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The Status of the Study of the Interaction of the Adjustment Structures with the Water Flow in the River

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Abstract
In this article, the reasons for carrying out riverbed correction works in rivers with a changing course, the analysis of the results of scientific research carried out by foreign and our republican researchers on the issues of ensuring the stability of the corrected riverbed section are covered.

Keywords: River, channel, coast, protection, hydrotechnical structure, water speed, straightening structures, water intake without dam, spur, dam.

Introduction

In the period of increasing global water scarcity, in order to effectively use the existing fresh water resources, managing them with the help of reservoirs and large hydroelectric networks, protecting the river banks and straightening the riverbed are one of the main issues. Well-known researchers from the developed countries of the world: the USA, Australia, the Netherlands, Austria, Germany, China, Russia, Kazakhstan, Kyrgyzstan, Uzbekistan and other countries are dealing with the issue of water resources management and the study of problematic processes occurring in the river bed. They are focusing on carrying out scientific research on issues such as complex use of water resources, improvement of hydroelectric operation, management of processes taking place in the riverbed.

Methodology

In practice, constructions of various types are used to straighten the river bed or protect its banks. Until today, in technical literature and magazines, A.G. Averkiev [2], T.F. Avrova [3], S.T. Altunin [4], K.F. Artamonov [5], M.R. Bakiev [6], V.V. Balanin and V.M. Seleznyov [7], A.M. Latyshenkov [11], I.V. Lebedev [12], M.A. Mikhalev [14], A.I. Rakhmanov [16], G.B. Rurua [17], V.M. Seleznev [18], R.L. The analysis of scientific articles published by Street [20], [Tracy H. V., Carter R.W] and others shows that the use of transverse embankments built from local soil is the most effective way to straighten (protect) the coasts. As a result of straightening (protection) of the riverbed with transverse

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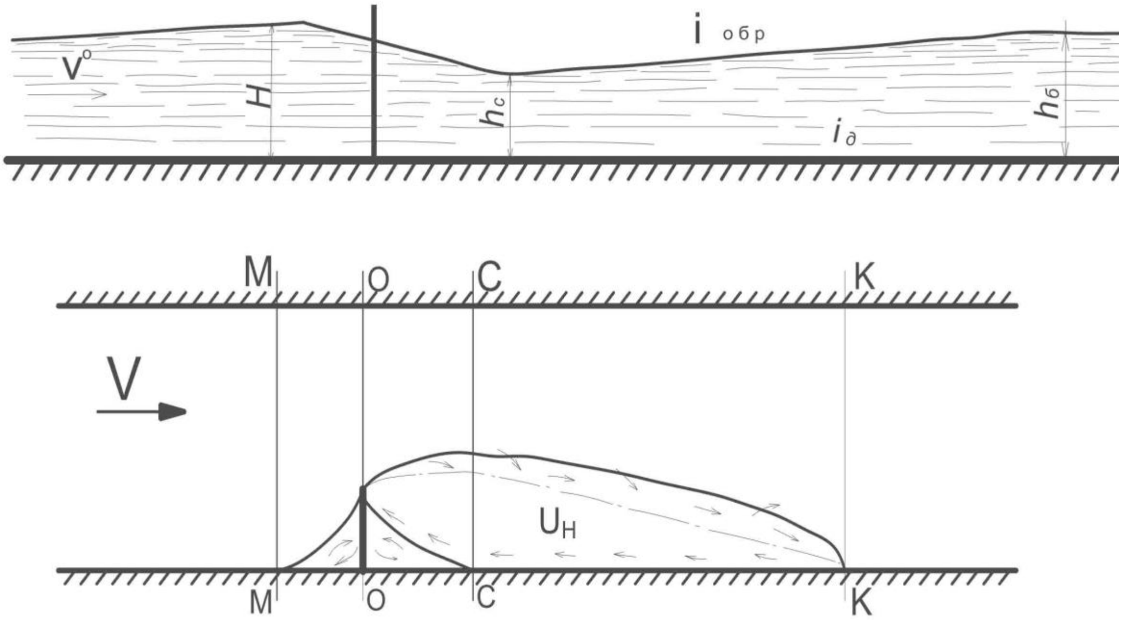
dams, the natural regime of flowing water changes, that is, zones of damping, compression and expansion are formed in the riverbed (See Figure 1.1):

1) damping zone (from the compression curve 0 - 0 to the limit of level rise M - M);

2) compression zone (from compression curve 0 - 0 to maximum compression limit C - C);

expansion zone (from the limit of maximum compression C - C to the end of the water pool formed in the lower part K - K).



1.1 - picture. Flow chart under the influence of a water-tight rectifier - protective structure

here M - M is the maximum level rise due to compression;

O - O - the compacted form of the riverbed;

C - C is the maximum compressible wall of the moving water level in the riverbed;

K - K - the wall that passes the compressed flow to the natural flow;

V - natural speed of water consumption in the riverbed, m / sec;

h_b - the depth of freely moving water in the riverbed, m;

h_c - C - depth of water consumption in the S wall, m;

H - the maximum water depth in the wetting zone, m;

I_d- is the natural slope of the river bed;

I_{obr}-is the reverse slope of the flow level in the zone of expansion;

U_n - reverse flow speed in the expansion zone, m / sec.

1. Humidification zone

In order to find out the features of the damping zone, the maximum value of damping formed on the upper surface of the bed (wall 0 - 0) compressed by the straightening (protective) structure (see Fig. 1.1) and its location (wall M - M), the length of the pile

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formed on the shore where the structure is located and there should be information representing the movement of the flow in the humidification zone. The problem of studying the properties of the damping zone caused by transverse structures: M.R. Bakiev [6], V.V. Balanin [7] , A.M. Latyshenkov [11], I.V. Lebedov [12], M.M. Ovchinnikov [15], V.M. Seleznev [18] , studied by foreign researchers: Street R.L [20], N. U. Tracy, R. W. Carter [21] and others. V.V. Balanin [7] experimentally studied the effect of the transverse protection (correction) structure on the flow and came to the general conclusion that the length of the upwelling zone depends on the bed compression coefficient (n) and the angle of installation of the structure (a0).

M.R. Bakiev [6], based on his experiments in laboratory conditions, proposed the following expression to determine the length of the humidification zone (Lk):

$$L_k = l_k + S, \qquad (1.1)$$

Here: S is the maximum rise from the start of the spur (M - M) to the spur
distance, its value is taken from the graph;
ℓ k - the distance affected by the rise.
To determine its value, M.R. Bakiev used the momentum equation.
M.M. Ovchinnikov [15]:
slope of the riverbed $i_d = 0.0045 \div 0.0015$;
Shezi coefficient C = 15 ÷ 30 m 0.5 / s;
ratio of normal depth of flow to critical depth
$h_0 \,/\, h_{кр} = 1{,}3 \div 2{,}3$;
Freud's number F r = 0.1 ÷ 0.42;
flow compression coefficient n = 0.2 ÷ 0.7;
semi-dammed installation angle $\alpha^0 = 30^0 \div 60^0$ conducted experiments on a river model with a threshold
As a result of his experiments, he proposed the following relationships for determining the parameters of the humidification zone:
a) the length of the rise curve: (see figure 1.2)

$$S\_k = (14 \ldots 16)(V - b0), \quad (1.2)$$

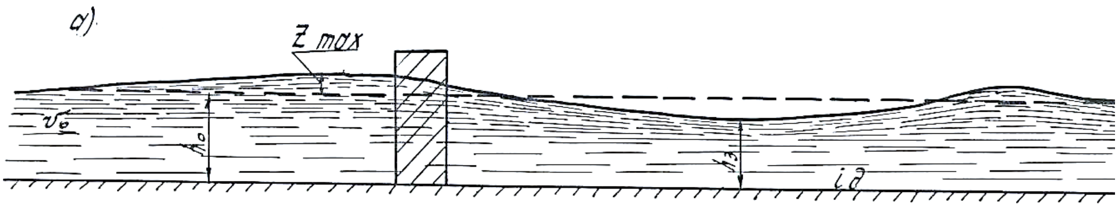
b) the distance from the beginning of the pole to the point of maximum lift (M - M):

$$S\_1 = (0.25 \ldots 0.3) V, \quad (1.3)$$

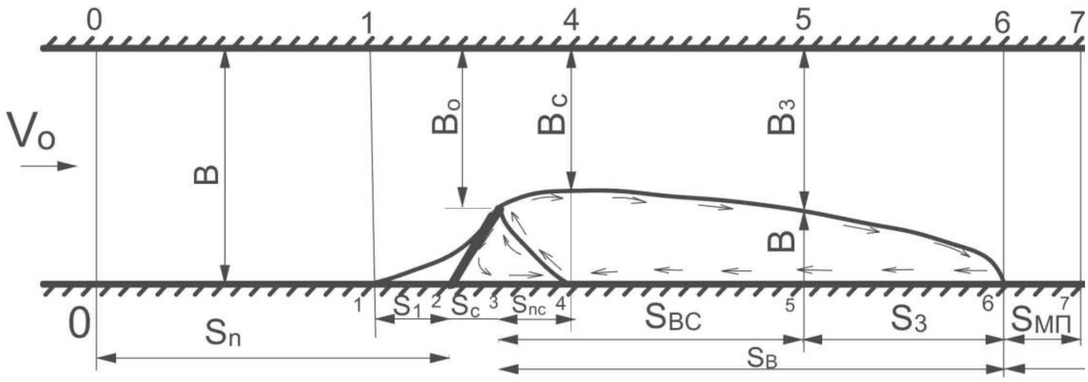
c) water depth in the wall with the maximum water level (M - M):

$$h\_1 = h_0 + Z_{max}, \quad (1.4)$$

where: $Z\_{max} = (1.03 \div 1.05) * (h\_2 - h_0)$ h_0 the depth of water in the compressed wall, its value is determined from the graph obtained as a result of the experiment.
M.M. The method proposed by Ovchinnikov can be used only when the conditions of the land on which the structure is built correspond to the experimental conditions.



б)



1.2 - picture. M. M. Calculation scheme according to the Ovchinnikov method: a) longitudinal section; b) plan.

where B_0 is the width of the river bed in the compressed form, m;
B_0 is the maximum moving water level in the river bed
width of the transit flow in the compressible stream, m;
B - the width of the river bed, m;
1; 2; 3; 4 ÷ 7 - streams where water flow characteristics are studied;
V_0 - the natural speed of water consumption in the river bed, m / sec;
h_0 - the depth of natural flowing water in the river bed, m;
hc - depth in the wall where the water level is maximally compressible, m;
Z_{max} is the additional pressure created in the damping zone, m;
I_d is the natural slope of the river bed;
S is the distance between characteristic beams, m.

In order to determine the amount of moisture that occurs above when the riverbed is compressed by a dam for the purpose of building a bridge, A.M. Latyshenkov [11] proposed the following expression:

Z_k = D 1. a Vc 2 / 2g , (1.5)

where: D1 is the coefficient taking into account the shape of the velocity profile in the narrow section, its value is determined by the following expression:

$$D_1 = 2\delta * (1 + \tau - \frac{\tau}{\tau_0})$$

Here:: $\delta = Q_{closed} / Q$; $\tau = Q_{riverbed} / Q$; $\alpha = V_{poyma} / V_{riverbed}$

Q Q is closed; Q uzan - respectively, from the complete, closed part
flowing and flowing water;
Vs; Vp; $V_{riverbed}$ - correspondingly narrow section; in the race
and the velocity of the water in the bed.

Using the expression (1.5), it is possible to determine the state of change of the velocity in the narrow section of the riverbed.

2. Compression zone

2.1. Level changes due to flow compression.

The movement of compressed flow using an obstacle (peremychka, spur, dam, etc.) T.F. Avrova [3], M.R. Bakiev [6], A.M. Latyshenkov [11]; I.V. Lebedev [12]; M.M.

Ovchinnikov [15]; Covered in the scientific works of R. L. Street [20] and others.

M.M. Ovchinnikov [15] proposed analytical and graphical expressions for calculating the changes in depth and plane of the flow compressed by a half-jet. Based on his experiments in laboratory conditions, he came to the conclusion that the maximum values of the depth and width of the flow are not located in the same column.

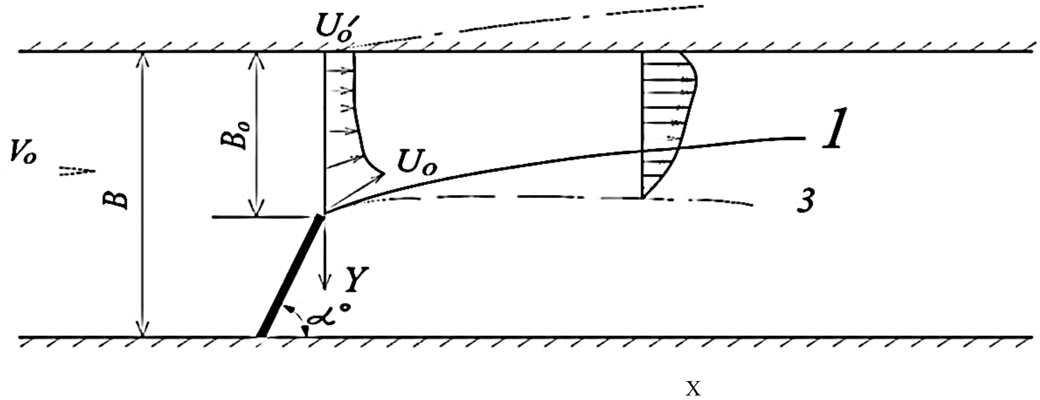
M.R. Bakiev [6] states that the location of the maximum values of depth and width compression depends on the compression coefficient - n and the Froude number - Fr. According to the author, when n ≤ 0.35 and Fr b ≤ 0.35, compression bars overlap, if n > 0.35 and Fr b > 0.35, the bars do not overlap, that is, the maximum compression in depth is the maximum in width located below the compression curve.

T.F. Avrova [3] in order to determine the coefficient of compression that occurs under the effect of a waterproof spur from Peremychka and its body; M.R. Bakiev [6]; A.M. Latyshenkov [11]; I.I. Levy [13]; Extensive experiments were conducted by I.V. Lebedov [12]. The problem of determining the amount of the maximum depth of compression (wall S - S) in the compression zone I.V. It was solved by Lebedev [12]. The issue of longitudinal and transverse changes in pressure in the compression zone T.F. Avrova [3]; M.R. Covered in articles published by Bakiev [6].

2.2. Calculation and plotting of the flow velocity field.

The construction of the speed field is the main issue in the design of adjustment (protection) structures. By knowing the current velocity field, we will be able to predict and take measures against possible washouts in the river bed and banks. T.F. Avrova [3] ; M.R. Bakiev [6] ; V.V. Balanin [7]; M.A. Mikhalyev [14]; V.M. Seleznov [18] and other researchers were involved.

V.V. Balanin [7] suggests building the velocity field in the following sequence, starting with compression (see Fig. 1.3):



1.3 - picture. The scheme for calculating the speed in the compressed zone (V.V. Balanin)

here B- the natural width of the riverbed, m;

B_0 - the width of the riverbed in compressed form, m;

U_0 - the natural speed of water consumption in the river bed, m / sec

1; 3 – trajectory of characteristic currents;

X:U – coordinate axes;

α^0 - the angle of the spur in the plan, in degrees.

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a) U_0 and U_0^1 speed (the speed at the head of the spur and the opposite bank, respectively), their value is determined based on the condition of passing an ideal flat liquid through the barrier;
b) the amount of vertical speed is determined using the following expression:

$$U = V_0\sqrt{C + y^2\alpha} \ , \qquad (1.7)$$

Here: U - average vertical speed;
V_0 - 0 - 0 is the average speed of the flow in the wall;
y - ordinate of the calculated point;
C and α are experimental parameters, their value is determined based on the following threshold values:

$y = 0; \quad y = a;$

c) the direction of the velocity in the initial section is taken as the direction of the flat potential flow.
V.V. Professor I.M. Balanin [7] used Professor I.M. By expressing the initial velocity in the equation (1.7) proposed by Kanovalov, he obtained the following equation:

$$U^2 = V_0^2 / 2 \{[C + 2d\gamma_1^2 x^2 + y^2 d][\Psi(a-y / 2\gamma_1 x) + \Psi(a + y / 2\gamma_1 x)] - 2d\gamma_1 x / \sqrt{\pi}\ [(a+y)e^{-(a-y)2/4\gamma_1 x} + (a-y)e^{-(a-y)2/4\gamma_1 x}]\}, \qquad (1.8)$$

Here: a is the half-width of the flow tube (stuey) in the compression curve;
$\gamma_1 = (0{,}0351 \ \dots\ 0{,}0469)$ - experience coefficients;
$\Psi(a \pm y / 2\gamma_1 x)$ - Cramp function.
Although it is possible to determine the speed value using the expression (1.8), its direction cannot be determined.
T.F. Avrova [3] experimentally studied the compressed flow with a "peremychka" and divided the flow in the compression zone into less affected zone (core), high turbulent flow and reverse flow zones.
Based on his experimental studies, the author proposes the following expressions for the construction of speed curves in characteristic zones:
a) for the velocity field in the less affected zone

$$U_{ya} = \sqrt{U_{min}^2 + (\frac{y}{b_{ya}})^2 * (U_{max}^2 + U_{min}^2)} \ , \qquad (1.9)$$

here: U_{min} is the minimum speed on the opposite bank;
U_{max} is the maximum speed at the boundary of the core and turbulent flow;
b_{ya} - less affected zone (core) width;
y - U_{ya} ordinate of the point being determined.
To determine the value of U_{max} and U_{min}, T.F. Links in graphical form are offered by Avrova.
b) the relationship proposed by Schlichting – Abramovich [1] for the velocity field in the turbulent flow zone:

$$(U - U_t)/(U_{tmax} - U_t) = (1 - \eta^{3/2})^2, \qquad (1.10)$$

Here: U- speed at a point located in the turbulent flow zone;
U_T - reverse flow rate;
$\eta = (y - y_1)/B$ - U speed is relative to the point being determined ordinate;
y_1-the coordinate of the inner boundary of the turbulent flow zone;

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B- the width of the turbulent flow zone.

Although the expression (1.10) makes it possible to accurately calculate the value of the velocities in the less affected zone (in the core), it cannot be used to determine the flow direction. Also T.F. The method proposed by Avrova is solved by successive approximation.

M.R. Bakiev [6], T.F. Avrova [3] proposes the following graph, which determines the direction angle of the velocity vector in the less affected zone (core), based on his experiments in order to improve the method proposed by [3]:

$$U_{max} cos\varphi_{ўрт}/U_{\max c} = f(x/L_{cc}), \quad (1.11)$$

Then the author brings the expression (1.9) into the following form, taking into account that the value of the direction angle of the velocity vector can be determined from the graph:

$$U_{я} = \sqrt{U_{min}^2 + (\frac{y}{b_{я}})^2 * \left[(U_{max} cos\varphi_{ўрт})^2 - U_{min}^2\right]}, \quad (1.12)$$

M.R. Bakiev's proposed expression (1.12) allows for direct construction of the flow velocity plan in the compressed zone.

3. Expansion zone

When calculating the expansion zone of a stream compressed by a transverse dam (spur), the following issues should be covered:

a) calculation of the velocity field and construction of the flow plan;

b) determining the length of the pile (vortex).

The founder of the construction of the flow plan of the water moving in the river K.M. Bernadsky is. Because K.M. Bernadsky was the first to propose a theoretical method for constructing a free flow plan. Later K.M. Bernadsky method I.I. Developed by Levy [13]. I.I. In the process of studying Levy flow, K.M. Although he used the Bernadsky scheme, he took into account the turbulent pressure in the flow tubes, which affects the flow characteristics, in his scientific research. I.I. Levi's idea I.V. Lebedev [12], Mikhalev M.A. [14] and other researchers' scientific works.

Later I.I. Levy used the equation of motion of the flow proposed by Reichard to construct the flow plan.

Movement characteristics of flow tubes passing through a channel compressed by means of a limited width or a straightening (protective) structure G.N. Abramovich [1], V.V. Balanin [7], M.R. Bakiev [6], I.M. Konovalov [9], T.D. Kumina [10], M.A. Mikhalev [14]; A.N. Rakhmanov [16]; A.V. It was studied by Slautina [19] and other researchers.

M.A. Mikhalev [14] succeeded in constructing a flow field representing the average values of the flow using the method of integral relations to illuminate the complex tubular flow caused by the protection structure. Also, this case I.V. It was also studied by Lebedev [12], and the results obtained by them allow to determine the parameters of the turbulent flow in the sharply widened part of the riverbed.

After we determine the hydraulic parameters of the compressed flow, it is an important issue to determine the value of the washing depth that can occur in the head of the rectifier (protective) structure. Today, when determining the depth of washing that occurs in the main part of the rectifier (protective) structure in our country, taking into account the technical parameters and flow characteristics of the planned structure, taking into account the composition of the ground in the riverbed and the saturation of the water flowing in the riverbed with turbidity, O.A. The calculation method proposed by Kayumov [8] is widely used. O.A. The calculation method proposed by Kayumov [8] is widely used. O.A. Kayumov proposed the following expression to determine the maximum value of the washing depth formed at the head of the dam (spur):

$$H_{max} = 10{,}4 \cdot \frac{(\sin\varphi)^{0,25} \cdot (\cos\theta)^{0,5} \cdot h\,Fr^{0.5}}{n\,\xi^{0,17}_{85\%}\,(1 + 0{,}09\rho)\,(1 + 1{,}35\,Fr)^{1,5}}, \qquad (1.16)$$

here φ - building location angle;

θ - the angle of inclination of the embankment;

n - flow compression coefficient;

$\xi = d_{85} / d_{50}$ - soil diversity coefficient;

ρ - the amount of turbidity of the stream;

Fr - Fruda number.

Summary

Well-known researchers from the developed countries of the world are dealing with the issue of water resources management and the study of problematic processes occurring in the river bed. They are conducting scientific research on issues such as the complex use of water resources, improvement of the operation of hydroelectric power stations, and management of processes occurring in the river bed. The analysis of the scientific works presented in this article shows that, despite the fact that the results of the study of the interaction of the river bank protection-rectification structures (dam, spur, peremichka, etc.) with the water flow in the riverbed are being effectively used by many researchers, even today water from the rivers without dams the issue of improving the constructions and calculation methods of the alignment structures used in obtaining has not lost its importance.

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