$$F_d = \gamma_f F_k$$

vigas com estribos verticais - modelo I

$$V_{Sd} \le \begin{cases} V_{Rd2} \\ V_{Rd3} \end{cases}$$

$$V_{Rd2} = 0{,}27\,\alpha_{v2}\, f_{cd}\, b_w\, d$$

$$\alpha_{v2} = 1 - \frac{f_{ck}}{250} \quad \langle f_{ck} \text{ em MPa} \rangle$$

$$V_{Rd3} = V_c + V_{sw}$$

$$V_c = 0{,}6\, f_{ctd}\, b_w d$$

$$f_{ctd} = \begin{cases} \dfrac{0{,}21 \times \sqrt[3]{f_{ck}^2}}{\gamma_c} & \langle f_{ck} \le 50\,\text{MPa} \rangle \\ \dfrac{1{,}484 \times \ln(1 + 0{,}11 f_{ck})}{\gamma_c} & \langle f_{ck} > 50\,\text{MPa} \rangle \end{cases}$$

$$V_{sw} = \left(\frac{A_{sw}}{s}\right) 0{,}9\, d\, f_{ywd}$$

$$f_{ywd} = \frac{f_{yk}}{\gamma_s} \le 435\,\text{MPa}$$

$$\rho_{sw} = \frac{A_{sw}}{b_w\, s} \ge 0{,}2\,\frac{f_{ct,m}}{f_{ywk}}$$

$$f_{ct,m} = \begin{cases} 0{,}3 \times \sqrt[3]{f_{ck}^2} & \langle f_{ck} \le 50\,\text{MPa} \rangle \\ 2{,}12 \times \ln(1 + 0{,}11 f_{ck}) & \langle f_{ck} > 50\,\text{MPa} \rangle \end{cases}$$

$$f_{ywk} = f_{yk} \le 500\,\text{MPa}$$

vigas com estribos verticais - modelo II

$$V_{Sd} \le \begin{cases} V_{Rd2} \\ V_{Rd3} \end{cases}$$

$$V_{Rd2} = 0{,}54\,\alpha_{v2}\, f_{cd}\, b_w\, d \operatorname{sen}\theta \cos\theta$$

$$\alpha_{v2} = 1 - \frac{f_{ck}}{250} \quad \langle f_{ck} \text{ em MPa} \rangle$$

$$30° \le \theta \le 45°$$

$$V_{Rd3} = V_c + V_{sw}$$

$$V_c = V_{c0}\left(\frac{V_{Rd2} - V_{Sd}}{V_{Rd2} - V_{c0}}\right) \le V_{c0}$$

$$V_{c0} = 0{,}6\, f_{ctd}\, b_w d$$

$$f_{ctd} = \begin{cases} \dfrac{0{,}21 \times \sqrt[3]{f_{ck}^2}}{\gamma_c} & \langle f_{ck} \le 50\,\text{MPa} \rangle \\ \dfrac{1{,}484 \times \ln(1 + 0{,}11 f_{ck})}{\gamma_c} & \langle f_{ck} > 50\,\text{MPa} \rangle \end{cases}$$

$$V_{sw} = \left(\frac{A_{sw}}{s}\right) 0{,}9\, d\, f_{ywd} \cot\theta$$

$$f_{ywd} = \frac{f_{yk}}{\gamma_s} \le 435\,\text{MPa}$$

$$\rho_{sw} = \frac{A_{sw}}{b_w\, s} \ge 0{,}2\,\frac{f_{ct,m}}{f_{ywk}}$$

$$f_{ct,m} = \begin{cases} 0{,}3 \times \sqrt[3]{f_{ck}^2} & \langle f_{ck} \le 50\,\text{MPa} \rangle \\ 2{,}12 \times \ln(1 + 0{,}11 f_{ck}) & \langle f_{ck} > 50\,\text{MPa} \rangle \end{cases}$$

$$f_{ywk} = f_{yk} \le 500\,\text{MPa}$$

$5\,\text{mm} \le \phi_t \le \dfrac{b_w}{10}$	$\dfrac{V_{Sd}}{V_{Rd2}} \le 0{,}67 \Rightarrow 7\,\text{cm} \le s \le \min\begin{bmatrix} 0{,}6\,d \\ 30\,\text{cm} \end{bmatrix}$	$\dfrac{V_{Sd}}{V_{Rd2}} > 0{,}67 \Rightarrow 7\,\text{cm} \le s \le \min\begin{bmatrix} 0{,}3\,d \\ 20\,\text{cm} \end{bmatrix}$

deslocamento de diagrama

vigas com estribos verticais - modelo I

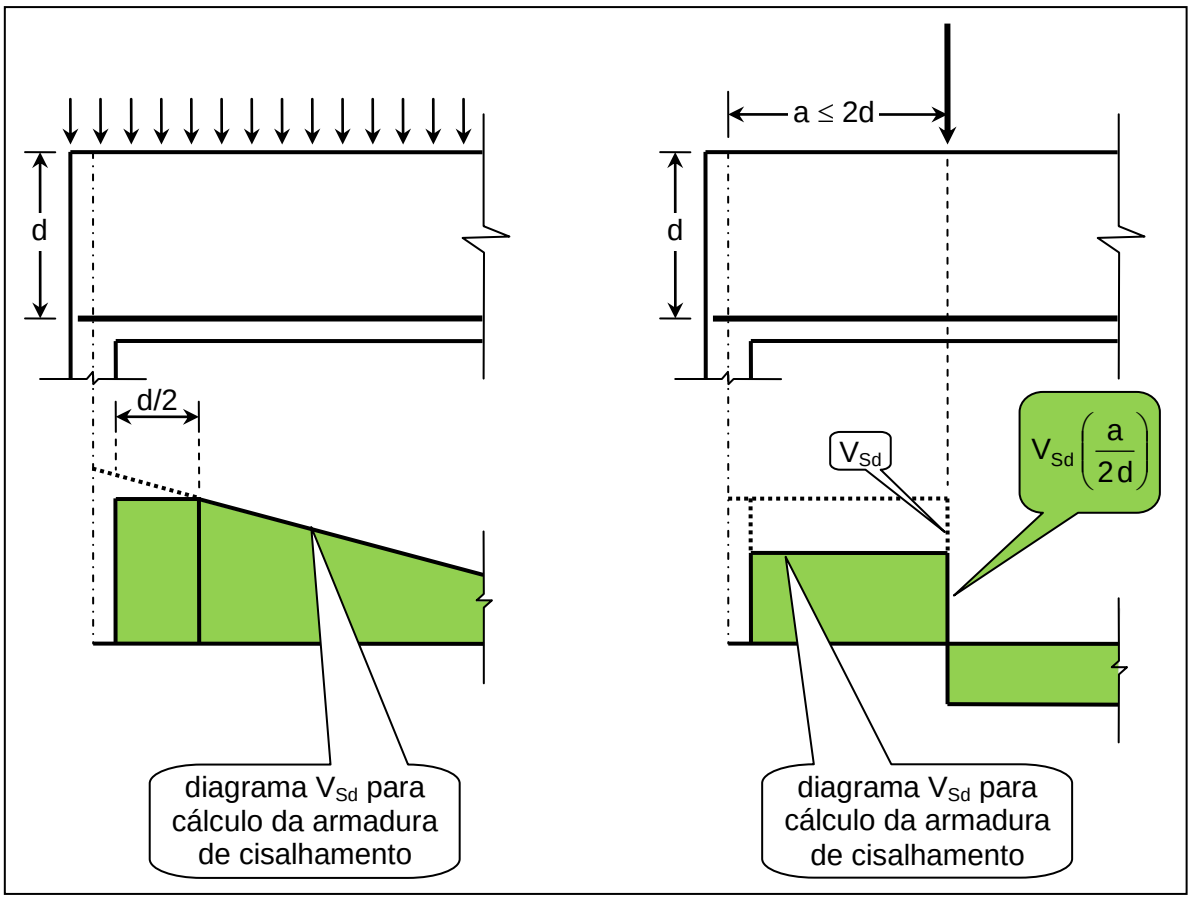
$$a_\ell = \frac{d}{2}\left(\frac{V_{Sd,max}}{(V_{Sd,max} - V_c)}\right) \begin{cases} \ge 0{,}5\,d \\ \le d \end{cases}$$

$$a_\ell = d \quad \langle |V_{Sd,max}| \le |V_c| \rangle$$

vigas com estribos verticais - modelo II

$$a_\ell = 0{,}5\, d \cot g\theta$$

$$30° \le \theta \le 45°$$



θ	sen	cos	cot
30º	0,500	0,866	1,732
35º	0,574	0,819	1,428
40º	0,643	0,766	1,192
45º	0,707	0,707	1,000