UDC 626.212:626.822:626.134
IRSTI70.17.29

https://doi.org/10.55452/1998-6688-2023-20-3-76-88

Joldassov S.K., Abildaev S.T.*, Tattibaev S.J., Sarbassova G.A.

M.Kh.DulatyTaraz Regional university, 080012, Taraz, Kazakhstan
*E-mail:sultan_feb@mail.ru

ON METHODS FOR DETERMINING THE ROUGHNESS COEFFICIENT OF CHANNELS ALONG THE PERIMETER

Abstract. The scientific article deals with the issues of uniform movement of the riverbed and the determination of the roughness coefficient of the riverbed (roughness coefficient). The analysis of existing methods for calculating the difference in the roughness coefficients of channels along the perimeter, methods for determining the roughness coefficient of the slopes of channels consisting of two or three parts along the perimeter, well–known scientists - P.N.Belokon, G.K.Lotter, N.N.Pavlovsky are given.There are a some varieties of calculation methods assigned for hydraulic calculations of water flow along the perimeter of a soil channel in the field of hydraulic engineering. A number of researchers states that the roughness of the channel bed imitates the motion of the flow in diverse channels with the movement of the flow under the ice layer. Nevertheless, it should be taken into account that the roughness of the channel bed has its own characteristic (specific) features of the movement of water in different open channels and below the ice cover. The common formulas proposed by number of authors for channels with different roughness along the perimeter cannot be used directly in hydraulic calculations of the flow under the ice cover, and vice versa, the equations of motion of water flow beneath the ice cover are not applied even for channels with various roughness along the perimeter. Therefore, the corresponding choice of methods for determining the roughness coefficients of the canal flow along the perimeter will be the key point to its long-term functioning.

Keywords: canal, uniform motion, roughness coefficient, steady motion, average speed, channel perimeter, channel cross-section, hydraulic radius.

Introduction

Majority of canals used in hydraulic engineering have same roughness coefficient on bothonslopes and on bottom.Due to the long term exploitation there is a possibility of change in roughness coefficient of canal along the perimeter caused by effluent change during the vegetation period.

Changes in roughness coefficient of slopes and bottom in canal also depends on water permeability and filtration features on the basic layer. Purpose of our primary research was the common defining of roughness coefficient by perimeter of canal [1].

Small part of efflunt's cross-section is key term for the appearance of canal's considered roughness coefficientfrom resistance along the canal's length and formation of bottom while planning flows passing through confirmed canal. Currently there are few proposed ways of calculated ratios for dealing with hydraulic accounts for water flows along the perimeter of our canal.Many researchers found similarity between flows in canals with various roughness level and flows beneath icy layer.Still, we have to emphasize the fact that they both have some unique features by themselves. Regular calculation formulas proposed by many authors for the canals with various roughness level never can be used in hydraulic accounts for flows under icy layer, as well as equations for flow beneath ice can not possibly be used for canals with different roughness indexes. Modifications made while generating this formulas can not be allowed.

Methods and materials

Method of the research is theoretical, materials in usage was accurately processed. According to the information we have, hydraulic circumstances of flow get more complicated in cases where canal crosssectionhave different roughness because of formation of new zones, and so it leads to the fact that planar and vertical distribution of velocities along the cross-section are experiencing sharp changes. To generalize main calculating ratios we make this note - despite of the different states of canal roughness the smoothness of flow remains steadily, that is roughness of canal sides keeps constant along the all considered areas.Moreover, we accept measurements allowed by general hydraulics: magnitude of the slope which could somehow impact to the movement on different partsof flow is same, velocities on separate surfaces of any rectilinear regions of cross-section are same for the first and second parts of the flow and this equals to the maximum velocity. In general, area of canal's cross-sectionapproximately divides to evaluate average index of canal roughness coefficient on bottom and on sides, we assume moisture perimeters χ_1, χ_2, χ_3 and roughness coefficient $n_1, n_2 ... n_N$ ofcanal like that.During calculations of this well-known scientists as Horton and Einstein made this proposal [2] – velocities on considered areas are same and equal to the average speed on any point, about roughness coefficient we are defining it can be determined in this way:

$$n = \left[\frac{\sum_{1}^{N} (\chi_N n_N^{1,5})}{\chi} \right]^{2/3} = \frac{(\chi_1 n_1^{1,5} + \chi_2 n_2^{1,5} + ... + \chi_N n_N^{1,5})^{2/3}}{\chi^{2/3}} \quad (1)$$

Pavlovsky, Mulkhofer, Einstein and Bank [2] are recommending this equation for defining canal's roughness coefficient:

$$n = \left[\frac{\sum_{1}^{N} (\chi_N n_N^{2})}{\chi^{1/2}} \right]^{1/2} = \frac{(\chi_1 n_1^{2} + \chi_2 n_2^{2} + ... + \chi_N n_N^{2})^{1/2}}{\chi^{1/2}} \quad (2)$$

Another scientist Lotter proposed this way of solution [1],

$$n = \frac{\chi R^{5-3}}{\sum_{1}^{N} \left(\frac{\chi_N R_N^{5/3}}{n_N} \right)} = \frac{\chi R^{5/3}}{\frac{\chi_1 R_1^{5/3}}{n_1} + \frac{\chi_2 R_2^{5/3}}{n_2} + ... + \frac{\chi_N R_N^{5/3}}{n_N}} \quad (3)$$

There are $R_1, R_2, ... R_N$ -hydraulic radiuses of considered sectors. In the any section $R_1 = R_2 = ... = R_N = R$ will remain.

Canals roughness can be changed due to the ice formation on the surface of our canal. To explain this phenomenon Lotter[2] came to the conclusion that definitions of roughness for deep canals with icy surface can be determined in the following way.

Chart 1 – approximately taken measures for roughness coefficient for deep canals with icy surface

Formation of icy layer	Velocity in the canal, cm/s	Roughness coefficient
With smooth surface: Without ice floes With ice floes	 0,39 – 0,6 0,6-high 0,39-0,6 0,6-higher than	 0,01-0,012 0,014-0,017 0,016-0,018 0,017-0,02
With ice floesandwithroughsurface	-	0,023-0,025

For instance, n1andn2are roughness coefficients for the canals with and without icy layer. Using first and second equations above we can find roughness coefficient for icy layer. Although coefficient defined in that way sometimes can be negative but is has no importance [1].

According to the Pavlovsky [2] to approach to the genuine solution of the equationwe should accept that the full resistance for liquid motion equals to the sum of resistances formed by canal's bottom and icy layer, so we will have

$$k\upsilon^2 \ell\chi = k_1\upsilon^2 l\chi_1 + k_2\upsilon^2 l\chi_2 \quad (4)$$

There 1 and 2 indexes arerespectively related to the canal bottom and icy layer.

If current and roughness of canal are known, then according to Menning's formula[3] we can find the slope of flow in prizmatic canal in steady motion by using given averagevalue.Slope defined in that way is known as regular slope. Steady surface flow with regular slope could be turbulent or laminar depending on factors like flow, slope, viscosity and roughness of surface. If velocity and depth of flow are relatively low, then viscosity will be dominant factor and flow moves in laminar regime. We certainly can notice thatit is not simple processfrom one glance to the details of flow movement with roughness coefficient.

Results and discussions

In general finding the main calculating ratios lays down on defining moisture perimeters and areas entering to individual sections with roughness.Defining moisture perimeters of individual section is not hard at all, moreover they are determined as relevant edge of geometric figure. It should be noted that edge of rib has to lay on the considered bottom space of canal.

However, finding areas of figures adjoining to sides with individual roughness is really complicated. Methods of P.N.Belokon, G.K.Lotter, N.N.Pavlovsky, E.E.Shiperko which are known in scientific literature are directed to the significant allowances in flow's phenomenon and equality of radiuses of separated parts and of the whole riverbed, and in equality of average velocities on different parts and in the whole flow, but they never have been approved in practical way.Current laborotoric measuresmade by us and other authors shows that they are significantly distinguished in max values and they have considerable mistakes in accounts. So, we came to solution that attempt of evaluating the problem of roughness coefficient by using standard methods not allowed to obtain results necessary for us: using only equation of steady motion is not enough, so according to that we have to consider another ways of dealing with this problem.We believe that dealing with equations for canals with different roughness is the most typical way which is used by all authors.

There can be negative effects caused by roughness. In practices this interaction creates following kinematics of flow's motion which can afford minimum walkthrough of considered cross-section amongst all possible conditions. In canals and open riverbeds with steady motion we can define water's velocity in this way [1, 2]:

$$\upsilon = CR^x i^y \quad (5)$$

there$v$ – average speed, m/s; C – coefficient of Shezi; R – hydraulic radius, м; i –г hydraulic slope; x *and* y – degree's index.

According to the famous scientist Shnekenberg[4]– main formula whencanal has spiral flow has to contain following options: area of canal's cross-section, average velocity of water flow, max speed of water, moisture perimeter of canal, hydraulic radius of canal, depth, slope of flow's free surface, roughness coefficient on cross-section, effluent of major and minor loads in water, dynamic viscosity and temperature of water.

Defining roughness coefficient[2] while solving coefficient of Shezi by formulas of scientists Kutter and Menning in equation of steady motion is really hard.

Main provisions

There was the research of rise of roughness coefficient in field conditions during 1 year in the process of determining the canal's roughness coefficient in natural conditions at university of Illinois and it's measure grew from 0.33 to 0.55 in one season. There shown the methods for defining roughness coefficient in below.

Method for roughness taken by all along the average canal perimeter

Meaning of this method is - measures of private parts along the canal's perimeter we write (n1 and n2) then appropriate to that moisture perimeters written like this χ_1, χ_2, knowing that we can define roughness coefficient of that type of canal by following way:

$$n_{pr} = \frac{(n_1\chi_1 + n_2\chi_2)}{(\chi_1 + \chi_2)} \quad (6)$$

This method is too rough. Considered roughness coefficient of canal is more dependend on hydraulic radius rather than canal's moisture perimeter.

Method of G.K. Lotter. G.K.Lotter [1–5] uses method of account of composite canal while calculating canals with different roughness along the canal's perimeter.

Effluent of composite canal will be:

$$Q = Q_1 + Q_2 \quad (7)$$

there: Q_1 and Q_2 – effluents of first and second parts of the flow.

We resolve effluent of water by formula of Shezi:

$$\omega \cdot C_{pr} \cdot \sqrt{R \cdot J} = \omega_1 \cdot C_1 \cdot \sqrt{R_1 \cdot J_1} + \omega_2 \cdot C_2 \cdot \sqrt{R_2 \cdot J}_{\,2}$$

there:–areaofcross-section; –hydraulicradiusofwholecross-sectionarea;–appropriatecoefficientofSheziforwholecross-section; and–cross-sectionareasofflowpartsinfluencedbyzoneswithsteadyroughness; and–hydraulic radiuses of first and second parts of cross-section;and–Shezi coefficient of first and second parts of cross-section; J - piezometricslope.

$\omega = R \cdot \chi$ in first and second parts of canal's cross-section and because of motion affected by slope are equal, we can write previous equation in this way:

$$C_{pr} \chi R^{3/2} = C_1 \chi_1 R_1^{\,3/2} + C_2 \chi_2 R_2^{\,3/2} \quad (8)$$

there: χ -moistureperimeterofwholecross-section; χ_1 and χ_2 -moisture perimeter of first and second parts of cross-section.

We divide both part of given equation by χ_1 then we write χ_2 / χ_1 proportion like (a):

$$C_{pr} = \frac{C_1 R^{3/2} + aC_2 R_2^{3/2}}{R^{3/2}(1+a)} \quad (9)$$

From equation(9) we can see that to solve we need both - moisture perimeters of parts with different roughness and hydraulic radiuses of cross-section'spersonal parts. In this situation hydraulic radiuses of cross-section's personal parts are defined exactly like for composite canal. For very wide canals moisture perimeter can be equal to width of canal, about hydraulic radius - it equals to depth of considered place. In this case equation (8) will be written in the following way:

$$Q = \left(C_1 b_1 h_1^{3/2} + C_2 b_2 h_2^{3/2}\right)\sqrt{J} \quad (10)$$

There b_1 and b_2 - relatively width of 1 and 2 parts, h_1 and h_2 - depth on first and second parts.

G.K.Lotter believes that hydraulic radiuses of flow's private parts are equal to the hydraulic radius of whole flow for canals with ice formation:

$$R_1 = R_2 = R \quad (11)$$

Because of moisture perimeter of canal - χ_1 and of ice- χ_2 are equal, then hydraulic radius of whole section is equal:

$$R = \frac{\omega}{\chi_1 + \chi_2} \quad (12)$$

In this case equation(9) will be written in the following way:

$$C_{pr} = \frac{C_1 + aC_2}{(1+a)} \quad (13)$$

Then independent on eachother methods of P.N.Belokon and N.N.Pavlovsky are published[1,6].

Method of P.N. Belokon

We consider canal's cross-section with any shape, then roughness of moisture perimeter on first part will be $n_1$and in the second is n_2.

We define fall along the length of canal by next formula

$$J = \frac{F}{\gamma\omega} \tag{14}$$

There: F - sum of fictitious friction forces on canal sides(walls. We mark average friction force falling on 1m²of canal's side in first part like and in second one

$$F = \tau_1\chi_1 + \tau_2\chi_2 \tag{15}$$

Then we can write equation(14) in following way:

$$\frac{\tau_1\chi_1}{\gamma} + \frac{\tau_2\chi_2}{\gamma} = \omega J$$

If take them as $\chi_1 = a\chi$ and $\chi_2 = a\chi$, then we get this:

$$a_1\frac{\tau_1}{\gamma} + a_2\frac{\tau_2}{\gamma} = \frac{\omega}{\chi}J = RJ \cdot$$

In turbulent steady motion it will look like this:

$$\frac{\tau_1}{\gamma} = \frac{\upsilon_1^2}{C_1^2} \quad \text{and} \quad \frac{\tau_2}{\gamma} = \frac{\upsilon_2^2}{C_2^2}$$

there: υ_1 and υ_2 - average velocity in first and second parts of flow. Then previous equations will look like that:

$$a_1\frac{\upsilon_1^2}{C_1^2} + a_2\frac{\upsilon_2^2}{C_2^2} = RJ \tag{16}$$

If and solved in Menning's way, then equation(16) will be like this:

$$a_1\frac{n_1^2\upsilon_1^2}{R_1^{1/3}} + a_2\frac{n_2^2\upsilon_2^2}{R_2^{1/3}} = RJ \tag{17}$$

If take this ratio like that $\frac{n_2}{n_1} = \psi$ we will see this:

$$n_1^2\left(a_1\frac{\upsilon_1^2}{R_1^{1/3}} + \psi^2 a_2\frac{\upsilon_2^2}{R_2^{1/3}}\right) = RJ \tag{18}$$

Moreover P.N.Belokon says that: if ratios for areas of cross-section relatively to zones with different roughness equals to θ, then we get this $\frac{\omega_1}{\omega_2} = \theta$

Then $\omega_1 + \omega_2 = \omega$ will be when $\omega_1 = \frac{\theta}{1+\theta}$ and $\omega_2 = \frac{\theta}{1+\theta}\omega \cdot$

P.N.Belokon finds answers of $R_1$and$R_2$from next equations:

$$R_1 = \frac{\omega_1}{\chi_1} = \frac{\theta}{a_1(1+\theta)}R \quad \text{and} \quad R_2 = \frac{\omega_2}{\chi_2} = \frac{\theta}{a_2(1+\theta)}R \tag{19}$$

Full effluent will be: $Q_1 + Q_2 = Q$.

We resolve effluent by Shezi-Menning formula:

$$Q_1 = \frac{1}{n_1}\omega_1 R_1^{2/3} J^{1/2} \text{ and } Q_2 = \frac{1}{n_2}\omega_2 R_2^{2/3} J^{1/2} \qquad (20)$$

We divide first part of equation(20) by second part because the slopes of them are equal: or we put answers of ω_1, ω_2 and R_1, R_2 into this $\frac{Q_1}{Q_2} = \frac{n_1}{n_2} \cdot \frac{R_1^{2/3}\omega_1}{R_2^{2/3}\omega_2}$ equation:

$$\frac{Q_1}{Q_2} = \psi \left(\frac{a_2}{a_1}\right)^{2/3} \theta^{2/3}$$

If we convert that equations, roughness coefficient will be:

$$n = n_1 \left(a_1 + a_2 \psi^{3/2}\right)^{3/2} \qquad (21)$$

Method of N.N. Pavlovsky

According to N.N.Pavlovsky [1,7–20] definition of considered roughness coefficient is taken from equation of steady motion for open canals written below:

$$RJ = \frac{\tau}{\gamma} \qquad (22)$$

If sides of canal are distinguished from eachother then we have to exchange this equation with another one, for that we need todivide liquid between cross-sections, direct impacting forces to direction of flow, then construct new motion equation for released part.

Then we get this equation(22):

$$RJ = \frac{\tau_1 + a\tau_2}{\gamma(1+a)} \qquad (23)$$

there:and–respectively average special friction in sides ofcanal, – ratio of moisture perimeters on two sides - $a = \frac{\chi_2}{\chi_1}$.

When sides are same average special friction in sides of canal is equal to the average depth in this subsequence $\frac{\tau}{\gamma} = \frac{\upsilon^2}{C^2}$.

According to that we can write and like this:

$$\frac{\tau_1}{\gamma} = \frac{\upsilon^2}{C^2}, \quad \frac{\tau_2}{\gamma} = \frac{\upsilon^2}{C^2} \qquad (24)$$

Before getting binders N.N.Pavlovsky takes that the average velocity of each part is equal - $\upsilon = \upsilon_1 = \upsilon_2$.

We put this equation(24) to another one(23):

$$RJ = \frac{\upsilon^2}{1+a}\left(\frac{1}{C_1^2} + \frac{a}{C_2^2}\right), \text{ follows to } \upsilon = C_1 C_2 \sqrt{\frac{1+a}{aC_1^2 + C_2^2}} \cdot \sqrt{RJ} \qquad (25)$$

N.N.Pavlovsky counts measure before $\sqrt{RJ}$ as “coefficient of Shezi”, then marks it like Cpr, because of that we can write equation(25) in next way:

$$\upsilon = C_{pr} \cdot \sqrt{RJ} \qquad (26)$$

Here $C_{pr} = C_1 C_2 \sqrt{\frac{1+a}{aC_1^2 + C_2^2}}$.

To find C_1 and C_2 we have to know measures of and . To determine them Pavlovsky proposed to count areas of private cross-section parts of canal and moisture perimeters as proportional, then

$$\frac{\omega_1}{\omega_2} = \frac{\chi_1}{\chi_2}, \text{ after that } \frac{\omega_1}{\omega} = \frac{\chi_1}{\chi}, \ \frac{\omega_2}{\omega} = \frac{\chi_2}{\chi} \qquad (27)$$

Then we get:

$$R_1 = \frac{\omega_1}{\chi_1} = \frac{\omega}{\chi} = R, \ R_2 = \frac{\omega_2}{\chi_2} = \frac{\omega}{\chi} = R \qquad (28)$$

Then, $R_1 = R_2 = R$ (29)

We can get next equation while solving coefficient of Shezi, of course by knowing measure of hydraulic radius, using this formula and define necessary equation for considered roughness coefficient:

$$C_{pr} = R^y \sqrt{\frac{1+a}{n_1^2 + an_2^2}} \qquad (30)$$

Applying information about considered roughness coefficient,Pavlovsky reforms equation(30) into this sight:

there: $n = \sqrt{\frac{n_1^2 + a \cdot n_2^2}{1+a}}$ (31)

If sides of canal are from three different parts and relatively moisture perimeters of three parts are not same, then equation for considered roughness coefficient will be like this:

$$n_{pr} = \sqrt{\frac{n_1^2 + a \cdot n_2^2 + a \cdot n_3^2}{1+a}}, \qquad (32)$$

there: $a^1 = \frac{\chi_3}{\chi_1}$.

By concluding, N.N.Pavlovsky writes this - method for defining roughness coefficient might be changed from anticipated extra researches in future [1,2,15-23].

Conclusion

Many factors influent to roughness coefficient of canal's bottom in field conditions, by considering them, famous scientist Covan proposed this way to deal with considered roughness coefficient [2]:

$$n = (n_0 + n_1 + n_2 + n_3 + n_4)m_5 \qquad (33)$$

there, n_0 – measure of roughness coefficient for canal's bottom with natural, smooth soil; n_1 – coefficient for bottoms with different soil; n_2 – coefficient for measuring and finding canal's cross-section; n_3 – coefficient for measuring possibility of barriers in the canal; n_4 – coefficient for describing regime of flow in the canal and for impact of resistance caused by plants outgrowth; m_5 – coefficient for measuring aftereffectof winding for considered water canal.

According to results of calculations,we get formulated measure of n:

$$n = \frac{(x-1)h^{1/6}}{6{,}78(x+0{,}95)} \qquad (34)$$

By concluding equation directed on determining of roughness coefficient we get this (34)equation. To approve reality of this equation were taken experimental results of works onconnectionsbetween canal roughness and average depth. Analyze of data taken from results of research shows that there is a some connection between coefficient of Menning and distribution of velocities along the canal's cross-section. To find out how much taken equation can be applied on manufacture, there would be needed data taken from researches occurred in laboratory and natural conditions[1–8,23–30].

References

1 Мусин Ж.А. Методологические обоснования пропускной способности каналов с составной шероховатостью по периметру: Монография / Ж.А. Мусин. – Тараз: ТОО «Формат-принт», 2012. – 232 с.

2 Чоу В.Т. Гидравлика открытых каналов: Монография / В.Т. Чоу. – М.: Издательство литературы по строительству, 1969. – 464 с.

3 Жолдасов С.Қ. Ашық ағындар гидравликасы : Оқу құралы / Жолдасов С.Қ. – Тараз: Тараз университеті, 2012. – 125 б.

4 Жолдасов С.Қ. Табиғи (болмыстық) жағдайларда бұжырлық коэффициентін анықтау қиыншылықтары туралы / Жолдасов С.Қ., Жандосов Д. // «Ғылым және білім: ізденіс, міндеттер, болашақ» Республикалық ғылыми-практикалық конференциясының материалдары. – Тараз.: Тараз университеті. – 2016. – Б. 84–88.

5 Мусин Ж.А., Орынбеков Б.А. Каналы с составной шероховатостью по периметру // Труды Межд. науч. конф. «Наука и образование – ведущий фактор стратегии «Казахстан-2030» (28–29 июня 2005 г.) – Караганда: КаргТУ, 2005. – С. 324–336.

7 Мусин Ж.А., Сарсекеев С.А. Влияние сезонного роста водной растительности на пропускную способность каналов // Проектирование, строительство и эксплуатация водохозяйственных систем : Тезисы докладов к зональному семинару. – Пенза, 1989. – С. 41–43.

8 Мусин Ж.А., Кажкенов М.З. К вопросу рационального использования оросительной воды // Экологическое совершенствование мелиоративных систем: Тезисы докладов Всесоюзной науч. прак. конф. молодых ученых / ВНИИГиМ. – М., 1989. – С. 258.

9 Гришанин К.В., Гладков Г.Л., Павыши А.М., Москаль А.В., Соколов Ю.П. Реакция речного потока на искусственные изменения его русла : Труды V Всесоюзн. гидрол. съезда. – М., 1988. – Т. 10. – С.362–373.

10 Гришанин К.В. Гидравлическое сопротивление естественных русел. – СПб.: Гидрометеоиздат, 1992. – 182 с.

11 Шиперко Е.Э. Исследования сопротивления жидкости в случае неоднородной шероховатости // Известия Днепропетровского горного института. – Днепропетровск, 1961. – Т. 40 – с. 272–282.

12 Рось У.С. Изменение приведенного коэффициента шероховатости в зависимости от глубины потока под ледяным покровом // Тр. Новосибирский ин-т инж. ж/д транспорта. – Новосибирск, 1967. – Вып. 60. – С.113–118.

13 Мусин Ж.А., Сенников М.Н. Основные факторы, нарушающие надежную работу оросительных систем, и эксплуатационные затруднения в определении коэффициента шероховатости в натурных условиях // Водные ресурсы Центральной Азии: Материалы науч.-прак.конф., посв. 10-летию МКВК. – Алматы, 2002. – С. 409–410.

14 Nikuradse J. Laminare Reibungsschichtenan der langsangestromten Platte. Zentrale f. wiss. Berichtswesen, Berlin, 1942.

15 Альтшуль А.Д., Лудов В.Д. О формуле Н.Н. Павловского для определения коэффициента Шези // Строительство и архитектура. – 1984. – №4. – С. 23–30.

16 Альтшуль А.Д. Обобщенная формула коэффициента Шези для открытых русел // Метеорология и гидрология. – 1952. – № 7.

17 Альтшуль А.Д., Срейо А. О гидравлических сопротивлениях в водотоках с большими уклонами // Гидравлические исследования и расчеты трубопроводных систем и портовых сооружений: Сб.научных трудов. МИСИ им. В.В. Куйбышева. – М., 1987. – С. 28–33.

18 Альтшуль А.Д., У-Вин-Тейн. Сравнение формул без коэффициента шероховатости для определения средней скорости течения воды в реках // Гидротехническое строительство. –Л., 1973. – С. 41–42.

19 Павловский Н.Н. К вопросу о расчетной формуле равномерного движения в водотоках с неоднородными стенками // Изв.ВНИИГ. – 1931. – Т.3. – С. 157–165.

20 Агроскин И.И., Штеренлихт Д.В. Уточненная формула для коэффициента Шези // Гидротехника и мелиорация. – 1979. – № 11. – С. 25–31.

21 Михалев М.А. К вопросу о сопротивлении открытых русел с неоднородной шероховатостью ложа // Изв. ВНИИГ. – 1981. – № 145. – С. 100–105.

22 Сарсекеев С.А., Мусин Ж.А. Деление потока воды под влиянием шероховатостей стенок и дна канала по смоченному периметру русла // Вестник с/х.науки Казахстана. – 1990. – № 4. – С. 92–95.

23 Мусин Ж.А. Расчет приведенного коэффициента шероховатости русел каналов // Новости науки Казахстана. – Алматы, 2006. – №4 (88). – С. 72–76.

24 Жандосов Д., Киргизбеков А.С., Байжигитова М.Т. Жасанды арна табанының бұжырлық коэффициентін

таңдау: «Ғылым және жаңашылдық – 2015» республикалық ғылыми-тәжірибелік конференциясының материалдары, ТарМУ, 13 наурыз, 2015 ж.

25 Байжигитова М.Т. Тікбұрышты арналы қиманың бұжырлық коэффициентін тәжірибелік жолмен анықтау: Материалы VI Международной научно-практической конференции «Менеджмент качества: поиск и решения», г. Лос-Анджелес, Калифорния, США. – 25–27 ноября 2020 г. – С. 300–306.

26 Жолдасов С.Қ. Табиғи (болмыстық) жағдайларда арна табанының бұжырлық коэффициентін анықтау қиыншылықтары / Жолдасов С.Қ., Байжигитова М.Т., Серимбетова Қ.Е. // Профессор Сейітқазиев Әдеубай Садақбайұлының 70 жылдығына орай ұйымдастырылған «Төртінші өнеркәсіптік революция жағдайындағы су шаруашылығының агроөнеркәсіптік кешені және мелиорациядағы экологиялық мәселелер» атты Халықаралық ғылыми-тәжірибелік конференция материалдары. – Тараз.: Тараз университеті. – 2020. – Б. 114–118.

27 Амангалиұлы А. Табаны бұжырлы каналдардағы бірқалыпты қозғалыс және бұжырлық коэффициентін анықтау /Аманғалиұлы А., Байжигитова М.Т., Тәттібаев С.Ж. // Глобальная наука и инновация 2020: Центральная Азия. – № 6 (11). – 2020. – Дек. – Астана, 2020. – Т. 2. – С.116–120.

28 Қожамқұлова Г.Е. Жергілікті шайылудан қорғауға арналған жасанды бұжырлықты жалғастыру құрылымдарының жаңа конструкциялары: М.Р.Қасенов 80 жылдығына орай өткізілген «Аймақтық экономиканың бәсекеге қабілеттілік мәселелері: теория және практика» тақырыбындағы халықаралық ғылыми-тәжірибелік конференциясының материалдары, 5 қараша 2021 ж. – Б. 205–209.

29 Байжигитова М. Топырақ арналы каналдардағы бұжырлық коэффициентін анықтау / Байжигитова М., Тәттібаев С.: The IV International Scientific and Practical Conference "Actual problems of practice and science and methods of their solution», January 31 – February 02, 2022, Milan, Italy. – Б. 616–620.

30 Жолдасов С.Қ. Периметрі бойынша бұжырлық коэффициенті әртүрлі каналдардағы су қозғалысы / Жолдасов С.Қ., Байжигитова М.Т., Тәттібаев С.Ж. // Механика және технологиялар. – №1. – 2022. – Б. 78–86.

References

1 Musin Zh.A. (2012) Metodologicheskie obosnovanija propusknoj sposobnosti kanalov s sostavnoj sherohovatost'ju po perimetru, Taraz, TOO "Format-print", 232 p. (In Russian)

2 Chou V.T. (1969) Gidravlika otkrytyh kanalov, Moscow, Izdatel'stvo literatury po stroitel'stvu, 464 p. (In Russian)

3 Joldasov S.Q. (2012) Aşyq ağyndar gidravlikasy, Taraz, Taraz universitetı, 125 p. (In Kazakh)

4 Joldasov S.Q. (2016) Tabiği (bolmystyq) jağdailarda būjyrlyq koefisientın anyqtau qiynşylyqtary turaly, «Ğylym jäne bılım: ızdenıs, mındetter, bolaşaq» Respublikalyq ğylymi-praktikalyq konferensiasynyñ materialdary, Taraz, Taraz universitetı, pp. 84–88. (In Kazakh)

5 Musin Zh.A., Orynbekov B.A. (2005) Kanaly s sostavnoj sherohovatost'ju po perimetru, Trudy Mezhd. nauch. konf. «Nauka i obrazovanie – vedushhij faktor strategii «Kazahstan-2030» (28–29 ijunja 2005 g.), Karaganda, KargTU, pp. 324–336. (In Russian)

7 Musin Zh.A., Sarsekeev S.A. (1989) Vlijanie sezonnogo rosta vodnoj rastitel'nosti na propusknuju sposobnost' kanalov, Proektirovanie, stroitel'stvo i jekspluatacija vodohozjajstvennyh sistem : Tezisy dokladov k zonal'nomu seminaru, Penza, pp. 41–43. (In Russian)

8 Musin Zh.A., Kazhkenov M.Z. (1989) K voprosu racional'nogo ispol'zovanija orositel'noj vody, Jekologicheskoe sovershenstvovanie meliorativnyh sistem: Tezisy dokladov Vsesojuznoj nauch. prak. konf. molodyh uchenyh, VNIIGiM, Moscow, 258 p. (In Russian)

9 Grishanin K.V., Gladkov G.L., Pavyshi A.M., Moskal' A.V., Sokolov Ju.P. (1988) Reakcija rechnogo potoka na iskusstvennye izmenenija ego rusla, Trudy V Vsesojuzn. gidrol. s#ezda, Moscow, v. 10, pp. 362–373. (In Russian)

10 Grishanin K.V. (1992) Gidravlicheskoe soprotivlenie estestvennyh rusel, Sankt-Peterburg, Gidrometeoizdatб 182 p. (In Russian)

11 Shiperko E.Je. (1961) Issledovanija soprotivlenija zhidkosti v sluchae neodnorodnoj sherohovatosti, Izvestija Dnepropetrovskogo gornogo institute, Dnepropetrovsk, vol. 40, pp. 272–282. (In Russian)

12 Ros' U.S. (1967) Izmenenie privedennogo kojefficienta sherohovatosti v zavisimosti ot glubiny potoka pod ledjanym pokrovom, Tr. Novosibirskij in-t inzh. zh/d transporta, Novosibirsk, vyp.60, pp.113–118. (In Russian)

13 Musin Zh.A., Sennikov M.N. (2002) Osnovnye faktory, narushajushhie nadezhnuju rabotu orositel'nyh sistem, i jekspluatacionnye zatrudnenija v opredelenii kojefficienta sherohovatosti v naturnyh uslovijah, Vodnye resursy Central'noj Azii, Materialy nauch.-prak.konf. posv. 10-letiju MKVK, Almaty, pp. 409–410. (In Russian)

14 Nikuradse J. (1942) Laminare Reibungsschichtenan der langsangestromten Platte. Zentrale f. wiss. Berichtswesen, Berlin.

15 Al'tshul' A.D., Ludov V.D. (1984) O formule N.N. Pavlovskogo dlja opredelenija kojefficienta Shezi, Stroitel'stvo i arhitektura, no 4, pp. 23–30. (In Russian)

16 Al'tshul' A.D. (1952) Obobshhennaja formula kojefficienta Shezi dlja otkrytyh rusel, Meteorologija i gidrologija, no 7. (In Russian)

17 Al'tshul' A.D., Srejo A. (1987) O gidravlicheskih soprotivlenijah v vodotokah s bol'shimi uklonami, Gidravlicheskie

issledovanija i raschety truboprovodnyh sistem i portovyh sooruzhenij, Sb.nauchnyh trudov. MISI im. V.V. Kujbysheva, Moscow, pp. 28–33. (In Russian)

18 Al'tshul' A.D., U-Vin-Tejn (1973) Sravnenie formul bez kojefficienta sherohovatosti dlja opredelenija srednej skorosti techenija vody v rekah, Gidrotehnicheskoe stroitel'stvo, L., pp. 41–42. (In Russian)

19 Pavlovskij N.N. (1931) K voprosu o raschetnoj formule ravnomernogo dvizhenija v vodotokah s neodnorodnymi stenkami, Izv.VNIIG, vol.3, pp. 157–165. (In Russian)

20 Agroskin I.I., Shterenliht D.V. (1979) Utochnennaja formula dlja kojefficienta Shezi, Gidrotehnika i melioracija, no11, pp. 25–31. (In Russian)

21 Mihalev M.A. (1981) K voprosu o soprotivlenii otkrytyh rusel s neodnorodnoj sherohovatost'ju lozha, Izv. VNIIG, no 145, pp. 100–105. (In Russian)

22 Sarsekeev S.A., Musin Zh.A. (1990) Delenie potoka vody pod vlijaniem sherohovatostej stenok i dna kanala po smochennomu perimetru rusla, Vestnik s/h.nauki Kazahstana, no 4, pp. 92–95. (In Russian)

23 Musin Zh.A. (2006) Raschet privedennogo kojefficienta sherohovatosti rusel kanalov, Novosti nauki Kazahstana, Almaty, no 4 (88), pp. 72–76. (In Russian)

24 Jandosov D., Kirgizbekov A.S., Baijigitova M.T. Jasandy arna tabanynyñ būjyrlyq koefisientın tañdau, "Ğylym jäne jañaşyldyq – 2015" respublikalyq ğylymi-täjıribelık konferensiasynyñ materialdary, TarMU, 13 nauryz, 2015 j. (In Kazakh)

25 Baijigitova M.T. Tıkbūryşty arnaly qimanyñ būjyrlyq koefisientın täjıribelık jolmen anyqtau: Materialy VI Mezhdunarodnoj nauchno-prakticheskoj konferencii "Menedzhment kachestva: poisk i reshenija", Los-Andzheles, Kalifornija, SshA, 25–27 nojabrja 2020 g., pp. 300–306. (In Kazakh)

26 Joldasov S.Q. (2020) Tabiği (bolmystyq) jağdailarda arna tabanynyñ būjyrlyq koefisientın anyqtau qiynşylyqtary, Profesor Seıitqaziev Ädeubai Sadaqbaiūlynyñ 70 jyldyğyna orai ūiymdastyrylğan "Törtınşı önerkäsıptık revolüsia jağdaiyndağy su şaruaşylyğynyñ agroönerkäsıptık keşenı jäne meliorasiadağy ekologialyq mäseleler" atty Halyqaralyq ğylymi-täjıribelık konferensia materialdary, Taraz, Taraz universitetı, .pp.114–118. (In Kazakh)

27 Amangaliūly A. (2020) Tabany būjyrly kanaldardağy bırqalypty qozğalys jäne būjyrlyq koefisientın anyqtau, Global'naja nauka i innovacija 2020: Central'naja Azija, no 6 (11), Astana, vol. 2, pp. 116–120. (In Kazakh)

28 Qojamqūlova G.E. Jergılıktı şaiyludan qorğauğa arnalğan jasandy būjyrlyqty jalğastyru qūrylymdarynyñ jaña konstruksialary: M.R.Qasenov 80 jyldyğyna orai ötkızılgen "Aimaqtyq ekonomikanyñ bäsekege qabılettılık mäselelerı: teoria jäne praktika" taqyrybyndağy halyqaralyq ğylymi-täjıribelık konferensiasynyñ materialdary, 5 qaraşa 2021 j., pp. 205–209. (In Kazakh)

29 Baijigitova M. Topyraq arnaly kanaldardağy būjyrlyq koefisientın anyqtau, The IV International Scientific and Practical Conference "Actual problems of practice and science and methods of their solution", January 31 – February 02, 2022, Milan, Italy, pp. 616–620. (In Kazakh)

30 Joldasov S.Q. (2022) Perimetrı boiynşa būjyrlyq koefisientı ärtürlı kanaldardağy su qozğalysy, Mehanika jäne tehnologialar, no1., pp. 78–86. (In Kazakh)

Information about authors

Joldassov Saparbek Kurakbayebich
Candidate of technical sciences, associate professor, M.Kh. DulatyTarazregional university, 40
Tole bi st.,080012, Taraz, Kazakhstan
ORCID ID: 0000-0002-3947-1411
E-mail:arnur_68@mail.ru

Abildaev Sultan Talasbaevish (corresponding author)
Acting Associate Professor, PhD, M.Kh. Dulaty Tarazregional university, 40
Tole bi st., 080012, Taraz, Kazakhstan
ORCID ID: 0000-0002-7525-5097
E-mail:sultan_feb@mail.ru

Tattibaev Sagintay Jakupaliulu
Doctoral student of the 3rd year of the educational program 8D07411 "Hydraulic engineering and structures", M.Kh.DulatyTarazregional university, 40
Tole bi st., 080012, Taraz, Kazakhstan
ORCID ID: 0000-0003-2687-0189
E-mail:tsagin75@mail.ru

Sarbassova Gulmira Azimbaevna
Candidate of technical sciences, associate professor, M.Kh. DulatyTarazregional university, 40 Tole bi st., 080012, Taraz, Kazakhstan
ORCID ID: 0000-0001-7517-234X
E-mail: gulimjan@mail.ru

Авторлар туралы мәліметтер

Джолдасов Сапарбек Куракбаевич
Техника ғылымдарының кандидаты, доцент, М.Х. Дулати атындағы Тараз өңірлік университеті, Төле би көш., 40, 080012, Тараз қ., Қазақстан
ORCID ID: 0000-0002-3947-1411
E-mail:arnur_68@mail.ru

Абилдаев Султан Таласбаевич (корреспонденция авторы)
Доцент м.а., PhD докторы, М.Х.Дулати атындағы Тараз өңірлік университеті, Төле би көш., 40, 080012, Тараз қ., Қазақстан
ORCID ID: 0000-0002-7525-5097
E-mail:sultan_feb@mail.ru

Таттибаев Сагынтай Жакыпалиевич
8D07411 «Гидротехникалық құрылыс және құрылымдар» білім беру бағдарламасының 3-курс докторанты, М.Х.Дулати атындағы Тараз өңірлік университеті, Төле би көш., 40, 080012, Тараз қ., Қазақстан
ORCID ID: 0000-0003-2687-0189
E-mail:tsagin75@mail.ru

Сарбасова Гульмира Азимбаевна
Техника ғылымдарының кандидаты, доцент, М.Х. Дулати атындағы Тараз өңірлік университеті, Төле би көш., 40, 080012, Тараз қ., Қазақстан
ORCID ID: 0000-0001-7517-234X
E-mail: gulimjan@mail.ru

Информация об авторах

Джолдасов Сапарбек Куракбаевич
Кандидат технических наук, доцент, Таразский региональный университет имени М.Х. Дулати, ул. Толе би, 40, 080012, г. Тараз, Казахстан
ORCID ID: 0000-0002-3947-1411
E-mail:arnur_68@mail.ru

Абилдаев Султан Таласбаевич (автор для корреспонденции)
И.о. доцента, доктор PhD, Таразский регионалный университет имени М.Х. Дулати, ул. Толе би, 40, 080012, г.Тараз, Казахстан
ORCID ID: 0000-0002-7525-5097
E-mail:sultan_feb@mail.ru

Таттибаев Сагынтай Жакыпалиевич
Докторант 3-го курса образовательной программы 8D07411 «Гидротехническое строительство и сооружения», Таразский регионалный университет имени М.Х. Дулати, ул. Толе би, 40, 080012, г. Тараз, Казахстан

ORCID ID: 0000-0003-2687-0189
E-mail:tsagin75@mail.ru

Сарбасова Гульмира Азимбаевна
Кандидат технических наук, доцент, Таразский регионалный университет имени М.Х. Дулати, ул. Толе би, 40, 080012, г. Тараз, Казахстан
ORCID ID: 0000-0001-7517-234X
E-mail: gulimjan@mail.ru

Джолдасов С.Қ., Абилдаев С.Т.*, Таттибаев С.Ж., Сарбасова Г.А.

М.Х. Дулати атындағы Тараз өңірлік университеті, 080012, Тараз қ., Қазақстан
*E-mail:sultan_feb@mail.ru

ПЕРИМЕТРІ БОЙЫНША КАНАЛДАРДЫҢ КЕДІР-БҰДЫРЛЫҚ КОЭФФИЦИЕНТІН АНЫҚТАУ ӘДІСТЕРІ ТУРАЛЫ

Аңдатпа. Ғылыми мақалада арнаның бірқалыпты қозғалысын және арнаның кедір-бұдырлық коэффициентін (кедір-бұдырлық коэффициенті) анықтау мәселелері қарастырылады. П.Н. Белоконь, Г.К. Лотер, Н.Н. Павловский сияқты атақты ғалымдардың периметрі бойынша каналдардың екі-үш бөлігінен тұратын кедір-бұдырлық коэффициентін анықтау әдістеріне, периметрі бойынша арналардың кедір-бұдырлық коэффициенттерінің айырмашылығын есептеудің қолданыстағы әдістеріне талдау жасалды. Гидротехника саласында жер асты каналының периметрі бойынша су ағынының гидравликалық есептеулері үшін ұсынылатын бірқатар есептеу әдістері бар. Бірқатар зерттеушілер арнаның кедір-бұдырлығы мұз қабатының астындағы ағынның қозғалысымен әртүрлі арналардағы ағынның қозғалысына ұқсайды деп мәлімдейді. Бірақ канал арнасының кедір-бұдырлығы әртүрлі ашық арналарда және мұз қабаты астындағы су қозғалысының өзіне тән (спецификалық) ерекшеліктеріне ие екенін ескеру қажет. Көптеген авторлардың ұсынған периметрі бойынша әр түрлі кедір-бұдырлы арналарды есептеу формулаларын мұз қабатының астындағы гидравликалық ағынды есептеулерде тікелей қолдану мүмкін емес, тіпті керісінше мұз қабатының астындағы су ағынының қозғалыс теңдеулерінің периметрі әр түрлі кедір-бұдырлы арналарды есептеуде де қолданылмайды. Сол себепті табан периметрі бойынша су арналарының кедір-бұдырлық коэффииценттерін анықтау әдістерін дұрыс таңдау, оның ұзақ мерзімді жұмыс істеуінің кепілі болады.

Тірек сөздер: арна, бірқалыпты қозғалыс, кедір-бұдырлық коэффициенті, тұрақты қозғалыс, орташа жылдамдық, арна периметрі, арнаның өтім (көлденең) қимасы (поперечное сечение), гидравликалық радиус.

Джолдасов С.К., Абилдаев С.Т.*, Тәттібаев С.Ж., Сарбасова Г.А.

Таразский регионалный университет имени М.Х. Дулати, г. Тараз, Казахстан
*E-mail:sultan_feb@mail.ru

О МЕТОДАХ ОПРЕДЕЛЕНИЯ КОЭФФИЦИЕНТА ШЕРОХОВАТОСТИ КАНАЛОВ ПО ПЕРИМЕТРУ

Аннотация. В научной статье рассматриваются вопросы равномерного движения русла и определения коэффициента шероховатости русла (коэффициента шероховатости). Приводится анализ существующих методов расчета разности коэффициентов шероховатости каналов по периметру, методы определения коэффициента шероховатости, состоящих из двух-трех частей откосов каналов по периметру, таких известных ученых, как П.Н. Белоконь, Г.К. Лоттер, Н.Н. Павловских. В области гидротехники существует ряд расчетных методов, предлагаемых для гидравлических расчетов расхода воды по периметру грунтового канала. Ряд исследователей утверждают, что шероховатость русла канала имитирует движение потока в разных каналах с движением потока под слоем льда. Но следует учитывать, что шероховатость русла канала имеет свои характерные (специфические) особенности движения воды в различных открытых каналах и под ледяным покровом. Расчетные формулы, предложенные многими авторами для каналов с разной шероховатостью по периметру, не могут быть использованы непосредственно при гидравлических расчетах потока под ледяным покровом, и, наоборот, уравнения движения потока воды под ледяным покровом не применяются даже для каналов с разной шероховатостью по периметру. Поэтому правильный выбор методов определения коэффициентов шероховатости русла каналов по периметру будет залогом его длительного функционирования.

Ключевые слова: канал, равномерное движение, коэффициент шероховатости, установившееся движение, средняя скорость, периметр канала, поперечное сечение канала, гидравлический радиус.