ALGORITMS FOR USING GEOMETRIC MODELLING METHODS IN CREATING PROJECT DRAWINGS OF HYDROTECHNICAL CONSTRUCTIONS

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Abstract

This article describes the application of modeling methods to the process's drawing up a project drawing's hydrotechnical structures connected to the topographic surface, the use of modern computer graphics programs and the creation of new computer technology algorithms. In this article, several variants of the project drawing of the dam, which is one of the hydrotechnical structures, are drawn.

On the example of the dam project drawing, simplified variants of existing drawing rules are shown, as well as are given methods of choosing the most optimal variant from several variants of the created project drawing.

The proposed algorithms are developed in accordance with modern programming languages

Key words: Geometric modeling, mathematical modeling, topographic surface, spline methods, slope planes, drawing algorithms, artificial and natural horizontals.

In today's developing period, the demand for digitalization of every system is increasing day by day, in this regard, many works are being carried out by our Republic, among them, the demand for automating the design process of hydraulic engineering structures is also increasing. Many decisions and decrees are being developed by our state in this regard, PF-200 of the President of April 6, 2021 "On further improvement of the state management and control system in the use of water resources and measures - measures to ensure the safety of water facilities" - By decree № 6200, the main measures for the development of these fields and ensuring the safety of hydrotechnical facilities have been determined [1,2].

One of the urgent problems of the present time is the creation of algorithms for the selection of the most optimal project option from the projects created during the design of the dam drawing on the topographic surface, which is one of the hydrotechnical structures, and the optimization of the design process by using these algorithms in automated graphic programs.

Today, with the development of modern computer technologies, it is possible to create digital models of various objects and introduce them into the production process. Digital models are widely used in design and production processes with the help of computer graphics programs. In all these processes, there is a need to describe the geometric shape of objects, so the field of applied mathematics called geometric modeling was formed [3,4].

In geometric modeling, the main geometric shapes are points, straight and curved lines, planes (surfaces). In automated design systems of objects bounded by a curved surface, the successful solution of engineering problems at all stages and the final results are related to the formation of the most accurate geometric model of the shape of the object. Geometric and mathematical modeling is currently one of the methods widely used in the design process, and with the help of these methods, we may be able to develop algorithms for selecting the most optimal option from the project drawings and create automated graphic programs based on these algorithms [4,5].

Algorithms for drawing up project drawings of a dam, which is one of the hydrotechnical structures, and algorithms for choosing the most optimal option from among several project options:

A dam is a hydraulic structure in the form of an earth lift built to block a waterway or change the flow direction in a river bed and bank. we can choose the most optimal version of the project drawing by using [6].

After drawing the horizontals lines of the ground, two parallel straight lines are first drawn according to the traditional algorithm for constructing a dam on the resulting topographic surface, these parallel lines represent the width of the Dam. The distance between the width of the embankment is given to us [7,8].

For example, if 2 parallel straight lines are given, then 2 arbitrary points are chosen from one of the horizontal lines in order to draw a straight line. As we know from analytical geometry, we can pass one straight line through the given 2 points (x_1, y_1), (x_2, y_2).

$$\frac{x - x_1}{x_2 - x_1} = \frac{y - y_1}{y_2 - y_1}$$

Using this formula, we can find the equation of a straight line:

$$y = \frac{y_2 - y_1}{x_2 - x_1}x + \frac{x_2 y_1 - x_1 y_2}{x_2 - x_1}$$

After that, we draw a parallel straight line by pouring the distance of the width of the embankment to the given straight line. For this:

If the general equation of a straight line $Ax + By + C = 0$ is given $Ax + By + C = 0$

$$d = |x_d \cos\alpha + y_d sin\alpha - p|$$

This: $\cos\alpha = \pm\frac{A}{\sqrt{A^2+B^2}}$ $sin\alpha = \pm\frac{B}{\sqrt{A^2+B^2}}$ $P = \mp\frac{C}{\sqrt{A^2+B^2}}$

For example: draw a straight line parallel to the straight line given by the general equation x+y+1=0, calculating the width of the embankment d=3m:

$$d = |x_d \cos\alpha + y_d sin\alpha - p|$$

Through this formula $\cos\alpha = \frac{1}{\sqrt{1^2+1^2}} = \frac{1}{\sqrt{2}}$, $sin\alpha = \frac{1}{\sqrt{2}}$, $P = \frac{1}{\sqrt{2}}$

By solving the equation, we can get the equation of a parallel straight-line Figure 2, that is

$$3 = \left| x_d \frac{1}{\sqrt{2}} + y_d \frac{1}{\sqrt{2}} - \frac{1}{\sqrt{2}} \right|$$
$$3 = x_d \frac{1}{\sqrt{2}} + y_d \frac{1}{\sqrt{2}} + \frac{1}{\sqrt{2}}$$
$$3\sqrt{2} = x_d + y_d + 1$$
$$x_d + y_d - 2.41 = 0$$

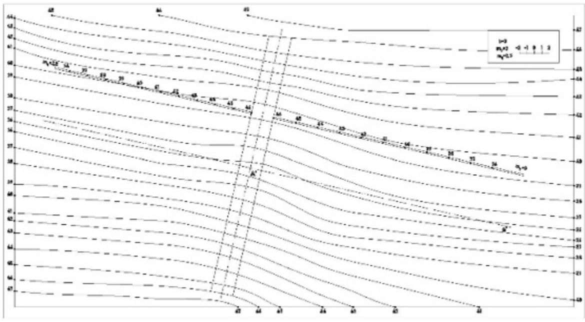
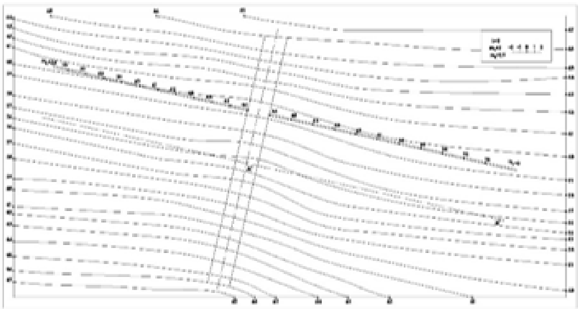


Figure 2. Draw a parallel straight line

After that, in order to draw perpendicular straight lines to the given parallel straight lines, $y = k_1x + b_1$ and $y = k_2x + b_2$ are given by the straight line equations, if $k_1 \times k_2 = -1$ then a straight line perpendicular to the given straight line is derived

To find the boundary of the earthwork of the dam, we need to determine the slope, the slope can be different according to the structure of the soil [6,7]:



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Grunts in dam body	Slopes according to dam heights are in m					
	up to 5 m		5 m to 10 m		From 10 to 15 m	
	Above m_1	Below m_2	Above m_1	Below m_2	Above m_1	Below m_2
Mud	2,5	1,75	2,5	2	3	2,5
Sandy land	2,25	2	2,75	2,25	3,25	2,75
Sand	2,5	2,25	3	2,5	3,5	3
Fine sand	3	2,5	3,5	3	3,75	3,25
Medium sand	2,5	2	3	2,5	3,25	2,75
Large sand and gravel	2	1,5	2,5	2	2,75	2,25

For example, if the ground in the body of the dam is medium sand, and the width of the dam structure to be built is 3 meters, height is 10 meters, length is 50 meters, then if we make several variants of its project drawing by changing the slopes based on the given norms:

In the 1st variant, we take the slope as i=1:2.5, i=1:3 and make artificial horizontal lines parallel to the main body of the dam. The process of transferring artificial horizontals is also found using the formula for transferring a parallel straight line by placing the distance between the given straight line above, that is, the slope scale lines to the main contour of the dam are λ=2.5m, λ=3m We draw a parallel straight line at 3m distances[8,9]. Figure 3.

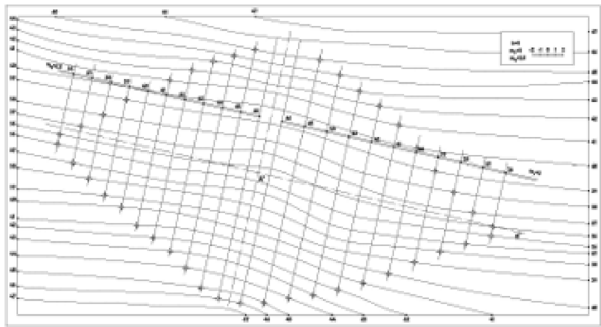


Figure 3. Straight lines drawn parallel through sloped scale lines

The distance between the artificial horizontals depends on the slope, after drawing the artificial horizontals on both sides, the points of intersection of the natural horizontals and artificial horizontals of the same name are marked, and we connect the found points to each other using the above spline method, and the resulting curve is our land determines the limits of work [10,11]. Figure 4

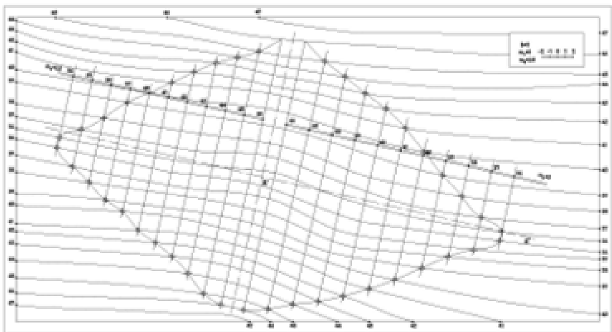
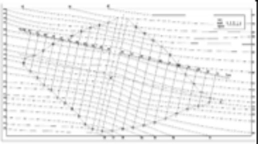
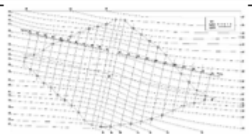
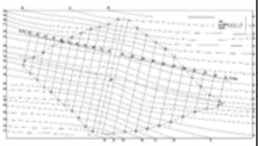
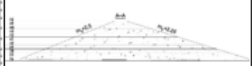
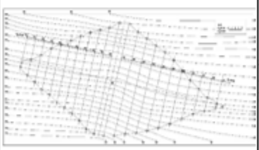
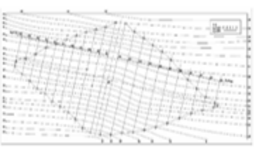


Figure 4. A drawing of the construction of the dam on a given topographic surface.

Based on the above sequence, 5 variants of the project drawing of the given dam structure without violating the given norms by changing the slopes are compiled in Table 1:

Among these project options, the most optimal project option can be selected by calculating the volume of earthworks of the given structure, that is, depending on the change in the volume of earthworks, the project's transportation costs and project price will change. To do this, it is necessary to calculate the volume of earthworks in all 5 variants of the dam structure, this process is currently being used by programs that calculate with the help of computer graphics programs, and in the case where mathematical modeling methods are used, that is, we can calculate with the help of the prismoid formula [12,13].

Table 1. Design drawings and cross-sectional surfaces of a given dam structure according to slopes.

№	Slopes	Project drawing of the dam	Cross section
1-p	$m_q = 2.5$ $m_y = 3$		
2-p	$m_q = 2.6$ $m_y = 3.1$		
3-p	$m_q = 2.5$ $m_y = 3.25$		
4-p	$m_q = 2.65$ $m_y = 3.15$		
5-p	$m_q = 2.75$ $m_y = 3.25$		

That is, as a result of cutting the project drawing of the dam according to the given slopes, a prismoid shape is formed between each slope, and a separate volume for each section is calculated using the following formula:

$$V = d\frac{A_1 + 4A_m + A_2}{6},$$

here, A_1 - the surface of one side of the prismoid, A_2 - the surface of the other side, A_m - the distance between the two sides of the prismoid, i.e. the average value of width, length and height, d- the distance between the two sides of the prismoid.

Using this formula, the volume of earthworks of each project drawing is approximately calculated and is presented in Table 2:

№	volume in m_q	volume in m_y	Total volume
1-p	412.5 m^3	494.3 m^3	906.8 m^3
2-p	429.4 m^3	511.5 m^3	940.9 m^3
3-p	412.5 m^3	536.25 m^3	948.75 m^3
4-p	437.25 m^3	519.75 m^3	957 m^3
5-p	453.75 m^3	536.25 m^3	990 m^3

Table 2. Approximately the volume of earthworks of each project drawing is

There are several methods for selecting the optimal project plan from the calculated volume of earthwork of the structure, based on the norms of the given slopes, the project plan of the second option . $m_q = 2.6$, $m_y = 3.1$ is closer to the project plan of the most optimal option compared to the others can select this project drawing [14,15].

Also, a three-dimensional model of this project drawing is presented in Figure 5:

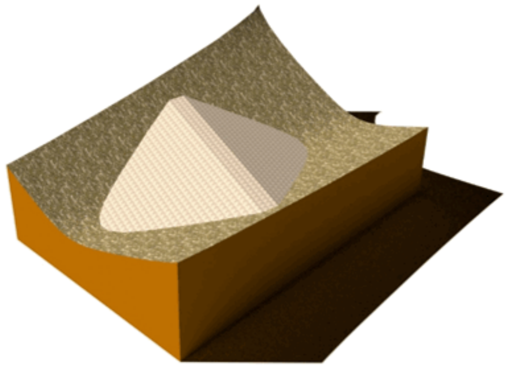


Figure 5. A three-dimensional model of this project drawing.

In conclusion, it can be said that the application of geometric modeling methods to the design process of hydrotechnical structures creates an opportunity to facilitate the solution of many current issues. The importance of using the recommended algorithms in the project of various district hydrotechnical structures will increase. Nowadays, CAD systems are widely used (CAD - we can consider it as an integral part of the automated design system, that is, design using digital methods and computer graphics systems).

The recommended methods are currently aimed at saving the designer's working time and help to choose the optimal option from among several options.

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