Kushpanov M.S., Rakhmatullayev R.M., Ospanov K.M., Murzabayev A.B.
Empirical constant of special form, the laws of displacement - a combination of fundamental constants
Summary. In this paper we consider the possibility to provide an empirical constant of Wien's law by combination of well-known fundamental constants in the forms, leading to almost identical results.
Key words: Displacement law, known constants, thermal radiation, the average energy of a classical oscillator, power spectral density of the blackbody luminosity.

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A.T. Kalbayeva, S.D. Kurakbayeva, A.D. Kurakbayev, A.M. Brener
(M.Auezov South Kazakhstan State University, Shymkent, Kazakhstan
sevam@mail.ru)

MATHEMATICAL MODEL AND SOFTWARE FOR METHODS OF CALCULATING LIQUID FILTRATION THROUGH THE SOIL DAMS

Annotation. The numerical solution of liquid filtration through dam with account of possible damage of the dam has been submitted. The numerical scheme is based on the boundary elements method which displays vast horizons for solving problems with free boundaries. The appropriate software called “Solving problems of liquid filtration through dams with the help of boundary elements method” has been worked out. It is shown that advantages of used method are conditioned by the opportunity to maximal correct modeling the localization of the filtration areas boundaries with allowing for the character and sizes of the damage. The results of our work can be used for design the dams and other hydro-technical structures.
Key words: water filtration, dam, earth block, boundary element method, free surface.

One of the important problems of the current stage of humanity development is the rational and effective use of water resources and their protection from the adverse effect that involves regulation of river runoff, including creation of reservoirs, ponds, storages, etc. [1]. In the vast majority of cases in the world (over 85%), earth barrages and dams serve as retaining structures for them. As the domestic and foreign experience in construction of barrages shows, there are cases of damage and destruction of earth barrages and dams, including severe consequences and loss of life [2]. At the same time, there is practically no analysis of features of mathematical modeling of filtration processes through the earth dams taking into account possible damages of the dams’ consistency in the literature.

The article considers numerical solution of the problem on filtration of fluid from open reservoirs through the dam, which takes into account presence of damages there.

For this purpose, scheme of the boundary element method, which showed great potential in solving problems with free surfaces, has been used [3].

It is accepted that the medium is homogeneous and isotropic, so the problem is reduced to the Laplace equation for the velocity potential u:

$$\Delta u = 0 \qquad (1)$$

boundary conditions:

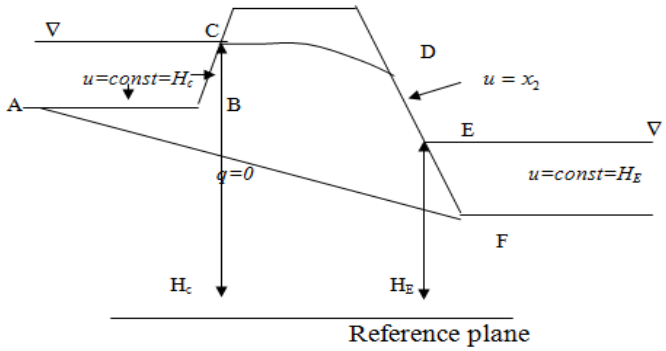
$q=0$ on the impermeable boundary (AF surface in Figure 1) (2)

$u=const$ on the surfaces ABC and EF of the porous medium (3)

$u = x_2$ – on the filtration surface DE (4)

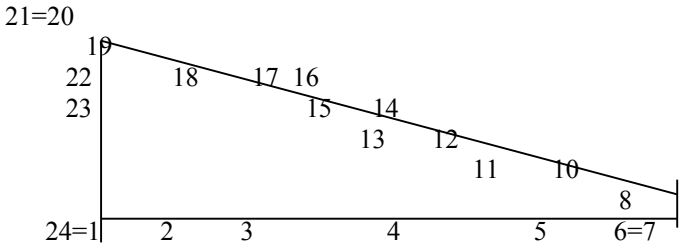
$u = x_2$ and $q=0$ on the free surface CD (5).

In the numerical calculation of this problem, the initial position of the free surface is set in an arbitrary way, moreover, $q=0$ condition is accepted in all points of the surface. Found for each double point of the free surface potential value is compared with the height of the water surface. If the difference between them is greater than the maximum permissible error, the difference is algebraically summarized with the surface height in the corresponding double point and new iteration is held.



ABC: u=H_c, CD: $u = x_2$, $q=0$, DE: $u = x_2$, EF: $u=H_E$, AF: $q=0$

Fig. 1. Boundary conditions in the problem on water current with free surface



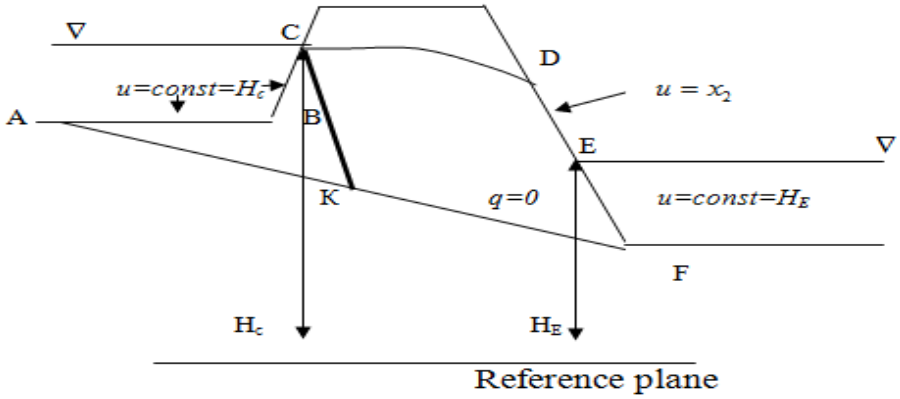
j=$\overline{1,6}$ $q_j=0$, j=$\overline{7,9}$ $u_j=0.1$, j=$\overline{10,20}$ $q_j=0$, $u_j=x_2$ j=$\overline{21,24}$ $u_j=0.5$

Fig. 2. Arrangement of the boundary elements for the earth block

Figure 2 shows division into the boundary elements in the problem on the current with the free surface through the block of porous material. The heights of the upper and lower pools are, respectively, 0.5 and 0.1 with respect to the reference surface.

The final position of the free surface was obtained after the 6th iteration [4].

Consider in more detail the filtration problem through the dam with damage in the input of the porous medium (Fig. 3), where ABCK section – fragment of the dam (damaged area of the dam). Respectively the boundary conditions for the problem of the water current through the dam will be different (Fig. 3).

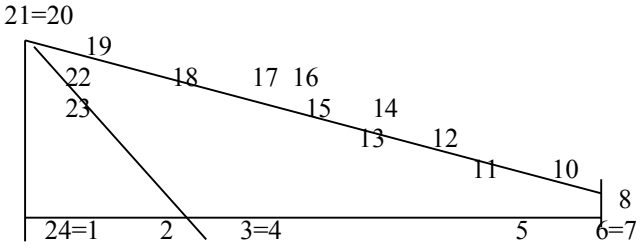


ABC: u=H_c, AK: u=H_c, CD: $u = x_2$, $q=0$, DE: $u = x_2$, EF: $u=H_E$, KF: $q=0$

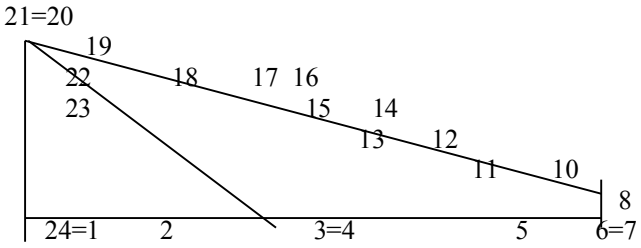
Fig. 3. Boundary conditions in the problem of the water current through the dam with the damage

Arrangement of the boundary elements for the earth block at the current with the free surface through the dam with the damage at the top is shown in Fig. 4. Arrangement of the boundary elements for the earth block at the current with the free surface through the dam with the damage in its midpoint is shown in Fig. 5.

a)



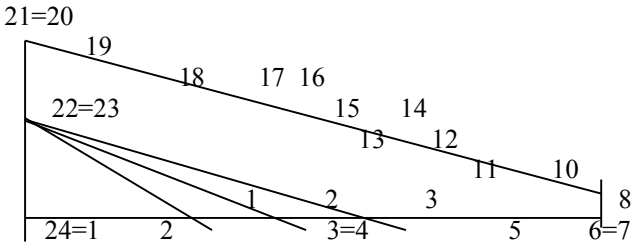
b)



$j=\overline{1,3}$ $u_j=0.5$, $j=\overline{4,6}$ $q_j=0$, $j=\overline{7,9}$ $u_j=0.1$, $j=\overline{10,20}$ $q_j=0$, $u_j=x_2$ $j=\overline{21,24}$ $u_j=0.5$

a) - $(x_1^3=0,2, x_1^4=0,2)$ b) - $(x_1^3=0,3, x_1^4=0,3)$

Fig. 4. Arrangement of the boundary elements for the earth block with the damage (beginning of the damage at the top of the dam)

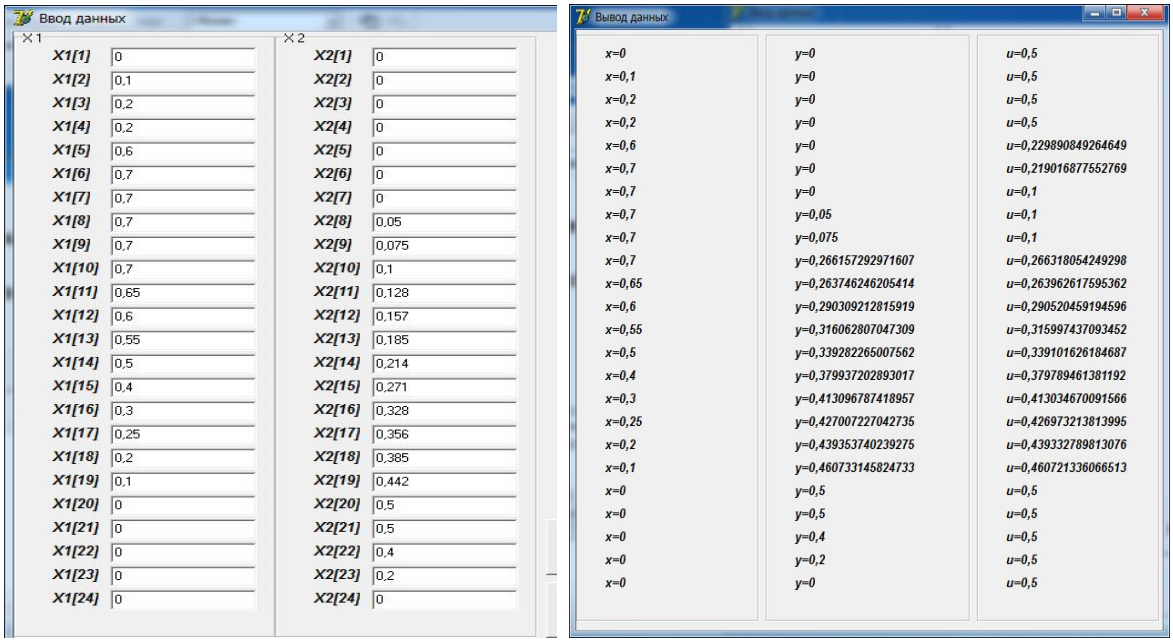


$j=\overline{1,3}$ $u_j=0.5$, $j=\overline{4,6}$ $q_j=0$, $j=\overline{7,9}$ $u_j=0.1$, $j=\overline{10,20}$ $q_j=0$, $u_j=x_2$ $j=\overline{21,22}$ $u_j=0.5$ $j=\overline{23,24}$ $u_j=0.3$

1) - $(x_1^3=0,3, x_1^4=0,3)$ 2) - $(x_1^3=0,4, x_1^4=0,4)$ 3) - $(x_1^3=0,5, x_1^4=0,5)$

Fig. 5. Arrangement of the boundary elements for the earth block with the damage (beginning of the damage – midpoint of the dam)

"Solution of problems on the water filtration through the dam by the boundary element method" software has been developed in the medium of visual programming Delphi 7. The program contains all necessary information and solutions of the set problem, Fig. 6 presents forms of the program: Fig. 6a) presents "Input of data" form, where we fill coordinates of the double points, Fig. 6b) "Output of data", where final results of the free surface position after iteration are presented. The final position of the free surface for the problem with the damage of the dam was obtained after the 7^{th} iteration (Figure 7).



a) b)

Fig. 6. Interface of the software

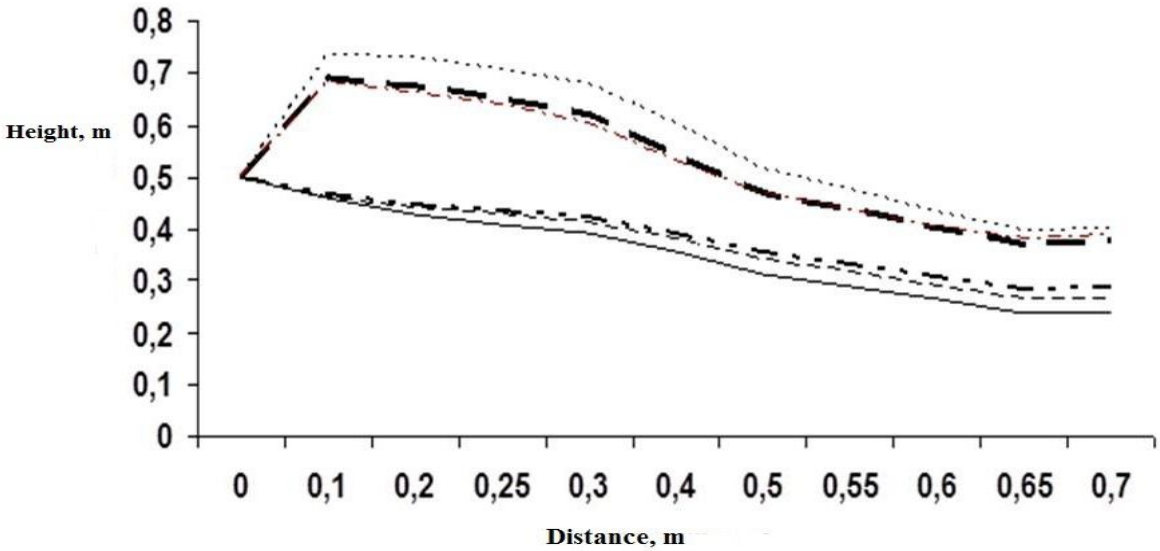


Fig. 7. Comparison of the calculated results for the potential at the current with the free surface through the dam and the dam with the damage

———— - the case of the dam without the damage

– – – – – – – – - the case with the damage of the dam at the top ($x_1^3 = 0{,}2$, $x_1^4 = 0{,}2$)

—·· —·· —·· - the case with the damage of the dam at the top ($x_1^3 = 0{,}3$, $x_1^4 = 0{,}3$)

..... - the case with the damage of the dam in the center ($x_1^3 = 0{,}3$, $x_1^4 = 0{,}3$)

— — — — - the case with the damage of the dam in the center ($x_1^3 = 0{,}4$, $x_1^4 = 0{,}4$)

–·–·–·–·– - the case with the damage of the dam in the center ($x_1^3 = 0{,}5$, $x_1^4 = 0{,}5$)

By the numerical experiment, we have obtained a picture of the current lines and position of the free boundary at the water filtration through the dam with the damage. It is seen from the obtained results that in the case with the damage of the dam in the center there is more moistening of the soil than in the case with the damage of the dam at the top.

The main conclusion of the work is that the possibility of effective use of the boundary element method for the modeling and computer investigation of the filtration processes through the damaged dams has been shown. Advantages of the boundary element method in this situation are determined by the possibility of maximally exact modeling of the filtration field boundary positions taking into account character and geometrical sizes of the damage. Results of the work can be used at the design of dams and hydraulic engineering structures.

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Калбаева А.Т., Куракбаева С.Д., Куракбаев А.Д., Бренер А.М.

Математическая модель и программная реализация методики расчета фильтрации воды через грунтовую дамбу

Резюме. Приведено численное решение задачи фильтрации жидкости из открытого водоема через дамбу, учитывающее наличие повреждения в дамбе на основе метода граничных элементов, который продемонстрировал большие возможности при решении задач со свободными поверхностями. Разработано программное обеспечение «Решение задач фильтрации жидкости через дамбу методом граничных элементов» в среде визуального программирования Delphi 7. Показано, что преимущества метода граничных элементов в данной ситуации обусловлены возможностью максимально точного моделирования положения границ области фильтрации с учетом характера и геометрических размеров повреждения. Результаты работы могут быть использованы при проектировании дамб и гидротехнических сооружений.

Ключевые слова: фильтрация воды, дамба, грунтовой блок, метод граничных элементов, свободная поверхность

Қалбаева А.Т., Құрақбаева С.Ж., Құрақбаев А.Ж., Бренер А.М.

Топырақтық дамба арқылы суды сүзгілеуді есептеу әдістемесінің математикалық моделі және программалық жүзеге асуы

Түйіндеме. Шекаралық элементтер әдісі негізінде дамба зақымдануын есептейтін ашық су қоймасынан дамба арқылы сұйықты сүзгілеу есебінің сандық шешімі келтірілген, ол еркін кеңістіктегі есептерді шешуде үлкен мүмкіндіктерді көрсетеді. Delphi 7 визуалды программалау ортасында «Шекаралық элементттер әдісімен дамба арқылы сұйықты сүзгілеу есебін шешу» программалық қамтамасы өңделді. Зақымдаудың сипаттамасы мен геометриялық өлшемін есепке ала отырып сүзгілеу облысы шекарасының жағдайын максималды дәл модельдеу мүмкіндігімен шартталған берілген жағдайдағы шекаралық элементтер әдісінің артықшылығы көрсетілген. Жұмыс нәтижесі дамбаларды жобалауда және гидротехникалық құрылымдарда қолданыла алады.

Кілттік сөздер: суды сүзгілеу, дамба, топырақтық блок, шекаралық элементтер әдісі, еркін кеңістік