Coefficient roughness of the riverbeds in conditions of regulated water flow

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Abstract. In article results change of coefficients of roughness riverbeds for conditions of regulated water streams for the river Amudarya are resulted. In the bottom of Amudarya current abounding in water years during the period from the beginning of operation Tahiatash and Tuyamuyun hydrounits to present time have been chosen and for each chosen year on the basis of correlation connections the analysis change of factor of a roughness is carried out.

1 Introduction

In conditions regulated a water flow below a dam there is a sharp change of a hydrological mode of a stream. The main change consists in drain alignment, i.e. the high water detained in a water basin is cut off, and dumps from the bottom lead to increase high-water flows. The flow of sediments sharply decreases. Thanks to it in downstream the smaller quantity of sediments arrives, than has arrived before water basin creation. Because, lowering of water discharge and water levels in a water basin flooding water meadow considerably decreases. If in water meadow there were beds it will lead to their dying off and transition of a river bed from multi-arm bed to single-arm bed; the bed from wandering becomes meandering forms of river. We limit a meandering and bed regulation by bilateral longitudinal dams.

2 Objects and methods of research

Because of long passage low-water flow within a year, the general width regulated river beds is divided on two parts. To the first part, the width of a bed where the stream current passes constantly concerns, the second part there, where the width of a bed works periodically, only during high water passage. On that parts, where the width of a bed works only during a high water, there is a shallowing, overgrowing vegetation and the consequence to it increase in a roughness characterizing resistance of a river bed. Division of width regulated riverbeds on constantly and periodically working parts leads to formation of a non-uniform roughness of a bottom on riverbed perimeters.

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3 Discussion of the results

In the presence of a non-uniform roughness on perimeters of a bed the coefficient of a roughness in the regulated river beds is established under the formula [1]:

$$n = \frac{B_{cons} \cdot n_{cons} + B_{per} \cdot n_{per}}{B_{cons} + B_{per}} \quad (1)$$

Where: B_{cons}, n_{cons} - width and coefficient of a roughness of constantly working part of a river beds;

B_{per}, n_{per} - width and coefficient of a roughness of periodically working part of a river beds;

Value of coefficient of a roughness for periodically working part of a river beds can be established on existing literary data [1, 2, 3].

Other values B_{cons}, B_{per} and n_{cons} were established on the basis of the analysis information of the given rivers of Amu Darya below the Tuyamuyun water basin.

As has shown the analysis of planned space pictures, the width of constantly working part on a rectilinear site of a bed made 0,4 - 0,6 and on a curvilinear site 0,2 - 0,4 from full width of a bed (Figure 1).

Studying of coefficient of a roughness of a river bed in conditions regulated a water flow was spent according to the bottom current of the river of Amu Darya. On the river Amu Darya in the bottom current in 1974 on 215 km above from the former mouth of the river the Tahiatash hydroknot is constructed and on 450 km from a mouth the Tuyamuyun water basin is constructed. Building of these objects has led to river bed rearrangement, sedimentation of deposits and bottom lifting in upstream, to washout and bottom decrease in downstream.

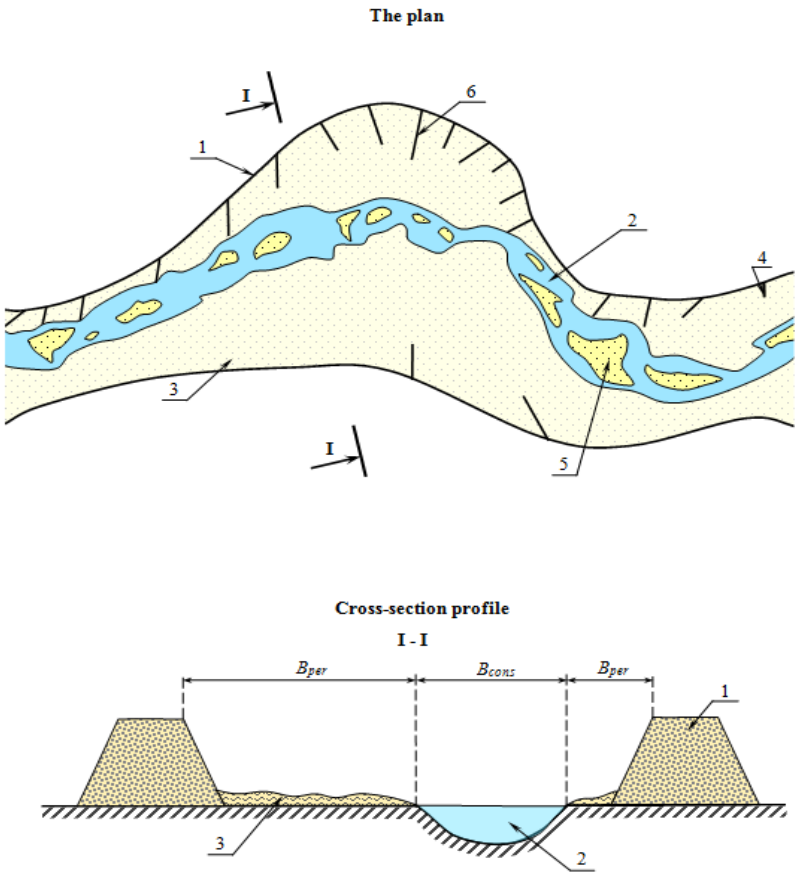

Fig. 1. The plan and cross-section profile regulated a site of bed of the river Amu Darya.
1- longitudinal dam; 2- constantly working part of a channel; 3- periodically working part of a bed; 4- spur; 5- island; 6- cross-section dam.

For the analysis of coefficient of a roughness the given hydrometeorological stations, the river of Amu Darya being in the bottom current have been used. Such stations in the bottom current five.

Station Tuyamuyun is located on 1,7 km below a dam and concerns a site of the general washout;

Station Kipchak on 185 km below the Tuyamuyun dam also is in a zone of the pontoon bridge and characterizes a mode of the constrained current of a stream;

Station Nietboytas is located on 230 km below the Tuyamuyun water basin and on 12 km above Tahiatash hydroknot and characterizes a mode of a retaining current of a stream;

Station Samanboy is on 17 km below Tahiatash hydroknot and on a site of the general washout. Station Samanboy is under the influence of two objects of Tuyamuyun and Tahiatash hydroknots;

Station Kiziljar is located on 105 km below Tahiatash hydroknot and characterizes a mode of a free current of a stream.

For the analysis of coefficient of a roughness data of years of the river of Amu Darya abounding in water after commissioning of the Tuyamuyun water basin have been used, i.e. data 1988, 1992, 1998, 2005 and 2010 years.

In years abounding in water there is more intensive river bed process and interaction of a bed of water and a river channel is actively shown.

On the hydrological given rivers of Amu Darya values of coefficient of a roughness with use of the formula received from formula Shezi-Manninga in a kind have been established:

$$n = \frac{\omega \cdot H^{2/3} \cdot i^{0.5}}{Q} = \frac{H^{2/3} \cdot i^{1/2}}{V} \quad (2)$$

Where n - coefficient of a roughness of a bed;
ω - area of water section of a bed, m^2;
H - depth of a stream, m;
i - water surface slope;
Q - water discharge in the rivers, m^3/sec;
V - velocity of a stream, m/sec.

Using the formula (2) values *"n"* for each measured discharge of water have been established and the constructed graphics of connection *n=f(Q)* for each year separately on all hydroposts of the bottom current of the river of Amu Darya: Tuyamuyun, Kipchak, Nietboytas, Samanboy and Kiziljar. In total 25 graphics of connection of coefficient of a roughness with the discharge of water have been constructed. On the basis of the received graphic dependences in the table empirical dependences for definition coefficient of a roughness are resulted.

Table 1. Graphic connection of coefficient of a roughness with the discharge of water in the river of Amu Darya for the bottom current on years for hydrological stations.

Years	Hydrological posts				
	Tuyamuyun	Kipchak	Nietboytas	Samanboy	Kiziljar
1988	$n = 0.026Q^{-4E-0.5Q}$	$n = 0.12\ Q^{-0.24}$	$n = 0.35\ Q^{-0.43}$	$n = 0.27\ Q^{-0.44}$	$n = 0.14\ Q^{-0.37}$
1992	$n = 0.008Q^{0.17}$	$n = 2E\text{-}0.93Q^2\text{-}9E\text{-}0.6Q$	$n = 0.19\ Q^{-0.29}$	$n = 0.21\ Q^{-0.33}$	$n = 0.11\ Q^{-0.32}$
1998	$n = 0.024Q^{0.03}$	n =-0.011 LnQ+0.1	$n = 0.43\ Q^{-0.45}$	$n = 0.47\ Q^{-0.48}$	$n = 0.17\ Q^{-0.35}$
2005	$n = 0.063Q^{-0.10}$	$n = 0.15Q^{-0.24}$	$n = 1.59\ Q^{-0.63}$	$n = 0.2\ Q^{-0.34}$	$n = 0.22\ Q^{-0.39}$
2010		n =-0.001 LnQ+0.048		n =–0.011 LnQ+0.032	$n = 0.074Q^{-0.24}$

The analysis of graphic connection on alignment Tuyamuyun has shown the following.

Connection between *"n"* and *"Q"* is absent. In 1992 year the roughness varied 0,016 - 0,035. This year growth of coefficient of a roughness connected with growth of the discharge of water was observed. In 1998 year of change of coefficient of a roughness made 0,018 - 0,058, connection between *"n"* and *"Q"* very weak. In 2005 year it was traced satisfactory connection between *"n"* and *"Q"*. The roughness coefficient changed from 0,026 to 0,04. To growth of the discharge of water there was a reduction of coefficient of a roughness. In 2010 year connection between *"n"* and *"Q"* has improved in comparison with 2005 year.

On alignment Tuyamuyun presence of unsatisfactory connection in 1988, 1992 and 1998 years are connected with occurring riverbed to processes and in the form of the general washout. Since 2005 riverbed process more - is less stabilized on years and the close connection between *"n"* and *"Q"* begins to be marked more.

On alignment Kipchak on connection graphics *n=f(Q)* unlike Tuyamuyun the tendency of decrease of coefficient of a roughness with growth of the discharge of water in the river was observed. The greatest values of coefficient of a roughness are traced at the minimum discharge of water, and the least values - at the maximum discharge of water. In 1988 year in connection *n=f(Q)* the least values of coefficient of correlation were observed. The next years connection *n=f(Q)* has improved and value of coefficient of correlation has increased to 0,6. As a whole, connection *n=f(Q)* the weak. Negative impact makes on connection

improvement presence of the pontoon bridge in the measurement alignment, making narrowing of width of a bed and a current of the stream occurring in the constrained kind.

In alignments Nietboytas, Samanboy and Kiziljar, values of coefficient of a roughness made from 0,01 to 0,1. The maximum value of coefficient of a roughness in these alignments is observed at the minimum discharge of water in the river, minimum values of coefficient of a roughness at the maximum value of the discharge of water in the rivers. The maximum discharge of water made 2700 m^3/sec.

Connection between coefficient of a roughness and the water discharge in the river for the subsequent three alignments - Nietboytas, Samanboy and Kiziljar has the following appearance:

$$n_{cons} = \frac{K}{Q^y} \tag{3}$$

Where K - proportionality coefficient;
y - exponent.

The coefficient correlation in the formula (3) fluctuates from 0,8 to 0,95. Value K and y on years are presented in the table. According to the table K=0,06-0,45; y=0,25-0,43.

Connection of coefficient of proportionality with an exponent is presented in Picture 2. In Picture 2 values K and y received by T. Juraev [4] for conditions of a household (natural) condition of the river of Amu Darya also are put. The point arrangement on the graphics shows, that in conditions regulated a flow of water after achievement stabilization river beds process of value of coefficient of proportionality and an exponent come nearer to values of a household condition.

Thus, it is possible to notice, that at achievement stabilization river beds process in conditions regulated a water flow and the bed roughness corresponds to a roughness household a river condition.

Apparently from Picture 2, connection between K and y good, has linear character. To exponent growth there is also a growth of coefficient of proportionality.

On the basis of the graphics of connaction of a following kind is received:

$$K = 1.25 \cdot y - 0.37 \tag{4}$$

Under the formula (4) having set value y from 0,25 to 0,47, it is possible to establish value of coefficient of proportionality (K) to the formula (3). Dependence (3) characterizes connection of coefficient of a roughness with the water discharge in the river, it is recommended to use for hydraulic calculation of the river beds at designing of hydraulic engineering constructions on the rivers and throughput estimation in conditions regulated beds of the river of Amu Darya.

4 Conclusions

In summary it is possible to note the following:

The analysis of coefficient of a roughness of a bed of the river in conditions regulated a water flow has shown, that value of coefficient depends on a course bed process in the river. On a site where occurs intensive riverbed process in the form of the general washout, the roughness coefficient fluctuates in the considerable degrees and has unstable character. On a river site, where riverbed process stable, the roughness coefficient also remains stable and has steady character and changes in insignificant degree.

It is necessary to notice also, that the minimum value of coefficient of a roughness in the bed of the river of Amu Darya equally n =0,010, and standard value on “building regulations (СНиП 11.54.74)” for the similar rivers equally n =0,025, i.e. in 2,5 times exceeds actual

value on the river to Amu Darya. Small sediments smooth ledges of a roughness of a bed, and lead to reduction of value of coefficient of a roughness.

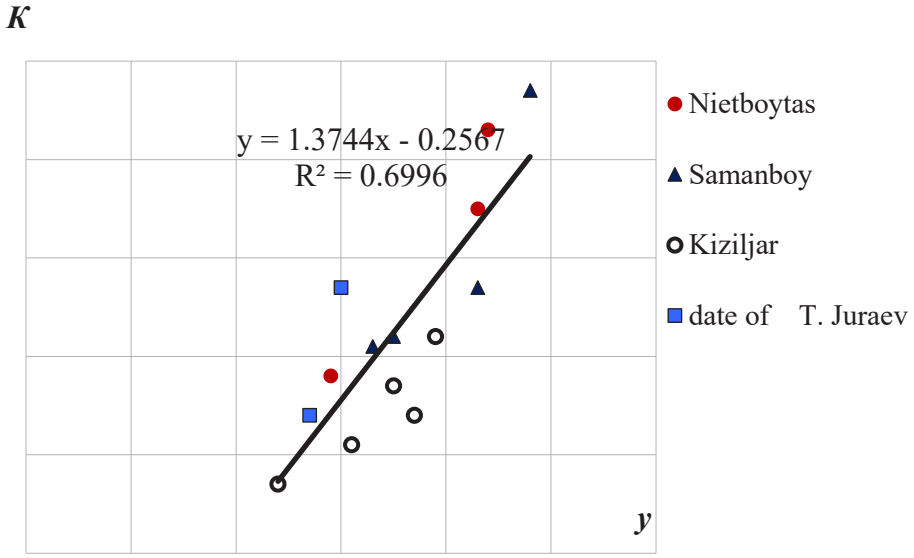

Fig. 2. The graphic of connection *K=f (y)* in the formula 2.

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