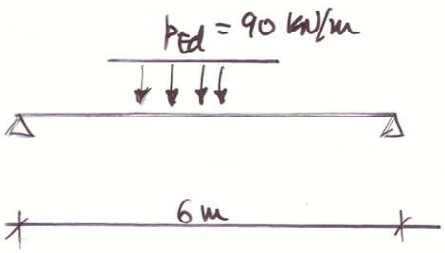
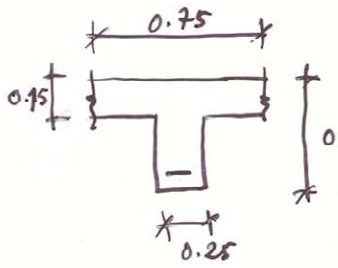
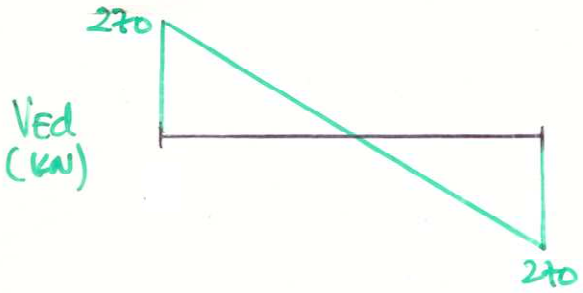
Dimensionamento de armaduras para V_{Ed} (estribos verticais)





$(d = 0,45\,m)$

C20/25
S400



$$M_{Ed} = \frac{90 \times 6^2}{8} = 405\ kN\,m \quad (1/2\ vão)$$

$$\mu = \frac{405}{0.75 \times 0.45^2 \times 13300} = 0,20$$

$$A_s = 0,226 \times 45 \times 75 \times \frac{13,3}{348} = 29.15\ cm^2$$

$6\phi 25\ (29.45\ cm^2)$

$$z = 0,28 \times 0.45 = 0.126\ m\ (OK)$$

$$V_{Rd,C} = \left[C_{Rd,C}\, k\, (100\, \rho_l\, f_{ck})^{1/3} + k_1\, \sigma_{cp}\right] b_w\, d$$

ϕ

$$\geq \left[v_{min} + k_1\, \sigma_{cp}\right] b_w\, d$$

ϕ

$\frac{0.18}{\gamma_c} = 0.12$

$\frac{29.45}{25 \times 45} = 0,026 \rightarrow 0,02\ (< 0.02)$

$1 + \sqrt{\frac{200}{d}} = 1 + \sqrt{\frac{200}{450}} = 1,67\ (< 2.0)$

$0,035\, k^{3/2} \sqrt{f_{ck}} = 0,3378$ (é condicionante)

$$V_{Rd,C} = 0,685 \times 250 \times 450 = 77,1\ kN$$

↳ Necessária armadura de esforço transverso A_{sw}

- **Controlo do esmagamento das diagonais comprimidas**

$$V_{Rd,max} = \frac{\overbrace{\alpha_{cw}}^{1.0}\, b_w\, z\, \nu_1\, f_{cd}}{\cot g\,\theta + \operatorname{tg}\,\theta} \geq 270\ kN$$

$$\nu_1 = \nu = 0,6\left[1 - \frac{f_{ck}}{250}\right] = 0.6\left[1 - \frac{20}{250}\right] = 0.552$$

$$V_{Rd,max} = 0.25 \times 0.9 \times 0.45 \times 0.552 \times 13300 \,/\, (\cot g\theta + \frac{1}{\cot g\theta}) = 270\ kN$$

$c = \cot g\theta$

$$2{,}7531 = c + \frac{1}{c} \Rightarrow c^2 - 2{,}7531\, c + 1 = 0$$

$$c = \frac{2{,}7531 + \sqrt{2{,}7531^2 - 4}}{2} = 2{,}32$$

$\cot g\theta = 2{,}32$ $(1 \leq \cot g\theta \leq 2{,}5)$ OK

- **Dimensionamento de A_{sw}/s**

  - **Armadura** (estribos verticais)

$$V_{Rd,s} = \frac{A_{sw}}{s} z\, f_{ywd}\, \cot g\theta = \frac{A_{sw}}{s} \times 326981$$

(z: $0{,}9 \times 0{,}45$; f_{ywd}: 348×10^3; $\cot g\theta$: $2{,}32$)

  - **Estribos mínimos** (EC2, 9.2.2 (5))

$$\rho_w = \frac{A_{sw}}{s\, b_w \underbrace{\sin\alpha}_{=1}} = \frac{A_{sw}}{s\, b_w} \Rightarrow \rho_{w,min} = 0{,}08 \frac{\sqrt{f_{ck}}}{f_{yk}} = 8{,}94 \times 10^{-4}$$

  - **$s_{l,max}$** (EC2, 9.2.2 (6))

$$s_{l,max} = 0{,}75\, d\, (1 + \cot g\alpha) = 0{,}75\, d = 0{,}34\ m \rightsquigarrow \boxed{0{,}30\ m}$$

$$\left(\frac{A_{sw}}{s}\right)_{min} = 8{,}94 \times 10^{-4} \times 0{,}25 = 2{,}235 \times 10^{-4}\ cm^2/m = 2{,}235\ cm^2/m$$

$2\phi 6 = 0{,}57\ cm^2 \rightarrow \phi 6 \,//\, 0{,}25$ (2r)

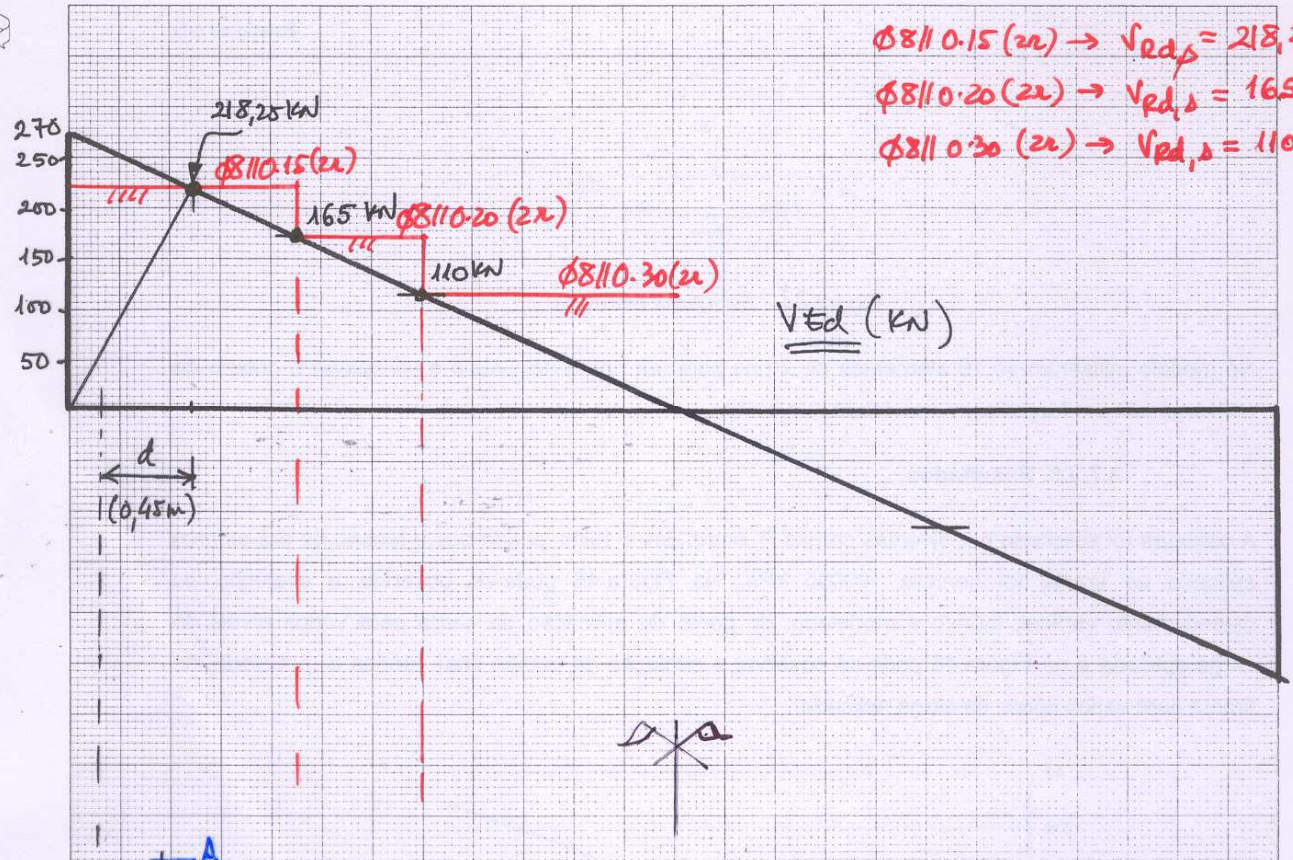
$2\phi 8 = 1.01\ cm^2 \rightarrow \phi 8 \,//\, 0{,}45 \rightarrow \boxed{\phi 8 \,//\, 0.30\ (2r)}$

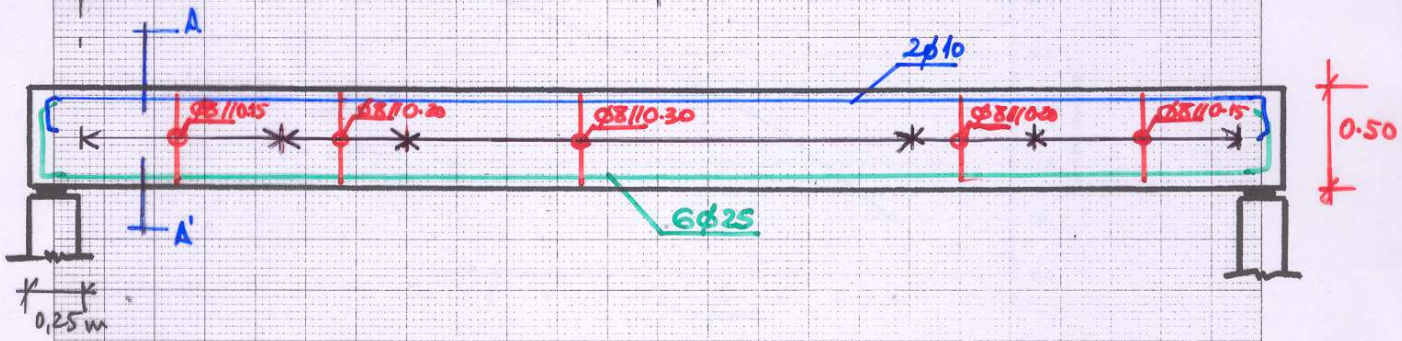
$$V_{Rd,s}\Big|_{\phi 8 // 0.30 (2r)} = \frac{1.01 \times 10^{-4}}{0.30} \times 326981 = 110\ kN$$

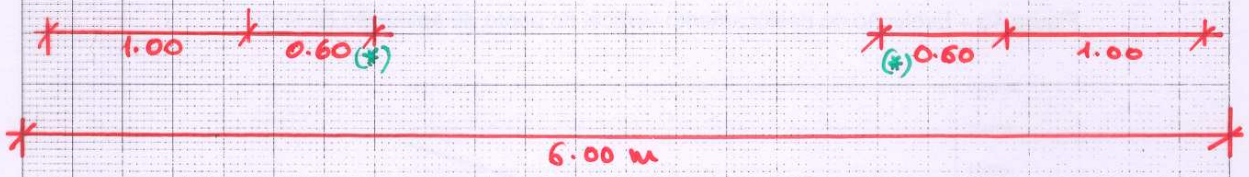
$\phi 8 // 0.15 (2r) \rightarrow V_{Rd,s} = 218,25\ kN$

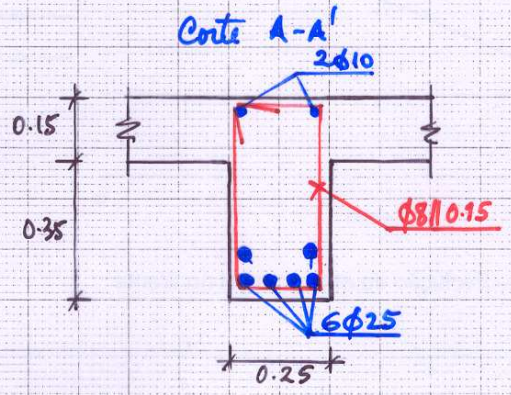
$\phi 8 // 0.20 (2r) \rightarrow V_{Rd,s} = 165\ kN$

$\phi 8 // 0.30 (2r) \rightarrow V_{Rd,s} = 110\ kN$









(*) - Zona eventualmente substituível por $\phi 8 // 0.15 (2r)$, dada a pequena economia.