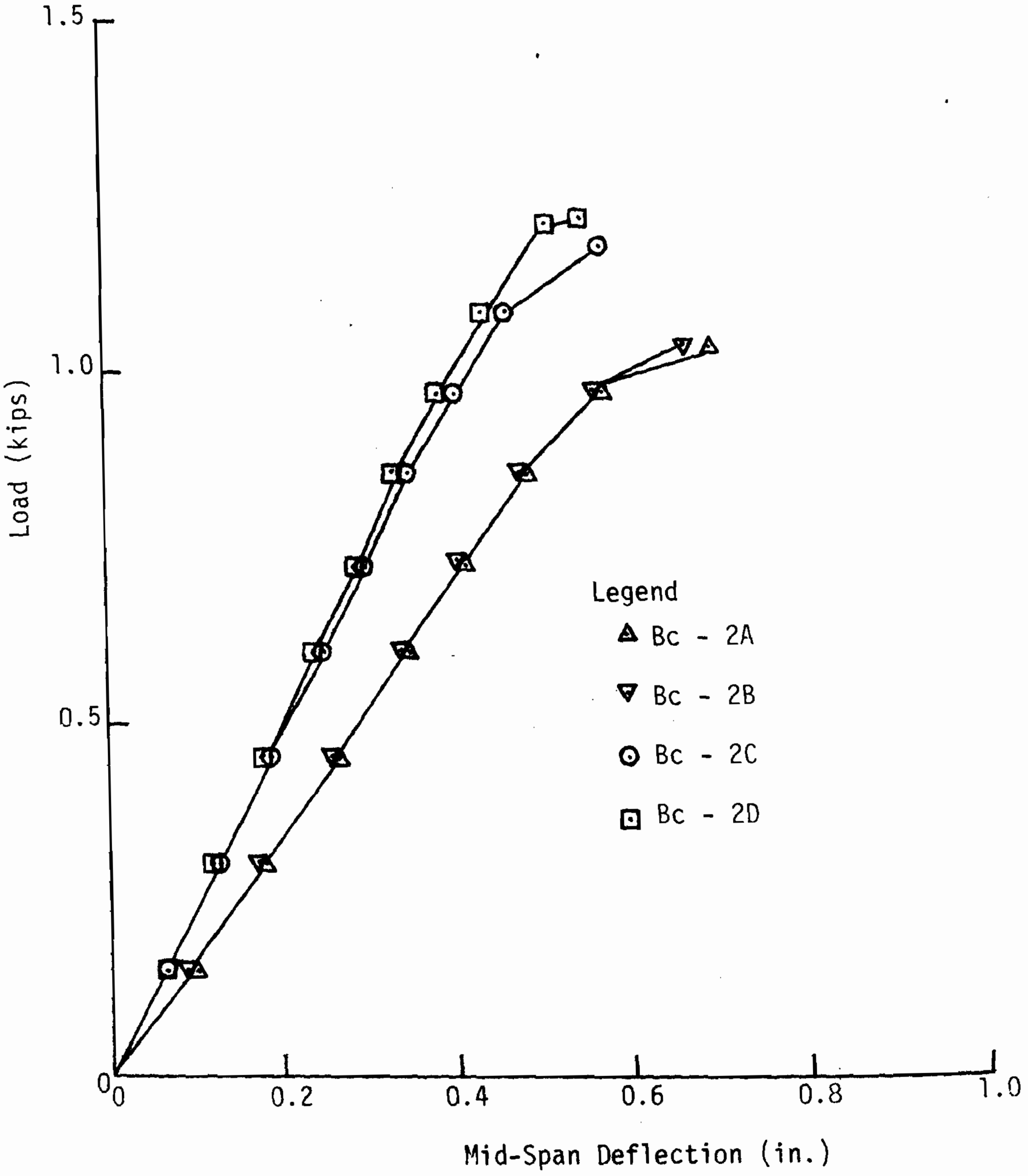


Fig. A2 Mid-Span Deflection of Steel Deck Specimens Nos. BC-2A, BC-2B, BC-2C, and BC-2D

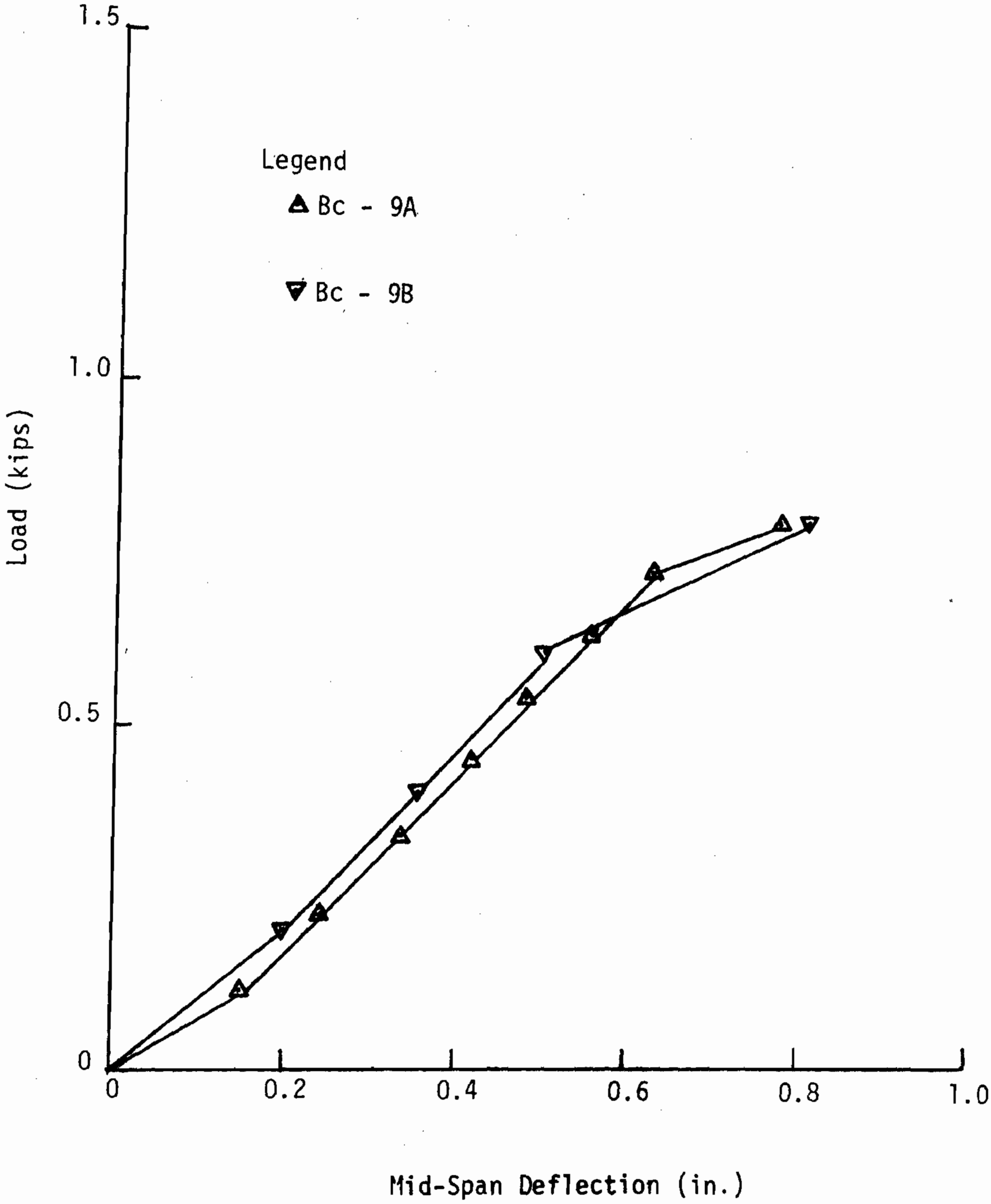


Fig. A3 Mid-Span Deflection of Steel Deck Specimens Nos. BC-9A and BC-9B

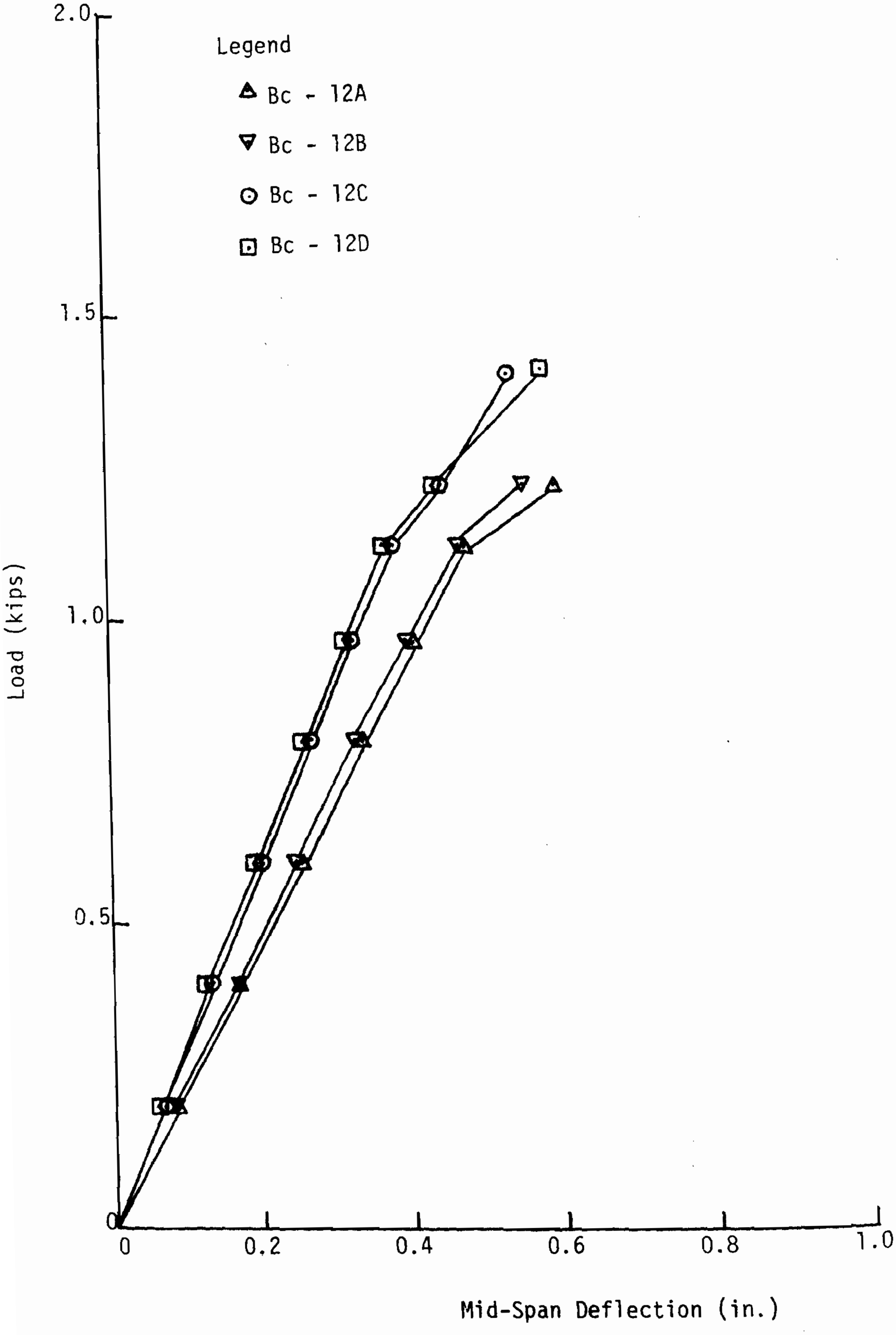


Fig. A4 Mid-Span Deflection of Steel Deck Specimens Nos. BC-12A, BC-12B, BC-12C and BC-12D

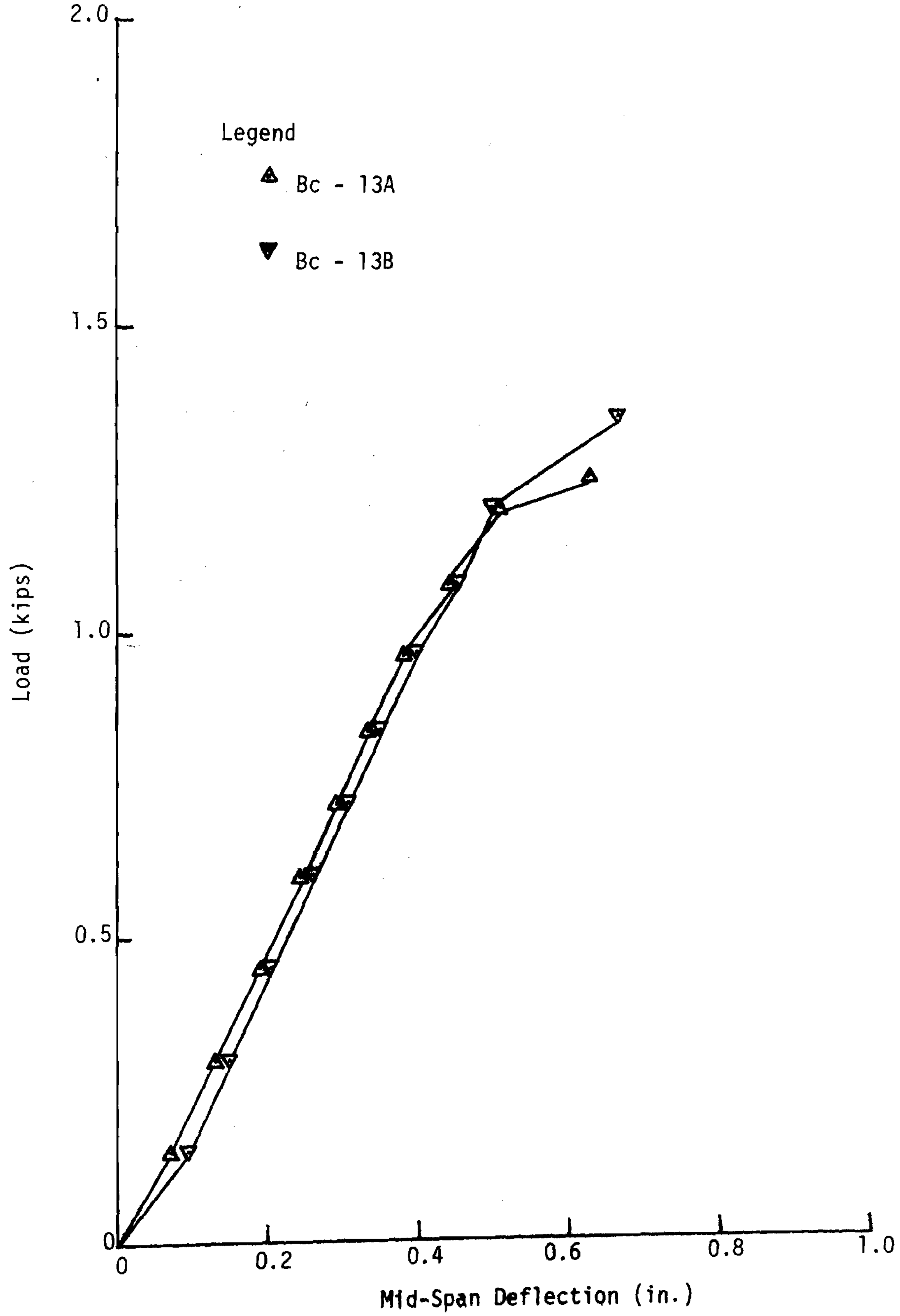


Fig. A5 Mid-Span Deflection of Steel Deck Specimens Nos. BC-13A and BC-13B

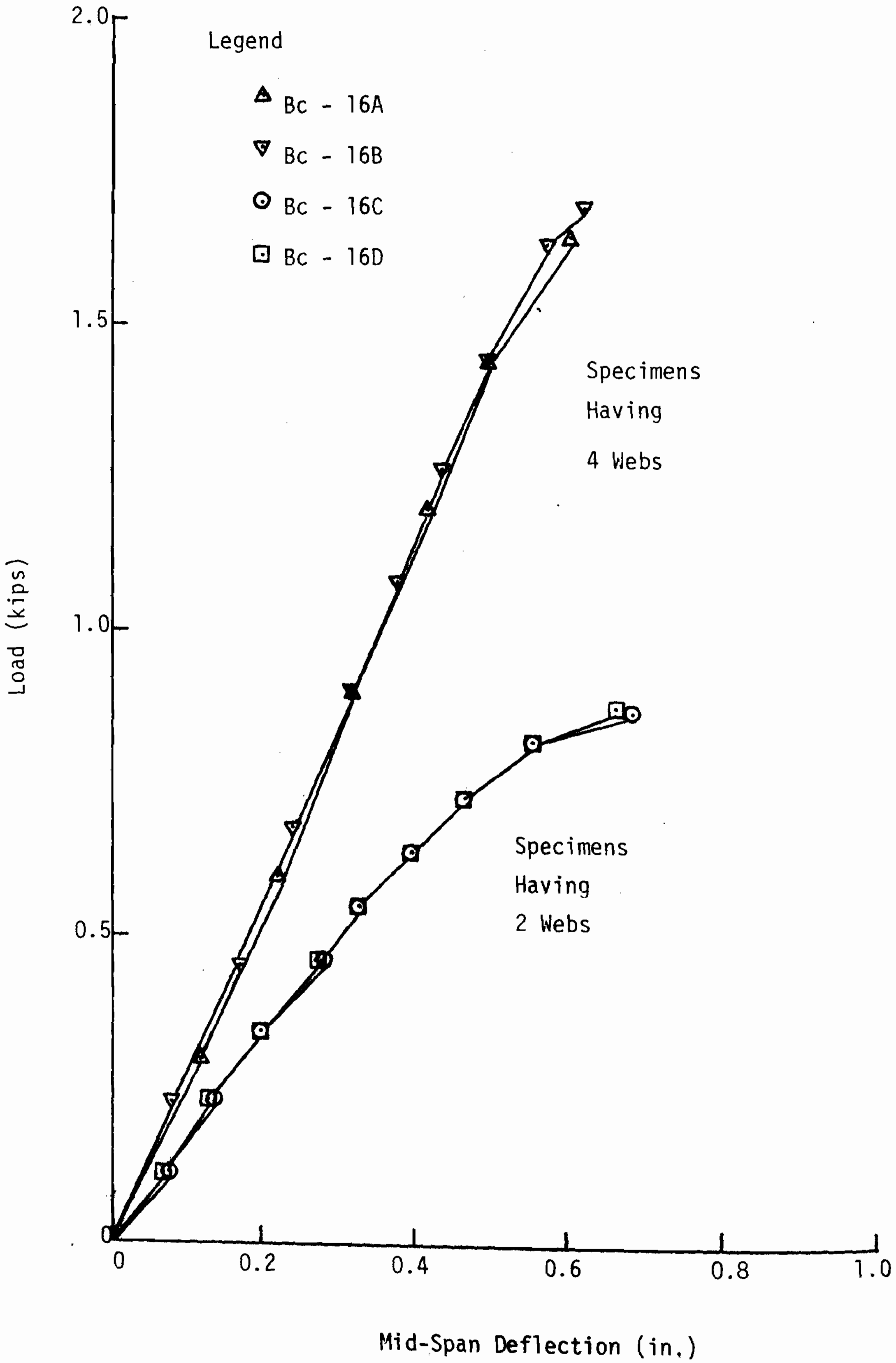


Fig. A6 Mid-Span Deflection of Steel Deck Specimens Nos. BC-16A, BC-16B, BC-16C, and BC-16D

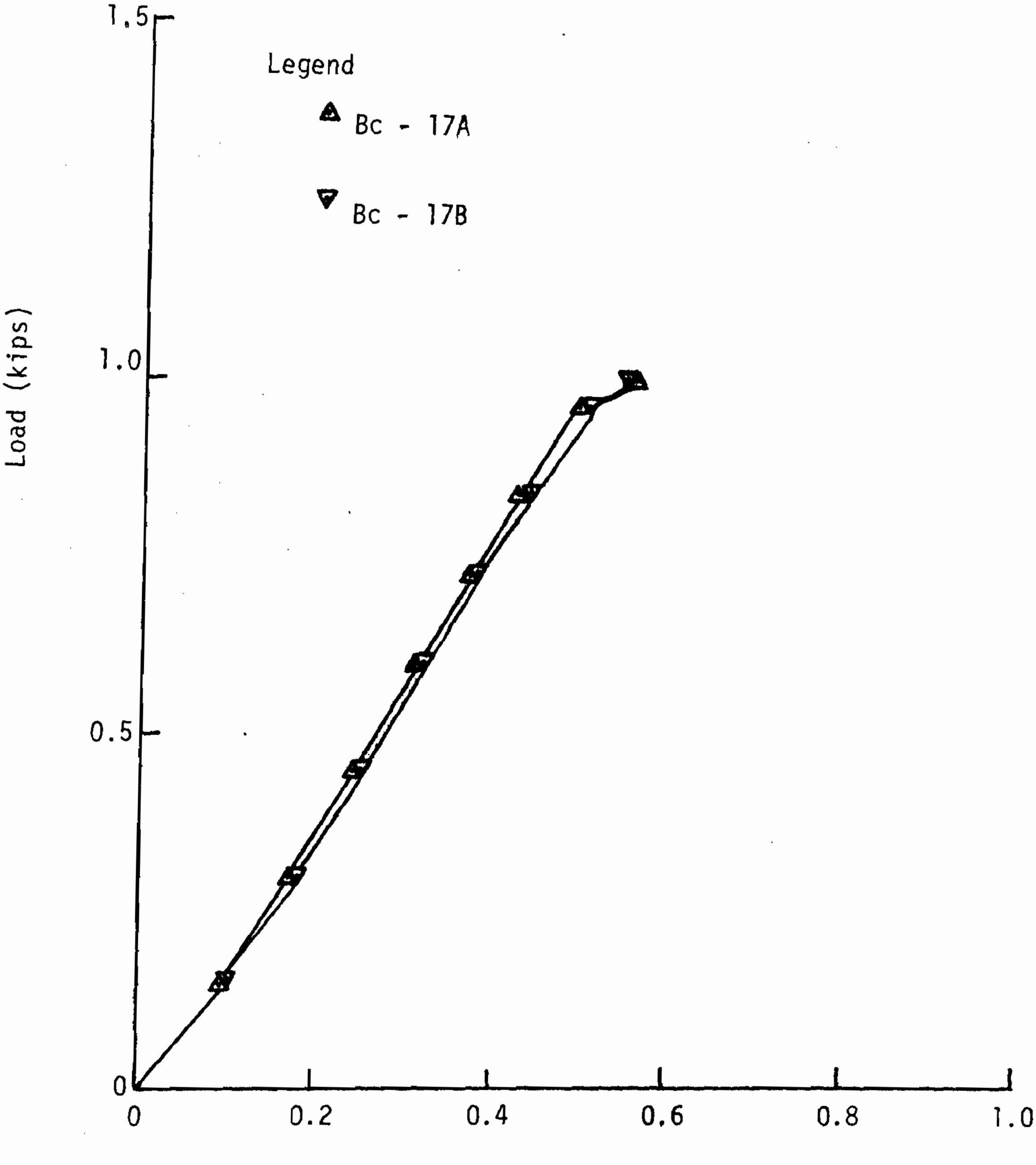


Fig. A7 Mid-Span Deflection of Steel Deck Specimens Nos. BC-17A and BC-17B

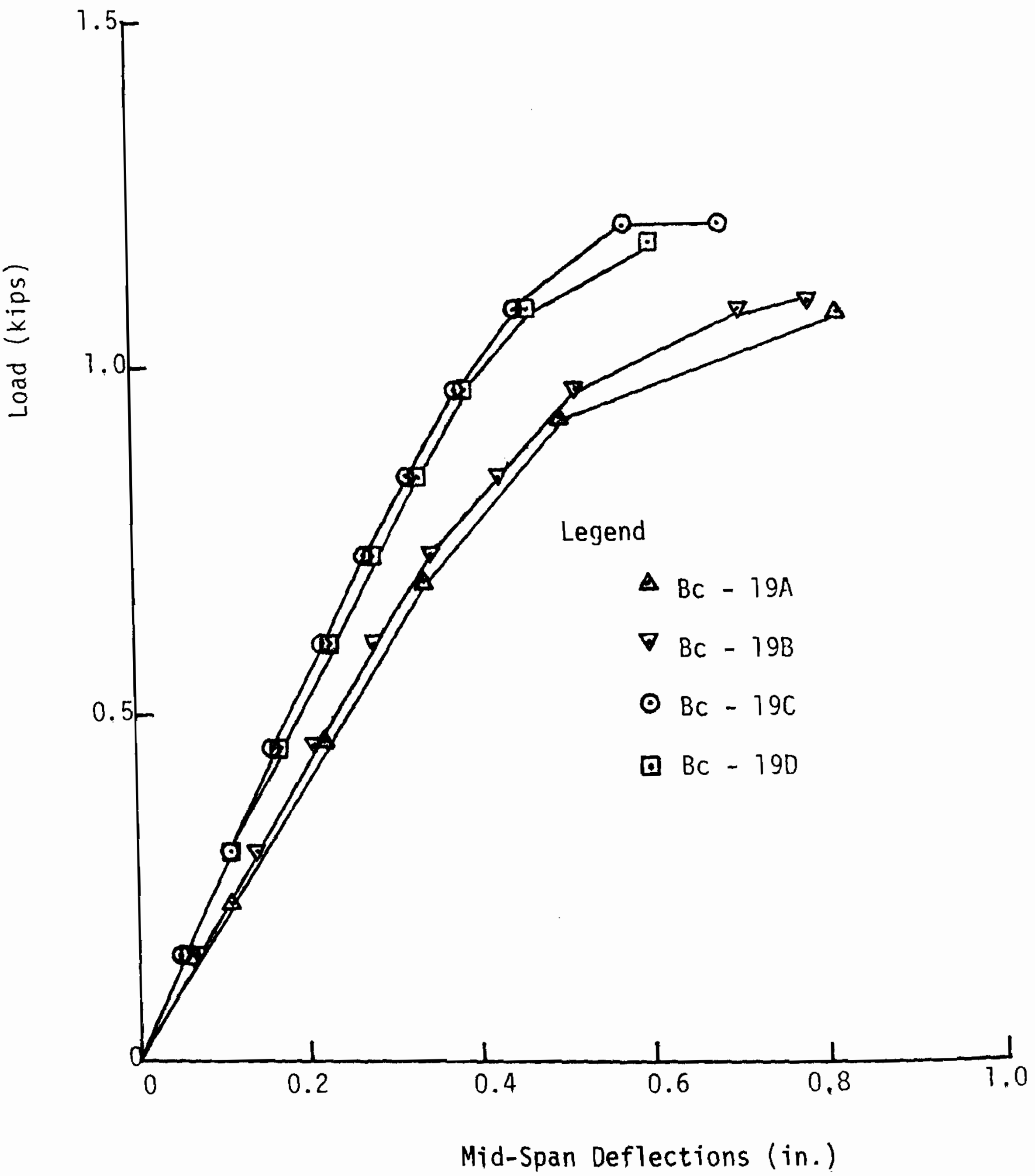


Fig. A8 Mid-Span Deflection of Steel Deck Specimens Nos. BC-19A, BC-19B, BC-19C, and BC-19D

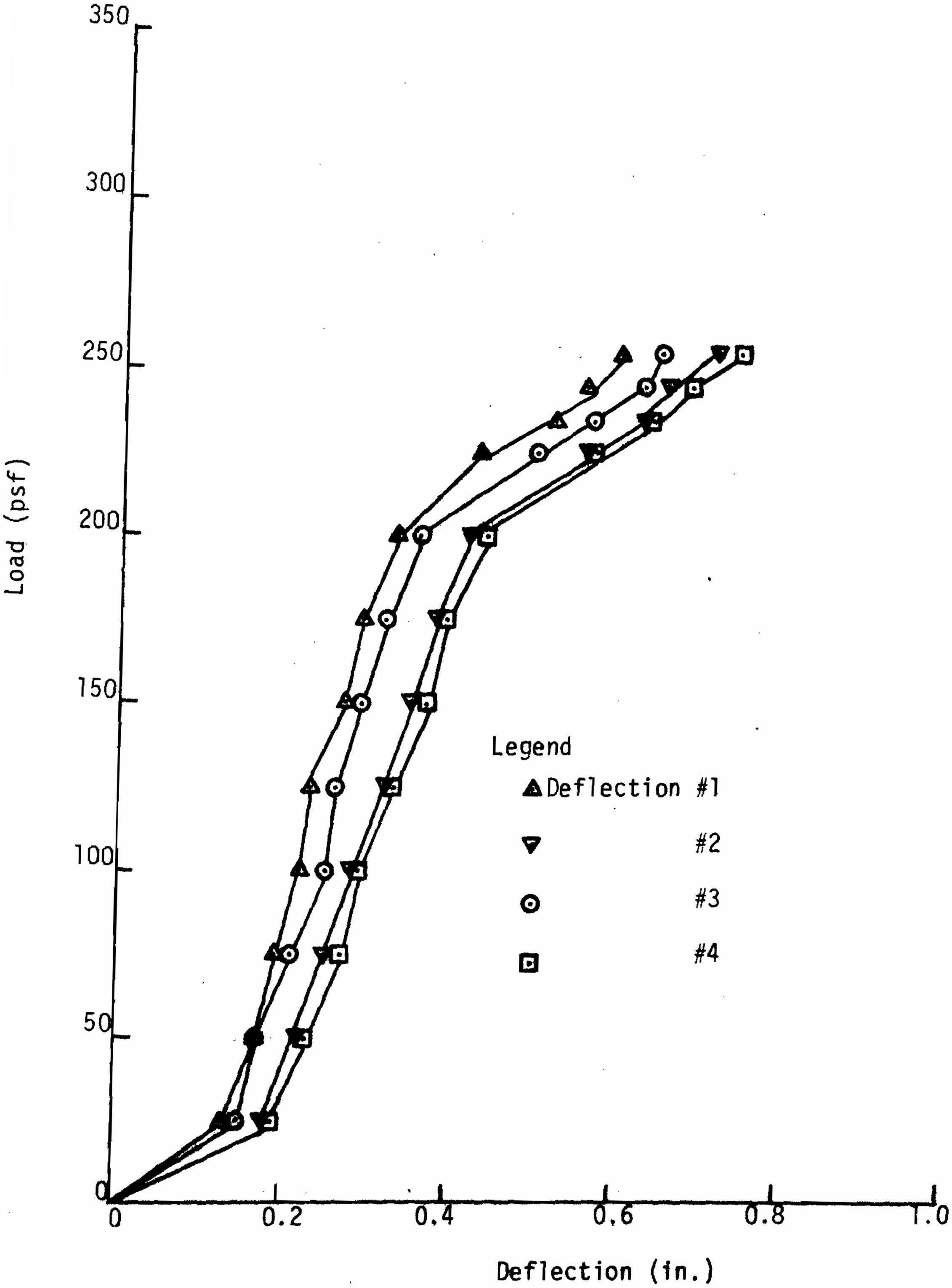


Fig. A9 Mid-Span Deflection of Two-Span Continuous Beam Specimen No. CB-1A

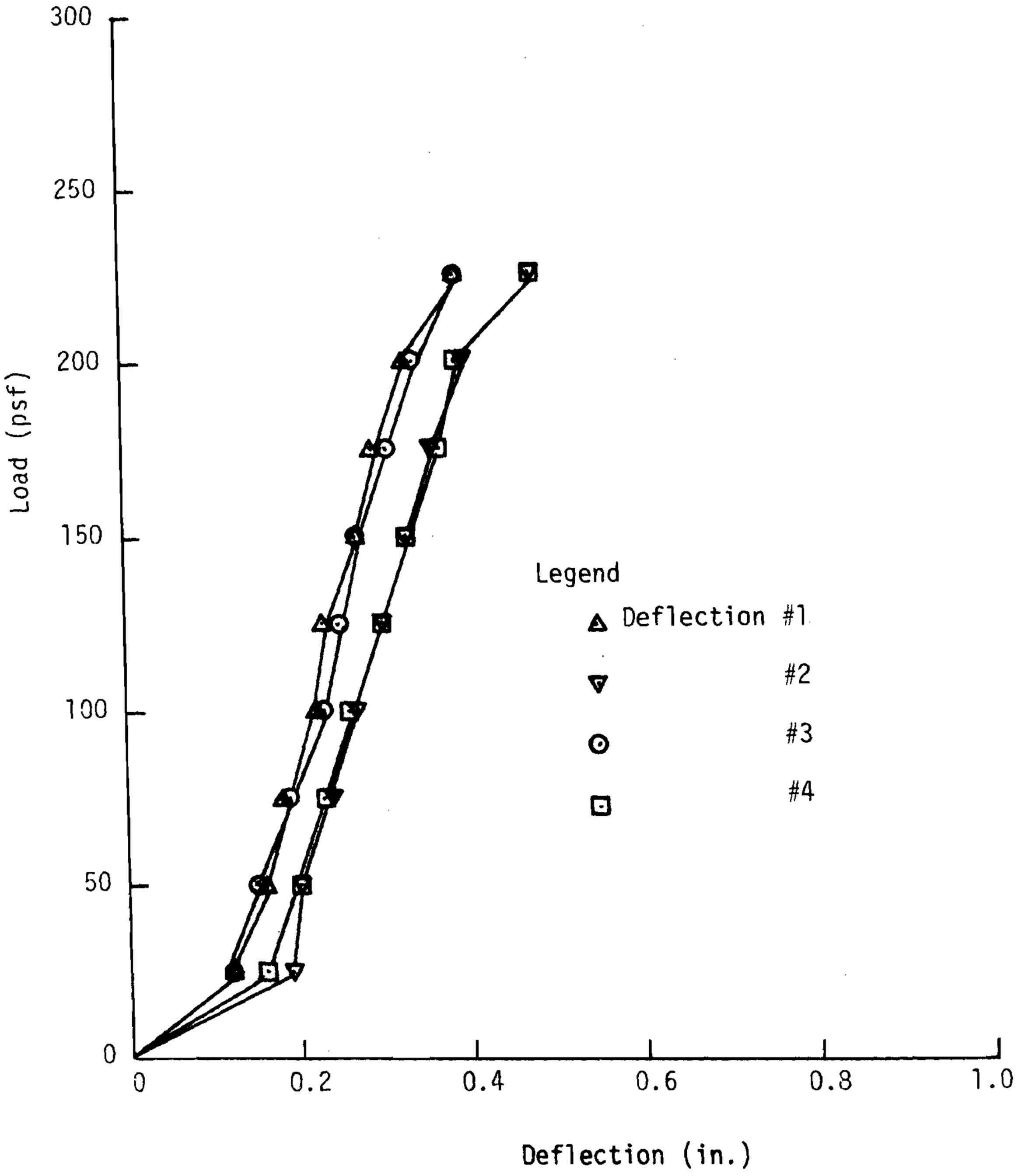


Fig. A10 Mid-Span Deflection of Two-Span Continuous Beam Specimen No. CB-1B

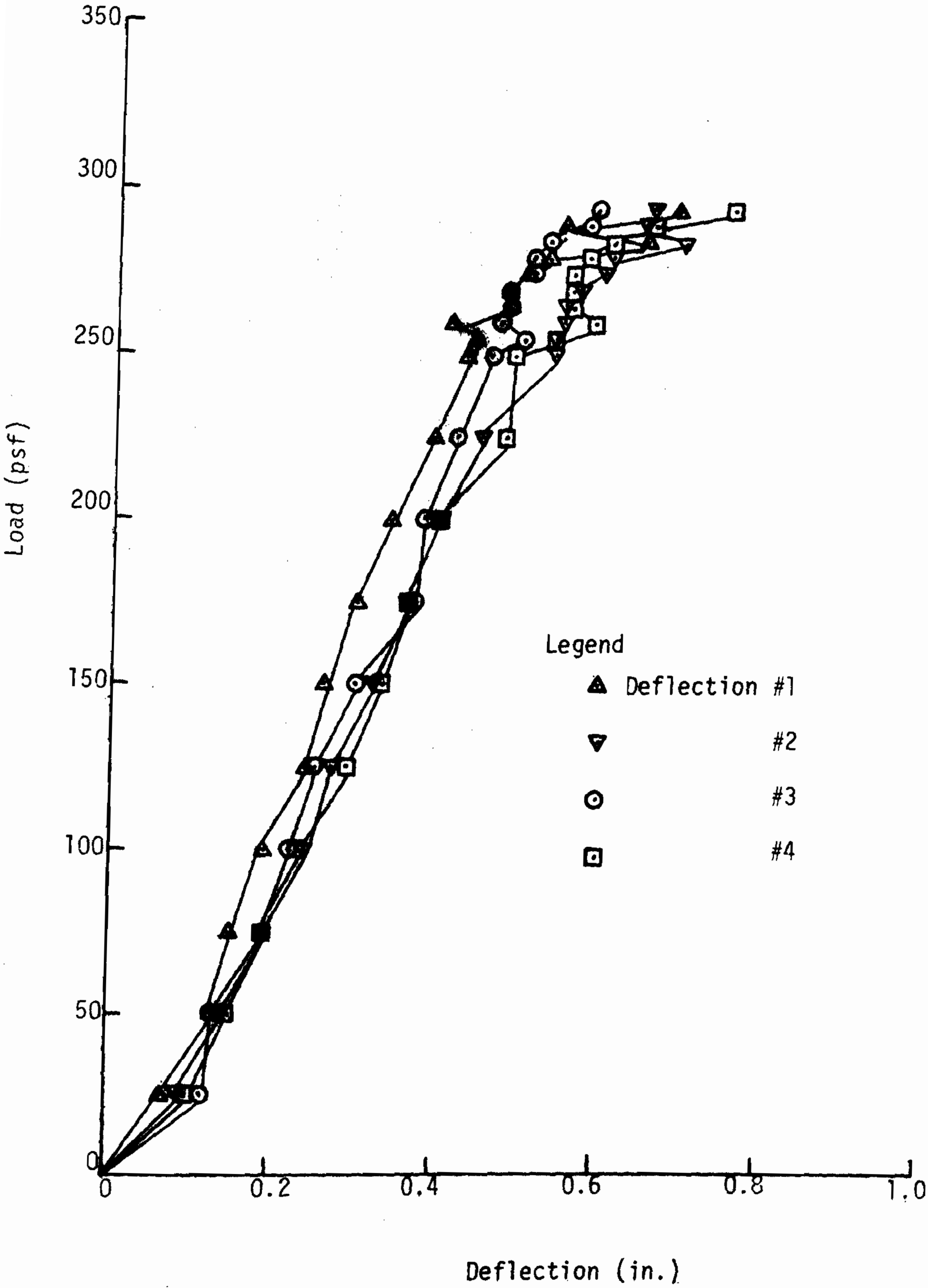


Fig. A11 Mid-Span Deflection of Two-Span Continuous Beam Specimen No. CB-2A

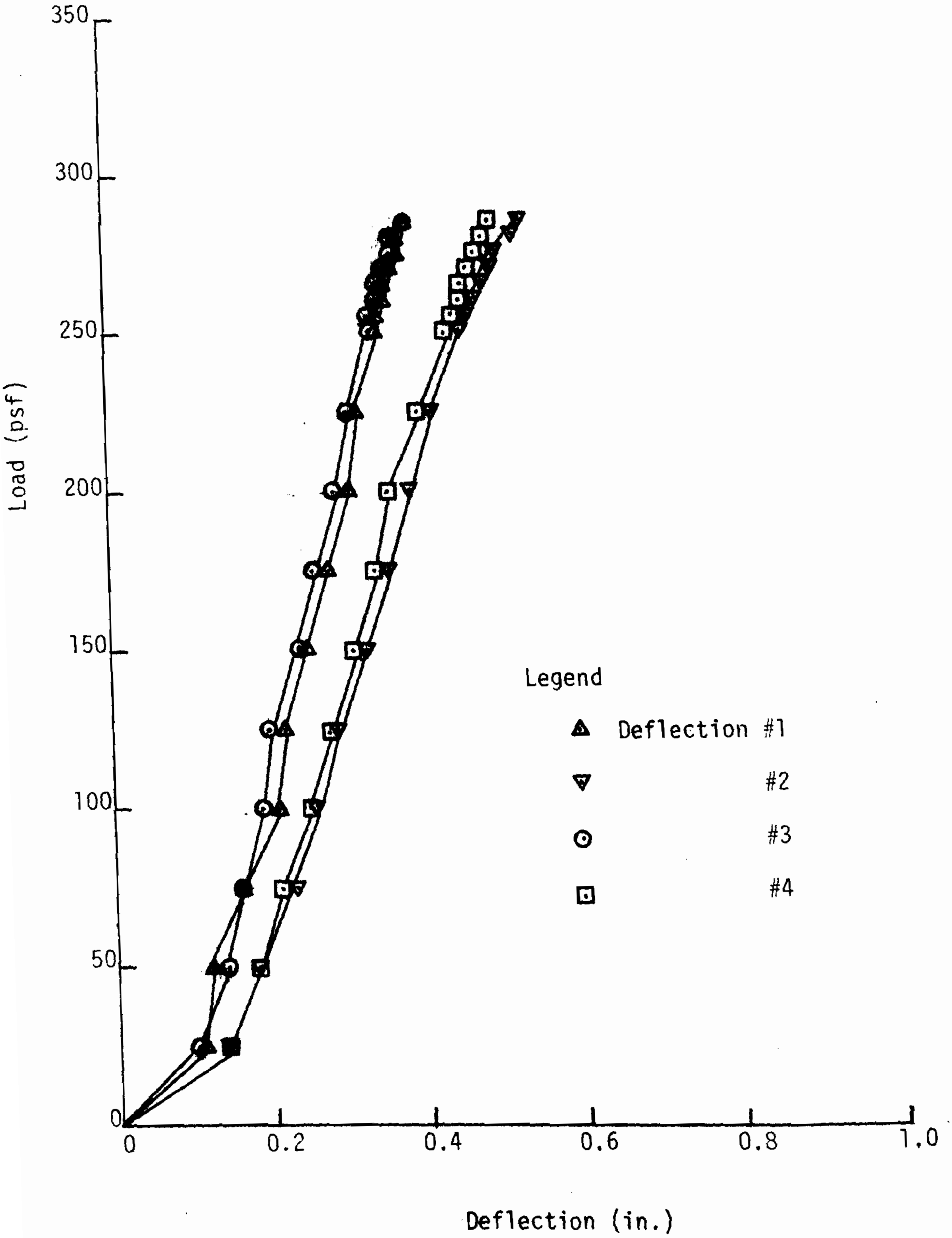


Fig. A12 Mid-Span Deflection of Two-Span Continuous Beam Specimen No. CB-2B

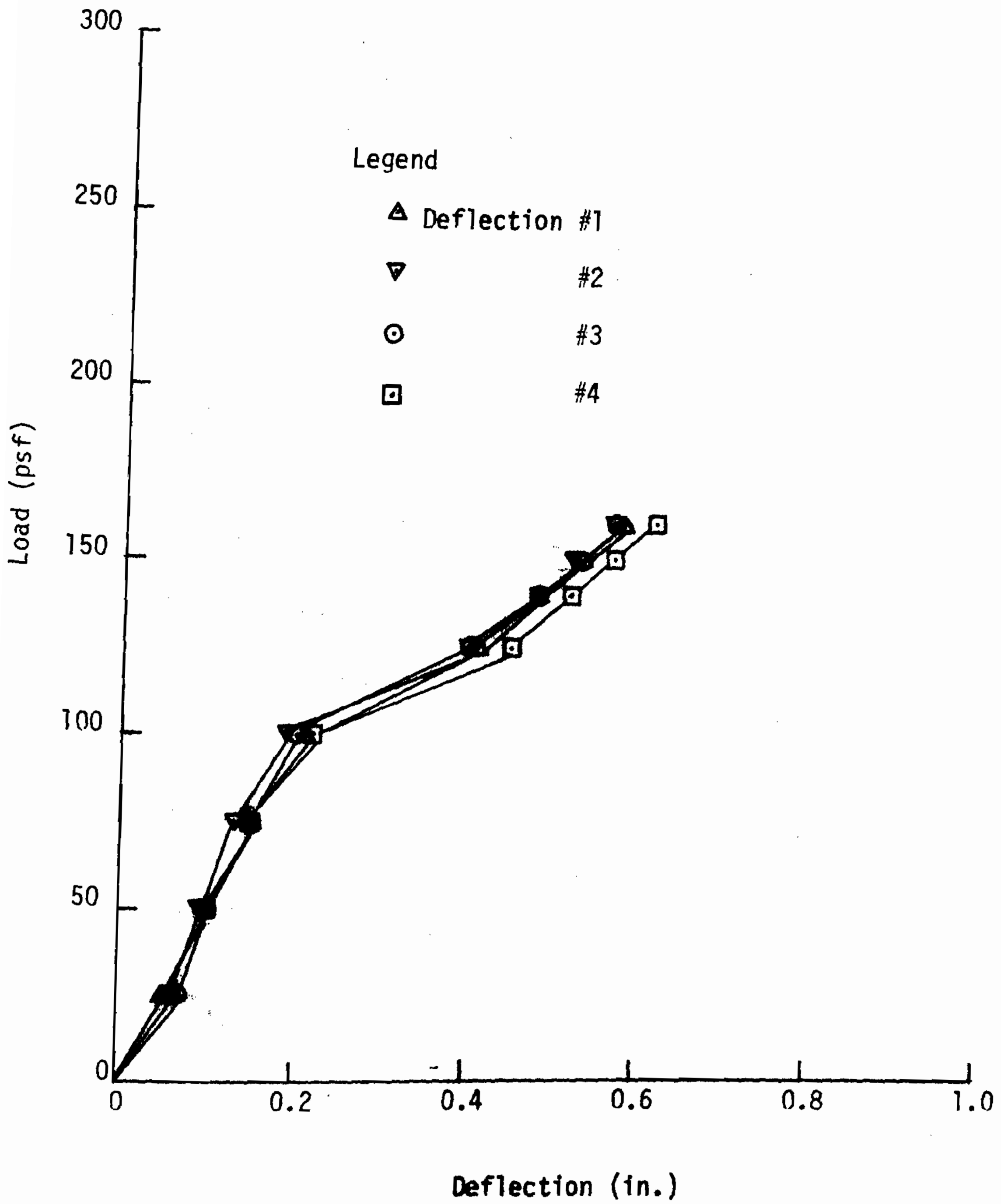


Fig. A13 Mid-Span Deflection of Two-Span Continuous Beam Specimen No. CB-5A

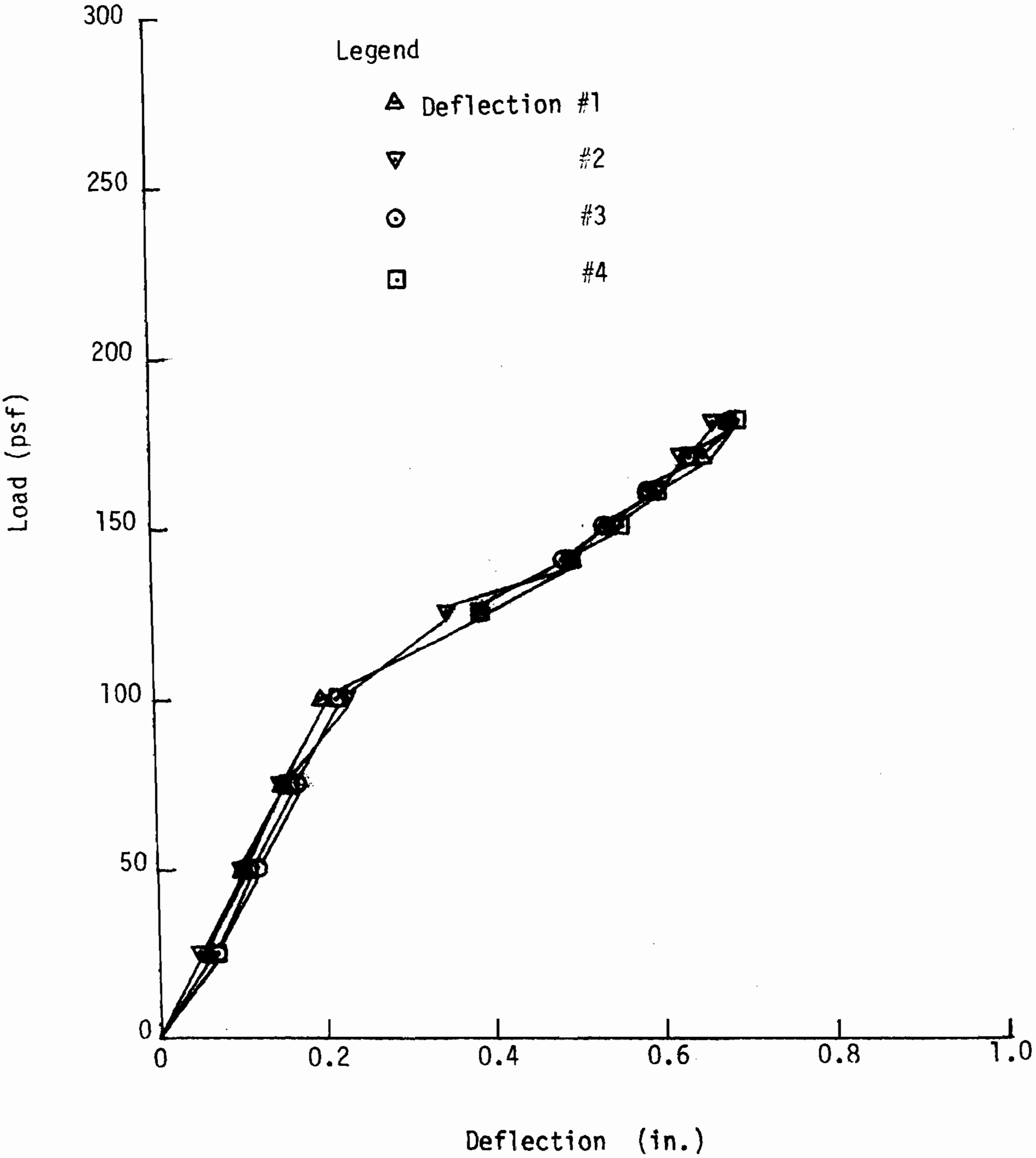


Fig. A14 Mid-Span Deflection of Two-Span Continuous Beam Specimen No. CB-5B

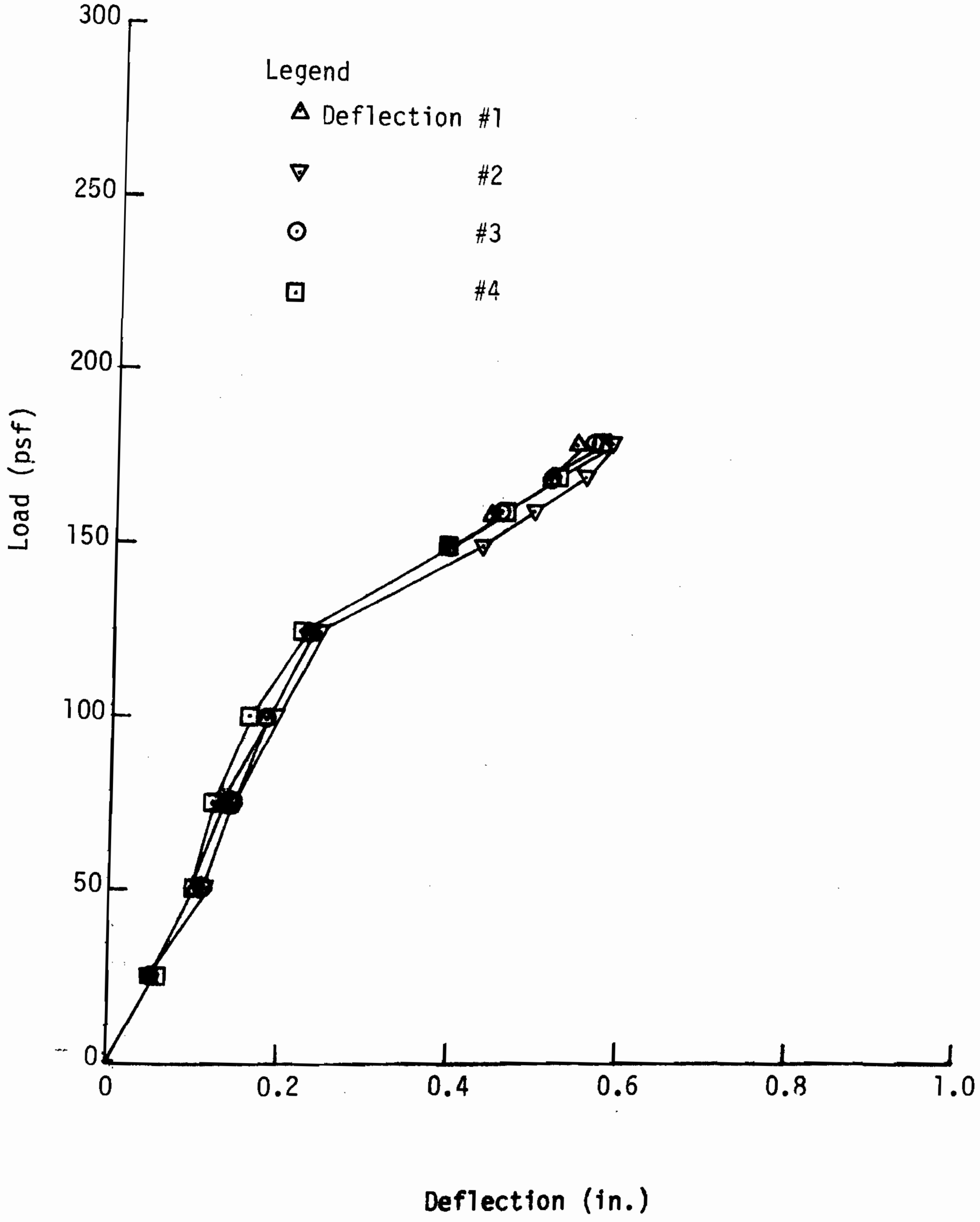


Fig. A15 Mid-Span Delfection of Two-Span Continuous Beam Specimen No. CB-6A

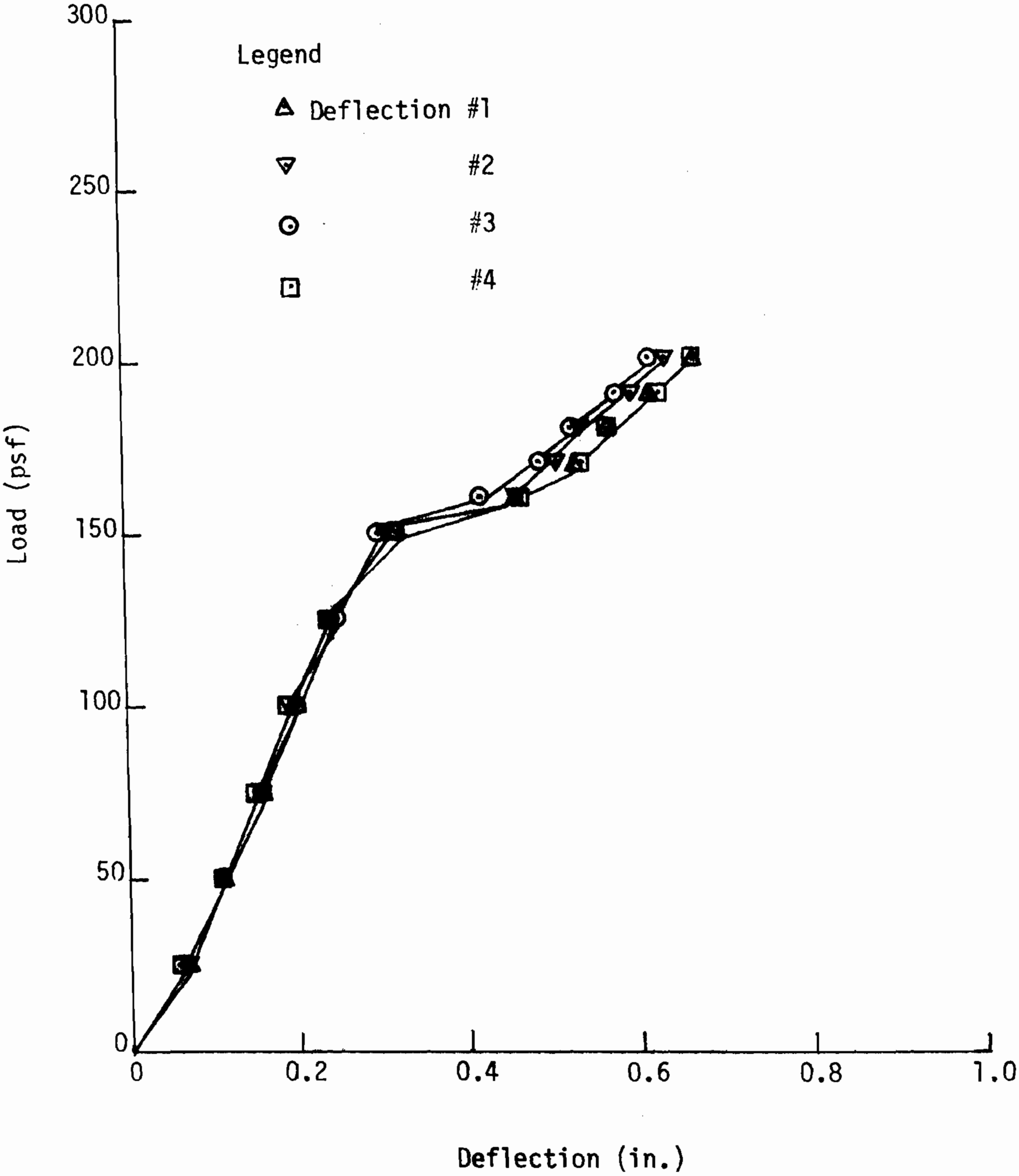


Fig. A16 Mid-Span Deflection of Two-Span Continuous Beam Specimen No. CB-6B

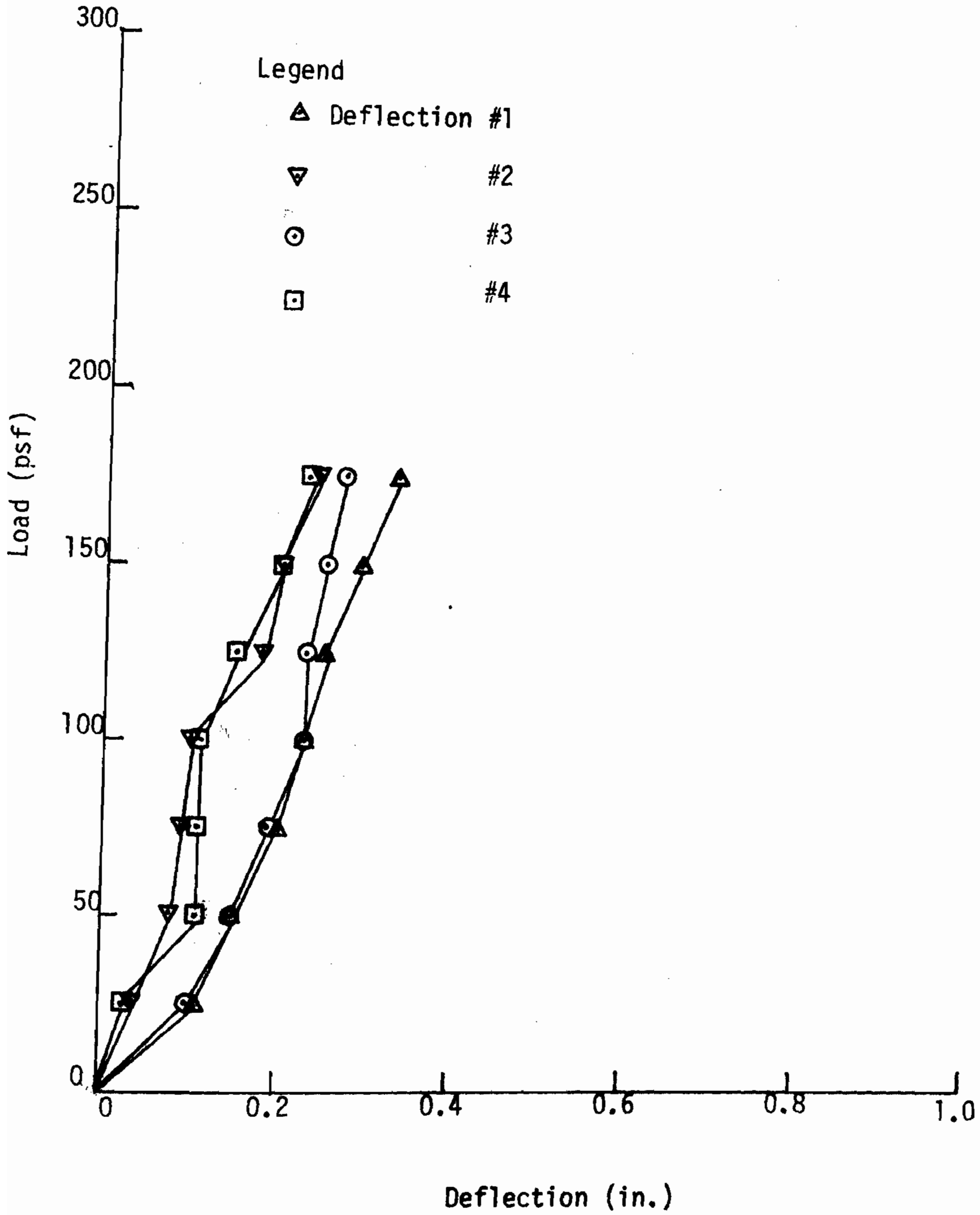


Fig. A17 Mid-Span Deflection of Two-Span Continuous Beam Specimen No. CB-9A

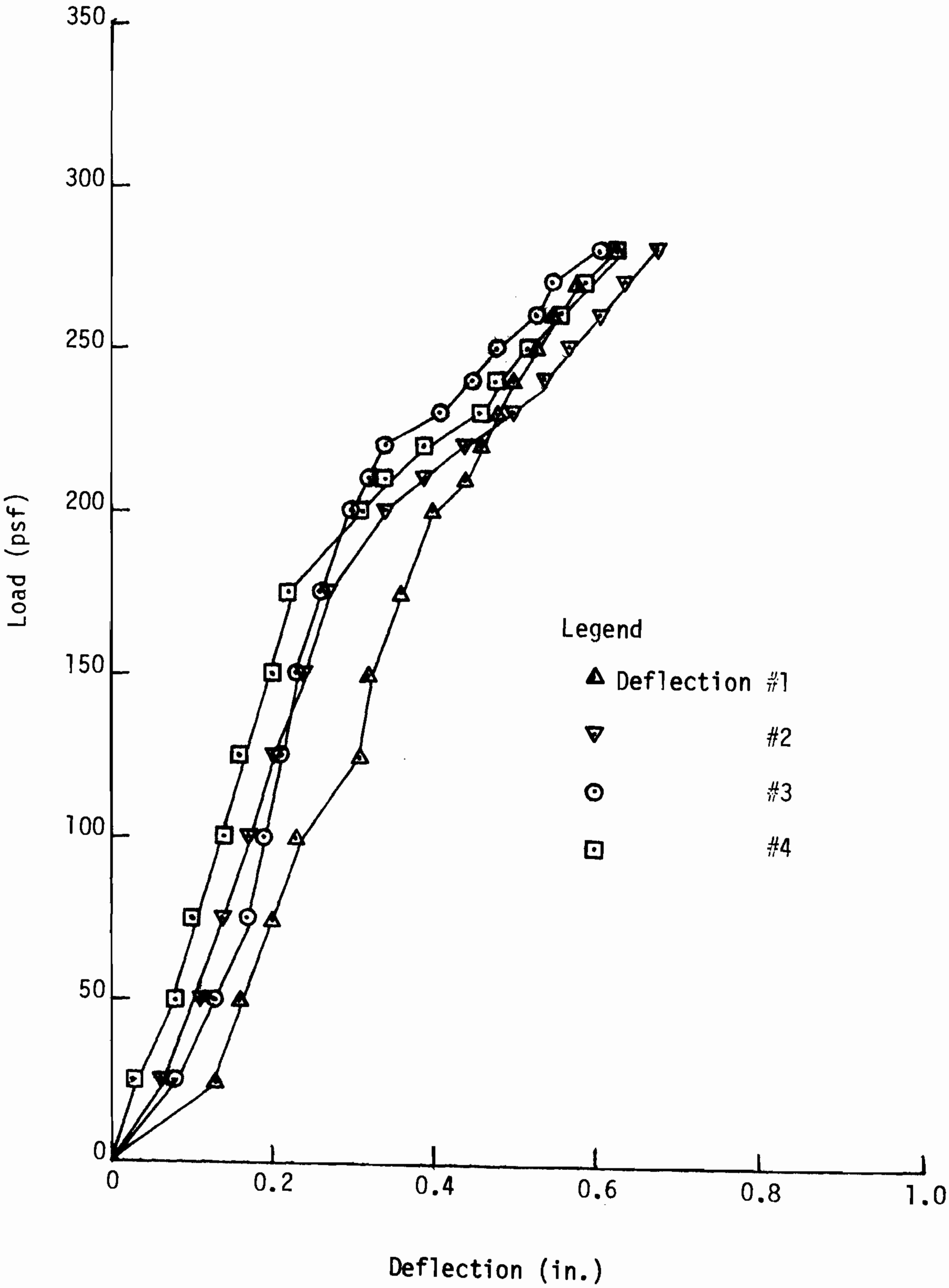


Fig. A18 Mid-Span Deflection of Two-Span Continuous Beam Specimen No. CB-9B

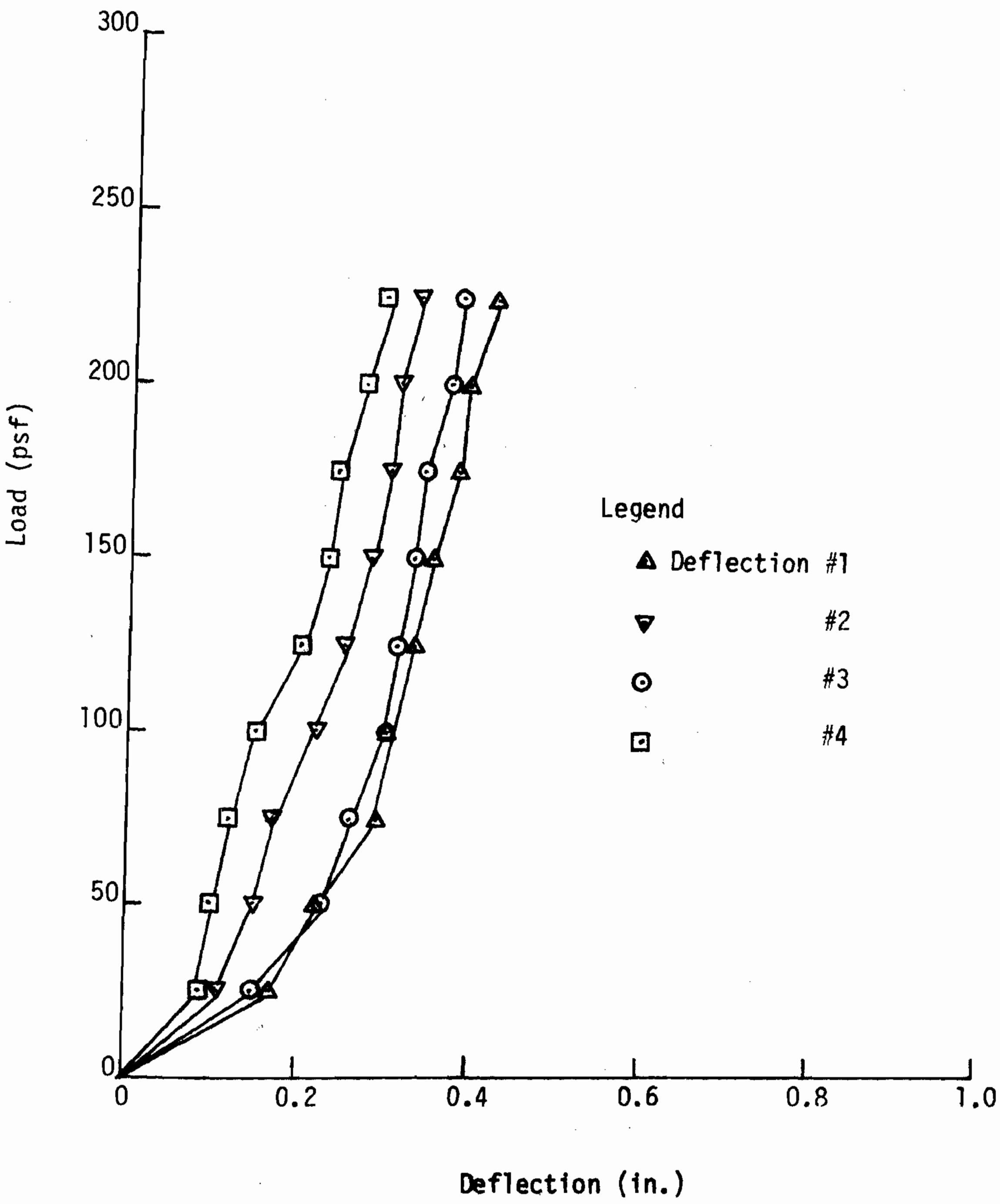


Fig. A19 Mid-Span Deflection of Two-Span Continuous Beam Specimen No. CB-10A

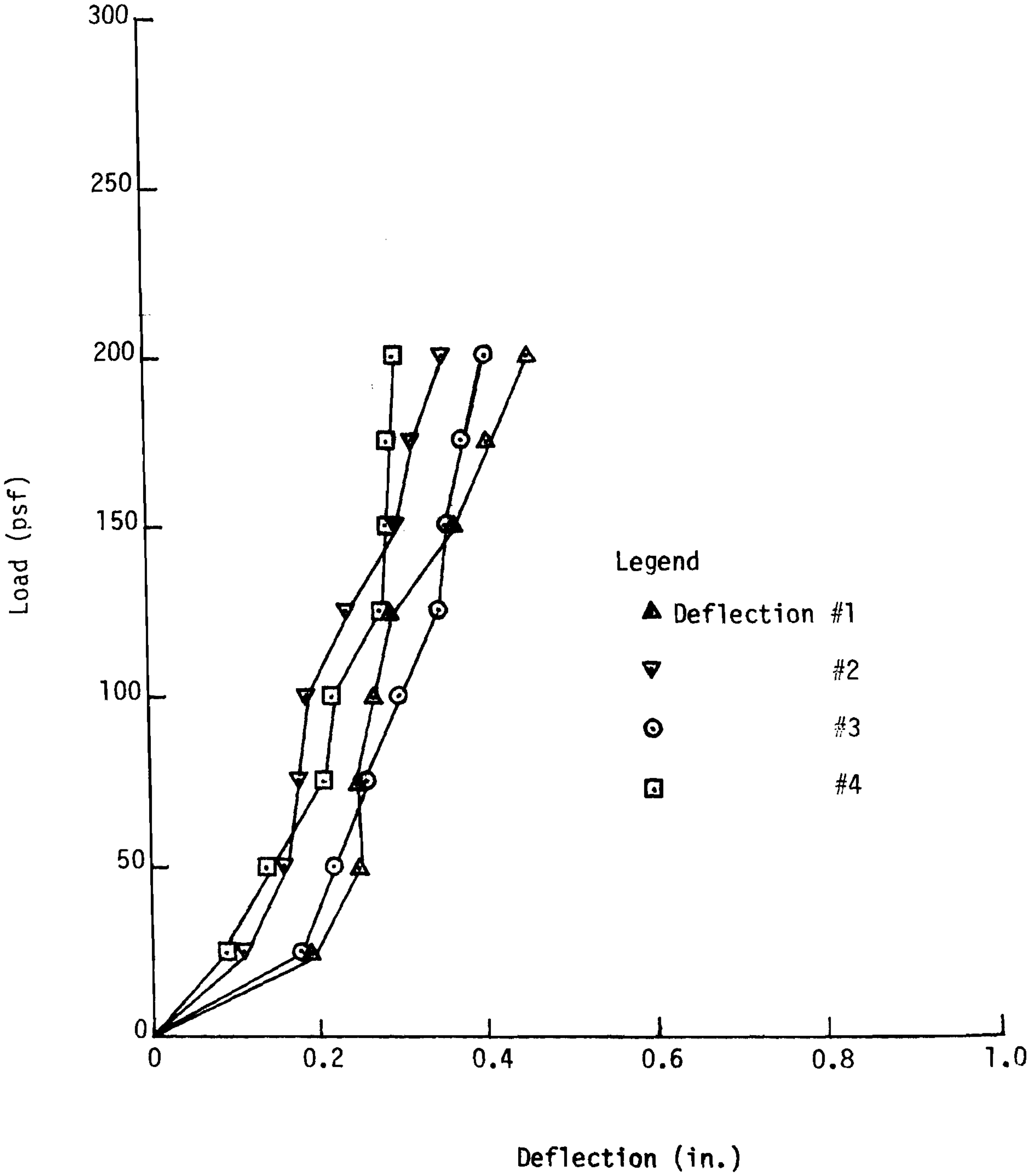


Fig. A20 Mid-Span Deflection of Two-Span Continuous Beam Specimen No. CB-10B

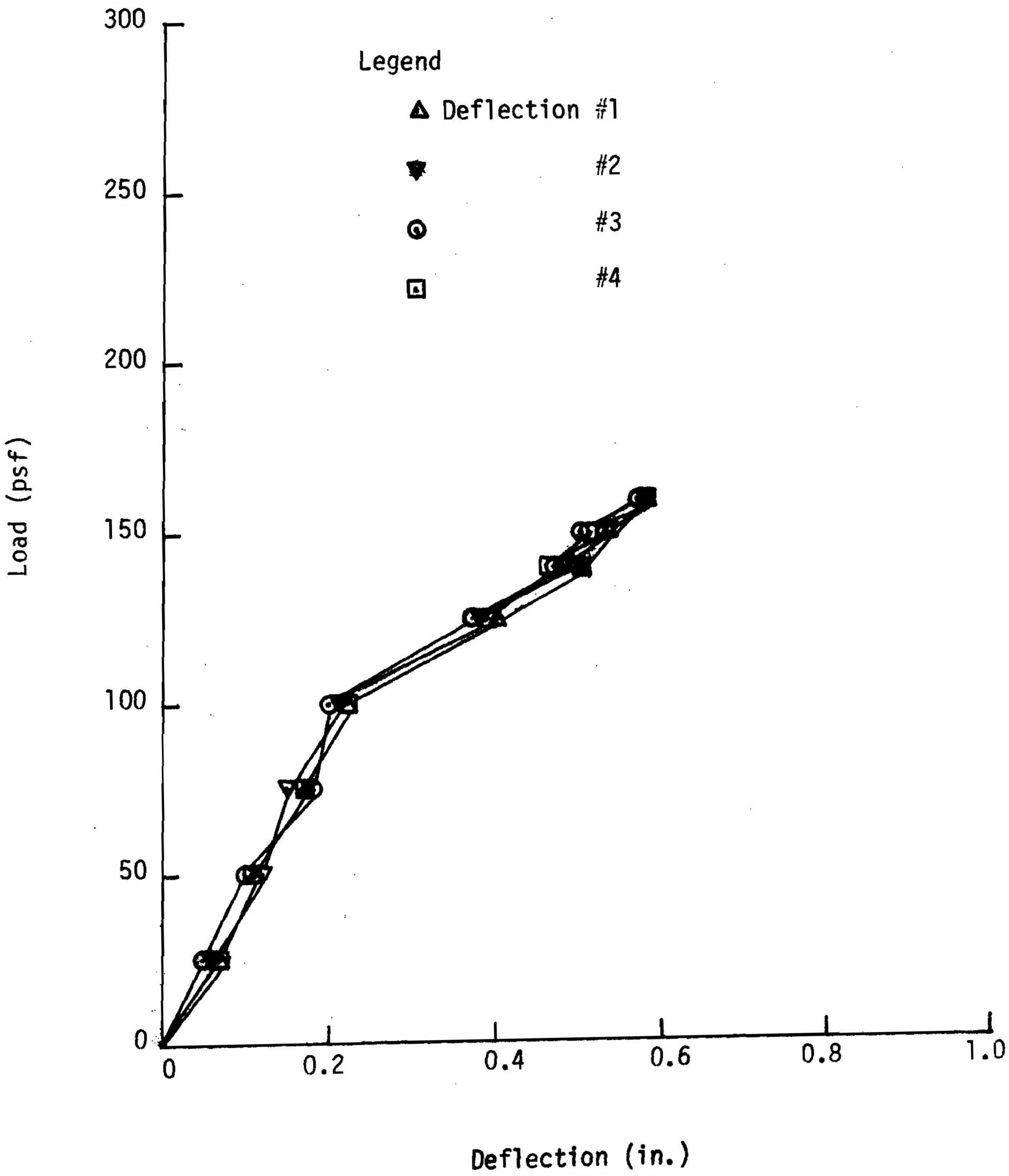


Fig. A21 Mid-Span Deflection of Two-Span Continuous Beam Specimen No. CB-11A

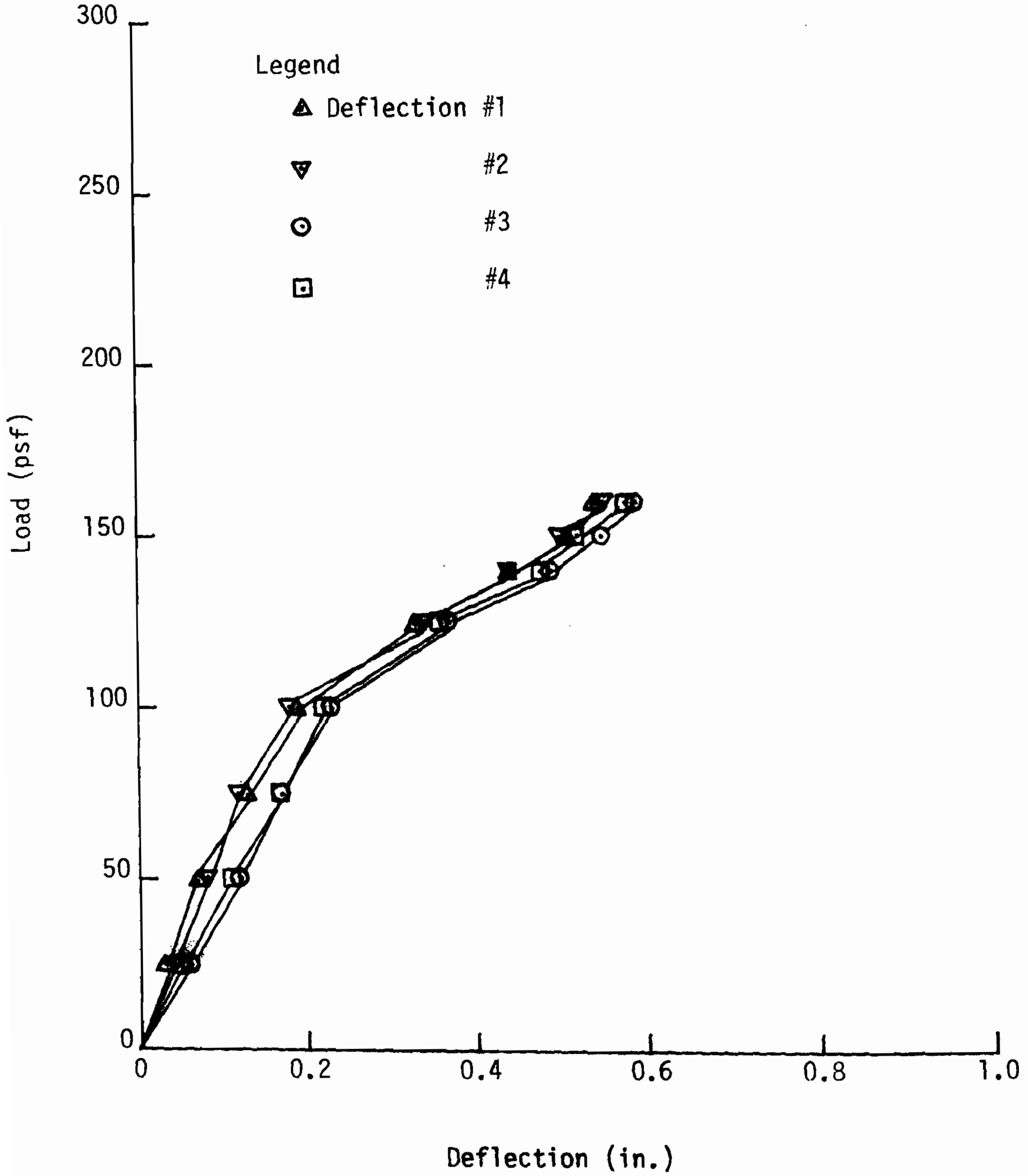


Fig. A22 Mid-Span Deflection of Two-Span Continuous Beam Specimen No. CB-11B

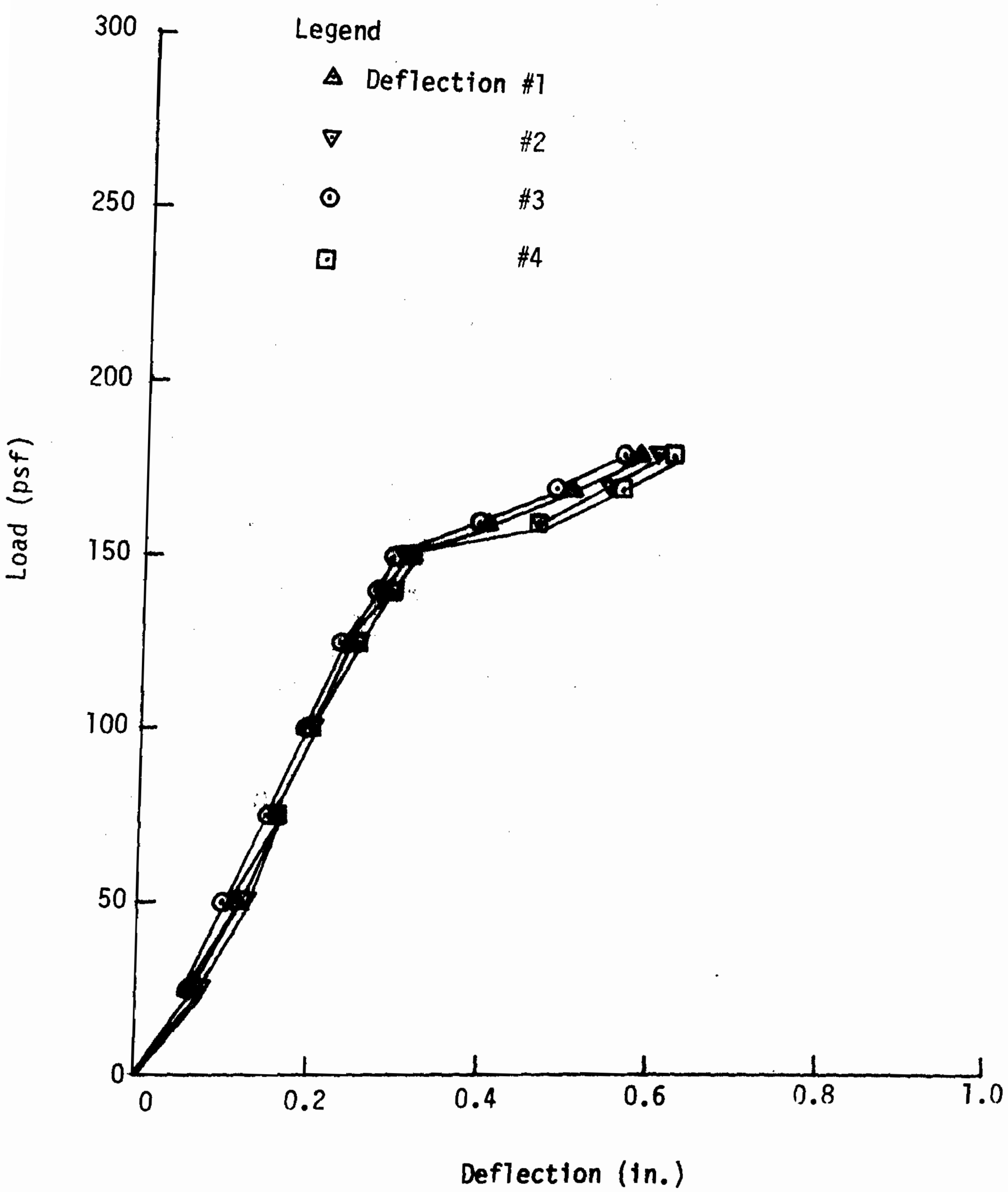


Fig. A23 Mid-Span Deflection of Two-Span Continuous Beam Specimen No. CB-12A

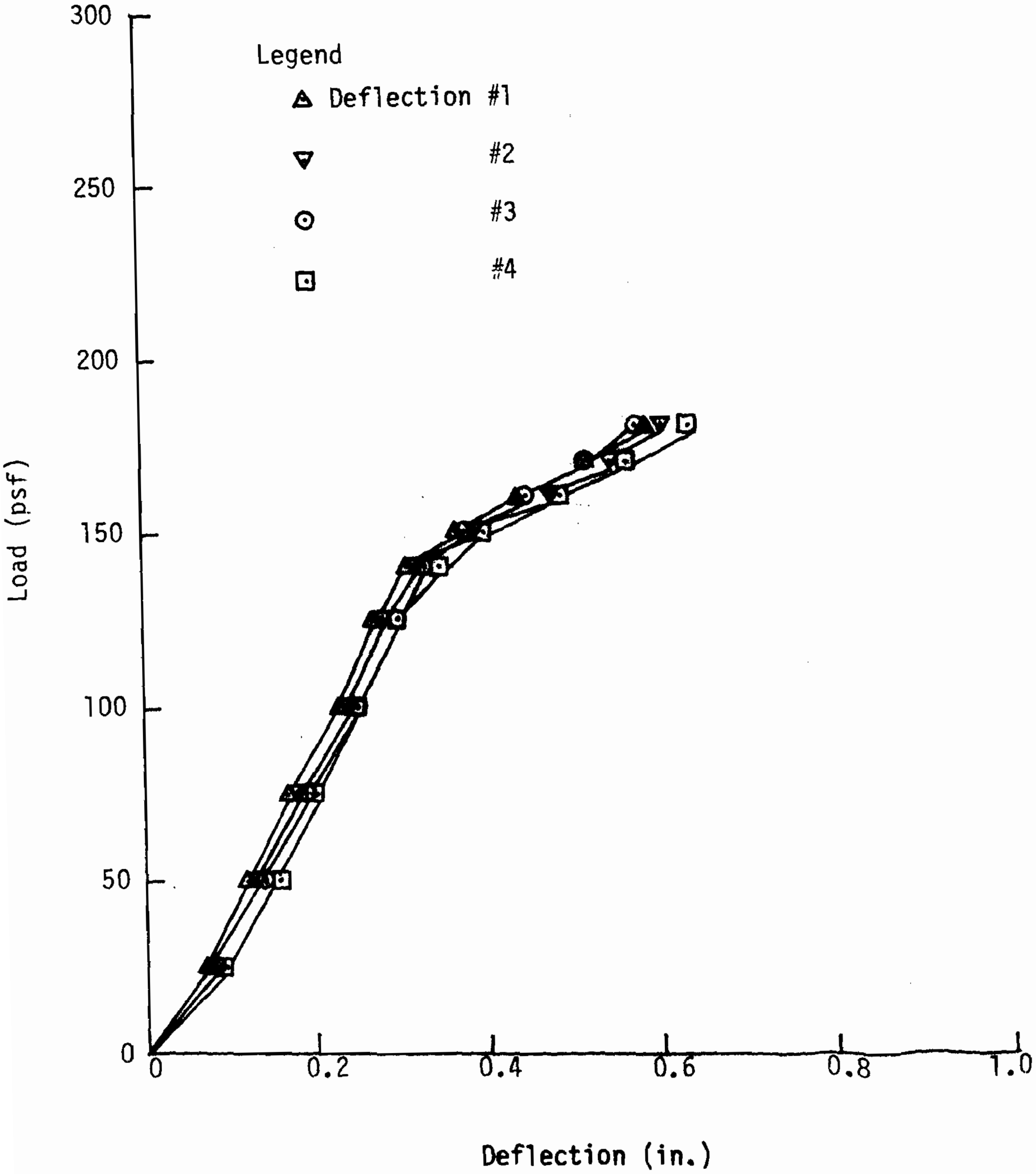


Fig. A24 Mid-Span Deflection of Two-Span Continuous Beam Specimen No. CB-12B

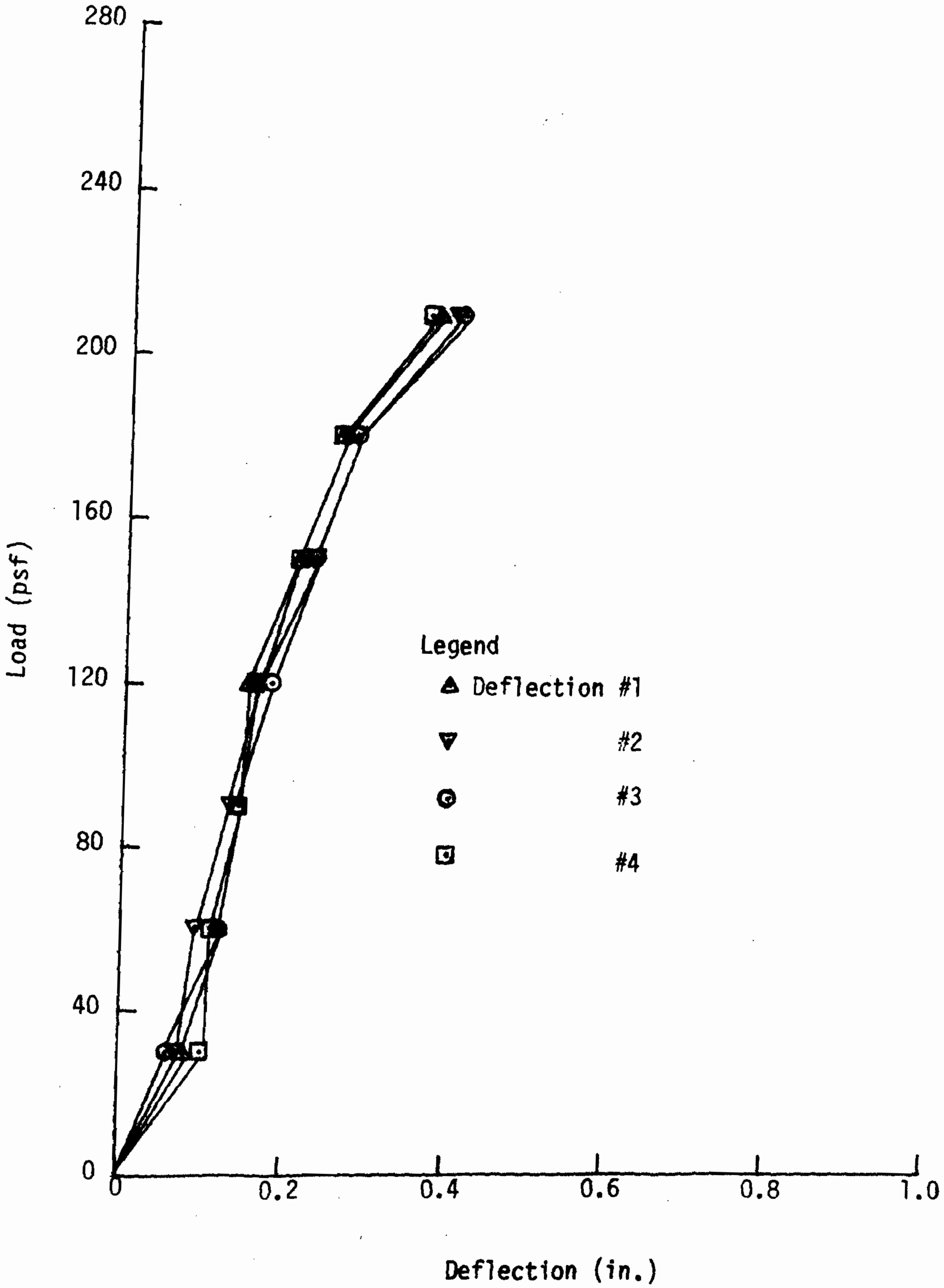


Fig. A25 Mid-Span Deflection of Two-Span Continuous Beam Specimen No. CB-13A

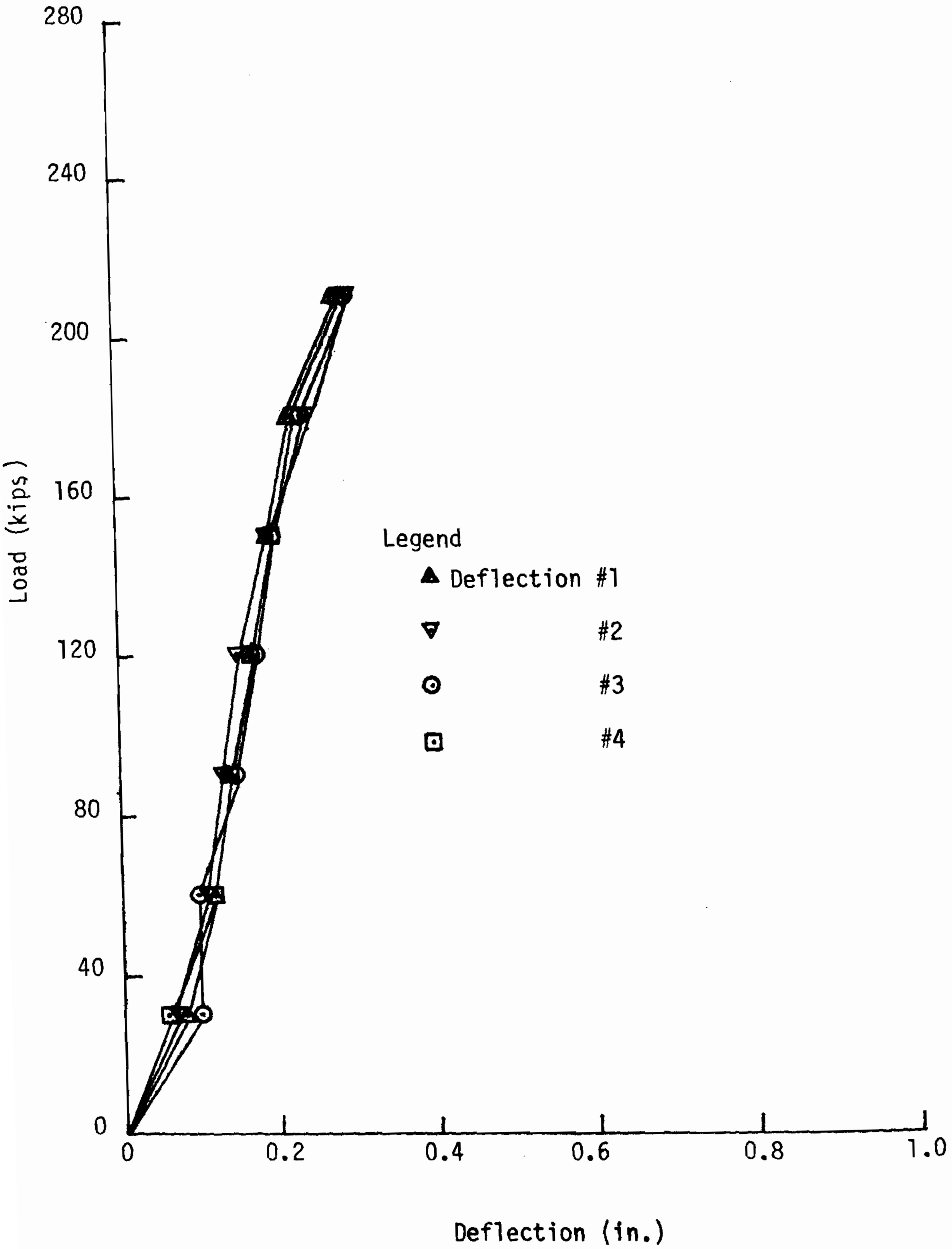


Fig. A26 Mid-Span Deflection of Two-Span Continuous Beam Specimen No. CB-13B

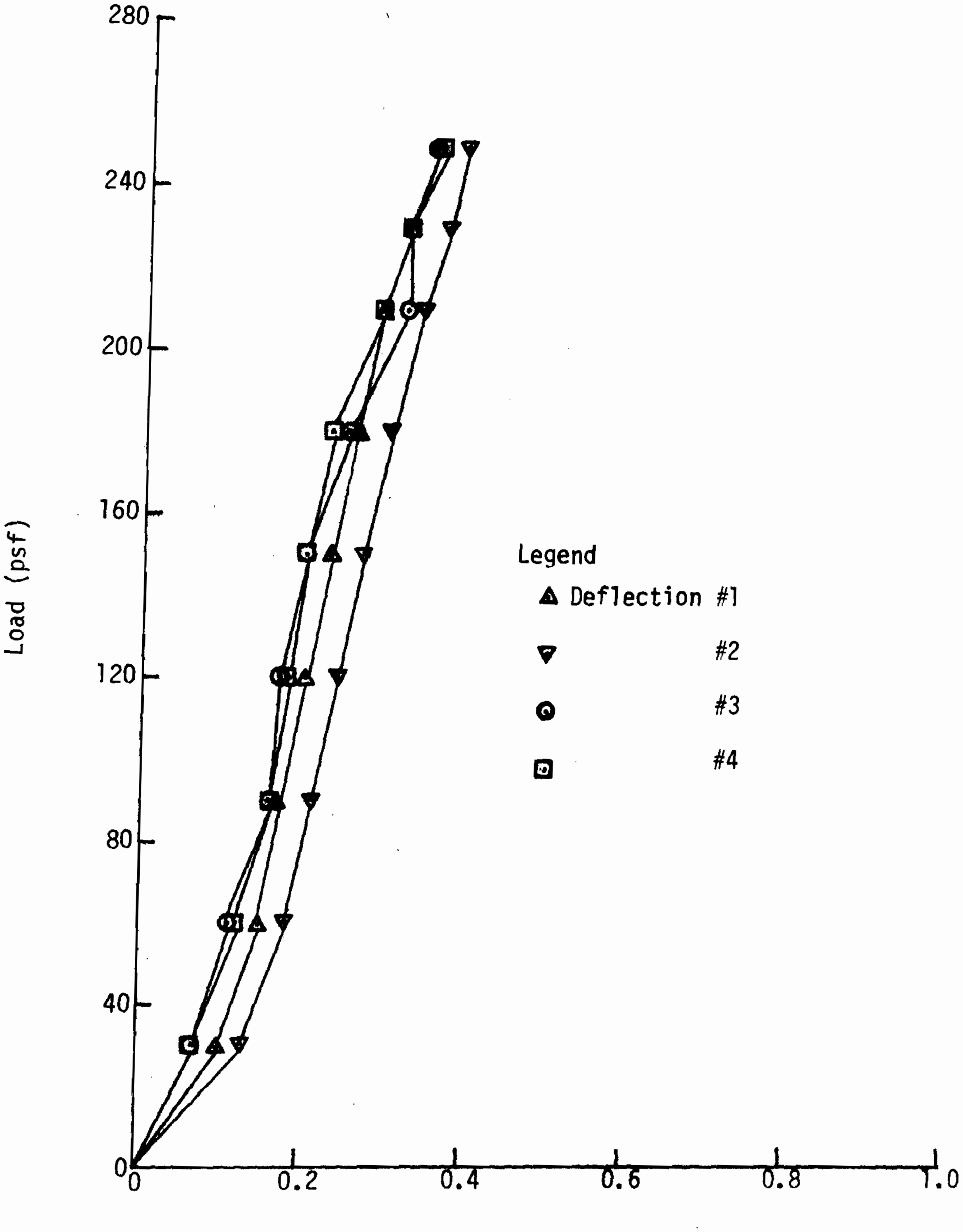


Fig. A27 Mid-Span Deflection of Two-Span Continuous Beam Specimen No. CB-14A

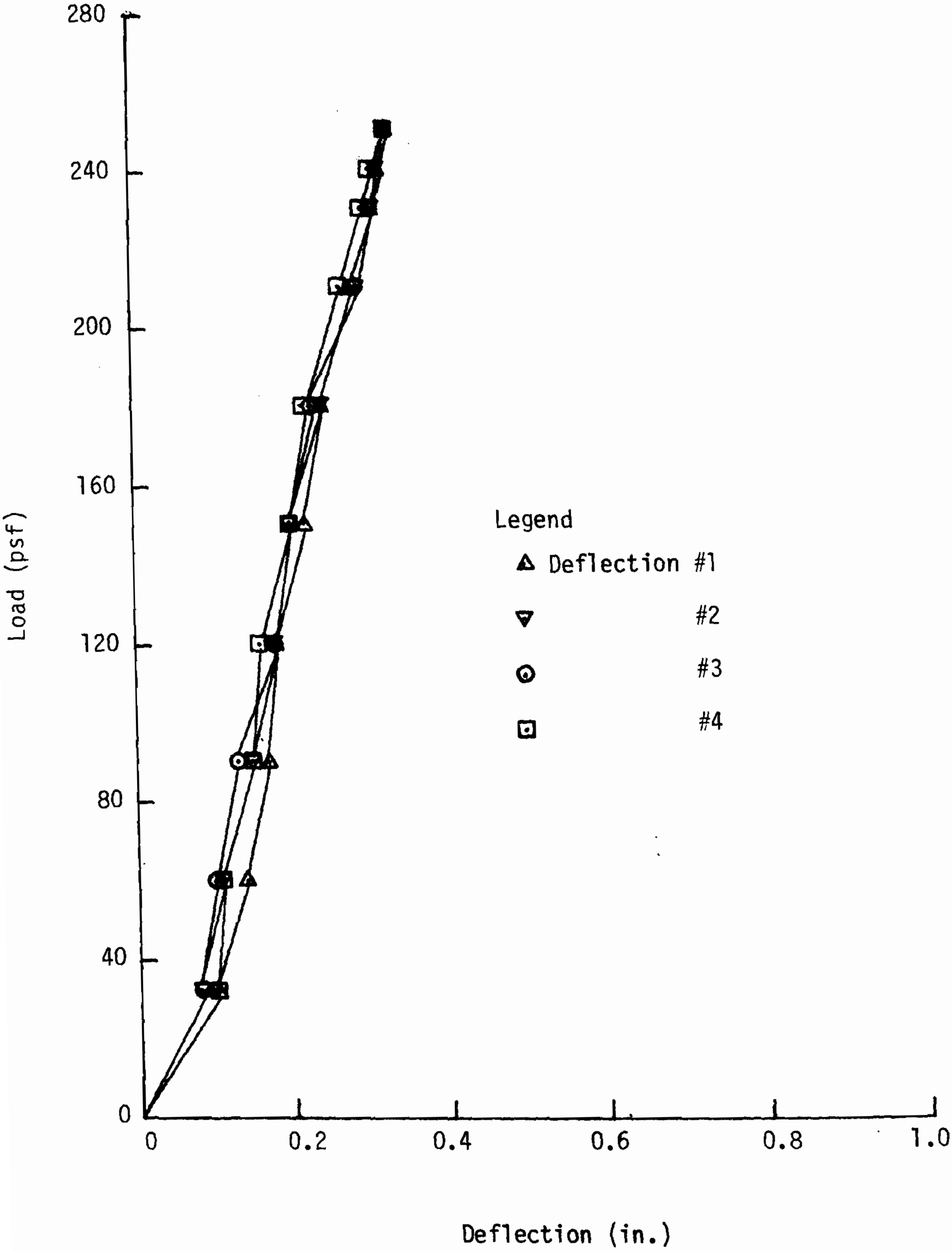


Fig. A28 Mid-Span Deflection of Two-Span Continuous Beam Specimen No. CB-14B

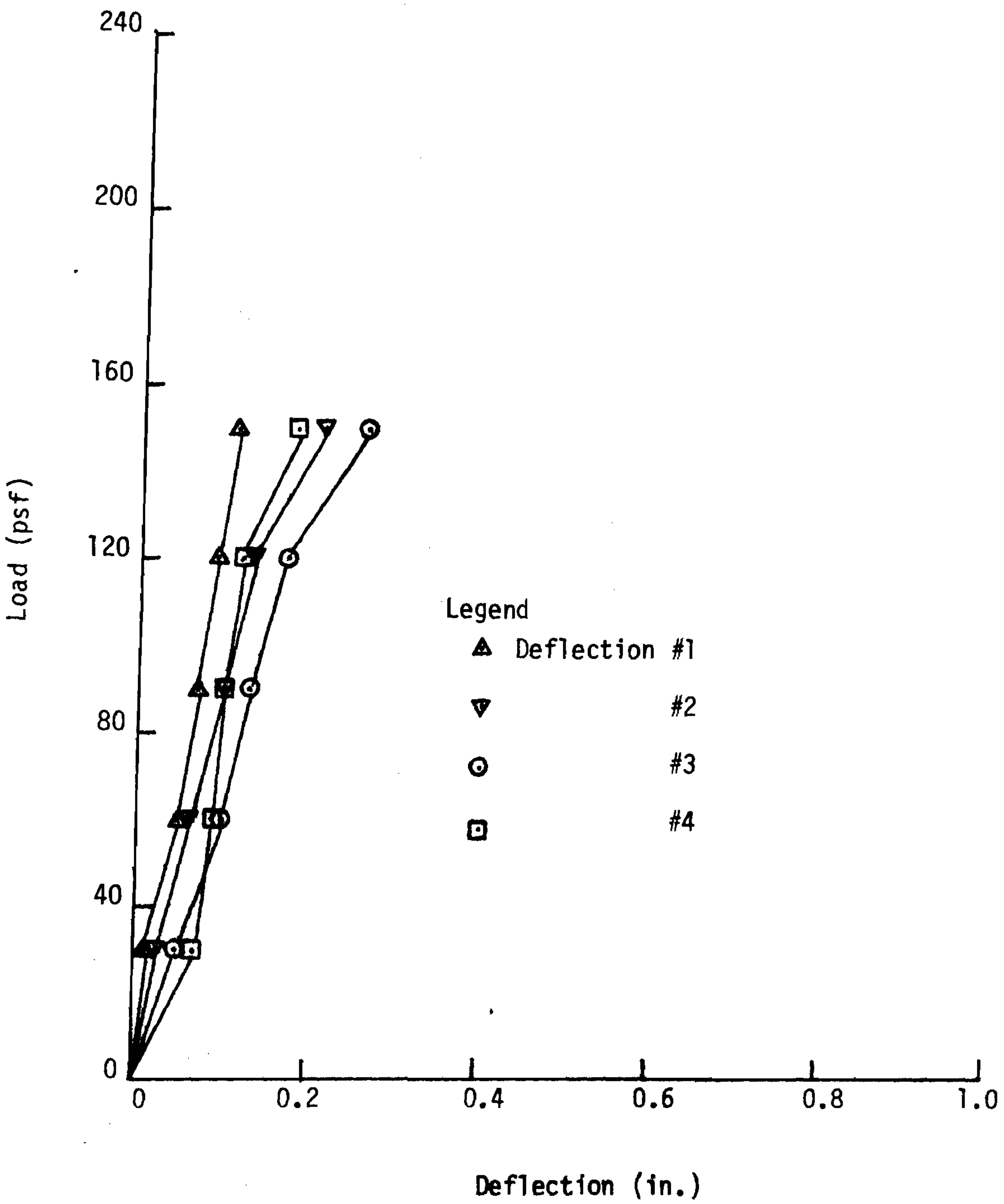


Fig. A29 Mid-Span Deflection of Two-Span Continuous Beam Specimen No. CB-15A

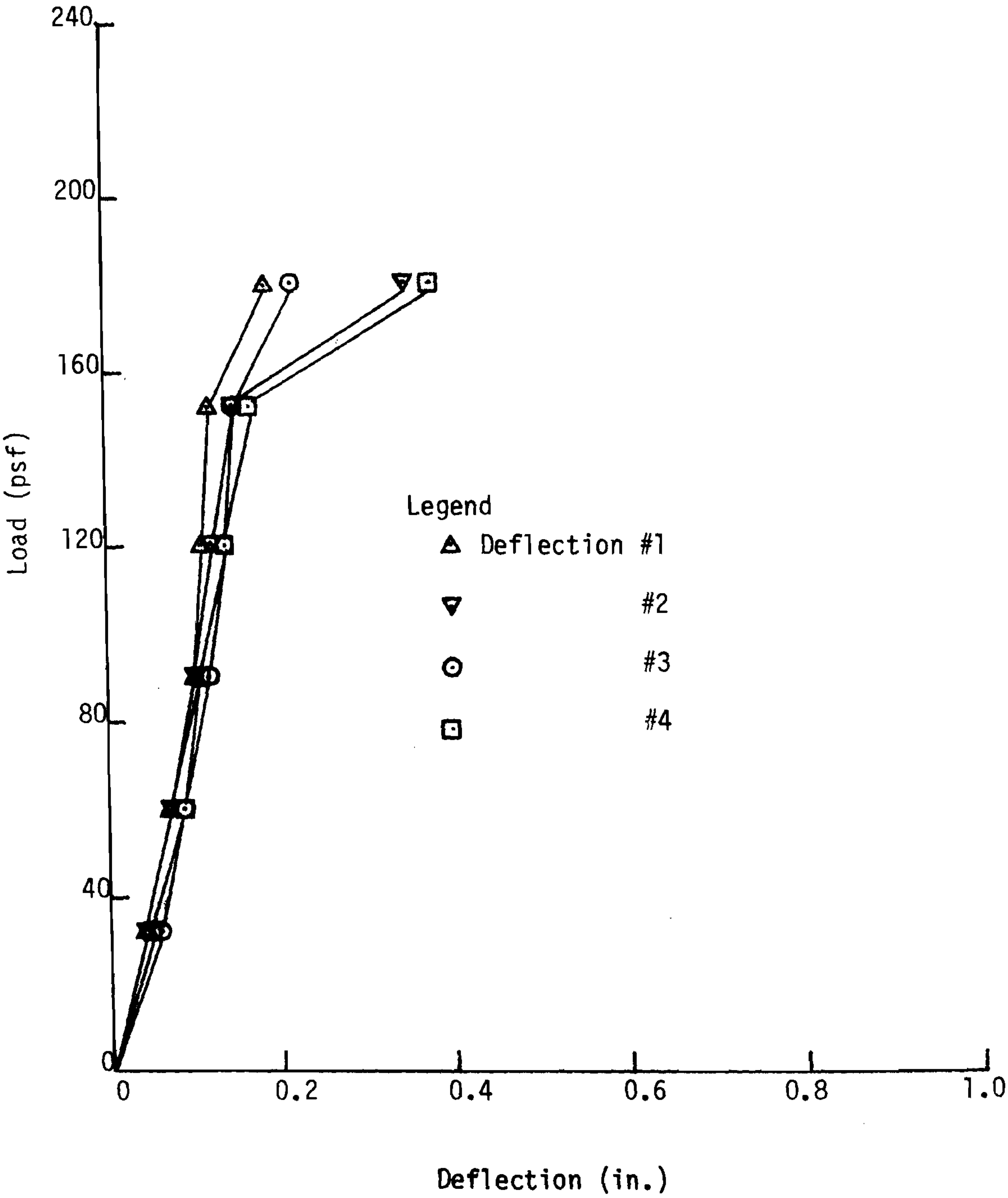


Fig. A30 Mid-Span Deflection of Two-Span Continuous Beam Specimen No. CB-15B

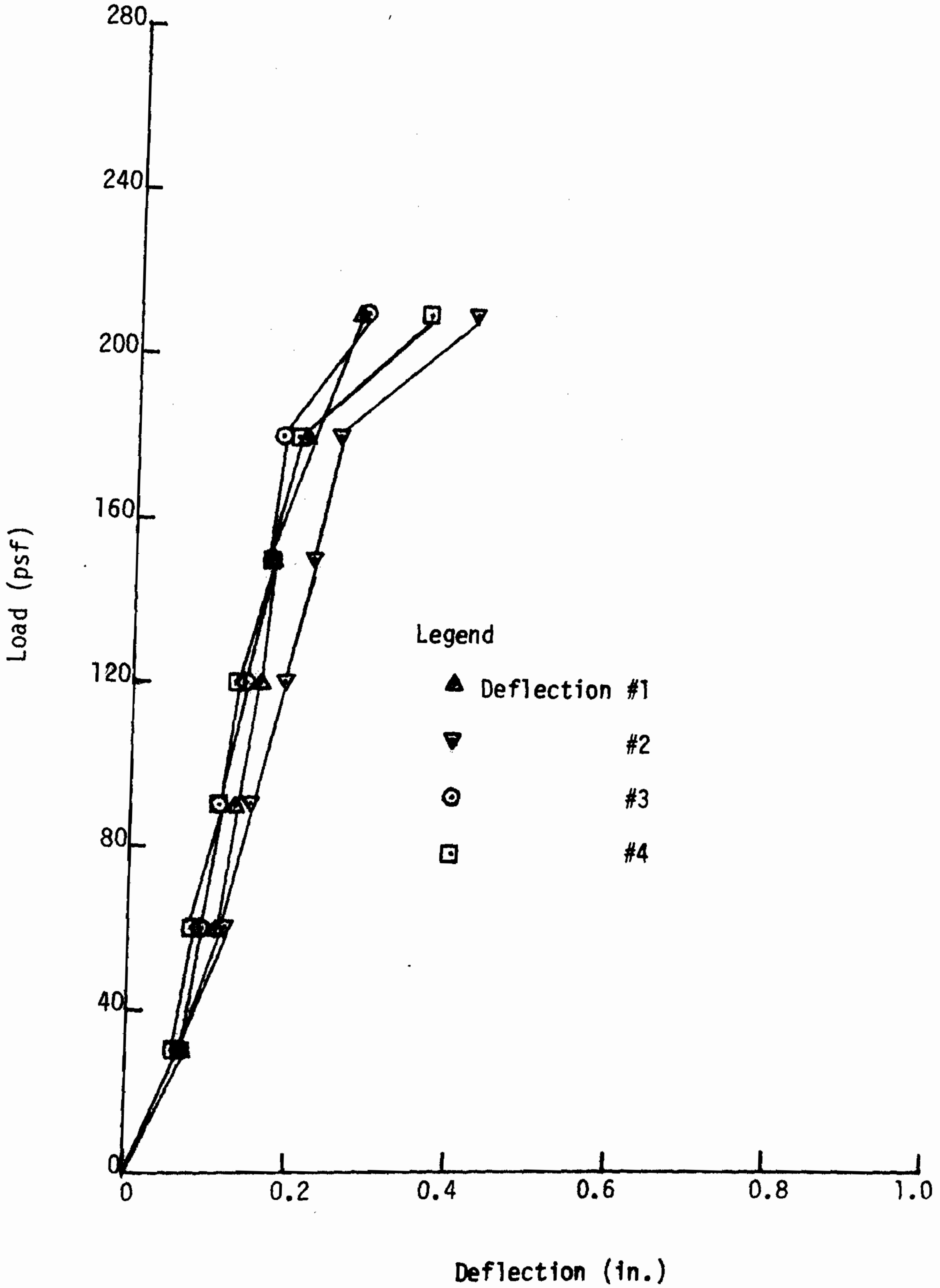


Fig. A31 Mid-Span Deflection of Two-Span Continuous Beam Specimen No. CB-16A

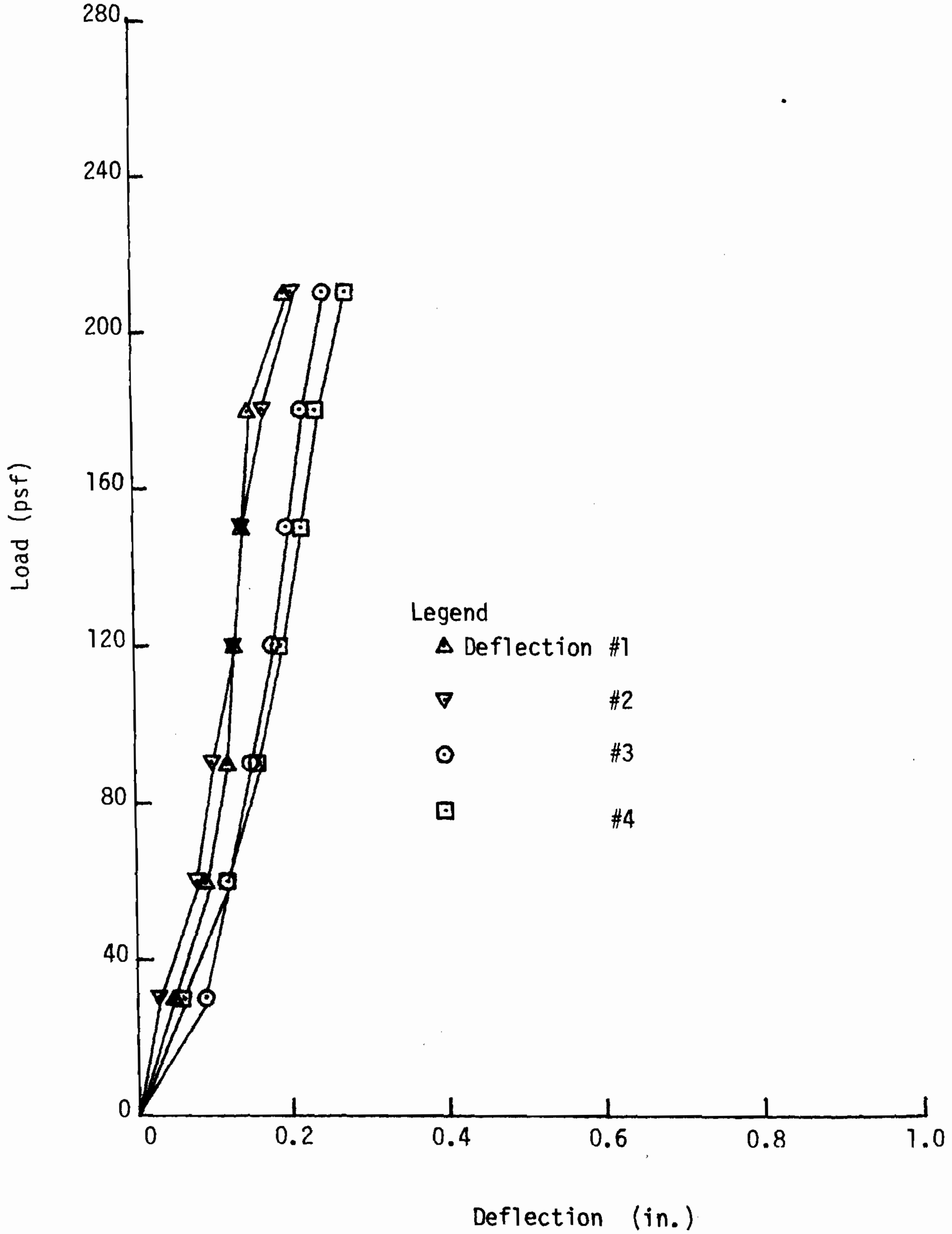


Fig. A32 Mid-Span Deflection of Two-Span Continuous Beam Specimen No. CB-16B

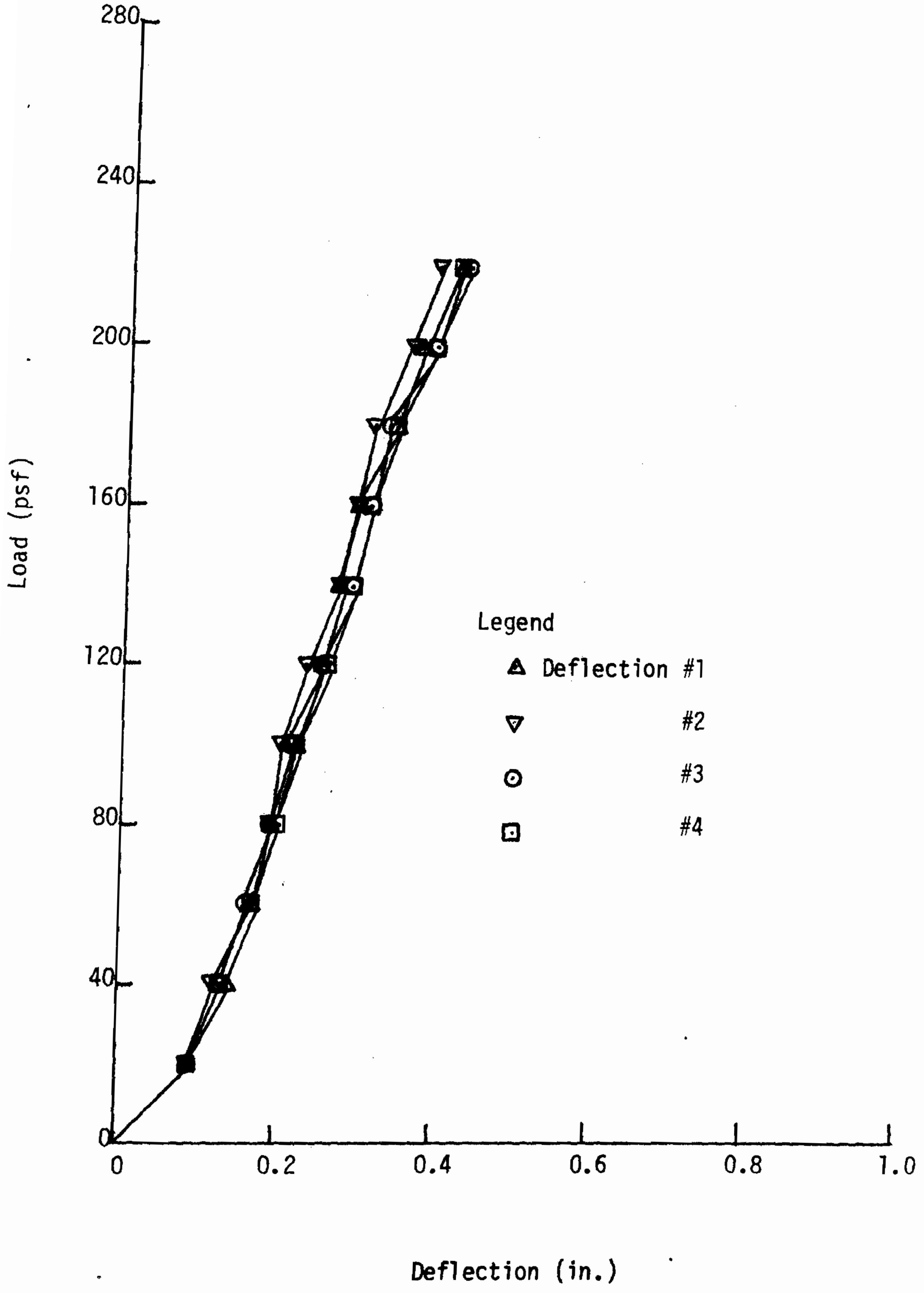


Fig. A33 Mid-Span Deflection of Two-Span Continuous Beam Specimen No. CB-19A

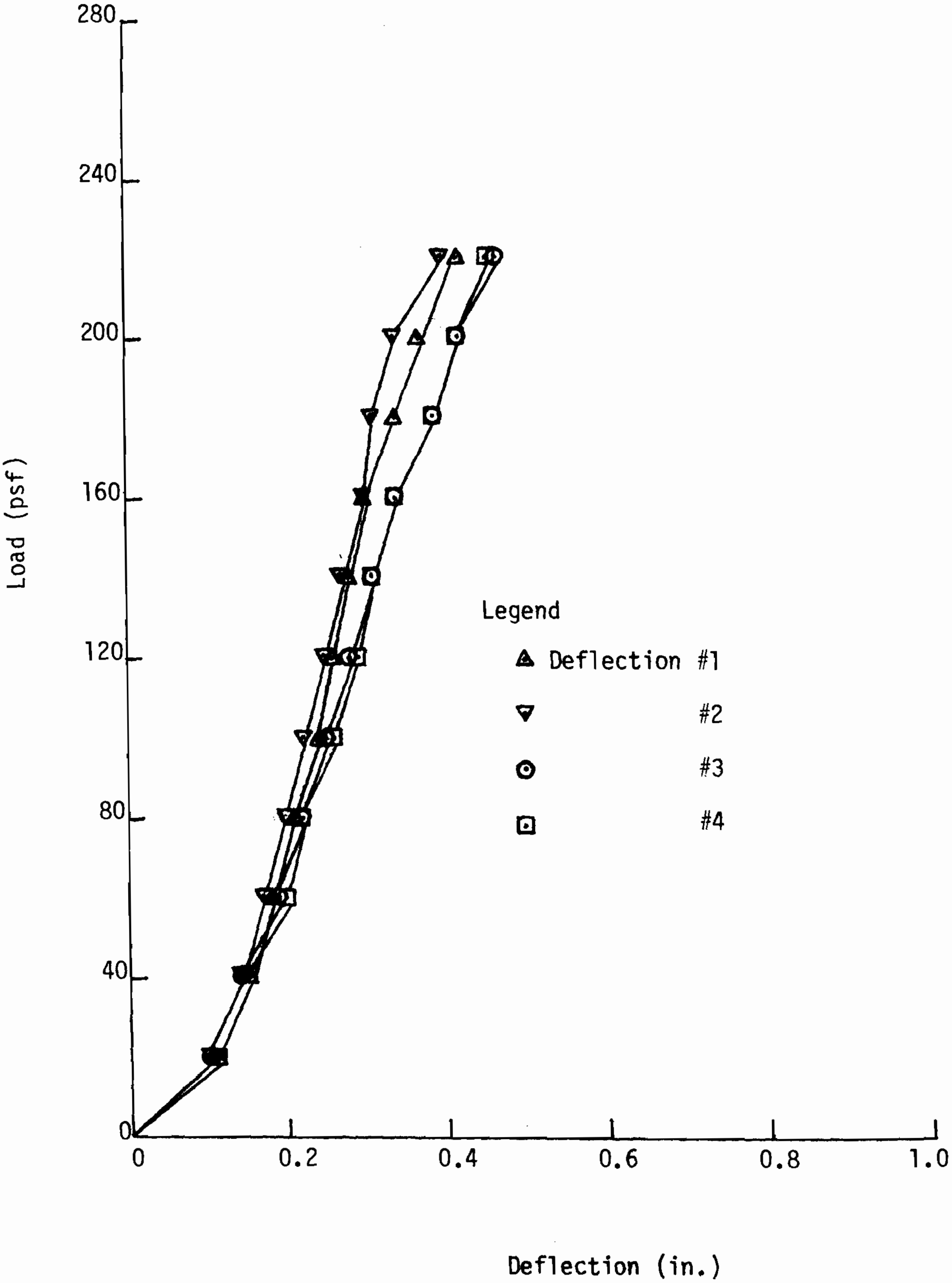


Fig. A34 Mid-Span Deflection of Two-Span Continuous Beam Specimen No. CB-19B

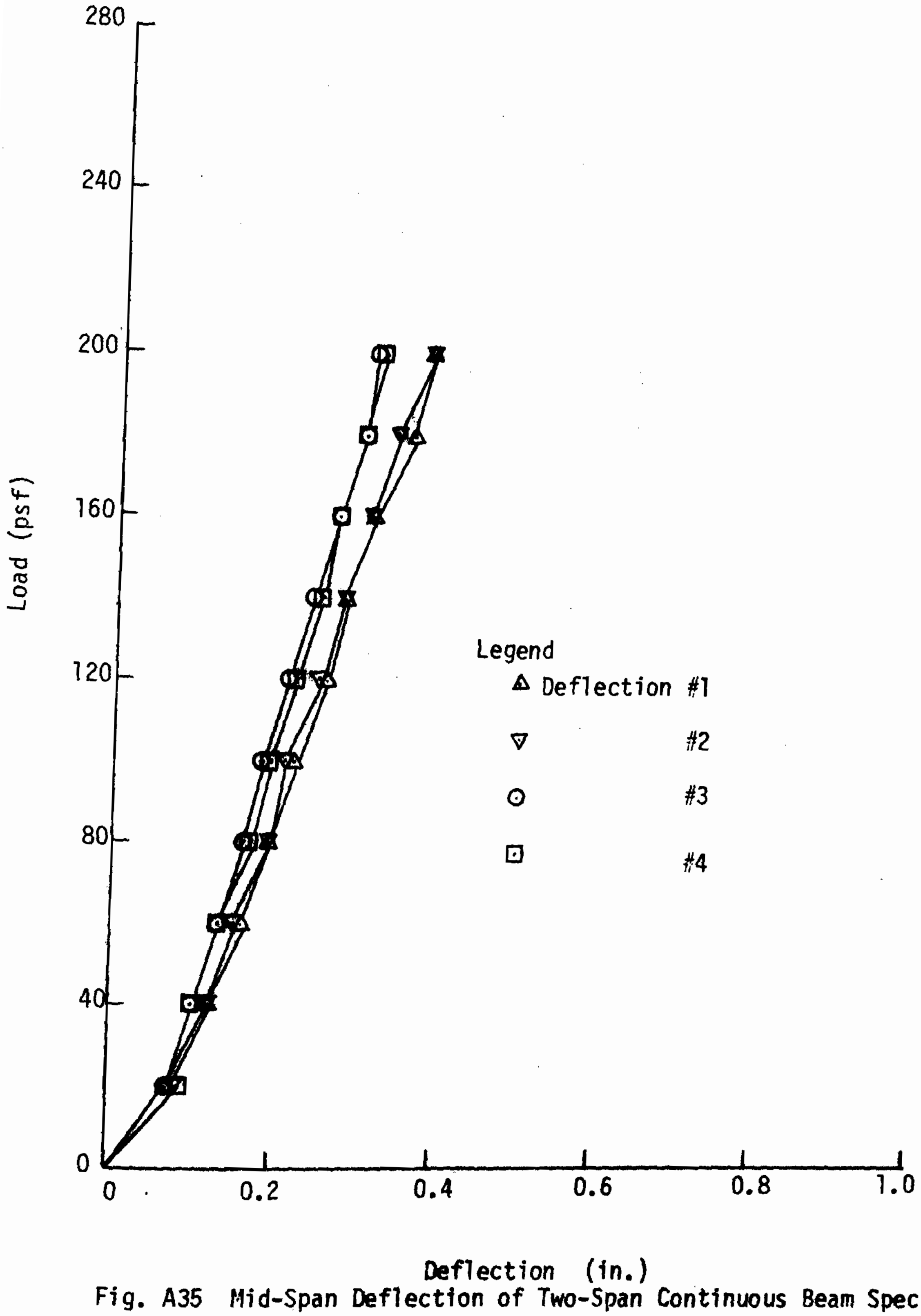


Fig. A35 Mid-Span Deflection of Two-Span Continuous Beam Specimen No. CB-20A

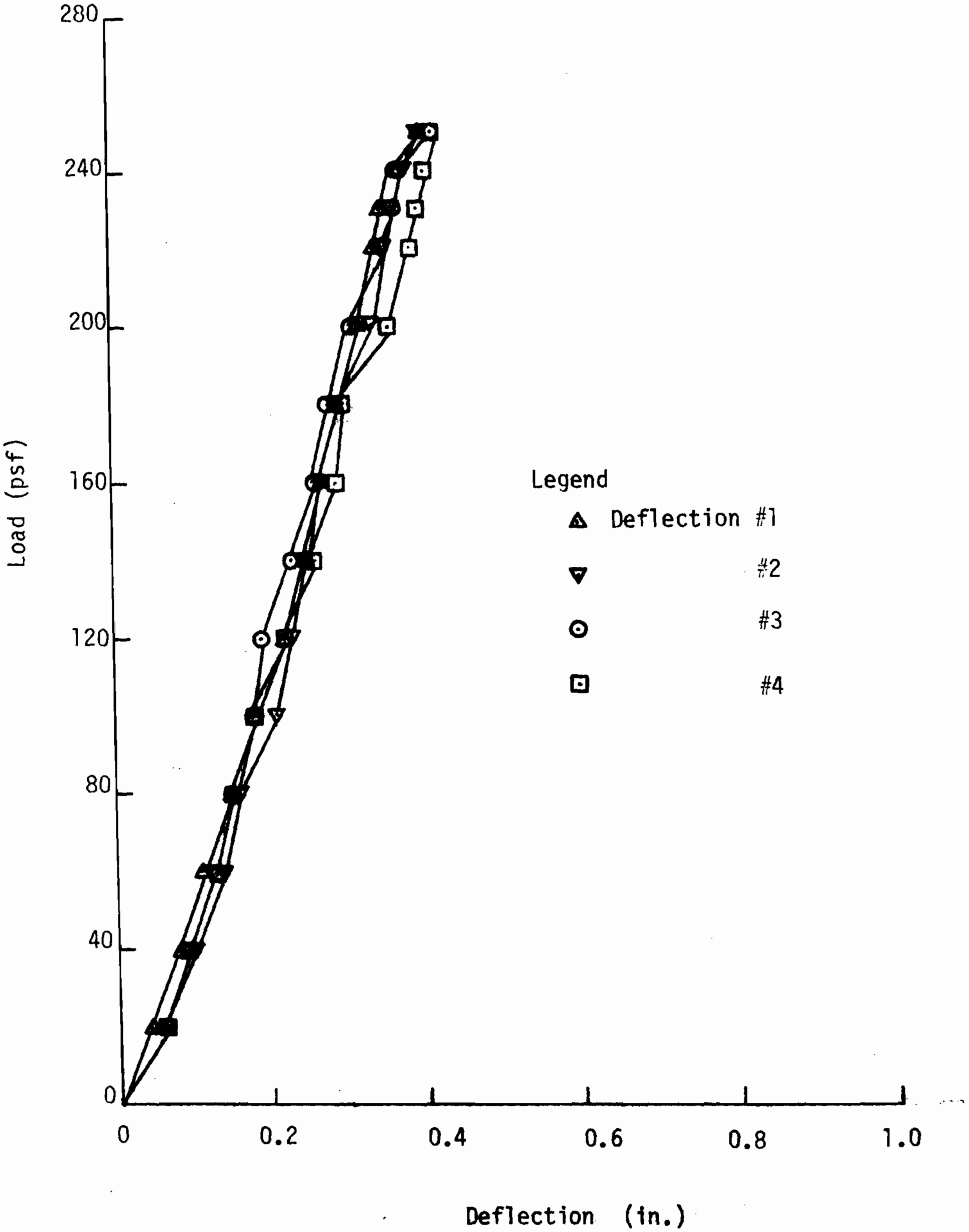


Fig. A36 Mid-Span Deflection of Two-Span Continuous Beam Specimen No. CB-20B

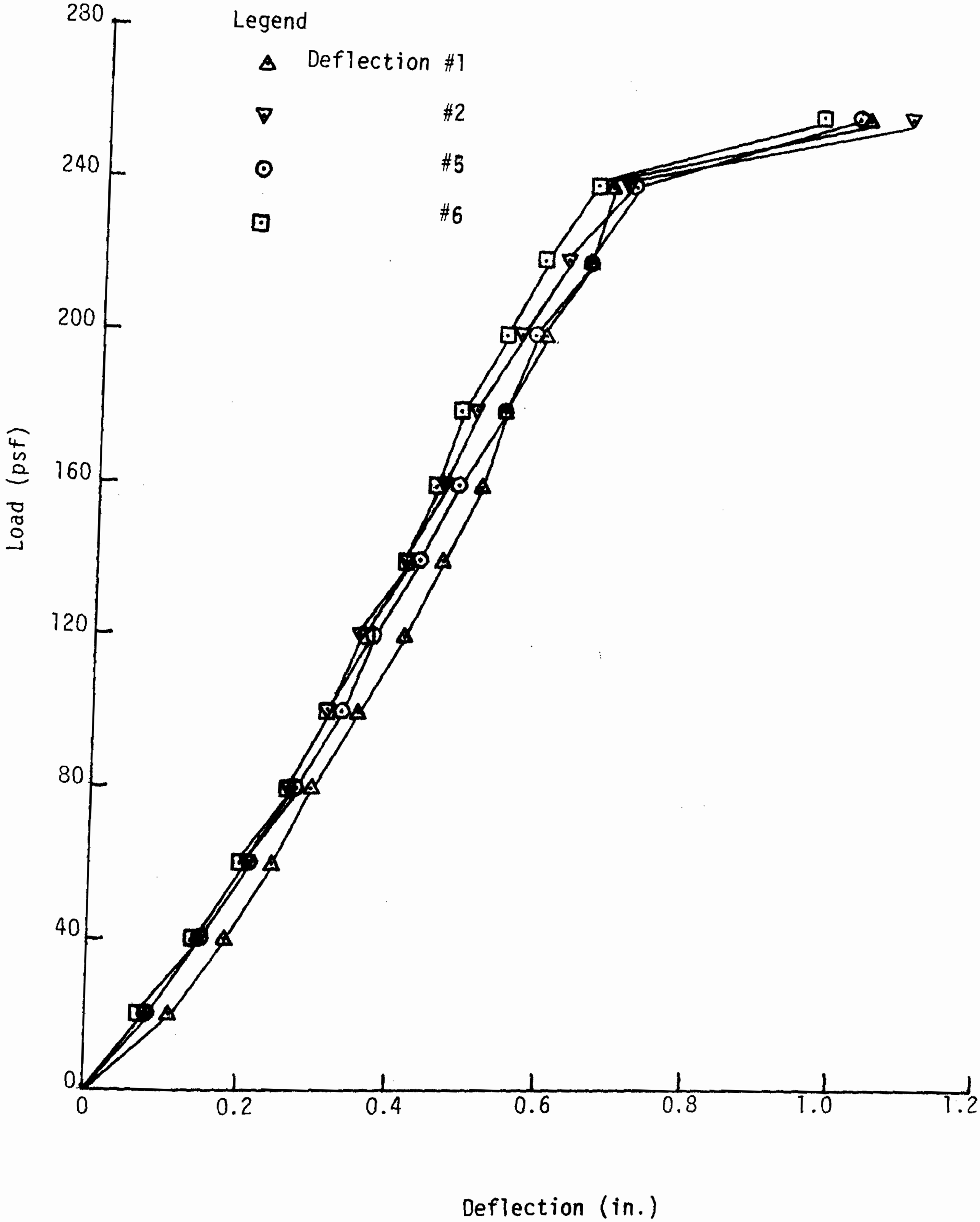


Fig. A37 Mid-Span Deflection of Three-Span Continuous Beam Specimen No. CB-3A

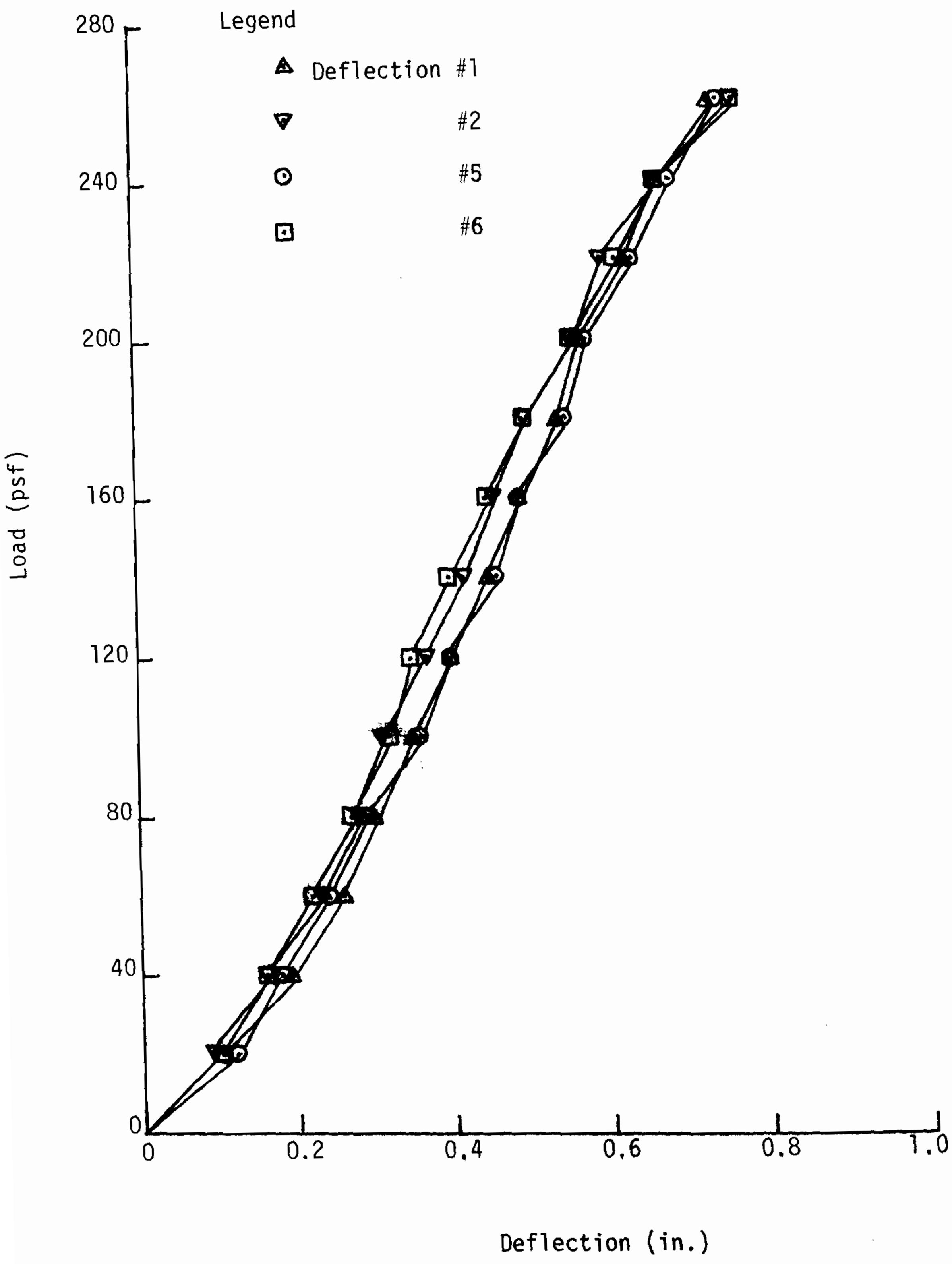


Fig. A38 Mid-Span Deflection of Three-Span Continuous Beam Specimen No. CB-3B

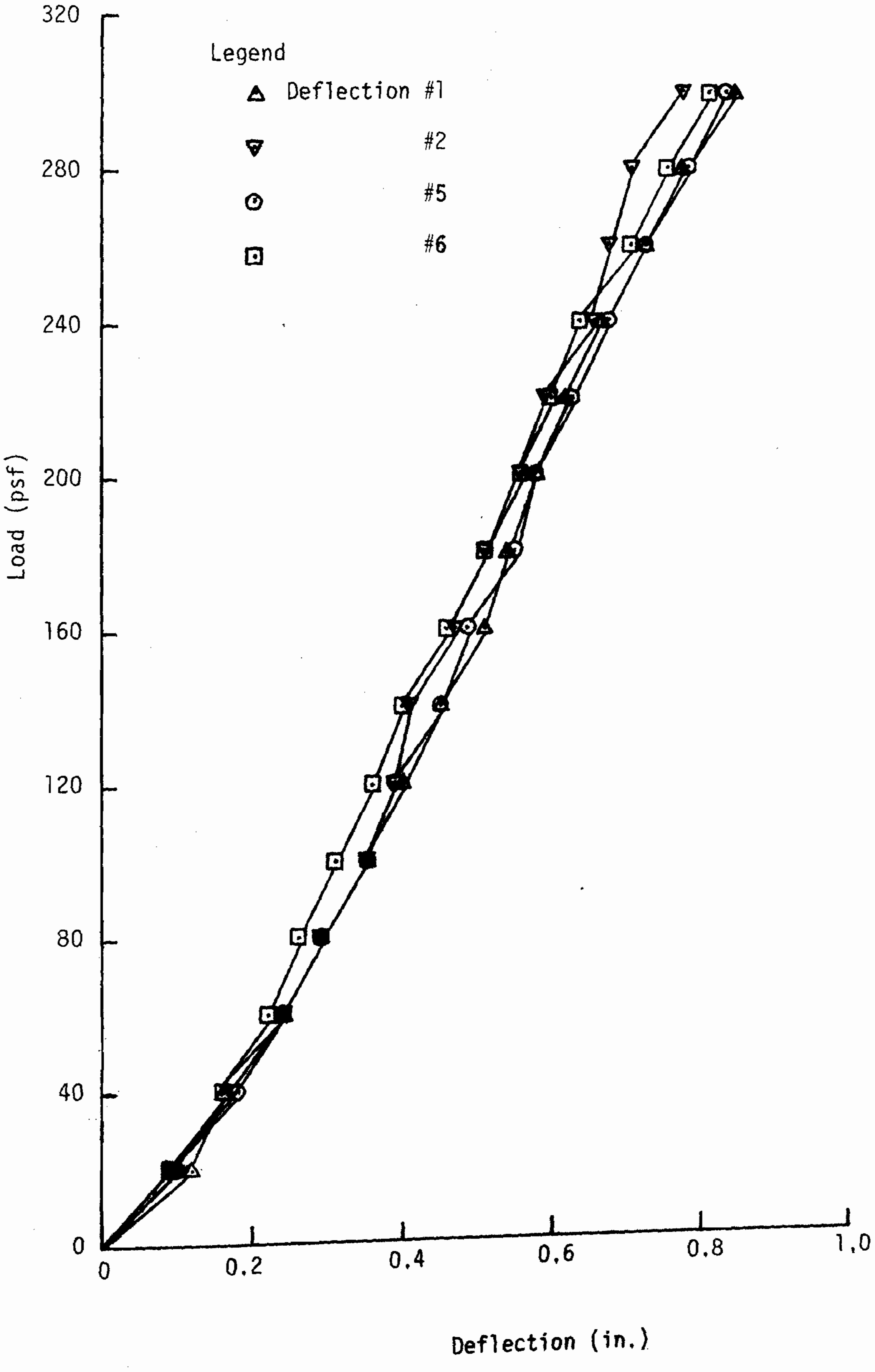


Fig. A39 Mid-Span Deflection of Three-Span Continuous Beam Specimen No. CB-4A

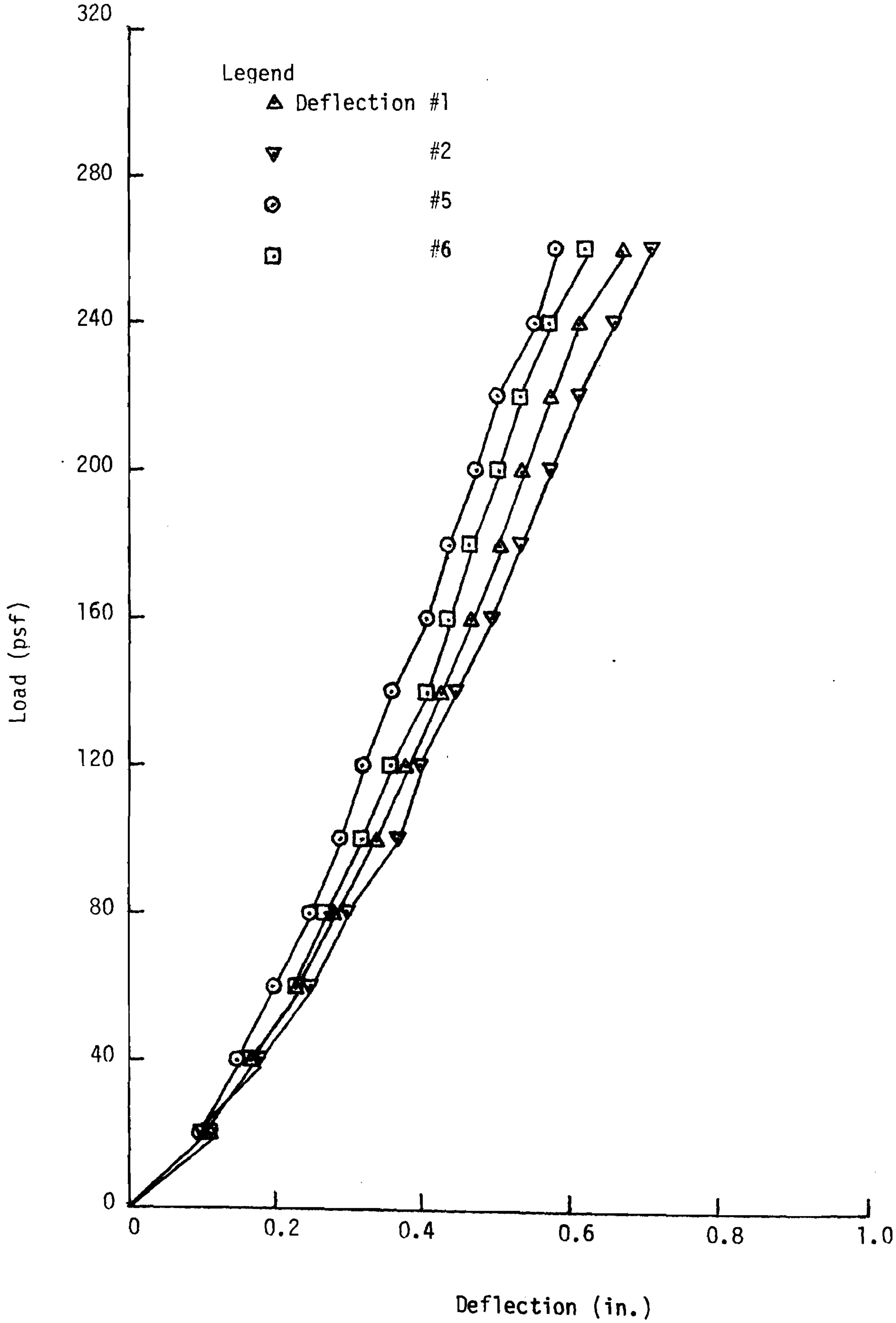


Fig. A40 Mid-Span Deflection of Three-Span Continuous Beam Specimen No. CB-4B

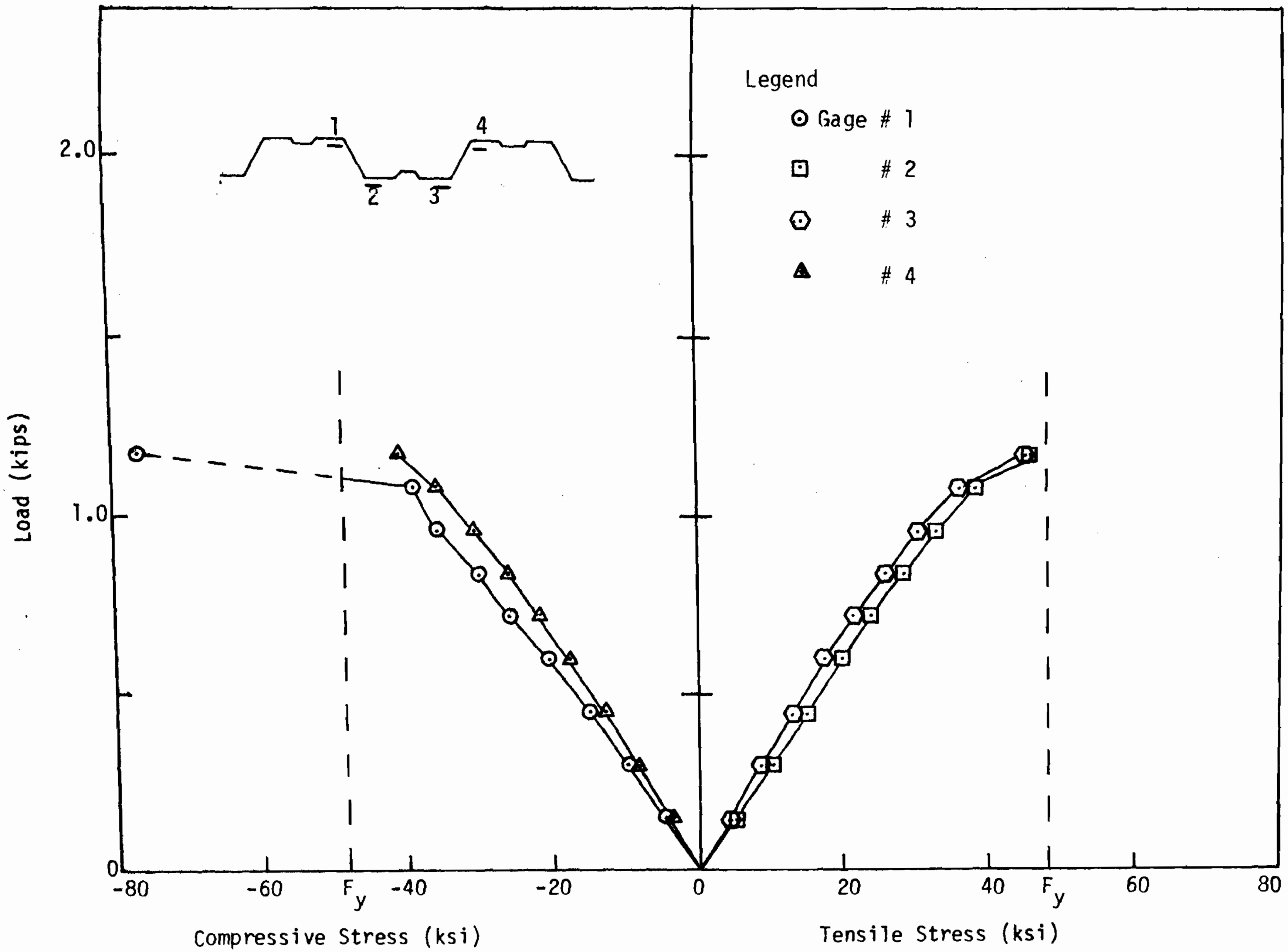


Fig. A41 Load vs Stress for Specimen No. BC - 2C

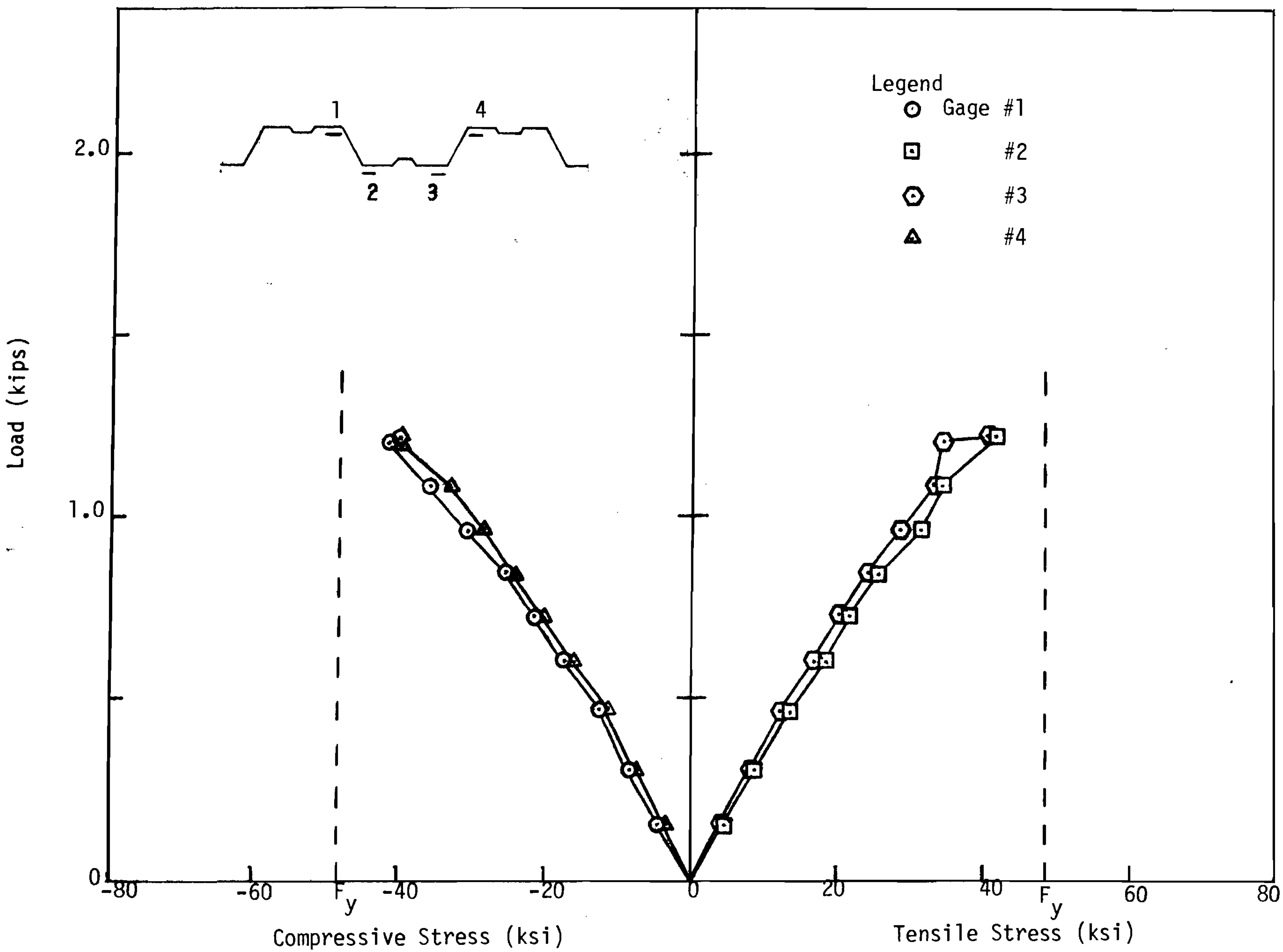


Fig. A42 Load vs Stress for Specimen No. BC - 2D

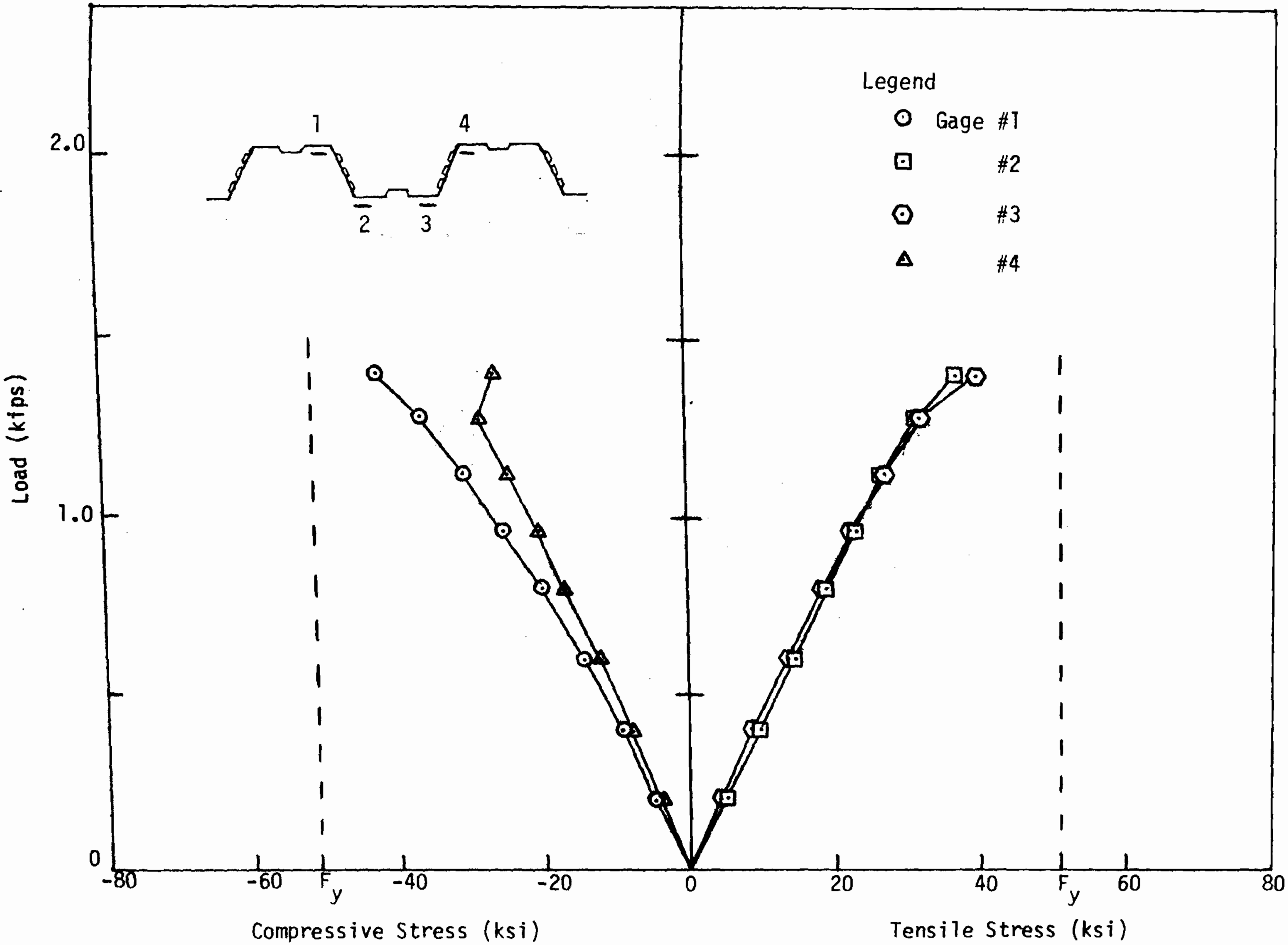


Fig. A43 Load vs Stress for Specimen No. BC - 12C

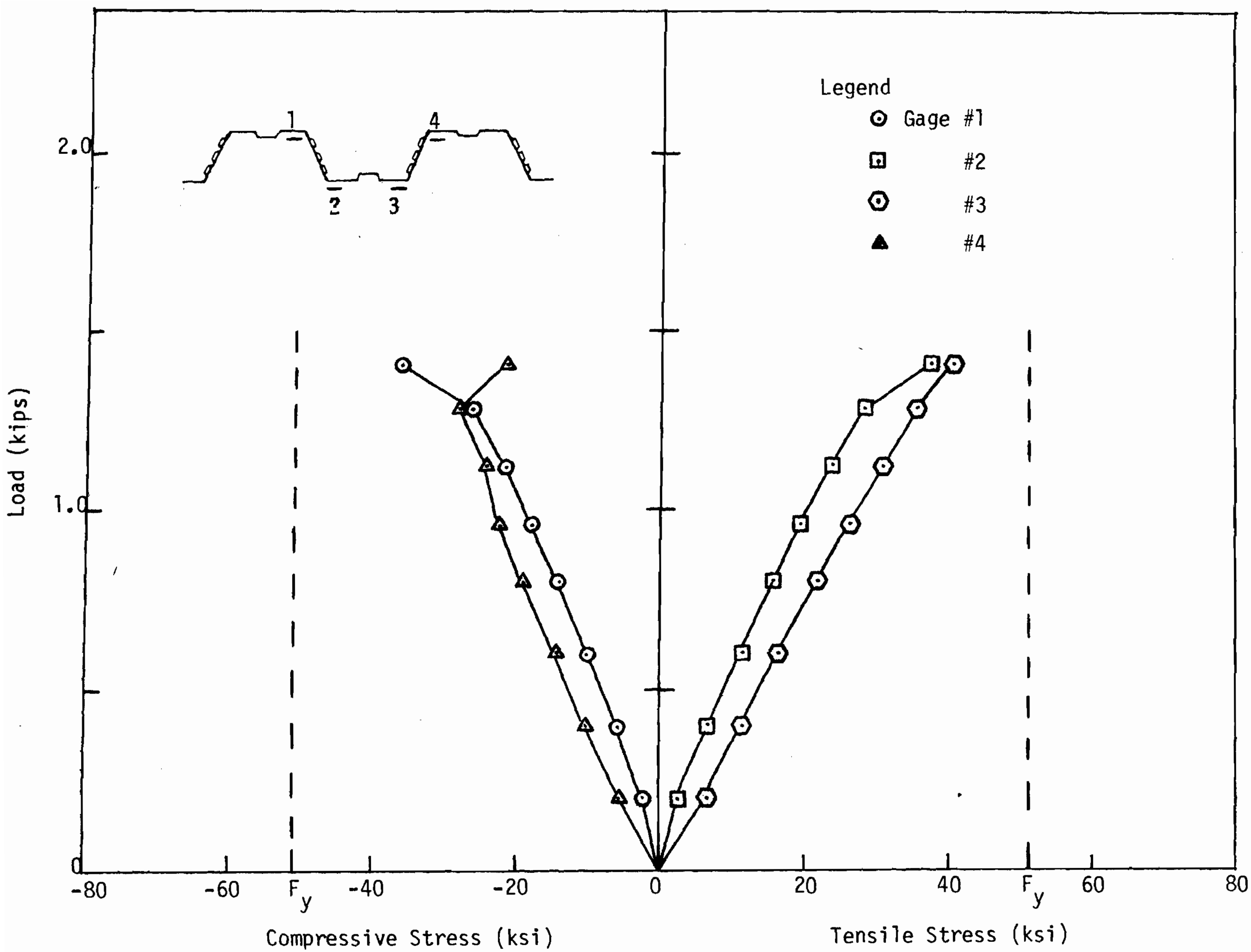


Fig. A44 Load vs Stress for Specimen No. BC - 12D

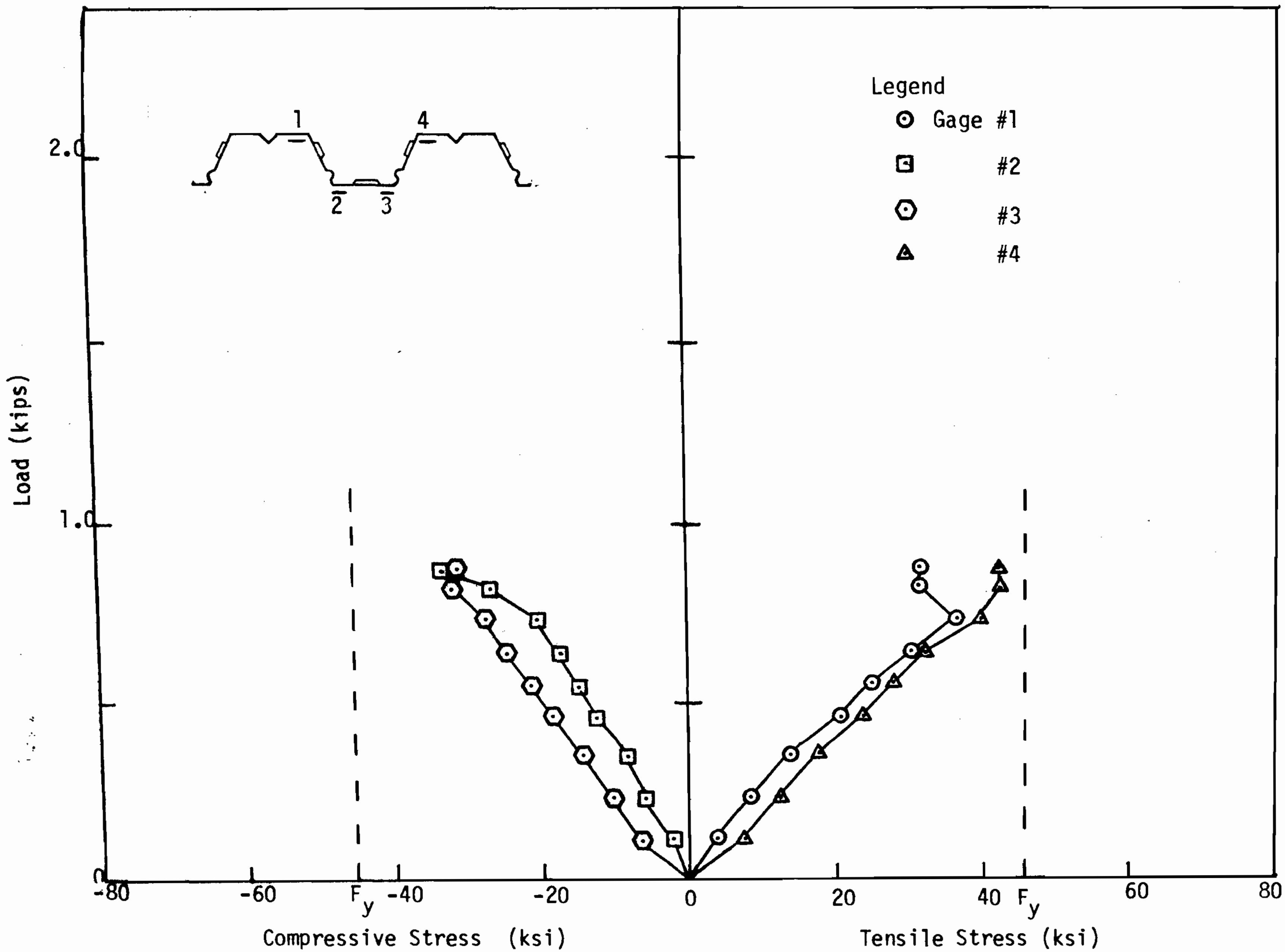


Fig. A45 Load vs Stress for Specimen No. BC - 16C

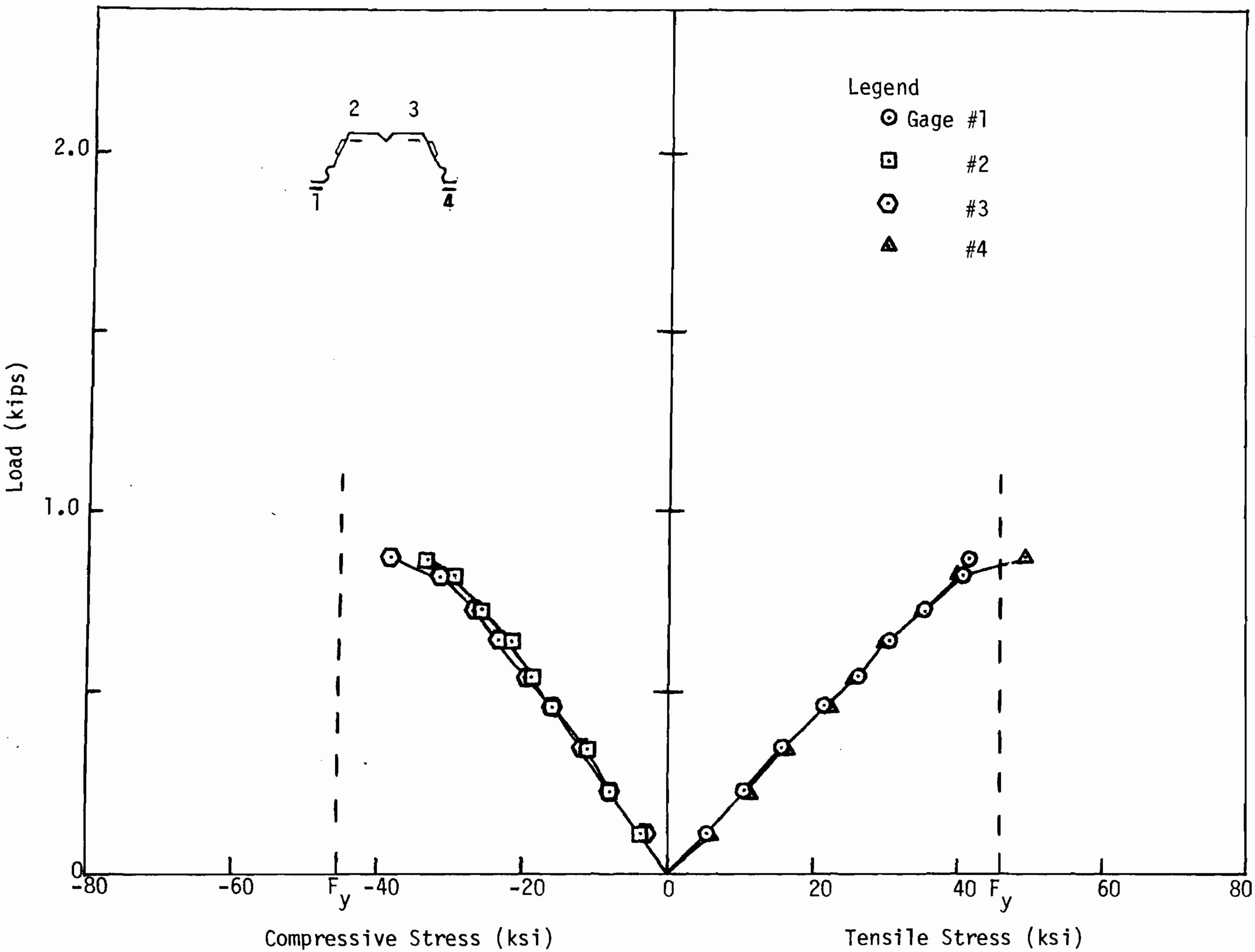


Fig. A46 Load vs Stress for Specimen No. BC - 16D

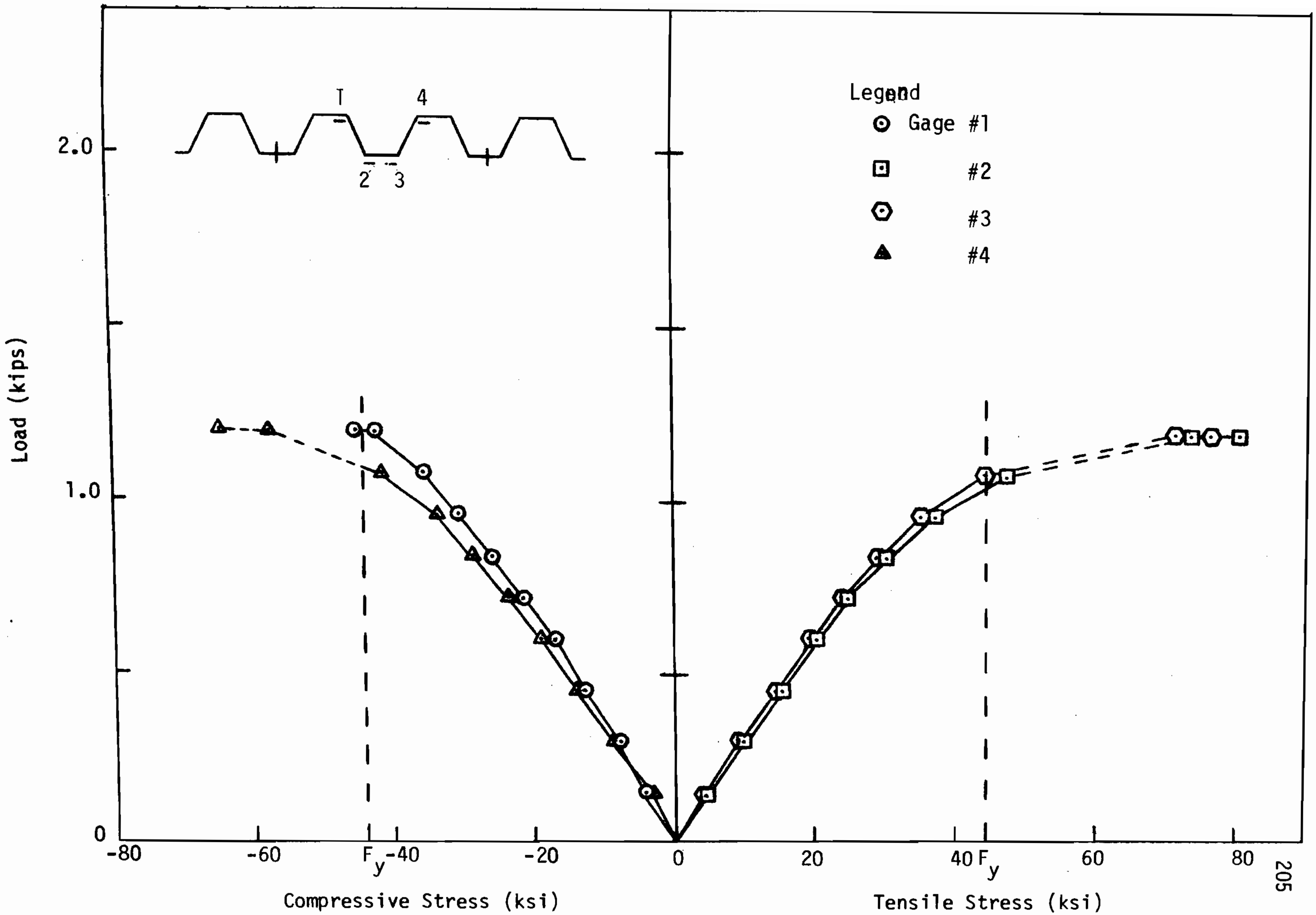


Fig. A47 Load vs Stress for Specimen No. BC - 19C

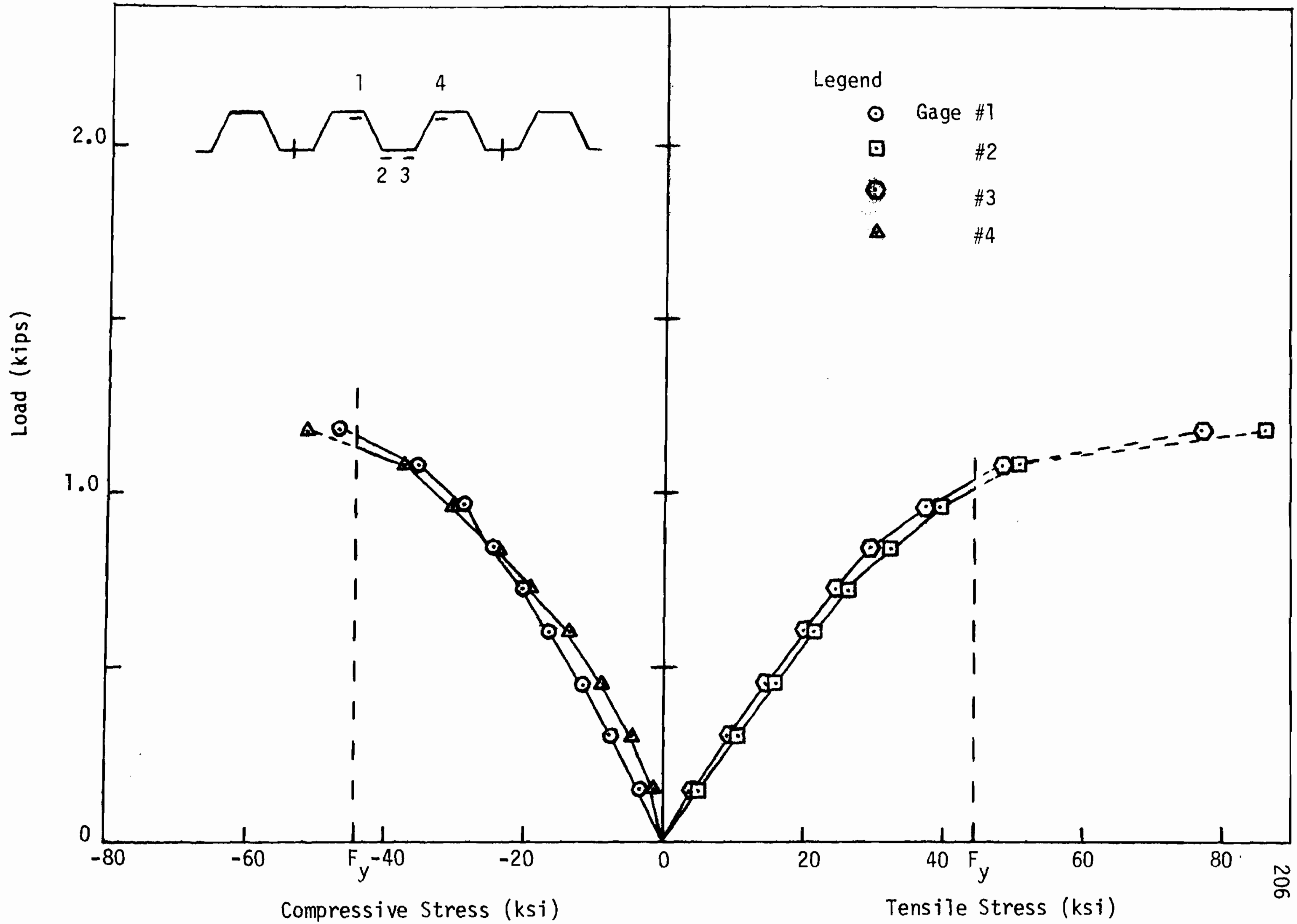


Fig. A48 Load vs Stress for Specimen No. BC - 19D

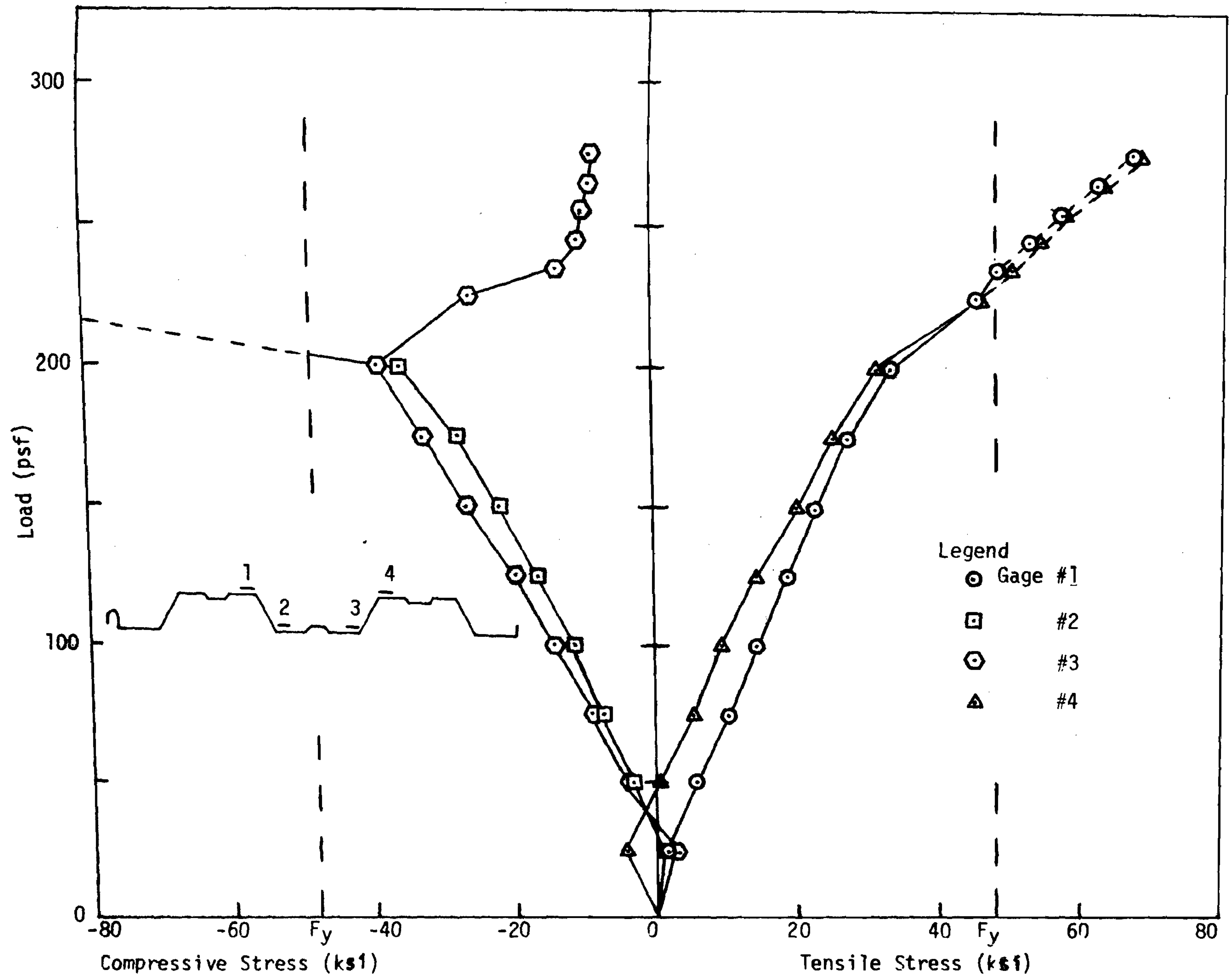


Fig.A49 Load vs Stress for Specimen No. CB - 1A

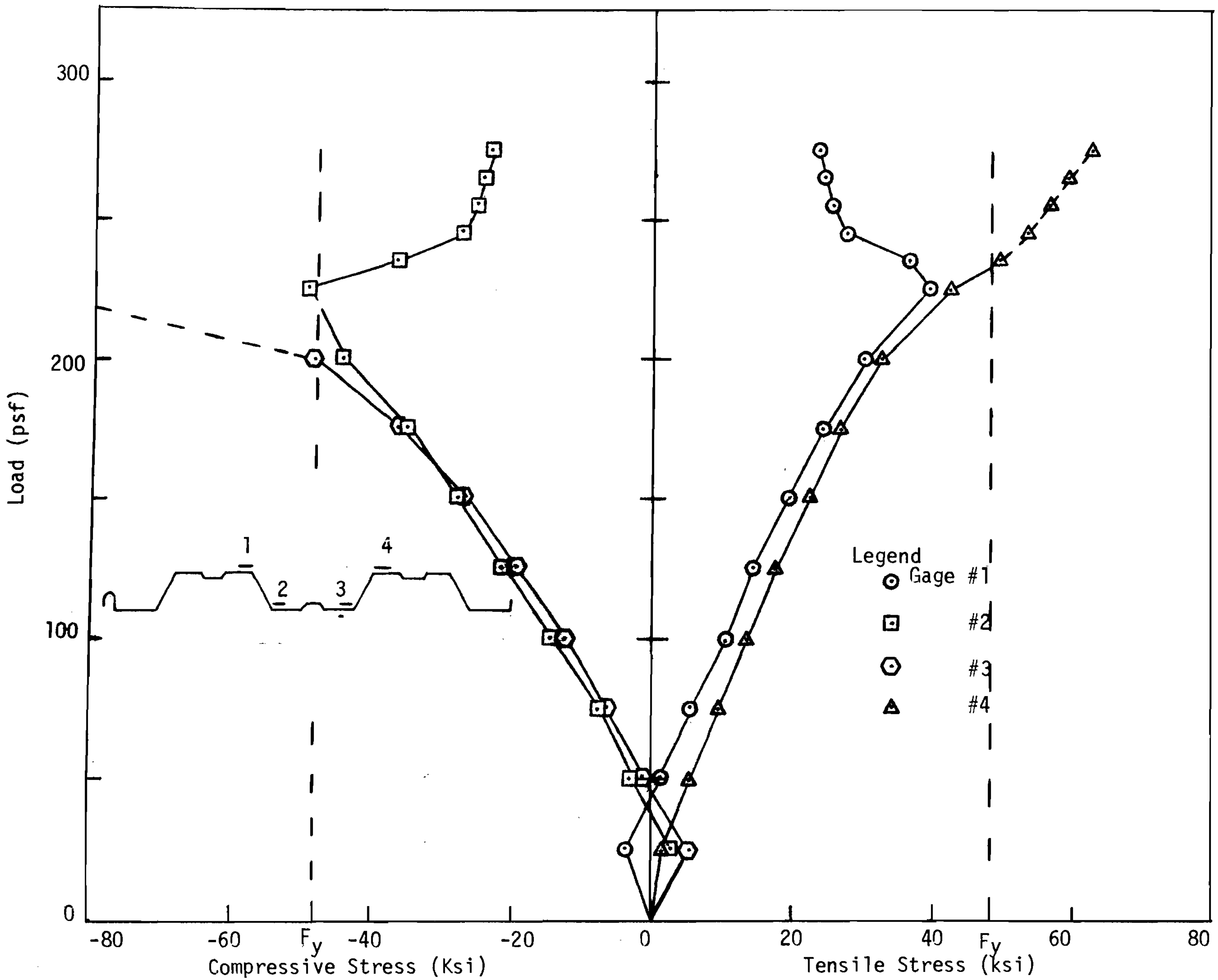


Fig. A50 Load vs Stress for Specimen No. CB - 1B

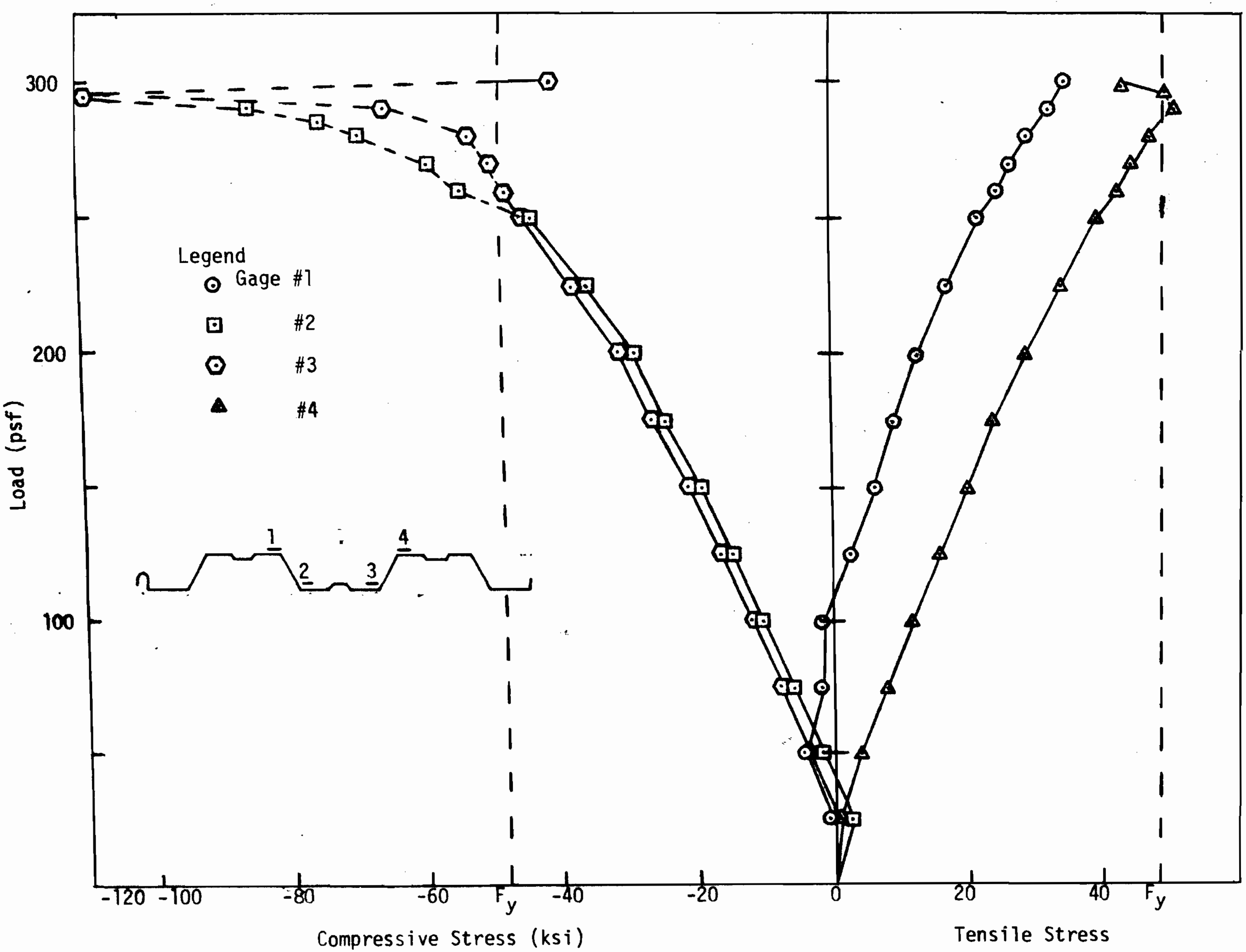


Fig. A51 Load vs Stress for Specimen No. CB - 2A

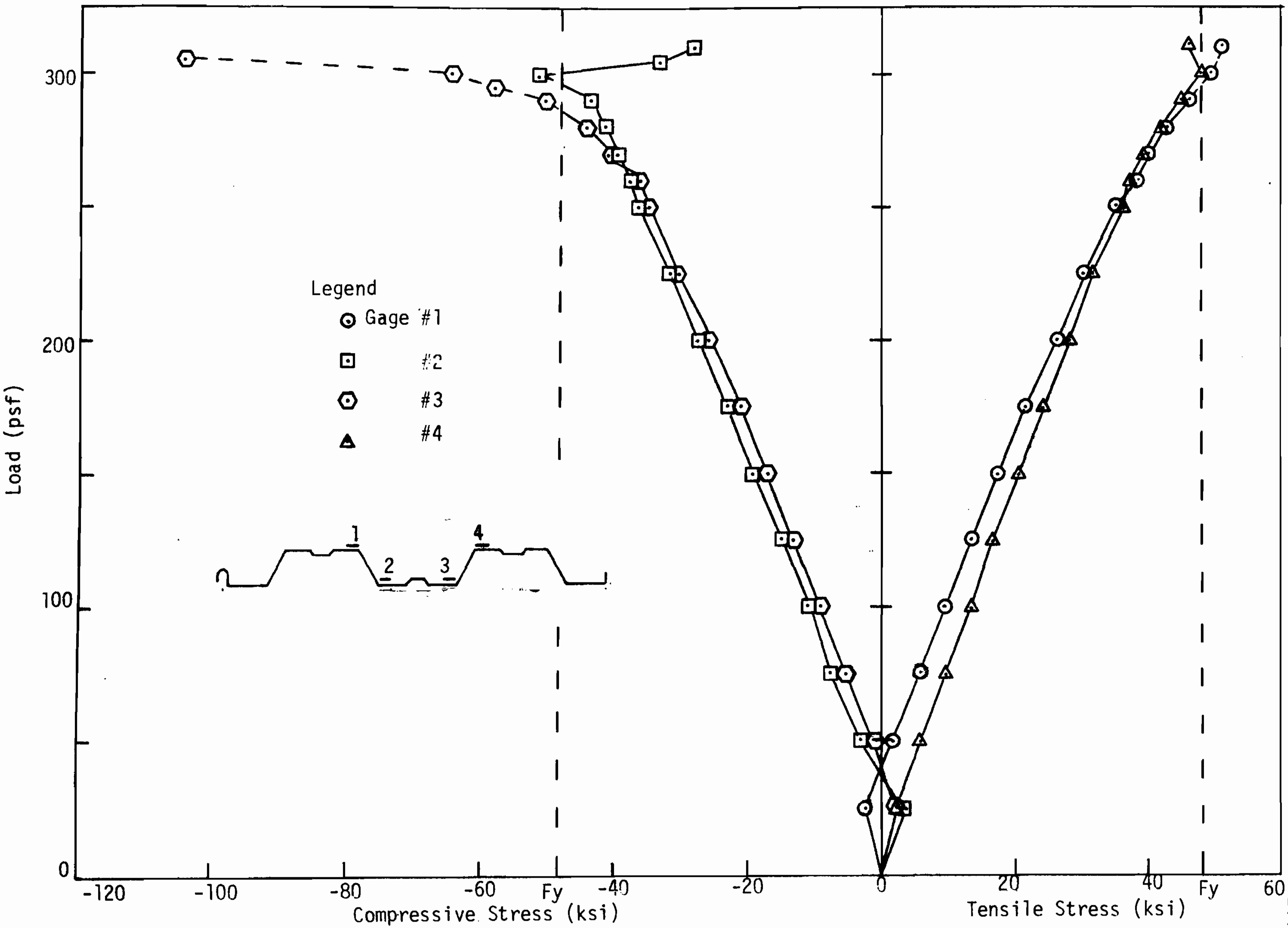


Fig. A52 Load vs Stress for Specimen No. BC - 2B

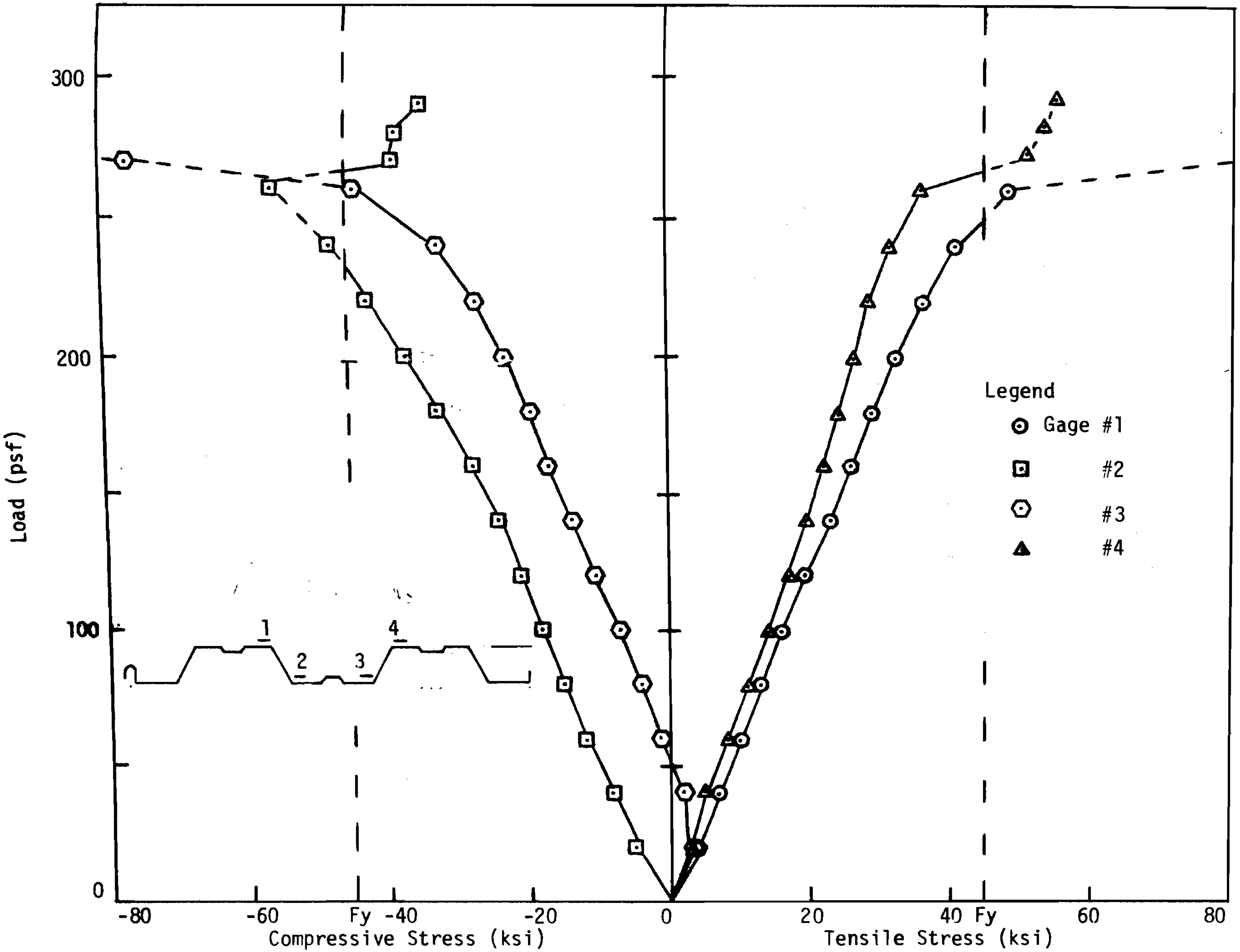


Fig. A53 Load vs Stress for Specimen No. CB - 3A

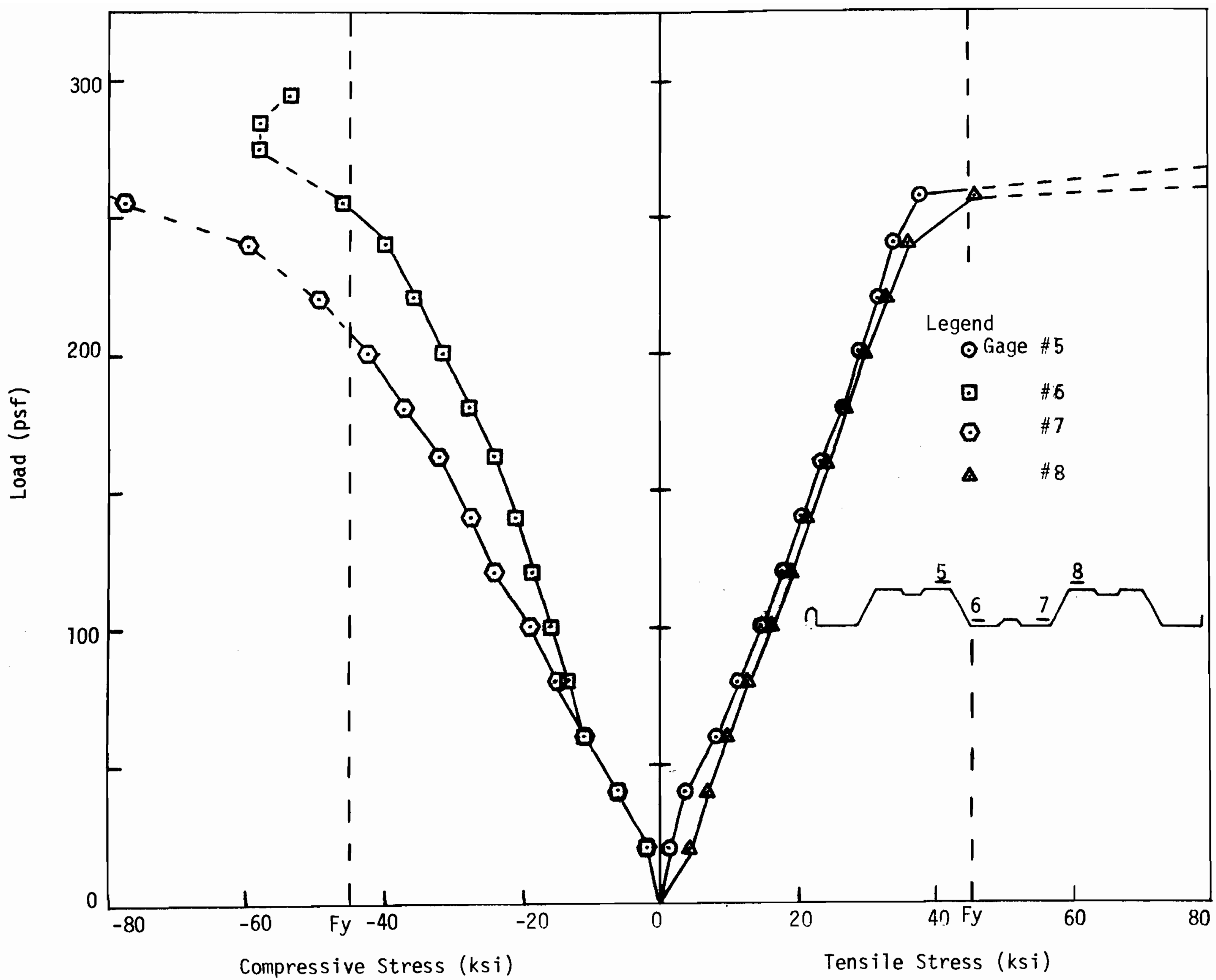


Fig. A54 Load vs Stress for Specimen No. CB - 3A

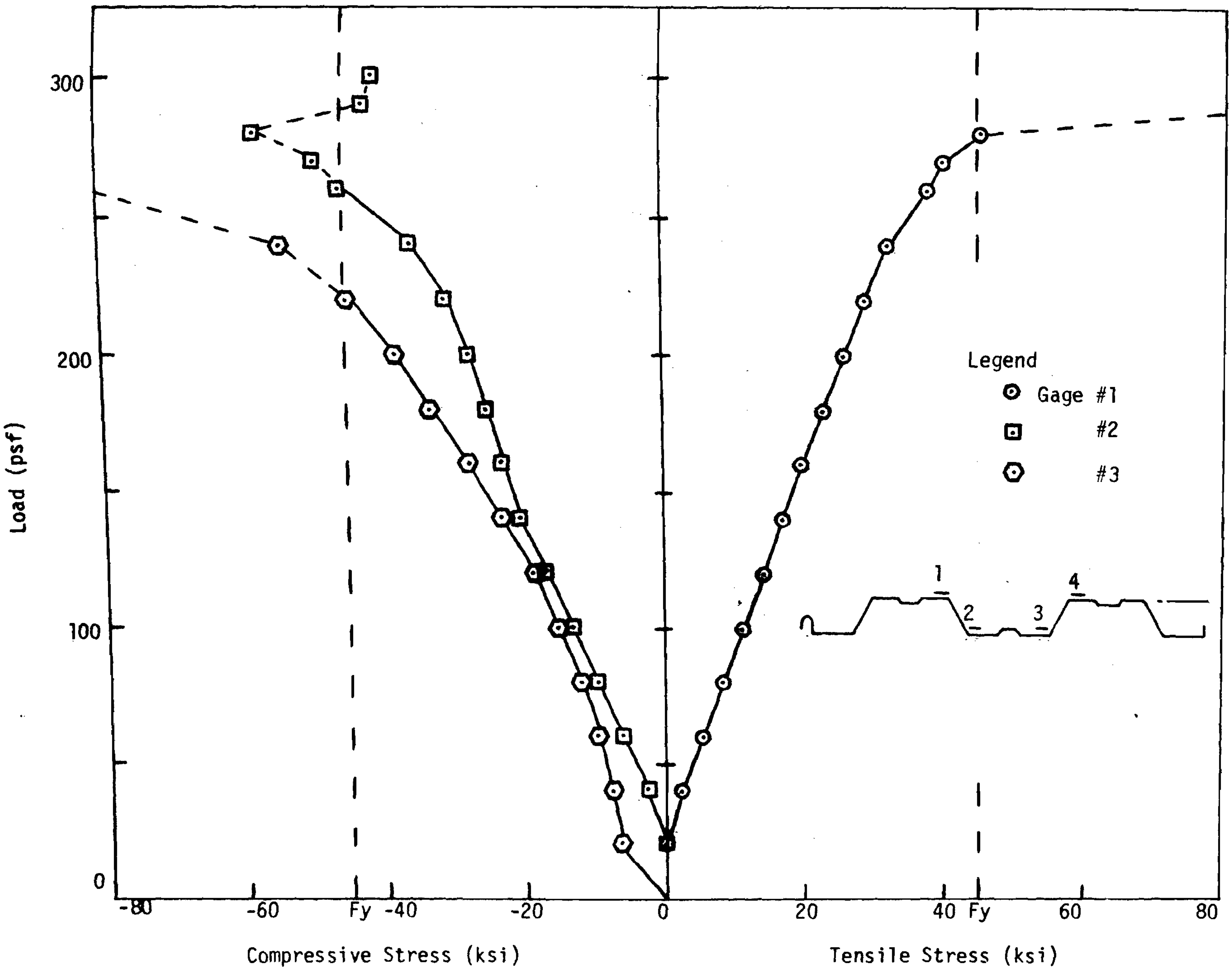


Fig. A55 Load vs Stress for Specimen No. CB - 3B

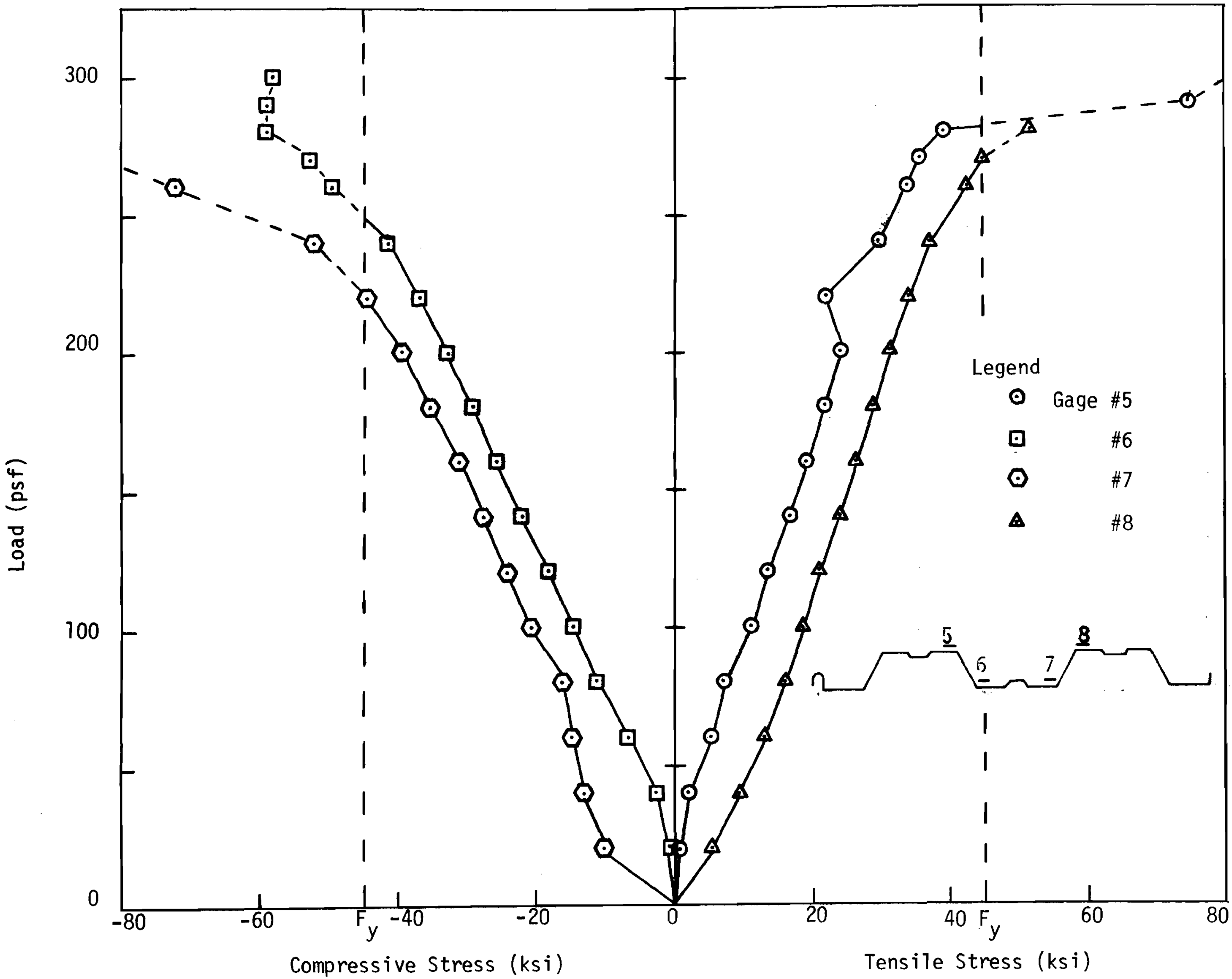


Fig. A56 Load vs Stress for Specimen No. CB - 3B

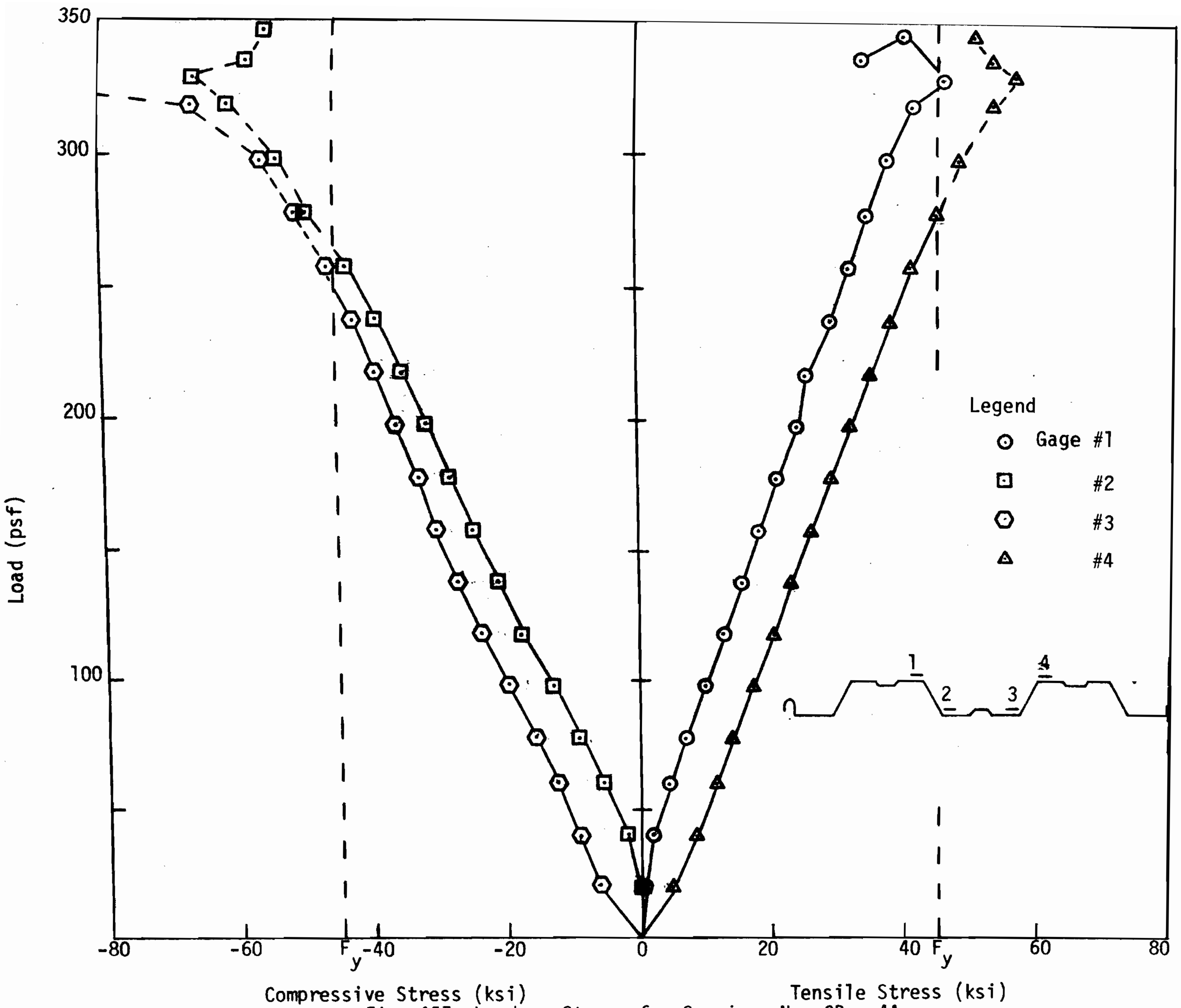


Fig. A57 Load vs Stress for Specimen No. CB - 4A

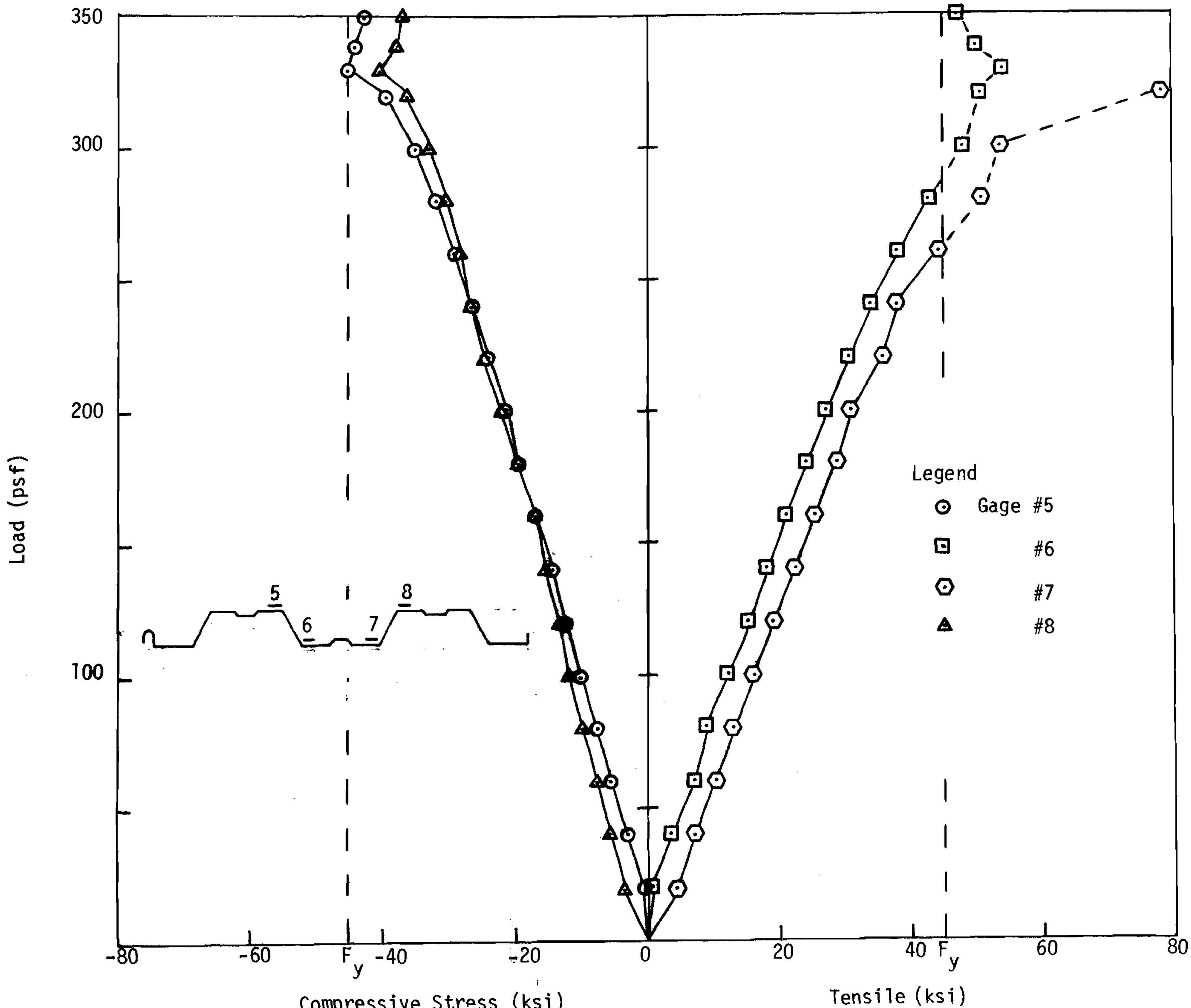


Fig. A58 Load vs Stress for Specimen No. CB - 4A

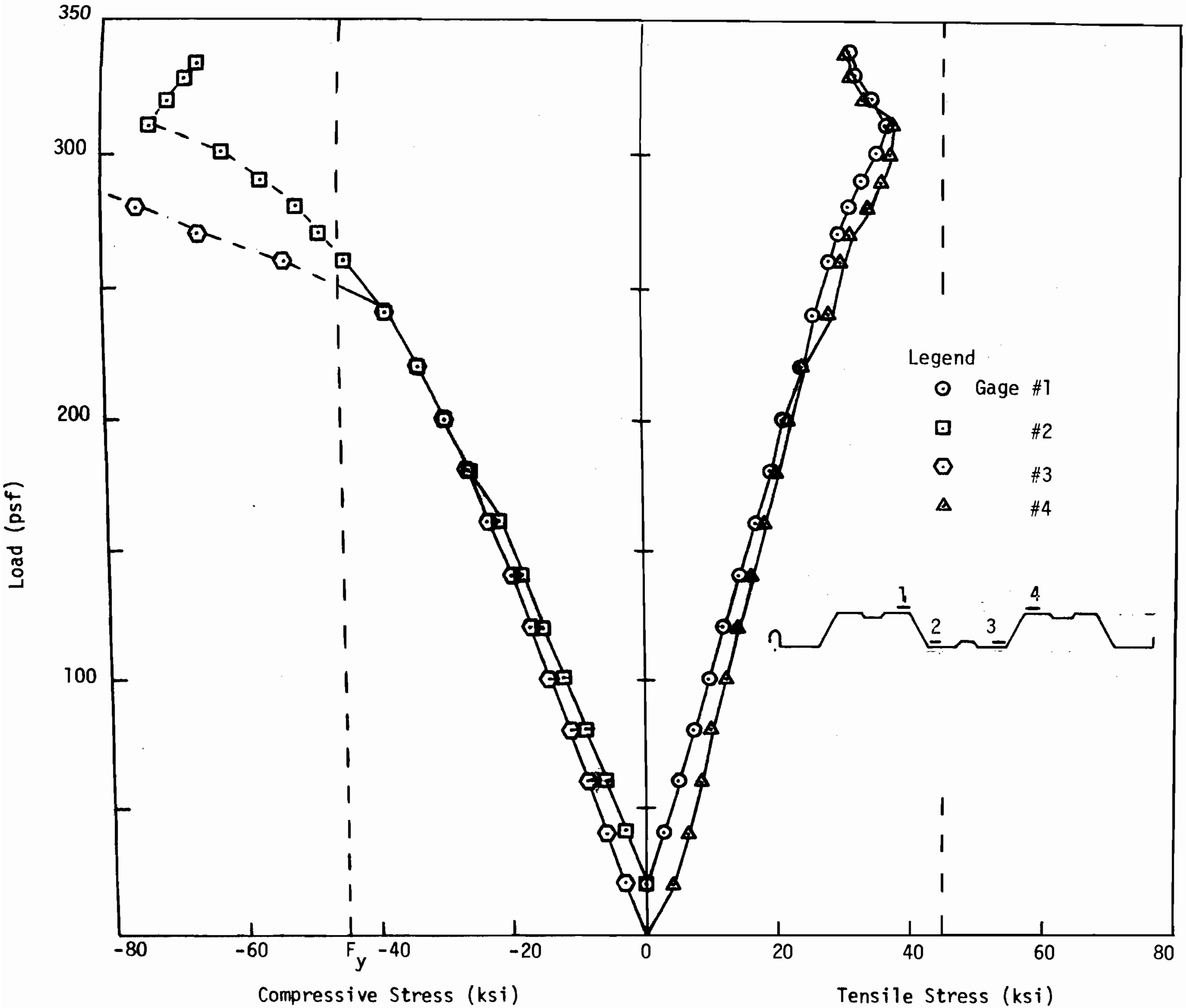


Fig. A59 Load vs Stress for Specimen No. CB - 4B

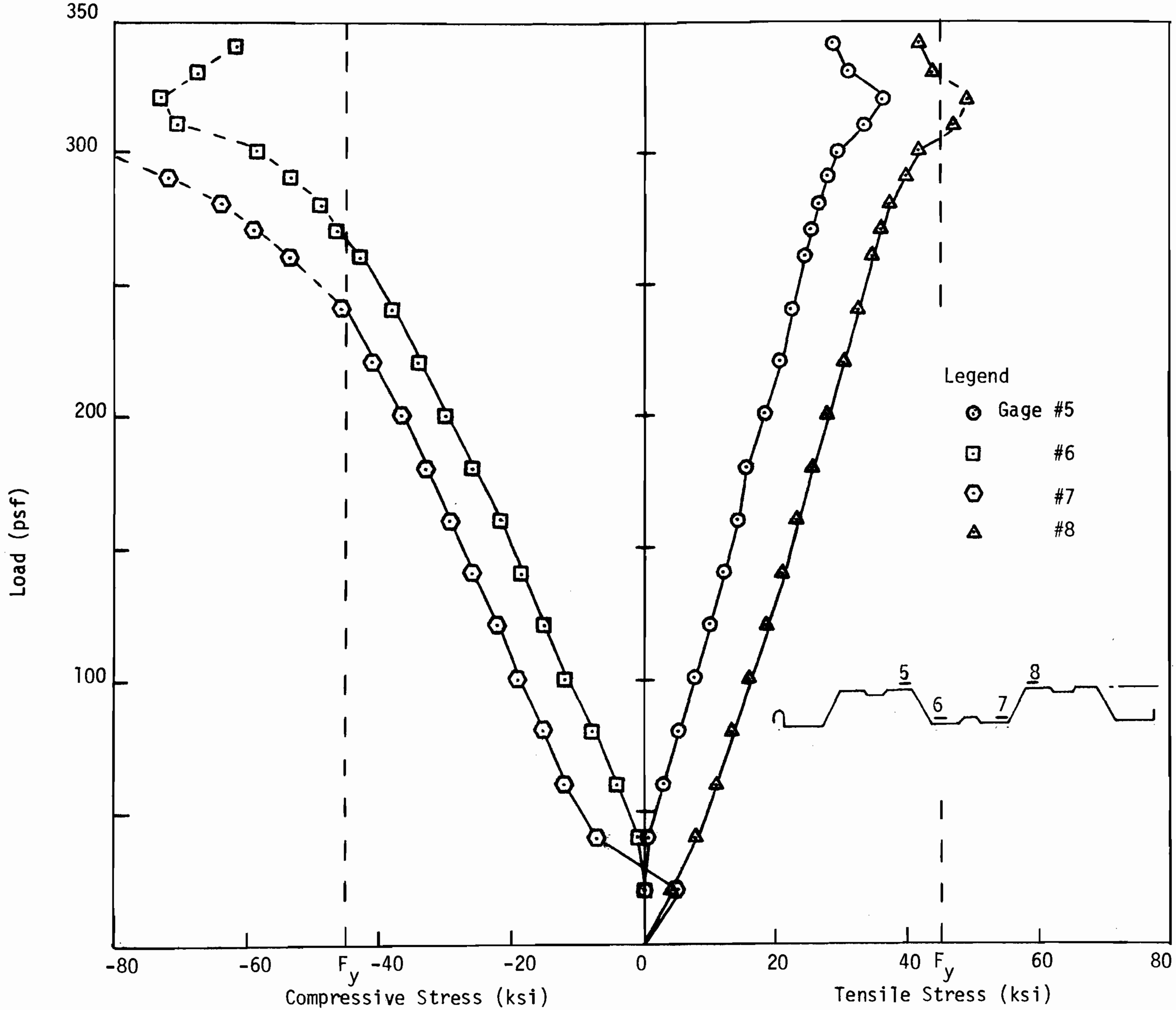


Fig. A60 Load vs Stress for Specimen No. CB - 4B

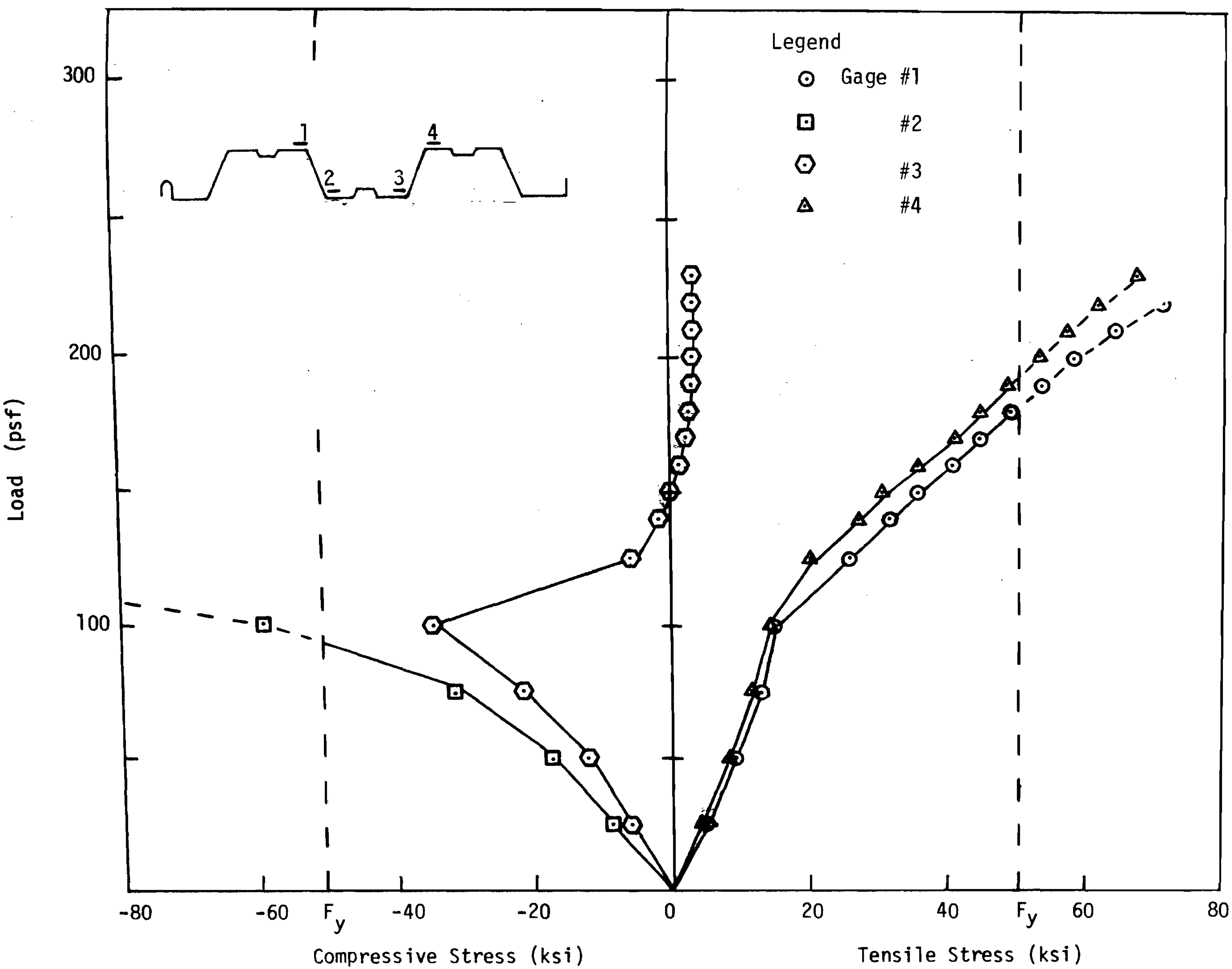


Fig. A61 Load vs Stress for Specimen No. CB - 5A

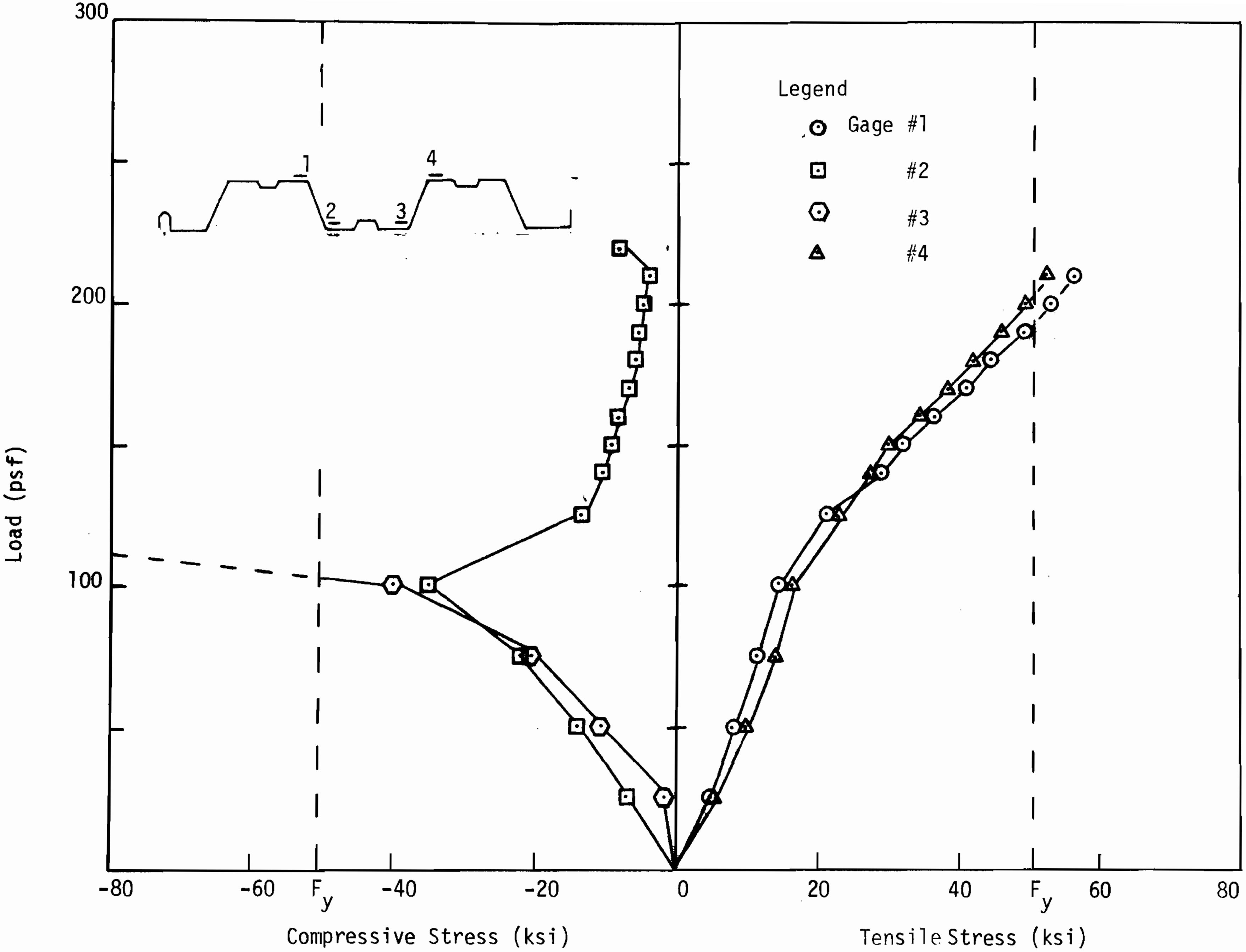


Fig. A62 Load vs Stress for Specimen No. CB - 5B

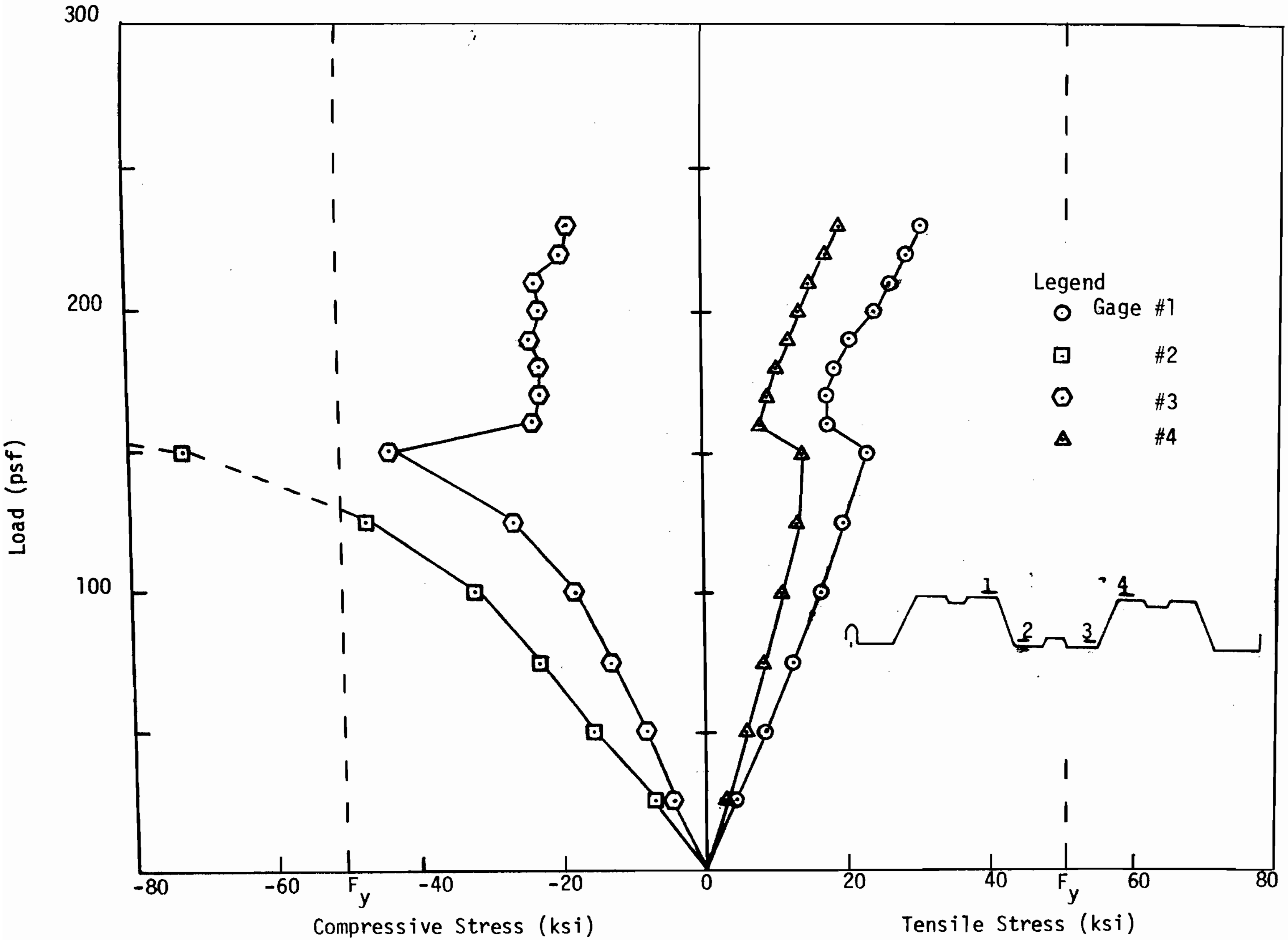


Fig. A63 Load vs Stress for Specimen No. CB - 6A

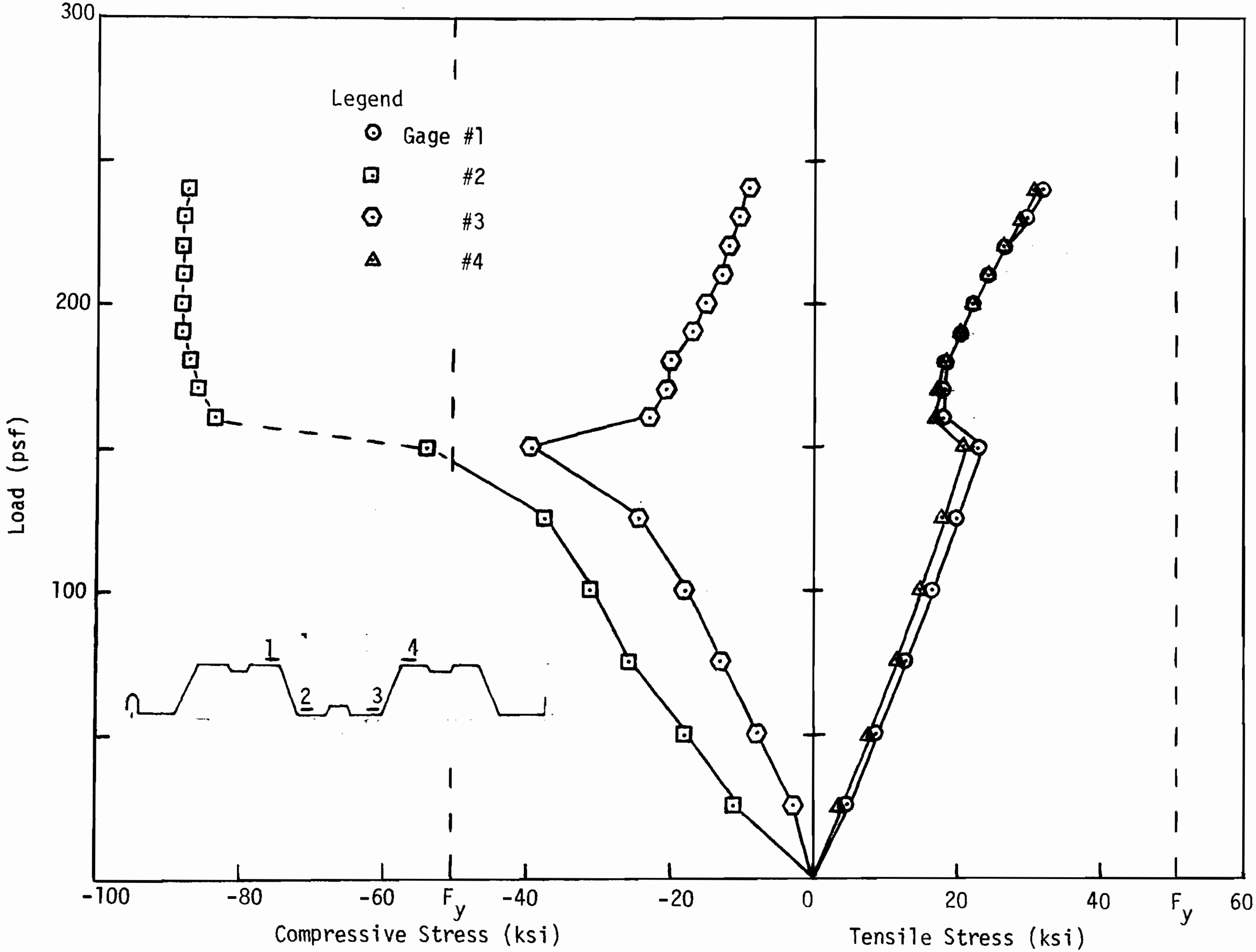


Fig. A64 Load vs Stress for Specimen No. CB - 6B

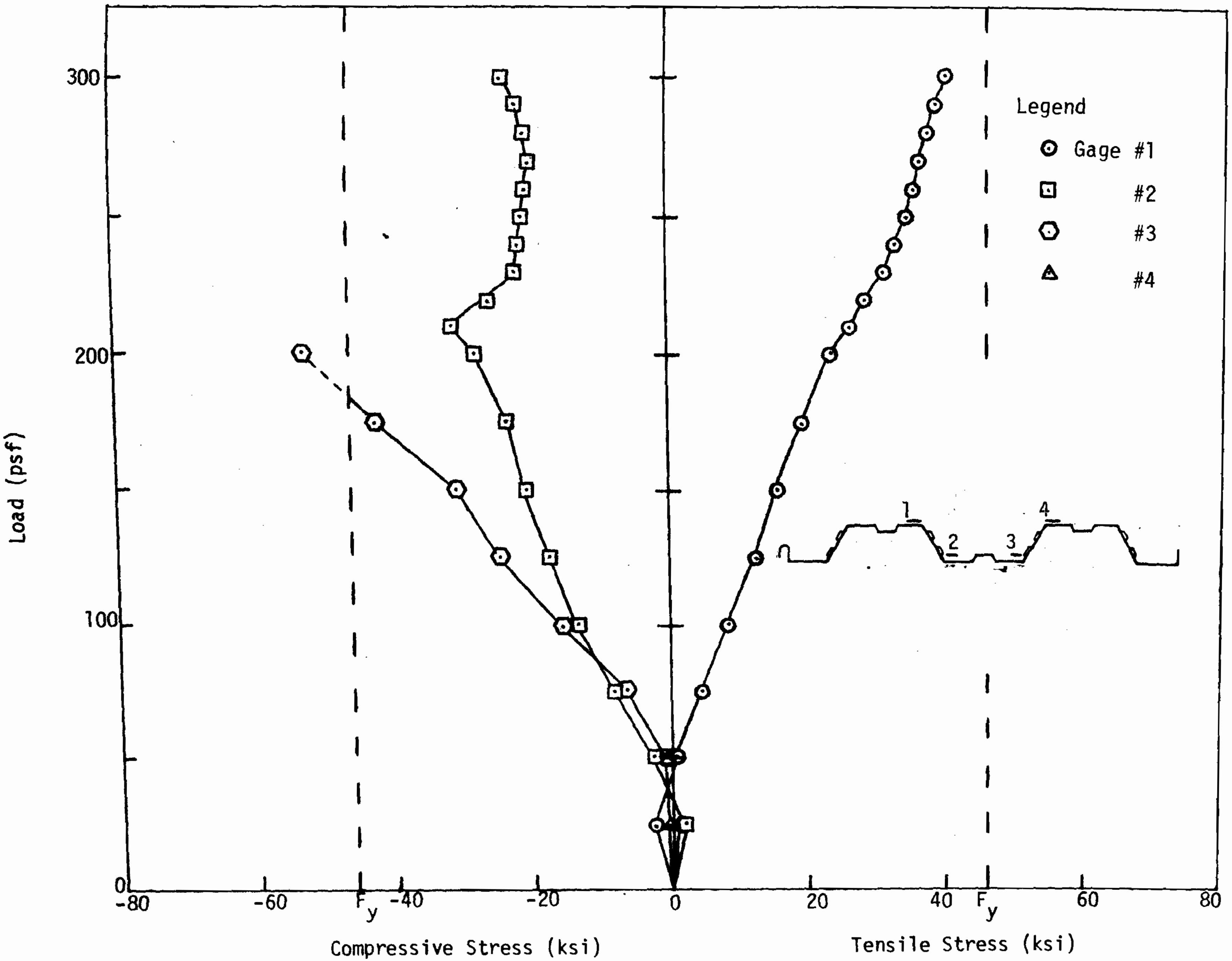


Fig. A65 Load vs Stress for Specimen No. CB - 9A

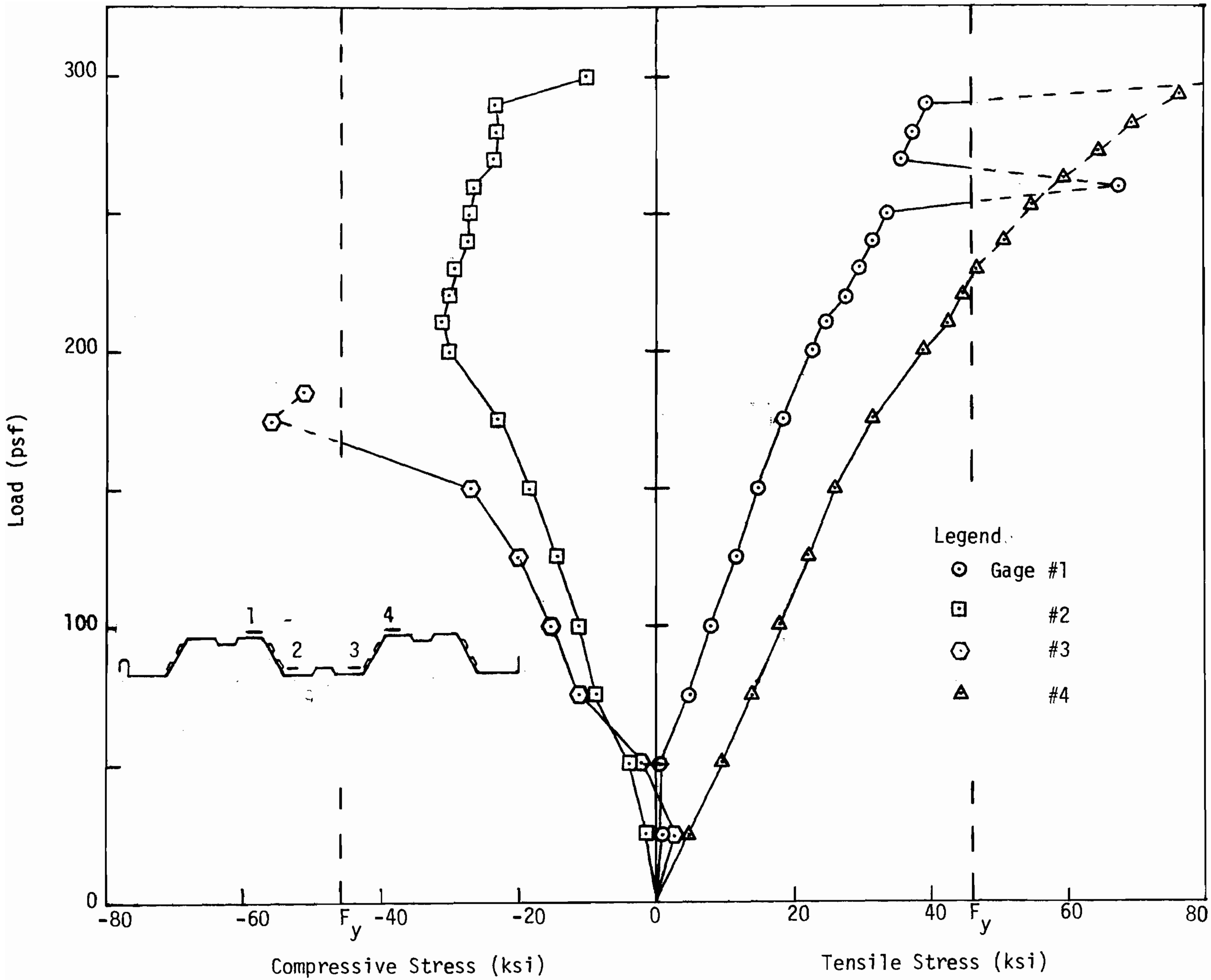


Fig. A66 Load vs Stress for Specimen No. CB - 9B

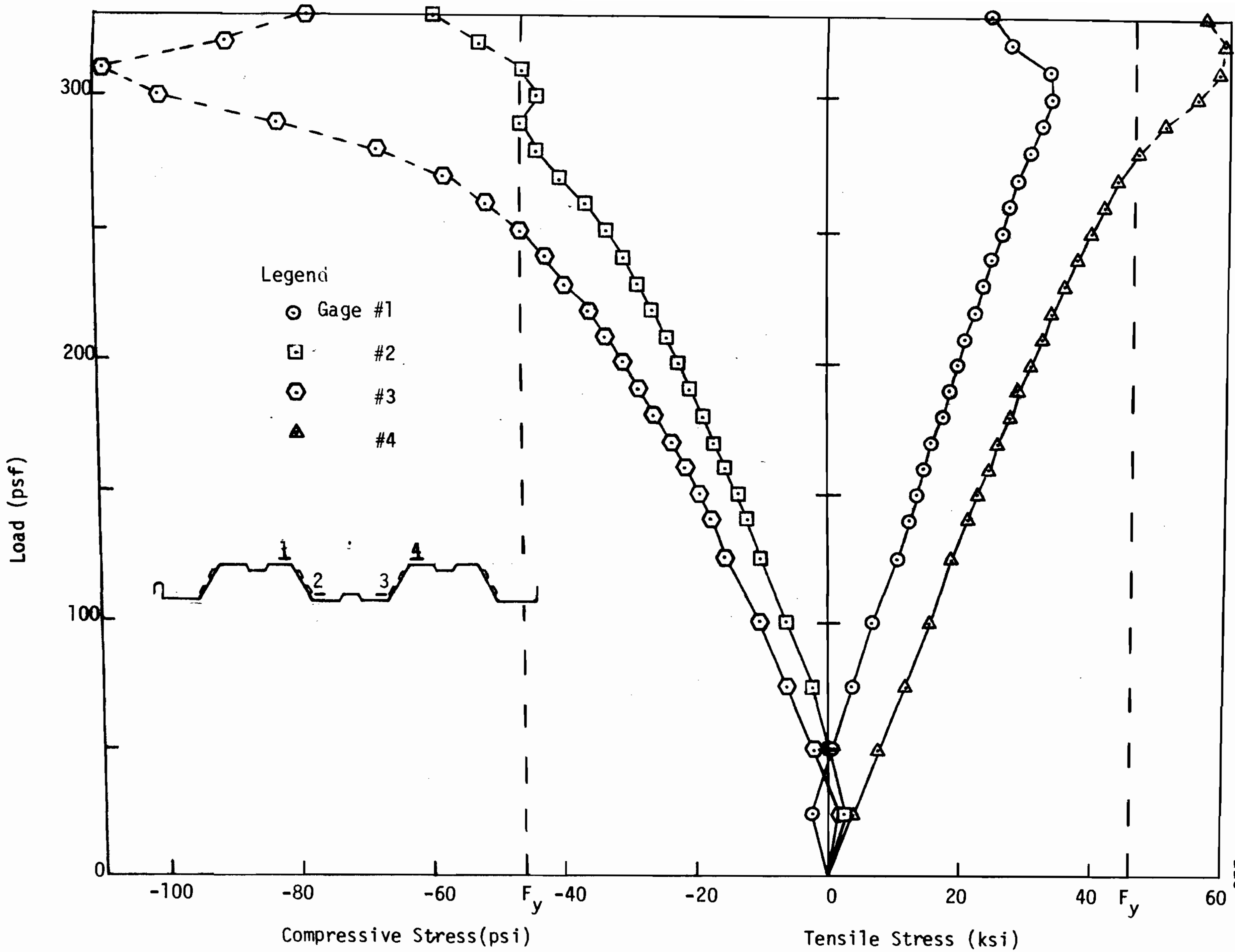


Fig. A67 Load vs Stress for Specimen No. CB - 10A

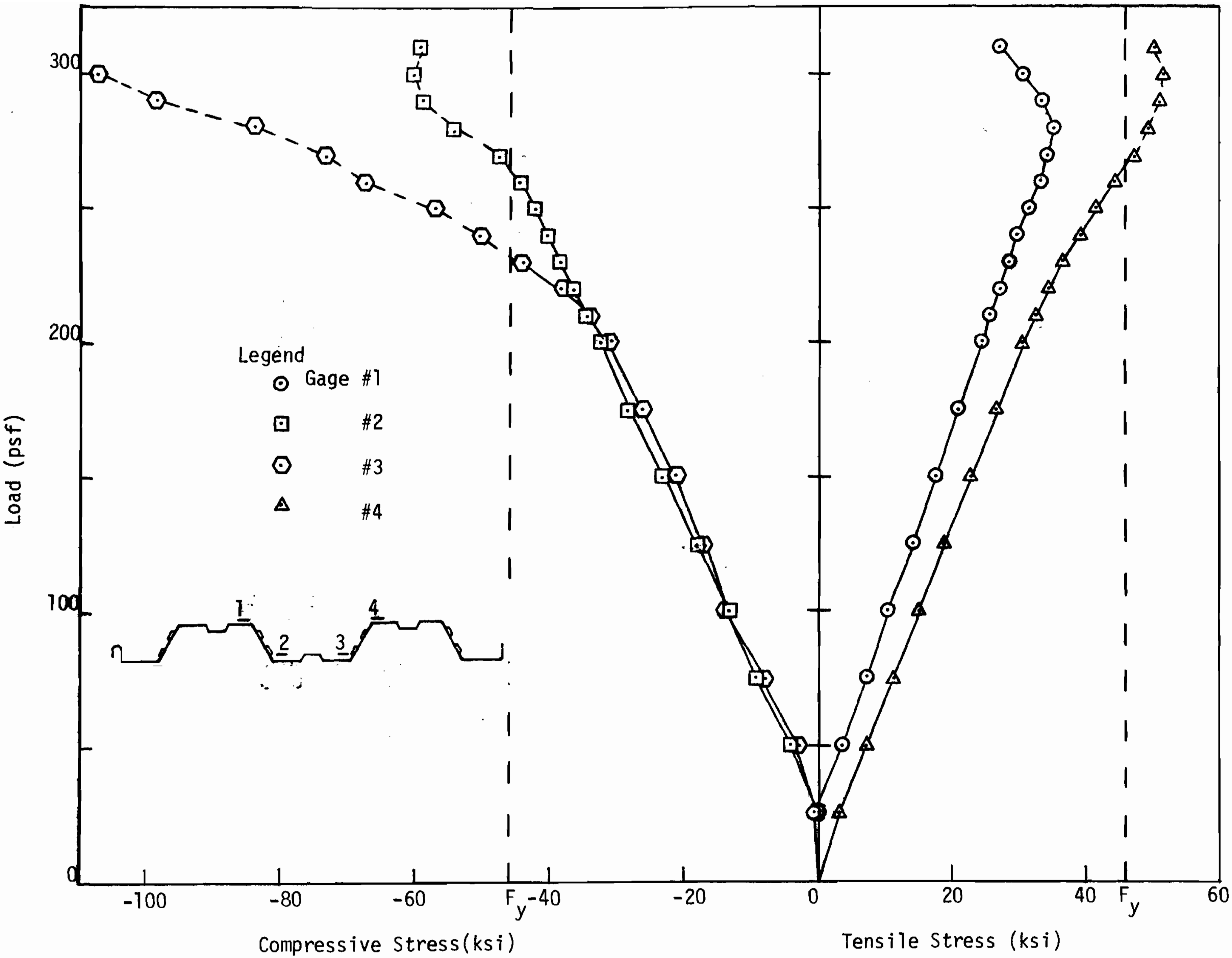


Fig. A68 Load vs Stress for Specimen No. CB - 10B

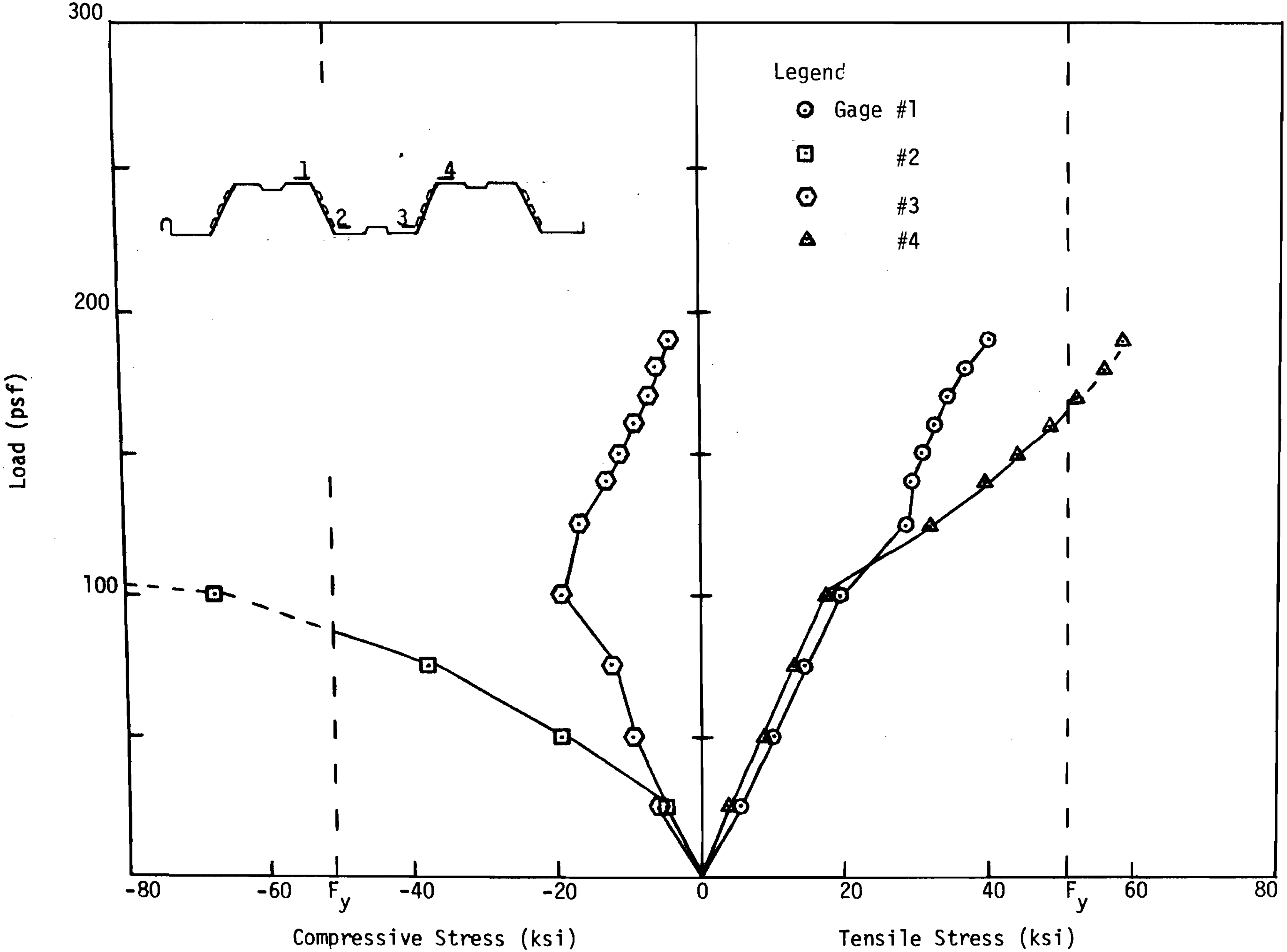


Fig. A69 Load vs Stress for Specimen No. CB - 11A

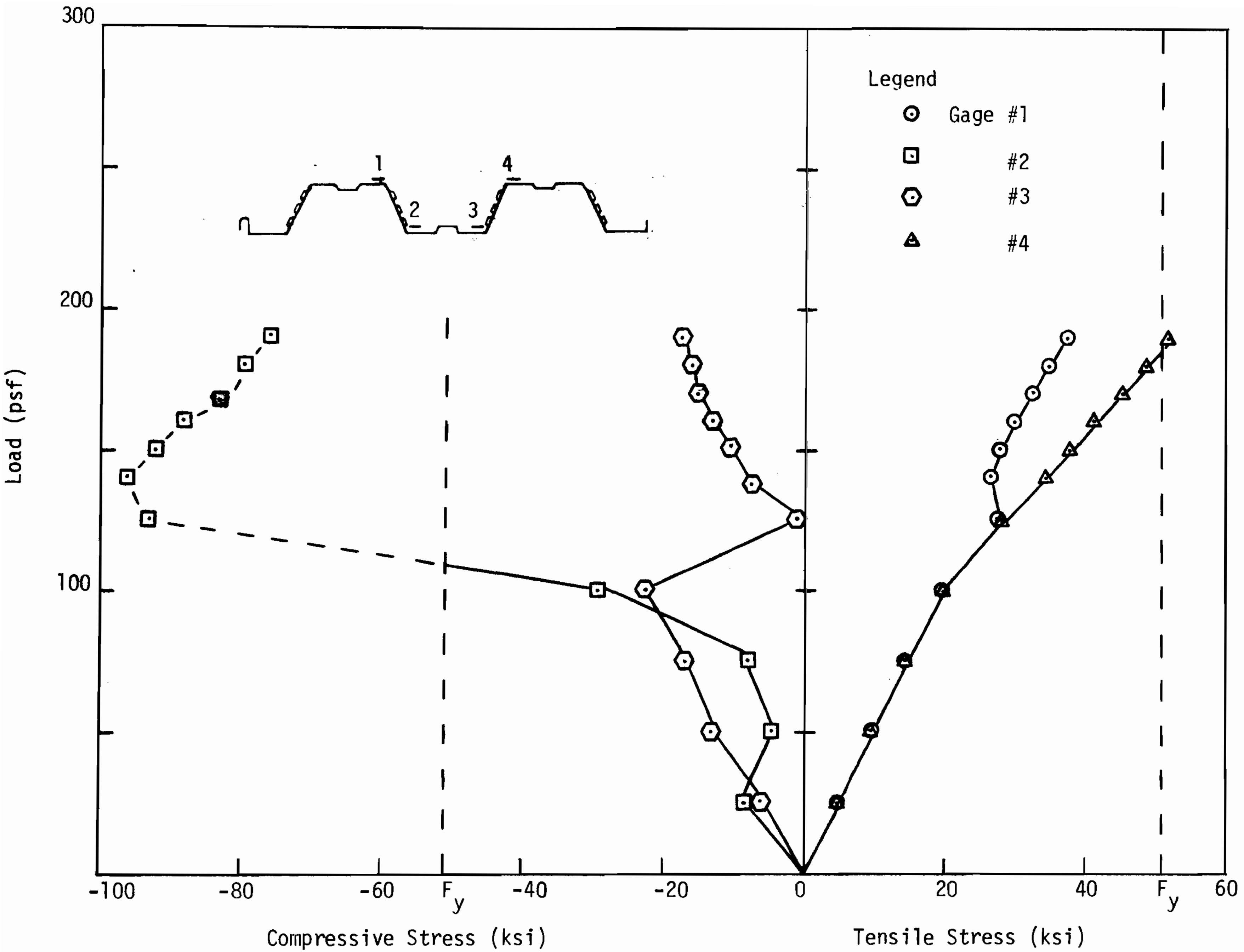


Fig. A70 Load vs Stress for Specimen No. CB - 11B

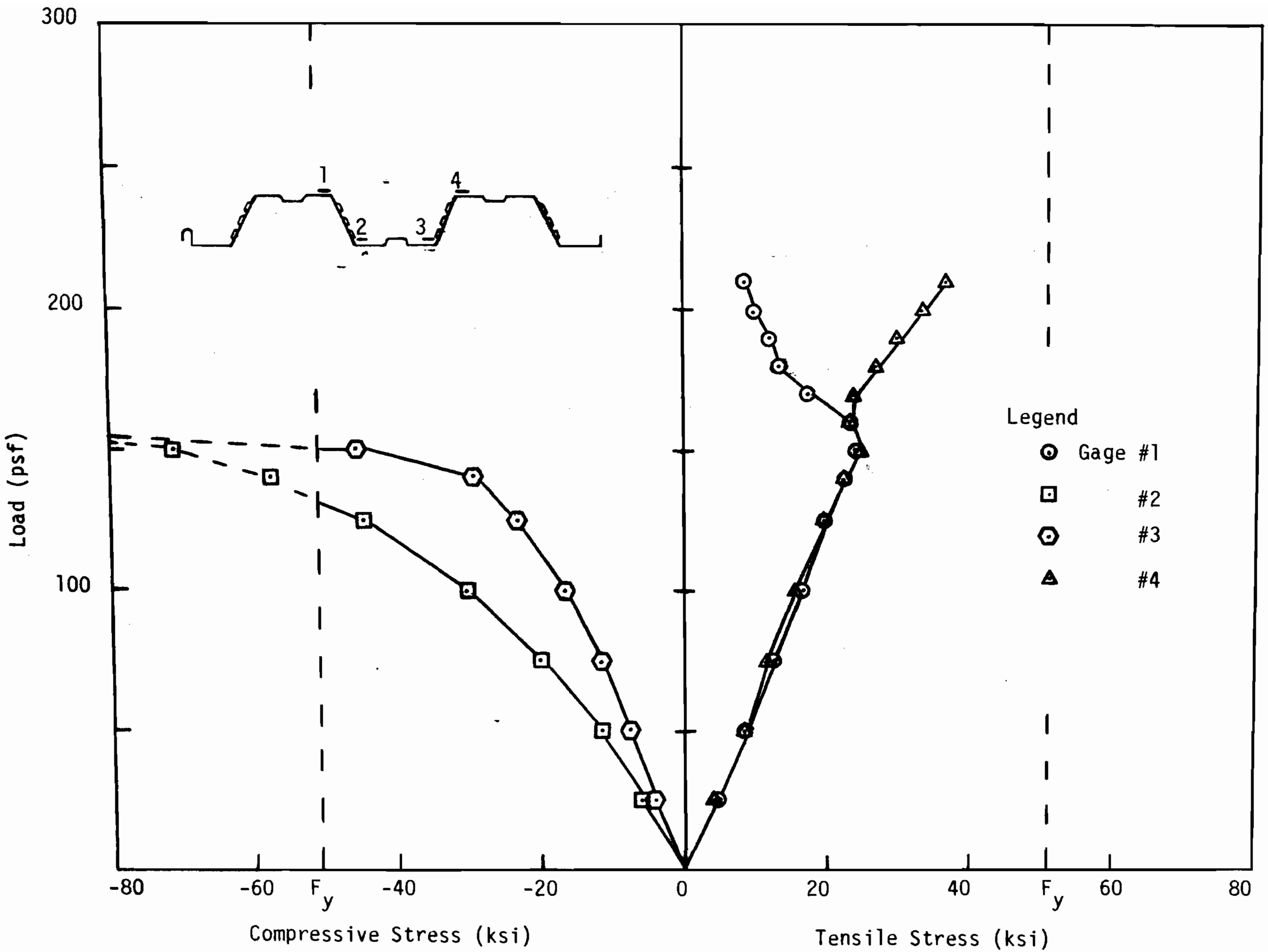


Fig. A71 Load vs Stress for Specimen No. CB - 12A

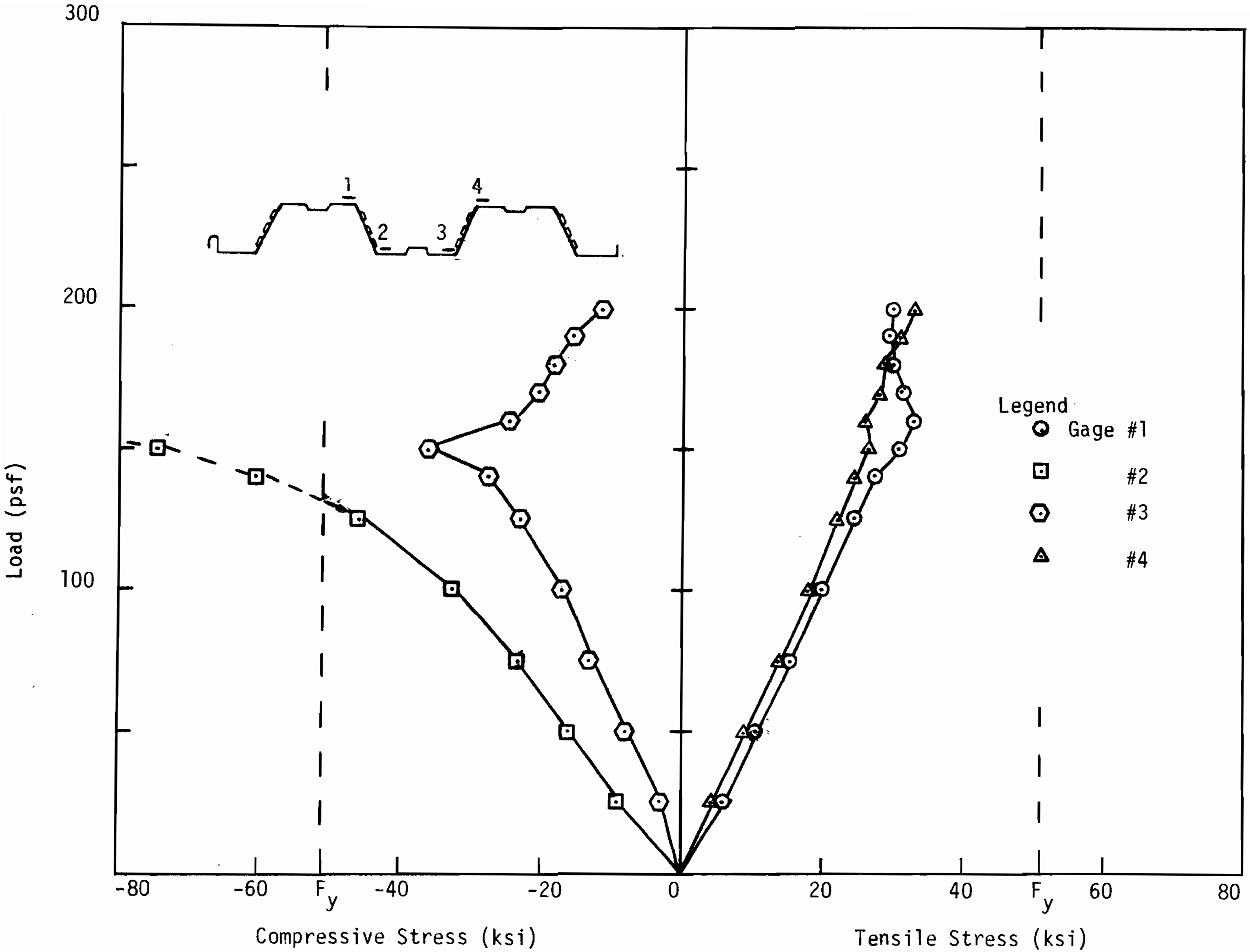


Fig. A72 Load vs Stress for Specimen No. CB - 12B

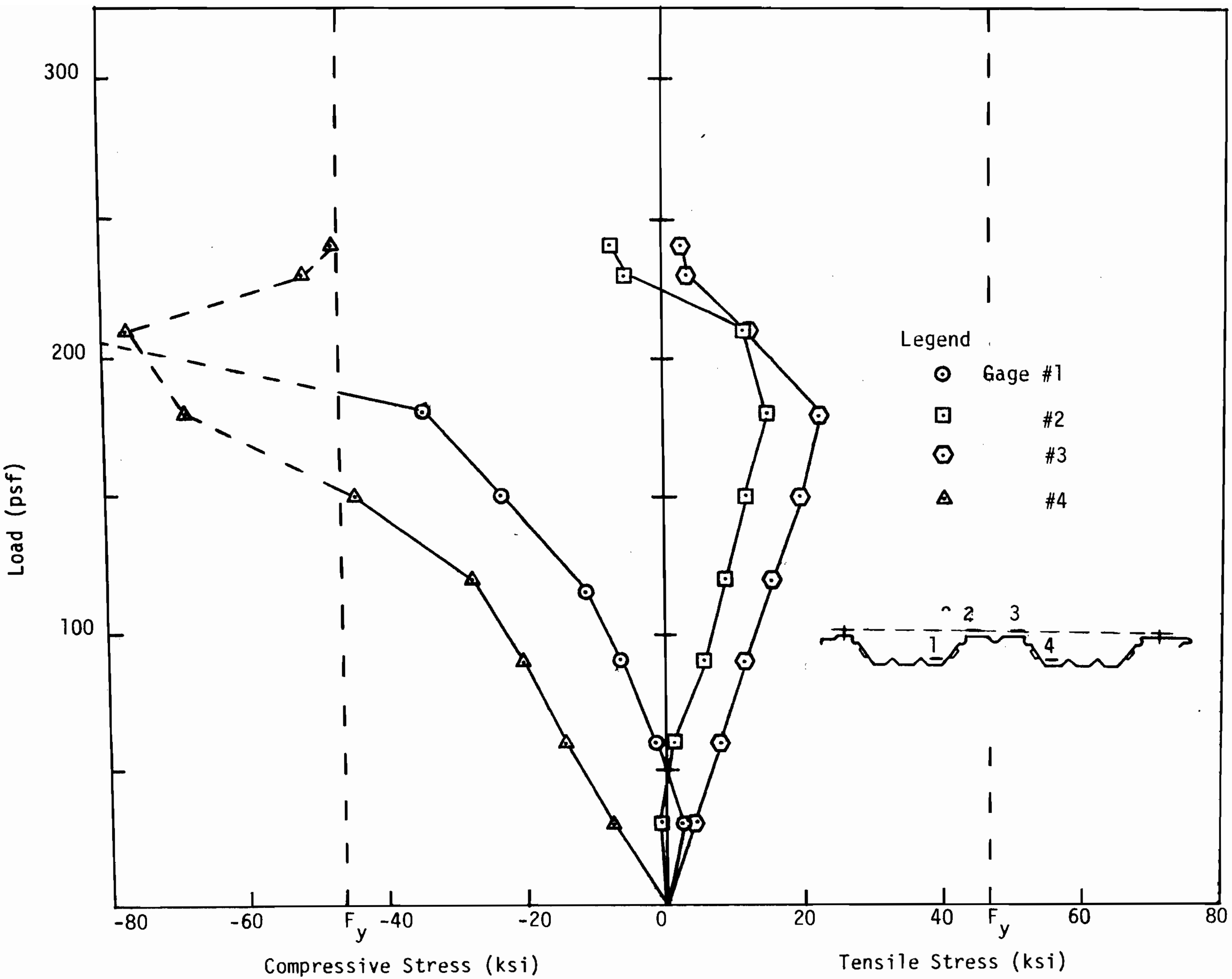


Fig. A73 Load vs Stress for Specimen No. BC - 13A

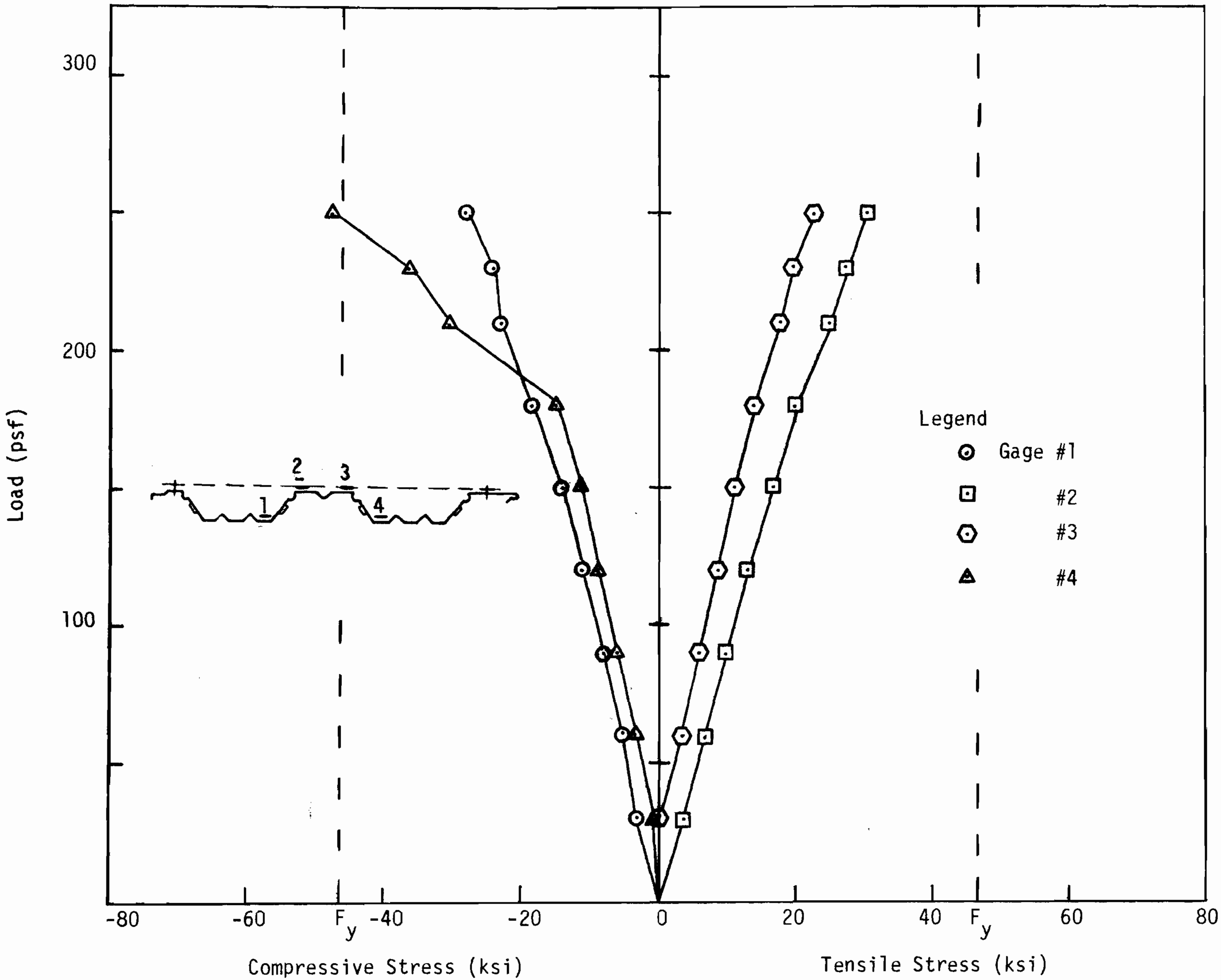


Fig. A74 Load vs Stress for Specimen No. CB - 14A

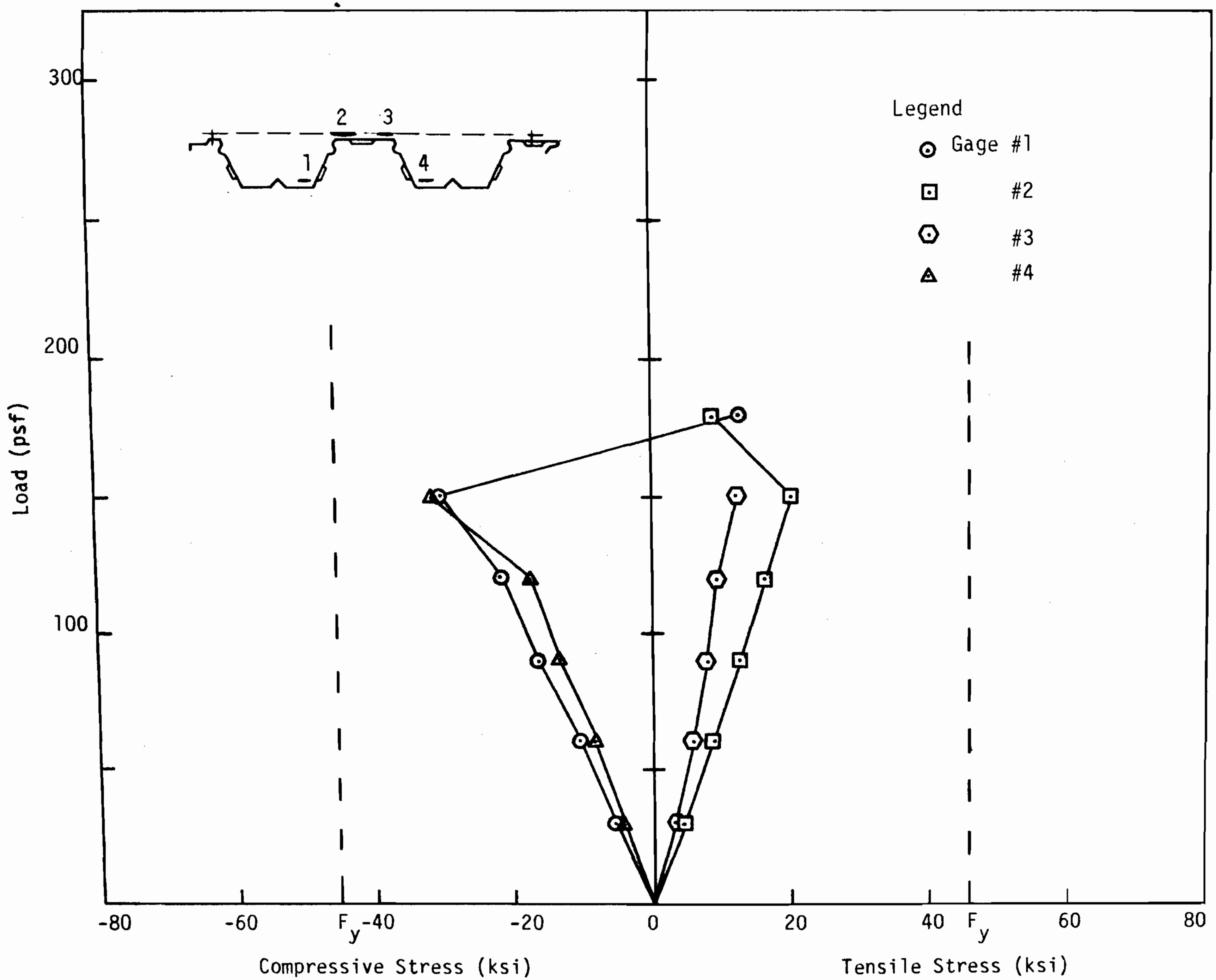


Fig. A75 Load vs Stress for Specimen No. CB - 15A

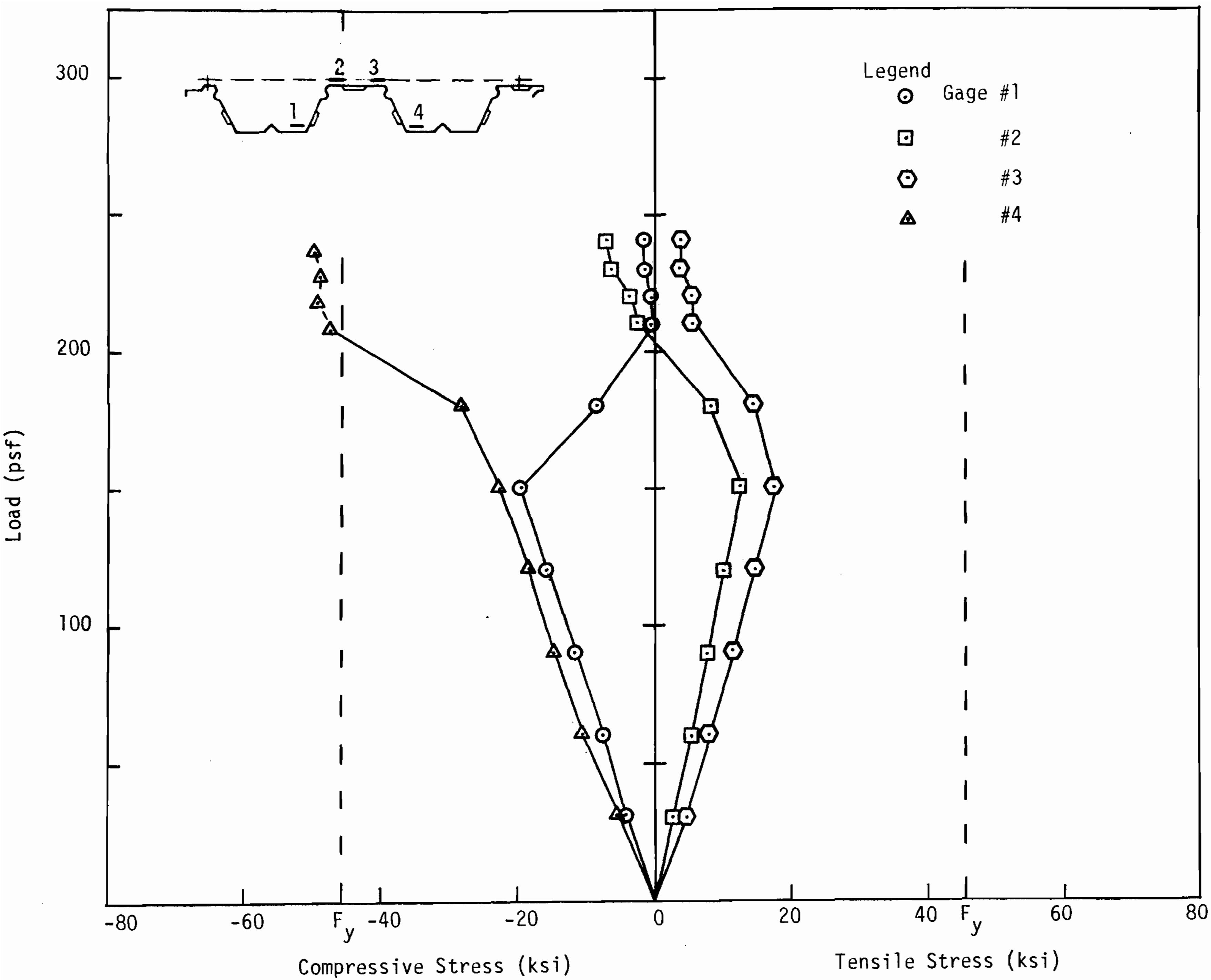


Fig. A76 Load vs Stress for Specimen No. CB - 15B

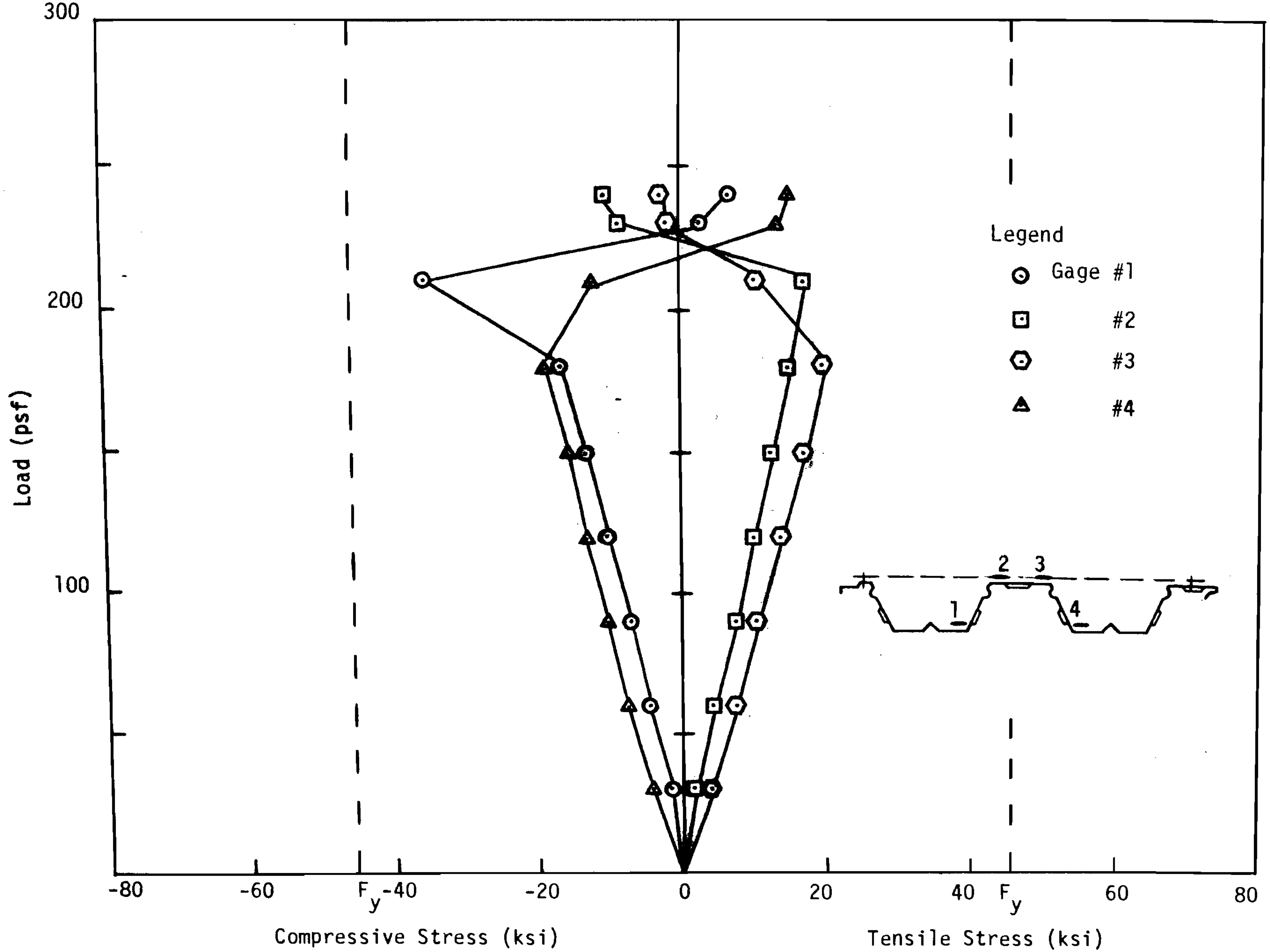


Fig. A77 Load vs Stress for Specimen No. CB - 16A

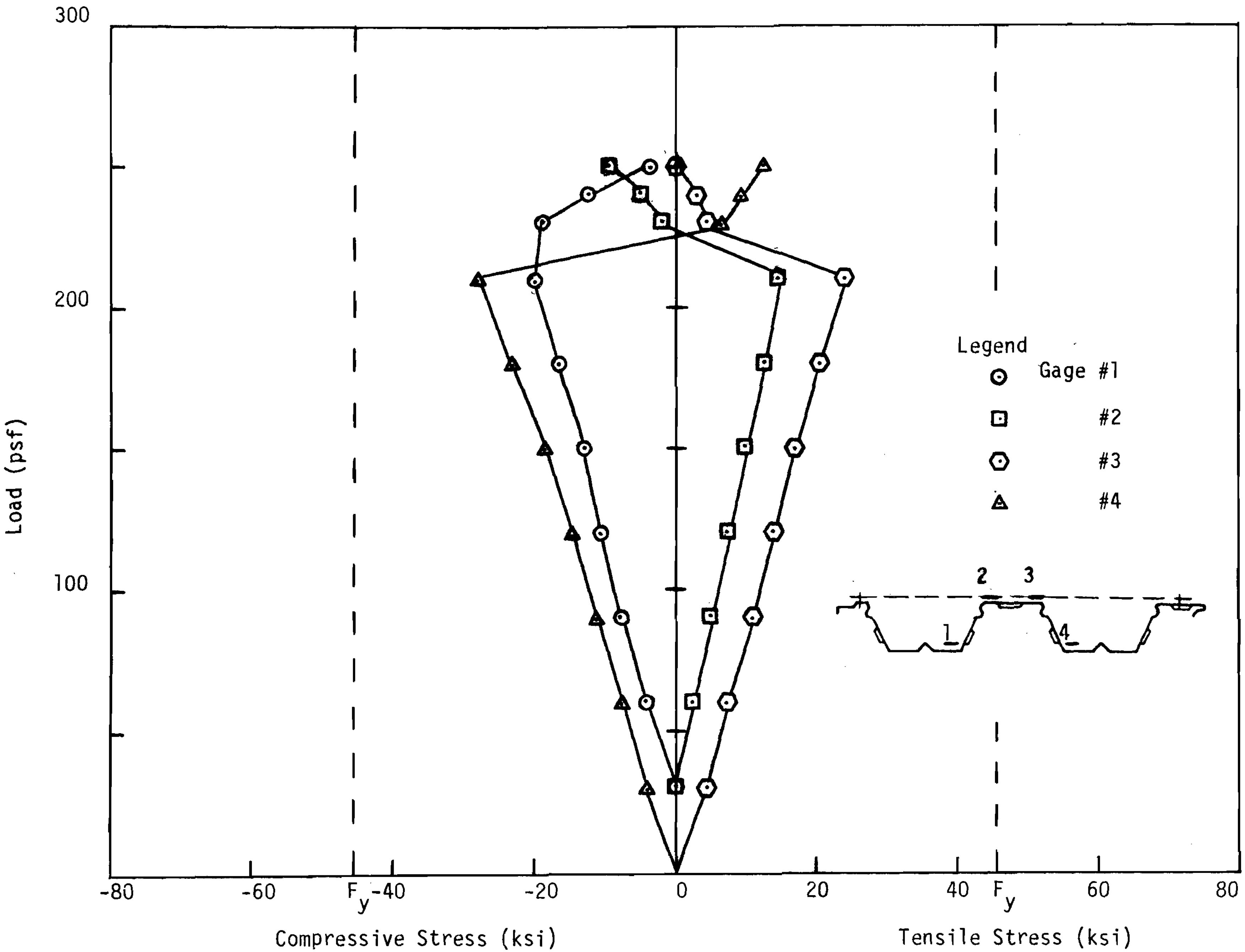


Fig. A78 Load vs Stress for Specimen No. CB - 16B

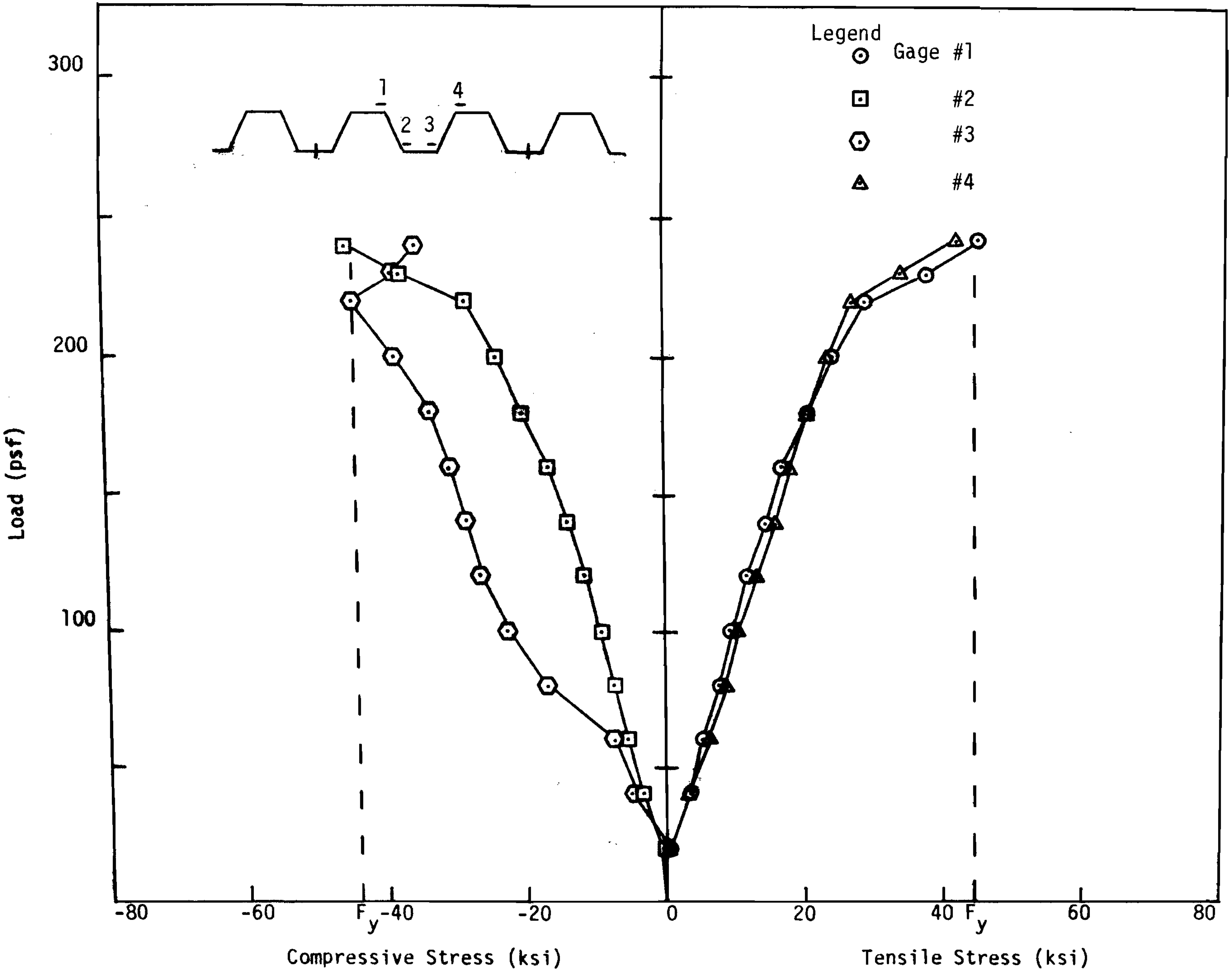


Fig. A79 Load vs Stress for Specimen No. CB - 19B

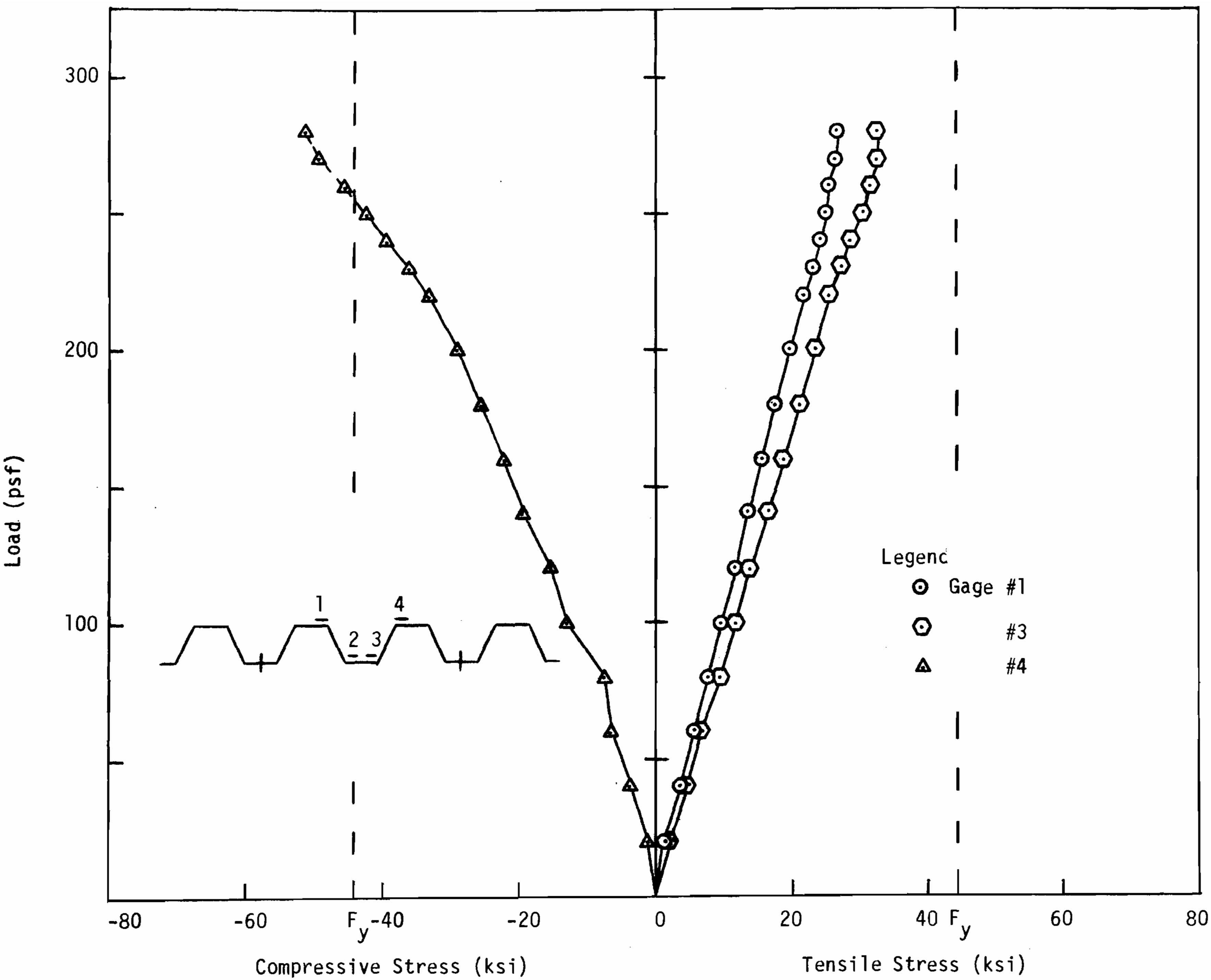


Fig. A80 Load vs Stress for Specimen No. CB - 20B