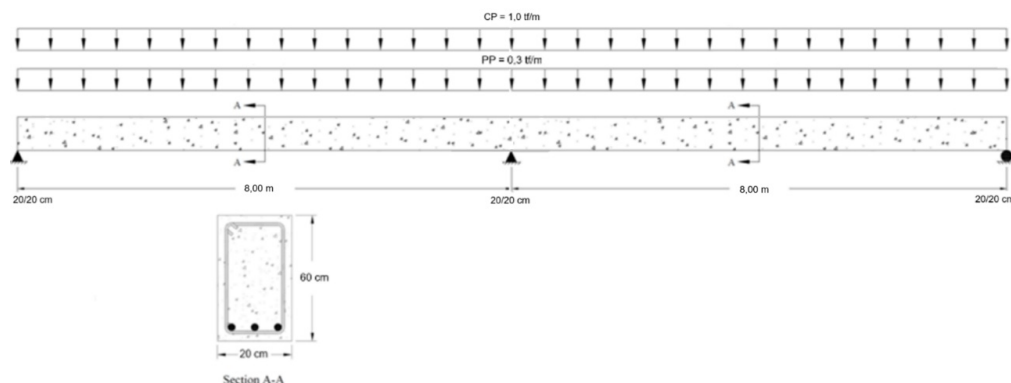


Vigas - Flexão Simples - Viga Continua 3

FLEXÃO SIMPLES

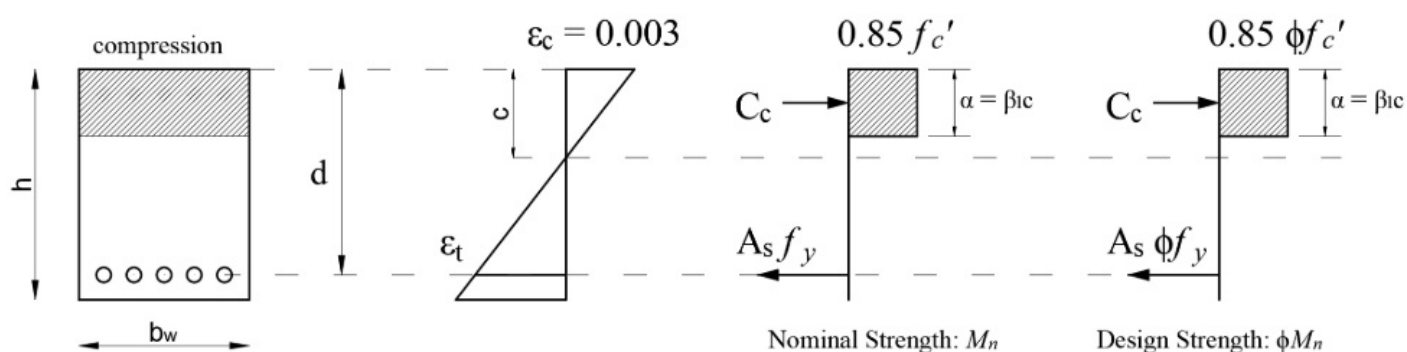
Neste exemplo, será dimensionada a armadura longitudinal e transversal de uma viga submetida a Flexão Simples utilizando como base a Norma ACI318-19, conforme dados abaixo:



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

b_w : 8 in / h : 24 in

TQS	Software B	Software C
Mu+ 681,45 kip.in	Mu+ 684,11 kip.in	Mu+ 641,63 kip.in
Mu- 1247,85 kip.in	Mu- 1258,47 kip.in	Mu- 1162 kip.in



Flexão+:

$$M_n = \frac{M_u}{\phi} = \frac{681,45}{0,9} = 757,17 \text{ kip.in}$$

$$d = h - C_c - d_{be} - \frac{d_b}{2} = 24 - 1,57 - 0,375 - 0,25 = 21,81 \text{ in}$$

$$R_n = \frac{M_{n,req}}{b_w \cdot d^2} = \frac{757,17}{8 \cdot 21,81^2} = 0,199 \text{ ksi} = 198,97 \text{ psi}$$

$$\rho = \left(0,85 \cdot \frac{f'_c}{f_y}\right) \cdot \left[1 - \sqrt{1 - \left(\frac{2 \cdot R_n}{0,85 \cdot f'_c}\right)}\right] = \left(0,85 \cdot \frac{4}{60}\right) \cdot \left(1 - \sqrt{1 - \left(\frac{2 \cdot 0,199}{0,85 \cdot 4}\right)}\right) = \mathbf{0,0034}$$

$$A_s = \rho \cdot b_w \cdot d = 0,0034 \cdot 8 \cdot 21,81 = \mathbf{0,60 \text{ in}^2}$$

As,min (ACI 318-19 – 9.6.1.2)

$$\left(\frac{3 \cdot \sqrt{f'_c}}{f_y}\right) \cdot b_w \cdot d = \left(\frac{3 \cdot \sqrt{4000}}{60000}\right) \cdot 8 \cdot 21,81 = \mathbf{0,55 \text{ in}^2}$$

$$\left(\frac{200}{f_y}\right) \cdot b_w \cdot d = \left(\frac{200}{60000}\right) \cdot 8 \cdot 21,81 = \mathbf{0,58 \text{ in}^2}$$

$$A_{s,min} = \mathbf{0,58 \text{ in}^2}$$

TQS = 0,60 in ²	Software B = 0,64 in ²	Software C = 0,58 in ²
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0,60 in² ≥ 0,60 in² → OK!

3#4 → 0,60 in²

øMn (685,20 kip.in) ≥ Mu (681,45 kip.in) → OK!!

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

$$\alpha = \frac{A_s \cdot f_y}{0,85 \cdot f'_c \cdot b_w} = \frac{0,60 \cdot 60}{0,85 \cdot 4 \cdot 8} = 1,32 \text{ in}$$

$$\text{Linha Neutra: } c = \frac{\alpha}{\beta_1} = \frac{1,32}{0,85} = 1,55 \text{ in}$$

$$\varepsilon_t = 0,003 \cdot \left(\frac{d - c}{c}\right) = 0,003 \cdot \left(\frac{21,81 - 1,55}{1,55}\right) = \mathbf{0,0393}$$

0,0393 ≥ 0,005 → OK! Tension Controlled! → ø 0,90 OK!

Flexão-:

$$M_n = \frac{Mu}{\phi} = \frac{1247,85}{0,9} = 1386,50 \text{ kip.in}$$

$$d = h - C_c - d_{be} - \frac{d_b}{2} = 24 - 1,57 - 0,375 - 0,3125 = \mathbf{21,75 \text{ in}}$$

$$R_n = \frac{M_{n,req}}{b_w \cdot d^2} = \frac{1386,50}{8 \cdot 21,75^2} = 0,366 \text{ ksi} = 366,45 \text{ psi}$$

$$\rho = \left(0,85 \cdot \frac{f'_c}{f_y}\right) \cdot \left[1 - \sqrt{1 - \left(\frac{2 \cdot R_n}{0,85 \cdot f'_c}\right)}\right] = \left(0,85 \cdot \frac{4}{60}\right) \cdot \left(1 - \sqrt{1 - \left(\frac{2 \cdot 0,366}{0,85 \cdot 4}\right)}\right) = 0,0065$$

$$A_s = \rho \cdot b_w \cdot d = 0,0065 \cdot 8 \cdot 21,75 = 1,13 \text{ in}^2$$

As,min (ACI 318-19 – 9.6.1.2)

$$\left(\frac{3 \cdot \sqrt{f'_c}}{f_y}\right) \cdot b_w \cdot d = \left(\frac{3 \cdot \sqrt{4000}}{60000}\right) \cdot 8 \cdot 21,75 = 0,55 \text{ in}^2$$

$$\left(\frac{200}{f_y}\right) \cdot b_w \cdot d = \left(\frac{200}{60000}\right) \cdot 8 \cdot 21,75 = 0,58 \text{ in}^2$$

$$A_{s,min} = 0,58 \text{ in}^2$$

TQS = 1,13 in ²	Software B = 1,17 in ²	Software C = 1,05 in ²
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1,24 in² ≥ 1,13 in² → OK!

4#5 → 1,24 in²

øMn (1364,63 kip.in) ≥ Mu (1247,85 kip.in) → OK!!

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

$$\alpha = \frac{A_s \cdot f_y}{0,85 \cdot f'_c \cdot b_w} = \frac{1,13 \cdot 60}{0,85 \cdot 4 \cdot 8} = 2,49 \text{ in}$$

$$\text{Linha Neutra: } c = \frac{\alpha}{\beta_1} = \frac{2,49}{0,85} = 2,92 \text{ in}$$

$$\varepsilon_t = 0,003 \cdot \left(\frac{d - c}{c}\right) = 0,003 \cdot \left(\frac{21,75 - 2,92}{2,92}\right) = 0,02$$

0,02 ≥ 0,005 → OK! Tension Controlled! → ø 0,90 OK!

Cortante:

TQS	Software B	Software C
$V_u = 19,47 \text{ kips}$	$V_u = 19,13 \text{ kips}$	$V_u = 19,20 \text{ kips}$
$V_{u,design} = 16,87 \text{ kips}$	$V_{u,design} = 16,98 \text{ kips}$	$V_{u,design} = 16,54 \text{ kips}$

$$V_n = V_c + V_s$$

$$V_u = 19,47 \text{ kips}$$

$$V_{u,design} = 16,87 \text{ kips}$$

$$V_c = 2 \cdot \lambda \cdot \sqrt{f'_c} \cdot b_w \cdot d = 2 \cdot 1 \cdot \sqrt{4000} \cdot 8 \cdot 21,75 = 22,01 \text{ kips}$$

$$V_n = \frac{V_{u,design}}{\phi_{0,75}} = V_c + V_s \rightarrow V_s = 0,49 \text{ kips} \rightarrow V_n = 22,49 \text{ kips}$$

$$V_{s,lim} = 8 \cdot \sqrt{f'_c} \cdot b_w \cdot d = 8 \cdot \sqrt{4000} \cdot 8 \cdot 21,75 = 88,03 \text{ kips}$$

$V_s \leq V_{s,lim}$ OK!

$\phi_{0,75} \rightarrow \phi V_n \geq V_u \rightarrow 16,87 \geq 16,87 \rightarrow \text{OK!!}$

Área de Aço:

$$A_v = \frac{V_s \cdot s}{f_{yt} \cdot d} = \frac{A_v}{s} = \frac{0,49}{60 \cdot 21,75} = 0,00037 \text{ in}^2$$

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

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

$$A_v \geq A_{v,min} \rightarrow 0,0004 \leq 0,0067 \rightarrow A_{v,min}!!$$

Espaçamento:

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

$$s_1 = \frac{d}{2} = 10,93 \text{ in ou } s_2 = 24 \text{ in} \rightarrow 10,93 \text{ in!} \rightarrow 10 \text{ in!!}$$

$$\phi_t = \#3 \rightarrow \#3 @ 10 \text{ in}$$

$\phi V_n (38,04 \text{ kips}) \geq V_u (16,87 \text{ kips})$

