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Calculation of Retaining Walls on City Riversides

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Abstract: In the article, the calculation of the retaining wall is also developed according to the calculation of the safety of the parameters of the retaining wall according to the topography and ground conditions of the place.

Keywords: retaining wall, grunt, load, height, priority, horizontal loads.

The main parameters of the retaining wall

The following parameters of the retaining wall are accepted according to the initial data (task code), topography and ground conditions:

h_d = d.t.b.+ cm+0,5=3,8+1,3+0,5=5,6 m.

d.t.r.b. -(depth of the river bed)

h_n=1.0 m (base plate thickness)

The front part of the wall (water side) is vertical, and the back part (soil side) is inclined, that is, it is calculated according to i=1:7.5. The width of the top of the retaining wall

b_1= 0.45+5.6/7.5=0.45+0.75=1.2 m

constructive criticism:

a=0.5m; a_1=1,5m The width of the base

V=b_1+a+a_1=1,2+0,5+1,5=3,2 m. V- the width of the foundation

Grunt descriptions:

$\varphi_0=33^0$- for unbound grunt;

$\varphi_0=20^0$- for bonded grout;

γ= 1800 kg/m^3 for dry unbound primer;

γ= 1900 kg/m^3 for wet unbound primer;

γ= 1950 kg/m^3 in natural humidity - for bonded soil;

s= 5,0 kPa for the associated grunt.

The pressure of the soil on the retaining wall

We replace the uniformly distributed load q_0 with the grunt layer h_b

$$h_b=\frac{q_0}{\gamma}=\frac{8{,}5}{19}=0{,}45\text{ m}$$

the intensity of the pressure from the time-drained soil

$R_b = \gamma_{urt} h_b tg^2 (45-\varphi/2) = 19.0*0.45*0.29 = 2.48$ kN/m^2

If the ground is immersed in water to a height of h_1, then the volume density of the ground in γ_{engil} this section is low and φ_{engil} the angle of internal friction is low.

Porosity coefficient of dry soil $\varepsilon = 0.6$ when it is the weight of its normative size

$$\gamma^{m}_{the\ water\ is\ saturated} = \frac{\gamma_{gr} + \varepsilon\gamma_{suv}}{1+\varepsilon} = \frac{1900 + 0.6 * 1000}{1 + 0.6} = 1562\ \mathrm{kg/m^3}$$

The normative volumetric weight of the soil in the lightened state

$$\gamma^{n}_{light} = \gamma^{n}_{the\ water\ is\ saturated} - \gamma^{n}_{water} = 1562 - 1000 = 562\ \mathrm{kg/m^3}$$

Calculated intensity of soil pressure on the wall

$$r = n_r \gamma h_g tg^2\left(45 - \frac{\varphi}{2}\right) = 1.05 * 19.0 * 5.6 tg^2\left(45 - \frac{33}{2}\right) = 30.85\ \mathrm{kN/m^3}$$

The pressure of the loosened soil on the wall

$$p_1 = \gamma^{n}_{light} h_1 tg^2\left(45 - \frac{\varphi_{light}}{2}\right) = 5.62 * 3.0 * tg^2\left(45 - \frac{27}{2}\right) = 6.88\ \mathrm{kN/m^3}$$

$$h_1 - minimum\ water\ level$$

Water pressure on the wall

$$p_{suv} = \gamma_{suv} h_2 = 10 * 1.8 = 18\ \mathrm{kN/m^2}$$

An equal effector of the pressure of soil and water from the side of the dam and the river

$E = 0.5ph_d = 0.5*30.85*5.6 = 86.38$ kN/m

$Z_p = h_d/3_b = 5.6/3 = 1.87$ m

$Ye_b = P_b*h_g = 2.48*5.6 = 13.9$ kN/m

$Z_b = 0.5*h_g = 0.5*5.6 = 2.8$ m

$E_1 = p_1 h_1 = 6.88*3.4 = 23.4$ kN/m

$Z_1 = h_1/3 = 3.4/3 = 1.13$ m

$E_c = 0.5 p_c h_c = 0.5*18*1.8 = 16.2$ kN/m

$Z_c = h_{suv}/3 = 1.8/3 = 0.6$ m

Checking the wall for overturning

Inspection of the wall for overturning is carried out according to the following condition:

$$K_{to'n} = \frac{\Sigma M_{ust}}{\Sigma M_{to'n}} \geq K_o \quad (11)$$

Here, $K_{to'n}$- priority reserve for wall overturning. Its value is the normative value obtained according to the capital of the coast in Table 1 of this methodological instruction. K_o should not be less than; M_{min}- the minimum limit of priority torque (the wall's ability to carry a load to overturn), O is equal to the sum of the moments of the calculated vertical forces relative to the horizontal axis passing through; $M_{to'n}$- calculated overturning moment, O equal to the algebraic sum of moments of horizontal active forces relative to the point.

We calculate the weights:

a) specific weight of the wall (picture)

$G_d = G_1 + G_2 = 63 + 52.5 = 115.5$ kN

$G_1 = bh_g\gamma_{ob} = 0.45*5.6*2.5 = 6.3$ t=63 kN

$G_2 = b_2\ h_d\ 0.5\gamma_{ob} = 0.75*5.6*0.5*2.5 = 5.25$ t =52.5 kN

b) the weight of the base plate

$G_p = Bh_n\gamma_{ob} = 3.2*1*2.5 = 8.0$ t=80 kN

v) specific gravity of soil

$G_{gr} = G_3 + G_4 = 39,9 + 159,6 = 199,5$ kN

$G_3 = b_2\ h_d\ 0.5\gamma_{urgr} = 0,75*5,6*0,5*1900 = 3990 = 39,9$ kN

$G_4 = a_1\ h_d\ 0.5\gamma_{ur} = 1,5*5,6*1900 = 15960$ kg=159,6 kN

We determine the center of gravity of the wall and backfill soil as follows

$$Sx_1 = h_d b\frac{b}{2} = 5.6 * 0.45 * \frac{0.45}{2} = 0.57\ \mathrm{m}^3$$

$$Sx_2 = h_d\frac{(b_1 - b)}{2}\frac{(b_1 - b)}{3} = 5.6 * \left(1.2 - \frac{0.45}{2}\right) * \frac{1.2 - 6}{3} = 2.1\mathrm{m}^3$$

$F_1 = h_d * 0.45 = 5.6*0.45 = 2.52\ \mathrm{m}^2$

$F_2 = b_2\ \frac{h_d}{2} = 0.75*2.8 = 2.1\ \mathrm{m}^2$

$$X_c = \frac{Sx_1 Sx_2}{F_1 + F_2} = \frac{0.57 + 2.1}{2.52 + 2.1} = 0.58\mathrm{m}$$

b) Center of gravity for soil

$$Sx_1' = h_g a_1\frac{a_1}{2} = 5.6 * 1.5 * \frac{1.5}{2} = 6.3\mathrm{m}^3$$

$$Sx_2' = h_g\frac{b_2}{2}\frac{b_2}{3} = 5.6 * \frac{0.75}{2} * \frac{0.75}{3} = 0.52\mathrm{m}^3$$

$$F_1' = h_g a_1 = 5.6 * 1.5 = 8.4\ \mathrm{m}^2$$

$$F_2' = \frac{b_2}{2}h_g = \frac{0.75}{2} * 5.6 = 2.1\mathrm{m}^2$$

$$x_c' = \frac{Sx_1' + Sx_2'}{F_1' + F_2'} = \frac{6.3 + 0.52}{8.4 + 2.1} = 0.65\ \mathrm{m}$$

We calculate the priority moment M $_{priority}$ as follows:

$\Sigma M_{priority} = n_r G_d x_c + n_r G_p x_c + n_r G_{gr} x_c' = 1{,}05*115{,}5*0{,}58 + 1{,}05*80*0{,}59 + 1{,}1*199{,}5*0{,}65 =$

70,34+48,72+142,64=264,7 kN.m

Overturning moment M_{coup} we calculate as follows:

$\Sigma M_{coup} = E + n_r Z_p + E_1 Z_1 - E_c Z_c =$ 86.38+*1.87+23.4*1.13-16.2*0.6=105 kN/m

$$K_{coup} = \frac{\Sigma M_{priority}}{\Sigma M_{coup}} = \frac{261{,}7}{105} = 2.5 > K_0 = 1.2$$

The conditions for the overthrow have been satisfied.

Checking the wall for displacement

The priority reserve coefficient for wall displacement is determined as follows:

$K_n T_{sil} \leq m_{sil} T_{ust}$

$T_{sil} = \Sigma E = E + E_b + E_1 - E_c = 86.38 + 13.9 + 23.4 - 16 = 107.68$ kN

$T_{ust} = (n_r G_g + n_r G_n + n_r G_{zp}) f = (1.05*115.5 + 1.05*80 + 1.1*199.5)0.3 = 127.42$ kN

$$\frac{T_{sil}}{T_{ust}} \leq m: \quad \frac{107.68}{127.42} = 0.84 < 1.1$$

$m - 9$ jadvaldan olinadi

The priority of the wall to move is ensured.

Stress from the calculated load on the retaining wall

The normal stress due to the design load in the reinforced concrete retaining wall

$$\sigma_{\substack{max \\ min}} = \frac{N_f}{F} \pm \frac{M_s}{w}$$

Here, N_f – sum of vertically supported loads; $N_f = \Sigma n_i G_i$; F – area of the base plate per 1 m, F1xB; M_s– the sum of moments of all horizontal and vertical loads resting on the foundation and passing through the center of gravity; W- moment of resistance under the foundation slab: $W = 1\frac{B^2}{6}$.

Sum of loads falling on the foundation.

$$N_f = n_r G_g + n_r G_n + n_r G_{gr} = 1{,}05 * 115{,}5 + 1{,}05 * 80 + 1{,}1 * 199 = 121{,}27 + 84 + 219{,}45 = 424{,}72 \text{ kN}$$

*F=1*B=1*3.2=3.2m²*

The center of gravity of the base plate

x_{sp}=B/2=3,2/2=1,6m.

$$M_c = n_r G_g 0.58 + n_r G_n 0.58 \quad - n_r G_{gr} 0.65 + E Z_p + Z_1 - E_c Z_c = 1.05 * 115.5 * 0.58 + 1.05 * 80 * 0.58 - 1.1 * 199.5 * 0.65 + 86.38 * 1.87 + 23.4 * 1.13 - -16.2 * 0.6 = 70.34 + 48.72 - 142.64 + 161.53 + 38.92 + 26.44 - 9.72 = 203.28 \text{ kNm}$$

$$W = 1\frac{b^2}{6} = 1 * \frac{(3.2)^2}{6} = 1.71 \text{ m}^3$$

$$\sigma_{\substack{max \\ min}} = \frac{N_f}{F} \pm \frac{M_s}{w}$$

$$\sigma_{max} = \frac{424.72}{3.2} + \frac{203.28}{1.71} = 132.72 + 118.88 = 251.6 \frac{\text{kN}}{\text{m}^2} = 2{,}51 \frac{\text{kg}}{\text{sm}^2}$$

$$\sigma_{min} = \frac{424.72}{3.2} - \frac{203.28}{1.71} = 132.72 - 118.88 = 13.84 \frac{\text{kN}}{\text{m}^2} = 0{,}14 \frac{\text{kg}}{\text{sm}^2}$$

$$\sigma_{max} \leq 1{,}2\, R_g$$

Here R_g- calculated resistance of the base ground, its size is determined by the following formula:

$$R_g = \frac{m_1 m_2}{K_H}(A\gamma_{ac} l + \text{B} h_n \gamma_n + D C_{acoc})$$

m_1, m_2- the coefficient of working conditions is obtained from table 8 of this methodological instruction; K_H- reliability coefficient -1.1; A,B,D-angle of internal friction of soil φ_{as} coefficients depending on; γ_{as}, C_{acoc} density and compaction of soil; l- a strip along the length of the wall=1m; h_n- depth of foundation heel placement; $\gamma_n - h_n$ density of soil at depth.

$$R_g = 1.2 * \frac{1}{1.1}(0.51 * 1850 * 1 + 3.06 * 7.1 * 1850 + 5.66 * 5.0) = 1.09(943.5 + 40193 + 28.3) = 44869 \frac{\text{kg}}{\text{m}^2} = 4{,}49 \frac{\text{kg}}{\text{sm}^2};$$

So

$$\sigma_{max} = 2{,}51\,\frac{\text{kg}}{\text{sm}^2} < 1{,}2R_g = 1.2 * 4.49 = 5.38\,\frac{\text{kg}}{cm^2}$$

$$\sigma_{min} = 0.14\,\frac{\text{kg}}{cm^2} > 0$$

The base voltage requirement has been met.

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