01 May 1941

Tests on light beams of cold formed steel

American Iron and Steel Institute

SCHOOL OF CIVIL ENGINEERING
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TESTS ON LIGHT BEAMS OF COLD FORMED STEEL

Nineteenth Progress Report
May 1941

1. SCOPE OF THIS REPORT

Failure tests have been carried out on beams O-3, P-3, Q-3, I-1, I-2, I-3 H-1, H-2, H-3, and K-1. As mentioned in the Sixteenth Progress Report (p. 15) it was anticipated that beams H,I,K, as originally designed, would fail in pure yielding. Since such a failure is not revealing for this investigation, an attempt was made to narrow both flanges of these beams. This work was done in the shops of the School of Civil Engineering and of the School of Mechanical Engineering. It turned out, however, that in cutting off parts of the flanges, the residual stresses, which had been created by the spot welding, gave rise to heavy warping and curving of the specimens. They were distorted to such an extent that they could not be used for test purposes. In this manner two specimens of type K were lost for test work. By means of tack welding before cutting it was possible to reduce the width of the top flange of beam I-1 to 2-1/2 in. without too much distorting the beam. On beam K-1 the width of the top flange was reduced to 2-1/2 in. and that of the bottom flange to 3-1/2 in. without too much distortion. All the flanges cut in this manner are not furnished with lips. Since out of four beams treated in the shop, only two more or less satisfactory specimens were obtained, it was decided to test the rest of the specimens as received. The present tests conclude the experimental

work on the 48 beam specimens of the last series.

In order to obtain some more data on lateral instability it is planned to test some of the 2x4 in. stud sections as beams. Such tests will result in a wider variety of data upon which to base final conclusions.

In addition to these tests work has been started on the detailed evaluation of the test results of beams A to G (local instability). This evaluation is not yet completed and will be reported on at a later date.

II. FAILURE TESTS ON BEAMS O-3, P-3, Q-3

(a) Method of Testing

The same method of testing was used as described in the Sixteenth Report for beams L,M,N. It was mentioned in the Eighteenth Report (pp. 4 and 5) that a definite twisting of the top flange had been observed on the first two specimens of beams O,P,Q. In order to facilitate a more accurate observation of this behavior, three level-bubble tubes, as used in geodetic instruments, were attached to the top flange of each of the specimens. One tube was fixed at the center of the span. On beam O-3 the second tube was attached 24 in. to one side and the third tube 18 in. to the other side of the center. On beams P-3 and O-3 the second and third tubes were attached at opposite distances from the center of 18 in. and 7-1/2 in. respectively. The bubbles did not allow a quantitative measurement of the amount of twist. They gave, however, a very sensitive indication of the occurence of torsional distortion and of the sense of rotation, and also allowed a comparison of the amount of rotation of each of the three points.

(b) Results

The preliminary results of thest tests are summarized in Table below.

TABLE I

Failure Tests on Triplicate Specimens O-3, P-3, Q-3

Beam	Gage	Ult. Load	Nominal Ult. Stress	Type of Failure
O-3	18	2490	26,600	lateral instability
P-3	18	3960	35,500	twisting and probably yielding
Q-3	18	3570	41,200	twisting and yielding

(c) Special Observations

Practically no twisting action was observed on beam O-3. In beam P-3 the twisting of the top flange began at a load of about 2250 lb (20,000 p.s.i.) and the twist distortion became rather heavy at about 3000 lb (27,000 p.s.i.). The lateral displacement of the beam was of negligible magnitude right up to the failure load. On beam Q-3 the twisting began at about 2250 lb (25,200 p.s.i.) and became rather heavy at 2750 lb (30,800 p.s.i.). The beam did not deflect laterally until failure.

(d) Discussion

The ultimate loads of the three beams are in good agreement with those obtained previously on the first two specimens of the same types (Eighteenth Report, Table 3). The types of failure diagnosed in the Eighteenth Report are confirmed for beams O and Q. However, on the basis of the present more precise measurements it appears that for beams P the twisting of the top flange was a more decisively contributing factor than lateral instability.

III. FAILURE TESTS ON BEAMS H,I,K

(a) Method of Testing

On beams I-1 and K-1 the method of testing was exactly the same as that discussed before for beams O-3, P-3, Q-3. On beams H-1 and H-2 no level-bubble tubes were used. (The test on beam H-1 had to be discontinued at a load of 16,000 lb. The reason was that at high loads the deflection became unexpectedly large and the beam was about to slip out from under the lateral supporting frames. For the other two specimens of this type the set-up was rearranged to take care of the large deflections.) On beams H-3, I-2, I-3 the set-up was changed in the following way: (1) an additional wire-gage-arrangement was used to allow independent observation of the horizontal displacements of the top and the bottom flange; bubble tubes were attached to the top and bottom flanges at the center of the span and one additional tube at about 18 in. from the center on the top flange.

(b) Results

The preliminary results of these tests are summarized in the following Table 2.

TABLE 2

Failure Tests on Specimens I-1, I-2, I-3, H-2, H-3, K-1

Beam	Gage	Ult. Load	Nominal Ult. Stress	Type of Failure
I-1	11	7,390	28,200	lateral instability
K-1	11	9,950	42,700	yielding
I-2	11	17,600	39,100	yielding
I-3	11	17,000	37,700	yielding
H-2	11	17,000	34,700	yielding
H-3	11	16,800	34,300	yielding

(c) Special Observations

All the beams of this series were more or less distorted to start with, partly twisted, partly curved. The worst specimens in this

respect were I-1 and H-2. When the beams were unpacked it was found that part of the welds was loose. For this reason all joints were furnished with additional tack welds over the whole length.

(d) Discussion

The preliminary evaluation of the test results seems to confirm the prediction made in the Sixteenth Report, namely, that these beams as originally designed would fail in simple yielding. The comparatively lower failure stresses of beams H-2 and H-3 are probably due to the fact that, because of the large free length of these beams, initial eccentricities and residual stresses are bound to have a greater effect than on short length beams. From the detailed observations made in these tests it appears that residual welding stresses had considerable influence on the behavior of these beams. A more complete discussion of this phase will be given after completion of the evaluation.

IV. SUMMARY

(1) The test work on all 48 beams of the last series has been completed. The evaluation of the data is now in progress. It is planned to supplement the present results by beam tests carried out on 2x4 in. I-stud sections. Additional tension tests are scheduled to furnish data on the mechanical properties of the sheets used. Further tests on cut-off parts of the present specimens are contemplated for investigating web stability and weld strength.

(2) The results of the present tests essentially confirm the conclusions drawn in the Sixteenth and Eighteenth Reports.

(3) The 18 gage specimens, O,P,Q are torsionally the weakest beams tested so far. From the present tests it is apparent that individual twisting of the top flange may occur in such beams. This twisting consists in an independent, wavelike pure rotation of the top flange, whereas in lateral buckling the entire beam is subject to uniform torsion in addition to lateral displacement. These two effects, therefore, are fundamentally different. Whether or not this independent twisting is of practical importance can be judged only after a more detailed evaluation of the test results is made.