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Exercise #13 –Plate Buckling -Part 2 – Post-buckling shear resistance of web panels

Consider an S355J2 steel open-section beam, with the distance between flange centerlines $h_f = 1500\,mm$, web thickness $t_w = 10\,mm$, and transverse stiffener spacing $a = 2000\,mm$. Compute the shear resistance of the web for the following cases:

1. With transverse stiffeners and anchoring of tension diagonal at the beam extremity;
2. Without transverse stiffeners, but with anchoring of tension diagonal at the beam extremity;
3. Without transverse stiffeners and without anchoring of tension diagonal at the beam extremity.

Solution to Exercise #13

Question 1:

$$\alpha = \frac{a}{h_f} = \frac{2000}{1500} = 1.33$$

§F.1.4 SIA263:2013

$$k = 5.34 + \frac{4.0}{\alpha^2} = 5.34 + \frac{4.0}{1.33^2} = 7.6$$

Eq. 104 – Annex F, SIA263:2013

$$\tau_{cr} = k\frac{\pi^2 E}{12(1-\nu^2)}\left(\frac{t_w}{h_f}\right)^2 = 7.6\frac{\pi^2 210e3}{12(1-0.3^2)}\left(\frac{10}{1500}\right)^2 = 64.1 \leq 0.8\tau_y = 0.8\frac{355}{\sqrt{3}} = 164\ N/mm2$$

Eq. 101 and Eq.102 – Annex F, SIA263:2013

$$V_{Rd} = \frac{1}{\gamma_{M1}}\left(\tau_{cr} + \frac{\sqrt{3}(\tau_y - \tau_{cr})}{2\sqrt{1+\alpha^2}}\right)A_w = \frac{1}{1.05}\left(64.1 + \frac{\sqrt{3}\left(\frac{355}{\sqrt{3}} - 64.1\right)}{2\sqrt{1+1.33^2}}\right)(1500 \cdot 10) = 1.96e6\ N$$

Question 2:

$$\alpha = 3$$

§F.1.4 SIA263:2013

$$k = 5.34 + \frac{4.0}{\alpha^2} = 5.34 + \frac{4.0}{3^2} = 5.78$$

Eq. 104 – Annex F, SIA263:2013

$$\tau_{cr} = k\frac{\pi^2 E}{12(1-\nu^2)}\left(\frac{t_w}{h_f}\right)^2 = 5.78\frac{\pi^2 210e3}{12(1-0.3^2)}\left(\frac{10}{1500}\right)^2 = 48.75 \leq 164\ N/mm2$$

Eq. 101 and Eq.102 – Annex F, SIA263:2013

$$V_{Rd} = \frac{1}{\gamma_{M1}}\left(\tau_{cr} + \frac{\sqrt{3}(\tau_y - \tau_{cr})}{2\sqrt{1+\alpha^2}}\right)A_w = \frac{1}{1.05}\left(48.75 + \frac{\sqrt{3}\left(\frac{355}{\sqrt{3}} - 48.75\right)}{2\sqrt{1+3^2}}\right)(1500 \cdot 10)$$
$$= 1.31e6\ N$$

Question 3:

$$\alpha = \infty \implies k = 5.34$$

$$\tau_{cr} = k\frac{\pi^2 E}{12(1-\nu^2)}\left(\frac{t_w}{h_f}\right)^2 = 5.34\frac{\pi^2 210e3}{12(1-0.3^2)}\left(\frac{10}{1500}\right)^2 = 45.04\ N/mm2$$

$$V_{Rd} = \frac{1}{\gamma_{M1}} 0.9 \sqrt{\tau_y \tau_{cr}} A_w = \frac{1}{1.05} 0.9 \sqrt{\frac{355}{\sqrt{3}} \cdot 45} \cdot (1500 \cdot 10) = 1.23e6N$$