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To cite this article: A Fatxulloyev *et al* 2020 *IOP Conf. Ser.: Earth Environ. Sci.* **614** 012054

IOP Conf. Series: Earth and Environmental Science **614** (2020) 012054 doi:10.1088/1755-1315/614/1/012054

Study of hydraulic parameters for concreting channels

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Abstract. Irrigation channels plays particular importance role to provide water for irrigated areas. In recent years, the irrigation channels of Central Asia have been negatively affected by deformation phenomena. As a result, their hydraulic parameters changed and their throughput decreased. The results of recent studies in the field of the phenomena of deformations in open and in the planning of irrigation channels show that a lot of work has been completed. Ensuring the static and dynamic stability of the channels, increasing the efficiency of the channels currently require to cover the channels with concrete cladding. A high cost of covering the channels with concrete cladding brings reveals the problems in these works. The best solution is to reduce concrete consumption. The article proposes a method for projecting a concrete channel from the condition of a hydraulically most advantageous section. According to the proposed method, the consumption of concrete mixture is reduced by 36% and increased the dynamic stability of the channel (when assessing the nanotransport ability of the channel) is increased by 26%. The rehabilitee of research results are confirmed by the formulas used in practice.

1. Introduction

More than 180 thousand km of irrigation channels which takes water from big rivers (as Amudarya, Syrdarya, Zerafshan et all.) are services for ensuring with water 3.2 million hectares of irrigated land and people in other sectors of water supply in our Republic. These main channels are Katta Fergana, Bozsuv, Tashkent, Parkent, South Mirzachul, Dustlik, Amu Bukhara, Mirishkor, Karshi, Karakum and Shovot [1, 2]. Most of these channels were built in the 20th century and serve to supply water to irrigated areas. The Big Fergana Channel is the largest irrigation network in the Fergana Valley. It receives water from the Narin, Qaradarya and Sokh rivers. The South Mirzachul channel was built in 1957-1962 and receives water from the Syrdarya River. The Dustlik Channel was built in 1895-1941 and receives water from the Syrdarya River. The Karshi main channel was built in 1965-1973 and receives water from the Amudarya River. The Bozsuv and Tashkent channels takes water from the Chirchik River and brings it to the fields [1, 2]. More than 88 percent of these channels were consist of soil bed, which allows high filtration losses, result of it 40 per cent of the water loses in the system, the required amount of water to the crop fields do not comes to the field [3]. Today, one of the main problems is lack of water during the vegetation period. As a result, irrigation works are delayed and yields are significantly reduced. To prevent such problems in the country prepared Government

Program for reconstructing irrigation systems, and provides concrete works for transferring soil bed channels. Covering soil channels with concrete coatings is a complex process and requires a big amount of money.

Scientists have conducted scientific research at various times to substantiate and construct hydraulic parameters in the projecting of ground bed channels. These include number of other scientists as examples R.Chugaev, S.Mirtskhulava, A.Cherkasov, B.Bakhmetev, A.Karaushev and et al [4-9].

About sediment transportation property of the channel E.Zamarin, S.Abalyans, K.Latipov, A.Arifjanov and other scientists provided many scientifically researches and gave their recommendations [10-13].

In order to ensure the hydraulic durability of the channel were proposed formulas by S.Girshkan for calculation bottom of cross section width of the exposed ground bed channel [14]. The formulas proposed by S.Girshkan are used in the projection of ground bed channels. However, the projection and construction of self-concreting channels on the basis of these formulas leads to an increase in costs. This is because, based on the projections, and chooses the geometric sizes of the channels are much longer, which leads to an increase in the amount of raw materials consume in the concrete.

Explanation of hydraulic parameters in projection of concrete channels is requires important attention. This is because, in addition to justifying the hydraulic parameters, it will be possible to project and build dynamically robust and economical effective sections.

2. Methods and Materials

Common methods of hydraulics used in the researches, in particular, field research, mathematical analysis, and a comparative analysis of existing computational methods.

Irrigation channels K-1-1 and K-2-5 in Khavas district of Syrdarya region were selected as the object of research. The K-1-1 irrigation channel was built in 1985 on the basis of project parameters (Table 1) (Figure 1). However, by now the project parameters of the channel have completely changed. Over the years, under the influence of water flow, washing processes have taken place in the channel bed. As a result, the bottom of the channel bed decreased 0.75 m and the water level decreased to 0.70 m. This situation is causing a number of problems. An example of this one can take construction of the channel water intake. Because, as a result of a decrease in the water level in the channel, to create enough pressure to get water to the irrigation started using of pumps. The use of pumps requires additional electricity and financial costs.

Table 1. Project parameters of irrigation channel

H.P / *Name*	*Q, m^3/s*	*b, m*	*m*	*h, m*	*ω, m^2*	*i*	*ϑ, m/s*
K-1-1	20	7	1,3	1,5	13,50	0,001	1,55
K-2-5	10	6	1,3	1,2	9,00	0,0004	0,80

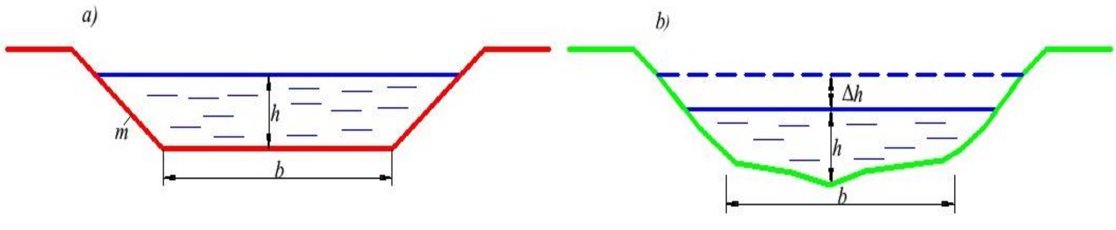

Figure 1. Cross section of K-1-1 irrigation channel (*a) project, b) existing)*

K-2-5 irrigation channel was built in 1982 on the basis of the following project parameters (Table 1). However, to date, the deformation process has occurred as a result of the turbidity of the canal bed,

IOP Conf. Series: Earth and Environmental Science **614** (2020) 012054 doi:10.1088/1755-1315/614/1/012054

which has reduced the cross-sectional area of the channel, resulting in a decrease in water discharge Q=6 m^3/s. This situation creates a problem of water shortage in irrigation.

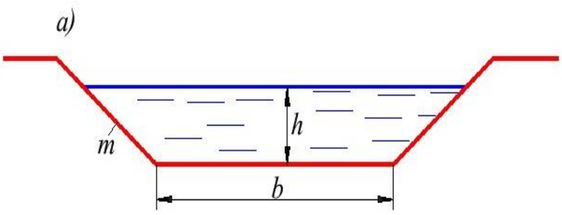

Figure 2. Cross section of K-2-5 irrigation channel *(a) project, b) existing)*

As a solution to the problems mentioned above, recommends concreting the channel. While concreting the canal bed ensures its priority, and prevents from being wasted the amount of water for filtration.
Currently, the section of the channels is built mainly in the form of a trapezoid. Based on the hydraulic elements of trapezoidal channels (Figure 3), the water discharge is often determined using the Shezi formula based on the design (or existing) parameters of the channels [15, 16]. Projection of the channels under the most convenient hydraulic section of the irrigation channel drastically reduces the consumption of construction materials and ensures the dynamic strength of the channel.
For assessing hydraulic elements of the cross section of irrigation channel used the following Shezi formula for mathematical analysis.

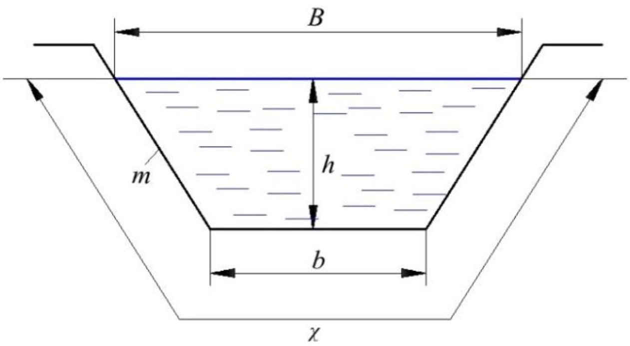

Figure 3. Cross section of trapezoidal channel: b - is the width of the bottom of the channel, B - is the width of the free surface of the water in the channel, h- is the depth of the water flow in the channel, m - is the slope coefficient of the river bank

$$\vartheta = C\sqrt{Ri} = \frac{\sqrt{i}}{n} R^{2/3} \tag{1}$$

$$\vartheta_{\max} \Rightarrow \begin{cases} i = const \\ n = const \end{cases} \Rightarrow R_{\max}$$

$$R = \frac{\omega}{\chi} \Rightarrow \begin{cases} \omega = const \\ \chi \neq const \end{cases} \Rightarrow R_{\max} = \frac{\omega}{\chi_{\min}}$$

According to this analysis, in order for irrigation channels to be hydraulically most convenient, the perimeter of wetting must be kept to a minimum in the condition of without changing the channel surface unit. This in turn allows minimizing the amount of used concrete in construction. The following is the minimum condition of the wetting perimeter (for a trapezoidal channel):

$$\chi = b + 2h\sqrt{1 + m^2} \tag{2}$$

in order to reduce the variables, we use the condition of invariance of the surface unit:

$$\chi = \frac{\omega}{h} - mh + 2h\sqrt{1+m^2} \tag{3}$$

for the equation to reach the minimum value, we obtain the first-order product from the equation on the variable (h) and set it to zero:

$$\frac{d\chi}{dh} = 0$$

$$\frac{d\left(\frac{\omega}{h} - mh + 2h\sqrt{1+m^2}\right)}{dh} = 0$$

$$-\frac{\omega}{h^2} - m + 2\sqrt{1+m^2} = 0 \rightarrow \frac{bh + mh^2}{h^2} - m + 2\sqrt{1+m^2} = 0$$

as a result, we obtained the following equation that satisfies the minimum condition of the wetting perimeter for the channel cross-section variables:

$$\frac{b}{h} = 2\left(\sqrt{1+m^2} - m\right) \tag{4}$$

It is possible to construct and project cross section of trapezoid-shaped channel in several sizes. In the hydraulic calculation, the concept of the relative width of the channel (the ratio of the width of the channel bottom to the depth of the water in it) is used and is written as follows:

$$\beta = \frac{b}{h} \rightarrow \beta = 2\left(\sqrt{1+m^2} - m\right) \tag{5}$$

Based on this (5) connection, the water consumption equation for a concreted irrigation canal will look like such:

$$Q = 0.63\frac{\sqrt{i}}{n}(\beta + m)h^{8/3} \tag{6}$$

the coefficient of roughness in concreted channels is n=0,012-0,015

$$Q = 45 \cdot \sqrt{i} \cdot (\beta + m)h^{8/3} \tag{7}$$

Based on equation (5) above, the width of the bottom of the most convenient hydraulic irrigation channel is determined as follows:

$$b_d = 2h\left(\sqrt{1+m^2} - m\right) \tag{8}$$

Based on the above equation channel concrete, construction work and conduct may cause some inconveniences. Because, in this case the channel breadth and the depth of the relatively small size of the exposed testified. In order to improve the existing formula, research was conducted during the construction of concrete channels. According to the results of the study, the coefficient of convenience in construction was determined. Together with coefficient of convenience in construction and most hydraulic comfortable width of the channel, we recommend the following formula:

$$b_{d.m} = b_d \cdot k \tag{9}$$

there: $k = 1{,}2 \div 1{,}3$ coefficient of convenience in construction.

The hydraulic parameters of the concrete channels are fully compatible with the most favorable cutting conditions of the hydraulics. Most hydraulic convenient cut - it allows to transfer the maximum water discharge in the existing surface unit. As a result, water comes the crop fields in a short time through these channels [17].

3. Results and Discussions

We examine the cost-effectiveness of the concrete raw material used in the K-2-5 channel, projected on the basis of the method proposed above (9). In this case, in determining the width of the bottom of the irrigation channel, S.Grishkan proposed by the formula (10) and concrete, allowing channels projected read the proposed formula (9) (improved), calculated using work.
With using S.Girshkan formula width of the channel bottom calculated following.

$$b_{G.M.} = 1{,}5 \cdot Q^{2/3} \tag{10}$$

there: Q=10 m^3/s, water discharge of channel.

We perform the calculations in the table.

Table 2. Comparative table of irrigation channel concreting costs

Projection method	Water discharge	Slope of the channel	Flow depth	The width of the channel bottom	Perimeter of application	Concrete thickness	Consumed for 1 pagonameter concrete volume	The total amount of money spent on 1 pagonameter of concrete	Money to be economized	Economic efficiency
Irrigation channel parameters	*Q, m^3/s*	*i*	*h, m*	*b, m*	*χ, m*	*t, m*	*W, m^3*	*dollars*	*dollars*	*%*
S.Girshkan	*10*	*0.0004*	*1.0*	*7*	*9.83*	*0.15*	*1.61*	*102*	*27*	*36*
Recommended (Improved)	*10*	*0.0004*	*1.8*	*2*	*6.95*	*0.15*	*1.18*	*75*		

When using S.Girshkan formula for concrete channels projection were chosen channel width 7 m, the current depth of 1 m, when using created formula (improved) concreting requires width of 2 meters, the depth of 1.8 meters (Figure 4).
According to the results of the calculation, using the proposed method, to the projection and constructing concrete irrigation channels, it is possible to save up to 36% of concrete raw materials and 27 dollars of money spent.

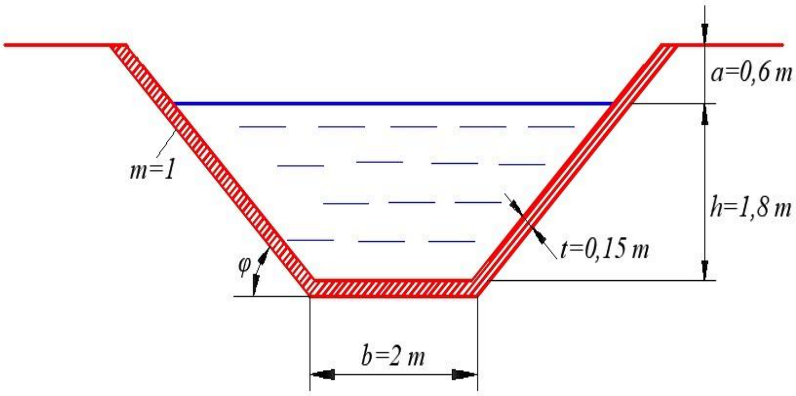

Figure 4. Cross-section of a concrete irrigation channel designed using the recommended method

In order to determine the dynamic strength of the evaporation channel using the proposed method, was determined transport capacity of the flow. Calculations were performed on the channels which projected in both methods, for comparison. In calculations, used A.Arifjanov formula for determine the ability of transportation of the flow [18, 19].

Table 3. Table for determining the transportation possibility of the flow

Project method	Flow velocity	Fall velocity	Transportation possibility of the flow
	ϑ, m/s	W, mm/s	S, g/l
S.Girshkan	1.25	6.92	6.24
		15.6	2.77
		21.6	2.00
		27	1.60
Recommended (Improved)	1.46	6.92	8.43
		15.6	3.74
		21.6	2.70
		27	2.16

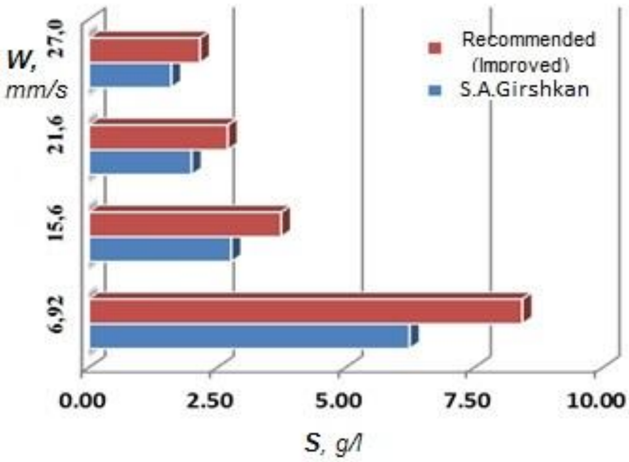

Figure 5. Comparative graph of the transportation possibility of the flow

According to the calculations, the flow capacity was 26% higher in the channel designed using the improved method. The transportation possibility of the flow is one of the important factors. This is because it is necessary to deliver the amount of turbidity in the stream to the fields without sinking into the irrigation channel.

4. Conclusions

To ensure the priority of the channels, to prevent deformation processes, to reduce water lose for filtration, they should be covered with concrete. In the construction of concrete channels, it will be necessary to perform hydraulic calculations when covering soil with concrete. When performing a hydraulic calculation, the improved calculation method proposed above. The using proposed method of application of the concrete decrease cost of raw materials 36%, gives the opportunity to save finance 27 dollars for m^3. The water in the irrigation channel comes to the crop fields in a short time with low lost. As a result of the increase in flow discharge, its transportation possibility of flow also increases by 26%. As a result, the current structure not changes their structure due to sediments of these irrigation channels, and provides dynamic stability.

Acknowledgments
We acknowledgment the project "Development of technologies to increase the efficiency and operational reliability of irrigation channels in variable mode" for close assistance in the preparation of this article and the organizers of the conference "Energy, Civil and Agricultural Engineering 2020" for assistance in publishing the article.

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