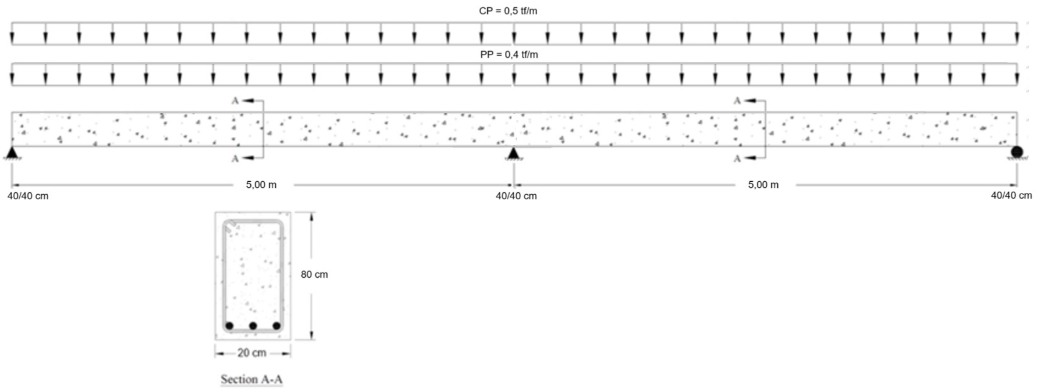
Vigas - Flexão Simples - Viga Continua 4

FLEXÃO SIMPLES

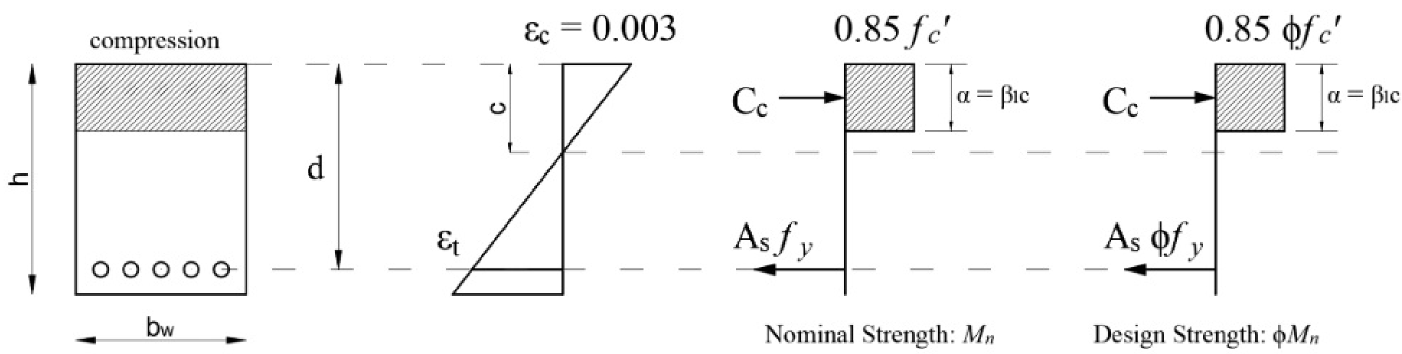
Neste exemplo, será dimensionada a armadura longitudinal e transversal de uma viga submetida a Flexão Simples utilizando como base a Norma ACI318-19, conforme dados abaixo:



Concreto - C25 (4000 psi) / Aço – ADN420 (60 ksi)

bw: 8 in / h: 31,5 in

TQS	Software B	Software C
Mu+ 160,19 kip.in	Mu+ 153,99 kip.in	Mu+ 172,58 kip.in
Mu- 299,13 kip.in	Mu- 312,41 kip.in	Mu- 307,98 kip.in



Flexão+:

$$M_n = \frac{Mu}{\emptyset} = \frac{160{,}19}{0{,}9} = 177{,}98\ \boldsymbol{kip.in}$$

$$d = h - C_c - d_{be} - \frac{d_b}{2} = 31{,}5 - 1{,}57 - 0{,}375 - 0{,}1875 = \mathbf{29{,}37\ in}$$

$$R_n = \frac{M_{n,req}}{b_w \cdot d^2} = \frac{177{,}98}{8 \cdot 29{,}37^2} = 0{,}026\ ksi = 25{,}79\ \boldsymbol{psi}$$

$$\rho = \left(0{,}85 \cdot \frac{f'_c}{f_y}\right) \cdot [1 - \sqrt{1 - \left(\frac{2 \cdot R_n}{0{,}85 \cdot f'_c}\right)} = (0{,}85 \cdot \frac{4}{60}) \cdot (1 - \sqrt{1 - (\frac{2 \cdot 0{,}026}{0{,}85 \cdot 4})}) = \mathbf{0{,}0004}$$

$$\boldsymbol{A_s} = \rho \cdot b_w \cdot d = 0{,}0004 \cdot 8 \cdot 29{,}37 = \mathbf{0{,}10\ in^2}$$

As,min (ACI 318-19 – 9.6.1.2)

$$\left(\frac{3 \cdot \sqrt{f'_c}}{f_y}\right) \cdot b_w \cdot d = \left(\frac{3 \cdot \sqrt{4000}}{60000}\right) \cdot 8 \cdot 29{,}37 = \mathbf{0{,}74\ in^2}$$

$$\left(\frac{200}{f_y}\right) \cdot b_w \cdot d = \left(\frac{200}{60000}\right) \cdot 8 \cdot 29{,}37 = \mathbf{0{,}78\ in^2}$$

$$A_{s,req} = A_s \cdot 1{,}33 = 0{,}14\ cm^2 \rightarrow TQS\ adota\ adicional\ devido\ a\ altura\ da\ viga\ \rightarrow 0{,}55\ in^2$$

$$\boldsymbol{A_{s,min}} = \mathbf{0{,}55\ in^2}$$

TQS = 0,55 in²	**Software B = 0,13 in²**	**Software C = 0,80 in²**

0,55 in2 ≥ 0,55 in2 → OK!

$5\#3 \rightarrow 0{,}55\ in2$

øMn (854,35 kip.in) ≥ Mu (160,19 kip.in) → OK!!

Verificação do fator de redução (ACI318-19 – 21.2.2)

$$\alpha = \frac{A_s \cdot f_y}{0{,}85 \cdot f'_c \cdot b_w} = \frac{0{,}1 \cdot 60}{0{,}85 \cdot 4 \cdot 8} = 0{,}22\ in$$

$$Linha\ Neutra: \boldsymbol{c} = \frac{\boldsymbol{\alpha}}{\boldsymbol{\beta_1}} = \frac{0{,}22}{\mathbf{0{,}85}} = 0{,}26\ \boldsymbol{in}$$

$$\varepsilon_t = 0{,}003 \cdot \left(\frac{d-c}{c}\right) = 0{,}003 \cdot \left(\frac{29{,}37 - 0{,}26}{0{,}26}\right) = \mathbf{0{,}33}$$

0,33 ≥ 0,005 → OK! Tension Controlled! → ø 0,90 OK!

Flexão-:

$$M_n = \frac{Mu}{\emptyset} = \frac{299{,}13}{0{,}9} = \mathbf{332{,}37\ kip.in}$$

$$d = h - C_c - d_{be} - \frac{d_b}{2} = 31{,}5 - 1{,}57 - 0{,}375 - 0{,}1875 = \mathbf{29,37\ in}$$

$$R_n = \frac{M_{n,req}}{b_w \cdot d^2} = \frac{332{,}37}{8 \cdot 29{,}37^2} = 0{,}048\ ksi = 48{,}16\ \boldsymbol{psi}$$

$$\rho = \left(0{,}85 \cdot \frac{f'_c}{f_y}\right) \cdot [1 - \sqrt{1 - \left(\frac{2 \cdot R_n}{0{,}85 \cdot f'_c}\right)} = (0{,}85 \cdot \frac{4}{60}) \cdot (1 - \sqrt{1 - (\frac{2 \cdot 0{,}048}{0{,}85 \cdot 4})}) = \mathbf{0,0008}$$

$$\boldsymbol{A_s} = \rho \cdot b_w \cdot d = 0{,}0008 \cdot 8 \cdot 29{,}37 = \mathbf{0,19\ in^2}$$

As,min (ACI 318-19 – 9.6.1.2)

$$\left(\frac{3 \cdot \sqrt{f'_c}}{f_y}\right) \cdot b_w \cdot d = \left(\frac{3 \cdot \sqrt{4000}}{60000}\right) \cdot 8 \cdot 29{,}37 = \mathbf{0,74\ in^2}$$

$$\left(\frac{200}{f_y}\right) \cdot b_w \cdot d = \left(\frac{200}{60000}\right) \cdot 8 \cdot 29{,}37 = \mathbf{0,78\ in^2}$$

$$A_{s,req} = A_s \cdot 1{,}33 = 0{,}25\ cm^2 \rightarrow TQS\ adota\ adicional\ devido\ a\ altura\ da\ viga \rightarrow 0{,}55\ in^2$$

$$\boldsymbol{A_{s,min} = 0,55\ in^2}$$

TQS = 0,55 in²	**Software B = 0,26 in²**	**Software C = 0,80 in²**

0,55 in2 ≥ 0,55 in2 → OK!

$5\#3 \rightarrow 0{,}55\ in2$

øMn (854,35 kip.in) ≥ Mu (299,13 kip.in) → OK!!

Verificação do fator de redução (ACI318-19 – 21.2.2)

$$\alpha = \frac{A_s \cdot f_y}{0{,}85 \cdot f'_c \cdot b_w} = \frac{0{,}19 \cdot 60}{0{,}85 \cdot 4 \cdot 8} = 0{,}42\ in$$

$$Linha\ Neutra\colon \boldsymbol{c} = \frac{\boldsymbol{\alpha}}{\boldsymbol{\beta_1}} = \frac{0{,}42}{\mathbf{0,85}} = 0{,}49\ \boldsymbol{in}$$

$$\varepsilon_t = 0{,}003 \cdot \left(\frac{d - c}{c}\right) = 0{,}003 \cdot \left(\frac{29{,}37 - 0{,}49}{0{,}49}\right) = \mathbf{0,16}$$

0,16 ≥ 0,005 → OK! Tension Controlled! → ø 0,90 OK!

Cortante:

TQS	Software B	Software C
Vu = 8,02 kips	Vu = 7,61 kips	Vu = 7,81 kips
Vu,design = 6,55 kips	Vu,design = 5,58 kips	Vu,design = 5,29 kips

$$V_n = V_c + V_s$$

$$\boldsymbol{V_u = 8,03\ kips}$$

$$\boldsymbol{V_{u,design} = 6,55\ kips}$$

$$V_c = 2 \cdot \lambda \cdot \sqrt{f'_c} \cdot b_w \cdot d = 2 \cdot 1 \cdot \sqrt{4000} \cdot 8 \cdot 29{,}37 = 29{,}72\ \boldsymbol{kips}$$

$$\boldsymbol{V_n = \frac{V_{u,design}}{\emptyset_{0,75}} = V_c + V_s \quad \rightarrow \quad V_s = 0\ kips \quad \rightarrow \quad V_n = 7,84\ kips}$$

$$V_{s,lim} = 8 \cdot \sqrt{f'_c} \cdot b_w \cdot d = 8 \cdot \sqrt{4000} \cdot 8 \cdot 29{,}37 = \boldsymbol{118,89\ kips}$$

Vs ≤ Vs,lim OK!

Ø0,75 → øVn ≥ Vu → 6,55 ≥ 6,55 → OK!!

Área de Aço:

$$A_v = \frac{V_s \cdot s}{f_{yt} \cdot d} = \frac{A_v}{s} = \frac{0}{60 \cdot 29{,}37} = 0{,}0\ in^2$$

$$\boldsymbol{\frac{A_{v,min}}{s} = \frac{0,75 \cdot \sqrt{f'_c} \cdot b_w}{f_{yt}} = 0,0063\ in^2}$$

$$\boldsymbol{\frac{A_{v,min}}{s} = \frac{50 \cdot b_w}{f_{yt}} = 0,0067\ in^2}$$

$$\boldsymbol{A_v \geq A_{v,min} \rightarrow 0,00 \leq 0,0067 \rightarrow A_{v,min}!!}$$

Espaçamento:

$$\boldsymbol{s \leq s_{max} \rightarrow s_{max} = menor\ valor\ entre\ s_1\ e\ s_2}$$

$$\boldsymbol{s_1 = \frac{d}{2} = 14,7\ in\ \ ou\ \ s_2 = 24\ in \rightarrow 14,7\ in! \rightarrow 10\ in!!}$$

$$\boldsymbol{\emptyset_t = \#3 \rightarrow \#3\ @\ 10\ in}$$

øVn (51,37 kips) ≥ Vu (6,55 kips)