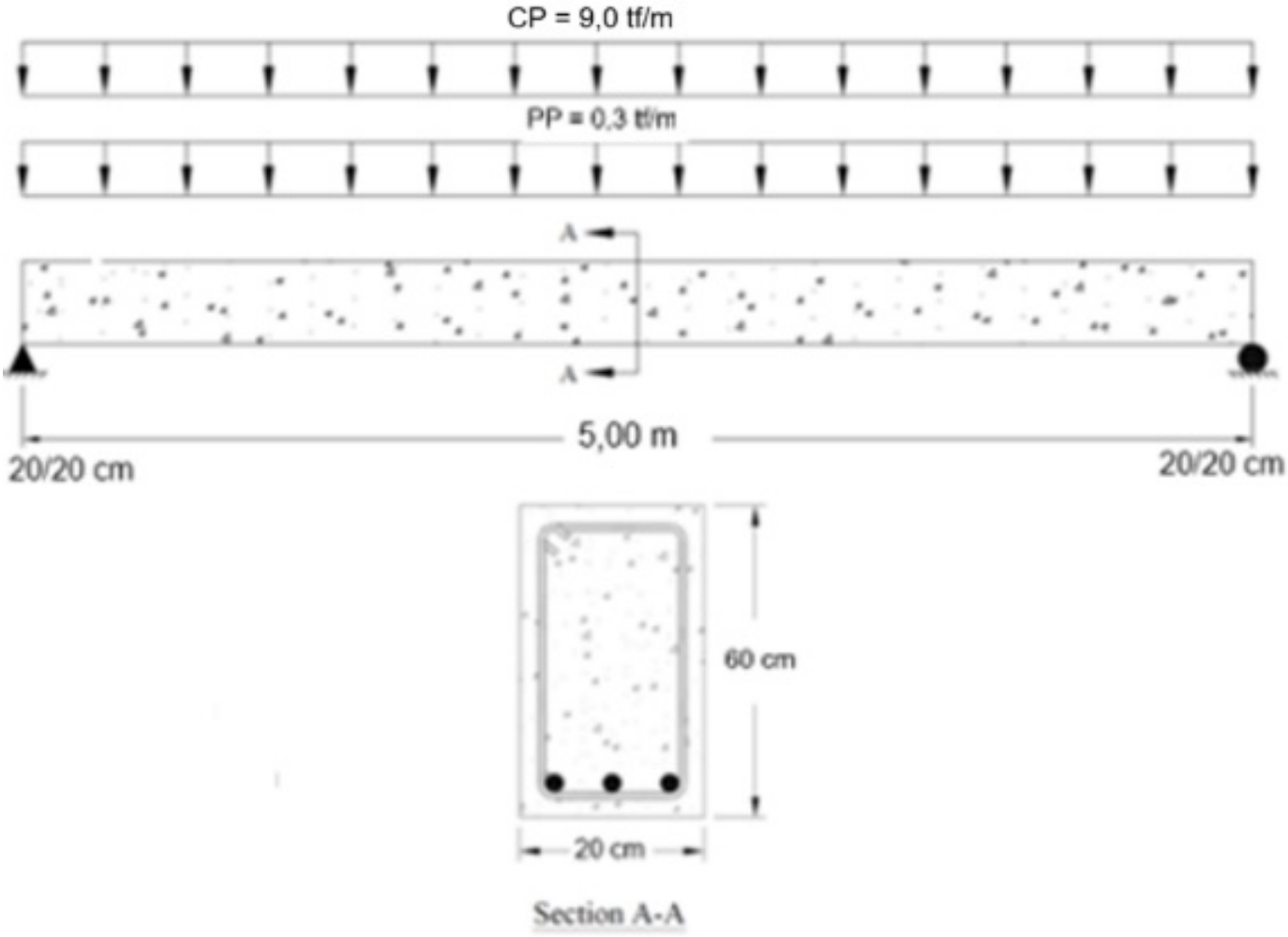
Vigas - Flexão Simples 11

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:

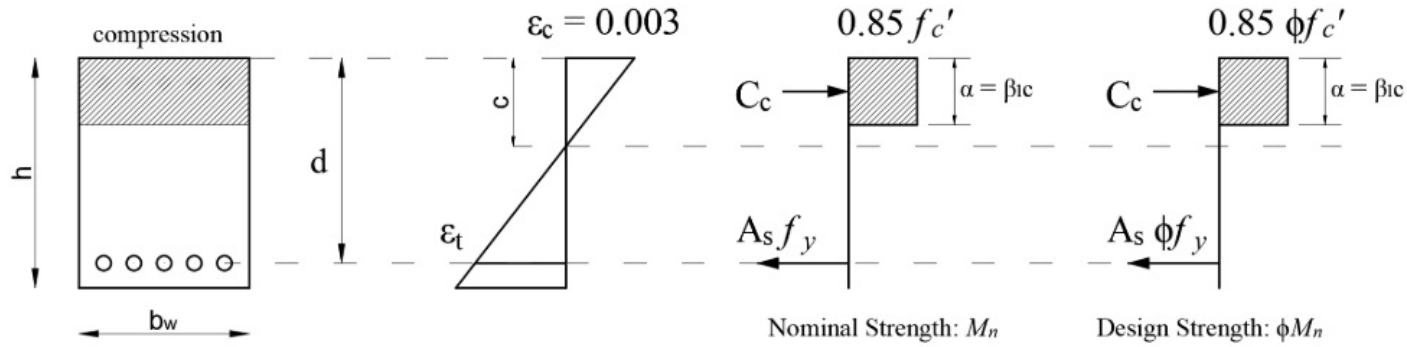


Concreto - C25 (4000 psi) / Aço – ADN420 (60 ksi)

bw: 8 in / h: 24 in

Mu:

TQS = 3301,05 kip.in	**Software B = 3395,75 kip.in**	**Software C = 3303,71 kip.in**



Flexão:

$$M_n = \frac{Mu}{\emptyset} = \frac{3301,05}{0,90} = 3667,83\ \boldsymbol{kip.in}$$

$$d = h - C_c - d_{be} - \frac{d_b}{2} = 24 - 1,57 - 0,375 - 0,4375 = \boldsymbol{21,62\ in}$$

$$R_n = \frac{M_{n,req}}{b_w \cdot d^2} = \frac{3667,83}{8 \cdot 21,62^2} = 0,980\ ksi = 980,64\ \boldsymbol{psi}$$

$$\rho = \left(0,85 \cdot \frac{f'_c}{f_y}\right) \cdot [1 - \sqrt{1 - \left(\frac{2 \cdot R_n}{0,85 \cdot f'_c}\right)} = (0,85 \cdot \frac{4}{60} \cdot (1 - \sqrt{1 - \left(\frac{2 \cdot 0,980}{0,85 \cdot 4}\right)}) = \boldsymbol{0,0198}$$

$$\boldsymbol{A_s} = \rho \cdot b_w \cdot d = 0,0198 \cdot 8 \cdot 24 = \boldsymbol{3,43\ in^2}$$

As,min (ACI 318-19 – 9.6.1.2)

$$\left(\frac{3 \cdot \sqrt{f'_c}}{f_y}\right) \cdot b_w \cdot d = \left(\frac{3 \cdot \sqrt{4000}}{60000}\right) \cdot 8 \cdot 21,62 = \boldsymbol{0,55\ in^2}$$

$$\left(\frac{200}{f_y}\right) \cdot b_w \cdot d = \left(\frac{200}{60000}\right) \cdot 8 \cdot 21,62 = \boldsymbol{0,58\ in^2}$$

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

3,60 in2 ≥ 3,43 in2 → OK!

6#7 → 3,60 $in2$

øMn (3571,52 kip.in) ≥ Mu (3301,05 kip.in) → OK!!

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

$$\alpha = \frac{A_s \cdot f_y}{0,85 \cdot f'_c \cdot b_w} = \frac{3,43 \cdot 60}{0,85 \cdot 4 \cdot 8} = 7,56\ in$$

$$Linha\ Neutra: \boldsymbol{c = \frac{\alpha}{\beta_1} = \frac{7{,}56}{0{,}85} = 8{,}89\ in}$$

$$\varepsilon_t = 0{,}003 \cdot \left(\frac{d-c}{c}\right) = 0{,}003 \cdot \left(\frac{21{,}62-8{,}89}{8{,}89}\right) = \mathbf{0{,}0043}$$

0,0043 ≤ 0,005 → Não OK!!

Recalculando para armadura dupla:

$$\varepsilon_t = 0{,}003 \cdot \left(\frac{d-c}{c}\right) = 0{,}005 = 0{,}003 \cdot \left(\frac{21{,}62-c}{c}\right) = \boldsymbol{c = 8{,}11\ in}$$

$$\boldsymbol{\alpha = c \cdot \beta_1 = 8{,}11 \cdot 0{,}85 = 6{,}90\ in}$$

$$A_s = \frac{\alpha \cdot 0{,}85 \cdot f'_c \cdot b_w}{f_y} = \frac{6{,}90 \cdot 0{,}85 \cdot 4 \cdot 8}{60} = 3{,}12\ in^2 \ \rightarrow\ M_n = 3402{,}61\ kip.in$$

$$\Delta M_n = 3667{,}83 - 3402{,}61 = 265{,}22\ kip.in$$

$$A'_s = \frac{\Delta M_n}{f_y \cdot (d-d')} = \frac{265{,}22}{60 \cdot (21{,}62-2{,}3)} = 0{,}23\ in^2$$

$$A_s = A_s + A'_s = 3{,}12 + 0{,}23 = 3{,}35\ in^2$$

TQS:	Software B	Software C
As = 3,35 in²	As = 4,15 in²	As = 3,29 in²
A's = 0,23 in²	A's = 0,65 in²	A's = 0,27 in²

3,60 in² ≥ 3,35 in² → OK!

$6\#7\ \rightarrow 3{,}60\ in2$

øMn (3430,56 kip.in) ≥ Mu (3301,05 kip.in) → OK!

Cortante:

TQS	Software B	Software C
Vu = 71,86 kips	Vu = 68,90 kips	Vu = 71,73 kips
Vu,design = 52,70 kips	Vu,design = 52,59 kips	Vu,design = 52,04 kips

$$V_n = V_c + V_s$$

$$V_u = 71,86\ kips$$

$$V_{u,design} = 52,70\ kips$$

$$V_c = 2 \cdot \lambda \cdot \sqrt{f'_c} \cdot b_w \cdot d = 2 \cdot 1 \cdot \sqrt{4000} \cdot 8 \cdot 21,62 = 21,88\ kips$$

$$V_n = \frac{V_{u,design}}{\emptyset_{0,75}} = V_c + V_s \ \rightarrow \ V_s = 47,66\ kips \ \rightarrow \ V_n = 70,27\ kips$$

$$V_{s,lim} = 8 \cdot \sqrt{f'_c} \cdot b_w \cdot d = 8 \cdot \sqrt{4000} \cdot 8 \cdot 21,62 = 87,52\ kips$$

Vs ≤ Vs,lim OK!

Ø0,75 → øVn ≥ Vu → 52,70 ≥ 52,70 → OK!!

Área de Aço:

$$A_v = \frac{V_s \cdot s}{f_{yt} \cdot d} = \frac{A_v}{s} = \frac{47,66}{60 \cdot 21,62} = 0,036\ in^2$$

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

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

$$A_v \geq A_{v,min} \rightarrow 0,036 \geq 0,0067$$

Espaçamento:

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

$$s_1 = \frac{d}{2} = 10,81\ in\ ou\ s_2 = 12\ in \ \rightarrow \ 10,81\ in! \rightarrow 10\ in!!$$

$$\emptyset_t = \#3 \ \rightarrow \#3\ @\ 6\ in$$

øVn (53,73 kips) ≥ Vu (52,70 kips)