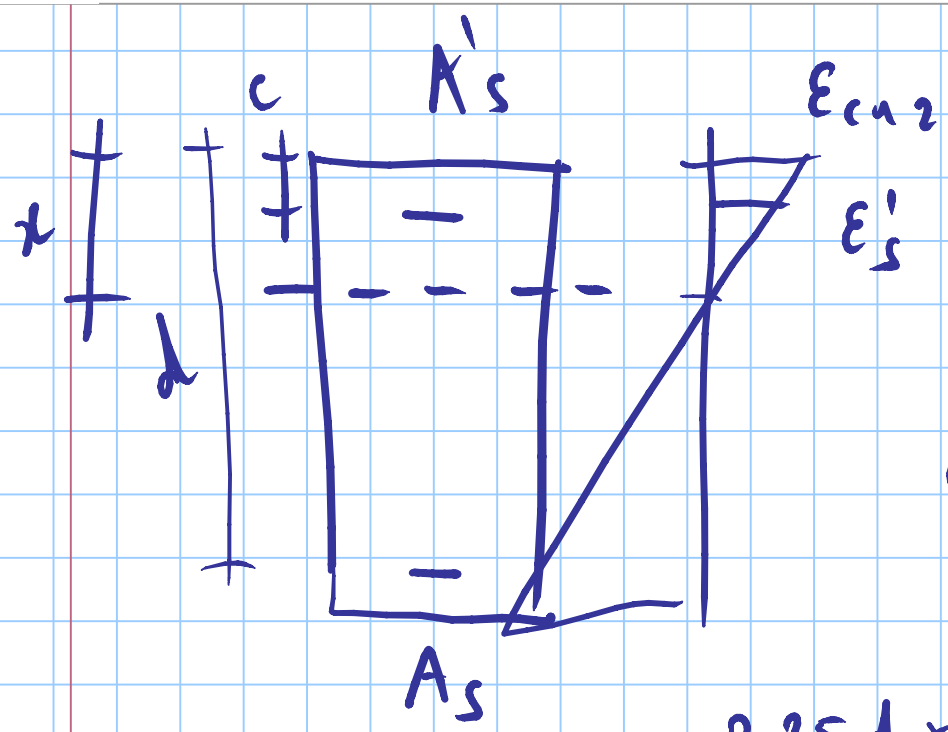
Titolo nota 27/11/2009



$$\varepsilon'_s = \frac{x - c}{x}\,\varepsilon_{cu2}$$

$$\varepsilon'_s = \frac{0.25\,d - c}{0.25\,d}\,0{,}0035 = \varepsilon_{yd}$$

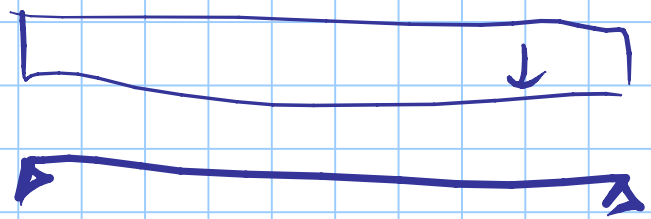
$$0.25\,d \times 0.0035 - c \times 0.0035 = 0.25\,d \times 0.00196$$

$$0.25 \times 0.44\,d = c$$

$$0.11\,d = c$$

$$d = 9\,c$$

$$\frac{0.00196}{0.0035} = 0.56$$



$g_d + q_d = 50\ KN/m$

6.00

$$M_{Ed} = \frac{50 \times 6^2}{8} = 225\ KNm$$

$$d = 2\sqrt{\frac{M}{b}} = 0{,}018\sqrt{\frac{225}{0.3}} = 0.49\ m \rightarrow h = 55.60\ m$$

30×60

$M_{Ed} = 225$ kNm

$$A_s = \frac{M}{0.9\, d\, f_{yd}} = \frac{225 \times 10}{0,9 \times 0,56 \times 391.3} = 11.4 \text{ cm}^2$$

$4\phi 18 + 1\phi 14$

(alla T.A. ~~225~~ 160 kNm

$$A_s = \frac{160 \times 10}{0.9 \times 0.56 \times 255} = 12.4 \text{ cm}^2$$

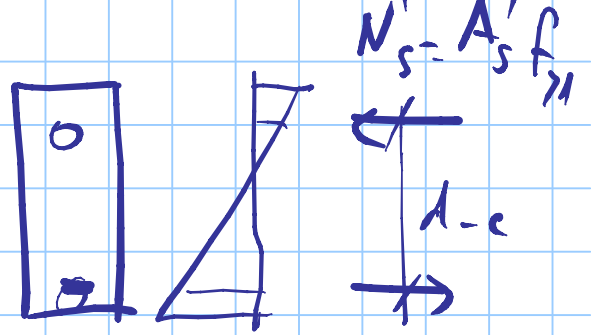
$$M = \frac{b\,d^2}{2^2} = \frac{0{,}30 \times 0{,}56^2}{0{,}0194^2} = 250\ \text{KNm}$$

$0{,}0194$

Aca T.A. $\quad \frac{0.30 \times 0.56^2}{0.0256^2} = 144\ \text{KNm}$

SEZ. 30×50

$$A_s = \frac{225 \times 10}{0.9 \times 0.46 \times 391.3} = 13.9 \text{ cm}^2$$



$$M = \frac{0.30 \times 0.46^2}{0.0194^2} = 169 \text{ KNm}$$

$$\Delta M = 225 - 169 = 56 \text{ KNm}$$

$$A'_s = \frac{\Delta M}{(d-c)\,\sigma'_s} = \frac{56 \times 10}{0.42 \times 391.3} = 3.4 \text{ cm}^2$$

SEZ 30×40

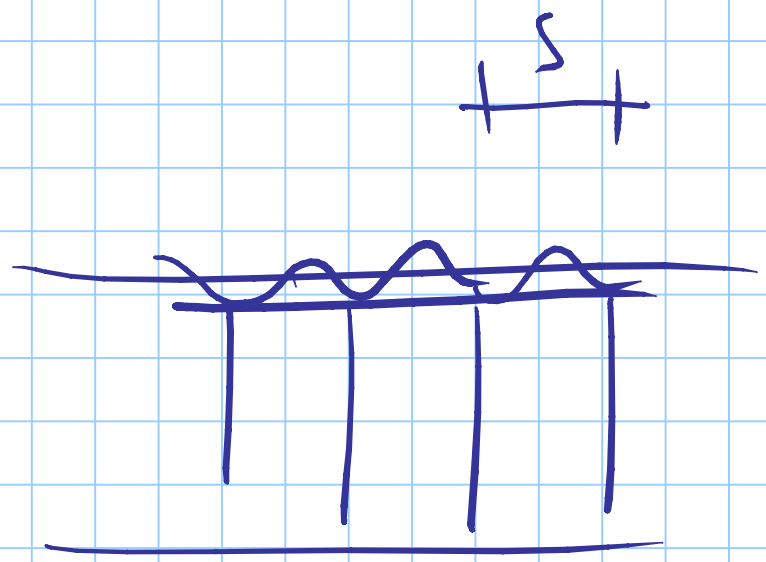
17.7

$$A_s = \frac{225 \times 10}{0.9 \times 0.36 \times 391.3} = 21.3 \text{ cm}^2$$

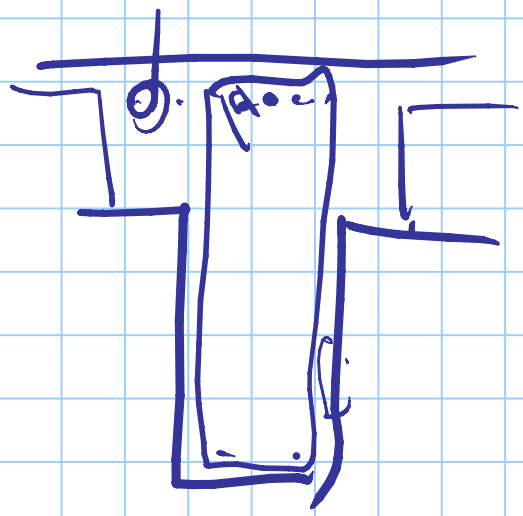
$$M = \frac{0.30 \times 0.36^2}{0.0194^2} = 103 \text{ kNm}$$

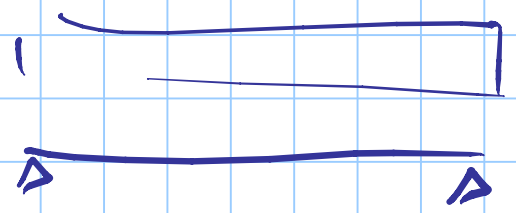
$\Delta M = 122$ kNm

$$A'_s = \frac{122 \times 10}{0.32 \times 391.3} = 9.7 \text{ cm}^2$$



$$l_0 = \frac{s}{2}$$





$50\ kN/m$

$s = 25\ cm$

$+ \quad 5.0$

$M_{Ed} = 156\ kNm$

$$b = \frac{M}{d^2 r^2} = \frac{156}{0.21^2 \times 0.018^2} = 1.15\ m$$

$b = 100\ cm$

$$A_s = \frac{156 \times 10}{0.9 \times 0.21 \times 391.3} = 21.1 \text{ cm}^2$$

$d = 21$ cm

$x = 5.25$ cm

$$M = \frac{1 \times 0.21^2}{0.0194^2} = 117 \text{ KN m}$$

$\Delta M = 39$ KN m

$$\varepsilon'_s = \frac{x - c}{x} \varepsilon_{cu2} = \frac{5.25 - 4}{5.25} \times 0.0035 = 0.00083$$

$$\sigma'_s = \varepsilon'_s E_s = 166.7 \text{ MPa}$$

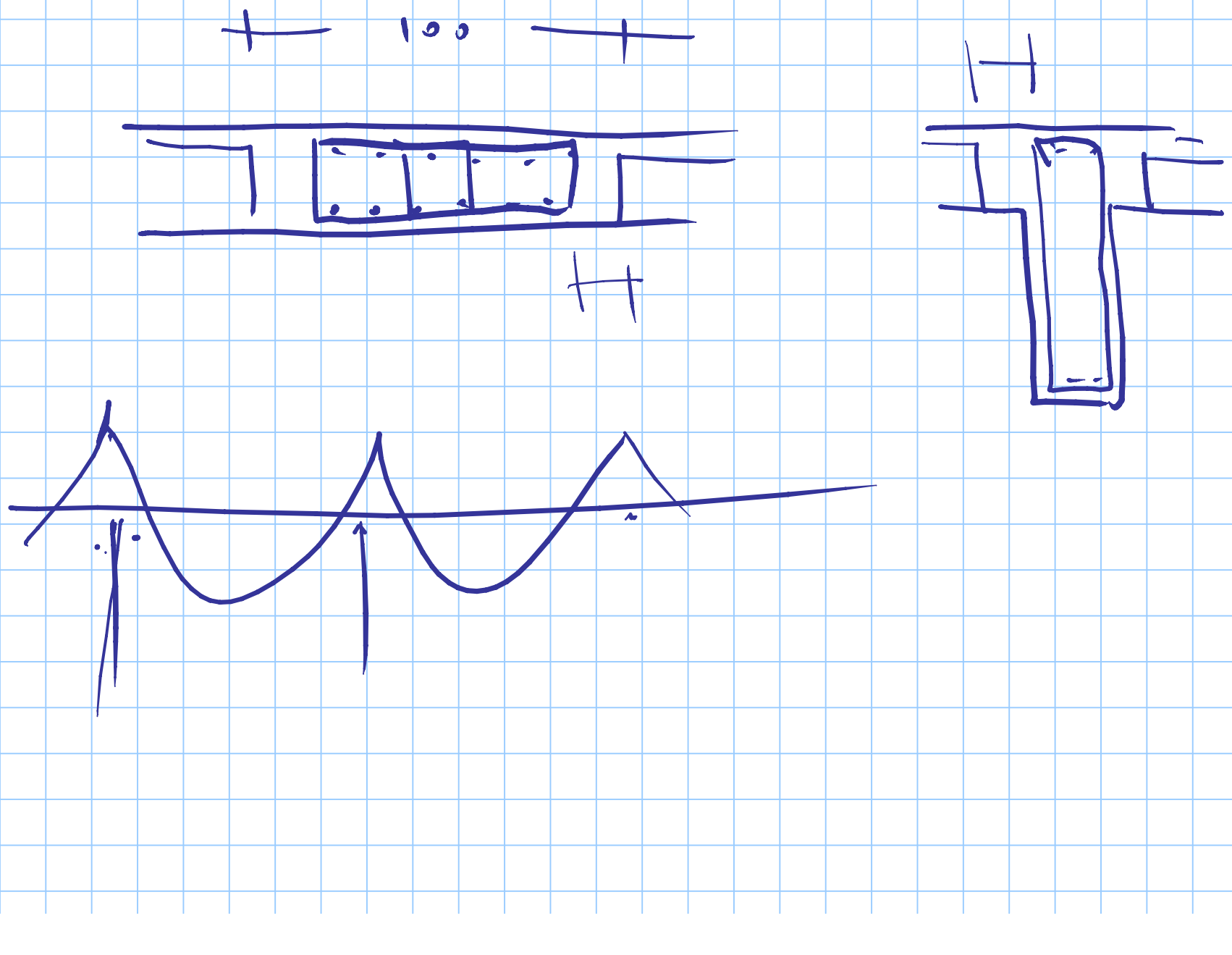
$$A'_s = \frac{39 \times 10}{0.17 \times 166.7} = 13.8 \text{ cm}^2$$

$$M = \frac{0.30 \times 0.46^2}{0.0154^2} = 169 \text{ kNm}$$

$$M = 300 \text{ kNm}$$

$$A_s = \frac{300 \times 10}{0.9 \times 0.46 \times 391.3} = 18.5 \text{ cm}^2$$

$$A'_s = \frac{131 \times 10}{0.42 \times 391.3} = 8.0 \text{ cm}^2$$


100

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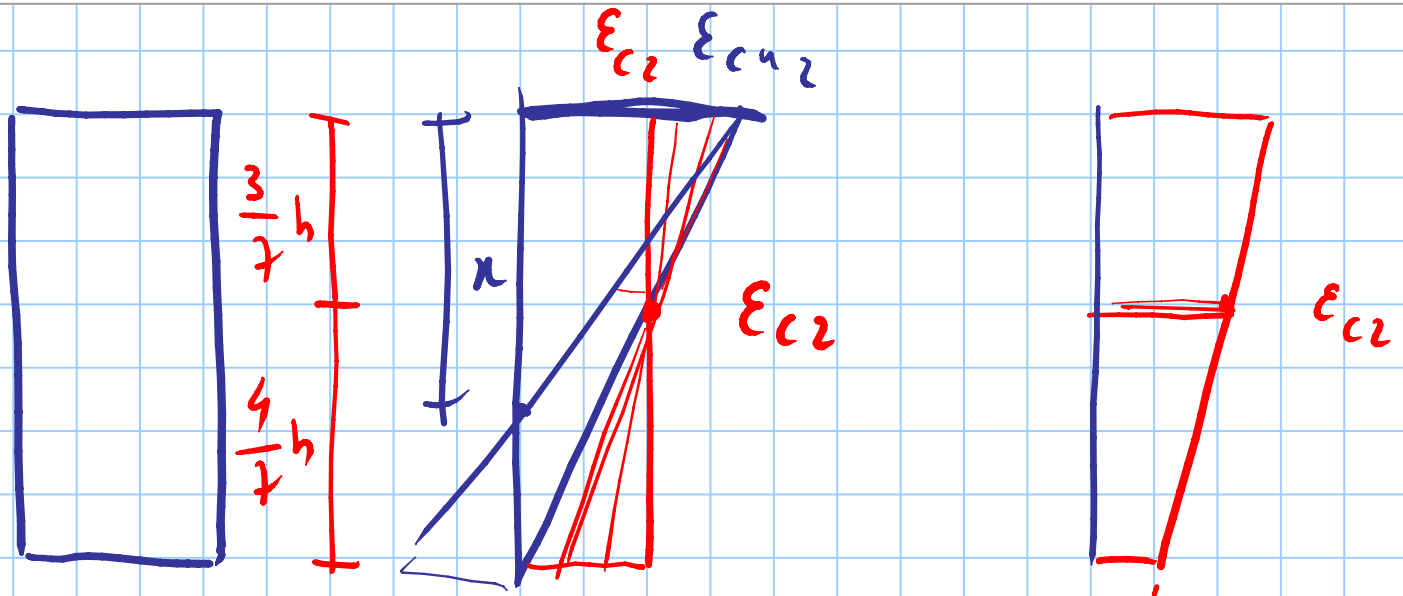


$$\eta_{inf} = \frac{\varepsilon_{c,inf}}{\varepsilon_{c2}}$$

$$0 \leq \eta_{inf} \leq 1$$

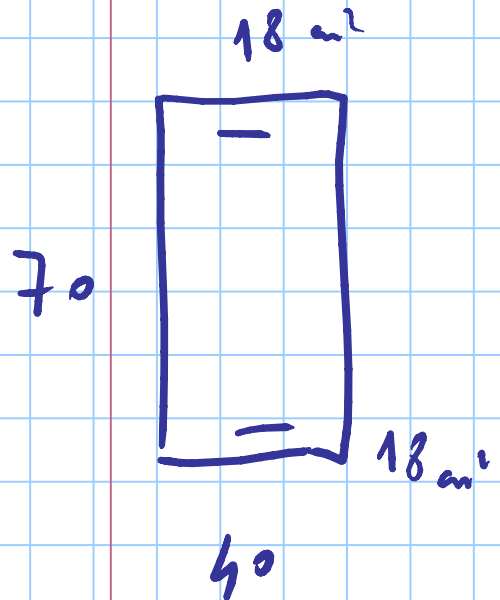
$N = 2550\ kN$

$e = 0{,}05\ h \quad > 20\ mm$

$0{,}05 \times 300 = 15\ mm$

$2550 \times 0{,}020 = 51\ kNm$

$2550 \times 0.015 = 38.2\ kNm$



$N = -3000$ KN

$N_{c,max} = 40 \times 70 \times 14.17 / 10 = 3968$ KN

$M_{c,max} = 0.12 \times 40 \times 70^2 \times 14.17 / 1000 = 333$ KNm

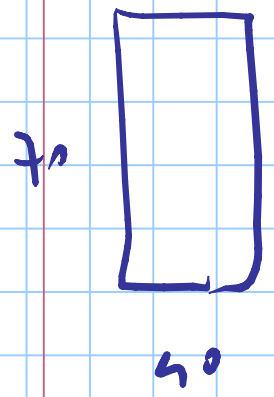
$N_{s,max} = 2 \times 18 \times 391.3 / 10 = 1409$ KN

$M_{s,max} = 18 \times 62 \times 391.3 / 1000 = 437$ KNm

$0.48\ N_{c,max} = 1905$ KN

$$m = 1 + \frac{1905}{1905 + 1409} = 1.57$$

$$M_{Rd} = (333 + 437)\left[1 - \underbrace{\underbrace{\left(\frac{3000 - 1905}{1905 + 1409}\right)^{1.57}}_{0.33}}_{0.176}\right] = 635 \text{ KNm}$$



$N_{C,RA} = 3968\ kN$

$M_{C,RA} = 333\ kNm$

$N_{S,RA} = 1409\ kN$

$M_{SA} = 437\ kNm$

$0{,}48 \times 3968 = 1905$

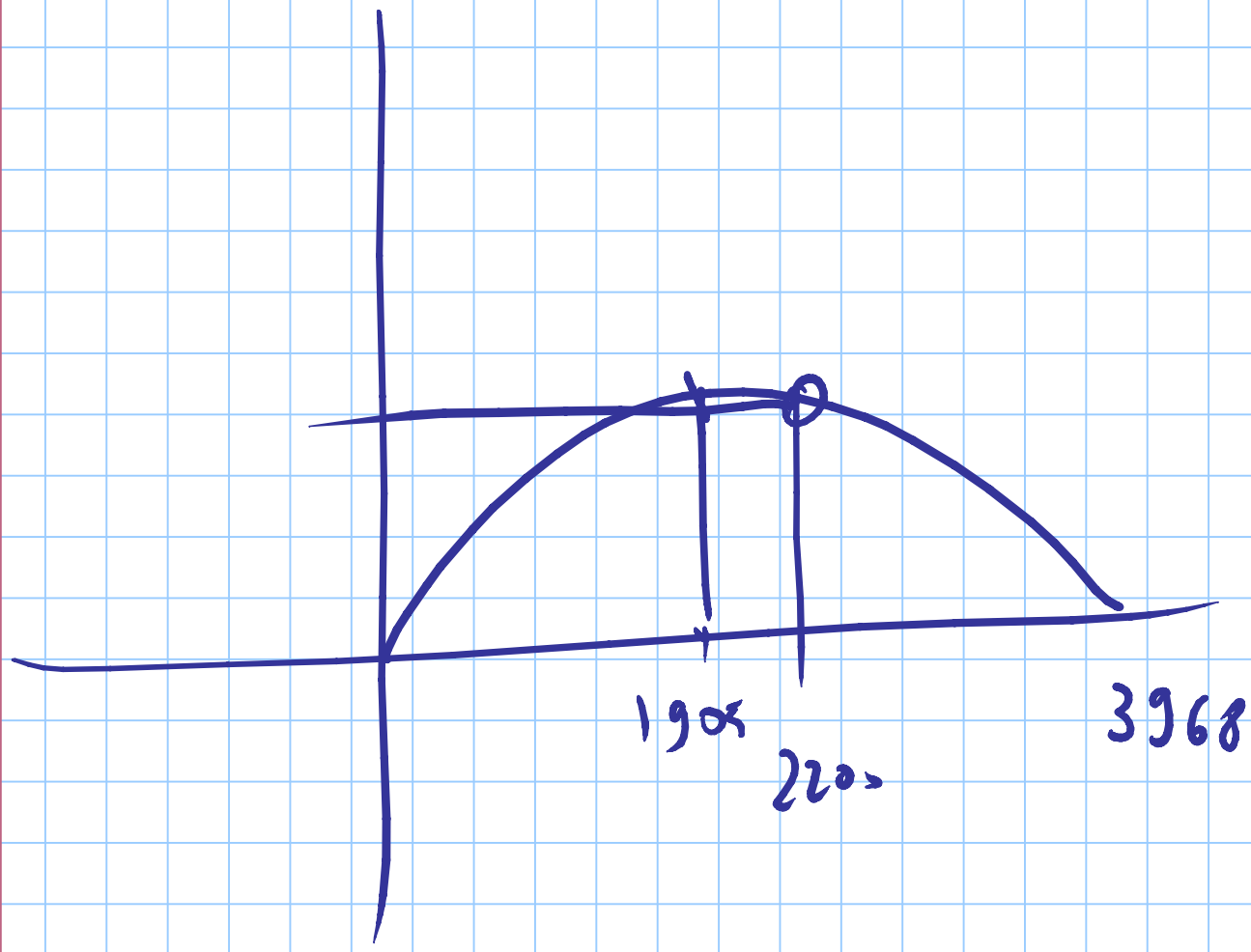
$N_{Ed} = 2200\ kN$

$M_{Ed} = 500\ kNm$

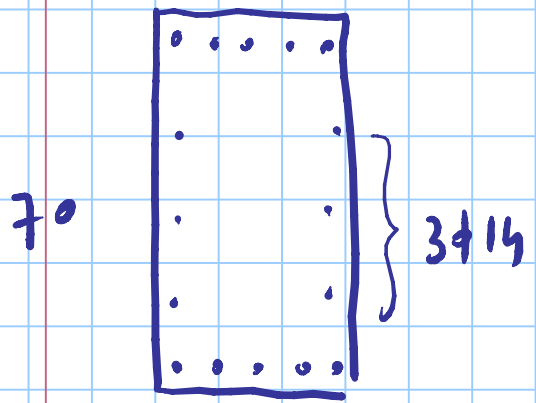
$$M_C = 333 \left[1 - \left(\frac{2200 - 1905}{1905}\right)^2\right] = 325$$

$\Delta M = 500 - 325 = 175\ kNm$

$$A_S = \frac{175 \times 10}{0{,}62 \times 391{,}3} = 7.2\ cm^2$$


190
220
3968

$5\phi 18 = 12.5\ cm^2$



$40 \times 70 \qquad A_s = 12.5\ cm^2$

$70 \times 40 \qquad A_s = 9.6\ cm^2$

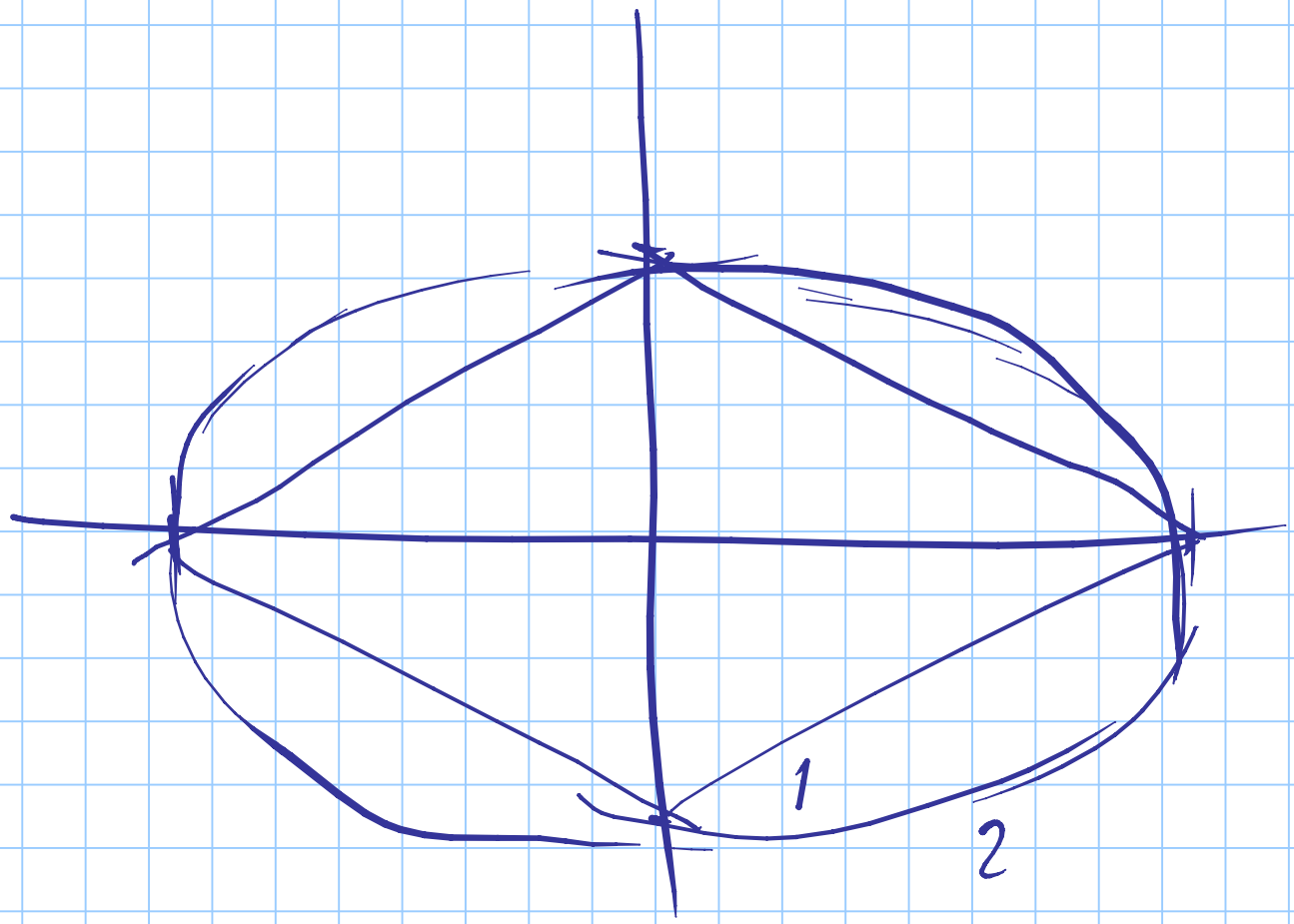
$$\left(\frac{320}{610}\right)^{1.5} + \left(\frac{160}{255}\right)^{1.5} \leq 1$$

$$\underbrace{0.38}_{\left(\frac{320}{610}\right)^{1.5}} + \underbrace{0.40}_{\left(\frac{160}{255}\right)^{1.5}} = 0.78 \quad \text{Ok}$$

$N_{Ed} = 2200\ kN$

$M_{Ed,x} = 320\ kNm \qquad M_{Rd,x} = 610\ kNm$

$M_{Ed,y} = 160\ kNm \qquad M_{Rd,y} = 255\ kNm$


1
2

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$$\tau = \frac{V}{0.9\, b\, d} \leq \tau_{c0}$$

C 25/30

$\tau_{c0} = 0.6$ MPa

$$V \leq \underbrace{\tau_{c0}}_{0.54}\, 0.9\, b\, d = 23.8 \text{ kN}$$

$q = 7$ kN/m²

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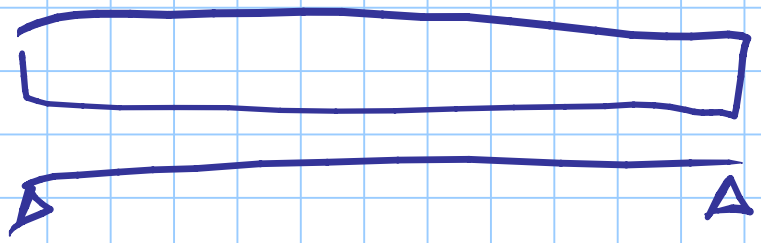
$$V_{Rd,s1} = \frac{2 A_{s1} f_{yd}}{\cot\vartheta}$$

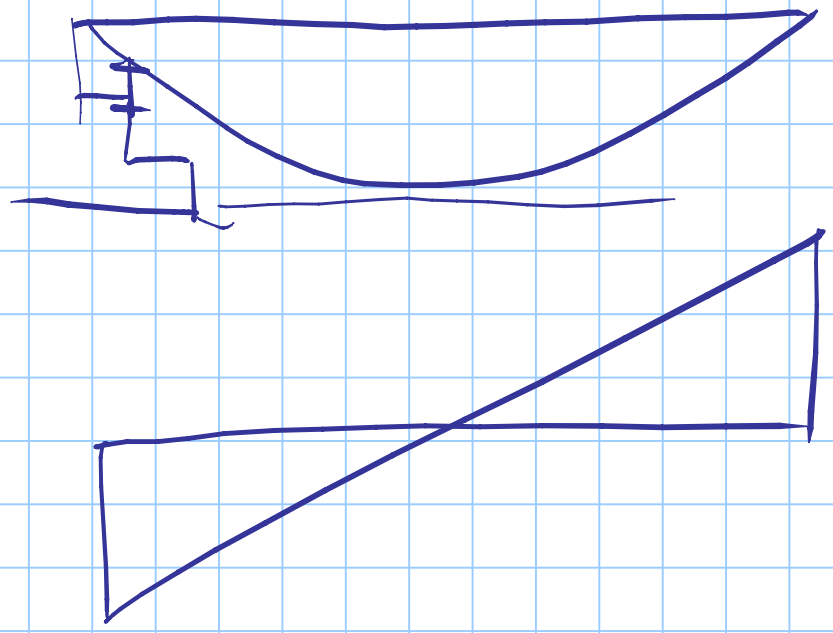
$$A_{s1} = \frac{V_{Ed} \cot\vartheta}{2 f_{yd}}$$

$$\frac{\Delta M}{z f_{yd}} = V \Delta z = \frac{V \frac{z}{2} \cot\vartheta}{z f_{yd}} = \frac{V_{Ed} \cot\vartheta}{2 f_{yd}}$$



$q_1 = 80\ kN/m$

6.00 m



$$M_{max} = \frac{80 \times 6^2}{8} = 360\ kNm$$

$$V_{max} = \frac{80 \times 6}{2} = 240\ kN$$

$$d = \alpha \sqrt{\frac{M}{b}} = 0{,}018 \sqrt{\frac{360}{0{,}30}} = 0{,}62 \text{ m}$$

30×60

$d = 56 \text{ cm}$

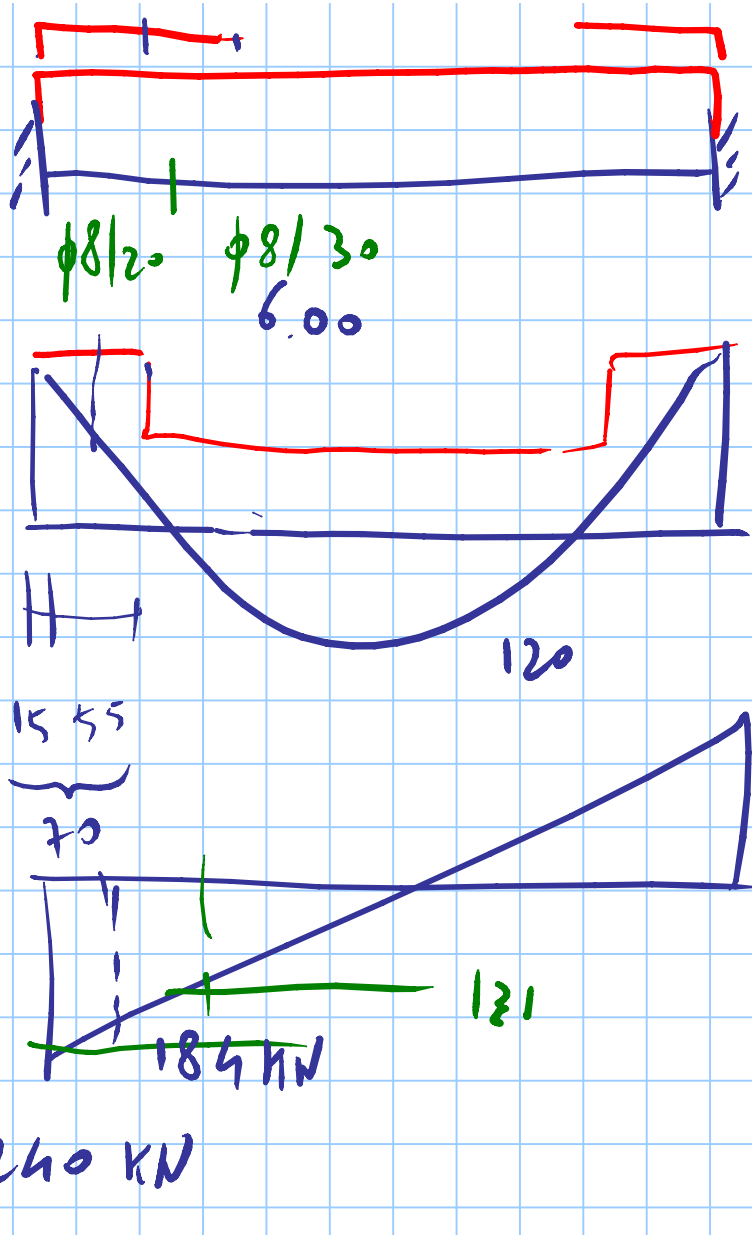
$$A_s = \frac{360 \times 10}{0{,}9 \times 0{,}56 \times 391{,}3} = 18.3 \text{ cm}^2$$

$6\phi 20 = 18.8 \text{ cm}^2$

$$M = \frac{b d^2}{2^2} = \frac{0{,}30 \times 0.56^2}{0.0194^2} = 250 \text{ kNm}$$

$$A'_s = \frac{110 \times 10}{0.52 \times 391.3} = 5.4 \text{ cm}^2$$

$2\phi 20 = 6.3 \text{ cm}^2$

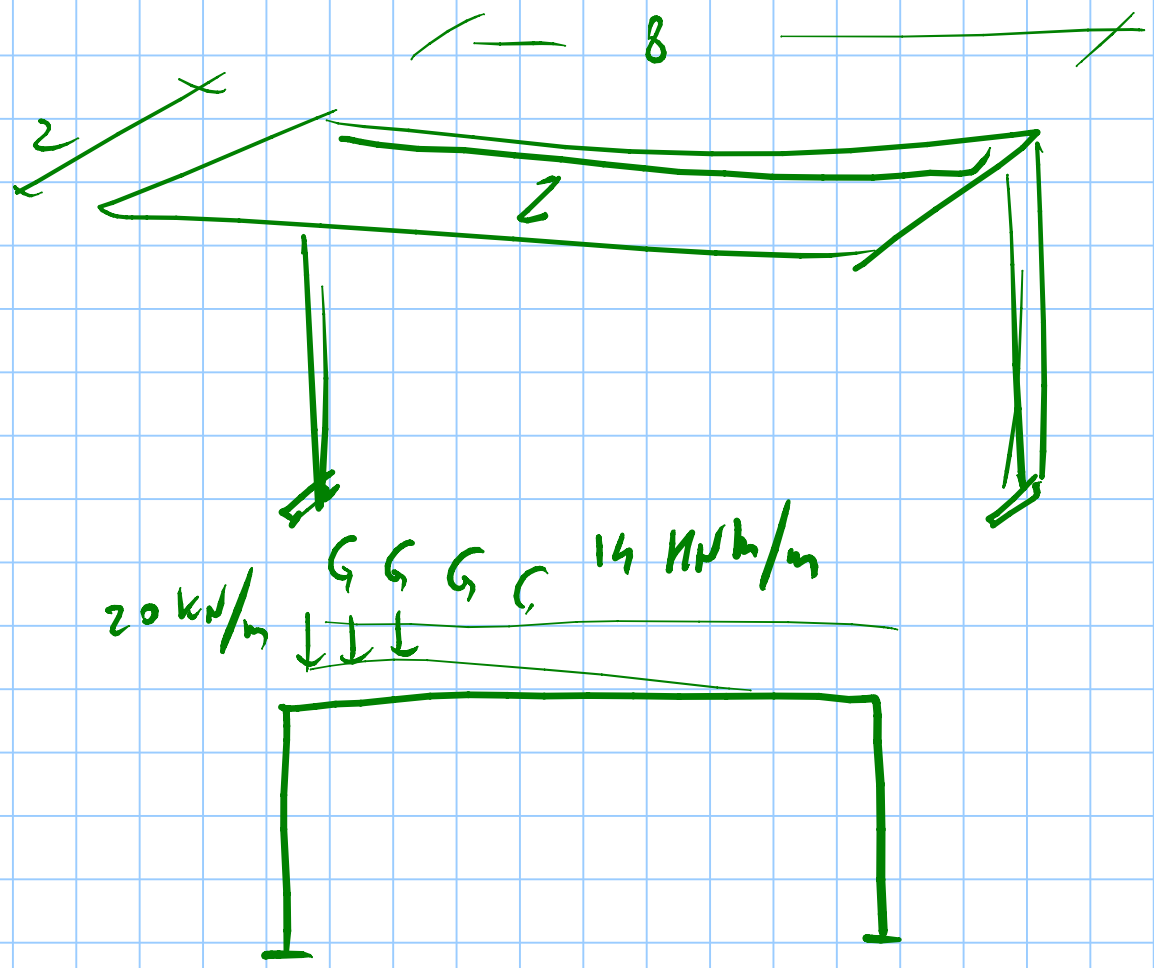

$T_1 = 80$ kN/m
30 x 60
$\phi 8/20$ $\phi 8/30$
6.00
240 kN m
$A_s = 12.2$ cm^2
4 ϕ 20
4 m^2
in +
120
15 55
70
121
137
184 kN
240 kN

$\cot\vartheta = 2$

$$V_{Rd,max} = \frac{\cot\vartheta}{1+\cot^2\vartheta} f'_{cd}\, b\, z = 428\ kN$$

ST	$\phi 8/20$	$V_{Rd,st} = 197\ kN$	con $A_{sw} = 5.0\ cm^2$
ST	$\phi 8/25$	$V_{Rd,st} = 158\ kN$	4.0
	$\phi 8/30$	131 kN	
ST	$\phi 8/15$	$V_{Rd,st} = 263\ kN$	6.7 cm^2

TORSIONE



$q_1 = 7\ kN/m^2$

$M_{Ed} = 160\ kNm$

$V_{Ed} = 80\ kN$

$T_{Ed} = 56\ kN_m$

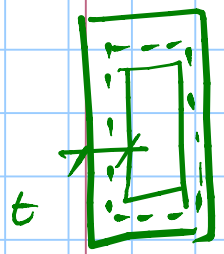
$$T_{Rd} = 2 A_k t f'_{cd} \frac{\cot\vartheta}{1+\cot^2\vartheta}$$

C 25/30

$f'_{cd} = 7.1$ MPa

30 × 50

$$t = \frac{150}{160} = 9.4 \text{ cm}$$



$$A_k = 20.6 \times 40.6 = 836 \text{ cm}^2$$

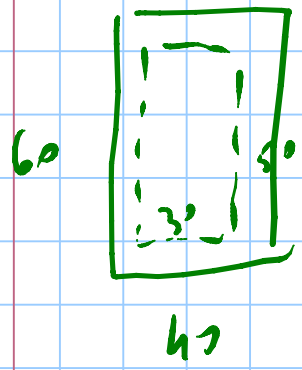
$$T_{Rd} = \underbrace{\frac{836 \times 9.4 \times 7.1}{1000}}_{55.8} \left(2 \frac{\cot\vartheta}{1+\cot^2\vartheta}\right)$$

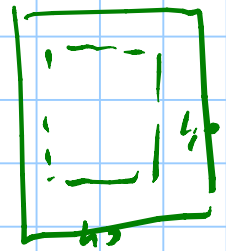
$\cot\vartheta = 1$	1
2	0.8

$T_{Ed} = 100\ kN_m$

$$A_k \cdot t = \frac{T_{Ed}}{f'_{cd}\ 0.9} = \frac{100 \times 1000}{7.1 \times 0.9} = 1550\ cm^3$$

$t = 10 \quad A_k = 155\ cm^2$





$$t = \frac{2400}{200} = 12\ cm^2$$

$A_k = 28 \times 48 = 1344$

$t\ A_k = 16128\ cm^3$

$$T_{Rd} = \frac{16128 \times 7.1}{1000} \cdot \frac{2 \cot\vartheta}{1 + \cot\vartheta} =$$

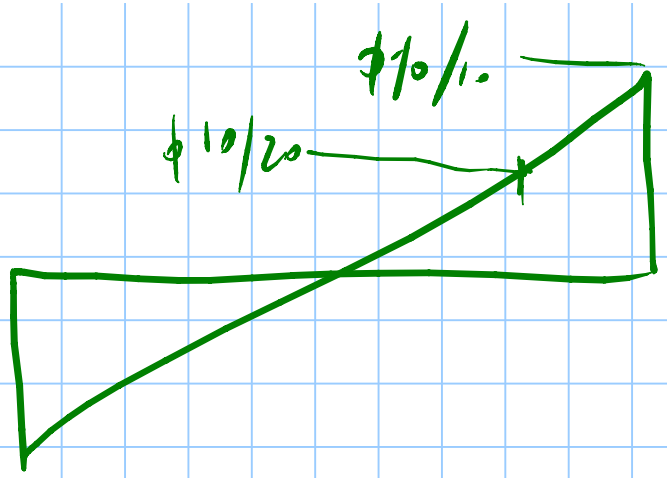
$$= 114.5$$

$$A_{sw} = \frac{T_{Ed} \cdot s}{2 A_k f_{yd} \cot\vartheta} = \frac{100 \times 100 \times 10^3}{2 \times 1344 \times 391.3 \times 1.7} = 5.6\ cm^2$$

$\phi 8/8 \cdot \phi 10/12.5$

$6.24\ cm^2$

$$A_{sl} = \frac{T_{Ed}\, u_k \cot\vartheta}{2 A_k f_{yd}}$$

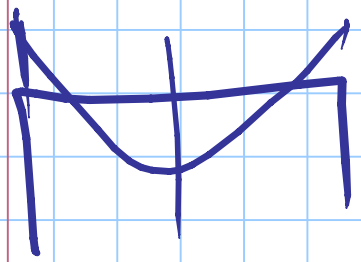


T = 100kN.

T

$A_{sl} = \cancel{17.6}\ cm^2$

20.2



M 4.0

$u_n = 152$

3.2

2ϕ20 T

0.32

48

5.6

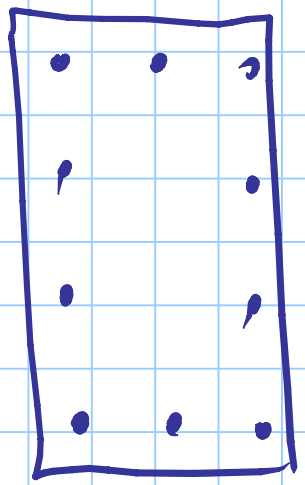
5.6

28

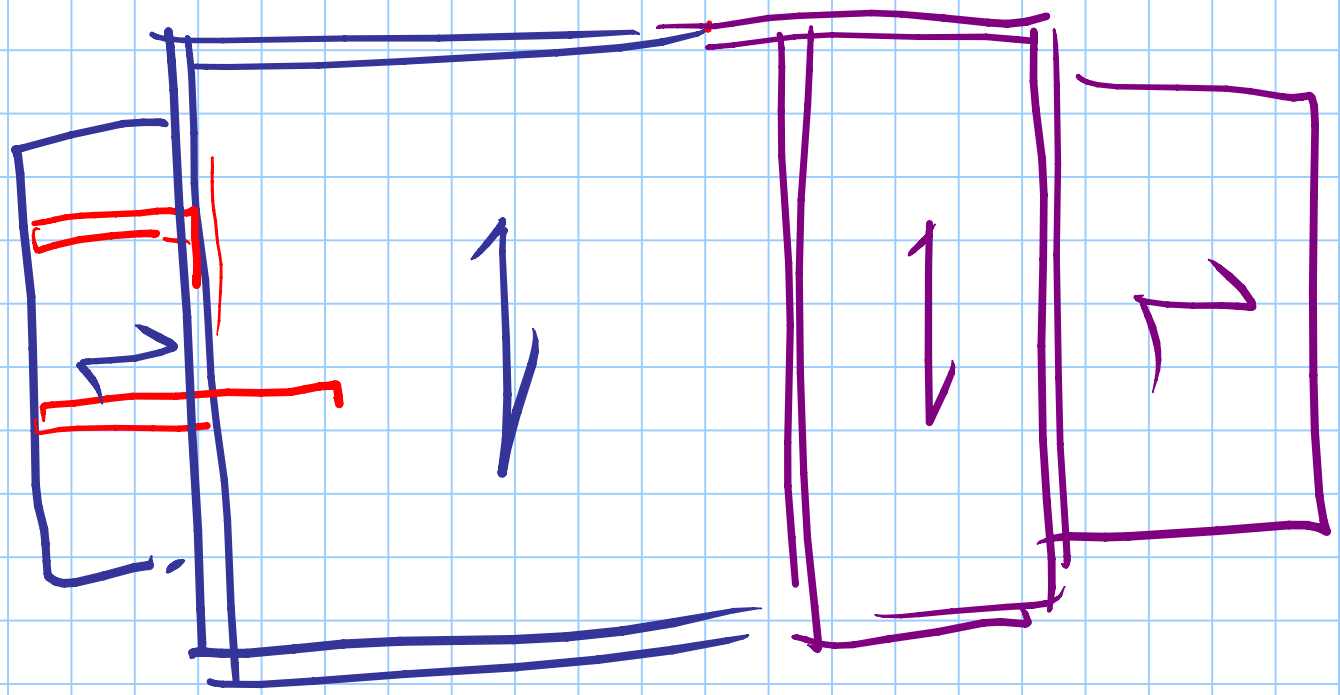
0.18

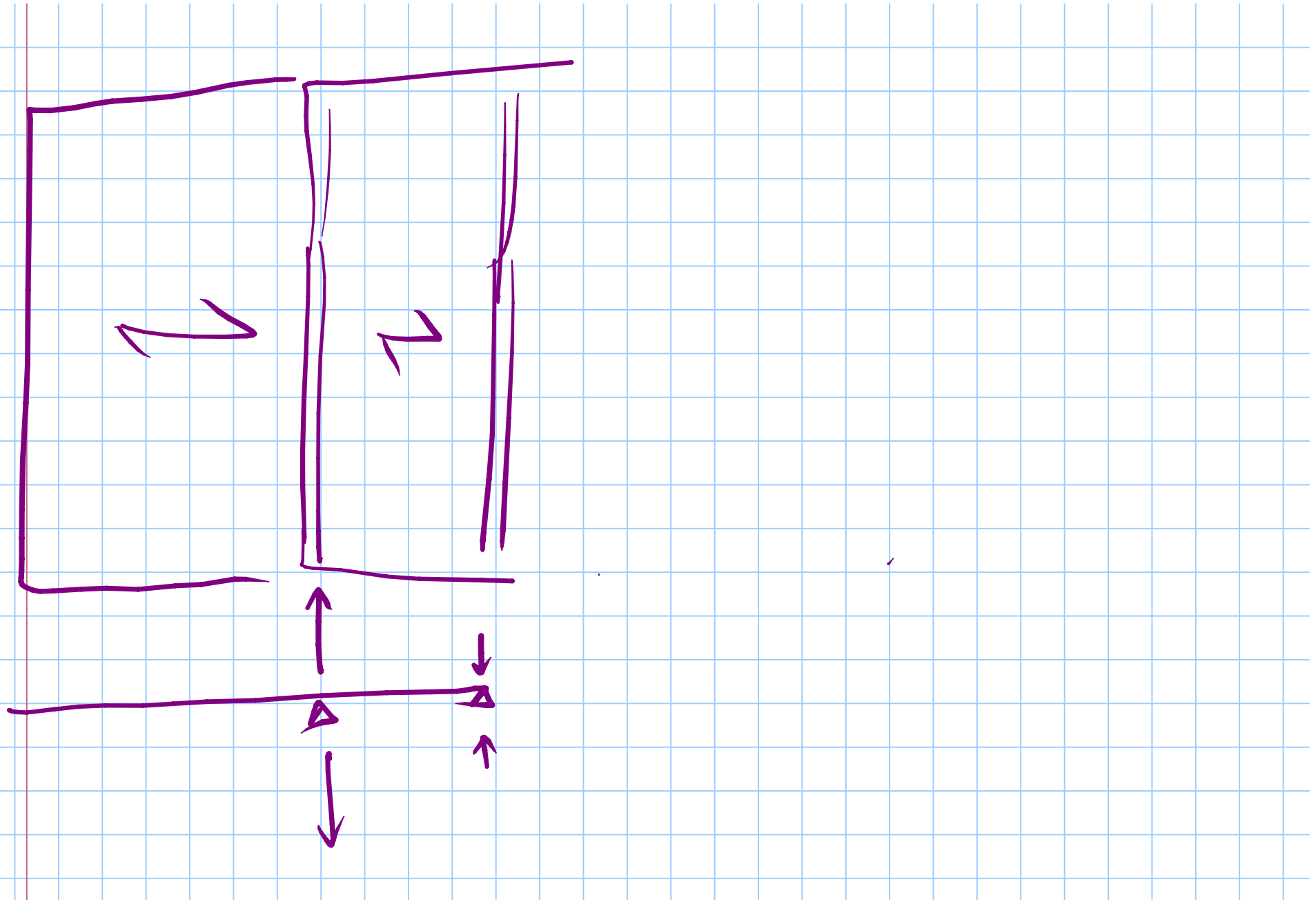
3.2

4ϕ14 = 6 cm^2



$10 \phi 16 = 20\ cm^2$





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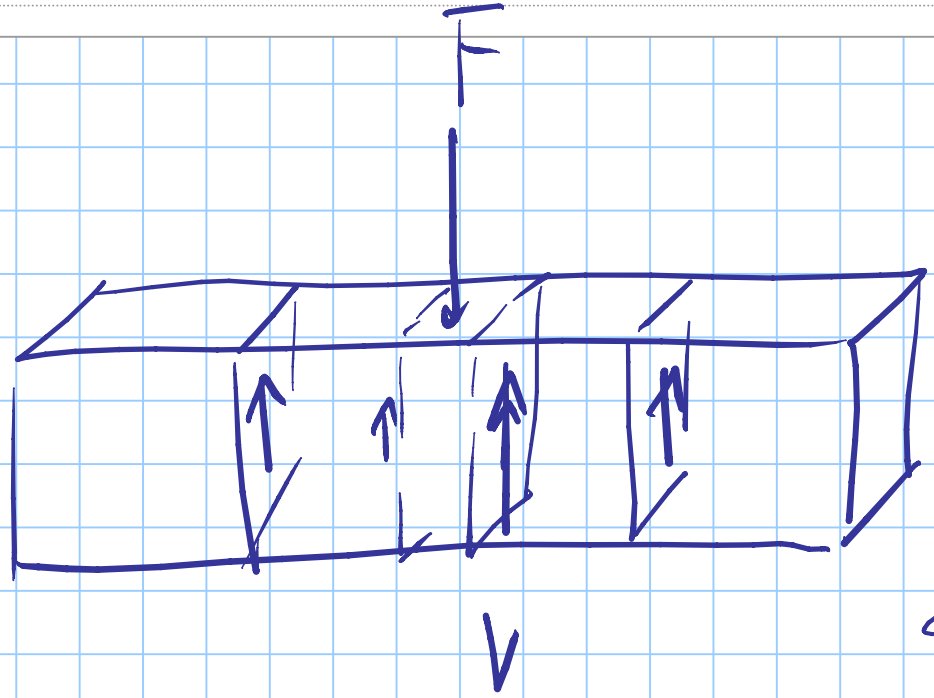
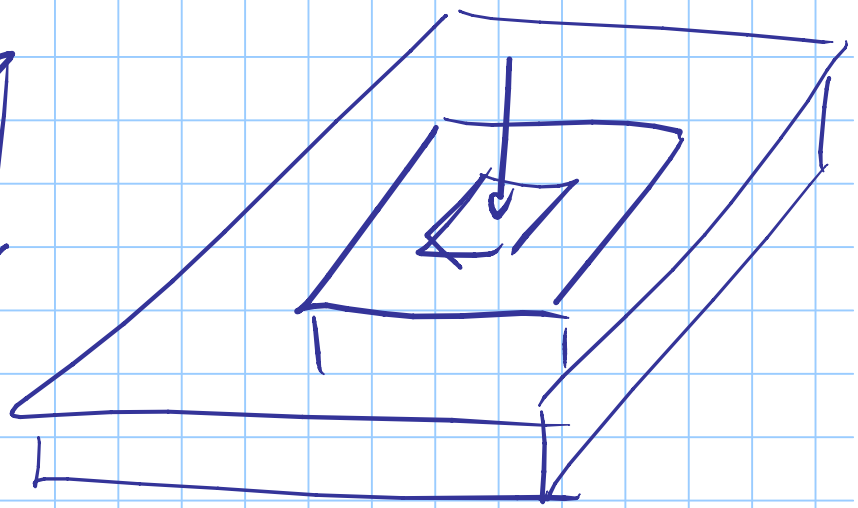
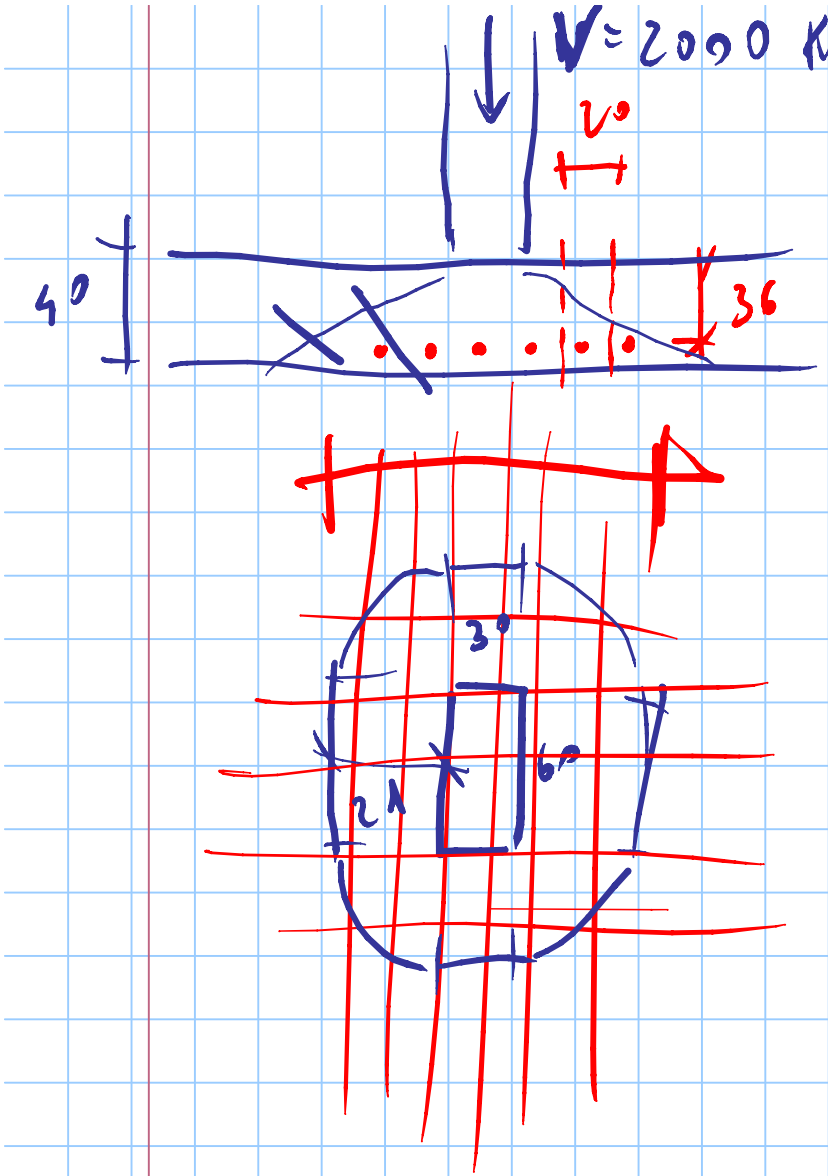






$d = 36$

$2d = 72\ cm$

$M_u = 180 + 6.28 \times 72 = 632\ cm$

$0.08\ Mr. - \frac{2000 \times 10^3}{25 \times 10^6}$

$1\phi 14/20\ cm$

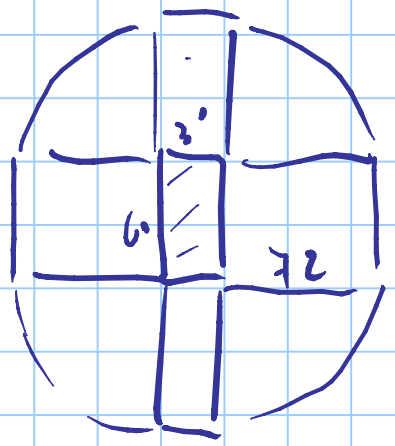
$\rho = \frac{1.54}{20 \times 36} = 0.0021$

$K = 1 + \sqrt{\frac{200}{360}} = 1.75$

$$\tau_{Rd} = 0{,}18 \times 1{,}75 \times \frac{\sqrt[3]{100 \times 0{,}0021 \times 25}}{1{,}5} = 0{,}365\ MPa$$

$$\tau_{min} = 0{,}035 \sqrt{1{,}75^3 \times 25} = 0{,}405\ MPa$$

$$\tau_{Rd,max} = 3{,}5\ MPa$$



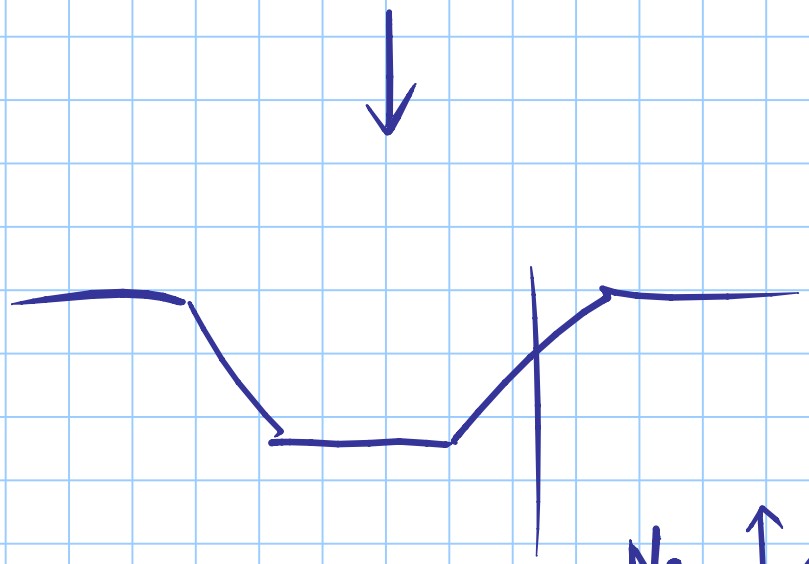
$180 \times 72 + 3.14 \times 72^2 \simeq 31040\ m^2$

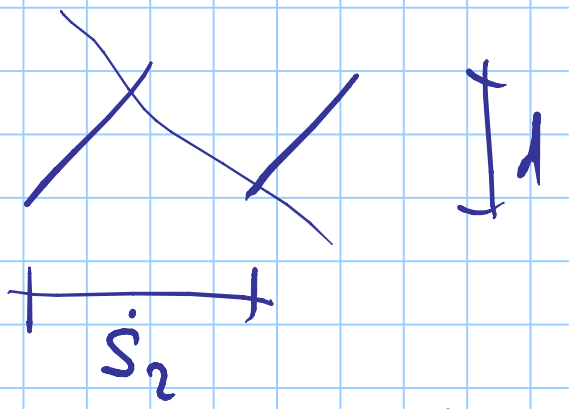
$+ 1800$

$$\frac{31040 \times 10^2 \times 0.08}{1000} = 248\ KN$$

$V_{E1} = 2000 - 248 = 1752\ KN$ $\qquad 0.4 < 0.88 < 3.5$

$$\upsilon_{E1} = \frac{1.15\ \beta\ 1752 \times 10^3}{632 \times 36 \times 10^2} = 0.88\ MPa$$





$$\frac{N_s}{\sqrt{2}} \uparrow\nearrow N_s = A_s f_{yd}$$

$$\frac{1.5\,d}{s_2}$$

$$V_{Rds} = \sum A_s f_{yd} \frac{\sqrt{2}}{2}$$

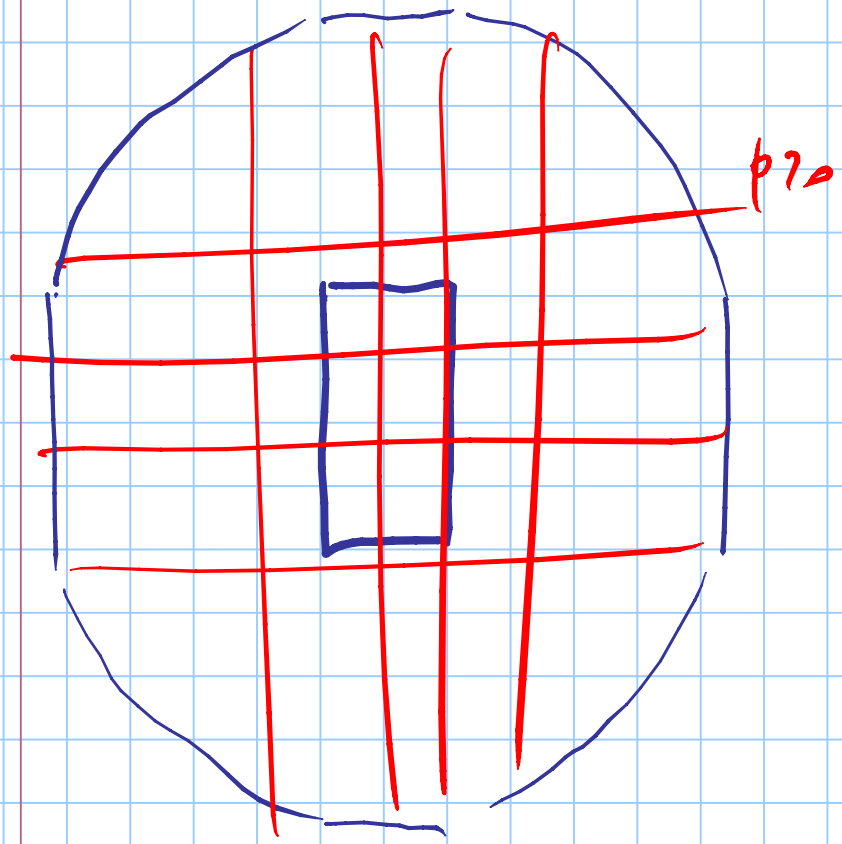
$$\nu_{Rds} = \frac{1}{\mu_a d} \sum A_s f_{yd} \psi_{na}$$

$$v_{Ed} = 0.75\, v_{Rdc} + \frac{A_{sw}\, f_{yd}\, \sin\alpha}{u\, d}$$

$$\downarrow$$

$$A_{sw} = \frac{\left(v_{Ed} - 0.75\, v_{Rdc}\right) u\, d}{f_{yd}\, \sin\alpha} =$$

$$= \frac{(0.88 - 0.75 \times 0.405)\ 632 \times 36}{391.3 \times 0.71} = 47\ cm^2$$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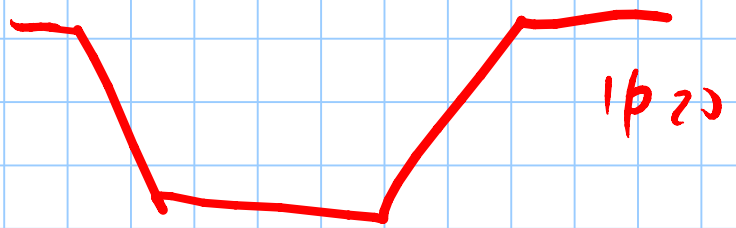
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