JEDIC
Journal of Ethics and Diversity in International Communication
| e-ISSN: 2792-4017 | www.openaccessjournals.eu | Volume: 3 Issue: 2

Development and Evaluation of an Algoritm for Hydrodynamic Water Pressure on the Surface of Platinum under Seismic Risk

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Annotation: Ensuring the strength, reliability and efficiency of hydraulic structures requires comprehensive consideration of the static and dynamic loads acting on the structure in a single statement. When calculating the seismic effects of structures such as ground dams that perceive water pressure, in addition to seismic inertial forces, it is necessary to take into account the hydrostatic and hydrodynamic pressure of water on the pressure face, as well as the pore pressure in the body of the dam as a multiphase medium. Currently, consideration of seismic water pressure is mandatory when designing hydraulic structures, because our republic is located in a seismically active area.

The purpose of this article is to describe a methodology for taking into account the hydrodynamic pressure of a liquid during seismic impacts on a dam without fastening plates, taking into account the interaction of the liquid and the skeleton of the soil.

Keywords: earth dam, hydrodynamic pressure, dynamic impact, stability, oscillation period, seismic active area, water-supporting hydraulic structure.

Introduction. The existing system of designing and monitoring the state of hydraulic structures has significant shortcomings, consisting in the absence of reliable and objective criteria that characterize the safety of structures. Therefore, when designing, it is necessary to choose the type of structure, the predominant oscillation period of which differs most from the oscillation period of the base [1,2]. rrently, consideration of seismic water pressure is mandatory when designing hydraulic structures, because our republic is located in a seismically active area. The magnitude and distribution of the seismic water pressure acting on the pressure face of the structure, as well as the pore pressure inside the body of the dam depends on many factors: the direction, intensity and regularity of the seismic impact, the geometric configuration of the structure and the reservoir, the elastic compliance of the structure and the base, the ratio of the prevailing frequencies of seismic impacts and the natural frequencies of the structure and the liquid (as acoustic environment), etc. [3,4]. The degree of accuracy with which these factors should be taken into account depends on what proportion of the total complex of loads acting on the structure is seismic water pressure. When determining the hydrodynamic pressure of a liquid, it is necessary to take into account the type of construction of a soil dam. This formulation of the problem will make it possible to more realistically describe the stress-strain state of ground dams [9, 10].

The state of the problem. In accordance with the requirements of KMK 2.06.05-98 “Dams from soil materials”, when designing earth dams of classes 1 and 2, justifying calculations of the structure structure for basic and special combinations of loads during construction and operation should be performed, including:

JEDIC Journal of Ethics and Diversity in International Communication

| e-ISSN: 2792-4017 | www.openaccessjournals.eu | Volume: 3 Issue: 2

- stress-strain state of the dam;
- stability of the dam.

Calculations of all hydraulic structures, foundations and coastal slopes both in the alignment of the structure and in the reservoir area should be carried out on static loads determined by linear spectral theory (LST) under the influences set by the conditional accelerations of the base *A* (expressed in fractions of *g* – acceleration of free fall).

Calculations must be made in accordance with the requirements of the heads of the KMK for the design of hydraulic structures of certain types. The calculations should take into account seismic loads from the mass of the structure, the attached mass of water (or hydrodynamic pressure), from waves in the reservoir caused by an earthquake, and from the dynamic pressure of the soil [5].

For water-retaining hydraulic structures of class I, when they are located in areas of seismicity J≥7 points, it is also necessary to make calculations for seismic effects specified by accelerograms (velocigrams, seismograms) of earthquakes.

In this case, the designing organization develops special technical conditions in which:

- the scheme of setting the seismic impact, the relationship between accelerations in different directions, changes in amplitudes along the perimeter of the canyon, the time shift of the impact at various points of the base of the structure are determined;
- the main provisions of computational or experimental studies are established;
- the composition and methodology of experimental field and laboratory studies of the physical and mechanical properties of the soils of foundations and building materials of structures are determined within the framework of the accepted models;
- criteria are formulated to determine the maximum bearing capacity of the structure and to assess its seismic resistance [6].

The solution to the problem. A typical reservoir area is shown in Fig.1, and its contour is determined by the water level in the reservoir, the outline of the upper face of the dam and the accepted length of the calculated area. With a sufficiently elongated area, the boundary conditions along the *AB* line do not significantly affect the results of the joint calculation of the reservoir-structure system.

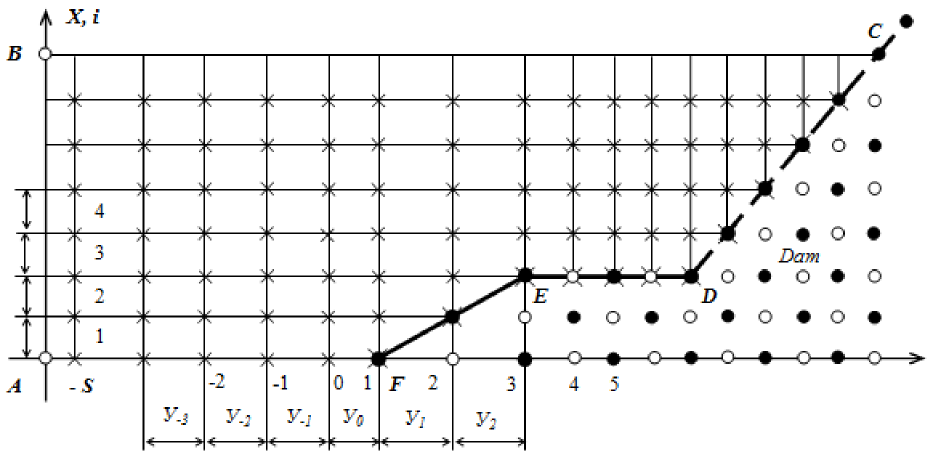

Fig.1. Finite difference grid for calculating the wave equation in the reservoir:

points for determining velocities in the dam; o - points for determining stresses in the dam; *X* - points for calculating the potential *Φ* in the water storage.

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Let the fluid motion equation have the form

$$\frac{\partial^2 \Phi}{\partial x^2} + \frac{\partial^2 \Phi}{\partial y^2} = \frac{\rho}{M_B} \frac{\partial^2 \Phi}{\partial t^2} \qquad (1)$$

where ρ - is the density of water; M_B - modulus of elasticity of water; Φ - potential speeds: $\dot{u} = d\Phi/dx; \dot{v} = d\Phi/dy;$ $\dot{u}, \dot{v}$ - vertical and horizontal fluid velocities.

The hydrodynamic pressure P is related to the velocity potential by the ratio

$$P = \rho \frac{\partial \Phi}{\partial t} \qquad (2)$$

To solve equation (1) along the contour of the computational domain, either the values of the potential or the velocity along the normal to the boundary must be specified. The initial conditions will be considered homogeneous, that is, for $t = 0,\ \Phi(x,y,0) = 0$ и $d\Phi/dt(x,y,0) = 0$.

For simplicity, let's consider the case when $\partial\Phi/\partial y = 0$ (symmetry conditions) are set on *AB*. Wave formation on the free surface will be neglected. The error of the assumption decreases with the increase in the height of the dams and is negligible for a dam with a height of *100-200 m*. It should be noted that at water flow rates characteristic of earth dams, the additional hydrodynamic pressure is very small and therefore it does not make sense to determine it with high accuracy. We will consider the section of the *BC* contour to be fixed and from the condition that there is an $P = 0$ on it, we will set the boundary condition of the $\Phi_{CB} = 0$. Along the *AFEDC* line, the speeds of water movement along the normal to the contour are given. According to the base *AF*, these speeds are determined by the given law of displacement of the base, and along the upper face of the dam *FEDC*, the speeds of soil movement, determined by the joint parallel calculation of the "dam - reservoir" system.

Let us take the structure of the difference grid shown in Fig.1. The physical meaning of equation (1) is that the amount of water flowing out of a unit of volume per unit of time (the left side of the equation) is proportional to the decrease in pressure due to elastic deformations of water. Consider the volume element shaded in Fig. 2, a, with the area:

$$\omega_{ij} = (x_i + x_{i-1})(y_j + y_{j-1})/4 .$$

The velocities at the points lying in the middle of the sides will be determined by the formulas:

$$\left.\begin{aligned}
\dot{u}_{i+\frac{1}{2},j} &= \frac{\Phi_{i+1,j} - \Phi_{i,j}}{x_i};\\
\dot{u}_{i-\frac{1}{2},j} &= \frac{\Phi_{i,j} - \Phi_{i-1,j}}{x_{i-1}};\\
\dot{v}_{i,j+\frac{1}{2}} &= \frac{\Phi_{i,j+1} - \Phi_{i,j}}{y_j};\\
\dot{v}_{i,j-\frac{1}{2}} &= \frac{\Phi_{i,j} - \Phi_{i,j-1}}{y_{j-1}}.
\end{aligned}\right\} \qquad (3)$$

Then the amount of liquid flowing from the volume element in question in 1 s is equal to:

$$Q_{ij}=\left(\dot{u}_{i+\frac{1}{2},j}-\dot{u}_{i-\frac{1}{2},j}\right)\frac{y_j+y_{j-1}}{2}+\left(\dot{v}_{i,j+\frac{1}{2}}-\dot{v}_{i,j-\frac{1}{2}}\right)\frac{x_i+x_{i-1}}{2}=\frac{\rho}{M_B}\frac{\partial^2\Phi_{ij}}{\partial t^2} \qquad (4)$$

Equation (4), when (3) is substituted into it, is a difference analog of equation (1) and can be obtained from it by a formal difference approximation of the second derivatives of Φ with respect to spatial coordinates. However, when considering points on the contour of a region, it is more convenient to keep in mind this physical meaning of difference equations.

Consider the volume element adjacent to the slope of the dam (Fig. 2, b), with the area:

$$\omega_{ij}=(y_j+y_{j-1})(x_i+x_{i-1})/8.$$

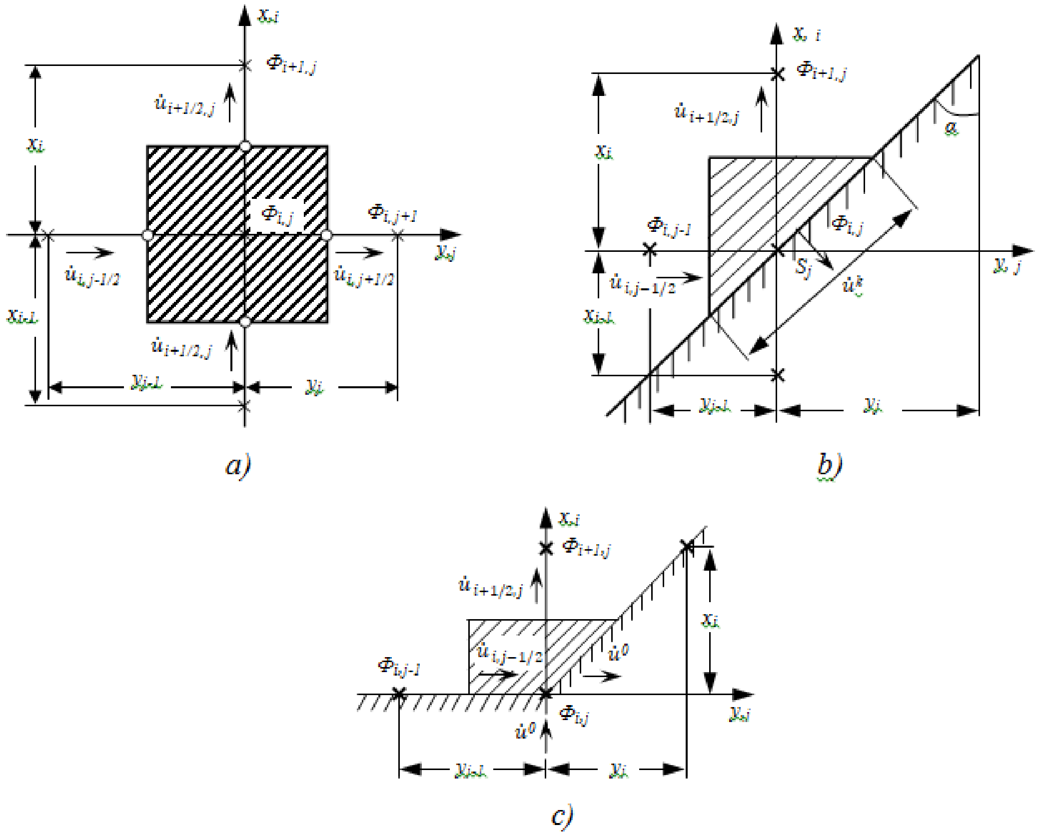

Fig.2. Difference analogues of wave equations: *a* - internal point of the reservoir area; *b* - point on the sloping boundary; *c* - point on the conjugation of the horizontal and inclined sections of the contour.

Let the speed $\dot{u}^k$ be given along the slope along the normal to the boundary. The volume of water flowing out of the element,

$$Q_{ij}=\dot{u}_{i+\frac{1}{2},j}\frac{y_j+y_{j-1}}{2}-\dot{v}_{i,j-\frac{1}{2}}\frac{x_i+x_{i-1}}{2}+\dot{u}^kS_j$$

where

JEDIC Journal of Ethics and Diversity in International Communication
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$$S_j = \frac{y_j + y_{j-1}}{2\sin\alpha}; \quad tg\alpha = \frac{y_j + y_{j-1}}{x_i + x_{i-1}}$$

Let the speed $\dot{u}^k$ given on the contour be represented by its projections $\dot{u}^0$ and $\dot{v}^0$:

$$\dot{u}^k = -\dot{u}^3 sin\alpha + \dot{v}^0 cos\alpha$$

Then the amount of water considered by the point we get:

$$\dot{u}^k S_j = -\dot{u}^0 \frac{y_j + y_{j-1}}{2} + \dot{v}^0 \frac{x_i + x_{i-1}}{2}$$

Finally , for the point under consideration, we get:

$$Q_{ij} = \left(\dot{u}_{i+\frac{1}{2},j} - \dot{u}^0 \right) \frac{y_j + y_{j-1}}{2} - \left(\dot{v}^0 - \dot{v}_{i,j-1} \right) \frac{x_i + x_{i-1}}{2} = \frac{\rho}{M_B} \frac{\partial^2 \Phi_{ij}}{\partial t^2} \omega_{ij} . \qquad (5)$$

As an example illustrating the obtaining of difference analogs of equation (1) at contour points, consider the case of conjugation of a horizontal and an inclined section of the contour (points of type F and D in Fig.1). The considered element of the area with area $\omega_{ij} = \frac{3}{16} x_i \times \left(y_i + y_{j-1} \right)$ is shown in Fig.2.2, b.

For this case

$$Q_{ij} = \left(\dot{u}_{i+\frac{1}{2},j} - \dot{u}^0 \right) \frac{y_j + y_{j-1}}{2} - \left(\dot{v}^0 - \dot{v}_{i,j-1} \right) \frac{x_i}{2} = \omega_{ij} \frac{\rho}{M_B} \frac{\partial^2 \Phi_{ij}}{\partial t^2} \qquad (6)$$

Similarly, difference equations are compiled for horizontal sections of the contour (the base, the berm of the dam) and for points of type *E*. Thus, the general record of difference equations has the following form:

$$Q_{ij} = \omega_{ij} \frac{\rho}{M_B} \frac{\partial^2 \Phi_{ij}}{\partial t^2} \qquad (7)$$

where Q_{ij} - is the flow rate of the fluid flowing from the element in question; ω_{ij} - is the area of this element.

Writing in finite differences

$$\frac{\partial^2 \Phi_{ij}}{\partial t^2} = \frac{\Phi_{ij}^{t+\Delta t} - 2\Phi_{ij}^{t} + \Phi_{ij}^{t-\Delta t}}{\Delta t}$$

and expressing explicitly the value of $\Phi_{ij}^{t+\Delta t}$, we get the recurrent formula:

$$\Phi_{ij}^{t+\Delta t} = 2\Phi_{ij}^{t} - \Phi_{ij}^{t-\Delta t} + \Delta t^2 \frac{Q_{ij} M_B}{\rho} \quad (8)$$

allowing step by step to calculate the values of Φ_{ij}^{t} - (and hence P) for any $t>0$. The joint calculation of the dam-reservoir system is carried out according to the following scheme:

1) let at some time step t be known:

a) the value of Φ^t and $\Phi^{t-\Delta}$ in the area occupied by the reservoir;

b) the values of the speeds of soil movement in the dam;

2) according to the set speeds on the contour and (8) in the entire region, the value Φ is determined at the next time $\Phi_{ij}^{t+\Delta t}$;

3) along the contact line of the dam with the reservoir, the pressure is determined by the formula

$$P_{ij}^{t} = \rho \frac{\Phi^{t-\Delta t} - \Phi^{t}}{\Delta t}, \quad (9)$$

which is the difference analogue of equation (2);

4) pressure P_{ij}^{t} is used in the formulation of equations of dynamic equilibrium in the contour elements of the dam, which determine the speed of the soil at time $t + \Delta t$. The process is then repeated for the next time step.

The speed of water movement cku and ckv at the contact of the dam with the reservoir is determined by the formulas

$$\dot{u}^0 = \dot{u}_c + \dot{w}_x m; \quad v^0 = \dot{v}_c + \dot{w}_y m; \quad (10)$$

where m - is porosity; $\dot{u}_c, \dot{v}_c$ - components of the skeletal material velocity vector; $\dot{w}_x, \dot{w}_y$ - components of fluid velocities relative to skeletal material.

Conclusion. The developed calculation method assumes the determination of the stress-strain state of the ground structure at any stage of deformation and therefore primarily includes an assessment of the work on the permissible deformations of the elements of the structure. Local destruction at some point of the ground does not mean that the structure is in a dangerous position. Only in the case when the whole area, which has an outlet to a free surface, goes into a limiting state, plastic deformations in this area will accumulate without a boundary. The progressive nature of the accumulation of plastic deformations in any element of the structure indicates that the structure is in a state of extreme strength.

Thus, the criterion for the overall stability of a soil structure is the absence in this structure of areas with a progressive accumulation of plastic deformations. In the numerical analysis of the stress-strain state of the designed dams, we used those introduced in the definitions of the limit state of the soil structure.

References:

1. L. Pelecanos. Seismic response and analysis of earth dams. London, United Kingdom, September 2013.
2. Jasmina Dražić, Nikolai Vatin, The Influence of Configuration on to the Seismic Resistance of a Building, Procedia Engineering, Volume 165, 2016, Pages 883-890.
3. Хамрабаева Н.А. Исследование землетрясения и сейсмобезопасности платин.. Архитектура, Строительство, Дизайн. Научно практический журнал. Ташкент .№4. 2021г. С.222-226.
4. Ахмедов М.А., Салямова К.Дж. Н.А.Хамрабаева. Сейсмобезопасность грунтовых гидротехнических сооружений (плотин). Архитектура, Строительство, Дизайн. Архитектура, Строительство, Дизайн. Научно- практический журнал. Ташкент №2. 2021г. С.194-199.
5. Хамрабаева Н.А. Исследования систем сейсмоизоляции для безопасности зданий и сооружений. Архитектура, Строительство, Дизайн. Научно –практический журнал. Ташкент. №1. 2019 г, С 97-101.
6. Н.А.Хамрабаева , П.Ш.Муслимова. Проблемы безопасности охрана труда в строительстве. Ўзбекистон кишлоқ ва сув хужалиги. №6 Тошкент 2021. С
7. Хамрабаева Н.А. Методический подход к оценке сейсмического риска системы с последовательным соединением цепи аппаратов медного обогатитетльной фабрики ОАО “АГМК”. ФарПИ ИТЖ НТЖ ФерПИ (STJ FerPI), 2019, №4 (No.4). С.167-170.