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

Cornell University School of Civil Engineering

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I. SCOPE OF THIS REPORT

1. A stress investigation has been made at the load points of beam E-18-14-88a for spans of 6 and 12 ft. with center load and for spans of 12 ft. with quarter point loading.

2. A similar investigation has been made on beam E-18-12-816a.

II. GRAPHICAL REPRESENTATION OF THE RESULTS

Drawings 89 to 91 show the stress distribution at the load points of beam E-18-14-88a.

Drawing 92 shows the stress distribution for this beam averaged over both halves of the flange for the three kinds of loading investigated.

Drawings 93 to 95 show the stress distribution at the load points of beam E-18-12-816a.

Drawing 96 shows the stress distribution for this beam averaged over both halves of the flange for the three kinds of loading investigated.

The types of loading are indicated on loading sketches on each of the drawings.

III. STRESS DISTRIBUTION IN BEAM E-18-14-88a.

Because of insufficient welding of the top flange, tack welds were made in the same manner as on beams E-18-12-816a and b (cf. 7th Progress Report, section V). In order to prevent lateral motion of the two halves of the bottom flange (cf. 7th Report, section III) additional tack welds at 3" c.c. were placed along the joint of the two halves of the flange, i.e. at the bottom side.

The method of representing and evaluating the experimental stress data is the same as that outlined in section III of the eighth progress report. However, the data obtained are less accurate than those of all other beams reported on for the following reason: On the beams E-18-12-816a and b the strain in the bent up stiffeners on the bottom flange has been measured at two points on each side of the flange (points n, o, p and q on drawings 77 to 85 and 93 to 96).
However, since the distance from the stiffeners to the web is only 4 in. for the present beam, while the length of the Huggenberger strain gages is 7 in., it has not been possible to mount these gages on the inside of the stiffeners. For this reason the stress could be measured only on points n and q, whereas no data could be obtained for the points o and p. This causes considerable uncertainty in the determination of the average stress in the stiffeners.

Inspection of the drawings 89 to 92 again reveals marked irregularities in the stress distribution. However in this particular beam, for reasons just pointed out, it is not possible to ascertain whether the irregularities in the stresses in the stiffener represent the true picture or whether they are due to the necessarily incomplete measurements. Judging from the experience on other beams the average stress in the stiffener as obtained from averaging the stresses measured on both surfaces, may differ considerably from the stress measured on only one of the surfaces. Therefore too much weight should not be given to the results of tests on beam E-18-14-88a.

Table 1 shows a comparison of the experimental and the analytical values of the stress ratios.

<table>
<thead>
<tr>
<th>Span</th>
<th>Load</th>
<th>$l/b$</th>
<th>$r_{act.}$</th>
<th>$r_{theor.}$</th>
<th>diff.</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 ft.</td>
<td>Center</td>
<td>14.4</td>
<td>1.19</td>
<td>1.28</td>
<td>- 7%</td>
</tr>
<tr>
<td>12 ft.</td>
<td>Center</td>
<td>7.2</td>
<td>1.00</td>
<td>1.10</td>
<td>- 10%</td>
</tr>
<tr>
<td>12 ft.</td>
<td>Quarter-point</td>
<td>7.2</td>
<td>1.20</td>
<td>1.10</td>
<td>+ 9%</td>
</tr>
</tbody>
</table>

It is seen from this table that the difference between experimental and analytical values is considerably greater than on any of the other beams reported heretofore. It is believed that this is due mainly to incomplete data on the stresses in the stiffener.

IV. STRESS DISTRIBUTION IN BEAM E-18-12-816a

Information obtained from beam A-14-612a (cf. 7th Report, section III) indicated that the possibility of lateral motion of both halves of the flange decidedly increase the stress concentration at the web. It has been thought desirable to gather additional data on this fact. For this reason the bottom flange of this beam has not been reconstructed in any way, i.e. the two halves of the flange are held together only by the original spot welds in the web. It will be remembered that the twin specimen of this beam, E-18-12-816b has been provided with bolts in the bottom flange before being tested. For this reason the data given in the 8th report on the latter beam are representative for a beam in which lateral motion of the flange halves is practically prevented. On the contrary the data of E-18-12-816a apply to a beam in which the flanges are able to move laterally to a certain extent. Table 2 gives the stress ratios for both of these beams.
TABLE 2

Ratio "r" of the stresses at joint of web and flange to stresses at upper end of stiffener at load point. Beam E-18-12-816b (with bolts) and beam E-18-12-816a (without bolts).

<table>
<thead>
<tr>
<th>Span</th>
<th>Load</th>
<th>1/b</th>
<th>F_{act.}</th>
<th>F_{act.}</th>
<th>r_{theor.}</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 ft.</td>
<td>Center</td>
<td>4.0</td>
<td>2.0</td>
<td>3.05</td>
<td>2.08</td>
</tr>
<tr>
<td>12 ft.</td>
<td>Center</td>
<td>8.0</td>
<td>1.25</td>
<td>1.38</td>
<td>1.28</td>
</tr>
<tr>
<td>12 ft.</td>
<td>Quarter-point</td>
<td>8.0</td>
<td>1.31</td>
<td>1.71</td>
<td>1.28</td>
</tr>
</tbody>
</table>

The influence of the bolts which were placed in the lower part of the web is clearly seen from these data. Whereas the coincidence of actual and analytical stress ratios is very close for the beam with bolts, these ratios are in all cases very much higher for the beam without bolts and, for the latter, are far above the theoretical values. Thus the evidence obtained from this beam confirms fully the information obtained from beam A-14-612a.

Inspection of drawings 93 to 96 again reveals some irregularity in the stress distribution, which, however, is less in this beam than in its twin specimen. This may be due to possible initial stress set up in beam E-18-12-816b due to inevitable differences in the tightening of the bolts. Most of the irregularity in the present beam takes place in the bent up stiffeners. However these stiffeners, as in previous beams, take part fully in the action of the beam and therefore may be included in the section modulus.

V. SPECIAL OBSERVATIONS

In the course of the strain observations on beam E-18-12-816a with 12 ft. span and center load this beam accidentally was loaded to twice the planned load, i.e. to a load corresponding to about 28000 p.s.i. maximum stress. The beam showed no signs of yielding or buckling at that load, but 6 spot welds in the web (bottom row) broke near one support. The beam however was not destroyed by this failure and the rest of the investigation was carried out as usual.

This is one more proof of the fact pointed out in the summary report; namely, that in some cases it is neither buckling of the top flange nor the yielding of the material but it is insufficient strength of the welds in the web that may cause failure. It is hoped that more information on this subject will be gathered from the failure tests now under way.
VI. CORRECTION

By mistake the stress ratios $k$ on drawings 77 to 84 (8th Report) have been computed on the basis of the section modulus for the beam D-18-12-816 instead of E-18-12-816. In order to correct this error, all these factors should be multiplied by the ratio of these two section moduli, i.e. by $7.78/7.12 = 1.09$. As yet no conclusions have been drawn from these figures. Therefore it will be sufficient to make the corresponding correction in the final report on the question of flange stresses.

VII. CONCLUSIONS

The present tests fully confirm the conclusions given in the 8th Report (Section V, 1, 2, 4, 5). In addition a comparison between the stress distribution of the twin beams E-18-12-816a and b again reveals the importance of designing beams in such a way that separating lateral movement of the halves of the flange is prevented. The presence of such movement greatly increases the stress concentration and thus diminishes the efficiency of the beam.

It is believed that at present enough data on the question of the stresses in the bottom flange have been gathered, so that a final report on this part of the problem can be worked out. This will be done after the completion of the failure tests on the present beams.
STRESS DISTRIBUTION IN BOTTOM FLANGE
AT LOAD POINT
E = 18,14 - 88 - \alpha

Top Surface

Bottom Surface

Mid Plane
STRESS DISTRIBUTION IN BOTTOM FLANGE
AT LOAD POINT
E = 18 - 14 - 88 - α

10,000 Top Surface

5000

0

10,000 Bottom Surface

5000

0

10,000 Mid Plane

5000

0

Letters:
- a b c d e f
- g h i j k l m n
STRESS DISTRIBUTION IN BOTTOM FLANGE AT LOAD POINT
E = 18 - 12 - 816 - ax

Top Surface

Bottom Surface

Mid Plane

WEB

0.25 0.75 1.25 1.75 2.25 2.75 3.25 3.75 4.25 4.75 5.25 5.75 6.25 6.75 7.25 7.75 8.25 8.75 9.25 9.75 10.25
STRESS DISTRIBUTION IN BOTTOM FLANGE AT LOAD POINT E-18-16-816-α

Top Surface

Bottom Surface

Mid Plane

WEIGHT

n q h i k l m p

12°
STRESS DISTRIBUTION IN BOTTOM FLANGE AT LOAD POINT
E-18-16-816-a

Top Surface

Bottom Surface

Mid Plane

Longitudinal Stress

10,000
5,000
0

-10,000
-5,000
0
AVERAGE STRESS DISTRIBUTION IN BOTTOM FLANGE AT LOAD POINT

E-10-12-816-a

WEB

\[ c, d \]
\[ b, e \]
\[ a, f \]