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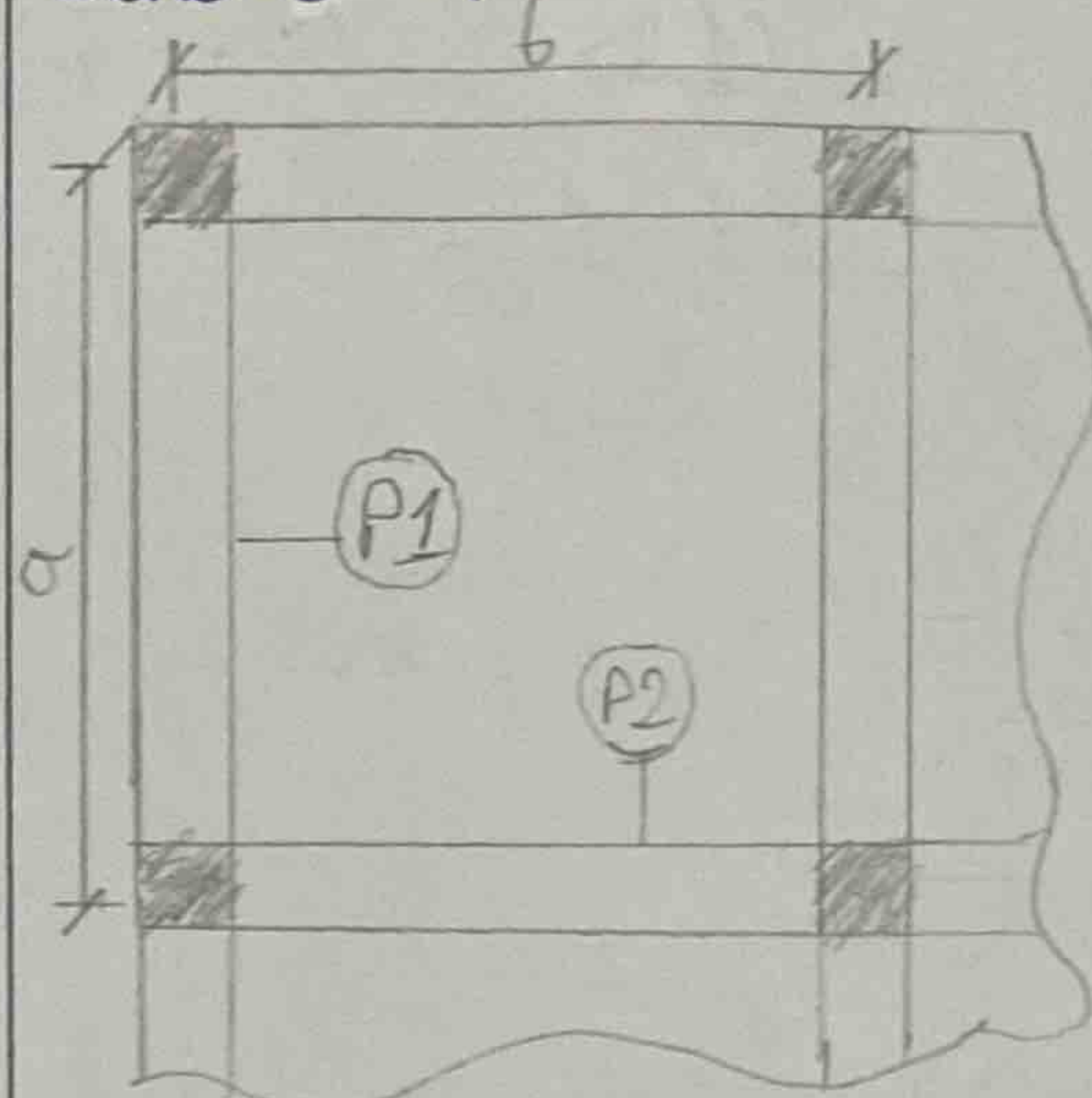
Erasmus Student

Two-way slab on four sides

INPUT DATA

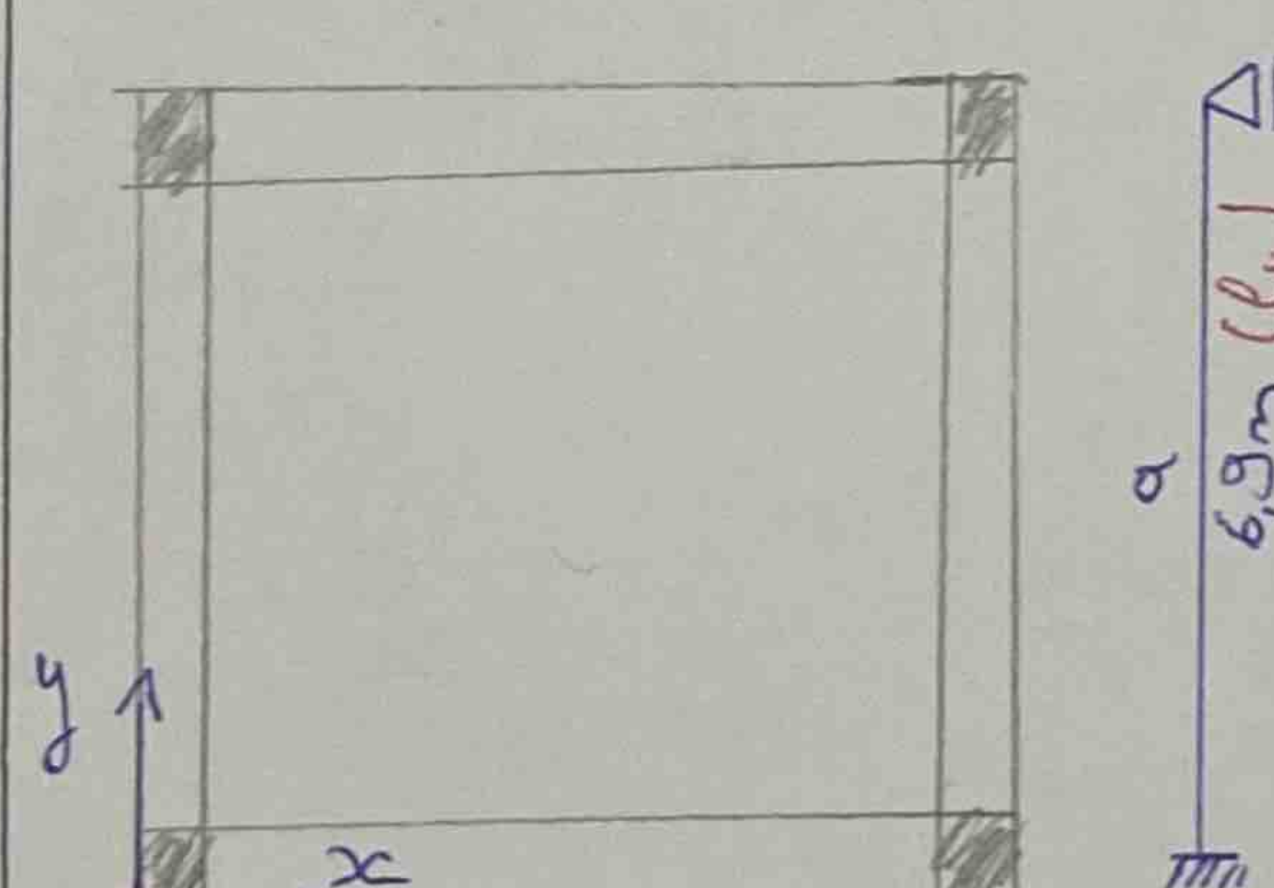
Scheme A



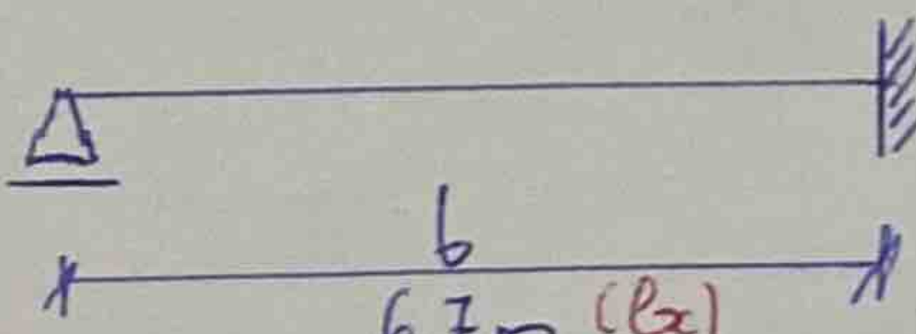
- Member : P1
- b : 6,7 m
- hs : 220 mm
- a : 6,9 m
- Concrete : C30/37
- P : XC2
- $(g-g_0)_{floor,k} = 1,6\ kN/m^2$
- ~~$(g-g_0)_{roof,k} = 1,8\ kN/m^2$~~
- $q_{floor,k} = 3,9\ kN/m^2$

1. Calculation of bending moments in the slab:

1.1. Calculation of bending moments using linear analysis



$$k_y = \frac{2}{384}$$



$$k_x = \frac{2}{384}$$

1.2. Calculation of loads at ULS

Type	Name	fk [kN/m²]	γ_F	fd [kN/m²]
Permanent	(g-g0) floor, k	1,6	1,35	2,16
	Self weight of the slab gslab	25 x 0,22 = 5,5	1,35	7,425
Variables	qfloor, k	3,9	1,5	5,85

$$f_d = 1{,}35g + 1{,}5q = 1{,}35 \times (2{,}16 + 7{,}425) + 1{,}5 \times 5{,}85$$

$$\simeq \underline{21{,}71 \ kN/m^2}$$

1.3. Forces in x and y direction

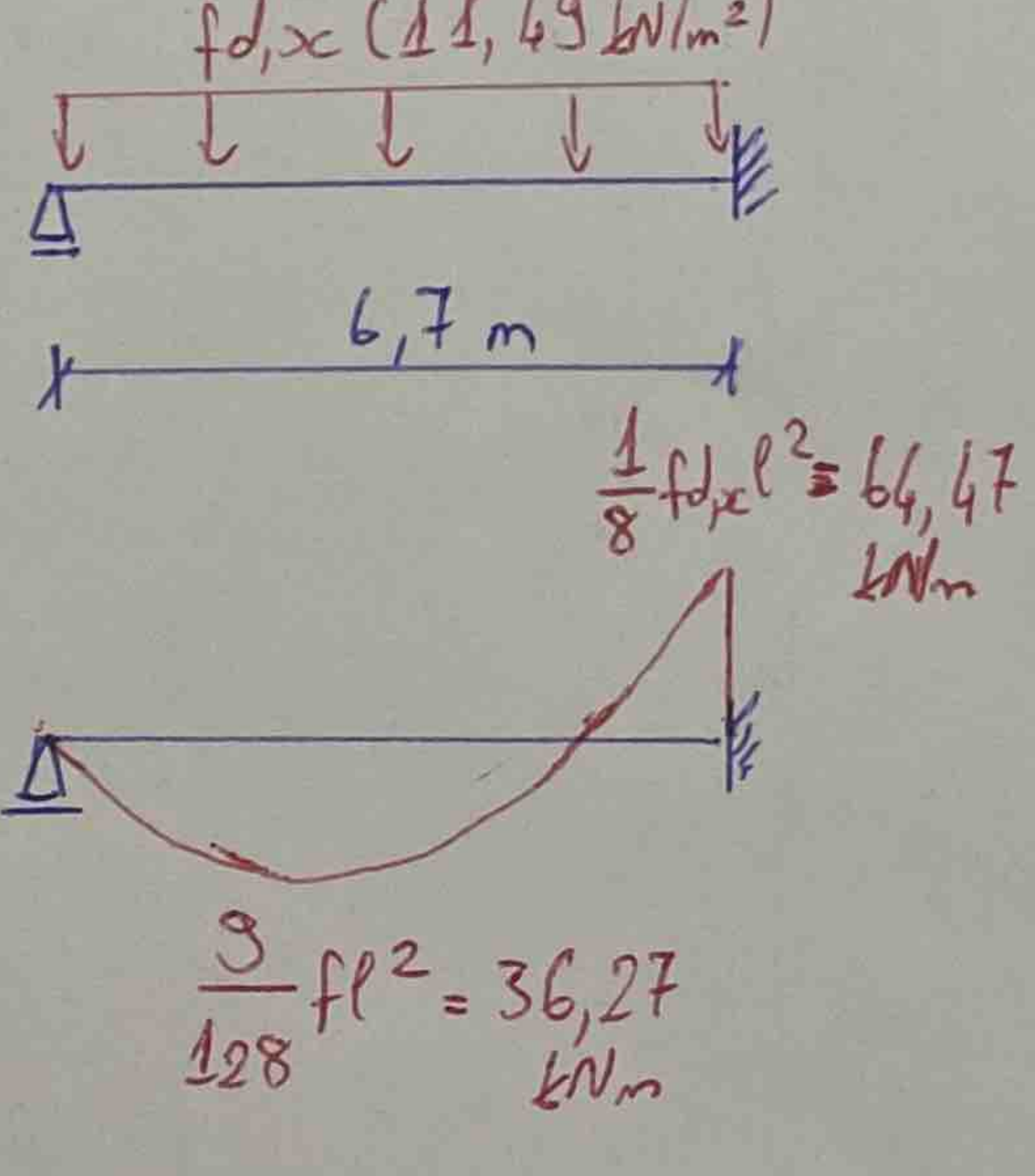
$$f_{d,x} = \frac{f_d \cdot \frac{k_y}{k_x} \cdot \left(\frac{l_y}{l_x}\right)^4}{1 + \frac{k_y}{k_x} \cdot \left(\frac{l_y}{l_x}\right)^4} \qquad k_x = k_y = \frac{2}{384}$$

$$f_{d,x} = \frac{f_d \cdot \left(\frac{l_y}{l_x}\right)^4}{1 + \left(\frac{l_y}{l_x}\right)^4} = \frac{21{,}71 \times \left(\frac{6{,}9}{6{,}7}\right)^4}{1 + \left(\frac{6{,}9}{6{,}7}\right)^4} = \underline{11{,}49 \ kN/m^2}$$

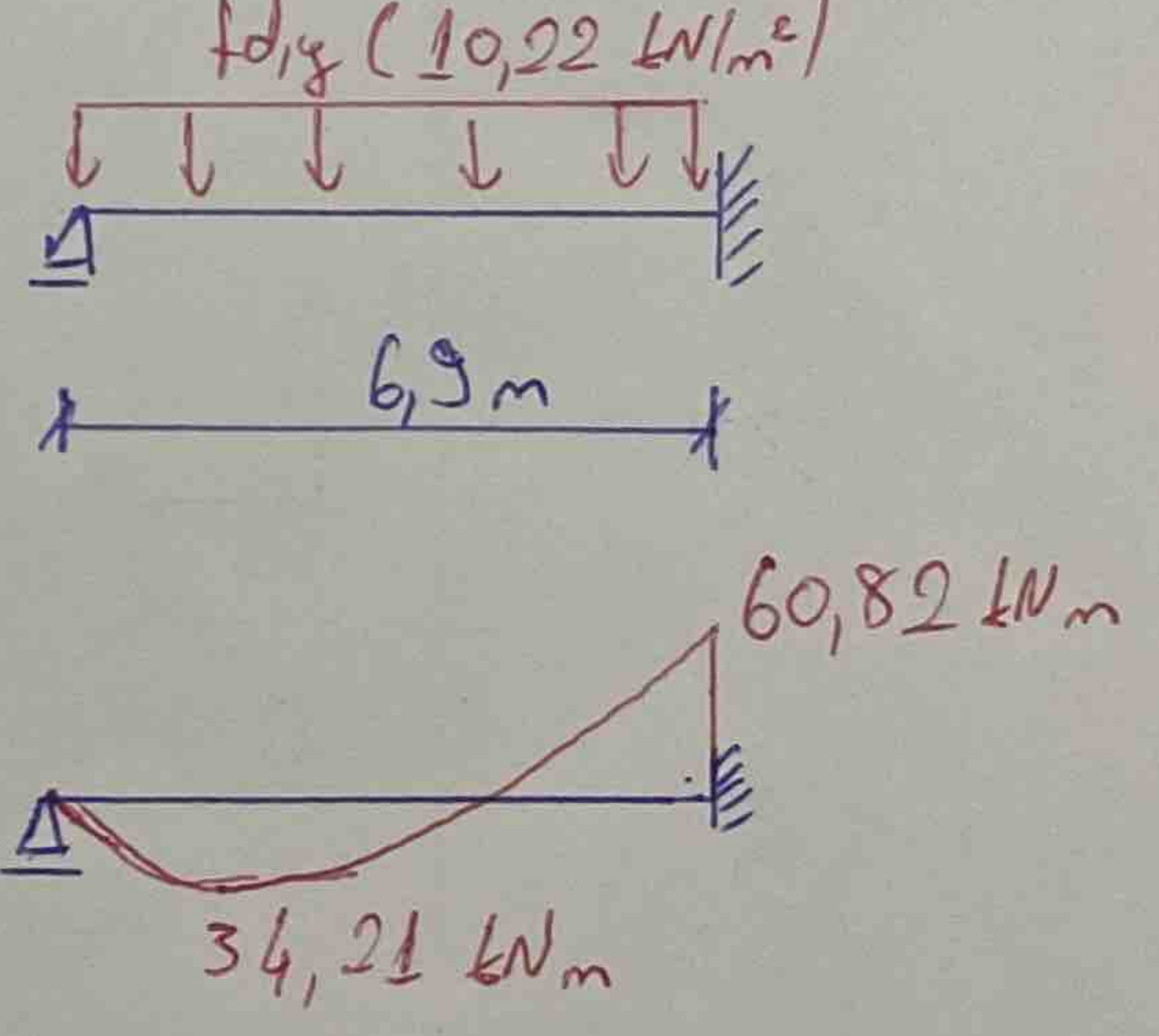
$$f_{d,y} = f_d - f_{d,x} = 21{,}71 - 11{,}49 = \underline{10{,}22 \ kN/m^2}$$

1.5. Bending moments using linear analysis

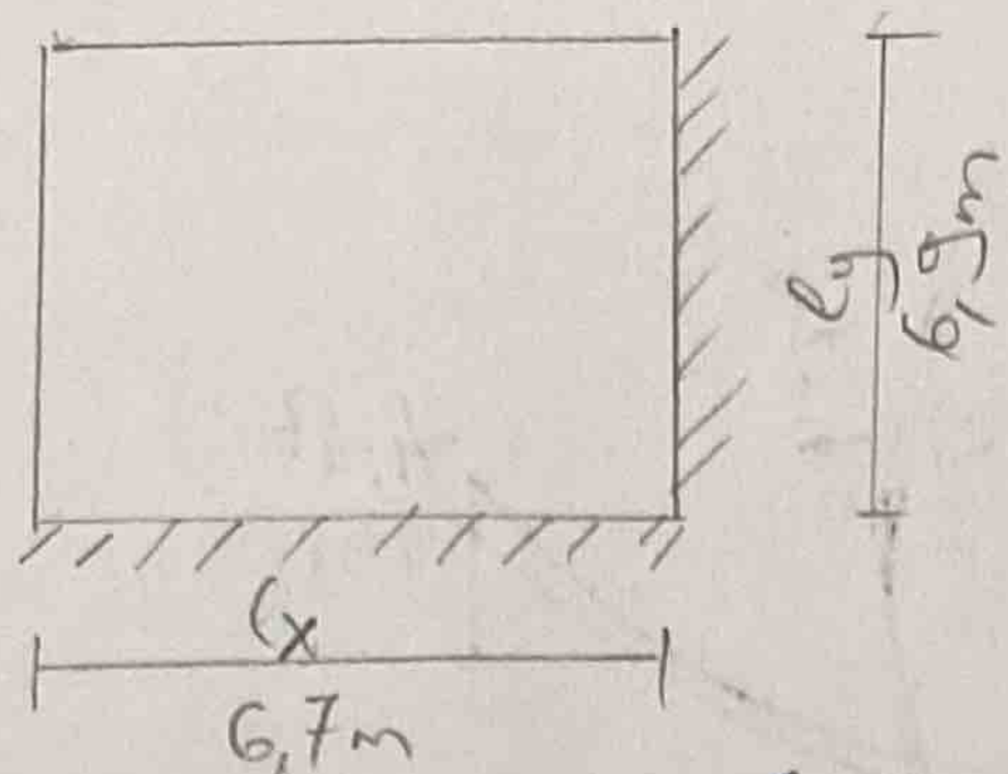
X DIRECTION



Y DIRECTION



2. Plastic analysis



$$\beta = \frac{l_y}{l_x} = \frac{6,9}{6,7} \simeq 1,03$$

$$\beta_{xe} = -0,047 + \left(\frac{-0,047+0,056}{1-1,1} \times 0,03\right) = -0,0497$$

$$\beta_{xm} = 0,036 + \left(\frac{0,036-0,042}{1-1,1} \times 0,03\right) = 0,0378$$

$$\beta_{ye} = -0,045$$

$$\beta_{ym} = 0,034$$

2.1. Calculation of bending moments in each direction

$$m_o = f_d \cdot l_x^2 = 21,71 \times 6,7^2 \simeq 974,56 \text{ kN}$$

X Direction

$$m_{xe} = \beta_{xe} \cdot m_o = -0,0497 \cdot 974,56 \simeq -48,43 \text{ kNm}$$

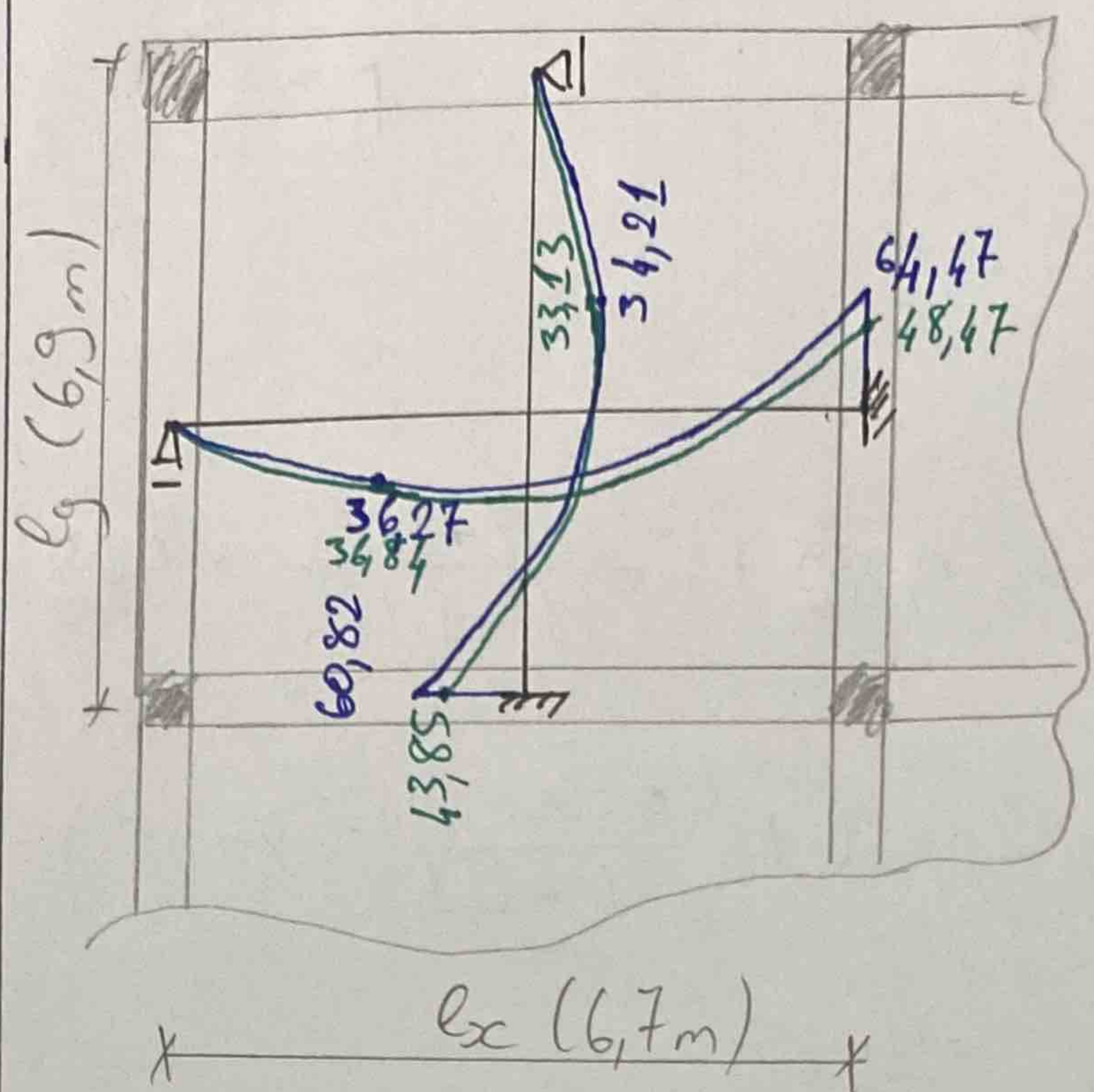
$$m_{xm} = \beta_{xm} \cdot m_o = 0,0378 \cdot 974,56 \simeq 36,84 \text{ kNm}$$

Y Direction

$$m_{ye} = \beta_{ye} \cdot m_o = -0,045 \times 974,56 = -43,85 \text{ kNm}$$

$$m_{ym} = \beta_{ym} \cdot m_o = 0,034 \cdot 974,56 \simeq 33,13 \text{ kNm}$$

3. Scheme of bending moments



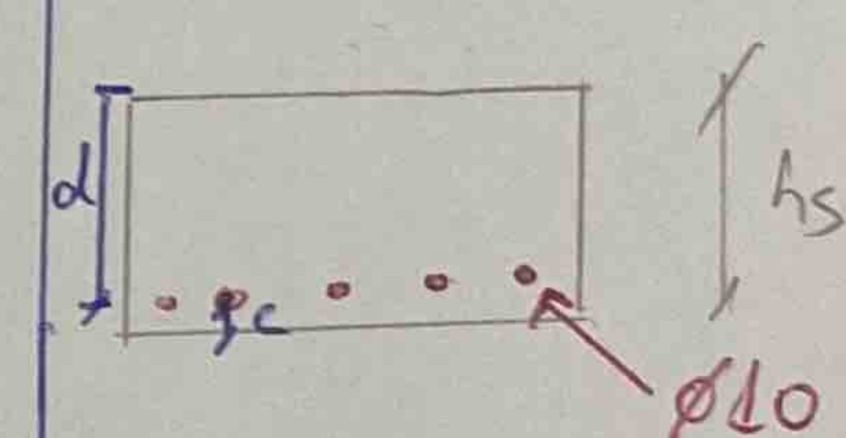
4. Check of given depth slab

- Required area of reinforcement : $a_{s,rqd} = \dfrac{M_{Ed,max}}{0{,}9 \cdot d \cdot f_{yd}}$

$M_{Ed,max} = 48{,}43\ kNm$

$$a_{s,rqd} = \left(\frac{48{,}43 \times 10^3}{0{,}9 \cdot 0{,}19 \cdot 435 \times 10^6}\right) \cdot 10^4$$

$$\simeq \underline{6{,}5\ cm^2/m}$$



$d = h_s - c - \dfrac{\phi}{2}$

$= 220 - 25 - \dfrac{10}{2}$

$= \underline{190\ mm}$

$f_{yd} = 435\ MPa$

$f_{cd} = 20\ MPa$

- Estimation of the depth of the compressed zone:

$$x = \frac{1{,}2 a_{s,rqd} \cdot f_{yd}}{0{,}8 \cdot b \cdot f_{cd}}$$

$$= \frac{1{,}2 \cdot 6{,}5 \times 10^{-4} \times 435}{0{,}8 \times 1 \times 20} \simeq 0{,}0212$$

$\underline{21{,}2\ mm}$

- $As_{min} = \max\left(0{,}26 \cdot \dfrac{f_{ctm}}{f_{yk}} \cdot b_s \cdot d_s \ ;\ 0{,}0013 \cdot b_s \cdot d_s\right)$

$\max\left(0{,}26 \cdot \dfrac{2{,}9}{500} \cdot 1 \cdot 0{,}19 \ ;\ 0{,}0013 \cdot 1 \cdot 0{,}19\right) \times 10^4$

$\max\left(2{,}86\ cm^2/m \ ;\ 2{,}47\ cm^2/m\right)$

$a_{s,rqd} > a_{s,min}$ Checked !

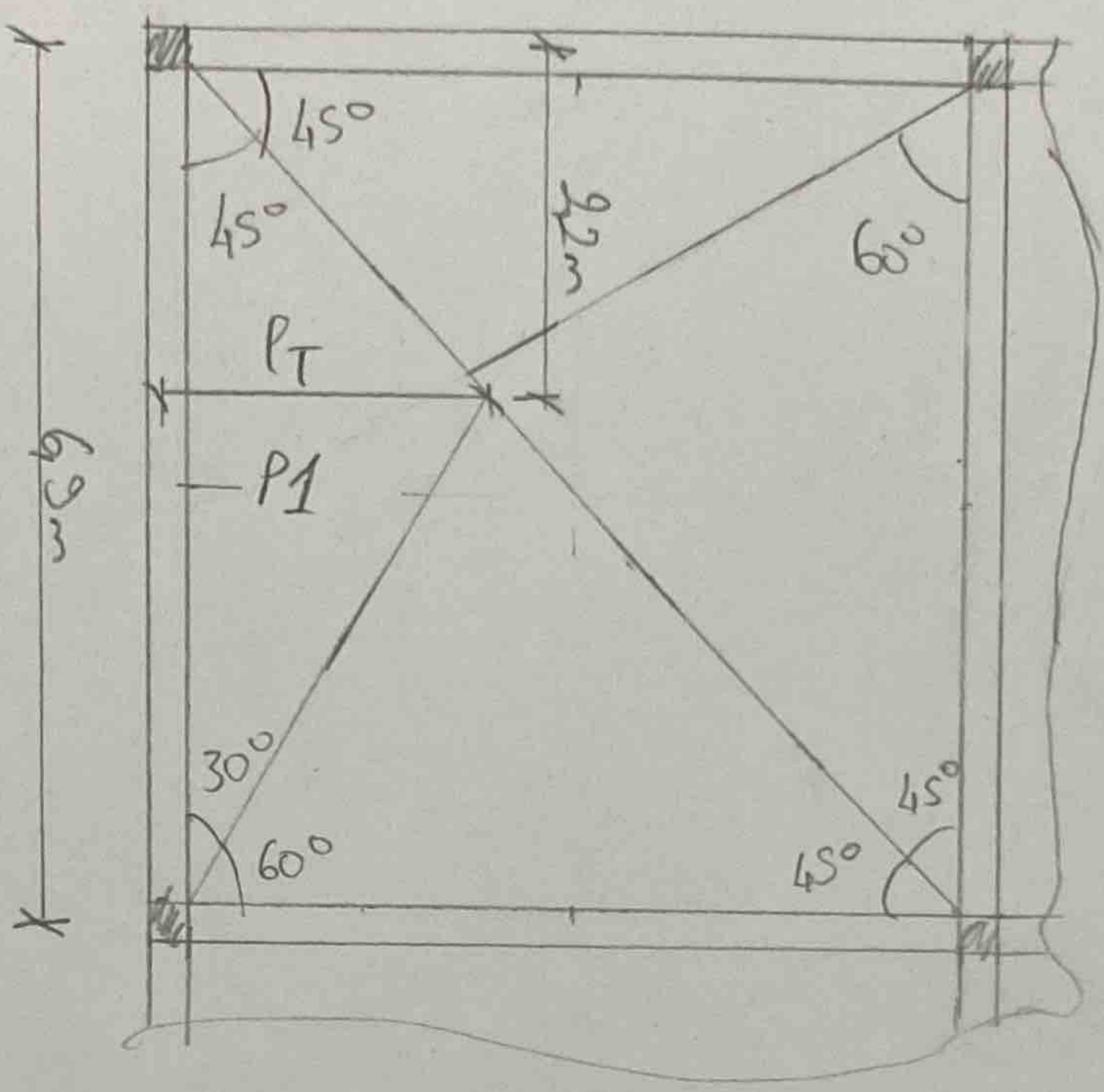
$\xi = \frac{x}{d} = \frac{21,2}{190} = 0,11 < 0,25$ checked!

These two conditions above have been verified. Therefore, the depth of the slab is correct.

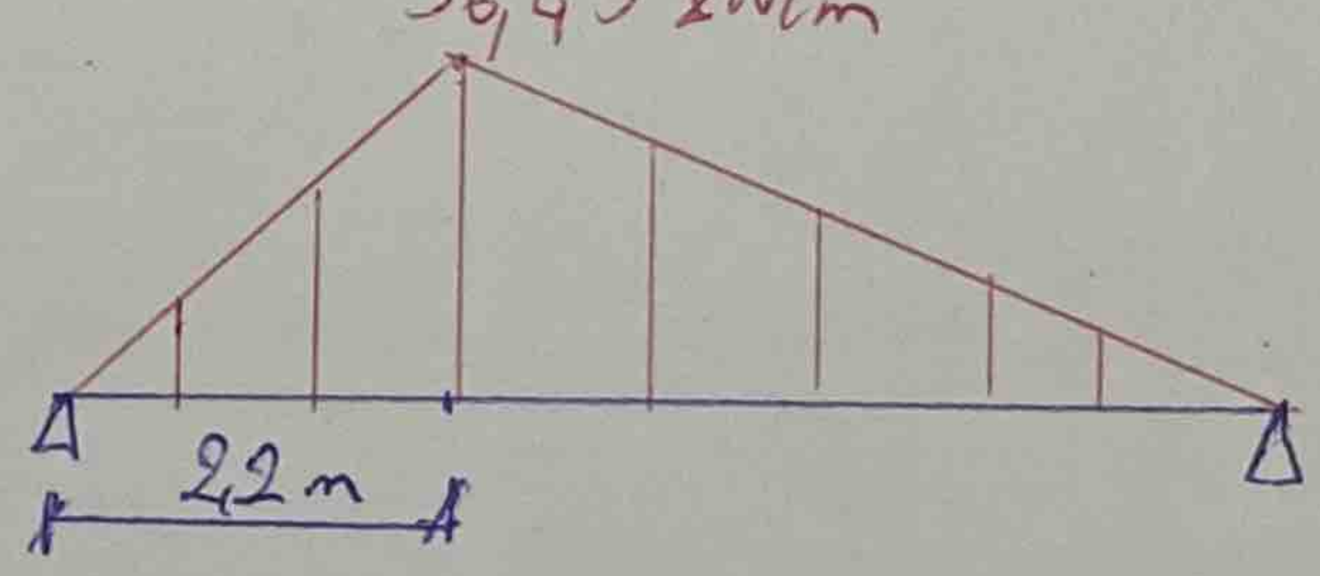
5. Calculation of loading of P1

Scale 1:100

$l_T = 2,6$ m



mechanical scheme of P1



$f_{P1} = f_d \times l_T$

$= 21,71 \times 2,6 = 56,45$ kN/m