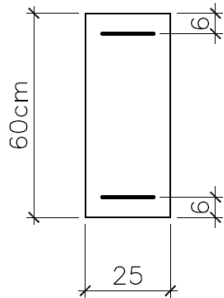


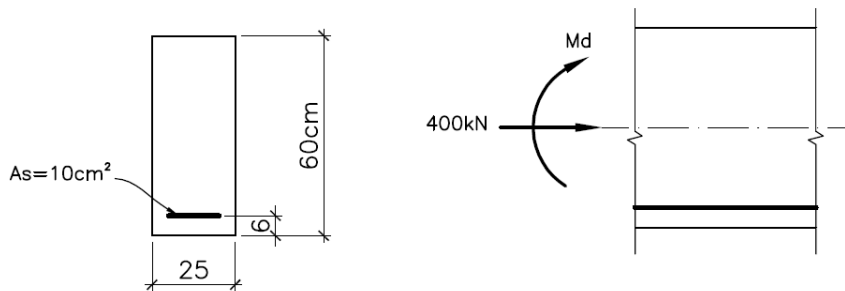
E1 Para a seção dada e os pares Nd x Md abaixo pede-se determinar: a excentricidade de Nd, as armaduras As e A's , a profundidade 'x' da linha neutra e o diagrama de deformações. fck = 25 MPa e CA50



Caso	Nd (kN)	Md (kNm)	e (cm)	As (cm ²)	A's (cm ²)	x (cm)	ε _{cd} (‰)	ε _{sd} (‰)	ε's _{sd} (‰)
1	-500	0	0	5,75	5,75	-∞	-10,0	-10,0	-10,0
2	-500	80	16	9,6	1,9	-∞	-10,0	-10,0	-10,0
3	-500	160	32	13,2	0	2,5	0,5	-10,0	---
4	0	160	---	7,4	0	10,6	2,4	-10,0	---
5	400	180	45	4,6	0	19,7	3,5	-10,0	---
6	500	320	64	11,5	4,1	27,0	3,5	-10,0	2,7
7	500	80	16	0	0	zona neutra – apenas o concreto !			
8	1700	240	14	---	7,4	45,5	3,5	---	3,0
9	3000	80	2,7	4,6	12,6	+∞	2,0	2,0	2,0

Obs: a armadura dupla foi calculada para x=0,5d, não foi revisto o cálculo para x=0,45d.

E2 Para o problema abaixo qual o maior Md que pode ser aplicado à seção? (supor que a armadura está escoando) - fck = 35 MPa e CA50.



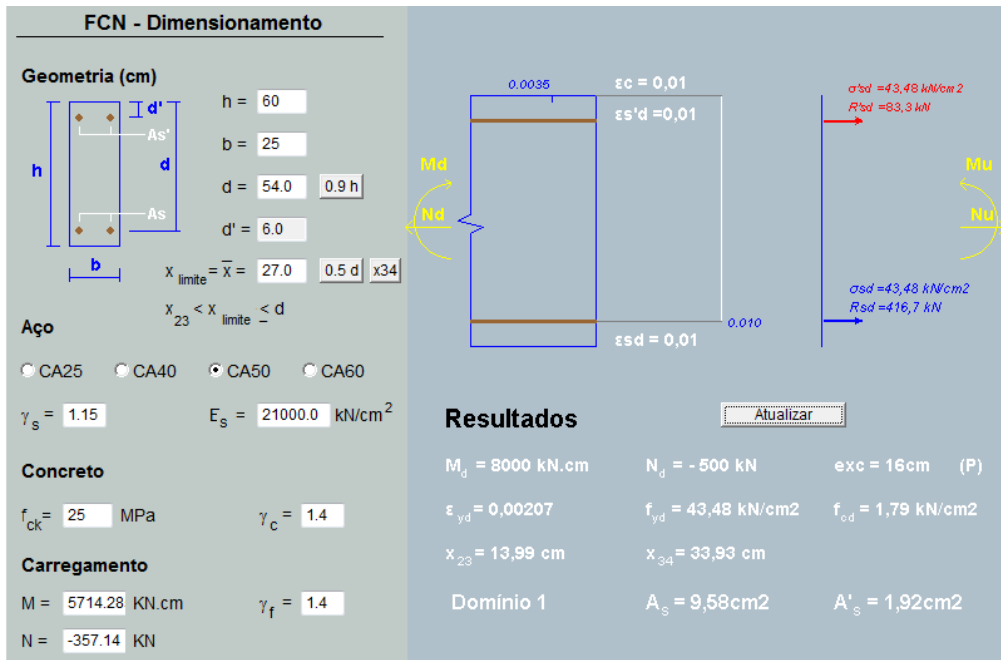
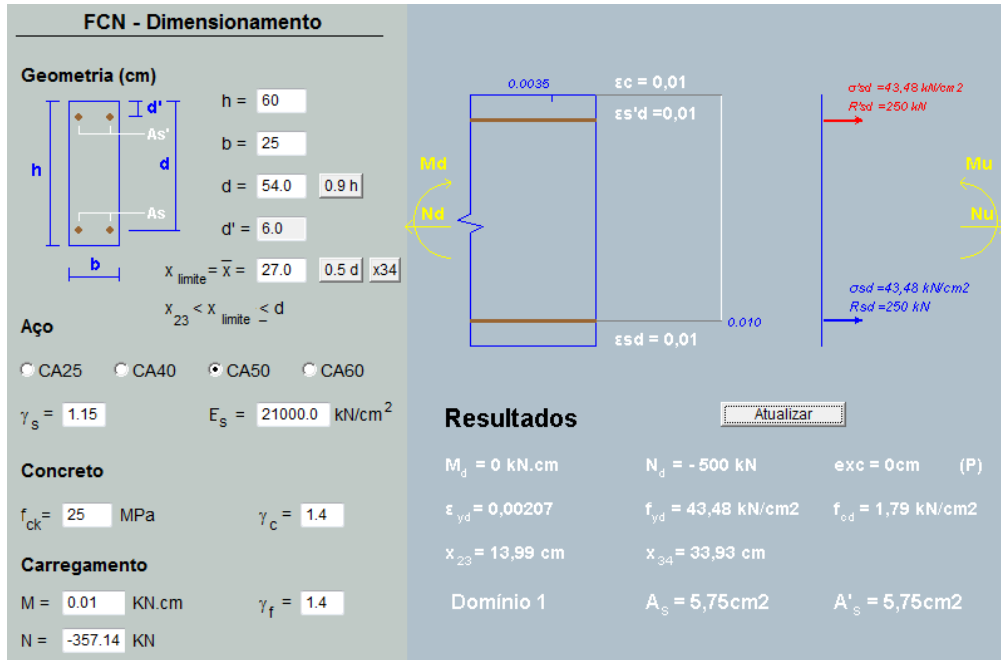
Hipótese: $\sigma_{sd} = f_{yd}$ Equilíbrio: $N_d + R_{sd} = R_{cd}$
 $400 + 10 \cdot 43,5 = 0,68 \cdot 25 \cdot x \cdot 3,5 / 1,4 \rightarrow x = 19,65 \text{ cm}$

Hipótese ok! $\frac{x}{d} = 0,36$ (D3), aço escoando,
 $\epsilon_{sd} = \frac{45 - 19,65}{19,65} \cdot 3,5\text{‰} = 4,5\text{‰}$

Momento M_d : $M_d = \underbrace{435}_{R_{sd}} \cdot \underbrace{(0,54 - 0,30)}_{d-h/2} + \underbrace{835}_{R_{cd}} \cdot \underbrace{(0,30 - 0,4 \cdot 0,1965)}_{h/2 - 0,4 \cdot x}$

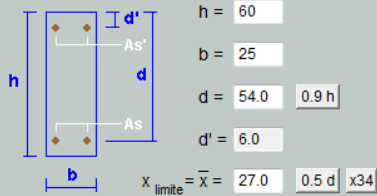
$M_d = 104,4 + 184,9 = 289,3$

$M_d = 289,3 \text{ kN.m}$



FCN - Dimensionamento

Geometria (cm)



$h = 60$

$b = 25$

$d = 54.0 \quad 0.9 h$

$d' = 6.0$

$x_{limite} = \bar{x} = 27.0 \quad 0.5 d \quad x34$

$x_{23} < x_{limite} \leq d$

Aço

CA25 CA40 CA50 CA60

$\gamma_s = 1.15$

$E_s = 21000.0 \text{ kN/cm}^2$

Concreto

$f_{ck} = 25 \text{ MPa}$

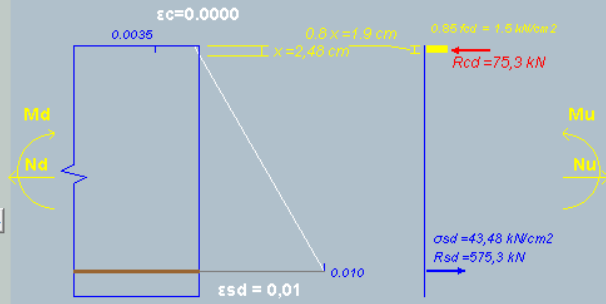
$\gamma_c = 1.4$

Carregamento

$M = 11428.5 \text{ KN.cm}$

$\gamma_f = 1.4$

$N = -357.14 \text{ KN}$



Resultados

Atualizar

$M_d = 16000 \text{ kN.cm}$ $N_d = -500 \text{ kN}$ $exc = 32 \text{ cm} \quad (C)$

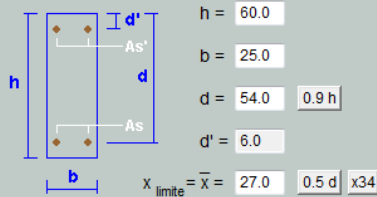
$\epsilon_{yd} = 0.00207$ $f_{yd} = 43.48 \text{ kN/cm}^2$ $f_{od} = 1.79 \text{ kN/cm}^2$

$x_{23} = 13.99 \text{ cm}$ $x_{34} = 33.93 \text{ cm}$

Domínio 2 $A_s = 13.24 \text{ cm}^2$ $A'_s = 0 \text{ cm}^2$

FCN - Dimensionamento

Geometria (cm)



$h = 60.0$

$b = 25.0$

$d = 54.0 \quad 0.9 h$

$d' = 6.0$

$x_{limite} = \bar{x} = 27.0 \quad 0.5 d \quad x34$

$x_{23} < x_{limite} \leq d$

Aço

CA25 CA40 CA50 CA60

$\gamma_s = 1.15$

$E_s = 21000.0 \text{ kN/cm}^2$

Concreto

$f_{ck} = 25.0 \text{ MPa}$

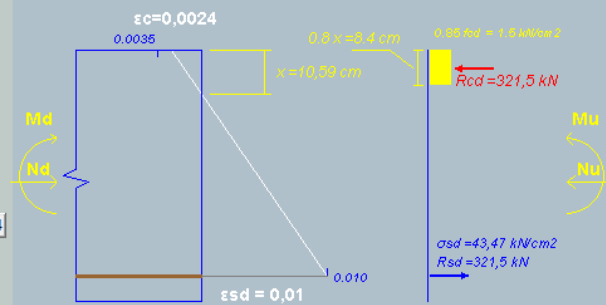
$\gamma_c = 1.4$

Carregamento

$M = 11428.5 \text{ KN.cm}$

$\gamma_f = 1.4$

$N = 0 \text{ KN}$



Resultados

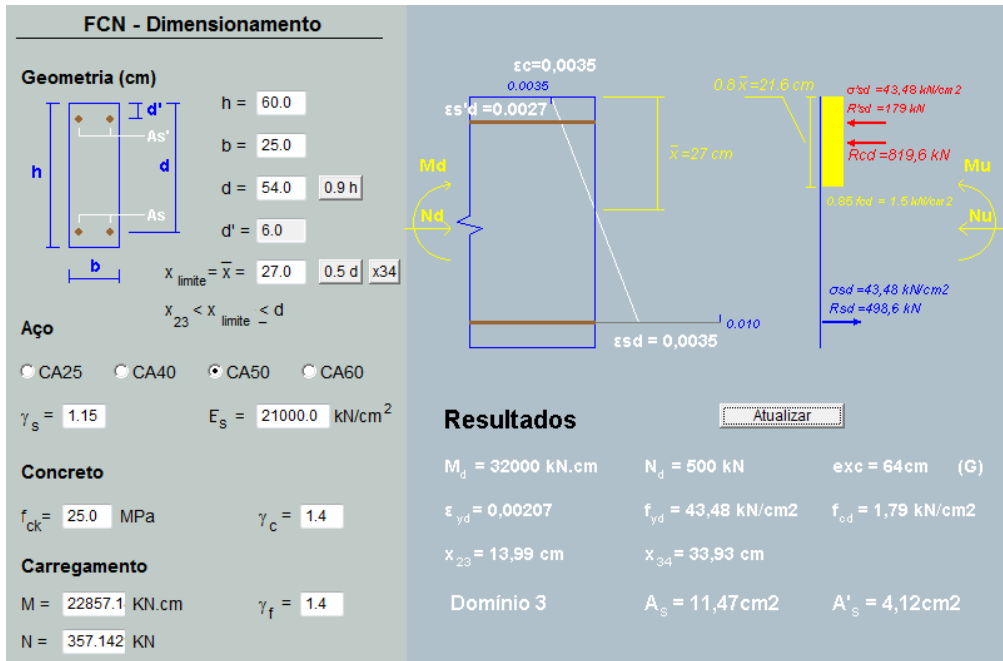
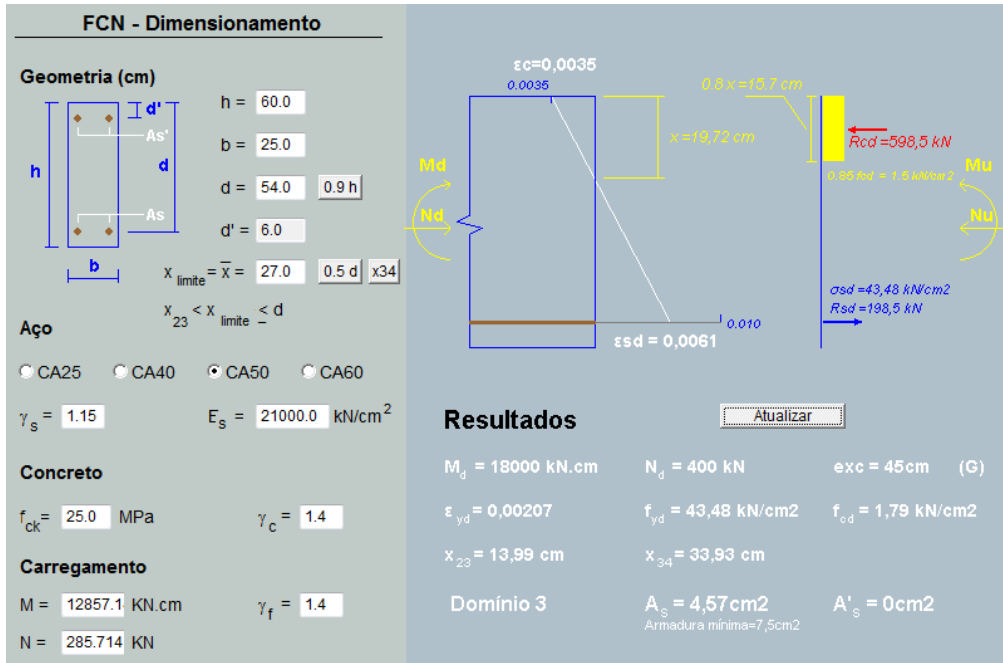
Atualizar

$M_d = 16000 \text{ kN.cm}$ $N_d = 0 \text{ kN}$ $exc = 0 \text{ cm}$

$\epsilon_{yd} = 0.00207$ $f_{yd} = 43.48 \text{ kN/cm}^2$ $f_{od} = 1.79 \text{ kN/cm}^2$

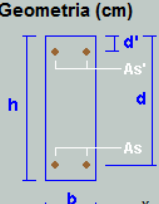
$x_{23} = 13.99 \text{ cm}$ $x_{34} = 33.93 \text{ cm}$

Domínio 2 $A_s = 7.4 \text{ cm}^2$ $A'_s = 0 \text{ cm}^2$
Armadura mínima=7.5cm2



FCN - Dimensionamento

Geometria (cm)



$h = 60.0$
 $b = 25.0$
 $d = 54.0$ (0.9 h)
 $d' = 6.0$
 $x_{limite} = \bar{x} = 27.0$ (0.5 d) x34
 $x_{23} < x_{limite} \leq d$

Aço

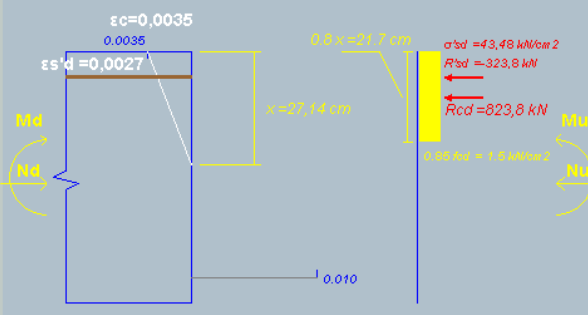
CA25 CA40 CA50 CA60
 $\gamma_s = 1.15$ $E_s = 21000.0 \text{ kN/cm}^2$

Concreto

$f_{ck} = 25.0 \text{ MPa}$ $\gamma_c = 1.4$

Carregamento

$M = 5714.28 \text{ KN.cm}$ $\gamma_f = 1.4$
 $N = 357.142 \text{ KN}$

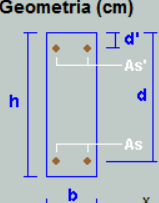


Resultados Atualizar

$M_d = 8000 \text{ kN.cm}$	$N_d = 500 \text{ kN}$	exc = 16 cm (P)
$\epsilon_{yd} = 0,00207$	$f_{yd} = 43,48 \text{ kN/cm}^2$	$f_{od} = 1,79 \text{ kN/cm}^2$
$x_{23} = 13,99 \text{ cm}$	$x_{34} = 33,93 \text{ cm}$	
Domínio 3	$A_s = 0\text{cm}^2$	$A'_s = 7,5\text{cm}^2$ Armadura mínima = 7,5cm ²

FCN - Dimensionamento

Geometria (cm)



$h = 60.0$
 $b = 25.0$
 $d = 54.0$ (0.9 h)
 $d' = 6.0$
 $x_{limite} = \bar{x} = 27.0$ (0.5 d) x34
 $x_{23} < x_{limite} \leq d$

Aço

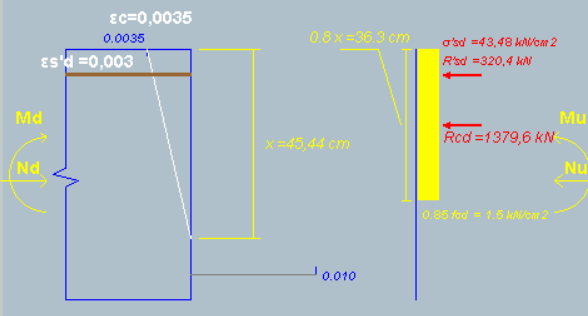
CA25 CA40 CA50 CA60
 $\gamma_s = 1.15$ $E_s = 21000.0 \text{ kN/cm}^2$

Concreto

$f_{ck} = 25.0 \text{ MPa}$ $\gamma_c = 1.4$

Carregamento

$M = 17142.8 \text{ KN.cm}$ $\gamma_f = 1.4$
 $N = 1214.28 \text{ KN}$

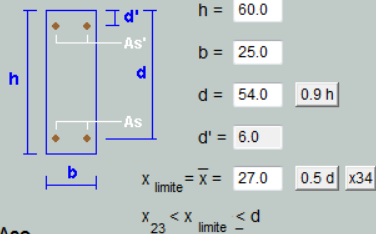


Resultados Atualizar

$M_d = 24000 \text{ kN.cm}$	$N_d = 1700 \text{ kN}$	exc = 14,1 cm (P)
$\epsilon_{yd} = 0,00207$	$f_{yd} = 43,48 \text{ kN/cm}^2$	$f_{od} = 1,79 \text{ kN/cm}^2$
$x_{23} = 13,99 \text{ cm}$	$x_{34} = 33,93 \text{ cm}$	
Domínio 4	$A_s = 0\text{cm}^2$	$A'_s = 7,5\text{cm}^2$ Armadura mínima = 7,5cm ²

FCN - Dimensionamento

Geometria (cm)



Aço

CA25 CA40 CA50 CA60

$\gamma_s = 1.15$

$E_s = 21000.0 \text{ kN/cm}^2$

Concreto

$f_{ck} = 25.0 \text{ MPa}$

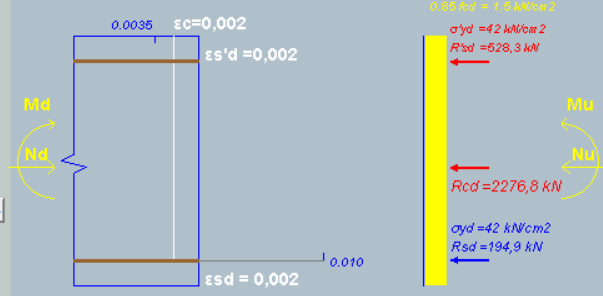
$\gamma_c = 1.4$

Carregamento

$M = 5714.28 \text{ KN.cm}$

$\gamma_f = 1.4$

$N = 2142.85 \text{ KN}$



$0.90 \text{ kN} = 1.0 \text{ kN/cm}^2$

$\sigma_{yd} = 42 \text{ kN/cm}^2$

$R_{sd} = 528.3 \text{ kN}$

$R_{cd} = 2276.8 \text{ kN}$

$\sigma_{yd} = 42 \text{ kN/cm}^2$

$R_{sd} = 194.9 \text{ kN}$

Resultados

Atualizar

$M_d = 8000 \text{ kN.cm}$

$N_d = 3000 \text{ kN}$

$\text{exc} = 2.7 \text{ cm (P)}$

$\epsilon_{yd} = 0.00207$

$f_{yd} = 42 \text{ kN/cm}^2$

$f_{od} = 1.79 \text{ kN/cm}^2$

$x_{23} = 13.99 \text{ cm}$

$x_{34} = 33.93 \text{ cm}$

Domínio 5

$A_s = 4.64 \text{ cm}^2$

$A'_s = 12.58 \text{ cm}^2$