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Requirement of connection ends of web stiffeners in CSR BC Rules Ch.6, Sec.2-4.1.3

1. Summary

By considering correctly the effect of inclination of web stiffener, the equation of stress range ($\Delta\delta$) in CSR BC Rule Ch.6, Sec.2-4.1.3 should be changed to Eq. (12) below.

2. Stress range for non-slanted web stiffener

As shown in Fig. 1, the model adopted in the CSR BC Rules Ch.6, Sec.2-4.1.3 assumes that the web stiffener is fixed at its end, i.e., any deflection of the primary member is ignored and any shear force working in the primary member is also ignored.

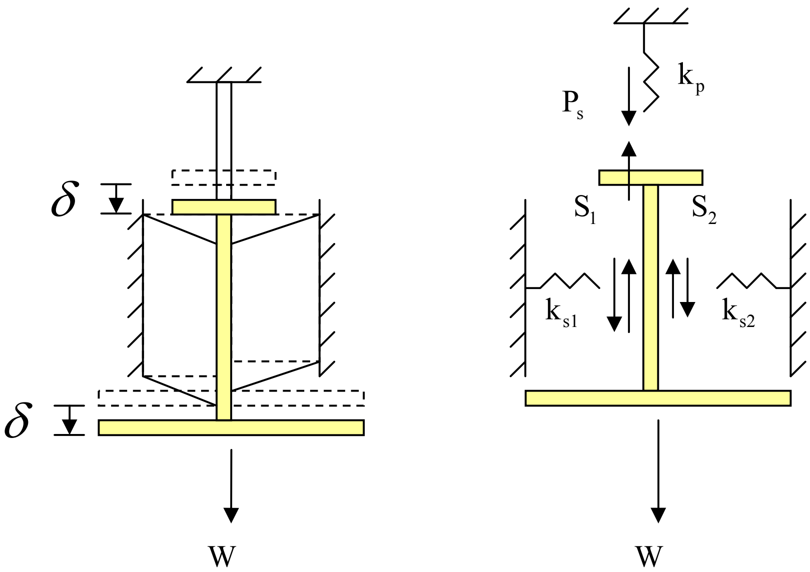


Fig. 1 Model used in CSR BC Rules Ch.6, Sec.2-4.1.3

From the equilibrium considerations of the vertical loads at the ordinary stiffener, we have

$$P_s + S_1 + S_2 = W. \tag{1}$$

Each vertical load at the web stiffener, the primary member web and the collar plate, if any, can be expressed as follows:

$$\begin{aligned}
P_s &= \frac{EA_{s0}}{h'}\delta, \\
S_1 &= \frac{GA_{w1e}}{l_1}\delta = \left(\frac{E}{2.6}\right)\left(\frac{A_{w1}}{1.2}\right)\frac{\delta}{l_1} = 0.321\frac{EA_{w1}}{l_1}\delta, \\
S_2 &= \frac{GA_{w2e}}{l_2}\delta = \left(\frac{E}{2.6}\right)\left(\frac{A_{w2}}{1.2}\right)\frac{\delta}{l_2} = 0.321\frac{EA_{w2}}{l_2}\delta,
\end{aligned} \tag{2a}$$

(2b)

(2c)

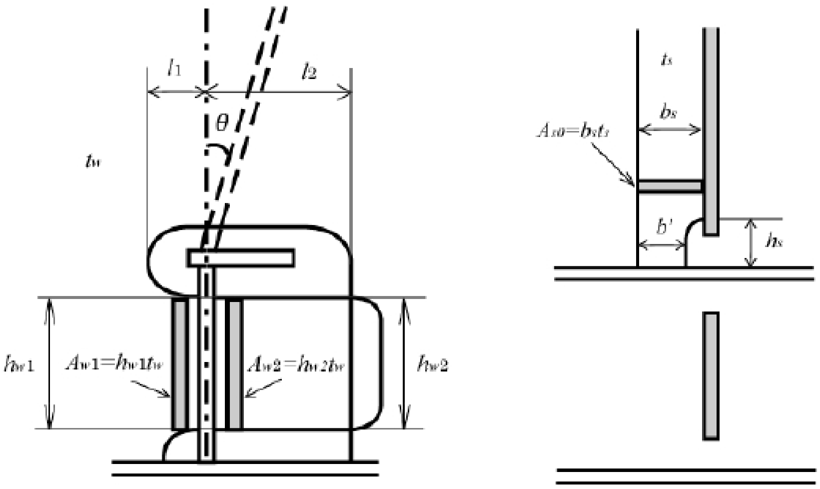
where:

A_{w1e}, A_{w2e}: Effective shear area, in mm^2, = $A_{w1}/1.2$, $A_{w2}/1.2$ respectively

h': As obtained from following formula, in mm:
$h' = h_s + h_0'$

h_0': As obtained from the following formula, in mm:
$h_0' = 0.636b'$ for $b' \leq 150$
$h_0' = 0.216b' + 63$ for $150 < b'$

other parameters: see Fig. 1 and 2.



Note:

t_s: net thickness of the web stiffener, in *mm*.

t_w: net thickness of the collar plate, in *mm*.

Fig. 2 Definitions of geometric parameters

Substitution of Eqs. (2.a), (2b) and (2.c) into Eq. (1) gives

$$E\left\{\frac{A_{s0}}{h'} + 0.321\left(\frac{A_{w1}}{l_1} + \frac{A_{w2}}{l_2}\right)\right\}\delta = W,$$

from which

$$\delta = \frac{h'}{A_{s0} + 0.321h'\left(\frac{A_{w1}}{l_1} + \frac{A_{w2}}{l_2}\right)}\frac{W}{E}. \tag{3}$$

Substituting Eq. (3) into Eq. (2.a), we obtain

$$P_s = \frac{A_{s0}}{A_{s0} + 0.321h'\left(\frac{A_{w1}}{l_1} + \frac{A_{w2}}{l_2}\right)}W. \tag{4}$$

Thus, the axial stress range at its base is:

$$\Delta\sigma = 2\frac{P_s}{A_{s0}} = \frac{2W}{A_{s0} + 0.321h'\left(\frac{A_{w1}}{l_1} + \frac{A_{w2}}{l_2}\right)}. \tag{5}$$

3. Stress range for slanted web stiffener

When the ordinary stiffener with a slanted web stiffener is deflected downward δ as shown in Fig. 3, the web stiffener is elongated by δs as follows:

$$\delta_s = \delta\cos\theta. \tag{6}$$

From the equilibrium considerations at the base of the web stiffener, we have

$$P_s = P_{so}\cos\theta. \tag{7}$$

The axial force in the web stiffener is given using its elongation as follows:

$$P_{so} = \frac{EA_{s0}}{h'}\delta_s. \tag{8}$$

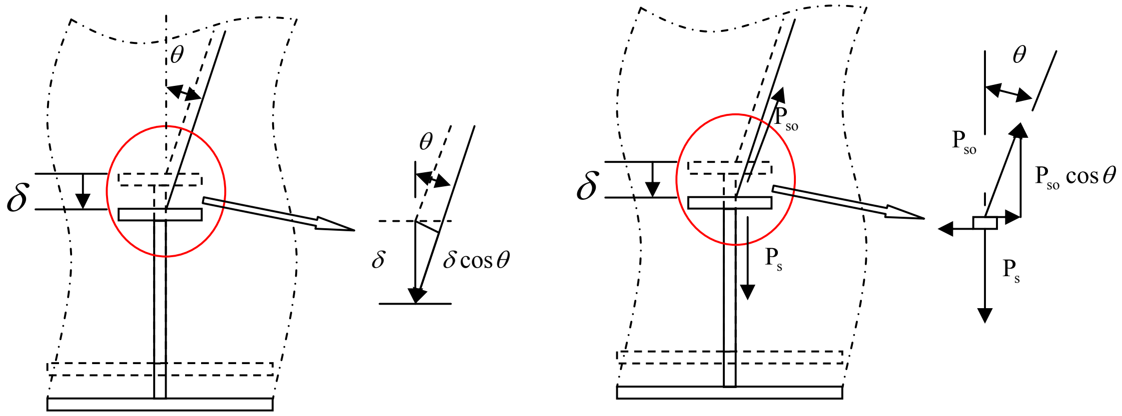


Fig. 3 Slanted web stiffener

Combined Eqs. (6), (8) with Eq. (7), we obtain

$$P_s = P_{so}\cos\theta = \frac{EA_{s0}}{h'}\cos\theta\delta_s = \frac{EA_{s0}}{h'}\cos^2\theta\delta. \tag{2a'}$$

The above differs from Eq. (2a) as to $\cos^2\theta$. This effect is to be taken into account in calculation of Ps. Substitution of Eqs. (2a'), (2b) and (2c) into Eq. (1) gives

$$\delta = \frac{h'}{A_{s0}\cos^2\theta + 0.321h'\left(\frac{A_{w1}}{l_1} + \frac{A_{w2}}{l_2}\right)}\frac{W}{E}. \tag{10}$$

Substituting Eq. (10) into Eq. (2.a'), we obtain

$$P_s = \frac{A_{s0}\cos^2\theta}{A_{s0}\cos^2\theta + 0.321h'\left(\frac{A_{w1}}{l_1} + \frac{A_{w2}}{l_2}\right)}W. \tag{11}$$

Therefore, the axial stress range at the base of the web stiffener becomes

$$\Delta\sigma_s = 2\frac{P_{so}}{A_{s0}} = 2\frac{P_s}{A_{s0}}\frac{1}{\cos\theta} = \frac{2W\cos\theta}{A_{s0}\cos^2\theta + 0.321h'\left(\frac{A_{w1}}{l_1} + \frac{A_{w2}}{l_2}\right)}. \tag{12}$$