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Laterally unsupported purlins subjected to uplift

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LATERALLY UNSUPPORTED PURLINS SUBJECTED TO UPLIFT

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INTRODUCTION

A research study, conducted at Cornell University, provided a theoretical method for evaluating the state of stress for both C- and Z- purlins subjected to wind uplift loading. According to the Cornell analytical method, a Z-purlin has more load carrying capability than a similar C-purlin. Although experimental verification was provided, questions were raised, within the Metal Building Industry, regarding the strength of the C- versus the Z-section.

The purpose of the work discussed herein was to develop information regarding the behavior of C- and Z-sections having identical cross-section dimensions. A brief description of the test program, along with a comparison between the tested ultimate capacity and computed capacity, is presented.

EXPERIMENTAL STUDY

A total of nine tests were conducted to study the behavior of laterally unsupported C- and Z-purlins subjected to a simulated wind uplift force. In addition to the nine full scale purlin tests, eight tests were conducted to determine the rotational restraint factor for the panel to purlin connection (F-test).

Full Scale Test Program

Each test specimen was composed of two 20-ft. long purlins having cross section dimensions as listed in Table 1. The tension flange of each purlin was attached to a conventional roof panel by using self-drilling screws.

As depicted by Figure 1, the test specimen was suspended over a vacuum chamber and as air was evacuated from the chamber, the specimen was subjected to a simulated uplift load. The load and corresponding horizontal and vertical purlin deflections were recorded at 5 psf increments. A detailed discussion, of the test fixture and instrumentation is contained in Reference 1.

All specimens were tested to failure. The failure load, P_u , was the maximum pressure prior to failure as indicated by the pressure transducer. Table 2 provides a summary of the failure load obtained for each test specimen. Also presented in Table 2 is the average test load for both the C and Z sections.

F-Test Program

The rotational restraint factor was experimentally determined for each purlin-panel configuration. This factor is required in order to execute the analytical study. Table 3 gives the four configurations that appeared in the full scale test program along with their corresponding rotational restraint factor. For a discussion on the test procedure, consult Reference 2.

ANALYTICAL STUDY

The Cornell analytical method was used to compute the ultimate capacity of each test specimen. For an indepth discussion of the analytical method, see Reference 2.

The computed ultimate load, P_c , for each of the nine full scale test specimens, is given in Table 2.

EXPERIMENTAL VS. ANALYTICAL RESULTS

A comparison between the tested and computed failure load for each specimen is represented by the ratio of P_u/P_c given in Table 2. For C-sections, the values of the ratio varied from 0.90 to 0.98. However, for the Z-sections the ratio ranged from 0.55 to 0.64.

CONCLUSIONS

Based upon the results obtained from the nine full scale tests and eight F-tests, the following conclusions can be drawn:

1. The average tested uplift load carrying capacity of a Z-section is from 17 to 24 percent greater than a C-section when both the C and Z have the same cross section dimensions.
2. Good correlation was obtained between the tested and computed ultimate capacity for the C-sections.
3. Poor correlation was realized when comparing the tested and computed capacities for the Z-purlin specimens.

REFERENCES

1. LaBoube, R. A., and Thompson, M. B., "Static Load Tests of Braced Purlins Subjected to Uplift Load," MRI Report No. 7485-6, August, 1982.

2. Haussler, R. W., and Pabers, R. F., "Connection Strength in Thin Metal Roof Structures," Proceedings of the Second International Specialty Conference on Cold-Formed Steel Structures, October, 1973.

3. Pekoz, T., and Soroushian, P., "Behavior of C- and Z-Purlins under Wind Uplift," Proceedings of the Sixth International Specialty Conference on Cold-Formed Steel Structures, November, 1982.

TABLE 1

CROSS SECTION DIMENSIONS

Test No.	Section Type	t (In.)	H (In.)	B1 (In.)	B2 (In.)	L1 (In.)	L2 (In.)	a_o (In.)
1	C	0.071	9.56	2.81	2.81	0.75	0.81	0.50
2	C	0.071	9.50	2.81	2.75	0.81	0.81	0.50
3	Z	0.071	9.50	2.75	2.81	0.88	0.88	-0.25
4	Z	0.071	9.50	2.75	2.75	0.81	0.81	-0.25
5	Z	0.071	9.63	2.81	2.75	0.75	0.81	-0.25
6	C	0.106	9.50	2.81	2.81	0.81	0.81	0.125
7	C	0.106	9.56	2.88	2.81	0.81	0.81	0.125
8	Z	0.106	9.44	2.88	2.81	0.81	0.81	-0.063
9	Z	0.106	9.56	2.81	2.88	0.88	0.81	-0.063

Notes:
(1) See Fig. 1 for definition of cross section notation.
(2) All corner radii are 0.313 in.
(3) All edge stiffeners were inclined at 90 degrees to the flange.
(4) F_y = 64.47 ksi.
(5) Sign convention for a_o : negative indicates sweep to the north
positive indicates sweep to the south

TABLE 2

LOAD COMPARISONS

Test No.	Section Type	P_u (lb/ft)	P_c (lb/ft)	P_u/P_c
1	.07 C	104.5	110.8	.94
2	.07 C	99.8	110.8	.90
Average		102.2		
3	.07 Z	123.5	218.5	.57
4	.07 Z	136.2	218.5	.62
5	.07 Z	120.3	218.5	.55
Average		126.7		
6	.10 C	197.6	215.3	.92
7	.10 C	210.3	215.3	.98
Average		204.0		
8	.10 Z	234.7	380.0	.62
9	.10 Z	243.8	380.0	.64
Average		239.3		

Notation: P_u = Maximum load at failure
P_c = Computed failure load using Cornell method.

Note: $P(\text{lb/ft}) = \text{Transducer Reading (psf)} \cdot \frac{76}{2} \cdot \frac{1}{12}$

TABLE 3

ROATIONAL RESTRAINT FACTORS

Test Configuration	Purlin Section Type	Purlin Thickness (in.)	Rotational Restraint Factor (lb/in/in)
1	C	0.071	1.46
2	Z	0.071	1.67
3	C	0.106	2.78
4	Z	0.106	3.32

Notes: (1) Two tests were performed for each configuration.

(2) 26 Gage conventional roof panel was used for all tests.

(3) The fasteners were 1/4 x 14 SDS.

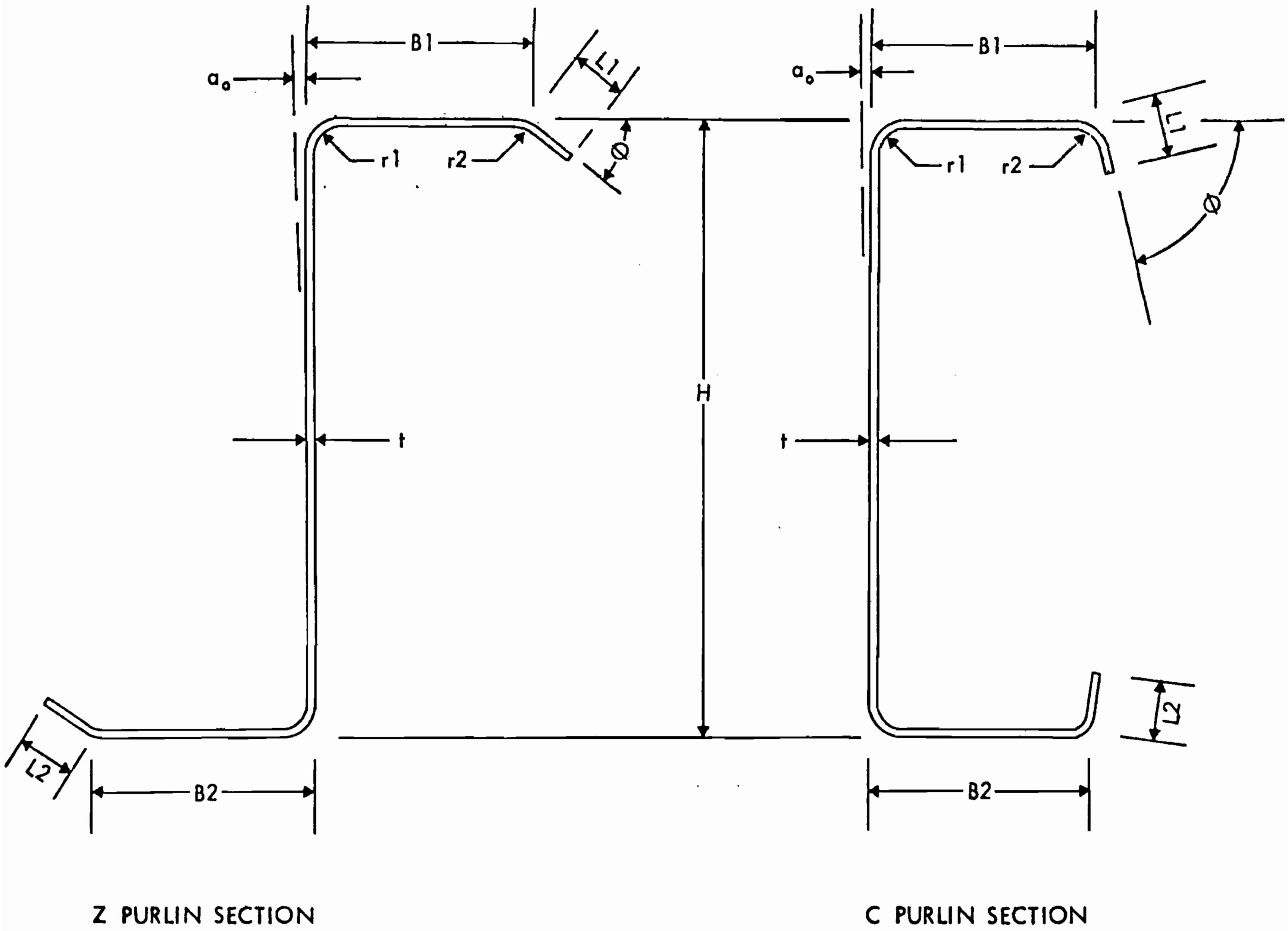

Figure 1 - Purlin Cross Section

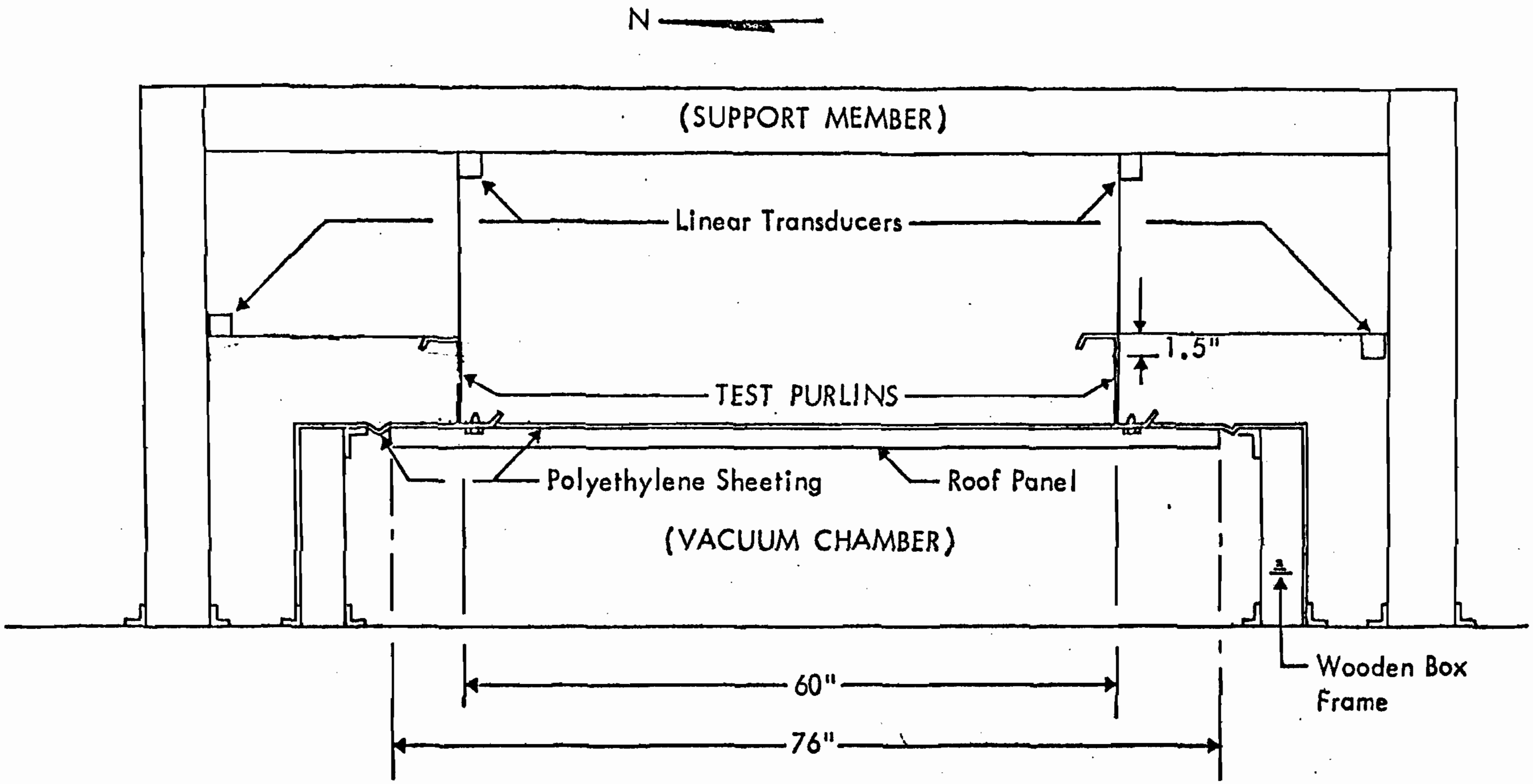

Figure 2 - Cross Section of Purlin Uplift Vacuum Test Chamber