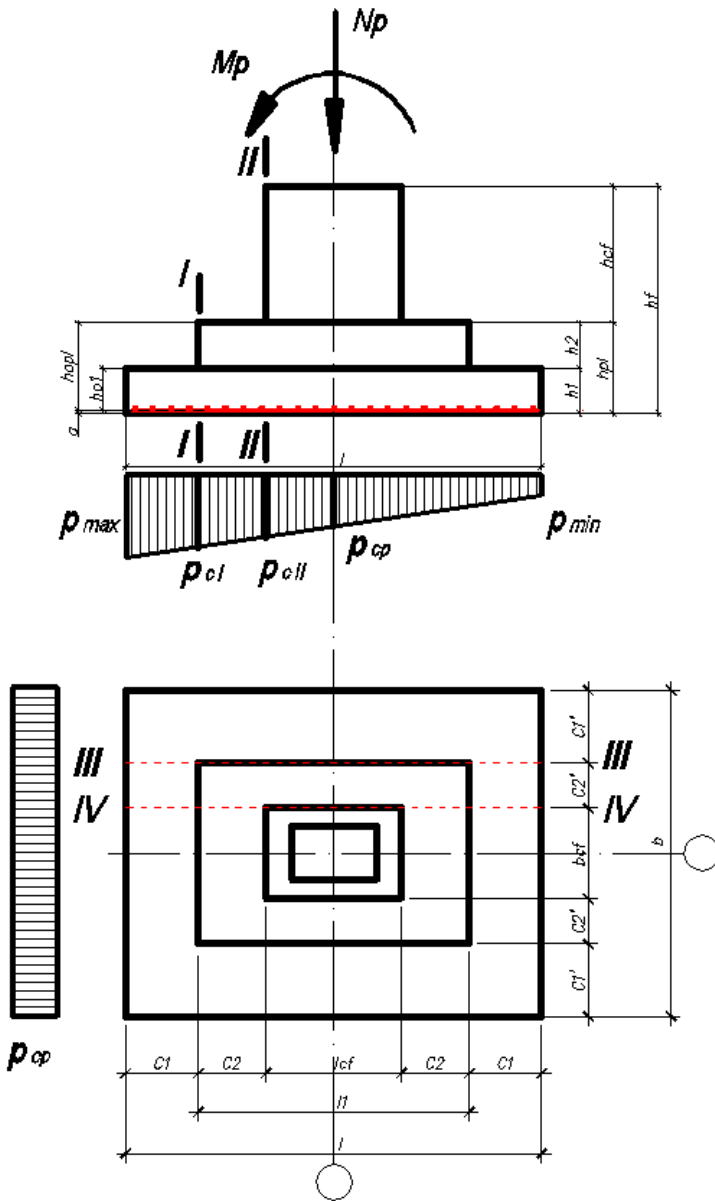


REINFORCEMENT OF THE FOUNDATION



The calculation scheme for determining the number of reinforcements

$$P_{c1} = P_{mid} + \frac{P_{max} - P_{mid}}{\frac{l}{2}} \left(\frac{l}{2} - c_1 \right)$$

$$P_{c2} = P_{mid} + \frac{P_{max} - P_{mid}}{\frac{l}{2}} \left(\frac{l}{2} - c_1 - c_2 \right)$$

Reinforcement is carried out according to the results of the calculation of normal cross-sections under the action of the bending moment in the first degree in the following way:

$$M_{I-I} = \frac{p_{c1} \cdot b \cdot c_1^2}{2} + \frac{(p'_{max} - p_{c1}) \cdot c_1^2 \cdot b}{3}$$

p'_{max} – calculated maximum pressure under the base of the foundation;

p_{c1} – calculated pressure under the sole of the foundation in section I - I;

b – the width of the base of the foundation;

c_1 - the projection of the first step relative to the column (for a single-step foundation) or the projection of the lower step relative to the one above (for two or more steps)

In the second step:

$$M_{II-II} = \frac{p_{c2} b \cdot (c_1 + c_2)^2}{2} + \frac{(p'_{\max} - p_{c2}) \cdot (c_1 + c_2)^2 b}{3}$$

where c_2 is the projection of the second step in relation to the column support, m.

The cross-section of the working reinforcement over the entire width of the foundation is calculated as follows.

For the first step (intersection I - I):

$$A_{sI} = \frac{M_{I-I}}{0,9h_{0I} f_{yd}}$$

For the second step (in the column support) (intersection II - II):

$$A_{s2} = \frac{M_{II-II}}{0,9h_{0,pl} f_{yd}}$$

where f_{yd} is design stress for reinforcement.

for reinforcement A400C $f_{yd}=365$ MPa

The step of the working armature is 100 - 200 mm. Non-working (constructive) rods of transverse reinforcement take a cross-section of at least 10% of the cross-section of the working reinforcement and install them in steps of 250-300 mm, but no more than 350 mm. The height of the protective layer of concrete is set: for monolithic foundations - not less than 35 mm in the presence of concrete or sand-gravel preparation and not less than 70 mm without it, for prefabricated foundations - not less than 30 mm.

Reinforcement must also be calculated along the second direction of the foundation:

$$M_{III-III}^{\cdot} = \frac{P_{mid}^{\cdot} \cdot l \cdot (c_1^{\cdot})^2}{2} \qquad M_{IV-IV}^{\cdot} = \frac{P_{mid}^{\cdot} \cdot l \cdot (c_1^{\cdot} + c_2^{\cdot})^2}{2}$$

where $c_1^{\cdot}$ and $c_2^{\cdot}$ are the departure of the foundation steps from side b;

$P_{mid}^{\cdot}$ — estimated average pressure under the base of the foundation.

Then the required amount of reinforcement for sections III-III and IV-IV will be

$$A_{sIII} = \frac{M_{III-III}}{0,9h_{01}f_{yd}} \qquad A_{sIV} = \frac{M_{IV-IV}}{0,9h_{0,pl}f_{yd}}$$

Example

Geological structure and hydrogeological conditions of the construction site

№ layer	Soil	Well number and the depth of the sole of each soil layer from the surface of the earth, m				
		1	2	3	4	5
1.	plant layer	0,3	0,3	0,3	0,3	
2.	Subsidence soil	4,8	4,6	4,9	4,8	
3.	Sand medium-sized	3,4	3,6	3,5	3,3	
4.	sandy loam	3,5	3,6	3,7	3,6	
5.	Clay gray	8,7	8,9	8,8	8,7	
	The depth of underground water	8,2	8,0	8,3	8,1	
	Well mark, m					

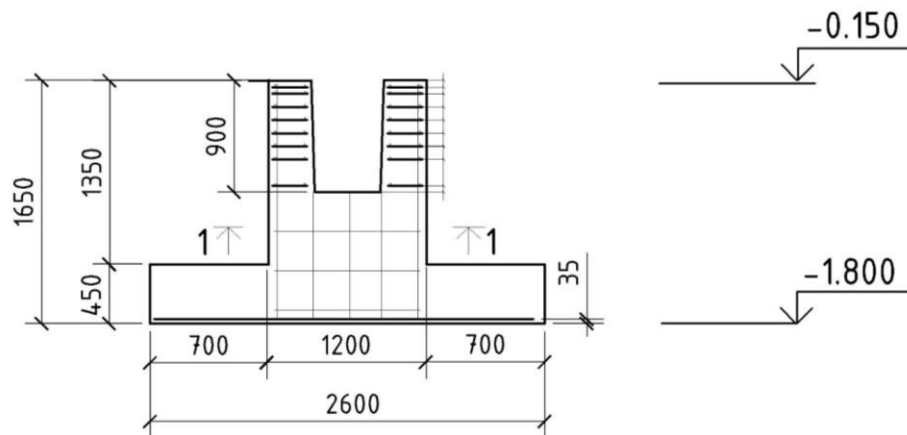
Variant	Cross section of the column , mm	Combination			
		I		II	
		N,MN	M, MNm	N,MN	M,MNm
	600x400	2,1	0,26	1,2	0,41

$b = 2,6 \text{ m}, l = 3,6 \text{ m}.$

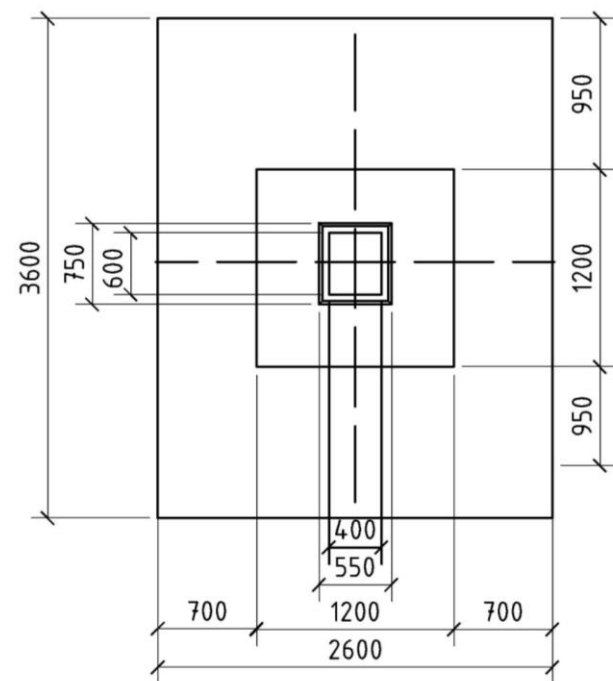
Characteristics of soil properties

Name	Legend	Units of measurement	Layer number				
			1	2	3	4	5
Density	ρ_{II}	t/m ³	1,39	1,72	2,01	1,98	2,06
Solid Particle density	ρ_s	t/m ³		2,73	2,68	2,69	2,70
Water content	W			0,15	0,24	0,26	0,22
Liquid limit	W _L			0,35		0,28	0,40
Plastic limit	W _p			0,19		0,22	0,20
Angle of internal friction	φ_{II}	degree		21	33	20	15
Specific cohesion	C _{II}	kPa		25	1	12	80
Modulus of Deformation	E	MPa		20	30	15	50
Relative subsidence under pressure p, MПа	ϵ_{SL}	p=0,1		0,04			
		p=0,2		0,073			
		p=0,3		0,082			
Angle of internal friction water-saturated soil	$\varphi_{II,sat}$	degree		19			
Specific cohesion water-saturated soil	C _{II,sat}	kPa		5			
Modulus of Deformation water-saturated soil	E _{sat}	MPa		6			

ФМ-1



1. $N=2100 \text{ kN}$ $M=260 \text{ kNm}$



$$P_{max} = \frac{2100}{2.6 \cdot 3.6} + 20 \cdot 1.8 + 20 + \frac{260}{5.616} = 326,7 \text{ kPa} < 338,6 \text{ kPa}$$

$$P_{min} = \frac{2100}{2.6 \cdot 3.6} + 20 \cdot 1.8 + 20 - \frac{260}{5.616} = 234 \text{ kPa} > 0 \text{ kPa}$$

$$P_{cp} = \frac{2100}{2.6 \cdot 3.6} + 20 \cdot 1.8 + 20 = 280,3 \text{ kPa} < 282,15 \text{ kPa}$$

$$p_{c1} = p_{cp} + \frac{p_{\max} - p_{cp}}{l/2} \left(\frac{l}{2} - c_1 \right) = 280,3 + \frac{(326,7 - 280,3)}{\frac{3,6}{2}} \left(\frac{3,6}{2} - 0,95 \right) = 302,2 \text{ kN/m}^2$$

$$M_{I-I} = \frac{p_{c1} b \cdot c_1^2}{2} + \frac{(p'_{\max} - p_{c1}) \cdot c_1^2 b}{3} = \frac{302,2 \cdot 2,6 \cdot 0,95^2}{2} + \frac{(326,7 - 302,2) 0,95^2 \cdot 2,6}{3} = 373,7 \text{ kN} \cdot \text{m}$$

$$A_{sI} = \frac{M_{I-I}}{0,9 h_{01} f_{yd}} = \frac{373,7}{0,9 \cdot 0,415 \cdot 365000} = 0,0027 \text{ m}^2$$

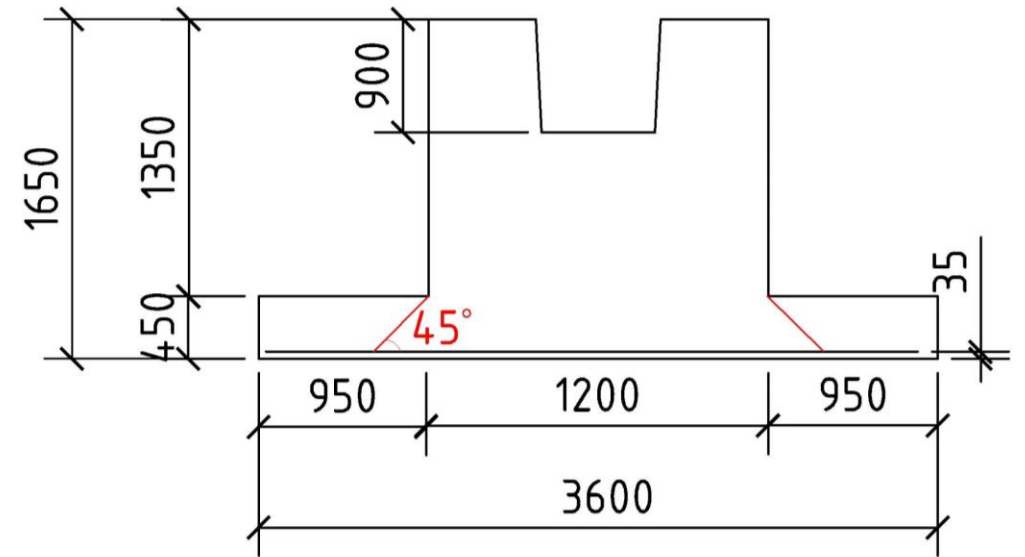
set the armature step $s=200 \text{ mm}$

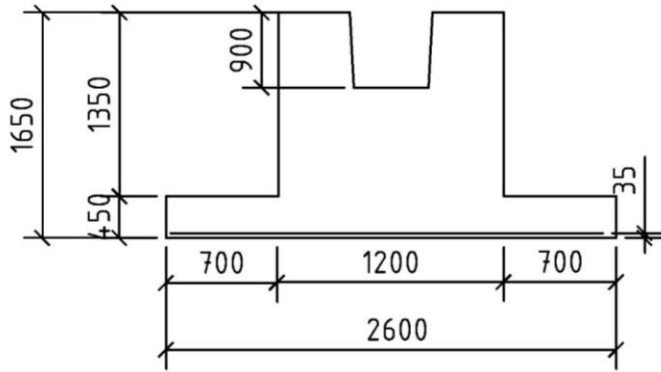
$$\text{required number of rods } n = \frac{b}{s} + 1 = \frac{2,6}{0,2} + 1 = 14 \text{ pieces}$$

$$\text{area one rod } A_{1 \text{ CT}} = \frac{A_{sI}}{n} = \frac{0,0027}{14} = 0,000196 \text{ cm}^2$$

$$d = \sqrt{\frac{4 \cdot A_{1 \text{ CT}}}{\pi}} = \sqrt{\frac{4 \cdot 0,000196}{3,14}} = 0,016 \text{ m} = 16 \text{ mm}$$

We accept 14Ø16A400C





$$M_{III-III} = \frac{P_{mid} \cdot l \cdot (c_1')^2}{2} = \frac{280,3 \cdot 3,6 \cdot 0,7^2}{2} = 206 \text{ kNm}$$

$$A_{sIII} = \frac{M_{III-III}}{0,9h_{01}f_{yd}} = \frac{206}{0,9 \cdot 0,415 \cdot 365000} = 0,0015 \text{ m}^2$$

set the armature step $s=200 \text{ mm}$

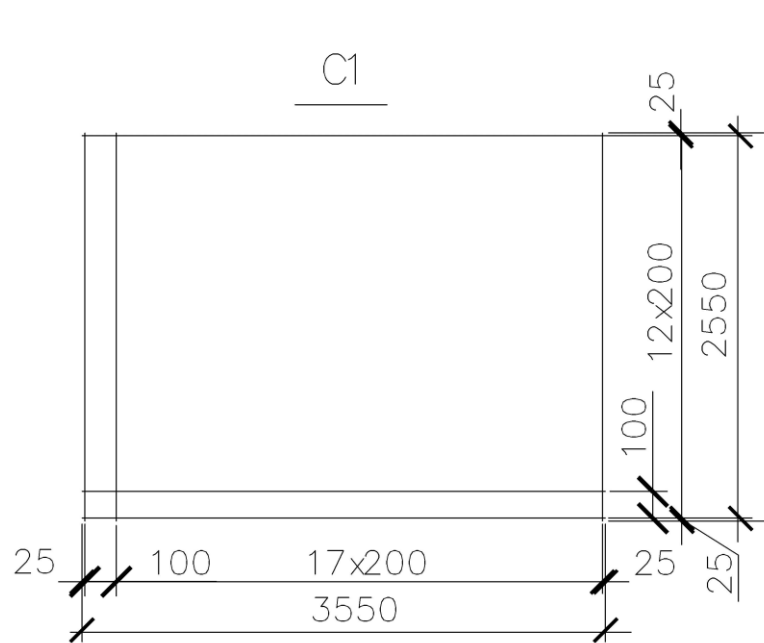
required number of rods $m = \frac{l}{s} + 1 = \frac{3,6}{0,2} + 1 = 19 \text{ pieces}$

area one rod $A_1 = \frac{A_{s1}}{n} = \frac{0,0015}{19} = 0,00008 \text{ m}^2$

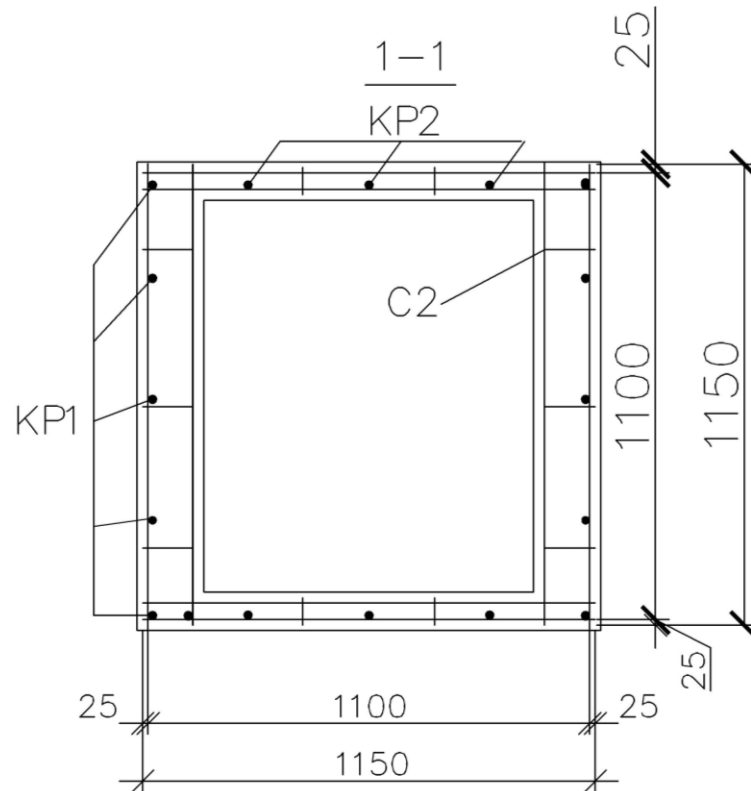
$$d = \sqrt{\frac{A_1 \cdot 4}{\pi}} = \sqrt{\frac{0,00008 \cdot 4}{3,14}} = 0,01 = 10 \text{ mm}$$

We accept 19Ø12A400C

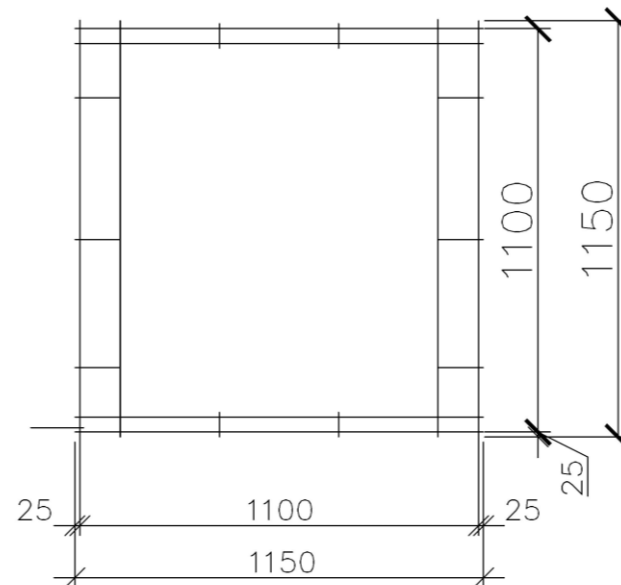
The rule: the minimum diameter of the working armature of the foundation is 12



KP1



C2



KP2

