(2) Underside of flange directly beneath wheel contact point, Point 1

\[ \sigma_{c1} = C_{c1} \frac{P}{I_{c1}} \]  
\[ \sigma_{c2} = C_{c2} \frac{P}{I_{c2}} \]  

(21) (22)

(3) Topside of flange at flange-to-web transition, Point 2

\[ \sigma_{c1} = -\sigma_{c2} \]  
\[ \sigma_{c2} = -\sigma_{c1} \]  

(23) (24)

(4) For tapered flange sections [see Fig. NUM-III-8232.3-1, illustration (b)]

\[ C_{c0} = -1.096 + 1.095a + 0.192e^{0.634} \]  
\[ C_{c1} = 3.965 - 4.835a - 3.965e^{-2.6734} \]  
\[ C_{c2} = -0.981 + 1.4979 + 1.20a^{0.3224} \]  
\[ C_{c3} = 1.810 - 1.150a + 1.060e^{0.7201} \]  
\[ t_f = \frac{b}{2} + \frac{|a|}{6} \]  

(25) (26) (27) (28) (29)

for standard "S" section, where

\[ t_f = \text{published flange thickness for standard "S" section, in.} \]

(5) For parallel flange section [Fig. NUM-III-8232.3-1, illustrations (c) and (d)]

\[ C_{c0} = -2.110 + 1.977a + 0.1027e^{3.234} \]  
\[ C_{c1} = 10.108 - 7.408a - 10.108e^{-3.6441} \]  
\[ C_{c2} = 0.050 - 0.580a + 0.148e^{1.051} \]  
\[ C_{c3} = 2.230 - 1.490a + 1.390e^{1.9334} \]  

(30) (31) (32) (33)

(6) For single-web symmetrical sections [Fig. NUM-III-8232.3-1, illustrations (b) and (c)]

\[ \lambda = \frac{2a}{b - t_f} \]  

(34)

where

\[ b = \text{section width across flanges, in.} \]

(7) For other cases [Fig. NUM-III-8232.3-1, illustration (d)]

\[ \lambda = \frac{a}{b - \left(\frac{t_f}{2}\right)} \]  

(35)

where

\[ a = \text{distance from edge of flange to point of wheel load application, in. (center of wheel contact)} \]  
\[ b' = \text{distance from centerline of web to edge of flange, in.} \]  
\[ P = \text{load per wheel including H/L, lb} \]  
\[ t_f = \text{flange thickness at point of load application, in.} \]  
\[ t_w = \text{web thickness} \]

NOTE: If \( \frac{1}{2} b - a < \text{centerline distance between adjacent wheels, then the load } P \text{ is equal to the maximum single wheel load without considering the effect of the adjacent wheel. Conversely, if } \frac{1}{2} b - a \geq \text{centerline distance between adjacent wheels, then the loading of the two adjacent wheels shall be combined into a single load.} \]

(b) The localized stresses due to local bending effects imposed by wheel loads calculated at Points 0 and 1 are to be combined with the stresses due to Case 2 loading specified in NUM-III-8213 of this specification. When calculating the combined stress, the flange bending stresses shall be diminished to 75% of the value calculated per (a) above.

The combined stress value \( \sigma_{ct} \) obtained by the method prescribed in (f) below shall not exceed the allowable Case 2 stress level of 0.66\( \sigma_y \) where \( \sigma_y \) = yield strength of the material.

(c) Additionally, in the case of welded plate girders only, the localized stresses on the top side of the flange at the flange-to-web transition (Point 2) shall be combined with the stresses due to the Case 2 loading specified in NUM-III-8213 of this specification.

The combined stress value \( \sigma_{ct} \) in the weld at Point 2 obtained by the method prescribed in (f) below shall not exceed the allowable weld stress specified in NUM-III-8224.1, nor shall the stress range in the weld exceed the value specified in Table NUM-III-8234.1-1 for joint category E.

(d) The local flange bending criteria per NUM-III-8223.2 shall be met in addition to the general criteria of NUM-III-8213 and NUM-III-8231.

(e) At load transfer points, consideration should be given to lower flange stresses that are not calculable by the formulae presented in NUM-III-8232.3.

(f) Combined Stresses. Where a state of combined plane stresses exists, the reference stress, \( \sigma_r \), can be calculated from the following formula:

\[ \sigma_r = \sqrt{\sigma_x^2 + \sigma_y^2 - \sigma_x \sigma_y + 3 \tau_{xy}^2} \leq \sigma_{all} \]  

(36)

where

\[ \sigma_{all} = \text{allowable stress} \]  
\[ \sigma_x, \sigma_y = \text{normal stress in respective x and y directions} \]  
\[ \tau_{xy} = \text{shear stress in plane} \]

For welds, the maximum combined stress, \( \sigma_{w} \), shall be calculated as follows:

\[ \sigma_w = \frac{1}{2} \left( \sigma_x + \sigma_y \right) + \frac{1}{2} \sqrt{(\sigma_x - \sigma_y)^2 + 4 \tau_{xy}^2} \leq \sigma_{all} \]  

(37)

See NUM-B-4000 for a lower flange bending calculation example.

NUM-III-8232.4 Shear and Tension of Bolts

(a) Bolts subject to combined shear and tension shall be so proportioned that the tension stress, in psi, produced by forces applied to the connected parts, shall not exceed the allowable tension value, \( \sigma_{all} \).