Discussion

Torsion of Rolled Steel Sections in Building Structures

Paper presented by JOHN G. HOTCHKISS (January, 1966, Issue)

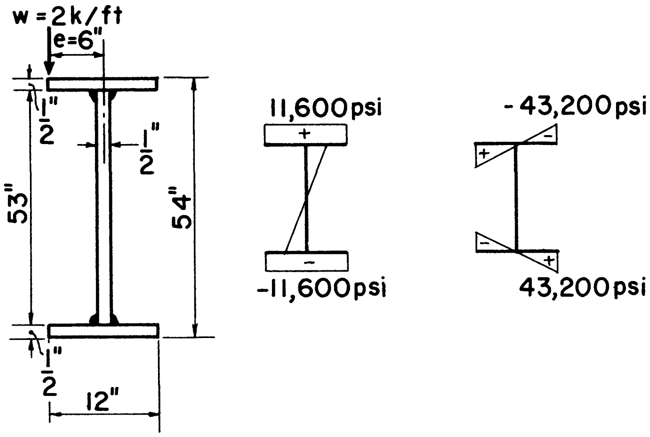
Discussion by JOHN C. BURTON

I SHOULD LIKE to suggest a very careful dimensional analysis of Example 4 on page 30, for I feel such an analysis may reveal an error of the magnitude of 10 in the calculations.

Discussion by JOHN G. HOTCHKISS

WE APPRECIATE your calling attention to Example 4. The error involved the incorrect solution for the maximum warping moment at midspan as determined from

John C. Burton is Associate Civil Engineer, San Diego Gas & Electric Company, San Diego, Calif.
John G. Hotchkiss is Senior Regional Engineer, American Institute of Steel Construction, New York, N. Y.



Figures 17 and 18 (corrected)

Table 2. The correct equation appearing in Table 2, Short Method, page 41, should read, max $M_w = \frac{D_2 m l^2}{h}$ (lb-in.). The term h was omitted in the original artwork.

A typographic error in the Nomenclature on page 31 should also be noted. The definition of m should read "Uniformly distributed torsional load (lb-in./in. or lb-ft/ft)".

Example 4 (revised)

Given: A beam built-up by welding three plates resembling an I-section is loaded with a uniformly distributed torsional moment m = 1,000 lb-ft/ft over the entire span of 46 ft. The end connections are assumed to be bolted web clip angles, Type 2 construction. Determine if the additive torsional normal stresses are within permissible limits by the "Quick Method" and check results by the Exact method. (e = 6 in., w = 2,000 lb/ft, see Fig. 17.)

Solution:

$m = (2{,}000 \times 6)/12 = 1{,}000$ lb-in./in. (positive moment, see Fig. 5)

Determine the torsional constants and properties from Chart 1:

$$C_w = \frac{1}{24} b^3 h^2 t = \frac{1}{24} 12^3 \times 53.5^2 \times 0.50$$

$$= 103{,}000 \text{ in.}^6$$

$$K = \frac{2}{3} b t^3 + \frac{1}{3} l_1 t_1^3$$

$$= \frac{2}{3} \times 12 \times 0.50^3 + \frac{1}{3} \times 53 \times 0.50^3$$

$$= 3.21 \text{ in.}^4$$

$$w_{\max} = \frac{bh}{4} = \frac{12 \times 53.5}{4} = 160.5 \text{ in.}^2$$

$$\lambda = 0.62\sqrt{\frac{K}{C_w}} = 0.62\sqrt{\frac{3.21}{103{,}000}} = 0.00341 \text{ in.}^{-1}$$

$$\lambda l = 0.00341 \times 552 = 1.88$$

$$S_w = \frac{C_w}{w_{\max}} = \frac{103{,}000}{160.5} = 642 \text{ in.}^4$$

Determine the moment of inertia $I_y/2$:

$$\text{Since } S_w = \frac{C_w}{w_{\max}} \text{ and } C_w = \frac{I_y}{2}\frac{h^2}{2}$$

$$\text{then } \frac{I_y}{2} = \frac{S_w \times w_{\max}}{h^2/2} = \frac{642 \times 160.5}{53.5^2/2} = 72 \text{ in.}^4$$

Determine maximum warping moment at midspan from Table 2, Short Method. (Note the moment M_w as used in Table 2 is expressed in lb-in. and should not be confused with M_w the bimoment expressed as lb-in.^{2} used elsewhere in this paper.) Since λl = 1.88, a linear interpolation between λl = 1.5 and 2.0 gives D_2 = 0.0911.

$$\text{Then max } M_w = \frac{D_2 m l^2}{h} = \frac{0.0911 \times 1{,}000 \times 552^2}{53.5}$$

$$= 518{,}000 \text{ lb-in.}$$

$$\max \sigma_w = \frac{M_w}{\frac{I_y}{2}} \times C_1 = \frac{518{,}000 \times 6}{72}$$

$$= 43{,}200 \text{ psi (where } c_1 = b/2)$$

Determine maximum moment due to plane bending at midspan:

$$\max M_b = \frac{wl^2}{8} = \frac{2{,}000 \times 46^2}{8} = 529{,}000 \text{ lb-ft}$$

$$\max \sigma_b = \frac{M_b}{S_x} = \frac{529{,}000 \times 12}{547} = 11{,}600 \text{ psi}$$

Combined normal stresses: max σ_w + max σ_b = 43,200 + 11,600 = 54,800 psi

Check by long method using Table 1 (Case 1)

$$\max M_w = \frac{m}{\lambda^2}\left[1 - \frac{1}{\cosh \frac{\lambda l}{2}}\right]$$

where $\lambda l/2 = 0.94$ and $\cosh 0.94 = 1.475$

$$\max M_w = \frac{1{,}000}{0.00341^2}\left[1 - \frac{1}{1.475}\right]$$

$$= 27{,}800{,}000 \text{ lb-in.}^2$$

$$\max \sigma_w = \frac{M_w}{S_w} = \frac{27{,}800{,}000}{642} = 43{,}300 \text{ psi}$$