CROSS-SECTION CHANNELS OF HYDRAULICALLY AND STATICALLY STABLE SHAPE

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Abstract. *The article presents the results of research on the substantiation of giving a stable shape of cross-section to the channels of hydro-reclamation systems of southern Kazakhstan. The calculations on the stability of irrigation channel slopes were made, as well as their design features and practical substantiation of stable profiles were presented. The shapes of stable slope were determined using of actual values of geotechnical parameters of slope soils. The results showed that the slope profile takes a stable shape during the channel operation, close to the parabolic.*

Keywords: *hydro-reclamation systems, channels, cross section, riverbed processes, slope stability.*

Introduction

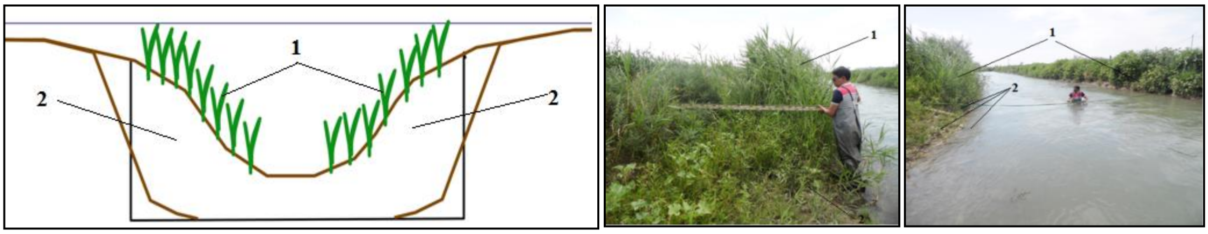
Most of the hydro-reclamation systems in southern Kazakhstan take water from mountain and foothill-rivers transporting a significant amount of sediment which leads to the channel deformation and a reduction in the channel flow capacity. The study of the operating experience of irrigation channels, their kinematic structure and the conditions for the formation of their stable shapes to cover the shortage of water resources due to siltation and reduced flow capacity is extremely relevant [1].

To design channels, the dimensions of the channels and their hydraulic characteristics must meet certain predetermined requirements which depend on the channel purpose. For irrigation channels designed in the ground (earthen channel), the requirements are reduced to ensure that the cross-section corresponds to the erosional features of the channel, non-silting and general channel stability. The reliability of channel operation without silting and erosion largely depends on the establishment of the deformation-resistant cross section of the channel and the corresponding hydraulic characteristics [2].

An analysis of the channels constructed in the ground or created by self-erosion showed that channel beds, as well as river beds are subject to free deformations, manifested in the self-formation of stable shapes and sizes [3].

The process of stable channel formation, in general development scheme, preserves the evolution of natural river bed features, but is carried out under the influence of relatively constant time and flow rate and proceeds actively until the dimensions and shape of the channel determine such high-speed flow structure which establishes the maximum equilibrium condition for the soils of channel bed [3-5].

In-situ observations have established that the trapezoidal shape of the cross-section is unstable: the slopes of such waterway are deformed, the angular spaces are silted, overgrown and, as a result, the original shape of the channel completely changes – it takes an incorrect arbitrary shape at the top and a curvilinear shape at the bottom (fig.1).



1 – overgrowing, 2 – silting
(inter-farm channel K-18, Turkestan region)
Figure 1 – In-situ observations of irrigation channels

The water flow produces a parabolic or hyperbolic channel shape on straight sections in loosely cohesive soil (alluvial) and elliptic shape in cohesive soil (clay and peat) [4].

A symmetrical and parabolic channel bed is produced on straight sections in homogeneous soil. The river banks in cohesive soils have a steeper slope and the cross section approaches the elliptical shape of the curve. Studies carried out on the channels of the Syrdarya river show that in alluvial soils, the channel cross-section has a shape outlined by parabolas of various orders: from the second to the twelfth [5].

Materials and methods

A channel survey to study the resistence to erosion and silting showed that the parabolic section (outlined by a fifth-order parabola) fits better with the actual section of the channel (Table 1).

Table 1 – Comparison of actual channel cross-section parameters with calculated parabolic, elliptical and semicircular section [2-5]

Cross section profiles	Relative channel width by water level, β	Specific wetted perimeter, χ0	Channel width by water level, B, m
Factual Parabolic % discrepancy	7,18 7,2 +0,279	10,8 10,3 -4,63	10,8 8,9 -0,892
Elliptical % discrepancy	6,75 -5,98	10,4 -3,7	8,8 -2
Semicircular % discrepancy	4,75 -33,8	8,54 -20,9	7,8 -13,15

Continuation of table 1

Channel filling depth, h, m	Cross-sectional wet area, ω, m^2	Wetted perimeter, *X, m*	Hydraulic radius, R, m	Flow velocity, ϑ, m/s
1,25 1,23 -1,6	8,76 9,1 +3,88	9,71 9,65 -0,62	0,9 0,94 +4,44	0,473 0,488 +3,16
1,31 +4,6	9,12 4,11	9,74 +0,31	0,94 +4,44	0,487 +2,96
1,64 +31,2	8,7 -0,685	8,6 +11,45	1,01 +12,2	0,512 +8,28

Statistical surveys of irrigation channels in the Syrdarya river basin, laid exclusively in the earthen bed, made it possible to establish the limits of their values for all basic technological parameters (width on the bottom, water depth, slope laying) when passing forced, maximum water flows, taking into account ground conditions, cross-section, etc. Their values, limits, frequency of occurrence and probability of P_i distribution have been identified (Table 2).

Table 2 – Statistical analysis of the survey results of inter-farm channels in the Syrdarya river basin [4-7]

Channel Settings	Designations	Quantitative indicators (m)			Frequency of occurrence (P_i)
		value limits	medium	for the dredger selection	
Bottom width	B	1,2÷36,0	12,4	6,0	0,1557
Water depth	H	1,15÷5,0	2,08	3,0	0,1317
Sloping	m	1,0÷2,0	1,5	1,5	0,4266
Bottom slope	i	0,00006÷0,0002	0,0001263	≤0,0001	0,377
Cross-section profile: sidehill cut - sidehill fill cut fill	PP (CS) Vp-v/ph (Kshc/Kshf) Kv (Kc) Kh (Kf)	up to 65% up to 26% up to 7%	- - -	+ + -	0,6683 0,292 0,0397
Riverbed soil: loamy sandy clay	Gr (S)	up to 80% up to 12% up to 8%	- - -	+ + +	0,8476 0,0981 0,0544
Width: surface width width ratio	B_2 B_0	4,25÷52,4 3,05÷17,8	20,9 7,95	6÷20 ≥6,0	0,1278 0,237

Calculation method based on analogy between slip curves and slopes

This method is based on the following two basic prerequisites:

1. The angle of stable (natural) slope for any rock soil is the angle of resistance to its shear (Ψ), i.e. the ratio of the shear stress to the normal stress in the limit equilibrium stage.

2. The critical stress in the thickness of the slope, which is in the stage of limit equilibrium, is determined by the equality of the two main stresses (coefficients) of the lateral pressure $\xi = 1$, equal to the weight of the ground column height, in turn, equal to the depth of the immersion point from the horizontal surface of the soil. According to the F_p method, the gradient of the stable slope curve at an angle a to the horizon at each point on the slope with coordinates z and x is determined by the condition $a' = \Psi_p$.

Shear resistance coefficient F_p is determined numerically by the ratio of soil shear resistance S_p to the load P corresponding to it, i.e.

$$F_p = \frac{S_p}{P} = tg\varphi + \frac{C}{P}, \tag{1}$$

in this case, the equation of the surface of the limiting free slope has the form

$$x = \frac{1}{\gamma_G tg\varphi}\left[tg\varphi Z\gamma_G + C\ln C - C\ln\left(g\varphi\gamma_G Z + C\right)\right], \tag{2}$$

where x and z are coordinates of the considered slope point.

Studies show [6-11] that the assessment of the degree of slope stability must be considered taking into account seepage pressure in the “most dangerous case”, when the depression curve occupies the highest position.

The contour equation of a curvilinear equally stable slope, filtering over the entire height, composed of ideally cohesive soil has the form [12, 13].

$$y = \frac{2K}{\gamma_{nas}}\ln\frac{\cos\left(\dfrac{x\gamma_{nas} + \gamma_0 H + P - 2K}{2K}\right)}{\cos\left(\dfrac{\gamma_0 H + P - 2K}{2K}\right)}. \tag{3}$$

If there is no load on the horizontal surface of the slope $\gamma_0 H = 2K - P$ an equally stable slope curve is obtained, expressed by the equation

$$y = \frac{2K}{\gamma_{nas}}\ln\left(\cos\frac{x\gamma_{nas}}{2K}\right), \tag{4}$$

where K is the specific cohesion force of the soil; γ_{nas} is the density of the saturated-soil; γ – water density; H – slope height; P is the intensity of the evenly distributed load; x and y are the coordinates of the point.

For a slope filtering in the lower part, the problem is considered similarly to the construction of contours of equally stable slopes in a two layered earth. The soil below the depression curve is considered as another layer with different characteristics.

In this case, it is assumed that the angle of internal friction in the non-filtering and filtering parts remains unchanged, and the specific cohesive force *K* decreases in the filtration area due to an increase in humidity.

Calculation of slope stability below the depression curve is to determine the equilibrium contour of the load on the surface of the depression curve from the above ground.

From the condition of the continuity of stresses at the contact of the layers – the depression lines $\sigma_{pnf}=\sigma_{nf}$ and τ_{pnf} τ_{nt} determine the functions φ_f, and σ_f, expressed through the characteristics of the filtering layer

$$\begin{gathered}\sigma_{pnf}\left[1+\sin\rho_{nf}\cos 2\left(\varphi_{nf}-a_1\right)-Kctg\rho_{nf}\right]=\\=\sigma_{nf}\left[1+\sin\rho_f\cos 2\left(\varphi_f-a_1\right)-Kctg\rho_f\right],\\\sigma_{nf}\sin\rho_{nf}\sin\left(\varphi_{nf}-a_1\right)=\sigma_{nf}\sin 2\left(\varphi_f-a_1\right),\end{gathered} \tag{5}$$

where a_1 is the angle of slope of the depression curve to the horizon; the indices *nf* and *f* mean, respectively, the non-filtering and filtering parts of the slope; φ is the angle of internal friction of the soil.

Calculation method based on the theory of limit equilibrium

It has been proven that an equilibrium slope, located in limit equilibrium, can maintain evenly distributed load on the horizontal surface of the ground mass with an intensity [14, 15].

$$p_0=\frac{2C\cos\varphi}{1-\sin\varphi}. \tag{6}$$

A much more difficult task is to determine the shape of equally stable slopes for the general case when the soil has both friction and cohesion. In this case, to construct the contours of the steepest equally stable slopes, the following solutions are given by numerical integration of the differential equations. Coordinates are given in dimensionless quantities

$$x^1=\frac{\gamma_\Gamma}{C}x;\ y^1=\frac{\gamma_\Gamma}{C}y. \tag{7}$$

Based on the calculated coordinates *x* and *y*, for the given values of φ, C and γ_G, an equally stable slope of maximum steepness is built, starting from the upper edge of the slope. The available solutions are extremely complex, and the assumption of the occurrence of a limiting state simultaneously at all points of the area under consideration is very conditional from a physical point of view, therefore, in the practice of calculations, these methods can be applied to schematized models of earthen channel slopes. The calculation formulas of these methods are given below.

The maximum permissible slope value

$$h=\frac{2C}{\gamma_G}\cdot\frac{\sin\theta\cos\varphi}{\sin^2\frac{\theta-\varphi}{2}}, \tag{8}$$

where h is the maximum slope height; C is the soil cohesion force; γ_G is soil density; θ is the slope angle; φ is the angle of internal friction of the soil.

The shape of an equally stable slope of the ground with perfect cohesion

$$y = \frac{2C}{\gamma_G} \ln \frac{\cos\left(\frac{P_0}{2C} - 1\right)}{\cos\left(\frac{P_0}{2C} - 1 - \frac{\gamma_G}{2C} x\right)}, \tag{9}$$

where P_0 is the intensity of evenly distributed load $P_0 = \frac{2C\cos\varphi}{1-\sin\varphi}$

$$(K_3)_{\min} \geq (K_3)_{\text{dop}}\,, \tag{10}$$

where $K_{3\min}$ is stability factor; $(K_3)_{\text{dop}}$ stands for the value of the allowable safety factor.

$$K_3 = \frac{в\gamma_{nas}\sum h_{pr}\cos\alpha tg\varphi + \sum C\ell}{в\gamma_{nas}\sum h_{pr}\sin\alpha + \Omega IV / R} \tag{11}$$

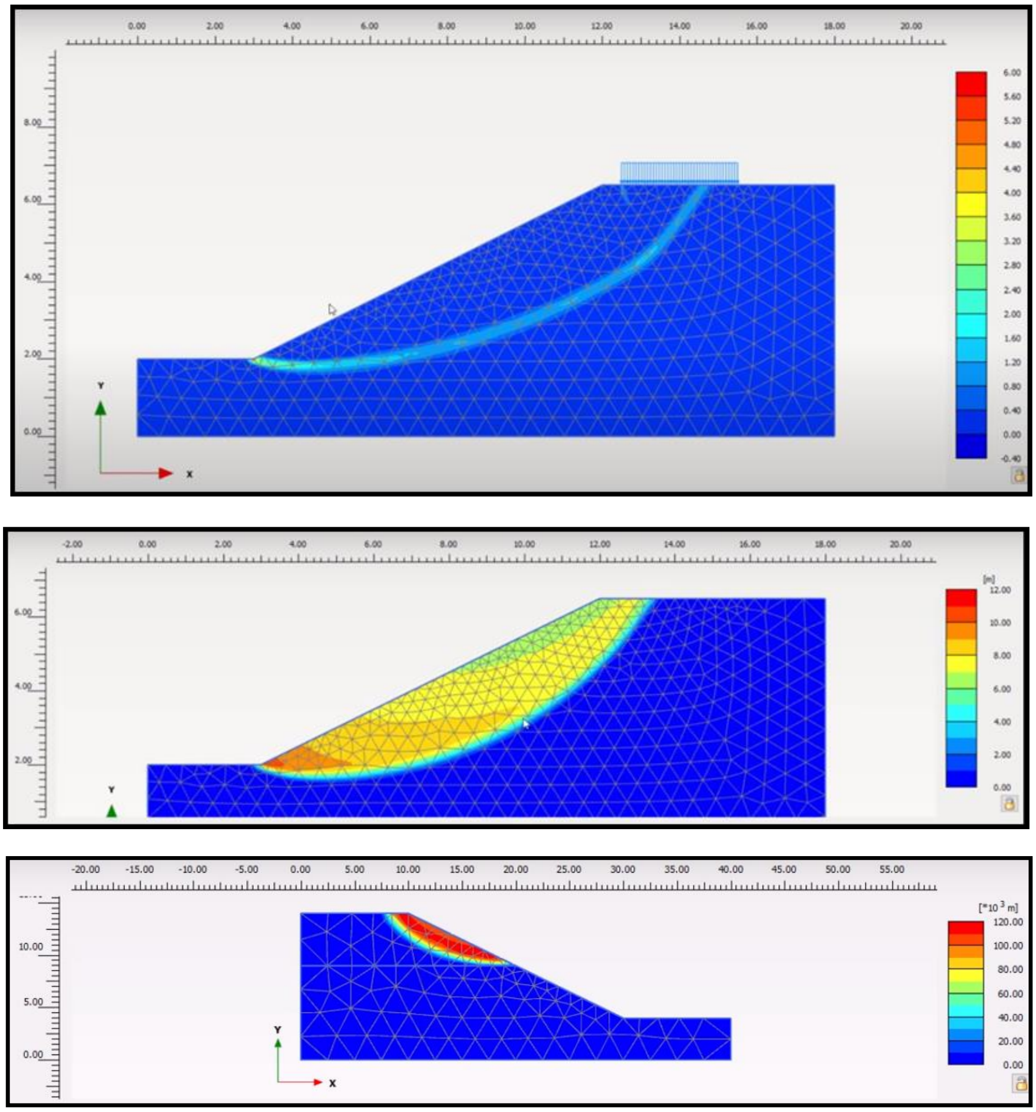
$$h_{pr} = h_{es} + \frac{\gamma_{nas}}{\gamma_{es}} h_{nas}$$

where γ_{es} and γ_{nas} are, respectively, the bulk masses of the soil at natural and saturated humidity; h_{es} and h_{nas} – the height of the soil strip at natural and saturated humidity, respectively; φ is the angle of internal friction of the soil; C – specific cohesion of the soil, $в$ – strip width ($в$=0,1); ℓ is the arc length of the slip curve; Ω is the filtration flow area in the zone of the sliding massif ($\Omega = \sum h_{nas} в$); I is the average gradient in this zone $\left(I = \frac{\Delta h}{\Delta \ell}\right)$; $ч$ - arm of force $I\Omega$.

The calculated stability coefficients of the channel slope fully satisfy the normal operating conditions of III - IV class structures ($(K_3)_{\text{dop}}$=1,1). At the same time, it should be noted that the specific cohesion of the soil should not be less than 0.3, otherwise, in the second case, the stability of the slope will not be ensured (Figure 2 a, b). The permissible slope steepness is determined by a special calculation. It is based on one of two theories: the theory of "limit equilibrium", according to which it is believed that there is an ultimate equilibrium in all points of shifting mass. The second theory is based on the use of the model of a hardened part of soil collapse. Special calculation models were performed using the PLAXIS 2D software package. Created geometric model program automatically generates unstructured mesh with the possibility of global and local change of its density. The use of high-order elements in the model is useful for evenly distribution of stresses in the soil and accurate prediction of unacceptable loads.

a)

b)



a – geometric model; b – strained mesh (full hydraulic and static load movements)

Figure 2 – Calculated cross-section model of earthen channels

From the calculations made, it should be noted that the correct choice of slopes is of particular importance. If the slopes are laid steeply, they sink and clog up the channel and if they are gentle, they increase the volume of earthworks and the loss of area under the right-of-way.

Results and discussion

Studies on the hydraulic and hydrotechnical assessment of channels of trapezoidal and parabolic cross-section shapes, taking into account the hydrogeological and morphological factors of stability of their sections, show that the curvilinear parabolic shape of the channel cross-sections is dynamically more stable. Channels with parabolic cross-section shapes compared to trapezoidal ones have the advantages of saving the flow section (volume of earthworks) by 2.3-8.23%, reducing the length of the wetted perimeter (volume of facing works) by 5.6-20.5% and reducing the width along the water table (right-of-way width) by 1.1-29%, depending on the coefficients of the slope and the degree of the parabola.

The use of channels with parabolic sections can significantly reduce the amount of earth work during their construction in comparison with channels with trapezoidal sections (Tables 3, 4). Firstly, by reducing the cross-section area of the channel by 8.04-14%, which gives greater savings in earthworks than savings only from the free flow section, since the dry slope of the parabolic channel is steeper than the slope of the trapezoidal channel. Secondly, by reducing the cross-section area of the cushion by 12.0-26.0%. Reducing the cross-sectional area of the cushion is achieved due to the fact that the width along the top of the channel of the parabolic section profile is 20-26.2% less than the trapezoidal one, therefore, the width of the cushion can be reduced by an appropriate amount. The nature of the change in the cross-section area of channel and channel cushion of parabolic and trapezoidal profiles shows that with an increase in the depth of the channel, the difference in the cross-section area of channel and cushion and the saving in earthworks increase.

Table 3 – Technological parameters of irrigation channels

Channel Options								
Type of profile section	Flow rate (m^3/s) Q	Channel depth (m) h_k	Filling depth (m) h	Bottom width (m) b	Slope laying (parabola parameter P) m	Top width B_k	Cross-section perimeter (m^2) χ_k	Cross-section area S_k
Trapezoidal	1,65	1,5	1,2	0,8	1:1,25	4,55	5,6	4,01
Parabolic	1,62	1,5	1,2	-	P=1,02	3,5	4,85	3,5
Trapezoidal	4,16	2,0	1,7	1,0	1:1,5	7	8,2	8
Parabolic	4,18	2,0	1,7	-	P=1,66	5,16	6,84	6,88
Trapezoidal	14,26	3,0	2,7	2,0	1:1,75	12,7	14,1	21,75
Parabolic	14,13	3,0	2,7	-	P=4,16	10	12	20

Table 4 – Changes of irrigation channels parameters

Changes			Change in the total cross-section area of structure, (m^2/%)
Top width, (m/%)	Perimeter, (m/%)	Cross-section area, (m^2/%)	
ΔB_k	$\Delta \chi_k$	ΔS_k	$\sum \Delta S$
-	-	-	-
1,06/13,4	0,75/13,3	0,51/12,7	1,35/12,3
-			-
1,84/26,2	1,36/16,6	1,12/14	2,96/15,17
-			-
2,5/20	2,1/14,9	1,75/8,04	4,25/8,78

The cross section of the channel, due to the interaction of the physical and mechanical properties of the soil, outcrop of groundwater, the eroding effect of the flow, and other factors, takes on a more stable curvilinear shape. This shape of the channel is most suitable for a parabola or semi-ellipse.

Trapezoidal channels without lining can be made only under conditions when they are completely in dry or cohesive soils that are unable to spread quickly from saturation (peat that has not lost its structure, solid boulder clay, non-podzolized coarse-grained sandy soil, etc.). Therefore, even with completely homogeneous soil, it is more profitable to use polygonal profiles. In such cases, steeper slopes are used in the upper slope layer, and more gentle slopes in the lower ones. Polygonal channels can easily be given a semi-elliptical or parabolic shape without reducing their stability.

Hydraulically, the most advantageous channel profile is the one that, with the same flow area and a defined slope, provides the highest carrying capasity or, in other words , at a defined flow rate, passes it with the smallest flow section [16-18].

Conclusion

Taking into account the hydromorphological and geotechnical factors of the stability of the channel sections, it can be concluded that the channels of parabolic sections are optimal in terms of the following parameters: stability improvement of the section against deformations; reduction of earthworks during the construction and cleaning of irrigation channels by 8.8...44.4%; reduction of materials and scope of work for possible lining (strengthening) of irrigation channels by 13.4...33.7%; reduction of the channel width along the top (exclusion zone) of irrigation channels by 10.5…26.2%; reduction of labor costs by 13.7…16.7%; reduction of construction costs (production costs) by 13.88...18.09%; reduction of mentioned specific costs by 14.36…17.78%.

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References:

1 *Sennikov M.N., Omarova G.E., Moldamuratov Z.N. Study of the development of soil in the formation of channels hydraulic and static stability of cross-sectional shapes // World Applied Sciences Journal. 2014. № 1 (30). (in Eng.)*
2 *Jakiyayev B.D., Moldamuratov Z.N. Study of local erosion and development of effective structures of transverse bank protection structures 2021. № 3 (9). C. 457–473. (in Eng.)*
3 *Shokirov B. Computer simulation of channel processes // E3S Web of Conferences. 2019. (97). (in Eng.)*
4 *Han Y. Cheng, Gao X. Ping, Xu Z. He. The best hydraulic section of horizontal-bottomed parabolic channel section // Journal of Hydrodynamics. 2017. № 2 (29). C. 305–313. (in Eng.)*
5 *Han Y.-C., Easa S. M. Exact Solution of Optimum Hydraulic Power-Law Section with General Exponent Parameter // Journal of Irrigation and Drainage Engineering. 2018. № 12 (144). C. 04018035. (in Eng.)*
6 *Han Y. Optimal hydraulic section of horizontal-bottom catenary channel // Nongye Gongcheng Xuebao/Transactions of the Chinese Society of Agricultural Engineering. 2019. № 6 (35). C. 90–99. (in Eng.)*
7 *Vatankhah A. R., Easa S. M. Explicit solutions for critical and normal depths in channels with different shapes // Flow Measurement and Instrumentation. 2011. № 1 (22). C. 43–49. (in Eng.)*

8 *Dai S., Ma Y., Jin S. Direct calculation formulas for normal depths of four kinds of parabola-shaped channels // Flow Measurement and Instrumentation. 2019. (65). C. 180–186. (in Eng.)*
9 *Han Y. Optimal hydraulic section of horizontal-bottom catenary channel // Nongye Gongcheng Xuebao/Transactions of the Chinese Society of Agricultural Engineering. 2019. № 6 (35). C. 90–99. (in Eng.)*
10 *Zhang X., Lü H. Explicit solution for normal depth in parabolic-shape channel // Nongye Gongcheng Xuebao/Transactions of the Chinese Society of Agricultural Engineering. 2012. № 21 (28). C. 121–125. (in Eng.)*
11 *Zhang Y., Wang Y., Wang W. Effects of sediment concentration on lateral distribution of water velocity in U-channel // Nongye Gongcheng Xuebao/Transactions of the Chinese Society of Agricultural Engineering. 2012. № 12 (28). C. 134–139. (in Eng.)*
12 *Liu D. Optimizing channel cross section in irrigation area using improved cat swarm optimization algorithm // International Journal of Agricultural and Biological Engineering. 2016. № 5 (9). (in Eng.)*
13 *Das A. Optimal Design of Channel Having Horizontal Bottom and Parabolic Sides // Journal of Irrigation and Drainage Engineering. 2007. № 2 (133). C. 192–197. (in Eng.)*
14 *Das A. Optimal Channel Cross Section with Composite Roughness // Journal of Irrigation and Drainage Engineering. 2000. № 1 (126). C. 68–72. (in Eng.)*
15 *Strelkoff T. S., Clemmens A. J. Approximating Wetted Perimeter in Power-Law Cross Section // Journal of Irrigation and Drainage Engineering. 2000. № 2 (126). C. 98–109. (in Eng.)*
16 *Mironenko A. P., Willardson L. S., Jenab S. A. Parabolic Canal Design and Analysis // Journal of Irrigation and Drainage Engineering. 1984. № 2 (110). C. 241–246. (in Eng.)*
17 *Loganathan G. V. Optimal Design of Parabolic Canals // Journal of Irrigation and Drainage Engineering. 1991. № 5 (117). C. 716–735. (in Eng.)*
18 *Anwar A. A., Vries T. T. de Hydraulically Efficient Power-Law Channels // Journal of Irrigation and Drainage Engineering. 2003. № 1 (129). C. 18–26. (in Eng.)*

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ГИДРАВЛИКАЛЫҚ ЖӘНЕ СТАТИКАЛЫҚ ТҰРАҚТЫ КӨЛДЕНЕҢ ҚИМАЛЫ КАНАЛДАР

Аңдатпа. *Қазақстан Республикасының оңтүстігіндегі гидромелиоративтік жүйелердің каналдарына орнықты көлденең қима пішінін беруді негіздеу бойынша зерттеу нәтижелері баяндалған. Суару каналдарының беткейлерінің тұрақтылығы және олардың конструктивтік ерекшеліктері, орнықты профильдердің практикалық негіздемесі бойынша есептеулер жүргізілді. Беткей топырақтарының геотехникалық параметрлерінің нақты мәндерін қолдана отырып, орнықты көлбеу формалары анықталды. Зерттеу нәтижелері каналды пайдалану кезінде көлбеу профиль параболаға жақын орнықты пішінді алатындығын көрсетті.*

Түйін сөздер: *гидромелиоративтік жүйелер, каналдар, көлденең қима, арналық процестер, беткейлердің орнықтылығы.*

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КАНАЛЫ ГИДРАВЛИЧЕСКИ И СТАТИЧЕСКИ УСТОЙЧИВОЙ ФОРМЫ ПОПЕРЕЧНОГО СЕЧЕНИЯ

Аннотация. *Изложены результаты исследований по обоснованию придания каналам гидромелиоративных систем юга Республики Казахстан устойчивой формы поперечного сечения. Выполнены расчеты по устойчивости откосов оросительных каналов и их конструктивные особенности, практическое обоснование устойчивых профилей. Определены формы устойчивого откоса с использованием фактических значений геотехнических параметров грунтов откосов. Результаты исследований показали, что в процессе эксплуатации канала профиль откоса принимает устойчивую форму, близкую к параболической.*

Ключевые слова: *гидромелиоративные системы, каналы, поперечное сечение, русловые процессы, устойчивость откосов.*