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Cornell University School of Civil Engineering Tests on light beams of cold-formed steel

Cornell University School of Civil Engineering

SCHOOL OF CIVIL ENGINEERING, CORNELL UNIVERSITY

TESTS ON LIGHT BEAMS OF COLD FORMED STEEL

FOR THE AMERICAN IRON AND STEEL INSTITUTE

Thirty-ninth Progress Report

January 1945

I. SCOPE OF THIS REPORT

In the Thirty-eighth Progress Report a series of 118 tests was reported on web crippling under concentrated loads. These 118 tests which included 17 representative tests of the Twenty-fifth Progress Report were carried out for web crippling by loads on the span, by simple end reactions, by end reactions with additional loads on top flange, and by reactions of continuous supports with similar additional loads. Two formulas were developed from the entire series of tests which represented, for the two cases (loads on span, and reactions), all test results with satisfactory accuracy.

However, only 8 out of these 118 tests were carried out on single web beams (all others referred to double webs). Therefore, 20 additional tests of single web specimens reported herein are designed to furnish more evidence on single web beams.

II. METHOD OF TESTING

The specimens, which were cut from undamaged outside portions of old beam specimens, were tested for 4 types of web-crippling as mentioned in the Thirty-eighth Progress Report:

(a) Only 2 specimens of 11 gage were tested to obtain web failure under a concentrated load on the span, because a series of 8 tests (6 of them were for 18 and 14 gages) under the same conditions had been tested and were reported in the Thirty-eighth Report. Six of these eight old tests, as mentioned in the Thirty-eighth Report, behaved satisfactorily.

However, doubt was expressed on the validity of the two old tests on 11 ga. specimens. On these two specimens high bending stresses obtained on a 36" span were thought to be responsible for the relatively low failure loads (p. 7 of Thirty-eighth Report). For this reason specimens cut from these same beams were tested on a 16" span as were most other specimens of the Thirty-eighth Report. Failure loads obtained were indeed higher than on the longer span and closer to those predicted by the empirical formula. These tests are designated as "web-crippling, span, top flange loading."

(a) Six (6) specimens were tested in a similar way, but so as to cause failure at the supports. These tests are designated as "web-crippling, reaction, top flange loading".

(b) Six (6) specimens were tested under direct compression load of the web somewhere along the span (removed from ends). These tests are designated as "web-crippling, span, two-flange loading".

(c) Six (6) specimens were tested under similar direct compression load, but with loads applied at one end of each specimen. These tests are designated as "web-crippling, reaction, two-flange loading".

In both "reaction" loadings (b and d, above) the outer edges of the distributing plates were aligned with the ends of the beams. All distributing plates were placed on rockers or rollers so as to obtain continuous contact despite deflection of the specimens.

III. RESULTS

The test results are summarized in table 1 and the graphical representation of the test evaluation is given on drawings 347 to 350.

Table 1

Results of Web Crippling Tests
-single web specimens-

Beam	s_{yp} p.s.i.	t in.	b in.	Failure Loads, lb. (per web) Span top fl.	Reaction top fl.	Span two fl.	Reaction two fl.
O3a	32,200	.0463	1			1,600	880
			2.5			1,660	920
O3b	32,200	.0463	1		1,130		
O3c	32,200	.0463	2.5		1,275		
N3a	35,800	.0757	1			6,200	2,450
			2.5			6,750	3,060
N3b	35,800	.0757	1		3,600		
N3c	35,800	.0757	2.5		4,075		
K3a	37,600	.1230	1			12,900	6,800
			2.5			14,600	7,500
K3b	37,600	.1230	1		7,125		
			2.5		10,325		
K3d	37,600	.1230	1	10,500			
			2.5	12,900			

IV. EVALUATION

In the manner as discussed under the same heading in the Thirty-eighth Report, the following same two equations were used: For span crippling, both top flange and two-flange loading:

$$P_{ult} = (15 + 3.25 \sqrt{b/t})\, t^2\, s_{yp}$$

For reaction crippling, both top flange and two flange loading:

$$P_{ult} = (10 + 1.25 \sqrt{b/t})\, t^2\, s_{yp}$$

The straight lines representing these equations are plotted on all four drawings. It is seen that the test points scatter within satisfactory limits around these lines.

Again, in order to show quantitatively the accuracy of these formulas for these 20 tests, the four tables below have been computed. These tables contain the actual failure loads, the failure loads computed from the above formulae, and the percentage of deviation for the tests.

Table 2

Comparison of Empirical and Computed Failure Loads

Span, Top Flange Loading

Beam	s_{yp}	t	b	P_w test	P_w formula	%
K3d	37,600	.1230	1	10,500	13,500	- 22.2
K3d	37,600	.1230	2.5	12,900	16,500	- 21.8

In this table:

s_{yp} = yield point

t = sheet thickness

b = width of bearing

P_w = ultimate test load, per web

$P_{w\ formula}$ = ultimate load computed from formula given in Thirty-eighth Report

% = percentage of deviation = 100 $(P_{w\ test} - P_{w\ form}) / P_{w\ form}$

The mean deviation of $P_{w\ test}$ from $P_{w\ form}$ for these two tests is - 22%, as compared with - 36% obtained in the old long-span tests on the same specimens.

Table 3

Comparison of Empirical and Computed Failure Loads

Reaction, Top Flange Loading

Beam	s_{yp}	t	b	P_w test	P_w form	%
O3b	32,200	.0463	1	1,130	1,080	+ 4.6
O3c	32,200	.0463	2.5	1,275	1,310	- 2.7
N3b	35,800	.0757	1	3,600	2,960	+ 21.6
N3c	35,800	.0757	2.5	4,070	3,490	+ 16.6
K3b	37,600	.1230	1	7,125	7,560	- 5.7
K3c	37,600	.1230	2.5	10,325	8,740	+ 18.1

The mean deviation is + 8.7%, the mean positive deviation is + 15.2%, the mean negative deviation is - 4.2%.

Table 4

Comparison of Empirical and Computed Failure Loads

Span, Two-Flange Loading

Beam	s_{yp}	t	b	P_w test	P_w form	%
O3a	32,200	.0463	1	1,600	2,050	- 22.0
O3a	32,200	.0463	2.5	1,960	2,670	- 26.6
N3a	35,800	.0757	1	6,260	5,450	+ 13.7
N3a	35,800	.0757	2.5	6,750	6,850	- 1.5
K3a	37,600	.1230	1	12,900	13,150	- 4.5
K3a	37,600	.1230	2.5	14,600	16,500	- 11.5

The mean deviation is - 8.7%, the mean positive deviation is + 13.7%, the mean negative deviation is - 13.2%.

Table 5

Comparison of Empirical and Computed Failure Loads

Reaction, Two-Flange Loading

Beam	s_{yp}	t	b	P_w test	P_w form	%
O3a	32,200	.0463	1	880	1,080	- 18.5
O3a	32,200	.0463	2.5	920	1,310	- 29.8
N3a	35,800	.0757	1	2,450	2,960	- 17.2
N3a	35,800	.0757	2.5	3,060	3,490	- 12.3
K3a	37,600	.1230	1	6,800	7,560	- 10.1
K3a	37,600	.1230	2.5	7,500	8,740	- 14.2

The mean deviation is - 17.0%.

V. OBSERVATIONS

(1) All #11 gage specimens failed by distortion of the part of the web directly under the load. The distortion, semicircular in shape, was strictly localized, usually spreading not further than one third of the depth of the beam from the loaded flange into the web.

(2) Under "top flange loading" all three #14 gage specimens failed by istortion locally of the part of the web directly under the load; while the rest of the three #14 gage specimens under "two flange loading" failed

due to bulging of the entire web from top to bottom directly at the loaded portion.

(3) All six #18 gage specimens failed due to bulging of the entire web from top to bottom under the loaded portion.

(4) In most of the tests for heavier gage (#11 gage here), distortion occurred not only in the web but also in the loaded flanges directly under the loaded area.

VI. SUMMARY

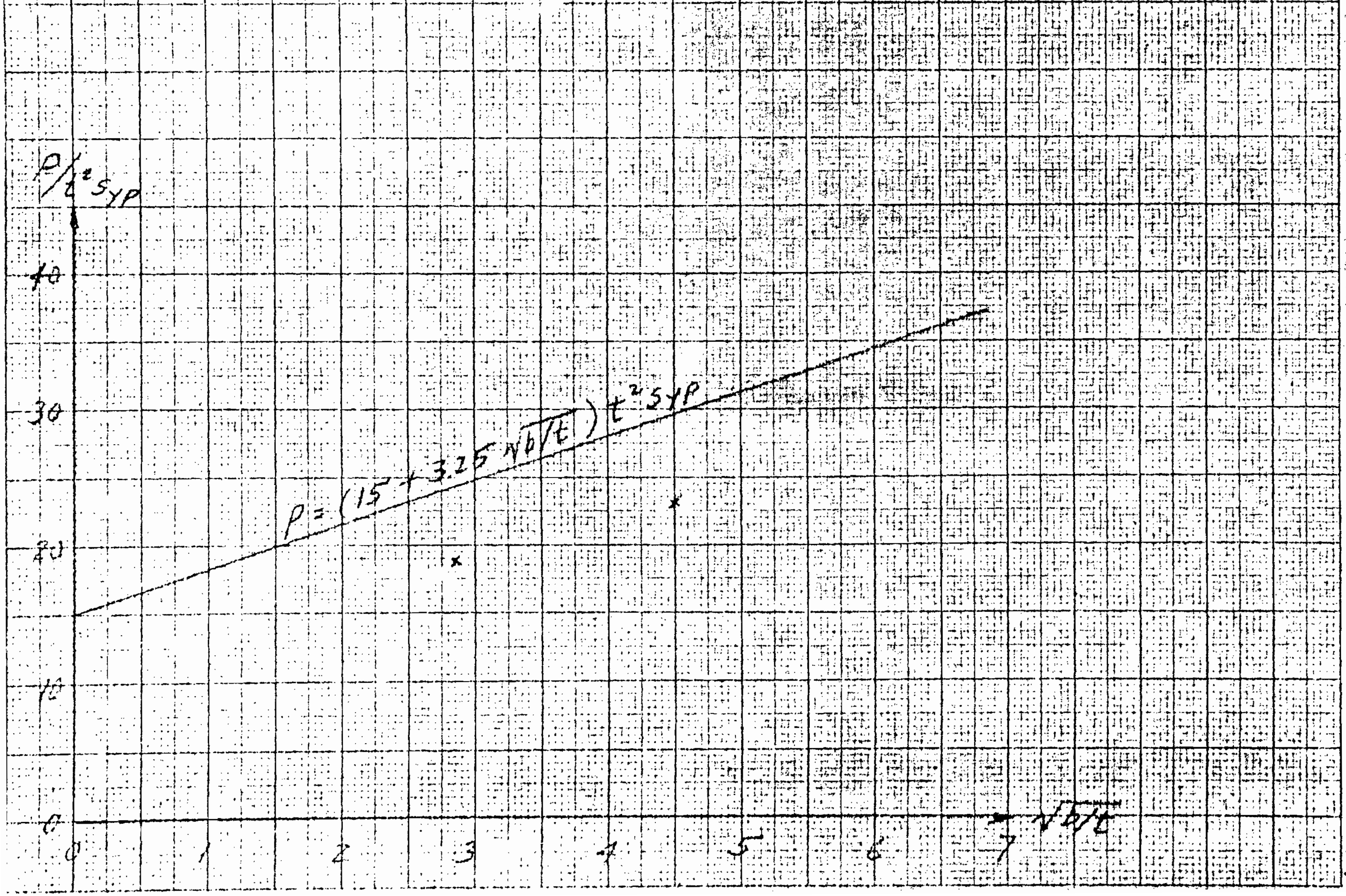
(1) A total of 20 tests of single web specimens on web crippling by local loading was carried out.

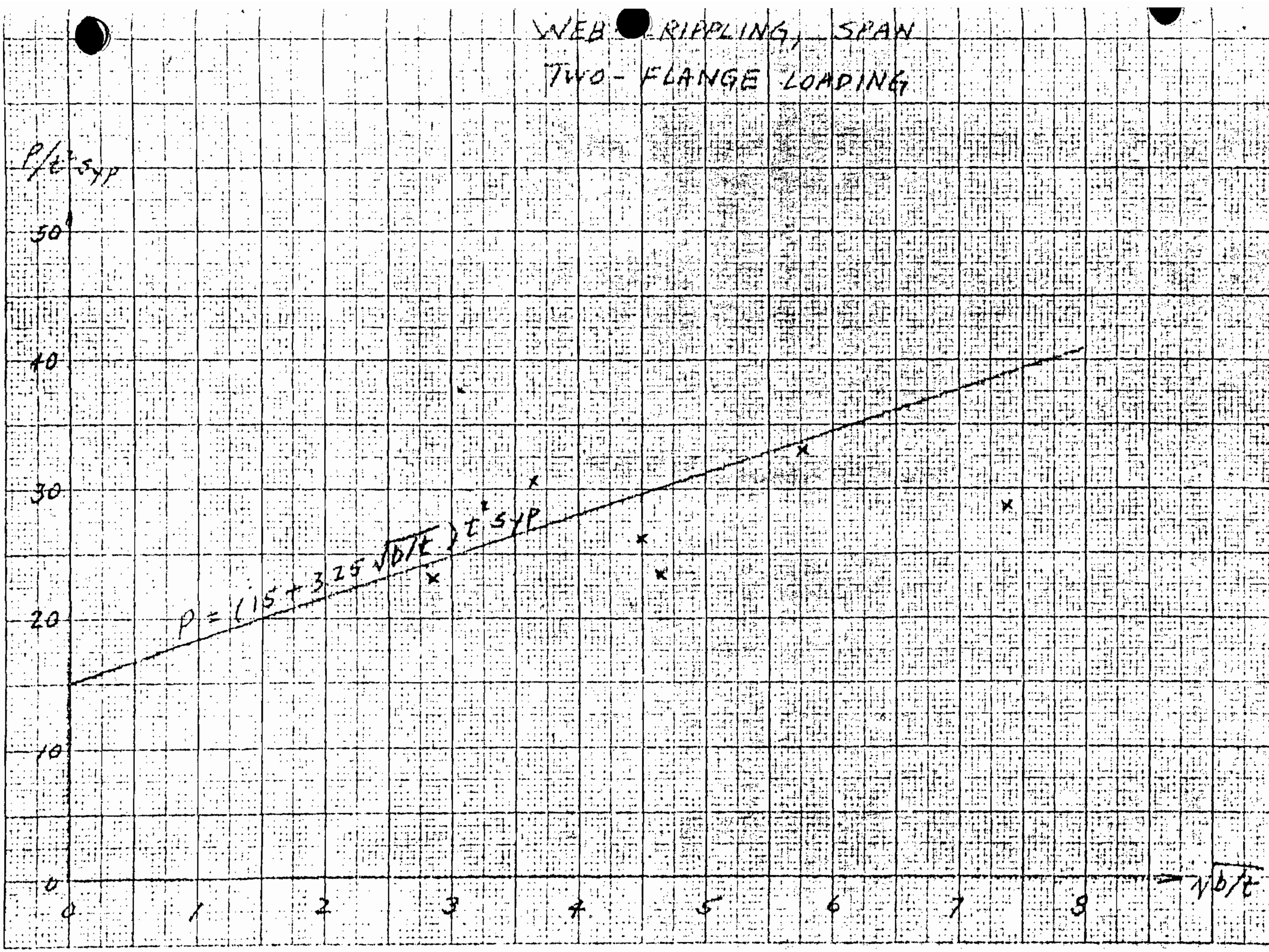
(2) Tests were carried out by loads on the span, by simple end reaction, by end reaction with additional loads on the top flange, and by reactions of continuous supports with similar additional loads.

(3) It was found that the two formulae which had been developed in the Thirty-eighth Progress Report could be used for single web specimens with sufficient accuracy. The amount of scattering of the results of these tests as compared with the data of the formula is about the same as on the double web tests of the Thirty-eighth Report, and is more than amply covered by the factor of safety of 2.5 used in the Design Specifications.

WEB - CRIPPLING, SPAN

TOP - FLANGE LOADING

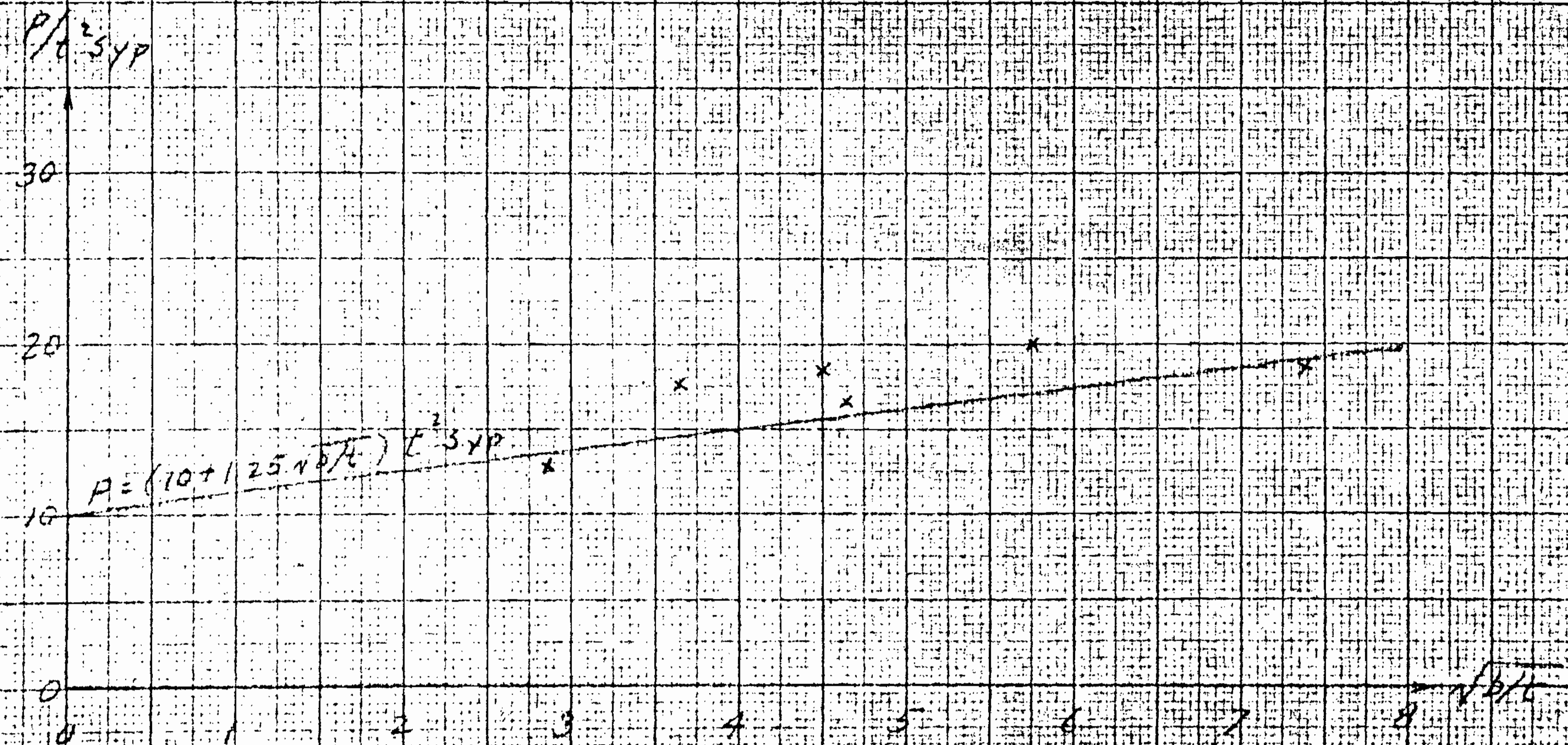




WEB CRIPPLING, SPAN
TWO-FLANGE LOADING
P/t² s_YP
50
40
30
20
10
0
P = (15 + 3.25 √b/t) t² s_YP
0
1
2
3
4
5
6
7
8
√b/t

WEB - CRI[illegible]ING, REACTION

Top - Flange Loading



WEB CRIPPLING REACTION

Two-Flange Loading