MATEC Web of Conferences **53**, 01035 (2016)
DOI: 10.1051/matecconf/20165301035

Measures of struggle against appearance of cracks in earth dams

Yulia Ibraeva [1,a], Georgiy Bulatov[1] and Philipp Tarasevskii[1]

[1] *Peter the Great St.Petersburg Polytechnic University, 195251,St. Petersburg, Russian Federation*

Abstract. The article describes a method calculation of the basic parameters of the transverse rows of pile of simple printed or precast dam. As well, in this article have been shown all the necessary formulas for this calculation and have been proposed solutions to prevent cracking in the dams.

1 Introduction

Despite the considerable progress made in the soil construction of dams, reserves to reduce the cost of construction of earth dams and increase their strength filtration completely exhausted. Mainly, in our opinion, is to increase reserves crack resistance ground shields, cores, and ensuring the principle of equal strength of all elements of the dam by further improving the design and technological solutions. Works in this direction have are many research in institutes and laboratories of the Russian Federation (in VNIIG, Waters GEO Gidroproekt and SPbSTU).

2 Materials and Methods

Known that nuclei in ground cracks occur due to insufficient compressive stresses. The application in earth dam the nucleus of dome shape [1] (Fig. 1.a) are reduce the negative impact of "suspension" nucleus and increase the level of its compressive stresses [2]. In this case, the core is been performed with a double curvature (in the form of sickle or bow) in cross section and in plan view.

Also envisaged the option of slope the axis O–O of the nucleus in the downstream direction at an angle of 45°, wherein the core takes the form of half bow. Due to the curved shape the nucleus is been achieved the increasing the stability how in the upper slope (compared with a flat–screen) so in the lower slope (compared with a flat core). For a given level of reliability of the dam, its slopes can be make steeper, and the kernel – spanning more thinly than the flat anti filtration elements. The weak point of the dam is a seam conjugation with the base kernel. However, the filtration resistance of the seam can be significantly enhanced if the kernel into the bottom section divided groove [3] filled with drainage fine–grained material into several branches, each of which independently interfaces with base [2].

[a] Corresponding author: ulchi412@mail.ru

In the grooves can be installed drainage galleries, which are connected the piping system. These devices allow you to optimize the distribution of pressure between the individual branches of the nucleus.

In case of an occurrence of cracks it is will not pass–through but its will be cross in several places of internal drainage, which provides the effect of "keyway" and contributes to making the reliability of conjugation with the base kernel [4].The possibility of a significant reduction in the thickness of the main part of the nucleus with subsequent benefits in addition provide the cost–effectiveness.

The destructive effect of cracking can be greatly weakened by the creation in a body of the dam (or unpaved impervious element) of artificial seam–incision, which filled with drainage material, the direction of which coincides with the direction of the expected cracks [3].

Fig. 1 shows a homogeneous dam of cohesive soil on the upper slope of the network of which is made of vertical grooves [2].

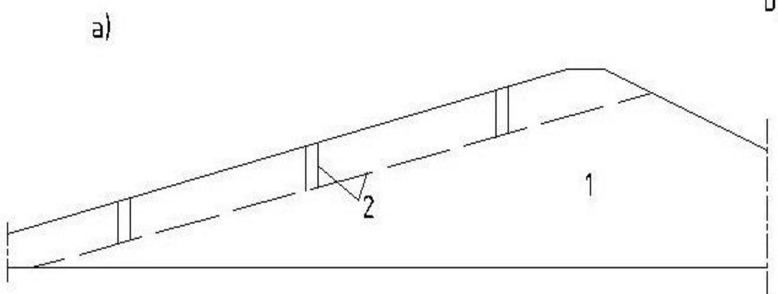

Figure 1.a Homogeneous dam of cohesive soil

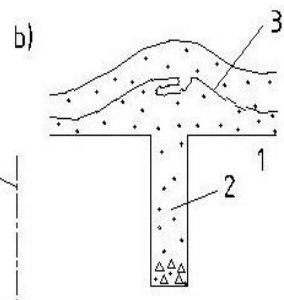

Figure 1.b Transverse section

One of the structural layouts of incisions (transverse section) is be presented in Fig. 2. Cavity which developed excavator are be filled a bulk material with formation a reverse filter and for improve tightness overlapped ribbon membrane with pleat, which compensates deformations. In another embodiment, the hermetic member can been formed as a V – shaped width which inserted in the cavity. Pressurization seam– notch may also been provided at the expense of installing it in the cavity of the balloon of elastic material, filled with pressurized fluid [3].

In the latest version is also will be achieved an additional compression of the array (block) the soil which located between the seams – incision. Application of seams – incisions, as well as use of the known solutions proposed V.N. Zhilenkov [5], eliminates the possibility of emergence destructive for the dam through cracks in its anti–filtration elements.

Eliminate cracking about–crest part of the dam can be due to hammer in cross pile rows [2], which will provide wedging dam, in the longitudinal direction [6]. Pile series (Fig. 3) may be precast, stamped and placed along the axis of alleged cracks in areas of increased deformation elongation dam crest [7].

To improve the crack resistance of the dam piles may been formed of two halves between which placed elastic chambers that filled with liquid at a pressure greater than the water pressure on the pile tip. For fully exclude the occurrence of any additional cracks in spacing between pile rows the anchor rods with prestressing connect the halves of piles in adjacent rows.

Below is shows a method of calculating the basic parameters of the transverse pile rows of simple printed or precast dam in accordance with the notation given in Fig. 2 (a–cross–section of the dam, b – its Area).

The length of piles row could been determined by the expression:

$$Lp=\frac{Hp}{[Jp]} \quad (1)$$

Where Hp – estimated pressure at around the bottom of the pile row, Jp – allowable seepage gradient material for a dam on his contact with material piles, which could been taken on the recommendations of [8].

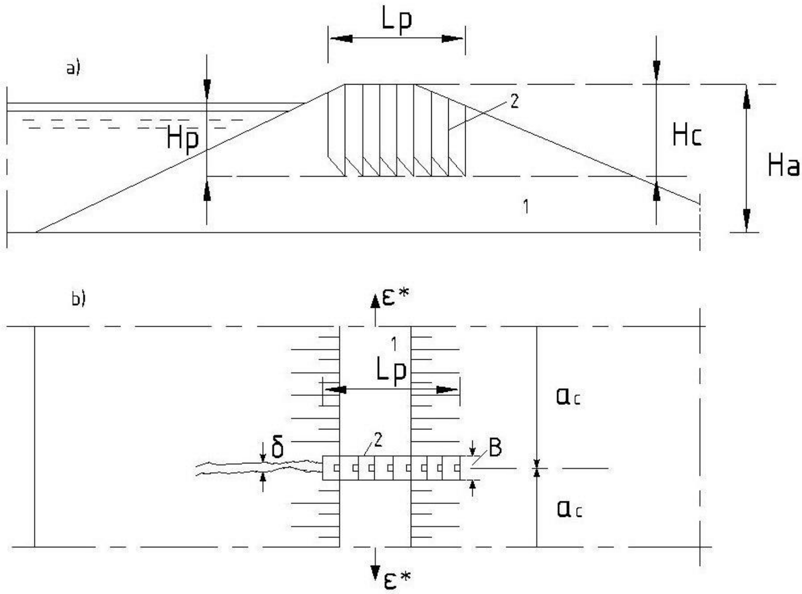

Figure 2. Transverse rows of pile

$$B=\delta(1+n) \quad (2)$$

Where δ – the maximum anticipated thickness of the crack, n – degree propping fractures (in first approximation n=2) [9].

The depth of pile series is be defined by the formula

$$H_p=h_c\cdot K_o \quad (3)$$

Where h_c – expected depth of the crack, K_o – factor over deepened pile of ($K_n \cong 1.2$).

Expected thickness of the crack recommended to define the expression similar to the one in the [10].

$$\partial=(\varepsilon^*-[\varepsilon_m])\cdot a_p \quad (4)$$

Where ε^*– the expected relative deformation elongation crest of the dam, ε_m – permissible relative deformation elongation array (block) of soil between adjacent rows of pile, a_p – step along the rows of pile rowing dam [11].

Step rows defined in the form

$$a_p=\frac{a_c}{m} \quad (5)$$

Where a_c – expected step cracks along the crest of the dam, m – frequency series ($m \cong 0.5 ... 1.0$). The greatest depth of the crack propagation is be determined by the expression [12]

$$h_t = \frac{2\cdot(C+C_w)}{\gamma_{gr}\cdot tan\,(\frac{\pi}{4}-\frac{\varphi}{2})} \quad (6)$$

Where φ and C – shear strength parameters, γ_{gr} – volumetric weight of soil dam (generally in a suspended state in water), C_w – extra grip equivalent to support the actions of seepage forces caused by the water pressure in the plane of the crack ρ_w [13].

In the first approximation we can take

$$C_w \approx 0.1\cdot\rho_w \quad (7)$$

Step cracks determined by the smallest of the following conditions:

$$a_c \leq (1 ... 3)\cdot h_c \quad (8)$$

$$a_c \leq (1 ... 2)\cdot H_D \quad (9)$$

Where H_D – height of the homogeneous dam or thickness of impervious element of cohesive soil layered dam [14].

In the case of the impact of undermining the base of the dam works in the above conditions accepted the largest value of numerical coefficients; the smallest of these values are be taken in the absence of undermining and in the case of seismic effects [15].

Since the individual parameters repeatedly associated with each other calculation to carried out using the method of selection followed by selection of the optimal variant [16].

As expected the strain ε^*evolve over time T_i gradually, the most logical wedging body of the dam by the introduction of additional compensating deformation elongation, volume administered in the form of piles in batches at certain stages of deformation of the dam.

5. The sample of conventional calculation the piling (excluding stages of protection). For subsurface dam of loam at $\varphi = 31^0$; $C = 0.12\ kg/cm^2$; $\gamma_{gr} = 1.1\ t/m^3$; $\varepsilon^* = 7\cdot 10^{-3}$; $[\varepsilon_m] = 1\cdot 10^{-3}$ were obtain, in accordance with the above procedure the following results: $L_p = 13.2\ m$; $a_p = 15\ m$; $H_p = 6.6\ m$; $\delta = 0.09\ m$; $h_c = 5.5\ m$; $H_p = 6.6\ m$; $B = 0.27\ m$.

The calculation results show the feasibility and effectiveness of the implementation of the pile rows of padded fine sand, as well as precast wood or concrete.

6. Each of stage there comes provided if

$$\varepsilon(T_i) = [\varepsilon_m]\cdot\eta_0 \quad (10)$$

Where $\varepsilon(T_i)$– increasing with time deformation of the dam or its anti–filtration element. The feature of this protection is continuous monitoring of deformation elongation, η_0 – degree of efficiency of the implementation phase of the protective measures, which depends both on the rate of increase of the deformation elongation, and the time required for installation of piles of this phase of protection against cracks [17].

Thus, depending on the thickness B_i piling will be not only extinguished tensile stress but also achieve compressive stress an optimal level on the protected portion of the dam. Moreover, continues to the total deformation of elongation ε^* a dam at the beginning should extinguish compressive stresses in the soil between the rows of pile and then create a tensile stress corresponding to the condition [18].

3 Results and Discussion

The article represented by four activities to enhance equal strength of the various elements of earth dams and for prevent cracking. Provided the methodology of calculation of the basic parameters for the event the installation of transverse rows of pile.

4 Conclusion

Considered above measures allow increase level equal strength of the various elements of earth dams intended for operation in difficult conditions (with increased risk of fracture), and reduce the cost of material resources to build structures while providing a specified level of reliability.

References

1. R. Usmanov, M. Rakočević, V. Murgul, N. Vatin, Applied Mechanics and Materials, **633–634**, 927–931 (2014)
2. R. Usmanov, I. Mrdak, N. Vatin, V. Murgul, Applied Mechanics and Materials, **633–634**, 932–935 (2014)
3. M. Jocovic, B. Melovic, N. Vatin, V. Murgul, Applied Mechanics and Materials, **678**, 644–647 (2014)
4. Y. Sonoda, Applied Mechanics and Materials, **566**, 10–25 (2014)
5. E. Panulinová, S. Harabinová, Advanced Materials Research, **969**, 245–248 (2014)
6. S. Harabinová, E. Panulinová, Advanced Materials Research, **969**, 208–211 (2014)
7. M. Sharp, Y. Seda–Sanabria, E. Matheu, Applied Mechanics and Materials, **82**, 428–433 (2011)
8. I. Mrdak, M. Rakočević, L. Žugić, R. Usmanov, V. Murgul, N. Vatin , Applied Mechanics and Materials, **633 – 634**, 1069–1076 (2014)
9. D. Kubečková, Advanced Materials Research, **1020**, 883–887 (2014)
10. G. Bulatov, V. Teleshev, V. Leonov, International Water Power & Dam Construction, **117**, 111–115 (2003)
11. D. Hilyard, International Water Power & Dam Construction, **5**, 20–22 (2010)
12. S. Bortkevich, Power Technology and Engineering, **5**, 287–292 (2009)
13. M. Jocovic, B. Melovic, N. Vatin, V. Murgul, Applied Mechanics and Materials, **678**, 644–647 (2014)
14. N. Vatin, N. Lavrov, N. Korzhavin, Applied Mechanics and Materials, **641–642**, 353–358 (2014)
15. V. Vladimirov, Yu. Zaretskii, V. Orekhov, Power Technology and Engineering, **3**, 161–166 (2003)
16. S. Shkol'nikov, I. Sekisova, Power Technology and Engineering, **5**, 331–339 (2008)
17. V. Bukhartsev, M. Petrichenko, Power Technology and Engineering, **46 (3)**, 185–189 (2012)
18. G. Bulatov, Trudy LPI, **375**, 91–94 (1981)
19. V. Istomina, V. Burenkova, G. Mishurova, *The filter strength of clay soils* (Stroyizdat, 220, 1975)
20. A. Bougrov, V. Markevich, Gidrotekhnicheskoye stroitel'stvo, **4**, 24–26 (1980)
21. G. Bulatov, N. Vatin, D. Nemova, Y. Ibraeva, P. Tarasevskii, Applied Mechanics and Materials, **725–726**, 342–349 (2014)
22. *V. Deković, A. Andelković, N. Milošević, G. Gajić, M. Janić, Carpathian Journal of Earth and Environmental Sciences,* ***8 (2)****, 107–112 (2013)*
23. *L. Rasskazov, M. Smirnova, Power Technology and Engineering,* ***48 (2)****, 85–88 (2014)*
24. *A. Bauer, S. Haug, WasserWirtschaft,* ***104 (4)****, 28–33 (2014)*
25. *J. Guo, I. Hasan, P. Graeber, Springer Series in Geomechanics and Geoengineering,* ***2015****, 195–209 (2014)*
26. *M. Balzannikov, M. Rodionov, International Journal on Hydropower and Dams,* ***20 (6)****, 60–63 (2013)*
27. *A. Feringer, N. Kabanov, Power Technology and Engineering,* ***46 (5)****, 380–383 (2013)*