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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

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I. SCOPE OF THIS REPORT

In the preceding 14th Progress Report a method was proposed to determine the forces acting in the welds in the web of I-beams composed of two channels. This method essentially has been based on the magnitude "e", the distance of the flexural center from the axis of the web. A formula for "e" was given which applies to symmetrical channels of uniform thickness.

In the present report this expression for "e" will be simplified and a more general expression will be derived for "e" for symmetrical channels with web thickness differing from flange thickness. Furthermore, a method will be proposed to apply this approach to channels non-symmetrical about the horizontal axis.

In addition to the work reported herein, an analytical investigation of the lateral stability of unsymmetrical thin walled I-beams has been under way for some time. Of necessity this analysis has to be of considerably wider scope than is required by the problems under consideration. The essential parts of this investigation are now worked out. They are expected to be helpful in the interpretation of the coming beam tests and will be reported on in connection therewith.

II. THE DISTANCE "e" FOR SYMMETRICAL CHANNELS

The general formula for "e" for symmetrical channels is

$$e = \frac{h\, H_{xy}}{4\, I_x}$$

where

h is the depth of the beam,

H_{xy} is the product of inertia of half the section (above horizontal axis of symmetry) with respect to the axis of symmetry (x) and the axis of the web (y).

I_x is the moment of inertia of the whole section with respect to the x-axis.

(see R.J. Roark: Formulas for Stress and Strain, p. 118)

If

b_1 and t_1 are respectively the width and the thickness of the flanges and

t is the thickness of the web

it is seen that

$$H_{xy} = \frac{b^2\, t_1\, h}{4} \quad \text{and}$$

$$I_x = 2\, b\, t_1 \frac{h^2}{4} + \frac{h^3\, t}{12}$$

If these values are substituted in the equation for e one obtains

$$e = \frac{b^2\, t_1}{2\, b\, t_1 + t\, h/3}$$

In particular for channels of uniform thickness ($t_1 = t$) the expression simplifies to

$$e = \frac{b^2}{2\, b + h/3}$$

These expressions should be used in determining the required weld diameters for I-beams composed of two symmetrical channels by means of the method proposed in the 14th Progress Report.

III. THE PROBLEM OF I-BEAMS WITH FLANGES DIFFERENT FROM EACH OTHER

For I-beams composed of two channels each of which is non-symmetrical about its horizontal axis the application of the method proposed in the 14th Report would require the determination of "e" for such cross sections.

A systematic search of the literature has revealed that apparently no explicit formula for determining "e" in this case has yet been developed. A paper by W.L.S. Schwalbe (Trans. Am. Soc. Mech. Eng. Vol. 54, APM11, p. 125, 1932), which at the time of the writing of the 14th Report had been believed to serve this purpose, has since been found to contain rather questionable assumptions. No other article in English or in German seems to answer this question. In addition it can be seen from the nature of the problem that any formula for "e" for unsymmetrical channel sections that could possibly be developed, would necessarily be of such an involved nature that it would be highly impracticable for design purposes.

For this reason the following approximate approach is proposed for use in the case under consideration.

Let

b_1 and t_1 be respectively the width and the thickness of the top flan[ge]

b_2 and t_2 respectively the width and the thickness of the bottom flan[ge]

h and t respectively the depth and the thickness of the web.

Imagine two symmetrical channels, one having the width of both flanges b_1 and the thickness t_1, the other having the width and the thickness of both flanges b_2 and t_2. The distances e_1 and e_2 for each of these symmetrical channels can now be determined from the general formula

$$e_n = \frac{b_n^2 \; t_n}{2 \, b_n \, t_n + t \, h/3}$$

It is evident that the magnitude of the actual distance "e" for the unsymmetrical channel will lie between the two values e_1 and e_2.

Two approaches are now possible. One may assume without detailed justification that for all practical purposes $e = 1/2 \, (e_1 + e_2)$ and determine the necessary weld diameter by means of this e. Or, alternatively, if a more conservative approach seems desirable, the larger of the two values e_1 and e_2 may be used in designing the welds. The results obtained by this latter approach are bound to be slightly on the safe side.

Numerical example:

Suppose $b_1 = 3.5"$; $t_1 = 14$ ga. $= .077"$; $b_2 = 5"$; $t_2 = 18$ ga. $= .049"$; $h = 8"$; $t = 14$ ga. $= .077"$

Then, using the formula given above, values for $e_1 = 1.27"$ and $e_2 = 1.76"$ are obtained. Consequently, for the weld design, use either $e = 1/2(e_1 + e_2) = 1.53"$ or $e = e_2 = 1.76"$. It is seen that in the given case these two values for e do not differ much from each other.

It is believed that a few rather simple tests would answer the question which one of these two values should be recommended for practical use. These tests could be either carried out with channels cut out of the present beams A to G after they have served for the main tests, or if it turns out that it is not possible to unfasten the welds of these beams without damage to the channels, simple specimens for this purpose could easily be made up from rolled sections.

IV. I-BEAMS WITH FLANGES FURNISHED WITH LIPS

If the flanges of the component channels of the I-beam are furnished with lips, the simple formulae developed before do not longer apply. In this case it is necessary to use the general formula

$$e = \frac{h\ H_{xy}}{4\ I_x}$$

If, in addition, the flanges are different from each other, the same approach may be applied as suggested in section III of this report.

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Analysis