STRENGTH EVALUATION OF STRUT-PURLINS

by

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Finally, the author wishes to thank his wife.

To

Elaine and Brian

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CHAPTER 1
INTRODUCTION

1.1 BACKGROUND

Strut-Purlins are commonly used as secondary framing members in the roof structure of metal buildings. They exist as part of the wind bracing system and are located between the end wall and the first wind-braced bay in the building (Figure 1.1). They are typically constructed of Z- or C- shaped cold-formed sections supporting a steel roof deck. The deck may be either of the conventional through fastened or standing seam type. All references to strut-purlins in this paper mean Z- or C-shaped cold-formed sections with conventional through fastened deck attached to one flange by self drilling screws.

When strut-purlins are subject to uplift and axial loads, the bottom flange is in compression and has little lateral bracing. However, rotational support provided by the purlin to roof deck connection provides some limited lateral bracing as shown in Figure 1.2. Because of these characteristics, analytical models for uplift capacity of Z- or C-purlin supported roof systems are complicated and require computer programs to be of practical use. An exact analytical model of strut-purlins subjected to combined uplift and axial loading is not available.

These roof systems are typically designed utilizing guidelines from the Metal Building Manufacturers Association *(Low Rise 1986)* and specification requirements of the American Iron and Steel Institute *(Specification 1986)*. In

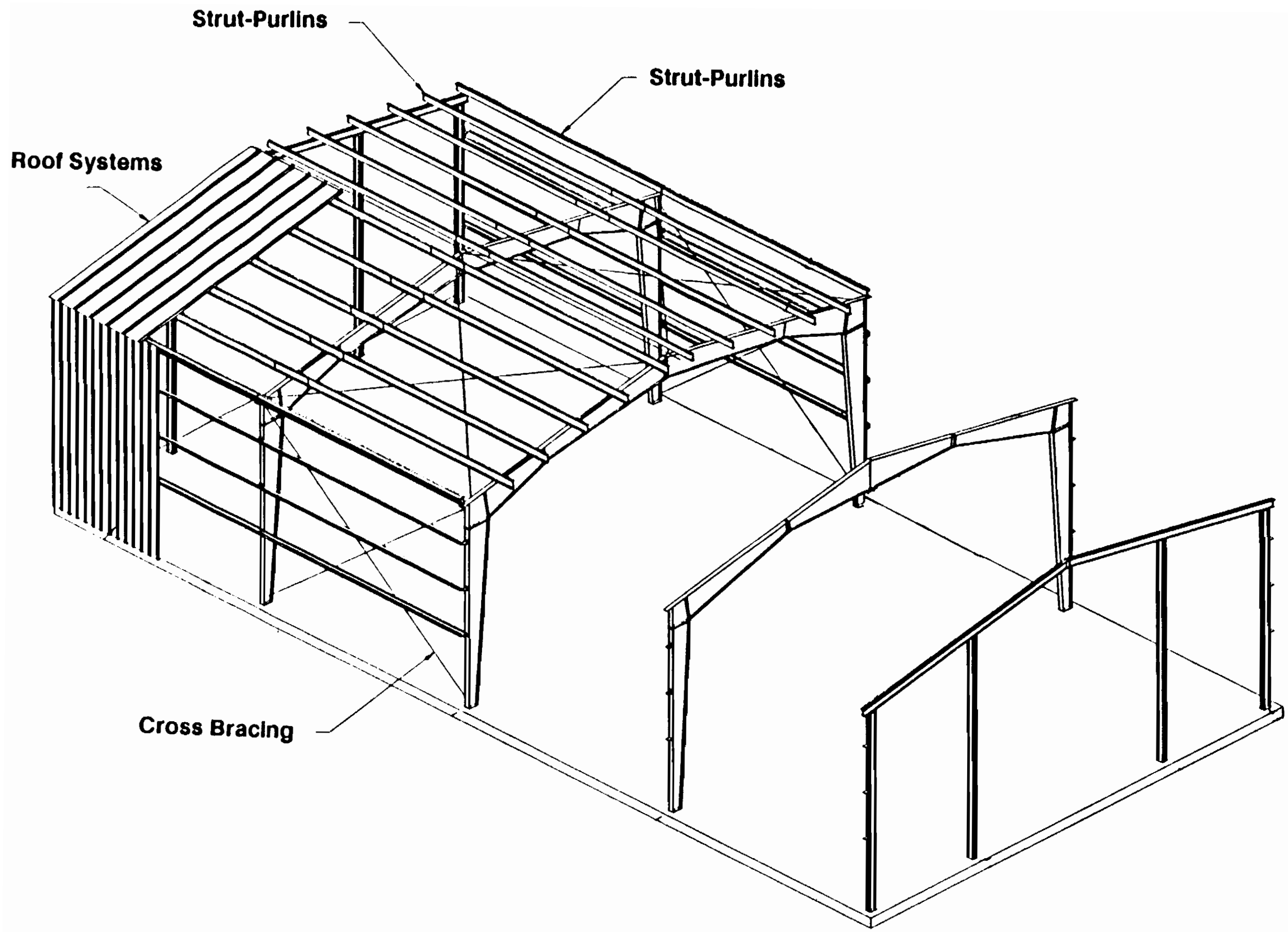

Figure 1.1 Typical Roof Assembly with Diaphragm Braced Purlins

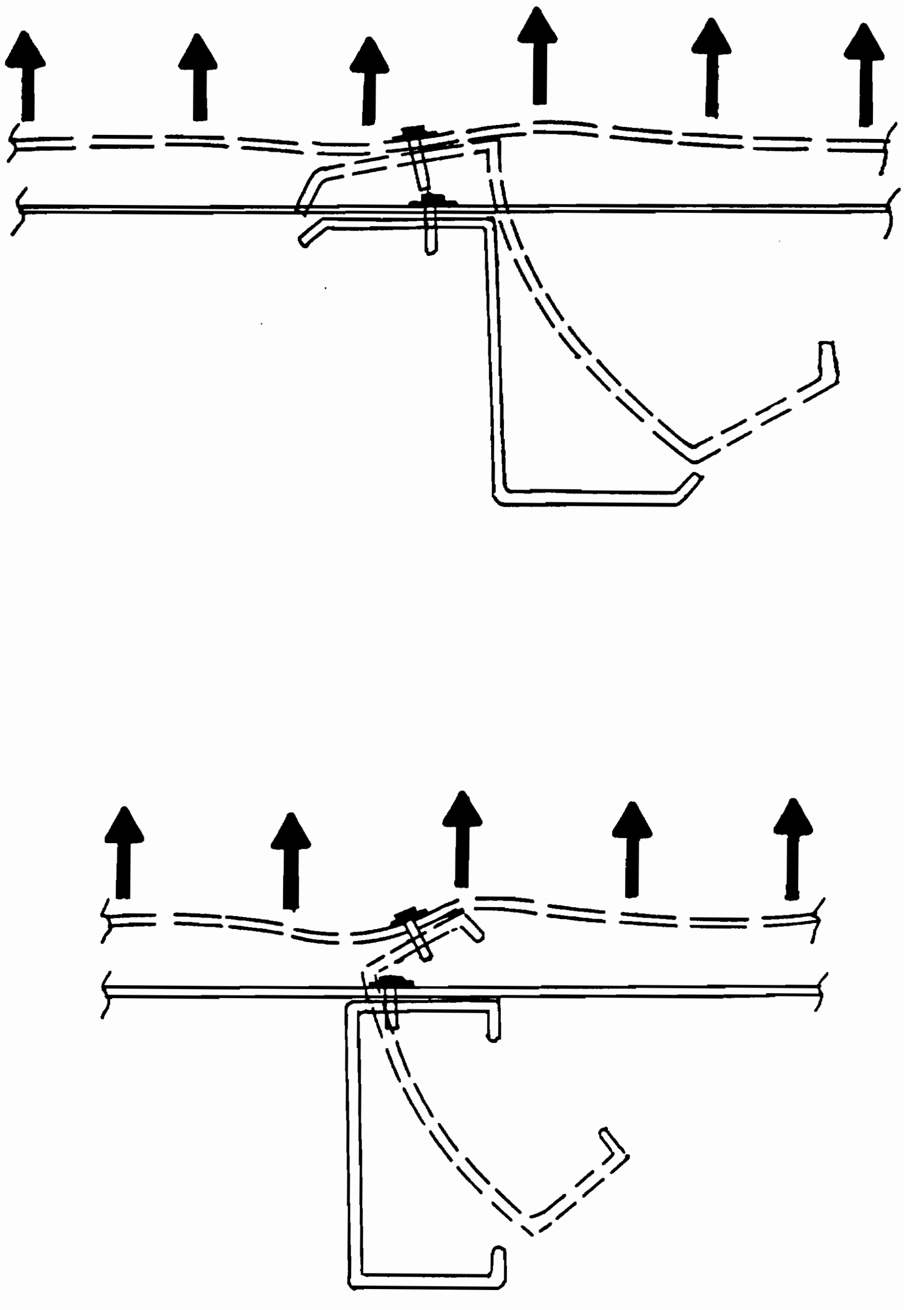

Figure 1.2 Deflected Shape of Purlins Subject to Uplift and Axial Loads

addition to resisting gravity loads, strut-purlins must resist uplift and axial loads introduced by wind. MBMA recognizes this loading condition but provides no method of analysis. AISI does not yet recognize this loading condition. Currently designers are left to using experimental data in determining strut-purlin capacity.

It is the focus of this study to present an evaluation of strut-purlins subject to uplift and axial loads and to present a rational method of analysis for this loading condition. Full scale testing of roof assemblies and analytical studies were conducted as part of the project.

1.2 SCOPE OF RESEARCH

Work has been done which shows that interaction equations reasonably predict metal wall stud (i.e. diaphragm-braced column) load carrying capacity *(Schurter et al. 1982)*. Based on this it seems likely that strut-purlins will respond similarly. The primary difference between metal wall studs and strut-purlins is the diaphragm material. Additionally, the Structural Stability Research Council discusses the versatility of interaction equations *(Guide 1988)*. Different forms of the interaction equation have been modified then verified against available theoretical and experimental data.

This project was initiated to verify, with experimental evidence, that strut-purlin capacity can be predicted using the interaction equation in the current AISI Specification (1986).

Initially a series of five interaction tests were performed with varying combinations of uplift and axial loads on 8 in. deep Z-shaped sections. The results of the tests were plotted on an experimental interaction curve. The axial load carrying capacity of the purlins was determined from a near zero uplift moment test, and the uplift moment load carrying capacity was determined from a zero axial load test. The results showed that the standard beam-column interaction form could be used to predict the strength of diaphragm braced beam-columns.

Based on the favorable interaction test results, an extensive literature search was undertaken to find analytical methods for determining axial load only and uplift load only capacities. An experimentally verified method for determining uplift loading capacity was found. A similar method was not available for axial capacity, but a method was found that determines the axial capacity of metal wall studs. In order to verify its applicability to strut-purlins, a series of eight axial load tests was conducted, along with needed rotational stiffness tests. The results of the axial tests show that the method provides reasonable estimates of axial capacity of strut-purlins.

Finally, two sets of five interaction tests were conducted. The purpose of these tests was to evaluate the accuracy of the interaction equation along with the method of determining uplift capacity and axial capacity. Purlins, 10 in. deep Z- and C- shaped sections of different thicknesses, were used in the testing program.

1.3 LITERATURE REVIEW

No studies were identified in the literature on diaphragm braced strut-purlins subject to uplift and axial loads. Although similar work has been conducted by Schurter et al. (1982) on exterior metal wall studs, the diaphragm materials used in their studies were gypsum and plywood.

Unbraced cold-formed Z-sections subject to combined axial loads and bending about the centroidal axes have been studied by Polyzois and Purnadi (1989). They present design criteria based on theoretical and experimental results.

The axial capacity of diaphragm braced I-sections was investigated by Apparao et al. (1969). Apparao presents theoretical and experimental evidence of the effect of combined diaphragm and girt bracing on the axial capacity of these members. A design procedure for diaphragm braced I-shaped sections is presented by Errera et al. (1976).

The axial capacity of diaphragm braced C- and Z-sections was studied by Simaan and Pekoz (1973) and (1976). In 1973 they presented a general discussion of diaphragm braced wall studs. In 1976 they presented the results of theoretical and experimental work along with a design procedure. Computer programs based on their method of determining axial capacity are presented by Simaan in his thesis *(Simaan 1973)*.

Other researchers have studied diaphragm braced beams and columns. These papers provide theoretical and experimental evidence of the increased load capacity of diaphragm braced sections *(Pincus and Fisher 1966, Errera et al 1967, and McDermott 1975)*.

The moment capacity of diaphragm braced purlins subject to uplifting loads has been studied by several researchers. Pekoz (1973) developed a computer program that calculates uplift capacity for single and multispan purlins. Pekoz and Soroushian (1982) present simplified design equations based on allowable stresses to predict uplift capacity. Polyzois and Birkemoe (1984) wrote a paper which presents results from a theoretical model for Z-section girts and purlins with torsionally elastic end supports. Natarajan et al. (1984) compares theoretical and experimental results for Z-purlins subject to uplift loads. In the work by Hendrick and Murray (1984) an experimental investigation of C-shaped purlins subject to uplift is presented.

A discussion of the shear strength of diaphragms is presented by Luttrell (1967). Luttrell investigated several variables and their general influence on behavior. Other reports which present specific design information on particular deck materials are available *(Engineering Report 1983, Product Development 1974, and University 1988).*

The rotational restraint of the purlin to deck connection is significant with respect to uplift and axial loading. Work by LaBoube (1986) illustrates the influence that different components have on the rotational stiffness of connections.

CHAPTER II

METHOD OF ANALYSIS

2.1 INTERACTION EQUATION

A logical choice of models to reflect the beam column response of strut-purlins is an interaction equation. Interaction equations are simple, convenient and have a broad range of application. They have been analytically and experimentally proven to predict capacity for elastic, inelastic and torsional flexural buckling problems of stand alone and intermittantly braced beam columns with various end conditins. It is the intention of the research presented to broaden the range of application to include diaphragm braced strut-purlins subject to uplift and axial loads. With this loading condition, the roof diaphragm is attached to the tension flange and the compression flange is laterally unbraced.

The interaction equation used in the work presented is Equation (C5-1) in the current AISI Specification (1986):

$$\frac{P}{P_a} + \frac{C_{mx}M_x}{M_{ax}\alpha_x} + \frac{C_{my}M_y}{M_{ay}\alpha_y} \leq 1.0 \qquad (2.1)$$

where

P = Applied axial load

M_x and M_y = Applied moments with respect to the centroidal axis

P_a = Allowable axial load

M_{ax} and M_{ay} = Allowable moments about the centroidal axis

$1/\alpha x$ and $1/\alpha y$ = Magnification factors

= $1/[1-(\Omega_c P/P_{cr})]$

Ω_c = Factor of safety used in determining P_a

P_{cr} = $\dfrac{\pi^2 EI_b}{(k_b L_b)^2}$

I_b = Moment of inertia of full, unreduced cross section about axes of bending

L_b = Actual unbraced length in the plane of bending

k_b = Effective length factor in the plane of bending

C_{mx} and C_{my} = Moment reduction factors

For design purposes, constrained bending is usually assumed and, thus, the third term of Eqution 2.1 is zero. For simple supports, C_{mx} is unity and, therefore, for the purposes of this study Equation 2.1 reduces to

$$\frac{P}{P_a} + \frac{M_x}{M_{ax}(1-P/P_a)} \leq 1.0 \tag{2.2}$$

Rearranging this equation results in an expression that predicts the axial capacity of the test specimens explicitly.

$$P = P_a\left(1 - \sqrt{\frac{M}{M_{ax}}}\right) \tag{2.3}$$

The following methods were used to determine M_{ax}, P_a and P_{cr} when evaluating the test results.

The allowable uplift moment capacity (M_{ax}) was determined using the 1989 revision to Section C3.1.3 of the AISI specification. This experimentally verified method defines uplift moment capacity as a fraction of the constrained bending capacity. This method is discussed in more detail in Section 2.2.

The allowable axial capacity (P_a) was determined using the method developed by Simaan. Simaan's method is discussed in Section 2.3.1. The elastic critical buckling load (P_{cr}) was also determined using Simaan's method. This was possible becasue all of the test specimens failed in the elastic region. Had they failed in the inelastic region, Simaan's method would had to have been modified since it automatically calculates the inelastic load if $P_a > 0.5\ Q\ F_y$.

2.2 MOMENT CAPACITY

The theoretical moment capacity in this research is determined using the 1989 revision to Section C3.1.3 of the AISI Specification. This method defines uplift moment capacity as a fraction of the fully laterally supported moment capacity. This fraction was determined experimentally (LaBoube, R. A., 1983). The AISI Equation is:

$$M_{ax} = R\ S_e F_y / \Omega_f$$

R = .4 for single span C-sections

F = .5 for single span Z-sections

S_e = Effective section modulus

F_V = Yield stress

Ω_f = Factor of safety

This method is simple but does introduce a degree of error into the evaluation due to the variation in rotational restraint. The effect of this variation in rotational restraint is discussed in Section 3.3.2.

2.3 AXIAL CAPACITY

2.3.1 Simaan's Method

The allowable axial load (P_a) for the purlins tested was determined using the method defined in the work by *Simaan et al. (1973)*. He developed a general procedure and applied it specifically to metal wall studs. Since the procedure was developed generally, it was assumed that it could also be applied to strut-purlins. A series of verification tests were then performed to evaluate the applicability of Simaan's method to strut-purlins. The primary difference between Simaan's work and the work presented in this thesis is the range of wall board parameters. Simaan evaluated studs braced by Gypsum, Homosote and Celotex, whereas metal roof deck was considered in this study.

The expressions that Simaan developes are too involved for design use. As a result he wrote four programs dealing with the axial capacity of diaphragm braced cold-formed sections. The program used in the present research (STUDA2) determines the axial capacity of cold-formed sections acttached to a diaphragm on one flange.

Simaan notes that in his work, the actual axial failure load was always less than the theoretical capacity for two reasons. The first reason is that his theory is based on an energy approach where his assumed deflected shape is not exactly the same as actual deflections. This is equivalent to introducing restraints to the member which increase the calculated buckling load. The second reason is that he assumes the stud to be a perfect column. And initial imperfections can affect the effective width of elements which affect load carrying capacity. As a result of these assumptions, his experimental results ranged from 92-99% of theory with two exceptions. One specimen failed at 85% of theory and the other at 102%. He attritubes the low load capacity to excessive initial imperfections and the high load capacity to failure by local buckling.

Simaan's method relies on experimental data obtained from rotational stiffness and shear rigidity tests. The influence of rotational stiffness is discussed in Section 2.3.2. The influence of diaphragm shear rigidity is discussed in Section 2.3.3.

2.3.2 Rotational Stiffness

The rotational restraint of the connection is the only support provided to the compression flange of strut-purlins subject to uplifting and axial loads. This support is comprised of two components. The first is the actual geometry of the connection and the second is the flexural rigidity of the web of the prulin acting as a cantilevered member.

The factors that most significantly contribute to the rotational stiffness of the connection, according to LaBoube (1986), are the purlin thickness, roof sheet thickness and fastener type and location within the flange width. Because of the large number of variables, the rotational stiffness of particular connections must be determined experimentally.

It is important to note that even for the same components, the rotational stiffness can vary widely, significantly affecting axial capacity. This is because the rotational stiffness is strongly influenced by the location of the purlin-to-deck fasteners. For the tests performed in this research, three rotational stiffness tests were performed for each purlin and deck combination tested. One was conducted with the fastener in the strong location, one in a weak location and one in between. The axial capacities were then calculated for each stiffeness (i.e. screw location). Then, based on actual fastener locations, a linear interpolation was performed between axial capacities to determine the capacity of the system (Figure 2.1). In the present research, the actual screw locations were measured and an average screw location was used in determining the axial capacity. The effect of assuming an average screw location is discussed in Section 3.3.2. The rotational stiffness data used in each test can be found in Appendix F.

2.3.3 SHEAR RIGIDITY

Manufacturer shear rigidity data was used in Simaan's method of determining axial capacity. The roof deck diaphragm is very rigid with respect to the purlin. As a result, Simaan's program is very insensitive to shear rigidity as long as it is above a certain value. The shear rigidity data used for each test can be found in Appendix E.

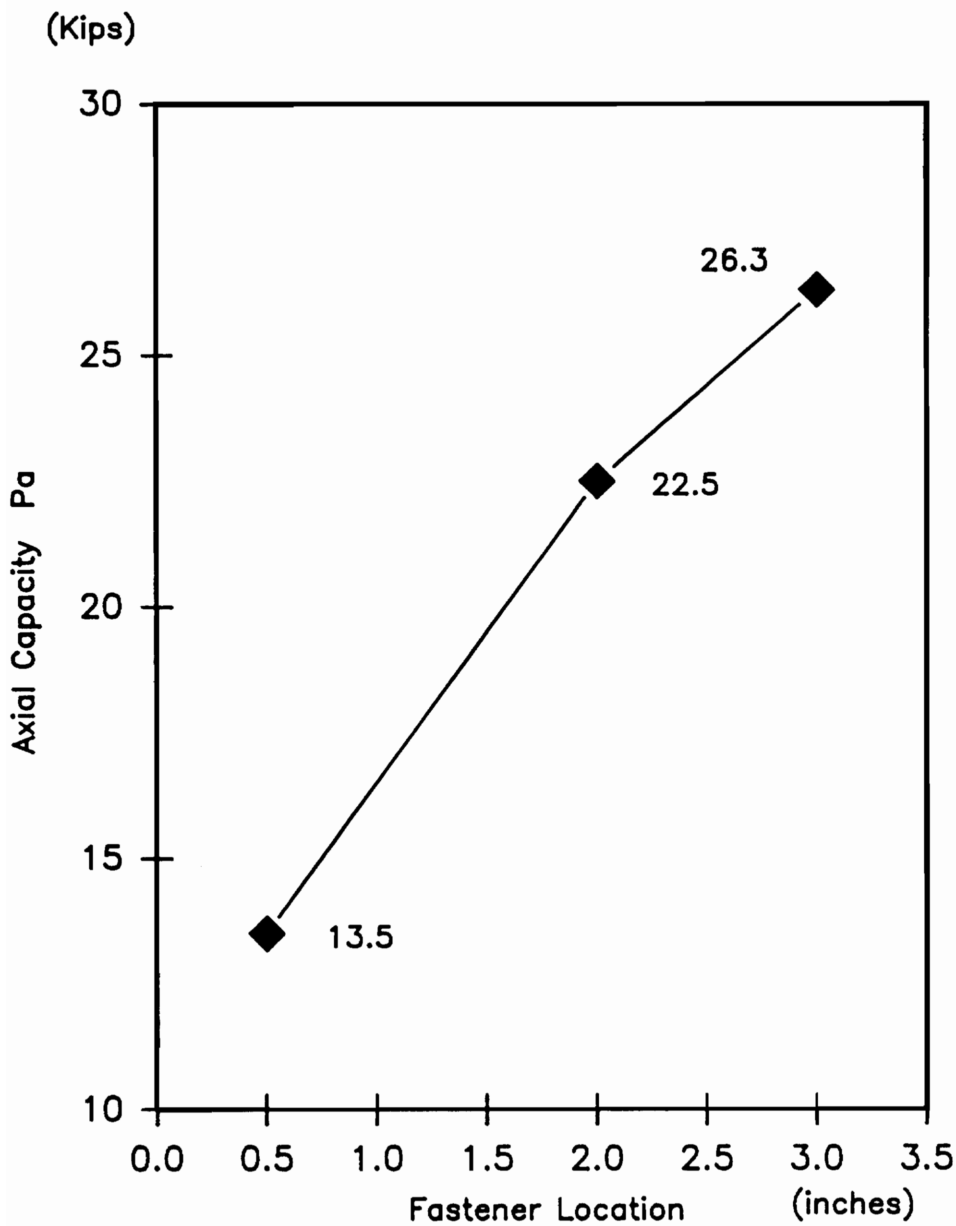

Figure 2.1 **Effect of Fastener Location on Axial Capacity of 10 in. Deep Z Strut Purlins**

CHAPTER III

EXPERIMENTAL INVESTIGATION

3.1 TEST NAMING CONVENTION AND DATA PACKS

The following naming convention was used for the various tests.

Interaction Tests

Example: SP-8Z-50

SP = Strut purlin strength evaluation project

8Z = 8 in. Z shaped sections tested

50 = Percentage of maximum uplift capacity moment to be applied during testing

Axial Load Only Tests

Example: SP-10C-12-1

SP = Strut purlin strength evaluation project

10C = 10 in. C-shaped sections tested

12 = Fastener spacing

1 = Sequence number

Rotational Stiffness Test

Example: F-10C-12-1

F = Rotational stiffness test

10C = 10 in. C-shaped section tested

12 = Fastener spacing

1 = Sequence number

The data packs for the axial tests and interaction tests are contained in Appendices G and H respectively. Each of the data packs contain the following information in the order presented.

Test Summary Sheet

Load vs. Deflection Curves

Purlin Dimensions

Calculation Sheet

Input/Output Files to "AISIPROC"

Input File to "STUDA2"

Input/Output Files to "CFS"

The program "CFS" calculates section properties for cold-formed sections. These "CFS" section properties were used in the "STUDA2" program to calculate axial capacity.

The program "AISIPROC" was used to calculate the constrained bending capacity of the purlins according to the 1986 AISI Specification.

The 8 in. deep Z purlin data packs do not contain the "STUDA2" or "CFS" files because fastener locations were not recorded. As a result needed rotational stiffness data cannot be adequately determined in order to calculate axial capacity.

3.2 TEST SET-UP

The roof assemblies tested in this research were constructed upside-down in the Virginia Tech vacuum chamber. Each assembly had two single span purlin lines facing each other on 5 ft. centers. The purlins tested ranged from 15 to 25 ft. and were from 7 to 10 in. deep with thicknesses ranging from 0.060 to 0.104 inches. The purlins were laterally supported over the supports by the connection to the spreader beams. Although the purlins are assumed simply supported, some degree of horizontal bending and torsional restraint was present due to this connection.

Conventional through fastened 26 ga. decking 7 ft. wide was attached to the bottom flange of the purlins with self-drilling screws forming a bracing diaphragm. The components used in each test is shown in Table 3.1.

The simulated uplift load was applied by evacuating the air underneath the sealed test assembly. A water filled manometer was used to record the applied pressure. The manometer was graduated to 0.1 inch.

The axial loads were applied with a load chain attached to the spreader beams. The load chain consisted of loading straps, a calibrated load cell and a

TABLE 3.1

Test Components

Test Group	Purlin Shape	Purlin Depth (in.)	Purlin Thickness (in.)	Deck Gage	Fastener	Fastener Spacing (in.)
A	Z	8	0.060	26	SDF	6
B	Z	10	0.083	26	SDF	12
C	C	10	0.104	26	SDF	12
D	Z	10	0.083	26	SDF	12
E	C	10	0.100	26	SDF	12
F	C	7	0.076	26	SDF	12

Group:

A	B	C	D	E	F
SP-8Z-0	SP-10Z-0	SP-10C-0	SP-10Z-12-1	SP-10C-12-1	SP-7C-12-1
SP-8Z-0-2	SP-10Z-25	SP-10C-25	SP-10Z-12-2	SP-10C-12-2	SP-7C-12-2
SP-8Z-25	SP-10Z-50	SP-10C-50	SP-10Z-12-3		SP-7C-12-3
SP-8Z-50	SP-10Z-75	SP-10C-75			
SP-8Z-75	SP-10Z-M	SP-10C-M			
SP-8Z-M					

SDF = #12 self drilling structural fasteners
and #14 self drilling side-lap fasteners at 2 ft 0 in. O.C.

hydraulic ram. The hydraulic ram was used to pull the spreader beams together thereby applying the axial load. Figure 3.1 is a schematic of the test setup.

Displacement transducers were used to measure midspan deflections of the purlins. Horizontal deflections of the top and bottom flanges were recorded, as well as, vertical deflections of the bottom flange.

3.3 TEST PROCEDURES

3.3.1 INTERACTION AND AXIAL TEST PROCEDURES

Before testing began, the initial sweep of both purlins was recorded. Then for each assembly an initial load was applied to seat the system. The initial loading was approximately 5 psf uplift or 2 kips axial load. The initial loading was then released and the displacement transducers rezeroed before the final test was started.

The uplift load was applied in 2.5 to 5 psf increments to a preselected level. The uplift load was then held constant for the remainder of the test. An axial load was then applied in 1.0 kip increments to failure of the system. The axial load tests were conducted in the same manor without uplift loads being applied (except the dead weight of the roof system).

For each purlin and decking combination, five interaction tests were conducted at 0%, 25%, 50%, 75% and 100% of the uplift moment capacity. This was done in order to plot experimental results over the full range of the interaction curve.

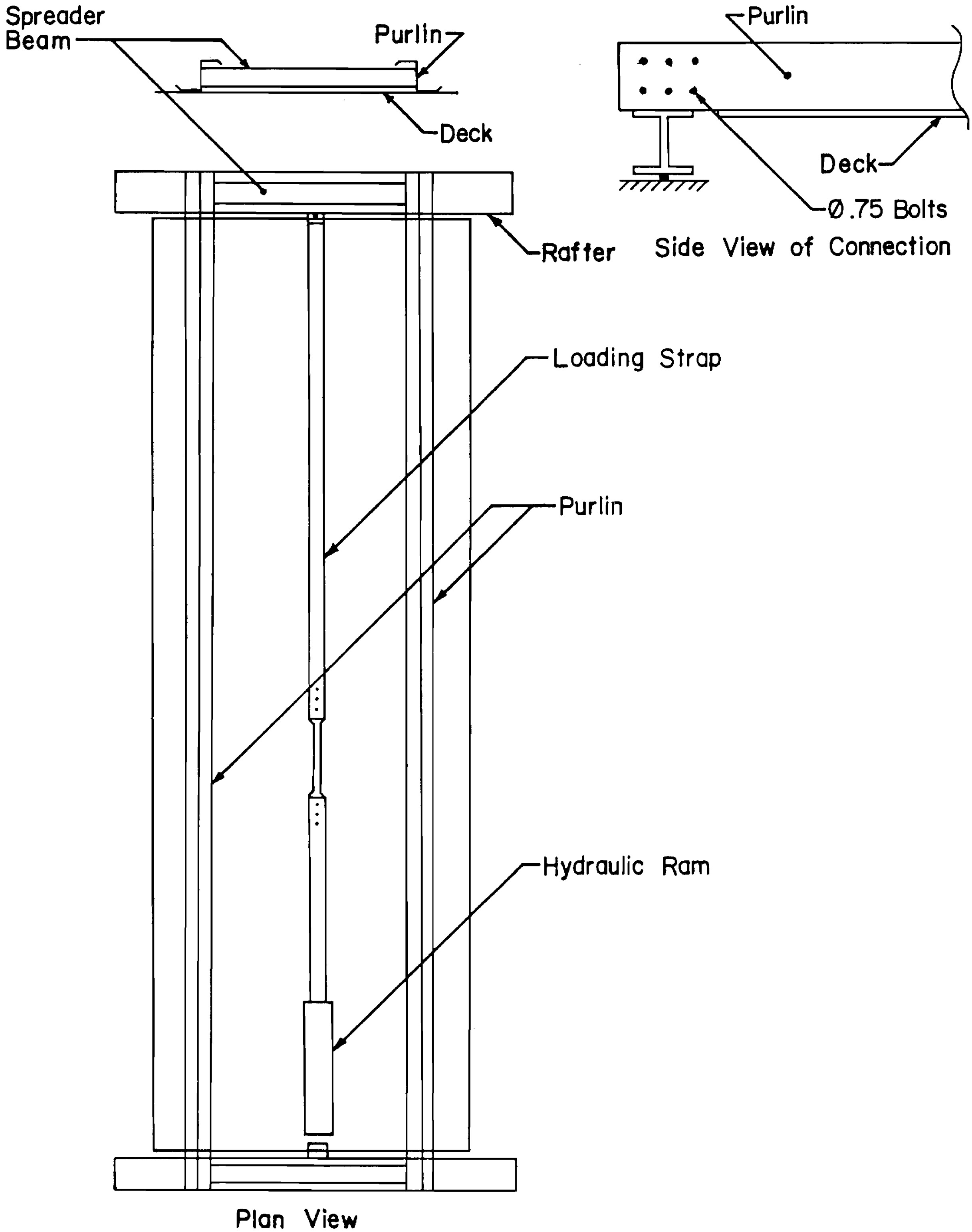

Figure 3.1 Interaction and Axial Test Set-Up

3.3.2 ROTATIONAL STIFFNESS TEST PROCEDURES

Three rotational stiffness tests were conducted for each purlin and decking combination. Fastener location was varied on each of the three tests. Rotational stiffness and allowable rotation data were obtained from the tests. A two feet wide section of purlin and decking was used for each test. Fastener spacing was the same as in the full system tests.

The purlin and deck segment was clamped into a stand with the deck positioned vertically as shown in Figure 3.2. The purlin was fastened to the deck 2.5 ft from the clamped end. Displacement transducers were used to measure vertical deflections of the loaded flange. No preload was used prior to testing and loads were applied statically to the unsupported flange. After each load increment the load and deflection were recorded.

3.4 TEST RESULTS

3.4.1 GENERAL

Eight axial tests and sixteen interaction tests were conducted as a part of this research in order to verify the proposed method of analysis. The axial tests were conducted with spans ranging from 15 ft to 25 ft. All of the tests were conducted horizontally with the roof system constructed upside-down so that the vacuum chamber could be used to simulate the uplift loads.

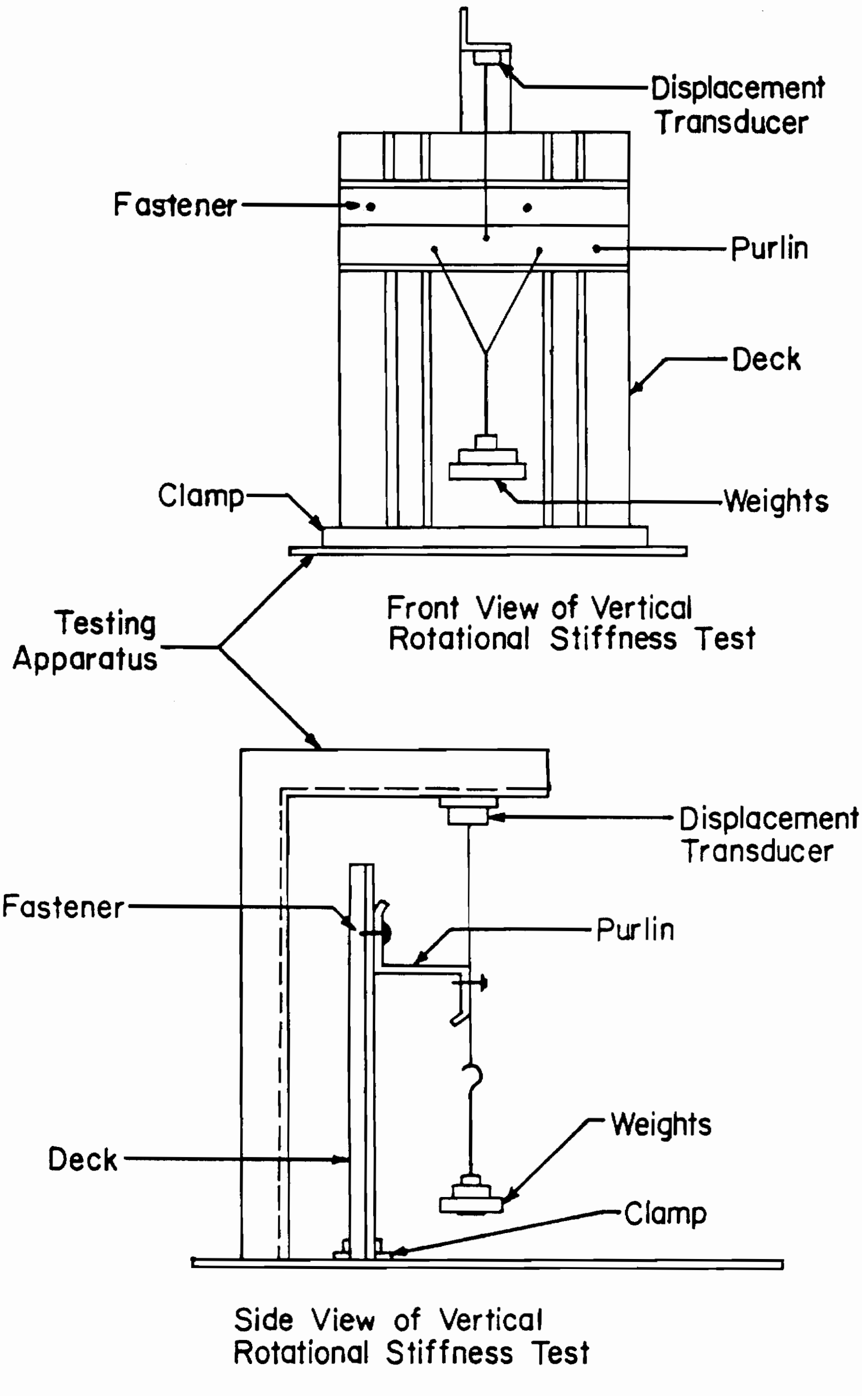

Figure 3.2 Rotational Stiffness Test Set-Up

3.4.2 AXIAL TEST RESULTS

The results of the tests evaluating the applicability of Simaan's method to strut-purlins are summarized in Table 3.2. The ratios of actual versus predicted axial capacity were generally in the same range of results that were obtained by Simaan using metal wall studs, indicating that his method is general enough to be applicable to strut-purlins.

The actual failure loads ranged between 88-107% of predicted values with one exception. One test failed at 83% of the predicted value. Error was introduced into the test data from estimates of rotational stiffness, variation from assumed uplift moment capacity, conservative inaccuracy of the interaction equations and eccentric loading of C-sections. These factors are discussed in more detail in Section 3.5.

All of the 7 in. deep C-shaped purlins had relatively large initial sweeps, accounting for the low capacities of these sections. All of the 10 in. deep Z-shaped purlins were relatively strong except for SP-10Z-12-1, which also had a large initial sweep.

Based on the results of these tests it appears that the Simaan method reasonably predicts strut-purlin axial capacity. An important observation about the method should be recognized. The method predicts axial capacities varying by as much as 100% based solely on the effect of fastener location on the flange of the purlin. To show this effect, each of the eight axial load only specimens were analyzed using the low and high rotational stiffness test values. The resulting axial load capacities and ratios of the high-to-low values are shown in Table 3.3. The ratios varied from 1.35 to 1.95. It is noted that the longer the span the more pronounced the effect.

TABLE 3.2

Summary of Axial Load Verification Study

Test Designation	Purlin Depth (in.)	Purlin Thickness (in.)	Span (ft.)	Initial Sweep (in.)	Predicted Failure Load (kips)	Actual Failure Load (kips)	Actual / Predicted
SP-7C-12-3	7.0	0.076	15	0.25	12.8	11.7	0.91
SP-7C-12-1	7.1	0.075	17	0.50	11.4	10.7	0.94
SP-7C-12-2	7.0	0.076	19	0.50	13.4	11.1	0.83
SP-10Z-12-1	10.0	0.074	17	0.25	17.1	15.0	0.88
SP-10Z-12-3	10.0	0.074	21	0.0	17.4	18.2	1.05
SP-10Z-12-2	10.0	0.074	25	0.0	13.1	12.6	0.96
SP-10C-12-1	10.0	0.100	17	0.38	19.8	20.8	1.05
SP-10C-12-2	10.0	0.100	25	0.25	16.8	18.0	1.07

TABLE 3.3

Effect of Screw Location on Purlin Strength

Test Designation	Span (ft.)	P_a (Low) (kips)	P_a (High) (kips)	$\frac{P_a \text{ (High)}}{P_a \text{ (Low)}}$
SP-7C-12-1	17	13.1	20.2	1.54
SP-7C-12-3	21	13.4	19.9	1.49
SP-7C-12-2	25	13.3	21.4	1.60
SP-10C-12-1	17	19.5	28.5	1.46
SP-10C-12-2	25	14.6	26.2	1.79
SP-10Z-12-1	17	17.7	23.9	1.35
SP-10Z-12-3	21	14.5	23.7	1.63
SP-10Z-12-2	25	13.5	26.3	1.95

NOTE: P_a (Low) was calculated using the weak rotational stiffness data.

P_a (High) was calculated using the strong rotational stiffness data.

3.4.3 INTERACTION TEST RESULTS

8 IN. Z TEST RESULTS. The results of the 8 in. Z purlin interaction tests are plotted along with interaction curves in Figure 3.3 and 3.4. The figures show two interaction curves: one with and one without the moment amplification factor. The latter curve was plotted for reference purposes only. Figure 3.3 was constructed using P_a and M_{ax} values determined experimentally from tests conducted with axial load and near zero uplift moment and with no axial load and full uplift loading, respectively. At the time the 8 in. Z tests were conducted, Simaan's method of calculating axial capacity was not known. Also, the importance of screw location on rotational stiffness was not known. Therefore screw locations were not recorded. As a result, data cannot be plotted with Pa based on theoretical data. However, rotational stiffness tests were conducted for these sections, and Figure 3.4 was plotted with a range of possible P/P_a values at each data point. Figure 3.3. shows conservative but reasonable results with respect to predicting failure. It should be noted here that the fastener spacing on these tests were 6 in., and that the deck did not pull over the screws during the full applied moment, Test SP-8Z-M.

10 IN. Z TEST RESULTS. The results of the 10 in. Z purlin interaction tests are plotted along with interaction curves in Figure 3.5 and 3.6. The figures show two interaction curves; one with and one without the moment amplification factor. The latter curve was plotted for reference purposes only. Figure 3.5 was constructed using P_a and M_{ax} values determined experimentally from tests conducted with axial load and near zero uplift moment and with no axial load and

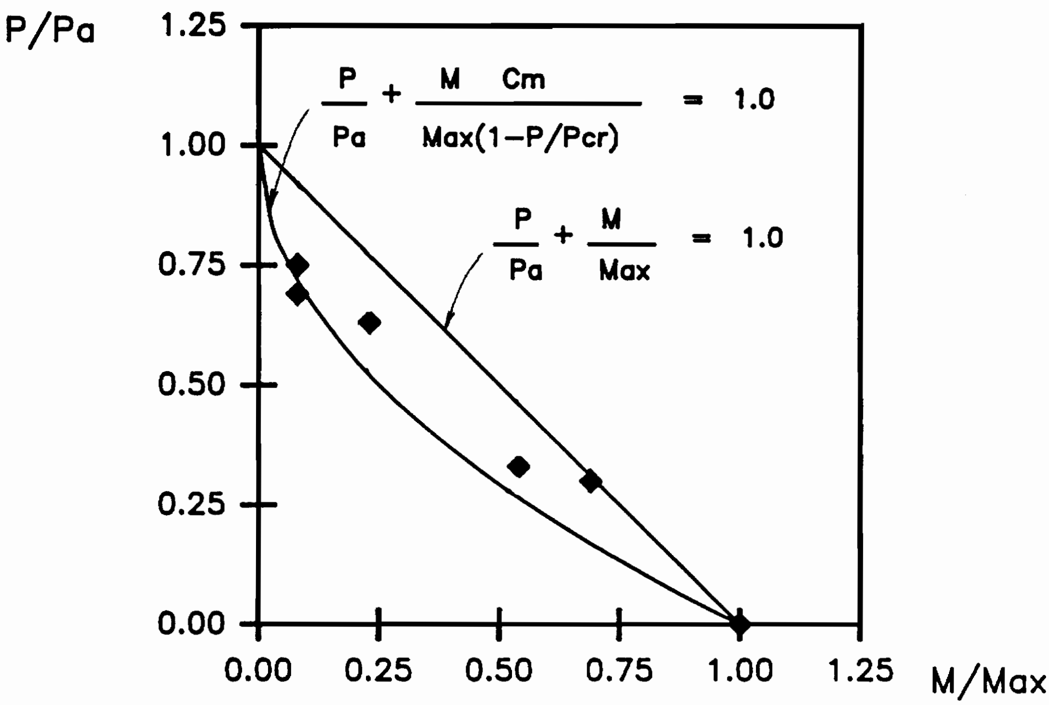

Figure 3.3 **Test Results and Interaction Curve Using Test Data For 8 in. Deep Z-Purlins**

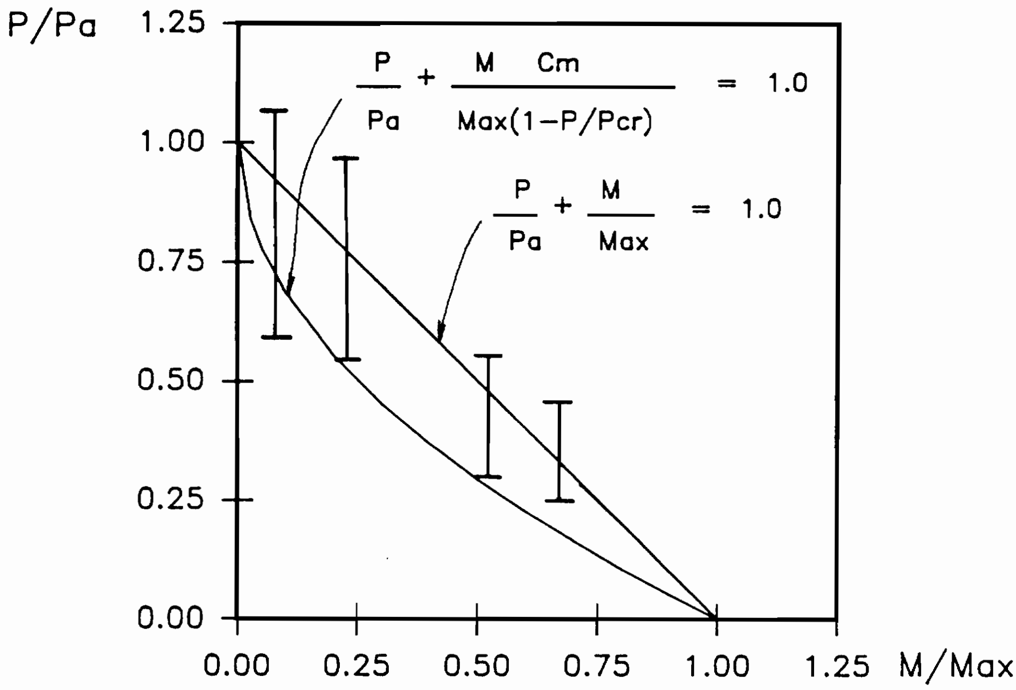

Figure 3.4 **Range of Test Results and Interaction Curve Using Theoretical Data for 8 in. Z-Purlins**

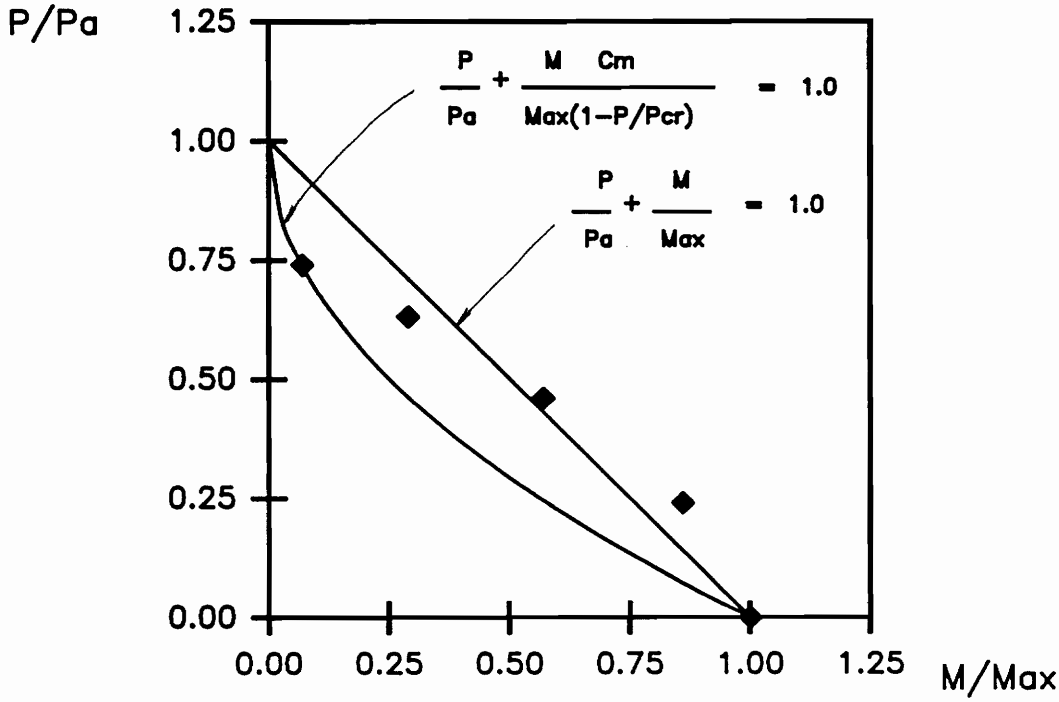

Figure 3.5 Test Results and Interaction Curve Using Test Data for 10 in. Deep Z-Purilns

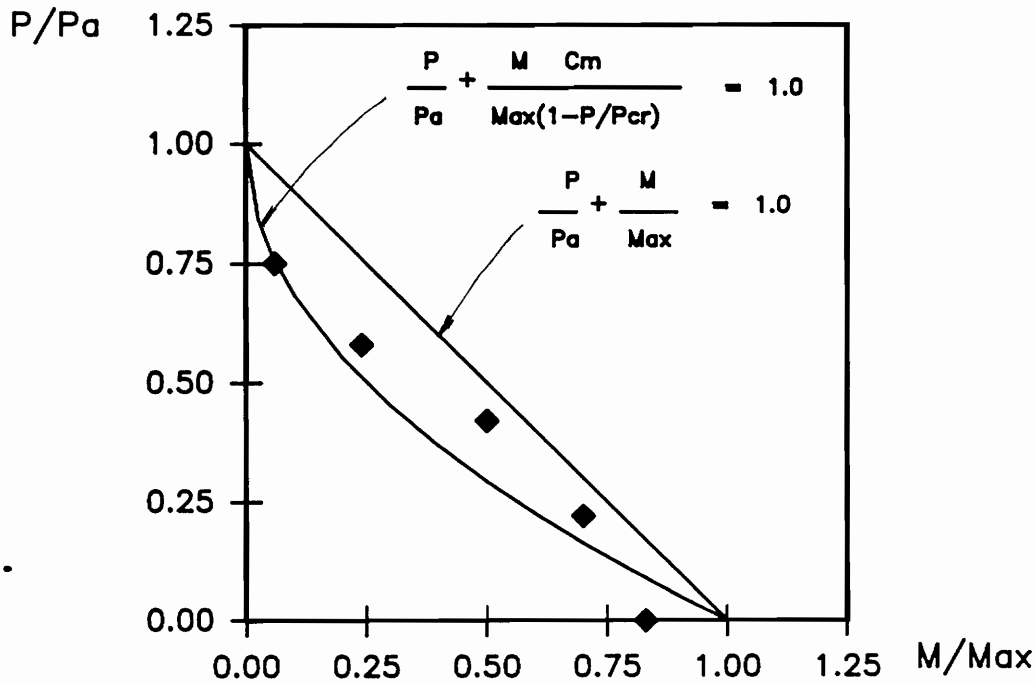

Figure 3.6 Test Results and Interaction Curve Using Theoretical Data for 10 in. Deep Z-Purlins

full uplift loading respectively. Figure 3.6 was constructed using P_a values from Simaan's method and M_{ax} values from the 1989 revision to the AISI Specification Section C3.1.3.

Figure 3.6 shows conservative, but reasonable, results with respect to predicting failure. One data point, test SP-10Z-M, fell below the interaction curve. Failure in this test was due to the deck pulling over the screws. The full uplift moment capacity (according to AISI C3.1.3) of the purlin was not allowed to develop as a result. Screw spacing was 12 in. in these tests. This makes clear the need to consider the pull over strength of the deck in design. It is interesting to note that the pull over strength of the screws was significantly affected by the prying action caused by the twisting of the purlins. Pekoz noticed the same affects in his work *(Pekoz 1975)*. Figure 3.5 shows even more conservative results than Figure 3.6 because M_{ax} was based on the experimental pullover strength of the deck.

10 IN. C TEST RESULTS. The results of the 10 in. C purlin interaction tests are plotted along with interaction curves in Figure 3.7 and 3.8. The figures show two interaction curves; one with and one without the moment amplification factor. The latter was plotted as reference. Figure 3.7 was constructed using P_a and M_{ax} values determined experimentally from tests conducted with axial load and near zero uplift moment and with no axial load and full uplift loading respectively. Figure 3.8 was constructed using P_a values from Simaan's method and M_{ax} values from the 1989 revision to the AISI Specification Section C3.1.3.

Figure 3.7 shows conservative, but reasonable, results with respect to predicting failure. Test SP-10C-M failed by the deck pulling over the screws as did test SP-10Z-M. Fastener spacing for both of these tests was 12 in. This is

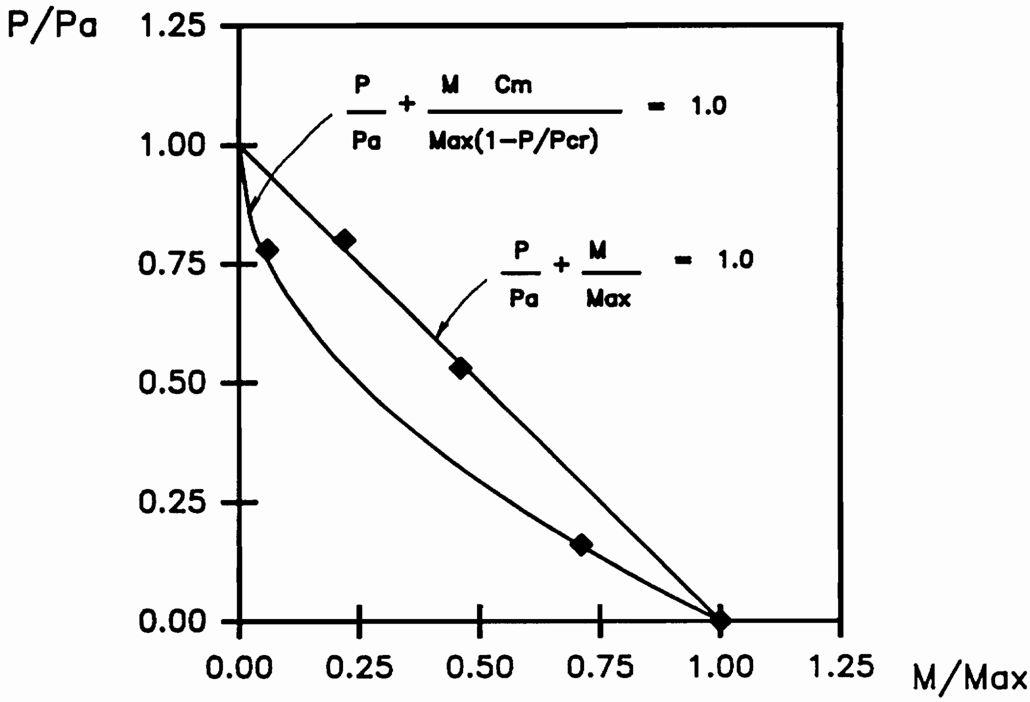

Figure 3.7 Test Results and Interaction Curve Using Test Data for 10 in. Deep C-Purlins

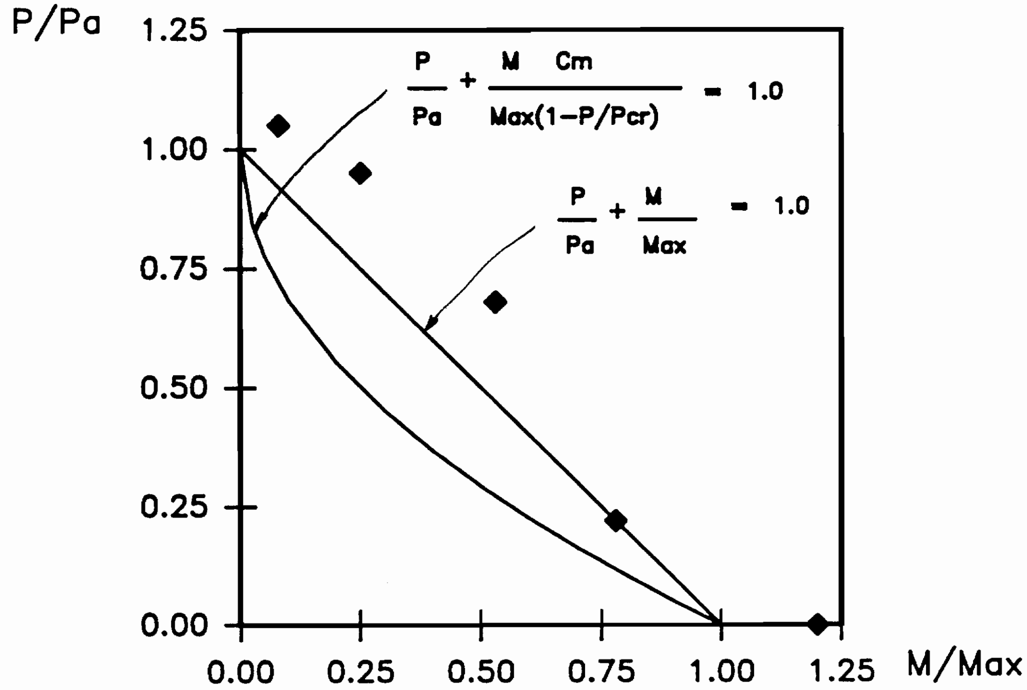

Figure 3.8 Test Results and Interaction Curve Using Theoretical Data for 10 in. Deep C-Purlins

further experimental evidence that the pull over strength of the deck can control the design strength. Figure 3.8 shows even more conservative results than Figure 3.7 for these members. This can be attributed to the uplift moment capacity for these purlins being considerably more than predicted by the AISI Equation C3.1.3. The experimental axial capacity was also greater than that predicted using Simaan's method.

3.4.4 ROTATIONAL STIFFNESS TEST RESULTS

The results of the rotational stiffness tests are presented in Table 3.4. In Simaan's Method, F is defined as the rotational stiffness of the purlin to deck connection. The rotational stiffness is strongly influenced by the fastener location on the flange of the purlin. The strongest fastener location is always farthest from the unsupported lip. This arrangement provides the most leverage in resisting lateral deflection of the unsupported flange. For Z shaped sections this means that fasteners located near the supported lip will result in the highest purlin capacity as illustrated in Figure 3.8a. For C-shaped sections this location is near the web as illustrated in Figure 3.8b.

Experimental values of rotational stiffness are from 0.1984 kips-in/in-rad. For a strong fastener location to 0.0591 kip-in/in-rad. for a weak fastener location for 10" C-shaped sections. For 10" Z-shaped sections these values ranged from .1731 strong to .0464 weak. The following list pairs rotational stiffness test data from Table 3.4 with interaction and axial test data.

TABLE 3.4

Results of Rotational Stiffness Tests

Test Group	Test Designation	F (k-in/in-rad)	FED (rad.)	Fastener Location (in.)	Fastener Spacing (in.)	Comment
A	F-8Z-6-1	0.1091	0.2473	Not Recorded	6	Strong
	F-8Z-6-2	0.0778	0.4417	Not Recorded	6	Weak
	F-Simaan-6-1	0.0305	0.2953	Not Recorded	6	Weak
B	F-10Z-12-7	0.1701	0.1860	3.00	12	Strong
	F-10Z-12-8	0.1395	0.2269	2.00	12	Medium
	F-10Z-12-9	0.0765	0.2557	0.50	12	Weak
C	F-10C-12-7	0.2301	0.2588	0.75	12	Strong
	F-10C-12-8	0.1816	0.2156	1.50	12	Medium
	F-10C-12-9	0.0596	0.4049	2.75	12	Weak
D	F-10Z-12-4	0.1401	0.2259	3.00	12	Strong
	F-10Z-12-5	0.1078	0.2588	2.00	12	Medium
	F-10Z-12-6	0.0445	0.2900	0.50	12	Weak
E	F-10C-12-4	0.1922	0.2557	0.50	12	Strong
	F-10C-12-5	0.1564	0.2023	1.50	12	Medium
	F-10C-12-6	0.0579	0.2013	2.75	12	Weak
F	F-7C-12-4	0.1426	0.2446	0.50	12	Strong
	F-7C-12-5	0.1192	0.2330	1.50	12	Medium
	F-7C-12-6	0.0487	0.2855	2.50	12	Weak

Note: Fastener location is horizontal distance from face of purlin web to fastener location.

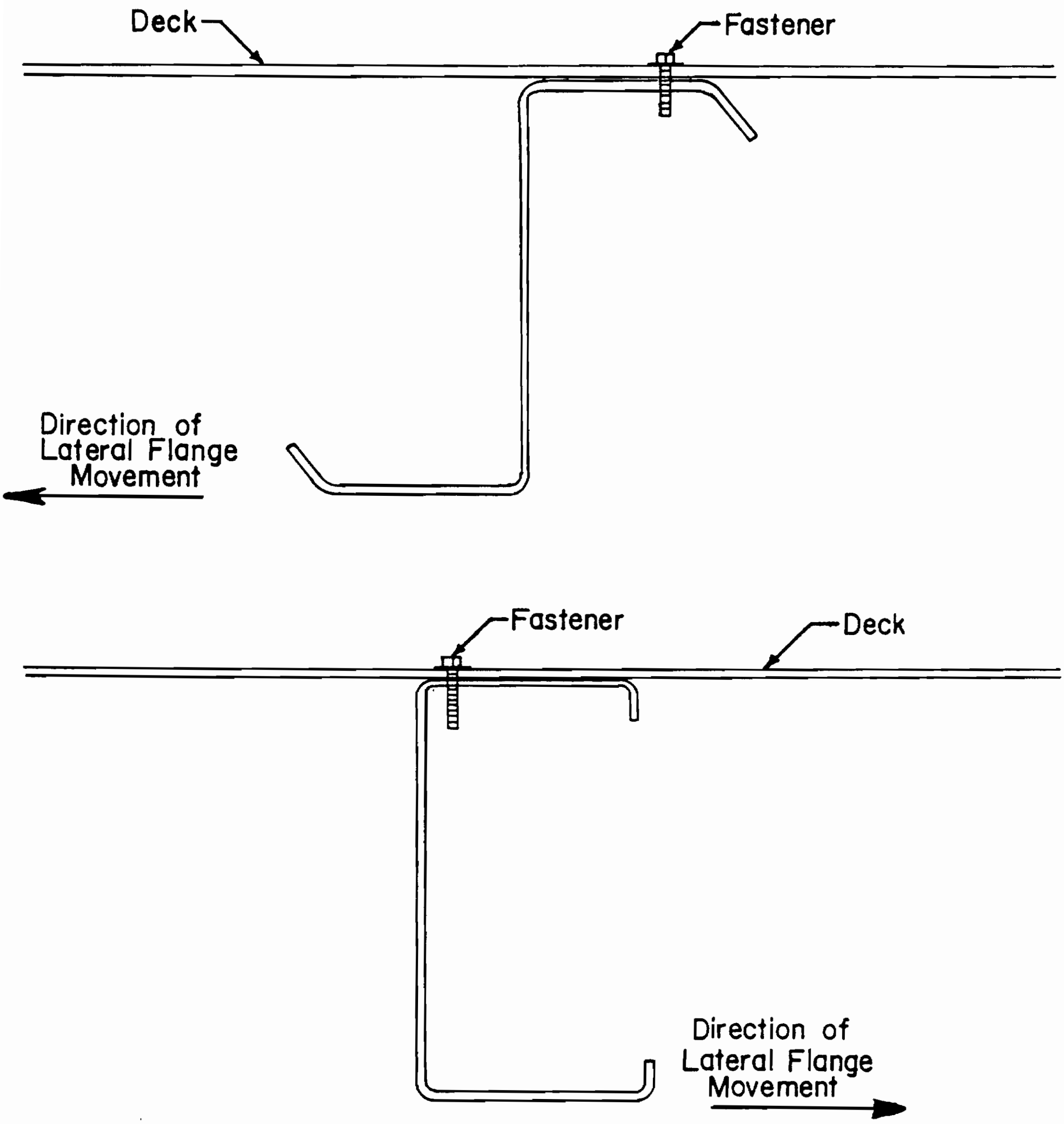

Figure 3.9 Fastener Location Resulting in Highest Purlin Capacity

Rotational Stiffness Test Group	Axial and Interaction Test Series
A	8 in Z Interaction
B	10 in Z Interaction
C	10 in C Interaction
D	10 in Z Axial
E	10 in C Axial
F	7 in C Axial

Coupled with the rotational stiffness for a particular test is the allowable rotation (FED). As the unsupported flange deflects laterally the purlin cross section rotates. The allowable rotation is determined from the rotational stiffness test and represents an estimate of purlin rotation at failure in the interaction and axial tests. The allowable rotation is always greater for weak fastener locations than for strong fastener locations. An experimental allowable rotations range from .2478 radians to .1829 radians.

3.4.5 COUPON TEST RESULTS

Standard ASTM tensile coupon tests were conducted by Butler Research, Grandview, Missouri for some of the tests. The remainder of the tests were conducted at the Virginia Tech Structures and Materials Research Laboratory. A summary of the results of these tests is found in Table 3.5. One coupon was cut from approximately midspan of each purlin that failed.

The tensile strength/yield strength for each of the purlins was approximately 1.3 except for the 10 in. C-shaped interaction test purlins. For tests SP-10C-0 through SP-10C-M the tensile strength/yield strength was 1.1. Test SP-10C-75 had a value of 1.06 which is lower than the 1.08 allowable by the AISI Specification.

TABLE 3.5

Summary of Coupon Test Results

Test Designation	Thickness (in.)	Yield Stress (ksi)	Tensile Strength (ksi)	Elongation %
SP-8Z-0	0.058	65.1	82.6	25.0
SP-8Z-0-2	0.060	65.1	82.8	24.5
SP-8Z-25	0.059	66.8	83.6	23.5
SP-8Z-50	0.059	66.0	81.7	25.0
SP-8Z-75	0.060	65.3	82.8	25.0
SP-8Z-M	0.059	65.6	82.4	23.2
SP-10Z-0	0.084	65.0	85.4	18.5
SP-10Z-25	0.084	66.2	87.4	28.5
SP-10Z-50	0.083	66.3	86.9	30.8
SP-10Z-75	0.083	67.8	88.2	15.7
SP-10Z-M	0.083	66.3	87.7	18.0
SP-10C-0	0.101	57.1	65.3	36.9
SP-10C-25	0.103	57.3	66.0	41.8
SP-10C-50	0.103	56.1	64.4	27.5
SP-10C-75	0.102	61.7	65.7	22.4
SP-10C-M	0.103	57.1	65.3	36.9
SP-7C-12-1	0.075	64.7	80.2	23.5
SP-7C-12-2	0.080	61.6	78.6	15.0
SP-7C-12-3	0.083	60.7	78.5	30.0
SP-10C-12-1	0.100	66.2	90.2	21.5
SP-10C-12-2	0.102	61.5	61.5	12.5
SP-10Z-12-1	0.074	61.4	78.6	25.3
SP-10Z-12-2	0.074	61.9	85.7	26.3
SP-10Z-12-3	0.075	59.5	82.4	25.0

3.5 SOURCES OF DISCREPANCY

The most significant source of discrepancy between the previously discussed theory and experimental results is due to estimates of rotational stiffness. The rotational stiffness of the purlin to deck connection is assumed constant along the purlin in Simaan's method requiring fasteners to be in the same relative location along the flange. This will not occur in actual construction unless the purlin flanges are pre-punched at screw locations. The effect of a rotational stiffness that varies along the length of the purlin is not known. But it is clear that it will have an affect on purlin capacity.

Another source of discrepancy is the variation from theoretical uplift moment capacity. Uplift moment capacity relies on the rotational stiffness of the connection for part of its strength and rotational stiffness is a function of screw location on the flange of the purlin. The uplift moment capacity, as determined by AISI Equation C3.1.3, is, in effect, statistically obtained based on experimental data with the screws located along the center of the flange. Therefore, uplift capacity will most likely vary from this statistical average, especially when screw locations vary from the center of the flange. This variation from assumed uplift capacity affects the magnification factor in the interaction equation which in turn influences the predicted axial failure load. See Equation 2.3.

Other factors such as size of corner radii, purlin thickness and lip angles can affect the magnitude of the uplift capacity. The individual influence of each of these factors is not fully accounted for in the AISI criteria.

Another source of discrepancy is the conservative inaccuracy of the interaction equation. The interaction equation is empirically based to consider second order moments introduced by the axial loads. As seen in Figures 3.3

through 3.8, the interaction equation predicts conservative capacities for the purlins. This is significant for the axial tests because they are conducted horizontally meaning the experimental axial capacity cannot be obtained directly. A dead load uplift moment on the order of 6 to 8% of capacity is always present during the axial tests. The experimental axial capacity is obtained by back calculating through the interaction equation thus introducing the conservative inaccuracy of the equation.

In all tests the axial load is applied through the web of the purlin. For C-sections, this means an eccentric axial load is being applied about the Y-axis since the centroid does not lie on the web. It is thought that two factors tend to cancel this applied moment permitting reasonable results in assuming the loads are concentrically applied. The first is that the purlin is assumed to be simply supported but in fact has some degree of Y-axis bending restraint due to the purlin to spreader beam connection. The second is that since the purlin is almost continuously attached to the deck along one flange, some Y-axis applied moment is transferred too and carried by the deck. Based on the results of the axial tests, it is thought that these two effects tend to cancel the effect of the applied eccentric load.

CHAPTER IV

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

4.1 SUMMARY

An experimental investigation was conducted to determine if strut-purlin capacity could be predicted using the interaction equation in the current AISI Specification [1986]. Three series of interaction tests were conducted to make this determination. The results of these tests indicate that the AISI interaction equation provides conservative but reasonable results in predicting strut-purlin capacity.

Additionally a method of determining the axial capacity of diaphragm braced cold-formed sections was found. A series of eight verification tests was conducted to determine the accuracy of the method. The method was found to provide reasonable results. It was also observed that strut-purlin axial capacity is significantly influenced by the location of purlin to deck fasteners. Needed rotational stiffness tests were also conducted in order to determine axial capacity.

4.2 CONCLUSIONS

The conclusions drawn from this study are:

1. The AISI interaction equation provides conservative but reasonable results with respect to predicting the ultimate failure strength of diaphragm braced strut-purlins.

2. Simaan's method of determining axial capacity of diaphragm braced cold-formed sections is general enough to be applicable to strut-purlins.
3. The axial capacity of diaphragm braced strut-purlins is significantly influenced by the location of the purlin to deck fastener.
4. The uplift capacity of the purlin and decking system can be limited by the fastener pull through strength of the deck.

4.3 RECOMMENDATIONS

Based on the results of this study it is recommended that strut-purlin strength be designed using the AISI Interaction equation, Simaan's method and section C3.1.3 of the AISI Specification. It is also recommended that weak rotational stiffness data be used in design for those members whose fastener locations are not prepunched. This is due to the fact that strut-purlin axial capacity can vary close to 100% as a result of variation in fastener location alone. The weak fastener location for Z- sections is adjacent to the web, for C- sections the weak fastener location is adjacent to the flange lip. If a weak fastener location is not assumed in design then it is recommended that two fasteners be used at each fastener location. This would more reliably provide an adequate estimate of rotational stiffness and axial capacity.

It is also recommended that further study be concentrated on attaining a simpler method of determining strut-purlin axial capacity. Since the strut-purlin diaphragm is close to being infinitely stiff, it seems likely that an empirical expression for axial capacity can be derived which is a function of unbraced capacity and rotational stiffness. This method would then have to be verified experimentally.

Experimental work should be conducted with actual building end conditions, ie. axial load transferred to the purlin through the flange.

APPENDIX A

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APPENDIX B

NOTATION

ALPHA = Angle of major axis relative to X axis

B = Centerline dimension of purlin web

C_{mx} and C_{my} = Moment reduction factors

C_w = Torsional warping constant

D = Centerline dimension of purlin lip

E = Modulus of Elasticity

F = Rotational stiffness of the connection (k-in/in-rad)

FED = Allowable purlin rotation (radians)

F_y = Design yield stress

GAMD = Allowable diaphragm strain (in/in)

H = Centerline depth of purlin web

HH = Top to bottom fiber depth of purlin web

I_b = Moment of inertia of full, unreduced cross-section about axis of bending

I_c = Polar moment of inertia about centroid

I_o = Polar moment of inertia about shear center

I_x = Moment of inertia about x centroidal axis

I_y = Moment of inertia about y centroidal axis

I_{xy} = Product of inertia

I_1 = Moment of inertia about major axis

I_2	=	Moment of inertia about minor axis
J	=	St. Venant Torsion Constant
J_x	=	$[\int x^3 dA + \int xy^2 dA]/(2I_y) - X_o$
J_y	=	$[\int y^3 dA + \int yx^2 dA]/(2I_x) - Y_o$
K_b	=	Effective length factor in the plane of bending
L_b	=	Actual unbraced length in the plane of bending
M_x and M_y	=	Applied moment with respect to the centroidal axes
M_{ax} and M_{ay}	=	Moment capacity about the centroidal axes
P	=	Applied axial load
P_a	=	Axial load capacity
P_{cr}	=	$\dfrac{\pi^2 E I_b}{(K_b L_b)^2}$
Q	=	Form factor
R	=	Reduction factor
r_c	=	Polar radius of gyration about centroid
r_o	=	Polar radius of gyration avout shear center
r_x	=	Radius of gyration about x centroidal axis
r_y	=	Radius of gyration about y centroidal axis
r_1	=	Radius of gyration about major axis
r_2	=	Radius of gyration about minor axis
S	=	Shear rigidity of deck (kips)
S_e	=	Effective section modulus
S_x	=	Section modulus about centroidal x-axis
S_y	=	Section modulus about centroidal y-axis
t	=	Purlin thickness
XL	=	Purlin length

X_o = X coordinate of shear center from centroid

Y_o = Y coordinate of shear center from centroid

$1/\alpha x$ and $1/\alpha y$ = Magnification factor, $1/[1-(\Omega_c P/P_{cr})]$

Ω_c = Factor of safety used in determining P_a

APPENDIX C

SAMPLE CALCULATIONS

The uplift moment capacity, M_{ax}, of a purlin was calculated in the following manner. All of the numbers referred to are found in the calculation sheet for Test SP-10Z-0.

A program (AISIPROC) was used to calculate the "allowable flexural capacity" of a purlin. This program is based on the 1986 AISI Specification and calculates the moment capacity of a purlin assuming constrained, fully laterally braced bending. This program applies a F.S. of 1.67 to the answers it provides. The provisions of AISI Section C3.1.3 are then applied such that the definition of (M_{ax}) is as follows:

$$M_{ax} = R \times 1.67 \times \text{"1986 Allowable Flexible Capacity"}/\Omega f$$

The factor of safety Ωf is taken as 1. A copy of the (AISIPROC) input and output files (1 page), for both purlins in each test, can be found in the Appendices G and H.

The applied uplift moment, M, is determined in two parts: first a uniformly distributed load which would cause a midspan moment equal to M_{ax} is determined and converted to an equivalent manometer reading (i.e. inches of water). Secondly, the applied uplift load is chosen for the particular test as a percentage of the total allowable. In test SP-10Z-0, no uplift load is applied so that only a dead weight of 7.6 lb/ft will contribute to the applied moment (M).

The applied moment is determined using the equation for midspan moment for a uniformly applied load.

$$M = \frac{wL^2}{8}$$

In Test SP-10Z-0, the dead weight causes an applied moment of 7.1 in-kips.

The axial capacity in these tests was determined using a computer program developed by Amir Simaan (STUDA2.EXE). This program was modified to accept section properties calculated using another program called CFS.EXE. This modified program is called (STUDCFS.EXE). The program STUDCFS.EXE reads input data from the file (STUDA2.DAT). A copy of STUDA2.DAT for each purlin can be found in each data pack in Appendices G and H. The input data required are the section properties, shear rigidity (S), allowable diaphragm strain (GAMD), rotational stiffness (F), allowable purlin rotation (FED), length of the purlin and distance between fasteners. Diaphragm properties are determined in Appendix E and the rotational stiffness data is obtained in Appendix F.

The information is typed into STUDA2.DAT using a line editor and the program is executed. The results are sent to file STUDA2.OUT. The results can be seen using the DOS type command.

Since axial capacity is sensitive to the rotational restraint of the connection, three axial capacities are calculated using three different values of rotational stiffness. Then the theoretical axial capacity of the system (P_a) is determined from a linear interpolation based on actual screw location. In Test SP-10Z-0, the average screw location was 1.6" from the web which interpolates to P_a = 25.3 k.

The interaction equation is rearranged to be an explicit expression for the axial failure load, P, of the purlin for the given applied moment, M, and axial capacity, P_a.

CALCULATION SHEET FOR TEST SP-10Z-0

Moment Capacity (M_{ax})

M_{ax} = R x 1.67 x AISI Allowable Capacity

M_{ax} = .5 x 1.67 x 150.9 in-k = 126.0 in-k

Distributed Load

Dead Weight = 7.6 lb/ft ÷ 19.5 lb/ft/in of water = .39 in of water

$$\text{Total Allowable} = \frac{M_{ax} \times 8}{L^2} = \frac{126.0 \text{ in-k} \times 1000 \text{ lb}/12" \times 8}{25'^2} = 134.4 \text{ lb/ft}$$

Total Allowable = 134.4 lb/ft ÷ 19.5 lb/ft/in of water = 6.9 in of water

Set vacuum at 0 inches of water

w = (0 inches) (19.5 lb/ft/in) + 7.6 lb/ft = 7.6 lb/ft

Applied Moment (M)

$$M(\text{applied}) = \frac{wL^2}{8}$$

$$M(\text{applied}) = \frac{7.6 \text{ lb/ft} \times \text{ft}/12" \times 300"^2}{8 \times 1000 \text{ lb/k}} = 7.1 \text{ in-k}$$

Axial Capacity (P_a)

Fastener Location In The Flange		P_a (k)
1/2	weak	19.2
2	medium	27.5
3	strong	30.2

Actual average fastener location was 1.6" from the web, ∴ P_a = 25.3 k based on linear interpolation

Assumption

$$\frac{P}{P_a} + \frac{M\,Cm}{M_{ax}\left(1 - \frac{P}{P_a}\right)} = 1.0$$

Predicted Axial Failure Load

$$P = P_a\left(1 - \sqrt{\frac{M}{M_{ax}}}\right) = 25.3 \text{ k}\left(1 - \sqrt{\frac{7.6}{126.0}}\right) = 19.3 \text{ k}$$

APPENDIX D

CALCULATION OF FORM FACTOR (Q)

Q considers the weakening influence due to local buckling. Q was determined according to the guidelines in the 1980 AISI Specification Section 3.6.1.

Q'_A = A'_{eff}/A

A'_{eff} = Full area of all unstiffened elements plus effective area of all stiffened elements

Q_S = F_c/F

F = $.6\,F_y$

F_y = 60 ksi

F_c = Eq. 3.51 - 3.55 (Yu) [for unstiffened elements]

Q = $Q'_A Q_S$

For unstiffened elements

if $\frac{w}{t} \leq \frac{63.3}{\sqrt{F_y}}$ then $F_c = .6\,F_y$ (Eq. 3.51)

if $\frac{63.3}{\sqrt{F_y}} \leq \frac{w}{t} \leq \frac{144}{\sqrt{F_y}}$ then $F_c = F_y[0.767 - (\frac{2.64}{10^3})(\frac{w}{t})\sqrt{F_y}]$ (Eq. 3.52)

if $\frac{144}{\sqrt{F_y}} \leq \frac{w}{t} \leq 25$ then $F_c = 8000/(\frac{w}{t})^2$ (Eq. 3.53)

if $25 \leq \frac{w}{t} \leq 60$ then $F_c = 19.8 - 0.28(\frac{w}{t})$ (Eq. 3.55)

TABLE E.1

Summary of Form Factors

Test Designation	Full Area	P_a (strong)	$\frac{P_a}{Area}$	Q	$.5\ QF_y$
SP-8Z-0	.876	12.3	14.0	.77	23.1
SP-10Z-12-2	1.354	22.2	16.3	.68	20.4
SP-7C-12-1	1.016	20.2	19.9	.81	24.3
SP-10C-12-1	1.788	28.5	15.9	.72	21.6

As shown in this graph, all of these representative sections fail in the elastic region since the average stress $< .5\ QF_y$.

These representative form factors were used in all tests of similar size and shape.

Form factor for SP-8Z-0

Element	w	t	k	λ	ρ	b (in)	Reduction in Area (in^2)
1	.725	.060	.43	--	--	.850	0
2	2.090	.060	4.00	.826	.888	1.856	.014
3	7.38	.060	4.00	2.918	.317	2.338	.302
4	1.99	.060	4.00	.787	.915	1.821	.010
5	.725	.060	.43	--	--	.850	0
							.326 in^2

$A'_{eff} = .876 - .326 = .55$

$$\lambda = \frac{1.052}{\sqrt{k}} \left(\frac{w}{t}\right) \sqrt{\frac{f}{E}}$$

$$\rho = (1 - .22/\lambda)/\lambda$$

$$f = 60^{ksi}$$

$$E = 29500^{ksi}$$

$$Q'_{eff} = A'_{eff}/A = .55/.876 = .63$$

$F_c = 44.6^{ksi}$ Eq. 3.52 (Yu)

$$Q_s = F_c/F = 44.6/(.6x60) = 1.239$$

$$Q = Q'_{eff}\, Q_s = (.63)(1.239) = .77$$

Form factor for SP-10Z-12-2

Element	w	t	k	λ	ρ	b (in)	A'_{eff}
1	.980	.074	.43	--	--	.980	.073
2	3.500	.074	4.00	1.122	.717	2.508	.186
3	9.900	.074	4.00	3.174	.293	2.903	.215
4	3.600	.074	4.00	1.154	.701	2.525	.187
5	.980	.074	.43	--	--	.980	.073
							0.734

$$\lambda = \frac{1.052}{\sqrt{k}} \left(\frac{w}{t}\right) \sqrt{\frac{f}{E}}$$

$$\rho = (1 - .22/\lambda)/\lambda$$

$$f = F_y = 60^{ksi}$$

$$E = 29500^{ksi}$$

$$Q'_{eff} = A'_{eff}/A = .734/1.348 = .544$$

$F_c = 44.8^{ksi}$ Eq. 3.52 (Yu)

$$Q_s = F_c/F = 44.8/(.6x60) = 1.244$$

$$Q = Q'_{eff}\, Q_s = (.544)(1.244) = .68$$

Form factor for SP-7C-12-1

Element	w	t	k	λ	ρ	b (in)	A'_{eff}
1	.800	.075	.43	--	--	.800	.060
2	3.000	.075	4.00	.644	1.022	3.000	.225
3	7.100	.075	4.00	1.842	.478	3.394	.255
4	3.000	.075	4.00	.644	1.022	3.000	.225
5	.800	.075	.43	--	--	.800	.060
							.825

$\lambda \quad = \frac{1.052}{\sqrt{k}} \left(\frac{w}{t}\right) \sqrt{\frac{f}{E}}$

$\rho \quad = (1 - .22/\lambda)/\lambda$

$f \quad = F_y = 60^{ksi}$

$E \quad = 29500^{ksi}$

$Q'_{eff} \quad = A'_{eff}/A = .825/1.016 = .81$

$F_c \quad = 36^{ksi}$ Eq. 3.51 (Yu)

$Q_s \quad = F_c/F = 36/(.6x60) = 1.00$

$Q \quad = Q'_{eff}\, Q_s = (.81)(1.00) = .81$

Form factor for SP-10C-12-1

Element	w	t	k	λ	ρ	b (in)	A'_{eff}
1	.900	.100	.43	--	--	.900	.090
2	3.500	.100	4.00	.664	1.007	3.500	.350
3	10.000	.100	4.00	2.206	.408	4.080	.408
4	3.500	.100	4.00	.664	1.007	3.500	.350
5	.900	.100	.43	--	--	.900	.090
							1.288

$$\lambda = \frac{1.052}{\sqrt{k}} \left(\frac{w}{t}\right) \sqrt{\frac{f}{E}}$$

$$\rho = (1 - .22/\lambda)/\lambda$$

$$f = F_y = 60^{ksi}$$

$$E = 29500^{ksi}$$

$$Q'_{eff} = A'_{eff}/A = 1.288/1.788 = .72$$

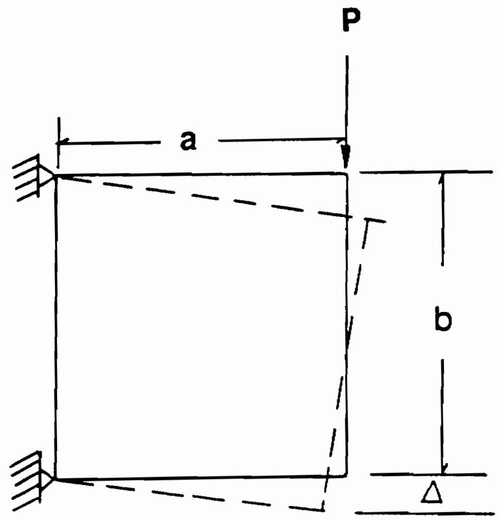
$$F_c = .6\,F_y \qquad \text{Eq. 3.51 (Yu)}$$

$$Q_s = F_c/F = .6\,F_y/.6\,F_y = 1.00$$

$$Q = Q'_{eff}\,Q_s = (.72)(1.00) = .72$$

APPENDIX E

SHEAR RIGIDITY DATA



$\Delta d \quad = \Delta @ 0.8 P_{ult}$

$\tau \quad = 0.8 P_{ult}/b$

$\gamma \quad =$ Shear strain = GAMD

$= \tan \frac{\Delta d}{a} \approx \Delta d/a$

G' = Shear stiffness

$$= \frac{\tau}{\gamma} = \frac{0.8 P_{ult}/b}{\Delta d/a}$$

w = Width of deck contributing to support of one purlin

S = Conservative estimate of shear rigidity

$= \frac{2}{3} G'w$

GAMD = Allowable shear strain $= \frac{\Delta d}{a}$

Test Group	C and E	A, B and D	F
S(k)	53.2	656	847
GAMD (RAD)	0.0955	0.0035	0.0003

APPENDIX F

ROTATIONAL STIFFNESS TEST RESULTS

The test group for which a particular set of rotational stiffness data was used is defined in Table 3.1. The rotational stiffness as defined by Simaan is:

$$F = 0.8\, M_{ult}/\phi_d \qquad \text{(k-in/in-rad)}$$

where

M_{ult} = Moment at failure (kip-in/in of purlin)

The allowable purlin rotation prior to failure is defined by Simaan as:

$$FED = \phi_d = \frac{\Delta}{L} \text{ or } \sin^{-1}\left(\frac{\Delta}{L}\right) \qquad \text{for large angles}$$

where

D = Vertical deflection of loaded flange at 0.8 M_{ult}

L = Depth of purlin web

Values of F and FED for each test group are listed in Table 3.4.

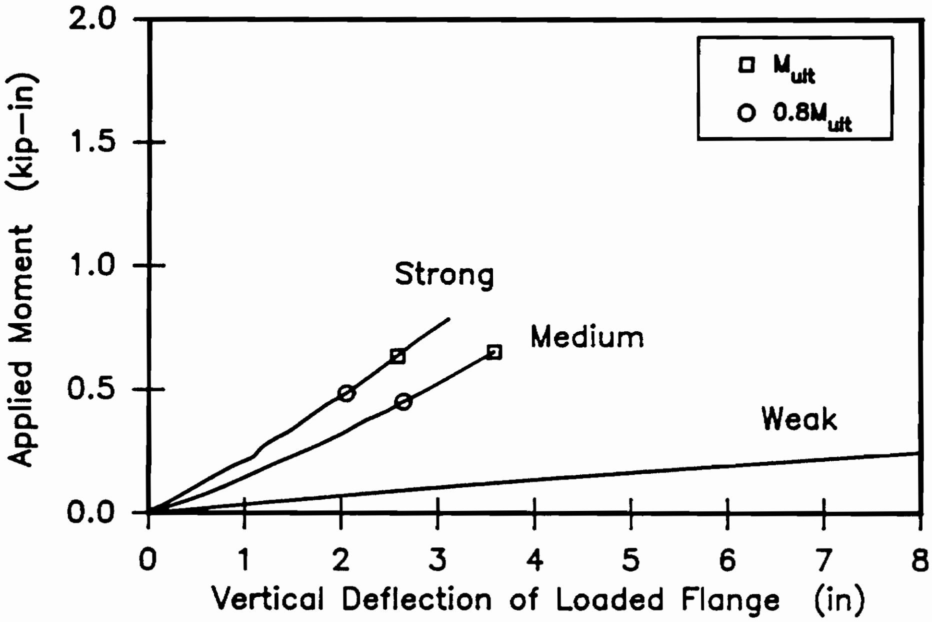


Figure F.1 **Moment Versus Deflection Curves for 8 in. Z-Shaped Rotational Stiffness Tests (i.e. Test Group A)**

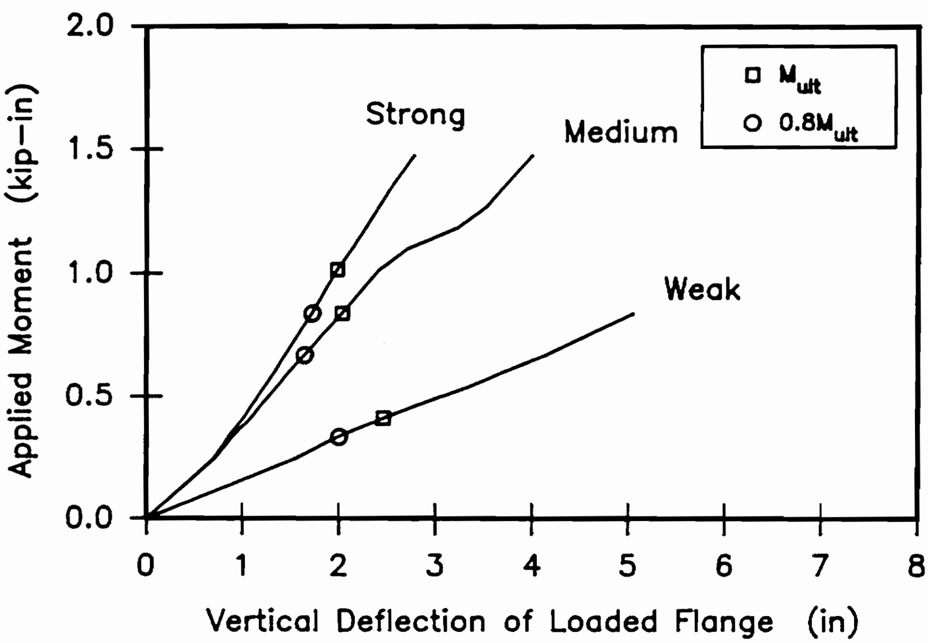


Figure F.2 **Moment Versus Deflection Curves for 7 in. C-Shaped Rotational Stiffness Tests (i.e. Test Group F)**

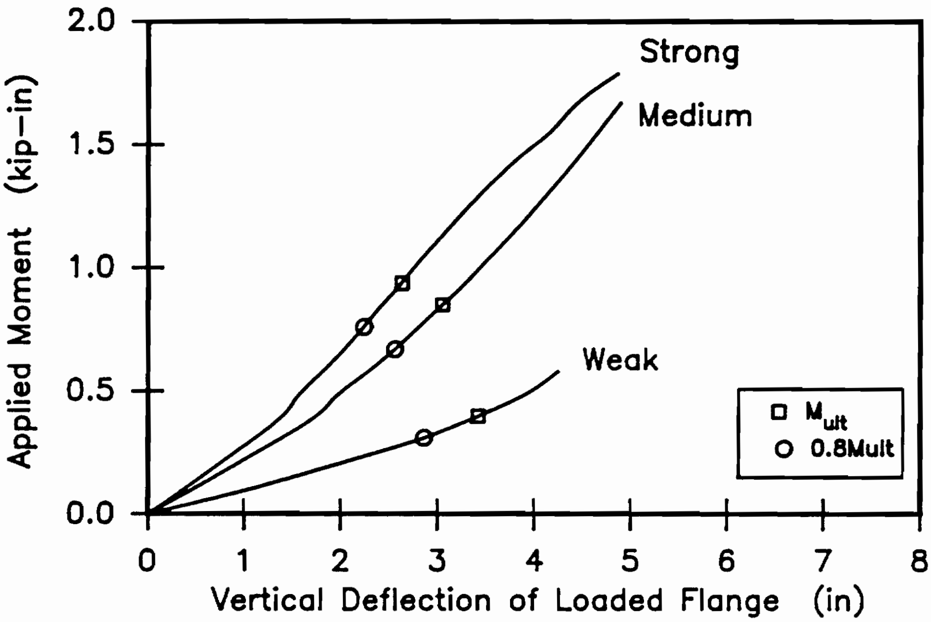


Figure F.3 **Moment Versus Deflection Curves for 10 in. Z-Shaped Rotational Stiffness Tests (i.e. Test Group B)**

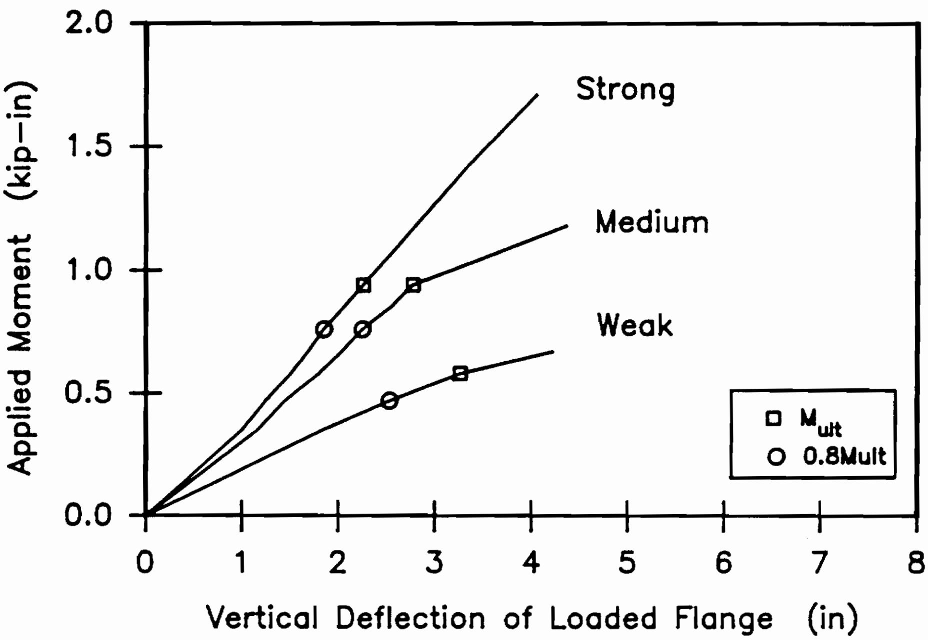


Figure F.4 **Moment Versus Deflection Curves for 10 in. Z-Shaped Rotational Stiffness Tests (i.e. Test Group D)**

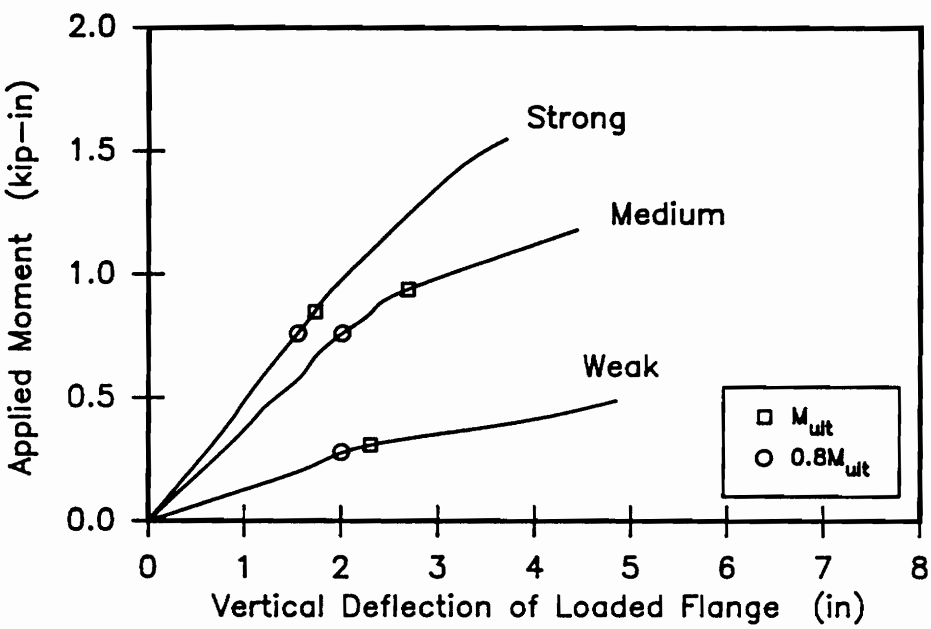


Figure F.5 **Moment Versus Deflection Curves for 10 in. C-Shaped Rotational Stiffness Tests (i.e. Test Group E)**

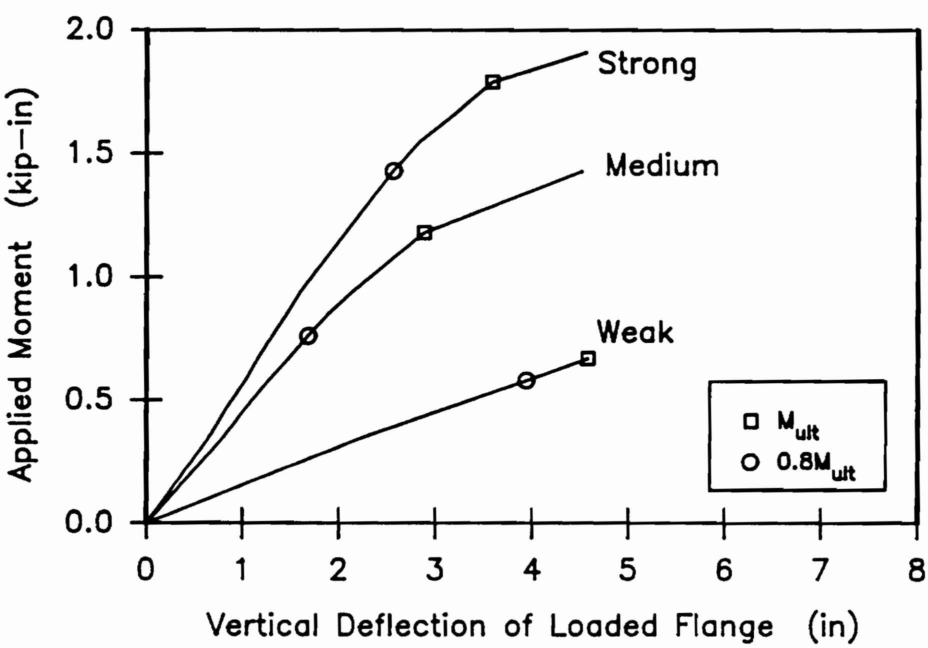


Figure F.6 **Moment Versus Deflection Curves for 10 in. C-Shaped Rotational Stiffness Tests (i.e. Test Group C)**

APPENDIX G

AXIAL TEST DATA PACKS

SP-7C-12-1

Test Summary

Test Date: September 28, 1989

Purpose: Verify Method of Determining Axial Capacity

Span(s): 1 @ 17'-0"

Measured Dimensions:

	North	South
Thickness	0.075"	0.075"
Sweep	1/2"	1/8"

Parameters:
- Axial load only
- Screw down type decking
- Two Purlin Lines 5'-0" O.C. 1'-0" overhang
- Purlins facing each other
- Simple supported
- Lateral supports at ends only

Predicted Failure Loads: (F_y = 64.7 ksi)

Uplift: 6 plf M: 2.6 in-kip

Axial: 11.4 k

Actual Failure Load:

Uplift: 6 plf M: 2.6 in-kip

Axial: 10.7 k

$P_{(actual)}/P_{(theory)}$ = .94

Discussion:

- Torsional-flexural buckling was followed by local buckling of the web to unsupported flange junction
- Initial imperfections were twice as great as those assumed in determining axial capacity
- Failure was in north purlin
- Maximum horizontal deflection was 2.00"
- Maximum vertical deflection was .13"

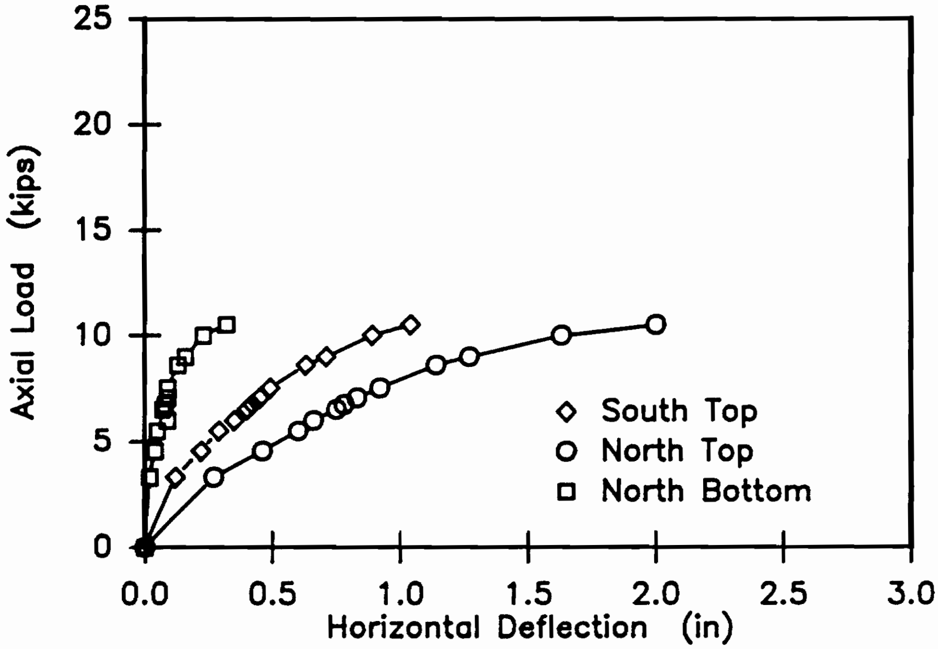


Figure G.1 Axial Load Versus Midspan Deflection of Purlin for Test SP-7C-12-1

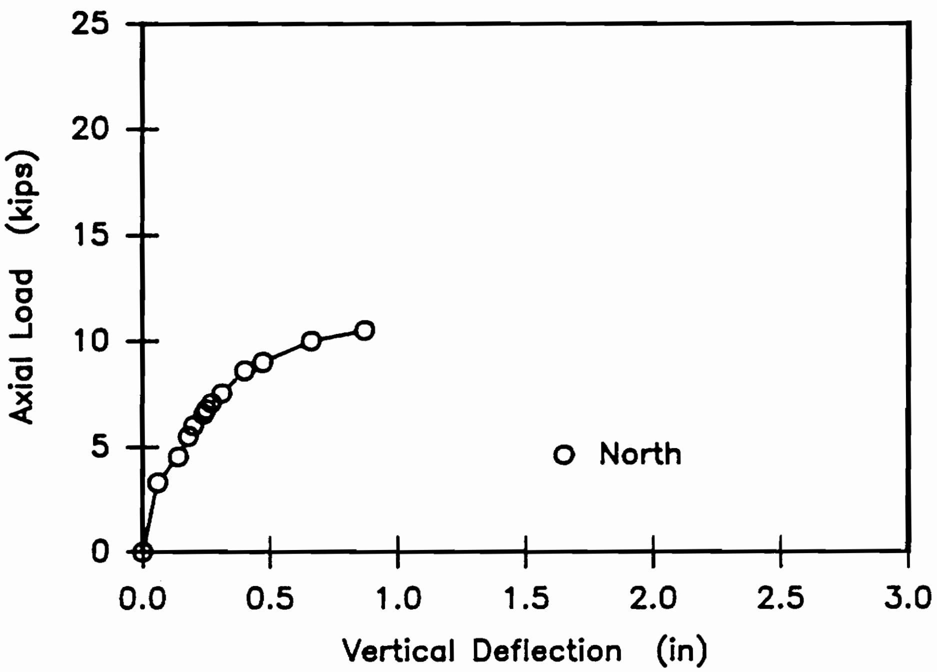
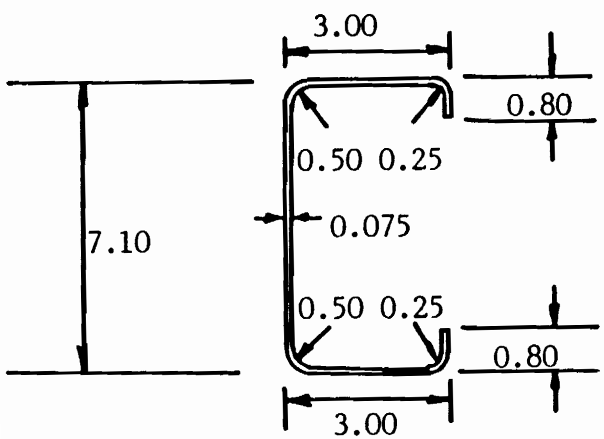
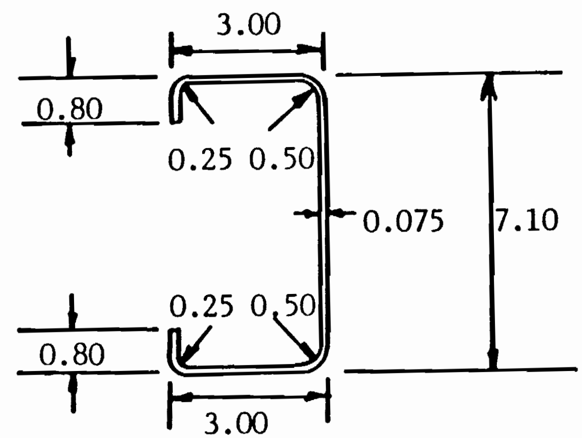


Figure G.2 Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-7C-12-1

Test No. SP-7C-12-1 Date 9-26-89 Recorder GLH



North Purlin



South Purlin

CALCULATION SHEET FOR TEST SP-7C-12-1

Moment Capacity (M_{ax})

M_{ax} = R x 1.67 x AISI Allowable Capacity

M_{ax} = .4 x 1.67 x 75.8 in-k = 50.6 in-k

Applied Moment (M)

$$M(\text{applied}) = \frac{wL^2}{8}$$

$$M(\text{applied}) = \frac{6 \text{ lb/ft} \times \text{ft}/12" \times 204"^2}{8 \times 1000 \text{ lb/k}} = 2.6 \text{ in-k}$$

Axial Capacity (P_a)

Fastener Location In The Flange		P_a (k)
2.5"	weak	12.9
1.5"	medium	18.9
.5"	strong	20.2

Actual average fastener location was 2.0" from the web, ∴ P_a = 14.8 k based on linear interpolation

Assumption

$$\frac{P}{P_a} + \frac{M\,Cm}{M_{ax}\left(1 - \frac{P}{P_a}\right)} = 1.0$$

Predicted Axial Failure Load

$$P = P_a\left(1 - \sqrt{\frac{M}{M_{ax}}}\right) = 14.8 \text{ k}\left(1 - \sqrt{\frac{2.6}{50.6}}\right) = 11.4 \text{ k}$$

SP7C1N

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.8000	0.8000
Lip angles	(degrees) :		90.0000	90.0000
Flange widths	(inches) :		3.0000	3.0000
Radii	(inches)			
Lip to flange	:		0.2500	0.2500
Flange to web	:		0.5000	0.5000
Total purlin depth	(inches) :	7.1000		
Purlin thickness	(inches) :	0.0750		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	64.7
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	2.1000
Gross moment of inertia	(in^4) :	8.02

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	:	1.6826	inches
Effective moment of inertia	:	7.34	in^4
Allowable flexural capacity	:	75.78	kip-in

SP7C1S

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.8000	0.8000
Lip angles	(degrees) :		90.0000	90.0000
Flange widths	(inches) :		3.0000	3.0000
Radii	(inches)			
Lip to flange	:		0.2500	0.2500
Flange to web	:		0.5000	0.5000
Total purlin depth	(inches) :	7.1000		
Purlin thickness	(inches) :	0.0750		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	64.7
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	2.1000
Gross moment of inertia	(in^4) :	8.02

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 1.6826	inches
Effective moment of inertia	: 7.34	in^4
Allowable flexural capacity	: 75.78	kip-in

2	ISEC (2=C SECTION, 3=Z SECTION)
204.	STUD LENGTH XL
7.1	SECTION DEPTH HH
7.04	CENTERLINE DIMENSION OF WEB H
2.94	CENTERLINE DIMENSION OF FLG B
.74	CENTERLINE DIMENSION OF LIP D
.075	THICKNESS
.81	FORM FACTOR Q
847.0	S (K) SHEAR RIGIDITY
.1441	F (K-IN/IN-RAD) ROTATIONAL CAPACITY
.0003	GAMD (IN/IN) DIAPHRAGM STRAIN @ FAILURE
.2433	FED (RAD) PURLIN TWIST @ FAILURE
64.68	FY YIELD STRESS
12.	DISTANCE BETWEEN FASTENERS XL1
0.	1=DETAILS PRINTED 0=DETAILS NOT PRINTED
1.016	AREA
7.257	XXI
1.192	YYI
0.0	XYI
2.292	XO
0.002	XJ
12.315	CW

INPUT DATA TO (STUDA2.EXE) FOR TEST SP-7C-12-1

COLD-FORMED STEEL DESIGN PROGRAM

PART: **North Purlin**

Thickness: 0.0750

	Length	Angle	Radius	w/t
1	0.800	96.000	0.0750	6.33
2	3.000	6.000	0.2500	27.15
3	7.100	-90.000	0.5000	77.64
4	3.000	174.000	0.5000	27.15
5	0.800	84.000	0.2500	6.33

SECTION PROPERTIES

Area	1.016	Wt/Ft	3.455
Top to CG	3.4864	Sx(t)	2.081
Bottom to CG	3.4864	Sx(b)	2.081
Left edge to CG	2.0162	Sy(l)	0.591
Right edge to CG	0.9352	Sy(r)	1.275
Ix	7.257	rx	2.672
Iy	1.192	ry	1.083
I1	7.257	r1	2.672
I2	1.192	r2	1.083
Ic	8.448	rc	2.883
Io	13.785	ro	3.683
Ixy	0.000	Xo	2.292
Alpha	0.000	Yo	-0.000
Cw	12.315	jx	-3.750
J	0.002	jy	0.000

COLD-FORMED STEEL DESIGN PROGRAM

PART: **South Purlin**

Thickness: 0.0760

	Length	Angle	Radius	w/t
1	0.800	90.000	0.0760	6.24
2	3.000	0.000	0.2500	27.61
3	7.100	-90.000	0.5000	78.26
4	3.000	180.000	0.5000	27.61
5	0.800	90.000	0.2500	6.24

SECTION PROPERTIES

Area	1.040	Wt/Ft	3.537
Top to CG	3.5500	Sx(t)	2.289
Bottom to CG	3.5500	Sx(b)	2.289
Left edge to CG	2.0624	Sy(l)	0.606
Right edge to CG	0.9376	Sy(r)	1.334
Ix	8.127	rx	2.795
Iy	1.251	ry	1.096
I1	8.127	r1	2.795
I2	1.251	r2	1.096
Ic	9.377	rc	3.002
Io	14.796	ro	3.772
Ixy	0.000	Xo	2.282
Alpha	0.000	Yo	-0.000
Cw	12.229	jx	-4.049
J	0.002	jy	0.000

SP-7C-12-2

Test Summary

Test Date: December 6, 1989

Purpose: Verify Method of Determining Axial Capacity

Span(s): 1 @ 19'-0"

Measured Dimensions:

	North	South
Thickness	0.076"	0.076"
Sweep	0"	1/2"

Parameters: Axial Load Only

Screw down type decking

Two Purlin Lines 5'-0" O.C. 1'-0" overhang

Purlins facing each other

Simply supported

Lateral supports at ends only

Predicted Failure Loads: (F_y = 61.6 ksi)

Uplift: 6 plf M: 3.3 in-kip

Axial: 13.4 k

Actual Failure Load:

Uplift: 6 plf M: 3.3 in-kip

Axial: 11.1 k

P_a(Actual)/P_a(theory) = .83

Discussion:

- Torsional-flexural buckling was followed by local buckling of the web to unsupported flange junction
- Failure occurred in the south purlin
- Maximum horizontal deflection was 1.75"
- Maximum vertical deflection was 0.38"

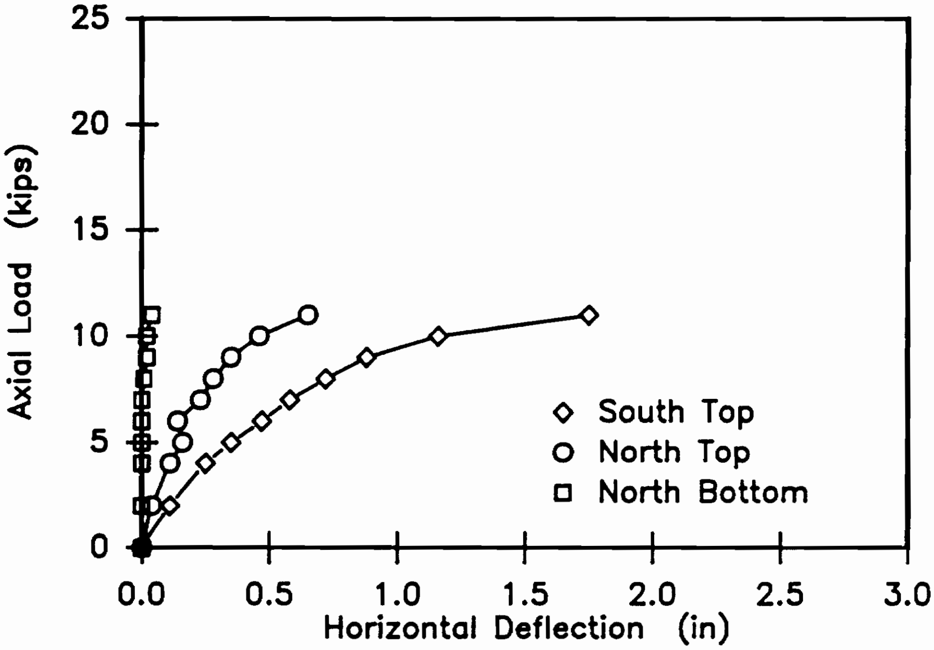


Figure G.3 Axial Load Versus Midspan Deflection of PUrlin Flanges for Test SP-7C-12-2

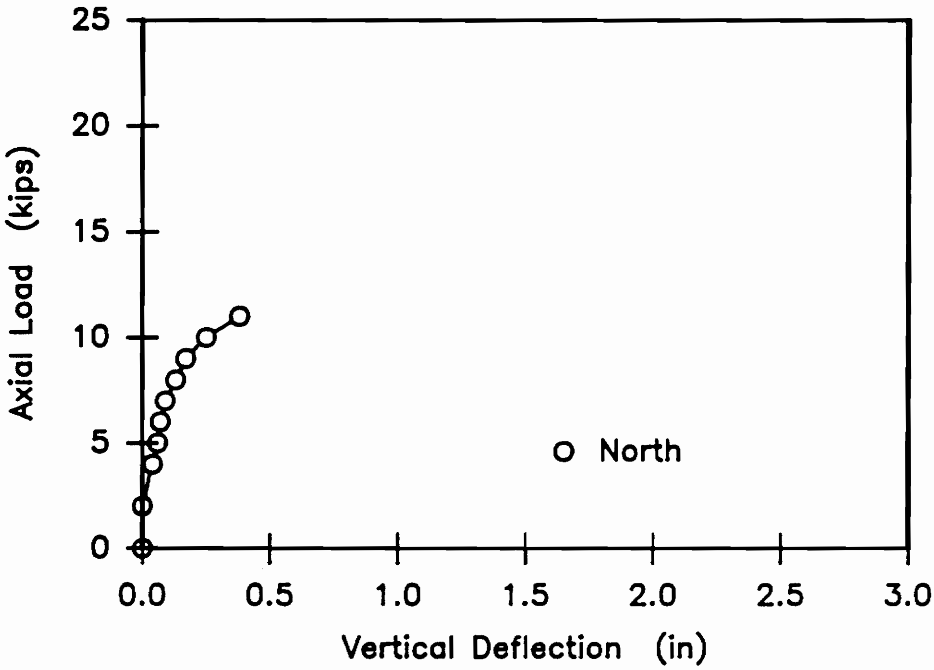
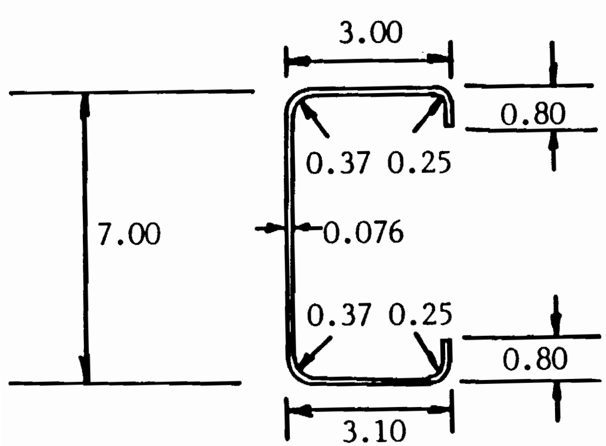
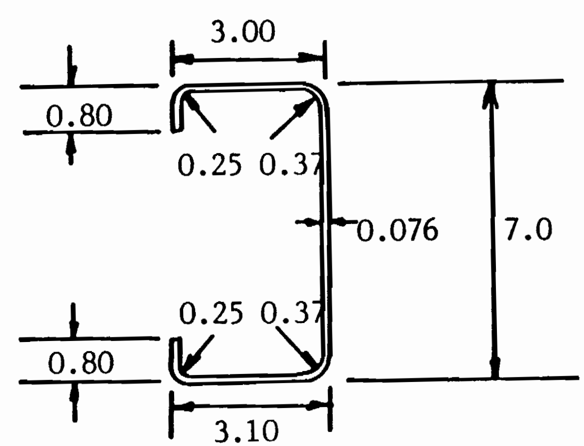


Figure G.4 Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-7C-12-2

Test No. SP-7C-12-2 Date 12-6-89 Recorder GLH



North Purlin



South Purlin

CALCULATION SHEET FOR TEST SP-7C-12-2

Moment Capacity (M_{ax})

M_{ax} = R x 1.67 x AISI Allowable Capacity

M_{ax} = .4 x 1.67 x 72.3 in-k = 48.3 in-k

Applied Moment (M)

$$M(\text{applied}) = \frac{wL^2}{8}$$

$$M(\text{applied}) = \frac{6\text{ lb/ft} \times \text{ft}/12" \times 229"^2}{8 \times 1000\text{ lb/k}} = 3.3\text{ in-k}$$

Axial Capacity (P_a)

Fastener Location In The Flange		P_a (k)
2.5"	weak	13.0
1.5"	medium	19.9
.5"	strong	21.3

Actual average fastener location was 1 3/4" from the web, ∴ P_a = 18.1 k based on linear interpolation

Assumption

$$\frac{P}{P_a} + \frac{M\,Cm}{M_{ax}\left(1 - \frac{P}{P_a}\right)} = 1.0$$

Predicted Axial Failure Load

$$P = P_a\left(1 - \sqrt{\frac{M}{M_{ax}}}\right) = 18.1\text{ k}\left(1 - \sqrt{\frac{3.3}{48.3}}\right) = 13.4\text{ k}$$

SP7C2N

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.8000	0.8000
Lip angles	(degrees) :		90.0000	90.0000
Flange widths	(inches) :		3.0000	3.1000
Radii	(inches)			
Lip to flange	:		0.2500	0.2500
Flange to web	:		0.3750	0.3750
Total purlin depth	(inches) :	7.0000		
Purlin thickness	(inches) :	0.0760		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	61.6
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	2.2230
Gross moment of inertia	(in^4) :	8.06

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 1.7642	inches
Effective moment of inertia	: 7.33	in^4
Allowable flexural capacity	: 72.33	kip-in

SP7C2S

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.8000	0.8000
Lip angles	(degrees) :		90.0000	90.0000
Flange widths	(inches) :		3.0000	3.1000
Radii	(inches)			
Lip to flange	:		0.2500	0.2500
Flange to web	:		0.3750	0.3750
Total purlin depth	(inches) :	7.0000		
Purlin thickness	(inches) :	0.0760		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	61.6
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	2.2230
Gross moment of inertia	(in^4) :	8.06

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 1.7642	inches
Effective moment of inertia	: 7.33	in^4
Allowable flexural capacity	: 72.33	kip-in

1980 AISI PROCEDURE

2	ISEC (2=C SECTION, 3=Z SECTION)
229.	STUD LENGTH XL
7.0	SECTION DEPTH HH
6.924	CENTERLINE DIMENSION OF WEB H
2.92	CENTERLINE DIMENSION OF FLG B
.76	CENTERLINE DIMENSION OF LIP D
.076	THICKNESS
.81	FORM FACTOR Q
847.0	S (K) SHEAR RIGIDITY
.1441	F (K-IN/IN-RAD) ROTATIONAL CAPACITY
.0003	GAMD (IN/IN) DIAPHRAGM STRAIN @ FAILURE
.2433	FED (RAD) PURLIN TWIST @ FAILURE
61.55	FY YIELD STRESS
12.	DISTANCE BETWEEN FASTENERS XL1
0.	1=DETAILS PRINTED 0=DETAILS NOT PRINTED
1.041	AREA
7.969	XXI
1.253	YYI
0.0	XYI
2.277	XO
0.002	XJ
12.185	CW

INPUT DATA TO (STUDA2.EXE) FOR TEST SP-7C-12-2

COLD-FORMED STEEL DESIGN PROGRAM

PART: **North Purlin**

Thickness: 0.0760

	Length	Angle	Radius	w/t
1	0.800	90.000	0.0760	6.24
2	3.000	180.000	0.2500	29.25
3	7.000	-90.000	0.3750	80.24
4	3.000	0.000	0.3750	29.25
5	0.800	90.000	0.2500	6.24

SECTION PROPERTIES

Area	1.041	Wt/Ft	3.539
Top to CG	3.5000	Sx(t)	2.277
Bottom to CG	3.5000	Sx(b)	2.277
Left edge to CG	0.9359	Sy(l)	1.339
Right edge to CG	2.0641	Sy(r)	0.607
Ix	7.969	rx	2.767
Iy	1.253	ry	1.097
I1	7.969	r1	2.767
I2	1.253	r2	1.097
Ic	9.222	rc	2.977
Io	14.619	ro	3.748
Ixy	0.000	Xo	-2.277
Alpha	0.000	Yo	-0.000
Cw	12.185	jx	3.974
J	0.002	jy	0.000

COLD-FORMED STEEL DESIGN PROGRAM

PART: **South Purlin**

Thickness: 0.0760

	Length	Angle	Radius	w/t
1	0.800	90.000	0.0760	6.24
2	3.000	180.000	0.2500	29.25
3	7.000	-90.000	0.3750	80.24
4	3.000	0.000	0.3750	29.25
5	0.800	90.000	0.2500	6.24

SECTION PROPERTIES

Area	1.041	Wt/Ft	3.539
Top to CG	3.5000	Sx(t)	2.277
Bottom to CG	3.5000	Sx(b)	2.277
Left edge to CG	0.9359	Sy(l)	1.339
Right edge to CG	2.0641	Sy(r)	0.607
Ix	7.969	rx	2.767
Iy	1.253	ry	1.097
I1	7.969	r1	2.767
I2	1.253	r2	1.097
Ic	9.222	rc	2.977
Io	14.619	ro	3.748
Ixy	0.000	Xo	-2.277
Alpha	0.000	Yo	-0.000
Cw	12.185	jx	3.974
J	0.002	jy	0.000

SP-7C-12-3

Test Summary

Test Date: December 19, 1989

Purpose: Verify Method of Determining Axial Capacity

Span(s): 1 @ 15'-0"

Measured Dimensions:

	North	South
Thickness	0.076"	0.076"
Sweep	1/4	1/4

Parameters:
Axial Load Only
Screw down type decking
Two Purlin Lines 5'-0" O.C. 1'-0" overhang
Purlins facing each other
Simply supported
Lateral supports at ends only

Predicted Failure Loads: (F_y = 60.7 ksi)

Uplift: 6 plf M: 2 in-kip

Axial: 12.8 k

Actual Failure Load:

Uplift: 6 plf M: 2 in-kip

Axial: 11.7 k

P_a(Actual)/P_a(theory) = .91

Discussion:

- Torsional-flexural buckling was followed by local buckling of the web to unsupported flange junction
- Failure occurred in the north purlin
- Maximum horizontal deflection was 1.60"
- Maximum vertical deflection was 0.56"

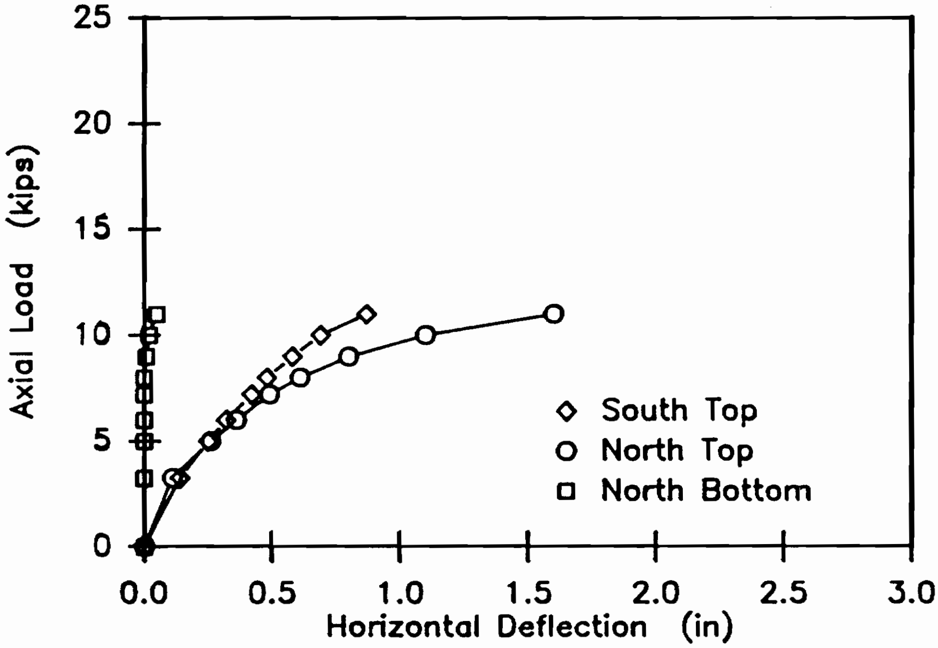


Figure G.5 Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-7C-12-3

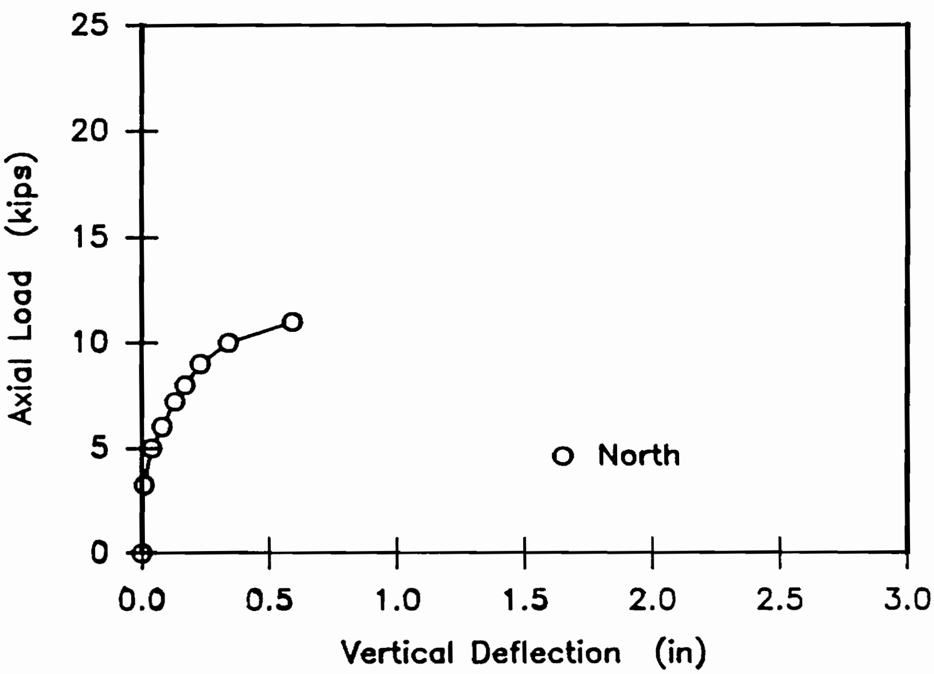
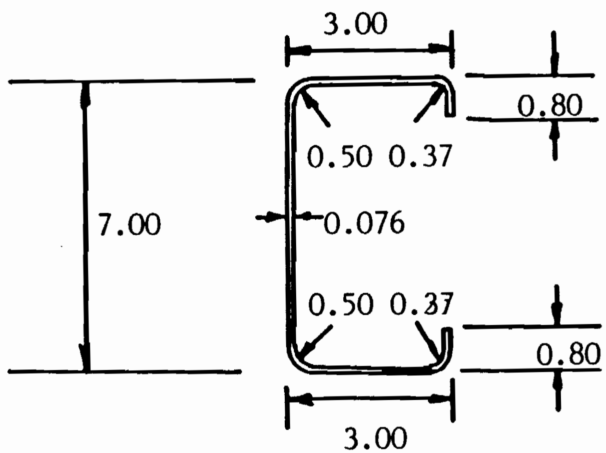
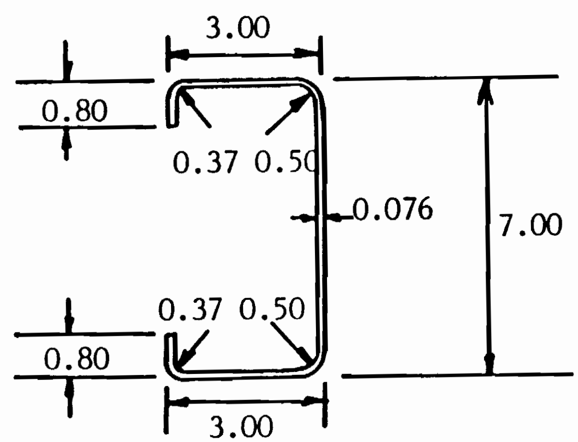


Figure G.6 Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-7C-12-3

Test No. SP-7C-12-3 Date 12-18-89 Recorder GLH



North Purlin



South Purlin

CALCULATION SHEET FOR TEST SP-7C-12-3

Moment Capacity (M_{ax})

M_{ax} = R x 1.67 x AISI Allowable Capacity

M_{ax} = .4 x 1.67 x 68.9 in-k = 46.0 in-k

Applied Moment (M)

$$M(\text{applied}) = \frac{wL^2}{8}$$

$$M(\text{applied}) = \frac{6\ \text{lb/ft} \times \text{ft}/12" \times 180"^{\,2}}{8 \times 1000\ \text{lb/k}} = 2.0\ \text{in-k}$$

Axial Capacity (P_a)

Fastener Location In The Flange		P_a (k)
2.5"	weak	13.3
1.5"	medium	18.9
.5"	strong	19.8

Actual average fastener location was 2.0" from the web, ∴ P_a = 16.2 k based on linear interpolation

Assumption

$$\frac{P}{P_a} + \frac{M\,Cm}{M_{ax}\left(1 - \frac{P}{P_a}\right)} = 1.0$$

Predicted Axial Failure Load

$$P = P_a\left(1 - \sqrt{\frac{M}{M_{ax}}}\right) = 16.2\ \text{k}\left(1 - \sqrt{\frac{2.0}{46.0}}\right) = 12.8\ \text{k}$$

SP7C3N

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.8000	0.8000
Lip angles	(degrees) :		90.0000	90.0000
Flange widths	(inches) :		3.0000	3.0000
Radii	(inches)			
Lip to flange	:		0.3750	0.3750
Flange to web	:		0.5000	0.5000
Total purlin depth	(inches) :	7.0000		
Purlin thickness	(inches) :	0.0760		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	60.7
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	1.9730
Gross moment of inertia	(in^4) :	7.76

1986 AISI PROCEDURE

Flange is not fully effective		
Effective flange width	: 1.4504	inches
Effective moment of inertia	: 7.04	in^4
Allowable flexural capacity	: 68.94	kip-in

SP7C3S

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.8000	0.8000
Lip angles	(degrees) :		90.0000	90.0000
Flange widths	(inches) :		3.0000	3.0000
Radii	(inches)			
Lip to flange	:		0.3750	0.3750
Flange to web	:		0.5000	0.5000
Total purlin depth	(inches) :	7.0000		
Purlin thickness	(inches) :	0.0760		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	60.7
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	1.9730
Gross moment of inertia	(in^4) :	7.76

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	:	1.4508	inches
Effective moment of inertia	:	7.04	in^4
Allowable flexural capacity	:	68.92	kip-in

2	ISEC (2=C SECTION, 3=Z SECTION)
180.	STUD LENGTH XL
7.0	SECTION DEPTH HH
6.924	CENTERLINE DIMENSION OF WEB H
2.924	CENTERLINE DIMENSION OF FLG B
.762	CENTERLINE DIMENSION OF LIP D
.076	THICKNESS
.81	FORM FACTOR Q
847.0	S (K) SHEAR RIGIDITY
.1441	F (K-IN/IN-RAD) ROTATIONAL CAPACITY
.0003	GAMD (IN/IN) DIAPHRAGM STRAIN @ FAILURE
.2433	FED (RAD) PURLIN TWIST @ FAILURE
60.73	FY YIELD STRESS
12.	DISTANCE BETWEEN FASTENERS XL1
0.	1=DETAILS PRINTED 0=DETAILS NOT PRINTED
1.024	AREA
7.758	XXI
1.207	YYI
0.0	XYI
2.257	XO
0.002	XJ
11.585	CW

INPUT DATA TO (STUDA2.EXE) FOR TEST SP-7C-12-3

COLD-FORMED STEEL DESIGN PROGRAM

PART: **North Purlin**

Thickness: 0.0760

	Length	Angle	Radius	w/t
1	0.800	90.000	0.0760	4.59
2	3.000	180.000	0.3750	25.96
3	7.000	-90.000	0.5000	76.95
4	3.000	0.000	0.5000	25.96
5	0.800	90.000	0.3750	4.59

SECTION PROPERTIES

Area	1.024	Wt/Ft	3.483
Top to CG	3.5000	Sx(t)	2.217
Bottom to CG	3.5000	Sx(b)	2.217
Left edge to CG	0.9272	Sy(l)	1.302
Right edge to CG	2.0728	Sy(r)	0.582
Ix	7.758	rx	2.752
Iy	1.207	ry	1.086
I1	7.758	r1	2.752
I2	1.207	r2	1.086
Ic	8.966	rc	2.958
Io	14.184	ro	3.721
Ixy	0.000	Xo	-2.257
Alpha	0.000	Yo	0.000
Cw	11.585	jx	3.983
J	0.002	jy	0.000

COLD-FORMED STEEL DESIGN PROGRAM

PART:

Thickness: 0.0760

	Length	Angle	Radius	w/t
1	0.800	90.000	0.0760	4.59
2	3.000	180.000	0.3750	25.96
3	7.000	-90.000	0.5000	76.95
4	3.000	0.000	0.5000	25.96
5	0.800	90.000	0.3750	4.59

SECTION PROPERTIES

Area	1.024	Wt/Ft	3.483
Top to CG	3.5000	Sx(t)	2.217
Bottom to CG	3.5000	Sx(b)	2.217
Left edge to CG	0.9272	Sy(l)	1.302
Right edge to CG	2.0728	Sy(r)	0.582
Ix	7.758	rx	2.752
Iy	1.207	ry	1.086
I1	7.758	r1	2.752
I2	1.207	r2	1.086
Ic	8.966	rc	2.958
Io	14.184	ro	3.721
Ixy	0.000	Xo	-2.257
Alpha	0.000	Yo	0.000
Cw	11.585	jx	3.983
J	0.002	jy	0.000

SP-10C-12-1

Test Summary

Test Date: September 9, 1989

Purpose: Verify Method of Determining Axial Capacity

Span(s): 1 @ 17'-0"

Measured Dimensions:

	North	South
Thickness	0.100"	0.100"
Sweep	0.375"	0.250"

Parameters:
- Axial load only
- Screw down type decking
- Two Purlin Lines 5'-0" O.C. 1'-0" overhang
- Purlins facing each other
- Simple supported
- Lateral supports at ends only

Predicted Failure Loads: (F_y = 66.2 ksi)

Uplift: 9 plf M: 3.9 in-kip

Axial: 19.8 k

Actual Failure Load:

Uplift: 9 plf M: 3.9 in-kip

Axial: 20.8 k

$P_{(actual)}/P_{(theory)}$ = 1.05

Discussion:

- Torsional-flexural buckling was followed by local buckling of the web to unsupported flange junction
- Failure occurred in the north purlin
- Maximum horizontal deflection was 2.14"
- Maximum vertical deflection was .44"

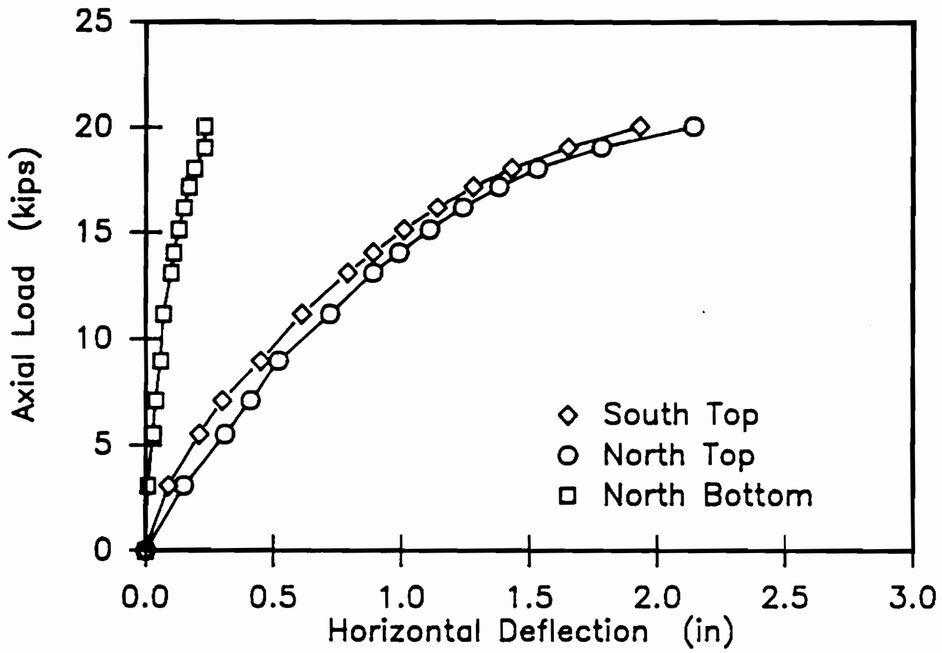


Figure G.7 Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-10C-12-1

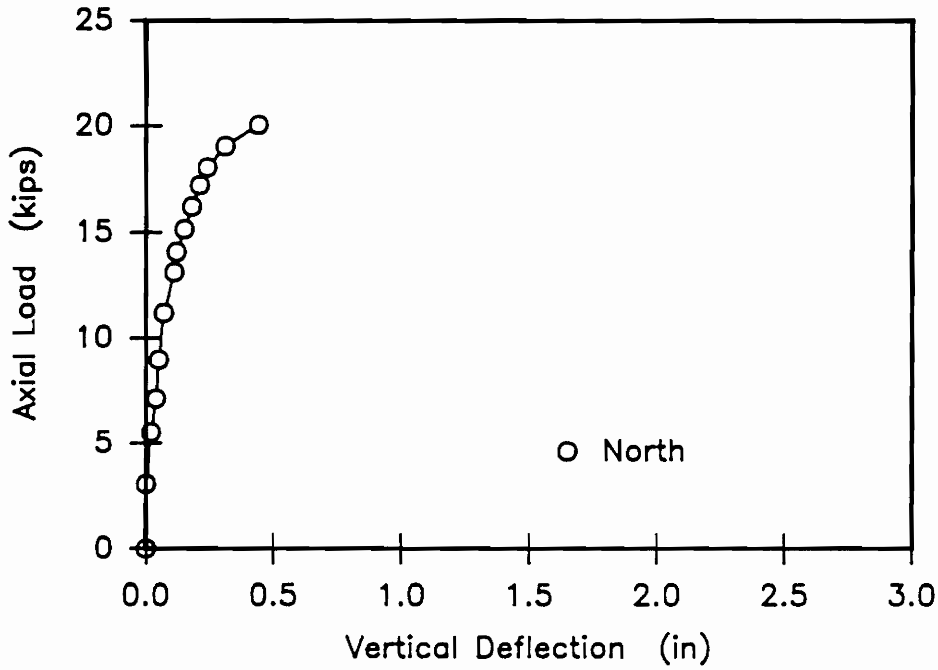
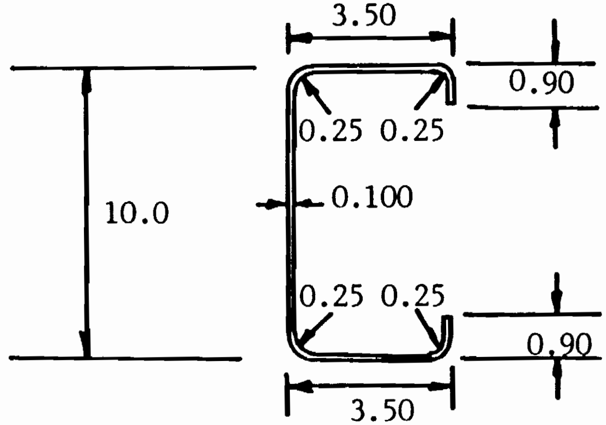
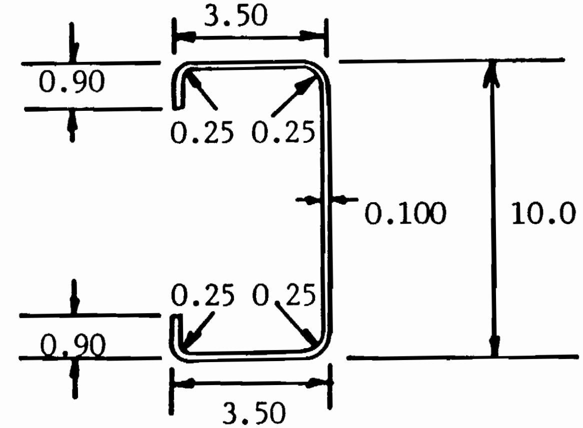


Figure G.8 Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-10C-12-1

Test No. SP-10C-12-1 Date 9-21-89 Recorder GLH



North Purlin



South Purlin

CALCULATION SHEET FOR TEST SP-10C-12-1

Moment Capacity (M_{ax})

M_{ax} = R x 1.67 x AISI Allowable Capacity

M_{ax} = .4 x 1.67 x 182.3 in-k = 121.8 in-k

Applied Moment (M)

$$M(\text{applied}) = \frac{wL^2}{8}$$

$$M(\text{applied}) = \frac{9\ \text{lb/ft} \times \text{ft}/12" \times 204"^{2}}{8 \times 1000\ \text{lb/k}} = 3.9\ \text{in-k}$$

Axial Capacity (P_a)

Fastener Location In The Flange		P_a (k)
2.75"	weak	19.7
1.50"	medium	25.4
.5"	strong	28.2

Actual average fastener location was 2.0" from the web, $\therefore$ P_a = 24.1 k based on linear interpolation

Assumption

$$\frac{P}{P_a} + \frac{M\,Cm}{M_{ax}\left(1 - \frac{P}{P_a}\right)} = 1.0$$

Predicted Axial Failure Load

$$P = P_a\left(1 - \sqrt{\frac{M}{M_{ax}}}\right) = 24.1\ \text{k}\left(1 - \sqrt{\frac{3.9}{121.8}}\right) = 19.8\ \text{k}$$

SP10C1N

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.9000	0.9000
Lip angles	(degrees) :		90.0000	90.0000
Flange widths	(inches) :		3.5000	3.5000
Radii	(inches)			
Lip to flange	:		0.2500	0.2500
Flange to web	:		0.2500	0.2500
Total purlin depth	(inches) :	10.0000		
Purlin thickness	(inches) :	0.1000		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	66.2
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	2.8000
Gross moment of inertia	(in^4) :	26.95

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 2.1960	inches
Effective moment of inertia	: 24.39	in^4
Allowable flexural capacity	: 182.29	kip-in

SP10C1S

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.9000	0.9000
Lip angles	(degrees) :		90.0000	90.0000
Flange widths	(inches) :		3.5000	3.5000
Radii	(inches)			
Lip to flange	:		0.2500	0.2500
Flange to web	:		0.2500	0.2500
Total purlin depth	(inches) :	10.0000		
Purlin thickness	(inches) :	0.1000		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	66.2
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	2.8000
Gross moment of inertia	(in^4) :	26.95

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 2.1960	inches
Effective moment of inertia	: 24.39	in^4
Allowable flexural capacity	: 182.29	kip-in

2	ISEC (2=C SECTION, 3=Z SECTION)
204.	STUD LENGTH XL
10.00	SECTION DEPTH HH
9.90	CENTERLINE DIMENSION OF WEB H
3.40	CENTERLINE DIMENSION OF FLG B
.85	CENTERLINE DIMENSION OF LIP D
.100	THICKNESS
.72	FORM FACTOR Q
53.2	S (K) SHEAR RIGIDITY
.1984	F (K-IN/IN-RAD) ROTATIONAL CAPACITY
.0955	GAMD (IN/IN) DIAPHRAGM STRAIN @ FAILURE
.2478	FED (RAD) PURLIN TWIST @ FAILURE
66.17	FY YIELD STRESS
12.	DISTANCE BETWEEN FASTENERS XL1
0.	1=DETAILS PRINTED 0=DETAILS NOT PRINTED
1.788	AREA
26.955	XXI
2.766	YYI
0.000	XYI
2.406	XO
0.006	XJ
53.429	CW

INPUT DATA TO (STUDA2.EXE) FOR TEST SP-10C-12-1

COLD-FORMED STEEL DESIGN PROGRAM

PART: **North Purlin**

Thickness: 0.1000

	Length	Angle	Radius	w/t
1	0.900	90.000	0.1000	5.50
2	3.500	180.000	0.2500	28.00
3	10.000	-90.000	0.2500	93.00
4	3.500	0.000	0.2500	28.00
5	0.900	90.000	0.2500	5.50

SECTION PROPERTIES

Area	1.788	Wt/Ft	6.081
Top to CG	5.0000	Sx(t)	5.391
Bottom to CG	5.0000	Sx(b)	5.391
Left edge to CG	0.9706	Sy(l)	2.850
Right edge to CG	2.5294	Sy(r)	1.093
Ix	26.955	rx	3.882
Iy	2.766	ry	1.244
I1	26.955	r1	3.882
I2	2.766	r2	1.244
Ic	29.721	rc	4.077
Io	40.071	ro	4.733
Ixy	0.000	Xo	-2.406
Alpha	0.000	Yo	-0.000
Cw	53.429	jx	5.385
J	0.006	jy	0.000

COLD-FORMED STEEL DESIGN PROGRAM

PART: **South Purlin**

Thickness: 0.1000

	Length	Angle	Radius	w/t
1	0.900	90.000	0.1000	5.50
2	3.500	180.000	0.2500	28.00
3	10.000	-90.000	0.2500	93.00
4	3.500	0.000	0.2500	28.00
5	0.900	90.000	0.2500	5.50

SECTION PROPERTIES

Area	1.788	Wt/Ft	6.081
Top to CG	5.0000	Sx(t)	5.391
Bottom to CG	5.0000	Sx(b)	5.391
Left edge to CG	0.9706	Sy(l)	2.850
Right edge to CG	2.5294	Sy(r)	1.093
Ix	26.955	rx	3.882
Iy	2.766	ry	1.244
I1	26.955	r1	3.882
I2	2.766	r2	1.244
Ic	29.721	rc	4.077
Io	40.071	ro	4.733
Ixy	0.000	Xo	-2.406
Alpha	0.000	Yo	-0.000
Cw	53.429	jx	5.385
J	0.006	jy	0.000

SP-10C-12-2

Test Summary

Test Date: November 2, 1989

Purpose: Verify Method of Determining Axial Capacity

Span(s): 1 @ 25'-0"

Measured Dimensions:

	North	South
Thickness	0.10"	0.10"
Sweep	1/2"	1/4"

Parameters:
Axial Load Only
Screw down type decking
Two Purlin Lines 5'-0" O.C. 1'-0" overhang
Purlins facing each other
Simply supported
Lateral supports at ends only

Predicted Failure Loads: (F_y = 61.5 ksi)

Uplift: 9 plf M: 8.5 in-kip
Axial: 16.8 k

Actual Failure Load:

Uplift: 9 plf M: 8.5 in-kip
Axial: 18.0 k

P_a(Actual)/P_a(theory) = 1.07

Discussion:

- The purlins failed by torsional-flexural buckling
- Local buckling did not occur in the purlin
- The decking did buckle at the connection to the purlin
- The purlins were repeatedly unloaded then reloaded to failure which occurred @ 90% of the initial failure load
- Failure was in the south purlin
- Maximum horizontal deflection was 2.50"
- Maximum vertical deflection was 0.32"

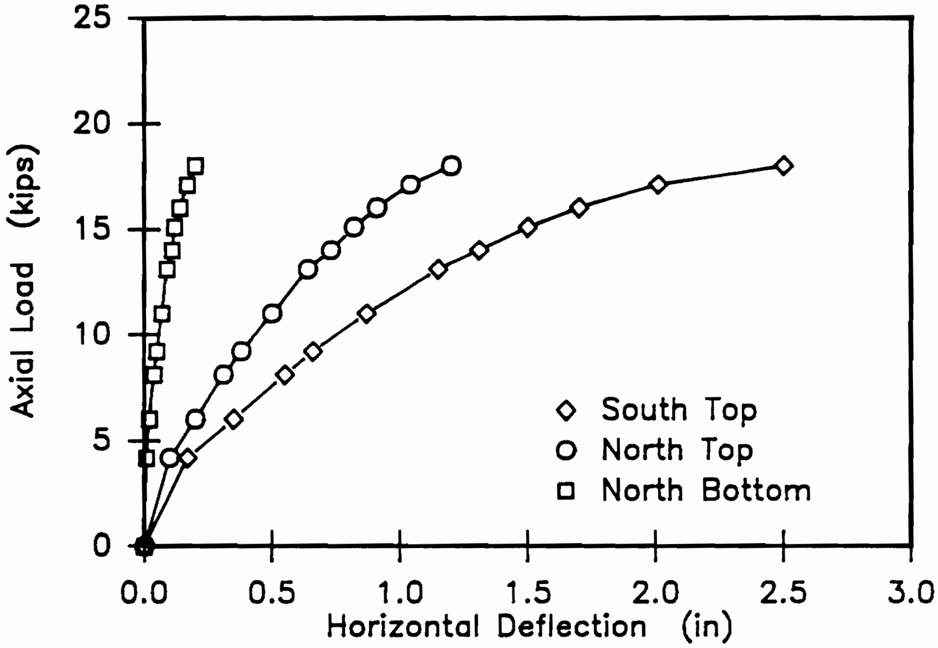


Figure G.10 Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-10C-12-2

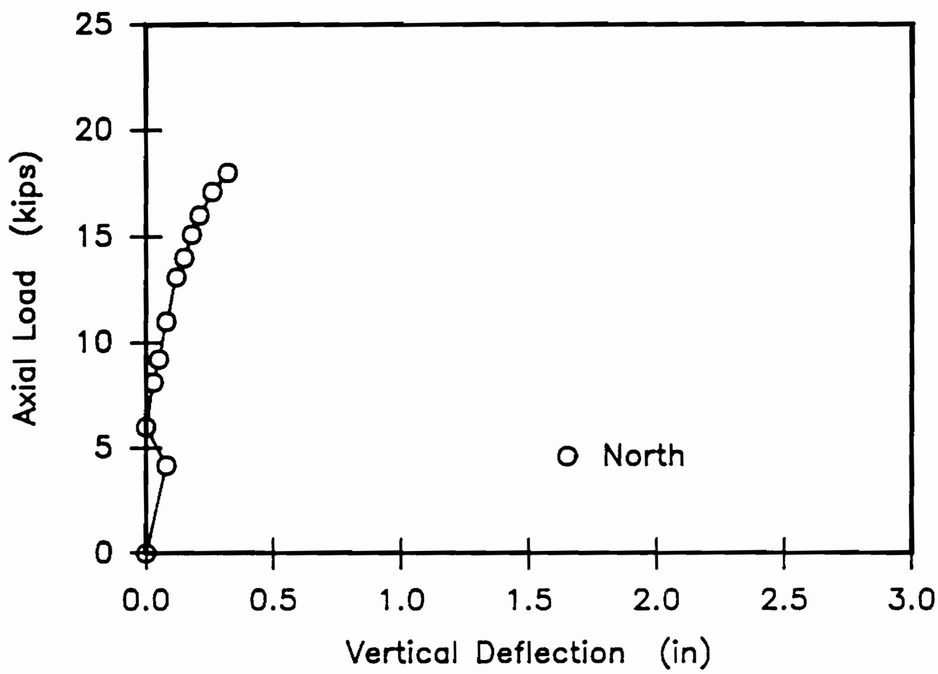
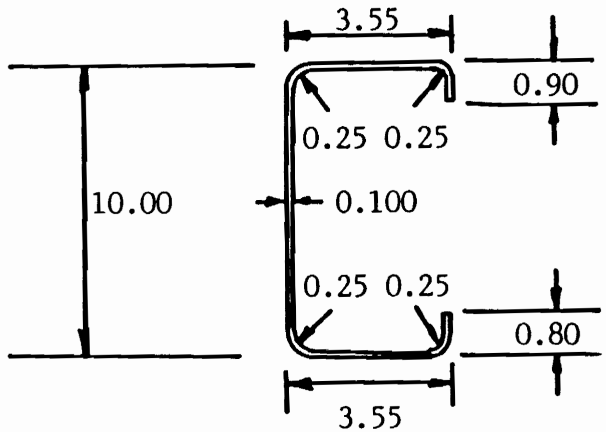
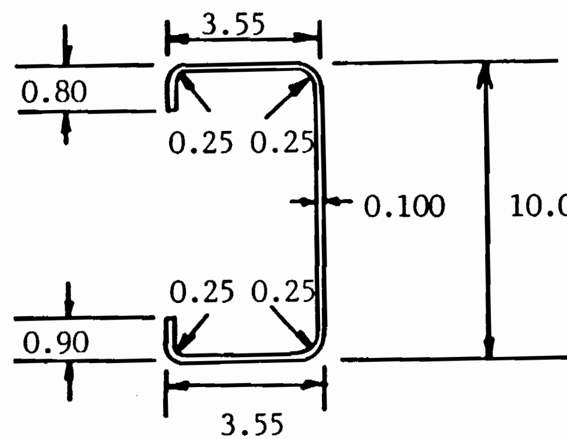


Figure G.9 Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-10C-12-2

Test No. SP-10C-12-2 Date 11-2-89 Recorder GLH



North Purlin



South Purlin

CALCULATION SHEET FOR TEST SP-10C-12-2

Moment Capacity (M_{ax})

M_{ax} = R x 1.67 x AISI Allowable Capacity

M_{ax} = .4 x 1.67 x 168.4 in-k = 112.5 in-k

Applied Moment (M)

$$M(\text{applied}) = \frac{wL^2}{8}$$

$$M(\text{applied}) = \frac{9\text{ lb/ft} \times \text{ft}/12'' \times 300''^2}{8 \times 1000\text{ lb/k}} = 8.5\text{ in-k}$$

Axial Capacity (P_a)

Fastener Location In The Flange		P_a (k)
2.75"	weak	19.7
1.50"	medium	25.5
.75"	strong	28.3

Actual average fastener location was 2.0" from the web, ∴ P_a = 23.2 k based on linear interpolation

Assumption

$$\frac{P}{P_a} + \frac{M\,Cm}{M_{ax}\left(1 - \frac{P}{P_a}\right)} = 1.0$$

Predicted Axial Failure Load

$$P = P_a\left(1 - \sqrt{\frac{M}{M_{ax}}}\right) = 23.2\text{ k}\left(1 - \sqrt{\frac{8.5}{112.5}}\right) = 16.8\text{ k}$$

SP10C2N

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.9000	0.8000
Lip angles	(degrees) :		90.0000	90.0000
Flange widths	(inches) :		3.5500	3.5500
Radii	(inches)			
Lip to flange	:		0.2500	0.2500
Flange to web	:		0.2500	0.2500
Total purlin depth	(inches) :	10.0000		
Purlin thickness	(inches) :	0.1000		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	61.5
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	2.8500
Gross moment of inertia	(in^4) :	27.02

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 2.2753	inches
Effective moment of inertia	: 24.57	in^4
Allowable flexural capacity	: 171.68	kip-in

SP10C2S

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.8000	0.9000
Lip angles	(degrees) :		90.0000	90.0000
Flange widths	(inches) :		3.5500	3.5500
Radii	(inches)			
Lip to flange	:		0.2500	0.2500
Flange to web	:		0.2500	0.2500
Total purlin depth	(inches) :	10.0000		
Purlin thickness	(inches) :	0.1000		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	61.5
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	2.8500
Gross moment of inertia	(in^4) :	27.02

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 2.1841	inches
Effective moment of inertia	: 24.39	in^4
Allowable flexural capacity	: 168.41	kip-in

2	ISEC (2=C SECTION, 3=Z SECTION
204.	STUD LENGTH XL
10.00	SECTION DEPTH HH
9.90	CENTERLINE DIMENSION OF WEB H
3.40	CENTERLINE DIMENSION OF FLG B
.85	CENTERLINE DIMENSION OF LIP D
.100	THICKNESS
.72	FORM FACTOR Q
53.2	S (K) SHEAR RIGIDITY
.1984	F (K-IN/IN-RAD) ROTATIONAL CAPACITY
.0955	GAMD (IN/IN) DIAPHRAGM STRAIN @ FAILURE
.2478	FED (RAD) PURLIN TWIST @ FAILURE
61.49	FY YIELD STRESS
12.	DISTANCE BETWEEN FASTENERS XL1
0.	1=DETAILS PRINTED 0=DETAILS NOT PRINTED
1.788	AREA
27.027	XXI
2.800	YYI
0.105	XYI
2.412	XO
0.006	XJ
53.388	CW

INPUT DATA TO (STUDA2.EXE) FOR TEST SP-10C-12-2

COLD-FORMED STEEL DESIGN PROGRAM

PART: **North Purlin**

Thickness: 0.1000

	Length	Angle	Radius	w/t
1	0.900	90.000	0.1000	5.50
2	3.550	0.000	0.2500	28.50
3	10.000	-90.000	0.2500	93.00
4	3.550	180.000	0.2500	28.50
5	0.800	90.000	0.2500	4.50

SECTION PROPERTIES

Area	1.788	Wt/Ft	6.081
Top to CG	4.9768	Sx(t)	5.431
Bottom to CG	5.0232	Sx(b)	5.380
Left edge to CG	2.5755	Sy(l)	1.087
Right edge to CG	0.9745	Sy(r)	2.874
Ix	27.027	rx	3.887
Iy	2.800	ry	1.251
I1	27.028	r1	3.887
I2	2.800	r2	1.251
Ic	29.828	rc	4.084
Io	40.250	ro	4.744
Ixy	-0.105	Xo	2.412
Alpha	0.248	Yo	0.099
Cw	53.388	jx	-5.409
J	0.006	jy	-0.117

COLD-FORMED STEEL DESIGN PROGRAM

PART: **South Purlin**

Thickness: 0.1000

	Length	Angle	Radius	w/t
1	0.800	90.000	0.1000	4.50
2	3.550	0.000	0.2500	28.50
3	10.000	-90.000	0.2500	93.00
4	3.550	180.000	0.2500	28.50
5	0.900	90.000	0.2500	5.50

SECTION PROPERTIES

Area	1.788	Wt/Ft	6.081
Top to CG	5.0232	Sx(t)	5.380
Bottom to CG	4.9768	Sx(b)	5.431
Left edge to CG	2.5755	Sy(l)	1.087
Right edge to CG	0.9745	Sy(r)	2.874
Ix	27.027	rx	3.887
Iy	2.800	ry	1.251
I1	27.028	r1	3.887
I2	2.800	r2	1.251
Ic	29.828	rc	4.084
Io	40.250	ro	4.744
Ixy	0.105	Xo	2.412
Alpha	-0.248	Yo	-0.099
Cw	53.388	jx	-5.409
J	0.006	jy	0.117

SP-10Z-12-1

Test Summary

Test Date: September 14, 1989

Purpose: Verify Method of Determining Axial Capacity

Span(s): 1 @ 17'-0"

Measured Dimensions:

	North	South
Thickness	0.074"	0.074"
Sweep	1/4"	1/8"

Parameters:
- Axial load only
- Screw down type decking
- Two Purlin Lines 5'-0" O.C. 1'-0" overhang
- Purlins facing each other
- Simple supported
- Lateral supports at ends only

Predicted Failure Loads: (F_y = 61.4 ksi)

Uplift: 7.6 plf M: 3.3 in-kip

Axial: 17.1 k

Actual Failure Load:

Uplift: 7.6 plf M: 3.3 in-kip

Axial: 15.0 k

$P_{(actual)}/P_{(theory)}$ = .88

M/M_{ax} = .03

Discussion:

- Torsional-flexural buckling was followed by local buckling of the web to unsupported flange junction
- Failure occurred in the north purlin
- Maximum horizontal deflection was 2.43"
- Maximum vertical deflection was 0.15"

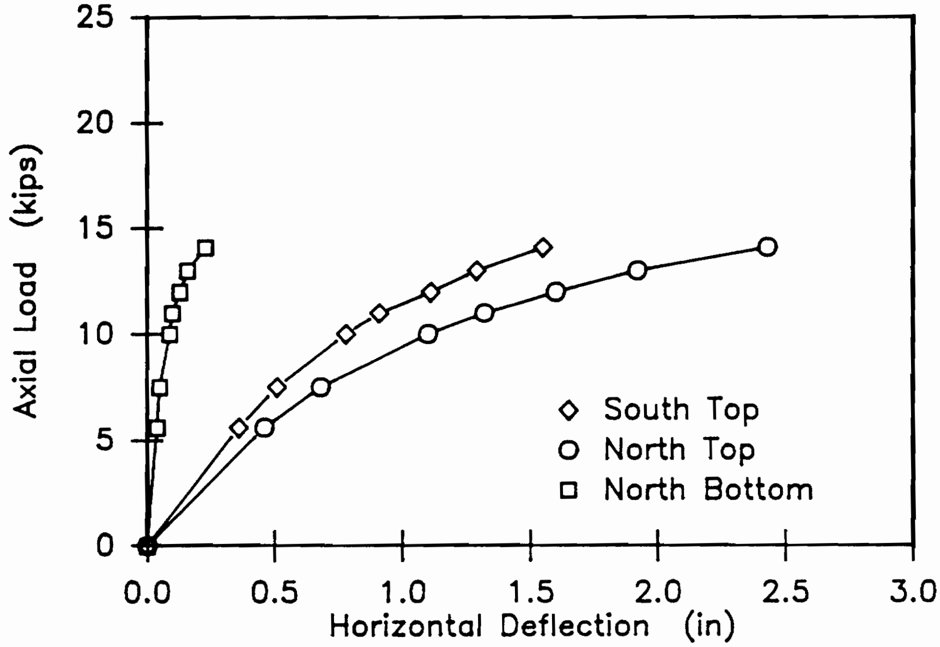


Figure G.11 Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-10Z-12-1

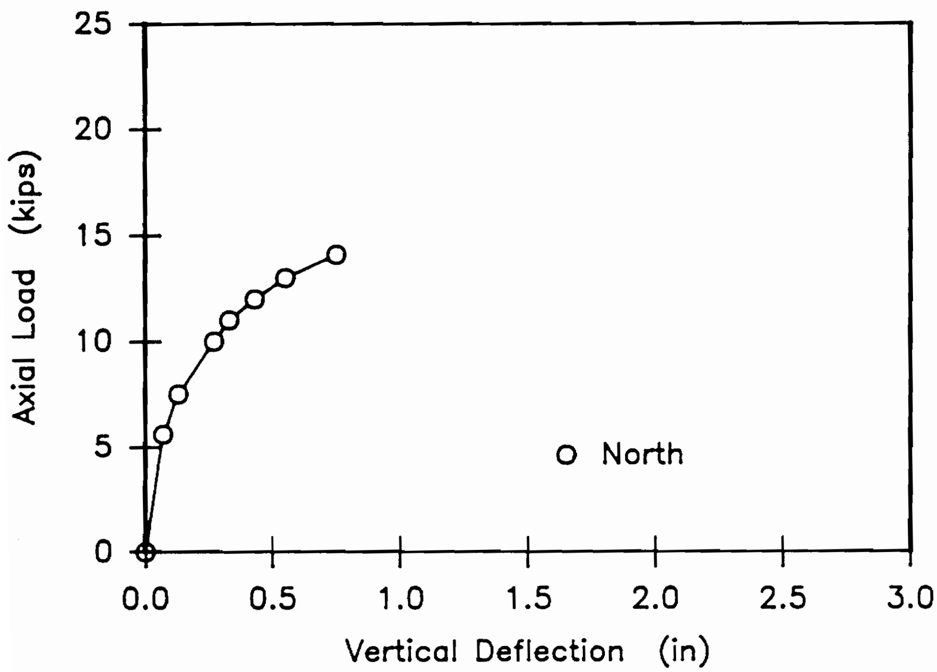
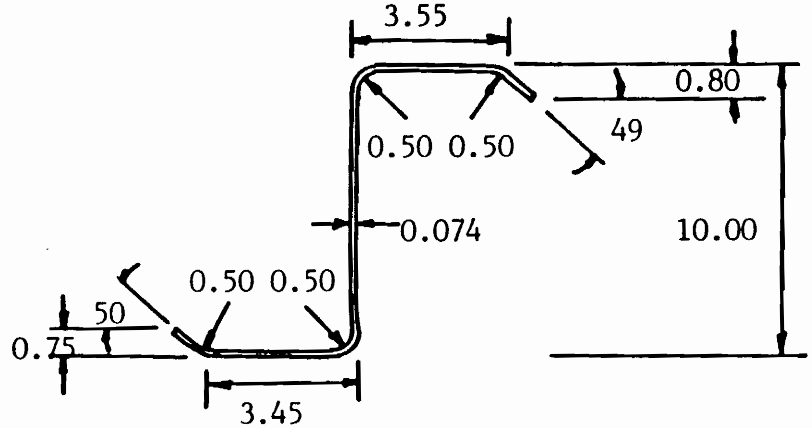
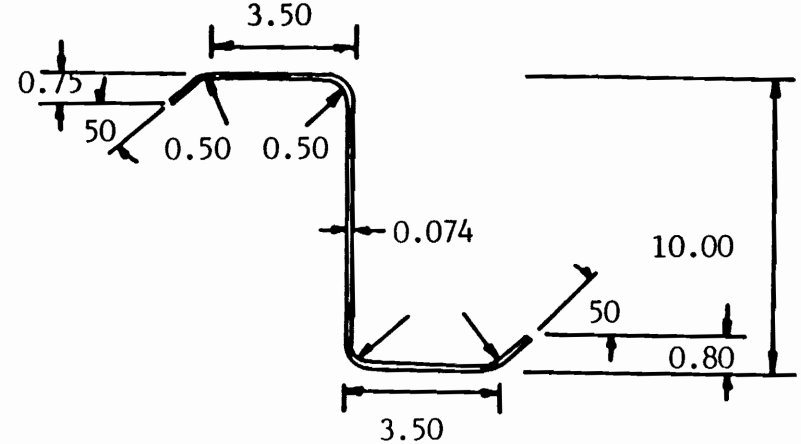


Figure G.12 Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-10Z-12-1

Test No. SP-10Z-12-1 Date 9-14-89 Recorder GLH



North Purlin



South Purlin

CALCULATION SHEET FOR TEST SP-10Z-12-1

Moment Capacity (M_{ax})

M_{ax} = R x 1.67 x AISI Allowable Capacity

M_{ax} = .5 x 1.67 x 126.7 in-k = 105.8 in-k

Applied Moment (M)

$$M(\text{applied}) = \frac{wL^2}{8}$$

$$M(\text{applied}) = \frac{7.6\ \text{lb/ft} \times \text{ft}/12" \times 204"^2}{8 \times 1000\ \text{lb/k}} = 3.3\ \text{in-k}$$

Axial Capacity (P_a)

Fastener Location In The Flange		P_a (k)
.5"	weak	17.0
2.0"	medium	20.8
3.0"	strong	22.2

Actual average fastener location was 2.0" from the web, ∴ P_a = 21.8 k based on linear interpolation

Assumption

$$\frac{P}{P_a} + \frac{M\,Cm}{M_{ax}\left(1 - \frac{P}{P_a}\right)} = 1.0$$

Predicted Axial Failure Load

$$P = P_a\left(1 - \sqrt{\frac{M}{M_{ax}}}\right) = 20.8\ \text{k}\left(1 - \sqrt{\frac{3.3}{105.8}}\right) = 17.1\ \text{k}$$

SP10Z1N

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.8000	0.7500
Lip angles	(degrees) :		49.0000	50.0000
Flange widths	(inches) :		3.5500	3.4500
Radii	(inches)			
Lip to flange	:		0.5000	0.5000
Flange to web	:		0.5000	0.5000
Total purlin depth	(inches) :	10.0000		
Purlin thickness	(inches) :	0.0740		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	61.4
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	2.7144
Gross moment of inertia	(in^4) :	20.64

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 1.9602	inches
Effective moment of inertia	: 18.35	in^4
Allowable flexural capacity	: 126.76	kip-in

SP10Z1S

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.7500	0.8000
Lip angles	(degrees) :		50.0000	50.0000
Flange widths	(inches) :		3.5000	3.5000
Radii	(inches)			
Lip to flange	:		0.5000	0.5000
Flange to web	:		0.5000	0.5000
Total purlin depth	(inches) :	10.0000		
Purlin thickness	(inches) :	0.0740		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	61.4
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	2.6583
Gross moment of inertia	(in^4) :	20.61

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 1.9137	inches
Effective moment of inertia	: 18.17	in^4
Allowable flexural capacity	: 123.35	kip-in

3	ISEC (2=C SECTION, 3=Z SECTION)
204.	STUD LENGTH XL
10.00	SECTION DEPTH HH
9.93	CENTERLINE DIMENSION OF WEB H
3.43	CENTERLINE DIMENSION OF FLG B
.73	CENTERLINE DIMENSION OF LIP D
.074	THICKNESS
.68	FORM FACTOR Q
656.	S (K) SHEAR RIGIDITY
.1437	F (K-IN/IN-RAD) ROTATIONAL CAPACITY
.0035	GAMD (IN/IN) DIAPHRAGM STRAIN @ FAILURE
.2204	FED (RAD) PURLIN TWIST @ FAILURE
61.38	FY YIELD STRESS
12.	DISTANCE BETWEEN FASTENERS XL1
0.	1=DETAILS PRINTED 0=DETAILS NOT PRINTED
1.354	AREA
20.703	XXI
4.067	YYI
-6.833	XYI
.022	XO
0.002	XJ
68.061	CW

INPUT DATA TO (STUDA2.EXE) FOR TEST SP-10Z-12-1

COLD-FORMED STEEL DESIGN PROGRAM

PART: **North Purlin**

Thickness: 0.0740

	Length	Angle	Radius	w/t
1	1.060	51.000	0.0740	10.62
2	3.550	0.000	0.5000	36.52
3	10.000	-90.000	0.5000	119.62
4	3.450	0.000	0.5000	35.25
5	0.980	50.000	0.5000	9.63

SECTION PROPERTIES

Area	1.354	Wt/Ft	4.603
Top to CG	4.9556	Sx(t)	4.178
Bottom to CG	5.0444	Sx(b)	4.104
Left edge to CG	4.1391	Sy(l)	0.983
Right edge to CG	4.0840	Sy(r)	0.996
Ix	20.703	rx	3.911
Iy	4.067	ry	1.733
I1	23.149	r1	4.135
I2	1.620	r2	1.094
Ic	24.770	rc	4.277
Io	24.888	ro	4.288
Ixy	-6.833	Xo	-0.022
Alpha	19.700	Yo	0.295
Cw	68.061	jx	-0.000
J	0.002	jy	-0.323

COLD-FORMED STEEL DESIGN PROGRAM

PART: **South Purlin**

Thickness: 0.0740

	Length	Angle	Radius	w/t
1	0.980	50.000	0.0740	9.63
2	3.500	0.000	0.5000	35.92
3	10.000	-90.000	0.5000	119.62
4	3.500	0.000	0.5000	35.92
5	1.040	50.000	0.5000	10.44

SECTION PROPERTIES

Area	1.353	Wt/Ft	4.599
Top to CG	5.0138	Sx(t)	4.126
Bottom to CG	4.9862	Sx(b)	4.149
Left edge to CG	4.1063	Sy(l)	0.986
Right edge to CG	4.1181	Sy(r)	0.983
Ix	20.689	rx	3.911
Iy	4.047	ry	1.730
I1	23.124	r1	4.135
I2	1.612	r2	1.092
Ic	24.736	rc	4.276
Io	24.750	ro	4.278
Ixy	-6.816	Xo	0.009
Alpha	19.660	Yo	-0.102
Cw	67.814	jx	-0.010
J	0.002	jy	0.113

SP-10Z-12-2

Test Summary

Test Date: November 12, 1989

Purpose: Verify Method of Determining P_a

Span(s): 1 @ 25'-0"

Measured Dimensions:

	North	South
Thickness	0.074"	0.074"
Sweep	1/4	0

Parameters:
Axial Load Only
Screw down type decking
Two Purlin Lines 5'-0" O.C. 1'-0" overhang
Purlins facing each other
Simply supported
Lateral supports at ends only

Predicted Failure Loads: (F_y = 62.0 ksi)

Uplift: 7.6 plf M: 7.1 in-kip

Axial: 13.1 k

Actual Failure Load:

Uplift: 7.6 plf M: 7.1 in-kip

Axial: 12.6 k

P_a(Actual)/P_a(theory) = .96

Discussion:

- Torsional-flexural buckling was followed by local buckling of the web to unsupported flange junction
- Local buckling occurred adjacent to the weakest screw location located 2 1/2 ft. from midspan.
- Weak screw locations were weaker than those used in the rotational stiffness test.
- Failure occurred in the south purlin
- Maximum horizontal deflection was 2.80"
- Maximum vertical deflection was 0.12"

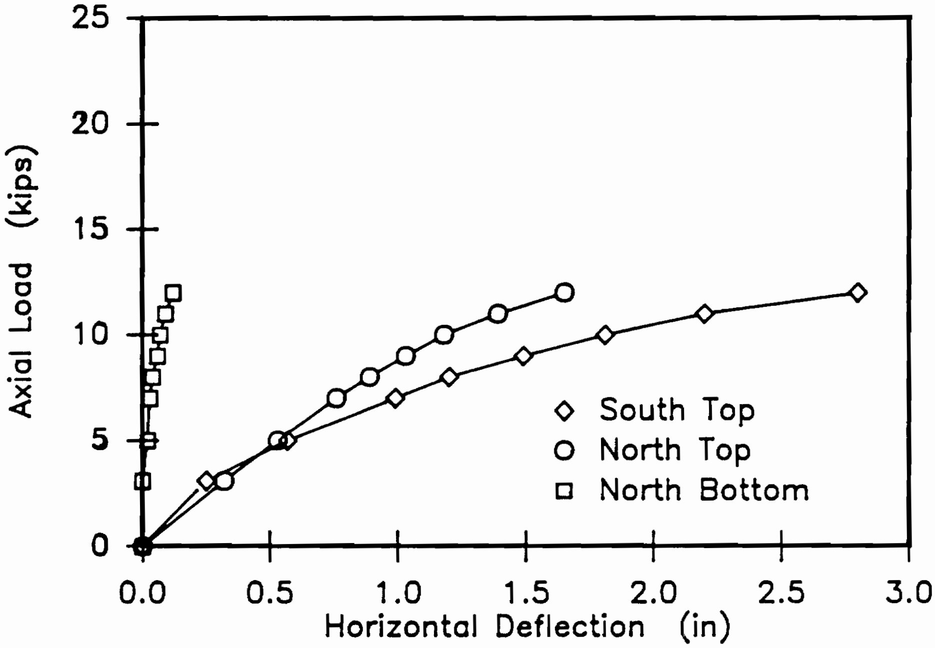


Figure G.13 Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-10Z-12-2

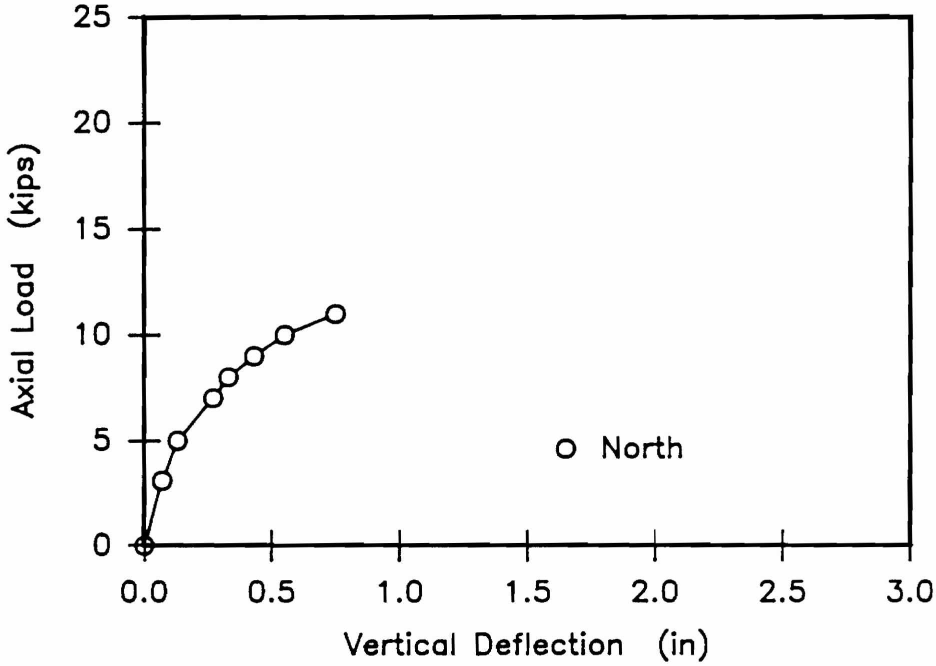
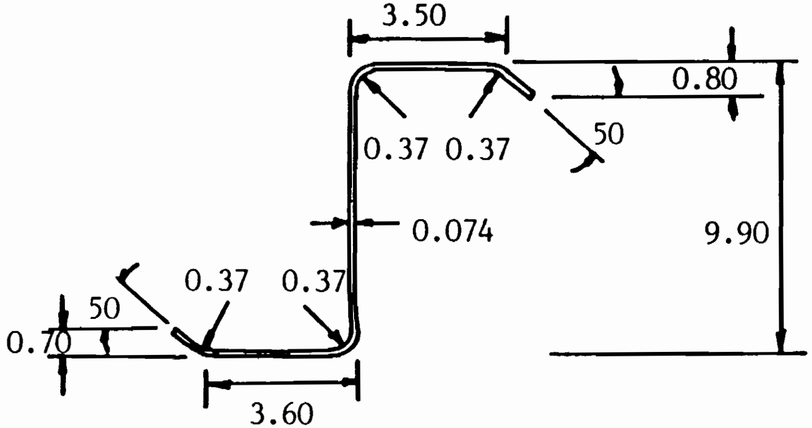
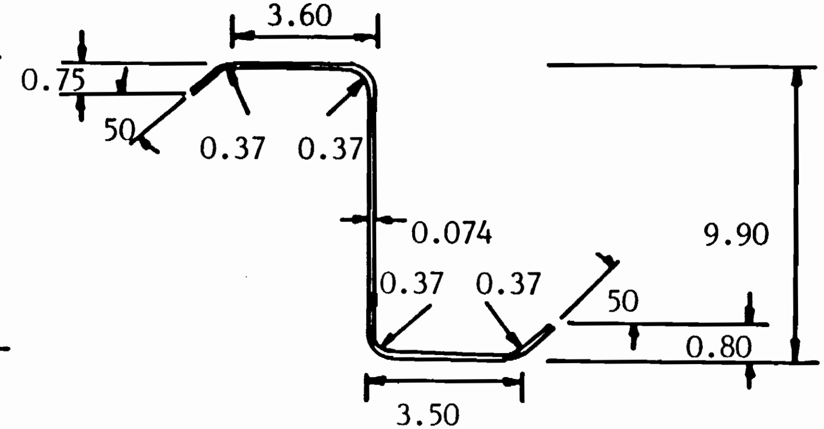


Figure G.14 Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-10Z-12-2

Test No. SP-10Z-12-2 Date 11-12-89 Recorder GLH



North Purlin



South Purlin

CALCULATION SHEET FOR
TEST SP-10Z-12-2

Moment Capacity (M_{ax})

M_{ax} = R x 1.67 x AISI Allowable Capacity

M_{ax} = .5 x 1.67 x 120.0 in-k = 100.2 in-k

Applied Moment (M)

$$M(\text{applied}) = \frac{wL^2}{8}$$

$$M(\text{applied}) = \frac{7.6\ \text{lb/ft} \times \text{ft}/12" \times 300"^2}{8 \times 1000\ \text{lb/k}} = 7.1\ \text{in-k}$$

Axial Capacity (P_a)

Fastener Location In The Flange		P_a (k)
.5"	weak	13.2
2.0"	medium	22.0
3.0"	strong	26.3

Actual average fastener location was 1 1/4" from the web, ∴ P_a = 17.8 k based on linear interpolation

Assumption

$$\frac{P}{P_a} + \frac{M\,Cm}{M_{ax}\left(1 - \frac{P}{P_a}\right)} = 1.0$$

Predicted Axial Failure Load

$$P = P_a\left(1 - \sqrt{\frac{M}{M_{ax}}}\right) = 17.8\ \text{k}\left(1 - \sqrt{\frac{7.1}{100.2}}\right) = 13.1\ \text{k}$$

SP10Z2N

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.8000	0.7000
Lip angles	(degrees) :		50.0000	50.0000
Flange widths	(inches) :		3.5000	3.6000
Radii	(inches)			
Lip to flange	:		0.3700	0.3700
Flange to web	:		0.3700	0.3700
Total purlin depth	(inches) :	9.9000		
Purlin thickness	(inches) :	0.0740		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	62.0
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	2.8490
Gross moment of inertia	(in^4) :	20.47

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 2.0275	inches
Effective moment of inertia	: 17.82	in^4
Allowable flexural capacity	: 122.54	kip-in

SP10Z2S

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.7500	0.8000
Lip angles	(degrees) :		50.0000	50.0000
Flange widths	(inches) :		3.6000	3.5000
Radii	(inches)			
Lip to flange	:		0.3700	0.3700
Flange to web	:		0.3700	0.3700
Total purlin depth	(inches) :	9.9000		
Purlin thickness	(inches) :	0.0740		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	62.0
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	2.9490
Gross moment of inertia	(in^4) :	20.55

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 2.0204	inches
Effective moment of inertia	: 17.59	in^4
Allowable flexural capacity	: 120.00	kip-in

3	ISEC (2=C SECTION, 3=Z SECTION)
300.	STUD LENGTH XL
10.00	SECTION DEPTH HH
9.90	CENTERLINE DIMENSION OF WEB H
3.45	CENTERLINE DIMENSION OF FLG B
.75	CENTERLINE DIMENSION OF LIP D
.074	THICKNESS
.68	FORM FACTOR Q
656.	S (K) SHEAR RIGIDITY
.1437	F (K-IN/IN-RAD) ROTATIONAL CAPACITY
.0035	GAMD (IN/IN) DIAPHRAGM STRAIN @ FAILURE
.2204	FED (RAD) PURLIN TWIST @ FAILURE
61.98	FY YIELD STRESS
12.	DISTANCE BETWEEN FASTENERS XL1
0.	1=DETAILS PRINTED 0=DETAILS NOT PRINTED
1.348	AREA
20.310	XXI
4.116	YYI
6.827	XYI
0.010	XO
0.002	XJ
67.025	CW

INPUT DATA TO (STUDA2.EXE) FOR TEST SP-10Z-12-2

COLD-FORMED STEEL DESIGN PROGRAM

PART: **North Purlin**

Thickness: 0.0740

	Length	Angle	Radius	w/t
1	0.980	-50.000	0.0740	9.63
2	3.500	0.000	0.5000	35.92
3	9.900	90.000	0.5000	118.27
4	3.600	0.000	0.5000	37.27
5	0.980	-50.000	0.5000	9.63

SECTION PROPERTIES

Area	1.348	Wt/Ft	4.584
Top to CG	4.9230	Sx(t)	4.126
Bottom to CG	4.9770	Sx(b)	4.081
Left edge to CG	4.1172	Sy(l)	1.000
Right edge to CG	4.1686	Sy(r)	0.987
Ix	20.310	rx	3.881
Iy	4.116	ry	1.747
I1	22.804	r1	4.113
I2	1.622	r2	1.097
Ic	24.426	rc	4.257
Io	24.462	ro	4.260
Ixy	6.827	Xo	0.010
Alpha	-20.067	Yo	0.163
Cw	67.025	jx	0.017
J	0.002	jy	-0.176

COLD-FORMED STEEL DESIGN PROGRAM

PART: **South Purlin**

Thickness: 0.0740

	Length	Angle	Radius	w/t
1	0.980	-50.000	0.0740	9.63
2	3.500	0.000	0.5000	35.92
3	9.900	90.000	0.5000	118.27
4	3.600	0.000	0.5000	37.27
5	0.980	-50.000	0.5000	9.63

SECTION PROPERTIES

Area	1.348	Wt/Ft	4.584
Top to CG	4.9230	Sx(t)	4.126
Bottom to CG	4.9770	Sx(b)	4.081
Left edge to CG	4.1172	Sy(l)	1.000
Right edge to CG	4.1686	Sy(r)	0.987
Ix	20.310	rx	3.881
Iy	4.116	ry	1.747
I1	22.804	r1	4.113
I2	1.622	r2	1.097
Ic	24.426	rc	4.257
Io	24.462	ro	4.260
Ixy	6.827	Xo	0.010
Alpha	-20.067	Yo	0.163
Cw	67.025	jx	0.017
J	0.002	jy	-0.176

SP-10Z-12-3

Test Summary

Test Date: November 25, 1989

Purpose: Verify Method of Determining P_a

Span(s): 1 @ 21'-0"

Measured Dimensions:

	North	South
Thickness	0.074"	0.074"
Sweep	1/8	0

Parameters: Axial Load Only

Screw down type decking

Two Purlin Lines 5'-0" O.C. 1'-0" overhang

Purlins facing each other

Simply supported

Lateral supports at ends only

Predicted Failure Loads: (F_y = 59.5 ksi)

Uplift: 7.6 plf M: 5.0 in-kip

Axial: 17.2 k

Actual Failure Load:

Uplift: 7.6 plf M: 5.0 in-kip

Axial: 18.2 k

P_a(Actual)/P_a(theory) = 1.05

Discussion:

- Torsional-flexural buckling was followed by local buckling of the web to unsupported flange junction
- Failure occurred in the south purlin
- Maximum horizontal deflection was 2.90"
- Maximum vertical deflection was 0.67"

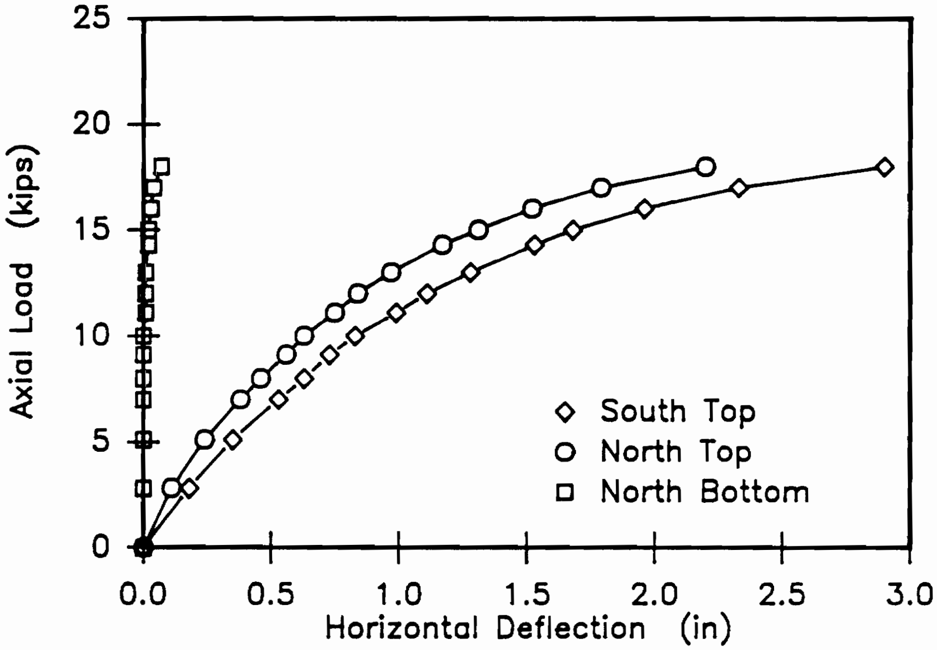


Figure G.16 Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-10Z-12-3

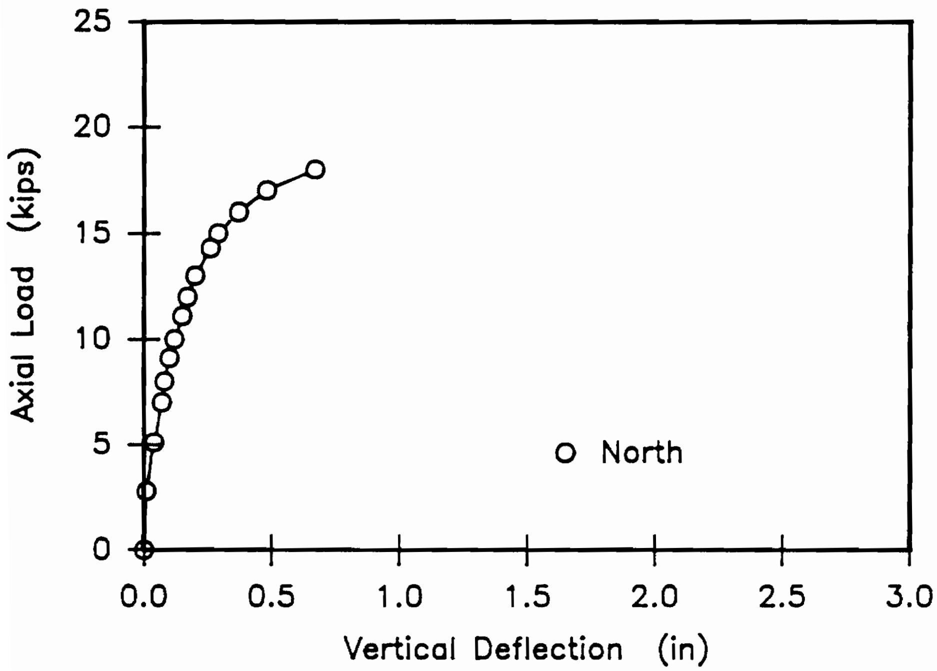
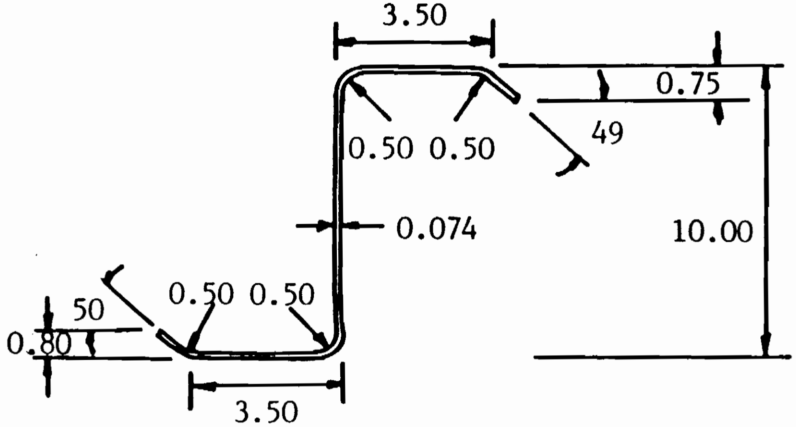
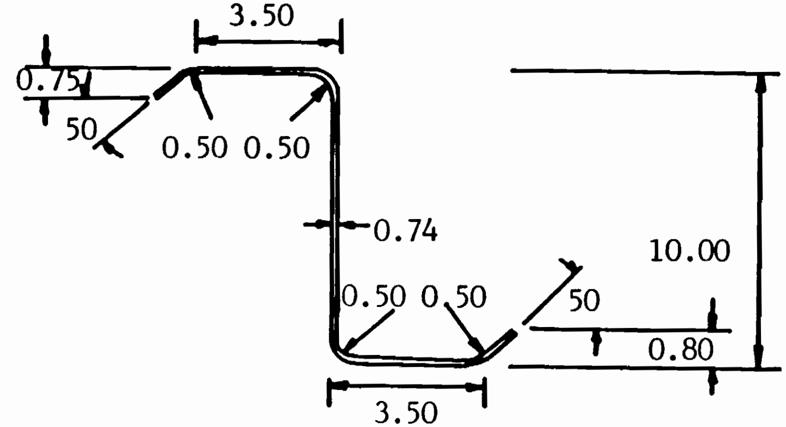


Figure G.15 Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-10Z-12-3

Test No. SP-10Z-12-3 Date 11-25-89 Recorder GLH



North Purlin



South Purlin

CALCULATION SHEET FOR
TEST SP-10Z-12-3

Moment Capacity (M_{ax})

M_{ax} = R x 1.67 x AISI Allowable Capacity

M_{ax} = .5 x 1.67 x 121.1 in-k = 101.1 in-k

Applied Moment (M)

$$M(\text{applied}) = \frac{wL^2}{8}$$

$$M(\text{applied}) = \frac{7.6\ \text{lb/ft} \times \text{ft}/12" \times 300"^2}{8 \times 1000\ \text{lb/k}} = 5.0\ \text{in-k}$$

Axial Capacity (P_a)

Fastener Location In The Flange		P_a (k)
.5"	weak	14.4
2.0"	medium	20.9
3.0"	strong	23.5

Actual average fastener location was 2.5" from the web, ∴ P_a = 22.2 k based on linear interpolation

Assumption

$$\frac{P}{P_a} + \frac{M\,C_m}{M_{ax}\left(1 - \frac{P}{P_a}\right)} = 1.0$$

Predicted Axial Failure Load

$$P = P_a\left(1 - \sqrt{\frac{M}{M_{ax}}}\right) = 22.2\ \text{k}\left(1 - \sqrt{\frac{5.0}{101.1}}\right) = 17.2\ \text{k}$$

SP10Z3N

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.7500	0.8000
Lip angles	(degrees) :		49.0000	50.0000
Flange widths	(inches) :		3.5000	3.5000
Radii	(inches)			
Lip to flange	:		0.5000	0.5000
Flange to web	:		0.5000	0.5000
Total purlin depth	(inches) :	10.0000		
Purlin thickness	(inches) :	0.0740		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	59.5
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	2.6644
Gross moment of inertia	(in^4) :	20.64

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 1.9467	inches
Effective moment of inertia	: 18.34	in^4
Allowable flexural capacity	: 121.40	kip-in

SP10Z3S

GEOMETRY OF CROSS-SECTION

		TOP	BOTTOM
Vertical lip dimensions	(inches) :	0.7500	0.8000
Lip angles	(degrees) :	50.0000	50.0000
Flange widths	(inches) :	3.5000	3.5000
Radii	(inches)		
Lip to flange	:	0.5000	0.5000
Flange to web	:	0.5000	0.5000

Total purlin depth	(inches) :	10.0000
Purlin thickness	(inches) :	0.0740

MATERIAL PROPERTIES

Material yield stress	(ksi) :	59.5
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	2.6583
Gross moment of inertia	(in^4) :	20.61

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 1.9395	inches
Effective moment of inertia	: 18.31	in^4
Allowable flexural capacity	: 121.08	kip-in

3	ISEC (2=C SECTION, 3=Z SECTION)
252.	STUD LENGTH XL
10.00	SECTION DEPTH HH
9.926	CENTERLINE DIMENSION OF WEB H
3.426	CENTERLINE DIMENSION OF FLG B
.75	CENTERLINE DIMENSION OF LIP D
.074	THICKNESS
.68	FORM FACTOR Q
656.0	S (K) SHEAR RIGIDITY
.1437	F (K-IN/IN-RAD) ROTATIONAL CAPACITY
.0035	GAMD (IN/IN) DIAPHRAGM STRAIN @ FAILURE
.2204	FED (RAD) PURLIN TWIST @ FAILURE
59.50	FY YIELD STRESS
12.	DISTANCE BETWEEN FASTENERS XL1
0.	1=DETAILS PRINTED 0=DETAILS NOT PRINTED
1.353	AREA
20.689	XXI
4.047	YYI
6.816	XYI
0.009	XO
0.002	XJ
67.814	CW

INPUT DATA TO (STUDA2.EXE) FOR TEST SP-10Z-12-3

COLD-FORMED STEEL DESIGN PROGRAM

PART: **North Purlin**

Thickness: 0.0740

	Length	Angle	Radius	w/t
1	0.990	49.000	0.0740	9.84
2	3.500	0.000	0.5000	36.01
3	10.000	-90.000	0.5000	119.62
4	3.500	0.000	0.5000	35.92
5	1.040	50.000	0.5000	10.44

SECTION PROPERTIES

Area	1.353	Wt/Ft	4.602
Top to CG	5.0104	Sx(t)	4.134
Bottom to CG	4.9896	Sx(b)	4.151
Left edge to CG	4.1228	Sy(l)	0.986
Right edge to CG	4.1212	Sy(r)	0.987
Ix	20.711	rx	3.912
Iy	4.066	ry	1.733
I1	23.158	r1	4.136
I2	1.619	r2	1.094
Ic	24.777	rc	4.279
Io	24.785	ro	4.279
Ixy	-6.836	Xo	0.007
Alpha	19.699	Yo	-0.079
Cw	68.116	jx	-0.011
J	0.002	jy	0.088

COLD-FORMED STEEL DESIGN PROGRAM

PART: **South Purlin**

Thickness: 0.0740

	Length	Angle	Radius	w/t
1	0.980	50.000	0.0740	9.63
2	3.500	0.000	0.5000	35.92
3	10.000	-90.000	0.5000	119.62
4	3.500	0.000	0.5000	35.92
5	1.040	50.000	0.5000	10.44

SECTION PROPERTIES

Area	1.353	Wt/Ft	4.599
Top to CG	5.0138	Sx(t)	4.126
Bottom to CG	4.9862	Sx(b)	4.149
Left edge to CG	4.1063	Sy(l)	0.986
Right edge to CG	4.1181	Sy(r)	0.983
Ix	20.689	rx	3.911
Iy	4.047	ry	1.730
I1	23.124	r1	4.135
I2	1.612	r2	1.092
Ic	24.736	rc	4.276
Io	24.750	ro	4.278
Ixy	-6.816	Xo	0.009
Alpha	19.660	Yo	-0.102
Cw	67.814	jx	-0.010
J	0.002	jy	0.113

APPENDIX H

INTERACTION TEST DATA PACKS

SP-8Z-0

Test Summary

Test Date: April 17, 1989

Purpose: Determine Axial Capacity

Span(s): 1 @ 25'-0"

Measured Dimensions:

	North	South
Thickness	0.060"	0.060"
Sweep	0"	0.25"

Parameters:
Axial Load Only
Screw down type decking
Two Purlin Lines 5'-0" O.C. 1'-0" overhang
Purlins facing each other
Simple supports W.R.T. vertical bending and torsion
Lateral supports at ends only

Failure Load:

Uplift: 5.0 plf M: 4.7 in-kip

Axial: 10.1 k Failure Mode: Lateral-Torsional Buckling

Predicted Failure Loads: (F_y = 65.1 ksi)

Uplift: 5.0 plf M: 4.7 in-kip

Axial: TBD k

Discussion:

- Maximum horizontal deflection was 1.90"
- Maximum vertical deflection was 1.05"
- Failure was in south purlin

Lateral torsional buckling was followed by local buckling of the web to top flange junction.

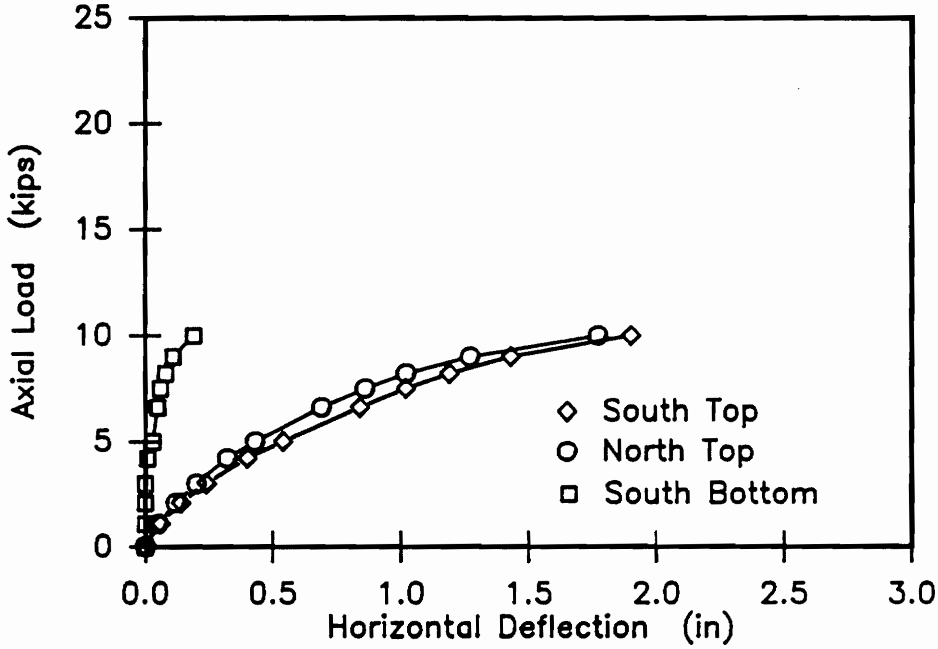


Figure H.1 Axial Load versus Midspan Deflection of Purlin Flanges for Test SP-8Z-0

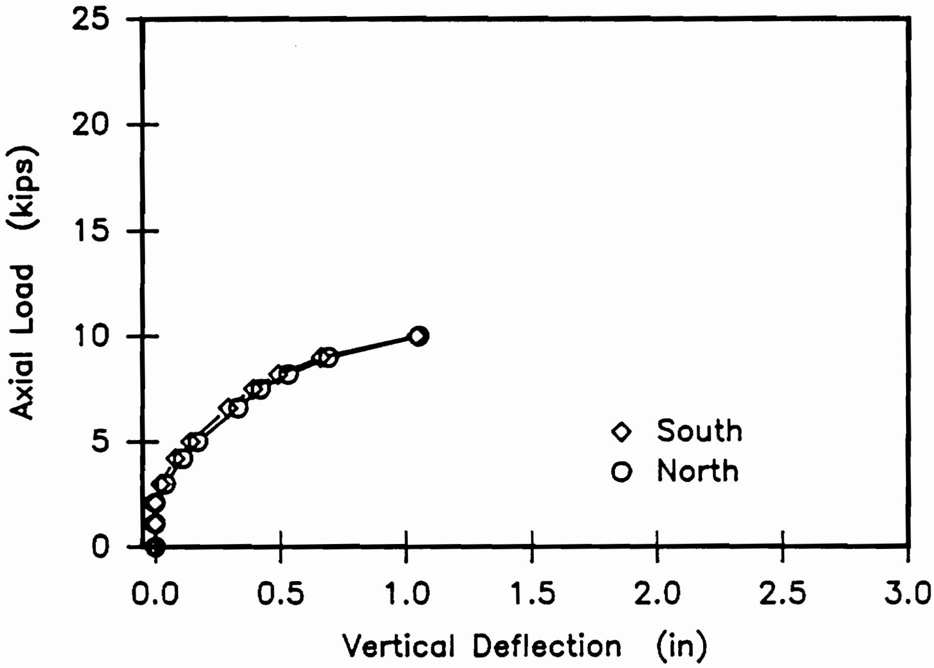
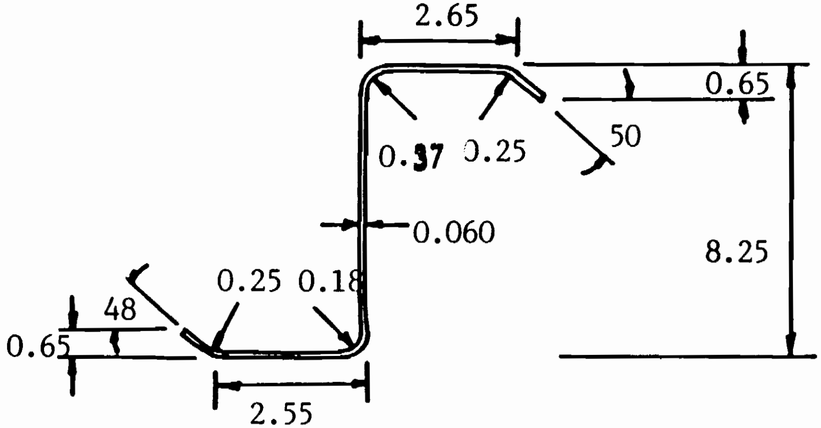
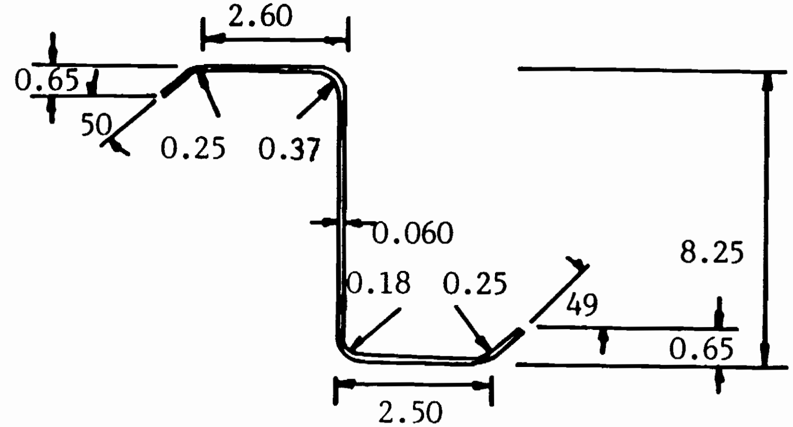


Figure H.2 Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-8Z-0

Test No. SP-8Z-0 Date 4-11-89 Recorder GLH



North Purlin



South Purlin

CALCULATION SHEET FOR TEST SP-8Z-0

Moment Capacity (M_{ax})

M_{ax} = R x 1.67 x AISI Allowable Capacity

M_{ax} = .5 x 1.67 x 71.1 in-k = 59.3 in-k

Distributed Load

Dead Weight = 5 lb/ft ÷ 19.175 lb/ft/in of water = .26 in

$$\text{Total Allowable} = \frac{M_{ax} \times 8}{L^2} = \frac{59.3 \text{ in-k} \times 1000 \text{ lb}/12'' \times 8}{25'^2} = 63.3 \text{ lb/ft}$$

Total Allowable = 63.3 lb/ft ÷ 19.175 lb/ft/in of water = 3.3 in of water

Set vacuum at 0 inches of water

w = (0 inches) (19.175 lb/ft/in) + 5 lb/ft = 5 lb/ft

Applied Moment (M)

$$M(\text{applied}) = \frac{wL^2}{8}$$

$$M(\text{applied}) = \frac{5 \text{ lb/ft} \times \text{ft}/12'' \times 300''^2}{8 \times 1000 \text{ lb/k}} = 4.7 \text{ in-k}$$

Assumption

$$\frac{P}{P_a} + \frac{M\,Cm}{M_{ax}\left(1 - \frac{P}{P_a}\right)} = 1.0$$

Predicted Axial Failure Load

P_a = TBD

SP8ZON

GEOMETRY OF CROSS-SECTION

		TOP	BOTTOM
Vertical lip dimensions	(inches) :	0.6500	0.6500
Lip angles	(degrees) :	50.0000	49.0000
Flange widths	(inches) :	2.6000	2.5000
Radii	(inches)		
Lip to flange	:	0.2500	0.2500
Flange to web	:	0.3750	0.3750

Total purlin depth	(inches) :	8.3750
Purlin thickness	(inches) :	0.0600

MATERIAL PROPERTIES

Material yield stress	(ksi) :	65.1
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	2.0204
Gross moment of inertia	(in^4) :	9.12

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 1.5491	inches
Effective moment of inertia	: 8.15	in^4
Allowable flexural capacity	: 71.06	kip-in

SP8ZOS

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.6500	0.6500
Lip angles	(degrees) :		50.0000	48.0000
Flange widths	(inches) :		2.6500	2.5500
Radii	(inches)			
Lip to flange	:		0.2500	0.2500
Flange to web	:		0.3750	0.3750
Total purlin depth	(inches) :	8.3750		
Purlin thickness	(inches) :	0.0600		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	65.1
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	2.0704
Gross moment of inertia	(in^4) :	9.23

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	:	1.5644	inches
Effective moment of inertia	:	8.20	in^4
Allowable flexural capacity	:	71.18	kip-in

SP-8Z-0-2

Test Summary

Test Date: May 12, 1989

Purpose: Determine Axial Capacity

Span(s): 1 @ 25'-0"

Measured Dimensions:

	North	South
Thickness	0.060"	0.061"
Sweep	0.50"	0.50"

Parameters: Axial Load Only

Screw down type decking

Two Purlin Lines 5'-0" O.C. 1'-0" overhang

Purlins facing each other

Simple supports W.R.T. vertical bending and torsion

Lateral supports at ends only

Failure Load:

Uplift: 5.0 plf M: 4.7 in-kip

Axial: 9.3 k Failure Mode: Lateral-Torsional Buckling

Predicted Failure Loads: (F_y = 65.1 ksi)

Uplift: 5.0 plf M: 4.7 in-kip

Axial: TBD k

Discussion:

- Maximum horizontal deflection was 1.98"
- Maximum vertical deflection was 1.19"
- Failure was in south purlin

Lateral torsional buckling was followed by local buckling of the web to top flange junction.

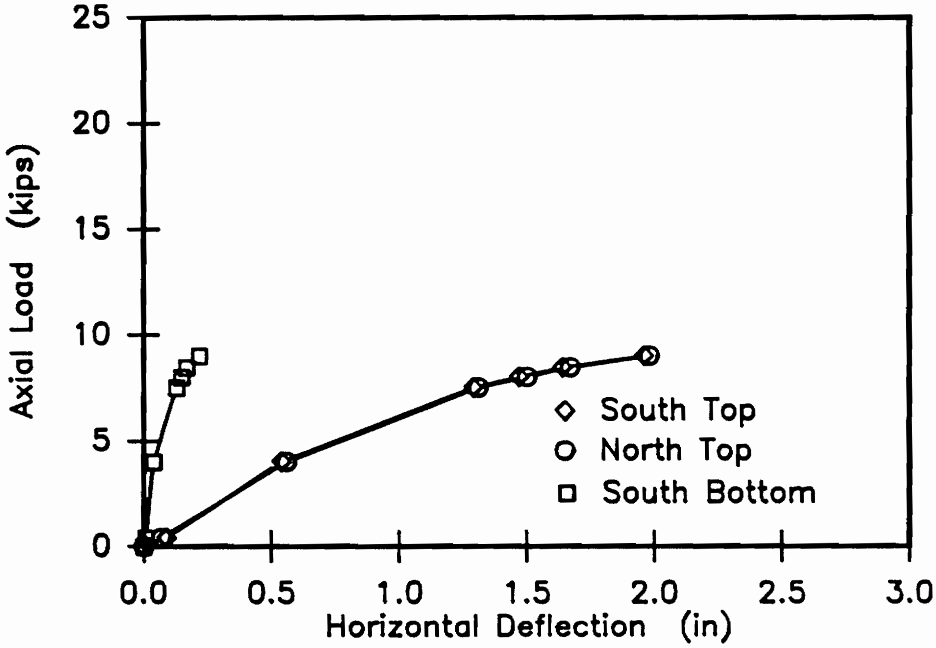


Figure H.3 Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-8Z-0-2

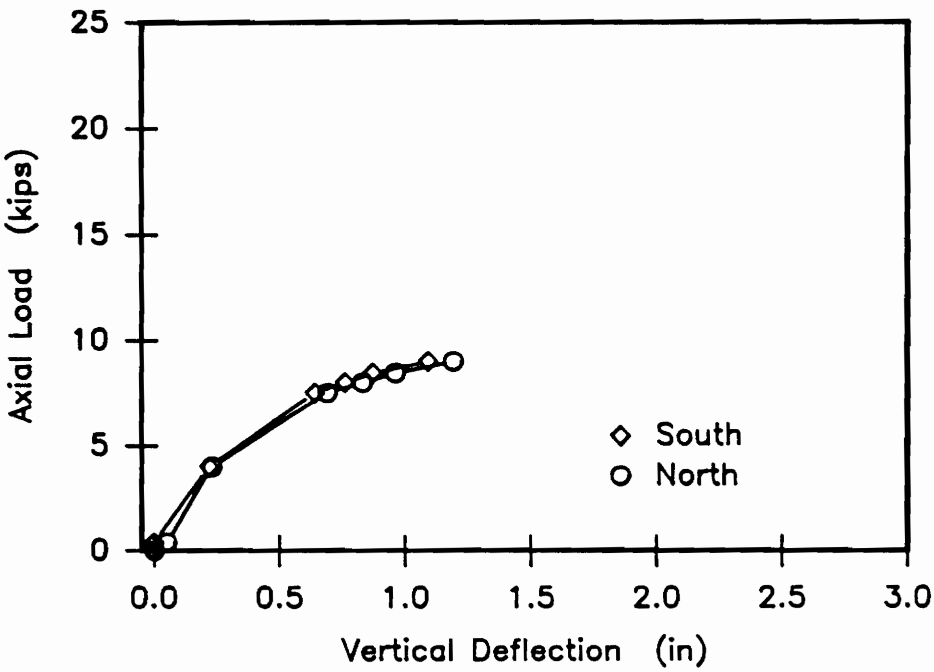
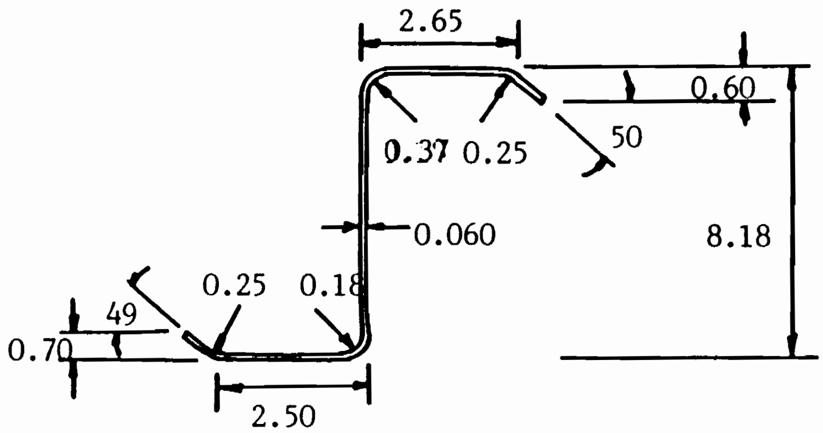
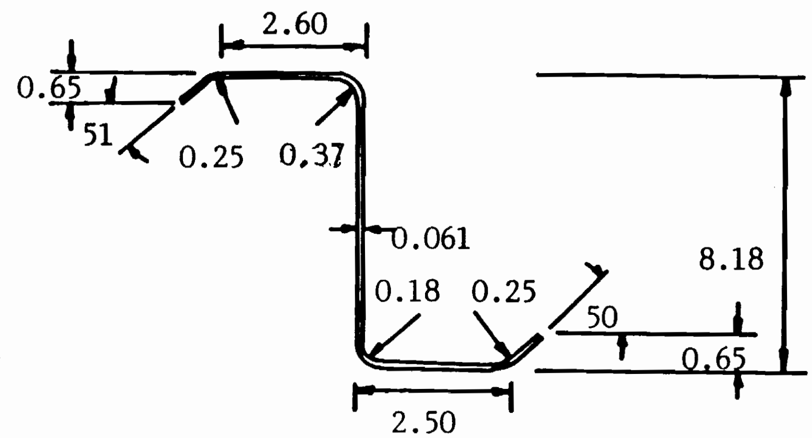


Figure H.4 Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-8Z-0-2

Test No. SP-8Z-0-2 Date 5-11-89 Recorder GLH



North Purlin



South Purlin

CALCULATION SHEET FOR TEST SP-8Z-0-2

Moment Capacity (M_{ax})

M_{ax} = R x 1.67 x AISI Allowable Capacity

M_{ax} = .5 x 1.67 x 69.1 in-k = 57.7 in-k

Distributed Load

Dead Weight = 5 lb/ft ÷ 19.175 lb/ft/in of water = .26 in

$$\text{Total Allowable} = \frac{M_{ax} \times 8}{L^2} = \frac{57.7 \text{ in-k} \times 1000 \text{ lb}/12" \times 8}{25'^2} = 61.5 \text{ lb/ft}$$

Total Allowable = 61.5 lb/ft ÷ 19.175 lb/ft/in of water = 3.2 in of water

Set vacuum at 0 inches of water

w = (0 inches) (19.175 lb/ft/in) + 5 lb/ft = 5 lb/ft

Applied Moment (M)

$$M(\text{applied}) = \frac{wL^2}{8}$$

$$M(\text{applied}) = \frac{5 \text{ lb/ft} \times \text{ft}/12" \times 300"^2}{8 \times 1000 \text{ lb/k}} = 4.7 \text{ in-k}$$

Assumption

$$\frac{P}{P_a} + \frac{M\,Cm}{M_{ax}\left(1 - \frac{P}{P_a}\right)} = 1.0$$

Predicted Axial Failure Load

P_a = TBD

SP8Z02N

GEOMETRY OF CROSS-SECTION

		TOP	BOTTOM
Vertical lip dimensions	(inches) :	0.6000	0.7000
Lip angles	(degrees) :	50.0000	49.0000
Flange widths	(inches) :	2.6500	2.5000
Radii	(inches)		
Lip to flange	:	0.2500	0.2500
Flange to web	:	0.3750	0.3750

Total purlin depth	(inches) :	8.3750
Purlin thickness	(inches) :	0.0600

MATERIAL PROPERTIES

Material yield stress	(ksi) :	65.1
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	2.0704
Gross moment of inertia	(in^4) :	9.17

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 1.5444	inches
Effective moment of inertia	: 8.05	in^4
Allowable flexural capacity	: 69.14	kip-in

1980 AISI PROCEDURE

SP8Z02S

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.6500	0.6500
Lip angles	(degrees) :		51.0000	50.0000
Flange widths	(inches) :		2.6000	2.5000
Radii	(inches)			
Lip to flange	:		0.2500	0.2500
Flange to web	:		0.3750	0.3750
Total purlin depth	(inches) :	8.3750		
Purlin thickness	(inches) :	0.0610		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	65.1
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	2.0157
Gross moment of inertia	(in^4) :	9.24

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	:	1.5599	inches
Effective moment of inertia	:	8.30	in^4
Allowable flexural capacity	:	72.63	kip-in

SP-8Z-25

Test Summary

Test Date: May 8, 1989

Purpose: Check interaction equation accuracy

Span(s): 1 @ 25'-0"

Measured Dimensions:

	North	South
Thickness	0.060"	0.061"
Sweep	0.20"	0.45"

Parameters:
25% of uplift capacity plus axial load
Screw down type decking
Two Purlin Lines 5'-0" O.C. 1'-0" overhang
Purlins facing each other
Simple supports W.R.T. vertical bending and torsion
Lateral supports at ends only

Failure Load:

Uplift: 14.6 plf M: 13.7 in-kip

Axial: 8.5 k Failure Mode: Lateral-Torsional Buckling

Predicted Failure Loads: (F_y = 66.8 ksi)

Uplift: 14.6 plf M: 13.7 in-kip

Axial: 7.3 k

Discussion:

- Maximum horizontal deflection was 2.79"
- Maximum vertical deflection was 1.98"
- Failure was in north purlin

Lateral torsional buckling was followed by local buckling of the web to top flange junction.

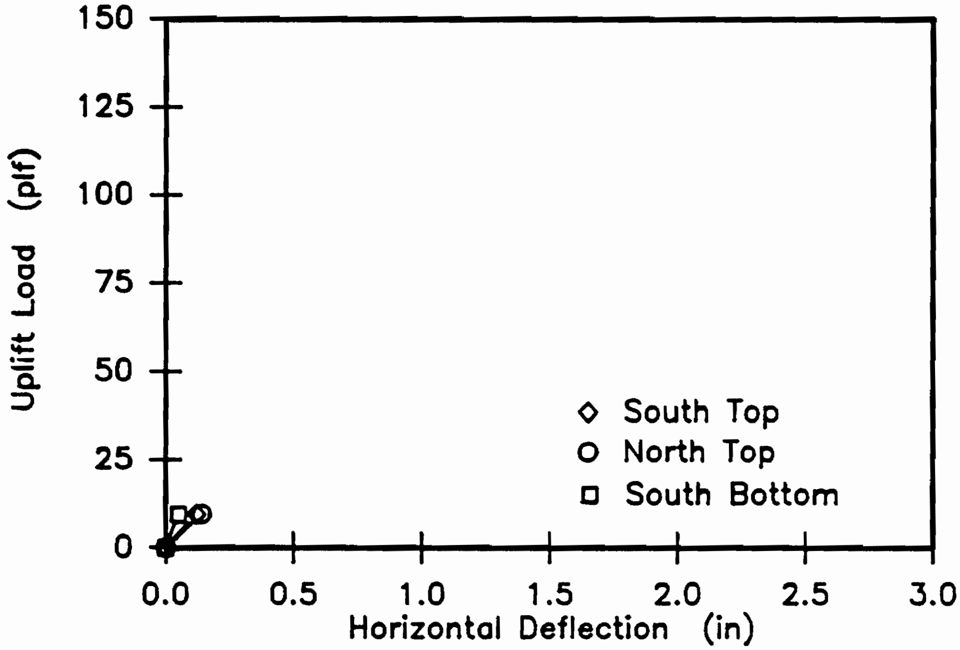


Figure H.5 **Uplift Load Versus Midspan Deflection of Purlin Flanges for Test SP-8Z-25**

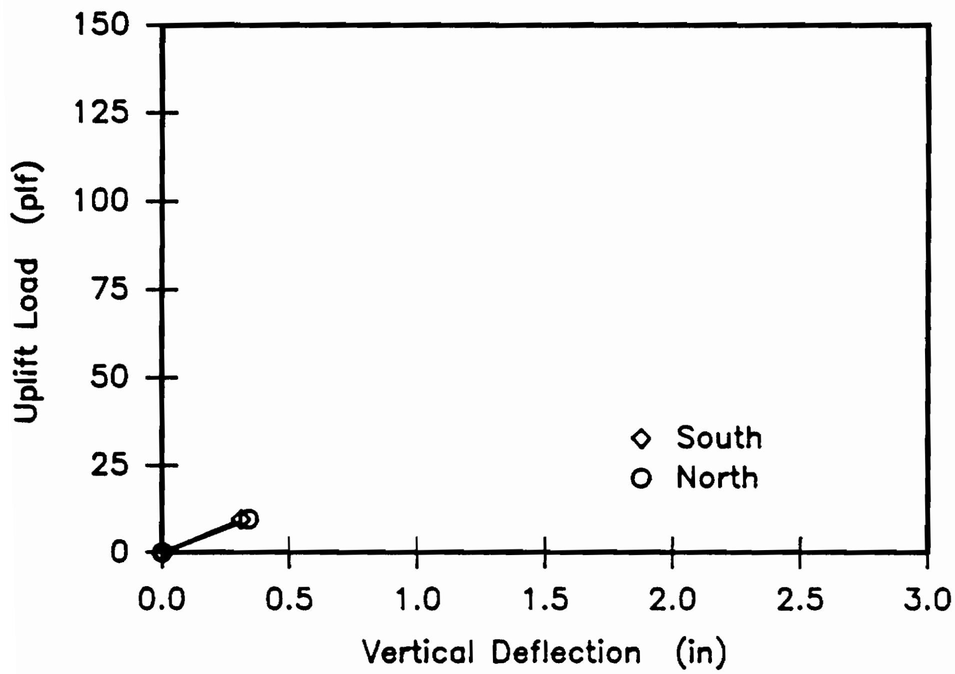


Figure H.6 **Uplift Load Versus Midspan Deflection of Purlin Flanges for Test SP-8Z-25**

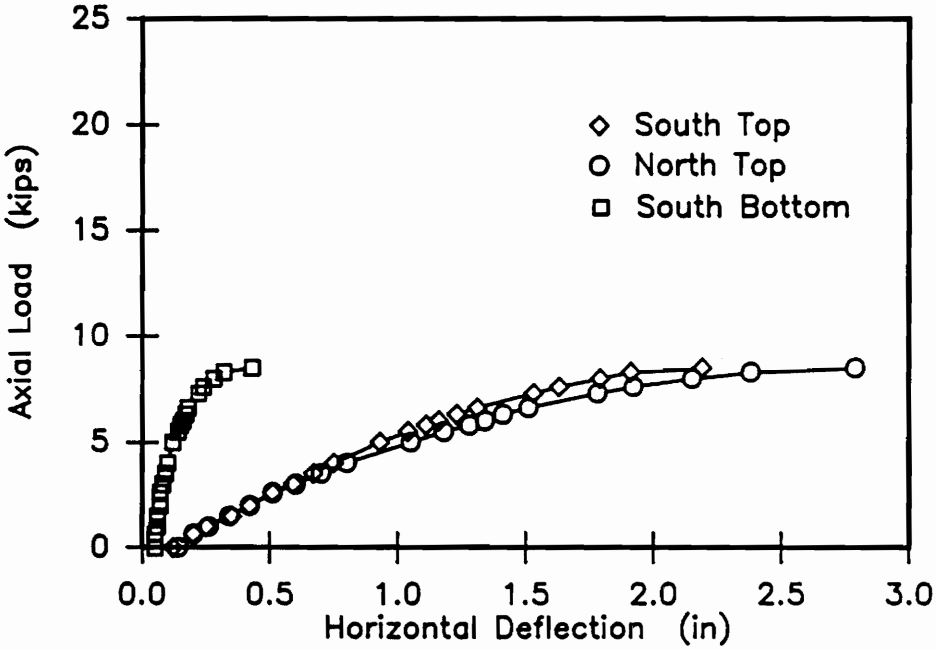


Figure H.7 **Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-8Z-25**

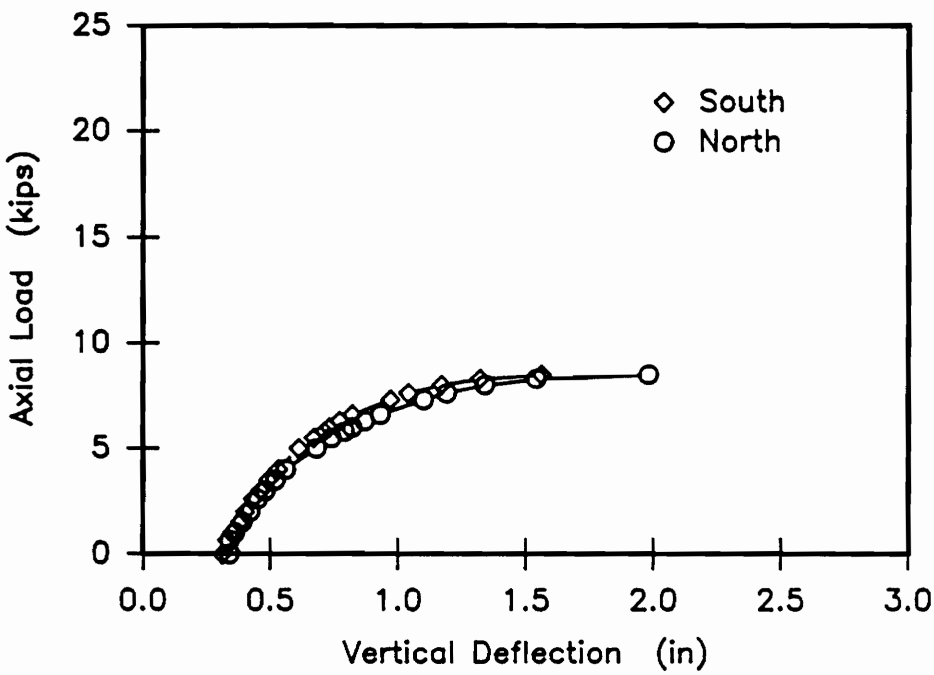
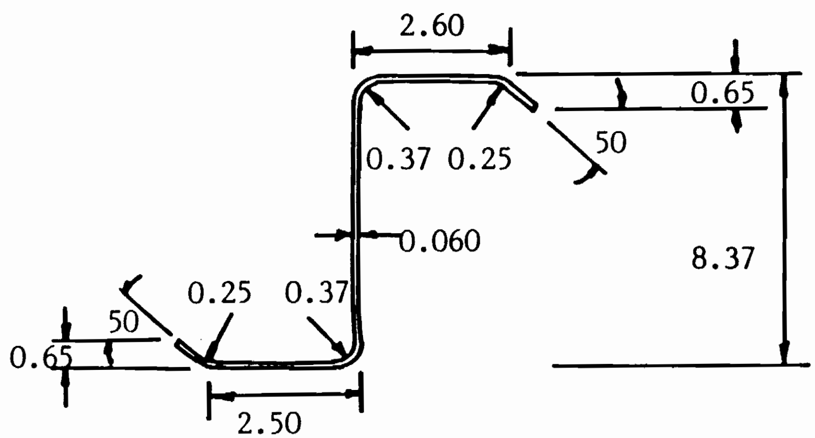
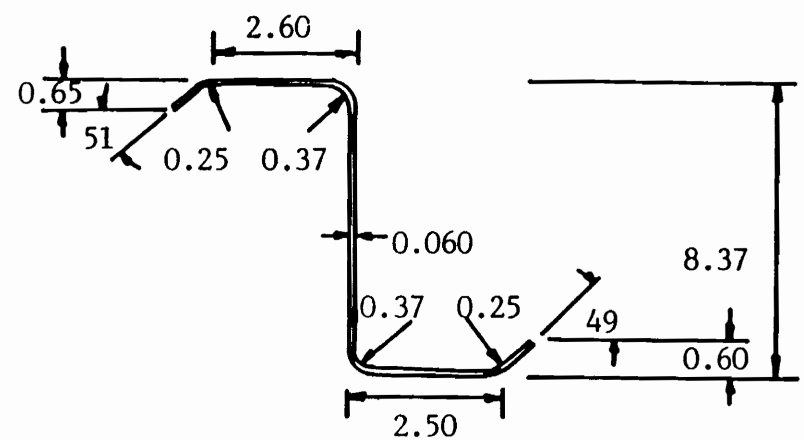


Figure H.8 **Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-8Z-25**

Test No. SP-8Z-25 Date 5-5-89 Recorder GLH



North Purlin



South Purlin

CALCULATION SHEET FOR TEST SP-8Z-25

Moment Capacity (M_{ax})

M_{ax} = R x 1.67 x AISI Allowable Capacity

M_{ax} = .5 x 1.67 x 72.0 in-k = 60.1 in-k

Distributed Load

Dead Weight = 5 lb/ft ÷ 19.175 lb/ft/in of water = .26 in

$$\text{Total Allowable} = \frac{M_{ax}\,8}{L^2} = \frac{58.4 \text{ in-k} \times 1000 \text{ lb}/12" \times 8}{25'^2} = 64.1 \text{ lb/ft}$$

Total Allowable = 64.1 lb/ft ÷ 19.175 lb/ft/in of water = 3.34 in of water

Set vacuum at 1/2 inches of water

w = (.50 inches) (19.175 lb/ft/in) + 5 lb/ft = 14.6 lb/ft

Applied Moment (M)

$$M(\text{applied}) = \frac{wL^2}{8}$$

$$M(\text{applied}) = \frac{14.6 \text{ lb/ft} \times \text{ft}/12" \times 300"^2}{8 \times 1000 \text{ lb/k}} = 13.7 \text{ in-k}$$

Assumption

$$\frac{P}{P_a} + \frac{M\,Cm}{M_{ax}\left(1 - \frac{P}{P_a}\right)} = 1.0$$

Predicted Axial Failure Load

P_a = 14.1 k as determined from test SP-8Z-0

$$P = P_a\left(1 - \sqrt{\frac{M}{M_{ax}}}\right) = 14.1 \text{ k}\left(1 - \sqrt{\frac{13.7}{60.1}}\right) = 7.3 \text{ k}$$

SP8Z25N

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.6500	0.6500
Lip angles	(degrees) :		50.0000	50.0000
Flange widths	(inches) :		2.6000	2.5000
Radii	(inches)			
Lip to flange	:		0.2500	0.2500
Flange to web	:		0.3750	0.3750
Total purlin depth	(inches) :	8.3750		
Purlin thickness	(inches) :	0.0600		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	66.8
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	2.0204
Gross moment of inertia	(in^4) :	9.10

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 1.5327	inches
Effective moment of inertia	: 8.09	in^4
Allowable flexural capacity	: 72.13	kip-in

SP8Z25S

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.6500	0.6000
Lip angles	(degrees) :		51.0000	49.0000
Flange widths	(inches) :		2.6000	2.5000
Radii	(inches)			
Lip to flange	:		0.2500	0.2500
Flange to web	:		0.3750	0.3750
Total purlin depth	(inches) :	8.3750		
Purlin thickness	(inches) :	0.0600		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	66.8
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	2.0171
Gross moment of inertia	(in^4) :	9.05

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 1.5309	inches
Effective moment of inertia	: 8.06	in^4
Allowable flexural capacity	: 72.03	kip-in

SP-8Z-50

Test Summary

Test Date: April 28, 1989

Purpose: Check Interaction Equation Accuracy

Span(s): 1 @ 25'-0"

Measured Dimensions:

	North	South
Thickness	0.059"	0.059"
Sweep	0"	0"

Parameters:
50% of uplift capacity plus axial loads
Screw down type decking
Two Purlin Lines 5'-0" O.C. 1'-0" overhang
Purlins facing each other
Simple supports W.R.T. vertical bending and torsion
Lateral supports at ends only

Failure Load:

Uplift: 33.8 plf M: 31.7 in-kip

Axial: 4.5 k Failure Mode: Lateral-Torsional Buckling

Predicted Failure Loads: (F_y = 66.0 ksi)

Uplift: 33.8 plf M: 31.7 in-kip

Axial: 3.7 k

Discussion:

- Maximum horizontal deflection was 2.79"
- Maximum vertical deflection was 1.98"
- Failure was in north purlin

Lateral torsional buckling was followed by local buckling of the web to top flange junction.

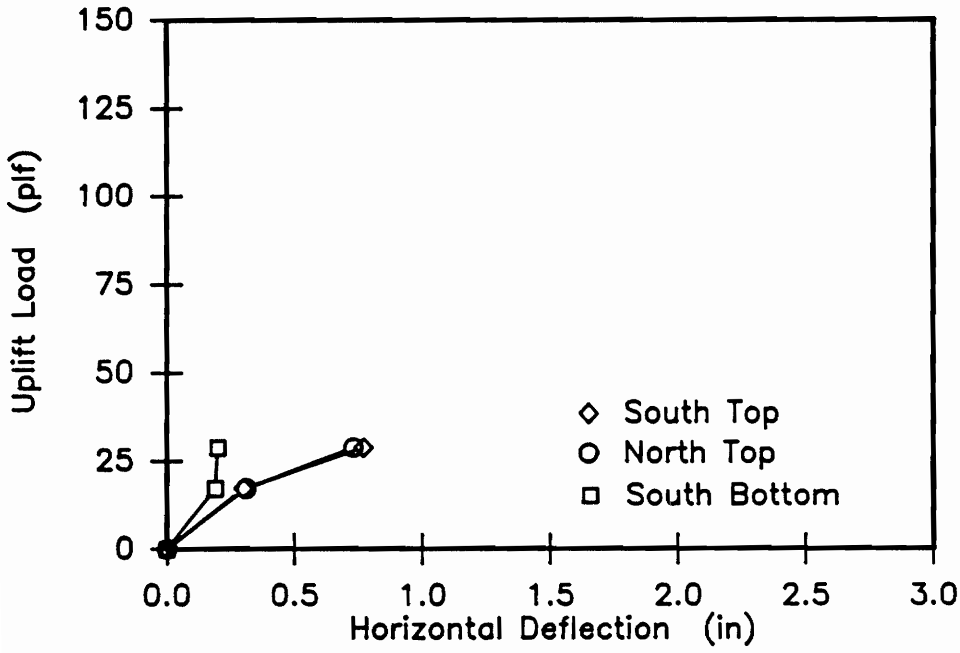


Figure H.9 Uplift Load Versus Midspan Deflection of Purlin Flanges for Test SP-8Z-50

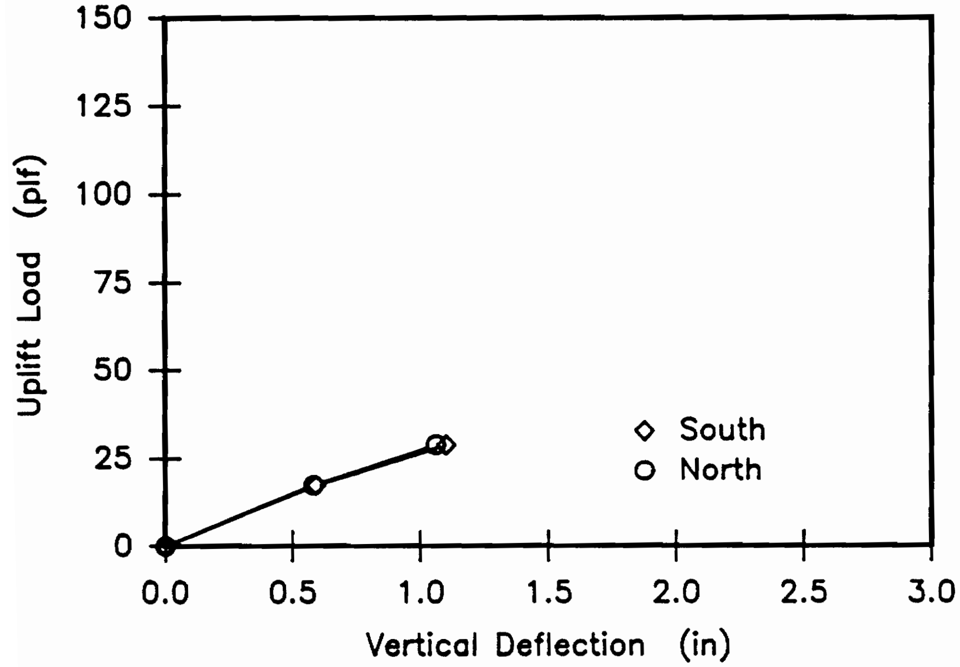


Figure H.10 Uplift Load Versus Midspan Deflection of Purlin Flanges for Test SP-8Z-50

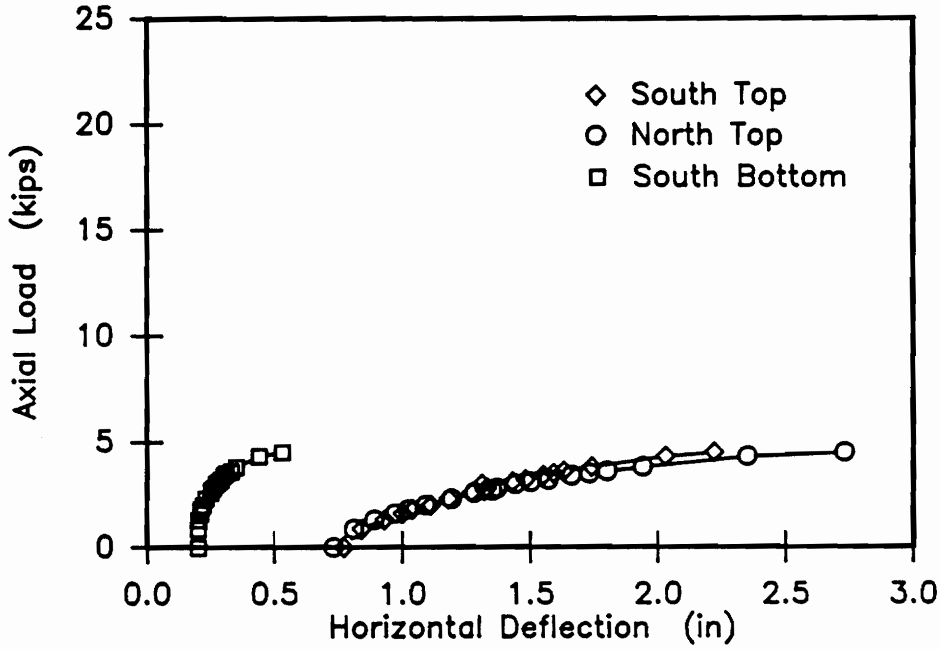


Figure H.11 Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-8Z-50

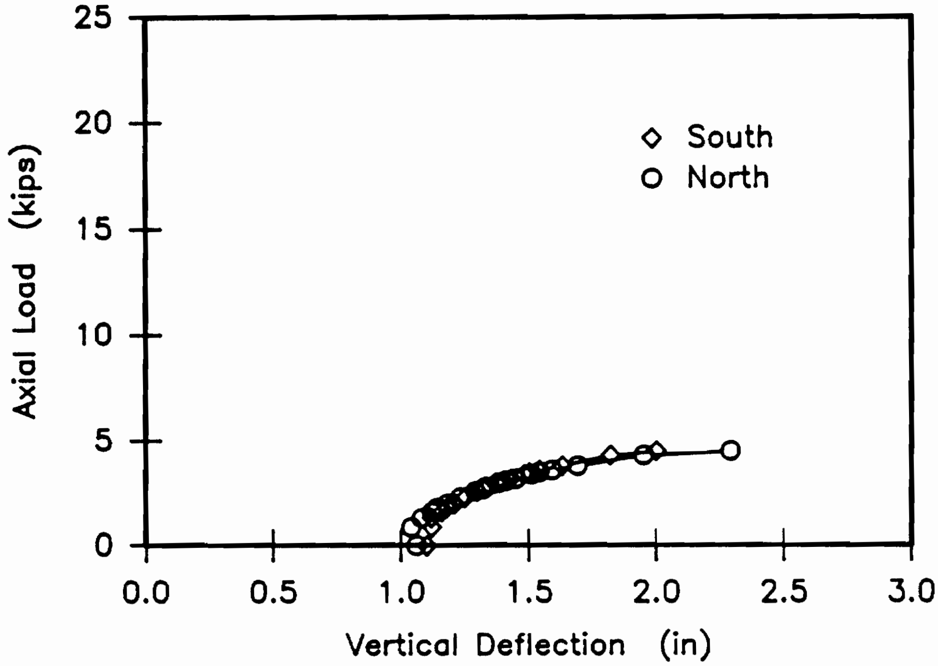
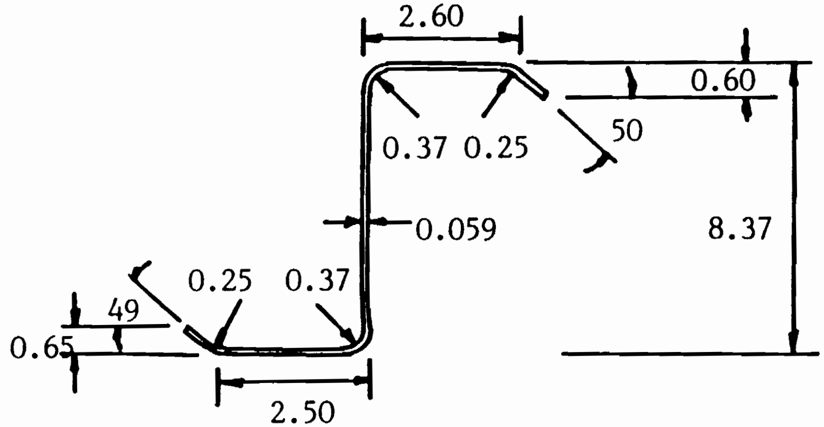
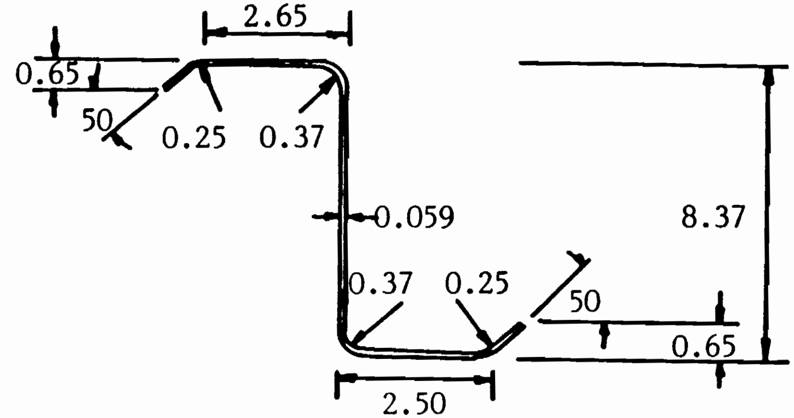


Figure H.12 Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-8Z-50

Test No. SP-8Z-50 Date 4-26-89 Recorder GLH



North Purlin



South Purlin

CALCULATION SHEET FOR
TEST SP-8Z-50

Moment Capacity (M_{ax})

M_{ax} = R x 1.67 x AISI Allowable Capacity

M_{ax} = .5 x 1.67 x 69.9 in-k = 58.4 in-k

Distributed Load

Dead Weight = 5 lb/ft + 19.175 lb/ft/in of water = .26 in

$$\text{Total Allowable} = \frac{M_{ax}\,8}{L^2} = \frac{58.4\text{ in-k} \times 1000\text{ lb}/12" \times 8}{25'^2} = 62.3\text{ lb/ft}$$

Total Allowable = 63.1 lb/ft + 19.175 lb/ft/in of water = 3.25 in of water

Set vacuum at 1 1/2 inches of water

w = (1.5 inches) (19.175 lb/ft/in) + 5 lb/ft = 33.8 lb/ft

Applied Moment (M)

$$M(\text{applied}) = \frac{wL^2}{8}$$

$$M(\text{applied}) = \frac{33.8\text{ lb/ft} \times \text{ft}/12" \times 300"^2}{8 \times 1000\text{ lb/k}} = 31.7\text{ in-k}$$

Assumption

$$\frac{P}{P_a} + \frac{M\,Cm}{M_{ax}\,(1 - \frac{P}{P_a})} = 1.0$$

Predicted Axial Failure Load

P_a = 14.1 k   as determined from test SP-8Z-0

$$P = P_a\,(1 - \sqrt{\frac{M}{M_{ax}}}) = 14.1\text{ k}\,(1 - \sqrt{\frac{31.7}{58.4}}) = 3.7\text{ k}$$

SP8Z50N

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.6500	0.6500
Lip angles	(degrees) :		50.0000	49.0000
Flange widths	(inches) :		2.6000	2.5000
Radii	(inches)			
Lip to flange	:		0.2500	0.2500
Flange to web	:		0.3750	0.3750
Total purlin depth	(inches) :	8.3750		
Purlin thickness	(inches) :	0.0590		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	66.0
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	2.0219
Gross moment of inertia	(in^4) :	8.97

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 1.5276	inches
Effective moment of inertia	: 7.95	in^4
Allowable flexural capacity	: 69.88	kip-in

SP8Z50S

GEOMETRY OF CROSS-SECTION

				TOP	BOTTOM
Vertical lip dimensions	(inches)	:		0.6500	0.6500
Lip angles	(degrees)	:		50.0000	50.0000
Flange widths	(inches)	:		2.6500	2.5000
Radii	(inches)				
Lip to flange		:		0.2500	0.2500
Flange to web		:		0.3750	0.3750
Total purlin depth	(inches)	:	8.3750		
Purlin thickness	(inches)	:	0.0590		

MATERIAL PROPERTIES

Material yield stress	(ksi)	:	66.0
Modulus of elasticity	(ksi)	:	29500.0

GENERAL

Flat width of compression flange	(inches)	:	2.0719
Gross moment of inertia	(in^4)	:	9.01

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	:	1.5425	inches
Effective moment of inertia	:	7.96	in^4
Allowable flexural capacity	:	70.05	kip-in

SP-8Z-75

Test Summary

Test Date: May 10, 1989

Purpose: Check Interaction Equation Accuracy

Span(s): 1 @ 25'-0"

Measured Dimensions:

	North	South
Thickness	0.060"	0.060"
Sweep	0.13"	0.38"

Parameters:
- 75% of uplift capacity plus axial loads
- Screw down type decking
- Two Purlin Lines 5'-0" O.C. 1'-0" overhang
- Purlins facing each other
- Simple supports W.R.T. vertical bending and torsion
- Lateral supports at ends only

Failure Load:

Uplift: 43.4 plf M: 40.6 in-kip

Axial: 4.1 k Failure Mode: Lateral-Torsional Buckling

Predicted Failure Loads: (F_y = 65.3 ksi)

Uplift: 43.4 plf M: 40.6 in-kip

Axial: 2.4 k

Discussion:

- Maximum horizontal deflection was 2.55"
- Maximum vertical deflection was 2.45"
- Failure was in north purlin

Lateral torsional buckling was followed by local buckling of the web to top flange junction.

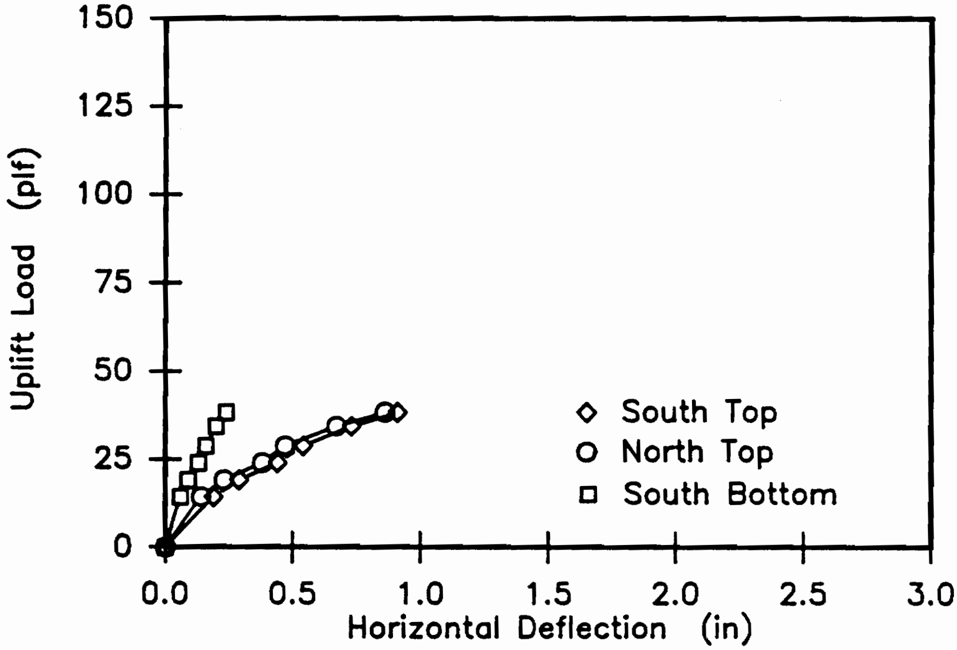


Figure H.13 Uplift Load Versus Midspan Deflection of Purlin Flanges for Test SP-8Z-75

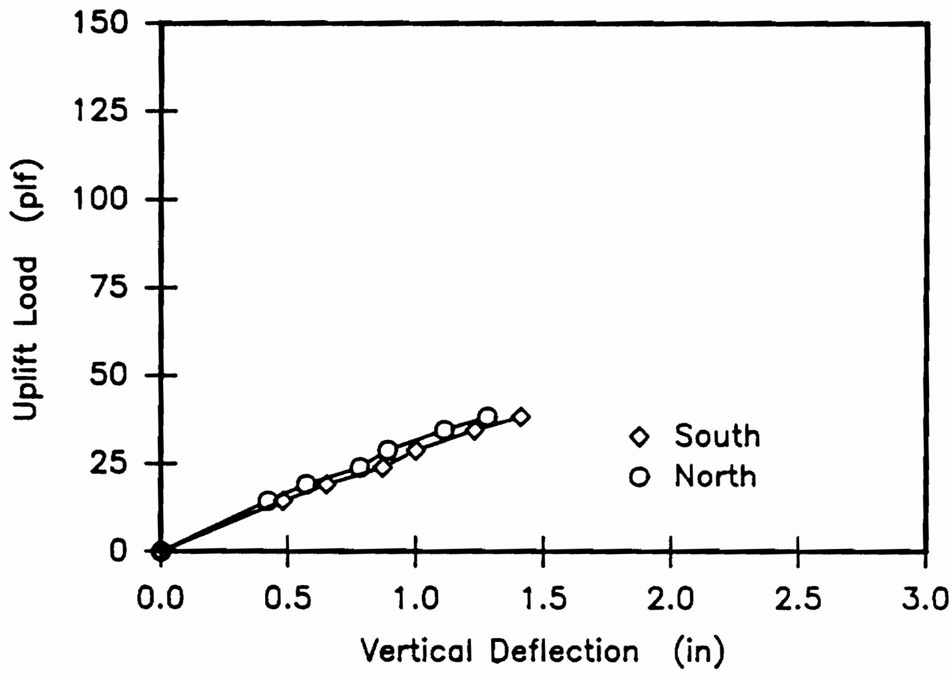


Figure H.14 Uplift Load Versus Midspan Deflection of Purlin Flanges for Test SP-8Z-75

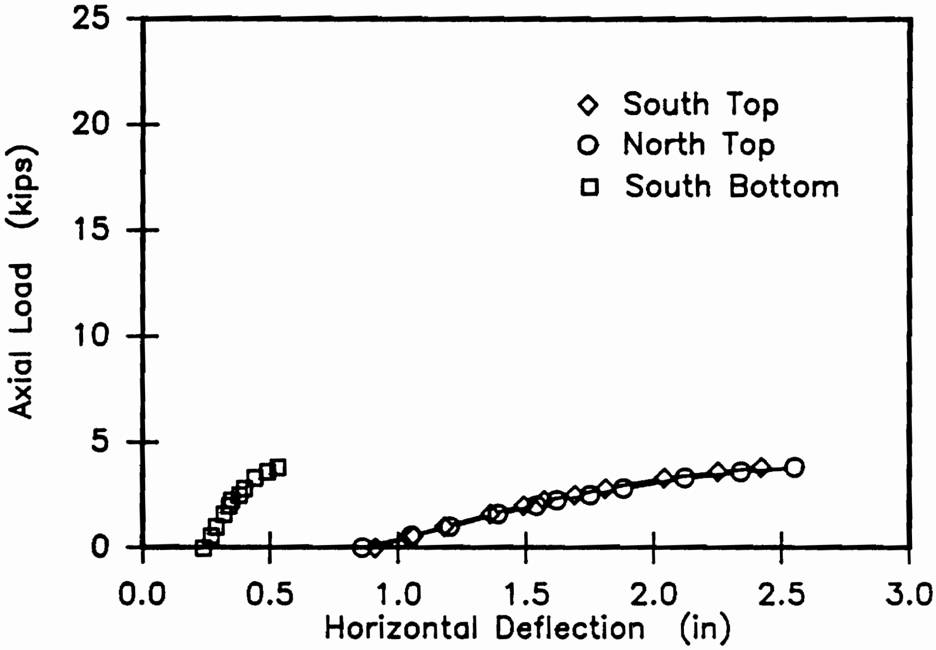


Figure H.15 Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-8Z-75

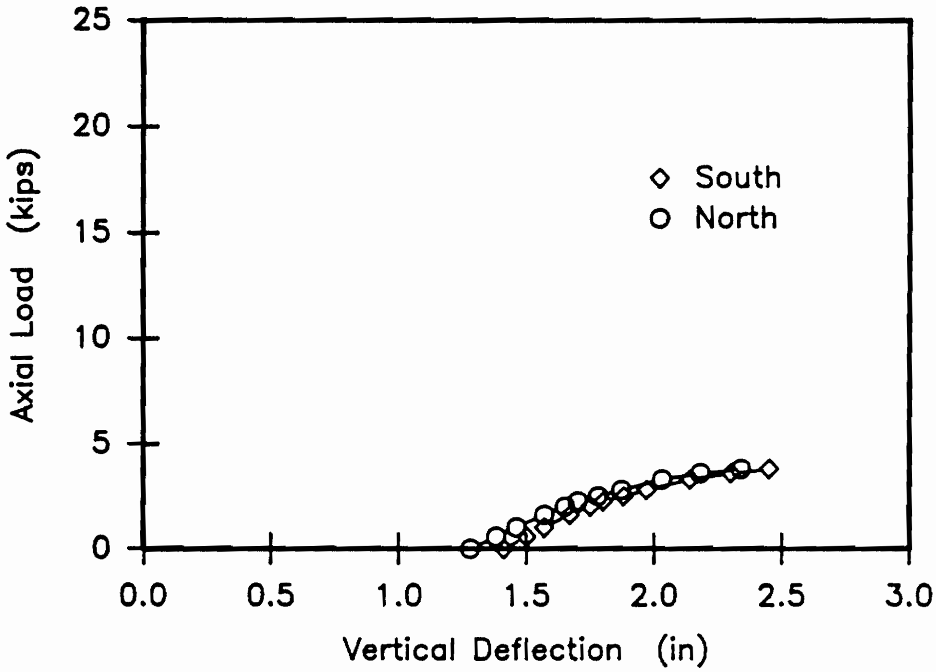
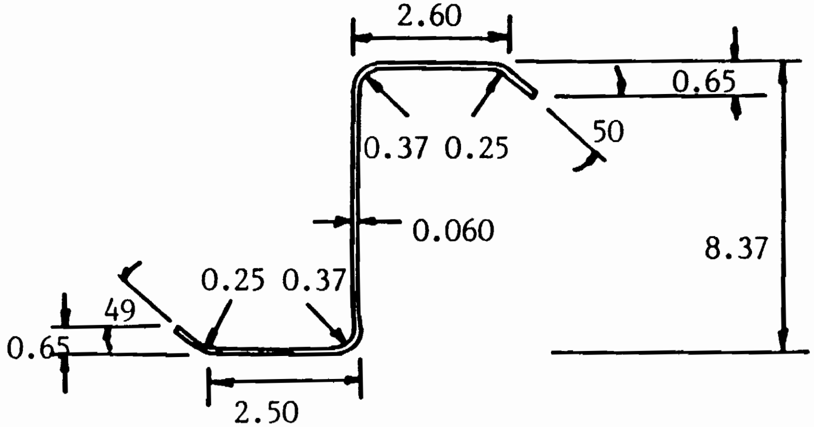
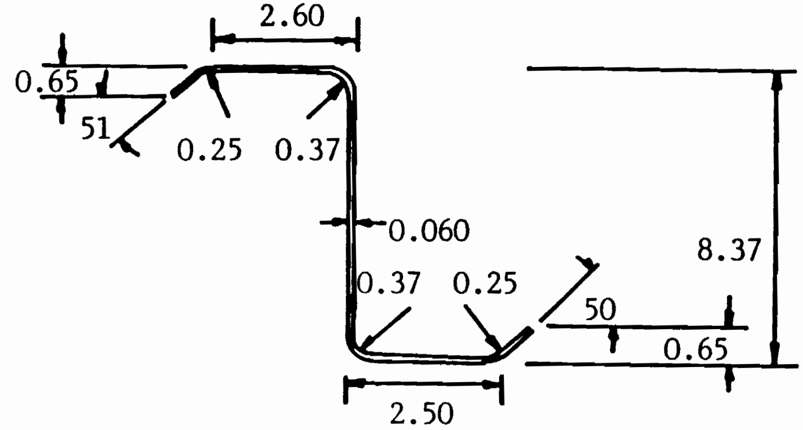


Figure H.16 Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-8Z-75

Test No. SP-8Z-75 Date 5-9-89 Recorder GLH



North Purlin



South Purlin

CALCULATION SHEET FOR
TEST SP-8Z-75

Moment Capacity (M_{ax})

M_{ax} = R x 1.67 x AISI Allowable Capacity

M_{ax} = .5 x 1.67 x 71.0 in-k = 59.3 in-k

Distributed Load

Dead Weight = 5 lb/ft ÷ 19.175 lb/ft/in of water = .26 in

$$\text{Total Allowable} = \frac{M_{ax}\,8}{L^2} = \frac{59.3 \text{ in-k} \times 1000 \text{ lb}/12" \times 8}{25'^2} = 63.2 \text{ lb/ft}$$

Total Allowable = 63.1 lb/ft ÷ 19.175 lb/ft/in of water = 3.30 in of water

Set vacuum at 0 inches of water

w = (2 inches) (19.175 lb/ft/in) + 5 lb/ft = 43.4 lb/ft

Applied Moment (M)

$$M(\text{applied}) = \frac{wL^2}{8}$$

$$M(\text{applied}) = \frac{43.4 \text{ lb/ft} \times \text{ft}/12" \times 300"^2}{8 \times 1000 \text{ lb/k}} = 40.6 \text{ in-k}$$

Assumption

$$\frac{P}{P_a} + \frac{M\,C_m}{M_{ax}\left(1 - \frac{P}{P_a}\right)} = 1.0$$

Predicted Axial Failure Load

P_a = 14.1 k as determined from test SP-8Z-0

$$P = P_a\left(1 - \sqrt{\frac{M}{M_{ax}}}\right) = 14.1 \text{ k}\left(1 - \sqrt{\frac{40.6}{59.3}}\right) = 2.4 \text{ k}$$

SP8Z75N

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.6500	0.6500
Lip angles	(degrees) :		50.0000	49.0000
Flange widths	(inches) :		2.6000	2.5000
Radii	(inches)			
Lip to flange	:		0.2500	0.2500
Flange to web	:		0.3750	0.3750
Total purlin depth	(inches) :	8.3750		
Purlin thickness	(inches) :	0.0600		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	65.3
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	2.0204
Gross moment of inertia	(in^4) :	9.12

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	:	1.5472	inches
Effective moment of inertia	:	8.14	in^4
Allowable flexural capacity	:	71.18	kip-in

SP8Z75S

GEOMETRY OF CROSS-SECTION

				TOP	BOTTOM
Vertical lip dimensions	(inches)	:		0.6500	0.6500
Lip angles	(degrees)	:		51.0000	50.0000
Flange widths	(inches)	:		2.6000	2.5000
Radii	(inches)				
Lip to flange		:		0.2500	0.2500
Flange to web		:		0.3750	0.3750
Total purlin depth	(inches)	:	8.3750		
Purlin thickness	(inches)	:	0.0600		

MATERIAL PROPERTIES

Material yield stress	(ksi)	:	65.3
Modulus of elasticity	(ksi)	:	29500.0

GENERAL

Flat width of compression flange	(inches)	:	2.0171
Gross moment of inertia	(in^4)	:	9.09

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	:	1.5454	inches
Effective moment of inertia	:	8.12	in^4
Allowable flexural capacity	:	71.00	kip-in

SP-8Z-M

Test Summary

Test Date: April 4, 1989

Purpose: Determine/Verify Max

Span(s): 1 @ 25'-0"

Measured Dimensions:

	North	South
Thickness	0.060"	0.060"
Sweep	-.50"	0.00"

Parameters:
Uplift load only
Screw down type decking
Two Purlin Lines 5'-0" O.C. 1'-0" overhang
Purlins facing each other
Simple supports W.R.T. vertical bending and torsion
Lateral supports at ends only

Failure Load:

Uplift: 62.5 plf M: 58.6 in-kip

Axial: 0 k Failure Mode: Lateral-Torsional Buckling

Predicted Failure Loads: (F_y = 65.6 ksi)

Uplift: 63.1 plf M: 59.2 in-kip

Axial: 0 k

Discussion:

- Maximum horizontal deflection was 2.21"
- Maximum vertical deflection was 2.66"
- Failure was in north purlin

Lateral torsional buckling was followed by local buckling of the web to top flange junction.

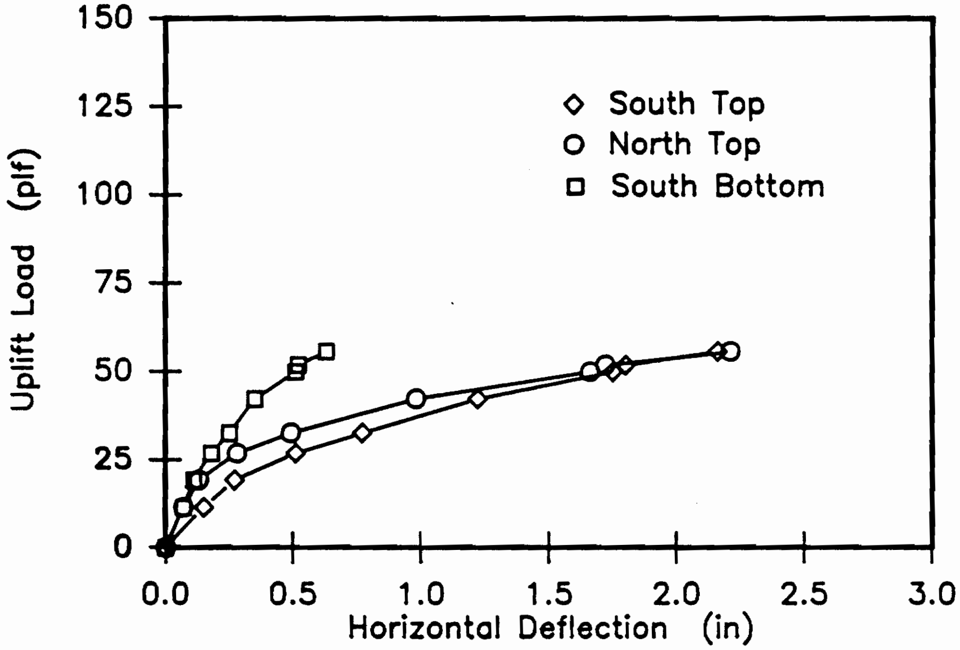


Figure H.17 **Uplift Load Versus Midspan Deflection of Purlin Flanges for Test SP-8Z-M**

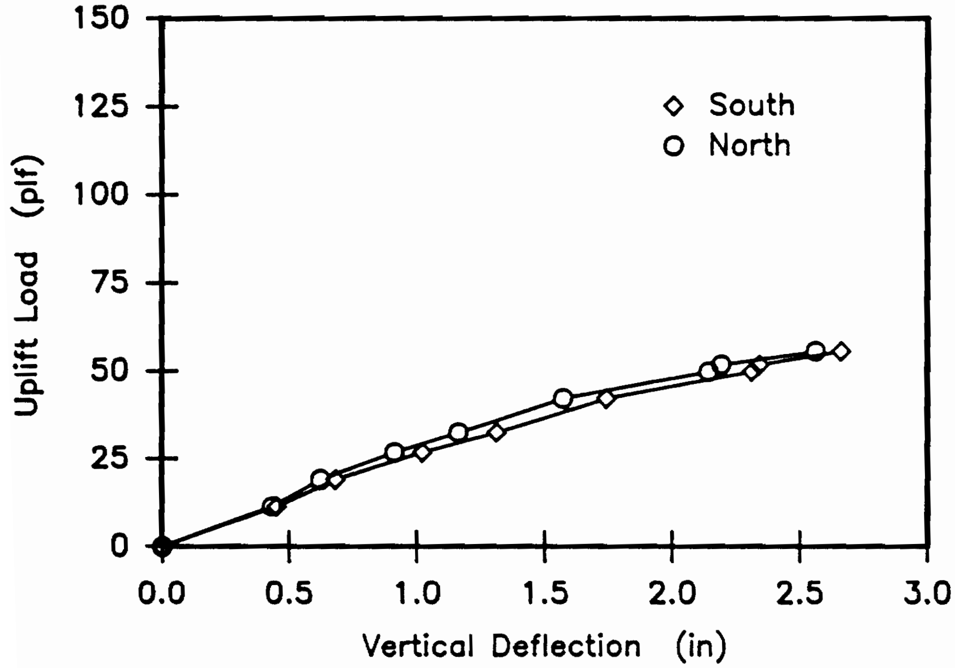
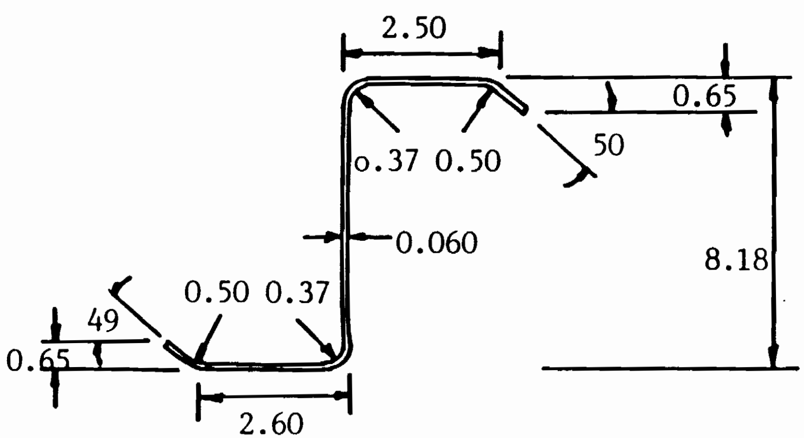
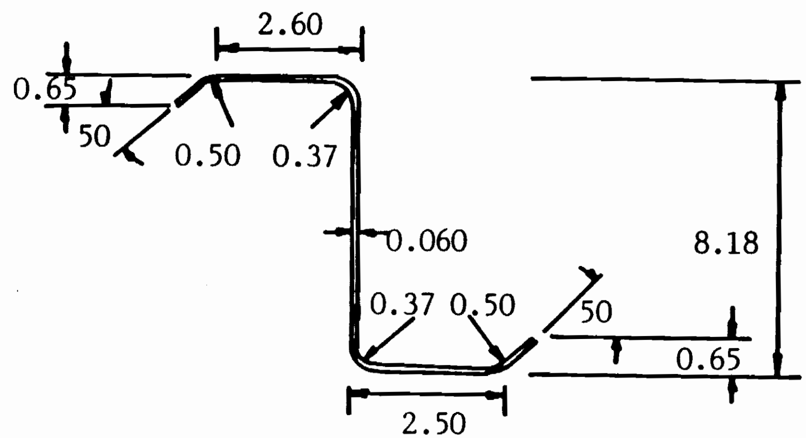


Figure H.18 **Uplift Load Versus Midspan Deflection of Purlin Flanges for Test SP-8Z-M**

Test No. SP-8Z-M Date 4-20-89 Recorder GLH



North Purlin



South Purlin

CALCULATION SHEET FOR TEST SP-8Z-M

Moment Capacity (M_{ax})

M_{ax} = R x 1.67 x AISI Allowable Capacity

M_{ax} = .5 x 1.67 x 70.9 in-k = 59.2 in-k

Distributed Load

Dead Weight = 5 lb/ft ÷ 19.175 lb/ft/in of water = .26 in

$$\text{Total Allowable} = \frac{M_{ax}\,8}{L^2} = \frac{59.2 \text{ in-k} \times 1000 \text{ lb}/12" \times 8}{25'^2} = 63.1 \text{ lb/ft}$$

Total Allowable = 63.1 lb/ft ÷ 19.175 lb/ft/in of water = 3.29 in of water

Set vacuum at 0 inches of water

w = (3.03 inches) (19.175 lb/ft/in) + 5 lb/ft = 63.1 lb/ft

Applied Moment (M)

$$M(\text{applied}) = \frac{wL^2}{8}$$

$$M(\text{applied}) = \frac{63.1 \text{ lb/ft} \times \text{ft}/12" \times 300"^2}{8 \times 1000 \text{ lb/k}} = 59.2 \text{ in-k}$$

Assumption

$$\frac{P}{P_a} + \frac{M\,Cm}{M_{ax}\left(1 - \frac{P}{P_a}\right)} = 1.0$$

Predicted Axial Failure Load

P_a = 14.1 as determined from test SP-8Z-0

P = 0 (No applied axial load)

SP8ZMN

GEOMETRY OF CROSS-SECTION

		TOP	BOTTOM
Vertical lip dimensions	(inches) :	0.6500	0.6500
Lip angles	(degrees) :	50.0000	49.0000
Flange widths	(inches) :	2.5000	2.6000
Radii	(inches)		
Lip to flange	:	0.2500	0.2500
Flange to web	:	0.3750	0.3750

Total purlin depth	(inches) :	8.3750
Purlin thickness	(inches) :	0.0600

MATERIAL PROPERTIES

Material yield stress	(ksi) :	65.6
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	1.9204
Gross moment of inertia	(in^4) :	9.12

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	:	1.5112	inches
Effective moment of inertia	:	8.17	in^4
Allowable flexural capacity	:	70.92	kip-in

SP8ZMS

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.6500	0.6500
Lip angles	(degrees) :		50.0000	50.0000
Flange widths	(inches) :		2.6000	2.5000
Radii	(inches)			
Lip to flange	:		0.2500	0.2500
Flange to web	:		0.3750	0.3750
Total purlin depth	(inches) :	8.3750		
Purlin thickness	(inches) :	0.0600		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	65.6
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	2.0204
Gross moment of inertia	(in^4) :	9.10

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	:	1.5442	inches
Effective moment of inertia	:	8.13	in^4
Allowable flexural capacity	:	71.39	kip-in

SP-10C-0

Test Summary

Test Date: April 20, 1990

Purpose: Verify Interaction Equation

Span(s): 1 @ 25'-0"

Measured Dimensions:

	North	South
Thickness	0.103"	0.103"
Sweep	0	0

Parameters:
- Axial Load Only
- Screw down type decking
- Two Purlin Lines 5'-0" O.C. 1'-0" overhang
- Purlins facing each other
- Simple supported
- Lateral supports at ends only

Predicted Failure Loads: (F_y = 57.1 ksi)

Uplift: 9 plf M: 8.4 in-kip

Axial: 16.1 k

Actual Failure Load:

Uplift: 9 plf M: 8.4 in-kip

Axial: 23.5 k

P/P_a = 1.05

M/M_{ax} = .08

Discussion:

- Torsional-flexural buckling was followed by local buckling of the web to unsupported flange junction
- Failure occurred in the north purlin
- Maximum horizontal deflection was 2.06"
- Maximum vertical deflection was 0.72"

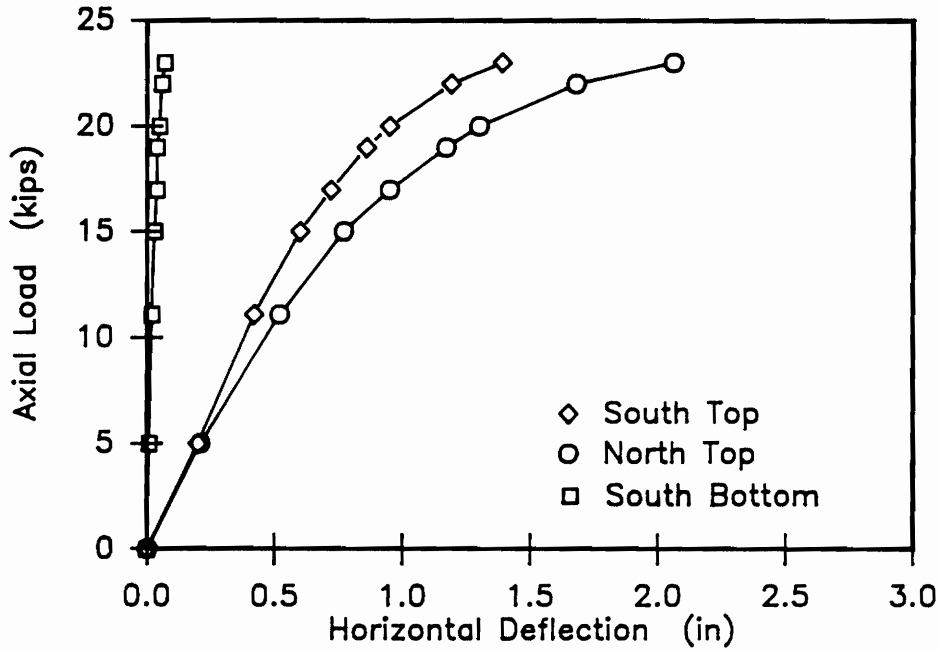


Figure H.35 **Uplift Load Versus Midspan Deflection of Purlin Flanges for Test SP-10C-0**

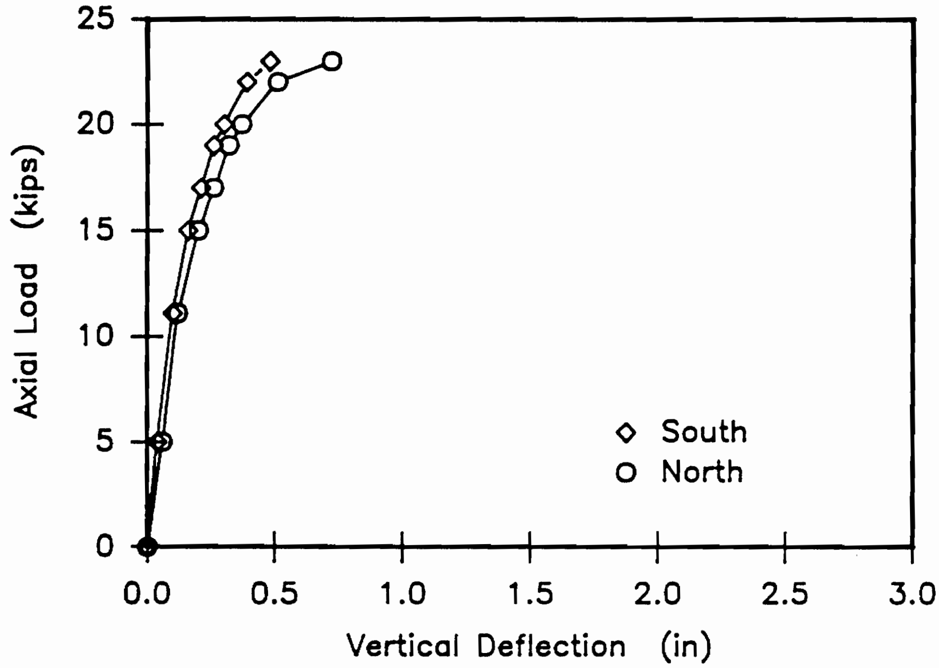
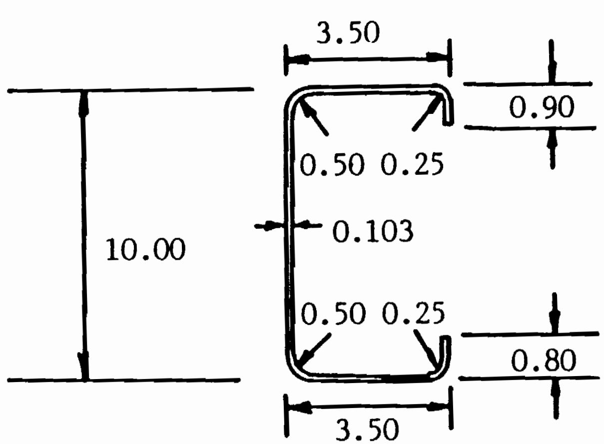
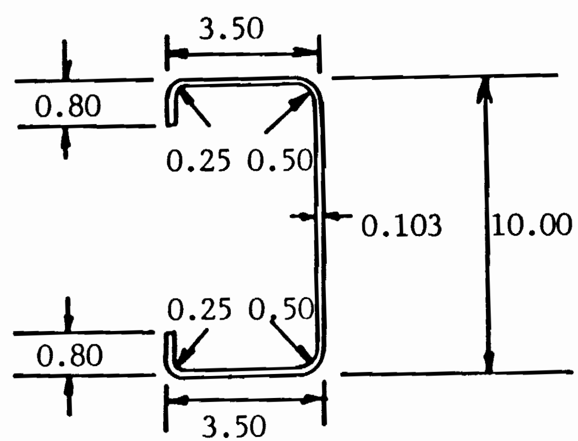


Figure H.36 **Uplift Load Versus Midspan Deflection of Purlin Flanges for Test SP-10C-0**

Test No. SP-10C-0 Date 4-20-90 Recorder GLH



North Purlin



South Purlin

CALCULATION SHEET FOR TEST SP-10C-0

Moment Capacity (M_{ax})

M_{ax} = R x 1.67 x AISI Allowable Capacity

M_{ax} = .4 x 1.67 x 167.5 in-k = 111.9 in-k

Distributed Load

Dead Weight = 9 lb/ft + 19.5 lb/ft/in of water = .47 in

$$\text{Total Allowable} = \frac{M_{ax}\,8}{L^2} = \frac{111.9 \text{ in-k} \times 1000 \text{ lb}/12" \times 8}{25'^2} = 119.3 \text{ lb/ft}$$

Total Allowable = 119.3 lb/ft + 19.5 lb/ft/in of water = 6.22 in of water

Set vacuum at 0 inches of water

w = (0 inches) (19.5 lb/ft/in) + 9 lb/ft = 9 lb/ft

Applied Moment (M)

$$M(\text{applied}) = \frac{wL^2}{8}$$

$$M(\text{applied}) = \frac{9 \text{ lb/ft} \times \text{ft}/12" \times 300"^2}{8 \times 1000 \text{ lb/k}} = 8.44 \text{ in-k}$$

Axial Capacity (P_a)

Fastener Location In The Flange		P_a (k)
2.75"	weak	16.5
1.50"	medium	26.0
.75"	strong	29.9

Actual average fastener location was 2" from the web, ∴ Pa = 22.2 k based on linear interpolation

Assumption

$$\frac{P}{P_a} + \frac{M\,Cm}{M_{ax}\left(1 - \frac{P}{P_a}\right)} = 1.0$$

Predicted Axial Failure Load

$$P = P_a\left(1 - \sqrt{\frac{M}{M_{ax}}}\right) = 22.2 \text{ k}\left(1 - \sqrt{\frac{8.44}{111.9}}\right) = 16.1 \text{ k}$$

SP10CON

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.9000	0.8000
Lip angles	(degrees) :		90.0000	90.0000
Flange widths	(inches) :		3.5000	3.5000
Radii	(inches)			
Lip to flange	:		0.2500	0.2500
Flange to web	:		0.5000	0.5000
Total purlin depth	(inches) :	10.0000		
Purlin thickness	(inches) :	0.1030		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	57.1
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	2.5440
Gross moment of inertia	(in^4) :	26.96

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 2.2437	inches
Effective moment of inertia	: 25.34	in^4
Allowable flexural capacity	: 167.52	kip-in

SP10COS

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.8000	0.8000
Lip angles	(degrees) :		90.0000	90.0000
Flange widths	(inches) :		3.5000	3.5000
Radii	(inches)			
Lip to flange	:		0.2500	0.2500
Flange to web	:		0.5000	0.5000
Total purlin depth	(inches) :	10.0000		
Purlin thickness	(inches) :	0.1030		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	57.1
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	2.5440
Gross moment of inertia	(in^4) :	26.79

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 2.1138	inches
Effective moment of inertia	: 24.83	in^4
Allowable flexural capacity	: 162.27	kip-in

2	ISEC (2=C SECTION, 3=Z SECTION)
300.	STUD LENGTH XL
10.00	SECTION DEPTH HH
9.90	CENTERLINE DIMENSION OF WEB H
3.40	CENTERLINE DIMENSION OF FLG B
.85	CENTERLINE DIMENSION OF LIP D
.103	THICKNESS
.72	FORM FACTOR Q
53.2	S (K) SHEAR RIGIDITY
.2377	F (K-IN/IN-RAD) ROTATIONAL CAPACITY
.0955	GAMD (IN/IN) DIAPHRAGM STRAIN @ FAILURE
.2506	FED (RAD) PURLIN TWIST @ FAILURE
57.1	FY YIELD STRESS
12.	DISTANCE BETWEEN FASTENERS XL1
0.	1=DETAILS PRINTED 0=DETAILS NOT PRINTED
1.808	AREA
26.968	XXI
2.753	YYI
0.106	XYI
2.400	XO
0.006	XJ
51.036	CW

INPUT DATA TO (STUDA2.EXE) FOR TEST SP-10C-0

COLD-FORMED STEEL DESIGN PROGRAM

PART: **North Purlin**

Thickness: 0.1030

	Length	Angle	Radius	w/t
1	0.900	90.000	0.1030	5.31
2	3.500	0.000	0.2500	24.70
3	10.000	-90.000	0.5000	85.38
4	3.500	180.000	0.5000	24.70
5	0.800	90.000	0.2500	4.34

SECTION PROPERTIES

Area	1.808	Wt/Ft	6.148
Top to CG	4.9764	Sx(t)	5.419
Bottom to CG	5.0236	Sx(b)	5.368
Left edge to CG	2.5305	Sy(l)	1.088
Right edge to CG	0.9695	Sy(r)	2.839
Ix	26.968	rx	3.862
Iy	2.753	ry	1.234
I1	26.968	r1	3.862
I2	2.752	r2	1.234
Ic	29.721	rc	4.054
Io	40.152	ro	4.712
Ixy	-0.106	Xo	2.400
Alpha	0.251	Yo	0.099
Cw	51.036	jx	-5.484
J	0.006	jy	-0.117

COLD-FORMED STEEL DESIGN PROGRAM

PART: **South Purlin**

Thickness: 0.1030

	Length	Angle	Radius	w/t
1	0.800	90.000	0.1030	4.34
2	3.500	0.000	0.2500	24.70
3	10.000	-90.000	0.5000	85.38
4	3.500	180.000	0.5000	24.70
5	0.800	90.000	0.2500	4.34

SECTION PROPERTIES

Area	1.798	Wt/Ft	6.113
Top to CG	5.0000	Sx(t)	5.358
Bottom to CG	5.0000	Sx(b)	5.358
Left edge to CG	2.5447	Sy(l)	1.057
Right edge to CG	0.9553	Sy(r)	2.815
Ix	26.791	rx	3.860
Iy	2.689	ry	1.223
I1	26.791	r1	3.860
I2	2.689	r2	1.223
Ic	29.480	rc	4.049
Io	39.538	ro	4.689
Ixy	0.000	Xo	2.365
Alpha	0.000	Yo	0.000
Cw	49.281	jx	-5.505
J	0.006	jy	-0.000

SP-10C-25

Test Summary

Test Date: March 9, 1990

Purpose: Verify Interaction Equation

Span(s): 1 @ 25'-0"

Measured Dimensions:

	North	South
Thickness	0.103"	0.103"
Sweep	-.5	-.5

Parameters: Axial Load Applied

Screw down type decking

Two Purlin Lines 5'-0" O.C. 1'-0" overhang

Purlins facing each other

Simple supported

Lateral supports at ends only

Predicted Failure Loads: (F_y = 57.3 ksi)

Uplift: 30.1 plf M: 28.2 in-kip

Axial: 12.4 k

Actual Failure Load:

Uplift: 30.1 plf M: 28.2 in-kip

Axial: 24.0 k

P/P_a = .96

M/M_{ax} = .26

Discussion:

- Torsional-flexural buckling was followed by local buckling of the web to unsupported flange junction
- Failure occurred in the north purlin
- Maximum horizontal deflection was 2.14"
- Maximum vertical deflection was 0.86"

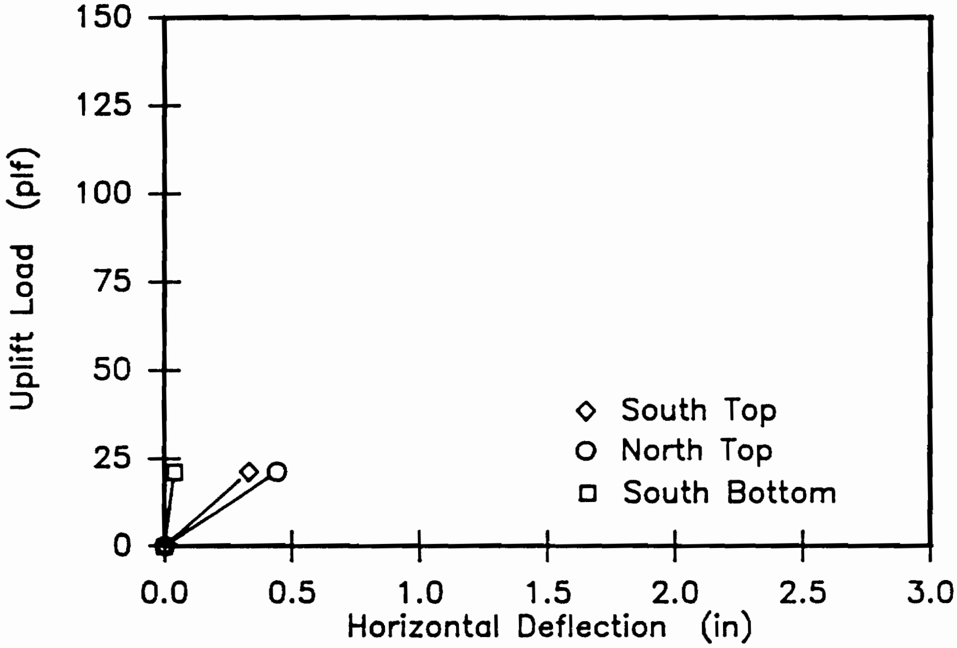


Figure H.37 Uplift Load Versus Midspan Deflection of Purlin Flanges for Test SP-10C-25

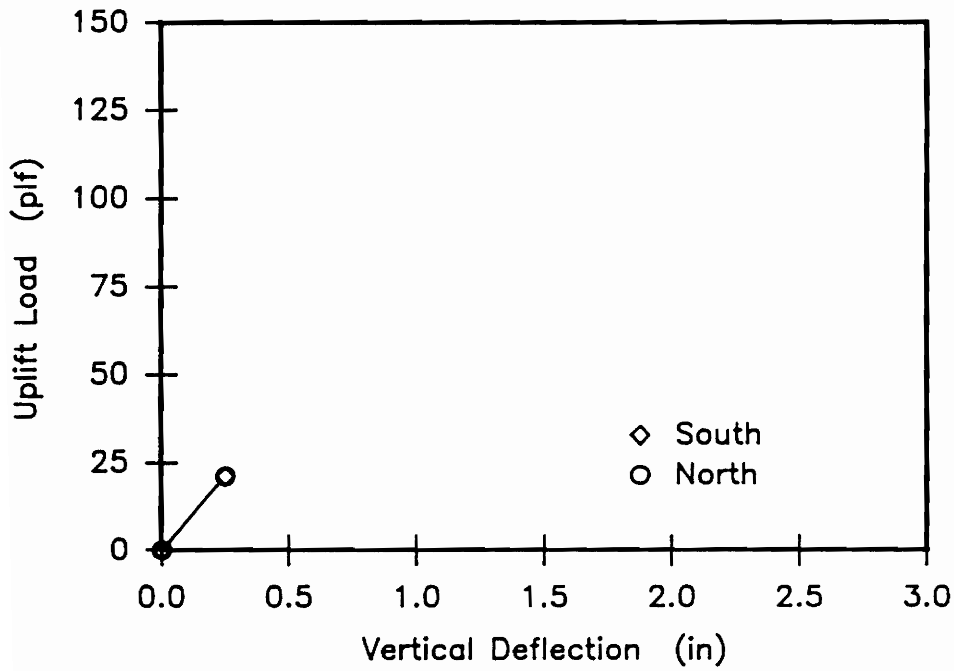


Figure H.38 Uplift Load Versus Midspan Deflection of Purlin Flanges for Test SP-10C-25

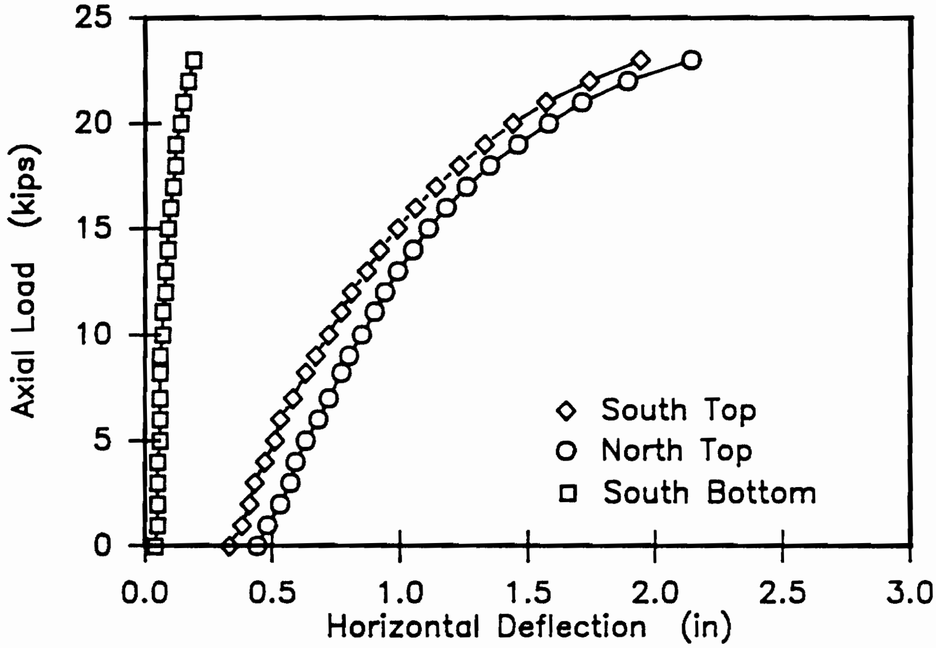


Figure H.39 **Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-10C-25**

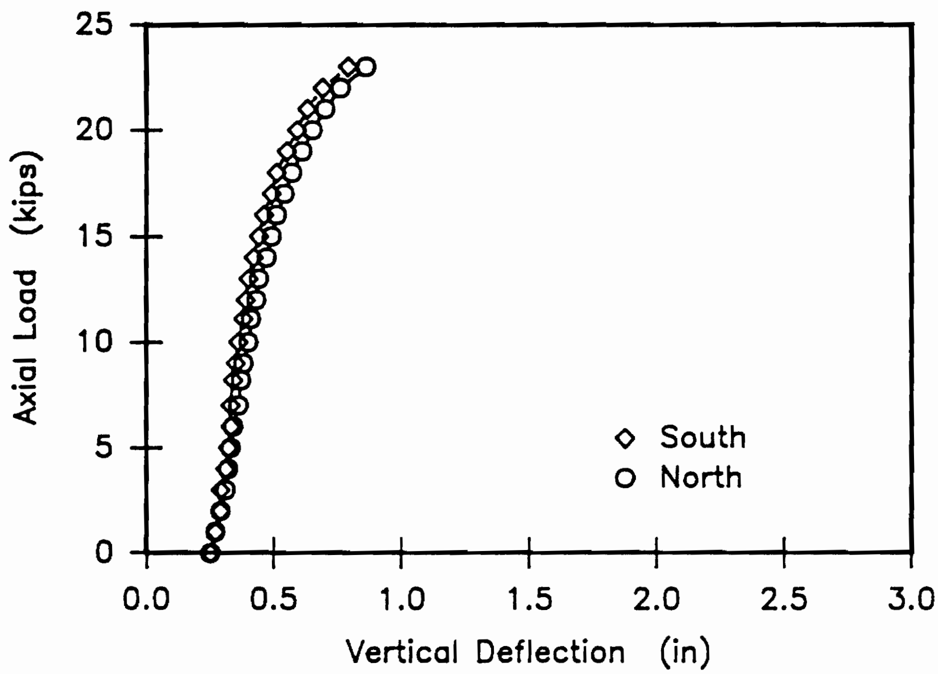
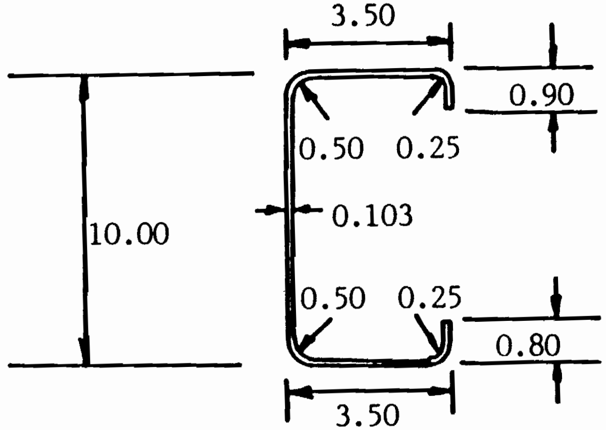
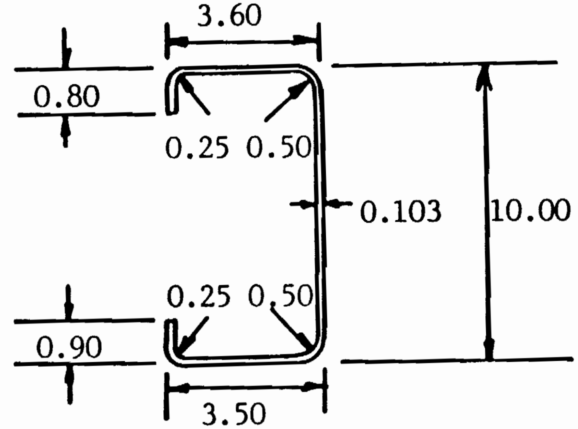


Figure H.40 **Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-10C-25**

Test No. SP-10C-25 Date 3-6-90 Recorder GLH



North Purlin



South Purlin

CALCULATION SHEET FOR TEST SP-10C-25

Moment Capacity (M_{ax})

M_{ax} = R x 1.67 x AISI Allowable Capacity

M_{ax} = .4 x 1.67 x 167.9 in-k = 112.2 in-k

Distributed Load

Dead Weight = 9 lb/ft ÷ 19.5 lb/ft/in of water = .47 in

$$\text{Total Allowable} = \frac{M_{ax}\, 8}{L^2} = \frac{112.2 \text{ in-k} \times 1000 \text{ lb}/12" \times 8}{25'^2} = 119.6 \text{ lb/ft}$$

Total Allowable = 119.6 lb/ft ÷ 19.5 lb/ft/in of water = 6.24 in of water

Set vacuum at 1.1 inches of water

w = (1.1 inches) (19.5 lb/ft/in) + 9 lb/ft = 30.1 lb/ft

Applied Moment (M)

$$M(\text{applied}) = \frac{wL^2}{8}$$

$$M(\text{applied}) = \frac{30.1 \text{ lb/ft} \times \text{ft}/12" \times 300"^2}{8 \times 1000 \text{ lb/k}} = 28.2 \text{ in-k}$$

Axial Capacity (P_a)

Fastener Location In The Flange		P_a (k)
2.75"	weak	16.5
1.50"	medium	26.0
.75"	strong	29.9

Actual average fastener location was 1.65" from the web, ∴ P_a = 24.9 k based on linear interpolation

Assumption

$$\frac{P}{P_a} + \frac{M\, Cm}{M_{ax}\left(1 - \frac{P}{P_a}\right)} = 1.0$$

Predicted Axial Failure Load

$$P = P_a\left(1 - \sqrt{\frac{M}{M_{ax}}}\right) = 24.9 \text{ k}\left(1 - \sqrt{\frac{28.2}{112.2}}\right) = 12.4 \text{ k}$$

SP10C25N

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.9000	0.8000
Lip angles	(degrees) :		90.0000	90.0000
Flange widths	(inches) :		3.5000	3.5000
Radii	(inches)			
Lip to flange	:		0.2500	0.2500
Flange to web	:		0.5000	0.5000
Total purlin depth	(inches) :	10.0000		
Purlin thickness	(inches) :	0.1030		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	57.3
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	2.5440
Gross moment of inertia	(in^4) :	26.96

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 2.2388	inches
Effective moment of inertia	: 25.33	in^4
Allowable flexural capacity	: 167.95	kip-in

1980 AISI PROCEDURE

SP10C25S

GEOMETRY OF CROSS-SECTION

				TOP	BOTTOM
Vertical lip dimensions	(inches)	:		0.8000	0.9000
Lip angles	(degrees)	:		90.0000	90.0000
Flange widths	(inches)	:		3.6000	3.5000
Radii	(inches)				
Lip to flange		:		0.2500	0.2500
Flange to web		:		0.5000	0.5000
Total purlin depth	(inches)	:	10.0000		
Purlin thickness	(inches)	:	0.1030		

MATERIAL PROPERTIES

Material yield stress	(ksi)	:	57.3
Modulus of elasticity	(ksi)	:	29500.0

GENERAL

Flat width of compression flange	(inches)	:	2.6440
Gross moment of inertia	(in^4)	:	27.22

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	:	2.0940	inches
Effective moment of inertia	:	24.91	in^4
Allowable flexural capacity	:	162.34	kip-in

2	ISEC (2=C SECTION, 3=Z SECTION)
300.	STUD LENGTH XL
10.00	SECTION DEPTH HH
9.90	CENTERLINE DIMENSION OF WEB H
3.40	CENTERLINE DIMENSION OF FLG B
.85	CENTERLINE DIMENSION OF LIP D
.103	THICKNESS
.72	FORM FACTOR Q
53.2	S (K) SHEAR RIGIDITY
.2377	F (K-IN/IN-RAD) ROTATIONAL CAPACITY
.0955	GAMD (IN/IN) DIAPHRAGM STRAIN @ FAILURE
.2506	FED (RAD) PURLIN TWIST @ FAILURE
57.30	FY YIELD STRESS
12.	DISTANCE BETWEEN FASTENERS XL1
0.	1=DETAILS PRINTED 0=DETAILS NOT PRINTED
1.808	AREA
26.968	XXI
2.753	YYI
-.106	XYI
2.400	XO
0.006	XJ
51.036	CW

INPUT DATA TO (STUDA2.EXE) FOR TEST SP-10C-25

SP10C25N
8393
06-06-1990

COLD-FORMED STEEL DESIGN PROGRAM

PART: **North Purlin**

Thickness: 0.1030

	Length	Angle	Radius	w/t
1	0.900	90.000	0.1030	5.31
2	3.500	0.000	0.2500	24.70
3	10.000	-90.000	0.5000	85.38
4	3.500	180.000	0.5000	24.70
5	0.800	90.000	0.2500	4.34

SECTION PROPERTIES

Area	1.808	Wt/Ft	6.148
Top to CG	4.9764	Sx(t)	5.419
Bottom to CG	5.0236	Sx(b)	5.368
Left edge to CG	2.5305	Sy(l)	1.088
Right edge to CG	0.9695	Sy(r)	2.839
Ix	26.968	rx	3.862
Iy	2.753	ry	1.234
I1	26.968	r1	3.862
I2	2.752	r2	1.234
Ic	29.721	rc	4.054
Io	40.152	ro	4.712
Ixy	-0.106	Xo	2.400
Alpha	0.251	Yo	0.099
Cw	51.036	jx	-5.484
J	0.006	jy	-0.117

SP10C25S
6124
06-06-1990

COLD-FORMED STEEL DESIGN PROGRAM

PART: **South Purlin**

Thickness: 0.1030

	Length	Angle	Radius	w/t
1	0.800	90.000	0.1030	4.34
2	3.600	0.000	0.2500	25.67
3	10.000	-90.000	0.5000	85.38
4	3.500	180.000	0.5000	24.70
5	0.900	90.000	0.2500	5.31

SECTION PROPERTIES

Area	1.819	Wt/Ft	6.183
Top to CG	4.9955	Sx(t)	5.449
Bottom to CG	5.0045	Sx(b)	5.439
Left edge to CG	2.6127	Sy(l)	1.091
Right edge to CG	0.9873	Sy(r)	2.887
Ix	27.221	rx	3.869
Iy	2.850	ry	1.252
I1	27.221	r1	3.869
I2	2.850	r2	1.252
Ic	30.071	rc	4.066
Io	40.915	ro	4.743
Ixy	-0.051	Xo	2.442
Alpha	0.121	Yo	0.021
Cw	52.832	jx	-5.495
J	0.006	jy	-0.015

SP-10C-50

Test Summary

Test Date: March 31, 1990

Purpose: Verify Interaction Equation

Span(s): 1 @ 25'-0"

Measured Dimensions:

	North	South
Thickness	0.103"	0.102"
Sweep	0	0

Parameters:
- Acial Load Applied
- Screw down type decking
- Two Purlin Lines 5'-0" O.C. 1'-0" overhang
- Purlins facing each other
- Simple supported
- Lateral supports at ends only

Predicted Failure Loads: (F_y = 57.1 ksi)

Uplift: 64.6 plf M: 60.6 in-kip

Axial: 6.2 k

Actual Failure Load:

Uplift: 64.6 plf M: 60.6 in-kip

Axial: 16 k

P/P_a = .69

M/M_{ax} = .54

Discussion:

- Torsional-flexural buckling was followed by local buckling of the web to unsupported flange junction
- Failure occurred in the north purlin
- Maximum horizontal deflection was 2.94"
- Maximum vertical deflection was 1.46"

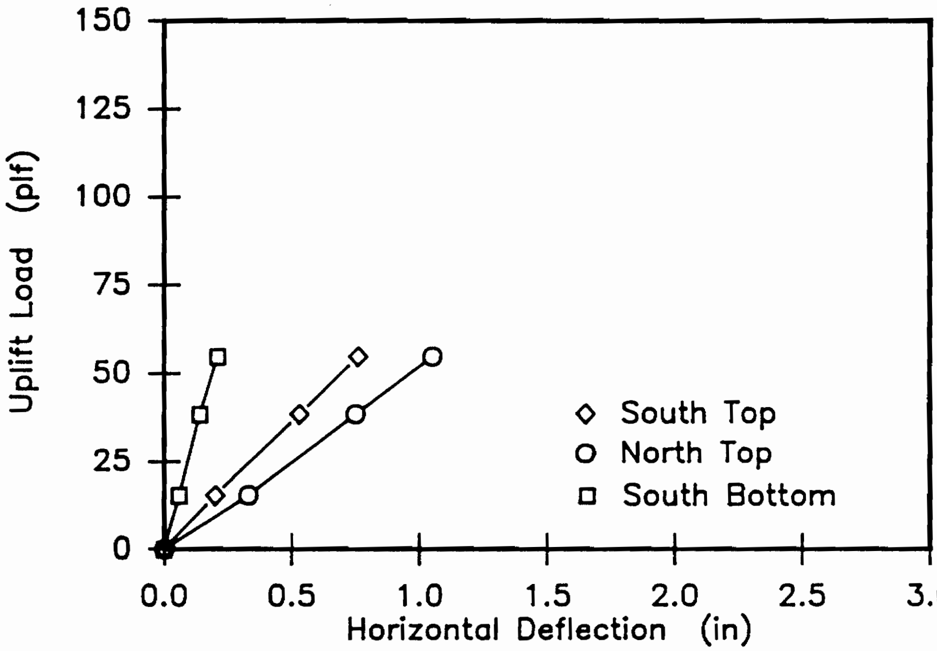


Figure H.41 **Uplift Load Versus Midspan Deflection of Purlin Flanges for Test SP-10C-50**

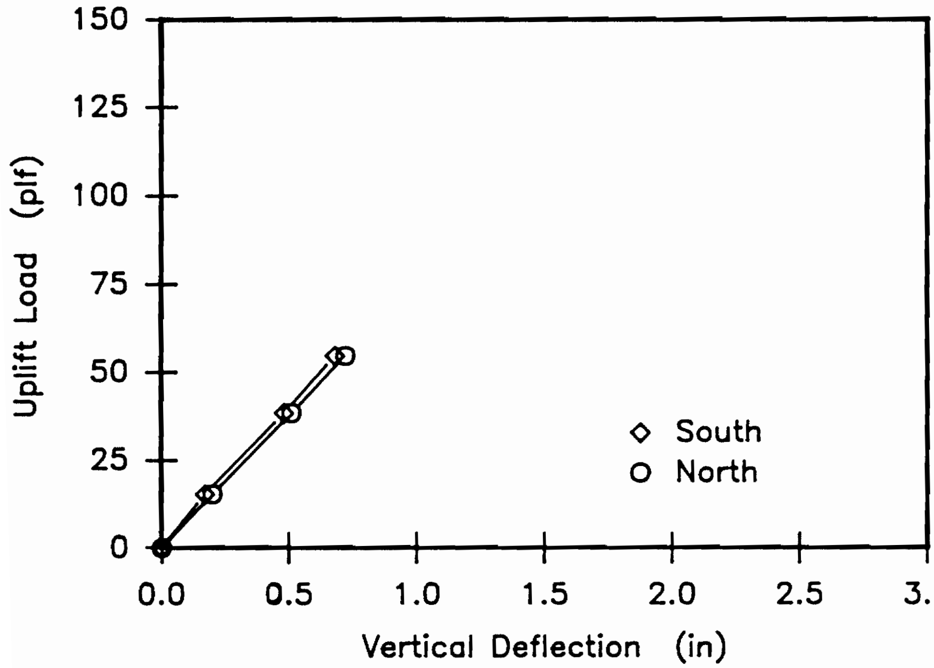


Figure H.42 **Uplift Load Versus Midspan Deflection of Purlin Flanges for Test SP-10C-50**

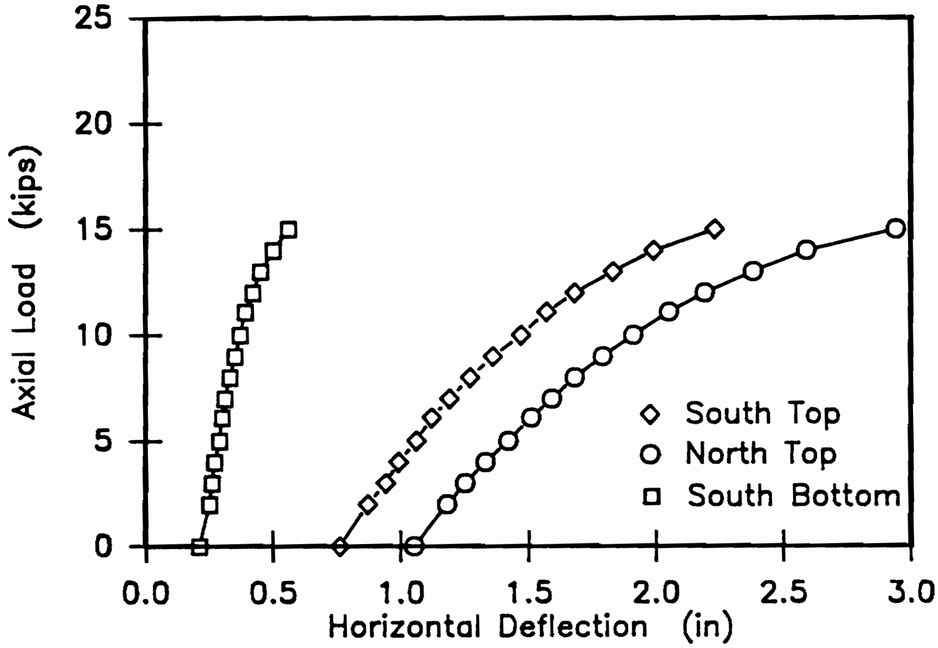


Figure H.43 Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-10C-50

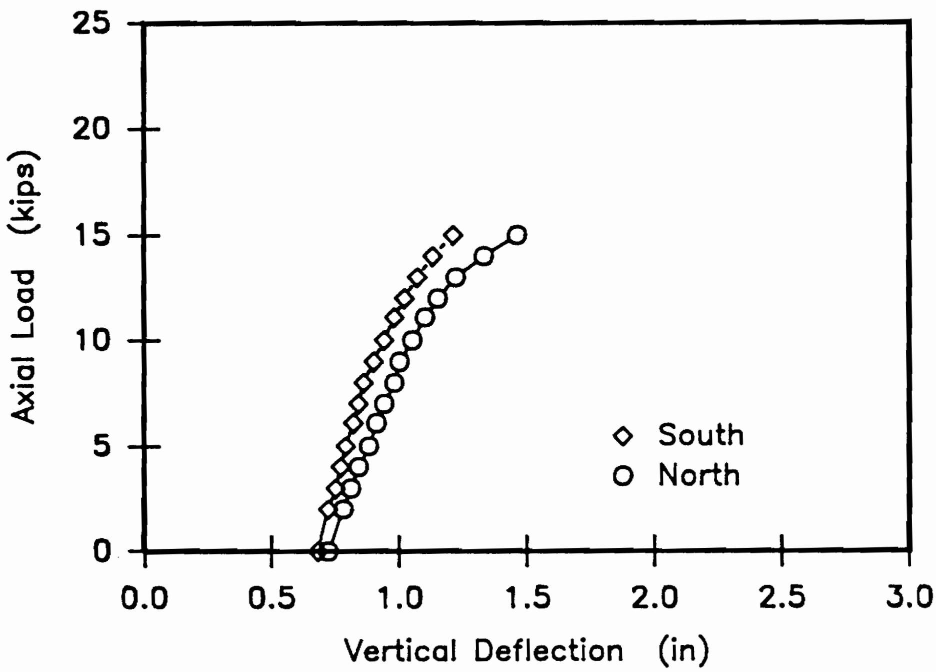
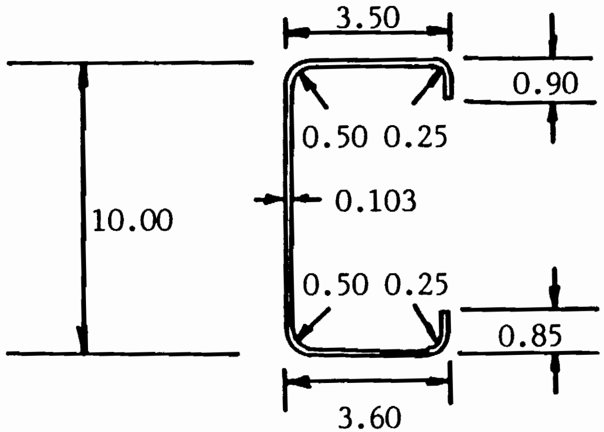
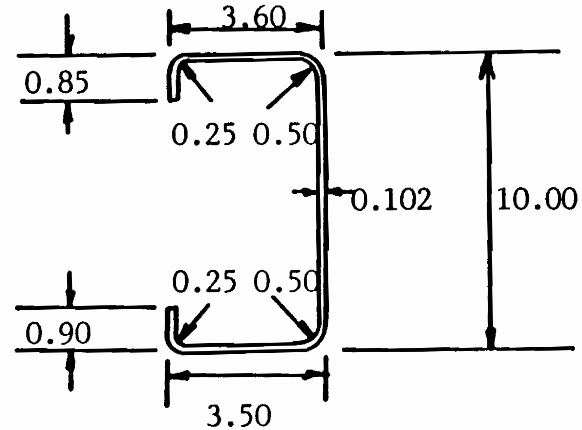


Figure H.44 Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-10C-50

Test No. SP-10C-50 Date 3-27-90 Recorder BLR



North Purlin



South Purlin

CALCULATION SHEET FOR
TEST SP-10C-50

Moment Capacity (M_{ax})

M_{ax} = R x 1.67 x AISI Allowable Capacity

M_{ax} = .4 x 1.67 x 168.3 in-k = 112.4 in-k

Distributed Load

Dead Weight = 9 lb/ft ÷ 19.5 lb/ft/in of water = .47 in

$$\text{Total Allowable} = \frac{M_{ax}\,8}{L^2} = \frac{112.4\text{ in-k} \times 1000\text{ lb}/12" \times 8}{25'^2} = 119.9\text{ lb/ft}$$

Total Allowable = 119.9 lb/ft ÷ 19.5 lb/ft/in of water = 6.15 in of water

Set vacuum at 2.85 inches of water

w = (2.85 inches) (19.5 lb/ft/in) + 9 lb/ft = 64.6 lb/ft

Applied Moment (M)

$$M(\text{applied}) = \frac{wL^2}{8}$$

$$M(\text{applied}) = \frac{64.6\text{ lb/ft} \times \text{ft}/12" \times 300"^2}{8 \times 1000\text{ lb/k}} = 60.6\text{ in-k}$$

Axial Capacity (P_a)

Fastener Location In The Flange		P_a (k)
2.75"	weak	16.7
1.50"	medium	26.2
.75"	strong	30.5

Actual average fastener location was 1.9" from the web, ∴ P_a = 23.3 k based on linear interpolation

Assumption

$$\frac{P}{P_a} + \frac{M\,Cm}{M_{ax}\left(1 - \frac{P}{P_a}\right)} = 1.0$$

Predicted Axial Failure Load

$$P = P_a\left(1 - \sqrt{\frac{M}{M_{ax}}}\right) = 23.3\text{ k}\left(1 - \sqrt{\frac{60.6}{112.4}}\right) = 6.2\text{ k}$$

SP10C50N

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.9000	0.8500
Lip angles	(degrees) :		90.0000	90.0000
Flange widths	(inches) :		3.5000	3.6000
Radii	(inches)			
Lip to flange	:		0.2500	0.2500
Flange to web	:		0.5000	0.5000
Total purlin depth	(inches) :	10.0000		
Purlin thickness	(inches) :	0.1030		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	57.1
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	2.5440
Gross moment of inertia	(in^4) :	27.31

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 2.2437	inches
Effective moment of inertia	: 25.66	in^4
Allowable flexural capacity	: 168.30	kip-in

SP10C50S

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.8500	0.9000
Lip angles	(degrees) :		90.0000	90.0000
Flange widths	(inches) :		3.6000	3.5000
Radii	(inches)			
Lip to flange	:		0.2500	0.2500
Flange to web	:		0.5000	0.5000
Total purlin depth	(inches) :	10.0000		
Purlin thickness	(inches) :	0.1020		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	57.1
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	2.6460
Gross moment of inertia	(in^4) :	27.06

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 2.1510	inches
Effective moment of inertia	: 24.89	in^4
Allowable flexural capacity	: 162.37	kip-in

2	ISEC (2=C SECTION, 3=Z SECTION)
300.	STUD LENGTH XL
10.00	SECTION DEPTH HH
9.89	CENTERLINE DIMENSION OF WEB H
3.39	CENTERLINE DIMENSION OF FLG B
.85	CENTERLINE DIMENSION OF LIP D
.102	THICKNESS
.72	FORM FACTOR Q
53.2	S (K) SHEAR RIGIDITY
.2377	F (K-IN/IN-RAD) ROTATIONAL CAPACITY
.0955	GAMD (IN/IN) DIAPHRAGM STRAIN @ FAILURE
.2506	FED (RAD) PURLIN TWIST @ FAILURE
56.10	FY YIELD STRESS
12.	DISTANCE BETWEEN FASTENERS XL1
0.	1=DETAILS PRINTED 0=DETAILS NOT PRINTED
1.824	AREA
27.310	XXI
2.884	YYI
0.106	XYI
2.459	XO
0.006	XJ
53.753	CW

INPUT DATA TO (STUDA2.EXE) FOR TEST SP-10C-50

COLD-FORMED STEEL DESIGN PROGRAM

PART: **North Purlin**

Thickness: 0.1030

	Length	Angle	Radius	w/t
1	0.900	90.000	0.1030	5.31
2	3.500	0.000	0.2500	24.70
3	10.000	-90.000	0.5000	85.38
4	3.600	180.000	0.5000	25.67
5	0.850	90.000	0.2500	4.83

SECTION PROPERTIES

Area	1.824	Wt/Ft	6.201
Top to CG	5.0163	Sx(t)	5.444
Bottom to CG	4.9837	Sx(b)	5.480
Left edge to CG	2.6055	Sy(l)	1.107
Right edge to CG	0.9945	Sy(r)	2.900
Ix	27.310	rx	3.870
Iy	2.884	ry	1.257
I1	27.311	r1	3.870
I2	2.883	r2	1.257
Ic	30.194	rc	4.069
Io	41.235	ro	4.755
Ixy	0.106	Xo	2.459
Alpha	-0.249	Yo	-0.071
Cw	53.753	jx	-5.486
J	0.006	jy	0.074

COLD-FORMED STEEL DESIGN PROGRAM

PART: **South Purlin**

Thickness: 0.1020

	Length	Angle	Radius	w/t
1	0.850	90.000	0.1020	4.88
2	3.600	0.000	0.2500	25.94
3	10.000	-90.000	0.5000	86.24
4	3.500	180.000	0.5000	24.96
5	0.900	90.000	0.2500	5.37

SECTION PROPERTIES

Area	1.806	Wt/Ft	6.142
Top to CG	4.9837	Sx(t)	5.430
Bottom to CG	5.0163	Sx(b)	5.395
Left edge to CG	2.6055	Sy(l)	1.097
Right edge to CG	0.9945	Sy(r)	2.875
Ix	27.061	rx	3.870
Iy	2.859	ry	1.258
I1	27.061	r1	3.870
I2	2.858	r2	1.258
Ic	29.919	rc	4.070
Io	40.866	ro	4.756
Ixy	-0.105	Xo	2.461
Alpha	0.249	Yo	0.071
Cw	53.306	jx	-5.486
J	0.006	jy	-0.073

SP-10C-75

Test Summary

Test Date: April 6, 1990

Purpose: Verify Interaction Equation

Span(s): 1 @ 25'-0"

Measured Dimensions:

	North	South
Thickness	0.103"	0.103"
Sweep	0	0

Parameters:
- Axial
- Screw down type decking
- Two Purlin Lines 5'-0" O.C. 1'-0" overhang
- Purlins facing each other
- Simple supported
- Lateral supports at ends only

Predicted Failure Loads: (F_y = 61.7 ksi)

Uplift: 100.9 plf M: 94.4 in-kip

Axial: 2.5 k

Actual Failure Load:

Uplift: 100.9 plf M: 94.4 in-kip

Axial: 5.0 k

P/P_a = .22

M/M_{ax} = .79

Discussion:

- Torsional-flexural buckling was followed by the deck pulling off of the screws at mid span
- Failure occurred in the north purlin
- Maximum horizontal deflection was 4.18
- Maximum vertical deflection was 2.24

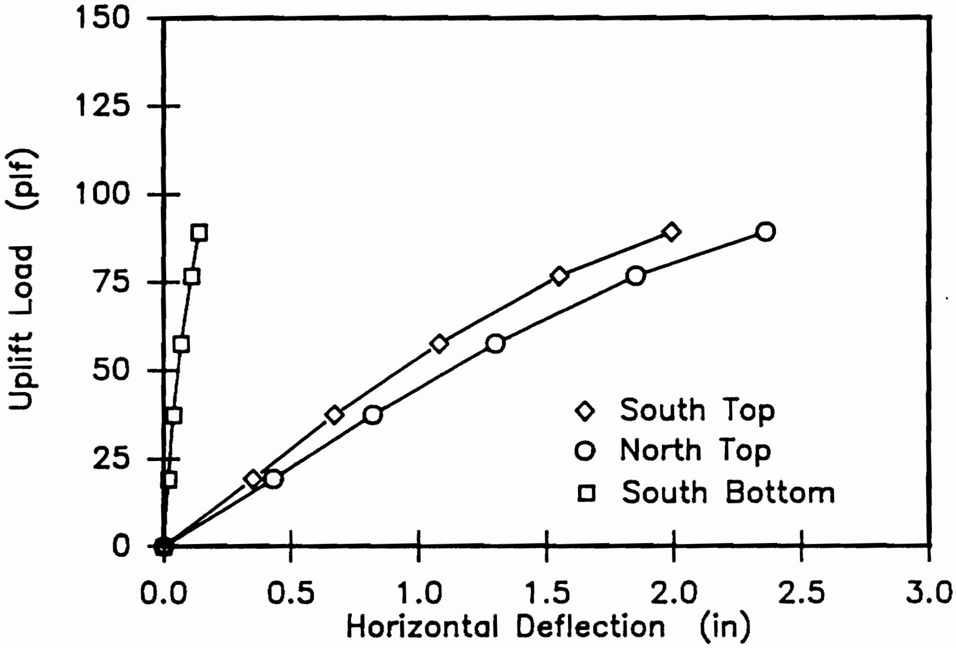


Figure H.45 Uplift Load Versus Midspan Deflection of Purlin Flanges for Test SP-10C-75

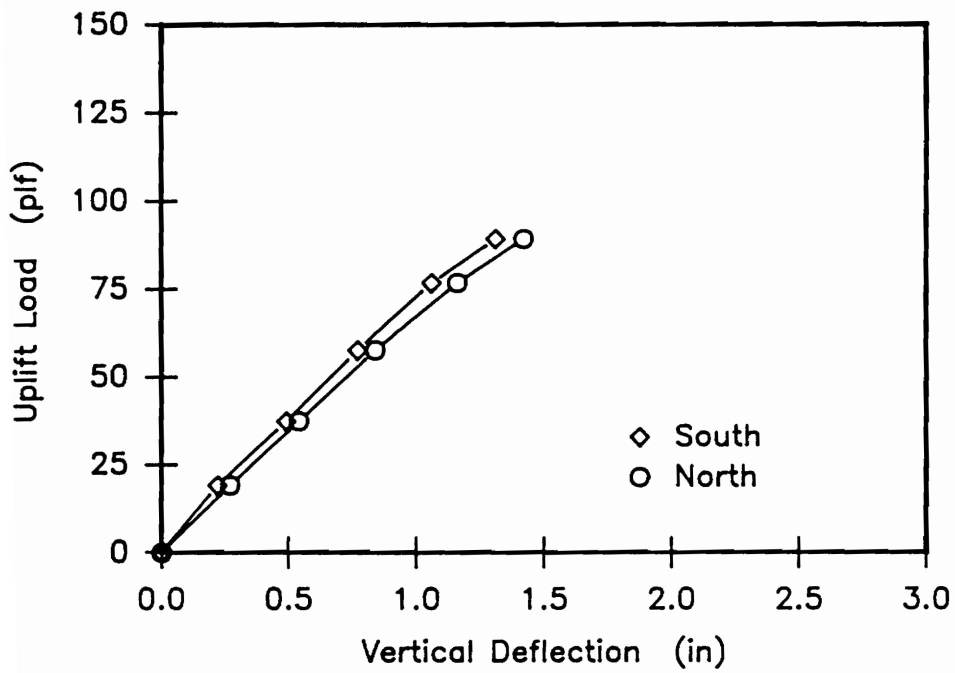


Figure H.46 Uplift Load Versus Midspan Deflection of Purlin Flanges for Test SP-10C-75

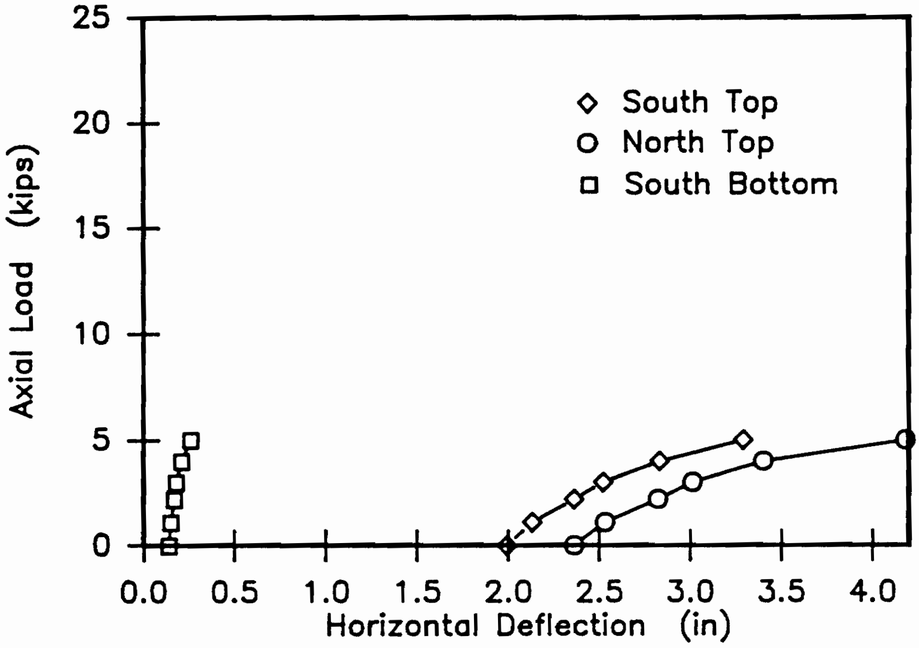


Figure H.47 **Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-10C-75**

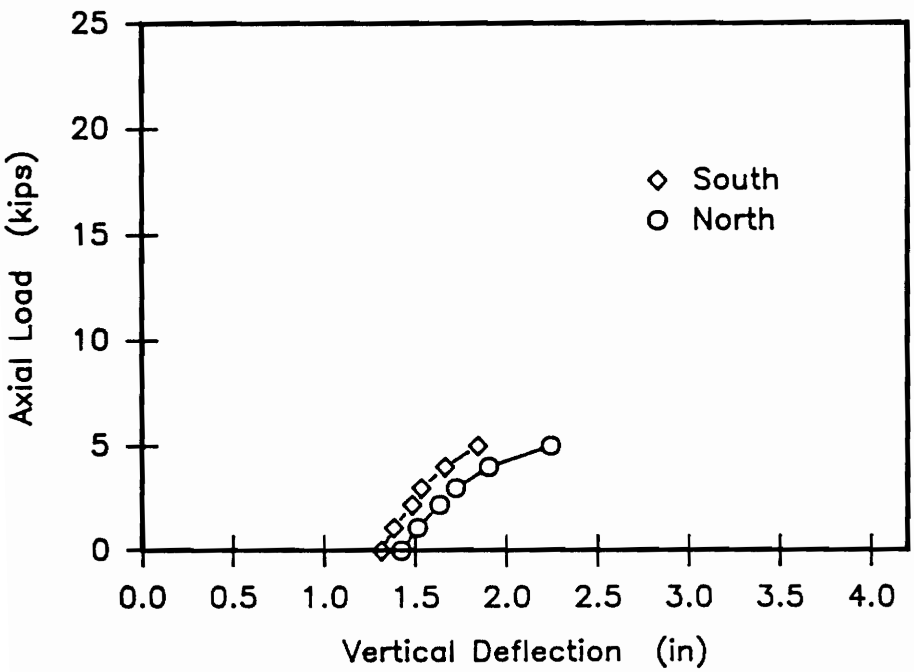
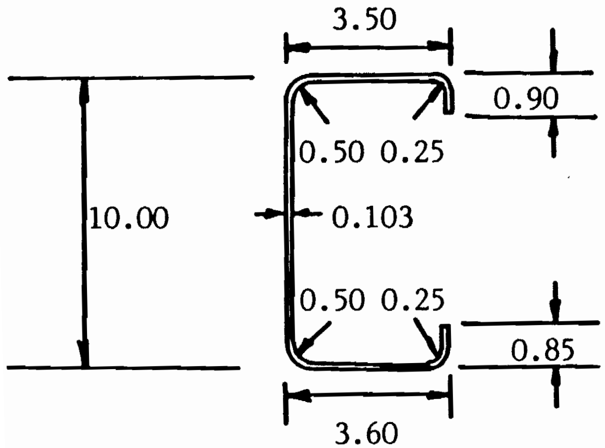
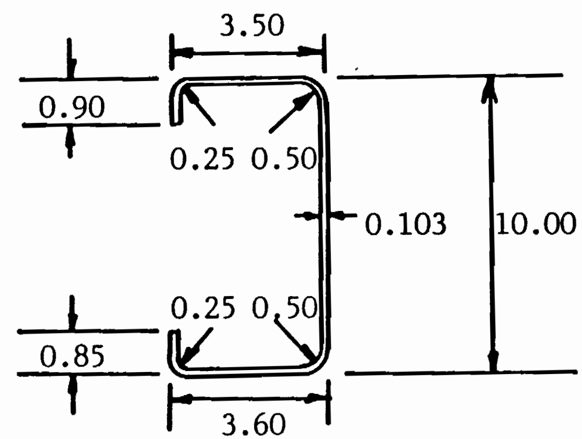


Figure H.48 **Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-10C-75**

Test No. SP-10C-75 Date 4-6-90 Recorder GLH



North Purlin



South Purlin

CALCULATION SHEET FOR
TEST SP-10C-75

Moment Capacity (M_{ax})

M_{ax} = R x 1.67 x AISI Allowable Capacity

M_{ax} = .4 x 1.67 x 178.1 in-k = 119.0 in-k

Distributed Load

Dead Weight = 9 lb/ft ÷ 19.5 lb/ft/in of water = .47 in

$$\text{Total Allowable} = \frac{M_{ax}\,8}{L^2} = \frac{119.0 \text{ in-k} \times 1000 \text{ lb}/12" \times 8}{25'^2} = 126.9 \text{ lb/ft}$$

Total Allowable = 126.9 lb/ft ÷ 19.5 lb/ft/in of water = 6.44 in of water

Set vacuum at 4.7 inches of water

w = (4.7 inches) (19.5 lb/ft/in) + 9 lb/ft = 100.7 lb/ft

Applied Moment (M)

$$M(\text{applied}) = \frac{wL^2}{8}$$

$$M(\text{applied}) = \frac{100.7 \text{ lb/ft} \times \text{ft}/12" \times 300^2}{8 \times 1000 \text{ lb/k}} = 94.4 \text{ in-k}$$

Axial Capacity (P_a)

Fastener Location In The Flange		P_a (k)
2.75"	weak	16.7
1.50"	medium	26.2
.75"	strong	30.5

Actual average fastener location was 2" from the web, ∴ P_a = 22.4 k based on linear interpolation

Assumption

$$\frac{P}{P_a} + \frac{M\,Cm}{M_{ax}\left(1 - \frac{P}{P_a}\right)} = 1.0$$

Predicted Axial Failure Load

$$P = P_a\left(1 - \sqrt{\frac{M}{M_{ax}}}\right) = 22.4 \text{ k}\left(1 - \sqrt{\frac{100.4}{119.0}}\right) = 2.5 \text{ k}$$

SP10C75N

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.9000	0.8500
Lip angles	(degrees) :		90.0000	90.0000
Flange widths	(inches) :		3.5000	3.6000
Radii	(inches)			
Lip to flange	:		0.2500	0.2500
Flange to web	:		0.5000	0.5000
Total purlin depth	(inches) :	10.0000		
Purlin thickness	(inches) :	0.1030		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	61.7
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	2.5440
Gross moment of inertia	(in^4) :	27.31

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 2.1361	inches
Effective moment of inertia	: 25.31	in^4
Allowable flexural capacity	: 178.08	kip-in

SP10C75S

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.9000	0.8500
Lip angles	(degrees) :		90.0000	90.0000
Flange widths	(inches) :		3.5000	3.6000
Radii	(inches)			
Lip to flange	:		0.2500	0.2500
Flange to web	:		0.5000	0.5000
Total purlin depth	(inches) :	10.0000		
Purlin thickness	(inches) :	0.1030		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	61.7
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	2.5440
Gross moment of inertia	(in^4) :	27.31

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 2.1361	inches
Effective moment of inertia	: 25.31	in^4
Allowable flexural capacity	: 178.08	kip-in

2	ISEC (2=C SECTION, 3=Z SECTION)
300.	STUD LENGTH XL
10.00	SECTION DEPTH HH
9.89	CENTERLINE DIMENSION OF WEB H
3.39	CENTERLINE DIMENSION OF FLG B
.85	CENTERLINE DIMENSION OF LIP D
.103	THICKNESS
.72	FORM FACTOR Q
53.2	S (K) SHEAR RIGIDITY
.2337	F (K-IN/IN-RAD) ROTATIONAL CAPACITY
.0955	GAMD (IN/IN) DIAPHRAGM STRAIN @ FAILURE
.2506	FED (RAD) PURLIN TWIST @ FAILURE
61.70	FY YIELD STRESS
12.	DISTANCE BETWEEN FASTENERS XL1
0.	1=DETAILS PRINTED 0=DETAILS NOT PRINTED
1.824	AREA
27.310	XXI
2.884	YYI
-.106	XYI
2.459	XO
0.006	XJ
53.753	CW

INPUT DATA TO (STUDA2.EXE) FOR TEST SP-10C-75

COLD-FORMED STEEL DESIGN PROGRAM

PART: **North Purlin**

Thickness: 0.1030

	Length	Angle	Radius	w/t
1	0.900	90.000	0.1030	5.31
2	3.500	180.000	0.2500	24.70
3	10.000	-90.000	0.5000	85.38
4	3.600	0.000	0.5000	25.67
5	0.850	90.000	0.2500	4.83

SECTION PROPERTIES

Area	1.824	Wt/Ft	6.201
Top to CG	5.0163	Sx(t)	5.444
Bottom to CG	4.9837	Sx(b)	5.480
Left edge to CG	0.9945	Sy(l)	2.900
Right edge to CG	2.6055	Sy(r)	1.107
Ix	27.310	rx	3.870
Iy	2.884	ry	1.257
I1	27.311	r1	3.870
I2	2.883	r2	1.257
Ic	30.194	rc	4.069
Io	41.234	ro	4.755
Ixy	-0.106	Xo	-2.459
Alpha	0.249	Yo	-0.071
Cw	53.753	jx	5.486
J	0.006	jy	0.074

COLD-FORMED STEEL DESIGN PROGRAM

PART: **South Purlin**

Thickness: 0.1030

	Length	Angle	Radius	w/t
1	0.900	90.000	0.1030	5.31
2	3.500	180.000	0.2500	24.70
3	10.000	-90.000	0.5000	85.38
4	3.600	0.000	0.5000	25.67
5	0.850	90.000	0.2500	4.83

SECTION PROPERTIES

Area	1.824	Wt/Ft	6.201
Top to CG	5.0163	Sx(t)	5.444
Bottom to CG	4.9837	Sx(b)	5.480
Left edge to CG	0.9945	Sy(l)	2.900
Right edge to CG	2.6055	Sy(r)	1.107
Ix	27.310	rx	3.870
Iy	2.884	ry	1.257
I1	27.311	r1	3.870
I2	2.883	r2	1.257
Ic	30.194	rc	4.069
Io	41.234	ro	4.755
Ixy	-0.106	Xo	-2.459
Alpha	0.249	Yo	-0.071
Cw	53.753	jx	5.486
J	0.006	jy	0.074

SP-10C-M

Test Summary

Test Date: March 23, 1990

Purpose: Verify Interaction Equation

Span(s): 1 @ 25'-0"

Measured Dimensions:

	North	South
Thickness	0.103"	0.104"
Sweep	0	0

Parameters:
- No axial load was applied
- Screw down type decking
- Two Purlin Lines 5'-0" O.C. 1'-0" overhang
- Purlins facing each other
- Simple supported
- Lateral supports at ends only

Predicted Failure Loads: (F_y = 57.1 ksi)

Uplift: 117.1 plf M: 109.7 in-kip

Axial: 0 k

Actual Failure Load:

Uplift: 140.0 plf M: 131.2 in-kip

Axial: 0 k

P/P_a = 0

M/M_{ax} = 1.20

Discussion:

- Torsional-flexural buckling was followed by the deck pulling off of the screws at mid span
- Failure occurred in the south purlin
- Maximum horizontal deflection was 3.88"
- Maximum vertical deflection was 2.47"

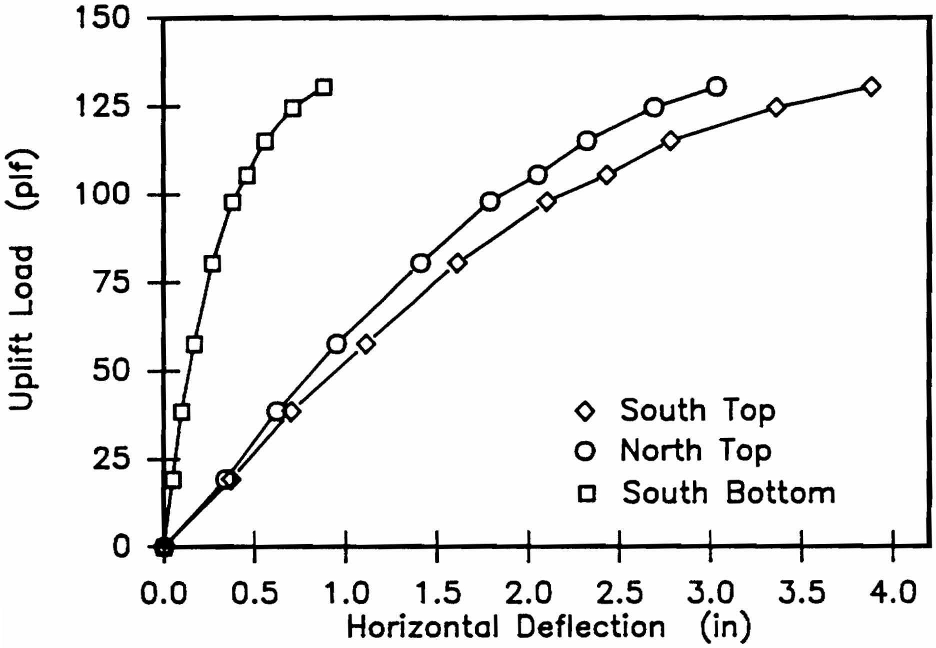


Figure H.49 Uplift Load Versus Midspan Deflection of Purlin Flanges for Test SP-10C-M

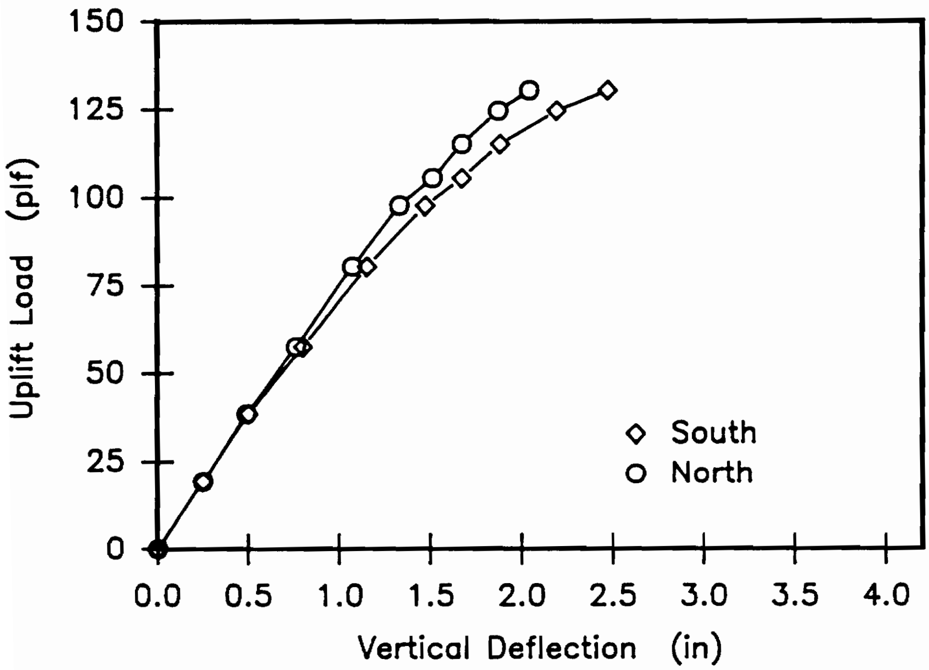
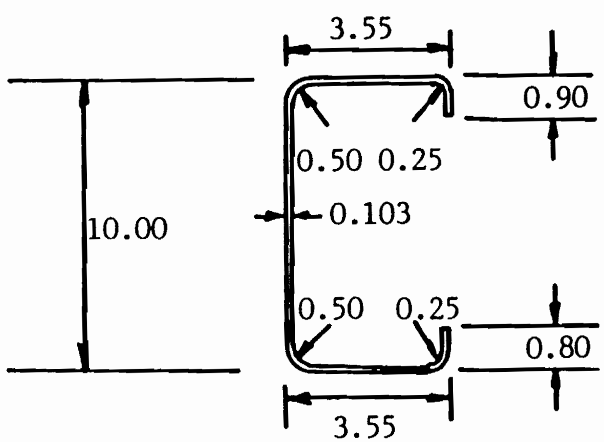
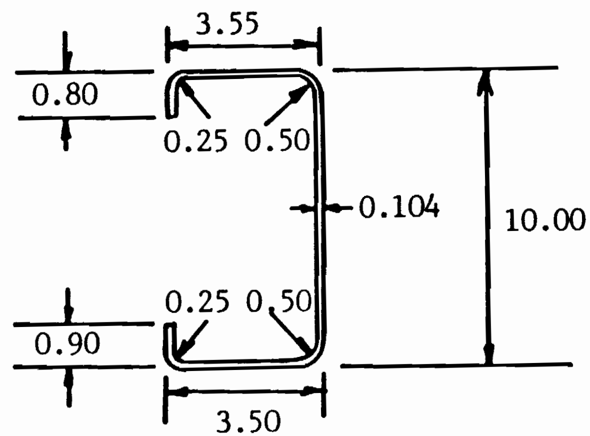


Figure H.50 Uplift Load Versus Midspan Deflection of Purlin Flanges for Test SP-10C-M

Test No. SP-10C-M Date 2-21-90 Recorder GLH



North Purlin



South Purlin

CALCULATION SHEET FOR TEST SP-10C-M

Moment Capacity (M_{ax})

M_{ax} = R x 1.67 x AISI Allowable Capacity

M_{ax} = .4 x 1.67 x 164.3 in-k = 109.7 in-k

Distributed Load

Dead Weight = 9 lb/ft ÷ 19.5 lb/ft/in of water = .47 in

$$\text{Total Allowable} = \frac{M_{ax}\,8}{L^2} = \frac{109.7\text{ in-k} \times 1000\text{ lb}/12" \times 8}{25'^2} = 117.1\text{ lb/ft}$$

Total Allowable = 117.1 lb/ft ÷ 19.5 lb/ft/in of water = 6.00 in of water

Set vacuum at 5.53 inches of water

w = (5.53 inches) (19.5 lb/ft/in) + 9 lb/ft = 117.1 lb/ft

Applied Moment (M)

$$M(\text{applied}) = \frac{wL^2}{8}$$

$$M(\text{applied}) = \frac{117.1\text{ lb/ft} \times \text{ft}/12" \times 300"^2}{8 \times 1000\text{ lb/k}} = 109.7\text{ in-k}$$

Axial Capacity (P_a)

Fastener Location In The Flange		P_a (k)
2.75"	weak	16.8
1.50"	medium	26.2
.75"	strong	30.1

Actual average fastener location was 1.75" from the web, ∴ P_a = 24.5 k based on linear interpolation

Assumption

$$\frac{P}{P_a} + \frac{M\,Cm}{M_{ax}\left(1 - \frac{P}{P_a}\right)} = 1.0$$

Predicted Axial Failure Load

P = 0 (No applied axial load)

SP10CMN

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.9000	0.8000
Lip angles	(degrees) :		90.0000	90.0000
Flange widths	(inches) :		3.5500	3.5500
Radii	(inches)			
Lip to flange	:		0.2500	0.2500
Flange to web	:		0.5000	0.5000
Total purlin depth	(inches) :	10.0000		
Purlin thickness	(inches) :	0.1030		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	57.1
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	2.5940
Gross moment of inertia	(in^4) :	27.22

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 2.2386	inches
Effective moment of inertia	: 25.42	in^4
Allowable flexural capacity	: 167.43	kip-in

SP10CMS

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches)	:	0.8000	0.9000
Lip angles	(degrees)	:	90.0000	90.0000
Flange widths	(inches)	:	3.5500	3.5000
Radii	(inches)			
Lip to flange		:	0.2500	0.2500
Flange to web		:	0.5000	0.5000
Total purlin depth	(inches)	: 10.0000		
Purlin thickness	(inches)	: 0.1040		

MATERIAL PROPERTIES

Material yield stress	(ksi)	: 57.1
Modulus of elasticity	(ksi)	: 29500.0

GENERAL

Flat width of compression flange	(inches)	: 2.5920
Gross moment of inertia	(in^4)	: 27.34

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 2.1239	inches
Effective moment of inertia	: 25.24	in^4
Allowable flexural capacity	: 154.30	kip-in

2	ISEC (2=C SECTION, 3=Z SECTION)
300.	STUD LENGTH XL
10.00	SECTION DEPTH HH
9.90	CENTERLINE DIMENSION OF WEB H
3.45	CENTERLINE DIMENSION OF FLG B
.85	CENTERLINE DIMENSION OF LIP D
.103	THICKNESS
.72	FORM FACTOR Q
53.2	S (K) SHEAR RIGIDITY
.2377	F (K-IN/IN-RAD) ROTATIONAL CAPACITY
.0955	GAMD (IN/IN) DIAPHRAGM STRAIN @ FAILURE
.2506	FED (RAD) PURLIN TWIST @ FAILURE
57.10	FY YIELD STRESS
12.	DISTANCE BETWEEN FASTENERS XL1
0.	1=DETAILS PRINTED 0=DETAILS NOT PRINTED
1.830	AREA
27.342	XXI
2.825	YYI
0.028	XYI
2.420	XO
0.007	XJ
52.368	CW

INPUT DATA TO (STUDA2.EXE) FOR TEST SP-10C-M

COLD-FORMED STEEL DESIGN PROGRAM

PART: **North Purlin**

Thickness: 0.1030

	Length	Angle	Radius	w/t
1	0.900	90.000	0.1030	5.31
2	3.550	0.000	0.2500	25.18
3	10.000	-90.000	0.5000	85.38
4	3.550	180.000	0.5000	25.18
5	0.800	90.000	0.2500	4.34

SECTION PROPERTIES

Area	1.819	Wt/Ft	6.183
Top to CG	4.9765	Sx(t)	5.470
Bottom to CG	5.0235	Sx(b)	5.419
Left edge to CG	2.5626	Sy(l)	1.113
Right edge to CG	0.9874	Sy(r)	2.887
Ix	27.220	rx	3.869
Iy	2.851	ry	1.252
I1	27.221	r1	3.869
I2	2.851	r2	1.252
Ic	30.071	rc	4.066
Io	40.930	ro	4.744
Ixy	-0.107	Xo	2.442
Alpha	0.252	Yo	0.098
Cw	52.826	jx	-5.493
J	0.006	jy	-0.116

COLD-FORMED STEEL DESIGN PROGRAM

PART: **South Purlin**

Thickness: 0.1040

	Length	Angle	Radius	w/t
1	0.800	90.000	0.1040	4.29
2	3.550	0.000	0.2500	24.92
3	10.000	-90.000	0.5000	84.54
4	3.500	180.000	0.5000	24.44
5	0.900	90.000	0.2500	5.25

SECTION PROPERTIES

Area	1.830	Wt/Ft	6.224
Top to CG	5.0095	Sx(t)	5.458
Bottom to CG	4.9905	Sx(b)	5.479
Left edge to CG	2.5716	Sy(l)	1.098
Right edge to CG	0.9784	Sy(r)	2.887
Ix	27.342	rx	3.865
Iy	2.825	ry	1.242
I1	27.342	r1	3.865
I2	2.825	r2	1.242
Ic	30.167	rc	4.060
Io	40.888	ro	4.726
Ixy	0.028	Xo	2.420
Alpha	-0.065	Yo	-0.038
Cw	52.368	jx	-5.490
J	0.007	jy	0.050

SP-10Z-0

Test Summary

Test Date: January 31, 1990

Purpose: Verify Interaction Equation

Span(s): 1 @ 25'-0"

Measured Dimensions:

	North	South
Thickness	0.083"	0.083"
Sweep	0	0

Parameters:

Axial load only applied

Screw down type decking

Two Purlin Lines 5'-0" O.C. 1'-0" overhang

Purlins facing each other

Simple supported

Lateral supports at ends only

Predicted Failure Loads: (F_y = 65.0 ksi)

Uplift: 7.6 plf M: 7.1 in-kip

Axial: 19.3 k

Actual Failure Load:

Uplift: 7.6 plf M: 7.1 in-kip

Axial: 18.9 k

P/P_a = .75

M/M_{ax} = .06

Discussion:

- Torsional-flexural buckling was followed by local buckling of the web to unsupported flange junction
- Failure occurred in the north purlin
- Maximum horizontal deflection was 2.11"
- Maximum vertical deflection was .35"

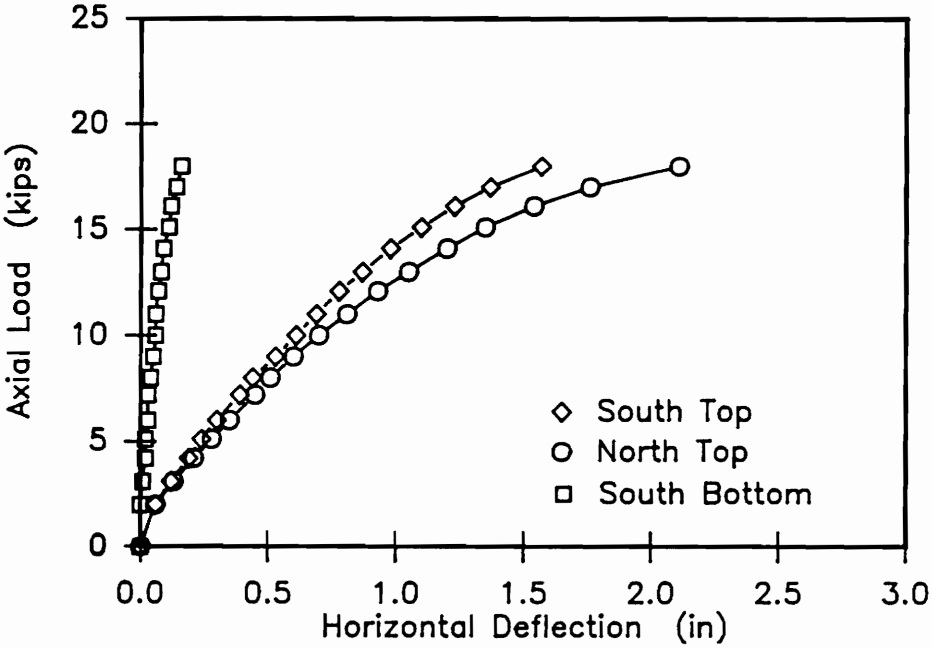


Figure H.19 Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-10Z-0

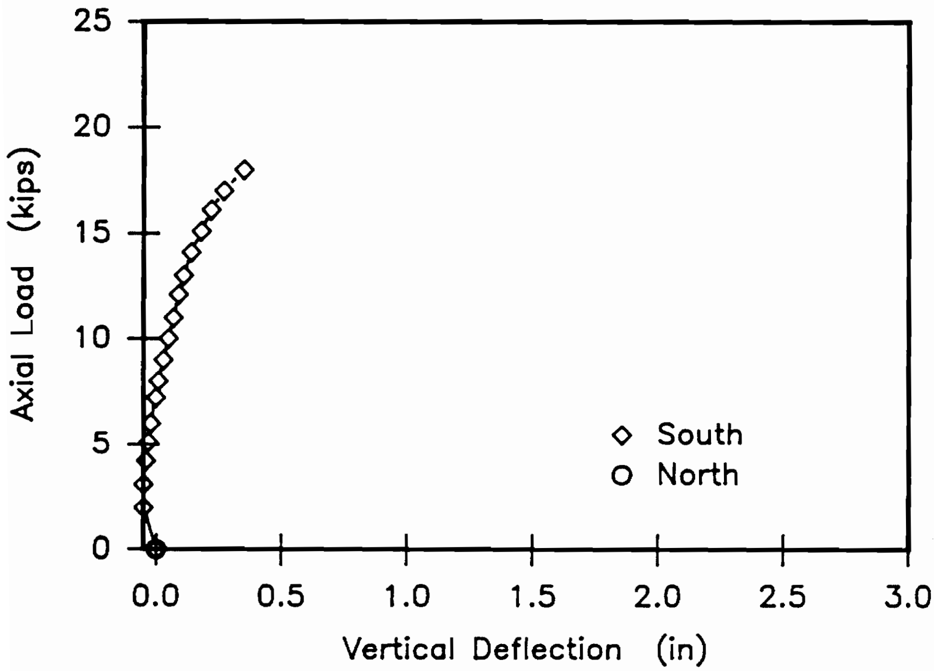
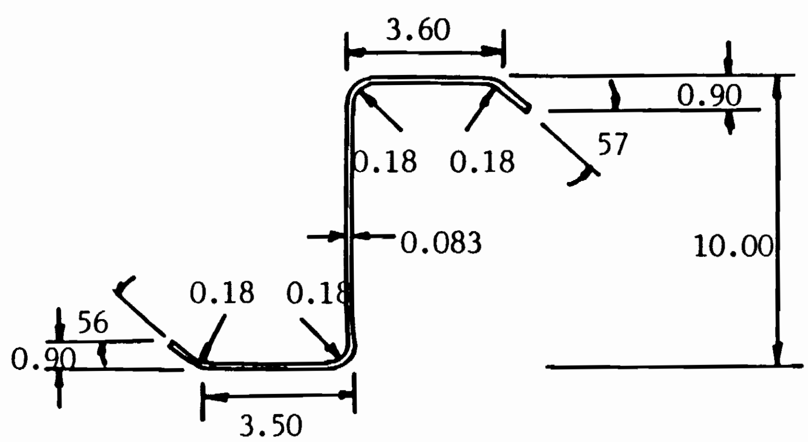
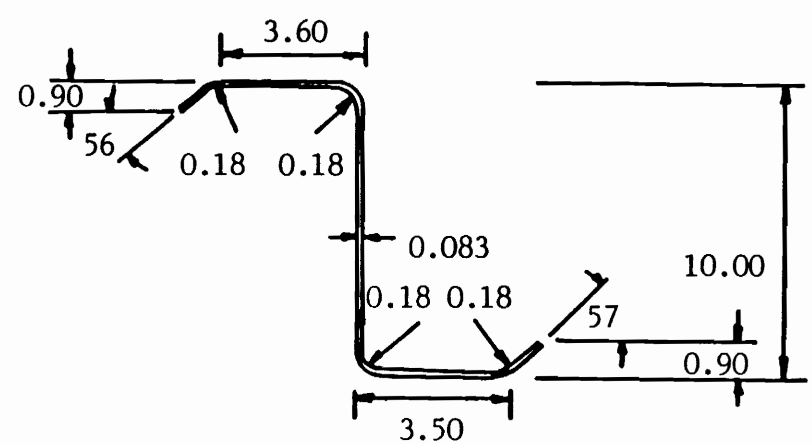


Figure H.20 Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-10Z-0

Test No. SP-10Z-0 Date 1-31-90 Recorder GLH



North Purlin



South Purlin

CALCULATION SHEET FOR TEST SP-10Z-0

Moment Capacity (M_{ax})

M_{ax} = R x 1.67 x AISI Allowable Capacity

M_{ax} = .5 x 1.67 x 150.9 in-k = 126.0 in-k

Distributed Load

Dead Weight = 7.6 lb/ft ÷ 19.5 lb/ft/in of water = .39 in of water

$$\text{Total Allowable} = \frac{M_{ax}\,8}{L^2} = \frac{126.0 \text{ in-k} \times 1000 \text{ lb}/12" \times 8}{25'^2} = 134.4 \text{ lb/ft}$$

Total Allowable = 134.4 lb/ft ÷ 19.5 lb/ft/in of water = 6.9 in of water

Set vacuum at 0 inches of water

w = (0 inches) (19.5 lb/ft/in) + 7.6 lb/ft = 7.6 lb/ft

Applied Moment (M)

$$M(\text{applied}) = \frac{wL^2}{8}$$

$$M(\text{applied}) = \frac{7.6 \text{ lb/ft} \times \text{ft}/12" \times 300"^2}{8 \times 1000 \text{ lb/k}} = 7.1 \text{ in-k}$$

Axial Capacity (P_a)

Fastener Location In The Flange		P_a (k)
1/2	weak	19.2
2	medium	27.5
3	strong	30.2

Actual average fastener location was 1.6" from the web, $\therefore P_a$ = 25.3 k based on linear interpolation

Assumption

$$\frac{P}{P_a} + \frac{M\,Cm}{M_{ax}\left(1 - \frac{P}{P_a}\right)} = 1.0$$

Predicted Axial Failure Load

$$P = P_a\left(1 - \sqrt{\frac{M}{M_{ax}}}\right) = 25.3 \text{ k}\left(1 - \sqrt{\frac{7.6}{126.0}}\right) = 19.3 \text{ k}$$

SP10ZON

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.9000	0.9000
Lip angles	(degrees) :		56.0000	57.0000
Flange widths	(inches) :		3.6000	3.5000
Radii	(inches)			
Lip to flange	:		0.1875	0.1875
Flange to web	:		0.1875	0.1875
Total purlin depth	(inches) :	10.0000		
Purlin thickness	(inches) :	0.0830		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	65.0
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	3.1857
Gross moment of inertia	(in^4) :	24.00

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 2.2982	inches
Effective moment of inertia	: 20.96	in^4
Allowable flexural capacity	: 150.94	kip-in

SP10ZOS

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.9000	0.9000
Lip angles	(degrees) :		56.0000	57.0000
Flange widths	(inches) :		3.6000	3.5000
Radii	(inches)			
Lip to flange	:		0.1875	0.1875
Flange to web	:		0.1875	0.1875
Total purlin depth	(inches) :	10.0000		
Purlin thickness	(inches) :	0.0830		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	65.0
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	3.1857
Gross moment of inertia	(in^4) :	24.00

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 2.2982	inches
Effective moment of inertia	: 20.96	in^4
Allowable flexural capacity	: 150.94	kip-in

3	ISEC (2=C SECTION, 3=Z SECTION)
300.	STUD LENGTH XL
10.00	SECTION DEPTH HH
9.917	CENTERLINE DIMENSION OF WEB H
3.50	CENTERLINE DIMENSION OF FLG B
.86	CENTERLINE DIMENSION OF LIP D
.083	THICKNESS
.68	FORM FACTOR Q
656.	S (K) SHEAR RIGIDITY
.1731	F (K-IN/IN-RAD) ROTATIONAL CAPACITY
.0035	GAMD (IN/IN) DIAPHRAGM STRAIN @ FAILURE
.1829	FED (RAD) PURLIN TWIST @ FAILURE
65.00	FY YIELD STRESS
12.	DISTANCE BETWEEN FASTENERS XL1
0.	1=DETAILS PRINTED 0=DETAILS NOT PRINTED
1.557	AREA
24.064	XXI
4.802	YYI
7.920	XYI
0.007	XO
0.004	XJ
82.334	CW

INPUT DATA TO (STUDA2.EXE) FOR TEST SP-10Z-0

COLD-FORMED STEEL DESIGN PROGRAM

PART: **North Purlin**

Thickness: 0.0830

	Length	Angle	Radius	w/t
1	1.080	-56.000	0.0830	11.28
2	3.500	0.000	0.1875	37.18
3	10.000	90.000	0.1875	113.96
4	3.600	0.000	0.1875	38.34
5	1.070	-57.000	0.1875	11.12

SECTION PROPERTIES

Area	1.557	Wt/Ft	5.293
Top to CG	4.9766	Sx(t)	4.835
Bottom to CG	5.0234	Sx(b)	4.790
Left edge to CG	4.0835	Sy(l)	1.176
Right edge to CG	4.1202	Sy(r)	1.165
Ix	24.064	rx	3.931
Iy	4.802	ry	1.756
I1	26.902	r1	4.157
I2	1.963	r2	1.123
Ic	28.865	rc	4.306
Io	28.896	ro	4.308
Ixy	7.920	Xo	0.007
Alpha	-19.717	Yo	0.140
Cw	82.334	jx	0.017
J	0.004	jy	-0.151

COLD-FORMED STEEL DESIGN PROGRAM

PART: **South Purlin**

Thickness: 0.0830

	Length	Angle	Radius	w/t
1	1.080	56.000	0.0830	11.28
2	3.600	0.000	0.1875	38.38
3	10.000	-90.000	0.1875	113.96
4	3.500	0.000	0.1875	37.14
5	1.070	57.000	0.1875	11.12

SECTION PROPERTIES

Area	1.557	Wt/Ft	5.293
Top to CG	4.9706	Sx(t)	4.841
Bottom to CG	5.0294	Sx(b)	4.784
Left edge to CG	4.1353	Sy(l)	1.161
Right edge to CG	4.0684	Sy(r)	1.180
Ix	24.063	rx	3.931
Iy	4.802	ry	1.756
I1	26.902	r1	4.157
I2	1.963	r2	1.123
Ic	28.865	rc	4.306
Io	28.920	ro	4.310
Ixy	-7.920	Xo	-0.012
Alpha	19.717	Yo	0.187
Cw	82.300	jx	-0.019
J	0.004	jy	-0.201

SP-10Z-25

Test Summary

Test Date: March 1, 1990

Purpose: Verify Interaction Equation

Span(s): 1 @ 25'-0"

Measured Dimensions:

	North	South
Thickness	0.084"	0.084"
Sweep	0	0

Parameters:
- Axial Load Applied
- Screw down type decking
- Two Purlin Lines 5'-0" O.C. 1'-0" overhang
- Purlins facing each other
- Simple supported
- Lateral supports at ends only

Predicted Failure Loads: (F_y = 66.2 ksi)

Uplift: 33.0 plf M: 30.9 in-kip

Axial: 14.1 k

Actual Failure Load:

Uplift: 33.0 plf M: 30.9 in-kip

Axial: 16.0 k

P/P_a = .58

M/M_{ax} = .24

Discussion:

- Torsional-flexural buckling was followed by local buckling of the web to unsupported flange junction
- Failure occurred in the south purlin
- Maximum horizontal deflection was 2.40"
- Maximum vertical deflection was 1.08"

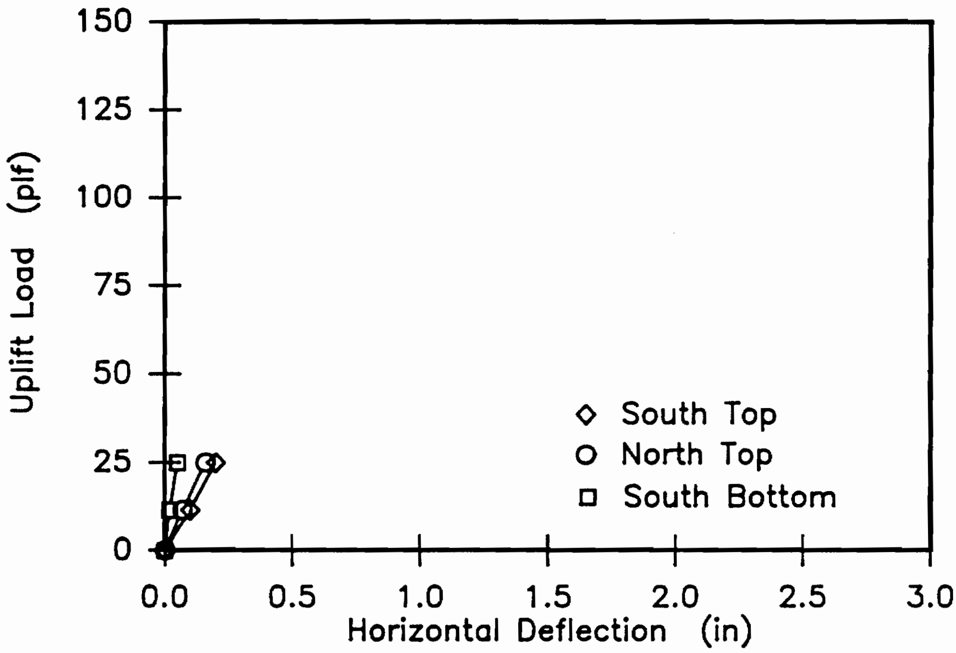


Figure H.21 Uplift Load Versus Midspan Deflection of Purlin Flanges for Test SP-10Z-25

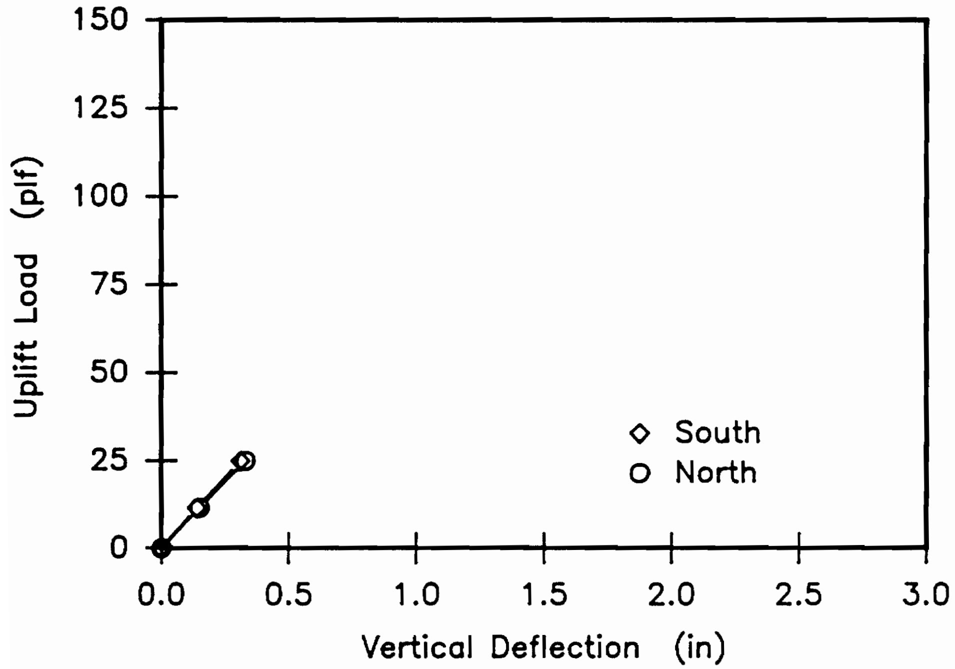


Figure H.22 Uplift Load Versus Midspan Deflection of Purlin Flanges for Test SP-10Z-25

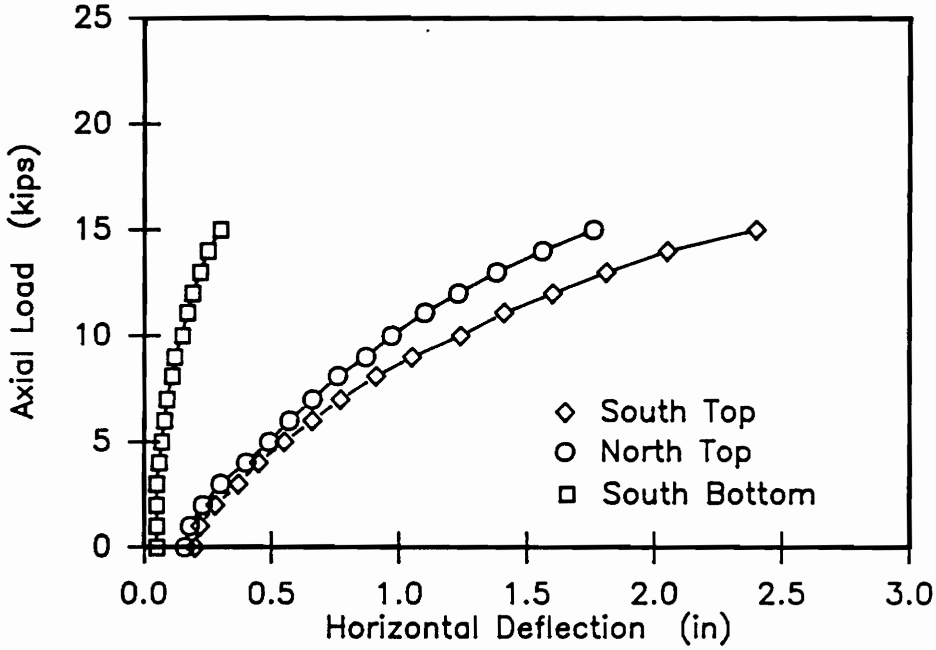


Figure H.23 Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-10Z-25

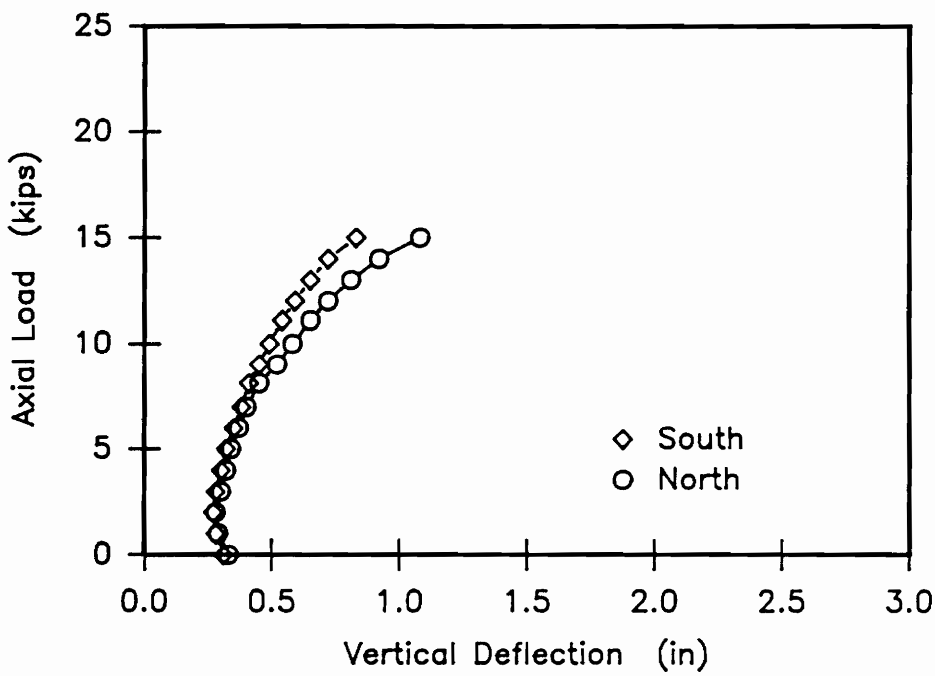
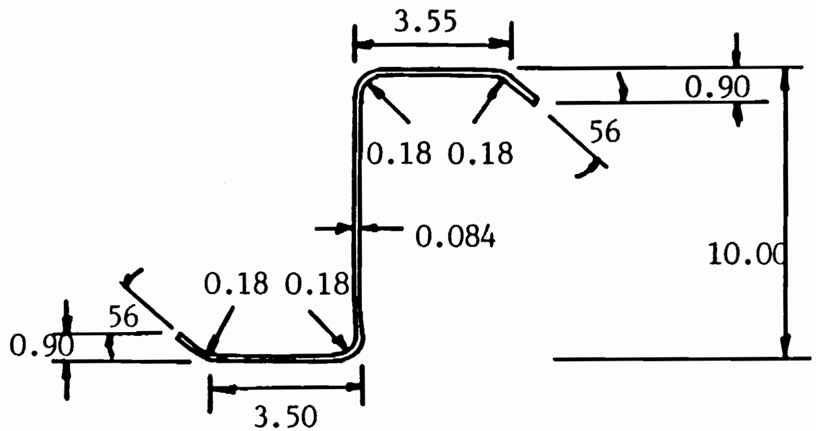
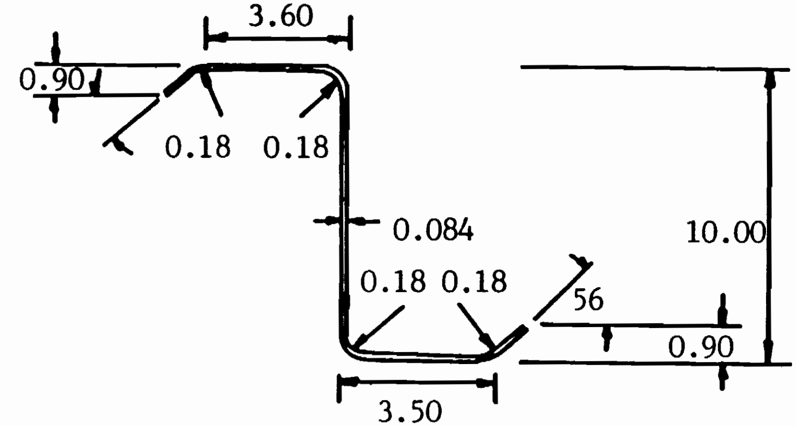


Figure H.24 Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-10Z-25

Test No. SP-10Z-25 Date 2-27-90 Recorder GLH



North Purlin



South Purlin

CALCULATION SHEET FOR TEST SP-10Z-25

Moment Capacity (M_{ax})

M_{ax} = R x 1.67 x AISI Allowable Capacity

M_{ax} = .5 x 1.67 x 154.8 in-k = 129.3 in-k

Distributed Load

Dead Weight = 7.6 lb/ft ÷ 19.5 lb/ft/in of water = .39 in

$$\text{Total Allowable} = \frac{M_{ax}\,8}{L^2} = \frac{129.3\text{ in-k} \times 1000\text{ lb}/12" \times 8}{25'^2} = 137.9\text{ lb/ft}$$

Total Allowable = 137.9 lb/ft ÷ 19.5 lb/ft/in of water = 7.07 in of water

Set vacuum at 1.3 inches of water

w = (1.3 inches) (19.5 lb/ft/in) + 7.6 lb/ft = 33.0 lb/ft

Applied Moment(M)

$$M(\text{applied}) = \frac{wL^2}{8}$$

$$M(\text{applied}) = \frac{33.0\text{ lb/ft} \times \text{ft}/12" \times 300"^2}{8 \times 1000\text{ lb/k}} = 30.94\text{ in-k}$$

Axial Capacity (P_a)

Fastener Location In The Flange		P_a (k)
1/2	weak	19.3
2	medium	27.6
3	strong	30.1

Actual average fastener location was 2" from the web, ∴ P_a = 27.6 k based on linear interpolation

Assumption

$$\frac{P}{P_a} + \frac{M\,Cm}{M_{ax}\left(1 - \frac{P}{P_a}\right)} = 1.0$$

Predicted Axial Failure Load

$$P = P_a\left(1 - \sqrt{\frac{M}{M_{ax}}}\right) = 27.6\text{ k}\left(1 - \sqrt{\frac{30.9}{129.3}}\right) = 14.1\text{ k}$$

SP10Z25N

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.9000	0.9000
Lip angles	(degrees) :		56.0000	56.0000
Flange widths	(inches) :		3.5500	3.5000
Radii	(inches)			
Lip to flange	:		0.1875	0.1875
Flange to web	:		0.1875	0.1875
Total purlin depth	(inches) :	10.0000		
Purlin thickness	(inches) :	0.0840		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	66.2
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	3.1341
Gross moment of inertia	(in^4) :	24.20

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 2.2825	inches
Effective moment of inertia	: 21.17	in^4
Allowable flexural capacity	: 154.97	kip-in

SP10Z25S

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.9000	0.9000
Lip angles	(degrees) :		57.0000	56.0000
Flange widths	(inches) :		3.6000	3.5000
Radii	(inches)			
Lip to flange	:		0.1875	0.1875
Flange to web	:		0.1875	0.1875
Total purlin depth	(inches) :	10.0000		
Purlin thickness	(inches) :	0.0840		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	66.2
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	3.1811
Gross moment of inertia	(in^4) :	24.28

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 2.2915	inches
Effective moment of inertia	: 21.16	in^4
Allowable flexural capacity	: 154.83	kip-in

3	ISEC (2=C SECTION, 3=Z SECTION)
300.	STUD LENGTH XL
10.00	SECTION DEPTH HH
9.916	CENTERLINE DIMENSION OF WEB H
3.50	CENTERLINE DIMENSION OF FLG B
.86	CENTERLINE DIMENSION OF LIP D
.084	THICKNESS
.68	FORM FACTOR Q
656.	S (K) SHEAR RIGIDITY
.0790	F (K-IN/IN-RAD) ROTATIONAL CAPACITY
.0035	GAMD (IN/IN) DIAPHRAGM STRAIN @ FAILURE
.2478	FED (RAD) PURLIN TWIST @ FAILURE
66.2	FY YIELD STRESS
12.	DISTANCE BETWEEN FASTENERS XL1
0.	1=DETAILS PRINTED 0=DETAILS NOT PRINTED
1.574	AREA
24.357	XXI
4.870	YYI
8.025	XYI
.006	XO
0.004	XJ
83.524	CW

INPUT DATA TO (STUDA2.EXE) FOR TEST SP-10Z-25

COLD-FORMED STEEL DESIGN PROGRAM

PART: **North Purlin**

Thickness: 0.0840

	Length	Angle	Radius	w/t
1	1.090	56.000	0.0840	11.26
2	3.550	0.000	0.1875	37.31
3	10.000	-90.000	0.1875	112.58
4	3.500	0.000	0.1875	36.72
5	1.090	56.000	0.1875	11.26

SECTION PROPERTIES

Area	1.574	Wt/Ft	5.351
Top to CG	4.9868	Sx(t)	4.871
Bottom to CG	5.0132	Sx(b)	4.845
Left edge to CG	4.1055	Sy(l)	1.174
Right edge to CG	4.0796	Sy(r)	1.182
Ix	24.290	rx	3.929
Iy	4.821	ry	1.750
I1	27.136	r1	4.152
I2	1.976	r2	1.120
Ic	29.112	rc	4.301
Io	29.122	ro	4.302
Ixy	-7.969	Xo	-0.005
Alpha	19.653	Yo	0.082
Cw	82.886	jx	-0.009
J	0.004	jy	-0.088

COLD-FORMED STEEL DESIGN PROGRAM

PART: South Purlin

Thickness: 0.0840

	Length	Angle	Radius	w/t
1	1.070	57.000	0.0840	10.98
2	3.600	0.000	0.1875	37.87
3	10.000	-90.000	0.1875	112.58
4	3.500	0.000	0.1875	36.72
5	1.090	56.000	0.1875	11.26

SECTION PROPERTIES

Area	1.576	Wt/Ft	5.359
Top to CG	4.9787	Sx(t)	4.892
Bottom to CG	5.0213	Sx(b)	4.851
Left edge to CG	4.1219	Sy(l)	1.181
Right edge to CG	4.0864	Sy(r)	1.192
Ix	24.357	rx	3.931
Iy	4.870	ry	1.758
I1	27.237	r1	4.157
I2	1.990	r2	1.124
Ic	29.227	rc	4.306
Io	29.251	ro	4.308
Ixy	-8.025	Xo	-0.006
Alpha	19.738	Yo	0.123
Cw	83.524	jx	-0.019
J	0.004	jy	-0.132

SP-10Z-50

Test Summary

Test Date: February 16, 1990

Purpose: Verify Interaction Equation

Span(s): 1 @ 25'-0"

Measured Dimensions:

	North	South
Thickness	0.083"	0.083"
Sweep	1/4	0

Parameters: Axial Load Applied

Screw down type decking

Two Purlin Lines 5'-0" O.C. 1'-0" overhang

Purlins facing each other

Simple supported

Lateral supports at ends only

Predicted Failure Loads: (F_y = 66.3 ksi)

Uplift: 64.1 plf M: 60.1 in-kip

Axial: 8.4 k

Actual Failure Load:

Uplift: 64.1 plf M: 60.1 in-kip

Axial: 11.7 k

P/P_a = .42

M/M_{ax} = .48

Discussion:

- Torsional-flexural buckling was followed by local buckling of the web to unsupported flange junction
- Failure occurred in the south purlin
- Maximum horizontal deflection was 2.94"
- Maximum vertical deflection was 1.74"

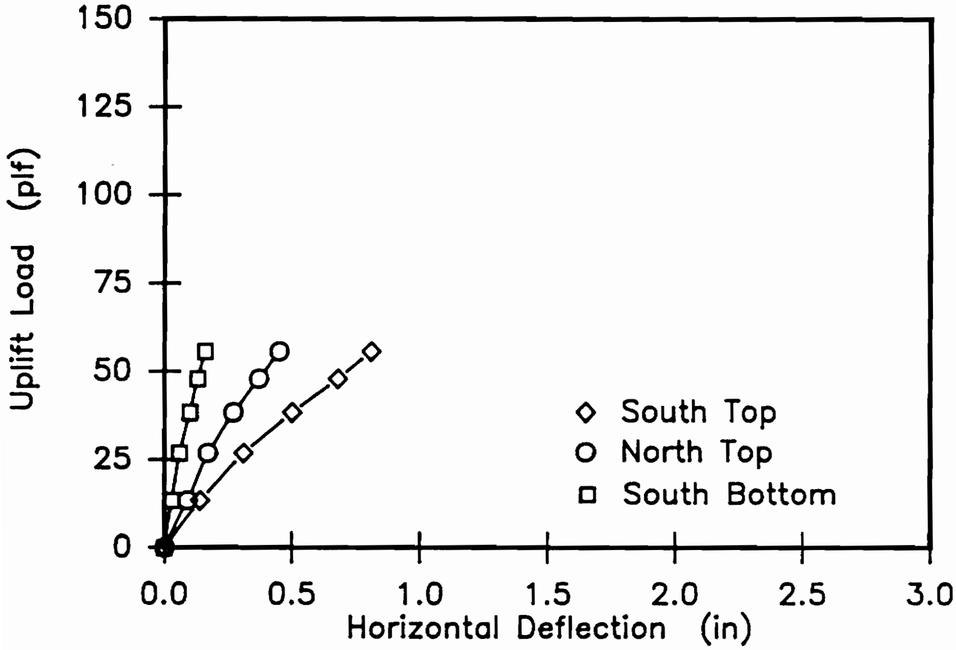


Figure H.25 Uplift Load Versus Midspan Deflection of Purlin Flanges for Test SP-10Z-50

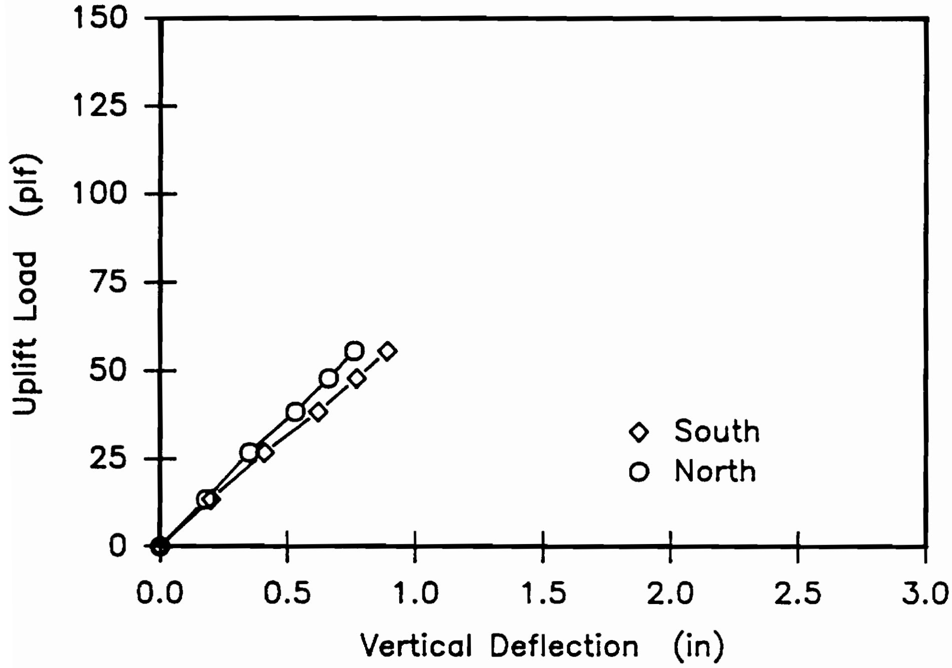


Figure H.26 Uplift Load Versus Midspan Deflection of Purlin Flanges for Test SP-10Z-50

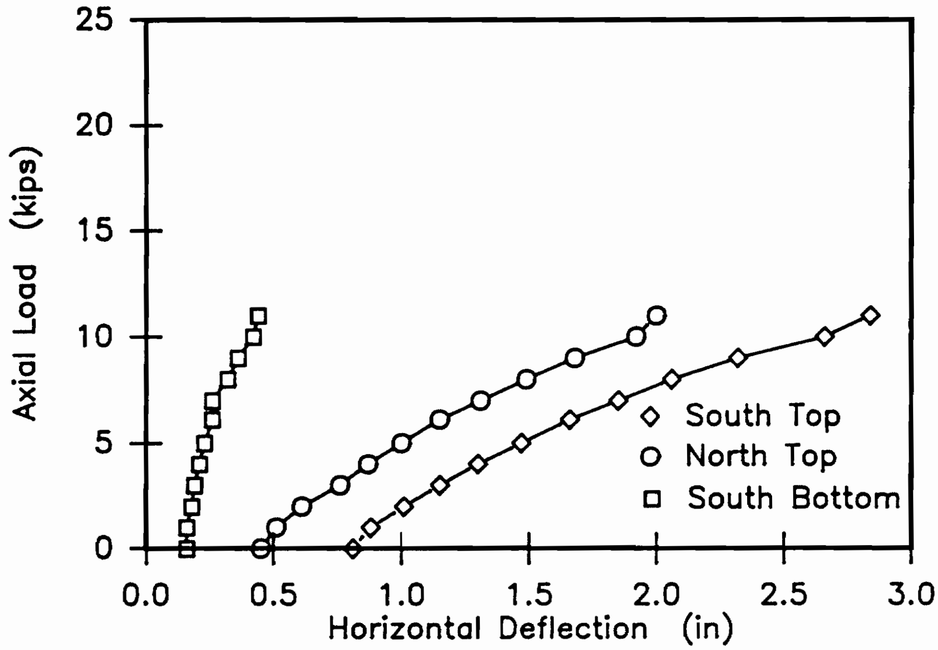


Figure H.27 Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-10Z-50

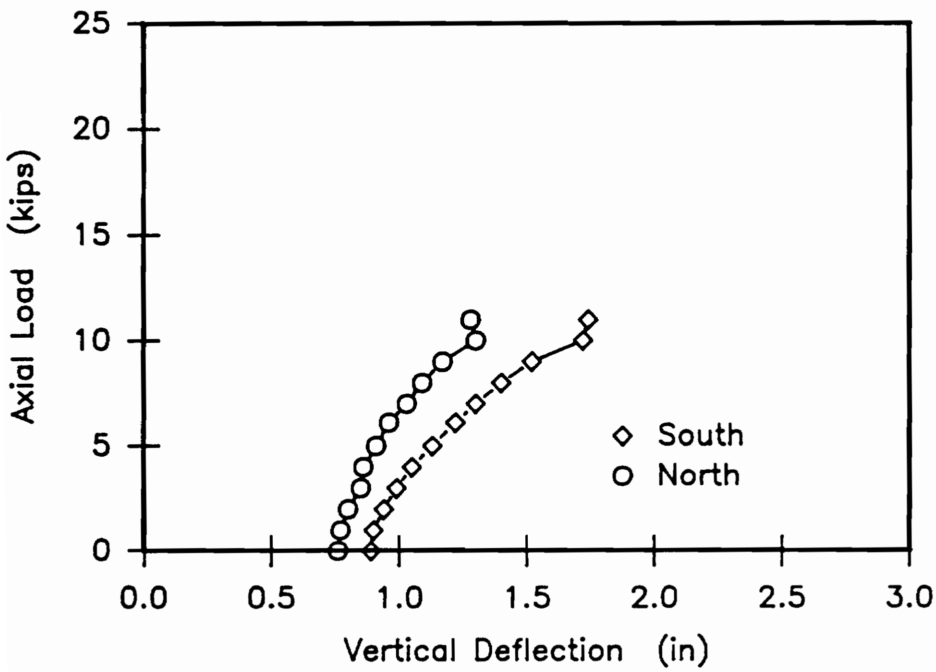
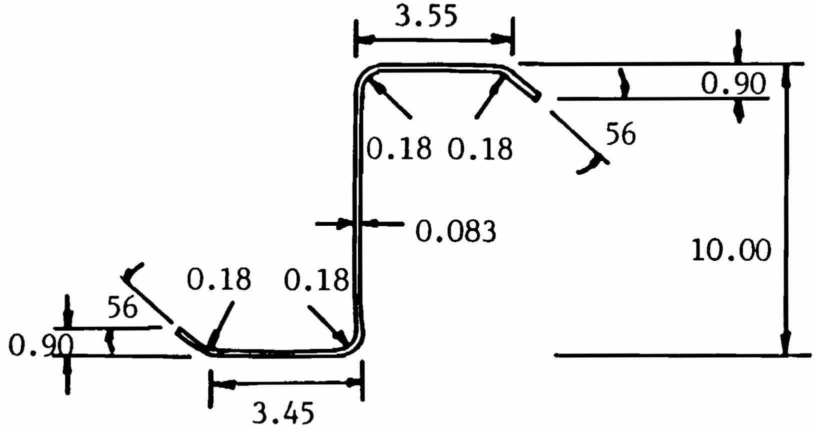
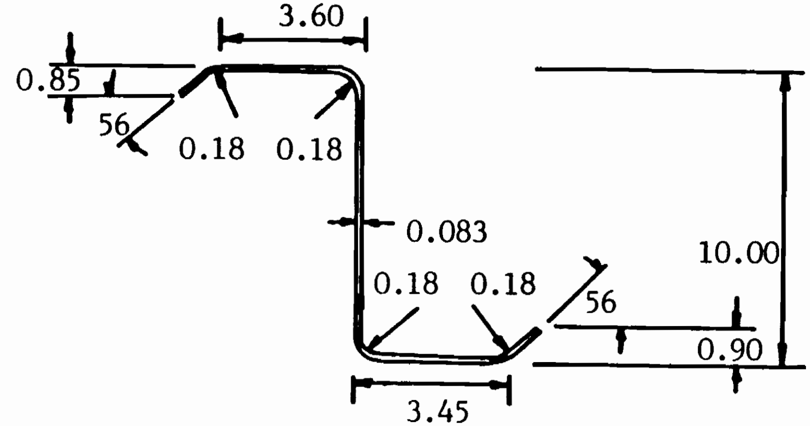


Figure H.28 Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-10Z-50

Test No. SP-10Z-50 Date 2-13-90 Recorder GLH



North Purlin



South Purlin

CALCULATION SHEET FOR TEST SP-10Z-50

Moment Capacity (M_{ax})

M_{ax} = R x 1.67 x AISI Allowable Capacity

M_{ax} = .5 x 1.67 x 149.1 in-k = 124.7 in-k

Distributed Load

Dead Weight = 7.6 lb/ft ÷ 19.5 lb/ft/in of water = .39 in

$$\text{Total Allowable} = \frac{M_{ax}\,8}{L^2} = \frac{124.7 \text{ in-k} \times 1000 \text{ lb}/12" \times 8}{25'^2} = 133.1 \text{ lb/ft}$$

Total Allowable = 133.1 lb/ft ÷ 19.5 lb/ft/in of water = 6.83 in of water

Set vacuum at 2.9 inches of water

w = (2.9 inches) (19.5 lb/ft/in) + 7.6 lb/ft = 64.1 lb/ft

Applied Moment (M)

$$M(\text{applied}) = \frac{wL^2}{8}$$

$$M(\text{applied}) = \frac{64.1 \text{ lb/ft} \times \text{ft}/12" \times 300"^2}{8 \times 1000 \text{ lb/k}} = 60.1 \text{ in-k}$$

Axial Capacity (P_a)

Fastener Location In The Flange		P_a (k)
1/2	weak	19.1
2	medium	27.5
3	strong	29.8

Actual average fastener location was 2" from the web, $\therefore P_a$ = 27.5 k based on linear interpolation

Assumption

$$\frac{P}{P_a} + \frac{M\,C_m}{M_{ax}\left(1 - \frac{P}{P_a}\right)} = 1.0$$

Predicted Axial Failure Load

$$P = P_a\left(1 - \sqrt{\frac{M}{M_{ax}}}\right) = 27.5 \text{ k}\left(1 - \sqrt{\frac{60.1}{124.7}}\right) = 8.4 \text{ k}$$

SP10Z50N

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.9000	0.9000
Lip angles	(degrees) :		56.0000	56.0000
Flange widths	(inches) :		3.5500	3.4500
Radii	(inches)			
Lip to flange	:		0.1875	0.1875
Flange to web	:		0.1875	0.1875
Total purlin depth	(inches) :	10.0000		
Purlin thickness	(inches) :	0.0830		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	66.3
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	3.1357
Gross moment of inertia	(in^4) :	23.82

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 2.2672	inches
Effective moment of inertia	: 20.78	in^4
Allowable flexural capacity	: 152.30	kip-in

SP10Z50S

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.8500	0.9000
Lip angles	(degrees) :		56.0000	56.0000
Flange widths	(inches) :		3.6000	3.4500
Radii	(inches)			
Lip to flange	:		0.1875	0.1875
Flange to web	:		0.1875	0.1875
Total purlin depth	(inches) :	10.0000		
Purlin thickness	(inches) :	0.0830		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	66.3
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	3.1857
Gross moment of inertia	(in^4) :	23.83

1986 AISI PROCEDURE

Flange is not fully effective		
Effective flange width	: 2.2522	inches
Effective moment of inertia	: 20.50	in^4
Allowable flexural capacity	: 149.10	kip-in

3	ISEC (2=C SECTION, 3=Z SECTION)
300.	STUD LENGTH XL
10.00	SECTION DEPTH HH
9.917	CENTERLINE DIMENSION OF WEB H
3.50	CENTERLINE DIMENSION OF FLG B
.86	CENTERLINE DIMENSION OF LIP D
.083	THICKNESS
.68	FORM FACTOR Q
656.	S (K) SHEAR RIGIDITY
.1731	F (K-IN/IN-RAD) ROTATIONAL CAPACITY
.0035	GAMD (IN/IN) DIAPHRAGM STRAIN @ FAILURE
.1829	FED (RAD) PURLIN TWIST @ FAILURE
65.00	FY YIELD STRESS
12.	DISTANCE BETWEEN FASTENERS XL1
0.	1=DETAILS PRINTED 0=DETAILS NOT PRINTED
1.557	AREA
23.915	XXI
4.674	YYI
7.784	XYI
.006	XO
0.004	XJ
80.136	CW

INPUT DATA TO (STUDA2.EXE) FOR TEST SP-10Z-50

COLD-FORMED STEEL DESIGN PROGRAM

PART: **North Purlin**

Thickness: 0.0830

	Length	Angle	Radius	w/t
1	1.086	56.000	0.0830	11.35
2	3.550	0.000	0.1875	37.78
3	10.000	-90.000	0.1875	113.96
4	3.450	0.000	0.1875	36.57
5	1.086	56.000	0.1875	11.35

SECTION PROPERTIES

Area	1.551	Wt/Ft	5.272
Top to CG	4.9735	Sx(t)	4.805
Bottom to CG	5.0265	Sx(b)	4.754
Left edge to CG	4.0918	Sy(l)	1.143
Right edge to CG	4.0398	Sy(r)	1.157
Ix	23.898	rx	3.926
Iy	4.675	ry	1.736
I1	26.650	r1	4.146
I2	1.923	r2	1.114
Ic	28.573	rc	4.293
Io	28.615	ro	4.296
Ixy	-7.777	Xo	-0.009
Alpha	19.489	Yo	0.165
Cw	80.457	jx	-0.018
J	0.004	jy	-0.178

COLD-FORMED STEEL DESIGN PROGRAM

PART: **South Purlin**

Thickness: 0.0830

	Length	Angle	Radius	w/t
1	1.025	56.000	0.0830	10.62
2	3.600	0.000	0.1875	38.38
3	10.000	-90.000	0.1875	113.96
4	3.450	0.000	0.1875	36.57
5	1.086	56.000	0.1875	11.35

SECTION PROPERTIES

Area	1.550	Wt/Ft	5.269
Top to CG	4.9736	Sx(t)	4.808
Bottom to CG	5.0264	Sx(b)	4.758
Left edge to CG	4.1089	Sy(l)	1.137
Right edge to CG	4.0385	Sy(r)	1.157
Ix	23.915	rx	3.928
Iy	4.674	ry	1.737
I1	26.669	r1	4.148
I2	1.919	r2	1.113
Ic	28.588	rc	4.295
Io	28.622	ro	4.298
Ixy	-7.784	Xo	-0.006
Alpha	19.488	Yo	0.148
Cw	80.136	jx	-0.039
J	0.004	jy	-0.156

SP-10Z-75

Test Summary

Test Date: February 22, 1990

Purpose: Verify Interaction Equation

Span(s): 1 @ 25'-0"

Measured Dimensions:

	North	South
Thickness	0.084"	0.084"
Sweep	1/2	0

Parameters:
- Axial Load Applied
- Screw down type decking
- Two Purlin Lines 5'-0" O.C. 1'-0" overhang
- Purlins facing each other
- Simple supported
- Lateral supports at ends only

Predicted Failure Loads: (F_y = 67.8 ksi)

Uplift: 97.3 plf M: 91.2 in-kip

Axial: 4.6 k

Actual Failure Load:

Uplift: 97.3 plf M: 91.2 in-kip

Axial: 6.0 k

P/P_a = .22

M/M_{ax} = .70

Discussion:

- Torsional-flexural buckling was followed by local buckling of the web to unsupported flange junction
- Failure occurred in the south purlin
- Maximum horizontal deflection was 2.99"
- Maximum vertical deflection was 2.23"

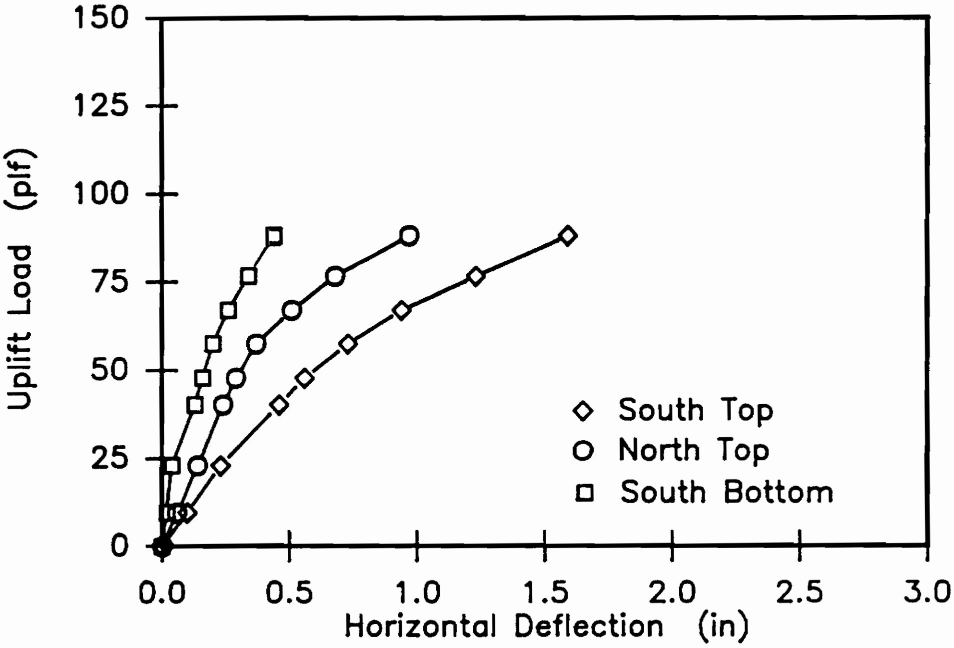


Figure H.29 Uplift Load Versus Midspan Deflection of Purlin Flanges for Test SP-10Z-75

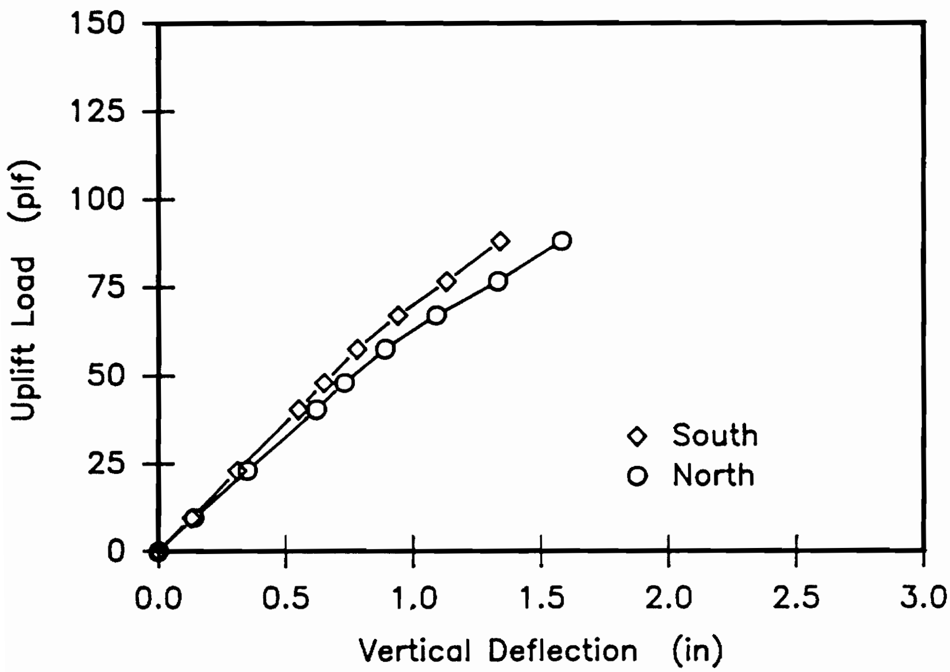


Figure H.30 Uplift Load Versus Midspan Deflection of Purlin Flanges for Test SP-10Z-75

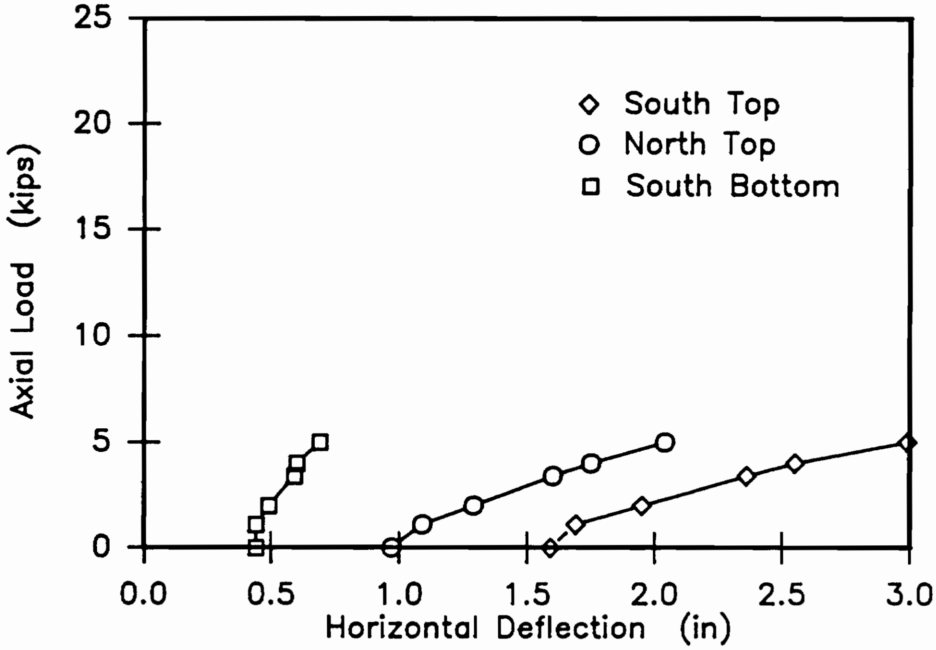


Figure H.31 **Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-10Z-75**

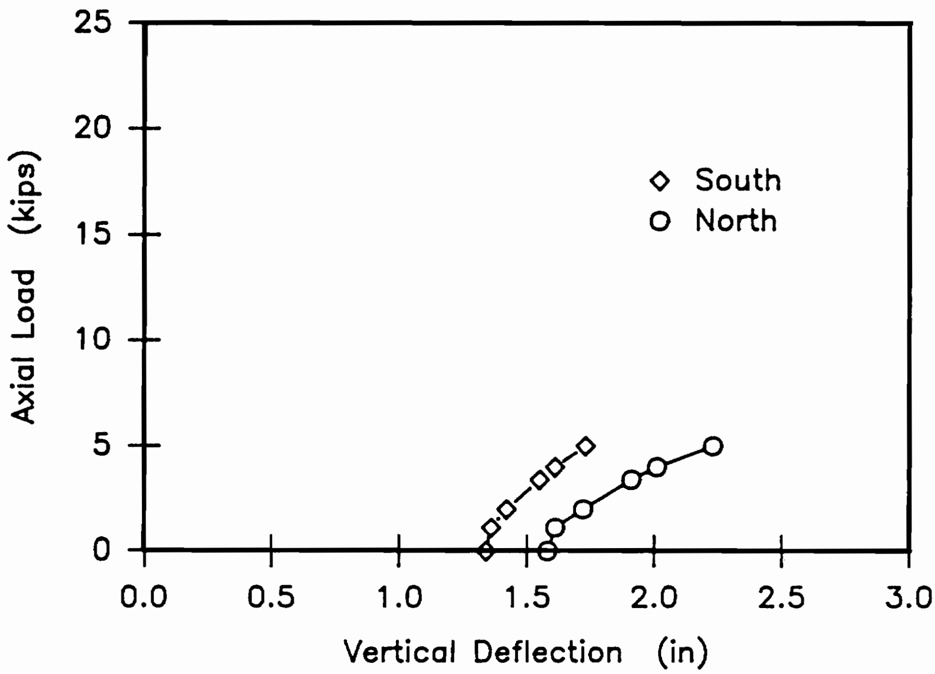
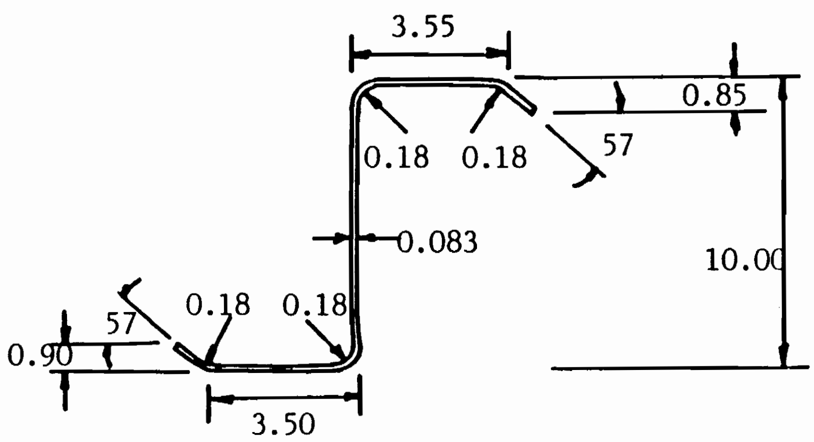
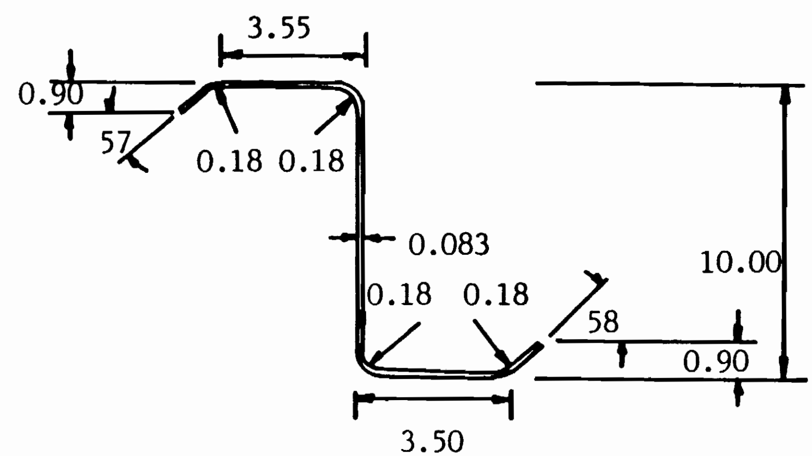


Figure H.32 **Axial Load Versus Midspan Deflection of Purlin Flanges for Test SP-10Z-75**

Test No. SP-10Z-75 Date 2-20-90 Recorder GLH



North Purlin



South Purlin

CALCULATION SHEET FOR
TEST SP-10Z-75

Moment Capacity (M_{ax})

M_{ax} = R x 1.67 x AISI Allowable Capacity

M_{ax} = .5 x 1.67 x 156.6 in-k = 130.7 in-k

Distributed Load

Dead Weight = 7.6 lb/ft ÷ 19.5 lb/ft/in of water = .39 in

$$\text{Total Allowable} = \frac{M_{ax}\,8}{L^2} = \frac{130.7\text{ in-k} \times 1000\text{ lb}/12" \times 8}{25'^2} = 139.5\text{ lb/ft}$$

Total Allowable = 139.5 lb/ft ÷ 19.5 lb/ft/in of water = 7.15 in of water

Set vacuum at 4.6 inches of water

w = (4.6 inches) (19.5 lb/ft/in) + 7.6 lb/ft = 97.3 lb/ft

Applied Moment (M)

$$M(\text{applied}) = \frac{wL^2}{8}$$

$$M(\text{applied}) = \frac{97.3\text{ lb/ft} \times \text{ft}/12" \times 300"^2}{8 \times 1000\text{ lb/k}} = 91.2\text{ in-k}$$

Axial Capacity (P_a)

Fastener Location In The Flange		P_a (k)
1/2	weak	19.2
2	medium	27.6
3	strong	30.2

Actual average fastener location was 1.9" from the web, ∴ P_a = 26.9 k based on linear interpolation

Assumption

$$\frac{P}{P_a} + \frac{M\,Cm}{M_{ax}\left(1 - \frac{P}{P_a}\right)} = 1.0$$

Predicted Axial Failure Load

$$P = Pa\left(1 - \sqrt{\frac{M}{M_{ax}}}\right) = 26.9\text{ k}\left(1 - \sqrt{\frac{91.2}{130.7}}\right) = 4.4\text{ k}$$

SP10Z75N

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.8500	0.9000
Lip angles	(degrees) :		57.0000	57.0000
Flange widths	(inches) :		3.5500	3.5000
Radii	(inches)			
Lip to flange	:		0.1875	0.1875
Flange to web	:		0.1875	0.1875
Total purlin depth	(inches) :	10.0000		
Purlin thickness	(inches) :	0.0840		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	67.8
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	3.1311
Gross moment of inertia	(in^4) :	24.06

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 2.2307	inches
Effective moment of inertia	: 20.69	in^4
Allowable flexural capacity	: 153.11	kip-in

SP10Z75S

GEOMETRY OF CROSS-SECTION

		TOP	BOTTOM
Vertical lip dimensions	(inches) :	0.9000	0.9000
Lip angles	(degrees) :	57.0000	58.0000
Flange widths	(inches) :	3.5500	3.5000
Radii	(inches)		
Lip to flange	:	0.1875	0.1875
Flange to web	:	0.1875	0.1875

Total purlin depth	(inches) :	10.0000
Purlin thickness	(inches) :	0.0840

MATERIAL PROPERTIES

Material yield stress	(ksi) :	67.8
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	3.1311
Gross moment of inertia	(in^4) :	24.13

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 2.2568	inches
Effective moment of inertia	: 20.97	in^4
Allowable flexural capacity	: 156.56	kip-in

3	ISEC (2=C SECTION, 3=Z SECTION)
300.	STUD LENGTH XL
10.00	SECTION DEPTH HH
9.917	CENTERLINE DIMENSION OF WEB H
3.50	CENTERLINE DIMENSION OF FLG B
.86	CENTERLINE DIMENSION OF LIP D
.083	THICKNESS
.68	FORM FACTOR Q
656.	S (K) SHEAR RIGIDITY
.0790	F (K-IN/IN-RAD) ROTATIONAL CAPACITY
.0035	GAMD (IN/IN) DIAPHRAGM STRAIN @ FAILURE
.2478	FED (RAD) PURLIN TWIST @ FAILURE
67.80	FY YIELD STRESS
12.	DISTANCE BETWEEN FASTENERS XL1
0.	1=DETAILS PRINTED 0=DETAILS NOT PRINTED
1.569	AREA
24.204	XXI
4.737	YYI
7.884	XYI
0.006	XO
0.004	XJ
81.379	CW

INPUT DATA TO (STUDA2.EXE) FOR TEST SP-10Z-75

COLD-FORMED STEEL DESIGN PROGRAM

PART: **North Purlin**

Thickness: 0.0840

	Length	Angle	Radius	w/t
1	1.070	-57.000	0.0840	10.98
2	3.500	0.000	0.1875	36.68
3	10.000	90.000	0.1875	112.58
4	3.550	0.000	0.1875	37.27
5	1.010	-57.000	0.1875	10.27

SECTION PROPERTIES

Area	1.565	Wt/Ft	5.321
Top to CG	4.9999	Sx(t)	4.827
Bottom to CG	5.0001	Sx(b)	4.827
Left edge to CG	4.0398	Sy(l)	1.156
Right edge to CG	4.0591	Sy(r)	1.150
Ix	24.134	rx	3.927
Iy	4.669	ry	1.727
I1	26.883	r1	4.144
I2	1.920	r2	1.108
Ic	28.802	rc	4.290
Io	28.803	ro	4.290
Ixy	7.814	Xo	-0.003
Alpha	-19.381	Yo	-0.015
Cw	80.104	jx	0.021
J	0.004	jy	0.020

COLD-FORMED STEEL DESIGN PROGRAM

PART: **South Purlin**

Thickness: 0.0840

	Length	Angle	Radius	w/t
1	1.070	57.000	0.0840	10.98
2	3.550	0.000	0.1875	37.27
3	10.000	-90.000	0.1875	112.58
4	3.500	0.000	0.1875	36.68
5	1.060	57.000	0.1875	10.86

SECTION PROPERTIES

Area	1.569	Wt/Ft	5.336
Top to CG	4.9845	Sx(t)	4.856
Bottom to CG	5.0155	Sx(b)	4.826
Left edge to CG	4.0766	Sy(l)	1.162
Right edge to CG	4.0495	Sy(r)	1.170
Ix	24.204	rx	3.927
Iy	4.737	ry	1.737
I1	26.997	r1	4.148
I2	1.945	r2	1.113
Ic	28.941	rc	4.294
Io	28.957	ro	4.296
Ixy	-7.884	Xo	-0.006
Alpha	19.503	Yo	0.099
Cw	81.379	jx	-0.007
J	0.004	jy	-0.107

SP-10Z-M

Test Summary

Test Date: February 2, 1990

Purpose: Verify Interaction Equation

Span(s): 1 @ 25'-0"

Measured Dimensions:

	North	South
Thickness	0.083"	0.083"
Sweep	0	0

Parameters:
- No Axial Load
- Screw down type decking
- Two Purlin Lines 5'-0" O.C. 1'-0" overhang
- Purlins facing each other
- Simple supports
- Lateral supports at ends only

Predicted Failure Loads: (F_y = 66.30 ksi)

Uplift: 133.8 plf M: 125.4 in-kip

Axial: 0 k

Actual Failure Load:

Uplift: 111.2 plf M: 104.2 in-kip

Axial: 0 k

P/P_a = 0

M/M_{ax} = .83

Discussion:

- Failure occurred in the decking
- Side lap fasteners were inadvertantly left out
- Maximum horizontal deflection was 2.35"
- Maximum vertical deflection was 2.24"

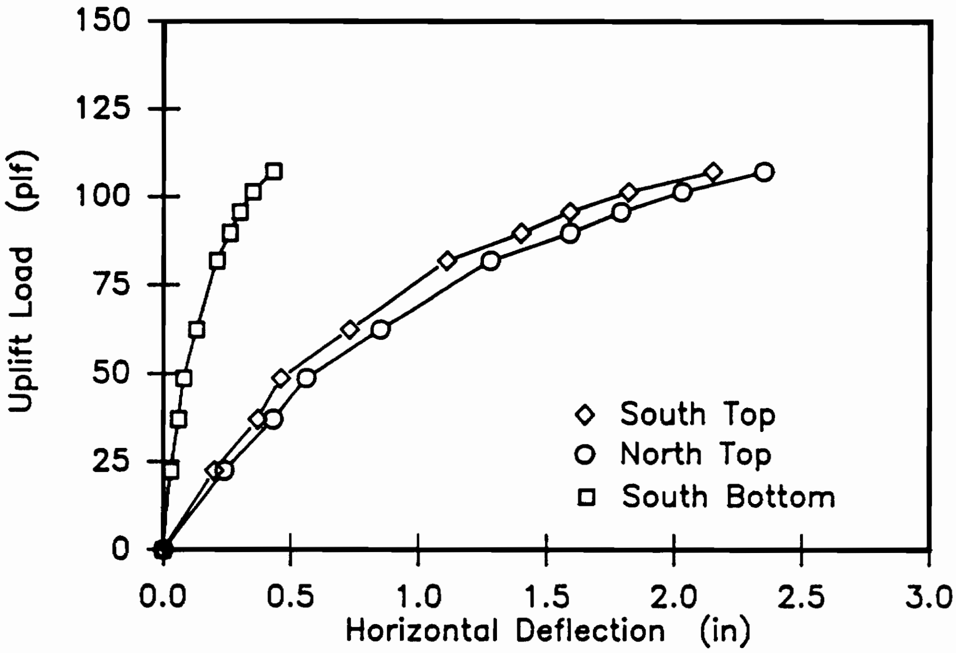


Figure H.33 Uplift Load Versus Midspan Deflection of Purlin Flanges for Test SP-10Z-M

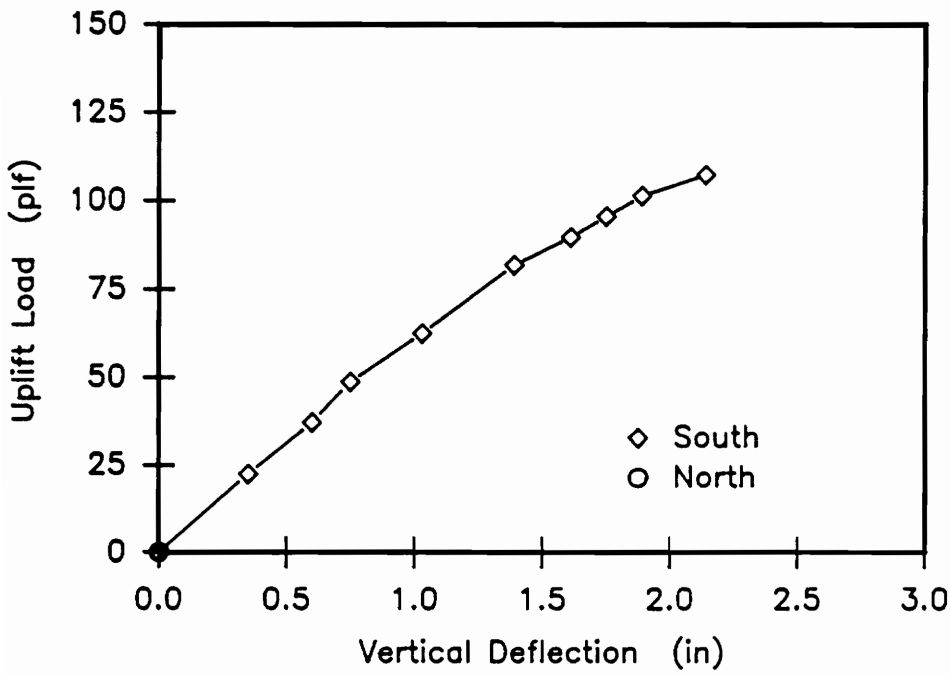
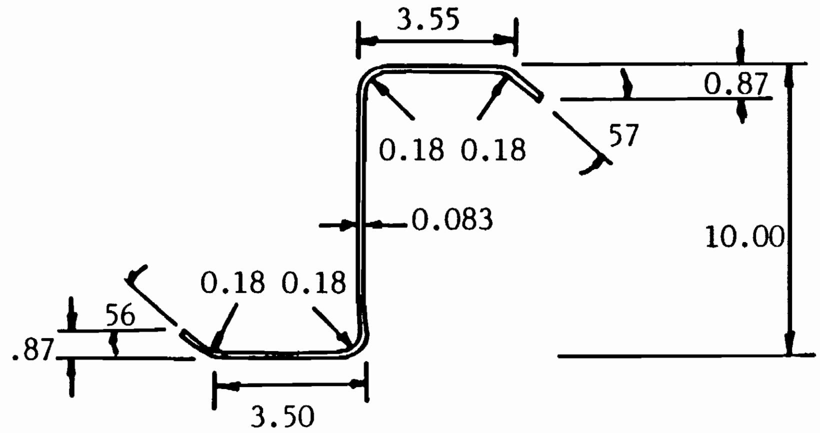
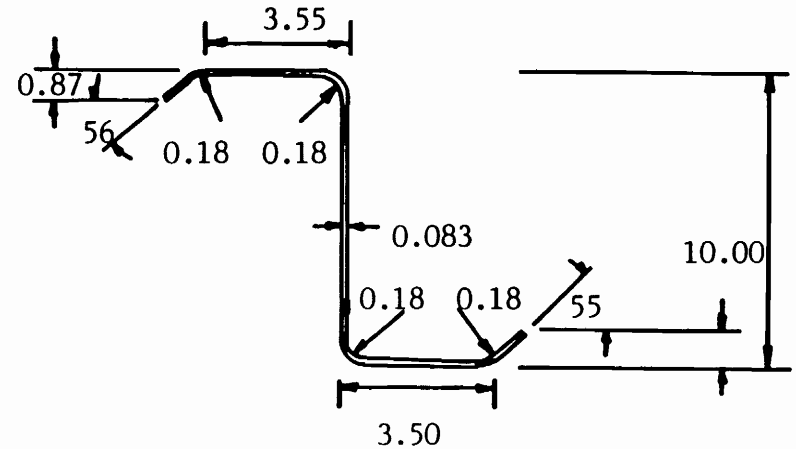


Figure H.34 Uplift Load Versus Midspan Deflection of Purlin Flanges for Test SP-10Z-M

Test No. SP-10Z-M Date 2-5-90 Recorder LR



North Purlin



South Purlin

CALCULATION SHEET FOR TEST SP-10Z-M

Moment Capacity (M_{ax})

Max = R x 1.67 x AISI Allowable Capacity

Max = .5 x 1.67 x 150.2 in-k = 125.4 in-k

Distributed Load

Dead Weight = 7.6 lb/ft ÷ 19.5 lb/ft/in of water = .39 in

$$\text{Total Allowable} = \frac{M_{ax}\ 8}{L^2} = \frac{125.4\ \text{in-k} \times 1000\ \text{lb}/12" \times 8}{25'^2} = 133.8\ \text{lb/ft}$$

Total Allowable = 133.8 lb/ft ÷ 19.5 lb/ft/in of water = 6.9 in of water

Set vacuum at 6.51 inches of water

w = (6.51 inches) (19.175 lb/ft/in) + 7.6 lb/ft = 133.8 lb/ft

Applied Moment (M)

$$M(\text{applied}) = \frac{wL^2}{8}$$

$$M(\text{applied}) = \frac{133.8\ \text{lb/ft} \times \text{ft}/12" \times 300"^2}{8 \times 1000\ \text{lb/k}} = 125.4\ \text{in-k}$$

Axial Capacity (P_a)

Fastener Location In The Flange		P_a (k)
1/2	weak	19.0
2	medium	27.1
3	strong	30.0

Actual average fastener location was 1.6" from the web, ∴ P_a = 25.1 k based on linear interpolation

Assumption

$$\frac{P}{P_a} + \frac{M\,Cm}{M_{ax}\left(1 - \frac{P}{P_a}\right)} = 1.0$$

Predicted Axial Failure Load

P = 0 (No applied axial load)

SP10ZMN

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.8750	0.8750
Lip angles	(degrees) :		57.0000	56.0000
Flange widths	(inches) :		3.5500	3.5000
Radii	(inches)			
Lip to flange	:		0.1875	0.1875
Flange to web	:		0.1875	0.1875
Total purlin depth	(inches) :	10.0000		
Purlin thickness	(inches) :	0.0830		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	66.3
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	3.1326
Gross moment of inertia	(in^4) :	23.81

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 2.2521	inches
Effective moment of inertia	: 20.64	in^4
Allowable flexural capacity	: 150.23	kip-in

SP10ZMS

GEOMETRY OF CROSS-SECTION

			TOP	BOTTOM
Vertical lip dimensions	(inches) :		0.8750	0.8750
Lip angles	(degrees) :		56.0000	55.0000
Flange widths	(inches) :		3.5500	3.5000
Radii	(inches)			
Lip to flange	:		0.1875	0.1875
Flange to web	:		0.1875	0.1875
Total purlin depth	(inches) :	10.0000		
Purlin thickness	(inches) :	0.0830		

MATERIAL PROPERTIES

Material yield stress	(ksi) :	66.3
Modulus of elasticity	(ksi) :	29500.0

GENERAL

Flat width of compression flange	(inches) :	3.1357
Gross moment of inertia	(in^4) :	23.86

1986 AISI PROCEDURE

Flange is not fully effective

Effective flange width	: 2.2549	inches
Effective moment of inertia	: 20.68	in^4
Allowable flexural capacity	: 150.54	kip-in

3	ISEC (2=C SECTION, 3=Z SECTION)
300.	STUD LENGTH XL
10.00	SECTION DEPTH HH
9.917	CENTERLINE DIMENSION OF WEB H
3.50	CENTERLINE DIMENSION OF FLG B
.875	CENTERLINE DIMENSION OF LIP D
.083	THICKNESS
.68	FORM FACTOR Q
656.	S (K) SHEAR RIGIDITY
.1731	F (K-IN/IN-RAD) ROTATIONAL CAPACITY
.0035	GAMD (IN/IN) DIAPHRAGM STRAIN @ FAILURE
.1829	FED (RAD) PURLIN TWIST @ FAILURE
66.30	FY YIELD STRESS
12.	DISTANCE BETWEEN FASTENERS XL1
0.	1=DETAILS PRINTED 0=DETAILS NOT PRINTED
1.548	AREA
23.879	XXI
4.638	YYI
7.747	XYI
0.003	XO
0.004	XJ
79.562	CW

INPUT DATA TO (STUDA2.EXE) FOR TEST SP-10Z-M

COLD-FORMED STEEL DESIGN PROGRAM

PART: **North Purlin**

Thickness: 0.0830

	Length	Angle	Radius	w/t
1	1.040	57.000	0.0830	10.76
2	3.550	0.000	0.1875	37.74
3	10.000	-90.000	0.1875	113.96
4	3.500	0.000	0.1875	37.18
5	1.050	56.000	0.1875	10.92

SECTION PROPERTIES

Area	1.548	Wt/Ft	5.262
Top to CG	4.9897	Sx(t)	4.786
Bottom to CG	5.0103	Sx(b)	4.766
Left edge to CG	4.0660	Sy(l)	1.141
Right edge to CG	4.0546	Sy(r)	1.144
Ix	23.879	rx	3.928
Iy	4.638	ry	1.731
I1	26.611	r1	4.146
I2	1.906	r2	1.110
Ic	28.517	rc	4.292
Io	28.522	ro	4.293
Ixy	-7.747	Xo	-0.003
Alpha	19.422	Yo	0.059
Cw	79.562	jx	-0.008
J	0.004	jy	-0.063

COLD-FORMED STEEL DESIGN PROGRAM

PART: **South Purlin**

Thickness: 0.0830

	Length	Angle	Radius	w/t
1	1.050	56.000	0.0830	10.92
2	3.550	0.000	0.1875	37.78
3	10.000	-90.000	0.1875	113.96
4	3.500	0.000	0.1875	37.21
5	1.070	55.000	0.1875	11.20

SECTION PROPERTIES

Area	1.551	Wt/Ft	5.272
Top to CG	4.9919	Sx(t)	4.795
Bottom to CG	5.0081	Sx(b)	4.780
Left edge to CG	4.0888	Sy(l)	1.148
Right edge to CG	4.0791	Sy(r)	1.151
Ix	23.936	rx	3.929
Iy	4.693	ry	1.740
I1	26.703	r1	4.150
I2	1.926	r2	1.115
Ic	28.629	rc	4.297
Io	28.632	ro	4.297
Ixy	-7.804	Xo	-0.001
Alpha	19.522	Yo	0.042
Cw	80.516	jx	-0.010
J	0.004	jy	-0.045

VITA

Gerald (Jerry) L. Hatch was born in Worchester Massachusetts on December 19, 1957. He was raised and attended school in Lincoln Nebraska. In 1982 he attained a Bachelor of Science in Construction Engineering from Mississippi State University. He worked as a Planning Engineer for Virginia Power at the North Anna Power Station in Mineral Virginia from 1982-1987. In December 1988 he earned a Bachelor of Science in Civil Engineering from Virginia Polytechnic Institute and State University. He then began the graduate program in Civil Engineering the following January at the same university.

STRENGTH EVALUATION OF STRUT-PURLINS

by

GERALD LEE HATCH

Committee Chairman: Thomas M. Murray

Civil Engineering

(ABSTRACT)

Diaphragm braced strut-purlins are commonly used in the roof systems of metal buildings. However, the design problem of combined uplift and axial loads on these members is not adequately addressed in the 1989 AISI specification. The objective of this thesis is to provide experimental evidence that strut-purlins can be designed with an existing interaction equation. It was also the objective of this thesis to find a method of determining the axial capacity of diaphragm braced strut-purlins and to experimentally verify the accuracy of the method.