ROOF SYSTEMS BEHAVIOR

Progress Report

EXPERIMENTAL INVESTIGATION OF C-PURLIN SUPPORTED ROOF SYSTEMS

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Sponsored by

MESCO Metal Buildings Corporation

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CHAPTER I

INTRODUCTION

A limited research program to study the behavior of metal building roof systems was conducted at the Fears Structural Engineering Laboratory, University of Oklahoma, under the sponsorship of the MESCO Metal Buildings Corporation. The purpose of this research was to evaluate the design of roof systems as opposed to individual structural components. The study was limited to simple span cold-formed C-purlin supported "conventional" roof systems under both gravity and uplift loading. This report summarizes the results of sixteen such tests. The specific objectives were: (1) to determine the effect of orientation of the test purlins on gravity load carrying capacity, (2) to determine the effects of intermediate lateral braces on purlin strength, (3) to determine the uplift loading capacity of specific configurations.

Each test consisted of four, nominally 25 ft. 0 in. simple span, C-purlins loaded to failure. The two inside purlins were the test purlins. The two outside purlins were approximately 60% as strong and stiff as that of the test purlins to prevent premature failure of these purlins. Four parameters were varied in the test series: purlin orientation, intermediate bracing, torsional restraint at the rafter, and purlin thickness. The sixteen purlin tests consisted of seven gravity loading

tests and nine uplift loading tests. Test configurations are summarized in Table 1.1 and were as follows:

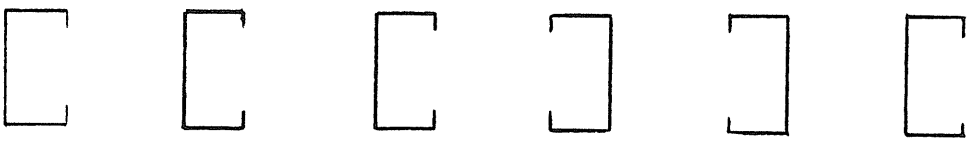
Gravity Loading Tests. The gravity load tests were Tests 1, 2, 3, 4, 5, 6 and 16. All tests were 25 ft. 0 in. simple span except Test 16, which was 24 ft. 8 in. Except for Tests 5 and 6, purlin material thickness was nominally 14 gage. The material thickness for Test 5 was nominally 12 gage and that for Test 6, 16 gage. In Test 1, the purlins were oriented in the same direction with no intermediate bracing. Dynamometers were placed between one outside purlin and one test purlin at the rafter lines to measure torsional restraint at the rafters. In Tests 2 and 3, the test purlins were oriented toward each other (flanges facing) with no intermediate bracing. Test 4 was similar to Test 1 except shear clips were used to attach the purlins to the rafters. In Tests 5 and 6, the purlins were oriented facing each other. In Test 16, the test purlins were in opposing directions with bracing at one-third points between the test purlins and between the test and outer purlins. In all tests, except Test 1, shear clips were used to connect purlins to the rafters. Details of a typical gravity load set-up are shown in Figure 1.1.

Uplift Loading Tests. Uplift loading tests were Tests 7 thru 15 and were 25 ft. 0 in. simple span except Test 15 which was 24 ft. 8 in. All tests were conducted with purlins formed from 14 gage material. In Test 7, the test purlins were oriented toward each other (flanges facing) with no intermediate bracing. In Tests 8 through 15, the test purlins were oriented with flanges opposing and various intermediate bracing spacings were used. Test 8 was conducted with braces only at the midspan. In Test 9, bracing was

Table 1.1
Test Matrix

	Test No.	Nominal Purlin Gage	Purlin Orientation	Shear Clips	Torsional Restraint	Intermediate Braces	Remarks
Simulated Gravity Loading	1	14	Same	No	Yes	None	
	2	14	Facing	Yes	No	None	
	3	14	Facing	Yes	No	None	
	4	14	Same	Yes	No	None	Same as 2
	5	12	Facing	Yes	No	None	
	6	16	Facing	Yes	No	None	
	16	14	Opposing	Yes	No	1/3rd Pts.	
Uplift Loading	7	14	Facing	Yes	No	None	
	8	14	Opposing	Yes	No	Midspan	
	9	14	Opposing	Yes	No	Midspan	Wood Stiffener @ midspan
	10	14	Opposing	Yes	No	None	Wood stiffeners (7)
	11	14	Opposing	Yes	No	None	7x3 C-Purlin added
	12	14	Opposing	Yes	No	1/3rd Pts.	
	13	14	Opposing	Yes	No	Yes	2.5' ea. side of midspan
	14	14	Opposing	Yes	No	1/3rd Pts.	
	15	14	Opposing	Yes	No	1/3rd Pts.	

Notes:



Same Orientation

Facing Orientation

Opposing Orientation

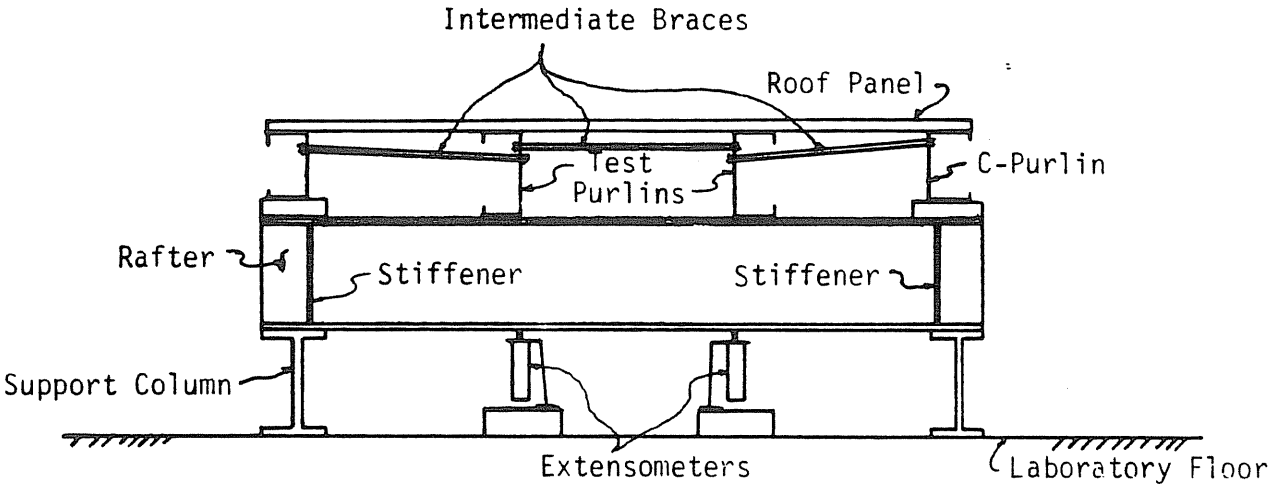
provided at each end and at the midspan. In addition, a wooden block was placed between the flanges of the test purlins at midspan to prevent roll of the C-purlin flanges. In Test 10, bracing was provided at the ends and at midspan, and wooden blocks were placed between the flanges at 2 ft., 5 ft., and 10 ft. from midspan as well as at midspan of the test purlins. In Test 11, a 15 ft. section of C-purlin was bolted to each test purlin and fastened to the roof deck to prevent lateral roll of the purlins. Tests 12, 14 and 15 were identical; bracing was provided at the ends and at the 1/3rd points of the span. Test 13 was conducted with intermediate bracing 2.5 ft. each side of midspan. Details of a typical uplift load set-up are shown in Figure 1.2.

For all tests, the purlins were supported by short sections of typical building rafters and simulated live load was applied using a vacuum chamber. Intermediate brace restraints and torsional restraints at the rafters were supplied using sections of steel tubing with threaded stud inserts. The braces were attached to the purlins as shown in Figure 1.3. Seven brace configurations were used in the test series: Figure 1.4(a) shows the location of torsional restraints at the rafters. Figure 1.4(b) shows the location of one-third point and torsional restraint braces. Figure 1.4(c) shows the location of midspan bracing. Figure 1.4(d) shows the location of midspan bracing and torsional restraint bracing. Figure 1.4(e) shows the location of bracing 2 ft. 6 in. each side of midspan and torsional restraint bracing. Figure 1.4(f) shows the location of the 15 ft. section of C-purlin that was attached to the test purlins and torsional restraint bracing. And, Figure 1.4(g) shows

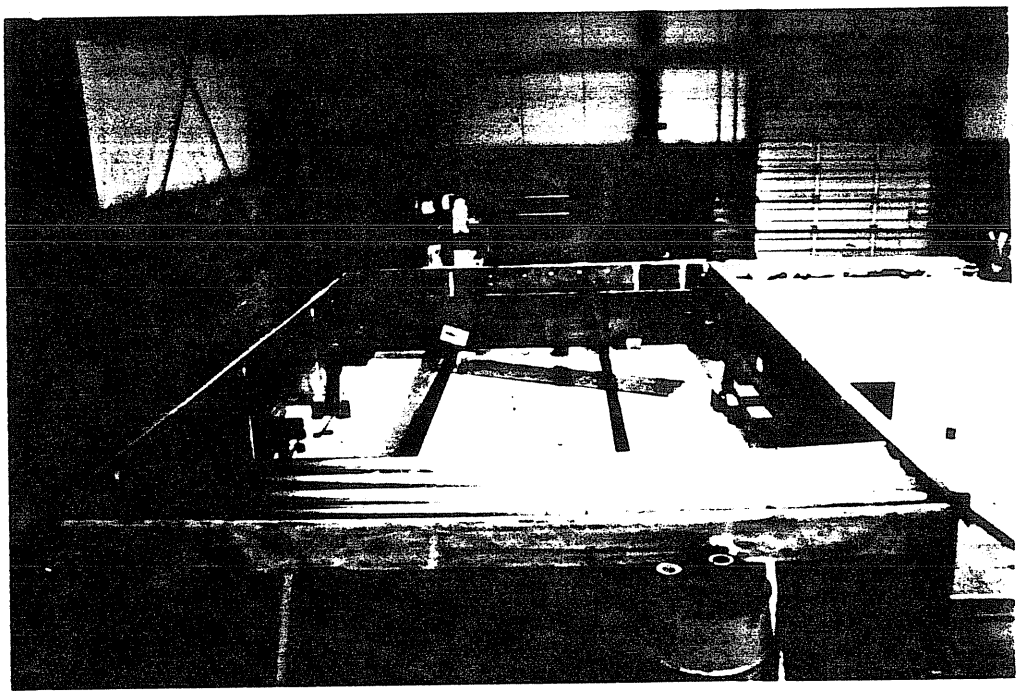
the configuration with no intermediate bracing.

All test purlins were cold-formed. The test set-ups were constructed by laboratory personnel using standard industry procedures. Care was taken to ensure that the purlin webs were vertical before installation of the panel. The testing procedure and test results are found in Chapters II and III, respectively.

Coupon test results for samples taken from a failed purlin in each of the test series are reported in Section 3.4. Predicted failure loads for these purlins using the constrained bending assumption, AISI criteria with factors of safety removed, and the measured yield stress are found in the appendices.

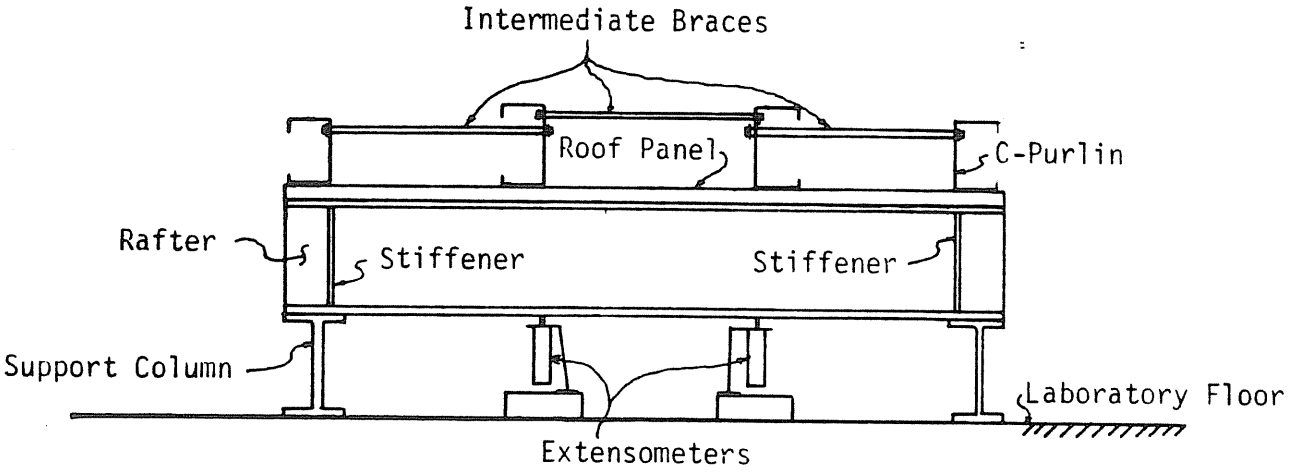


(a) Elevation

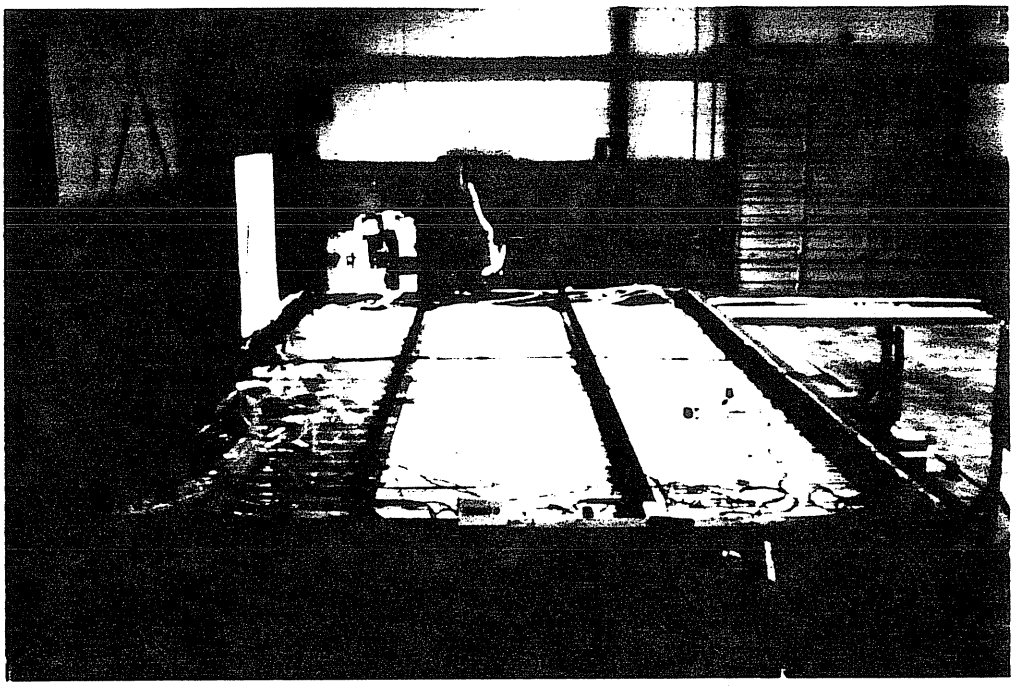


(b) Photograph

Figure 1.1 Typical Gravity Load Test Setup

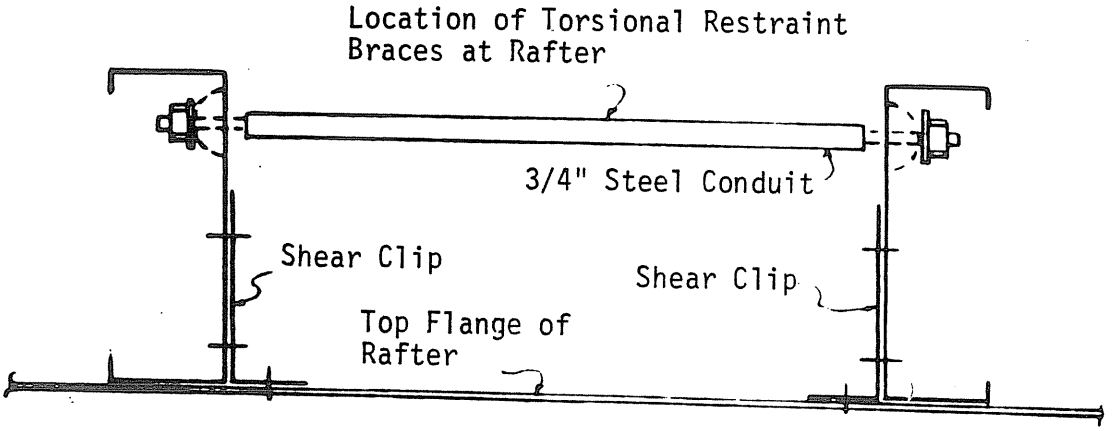


(a) Elevation

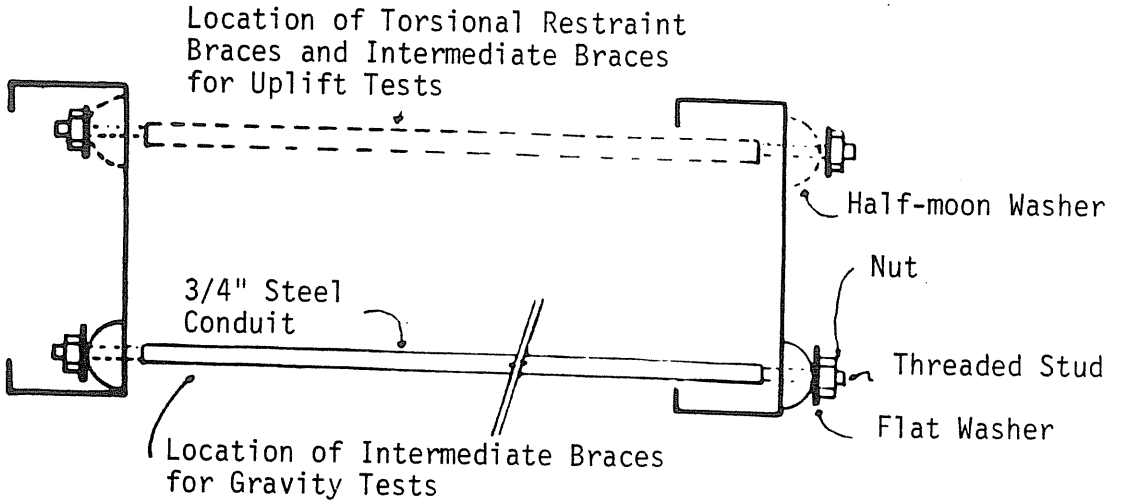


(b) Photograph

Figure 1.2 Typical Uplift Load Setup

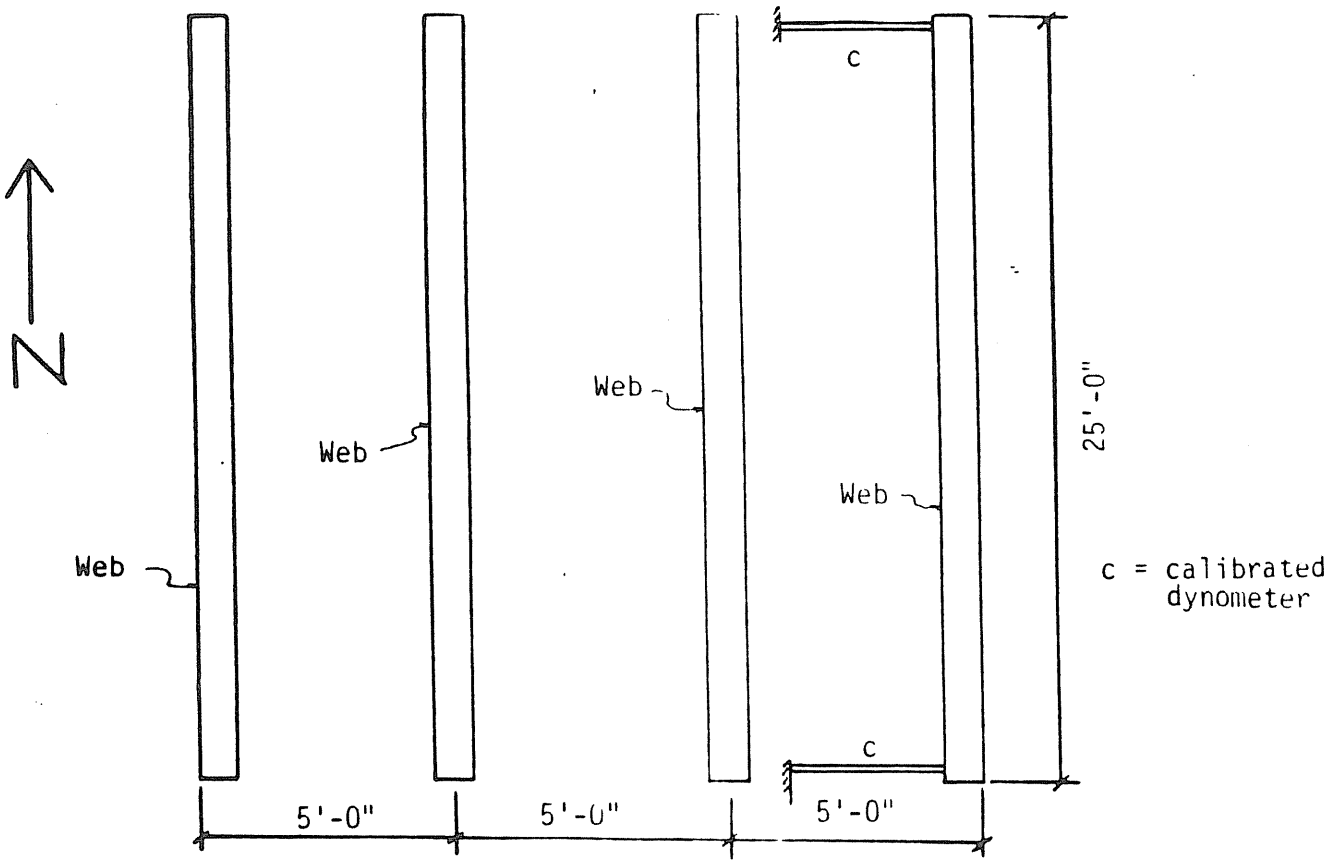


(a) Torsional Brace

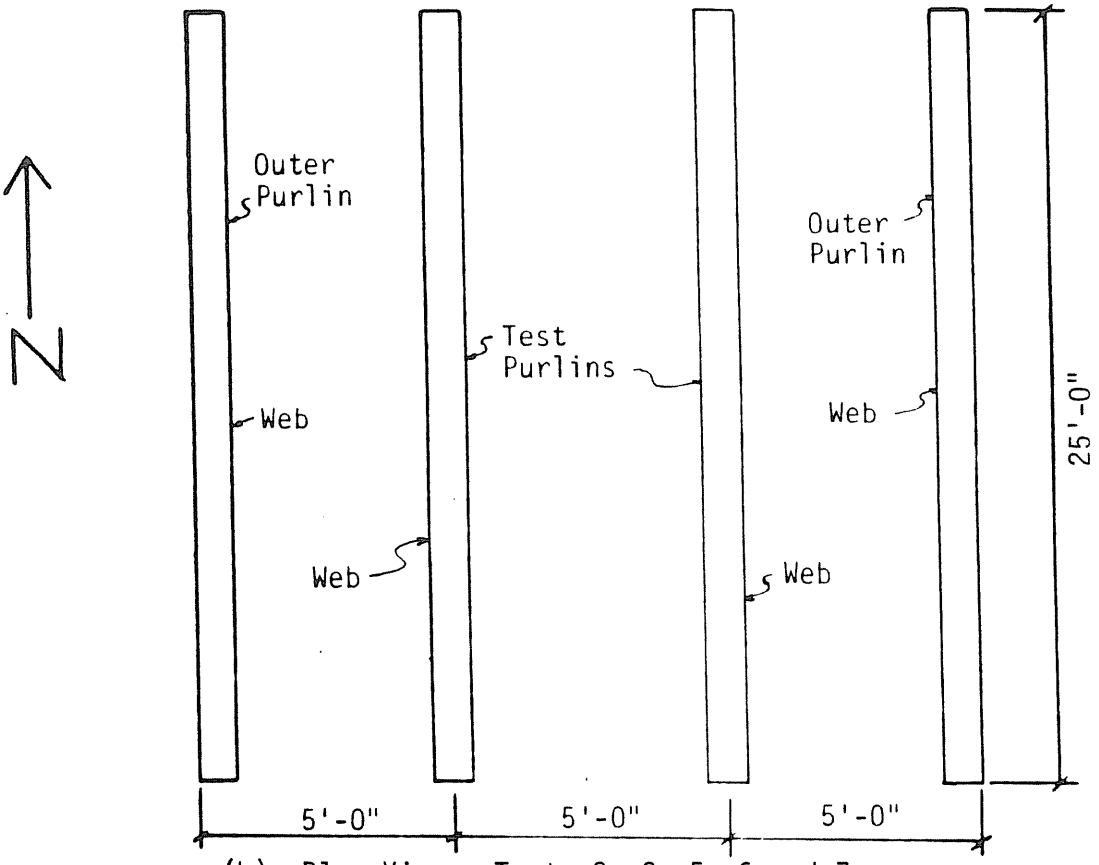


(b) Intermediate Braces

Figure 1.3 Intermediate and Torsional Restraint Brace Connections

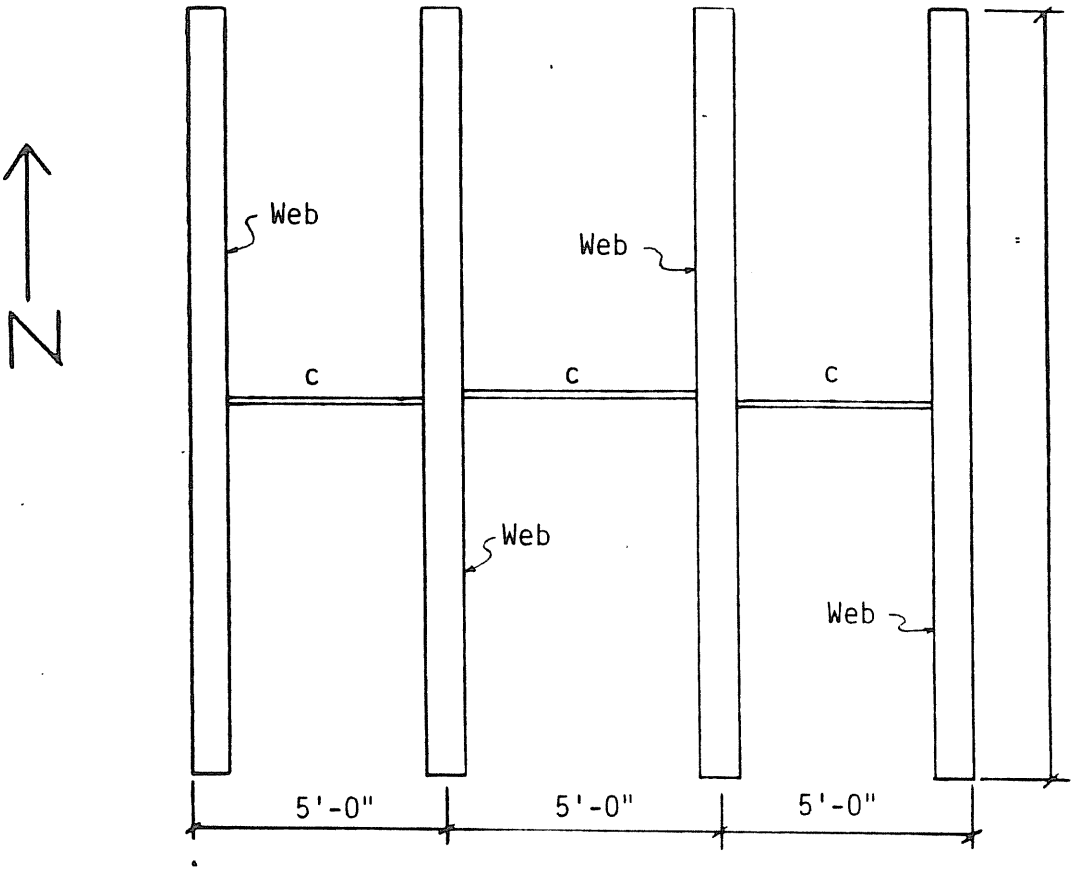


(a) Plan View - Tests 1 and 4

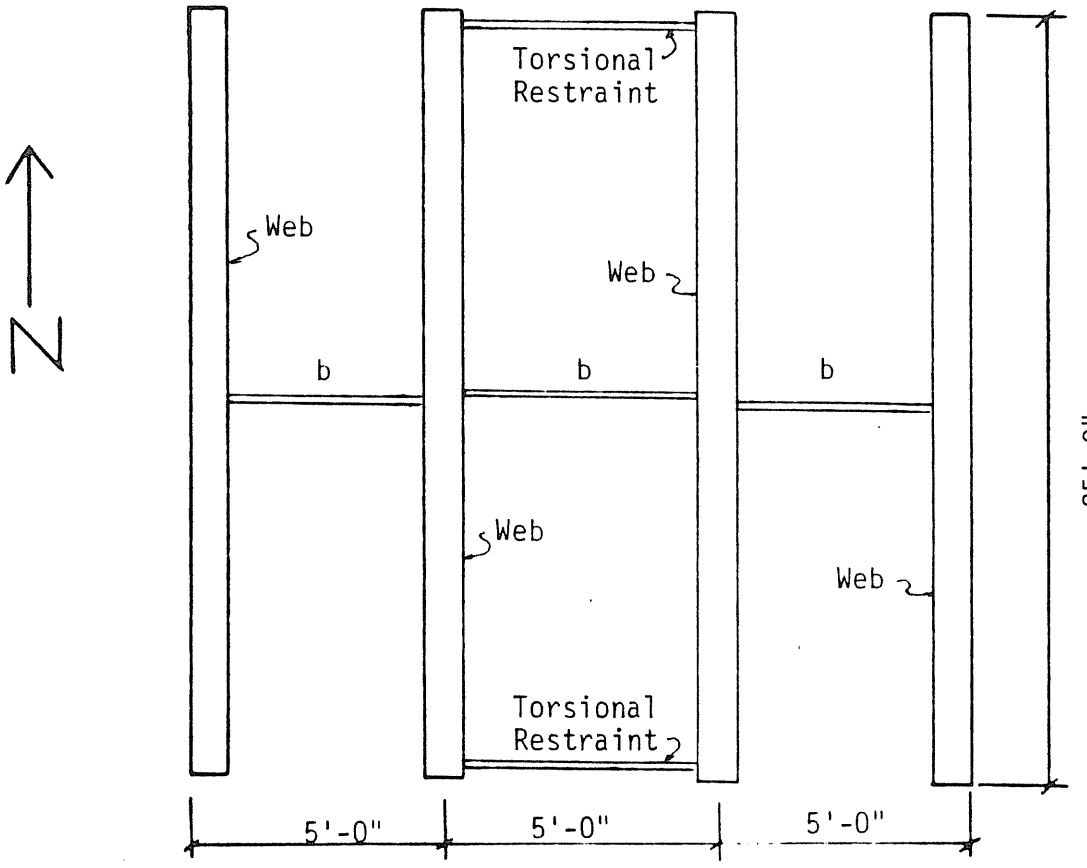


(b) Plan View - Tests 2, 3, 5, 6 and 7

Figure 1.4 Brace Configurations for Gravity and Uplift Tests

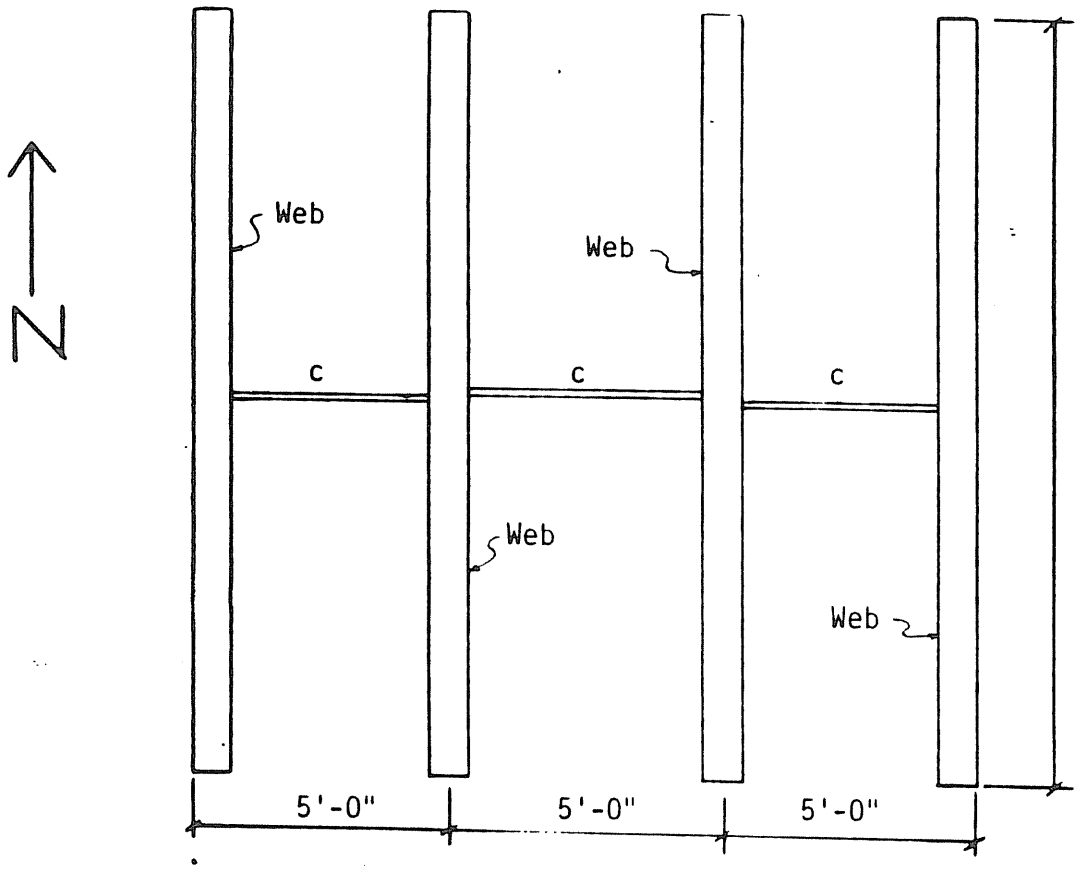


(c) Plan View - Test 8

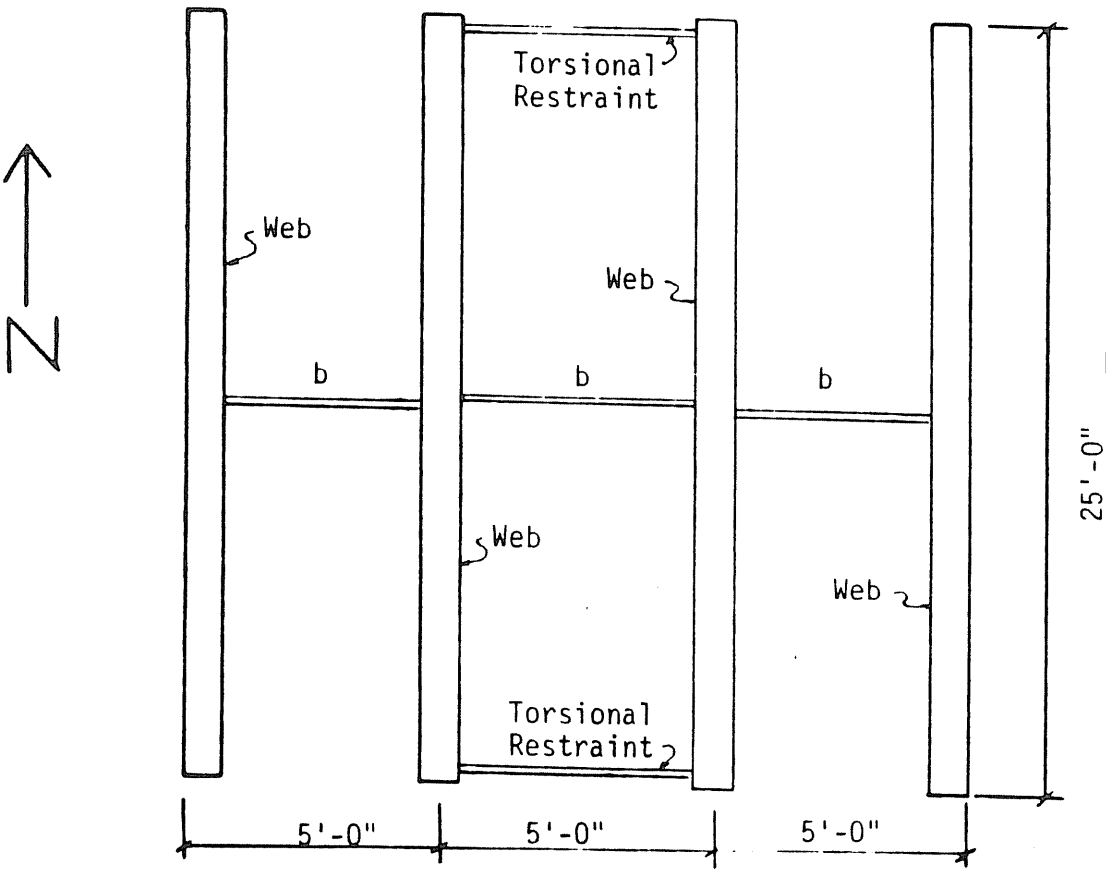


(d) Plan View - Tests 9-10

Figure 1.4 Brace Configurations for Gravity and Uplift Tests, Continued

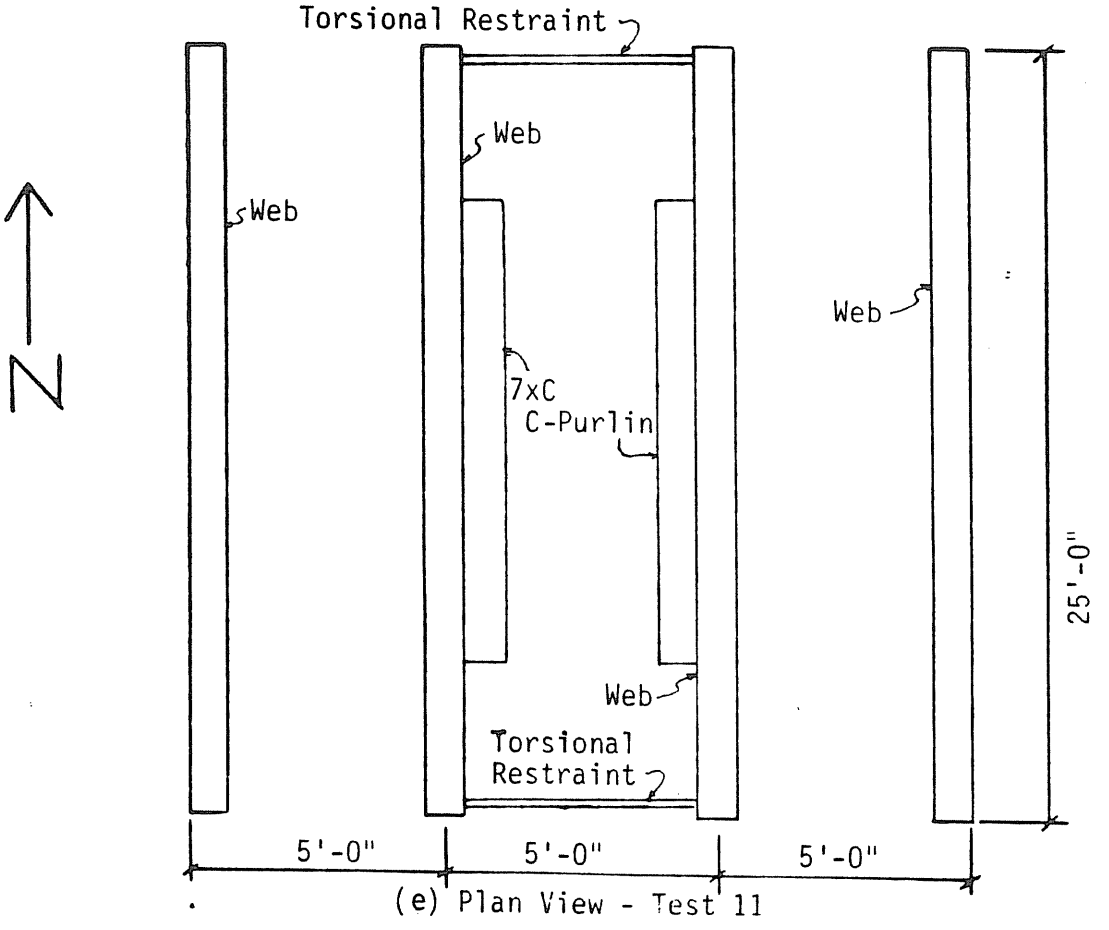


(c) Plan View - Test 8

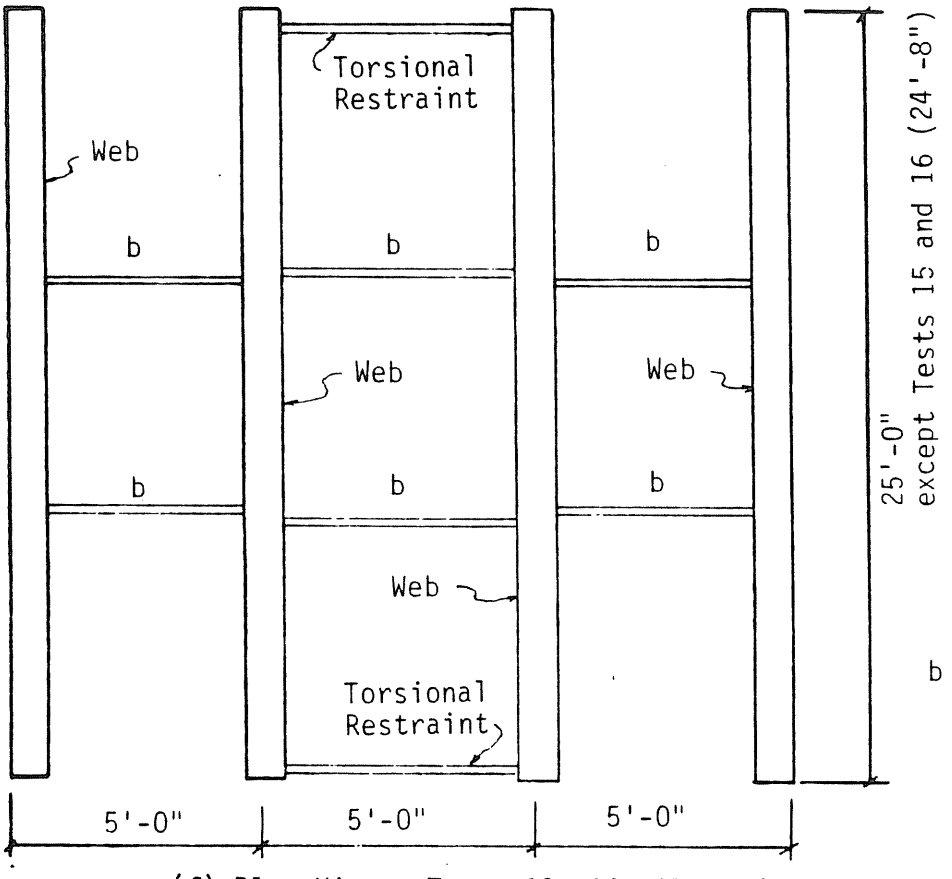


(d) Plan View - Tests 9-10

Figure 1.4 Brace Configurations for Gravity and Uplift Tests, Continued

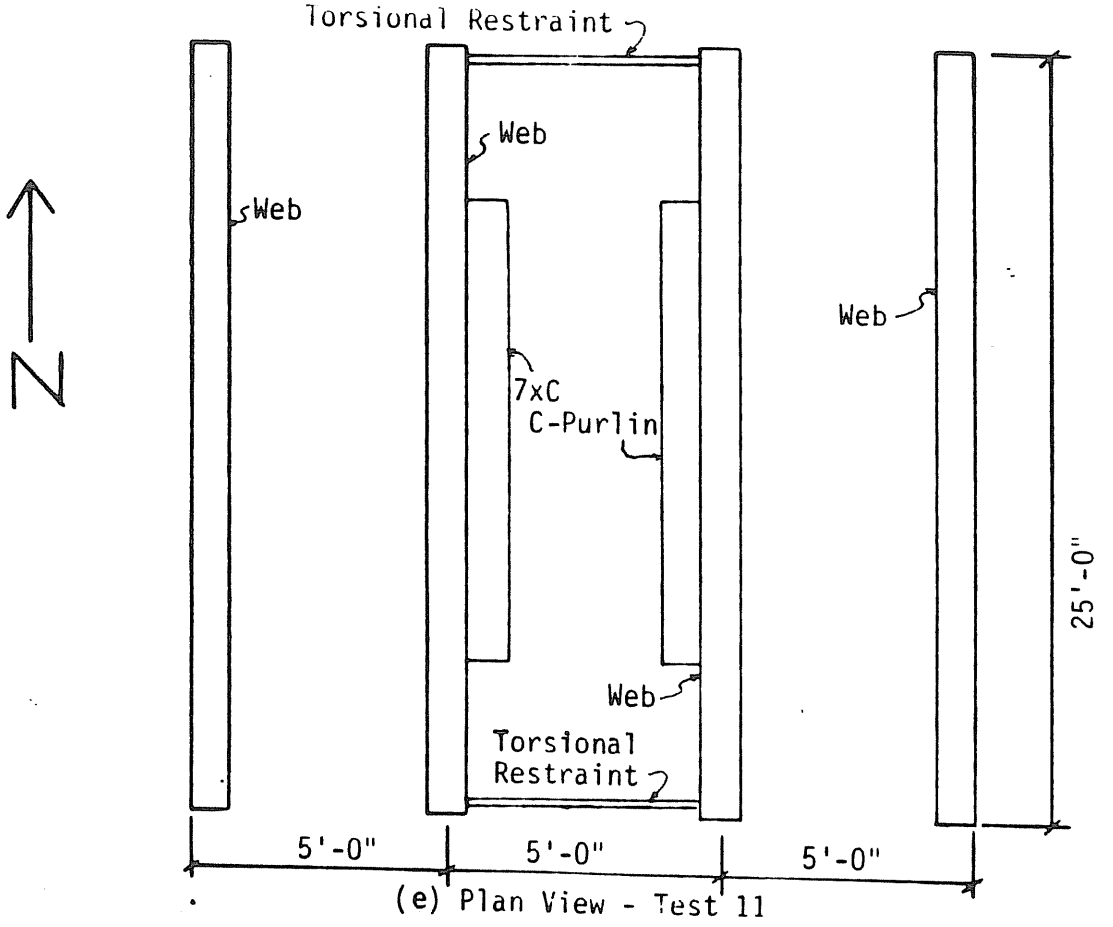


(e) Plan View - Test 11

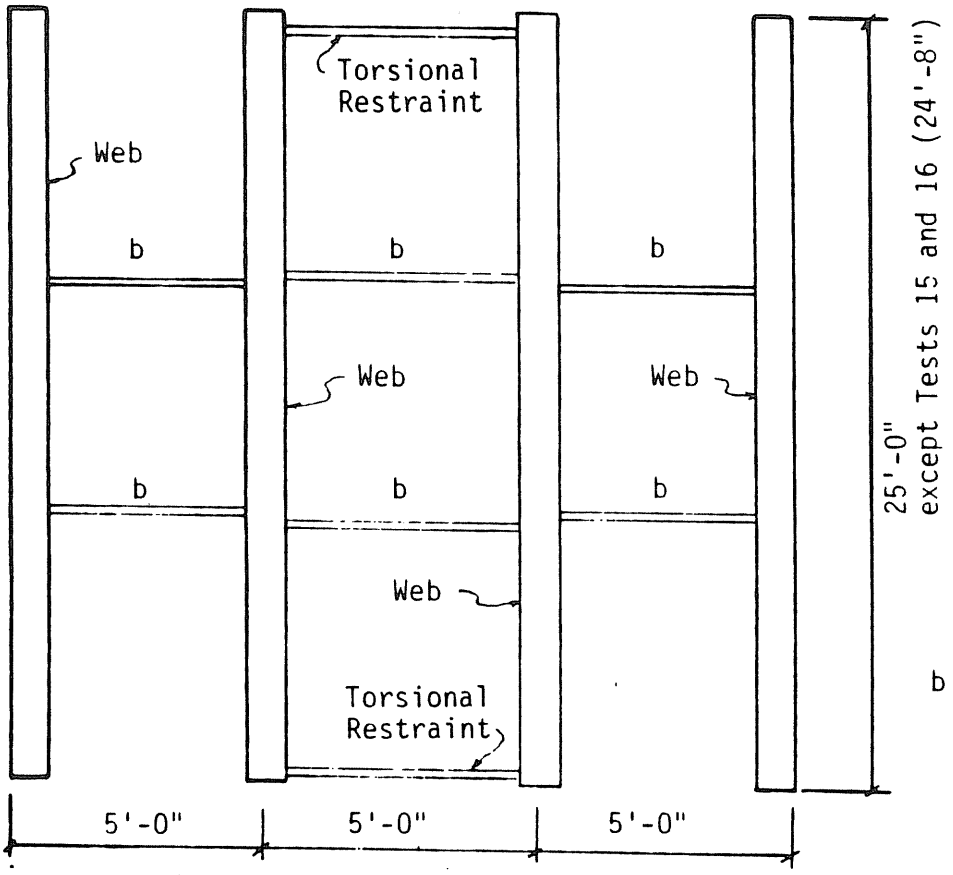


(f) Plan View - Tests 12, 14, 15, and 16

Figure 1.4 Brace Configurations for Gravity and Uplift Tests, Continued

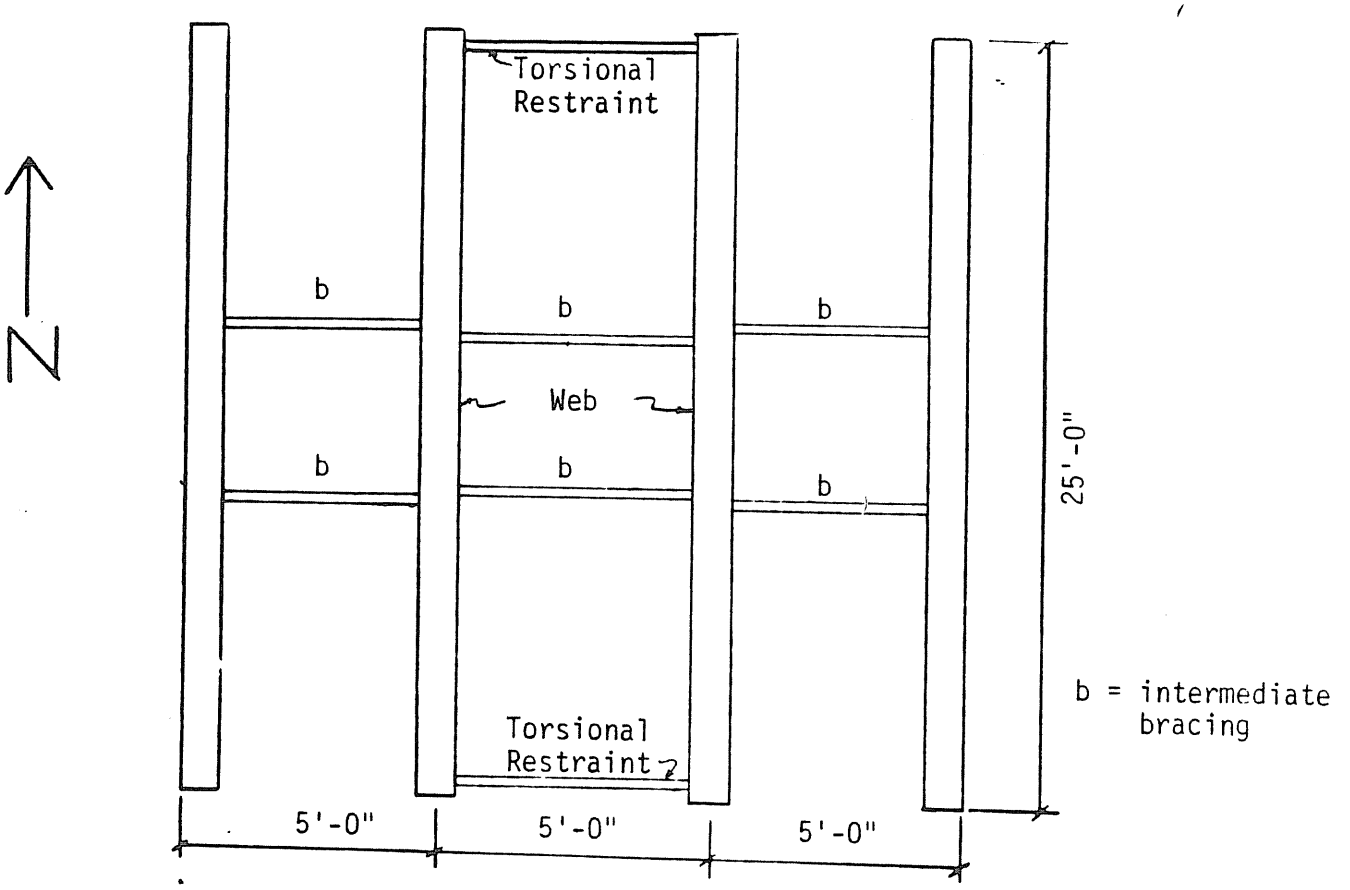


(e) Plan View - Test 11



(f) Plan View - Tests 12, 14, 15, and 16

Figure 1.4 Brace Configurations for Gravity and Uplift Tests, Continued



(g) Plan View - Test 13

Figure 1.4 Brace Configurations for Gravity and Uplift Tests, Continued

CHAPTER II

TEST DETAILS

2.1 Test Components

C-Purlins. The C-purlins used for this test were supplied by MESCO. All C-purlins were carefully measured and the dimensions are shown in Table 2.1 with nomenclature defined in Figure 2.1. Nominally 14 gage material was used to cold-form the test purlins used in Tests 1 through 4 and 7 through 16; 12 gage material was used for the purlins in Test 5, and 16 gage material for the purlins in Test 6. The measured material thickness of the west test purlin of Test 9 and both test purlins of Test 14 was found to be approximately 0.010 in. less than the nominal thickness for 14 gage material. Table 2.2 shows cross-sectional properties and load and deflection data for a uniformly loaded simple span of 25 ft. 0 in. calculated using AISI local buckling and effective width criteria with an assumed yield stress of 56 ksi. (Measured yield stress averaged 54.0 ksi, Table 3.3.)

Panels and Fasteners. The panels were conventional panels with profile as shown in Figure 2.2. Sheet size was 2 ft. 6 in. by 15 ft. and nominally 26 gage. Self-drilling fasteners, No. 12 by 1 in. were used for both sheet-to-sheet and sheet-to-purlin connection. Sheet-to-purlin fasteners were uniformly spaced at 15 3/4 inches on center and sheet-to-

Table 2.1
Measured C-Purlin Dimensions

Test No.		Total Depth (in.)	Thick-ness (in.)	Top					Bottom				
				W_1^* (in.)	T_1^* (in.)	R_1^* (in.)	R_2^* (in.)	θ_1^* (deg)	W_2^* (in.)	T_2^* (in.)	R_3^* (in.)	R_4^* (in.)	θ_2^* (deg)
1	East	9.00	0.074	2.66	0.44	0.25	0.31	93	2.60	0.42	0.31	0.25	91
	West	9.00	0.074	2.64	0.44	0.25	0.31	93	2.60	0.42	0.31	0.25	93
2	East	9.00	0.076	2.68	0.50	0.25	0.31	92	2.62	0.48	0.31	0.25	93
	West	9.00	0.074	2.66	0.46	0.25	0.31	92	2.60	0.48	0.31	0.25	92
3	East	9.00	0.074	2.64	0.44	0.25	0.31	87	2.60	0.42	0.31	0.25	89
	West	9.00	0.075	2.64	0.42	0.25	0.31	88	2.62	0.40	0.31	0.25	85
4	East	9.00	0.075	2.64	0.42	0.25	0.31	87	2.62	0.44	0.31	0.25	87
	West	9.00	0.074	2.66	0.44	0.25	0.31	88	2.60	0.40	0.31	0.25	86
5	East	9.00	0.100	2.64	0.46	0.25	0.38	84	2.68	0.44	0.38	0.25	90
	West	9.00	0.100	2.64	0.46	0.25	0.38	85	2.68	0.44	0.38	0.25	87
6	East	9.00	0.057	2.68	0.42	0.25	0.31	87	2.64	0.42	0.31	0.25	86
	West	9.00	0.057	2.62	0.42	0.25	0.31	85	2.66	0.44	0.31	0.25	86
7	East	9.00	0.073	2.68	0.42	0.25	0.31	87	2.62	0.42	0.31	0.25	87
	West	9.00	0.075	2.68	0.44	0.25	0.31	90	2.66	0.42	0.31	0.25	87
8	East	9.00	0.080	2.60	0.44	0.25	0.38	87	2.60	0.44	0.38	0.25	86
	West	9.00	0.080	2.60	0.42	0.25	0.38	88	2.64	0.44	0.38	0.25	87
9	East	9.00	0.074	2.62	0.44	0.25	0.38	88	2.62	0.42	0.38	0.25	85
	West	9.00	0.067	2.66	0.44	0.25	0.31	87	2.64	0.44	0.31	0.25	88
10	East	9.00	0.081	2.64	0.48	0.25	0.31	89	2.62	0.42	0.31	0.25	88
	West	9.00	0.080	2.68	0.42	0.25	0.31	89	2.62	0.50	0.31	0.25	87
11	East	9.00	0.079	2.62	0.44	0.25	0.31	88	2.66	0.42	0.31	0.25	84
	West	9.00	0.079	2.64	0.42	0.25	0.31	85	2.64	0.50	0.31	0.25	88
12	East	9.00	0.079	2.70	0.44	0.25	0.38	88	2.60	0.42	0.38	0.25	88
	West	9.00	0.079	2.66	0.46	0.25	0.31	88	2.62	0.40	0.31	0.25	87
13	East	9.00	0.079	2.60	0.46	0.25	0.31	87	2.60	0.42	0.38	0.25	88
	West	9.00	0.079	2.66	0.44	0.25	0.38	87	2.68	0.44	0.31	0.25	88
14	East	9.00	0.067	2.52	0.44	0.25	0.31	85	2.68	0.40	0.31	0.25	86
	West	9.00	0.067	2.62	0.38	0.25	0.31	87	2.54	0.44	0.31	0.25	85
15	East	9.00	0.079	2.68	0.53	0.25	0.38	86	2.66	0.46	0.38	0.25	87
	West	9.00	0.079	2.66	0.40	0.25	0.38	87	2.66	0.51	0.38	0.25	88
16	East	9.00	0.079	2.66	0.42	0.25	0.38	87	2.70	0.52	0.31	0.25	88
	West	9.00	0.080	2.66	0.52	0.25	0.31	90	2.66	0.44	0.38	0.25	88

* See Figure 2.1

Table 2.1
Measured C-Purlin Dimensions

Test No.		Total Depth (in.)	Thickness (in.)	Top					Bottom				
				W_1^* (in.)	T_1^* (in.)	R_1^* (in.)	R_2^* (in.)	θ_1^* (deg)	W_2^* (in.)	T_2^* (in.)	R_3^* (in.)	R_4^* (in.)	θ_2^* (deg)
1	East	9.00	0.074	2.66	0.44	0.25	0.31	93	2.60	0.42	0.31	0.25	91
	West	9.00	0.074	2.64	0.44	0.25	0.31	93	2.60	0.42	0.31	0.25	93
2	East	9.00	0.076	2.68	0.50	0.25	0.31	92	2.62	0.48	0.31	0.25	93
	West	9.00	0.074	2.66	0.46	0.25	0.31	92	2.60	0.48	0.31	0.25	92
3	East	9.00	0.074	2.64	0.44	0.25	0.31	87	2.60	0.42	0.31	0.25	89
	West	9.00	0.075	2.64	0.42	0.25	0.31	88	2.62	0.40	0.31	0.25	85
4	East	9.00	0.075	2.64	0.42	0.25	0.31	87	2.62	0.44	0.31	0.25	87
	West	9.00	0.074	2.66	0.44	0.25	0.31	88	2.60	0.40	0.31	0.25	86
5	East	9.00	0.100	2.64	0.46	0.25	0.38	84	2.68	0.44	0.38	0.25	90
	West	9.00	0.100	2.64	0.46	0.25	0.38	85	2.68	0.44	0.38	0.25	87
6	East	9.00	0.057	2.68	0.42	0.25	0.31	87	2.64	0.42	0.31	0.25	86
	West	9.00	0.057	2.62	0.42	0.25	0.31	85	2.66	0.44	0.31	0.25	86
7	East	9.00	0.073	2.68	0.42	0.25	0.31	87	2.62	0.42	0.31	0.25	87
	West	9.00	0.075	2.68	0.44	0.25	0.31	90	2.66	0.42	0.31	0.25	87
8	East	9.00	0.080	2.60	0.44	0.25	0.38	87	2.60	0.44	0.38	0.25	86
	West	9.00	0.080	2.60	0.42	0.25	0.38	88	2.64	0.44	0.38	0.25	87
9	East	9.00	0.074	2.62	0.44	0.25	0.38	88	2.62	0.42	0.38	0.25	85
	West	9.00	0.067	2.66	0.44	0.25	0.31	87	2.64	0.44	0.31	0.25	88
10	East	9.00	0.081	2.64	0.48	0.25	0.31	89	2.62	0.42	0.31	0.25	88
	West	9.00	0.080	2.68	0.42	0.25	0.31	89	2.62	0.50	0.31	0.25	87
11	East	9.00	0.079	2.62	0.44	0.25	0.31	88	2.66	0.42	0.31	0.25	84
	West	9.00	0.079	2.64	0.42	0.25	0.31	85	2.64	0.50	0.31	0.25	88
12	East	9.00	0.079	2.70	0.44	0.25	0.38	88	2.60	0.42	0.38	0.25	88
	West	9.00	0.079	2.66	0.46	0.25	0.31	88	2.62	0.40	0.31	0.25	87
13	East	9.00	0.079	2.60	0.46	0.25	0.31	87	2.60	0.42	0.38	0.25	88
	West	9.00	0.079	2.66	0.44	0.25	0.38	87	2.68	0.44	0.31	0.25	88
14	East	9.00	0.067	2.52	0.44	0.25	0.31	85	2.68	0.40	0.31	0.25	86
	West	9.00	0.067	2.62	0.38	0.25	0.31	87	2.54	0.44	0.31	0.25	85
15	East	9.00	0.079	2.68	0.53	0.25	0.38	86	2.66	0.46	0.38	0.25	87
	West	9.00	0.079	2.66	0.40	0.25	0.38	87	2.66	0.51	0.38	0.25	88
16	East	9.00	0.079	2.66	0.42	0.25	0.38	87	2.70	0.52	0.31	0.25	88
	West	9.00	0.080	2.66	0.52	0.25	0.31	90	2.66	0.44	0.38	0.25	88

* See Figure 2.1

Table 2.1
Measured C-Purlin Dimensions

Test No.		Total Depth (in.)	Thickness (in.)	Top					Bottom				
				W_1^* (in.)	T_1^* (in.)	R_1^* (in.)	R_2^* (in.)	θ_1^* (deg)	W_2^* (in.)	T_2^* (in.)	R_3^* (in.)	R_4^* (in.)	θ_2^* (deg)
1	East	9.00	0.074	2.66	0.44	0.25	0.31	93	2.60	0.42	0.31	0.25	91
	West	9.00	0.074	2.64	0.44	0.25	0.31	93	2.60	0.42	0.31	0.25	93
2	East	9.00	0.076	2.68	0.50	0.25	0.31	92	2.62	0.48	0.31	0.25	93
	West	9.00	0.074	2.66	0.46	0.25	0.31	92	2.60	0.48	0.31	0.25	92
3	East	9.00	0.074	2.64	0.44	0.25	0.31	87	2.60	0.42	0.31	0.25	89
	West	9.00	0.075	2.64	0.42	0.25	0.31	88	2.62	0.40	0.31	0.25	85
4	East	9.00	0.075	2.64	0.42	0.25	0.31	87	2.62	0.44	0.31	0.25	87
	West	9.00	0.074	2.66	0.44	0.25	0.31	88	2.60	0.40	0.31	0.25	86
5	East	9.00	0.100	2.64	0.46	0.25	0.38	84	2.68	0.44	0.38	0.25	90
	West	9.00	0.100	2.64	0.46	0.25	0.38	85	2.68	0.44	0.38	0.25	87
6	East	9.00	0.057	2.68	0.42	0.25	0.31	87	2.64	0.42	0.31	0.25	86
	West	9.00	0.057	2.62	0.42	0.25	0.31	85	2.66	0.44	0.31	0.25	86
7	East	9.00	0.073	2.68	0.42	0.25	0.31	87	2.62	0.42	0.31	0.25	87
	West	9.00	0.075	2.68	0.44	0.25	0.31	90	2.66	0.42	0.31	0.25	87
8	East	9.00	0.080	2.60	0.44	0.25	0.38	87	2.60	0.44	0.38	0.25	86
	West	9.00	0.080	2.60	0.42	0.25	0.38	88	2.64	0.44	0.38	0.25	87
9	East	9.00	0.074	2.62	0.44	0.25	0.38	88	2.62	0.42	0.38	0.25	85
	West	9.00	0.067	2.66	0.44	0.25	0.31	87	2.64	0.44	0.31	0.25	88
10	East	9.00	0.081	2.64	0.48	0.25	0.31	89	2.62	0.42	0.31	0.25	88
	West	9.00	0.080	2.68	0.42	0.25	0.31	89	2.62	0.50	0.31	0.25	87
11	East	9.00	0.079	2.62	0.44	0.25	0.31	88	2.66	0.42	0.31	0.25	84
	West	9.00	0.079	2.64	0.42	0.25	0.31	85	2.64	0.50	0.31	0.25	88
12	East	9.00	0.079	2.70	0.44	0.25	0.38	88	2.60	0.42	0.38	0.25	88
	West	9.00	0.079	2.66	0.46	0.25	0.31	88	2.62	0.40	0.31	0.25	87
13	East	9.00	0.079	2.60	0.46	0.25	0.31	87	2.60	0.42	0.38	0.25	88
	West	9.00	0.079	2.66	0.44	0.25	0.38	87	2.68	0.44	0.31	0.25	88
14	East	9.00	0.067	2.52	0.44	0.25	0.31	85	2.68	0.40	0.31	0.25	86
	West	9.00	0.067	2.62	0.38	0.25	0.31	87	2.54	0.44	0.31	0.25	85
15	East	9.00	0.079	2.68	0.53	0.25	0.38	86	2.66	0.46	0.38	0.25	87
	West	9.00	0.079	2.66	0.40	0.25	0.38	87	2.66	0.51	0.38	0.25	88
16	East	9.00	0.079	2.66	0.42	0.25	0.38	87	2.70	0.52	0.31	0.25	88
	West	9.00	0.080	2.66	0.52	0.25	0.31	90	2.66	0.44	0.38	0.25	88

* See Figure 2.1

T_1 and T_2 measured from free end of lip to tangent of radius.

W_1 and W_2 measured from outside of web to tangent of radius.

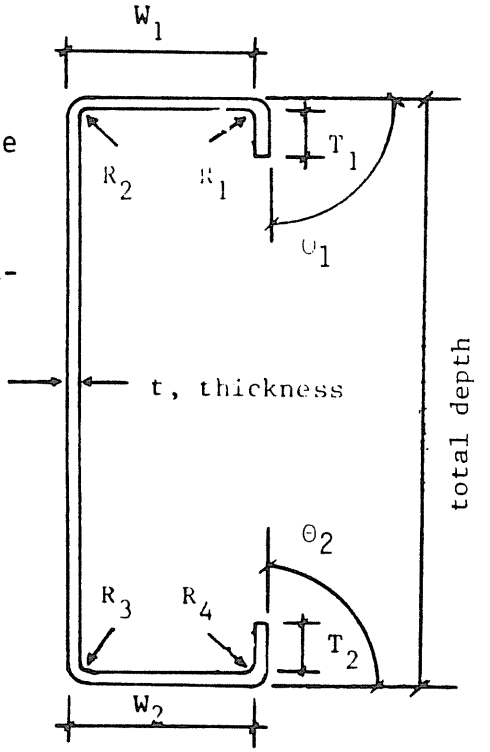


Figure 2.1 Cross-Section Measurements

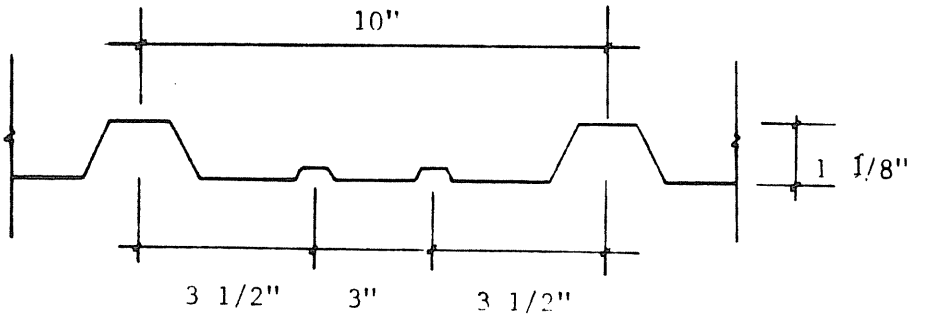


Figure 2.2 Panel Shape

T_1 and T_2 measured from free end of lip to tangent of radius.

W_1 and W_2 measured from outside of web to tangent of radius.

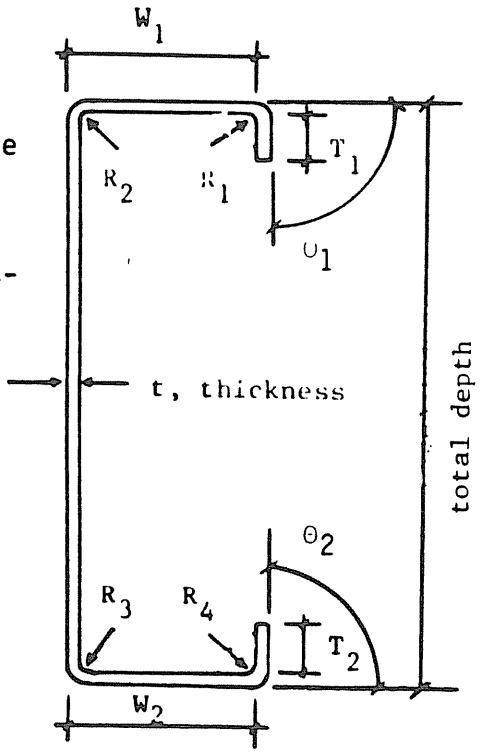


Figure 2.1 Cross-Section Measurements

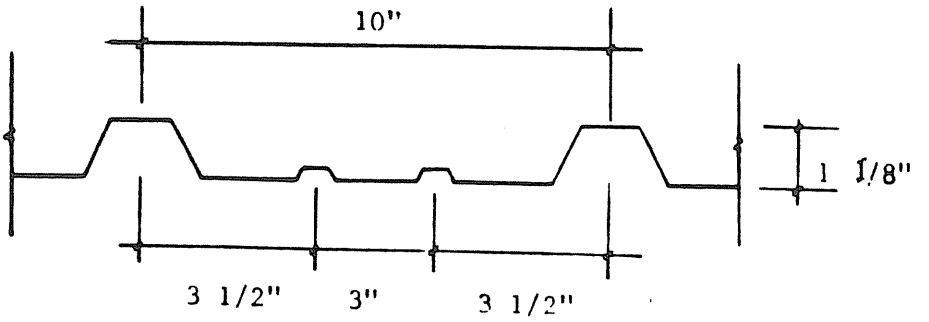


Figure 2.2 Panel Shape

Table 2.2
C-Purlin Properties (F_y = 56 ksi)

Test No.		Gross			Strength							Moment Cpcty.(AISI) (1.65*allowable)					Deflection	
		I (in^4)	S_t (in^3)	S_b (in^3)	I (in^4)	S_t (in^3)	S_b (in^3)	t_e (in^3)	F_c (ksi)	F_t (ksi)	F_{bw} (ksi)	M_c (Ft-k)	M_t (Ft-k)	M_w (Ft-k)	M_u (Ft-k)	w_u (lb/ft)	I (in^4)	$\Delta/100$ plf(in)
1	East	13.107	2.952	2.922	13.038	2.927	2.915	2.227	33.600	33.600	30.430	8.197	8.163	8.056	13.453	172.196	13.107	2.273
	West	13.076	2.941	2.918	13.024	2.923	2.914	2.218	33.600	33.600	30.430	8.183	8.158	8.042	13.430	171.906	13.076	2.279
2	East	13.570	3.057	3.025	13.522	3.040	3.021	2.260	33.600	33.600	30.430	8.511	8.459	8.424	14.068	180.064	13.570	2.196
	West	13.204	2.967	2.950	13.136	2.942	2.944	2.227	33.600	33.600	30.430	8.238	8.244	8.095	13.518	173.035	13.204	2.256
3	East	13.084	2.943	2.920	13.032	2.925	2.915	2.218	33.600	33.600	30.430	8.189	8.163	8.048	13.084	172.025	13.084	2.277
	West	13.237	2.974	2.959	13.209	2.964	2.957	2.234	33.600	33.600	30.568	8.298	8.279	8.193	13.681	175.123	13.237	2.251
4	East	13.311	2.987	2.979	13.283	2.977	2.976	2.234	33.600	33.600	30.568	8.335	8.334	8.229	13.742	175.893	13.311	2.238
	West	13.090	2.952	2.914	13.022	2.927	2.908	2.227	33.600	33.600	30.430	8.196	8.143	8.056	13.453	172.202	13.090	2.276
5	East	17.588	3.948	3.957	17.588	3.948	3.957	2.165	33.600	33.600	33.133	11.055	11.079	12.051	18.461	236.306	17.588	1.694
	West	17.591	3.948	3.958	17.591	3.948	3.958	2.165	33.600	33.600	33.133	11.054	11.083	12.049	18.460	236.287	17.591	1.694
6	East	10.230	2.294	2.282	9.754	2.128	2.238	1.902	33.600	33.600	27.329	5.958	6.266	5.235	8.743	111.906	10.142	2.938
	West	10.205	2.273	2.291	9.776	2.215	2.251	1.887	33.600	33.600	27.329	5.950	6.303	5.227	8.730	111.739	10.154	2.934
7	East	12.977	2.919	2.896	12.868	2.880	2.886	2.219	33.600	33.600	30.287	8.064	8.081	7.885	13.168	168.545	12.977	2.296
	West	13.403	3.011	2.996	13.342	2.989	2.991	2.252	33.600	33.600	30.568	8.369	8.374	8.262	13.797	176.607	13.403	2.233
8	East	13.982	3.135	3.135	13.982	3.135	3.135	2.145	33.600	33.600	31.209	8.778	8.778	8.989	14.658	187.629	13.982	2.151
	West	14.017	3.130	3.155	14.017	3.130	3.155	2.145	33.600	33.600	31.209	8.765	8.835	8.973	14.637	187.358	14.017	2.126
9	East	13.003	2.917	2.910	13.003	2.917	2.910	2.171	33.600	33.600	30.430	8.167	8.149	8.149	13.609	174.196	13.003	2.291
	West	11.987	2.687	2.680	11.750	2.603	2.658	2.105	33.600	33.600	29.343	7.290	7.444	6.895	11.514	147.381	11.987	2.485
10	East	14.360	3.236	3.204	14.360	3.236	3.204	2.247	33.600	33.600	31.238	9.061	8.972	9.178	14.983	191.779	14.360	2.075
	West	14.280	3.199	3.205	14.280	3.199	3.205	2.288	33.600	33.600	31.209	8.957	8.973	9.033	14.957	191.455	14.280	2.086
11	East	14.003	3.134	3.145	14.003	3.134	3.145	2.229	33.600	33.600	31.008	8.776	8.805	8.814	14.656	187.593	14.003	2.128
	West	14.079	3.142	3.171	14.079	3.142	3.171	2.249	33.600	33.600	31.008	8.797	8.879	8.833	14.690	188.034	14.079	2.116
12	East	13.940	3.150	3.101	13.940	3.150	3.101	2.246	33.600	33.600	31.088	8.821	8.682	9.005	14.498	185.579	13.940	2.137
	West	14.008	3.147	3.134	14.008	3.147	3.134	2.269	33.600	33.600	31.088	8.811	8.776	8.852	14.656	187.598	14.008	2.127
13	East	13.855	3.108	3.105	13.855	3.108	3.105	2.209	33.600	33.600	31.088	8.702	8.693	8.741	14.517	185.818	13.855	2.150
	West	14.075	3.158	3.153	14.075	3.158	3.153	2.206	33.600	33.600	31.088	8.842	8.830	9.019	14.745	188.741	14.075	2.117
14	East	11.811	2.623	2.666	11.688	2.580	2.655	2.051	33.600	33.600	29.343	7.224	7.434	6.830	11.406	146.002	11.811	2.523
	West	11.650	2.612	2.604	11.436	2.537	2.584	2.081	33.600	33.600	29.257	7.103	7.236	6.698	11.186	143.180	11.650	2.557
15	East	14.174	3.195	3.160	14.174	3.196	3.160	2.226	33.600	33.600	31.088	8.947	8.848	9.131	14.776	194.277	14.174	1.992
	West	14.036	3.126	3.168	14.036	3.126	3.168	2.206	33.600	33.600	31.088	8.753	8.870	8.922	14.617	192.188	14.036	2.012
16	East	14.182	3.158	3.201	14.182	3.158	3.210	2.206	33.600	33.600	31.088	8.844	8.962	9.014	14.769	194.183	14.182	1.991
	West	14.316	3.219	3.210	14.316	3.219	3.210	2.268	33.600	33.600	31.209	9.012	8.963	9.091	14.968	196.801	14.316	1.972

t = top
b = bottom
Note: All calculations are based on an assumed yield stress of 56 ksi.

sheet fasteners were spaced at 30 in. on center (five per lap).

2.2 Test Set-Ups

The test set-ups were constructed in a specially designed 15 ft. 3 in. wide vacuum chamber. The outside walls of the chamber are metal panels bolted together and attached to the laboratory floor. Lateral support for the walls was provided at the top by angle braces. Polyethylene and vinyl tape were used to seal the assemblies. Suction was applied using a vacuum pump and two auxiliary 55 gallon drum type industrial vacuum cleaners. Specific details follow.

2.2.1 Gravity Loading

General details of the test set-up are shown in Figure 1.1. To provide free rotation at the supports, a ½ in. diameter roller was inserted between each rafter section and support column.

Intermediate and torsional restraint braces were fabricated from 3/4 in. diameter steel electrical conduit. Nuts were welded into each end of the conduit and a 9 in. length of ½ in. diameter threaded stud was inserted. Holes were drilled at the proper location in the purlin webs and connection was made using half moon and flat washers together with a standard nut as shown in Figure 1.2 for a tension brace connection. The washers and nuts were placed on the opposite side of the web for a compression brace connection.

For all tests, the panels were connected to the purlins using self-drilling fasteners through the panel and the purlin top flange. All purlins were connected to the rafters with shear clips using A307 bolts and ½ in. diameter nuts, except for Test I. In Test I, the purlins were

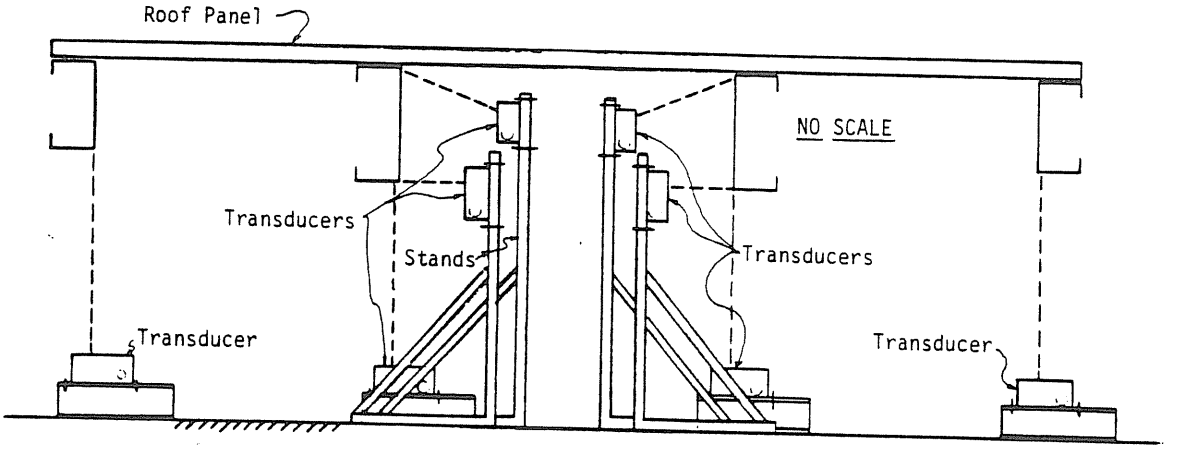
connected directly to the rafter.

2.2.2 Uplift Loading

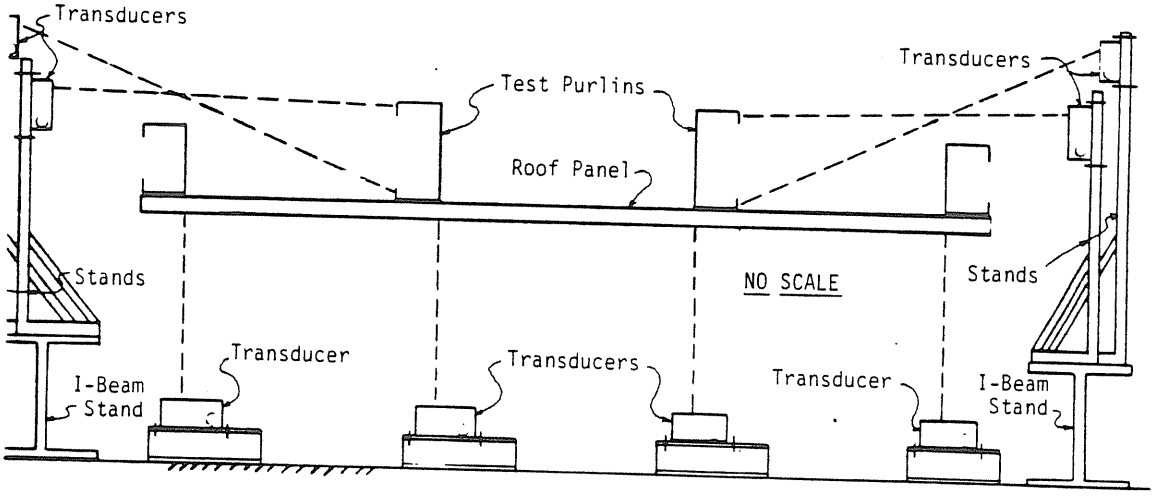
General details of the test set-up are shown in Figure 1.2. Uplift loading test set-ups were identical to gravity loading except the entire assembly was turned over. The fasteners were installed from the underside. Polyethylene was placed over the panels prior to installing the purlins. By applying suction on the roof panel, a simulated uplift loading was produced. In all tests, purlins were attached to the rafters using shear clips.

2.3 Instrumentation

Instrumentation consisted of calibrated dynamometers (Tests 1 and 8), extensometers, a U shape monometer, and linear displacement transducers. The calibrated dynamometers were typical intermediate or torsional restraint braces with a full strain gage bridge installed at approximately the brace centerline. The braces were then calibrated using a universal testing machine. Eight linear displacement transducers were used to measure vertical and lateral displacement of the purlins. Four transducers were used to measure vertical deflection at the midspan of each purlin, and four transducers were used to measure lateral displacement of the test purlins, also at the midspan. As shown in Figure 2.3, one of these transducers was used to measure horizontal displacement of the bottom flange and a second was used to measure horizontal displacement of the top flange of each test purlin. Transducers were also placed directly underneath the test purlin support points on the rafters as shown in Figure 1.1. Data from these transducers permitted correction for rafter deflections.



(a) Gravity Load Test



(b) Uplift Load Test

Figure 2.3 Location of Displacement Transducers

The applied vacuum load was measured by a U-tube monometer. The U-tube monometer was calibrated in 0.5 in. of water and has an estimated accuracy of $\pm$0.1 psf. A micro-computer based data acquisition system was used to collect, record, process and plot the test data in "real" time.

2.4 Testing Procedure

At the beginning of each test, approximately 20% of the failure load, calculated using AISI criteria and with the constrained bending assumption times 1.67, was applied and then removed. Following this initial loading, zero readings were recorded for all dynamometers and displacement transducers. The system was then loaded by slowly increasing the vacuum in 0.5 in. of water increments. After each increment, readings of all instrumentation were recorded. When the purlins were near failure as determined from plotted load-deflection curves, the loading rate was decreased to less than 0.25 in. of water increments. Notes were taken concerning deformation of the roof system and the failure mode along with photographs.

2.5 Supplementary Tests

Standard tensile coupon tests were made from samples cut from the test purlins and typical panel material. Results from these tests are given in Table 3.3.

CHAPTER III

TESTS RESULTS

3.1 General

Test results consist of load versus deflection data, load versus brace force data, photographic record and description of failure load. Load vs. deflection data includes plots of simulated live load vs. vertical deflection at the centerline of each purlin, and simulated live load vs. lateral deflection of top and bottom flanges of the test purlins. The vertical deflection plots also include theoretical deflection as computed assuming constrained bending:

$$\Delta = \frac{5wL^4}{384EI} \tag{3.1}$$

where I = the moment of inertia of the purlin with respect to the horizontal axis, w = uniform load, L = span, and E = modulus of elasticity. Simulated live load versus brace force for Tests 1 and 7 are also included.

Tables 3.1 and 3.3 are summaries of the test results. Detailed descriptions and data for each test are found in the appendices. Gravity loading test results (Tests 1 through 6 and 16) are found in Appendix A. Uplift loading test results (Tests 7 through 15) are found in Appendix B. Figures 3.1 and 3.2 are photographs of typical gravity and uplift loading failures.

In the discussion that follows, "test purlin" refers to the inside 9 x 3 C-purlin and "outside purlin" refers to the edge 7 x 3 C-purlins.

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In the discussion that follows, "test purlin" refers to the inside 9 x 3 C-purlin and "outside purlin" refers to the edge 7 x 3 C-purlins.

Table 3.1
Summary of Gravity Loading Test Results

Test No.	AISI Constrained Bending Failure Load (plf)*	Actual Failure Load (plf) (Actual/Predicted)	Failure Mode	Remarks
1	172.2	149.5 (0.87)	Local buckling of the flange and/or web of east and west test purlin	All purlins in same direction. No intermediate bracing.
2	180.1	167.4 (0.93)	"	Test purlins facing each other. No intermediate bracing.
3	172.0	162.3 (0.94)	"	"
4	175.9	154.6 (0.88)	Local buckling of comp. flange and/or web of east test purlin.	Same as test 1 except purlins clipped to rafters.
5	236.3	266.3 (1.13)	Local buckling of comp. flange and/or web of test purlins	Same as test 2 except 12 gage purlins were used.
6	111.7	97.7 (0.87)	Local buckling of comp. flange and/or web of east test purlins.	Same as test 2 except 16 gage purlins were used.
16	194.2	182.0 (0.94)	Local buckling of comp. flange and/or web of east test purlin	Bracing @ ends and @ one-third points.

Notes: 1. The test matrix is found in Table 1.1, page 3,

* Based on F_y = 56 ksi and on implied factor of safety of 1.67.

Table 3.2
Summary of Uplift Loading Test Results

Test No.	AISI Constrained Bending Failure Load (plf)*	Actual Failure Load (plf) (Actual/Predicted)	Failure Mode	Remarks
7	168.5	88.2 (0.52)	Local Buckling of comp. flange and/or web of east test purlin.	No intermediate bracing. Fasteners pulled out of deck @ failure due to horiz. displacement.
8	187.4	116.3 (0.62)	Local buckling of comp. flange of west test purlin.	Bracing of purlins @ ℄. Test purlins in opposing directions.
9	147.4	85.6 (0.58)	"	Bracing @ ends and @ ℄. Wood stiffener placed at center of test purlin.
10	191.5	116.3 (0.61)	Local buckling of comp. flange of east test purlin.	Bracing @ ends and ℄. Wood stiffeners placed @ 2, 5, & 10 ft. from ℄ & @ ℄.
11	187.6	111.2 (0.59)	Local buckling of comp. lip and flange of east test purlin.	15 ft. 7x3 C-purlin attached to test purlins.
12	185.6	131.6 (0.71)	Local buckling of comp. flange and/or web of test purlins.	Bracing @ third-points and @ ends.
13 **	185.8	124.0 (0.67)	Local buckling of comp. flange and/or web of east test purlin.	Bracing @ ends and 2.5 ft. on each side of ℄.
14	143.2	93.3 (0.65)	Local buckling of comp. flange and lip of test purlins.	Bracing @ ends and one-third points.
15	192.2	131.6 (0.68)	Local buckling of comp. flange and/or web of test purlins.	"

Notes: 1. The test matrix is found in Table 1.1, page 3.

* Based on F_y = 56 ksi and on implied factor of safety of 1.67.

** Failed due to error during construction of test setup.

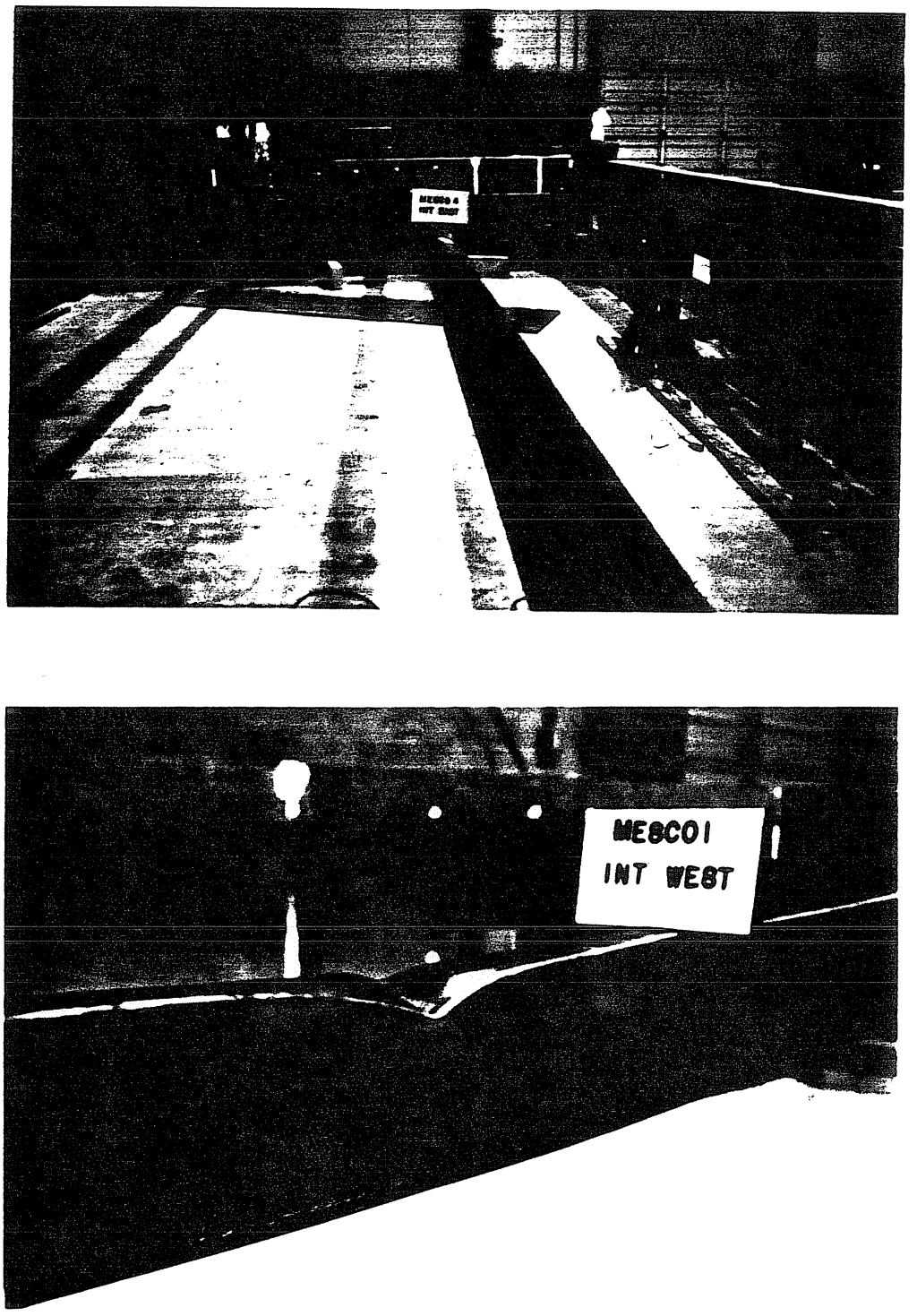


Figure 3.1 Photographs of Typical Gravity Loading Failures

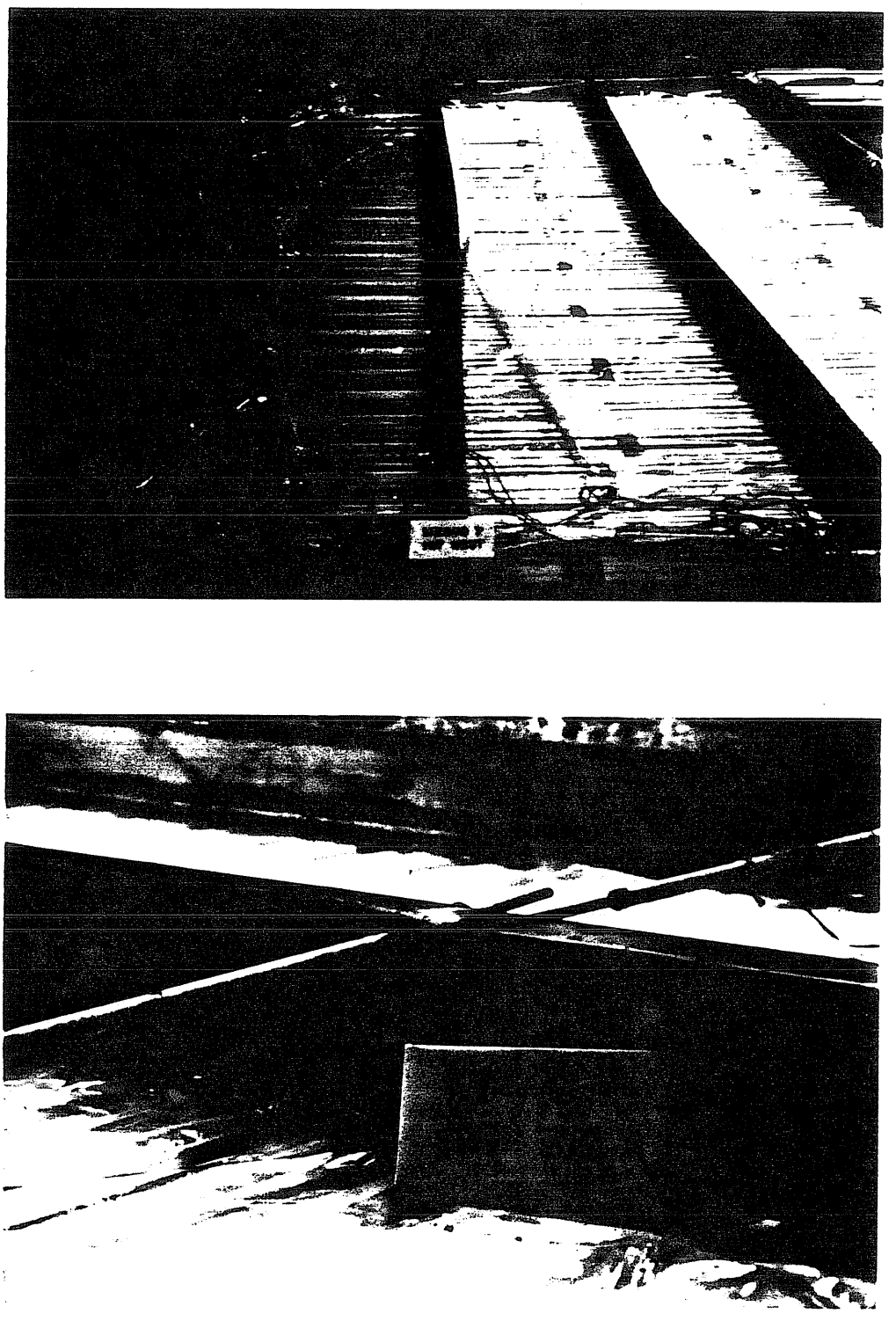


Figure 3.2 Photographs of Typical Uplift Loading Failures

The reported failure loads are the sum of applied loads plus the dead load supported by a test purlin. In all tests, one or both test purlins failed prior to failure of an outside purlin. The outside purlins did not fail in most tests. Material thickness is 14 gage unless noted.

3.2 Gravity Loading Test Results

The purpose of the gravity loading tests was to determine if various parameters affected the strength of the test purlins. In Test 1, the purlins were oriented in the same direction and were connected with bolts through the bottom flanges directly to the rafters. The required restraining force at the rafters was determined with the use of dynamometers attached to the east outside purlins. Failure occurred at 149.5 plf (140.6 plf applied load plus 8.9 plf dead load) by local buckling of the compression flange near midspan of the test purlins. Using AISI criteria, the constrained bending assumption, the predicted failure load was 172.2 plf. The actual failure load was 86.8% of this value. The maximum brace force was 504 lbs. in compression or 4.5% of the total supported load. The measured vertical deflections were 4% more than the predicted values, and the test purlins deflected 15% more than the outside purlins.

In Tests 2 and 3, the test purlins were oriented toward each other and connected to the rafters with shear clips. No intermediate bracing was used. Failure of Test 2 occured at 167.4 plf. Using AISI criteria, the predicted failure load was 180.1 plf. In Test 3, the failure load was 162.3 plf, and the predicted AISI load was 172.0 plf. The actual failure loads represent 93.0% and 94.4% of the predicted loads. In both tests, failure occurred by local buckling of the compression flange

and/or web of the test purlins near midspan. Vertical deflections were 6-11% more than predicted by the constrained bending assumption. The test purlins deflected approximately 25% more than the outside purlins.

Test 4 was similar to Test 1, except the purlins were clipped to the rafters, and brace forces were not measured. Failure occurred at 154.6 plf by local buckling of the compression flange and/or web of the east test purlin, again near midspan. The AISI predicted failure load was 175.9 plf. The actual failure load was 87.8% of predicted. The measured vertical deflections of the test purlins were 13-15% more than predicted, and the test purlins deflected 25-30% more than the outside purlins.

Tests 5 and 6 were conducted with the purlin flanges opposing (similar to Test 3). The purlin material was 12 gage for Test 5 and 16 gage for Test 6 (versus 14 gage for Test 3). The failure load of Test 5, 266.3 plf, exceeded the AISI predicted load, 236.3 plf, by 13%. The failure load of Test 6 was 97.7 plf and the predicted load was 111.7 plf. The failure load was 87.5% of predicted. Vertical deflections of Test 5 were 30-40% more than predicted, and the test purlins deflected 30-40% more than the outside purlins. For Test 6, vertical deflections were 5-10% more than predicted and the test purlin deflections exceeded outside purlin deflections by 30%. Both failure modes were local buckling of the compression flange and/or web of the test purlins near midspan.

Test 16 was conducted with intermediate braces at the one-third point. The failure load was 182.0 plf as compared to the AISI predicted load of 194.2 plf. The failure load is 93.7% of the predicted load.

Vertical deflections were 6-9% more than predicted by constrained bending, and the test purlins deflected 12-19% more than the outside purlins.

3.3 Uplift Loading Test Results

Simulated wind uplift loading was applied in Tests 7 thru 15. Several brace configurations and other modifications were used for the tests. Test results are compared to moment capacities calculated using the constrained bending assumption and AISI local buckling provisions with the factor of safety (1.67) removed. In these calculations, the unbraced length of the compression flange was not considered. This load will be referred to as the "reference" load. The reported failure loads include effects of the dead load of the roof deck and the purlins.

Test 7 was conducted without intermediate braces. The purlins were supported at the ends with shear clips as shown in Figure 1.3(a), however, the braces shown in Figure 1.3(b) were not installed. The failure load was 88.2 plf or 52% of the reference load (168.5 plf). Measured vertical deflections were 200-300% greater than predicted by Equation 3.1 and the test purlin deflections exceeded the outside purlin deflections by 100-200%. Failure was due to excessive lateral displacement which caused web buckling and purlin-to-panel connection failure.

For Test 8, intermediate braces were installed between the test purlins at midspan approximately 1 in. below the compression flange. The support conditions were the same as for Test 7. Failure occurred by local buckling near midspan of the compression flange of the west test purlin. The failure load was 116.3 plf or 62% of the reference load. Measured vertical deflections were 20-30% greater than predicted.

The test purlins deflected 7-9% more than the outer purlins. The maximum measured brace force between the test purlins was 556 lb. and 127 lb. between the outside purlins and the test purlins.

Test 9 was similar to Test 8 except braces were installed between the purlins at the purlin-to-rafter clip locations as shown in Figure 1.3(b) and a wood block was placed between flanges at the misdpan of each test purlin. The block was used to prevent the flanges from rolling toward each other. Failure occurred at the wood block locations by local buckling of the compression flange. The failure load was 85.6 plf or 58% of the reference failure load, 147.4 plf. Vertical deflections were 28% more than predicted, and the test purlins deflected 31-38% more than the outside purlins. No brace forces were measured.

Test 10 was similar to Test 9 except additional blocks were placed 2 ft., 5 ft., and 10 ft. from midspan of each test purlin. Failure occurred at 116.3 plf or 61% of the reference load, 191.5 plf. Vertical deflections were 28% more than predicted, and the test purlin deflections exceeded the outside purlin deflections by 31-38%.

In Test 11, a 15 ft. 7x3 C-purlin was attached to each test purlin, centered at midspan. The roof panel was attached to the 7x3 purlin along its length and to the 9x3 test purlin over the remaining 10 ft. The failure mode was local buckling of the compression lip and flange of the east test purlin. The failure occurred at 111.2 plf or 59% of reference load, 187.6 plf. Vertical deflections were 4% more than predicted for the test purlin without consideration of the additional 7x3 purlin. The test purlins deflected 2-13% more than the

outside purlins.

Test 12 was conducted with intermediate braces at the third points, Figure 1.3(a) and between the test purlins at the rafters, Figure 1.3(b). Failure occurred by local buckling of the compression flange of one or both test purlins near midspan. The experimental failure load for Test 12 was 131.6 plf or 71% of the reference load, 185.6 plf. The measured vertical deflections were 25% more than predicted and the test purlins deflected 27-30% more than the outside purlins.

In Test 13, failure occurred because of an error during construction of the test setup. The test results are not considered to be valid.

Test 14 was conducted using purlins formed from material slightly less thick than that used for the other test purlins. Two intermediate braces were installed 2.5 ft. each side of midspan and braces were used between the test purlins at the rafter locations. The failure load was 93.3 plf or 65% of the reference load. Failure was caused by local buckling of the compression flange of one or both purlins near midspan. Vertical deflections were approximately 18% more than predicted and the test purlins deflected 45-60% more than the outside purlins.

The span for Test 15 was 24 ft. 8 in. Intermediate braces were installed at the span one third points and between the test purlins at the rafters. The failure load was 131.6 plf or 68% of the reference load, 192.2 plf. Failure was by local buckling of the compression flange of one or more purlins near midspan. Vertical deflections were 24-29% more than predicted and the test purlin deflections exceeded the

outside purlin deflections by 44-48%.

3.4 Results of Supplementary Tests

Coupon test results from samples of test purlins are given in Table 3.3. The average yield stress for the 32 samples was 54.05 ksi, the highest was from Test 6 with a value of 60.22 ksi, and the lowest was 47.21 for Test 8. It is noted that the predicted failure loads were calculated using an assumed yield stress of 56 ksi or 3.6% above the average measured yield stress.

Table 3.3
Tensile Coupon Test Results

Test No.	Thickness (in.)	Width (in.)	Yield Stress (ksi)	Ultimate Stress (ksi)	Elongation %
1 E	0.073	0.493	55.97	70.28	25.5
Ext E	0.076	0.499	56.81	71.20	25.5
2 E	0.074	0.498	57.18	70.73	26.5
W	0.074	0.496	57.22	70.84	27.0
3 E	0.074	0.495	57.65	71.58	27.5
W	0.075	0.493	55.68	68.97	28.5
4 E	0.075	0.500	55.47	69.87	26.2
W	0.074	0.487	56.94	70.28	26.5
5 E	0.100	0.498	54.71	69.74	31.0
W	0.100	0.501	55.47	68.79	30.5
6 E	0.056	0.499	58.72	70.46	27.5
W	0.056	0.498	60.22	71.33	26.0
7 E	0.072	0.496	56.55	70.19	25.5
W	0.075	0.500	54.13	68.80	32.5
8 E	0.079	0.497	47.21	70.05	29.0
W	0.078	0.498	49.95	72.35	26.0
9 E	0.074	0.498	60.16	72.63	27.0
W	0.067	0.497	56.33	69.88	30.0
10 E	0.081	0.494	52.25	71.75	28.5
W	0.080	0.493	57.87	70.81	29.0
11 E	0.080	0.499	49.12	72.68	26.5
W	0.079	0.493	49.87	71.47	27.0
12 E	0.079	0.493	53.21	72.24	26.0
W	0.080	0.493	49.75	70.56	28.0
13 E	0.078	0.494	47.53	69.87	29.0
W	0.079	0.493	51.16	71.21	30.5
14 E	0.068	0.493	55.22	67.76	25.0
W	0.067	0.494	55.29	68.58	25.5
15 E	0.079	0.494	48.46	69.74	29.0
W	0.079	0.493	49.87	70.95	29.5
16 E	0.081	0.499	52.23	70.05	30.5
W	0.081	0.495	51.37	71.57	30.0
		Avg.	54.05	70.54	27.9

E = east test purlin
W = west test purlin
Ext = exterior purlin

CHAPTER IV

SUMMARY AND OBSERVATIONS

Seven simulated gravity load tests and nine uplift load, simple span, C-purlin tests were conducted to investigate the effects of purlin direction, end restraint, thickness and bracing parameters on purlin strength. The full-scale test setups were built in a vacuum chamber and both simulated gravity loading and uplift loading were applied using suction. Each test setup was fully instrumented and each test was conducted to failure. Test results were compared to predicted failure loads calculated using the constrained bending assumption and AISI local buckling criteria with factors of safety removed. Unbraced length of the compression flange was not considered in determining the reference load. As assumed yield stress of 56 ksi was used for all calculations. (The average yield stress from 32 samples cut from each of the test purlins was 54.0 ksi.)

The complete test matrix is given in Table 1.1 and a summary of the test results is found in Table 3.1. Major observations follow.

Gravity Loading Tests. The following observations are made from the results of the simulated gravity loading tests:

1. Test 5 (12 gage purlin material and flanges facing) was the only test where the experimental failure load exceeded the reference fail-

ure load (constrained bending assumption and AISI local buckling criteria increased by 1.67 to account for the implied factor of safety). The actual failure load was 13% greater than predicted. Test 3 (14 gage purlin material and flanges facing) and Test 16 (14 gage material, flanges facing and 1/3rd point intermediate bracing) failed at 94% of the reference load. For Test 3 (same configuration as Test 2), the failure load was 93% of the reference load. For Test 1 (14 gage material and purlins in same direction), Test 4 (same as Test 1 except with shear clips), and Test 6 (16 gage material and purlins facing), the actual failure loads were 87%, 88% and 87%, respectively, of the reference failure loads.

2. Results from Tests 1 and 2 indicate that purlin orientation influences the purlin strength and stiffness (see Figures A.7 and A.16). The experimental failure load for the test with the purlins facing (Test 2) was 6% larger than for the test with the purlins oriented in the same direction (Test 1).

3. Results of Tests 2 and 16 indicate that intermediate bracing at the 1/3rd points (Test 16) does not influence flexural strength under simulated gravity loading.

4. Results of Test 2 (14 gage, 94%), Test 5 (12 gage, 113%) and Test 6 (16 gage, 87%) indicate that material thickness has an influence on flexural capacity.

5. The constrained bending assumption for estimating deflections (Equation 3.1) is adequate for design. The ratio of measured to predicted vertical deflections ranged from 1.04 to 1.15 for all tests except Test 5 where the ratio was between 1.30 and 1.40.

Uplift Tests. The following observations are made as a result of the uplift loading tests:

1. Tests conducted with two rows of intermediate bracing (1/3rd points, Test 12, 14 and 15; 2.5 ft. each side of midspan, Test 13) resulted in the highest failure loads, measured as a percent of the constrained bending, AISI local buckling criteria load with the implied factors of safety (1.67) removed. The failure loads for the three tests conducted with 1/3rd point bracing were 71% (Test 12), 65% (Test 14), and 68% (Test 15) of the reference load. The failure load for the test with intermediate bracing 2.5 ft. each side of midspan (Test 13) was 67%.

2. Tests conducted with an intermediate brace at midspan failed at 62% (Test 8) and 58% (Test 9) of the reference load.

3. Tests 7 and 10 were conducted without intermediate braces and the failure loads were 52% (Test 7) and 61% (Test 10) of the reference load.

4. Use of wooden blocks to prevent flange roll, Tests 9 and 10 had little influence on purlin strength, 58% and 61% of the reference load, respectively.

5. The attachment of a side channel to a test channel, Test 11, did not significantly influence the flexural strength for uplift loading. The failure load was 59% of the reference load.

6. Comparison of the results of Test 7 with the other tests indicates that intermediate bracing has a major effect on midspan vertical deflections. The unbraced purlins in this test deflected 300-400% more than predicted.

7. Deflections calculated using the constrained bending assumption (Equation 3.1) underestimate the measured vertical deflections by 20% to 30%.

From the results of this limited testing program, it is recommended that simple span C-purlins, subject to gravity be placed in pairs with flanges facing or opposing and that end restraint clips be used. It is recommended that such C-purlins be designed for gravity loading based on cross-section stresses calculated using the constrained bending assumption (standard flexure formulas) with failure criteria based on the local buckling provisions of the latest AISI Specification.

It is recommended that C-purlins be designed for uplift loading based on 70% of the capacity calculated for gravity loading if the purlins are placed in pairs with flanges facing or opposing and intermediate bracing is installed at the 1/3rd points of the purlin span near the uplift loading compression flange. If intermediate bracing is not provided, it is suggested that such C-purlins be designed for uplift loading based on 50% of the capacity for gravity loading.

Finally, it is recommended that gravity load deflections be estimated using Equation 3.1 but increased by 10% and uplift deflections be estimated using the same equation but increased by 30%.

APPENDIX A

GRAVITY LOADING TEST DATA

TEST SUMMARY

Project: MESCO C-Purlin Supported Test Purlins

Test No.: 1 Gravity

Test Date: 9-21-83

Purpose: Determine strength & brace force with purlins in same direction.

Span(s): 25'-0"

Thickness: 0.074" (14 gage) Moment of Inertia: 13.107 $in.^4$

Parameters: All flanges in the same direction
Torsional restraint at east external rafters
No intermediate braces

Failure Load: 140.63 plf + 8.9 plf dead load of east test purlin

Failure Mode: Local buckling of compression flange

Predicted Failure Loads:

Method	AISI	Load	172.2 plf
Method		Load	
Method		Load	

Discussion:

-Failed after 5½" of water/140.63 plf.

-East test purlin failed first and then east outside purlin.

-Local buckling of top flange of west test purlin, east test purlin and east outside purlin.

-No buckling of west outside purlin.

-Maximum lateral displacement was 0.74 in.

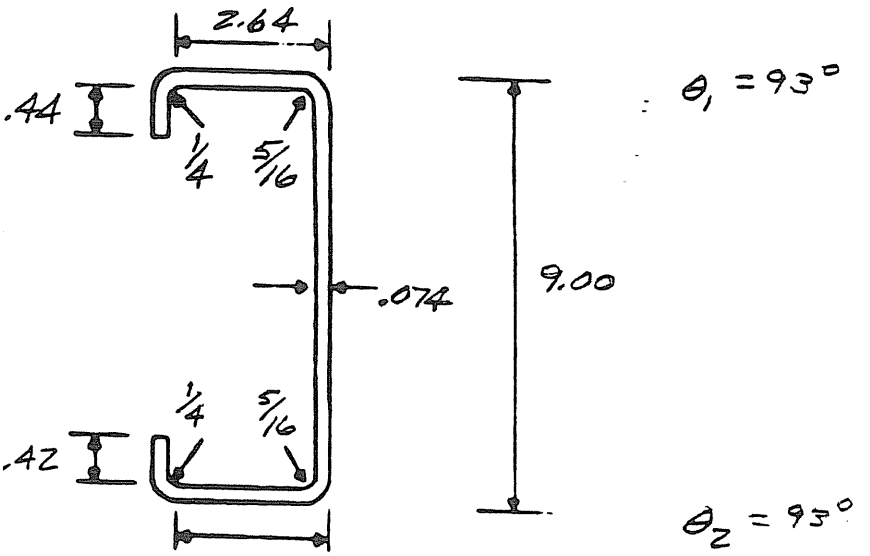
-Top flange lateral displacement exceeded bottom flange.

-Vertical deflection of test purlin was approximately 15% greater than outside purlins.

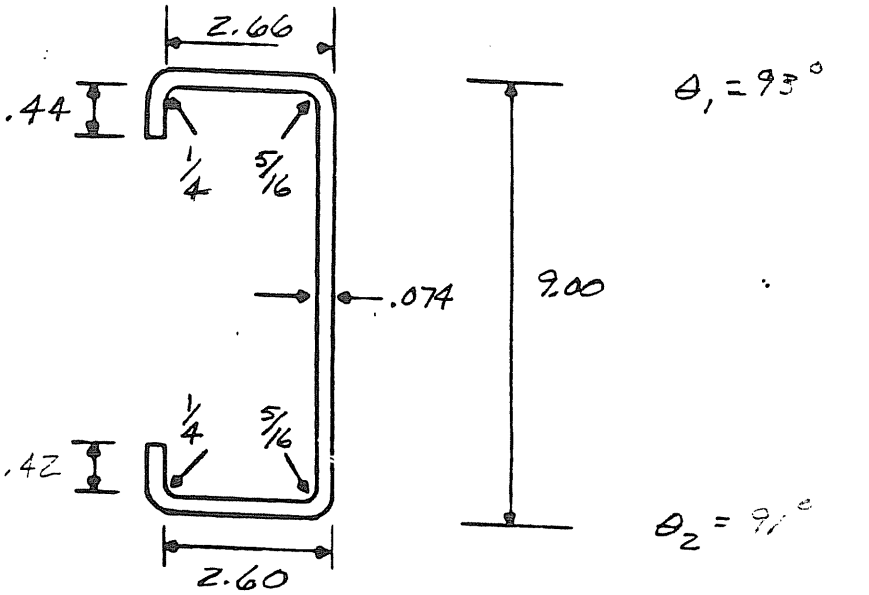
-Brace forces were all in compression.

-Vertical deflection of test purlins were 4% more than predicted.

-Failure load was 13% less than using constrained bending and AISI criteria.

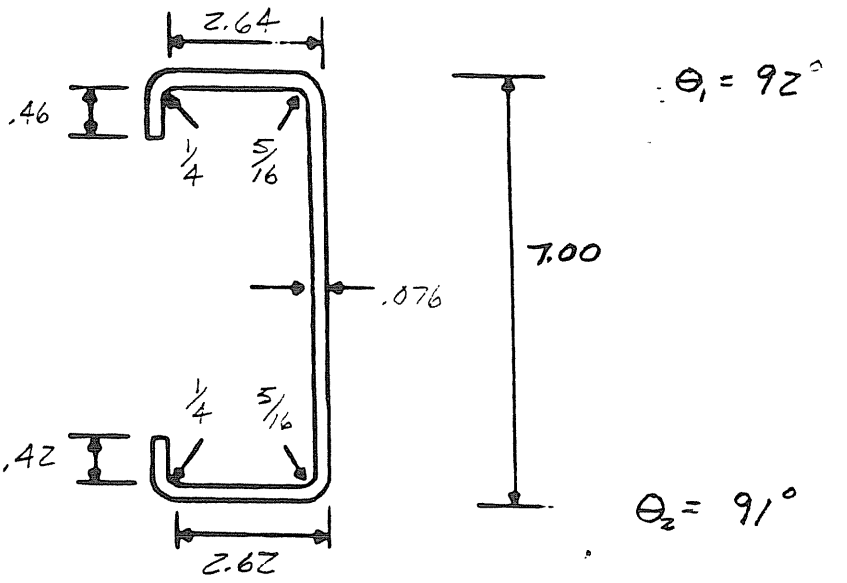


Interior (West) Purlin

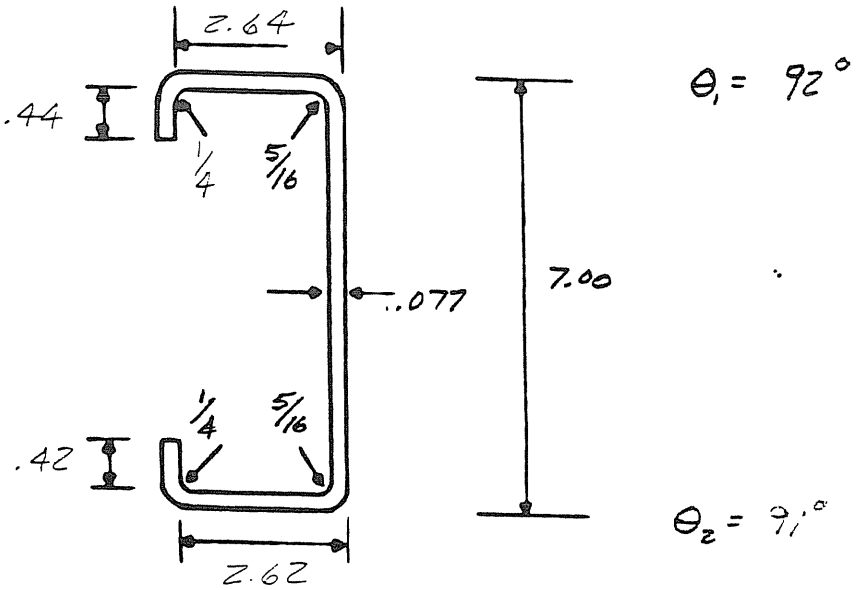


Interior (East) Purlin

Figure A.1 Measured Purlin Dimensions, Test 1



Exterior (West) Purlin



Exterior (East) Purlin

Figure A.2 Measured Purlin Dimensions, Test 1

```
A I S I   P U R L I N   A N A L Y S I S
                C-SECTION
IDENTIFICATION: MESCO TEST 1 INTERIOR EAST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.660	2.600
LIP(in)	0.440	0.420
LIP ANGLE(deg)	93.000	91.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	9
THICKNESS(in)	0.074
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	13.107	2.952	2.922
STRENGTH=	13.038	2.927	2.915
DEFLECTION=	13.107		

BE=	2.227	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	30.430	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	8.197	ft-k
MT=	8.163	ft-k
MW=	8.056	ft-k
MU=	13.453	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	172.196	plf (1.67*allowable)
DEFLECTION =	2.273	in./100plf

Figure A.3 AISI Purlin Analysis, Test 1 Interior Purlin (East)

```
A I S I   P U R L I N   A N A L Y S I S
                Z-SECTION
IDENTIFICATION: MESCO-TEST  1 INTERIOR(WEST) PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.640	2.600
LIP(in)	0.440	0.420
LIP ANGLE(deg)	93.000	93.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	9
THICKNESS(in)	0.074
YIELD STRENGTH(ksi)	56

	MOMENTS OF INERTIA(in^4)	SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	13.076	2.941	2.918
STRENGTH=	13.024	2.923	2.914
DEFLECTION=	13.076		

```
BE=    2.218  in
FC=   33.600  ksi
FT=   33.600  ksi
FBW=  30.430  ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)
            MC=      8.183  ft-k
            MT=      8.158  ft-k
            MW=      8.042  ft-k
            MU=     13.430  ft-k (1.67*allowable)
SPAN          =     25.000  ft.
UNIFORM LOAD=    171.906  plf (1.67*allowable)
DEFLECTION  =      2.279  in./100plf
```

Figure A.4 AISI Purlin Analysis, Test 1 Interior Purlin (West)

```
A I S I  P U R L I N  A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 1-EXTERIOR  EAST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.640	2.620
LIP(in)	0.440	0.420
LIP ANGLE(deg)	92.000	91.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	7
THICKNESS(in)	0.077
YIELD STRENGTH(ksi)	56

	MOMENTS OF INERTIA(in^4)	SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	7.563	2.191	2.179
STRENGTH=	7.563	2.191	2.179
DEFLECTION=	7.563		

BE=	2.251	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	33.055	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	6.136	ft-k
MT=	6.100	ft-k
MW=	6.719	ft-k
MU=	10.188	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	130.402	plf (1.67*allowable)
DEFLECTION =	3.939	in./100plf

Figure A.5 AISI Purlin Analysis, Test 1 Exterior Purlin (East)

```
A I S I   P U R L I N   A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 1- EXTERIOR  WEST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.640	2.620
LIP(in)	0.460	0.420
LIP ANGLE(deg)	92.000	91.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	7
THICKNESS(in)	0.076
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	7.483	2.171	2.152
STRENGTH=	7.481	2.170	2.152
DEFLECTION=	7.483		

BE=	2.249	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	32.953	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	6.075	ft-k
MT=	6.026	ft-k
MW=	6.632	ft-k
MU=	10.063	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	128.813	plf (1.67*allowable)
DEFLECTION =	3.981	in./100#lf

Figure A.6 AISI Purlin Analysis, Test 1 Exterior Purlin (West)

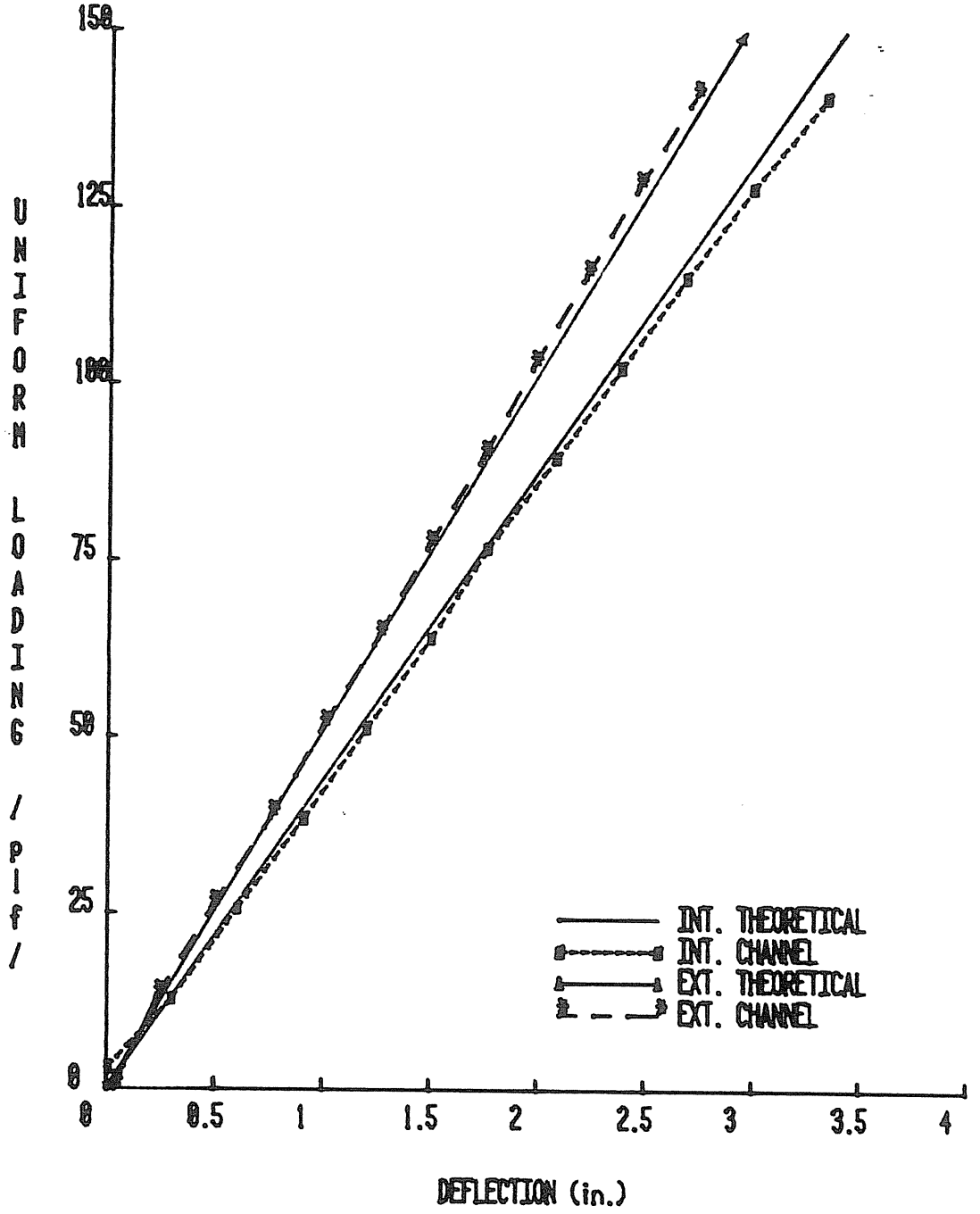


Figure A.7 Load vs. Vertical Deflection, Test 1

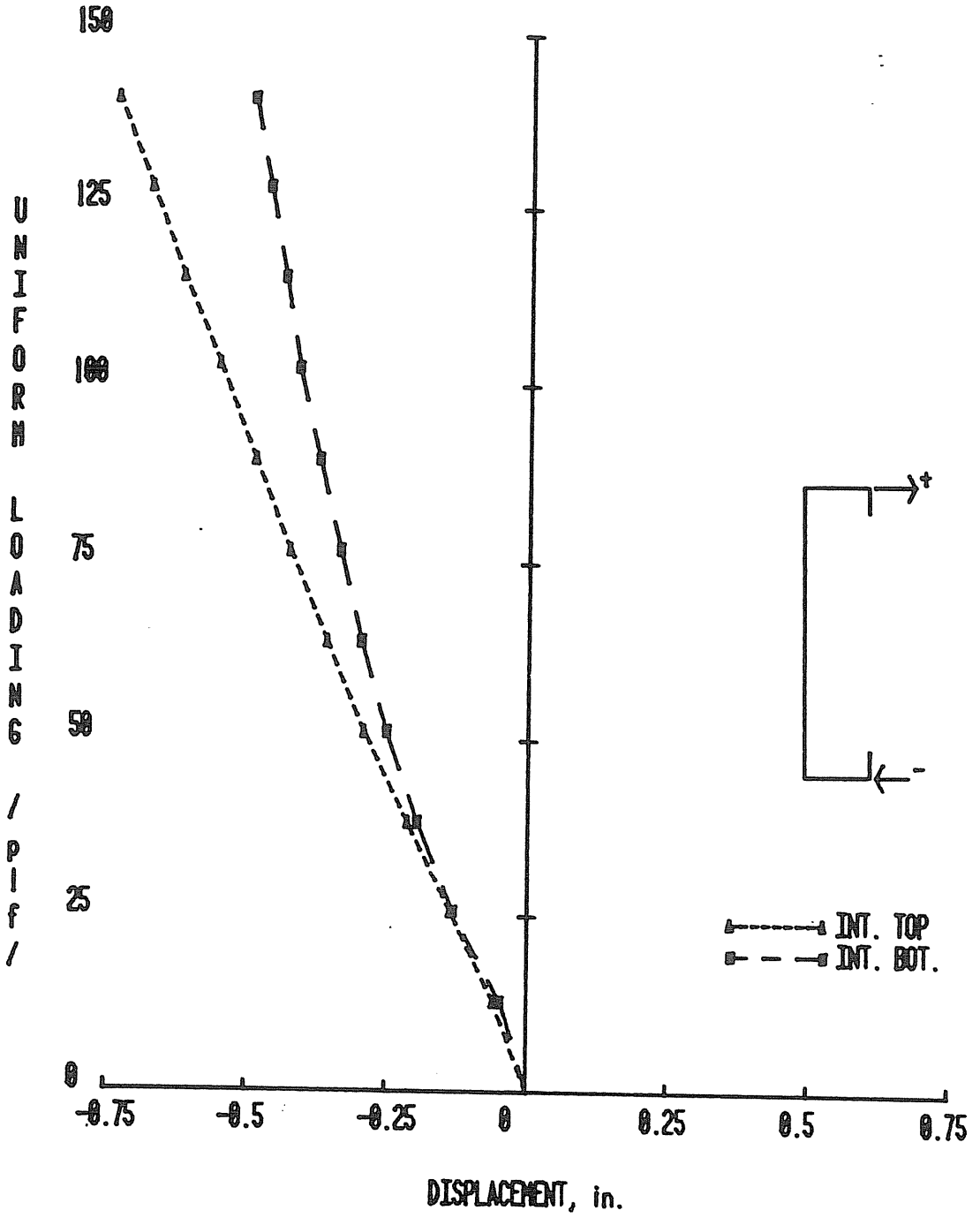


Figure A.8 Vertical Loading vs. Lateral Displacement, Test 1

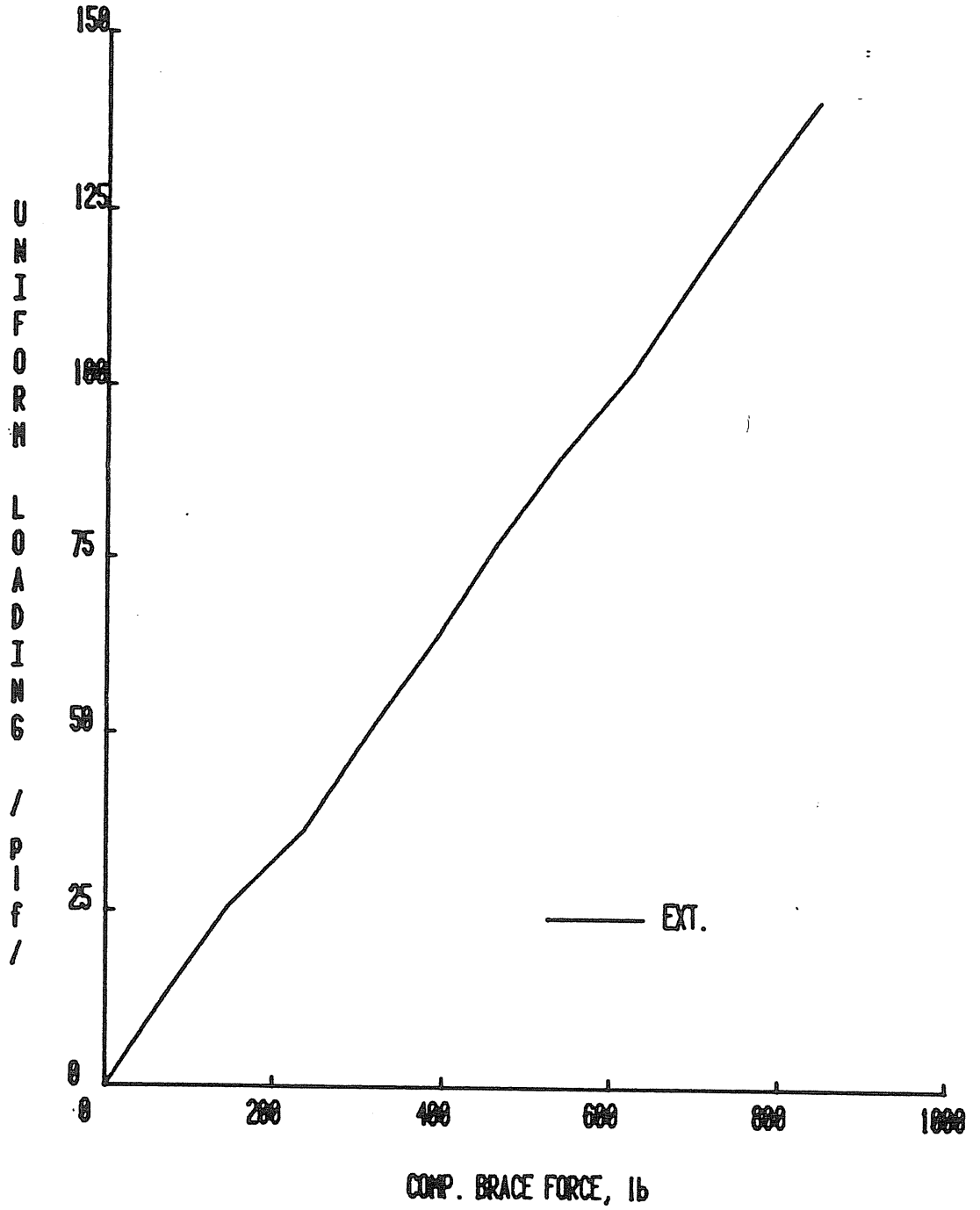


Figure A.9 Vertical Loading vs. Brace Force, Test 1

TEST SUMMARY

Project: MESCO C-Purlin Supported Roof Systems

Test No.: 2 Gravity

Test Date: September 26, 1983

Purpose: Determine strength with purlins in facing orientation.

Span(s): 25'-0"

Thickness: 0.0755 in. (14 gage) **Moment of Inertia:** 13.57 in.^{4}

Parameters: Interior purlins in facing orientation
Panel torsional restraint
Purlins clipped to rafters
No intermediate braces

Failure Load: 158.52 plf + 8.9 plf/dead load

Failure Mode: Local buckling of top flange

Predicted Failure Loads:

Method	AISI Constrained Bending	**Load**	180.1 plf
Method		**Load**	
Method		**Load**	

Discussion:

-Local buckling of interior east and west purlins approximately 1 ft. south of centerline.

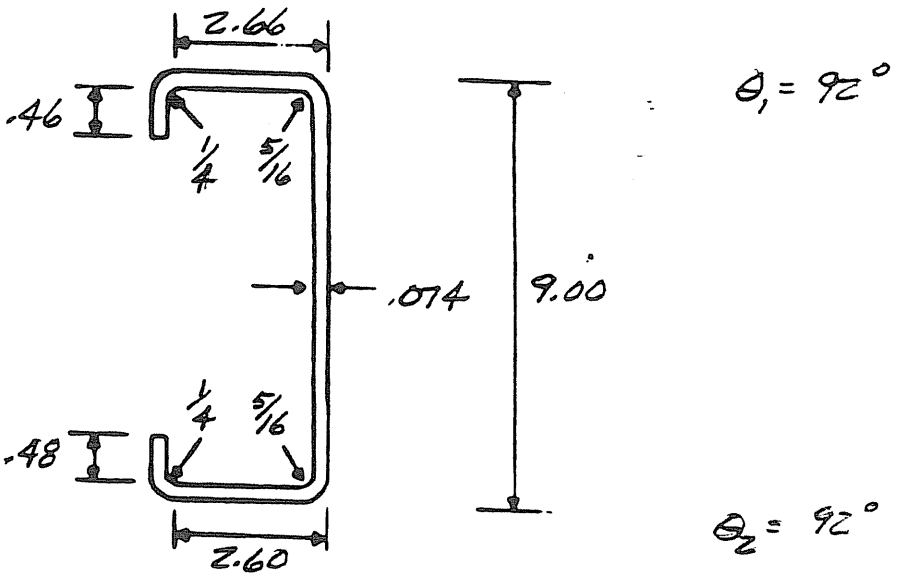
-Buckling occurred at 6.2" of water (167.4 plf).

-Vertical deflections were 6-11% greater than predicted using constrained bending assumption.

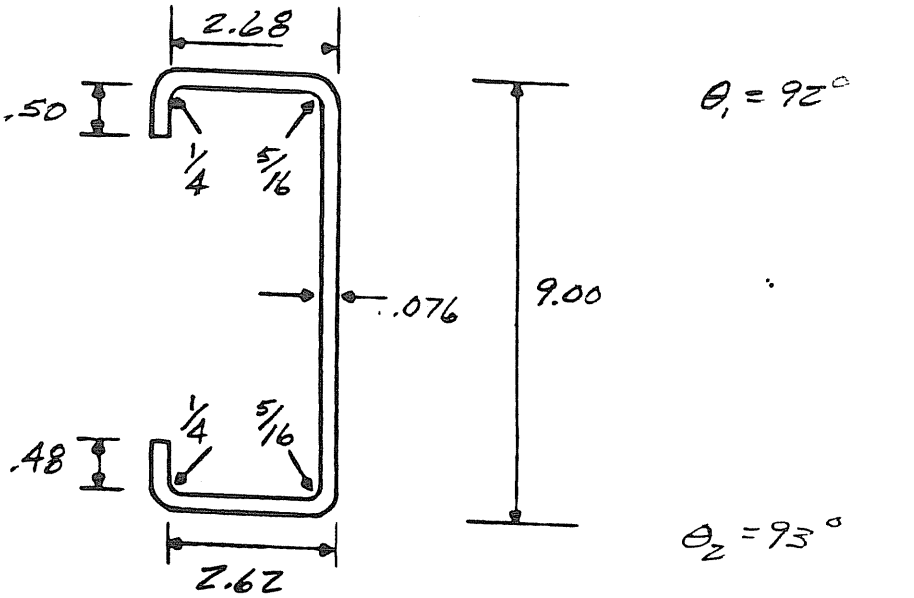
-Bottom flange lateral displacements exceeded top flange by 17-45%.

-Maximum lateral displacement was 1.57 in.

-Exterior vertical deflections were 14% less than expected.

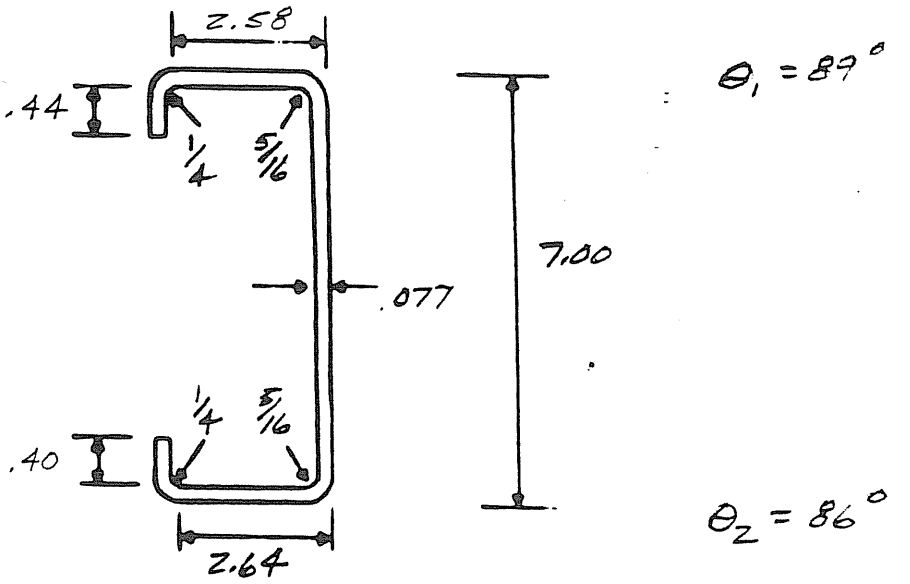


Interior (West) Purlin

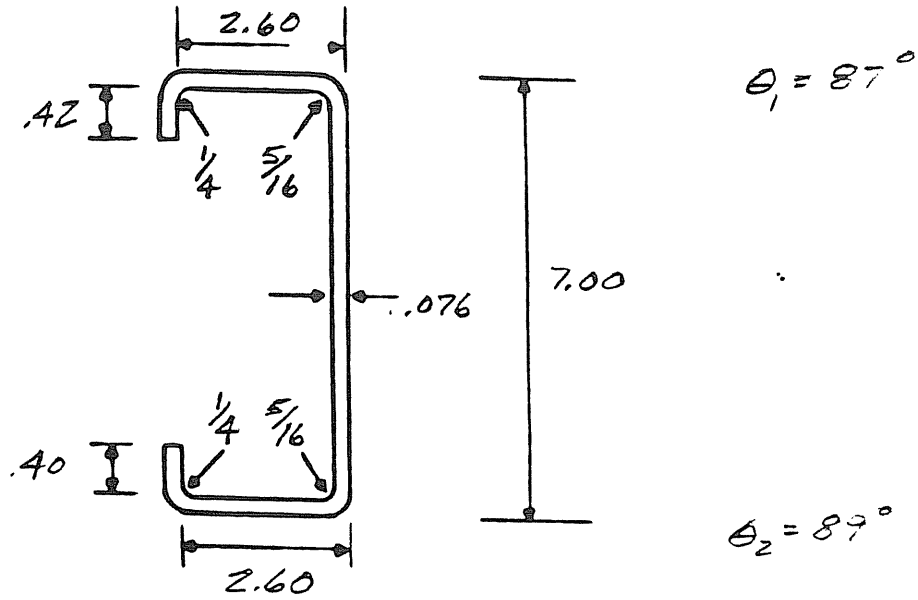


Interior (East) Purlin

Figure A.10 Measured Purlin Dimensions, Test 2



Exterior (West) Purlin



Exterior (East) Purlin

Figure A.11 Measured Purlin Dimensions, Test 2

```
A I S I   P U R L I N   A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 2 INTERIOR   EAST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.680	2.620
LIP(in)	0.500	0.480
LIP ANGLE(deg)	92.000	93.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	9
THICKNESS(in)	0.0755
YIELD STRENGTH(ksi)	56

	MOMENTS OF INERTIA(in^4)	SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	13.570	3.057	3.025
STRENGTH=	13.522	3.040	3.021
DEFLECTION=	13.570		

BE=	2.260	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	30.636	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	8.511	ft-k
MT=	8.459	ft-k
MW=	8.424	ft-k
MU=	14.068	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	180.064	plf (1.67*allowable)
DEFLECTION =	2.195	in./100plf

Figure A.12 AISI Purlin Analysis, Test 2 Interior Purlin (East)

```
A I S I   P U R L I N   A N A L Y S I S
              C-SECTION
IDENTIFICATION; MESCO TEST 2 INTERIOR    WEST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.660	2.600
LIP(in)	0.460	0.480
LIP ANGLE(deg)	92.000	92.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	9
THICKNESS(in)	0.074
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	13.204	2.967	2.950
STRENGTH=	13.136	2.942	2.944
DEFLECTION=	13.204		

BE=	2.227	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	30.430	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	8.238	ft-k
MT=	8.244	ft-k
MW=	8.095	ft-k
MU=	13.518	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	173.035	plf (1.67*allowable)
DEFLECTION =	2.256	in./100plf

Figure A.13 AISI Purlin Analysis, Test 2 Interior Purlin (West)

```
A I S I   P U R L I N   A N A L Y S I S
                C-SECTION
IDENTIFICATION: MESCO TEST 2 EXTERIOR EAST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.600	2.600
LIP(in)	0.420	0.400
LIP ANGLE(deg)	87.000	89.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	7
THICKNESS(in)	0.076
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	7.389	2.138	2.131
STRENGTH=	7.389	2.138	2.131
DEFLECTION=	7.389		

BE=	2.212	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	32.953	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	5.985	ft-k
MT=	5.967	ft-k
MW=	6.532	ft-k
MU=	9.965	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	127.557	plf (1.67*allowable)
DEFLECTION =	4.032	in./100plf

Figure A.14 AISI Purlin Analysis, Test 2 Exterior Purlin (East)

```
A I S I   P U R L I N   A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 2 EXTERIOR WEST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.580	2.640
LIP(in)	0.440	0.400
LIP ANGLE(deg)	89.000	86.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	7
THICKNESS(in)	0.077
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	7.516	2.167	2.176
STRENGTH=	7.516	2.167	2.176
DEFLECTION=	7.516		

BE=	2.191	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	33.055	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	6.067	ft-k
MT=	6.092	ft-k
MW=	6.641	ft-k
MU=	10.132	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	129.690	plf (1.67*allowable)
DEFLECTION =	3.964	in./100plf

Figure A.15 AISI Purlin Analysis, Test 2 Exterior Purlin (West)

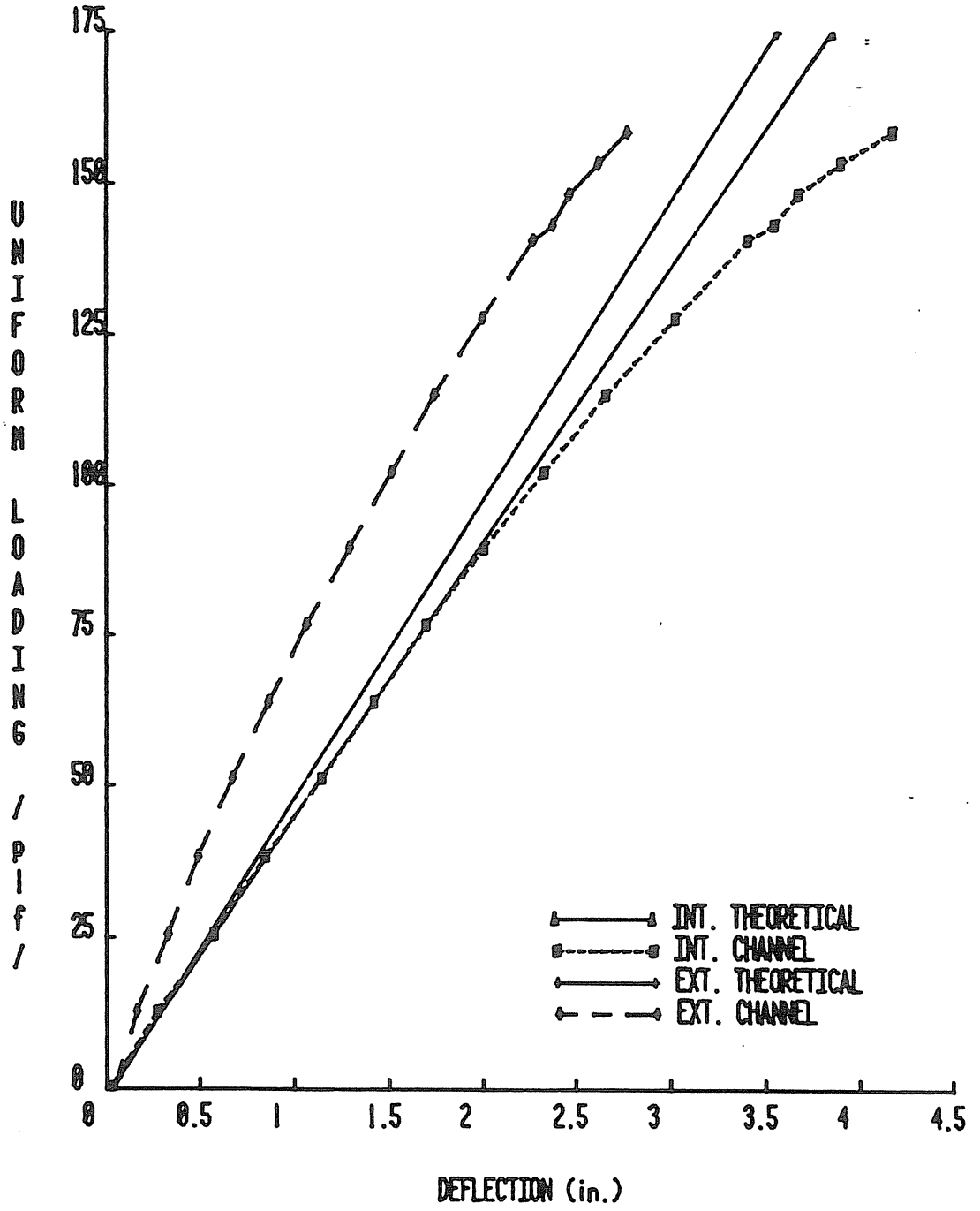


Figure A.16 Load vs. Vertical Deflection, Test 2

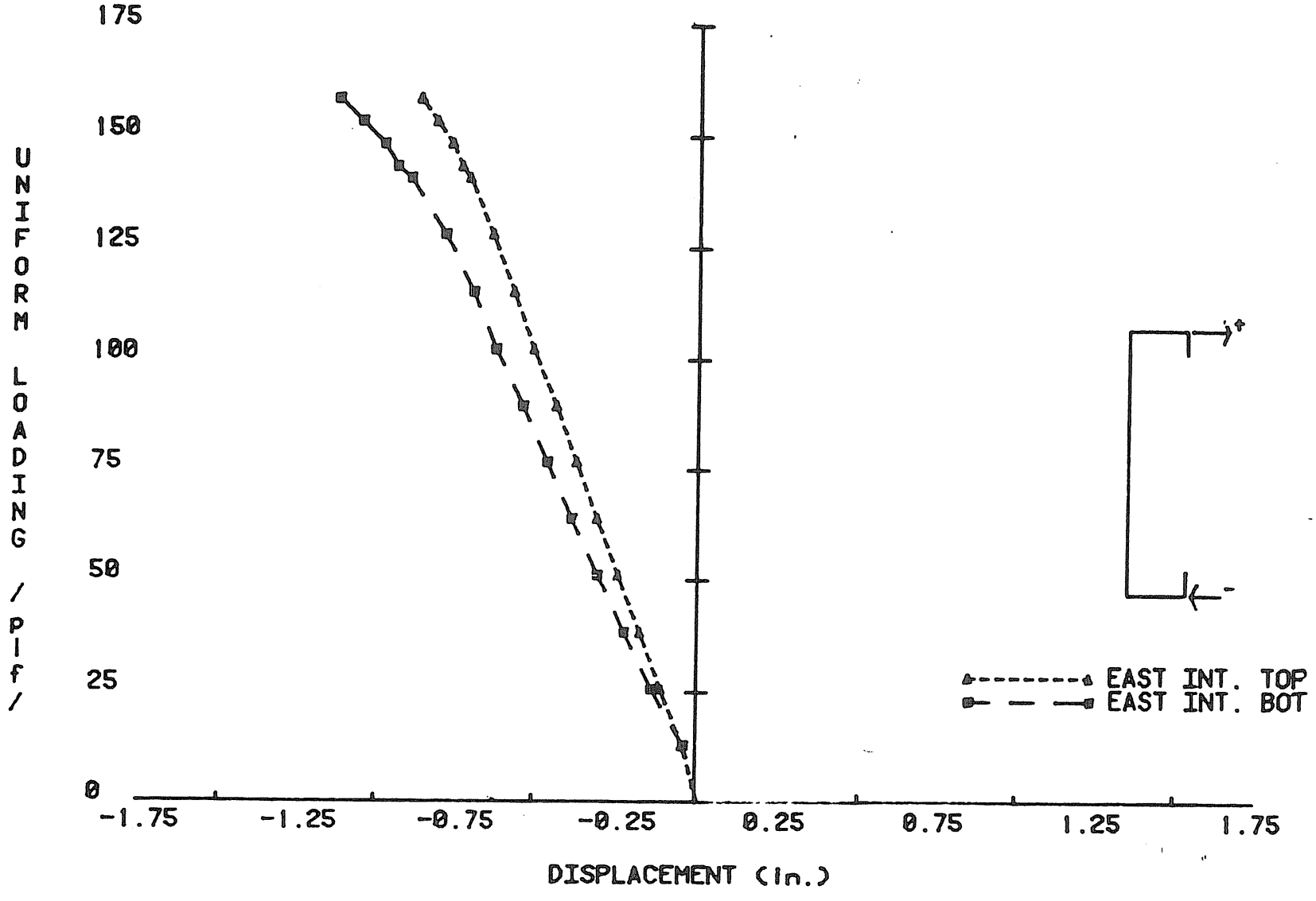


Figure A.19 Vertical Loading vs. Lateral Displacement, Test 2 (East)

TEST SUMMARY

Project: MESCO C-Purlin Supported Roof Systems

Test No.: 3 Gravity

Test Date: 9-29-83

Purpose: Determine strength with purlins in facing orientation

Span(s): 25'-0"

Thickness: 0.074" (14 gage) Moment of Inertia: 13.08 in^4

Parameters: Test purlins in facing orientation

Panel torsional restraint

Purlins clipped to rafters

No intermediate braces

Failure Load: 153.41 + 8.9 plf dead load = 162.31 plf

Failure Mode: Local buckling of top flange of test purlins

Predicted Failure Loads:

Method AISI Constrained Bending Load 172.0 plf

Method _____ Load _____

Method _____ Load _____

Discussion:

-Local buckling of top flange of test purlins.

-Vertical deflections were 7-9% greater than predicted.

-Failure load was 6% less than calculated by AISI Constrained Bending.

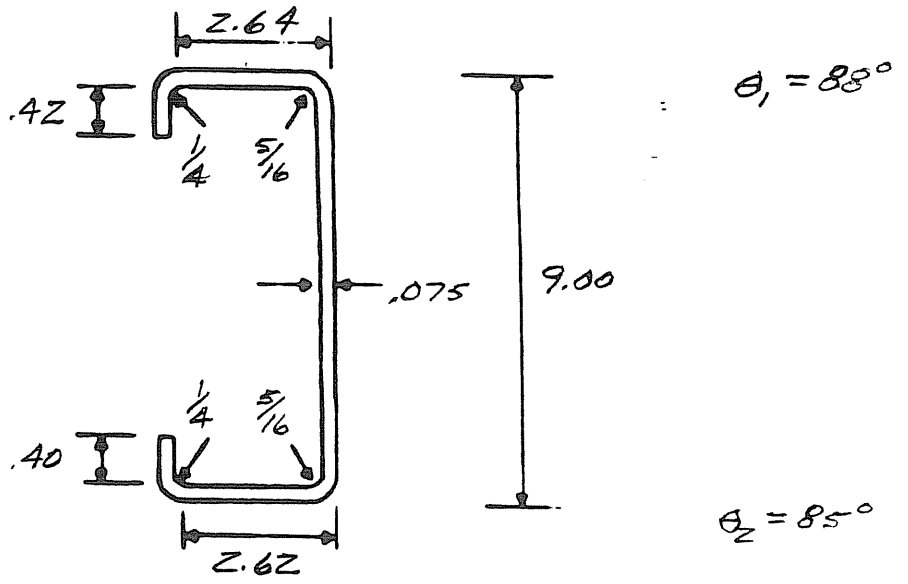
-Bottom flange lateral displacement exceeded top by 45%.

-Maximum lateral displacement of top flange was 0.99 in.

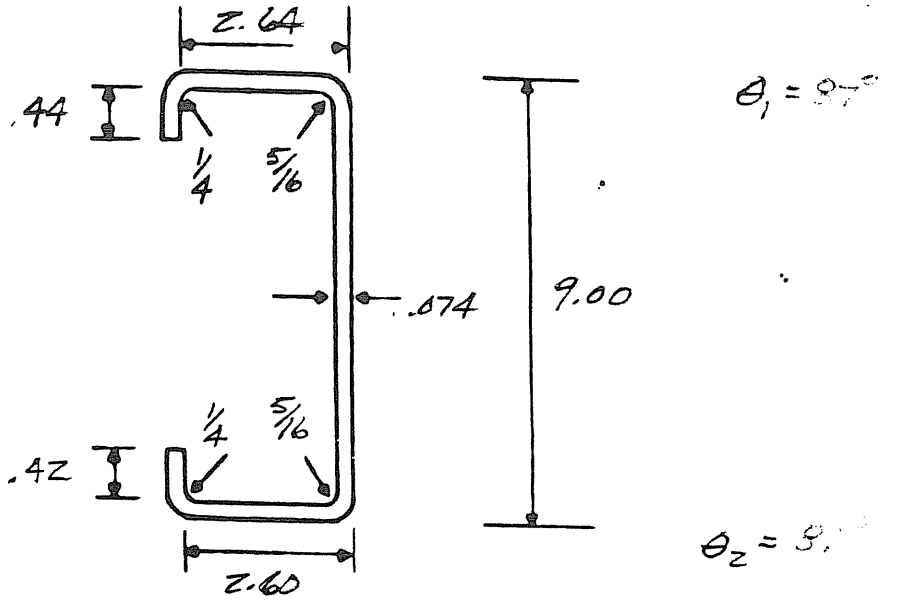
-Maximum lateral displacement of bottom flange was 1.79 in.

-Maximum vertical displacement of test flange was 4.04 in.

-Exterior test purlins deflected 6% less than predicted.

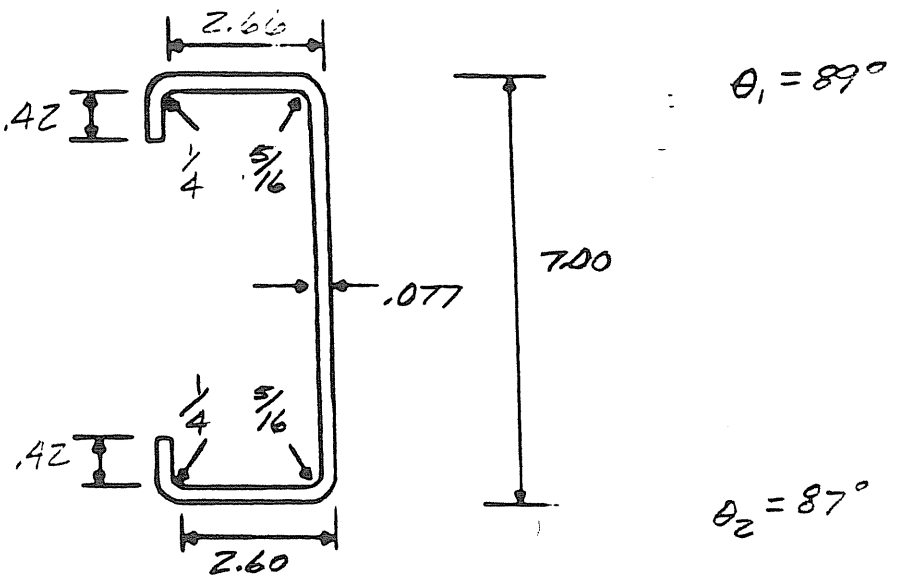


Interior (West) Purlin

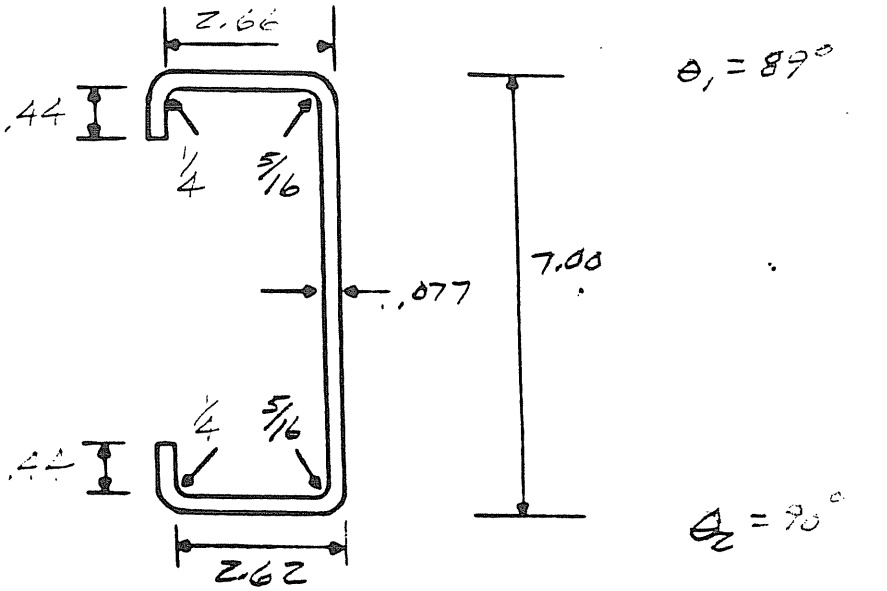


Interior (East) Purlin

Figure A.18 Measured Purlin Dimensions, Test 3



Exterior (West) Purlin



Exterior (East) Purlin

Figure A.19 Measured Purlin Dimensions, Test 3

```
A I S I  P U R L I N  A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 3 INTERIOR EAST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.640	2.600
LIP(in)	0.440	0.420
LIP ANGLE(deg)	87.000	89.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	9
THICKNESS(in)	0.074
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	13.084	2.943	2.920
STRENGTH=	13.032	2.925	2.915
DEFLECTION=	13.084		

BE=	2.218	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	30.430	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	8.189	ft-k
MT=	8.163	ft-k
MW=	8.048	ft-k
MU=	13.439	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	172.025	plf (1.67*allowable)
DEFLECTION =	2.277	in./100plf

Figure A.20 AISI Purlin Analysis, Test 3 Interior Purlin (East)

```
A I S I   P U R L I N   A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 3 INTERIOR WEST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.640	2.620
LIP(in)	0.420	0.400
LIP ANGLE(deg)	88.000	85.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	9
THICKNESS(in)	0.075
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	13.237	2.974	2.959
STRENGTH=	13.209	2.964	2.957
DEFLECTION=	13.237		

BE=	2.234	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	30.568	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	8.298	ft-k
MT=	8.279	ft-k
MW=	8.193	ft-k
MU=	13.681	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	175.123	plf (1.67*allowable)
DEFLECTION =	2.251	in./100plf

Figure A.21 AISI Purlin Analysis, Test 3 Interior Purlin (West)

```
A I S I   P U R L I N   A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 3 EXTERIOR EAST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.660	2.620
LIP(in)	0.440	0.440
LIP ANGLE(deg)	89.000	90.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	7
THICKNESS(in)	0.077
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	7.598	2.202	2.188
STRENGTH=	7.598	2.202	2.188
DEFLECTION=	7.598		

RE =	2.271	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	33.055	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	6.165	ft-k
MT=	6.127	ft-k
MW=	6.752	ft-k
MU=	10.232	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	130.970	plf (1.67*allowable)
DEFLECTION =	3.921	in./100plf

Figure A.22 AISI Purlin Analysis, Test 3 Exterior Purlin (East)

```
A I S I  P U R L I N  A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 3 EXTERIOR WEST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.660	2.600
LIP(in)	0.420	0.420
LIP ANGLE(deg)	89.000	87.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	7
THICKNESS(in)	0.077
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	7.552	2.192	2.172
STRENGTH=	7.552	2.192	2.172
DEFLECTION=	7.552		

BE=	2.271	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	33.055	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	6.137	ft-k
MT=	6.081	ft-k
MW=	6.722	ft-k
MU=	10.156	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	129.993	#lf (1.67*allowable)
DEFLECTION =	3.945	in./100#lf

Figure A.23 AISI Purlin Analysis, Test 3 Exterior Purlin (West)

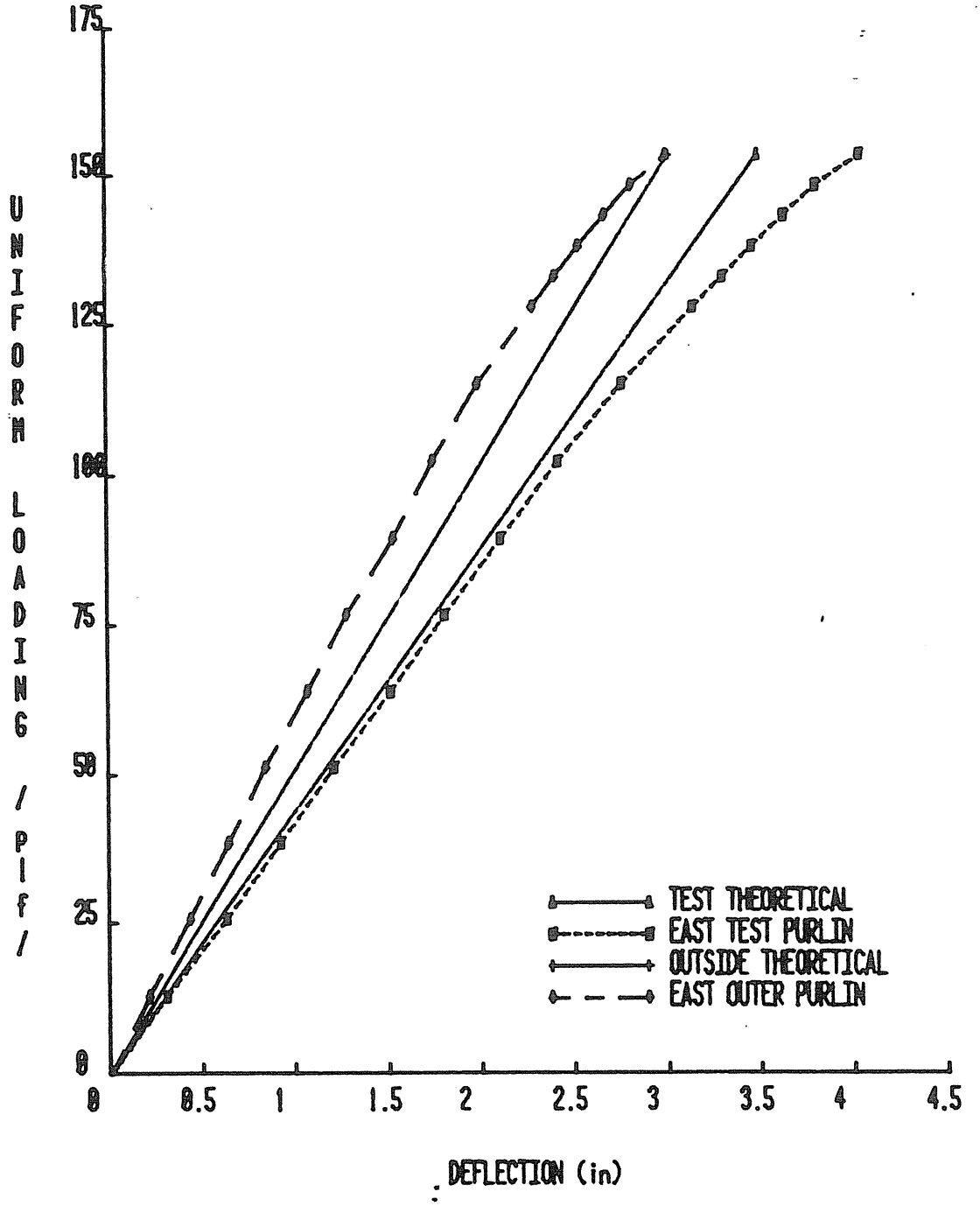


Figure A.24 Load vs. Vertical Deflection, Test 3

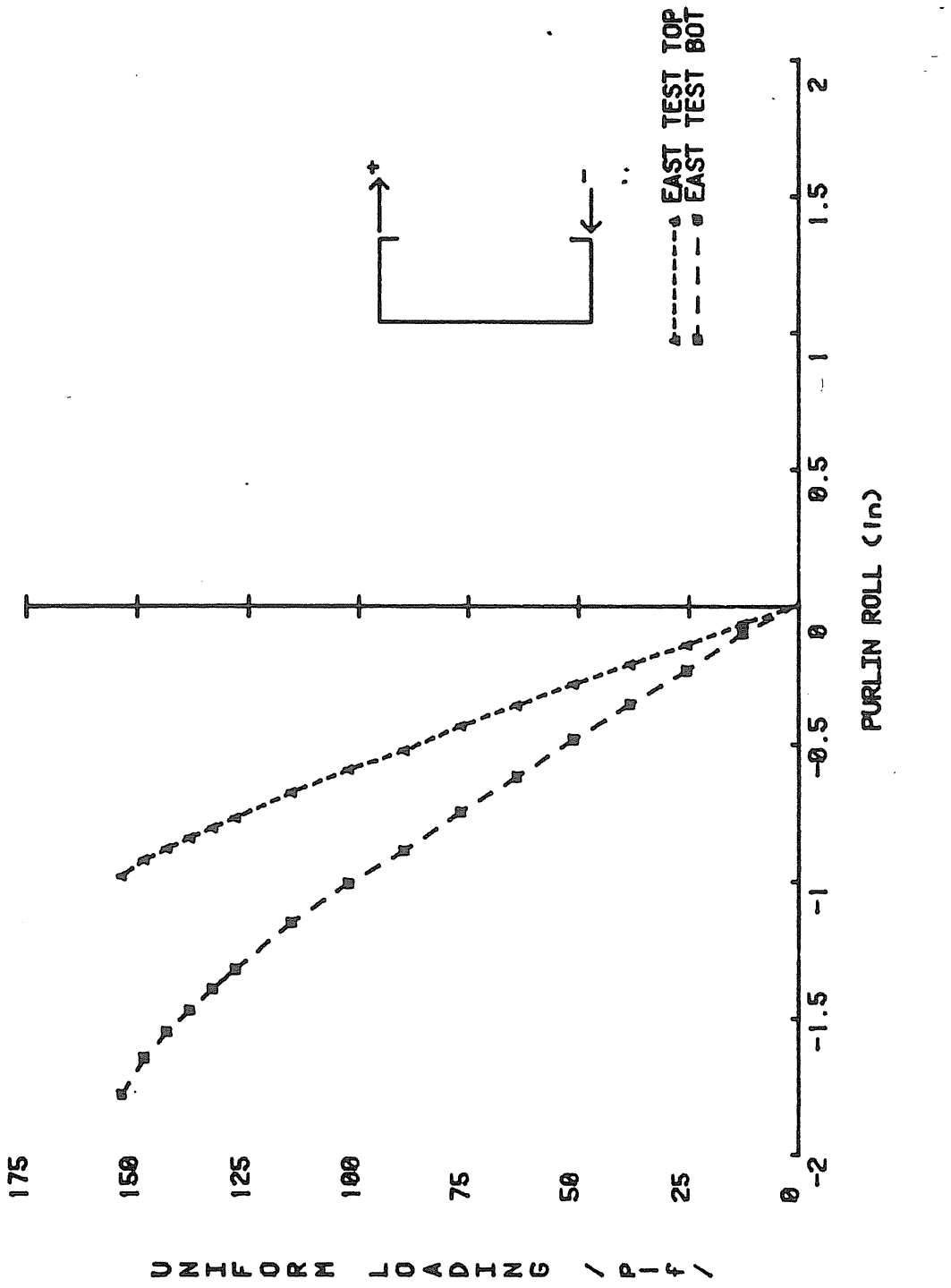


Figure A.25 Vertical Loading vs. Lateral Displacement, Test 3 (East)

TEST SUMMARY

Project: MESCO C-Purlin Supported Roof Systems

Test No.: 4 Gravity

Test Date: 10-5-83

Purpose: Determine purlin strength with all purlins oriented the same direction.

Span(s): 25'-0"

Thickness: 0.075 (14 gage) Moment of Inertia: 13.3 in^4

Parameters: All purlins in same direction
No intermediate braces
Purlins clipped to rafter
Panel torsional restraint

Failure Load: 145.74 plf + 8.9 plf dead load = 154.64 plf

Failure Mode: Local buckling of compression flange of east test purlin

Predicted Failure Loads:

Method AISI Constrained Bending Load 175.89 plf

Method _____ Load _____

Method _____ Load _____

Discussion:

-Local buckling of east test purlin.

-No buckling of west test purlin.

-Failed after 5.7 in. of water.

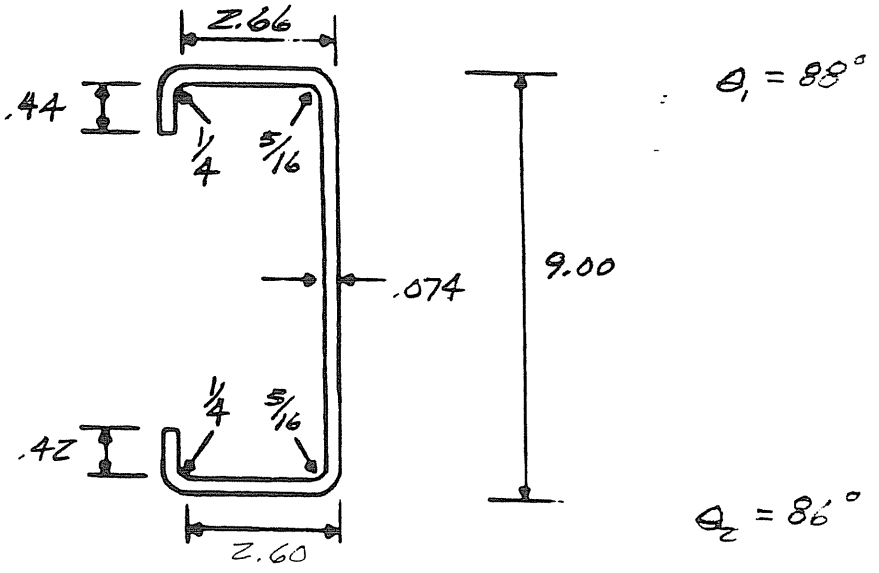
-Vertical deflections of test purlins were 13-15% more than predicted.

-Failure load was 12% less than using constrained bending and AISI criteria.

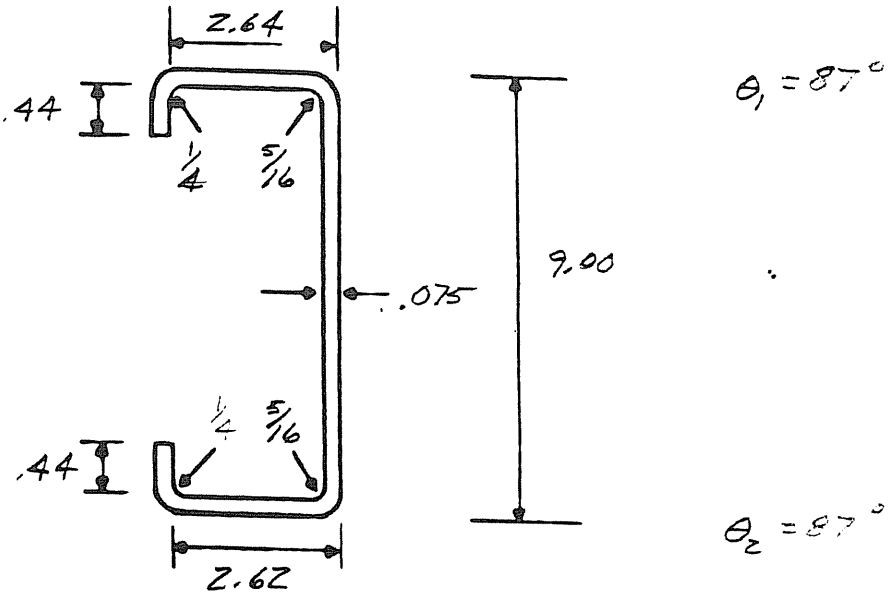
-Bottom flange lateral displacement exceeded top flange by 9-48%.

-Maximum lateral displacement was 1.63 in. (west test purlin).

-Outside purlin vertical deflections were 8-11% less than expected.

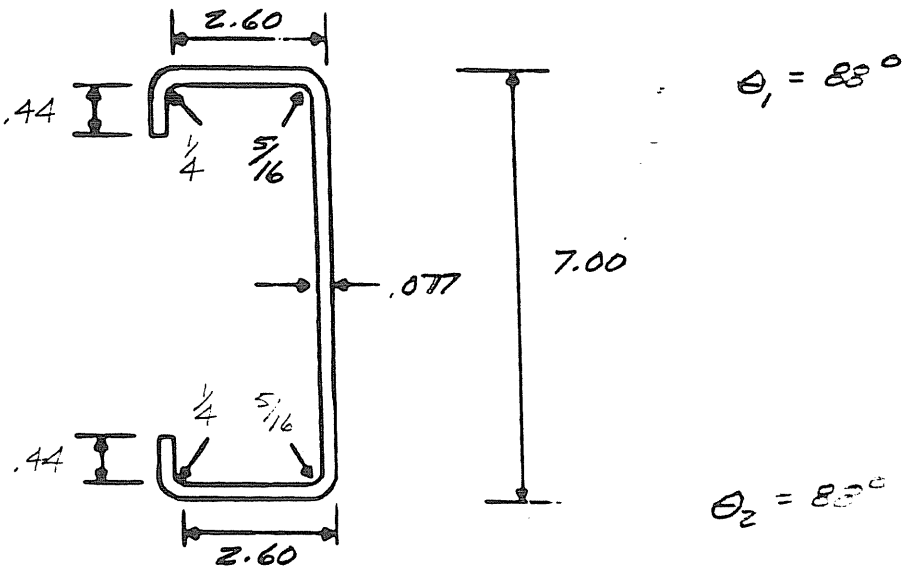


Interior (West) Purlin

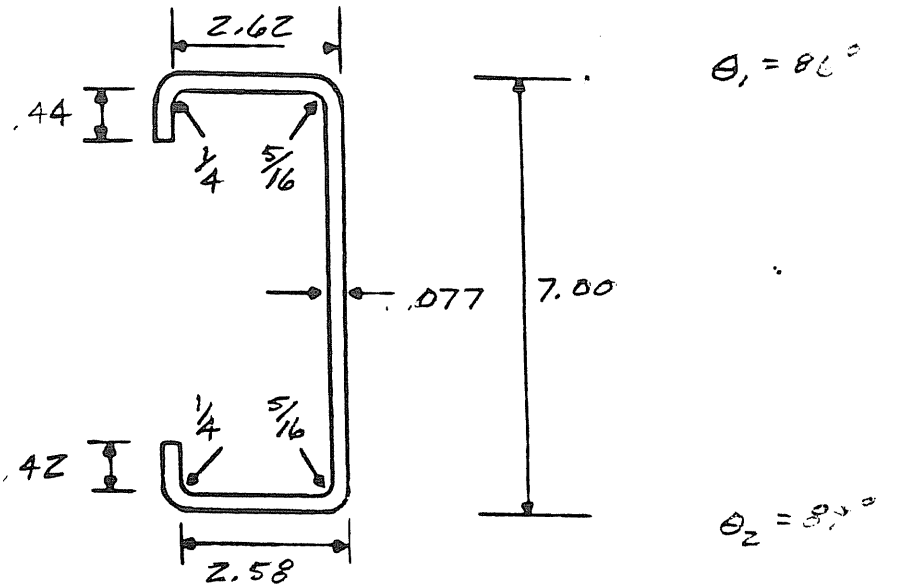


Interior (East) Purlin

Figure A.26 Measured Purlin Dimensions, Test 4



Exterior (West) Purlin



Exterior (East) Purlin

Figure A.27 Measured Purlin Dimensions, Test 4

```
A I S I   P U R L I N   A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 4 EAST TEST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.640	2.620
LIP(in)	0.440	0.440
LIP ANGLE(deg)	87.000	87.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	9
THICKNESS(in)	0.075
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	13.311	2.987	2.979
STRENGTH=	13.283	2.977	2.976
DEFLECTION=	13.311		

```
BE=    2.234   in
FC=   33.600   ksi
FT=   33.600   ksi
FBW=  30.568   ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)
           MC=      8.335   ft-k
           MT=      8.334   ft-k
           MW=      8.229   ft-k
           MU=     13.742   ft-k (1.67*allowable)
SPAN         =     25.000   ft.
UNIFORM LOAD=    175.893   plf (1.67*allowable)
DEFLECTION   =      2.238   in./100plf
```

Figure A.28 AISI Purlin Analysis, Test 4 Interior Purlin (East)

```
A I S I   P U R L I N   A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 4 WEST TEST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.660	2.600
LIP(in)	0.440	0.400
LIP ANGLE(deg)	88.000	86.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	9
THICKNESS(in)	0.074
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	13.090	2.952	2.914
STRENGTH=	13.022	2.927	2.908
DEFLECTION=	13.090		

```
BE=    2.227  in
FC=   33.600  ksi
FT=   33.600  ksi
FBW=  30.430  ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)
           MC=     8.196  ft-k
           MT=     8.143  ft-k
           MW=     8.056  ft-k
           MU=    13.453  ft-k (1.67*allowable)
SPAN         =    25.000  ft.
UNIFORM LOAD=   172.202  plf (1.67*allowable)
DEFLECTION   =     2.276  in./100plf
```

Figure A.29 AISI Purlin Analysis, Test 4 Interior Purlin (West)

```
A I S I   P U R L I N   A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 4  OUTSIDE EAST PURLIN
-------------------------------------------------------------------------

                          TOP              BOTTOM
FLANGE(in)              2.600              2.600
LIP(in)                 0.440              0.440
LIP ANGLE(deg)         88.000             88.000
RADIUS L/F(in)          0.250              0.250
RADIUS F/W(in)          0.313              0.313

TOTAL DEPTH(in)                  7
THICKNESS(in)                0.077
YIELD STRENGTH(ksi)             56

                                                 SECTION MODULII(in^3)
     MOMENTS OF INERTIA(in^4)                     TOP                BOTTOM
GROSS=          7.526                          2.174                2.174
STRENGTH=       7.526                          2.174                2.174
DEFLECTION=     7.526
BE=    2.211   in
FC=    33.600  ksi
FT=    33.600  ksi
FBW=   33.055  ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)
            MC=      6.088  ft-k
            MT=      6.088  ft-k
            MW=      6.665  ft-k
            MU=     10.167  ft-k (1.67*allowable)
SPAN          =     25.000  ft.
UNIFORM LOAD=    130.133  plf (1.67*allowable)
DEFLECTION    =      3.959  in./100plf
```

Figure A.31 AISI Purlin Analysis, Test 4 Exterior Purlin (West)

```
A I S I  P U R L I N  A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST-4 OUTSIDE WEST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.620	2.580
LIP(in)	0.440	0.420
LIP ANGLE(deg)	86.000	89.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	7
THICKNESS(in)	0.077
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	7.512	2.180	2.160
STRENGTH=	7.512	2.180	2.160
DEFLECTION=	7.512		

BE=	2.231	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	33.055	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	6.105	ft-k
MT=	6.048	ft-k
MW=	6.687	ft-k
MU=	10.101	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	129.287	plf (1.67*allowable)
DEFLECTION =	3.966	in./100plf

Figure A.30 AISI Purlin Analysis, Test 4 Exterior Purlin (East)

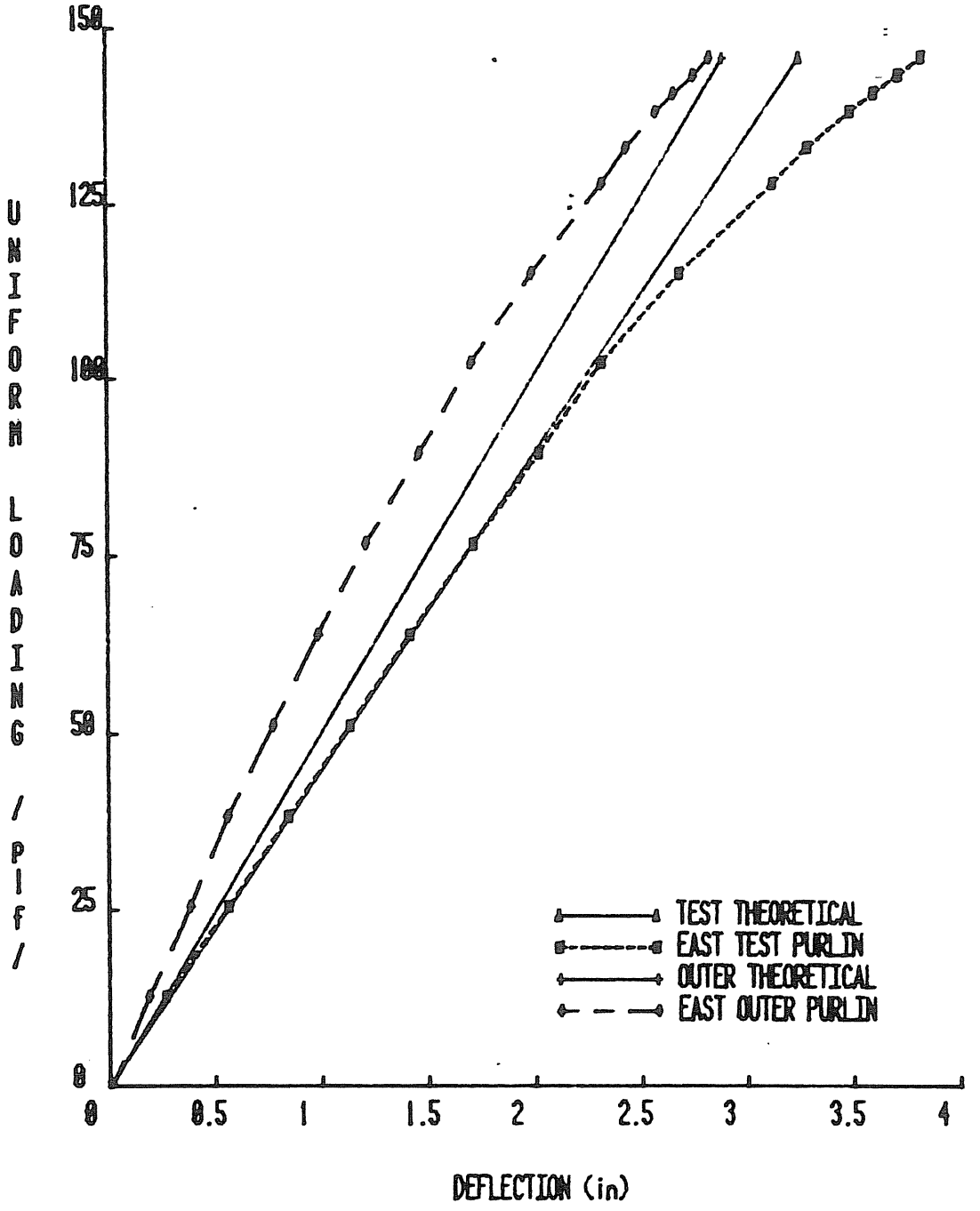


Figure A.32 Load vs. Vertical Deflection, Test 4

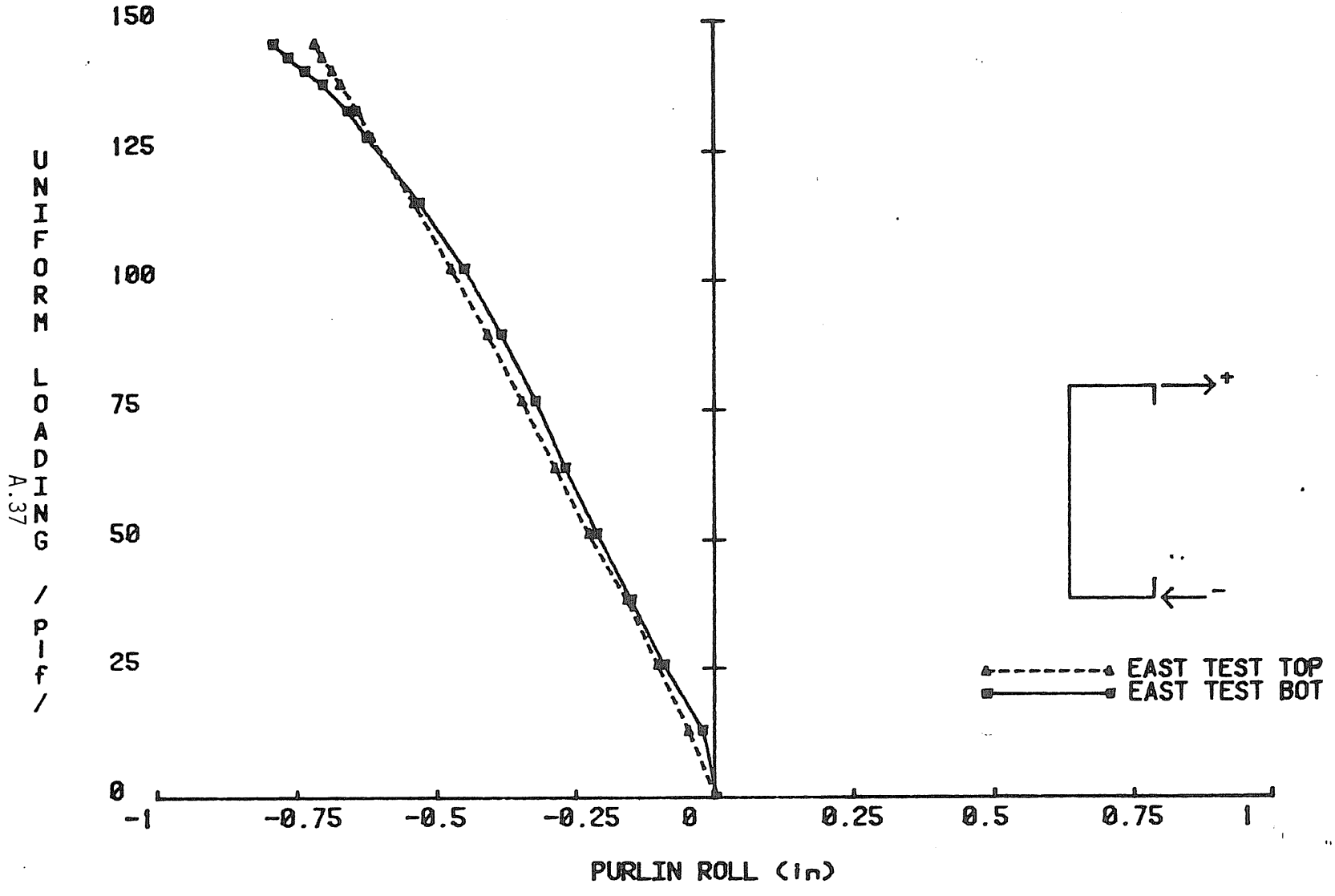


Figure A.33 Vertical Loading vs. Lateral Displacement, Test 4 (East)

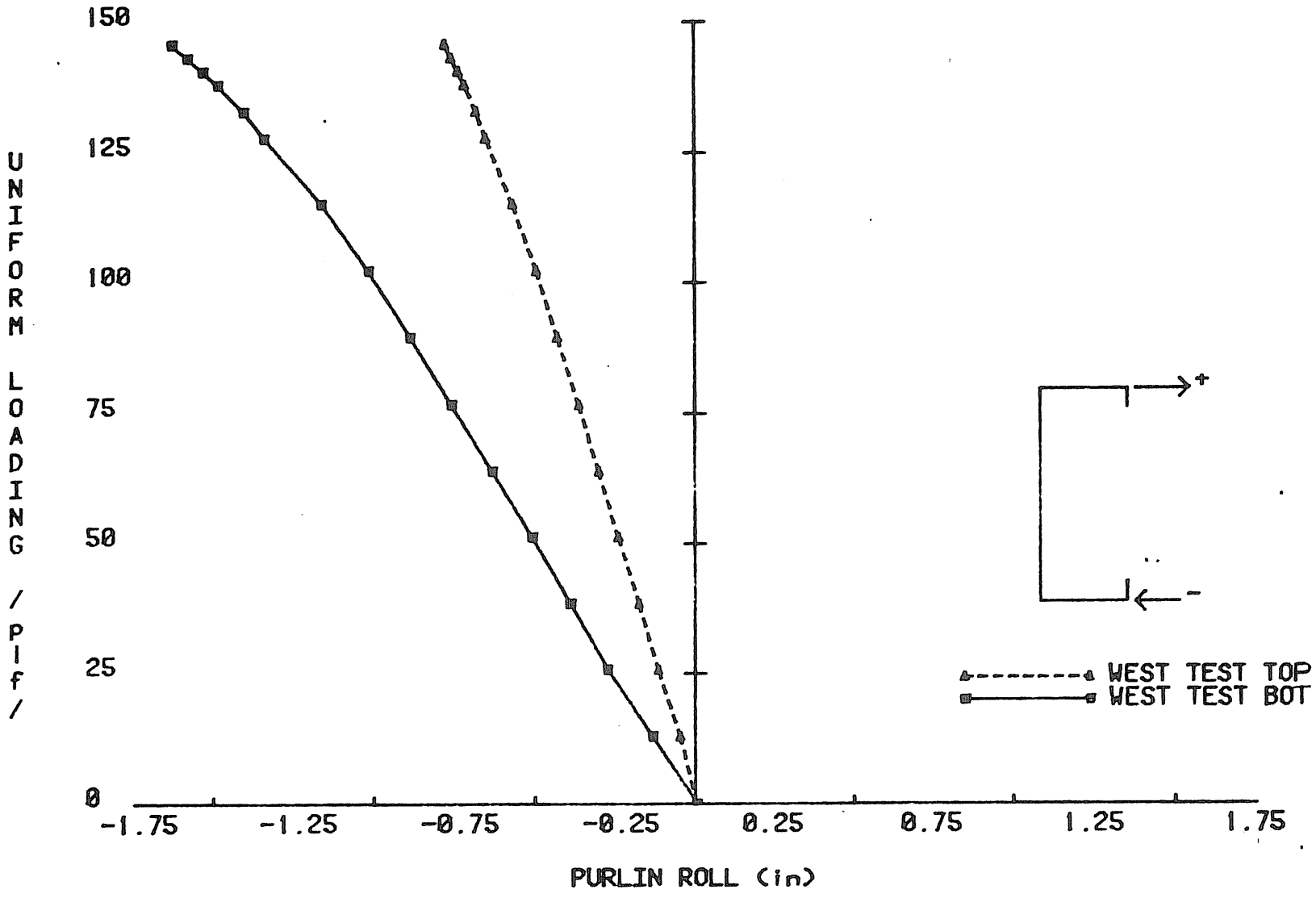


Figure A.34 Vertical Loading vs. Lateral Displacement, Test 4 (West)

TEST SUMMARY

Project: MESCO C-Purlin Supported Roof Systems

Test No.: 5 Gravity

Test Date: 10-14-83

Purpose: Determine purlin strength in facing orientation

Span(s): 25'-0"

Thickness: 0.100 in.(12 gage) Moment of Inertia: 17.6 in^4

Parameters: Test purlins in facing orientation

Panel torsional restraint

No intermediate braces

12 gage test purlins

Panels clipped to rafters

Failure Load: 255.68 plf + 10.6 plf Dead Load

Failure Mode: Local buckling of compression flange of test purlins

Predicted Failure Loads:

Method AISI Constrained Bending Load 236.3 plf

Method _____ Load _____

Method _____ Load _____

Discussion:

-Local buckling of top flange of both test purlins caused failure.

-Failure load was 13% more than using constrained bending and AISI criteria.

-Vertical deflection was 32-40% more than expected.

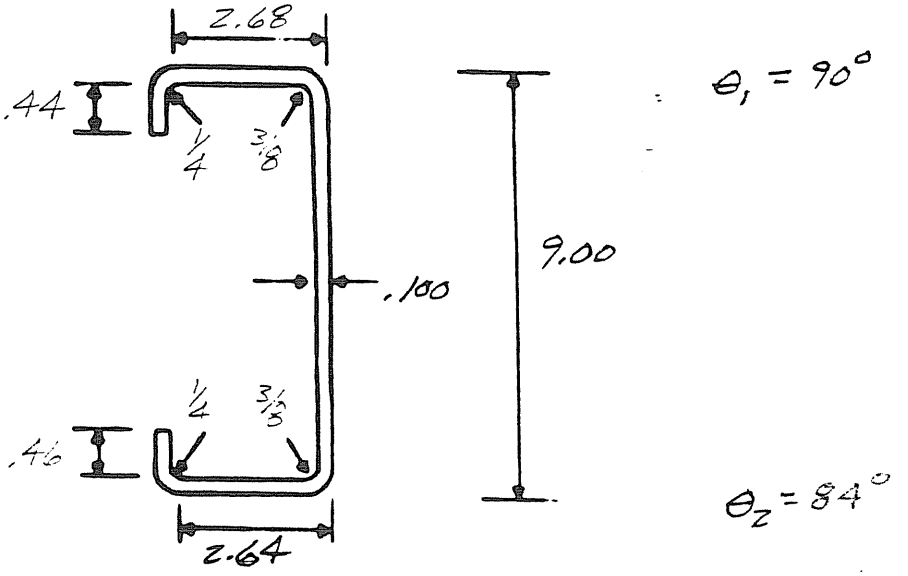
-Maximum vertical deflection for west and east test purlins was 6.07 and 5.70 inches respectively.

-Vertical deflection of test purlins was 32-42% more than outer purlins.

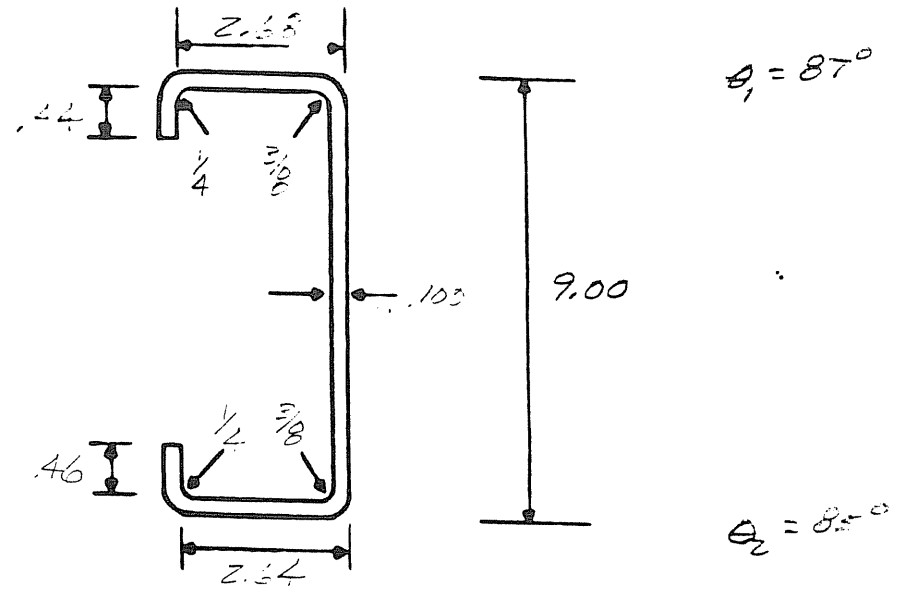
-Bottom flanges of test purlins deflected 42-50% more than top flanges.

-Maximum horizontal deflection of west and east purlins was 2.05 and 2.50 inches respectively.

-Outer purlin vertical deflections were 5% less for the east and 5% more for the west purlins than expected.

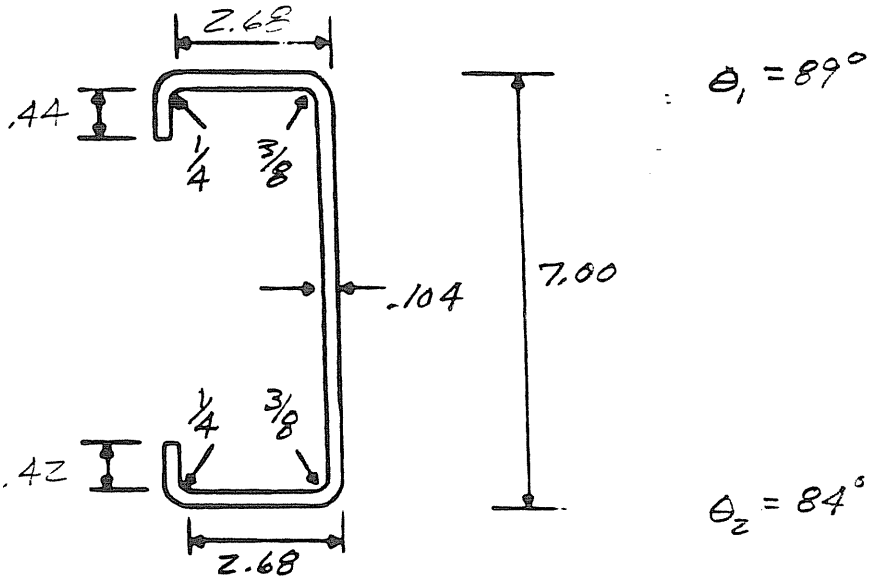


Interior (West) Purlin

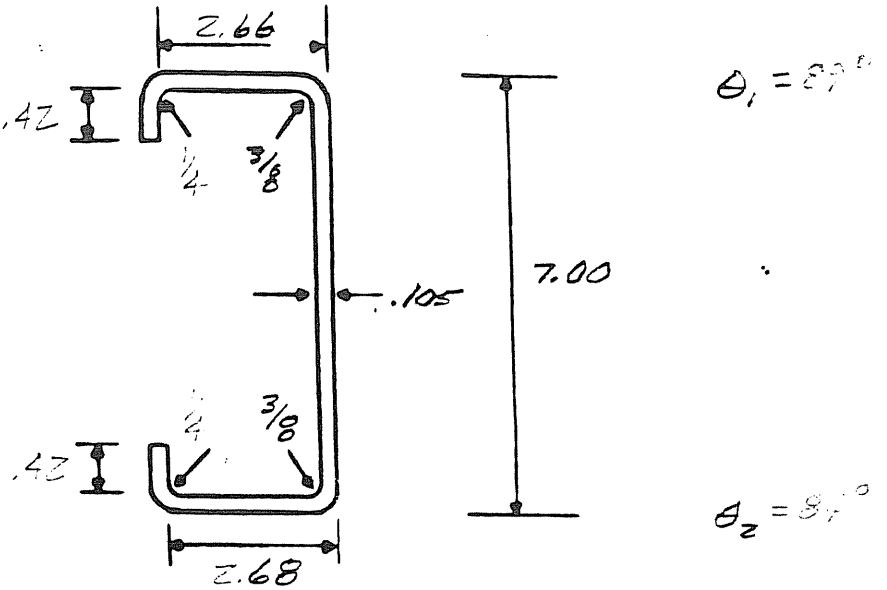


Interior (East) Purlin

Figure A.35 Measured Purlin Dimensions, Test 5



Exterior (West) Purlin



Exterior (East) Purlin

Figure A.36 Measured Purlin Dimensions, Test 5

```
A I S I   F U R L I N   A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 5 EAST TEST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.680	2.640
LIP(in)	0.440	0.460
LIP ANGLE(deg)	87.000	85.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.375	0.375

TOTAL DEPTH(in)	9
THICKNESS(in)	0.1
YIELD STRENGTH(ksi)	56

	MOMENTS OF INERTIA(in^4)	SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	17.591	3.958	3.948
STRENGTH=	17.591	3.958	3.948
DEFLECTION=	17.591		

```
BE=    2.205   in
FC=   33.600   ksi
FT=   33.600   ksi
FbW=  33.133   ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)
            MC=     11.083   ft-k
            MT=     11.054   ft-k
            MW=     12.085   ft-k
            MU=     18.460   ft-k (1.67*allowable)
SPAN          =     25.000   ft.
UNIFORM LOAD=    236.287   plf (1.67*allowable)
DEFLECTION   =      1.694   in./100plf
```

Figure A.37 AISI Purlin Analysis, Test 5 Interior Purlin(East)

```
A I S I  P U R L I N  A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 5 WEST TEST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.660	2.680
LIP(in)	0.420	0.420
LIP ANGLE(deg)	89.000	84.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.375	0.375

TOTAL DEPTH(in)	7
THICKNESS(in)	0.105
YIELD STRENGTH(ksi)	56

	MOMENTS OF INERTIA(in^4)	SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	10.176	2.946	2.957
STRENGTH=	10.176	2.946	2.957
DEFLECTION=	10.176		

BE=	2.180	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	33.600	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	8.249	ft-k
MI=	8.280	ft-k
MW=	9.414	ft-k
MU=	13.776	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	176.327	plf (1.67*allowable)
DEFLECTION =	2.928	in./100-lf

Figure A.38 AISI Purlin Analysis, Test 5 Interior Purlin (West)

```
A I S I  P U R L I N  A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 5 OUTER WEST PURLIN
-------------------------------------------------------------------------

                          TOP              BOTTOM
FLANGE(in)              2.680              2.680
LIP(in)                 0.440              0.420
LIP ANGLE(deg)         89.000             84.000
RADIUS L/F(in)          0.250              0.250
RADIUS F/W(in)          0.375              0.375

TOTAL DEPTH(in)                 7
THICKNESS(in)                   0.104
YIELD STRENGTH(ksi)             56

                                          SECTION MODULII(in^3)
      MOMENTS OF INERTIA(in^4)              TOP                 BOTTOM
GROSS=          10.129                    2.941               2.935
STRENGTH=       10.129                    2.941               2.935
DEFLECTION=     10.129
RE=    2.201    in
FC=   33.600    ksi
FT=   33.600    ksi
FBW=  33.600    ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)
            MC=      8.234   ft-k
            MT=      8.217   ft-k
            MW=      9.399   ft-k
            MU=     13.722   ft-k (1.67*allowable)
SPAN          =     25.000   ft.
UNIFORM LOAD=    175.639   plf (1.67*allowable)
DEFLECTION  =      2.941   in./100plf
```

Figure A.40 AISI Purlin Analysis, Test 5 Exterior Purlin (West)

```
A I S I  P U R L I N  A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 5 OUTER EAST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.680	2.640
LIP(in)	0.440	0.460
LIP ANGLE(deg)	90.000	84.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.375	0.375

TOTAL DEPTH(in)	9
THICKNESS(in)	0.1
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	17.588	3.957	3.948
STRENGTH=	17.588	3.957	3.948
DEFLECTION=	17.588		

```
BE=    2.205   in
FC=   33.600   ksi
FT=   33.600   ksi
FBW=  33.133   ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)
            MC=     11.079   ft-k
            MT=     11.055   ft-k
            MW=     12.080   ft-k
            MU=     18.461   ft-k (1.67*allowable)
SPAN          =     25.000   ft.
UNIFORM LOAD=    236.306   plf (1.67*allowable)
DEFLECTION  =      1.494   in./100plf
```

Figure A.39 AISI Purlin Analysis, Test 5 Exterior Purlin (East)

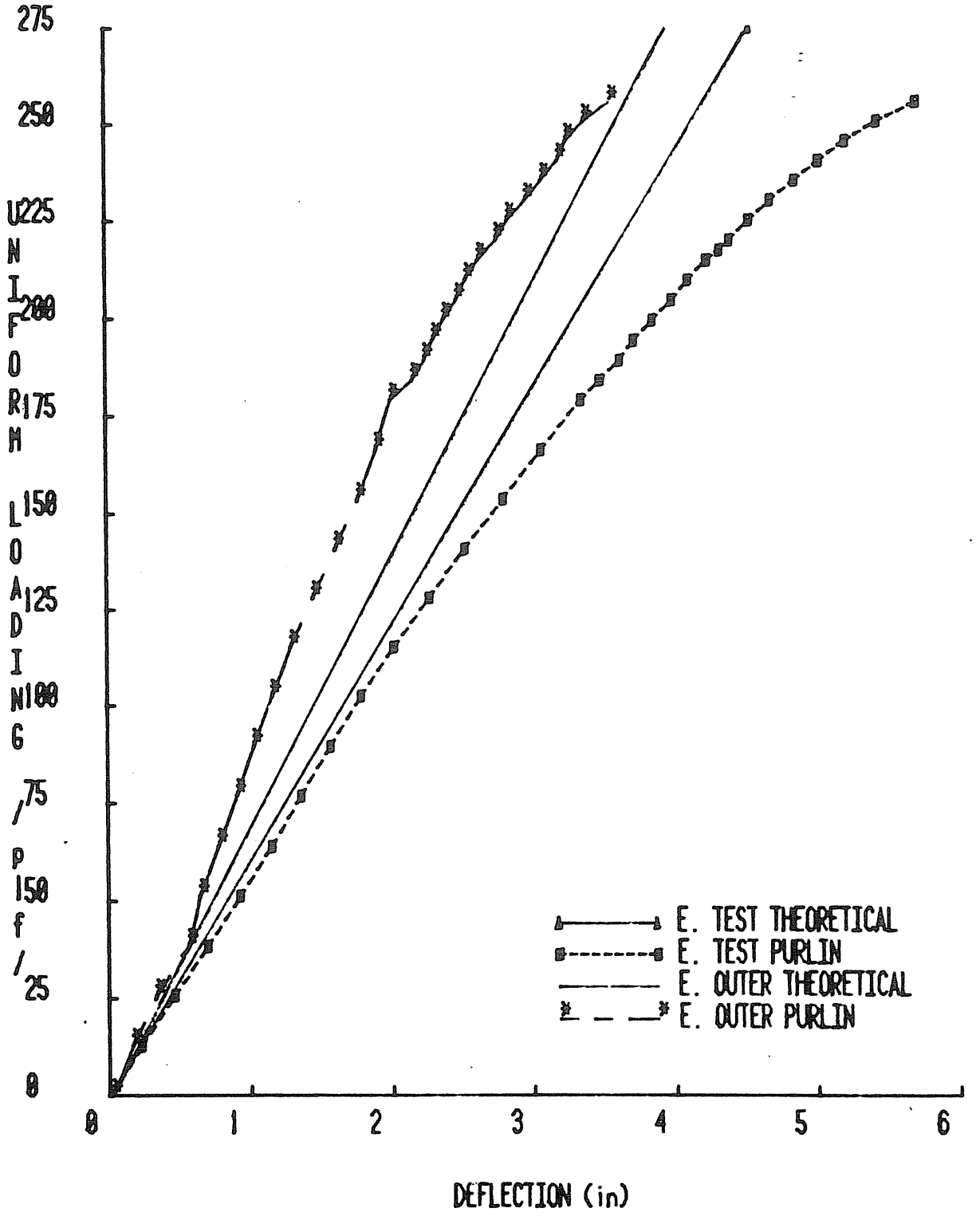


Figure A.41 Load vs. Vertical Deflection, Test 5

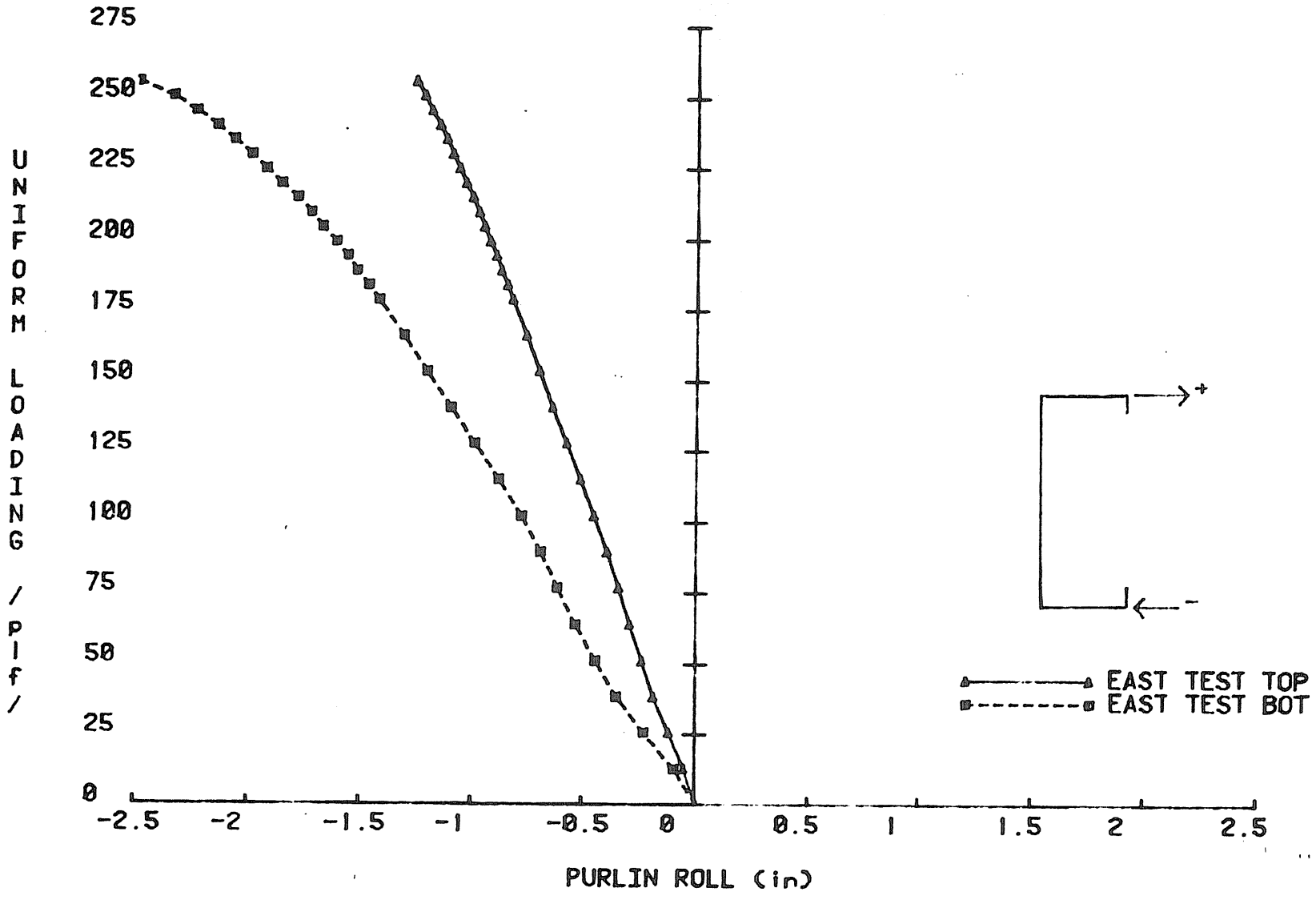


Figure A.42 Vertical Loading vs. Lateral Displacement, Test 5 (East)

TEST SUMMARY

Project: Mesco C-Purlin Supported Roof Systems

Test No.: 6 Gravity

Test Date: 10-18-83

Purpose: Determine strength of 16 ga. purlins in facing orientation

Span(s): 25'-0"

Thickness: 0.057 in. (16 gage) Moment of Inertia: 9.8 in^4

Parameters: Test Purlins in facing orientation

Panel torsional restraint

No intermediate braces

16 gage purlins

Purlins are clipped to rafters

Failure Load: 89.5 plf + 8.2 Dead Load = 97.7 plf

Failure Mode: Local buckling of top flange of east test purlin

Predicted Failure Loads:

Method AISI Constrained Bending Load 111.7 plf

Method _____ Load _____

Method _____ Load _____

Discussion:

-Local buckling of east test purlin caused failure.

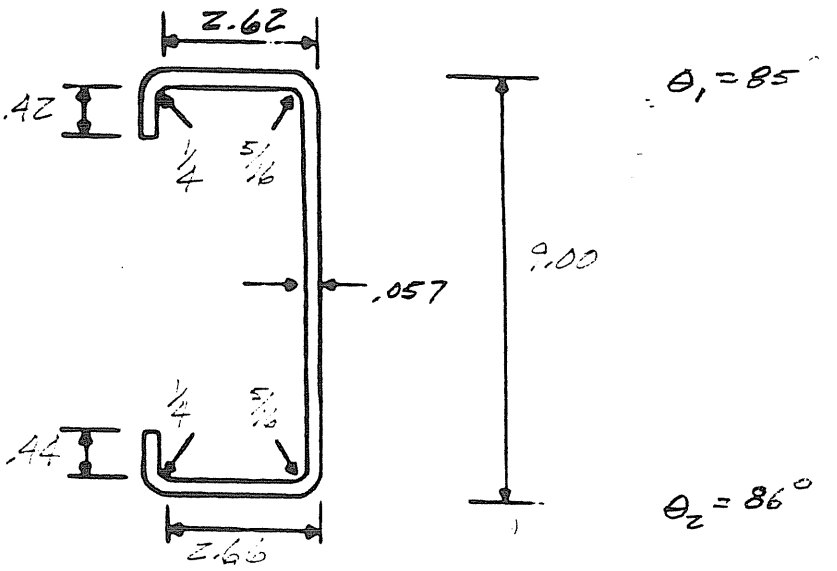
-Failure load was 12% less than using AISI constrained bending criteria.

-Vertical deflection was 5-10% more than expected for test purlins and 16-18% less than expected for outer purlins.

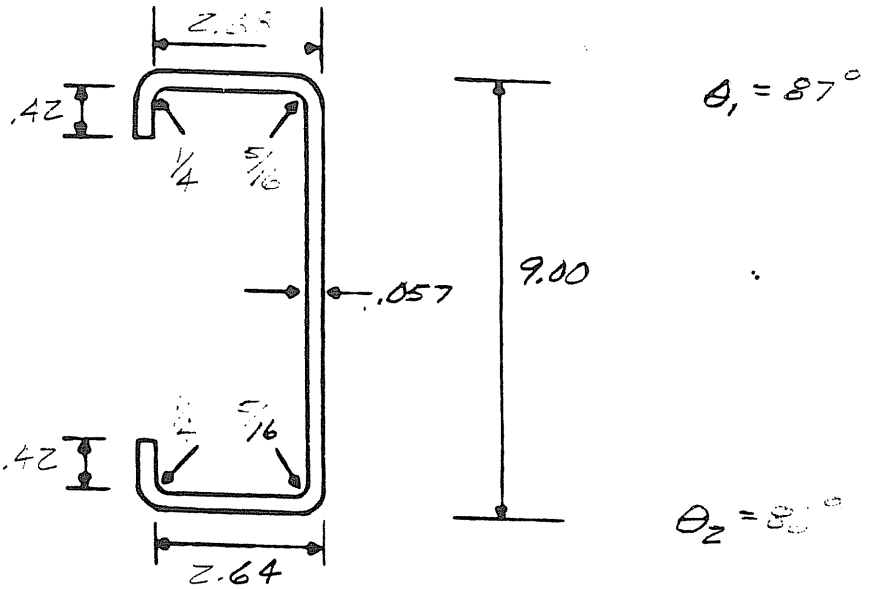
-Maximum vertical deflection for test purlin was 2.80 in. and 1.99 in. for the outer purlins.

-Horizontal displacement of bottom flange of test purlins was 18% and 56% more than the top flange of the east and west purlins respectively.

-Maximum horizontal displacement was 1.45 in.

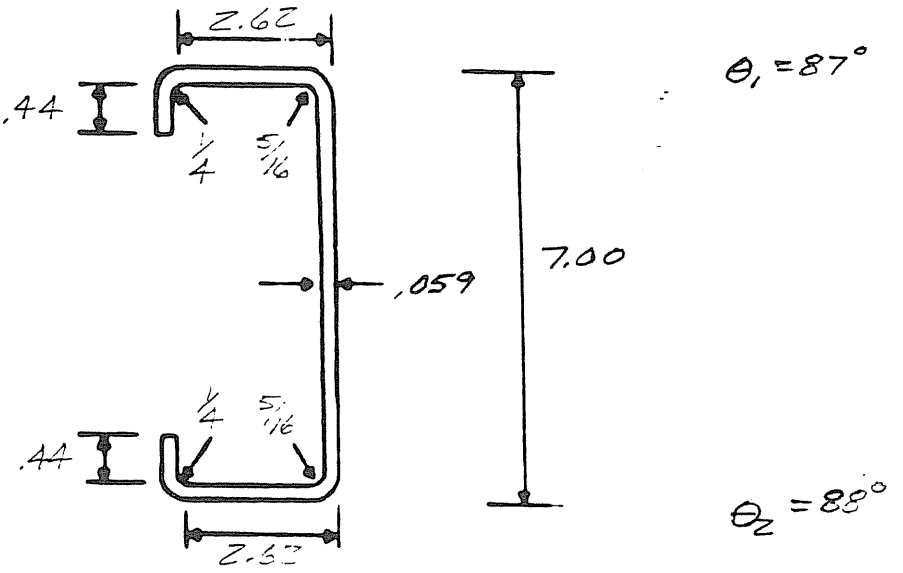


Interior (West) Purlin

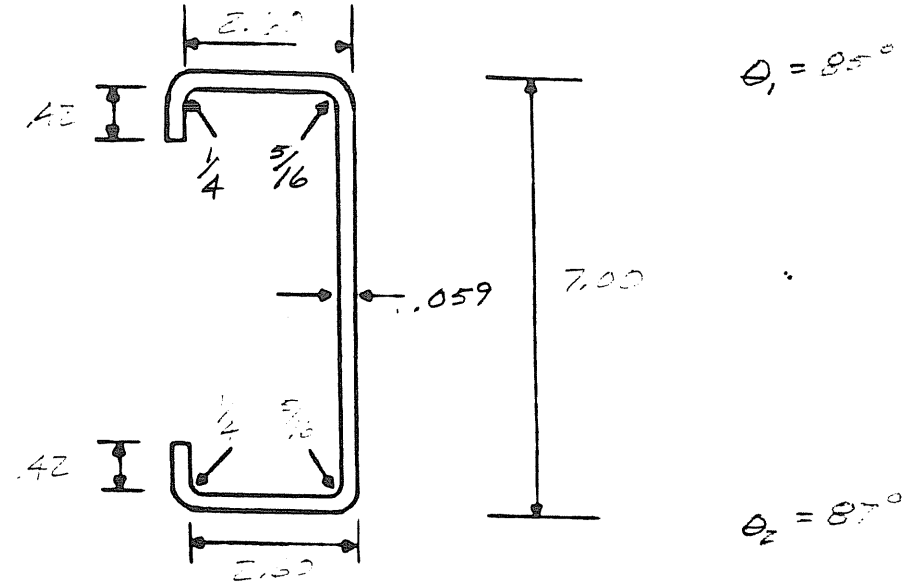


Interior (East) Purlin

Figure A.43 Measured Purlin Dimensions, Test 6



Exterior (West) Purlin



Exterior (East) Purlin

Figure A.44 Measured Purlin Dimensions, Test 6

```
A I S I   P U R L I N   A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 6 EAST TEST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.680	2.640
LIP(in)	0.420	0.420
LIP ANGLE(deg)	87.000	86.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	9
THICKNESS(in)	0.057
YIELD STRENGTH(ksi)	56

	MOMENTS OF INERTIA(in^4)	SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	10.230	2.294	2.282
STRENGTH=	9.754	2.128	2.238
DEFLECTION=	10.142		

BE=	1.902	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	27.329	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	5.958	ft-k
MT=	6.266	ft-k
MW=	5.235	ft-k
MU=	8.743	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	111.906	#/ft (1.67*allowable)
DEFLECTION =	2.938	in./100#/ft

Figure A.45 AISI Purlin Analysis, Test 6 Interior Purlin (East)

```
A I S I  P U R L I N  A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 6 WEST TEST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.620	2.660
LIP(in)	0.420	0.440
LIP ANGLE(deg)	85.000	86.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	9
THICKNESS(in)	0.057
YIELD STRENGTH(ksi)	56

	MOMENTS OF INERTIA(in^4)	SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	10.205	2.273	2.291
STRENGTH=	9.776	2.125	2.251
DEFLECTION=	10.154		

BE=	1.887	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	27.329	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	5.950	ft-k
MT=	6.303	ft-k
MW=	5.227	ft-k
MU=	8.730	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	111.739	plf (1.67*allowable)
DEFLECTION =	2.934	in./100plf

Figure A.46 AISI Purlin Analysis, Test 6 Interior Purlin (West)

```
A I S I   P U R L I N   A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 6 OUTER EAST PURLIN
-------------------------------------------------------------------------

                          TOP              BOTTOM
FLANGE(in)              2.600              2.600
LIP(in)                 0.420              0.420
LIP ANGLE(deg)         85.000             87.000
RADIUS L/F(in)          0.250              0.250
RADIUS F/W(in)          0.313              0.313

TOTAL DEPTH(in)                7
THICKNESS(in)                  0.059
YIELD STRENGTH(ksi)            56

                                          SECTION MODULII(in^3)
      MOMENTS OF INERTIA(in^4)              TOP                BOTTOM
GROSS=          5.802                    1.672                1.672
STRENGTH=       5.581                    1.570                1.648
DEFLECTION=     5.802
BE=    1.925   in
FC=   33.600   ksi
FT=   33.600   ksi
FBW=  30.684   ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)
            MC=      4.397   ft-k
            MT=      4.613   ft-k
            MW=      4.443   ft-k
            MU=      7.343   ft-k (1.67*allowable)
SPAN          =     25.000   ft.
UNIFORM LOAD=     93.986   plf (1.67*allowable)
DEFLECTION    =    5.135   in./100plf
```

Figure A.47 AISI Purlin Analysis, Test 6 Exterior Purlin (East)

```
A I S I   P U R L I N   A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 6 OUTER WEST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.620	2.620
LIP(in)	0.440	0.440
LIP ANGLE(deg)	87.000	88.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	7
THICKNESS(in)	0.059
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	5.851	1.686	1.686
STRENGTH=	5.620	1.580	1.661
DEFLECTION=	5.851		

BE=	1.931	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	30.684	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	4.423	ft-k
MT=	4.651	ft-k
MW=	4.469	ft-k
MU=	7.386	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	94.545	plf (1.67*allowable)
DEFLECTION =	5.092	in./100plf

Figure A.48 AISI Purlin Analysis, Test 6 Exterior Purlin (West)

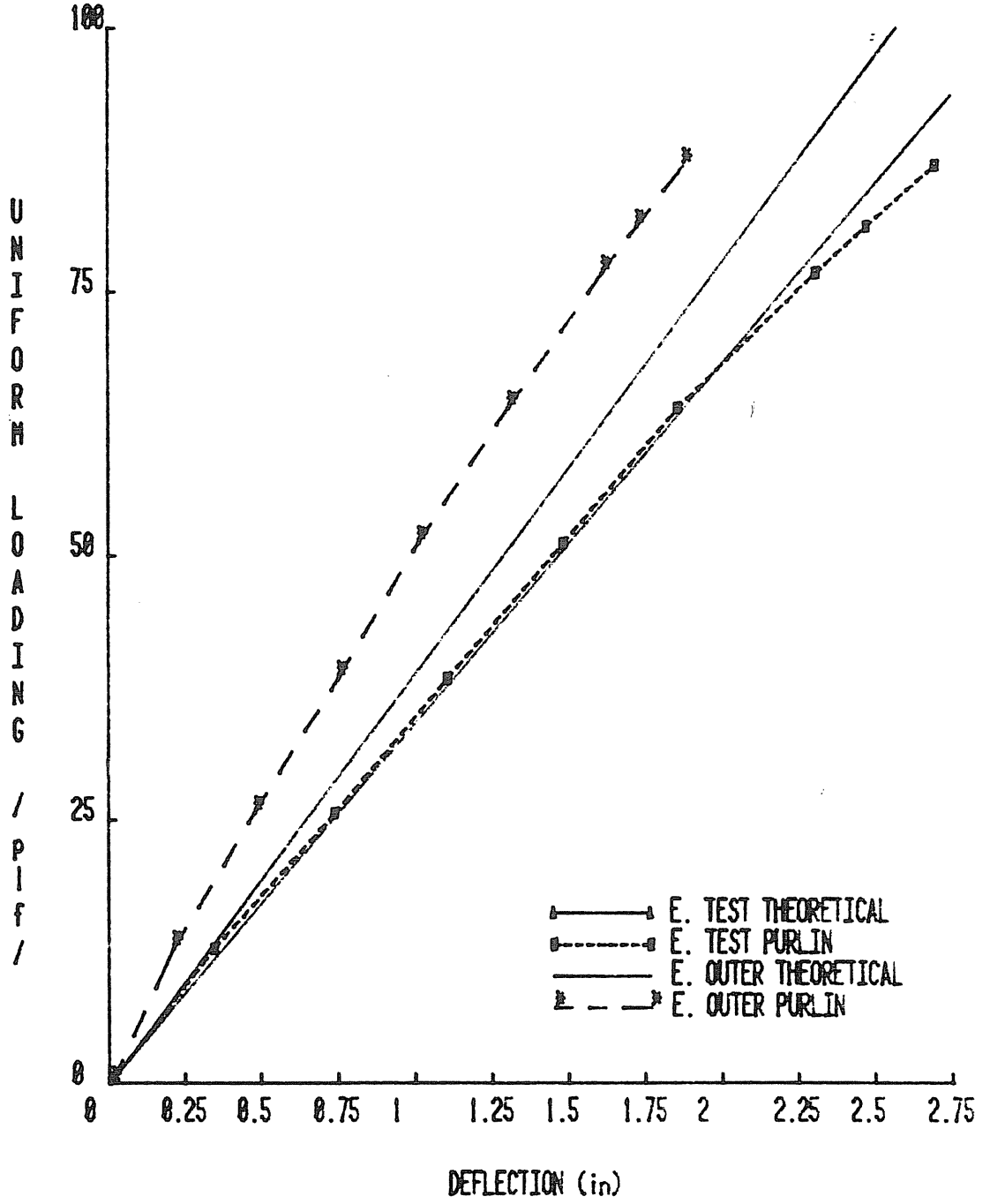


Figure A.49 Load vs. Vertical Deflection, Test 6

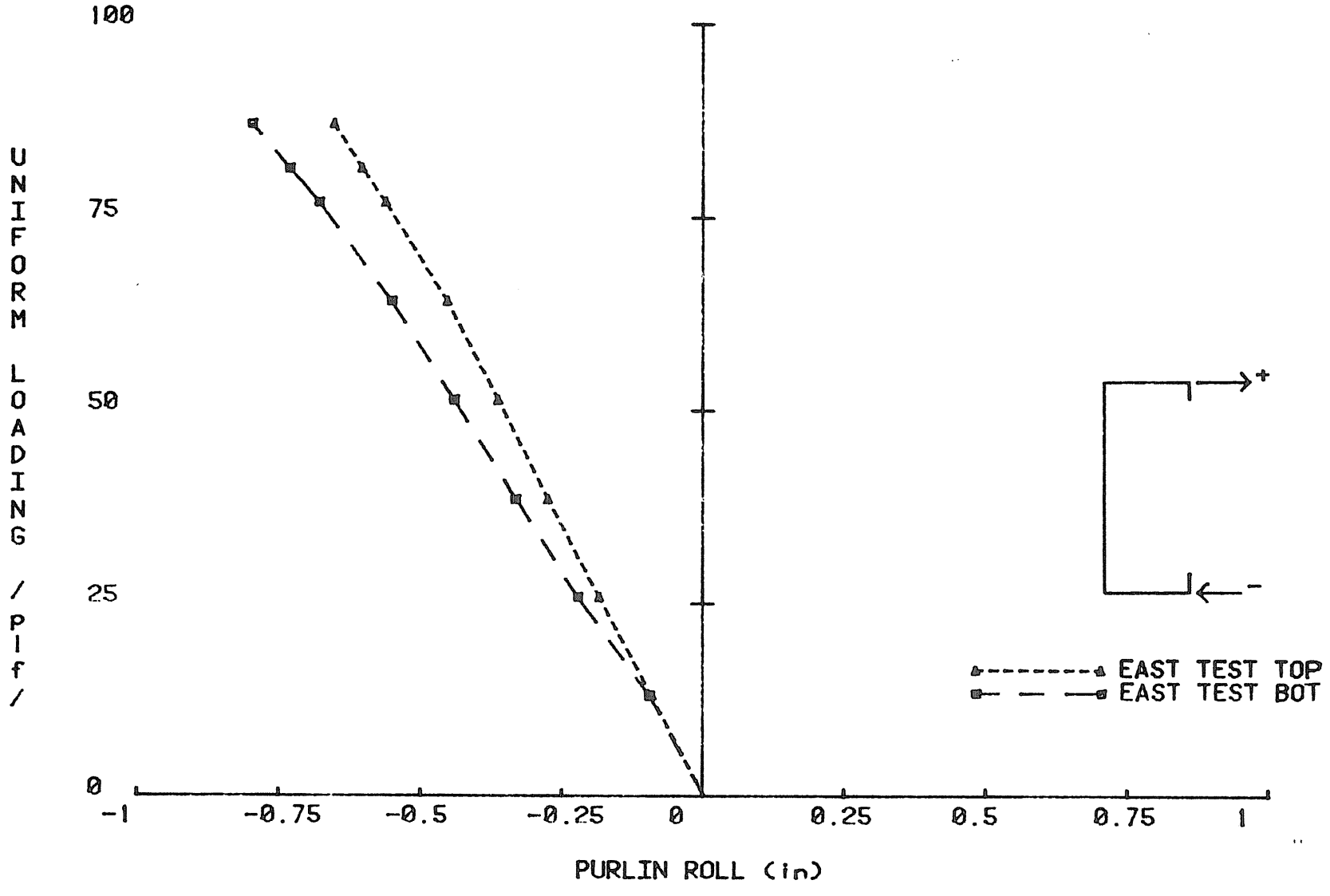


Figure A.50 Vertical Loading vs. Lateral Displacement, Test 6 (East)

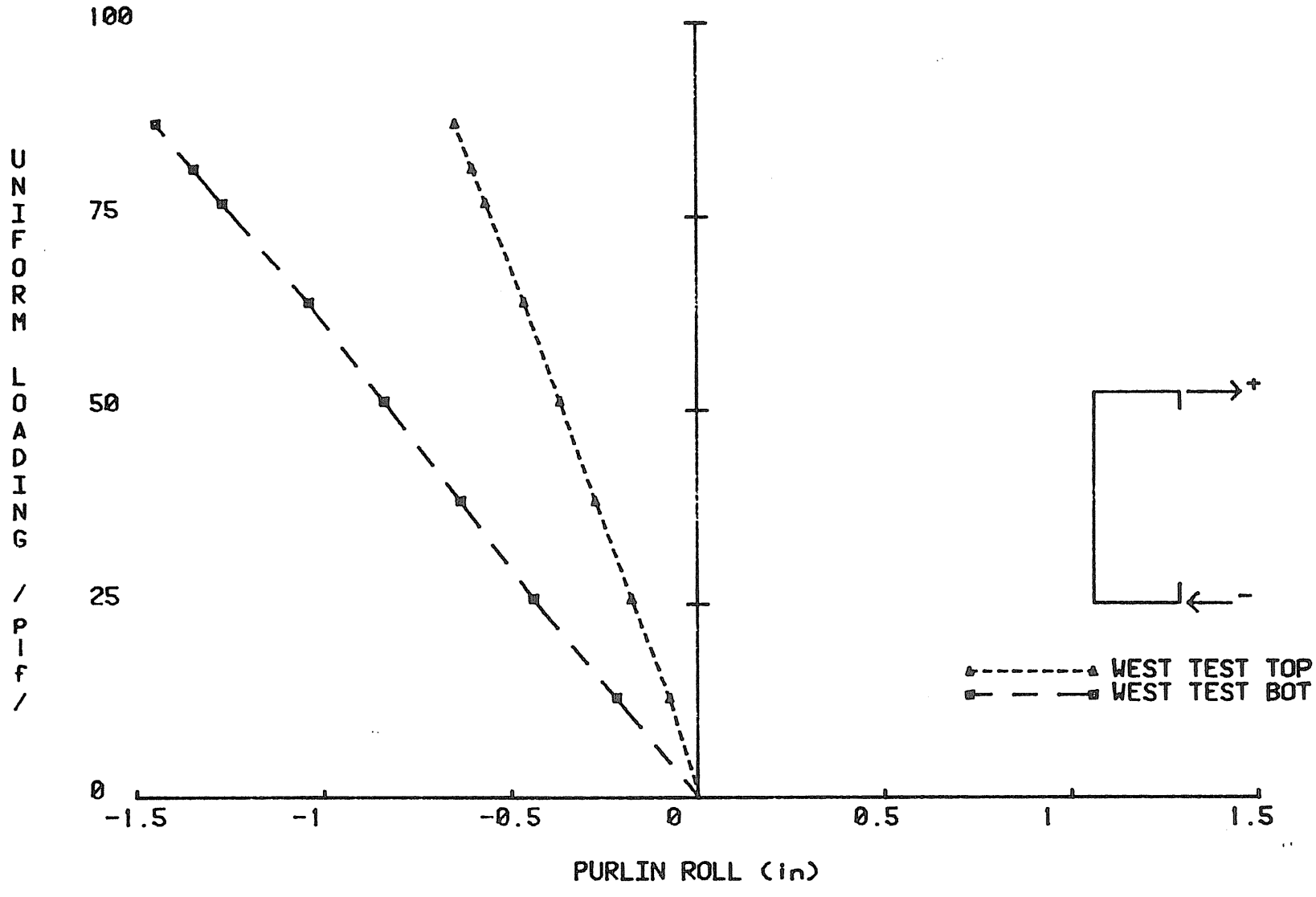


Figure A.51 Vertical Loading vs. Lateral Displacement, Test 6 (West)

TEST SUMMARY

Project: MESCO C-Purlin Supported Roof Systems

Test No.: 16 Gravity

Test Date: 12-15-83

Purpose: Determine purlin strength for resisting gravity load

Span(s): 24'-8"

Thickness: 0.079 (14 gage) Moment of Inertia: 14.18 $in.^4$

Parameters: Test purlins in opposing orientation
Panel torsional restraint
Purlins clipped to rafters
Bracing at ends and third points at test and outer purlins

Failure Load: 173.9 + 8.9 D.L. = 182 plf

Failure Mode: Local buckling of compression flange of east test purlin near center line.

Predicted Failure Loads:

Method	AISI	Load	194.2 plf
Method		Load	
Method		Load	

Discussion:

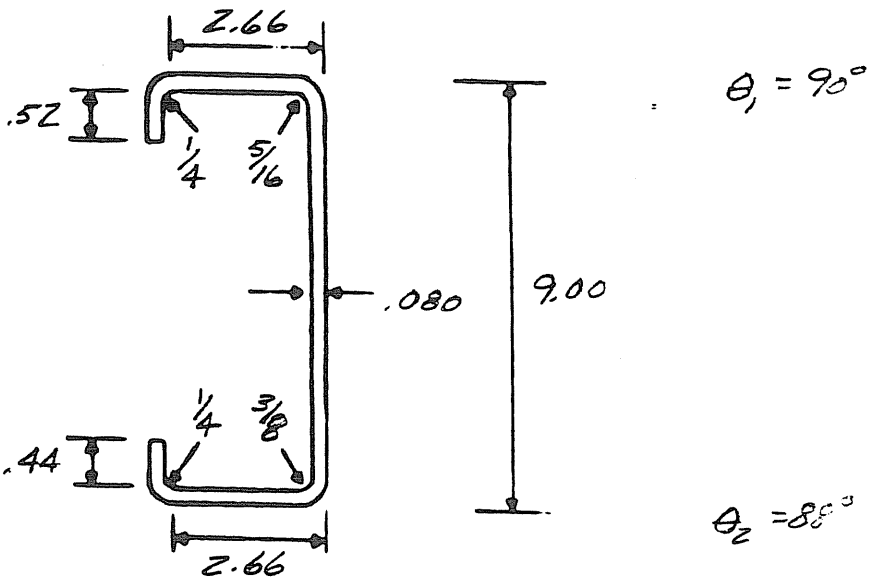
-Failure load was 94% of AISI constrained bending.

-Compression flange of east test purlin buckled near center line.

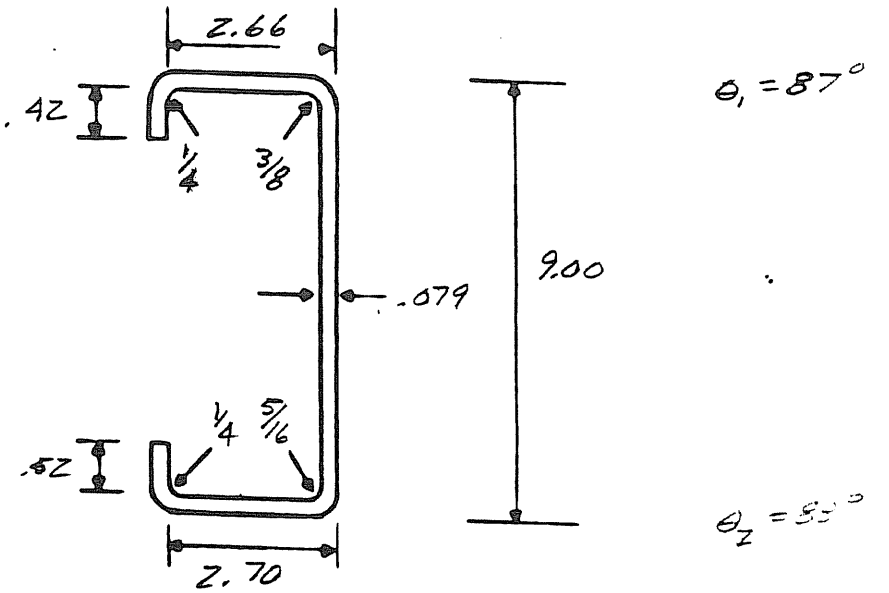
-Maximum vertical deflection was 3.89 in.

-Vertical deflections of test purlins were 6-9% more than predicted by AISI.

-Test purlins deflected 12-19% more than outer purlins.

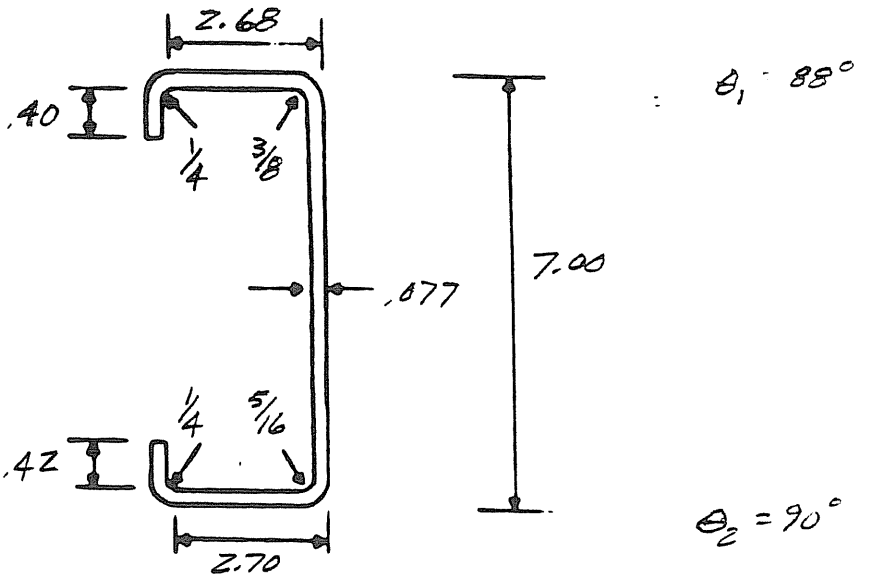


Interior (West) Purlin

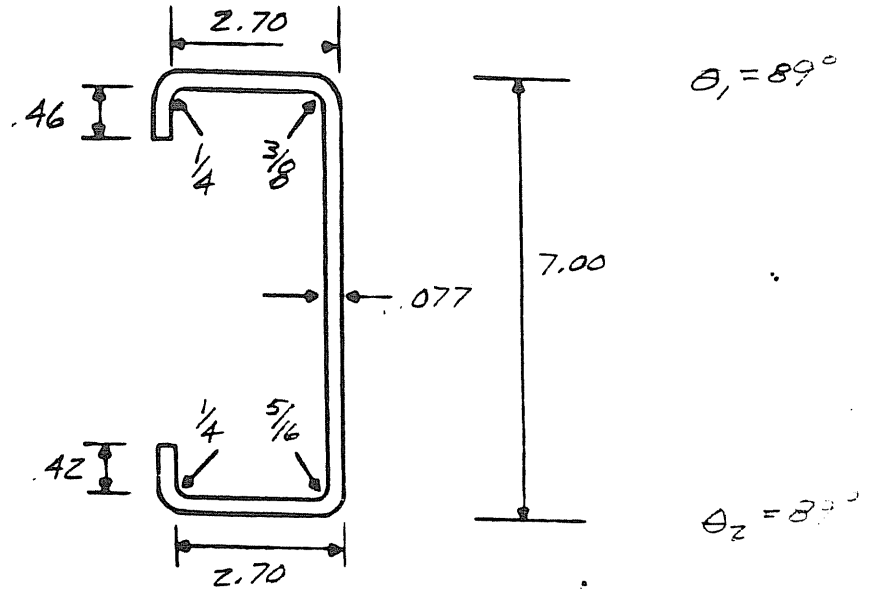


Interior (East) Purlin

Figure A.52 Measured Purlin Dimensions, Test 16



Exterior (West) Purlin



Exterior (East) Purlin

Figure A.53 Measured Purlin Dimensions, Test 16

```
A I S I   P U R L I N   A N A L Y S I S
                C-SECTION
IDENTIFICATION: MESCO TEST 16 EAST TEST PURLIN
-------------------------------------------------------------------

                          TOP              BOTTOM
FLANGE(in)              2.660              2.700
LIP(in)                 0.420              0.520
LIP ANGLE(deg)         87.000             88.000
RADIUS L/F(in)          0.250              0.250
RADIUS F/W(in)          0.375              0.313

TOTAL DEPTH(in)                 9
THICKNESS(in)                   0.079
YIELD STRENGTH(ksi)             56

                                                SECTION MODULI(in^3)
      MOMENTS OF INERTIA(in^4)                  TOP                BOT.OM
GROSS=          14.182                          3.158              3.201
STRENGTH=       14.182                          3.158              3.201
DEFLECTION=     14.182
RE      2.206   in
FC=     33.600  ksi
FT      33.600  ksi
FW=     31.088  ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)
              MC=       8.844   ft-k
              MT=       8.962   ft-k
              MW=       9.014   ft-k
              MU=      14.769   ft-k (1.67*allowable)
SPAN          =         24.667  ft.
UNIFORM LOAD  =        194.183  plf (1.67*allowable)
DEFLECTION    =          1.991  in./100-lf
```

Figure A. 54 AISI Purlin Analysis, Test 16 Interior Purlin (East)

A I S I P U R L I N A N A L Y S I S
C-SECTION
IDENTIFICATION: MESCO TEST 16 WEST TEST PURLIN

	TOP	BOTTOM
FLANGE(in)	2.660	2.660
LIP(in)	0.520	0.440
LIP ANGLE(deg)	90.000	88.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.375

TOTAL DEPTH(in)	9
THICKNESS(in)	0.08
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)	SECTION MODULI(in^3) TOP	BOT
GROSS= 14.316	3.219	3.201
STRENGTH= 14.316	3.219	3.201
DEFLECTION= 14.316		

RE=	2.268	in
FC=	33.600	ksi
FT	33.600	ksi
FBW=	31.209	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	9.012	ft-k
MT=	8.963	ft-k
MW=	9.091	ft-k
MU=	14.968	ft-k (1.67*allow.)
SPAN =	24.667	ft.
UNIFORM LOAD=	196.801	plf (1.67*allow.)
DEFLECTION =	1.972	in./100plf

Figure A.55 AISI Purlin Analysis, Test 16 Interior Purlin (West)

A I S I P U R L I N A N A L Y S I S
C-SECTION
IDENTIFICATION: MESCO TEST 16 OUTER EAST PURLIN

	TOP	BOTTOM
FLANGE(in)	2.700	2.700
LIP(in)	0.460	0.420
LIP ANGLE(deg)	89.000	89.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	7
THICKNESS(in)	0.077
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)	SECTION MODULI(in^3) TOP	BOTTOM
GROSS= 7.709	2.233	2.221
STRENGTH= 7.692	2.225	2.219
DEFLECTION= 7.709		

be=	2.292	in
FC=	33.600	ksi
FT	33.600	ksi
FBW=	33.055	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	6.231	ft-k
MT=	6.214	ft-k
MW=	6.822	ft-k
MU=	10.378	ft-k (1.67*allow...
SPAN =	24.667	ft.
UNIFORM LOAD=	136.451	plf (1.67*allow...
DEFLECTION =	3.663	in./100plf

Figure A.56 AISI Purlin Analysis, Test 16 Exterior Purlin (East)

A I S I P U R L I N A N A L Y S I S
C-SECTION
IDENTIFICATION: MESCO TEST 16 OUTER WEST PURLIN

	TOP	BOTTOM
FLANGE(in)	2.680	2.700
LIP(in)	0.400	0.420
LIP ANGLE(deg)	88.000	90.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.375	0.313

TOTAL DEPTH(in)	7
THICKNESS(in)	0.077
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULI(in^3) TOP	BOTTOM
GROSS=	7.620	2.200	2.305
STRENGTH=	7.620	2.200	2.305
DEFLECTION=	7.620		

RB=	2.228	in
FC=	33.600	ksi
FT	33.600	ksi
FBW=	33.055	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	6.160	ft-k
MT=	6.168	ft-k
MW=	6.882	ft-k
MU=	10.287	ft-k (1.67*allowable)
SPAN =	24.667	ft.
UNIFORM LOAD=	135.257	plf (1.67*allowable)
DEFLECTION =	3.705	in./allowable

Figure A.57 AISI Purlin Analysis, Test 16 Exterior Purlin (West)

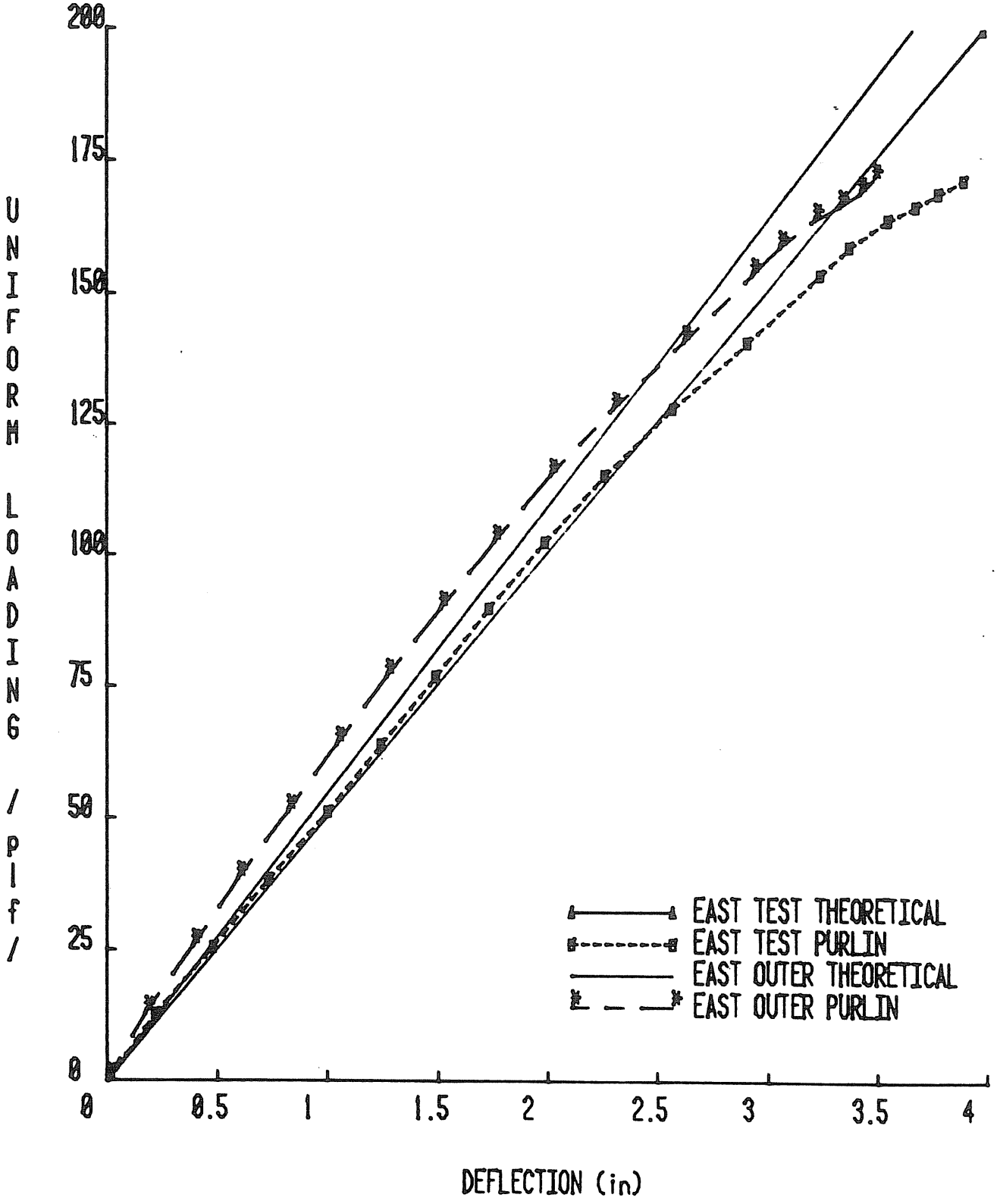


Figure A.58 Load vs. Vertical Deflection, Test 16

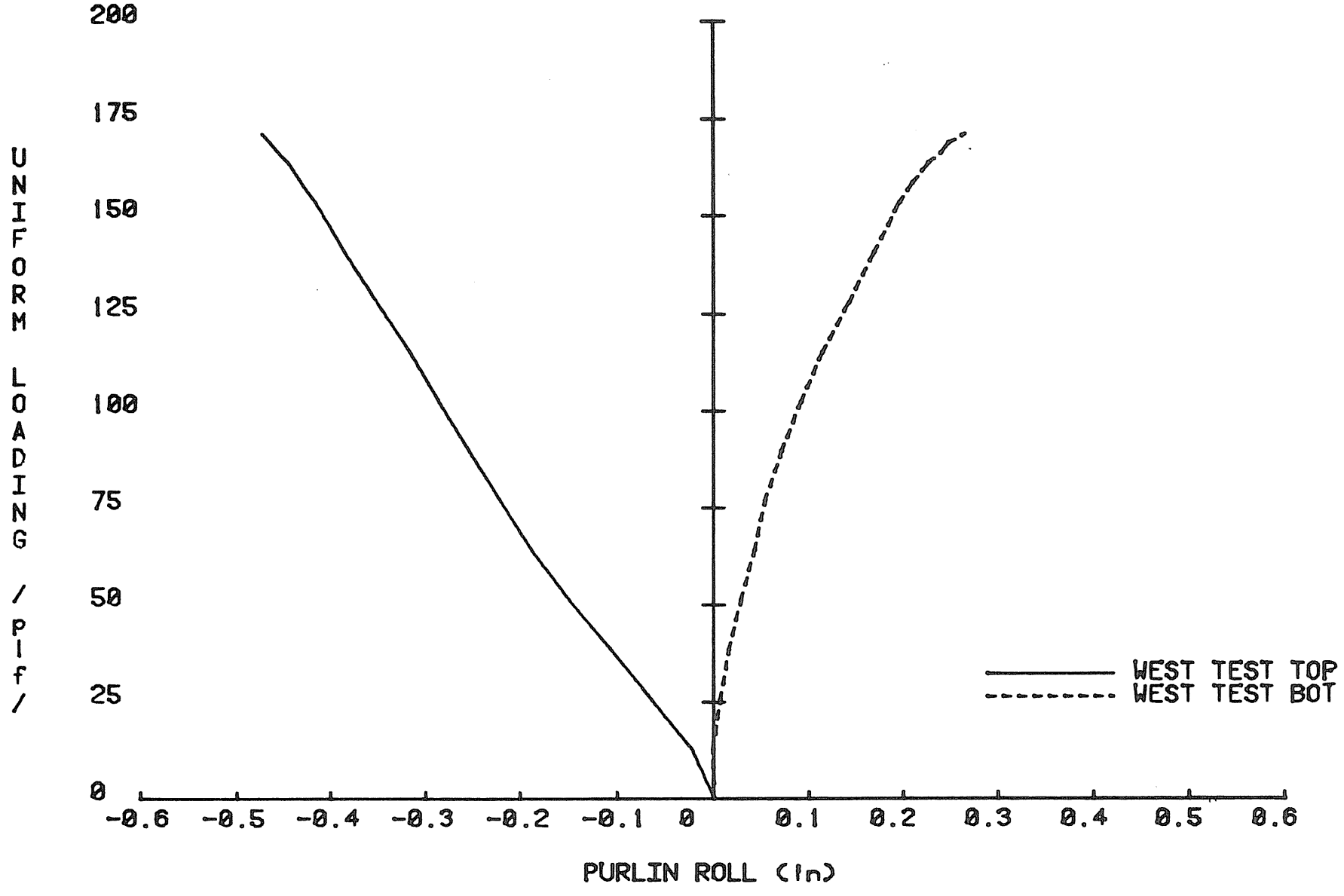


Figure A.59 Vertical Loading vs. Lateral Displacement, Test 16 (East)

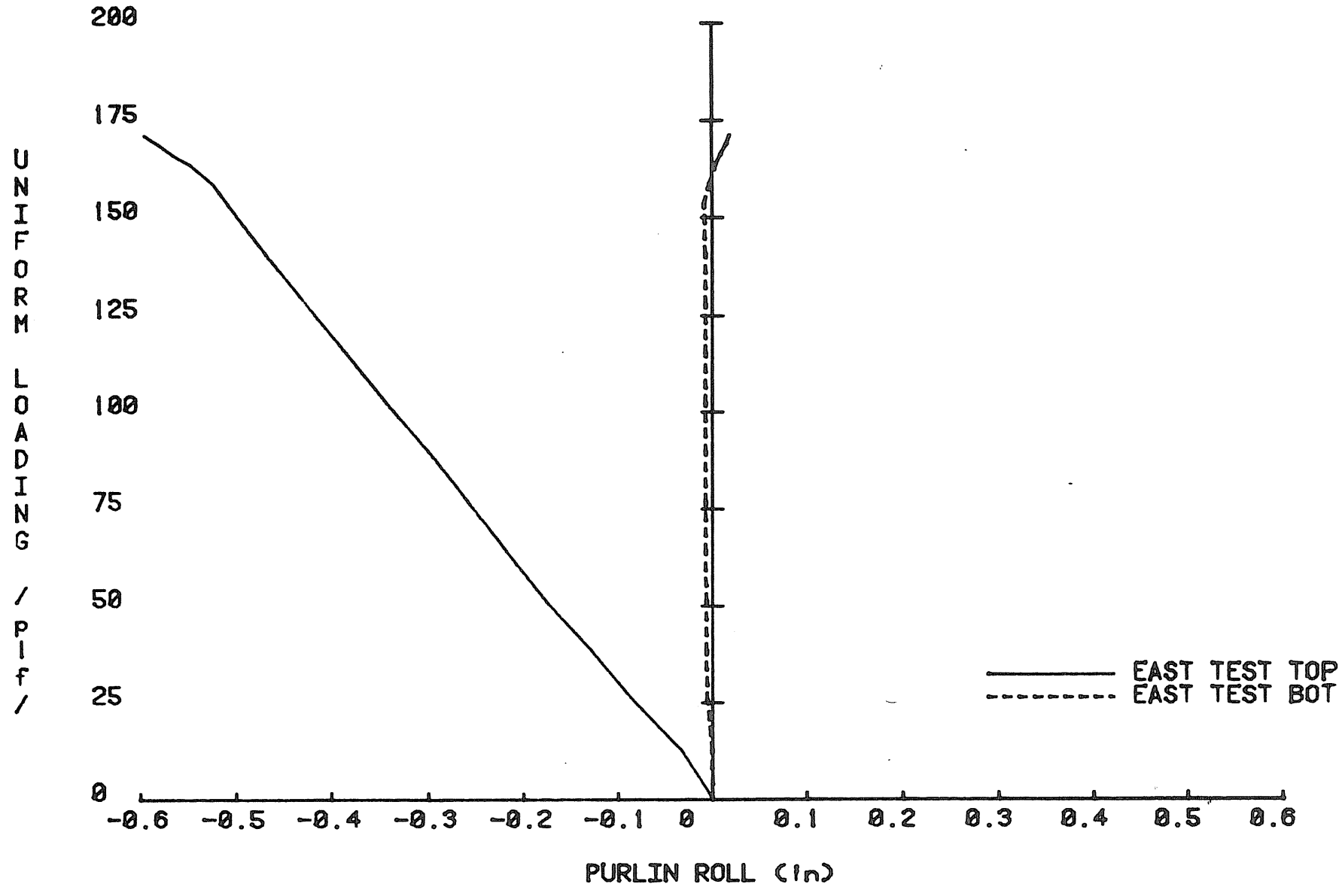


Figure A.60 Vertical Loading vs. Lateral Displacement, Test 16 (West)

APPENDIX B

UPLIFT LOADING TEST DATA

TEST SUMMARY

Project: Mesco

Test No.: 7 Uplift

Test Date: 10-26-83

Purpose: Determine purlin strength for resisting uplift.

Span(s): 25'-0"

Thickness: 0.075 in. (14 gage) Moment of Inertia: 12.98 in^4

Parameters: Test purlins in facing orientation

Panel torsional restraint

Purlins clipped to rafters

No intermediate bracing

Failure Load: 79.3 plf + 8.9 plf dead load

Failure Mode: Web buckling of east test purlin

Predicted Failure Loads:

Method 50-75% of working load Load 84-125 plf

Method _____ Load _____

Method _____ Load _____

Discussion:

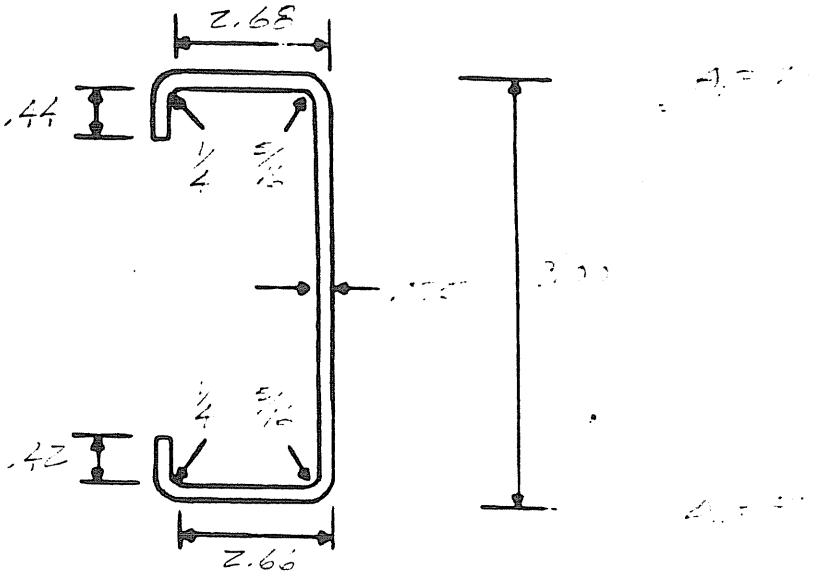
-Failure load was 88.2 plf or 52% of AISI Constrained Bending Criteria.

-Failure was due to excessive amount of lateral displacement of test purlins which caused web buckling as well as pulling the fasteners out of the deck.

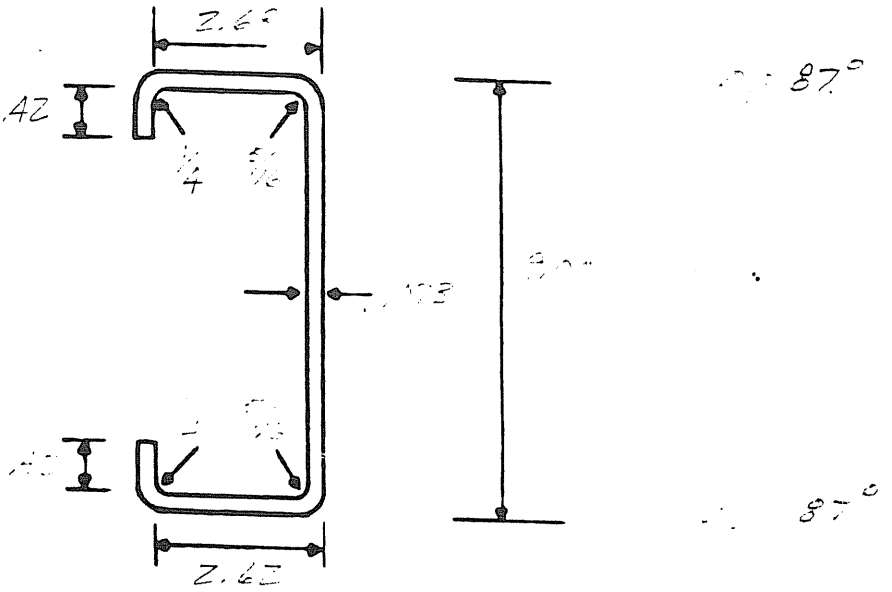
-Maximum lateral displacement was 6.9 in. for the bottom flange and 2.9 in. for the top flange.

-Top flanges displaced 40-45% less than bottom flanges.

-Maximum vertical deflection was 8.3 in. for the test purlins and 3.7 in. for the outer purlins.

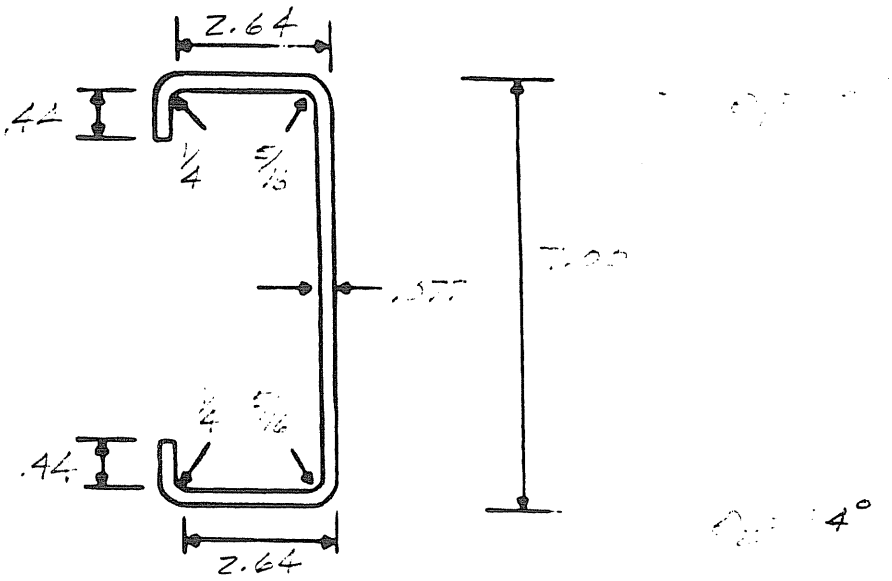


Interior (West) Purlin

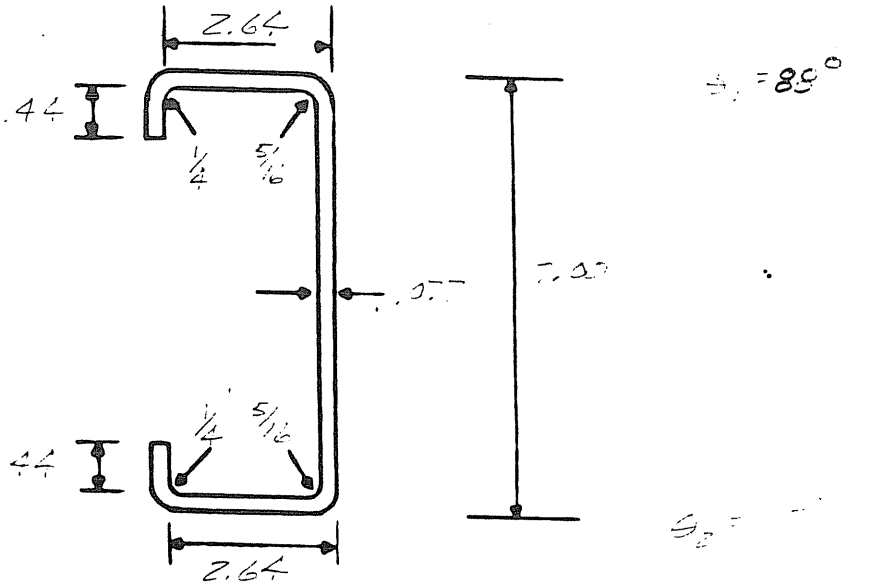


Interior (East) Purlin

Figure B.1 Measured Purlin Dimensions, Test 7 (Interior)



Exterior (West) Purlin



Exterior (East) Purlin

Figure B.2 Measured Purlin Dimensions, Test 7 (Exterior)

```
A I S I   P U R L I N   A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 7 EAST TEST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.680	2.620
LIP(in)	0.420	0.420
LIP ANGLE(deg)	87.000	87.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	9
THICKNESS(in)	0.073
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	12.977	2.919	2.896
STRENGTH=	12.868	2.880	2.886
DEFLECTION=	12.977		

BE=	2.219	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	30.287	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	8.064	ft-k
MT=	8.081	ft-k
MW=	7.885	ft-k
MU=	13.168	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	168.545	plf (1.67*allowable)
DEFLECTION =	2.296	in./100plf

Figure B.3 AISI Purlin Analysis, Test 7 Interior Purlin (East)

```
A I S I  P U R L I N  A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 7 WEST TEST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.680	2.660
LIP(in)	0.440	0.420
LIP ANGLE(deg)	90.000	87.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	9
THICKNESS(in)	0.075
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	13.403	3.011	2.996
STRENGTH=	13.342	2.989	2.991
DEFLECTION=	13.403		

BE=	2.252	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	30.568	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	8.369	ft-k
MT=	8.374	ft-k
MW=	8.262	ft-k
MU=	13.797	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	176.607	plf (1.67*allowable)
DEFLECTION =	2.223	in./100plf

Figure B.4 AISI Purlin Analysis, Test 7 Interior Purlin (West)

```
A I S I   P U R L I N   A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 7 OUTER EAST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.640	2.640
LIP(in)	0.440	0.440
LIP ANGLE(deg)	88.000	85.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	7
THICKNESS(in)	0.077
YIELD STRENGTH(ksi)	56

	MOMENTS OF INERTIA(in^4)	SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	7.602	2.196	2.196
STRENGTH=	7.602	2.196	2.196
DEFLECTION=	7.602		

BE=	2.251	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	33.055	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	6.148	ft-k
MT=	6.150	ft-k
MW=	6.731	ft-k
MU=	10.267	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	131.418	plf (1.67*allowable)
DEFLECTION =	3.919	in./100plf

Figure B.5 AISI Purlin Analysis, Test 7 Exterior Purlin (East)

```
A I S I   P U R L I N   A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 7 EXTERIOR WEST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.640	2.640
LIP(in)	0.440	0.440
LIP ANGLE(deg)	85.000	84.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	7
THICKNESS(in)	0.077
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	7.604	2.197	2.197
STRENGTH=	7.604	2.197	2.197
DEFLECTION=	7.604		

BE=	2.251	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	33.055	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	6.151	ft-k
MT=	6.151	ft-k
MW=	6.734	ft-k
MU=	10.271	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	131.474	plf (1.67*allowable)
DEFLECTION =	3.918	in./100plf

Figure B.6 AISI Purlin Analysis, Test 7 Exterior Purlin (West)

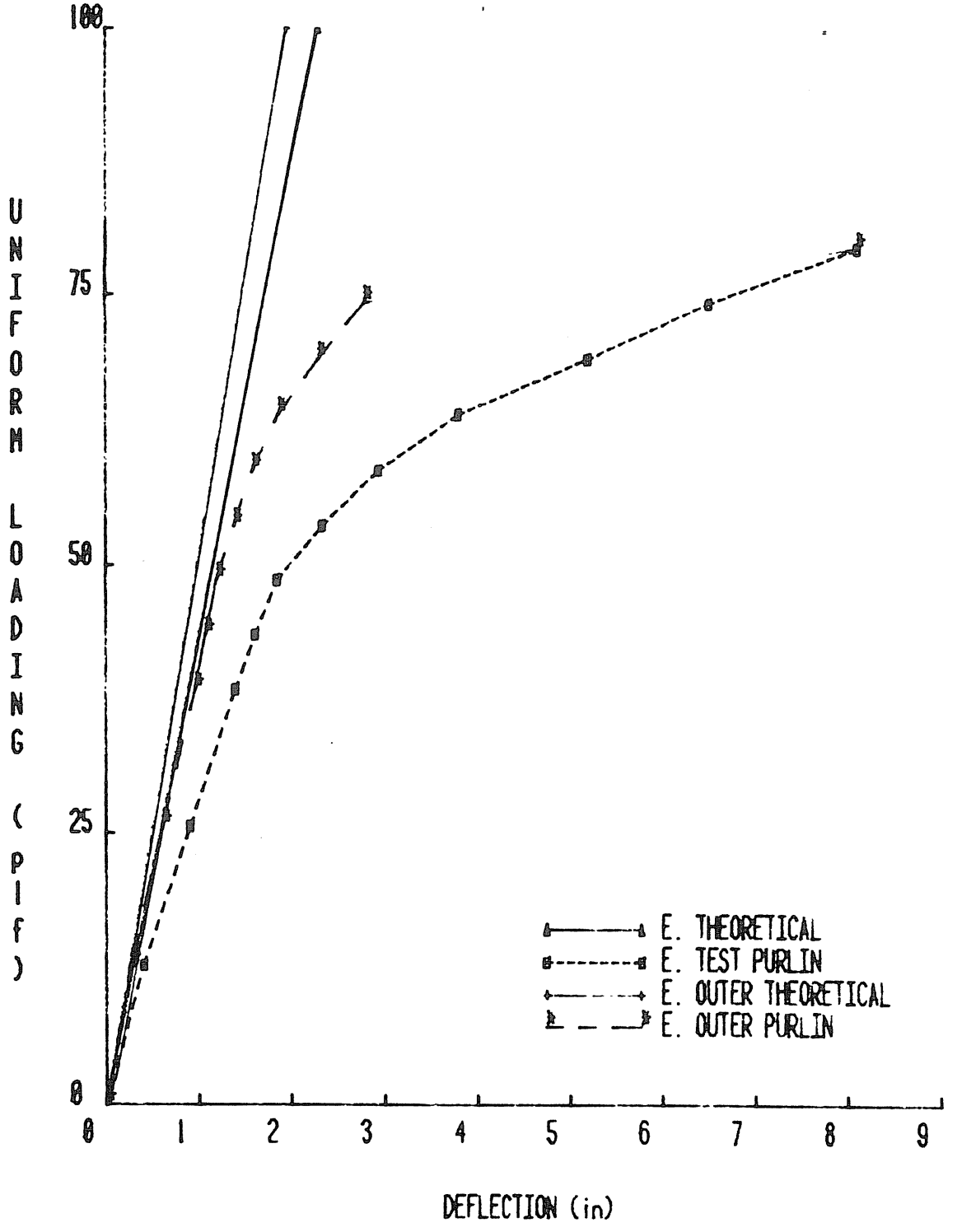


Figure B.7 Vertical Loading vs. Lateral Displacement, Test 7

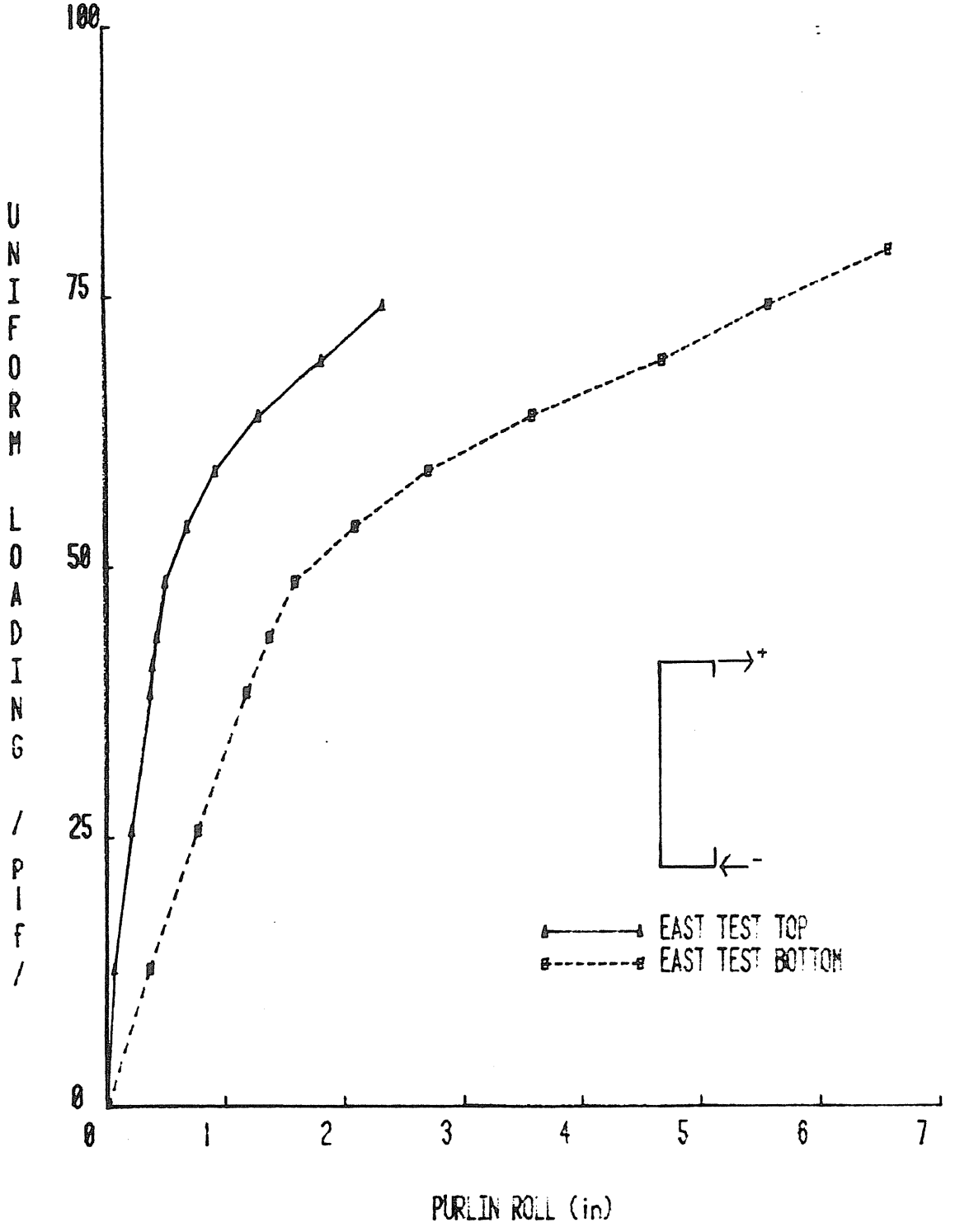


Figure B.8 Vertical Loading vs. Lateral Displacement, Test 7 (East)

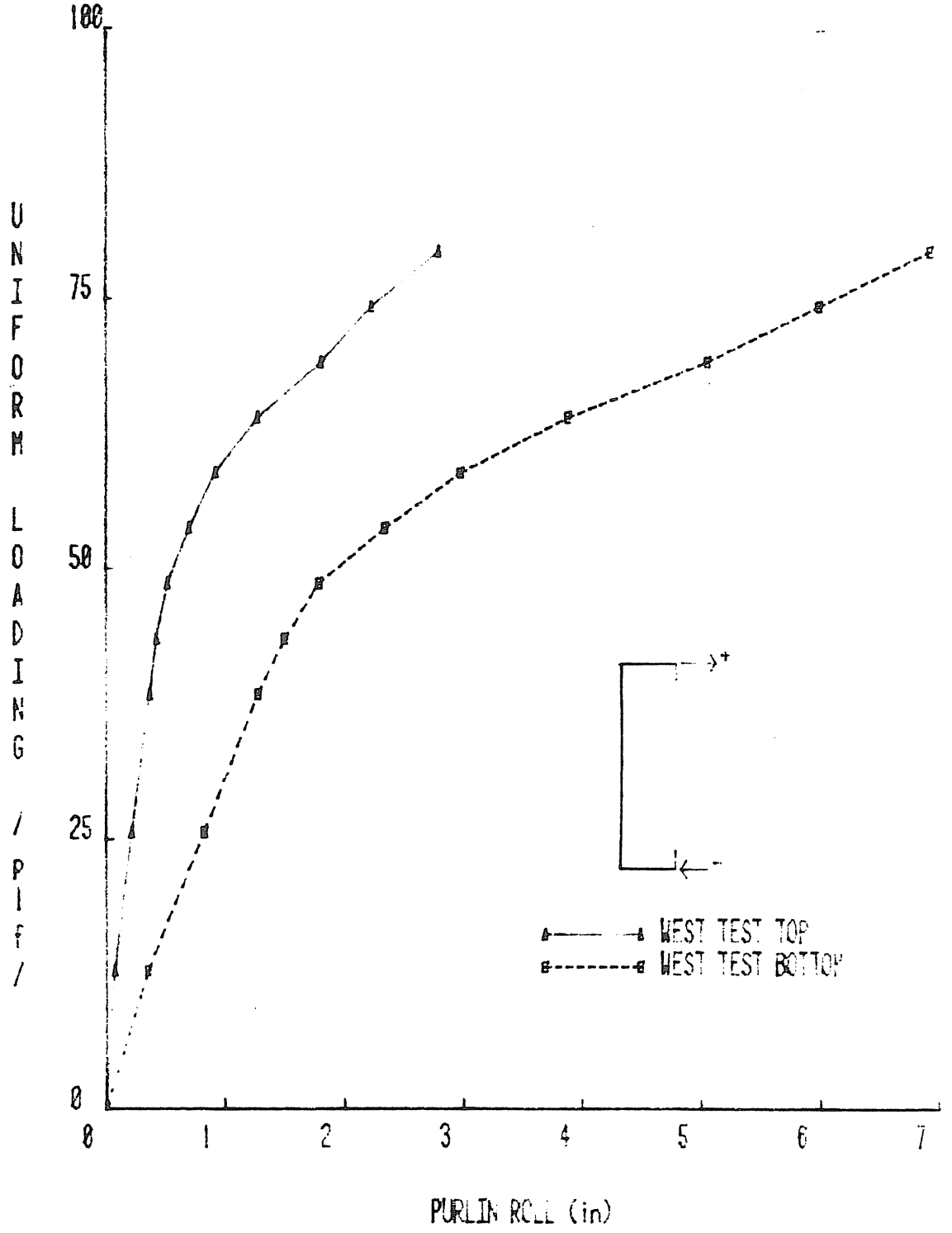


Figure B.9 Vertical Loading vs. Lateral Displacement, Test 7 (West)

TEST SUMMARY

Project: Mesco C-Purlin Supported Roof Systems

Test No.: 8 Uplift

Test Date: 11-3-83

Purpose: Determine purlin strength for resisting uplift

Span(s): 25'-0"

Thickness: 0.08 in. (14 gage) Moment of Inertia: 13.98 in^4

Parameters: Test purlins in opposing orientation
Panel torsional restraint
Purlins clipped to rafters
Bracing at ℓ, 1" from bottom flange.

Failure Load: 107.4 plf + 8.9 plf dead load

Failure Mode: Local buckling of bottom flange of west test purlin

Predicted Failure Loads:

Method 50-75% of AISI Load 93.8 to 140.7 plf

Method _____ Load _____

Method _____ Load _____

Discussion:

-Failure load was 62% of AISI Constrained Bending.

-Bottom flange of west test purlin buckled at 116.3 plf.

-Maximum vertical deflection was 22-34% more than expected from AISI Constrained Bending for the test purlins and 7-9% less for the outer purlins.

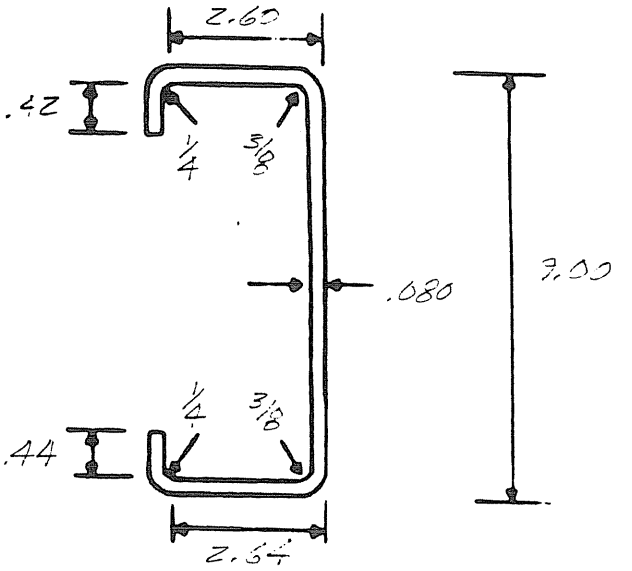
-Maximum vertical deflection was 3.1 in.

-Maximum lateral displacement was 0.43 in. for the top flange of the east test purlin.

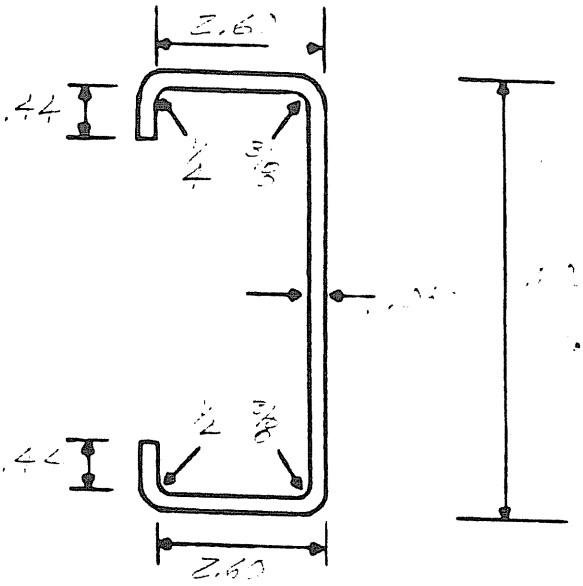
-Bottom flange displacement was 51% less than the top flange.

-Maximum bracing force was 556 lbs. between the two test purlins.

-Maximum bracing forces between the test and outer purlins was 58 and 127 lbs. tension for the east and west outer braces respectively.

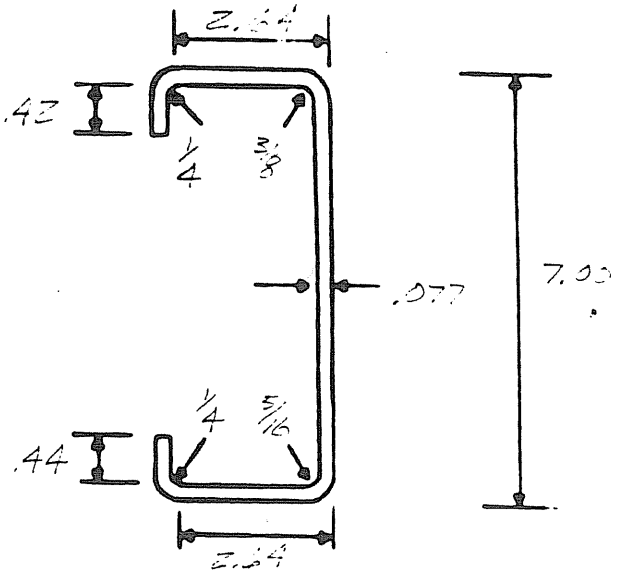


Interior (West) Purlin

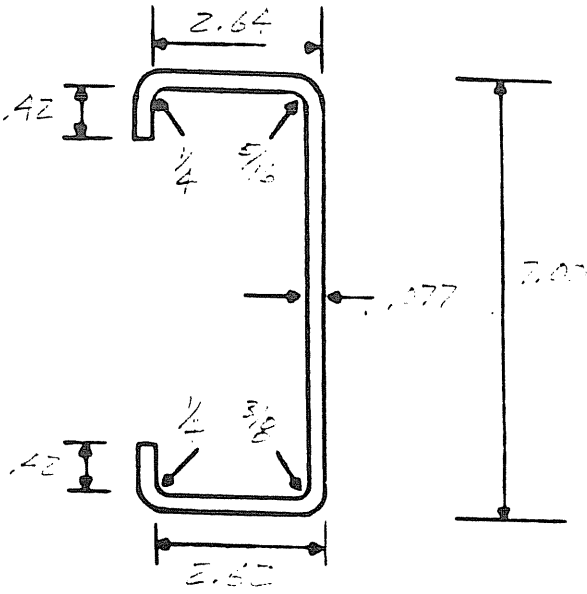


Interior (East) Purlin

Figure B.10 Measured Purlin Dimensions, Test 8 (Interior)



Exterior (West) Purlin



Exterior (East) Purlin

Figure B.11 Measured Purlin Dimensions, Test 8(Exterior)

```
A I S I   P U R L I N   A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 8 EAST TEST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.600	2.600
LIP(in)	0.440	0.440
LIP ANGLE(deg)	87.000	86.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.375	0.375

TOTAL DEPTH(in)	9
THICKNESS(in)	0.08
YIELD STRENGTH(ksi)	56

	MOMENTS OF INERTIA(in^4)	SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	13.982	3.135	3.135
STRENGTH=	13.982	3.135	3.135
DEFLECTION=	13.982		

BE=	2.145	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	31.209	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	8.778	ft-k
MT=	8.778	ft-k
MW=	8.989	ft-k
MU=	14.658	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	187.629	plf (1.67*allowable)
DEFLECTION =	2.131	in./100plf

Figure B.12 AISI Purlin Analysis, Test 8 Interior Purlin (East)

```
A I S I  P U R L I N  A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 8 WEST TEST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.600	2.640
LIP(in)	0.420	0.440
LIP ANGLE(deg)	88.000	87.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.375	0.375

TOTAL DEPTH(in)	9
THICKNESS(in)	0.08
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	14.017	3.130	3.155
STRENGTH=	14.017	3.130	3.155
DEFLECTION=	14.017		

BE=	2.145	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	31.209	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	8.765	ft-k
MT=	8.835	ft-k
MW=	8.973	ft-k
MU=	14.637	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	187.358	plf (1.67*allowable)
DEFLECTION =	2.126	in./100plf

Figure B.13 AISI Purlin Analysis, Test 8 Interior Purlin (West)

```
A I S I   P U R L I N   A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 8 OUTER EAST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.640	2.620
LIP(in)	0.420	0.420
LIP ANGLE(deg)	87.000	87.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.375

TOTAL DEPTH(in)	7
THICKNESS(in)	0.077
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	7.526	2.173	2.176
STRENGTH=	7.526	2.173	2.176
DEFLECTION=	7.526		

BE=	2.251	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	33.055	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	6.085	ft-k
MT=	6.092	ft-k
MW=	6.661	ft-k
MU=	10.161	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	130.062	plf (1.67*allowable)
DEFLECTION =	3.958	in./100plf

Figure B.14 AISI Purlin Analysis, Test 8 Exterior Purlin (East)

```
A I S I   P U R L I N   A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 8 OUTER WEST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.640	2.640
LIP(in)	0.420	0.440
LIP ANGLE(deg)	88.000	86.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.375	0.313

TOTAL DEPTH(in)	7
THICKNESS(in)	0.077
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	7.560	2.185	2.182
STRENGTH=	7.560	2.185	2.182
DEFLECTION=	7.560		

BE=	2.188	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	33.055	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	6.119	ft-k
MT=	6.111	ft-k
MW=	6.837	ft-k
MU=	10.205	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	130.624	plf (1.67*allowable)
DEFLECTION =	3.941	in./100plf

Figure B.15 AISI Purlin Analysis, Test 8 Exterior Purlin (West)

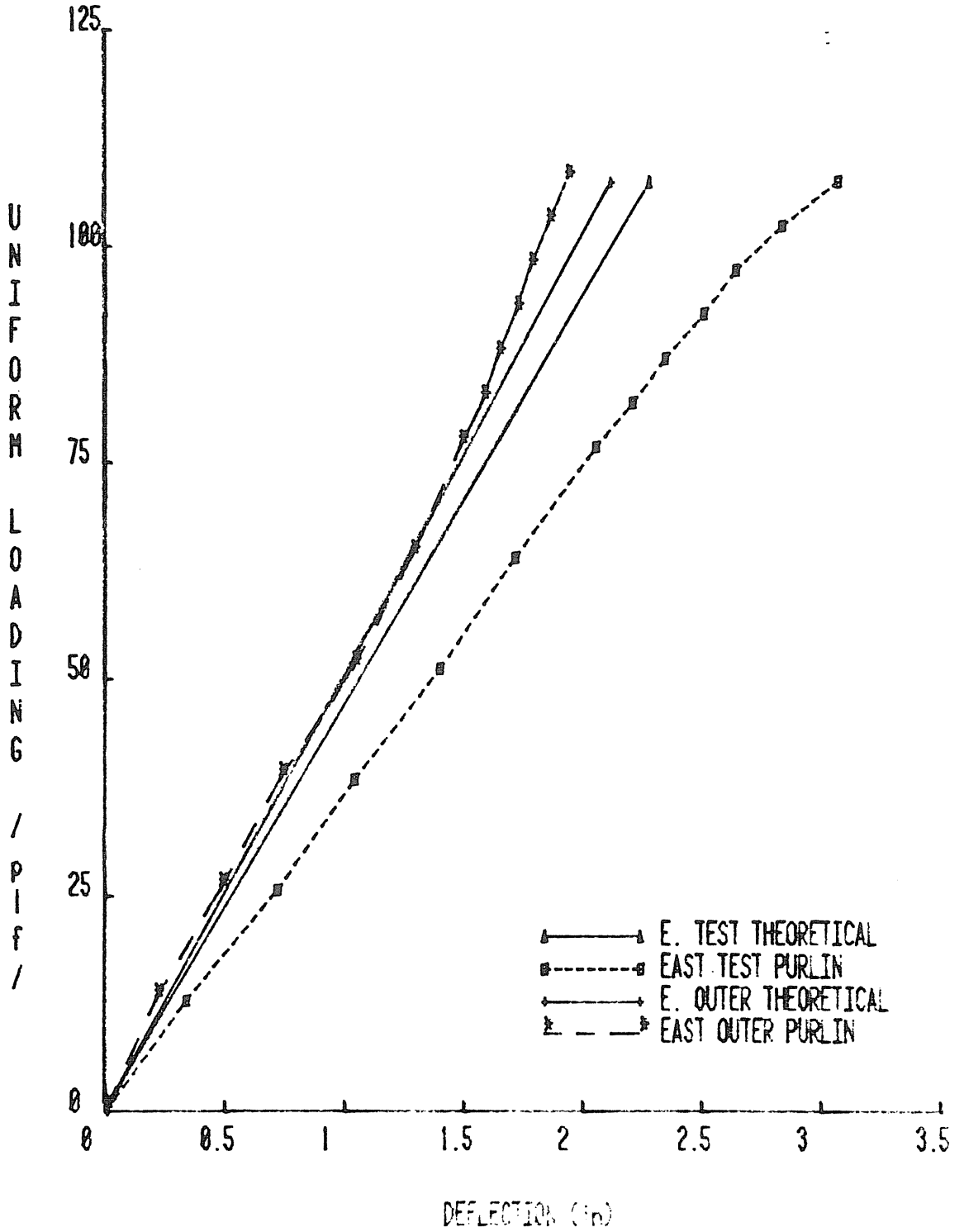


Figure B.16 Load vs. Vertical Delfection, Test 8

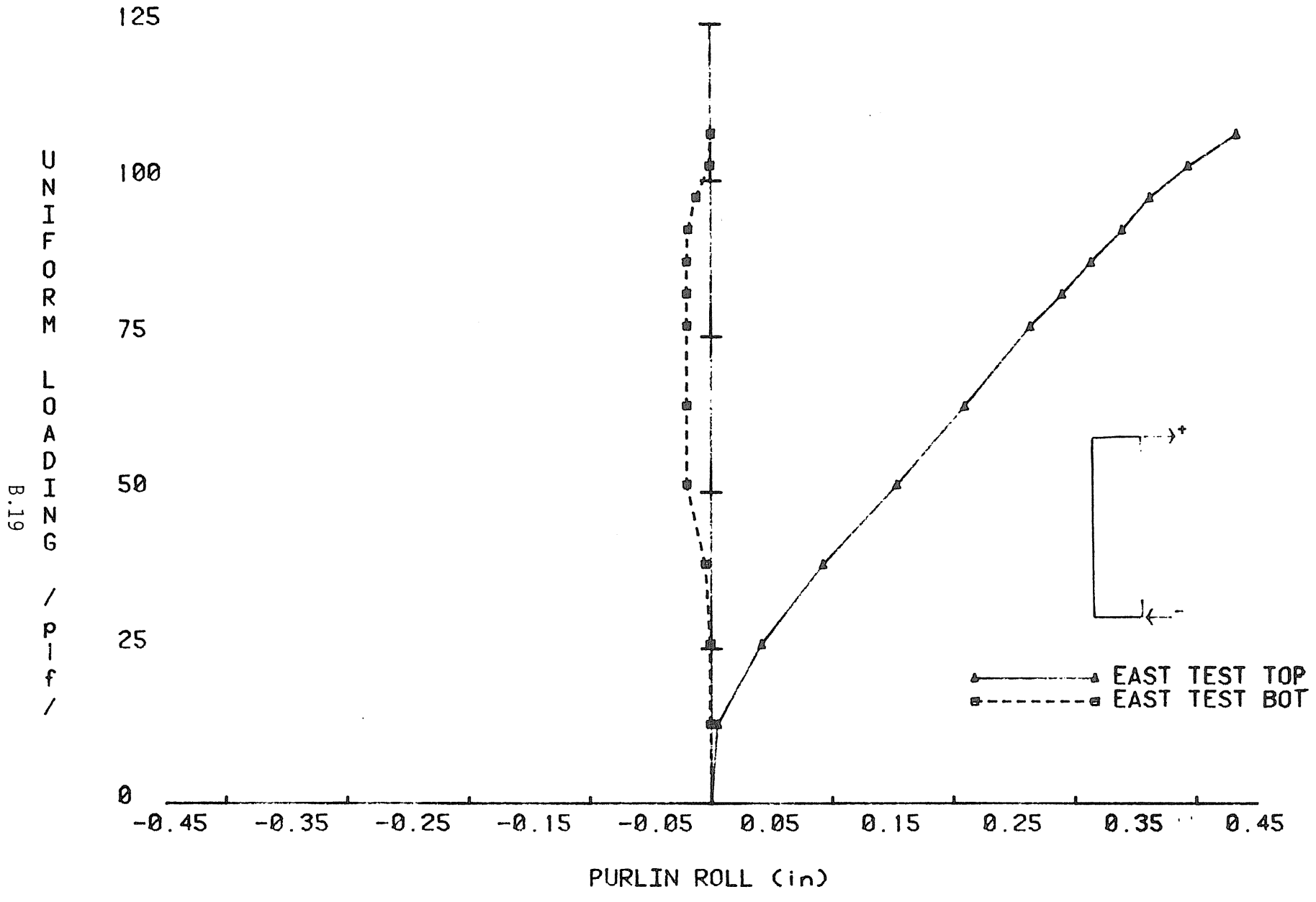


Figure B.17 Vertical Loading vs. Lateral Displacement, Test 8 (East)

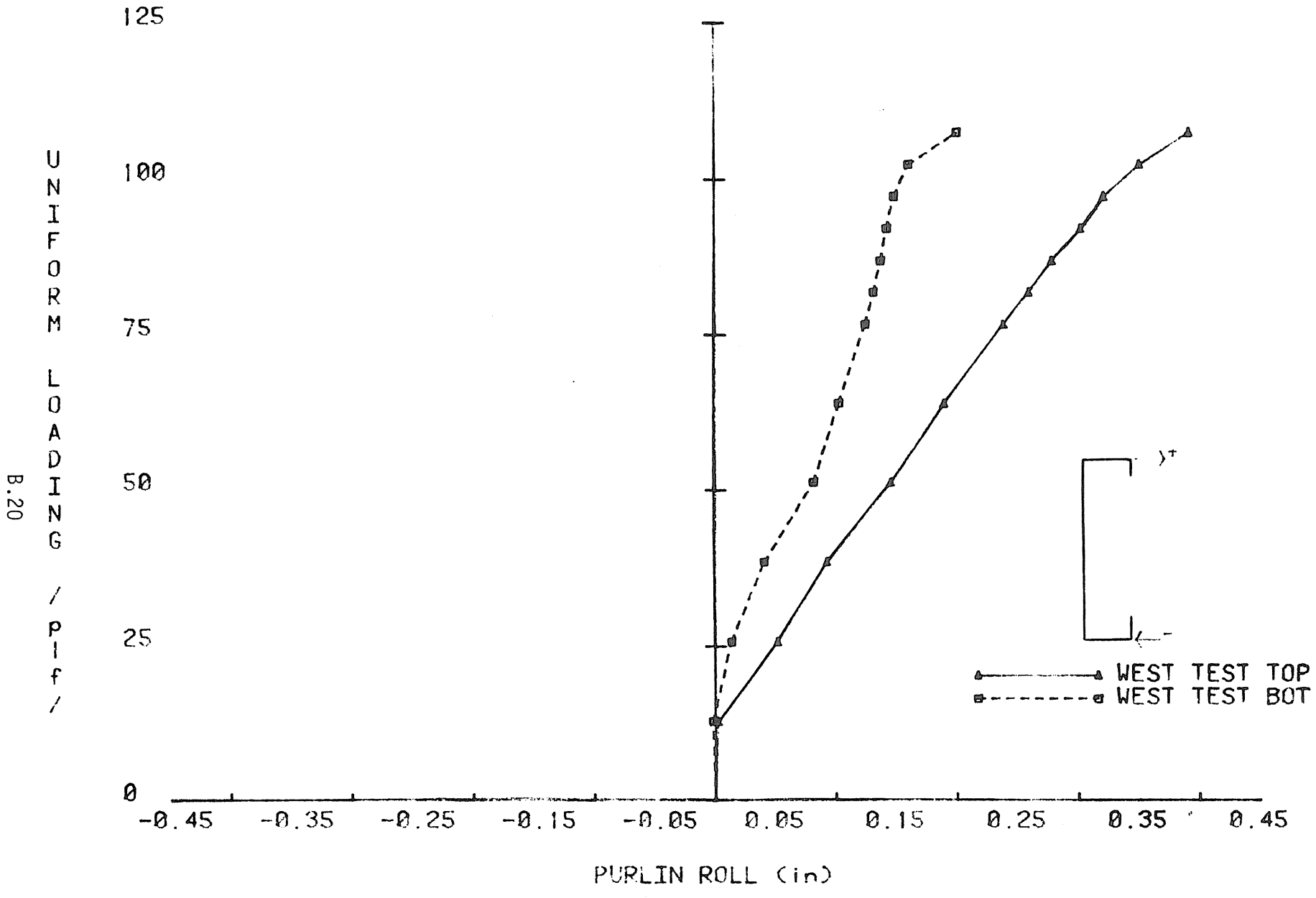


Figure B.18 Vertical Loading vs. Lateral Displacement, Test 8 (West)

TEST SUMMARY

Project: Mesco C-Purlin Supported Roof Systems

Test No.: 9 Uplift

Test Date: 11-8-83

Purpose: Determine purlin strength for resisting uplift.

Span(s): 25'-0"

Thickness: 0.067 in. (14 gage) Moment of Inertia: 11.99 in^4

Parameters: Test purlins in opposing orientation

Panel torsional restraint.

Bracing at centerline, ±1" from bottom flange.

West test purlin approximately 10% stronger than east test purlin.

Purlins clipped to rafters.

Failure Load:

Failure Mode:

Predicted Failure Loads:

Method 50-75% of AISI Load 73.7 - 110 plf

Method Load

Method Load

Discussion:

-Note: Test C1-9 consisted of three separate tests:

1. C1-9 - Same as C1-8, with bracing at centerline.
2. C1-9A - Bracing at both ends between test purlins as well as bracing at centerline of all purlins.
3. C1-9B - Same as C1-9A except a 2 x 4 wood block was cut to fit between the flanges of the test purlins at centerline.

-Tests C1-9 and C1-9A were loaded to 60 plf and then released.

-Test C1-9B was loaded to failure.

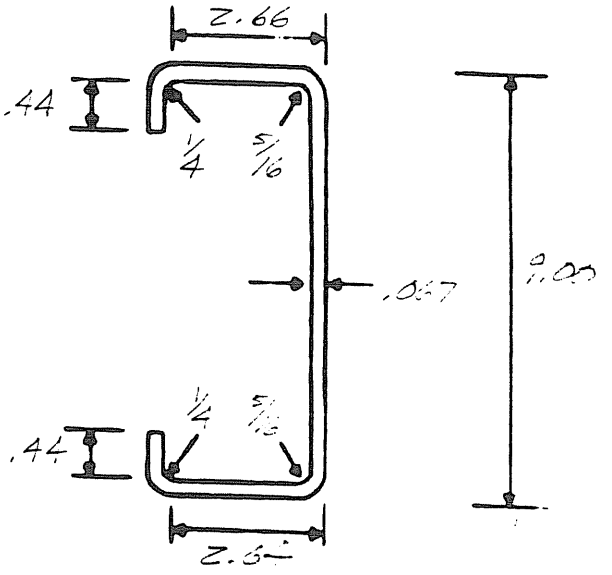
-Failure load was 85.6 plf or 58% of AISI Constrained Bending.

-Local buckling of bottom flange of west test purlin caused failure.

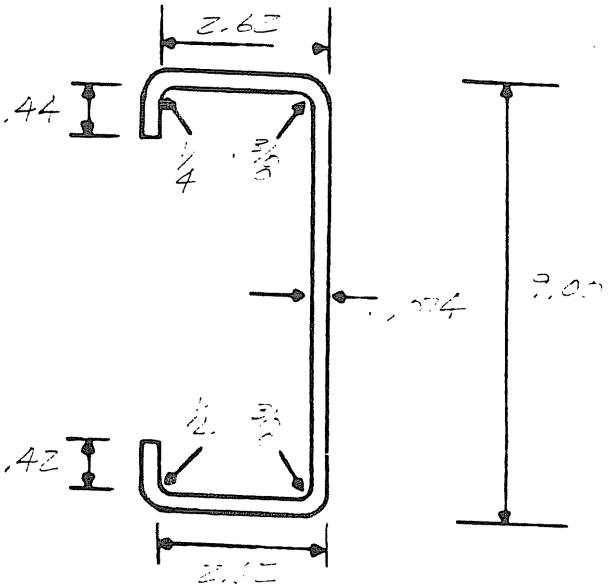
-Maximum vertical deflection was 2.8 in.

-Maximum lateral displacement was 0.32 in.

-Maximum brace force was 410 lbs. between the two test purlins.

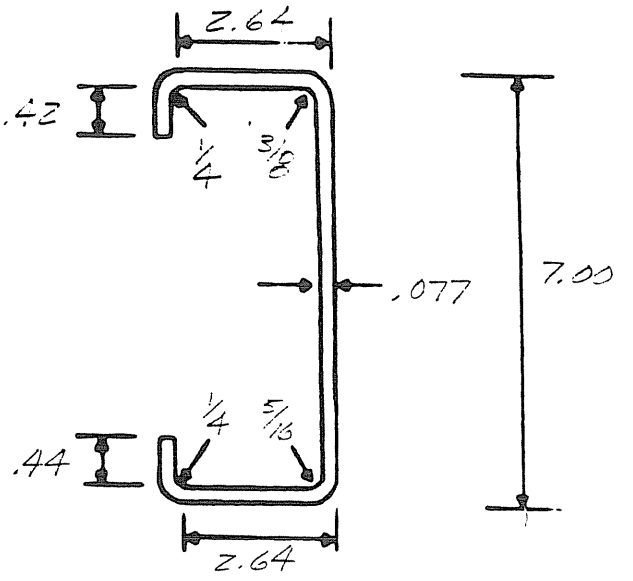


Interior (West) Purlin

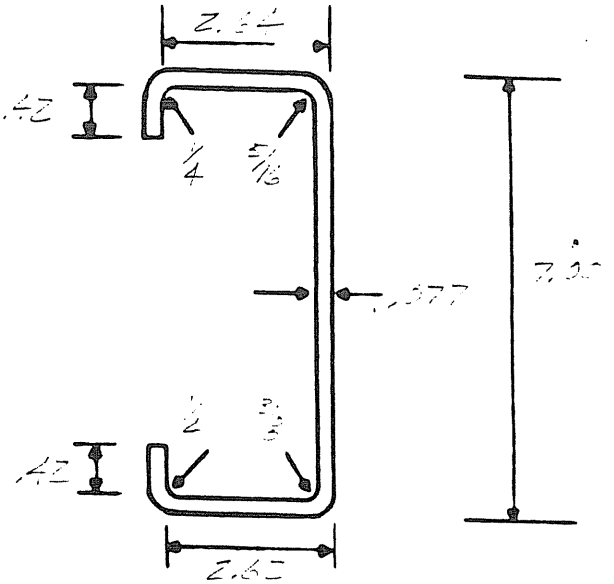


Interior (East) Purlin

Figure B.19 Measured Purlin Dimensions, Test 9(Interior)



Exterior (West) Purlin



Exterior (East) Purlin

Figure B.20 Measured Purlin Dimensions, Test 9 (Exterior)

```
---------------------------------------------------------------
A I S I  P U R L I N  A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 9 EAST TEST PURLIN
---------------------------------------------------------------

                          TOP              BOTTOM
FLANGE(in)              2.620              2.620
LIP(in)                 0.440              0.420
LIP ANGLE(deg)         88.000             85.000
RADIUS L/F(in)          0.250              0.250
RADIUS F/W(in)          0.375              0.375

TOTAL DEPTH(in)                 9
THICKNESS(in)                   0.074
YIELD STRENGTH(ksi)             56

                                          SECTION MODULII(in^3)
     MOMENTS OF INERTIA(in^4)          TOP                BOTTOM
GROSS=          13.003               2.917               2.910
STRENGTH=       13.003               2.917               2.910
DEFLECTION=     13.003
BE=    2.171   in
FC=    33.600   ksi
FT=    33.600   ksi
FBW=   30.430   ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)
           MC=      8.167   ft-k
           MT=      8.149   ft-k
           MW=      8.149   ft-k
           MU=     13.609   ft-k (1.67*allowable)
SPAN         =     25.000   ft.
UNIFORM LOAD=    174.196   plf (1.67*allowable)
DEFLECTION   =      2.291   in./100plf
```

Figure B.21 AISI Purlin Analysis, Test 9 Interior Purlin (East)

```
A I S I   P U R L I N   A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 9 WEST TEST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.660	2.640
LIP(in)	0.440	0.440
LIP ANGLE(deg)	87.000	88.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	9
THICKNESS(in)	0.067
YIELD STRENGTH(ksi)	56

	MOMENTS OF INERTIA(in^4)	SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	11.987	2.687	2.680
STRENGTH=	11.750	2.603	2.658
DEFLECTION=	11.987		

BE=	2.105	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	29.343	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	7.290	ft-k
MT=	7.444	ft-k
MW=	6.895	ft-k
MU=	11.514	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	147.381	plf (1.67*allowable)
DEFLECTION =	2.485	in./100plf

Figure B.22 AISI Purlin Analysis, Test 9 Interior Purlin (West)

```
A I S I   P U R L I N   A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 9 OUTER EAST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.640	2.620
LIP(in)	0.420	0.420
LIP ANGLE(deg)	87.000	87.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.375

TOTAL DEPTH(in)	7
THICKNESS(in)	0.077
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	7.526	2.173	2.176
STRENGTH=	7.526	2.173	2.176
DEFLECTION=	7.526		

```
BE=    2.251  in
FC=   33.600  ksi
FT=   33.600  ksi
FBW=  33.055  ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)
           MC=     6.085  ft-k
           MT=     6.092  ft-k
           MW=     6.661  ft-k
           MU=    10.161  ft-k (1.67*allowable)
SPAN         =    25.000  ft.
UNIFORM LOAD=   130.062  plf (1.67*allowable)
DEFLECTION   =     3.958  in./100plf
```

Figure B.23 AISI Purlin Analysis, Test 9 Exterior Purlin (East)

```
A I S I   P U R L I N   A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 9 OUTER WEST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.640	2.640
LIP(in)	0.420	0.440
LIP ANGLE(deg)	88.000	86.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.375	0.313

TOTAL DEPTH(in)	7
THICKNESS(in)	0.077
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	7.560	2.185	2.182
STRENGTH=	7.560	2.185	2.182
DEFLECTION=	7.560		

BE=	2.188	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	33.055	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	6.119	ft-k
MT=	6.111	ft-k
MW=	6.837	ft-k
MU=	10.205	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	130.624	plf (1.67*allowable)
DEFLECTION =	3.941	in./100plf

Figure B.24 AISI Purlin Anlaysis, Test 9 Exterior Purlin (West)

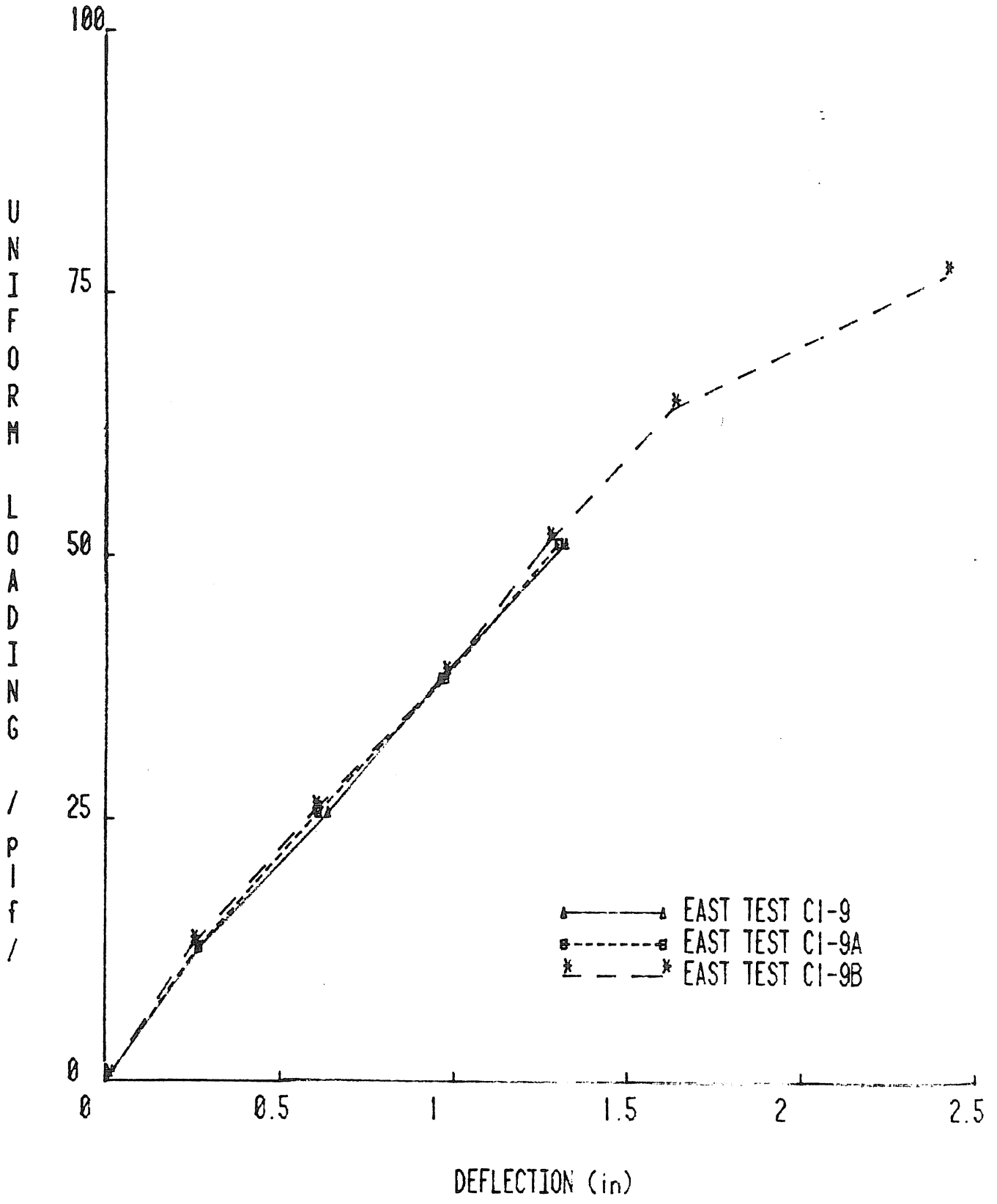


Figure B.25 Load vs. Vertical Deflection, Test 9

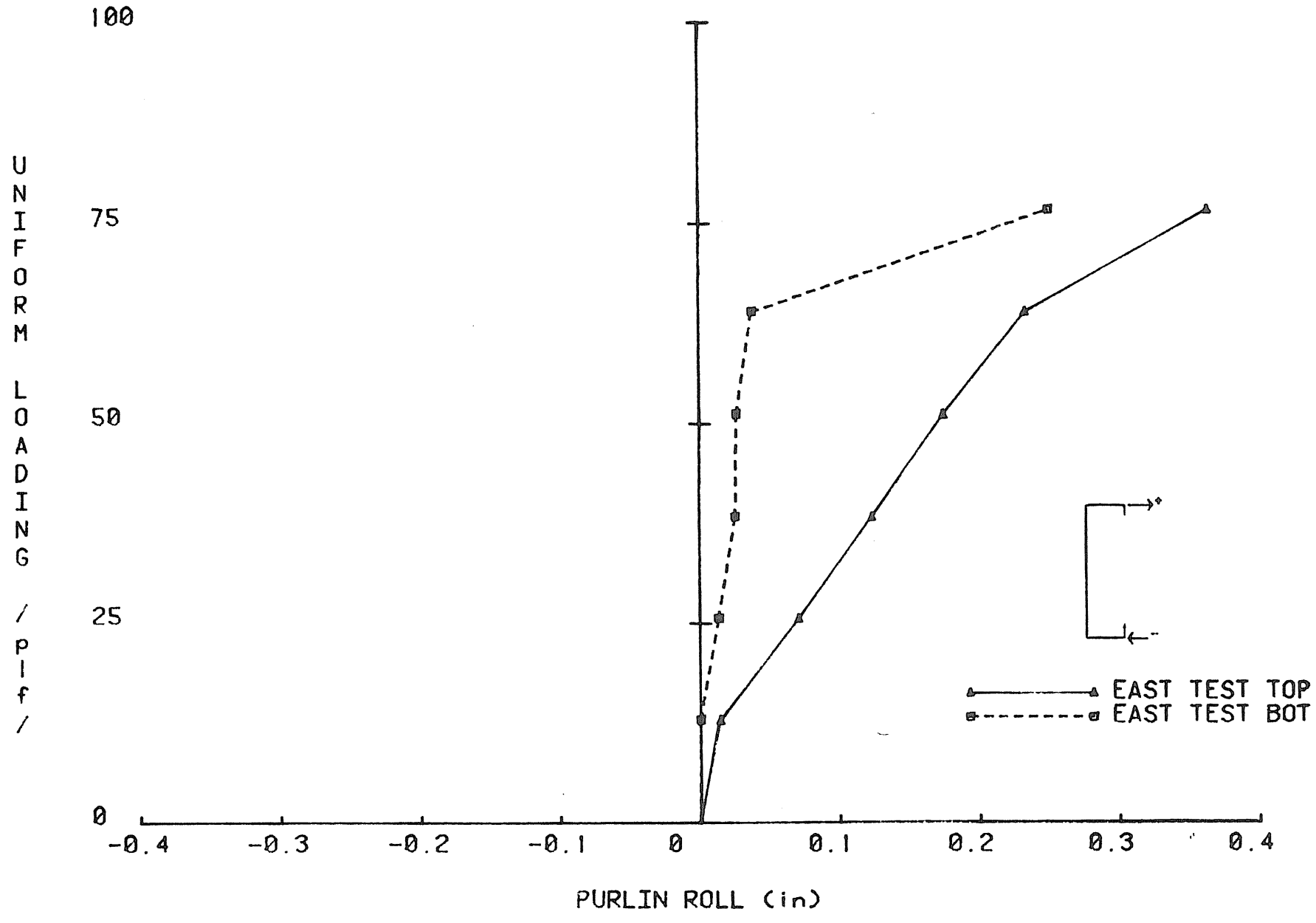


Figure B.26 Vertical Loading vs. Lateral Displacement, Test 9 (East)

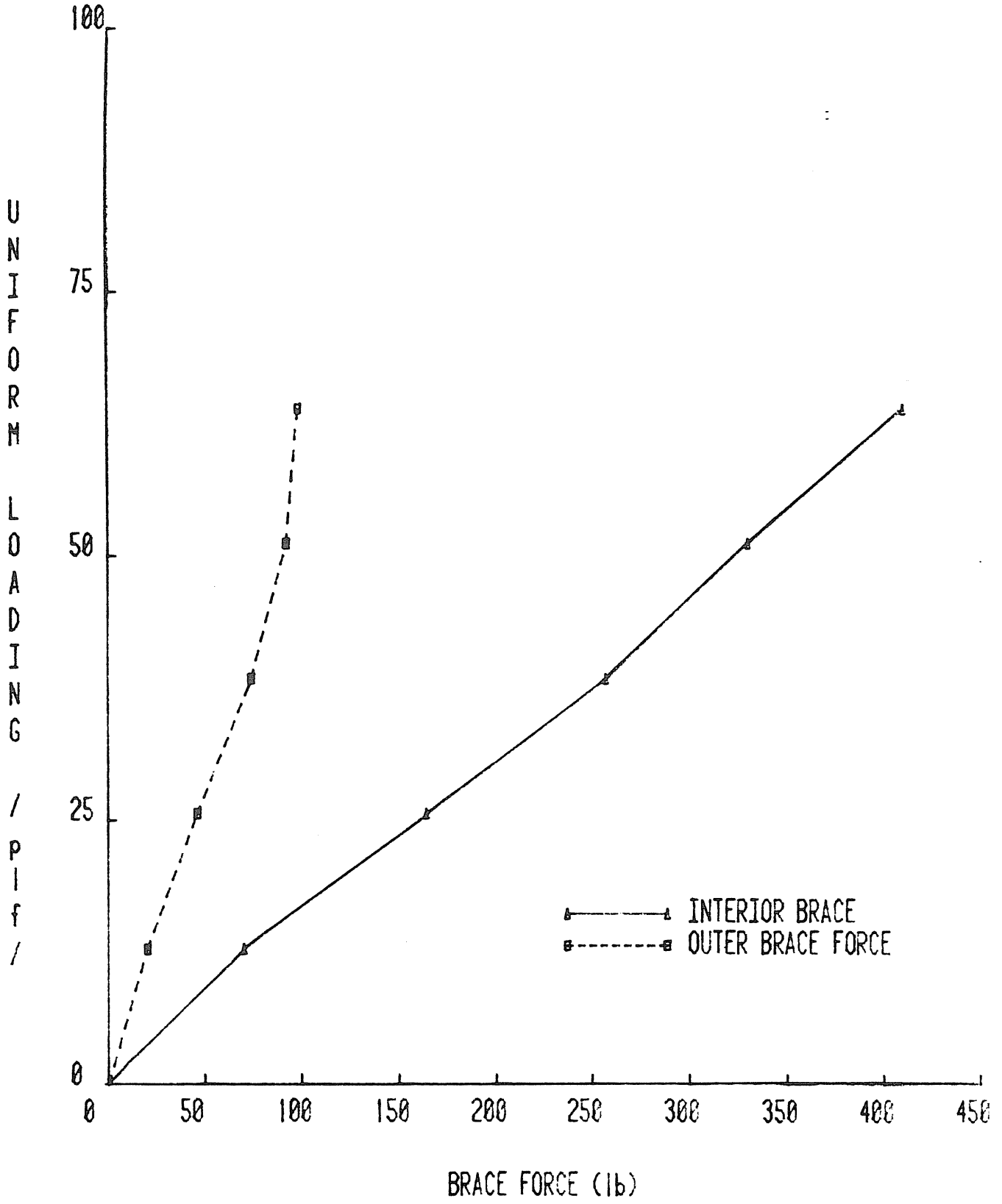


Figure B.27 Vertical Loading vs. Brace Force, Test 9

TEST SUMMARY

Project: MESCO C-Purlin Supported Roof Systems

Test No.: 10 Uplift

Test Date: 11-14-83

Purpose: Determine purlin strength for resisting uplift.

Span(s): 25'-0"

Thickness: 0.08 in. (14 gage) Moment of Inertia: 14.36 in.^{4}

Parameters: Test purlins in opposing orientation
Panel torsional restraint
Purlins clipped to rafters
2x4 wood blocks placed between flanges at 2, 5, & 10 ft. from center line and at center line of test purlins

Failure Load: 107.39 plf + 8.9 plf dead load = 116.3 plf

Failure Mode: Local buckling of compression flange of east test purlin at center line

Predicted Failure Loads:

Method	50-75% of AISI	Load	95.9 to 143.9 plf
Method		Load	
Method		Load	

Discussion:

-Failure load was 61% of AISI Constrained Bending.

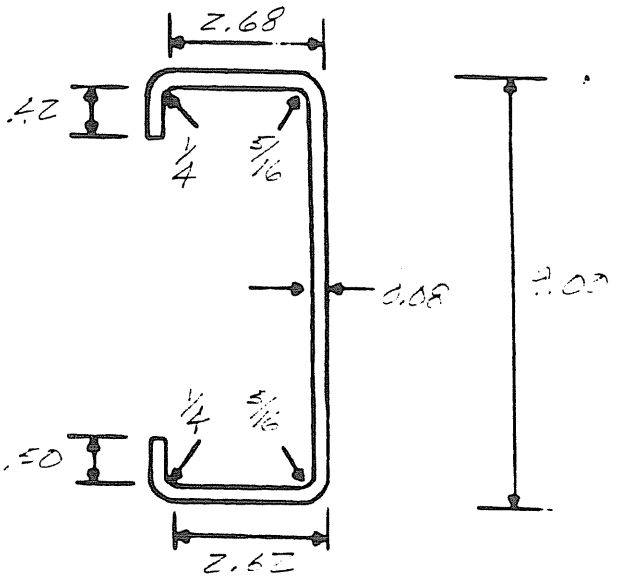
-Test purlins were braced at center line.

-Maximum vertical deflection was 3.1 in.

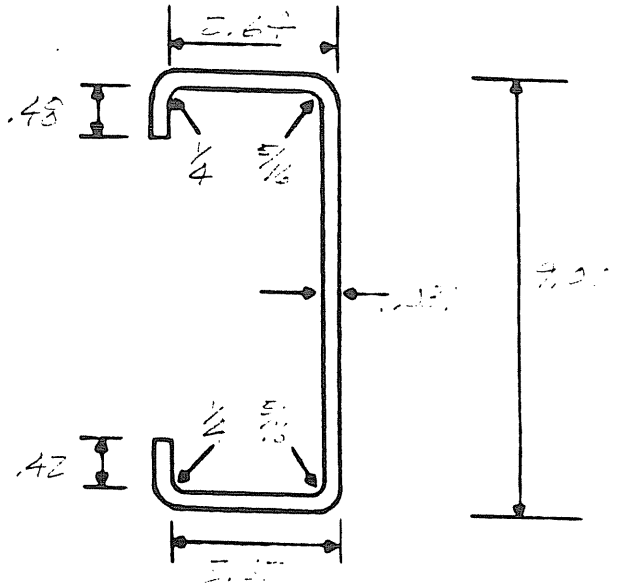
-Deflections were 28% more than predicted by AISI.

-Test purlins deflected 31-38% more than outer purlins.

-Maximum horizontal deflection was 0.5 in. and occurred at top flange of east test purlin. West test purlin was 14% less.

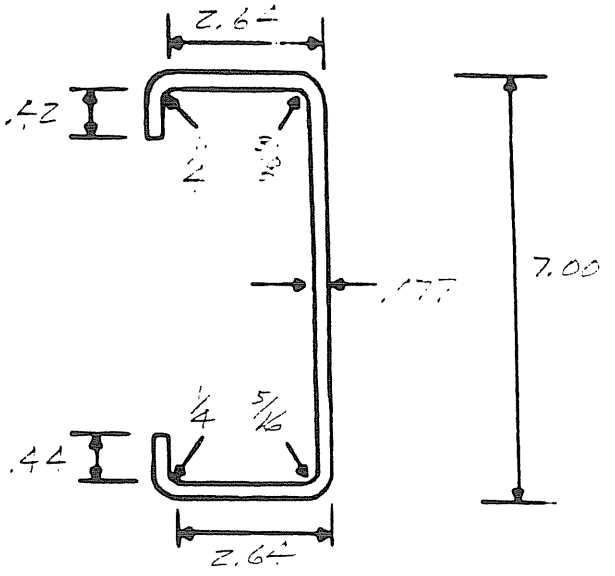


Interior (West) Purlin

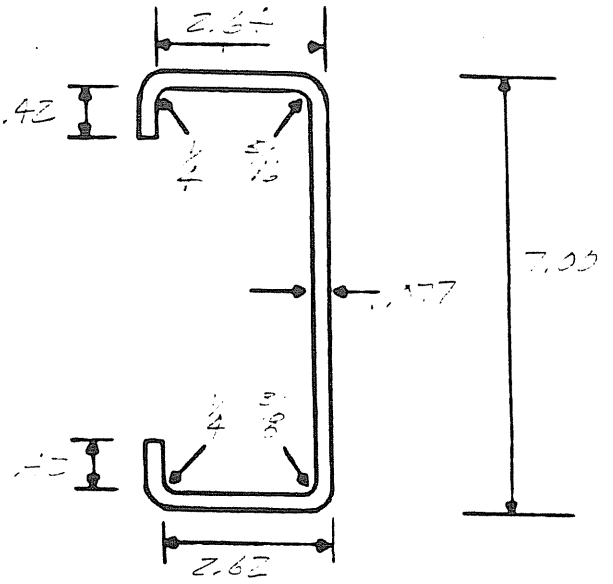


Interior (East) Purlin

Figure B.28 Measured Purlin Dimensions, Test 10 (Interior)



Exterior (West) Purlin



Exterior (East) Purlin

Figure B.29 Measured Purlin Dimensions, Test 10 (Exterior)

```
A I S I   P U R L I N   A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 10 UPLIFT EAST TEST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.640	2.620
LIP(in)	0.480	0.420
LIP ANGLE(deg)	89.000	88.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	9
THICKNESS(in)	0.081
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	14.360	3.236	3.204
STRENGTH=	14.360	3.236	3.204
DEFLECTION=	14.360		

BE=	2.247	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	31.328	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	9.061	ft-k
MT=	8.972	ft-k
MW=	9.178	ft-k
MU=	14.983	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	191.779	plf (1.67*allowable)
DEFLECTION =	2.075	in./100plf

Figure B.30 AISI Purlin Analysis, Test 10 Interior Purlin (East)

```
A I S I   P U R L I N   A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 10 UPLIFT WEST TEST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.680	2.620
LIP(in)	0.420	0.500
LIP ANGLE(deg)	89.000	87.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	9
THICKNESS(in)	0.08
YIELD STRENGTH(ksi)	56

	MOMENTS OF INERTIA(in^4)	SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	14.280	3.199	3.205
STRENGTH=	14.280	3.199	3.205
DEFLECTION=	14.280		

BE=	2.288	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	31.209	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	8.957	ft-k
MT=	8.973	ft-k
MW=	9.033	ft-k
MU=	14.957	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	191.455	plf (1.67*allowable)
DEFLECTION =	2.086	in./100plf

Figure B.31 AISI Purlin Analysis, Test 10 Interior Purlin (West)

```
A I S I   P U R L I N   A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 10 UPLIFT OUTER WEST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.640	2.640
LIP(in)	0.420	0.440
LIP ANGLE(deg)	88.000	86.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.375	0.313

TOTAL DEPTH(in)	7
THICKNESS(in)	0.077
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	7.560	2.185	2.182
STRENGTH=	7.560	2.185	2.182
DEFLECTION=	7.560		

BE=	2.188	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	33.055	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	6.119	ft-k
MT=	6.111	ft-k
MW=	6.837	ft-k
MU=	10.205	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	130.624	plf (1.67*allowable)
DEFLECTION =	3.941	in./100plf

Figure B.32 AISI Purlin Analysis, Test 10 Exterior Purlin (East)

```
A I S I   P U R L I N   A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 10 UPLIFT OUTER WEST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.640	2.620
LIP(in)	0.420	0.420
LIP ANGLE(deg)	87.000	87.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.375

TOTAL DEPTH(in)	7
THICKNESS(in)	0.077
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	7.526	2.173	2.176
STRENGTH=	7.526	2.173	2.176
DEFLECTION=	7.526		

```
BE=    2.251   in
FC=   33.600   ksi
FT=   33.600   ksi
FBW=  33.055   ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)
            MC=      6.085   ft-k
            MT=      6.092   ft-k
            MW=      6.061   ft-k
            MU=     10.161   ft-k (1.67*allowable)
SPAN          =     25.000   ft.
UNIFORM LOAD=    130.062   plf (1.67*allowable)
DEFLECTION    =      3.958   in./100plf
```

Figure B.33 AISI Purlin Analysis, Test 10 Exterior Purlin (West)

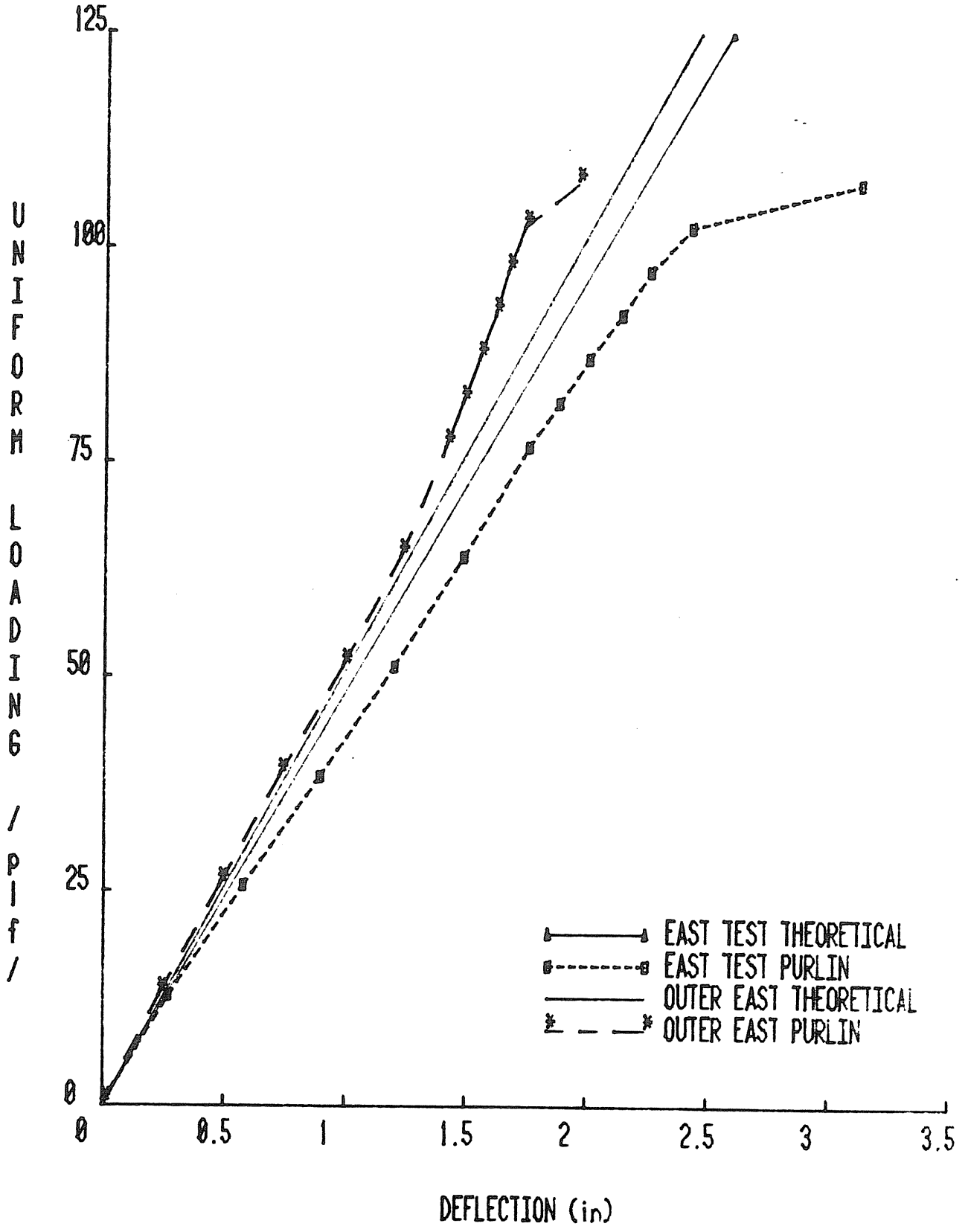


Figure B.34 Load vs. Vertical Deflection, Test 10

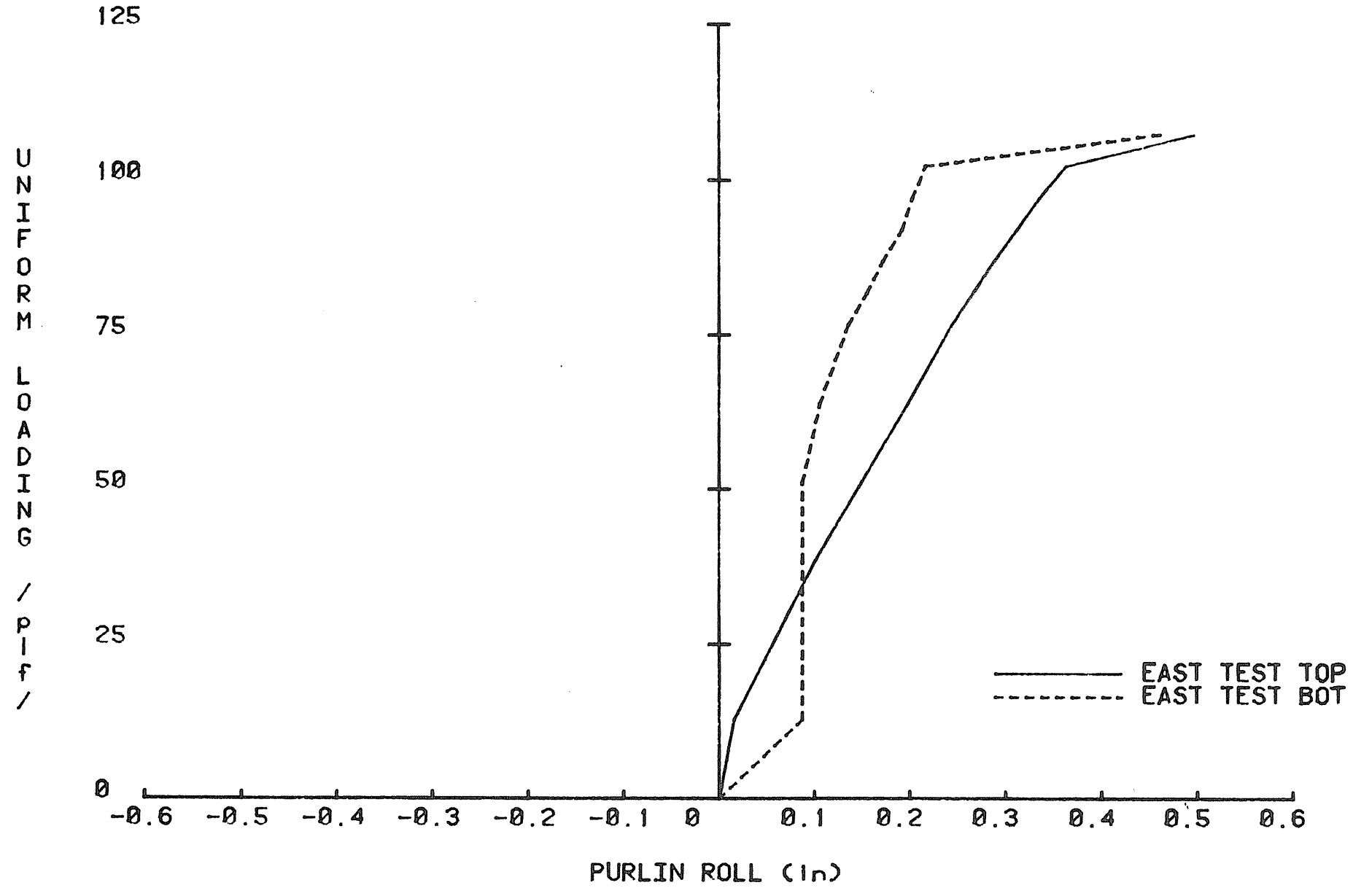


Figure B.35 Vertical Loading vs. Lateral Displacement, Test 10 (East)

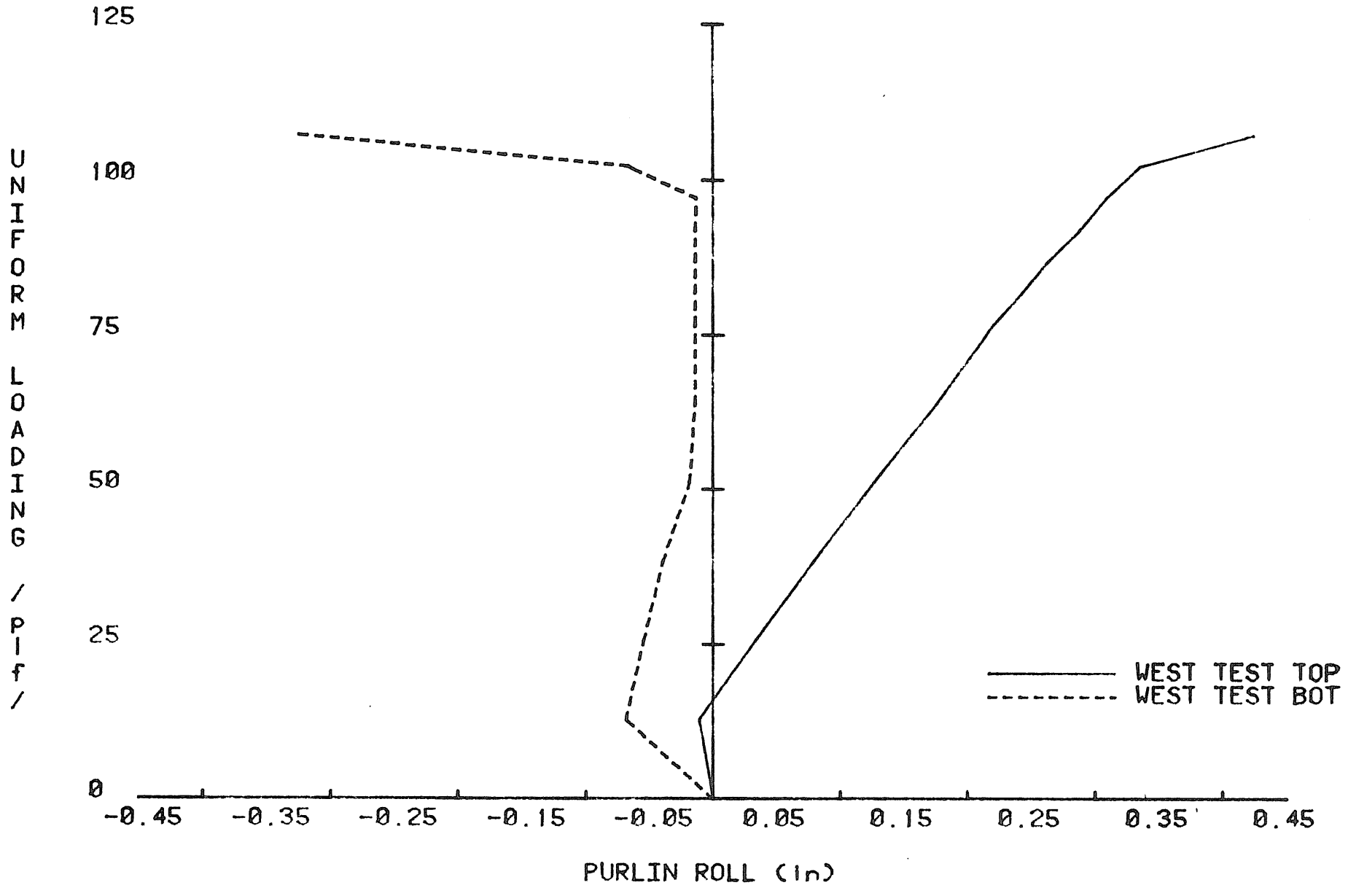


Figure B.36 Vertical Loading vs. Lateral Displacement, Test 10(West)

TEST SUMMARY

Project: MESCO C-Purlin Supported Roof Systems

Test No.: 11 Uplift

Test Date: 11-21-83

Purpose: Determine purlin strength to resist uplift.

Span(s): 25'-0"

Thickness: 0.079" (14 gage) Moment of Inertia: 14.0 $in.^4$

Parameters: Test purlins in opposing orientation
Panel torsional restraint
Purlins clipped to rafters
15 ft. 7x3 C-purlin was bolted to each test purlin, 7.5 ft. from center line

Failure Load: 102.3 plf + 8.9 plf dead load = 111.2 plf

Failure Mode: Local buckling of compression flange of east test purlin

Predicted Failure Loads:

Method 50-75% of AISI Load 93.8 to 140.7 plf

Method _____ Load _____

Method _____ Load _____

Discussion:

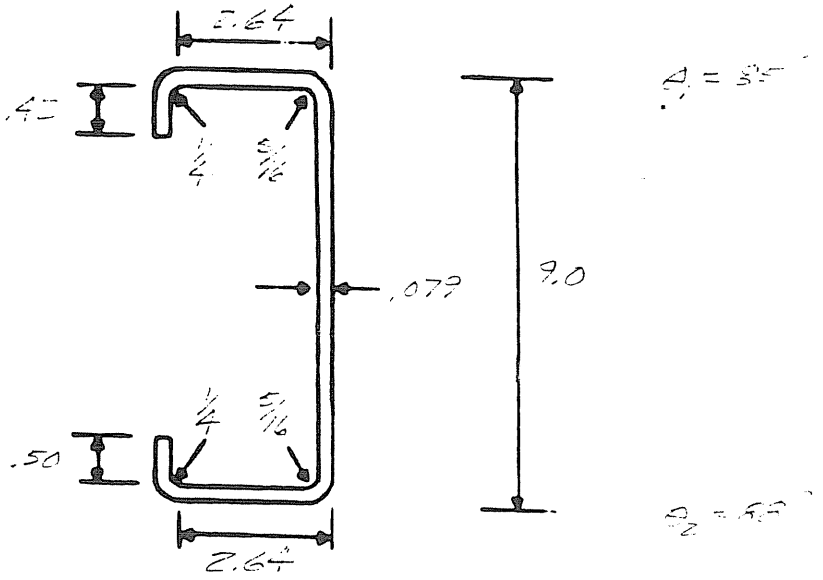
-Failure load was 59% of AISI Constrained Bending.

-Compression flange buckled near center line at 111.2 plf.

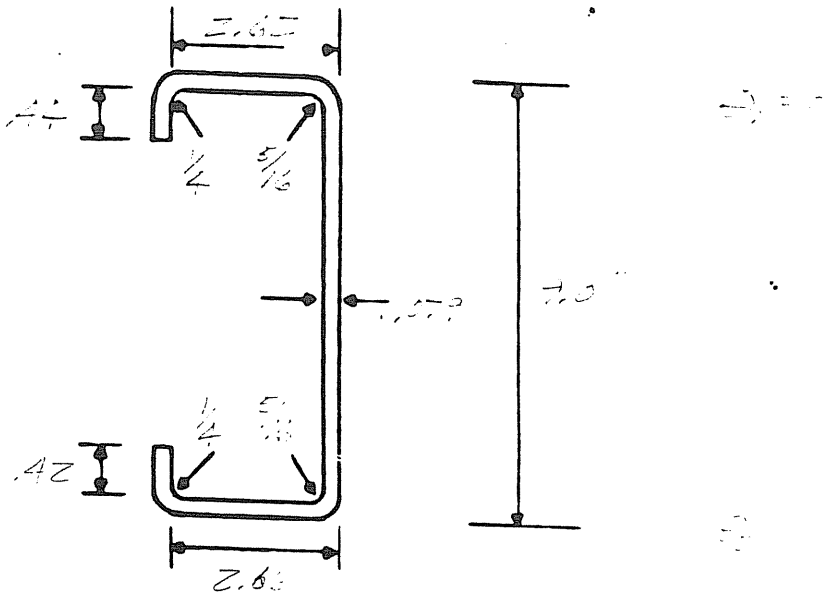
-Maximum vertical deflection was 2.3 in.

-Deflections were 4% more than predicted by AISI.

-Test purlins deflected 2-13% more than outer purlins.

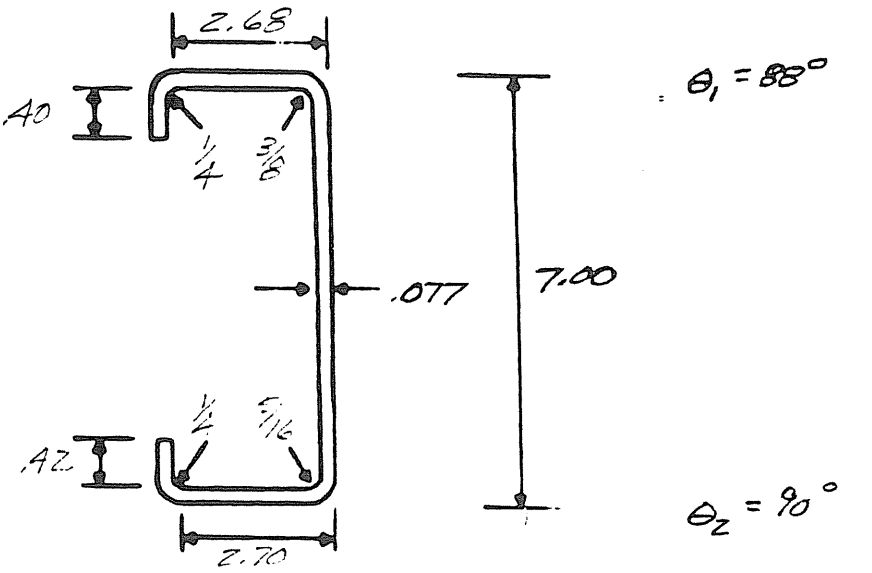


Interior (West) Purlin

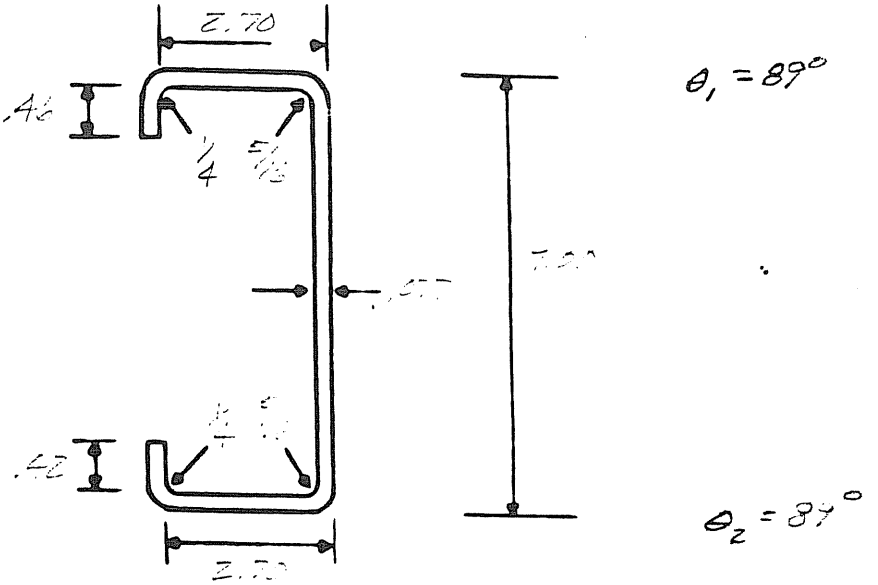


Interior (East) Purlin

Figure B.37 Measured Purlin Dimensions, Test 11 (Interior)



Exterior (West) Purlin



Exterior (East) Purlin

Figure B.38 Measured Purlin Dimensions, Test 11 (Exterior)

```
A I S I   P U R L I N   A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 11 INTERIOR EAST
```

	TOP	BOTTOM
FLANGE(in)	2.620	2.660
LIP(in)	0.440	0.420
LIP ANGLE(deg)	88.000	84.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	9
THICKNESS(in)	0.079
YIELD STRENGTH(ksi)	56

	MOMENTS OF INERTIA(in^4)	SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	14.003	3.134	3.145
STRENGTH=	14.003	3.134	3.145
DEFLECTION=	14.003		

BE=	2.229	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	31.088	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	8.776	ft-k
MT=	8.805	ft-k
MW=	8.314	ft-k
MU=	14.656	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	187.593	plf (1.67*allowable)
DEFLECTION =	2.128	in./100plf

Figure B.39 AISI Purlin Analysis, Test 11 Interior Purlin (East)

```
A I S I  P U R L I N  A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO 11 INTERIOR WEST
```

	TOP	BOTTOM
FLANGE(in)	2.640	2.640
LIP(in)	0.420	0.500
LIP ANGLE(deg)	85.000	88.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	9
THICKNESS(in)	0.079
YIELD STRENGTH(ksi)	56

	MOMENTS OF INERTIA(in^4)	SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	14.079	3.142	3.171
STRENGTH=	14.079	3.142	3.171
DEFLECTION=	14.079		

```
BE=    2.249   in
FC=   33.600   ksi
FT=   33.600   ksi
FBW=  31.088   ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)
           MC=     8.797   ft-k
           MT=     8.879   ft-k
           MW=     8.833   ft-k
           MU=    14.690   ft-k (1.67*allowable)
SPAN         =    25.000   ft.
UNIFORM LOAD=   188.034   plf (1.67*allowable)
DEFLECTION   =     2.116   in./100plf
```

Figure B.40 AISI Purlin Analysis, Test 11 Interior Purlin (West)

```
A I S I  P U R L I N  A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 11 OUTER EAST
```

	TOP	BOTTOM
FLANGE(in)	2.700	2.700
LIP(in)	0.460	0.420
LIP ANGLE(deg)	89.000	89.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	7
THICKNESS(in)	0.077
YIELD STRENGTH(ksi)	56

	MOMENTS OF INERTIA(in^4)	SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	7.709	2.233	2.221
STRENGTH=	7.692	2.225	2.219
DEFLECTION=	7.709		

BE=	2.292	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	33.055	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	6.231	ft-k
MT=	6.214	ft-k
MW=	6.822	ft-k
MU=	10.378	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	132.837	plf (1.67*allowable)
DEFLECTION =	3.865	in./100plf

Figure B.41 AISI Purlin Analysis, Test 11 Exterior Purlin (East)

```
A I S I  P U R L I N  A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 11 OUTER WEST
```

	TOP	BOTTOM
FLANGE(in)	2.680	2.700
LIP(in)	0.400	0.420
LIP ANGLE(deg)	88.000	90.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.375	0.313

TOTAL DEPTH(in)	7
THICKNESS(in)	0.077
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)	SECTION MODULII(in^3) TOP	BOTTOM
GROSS= 7.620	2.200	2.203
STRENGTH= 7.620	2.200	2.203
DEFLECTION= 7.620		

BE=	2.228	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	33.055	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	6.160	ft-k
MT=	6.168	ft-k
MW=	6.882	ft-k
MU=	10.287	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	131.674	plf (1.67*allowable)
DEFLECTION =	3.910	in./100plf

Figure B.42 AISI Purlin Analysis, Test 11 Exterior Purlin (West)

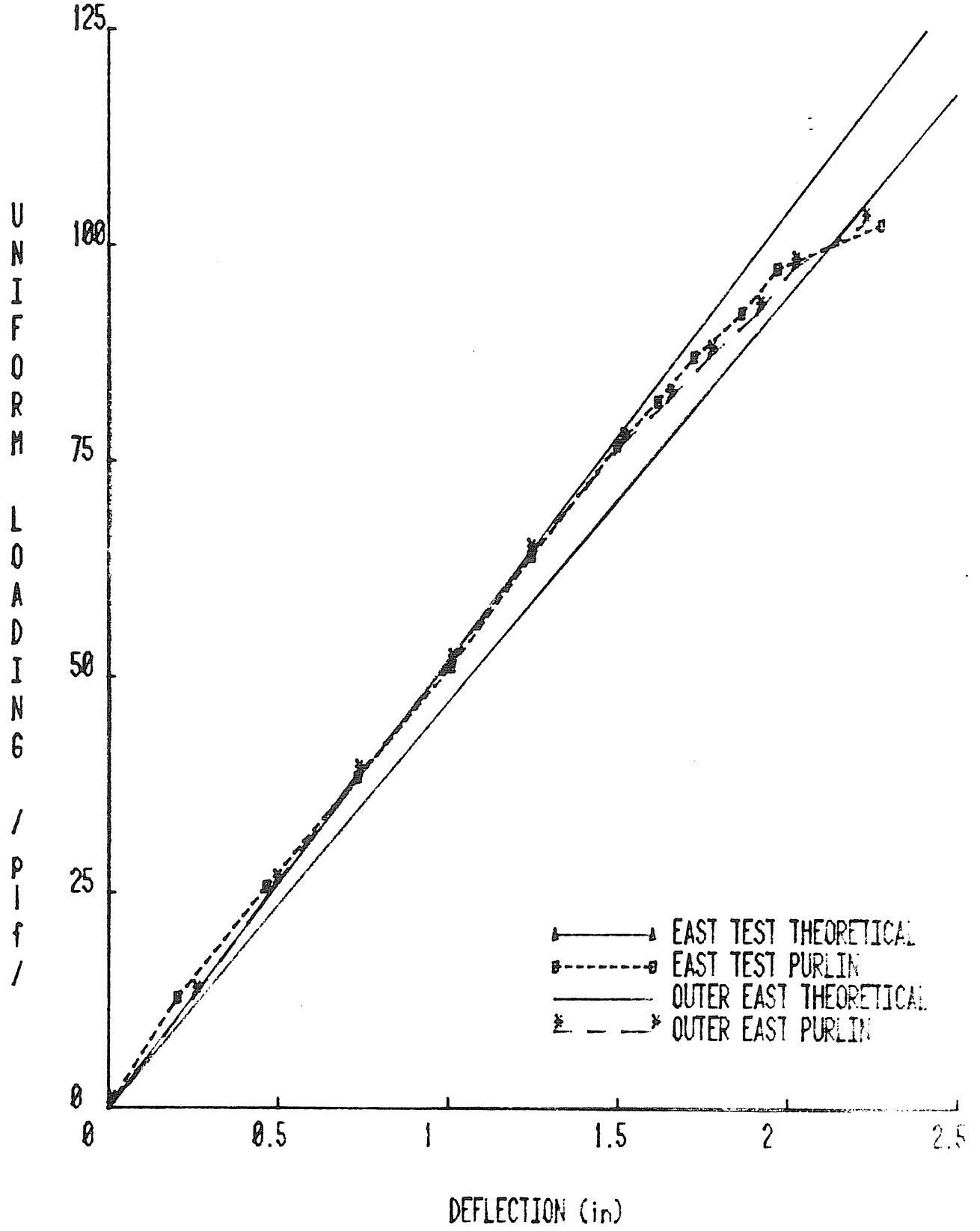


Figure B.43 Load vs. Vertical Deflection, Test 11

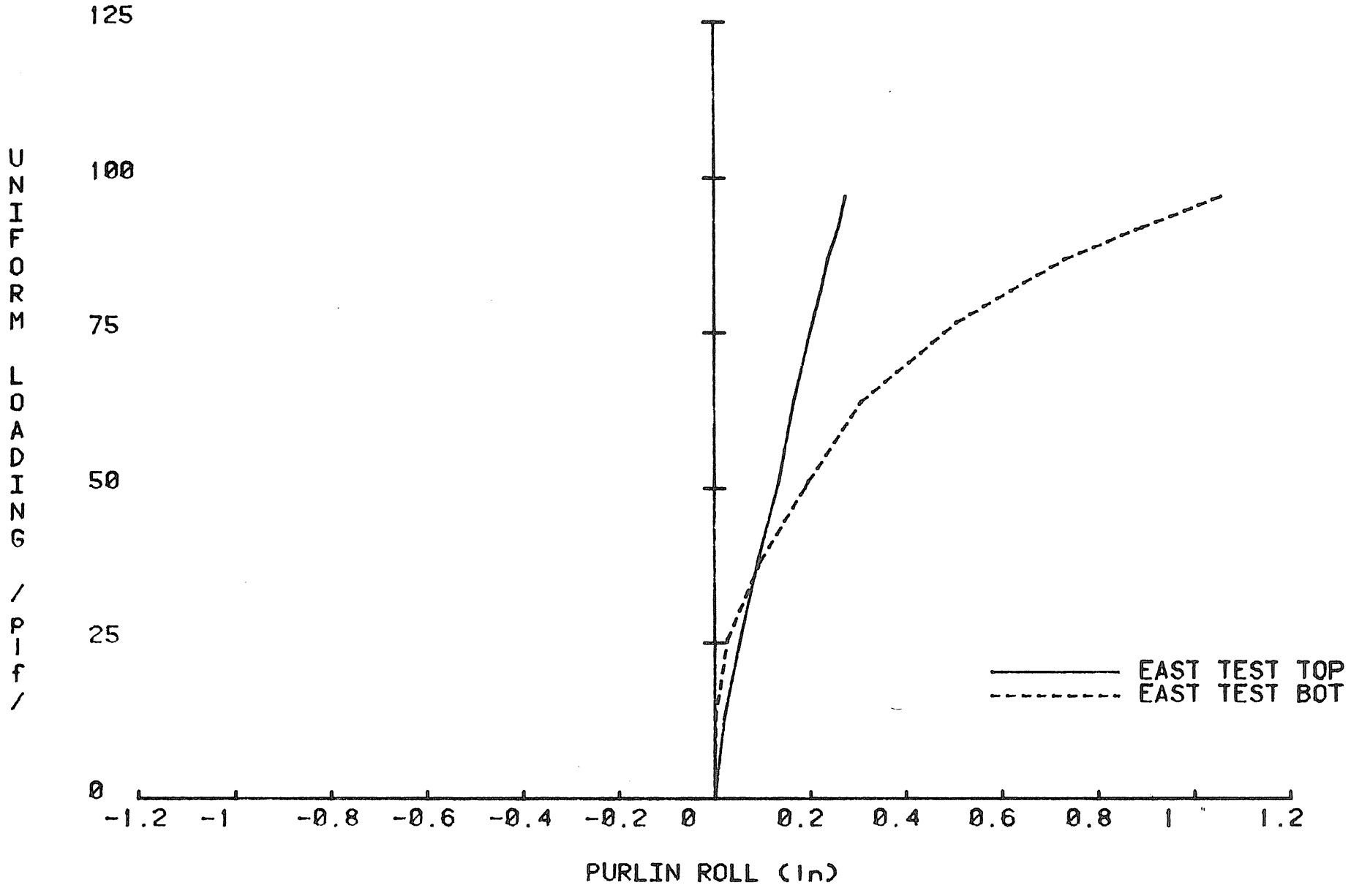


Figure B.44 Vertical Loading vs. Lateral Displacement, Test 11 (East)

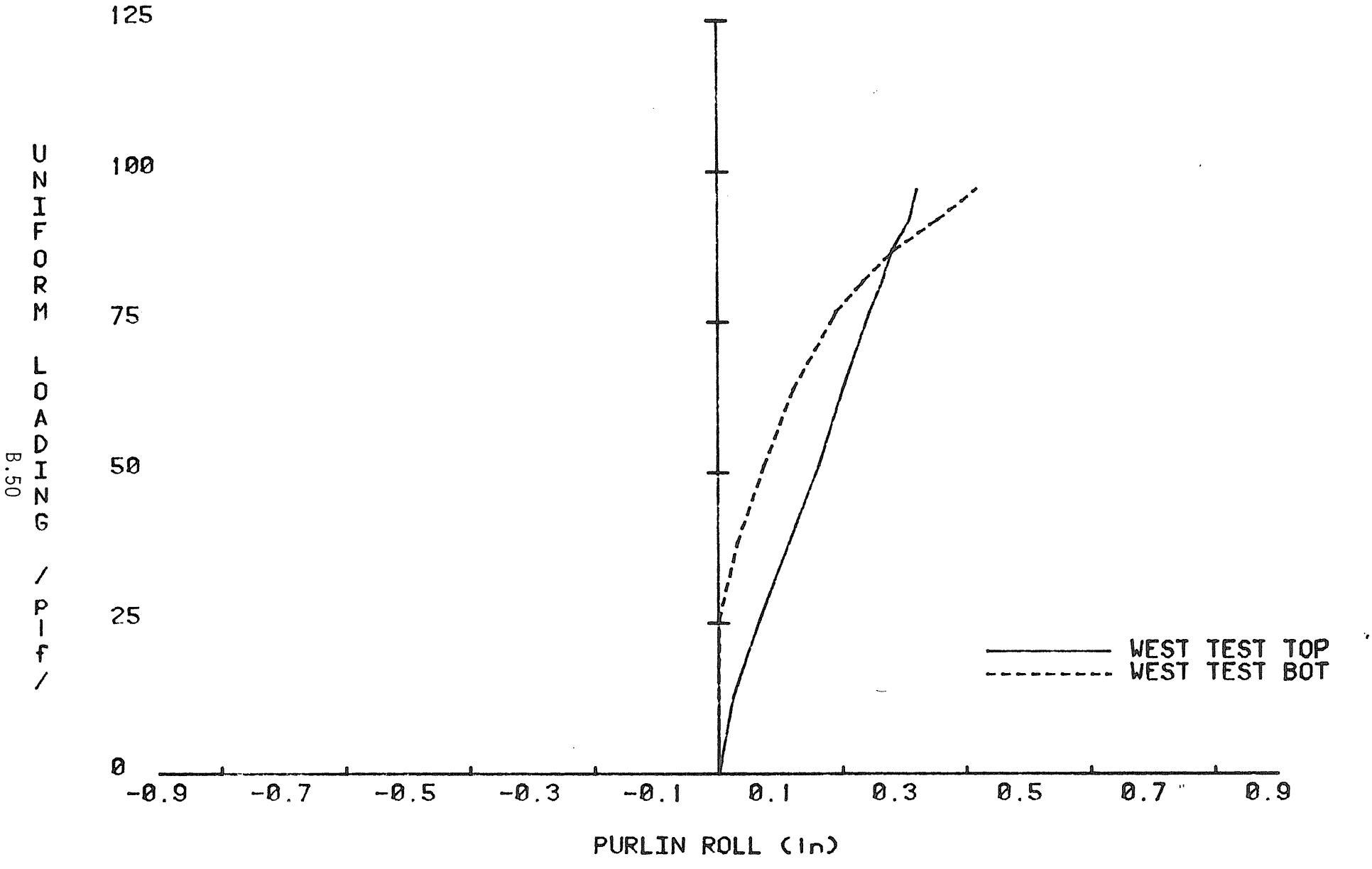


Figure B.45 Vertical Loading vs. Lateral Displacement, Test 11 (West)

TEST SUMMARY

Project: MESCO C-Purlin Supported Roof Systems

Test No.: 12 Uplift

Test Date: 11-30-83

Purpose: Determine purlin strength for resisting uplift.

Span(s): 25'-0"

Thickness: .079 (14 gage) Moment of Inertia: 13.94

Parameters: Test purlins in opposing orientation
Panel torsional restraint
Purlins clipped to rafters
Bracing at third points of all purlins,
2 in. from compression flange

Failure Load 122.73 plf + 8.9 plf dead load = 131.6 plf

Failure Mode: Local buckling of compression flange of east test purlin

Predicted Failure Loads:

Method 50-75% of AISI Load 92.8 to 139.2 plf

Method _____ Load _____

Method _____ Load _____

Discussion:

-Failure load was 71% of AISI Constrained Bending.

-Compression flange of east test purlin buckled at 131.6 plf.

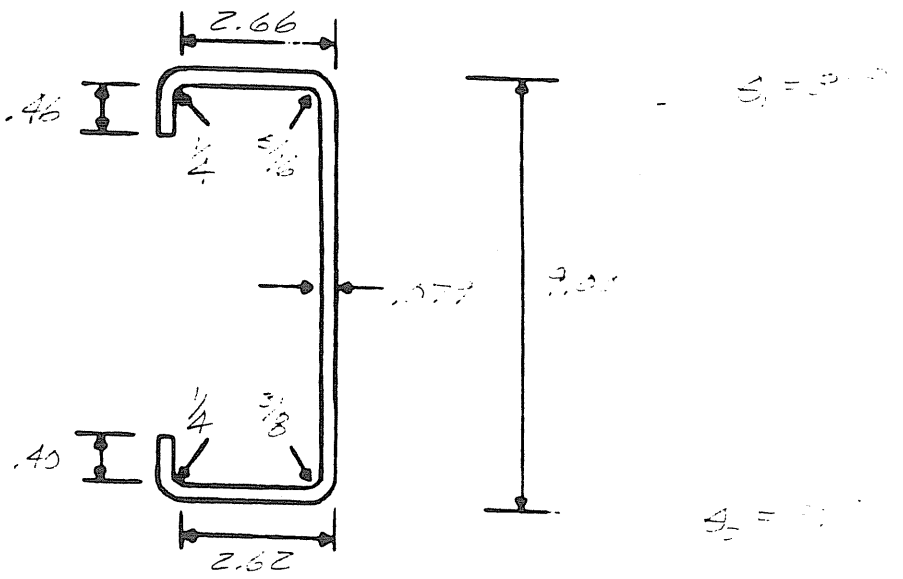
-Maximum vertical deflection was 3.5 in.

-Vertical deflections were 25% more than predicted by AISI.

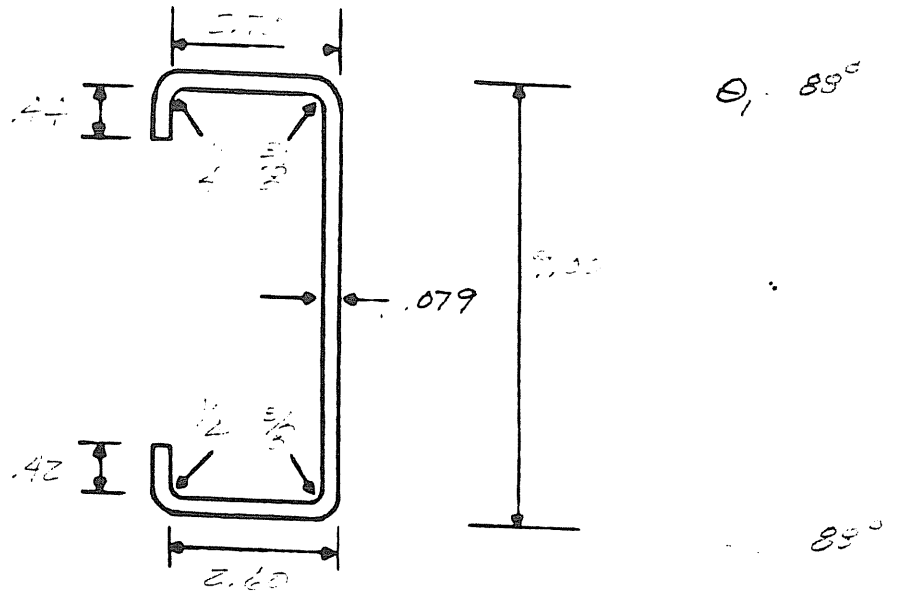
-Test purlins deflected 27-30% more than outer purlins.

-Maximum horizontal deflection was 0.59 in. and occurred at the top flange of west test purlin.

-Horizontal deflection of bottom flanges was approximately zero.

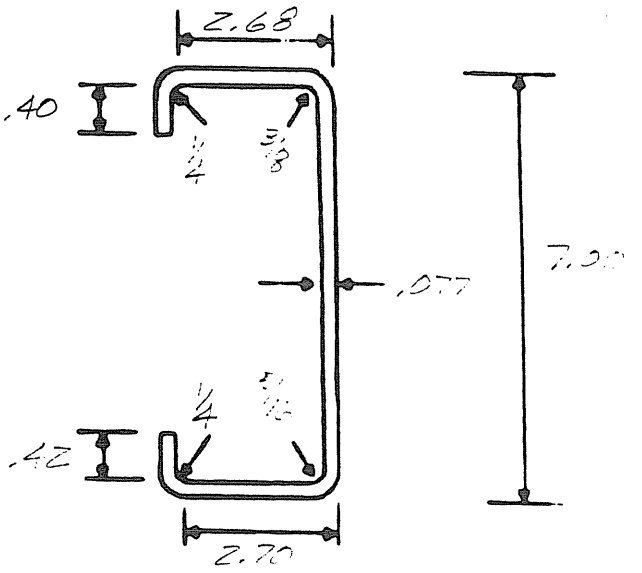


Interior (West) Purlin

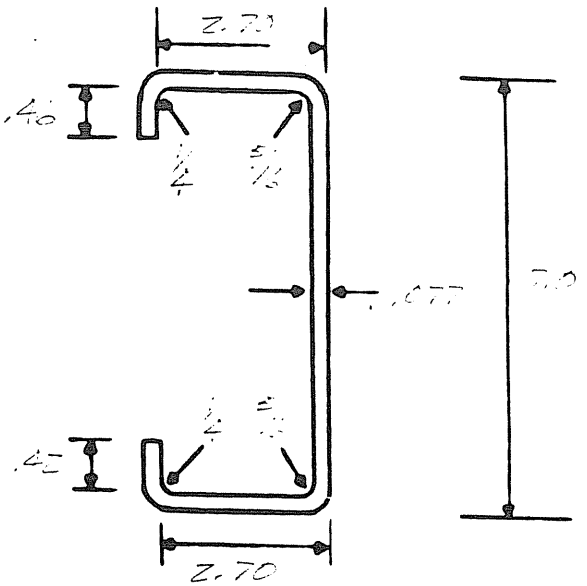


Interior (East) Purlin

Figure B.46 Measured Purlin Dimensions, Test 12 (Interior)



Exterior (West) Purlin



Exterior (East) Purlin

Figure B.47 Measured Purlin Dimensions, Test 12 (Exterior)

```
A I S I   P U R L I N   A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 12 UPLIFT EAST TEST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.700	2.600
LIP(in)	0.440	0.420
LIP ANGLE(deg)	88.000	88.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.375	0.375

TOTAL DEPTH(in)	9
THICKNESS(in)	0.079
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	13.940	3.150	3.101
STRENGTH=	13.940	3.150	3.101
DEFLECTION=	13.940		

BE=	2.246	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	31.088	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	8.821	ft-k
MT=	8.682	ft-k
MW=	9.005	ft-k
MU=	14.498	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	185.579	plf (1.67*allowable)
DEFLECTION =	2.137	in./100plf

Figure B.48 AISI Purlin Analysis, Test 12 Interior Purlin (East)

```
A I S I   P U R L I N   A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 12 UPLIFT WEST TEST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.660	2.620
LIP(in)	0.460	0.400
LIP ANGLE(deg)	88.000	87.000
RADIUS L/F(in)	0.250	0.313
RADIUS F/W(in)	0.313	0.375

TOTAL DEPTH(in)	9
THICKNESS(in)	0.079
YIELD STRENGTH(ksi)	56

	MOMENTS OF INERTIA(in^4)	SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	14.008	3.147	3.134
STRENGTH=	14.008	3.147	3.134
DEFLECTION=	14.008		

BE=	2.269	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	31.088	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	8.811	ft-k
MT=	8.776	ft-k
MW=	8.852	ft-k
MU=	14.656	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	187.598	plf (1.67*allowable)
DEFLECTION =	2.127	in./100plf

Figure B.49 AISI Purlin Analysis, Test 12 Interior Purlin (West)

```
---------------------------------------------------------
A I S I  P U R L I N  A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 12 UPLIFT OUTER EAST PURLIN
---------------------------------------------------------
                        TOP             BOTTOM
FLANGE(in)            2.700             2.700
LIP(in)               0.460             0.420
LIP ANGLE(deg)       89.000            89.000
RADIUS L/F(in)        0.250             0.250
RADIUS F/W(in)        0.313             0.313

TOTAL DEPTH(in)               7
THICKNESS(in)             0.077
YIELD STRENGTH(ksi)          56

                                        SECTION MODULII(in^3)
     MOMENTS OF INERTIA(in^4)            TOP              BOTTOM
GROSS=          7.709                 2.233             2.221
STRENGTH=       7.692                 2.225             2.219
DEFLECTION=     7.709
BE=    2.292  in
FC=   33.600  ksi
FT=   33.600  ksi
FBW=  33.055  ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)
           MC=      6.231  ft-k
           MT=      6.214  ft-k
           MW=      6.822  ft-k
           MU=     10.378  ft-k (1.67*allowable)
SPAN         =     25.000  ft.
UNIFORM LOAD=    132.837  plf (1.67*allowable)
DEFLECTION   =      3.865  in./100plf
```

Figure B.50 AISI Purlin Analysis, Test 12 Exterior Purlin (East)

```
------------------------------------------------------------
A I S I  P U R L I N  A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST  12 UPLIFT OUTER WEST PURLIN
------------------------------------------------------------

                          TOP              BOTTOM
FLANGE(in)              2.680              2.700
LIP(in)                 0.400              0.420
LIP ANGLE(deg)         88.000             90.000
RADIUS L/F(in)          0.250              0.250
RADIUS F/W(in)          0.375              0.313

TOTAL DEPTH(in)                 7
THICKNESS(in)                   0.077
YIELD STRENGTH(ksi)             56

                                          SECTION MODULII(in^3)
     MOMENTS OF INERTIA(in^4)          TOP                BOTTOM
GROSS=          7.620              2.200              2.203
STRENGTH=       7.620              2.200              2.203
DEFLECTION=     7.620
BE=    2.228  in
FC=    33.600  ksi
FT=    33.600  ksi
FBW=   33.055  ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)
           MC=      6.160  ft-k
           MT=      6.168  ft-k
           MW=      6.882  ft-k
           MU=     10.287  ft-k (1.67*allowable)
SPAN         =     25.000  ft.
UNIFORM LOAD=    131.674  plf (1.67*allowable)
DEFLECTION   =      3.910  in./100plf
```

Figure B.51 AISI Purlin Analysis, Test 12 Exterior Purlin (West)

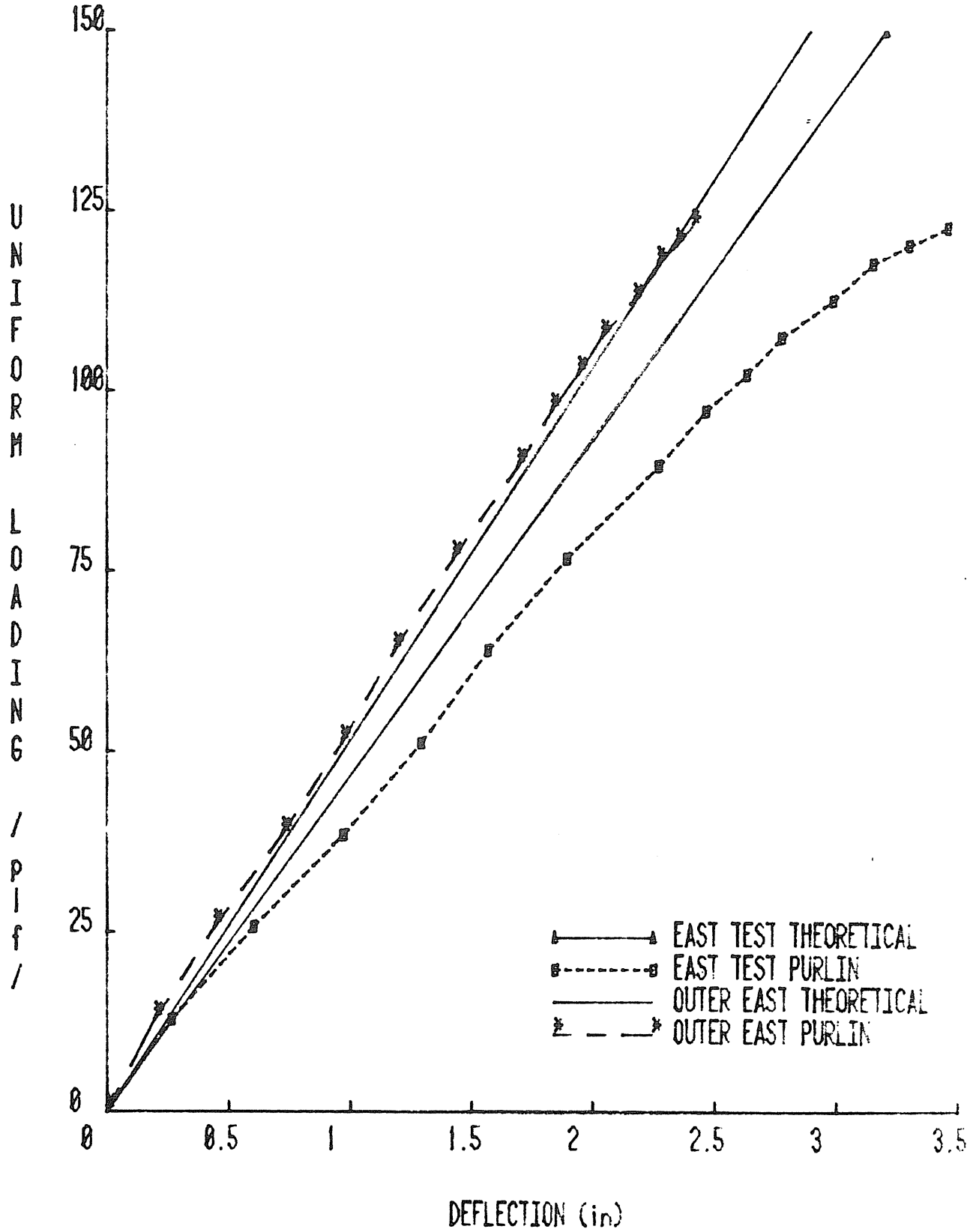


Figure B.52 Load vs. Vertical Deflection, Test 12

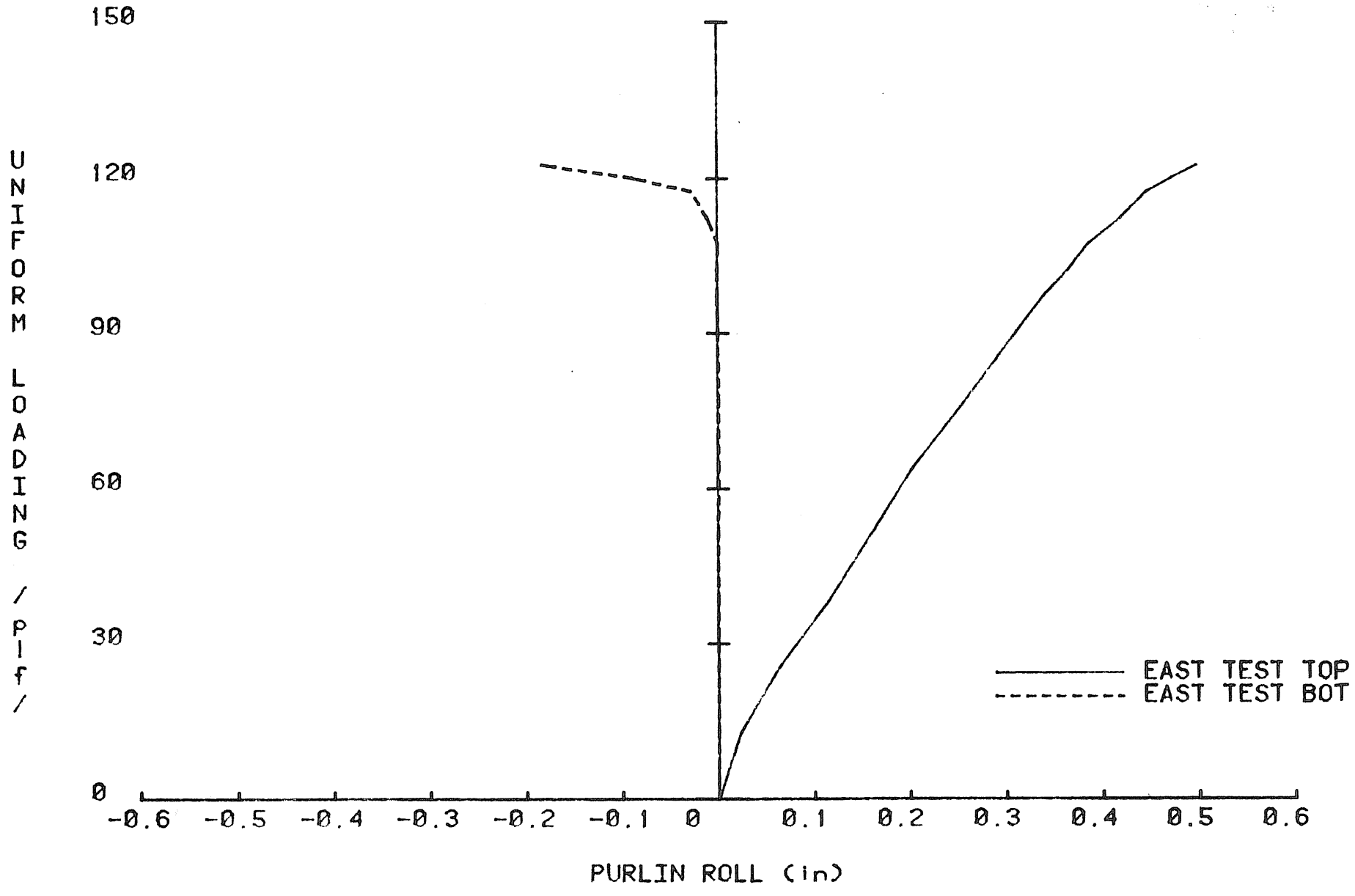


Figure B.53 Vertical Loading vs. Lateral Displacement, Test 12 (East)

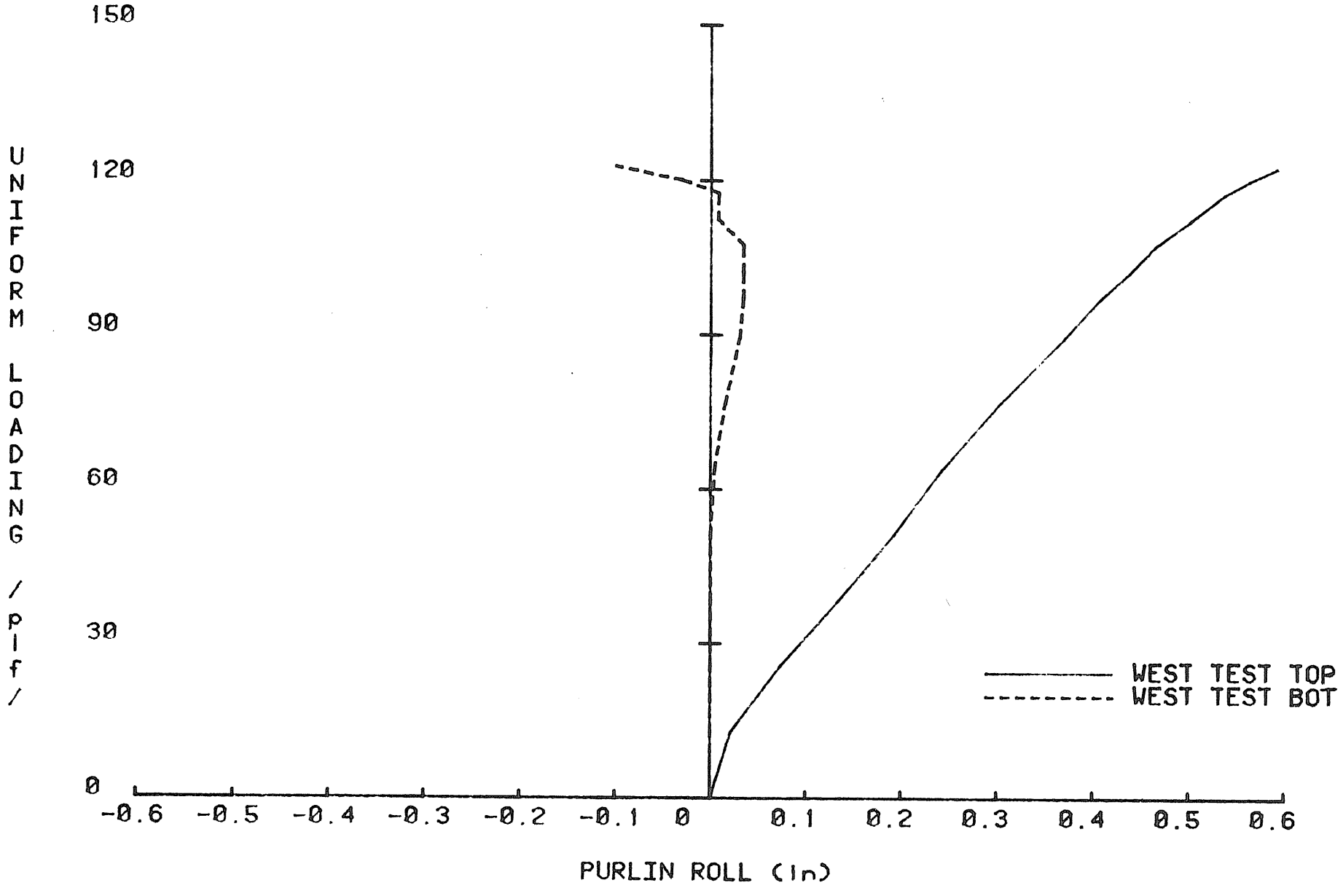


Figure B.54 Vertical Loading vs. Lateral Displacement, Test 12 (West)

TEST SUMMARY

Project: MESCO C-Purlin Supported Roof Systems

Test No.: 13 Uplift

Test Date: 12-5-83

Purpose: Determine purlin strength for resisting uplift.

Span(s): 25'-0"

Thickness: 0.079 in. (14 gage) Moment of Inertia: 13.86 $in.^4$

Parameters: Test purlins in opposing orientation
Panel torsional restraint
Purlins clipped to rafters
Bracing at ends and 2.5' each side of center line

Failure Load: 115.06 plf + 8.9 plf D.L. = 123.96 plf

Failure Mode: Local buckling of compression flange of east test purlin

Predicted Failure Loads:

Method	50-75% of AISI	Load	92.6 to 138.9 plf
Method		Load	
Method		Load	

Discussion:

-Failure load was 67% of AISI Constrained Bending.

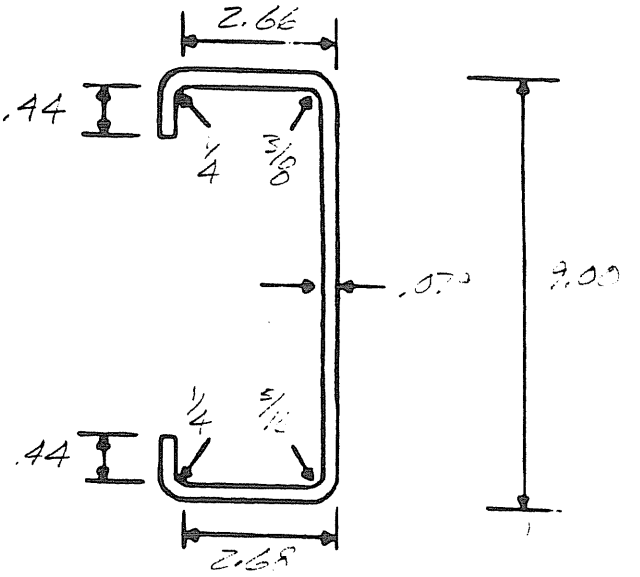
-Compression flange of east test purlin buckled at 123.96 plf.

-Maximum vertical deflection was 3.02 in.

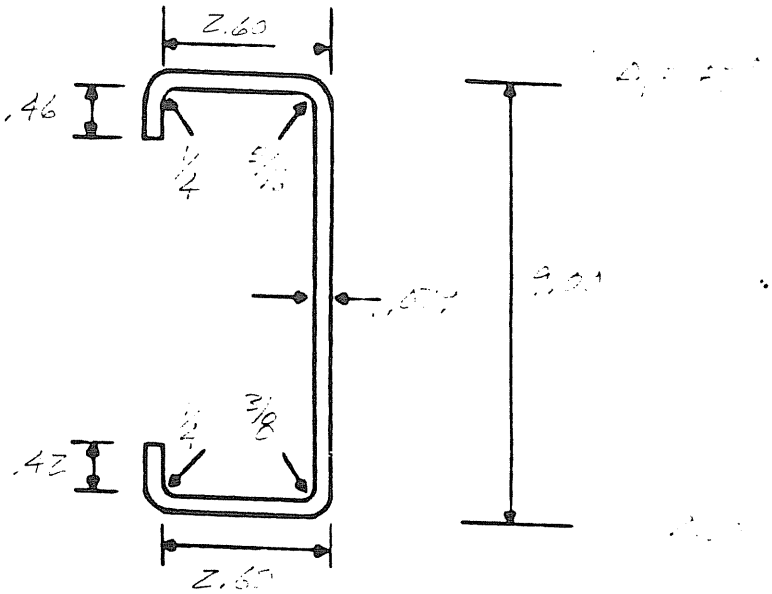
-Vertical deflections were 18% more than predicted by AISI.

-Test purlins deflected 26-28% more than outer purlins.

-Top flange rolled 75-80% more than bottom flange.

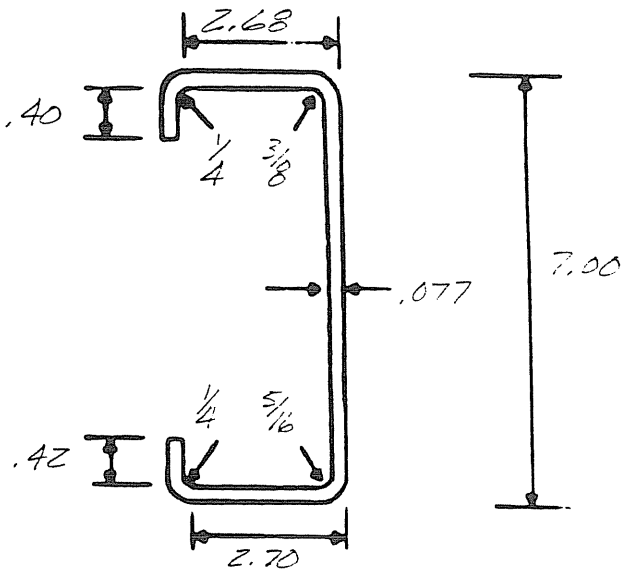


Interior (West) Purlin

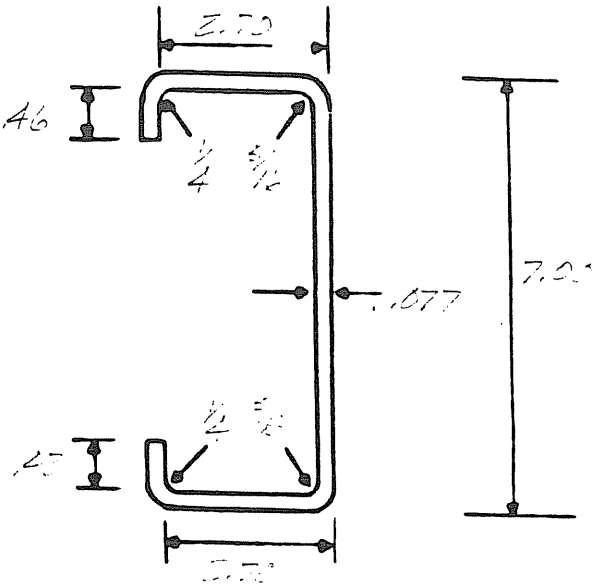


Interior (East) Purlin

Figure B.55 Measured Purlin Dimensions, Test 13 (Interior)



Exterior (West) Purlin



Exterior (East) Purlin

Figure B.56 Measured Purlin Dimensions, Test 13 (Exterior)

A I S I P U R L I N A N A L Y S I S
C-SECTION
IDENTIFICATION: MESCO TEST 13 UPLIFT EAST TEST PURLIN

	TOP	BOTTOM
FLANGE(in)	2.600	2.600
LIP(in)	0.460	0.420
LIP ANGLE(deg)	87.000	88.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.375

TOTAL DEPTH(in)	9
THICKNESS(in)	0.079
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULI(in^3) TOP	BOTTOM
GROSS=	13.855	3.108	3.105
STRENGTH=	13.855	3.108	3.105
DEFLECTION=	13.855		

BE=	2.209	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	31.088	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	8.702	ft-k
MT=	8.693	ft-k
MW=	8.741	ft-k
MU=	14.517	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	185.818	PLF (1.67*allowable)
DEFLECTION =	2.150	in./100#/ft

Figure B.57 AISI Purlin Analysis, Test 13 Interior Purlin (East)

A I S I P U R L I N A N A L Y S I S
C-SECTION
IDENTIFICATION: MESCO TEST 13 UPLIFT WEST TEST PURLIN

	TOP	BOTTOM
FLANGE(in)	2.660	2.680
LIP(in)	0.440	0.440
LIP ANGLE(deg)	87.000	88.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.375	0.313

TOTAL DEPTH(in)	9
THICKNESS(in)	0.079
YIELD STRENGTH(ksi)	58

MOMENTS OF INERTIA(in^4)		SECTION MODULI (in^3) TOP	BOTTOM
GROSS=	14.075	3.158	3.173
STRENGTH=	14.075	3.158	3.153
DEFLECTION=	14.075		

BE=	2.206	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	31.088	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	8.842	ft-k
MT=	8.830	ft-k
MW=	9.019	ft-k
MU=	14.745	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	188.741	plf (1.67*allowable)
DEFLECTION =	2.117	in./100-lf

Figure B.58 AISI Purlin Analysis, Test 13 Interior Purlin (West)

A I S I P U R L I N A N A L Y S I S
C-SECTION
IDENTIFICATION: MESCO TEST 13 UPLIFT OUTER EAST PURLIN

	TOP	BOTTOM
FLANGE(in)	2.700	2.700
LIP(in)	0.460	0.420
LIP ANGLE(deg)	89.000	89.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	7
THICKNESS(in)	0.077
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULI(in^3) TOP	BOTTOM
GROSS=	7.709	2.233	2.225
STRENGTH=	7.692	2.225	2.219
DEFLECTION=	7.709		

XC=	2.292	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	33.055	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	6.231	ft-k
MT=	6.214	ft-k
MW=	6.822	ft-k
MU=	10.378	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	132.837	plf (1.67*allowable)
DEFLECTION =	3.865	in./100plf

Figure B.59 AISI Purlin Analysis, Test 13 Exterior Purlin (East)

A I S I P U R L I N A N A L Y S I S
C-SECTION
IDENTIFICATION: MESCO TEST 13 UPLIFT OUTER WEST PURLIN

	TOP	BOTTOM
FLANGE(in)	2.680	2.700
LIP(in)	0.400	0.420
LIP ANGLE(deg)	88.000	90.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.375	0.313

TOTAL DEPTH(in)	7
THICKNESS(in)	0.077
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULI(in^3) TOP	BOTTOM
GROSS=	7.620	2.200	2.203
STRENGTH=	7.620	2.200	2.203
DEFLECTION=	7.620		

BE=	2.228	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	33.055	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	6.160	ft-k
MT=	6.168	ft-k
MW=	6.882	ft-k
MU=	10.287	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	131.674	plf (1.67*allowable)
DEFLECTION =	3.910	in./100plf

Figure B.60 AISI Purlin Analysis, Test 13 Exterior Purlin (West)

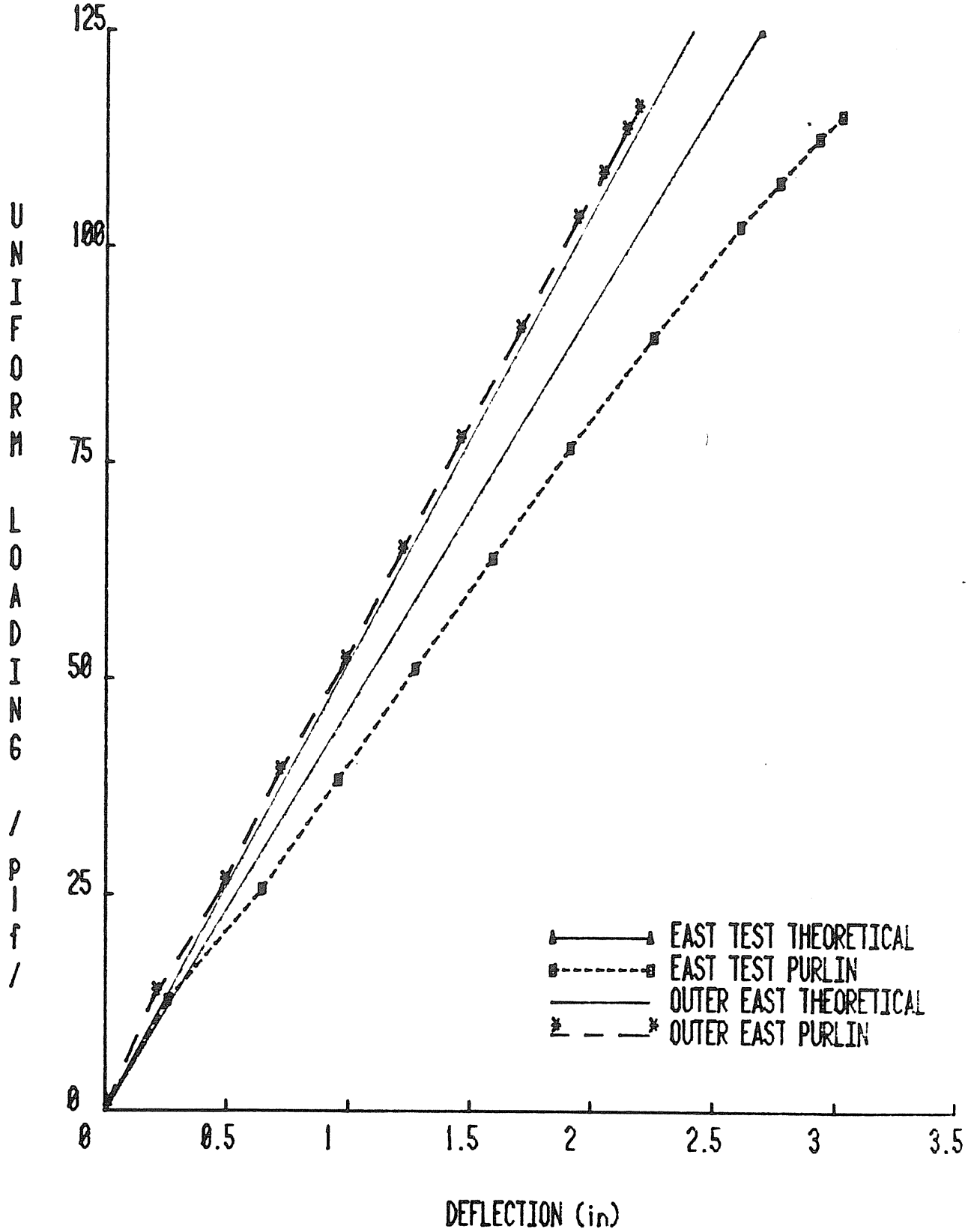


Figure B.61 Load vs. Vertical Deflection, Test 13

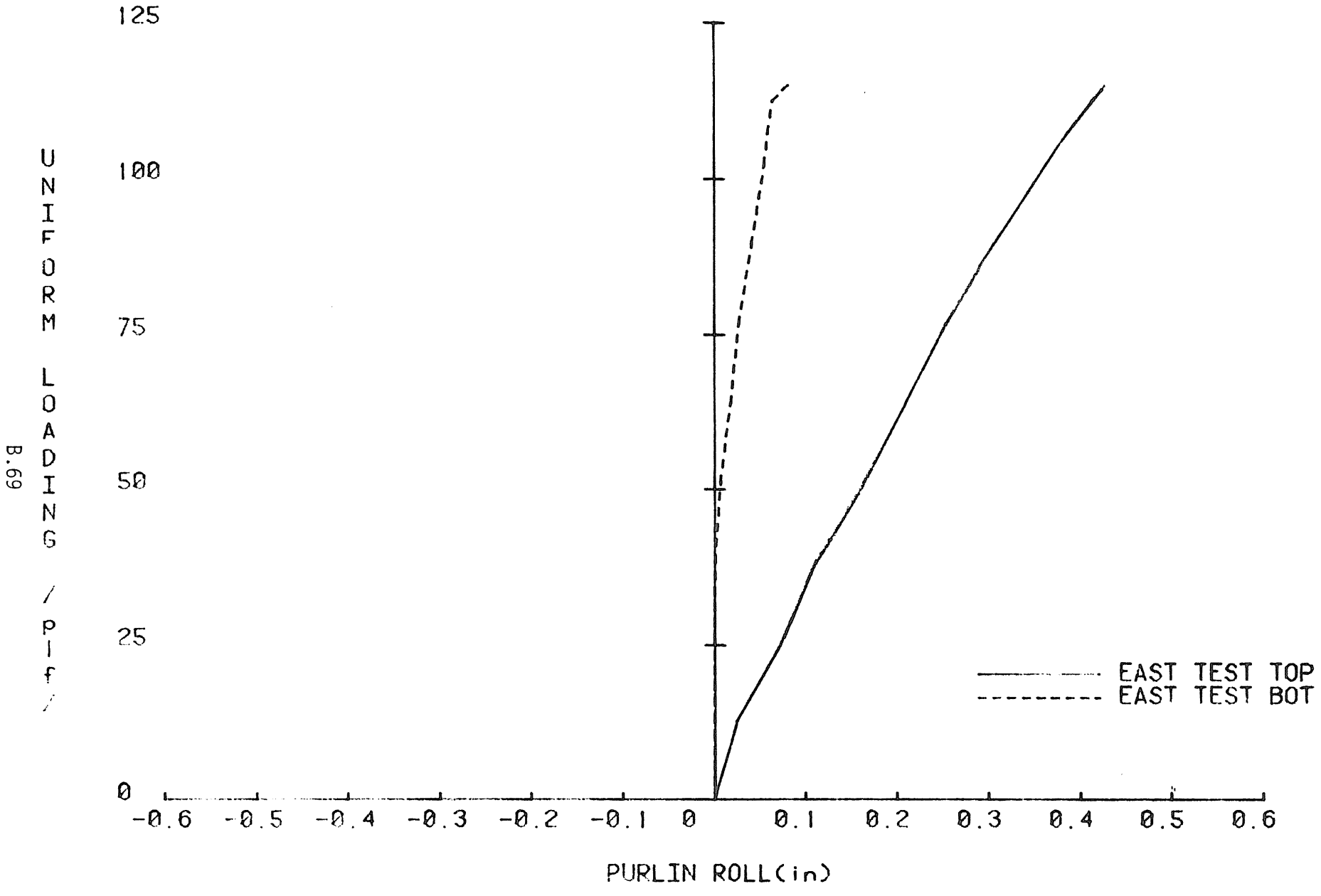


Figure B.62 Vertical Loading vs. Lateral Displacement, Test 13 (East)

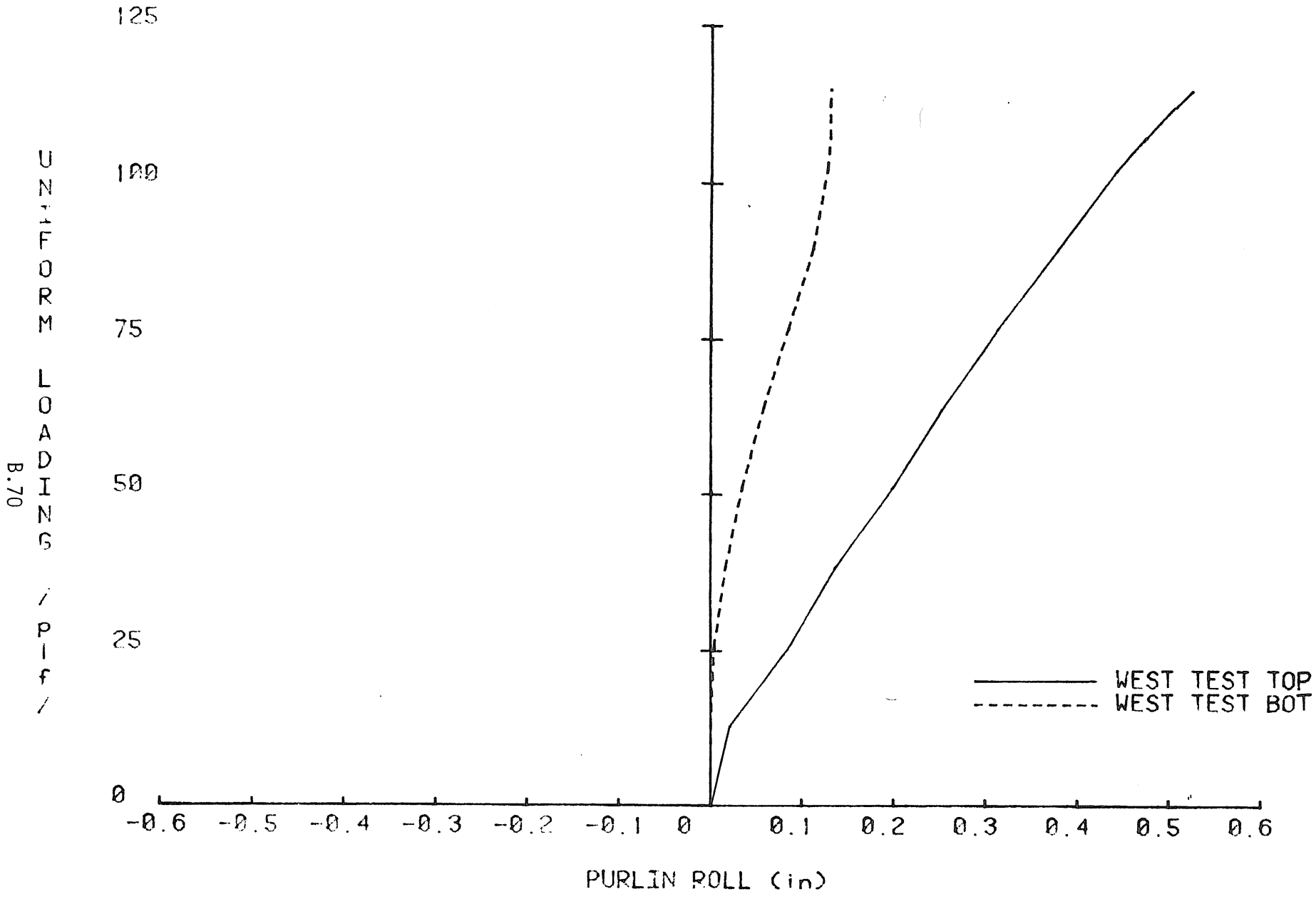


Figure B.63 Vertical Loading vs. Lateral Displacement, Test 13 (West)

TEST SUMMARY

Project: MESCO C-Purlin Supported Roof Systems

Test No.: 14 Uplift

Test Date: 12-7-83

Purpose: Determine purlin strength for resisting uplift.

Span(s): 25'-0"

Thickness: 0.067 (14 gage) Moment of Inertia: 11.69 $in.^4$

Parameters: Test purlins in opposing orientation
Panel torsional restraint
Purlins clipped to rafters
Bracing at ends and third points of test and outer purlins

Failure Load: 84.4 plf + 8.9 D.L. = 93.3 plf

Failure Mode: Local buckling of compression flange of test purlins near third point brace.

Predicted Failure Loads:

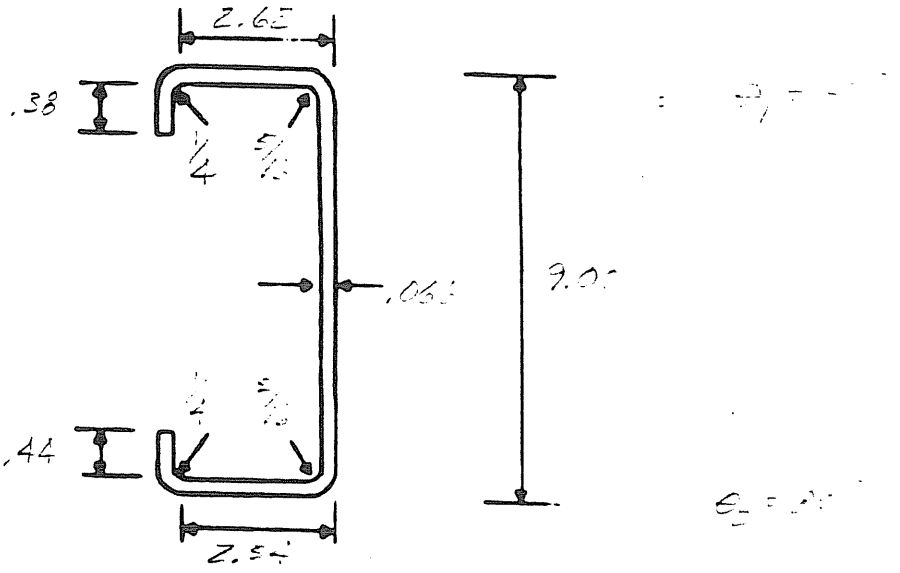
Method 50-75% AISI Load 73-109.5 plf

Method _____ Load _____

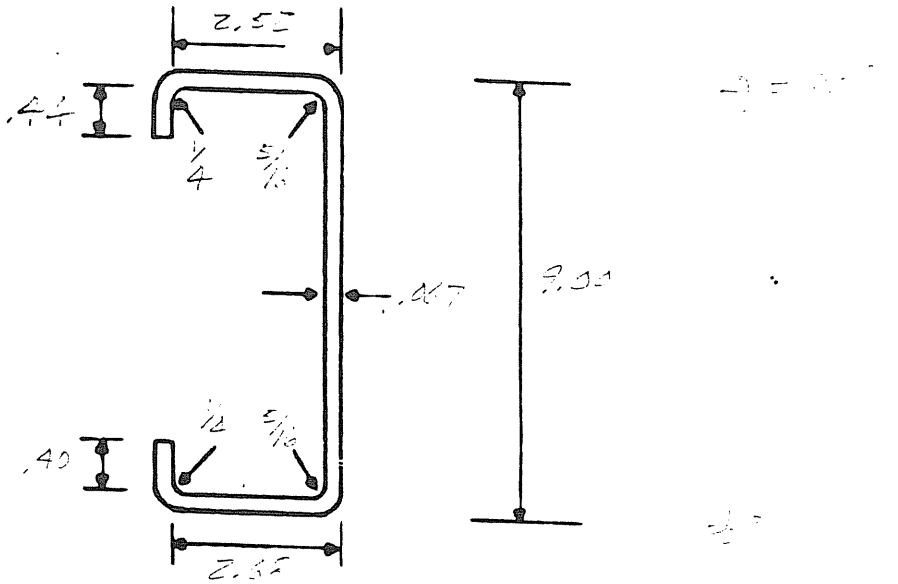
Method _____ Load _____

Discussion:

-Failure load was 64% of AISI constrained bending.
-Compression flanges of test purlins buckled near the third point braces.
-Maximum vertical deflection was 2.66 in.
-Vertical deflections were 18% more than predicted by AISI.
-Test purlins deflected 45-60% more than outer purlins.

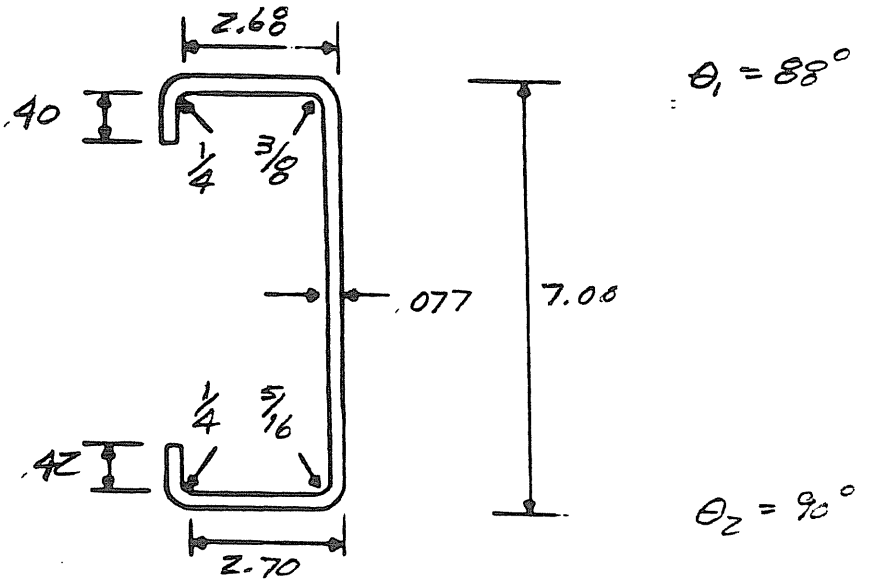


Interior (West) Purlin

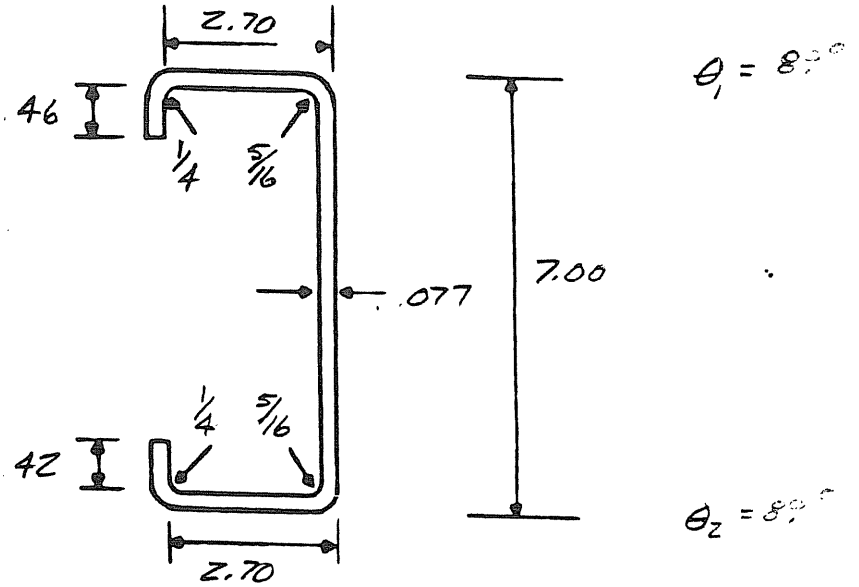


Interior (East) Purlin

Figure B.64 Measured Purlin Dimensions, Test 14 (Interior)



Exterior (West) Purlin



Exterior (East) Purlin

Figure B.65 Measured Purlin Dimensions, Test 14 (Exterior)

```
A I S I   P U R L I N   A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST 14 UPLIFT EAST TEST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.520	2.680
LIP(in)	0.440	0.400
LIP ANGLE(deg)	85.000	86.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	9
THICKNESS(in)	0.067
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)	SECTION MODULII(in^3) TOP	BOTTOM
GROSS= 11.811	2.623	2.666
STRENGTH= 11.688	2.580	2.655
DEFLECTION= 11.811		

BE=	2.051	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	29.343	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	7.224	ft-k
MT=	7.434	ft-k
MW=	6.830	ft-k
MU=	11.406	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	146.002	plf (1.67*allowable)
DEFLECTION =	2.523	in./100plf

Figure B.66 AISI Purlin Analysis, Test 14 Interior Purlin (East)

A I S I P U R L I N A N A L Y S I S
C-SECTION
IDENTIFICATION: MESCO TEST 14 UPLIFT WEST TEST PURLIN

	TOP	BOTTOM
FLANGE(in)	2.620	2.540
LIP(in)	0.380	0.440
LIP ANGLE(deg)	87.000	85.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	9
THICKNESS(in)	0.0665
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	11.650	2.612	2.604
STRENGTH=	11.436	2.537	2.584
DEFLECTION=	11.650		

RB=	2.081	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	29.257	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	7.103	ft-k
MT=	7.236	ft-k
MW=	6.698	ft-k
MU=	11.186	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	143.180	plf (1.67*allowable)
DEFLECTION =	2.557	in./100#lf

Figure B.67 AISI Purlin Analysis, Test 14 Interior Purlin (West)

```
A I S I   P U R L I N   A N A L Y S I S
                C-SECTION
IDENTIFICATION: MESCO TEST 14 UPLIFT OUTER EAST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.700	2.700
LIP(in)	0.460	0.420
LIP ANGLE(deg)	89.000	89.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	7
THICKNESS(in)	0.077
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULII(in^3) TOP	BOTTOM
GROSS=	7.709	2.233	2.221
STRENGTH=	7.692	2.225	2.219
DEFLECTION=	7.709		

BE=	2.292	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	33.055	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	6.231	ft-k
MT=	6.214	ft-k
MW=	6.822	ft-k
MU=	10.378	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	132.837	plf (1.67*allowable)
DEFLECTION =	3.865	in./100plf

Figure B.68 AISI Purlin Analysis, Test 14 Exterior Purlin (East)

```
A I S I   P U R L I N   A N A L Y S I S
                C-SECTION
IDENTIFICATION: MESCO TEST 14 UPLIFT OUTER WEST PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.680	2.700
LIP(in)	0.400	0.420
LIP ANGLE(deg)	88.000	90.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.375	0.313

TOTAL DEPTH(in)	7
THICKNESS(in)	0.077
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)	SECTION MODULII(in^3) TOP	BOTTOM
GROSS= 7.620	2.200	2.203
STRENGTH= 7.620	2.200	2.203
DEFLECTION= 7.620		

BF=	2.228	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	33.055	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	6.160	ft-k
MT=	6.168	ft-k
MW=	6.882	ft-k
MU=	10.287	ft-k (1.67*allowable)
SPAN =	25.000	ft.
UNIFORM LOAD=	131.674	plf (1.67*allowable)
DEFLECTION =	3.910	in./100plf

Figure B.69 AISI Purlin Analysis, Test 14 Exterior Purlin (West)

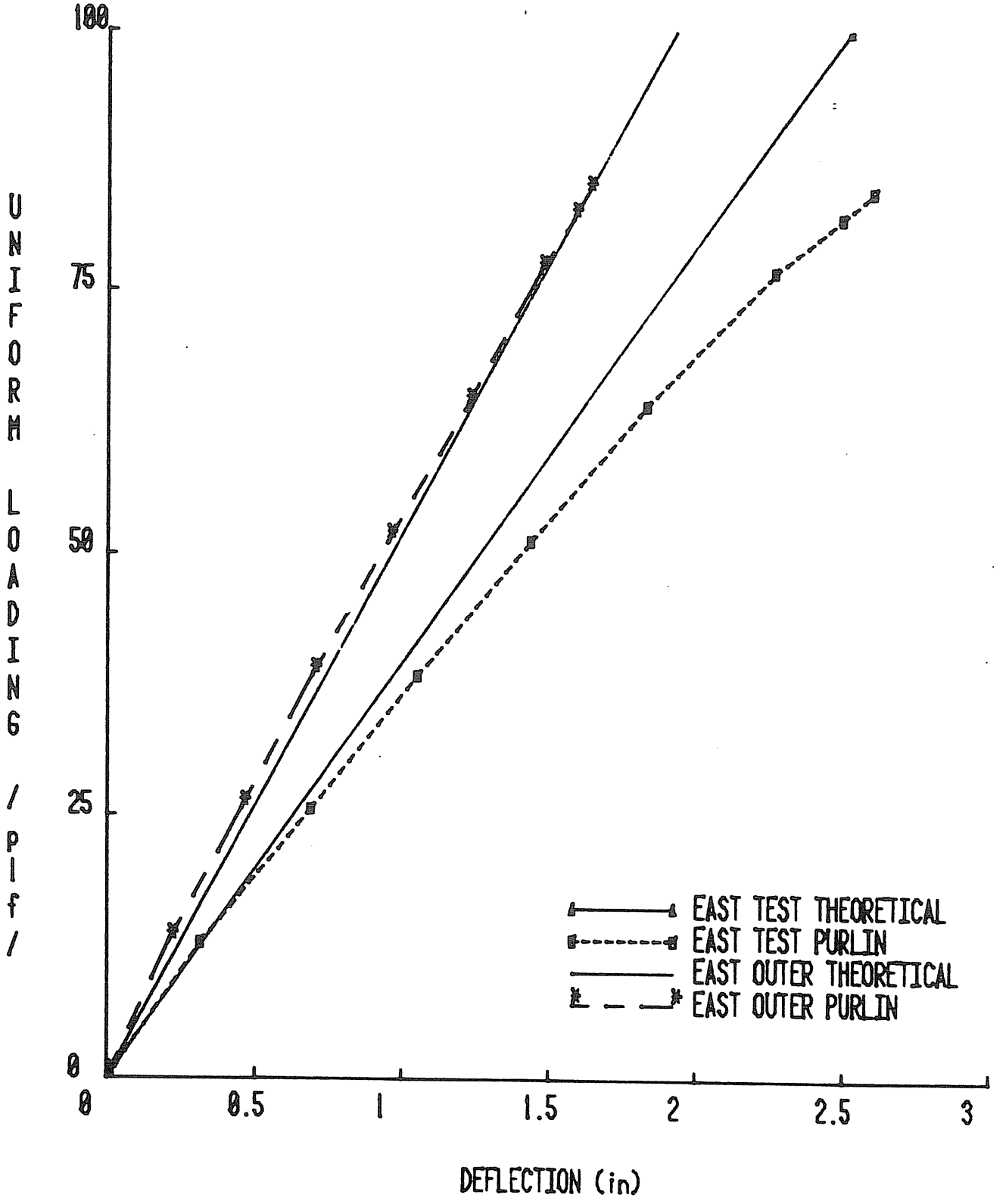


Figure B.70 Load vs. Vertical Deflection, Test 14

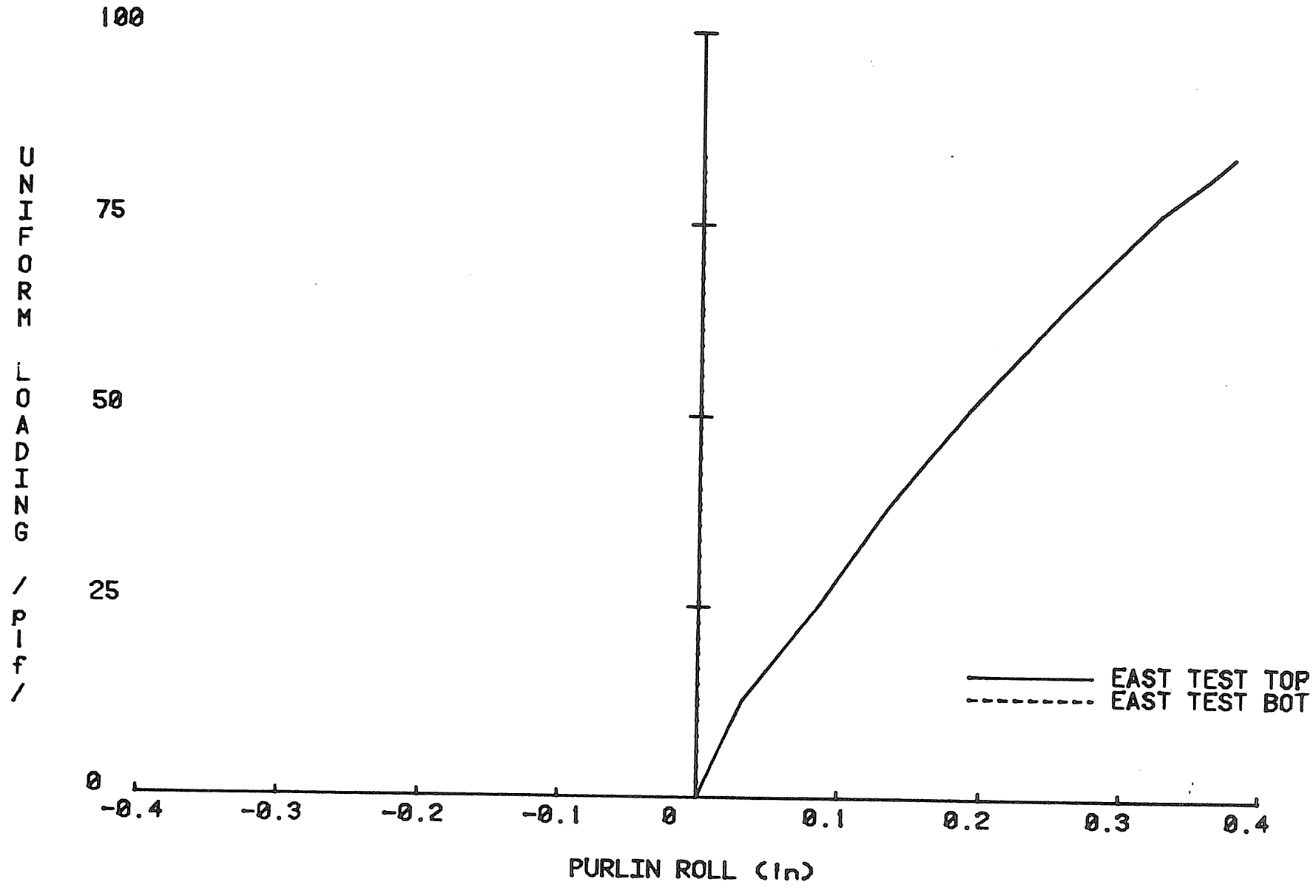


Figure B.71 Vertical Loading vs. Lateral Displacement, Test 14 (East)

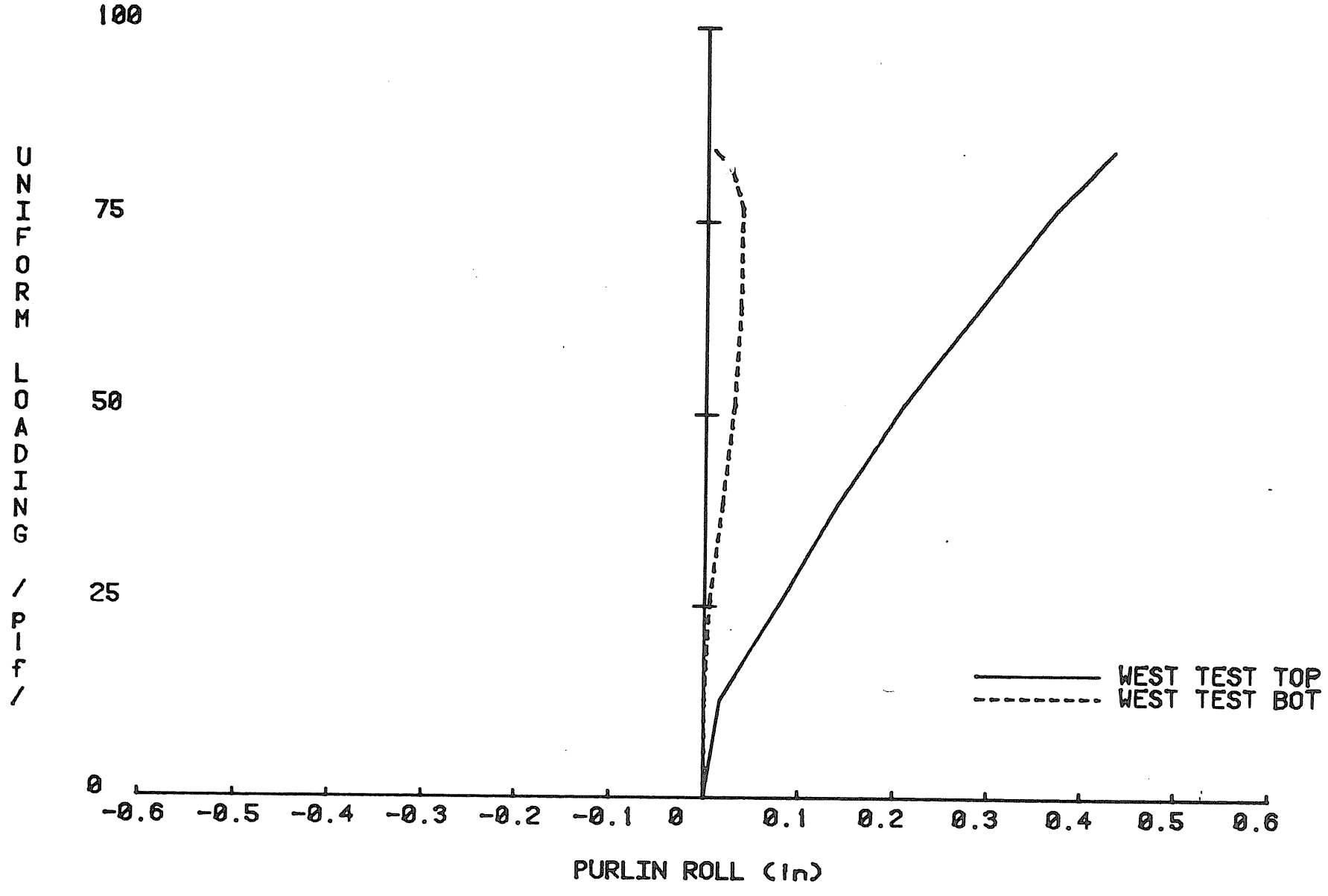


Figure B.72 Vertical Loading vs. Lateral Displacement, Test 14 (West)

TEST SUMMARY

Project: MESCO C-Furlin Supported Roof Systems

Test No.: 15 Uplift

Test Date: 12-9-83

Purpose: Determine purlin strength to resist uplift.

Span(s): 24'-8"

Thickness: 0.079 (14 gage) Moment of Inertia: 14.036 $in.^4$

Parameters: Test purlins in opposing orientation
Panel torsional restraint
Purlins clipped to rafters
Bracing at third points of compression flange

Failure Load: 122.74 + 8.9 plf D.L. = 131.6 plf

Failure Mode: Local buckling of compression flange of east and west

Predicted Failure Loads:

Method 50-75% of AISI Load 96.1-144 plf

Method _____ Load _____

Method _____ Load _____

Discussion:

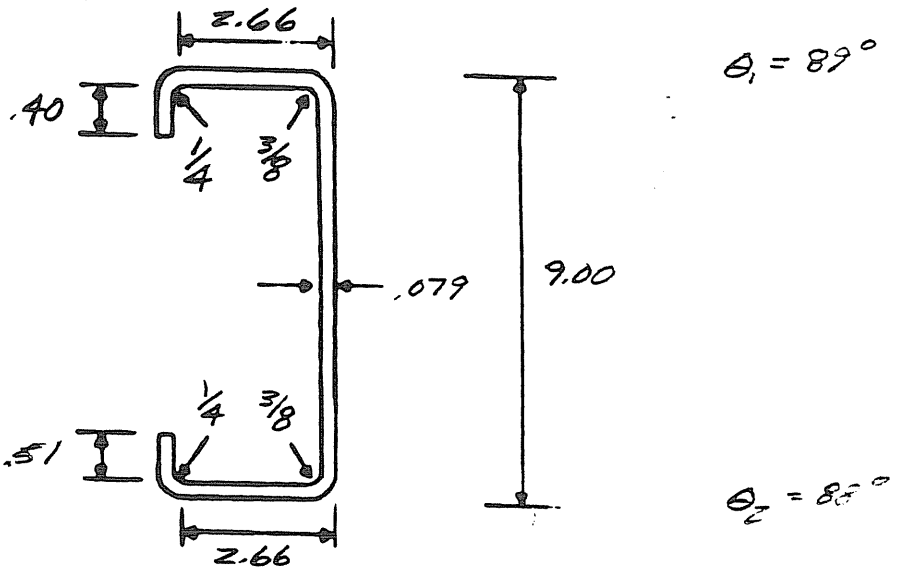
-Failure load was 68% of AISI constrained bending.

-Compression flange of test purlins buckled near center line.

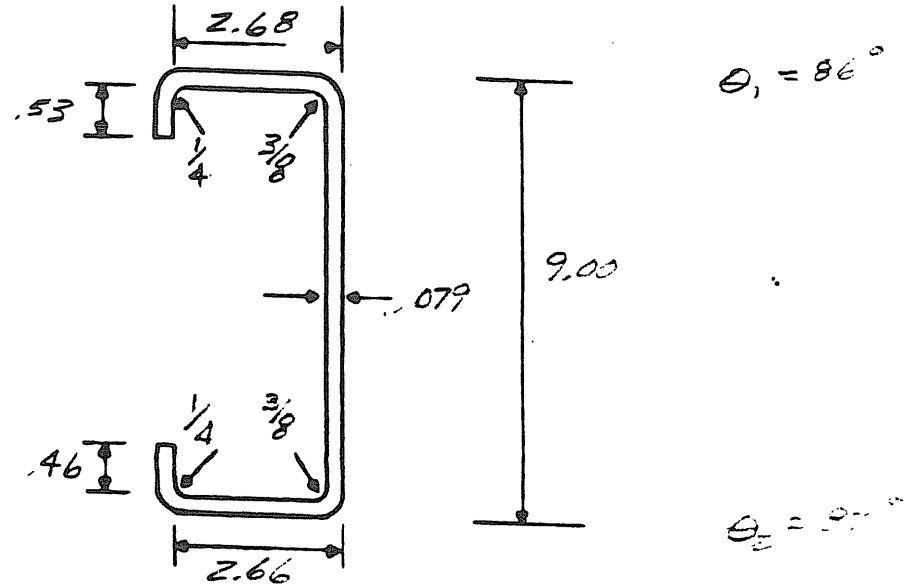
-Maximum vertical deflection was 3.34 in.

-Vertical deflections were 24-29% more than predicted by AISI.

-Test purlins deflected 44-48% more than outside purlins.

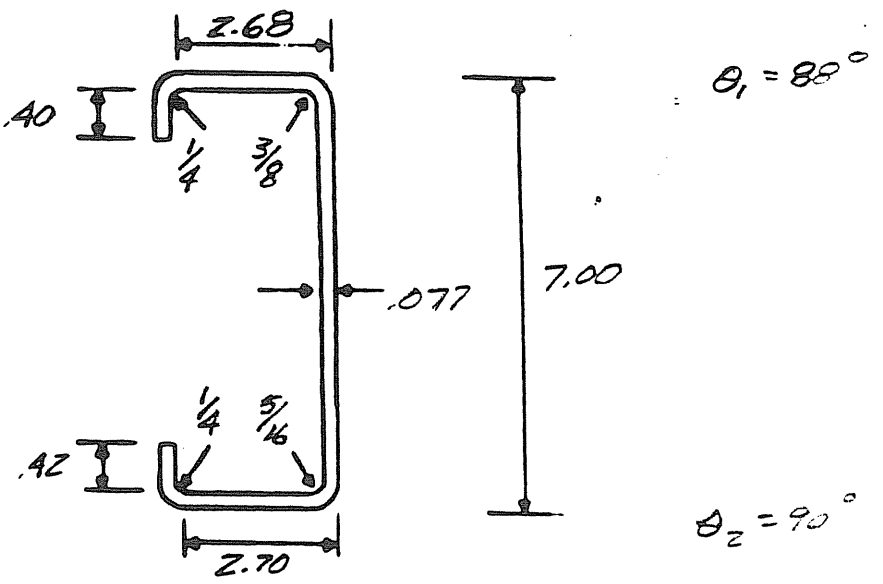


Interior (West) Purlin

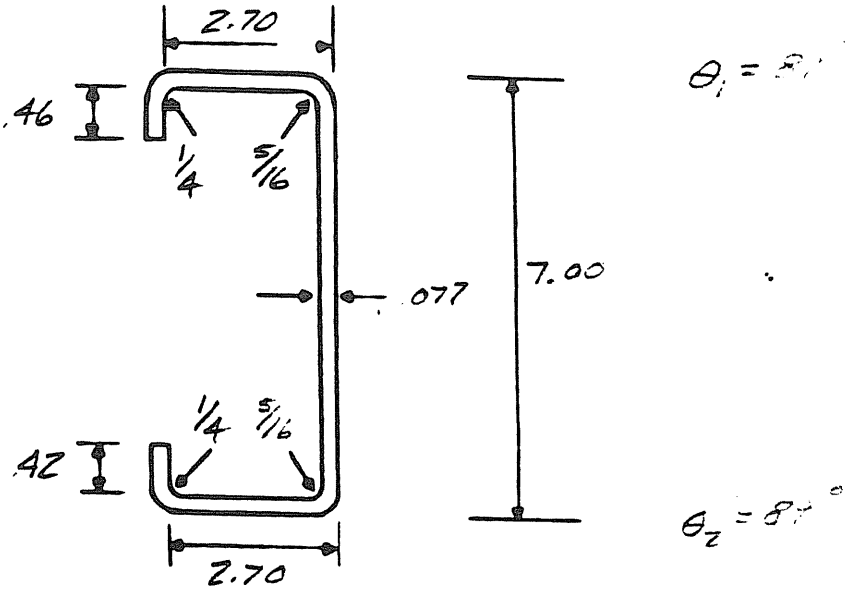


Interior (East) Purlin

Figure B.73 Measured Purlin Dimensions, Test 15 (Interior)



Exterior (West) Purlin



Exterior (East) Purlin

Figure B.74 Measured Purlin Dimensions, Test 15 (Exterior)

```
A I S I  P U R L I N  A N A L Y S I S
              C-SECTION
IDENTIFICATION: MESCO TEST  15 UPLIFT EAST TEST PURLIN
-------------------------------------------------------------

                          TOP              BOTTOM
FLANGE(in)              2.680              2.660
LIP(in)                 0.530              0.460
LIP ANGLE(deg)         86.000             87.000
RADIUS L/F(in)          0.250              0.250
RADIUS F/W(in)          0.375              0.375

TOTAL DEPTH(in)             9
THICKNESS(in)           0.079
YIELD STRENGTH(ksi)        56

                                          SECTION MODULUS (in^3)
     MOMENTS OF INERTIA(in^4)              TOP              BOTTOM
GROSS=          14.174                  3.195              3.160
STRENGTH=       14.174                  3.195              3.160
DEFLECTION=     14.174
BE=    2.226   in
FC=   33.600   ksi
FT=   33.600   ksi
FBW=  31.088   ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)
            MC=      8.947   ft-k
            MT=      8.848   ft-k
            MW=      9.131   ft-k
            MU=     14.776   ft-k (1.67*allowable)
SPAN          =     24.667   ft.
UNIFORM LOAD=    194.277   plf (1.67*allowable)
DEFLECTION  =      1.992   in./100plf
```

Figure B.75 AISI Purlin Analysis, Test 15 Interior Purlin (East)

A I S I P U R L I N A N A L Y S I S

C-SECTION

IDENTIFICATION: MESCO TEST 15 UPLIFT WEST TEST PURLIN

	TOP	BOTTOM
FLANGE(in)	2.660	2.660
LIP(in)	0.400	0.510
LIP ANGLE(deg)	87.000	88.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.375	0.375

TOTAL DEPTH(in)	9
THICKNESS(in)	0.079
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULUS(in^3) TOP	BOTTOM
GROSS=	14.036	3.126	3.168
STRENGTH=	14.036	3.126	3.168
DEFLECTION=	14.036		

BE=	2.206	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	31.088	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	8.753	ft-k
MT=	8.870	ft-k
MW=	8.922	ft-k
MU=	14.617	ft-k (1.67*allowable)
SPAN =	24.667	ft.
UNIFORM LOAD=	192.188	plf (1.67*allowable)
DEFLECTION =	2.012	in./100plf

Figure B.76 AISI Purlin Analysis, Test 15 Interior Purlin (West)

```
A I S I   P U R L I N   A N A L Y S I S
                C-SECTION
IDENTIFICATION: MESCO TEST 15 UPLIFT EAST OUTER PURLIN
```

	TOP	BOTTOM
FLANGE(in)	2.700	2.700
LIP(in)	0.460	0.420
LIP ANGLE(deg)	89.000	89.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.313	0.313

TOTAL DEPTH(in)	7
THICKNESS(in)	0.077
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULI(in^3) TOP	BOTTOM
GROSS=	7.709	2.233	2.221
STRENGTH=	7.692	2.225	2.219
DEFLECTION=	7.709		

BE=	2.292	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	33.055	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	6.231	ft-k
MT=	6.214	ft-k
MW=	6.822	ft-k
MU=	10.378	ft-k (1.67*allowable)
SPAN =	24.667	ft.
UNIFORM LOAD=	136.448	plf (1.67*allowable)
DEFLECTION =	3.663	in./100plf

Figure B.77 AISI Purlin Analysis, Test 15 Exterior Purlin (East)

A I S I P U R L I N A N A L Y S I S
C-SECTION
IDENTIFICATION: MESCO TEST 15 UPLIFT WEST OUTER PURLIN

	TOP	BOTTOM
FLANGE(in)	2.680	2.700
LIP(in)	0.400	0.420
LIP ANGLE(deg)	88.000	90.000
RADIUS L/F(in)	0.250	0.250
RADIUS F/W(in)	0.375	0.313

TOTAL DEPTH(in)	7
THICKNESS(in)	0.077
YIELD STRENGTH(ksi)	56

MOMENTS OF INERTIA(in^4)		SECTION MODULI(in^3) TOP	BOTTOM
GROSS=	7.620	2.200	2.203
STRENGTH=	7.620	2.200	2.203
DEFLECTION=	7.620		

BE=	2.228	in
FC=	33.600	ksi
FT=	33.600	ksi
FBW=	33.055	ksi

MOMENT CARRYING CAPACITY (AISI CRITERIA)

MC=	6.160	ft-k
MT=	6.168	ft-k
MW=	6.882	ft-k
MU=	10.287	ft-k (1.67*allowable)
SPAN =	24.667	ft.
UNIFORM LOAD=	135.253	plf (1.67*allowable)
DEFLECTION =	3.706	in./100plf

Figure B.78 AISI Purlin Analysis, Test 15 Exterior Purlin (West)

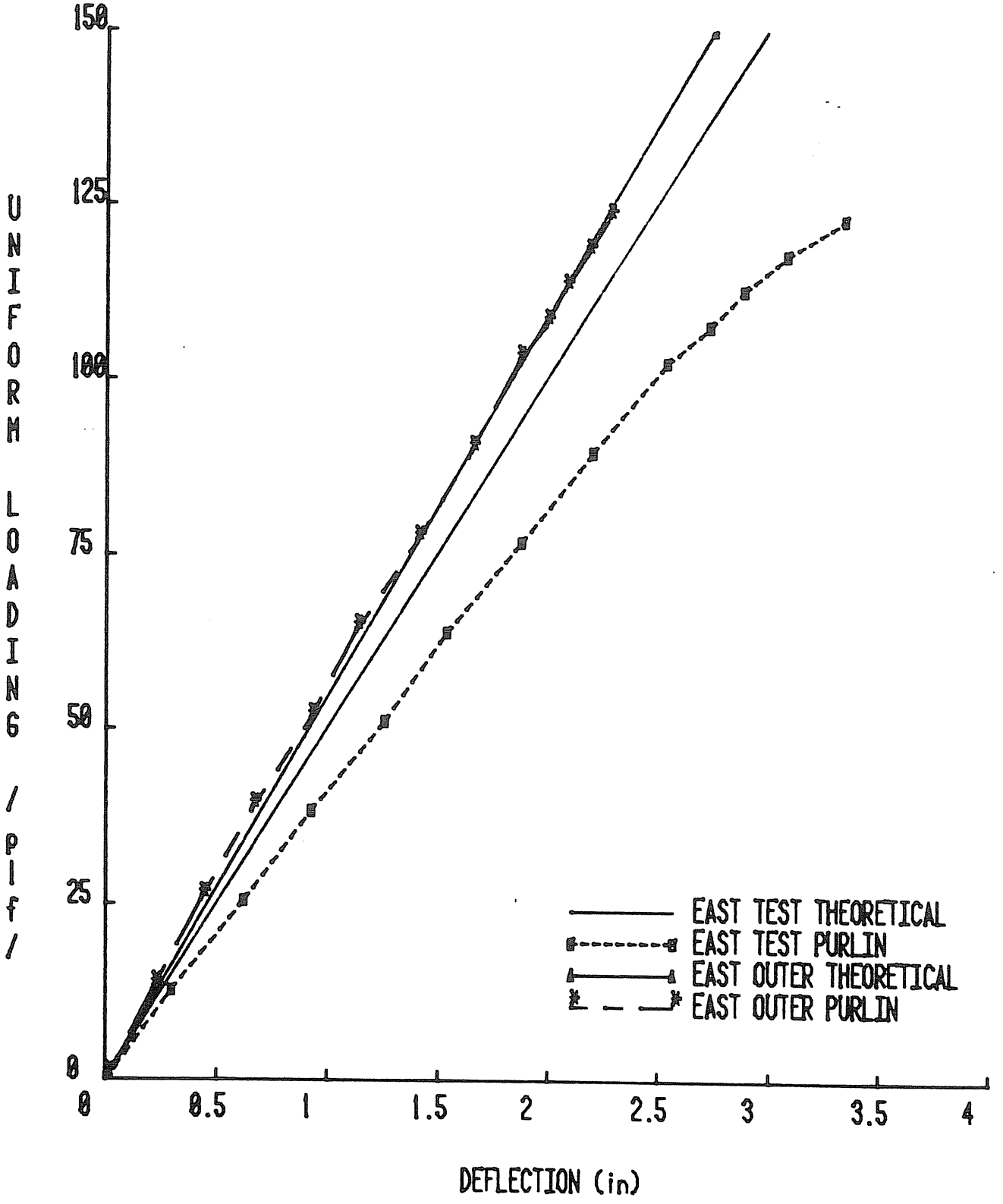


Figure B.79 Load vs. Vertical Deflection, Test 15

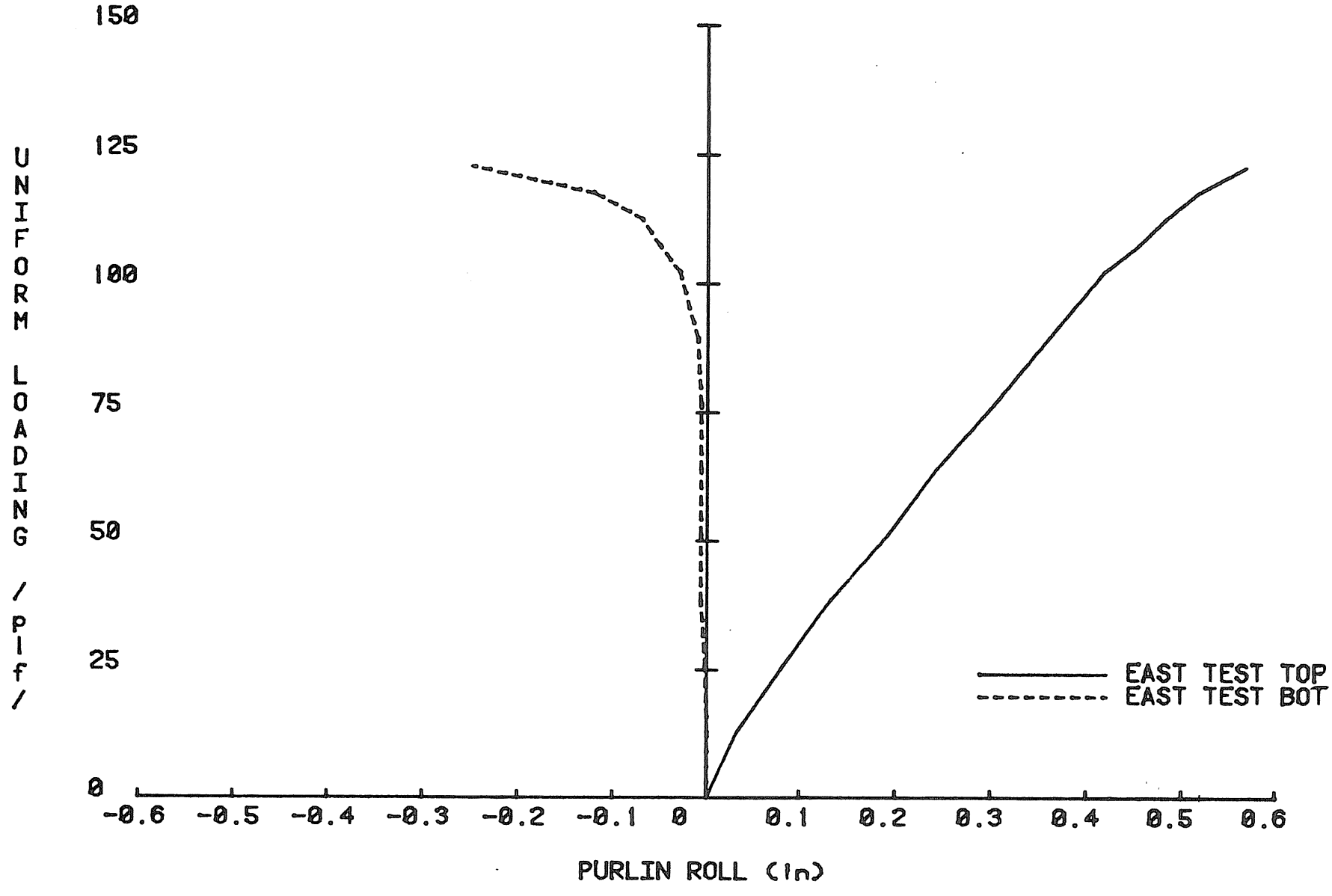


Figure B.8 0 Vertical Loading vs. Lateral Displacement, Test 15 (East)

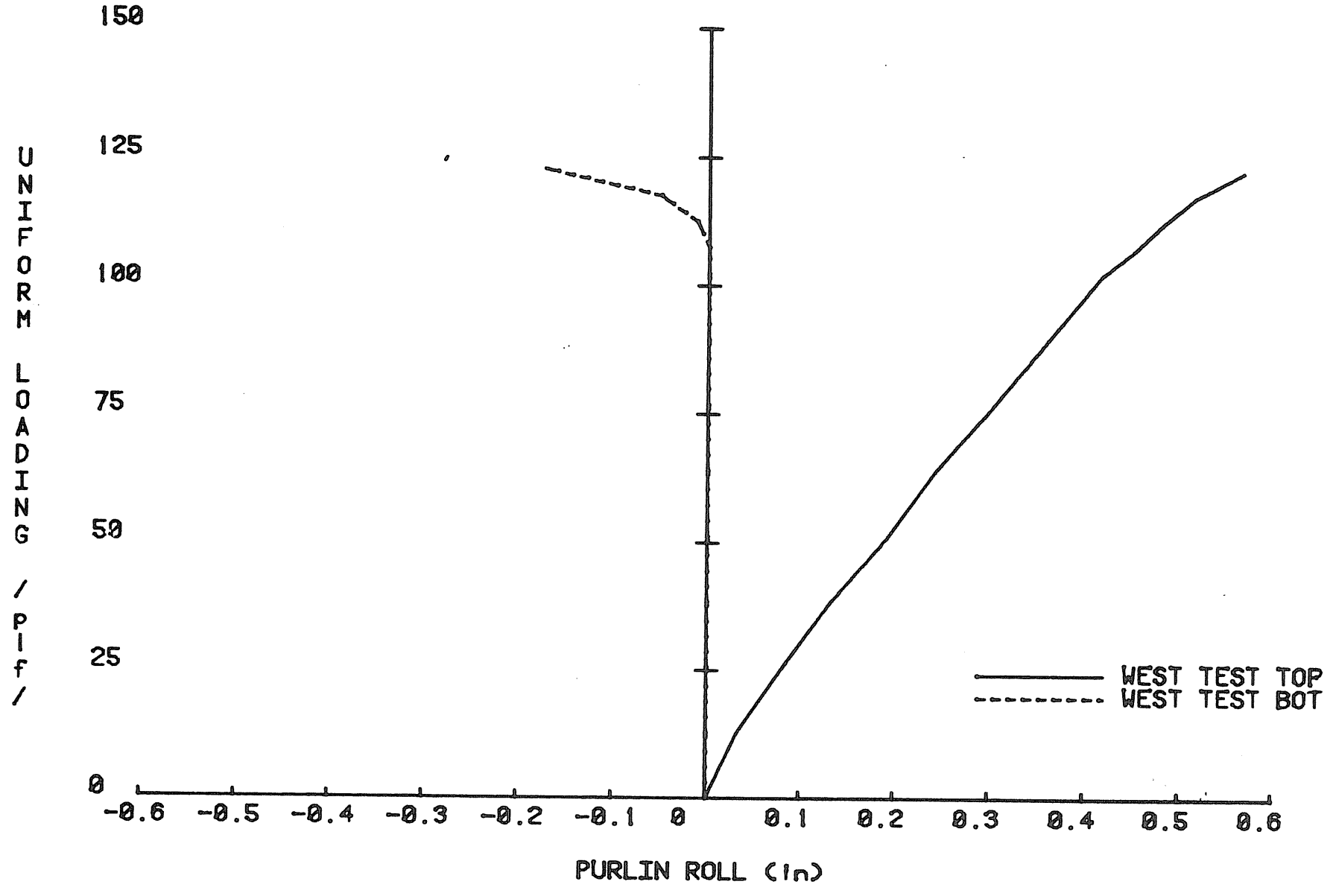


Figure B.81 Vertical Loading vs. Lateral Displacement, Test 15 (West)