Investigations of dams stability

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ABSTRACT

Retaining hydraulic structures is quite reliable and durable – many of them there are dozens and even hundreds of years. However, the world statistics and the events of recent years show that the accident on the waterworks possible, they can lead to damage and destruction of dams and adjacent structures. The consequences of the accident of the reservoir (for example, the breakthrough of a large dam on a river) can be extremely large. Unlike industrial, transport and other facilities, damage from accidents which in many cases is measured by the cost of restoration of damaged parts of the structure itself, the damage from the accident, retaining dikes usually many times greater than its cost. The paper presents investigation of the stability of reinforced and unreinforced soil dams under the influence of horizontal and vertical deformations of the subgrade and on the basis of the results of these studies to assess the possibility of formation in models of ground mounds cracks with the definition of the area of their distribution, and determining the degree of influence of reinforcement on their overall sustainability.

Keywords: dams, stability, soil, test, structure

1 INTRODUCTION

Retaining hydraulic structures is quite reliable and durable – many of them there are dozens and even hundreds of years. However, the world statistics and the events of recent years show that the accident on the waterworks possible, they can lead to damage and destruction of dams and adjacent structures.

Statistics shows that the percentage of wear of check dams is very high: 59,48, 61,58, 72,2%. Accordingly, the negative consequences of such technical specifications are not forced to wait long.

For the last period there have been numerous emergencies with the dam breaks [2]. One of the worst tragedies occurred in the night from 11 to 12 March 2010 in the village of Kyzyl–Agash Almaty region. Heavy rainfall and melting snow led to the rupture of the dam and the dam of a local reservoir (in accordance with figures 1-4). In several villages flooded houses.

Fig. 1. Breakthrough of "Kyzylagash" dam

Fig. 2. The ruined dam "Kyzylagash"

According to the Almaty Department of emergency situations, the accident occurred due to heavy rain and the temperature rise of air caused a mixture of ice and provoked the occurrence of debris flows. In the path of mud masses were Kyzylagash village. According to official data, heavily damaged a large part of the village. Thousands of people were evacuated. Dozens of people were killed.

Fig. 3. The consequences of a dam break "Kyzylagash"

Another tragedy occurred in Kokpekty village of Karaganda region. On the night of 31 March, 2014 has been a breakthrough of the dam (in accordance with

Figs 4-5). Water flooded about 300 houses. The disaster killed five people, six more were hospitalized.

Fig. 4 The ruined dam "Kokpekty"

Fig. 5. Breakthrough of the dam in the village of Kokpekty

2 MODELING THE IMPACT OF HORIZONTAL AND VERTICAL GROUND DEFORMATIONS

The problem of increase of stability of functioning of all hydraulic structures in modern conditions is becoming increasingly important in connection with:

– reducing labor and technological discipline at all levels;

– high production depreciation of fixed assets, while reducing the pace of their updates;

– weak regulatory framework, providing insurance facility in case of damage;

– lag domestic practice from overseas in the use of scientific bases of the problem of risk management of safety and prevention of emergencies;

– increasing the likelihood of military conflict and the terrorist attacks.

Modeling the impact of horizontal and vertical ground deformations on the stability of the dam unreinforced model it was carried out under the terms of a two–dimensional model of the plane problem.

Dimensions geometric patterns taken from the condition that the distribution of the horizontal and vertical deformation are negligibly small within a given area.

Fig. 6 is represented by step input parameter setting geometrical model of numerical simulation of unreinforced dam model with ground base and set it horizontal and vertical deformation.

To set the standard boundary conditions are created in the base model, a partial securing (sealing), and the right vertical border – sliding terminations.

Incorporation (in accordance with Fig. 6) in a particular direction will appear on the screen in the form of two parallel lines, extending perpendicular to this direction. Thus, moving the movable support are presented in the form of two vertical parallel lines and the solid seal – hatching.

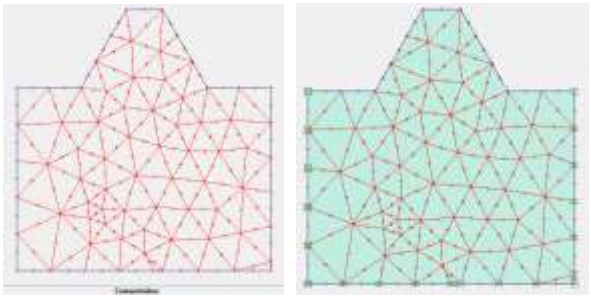

Fig. 6. The general and Closing geometrical model unreinforced model dam on grade

Boundary conditions

To select the boundary conditions there are two types: defined displacement and load.

All boundaries must have one boundary condition in each direction. That is, when for a certain limit (free boundary) is not given the appropriate boundary condition, then the natural conditions, i.e., a predetermined load is equal to zero and a free displacement.

To avoid a situation where the displacement is unknown, it is necessary that certain terms have defined geometric model bias. The simplest example of a given displacement is binding (zero displacement), but can also be specified and non–zero offset.

In this case, the boundary conditions are wall models were specified as pinchers and movable supports with free movement of +x–axis in the coordinate within the y–axis (140.0-140.100).

The base model is set as a movement along the axes y=0 in the coordinate range in the x (0.0-80.0), and moving along the y axis in the coordinate range in the x (80.0-140.0).

The software package Plaxis this type of boundary condition is automatically set as the most suitable for solving geotechnical problems.

To simulate the behavior of the soil for the geometric model to be taken by the appropriate soil type and its parameters. The characteristics of the soil Plaxis collected material data sets that are stored in the appropriate database. The data set from the database can be assigned to one or more clusters.

On a set of material data, select Soil & Interfaces (Soil and contact surfaces).

Material data sets are mostly after entering the boundary conditions. Before the creation of the grid should be set data sets of all the materials and all clusters and structures must have their corresponding data set.

Given the study model of the dam and its subgrade assigned to the same parameters of physico–mechanical

properties of the soil (Table 1), obtained from the results of laboratory tests, and model as the unreinforced dam and its foundation soil it was constructed from a single the equivalent material.

Table 1. Physico–mechanical properties of the soil

Side	Desig-nation	Value	Unit
Model soil	*Model*	Mohr – Coulomb	–
Type of soil behavior	*Type*	drain	–
The specific weight of the soil	γ_{unsat}	17.0	kN/m^3
The proportion of saturated soil	γ_{sat}	20.0	kN/m^3
The permeability of the soil in horizontal direction	k_x	3,000E^{-4}	m/day
The permeability of the soil in the vertical direction	k_y	3,000E^{-4}	m/day
Young's modulus (constant)	E_{ref}	260	kN/m^2
Poisson's ratio	ν	0.25	–
Clutch (constant)	c_{ref}	1.0	kN/m^2
The angle of friction	φ	21.0	°
The angle of dilatancy	ψ	0.0	°

The correctness of the data set assignment for the cluster due to a change in its color.

Mesh. Upon completion of construction of geometrical model is created finite element model (mesh). Plaxis allows for the procedure to create the grid automatically. Using this procedure, the geometric model is divided into elements of the basic type and compatible structural elements, if any. In constructing the grid position is taken into account points and lines geometric model. Thus, consider the location of the layers, loads and structures. The method of construction is a stable principle of triangulation by which are the optimum size of the triangles, which are involved in the construction of unstructured grid. Unstructured meshes are not formed properly disposed of elements. However, numerical results for these networks usually better numerical results for structured meshes with the correct layout.

Initial conditions. We determine the initial conditions. For the initial conditions are the initial conditions for ground, the initial geometrical configuration and the initial effective stress state. In this embodiment, there is no need to enter ground conditions, however, need to identify effective initial stresses using K_0–procedure (procedure K_0).

Since this project does not include the water pressure coming into geometric configuration. To receive the total weight of the soil factor $\Sigma Mweight$ equal to 1. This means that the construction of the initial stress is taken into account the full weight of the soil.

It includes several computational modeling steps horizontal tensile deformation along the x axis and the vertical deformation along the y axis with the given parameters ε and Δd.

After completion of the calculation, the results were evaluated program output (Output program). Are obtained and the offset voltage in the full geometric model.

After setting the design parameters chosen nodes or stress points for plotting the displacement of the deformation (in accordance with Fig. 7(a).

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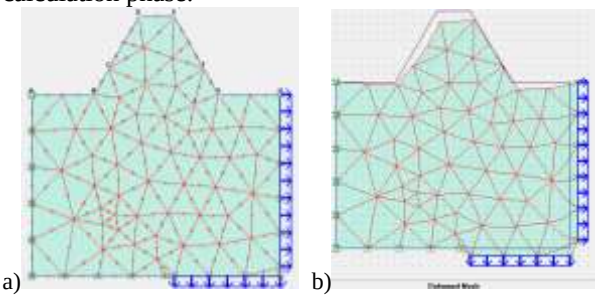


a) b)

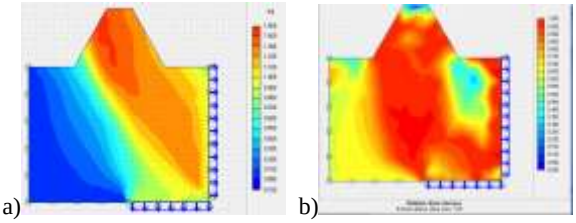
Fig. 7. a)Points of voltages for plotting the offset from the horizontal and vertical deformation

b) The deformed mesh model unreinforced dam calculated at the end of the selected phase

Fig.8 (a) shows the horizontal and vertical displacements of all nodes in the form of arrows and displacement zones with respective quantities.

For these values can be seen in the maximum deformation of the left side of the crest of the dam and the slope of the model, which coincide with deformation model experiment.

Fig.8 (b) shows the data of shear stress on the values of which also can be seen that failure in unreinforced dam model is much stronger in the left part of the model from the beginning of the horizontal and vertical deformation of subgrade.



a) b)

Fig. 8. Horizontal and vertical displacement units and Data shear model unreinforced dam on grade

3 TWO–DIMENSIONAL WORK SIMULATION OF THE REINFORCED DAM MODEL ON SOIL FOUNDATION IN THE SOFTWARE PACKAGE PLAXIS

Modeling the impact of horizontal and vertical deformations on the stability of reinforced soil dike model was also performed on the conditions of the plane problem of the two–dimensional model.

Dimensions geometric patterns taken from the condition that the distribution of the horizontal and vertical

deformation are negligibly small within a given area.

Fig. 10 is presented step input parameter setting geometrical model of numerical simulation model of the dam with a reinforced soil foundation and set it horizontal and vertical deformation.

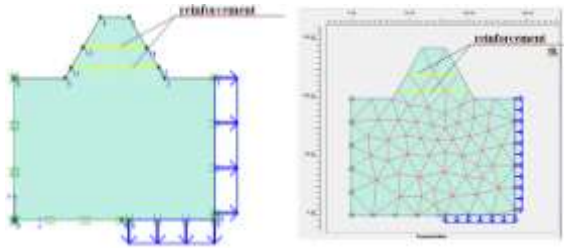


Fig. 10. geometrical model of numerical simulation model of the dam with a reinforced soil foundation

To set the standard boundary to create a model based on the partial consolidation (sealing), and the right vertical border – sliding terminations. Embedding in a particular direction will appear on the screen in the form of two parallel lines, extending perpendicular to this direction. Thus, moving the movable support are presented in the form of two vertical parallel lines and the solid seal – hatching.

Boundary conditions. To select the boundary conditions there are two types: defined displacement and load.

All boundaries must have one boundary condition in each direction. That is, when for a certain limit (free boundary) is not given the appropriate boundary condition, then the natural conditions, i.e., predetermined load is zero and the free displacement.

To avoid a situation where the displacement is unknown, it is necessary that certain terms have defined geometric model bias. The simplest example of a given displacement is binding (zero displacement), but can also be specified and non–zero offset.

In this case, the boundary conditions are wall models were specified as pinchers and movable supports with free movement of +x–axis in the coordinate within the y–axis (140,0-140,100).

CONCLUSIONS

The dependences, with which you can determine the amount of allowable values of deformations of embankment dams on undermined areas and other difficult substrates.

Obtained a valid model for dam deformation of the horizontal and vertical extension of collapse from the effects of part–time work before the faulting.

The comparison of the effect of reinforcing dependency on the stability of models of dams on the horizontal and vertical deformation, the results of which show that the average value of the displacements of points on the horizontal deformations: $\varepsilon = 3\times10^{-3}$, $\varepsilon = 6\times10^{-3}$, $\varepsilon = 9\times10^{-3}$, $\varepsilon = 12\times10^{-3}$, $\varepsilon = 15\times10^{-3}$, and vertical settlement: $\Delta d = 8\,mm$, $\Delta d = 16\,mm$, $\Delta d = 24\,mm$, $\Delta d = 32\,mm$, $\Delta d = 40\,mm$ on reinforced model dam less on average three times higher than the model unreinforced dam as shown by the chart in accordance.

The above method of comparing the simulation data allows you to set the required structural and technological protection measures to strengthen dams models to predict the behavior of dams and their degree of reliability for a given deformation.

Using the above modeling method can be performed ordinary reliability prediction also of earth dams without undermining.

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