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ON DETERMINATION OF STABLE LONGITUDINAL PROFILE OF THE RIVER CHANNEL

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One of the main problems of channel processes' prediction is the determination of a stable longitudinal profile of the channel of river. Related to it there are also problems of rivers` meandering. The proposed method of forecasting the channel processes is based on determination of the stable longitudinal profile of a river and its comparison with the actual longitudinal profile. Comparison of these two profiles enables evaluating the entire description of the channel deformations in the given section of the course of river. It is also reasoned in what case it is advisable to carry out the corridor of the rivers, and in what case should it be limited to taking bank-protection measures on the old channel of the river.

Key words: *ground, channel, river-training, channel wash up, hydrograph, bank-protection measures, hydraulic size*

Introduction

River channels are steadily subject to changes until the stable state of the channel is reached. In addition, the wash-up depends on characteristics of the current and channel, as well as the channel's soil composition.

The term "stable channel" is often used with different meanings.

According to K.V. Grisanin [1, 2], defined the term "stable channel" as a prismatic channel of stable gradient and insensitive to small excitations with a solid bottom formed by unbound particles.

Static stability is the time invariability of hydromorphological parameters of the channel in the course of time. The stability of the channel refers to some sections of a certain length where cross-sections shape and width remain unchanged for a long period of time. Considering that such an approach does not take into consideration the channel bed fluctuation caused by movement of carried down and deposited earth, gravel, rock (lat. Fluctuatio: fluctuatio, fluctuatio variation, random variation of any magnitude and index), this paper suggests replacing the term "time stability of the channel" by the concept of "time pseudo-stability of the channel".

The channel processes taking place in the mountainous rivers essentially differ from the channel processes taking place in lowlands. If the size of the soil particles in the lowland rivers form the channel of the rivers does not exceed 1 mm, then in the mountainous rivers they reach several hundred millimeters. Moreover, if the dimensions of particles in the lowland river channels are not practically subject to change along the current, then in the mountainous streams self-evenning process creates rearrangement of particles according to their size. The slopes and hydrographs of the mountainous and plains rivers are very different.

The complicated morphology and current fluctuations of natural channels pose many problems, from which K.V. Grishan [1], as important, underlined the following two of them.

1) How long the average velocity of the stream can practically remain constant along the length of the river course.
2) Can the condition $\frac{du}{dx} = 0$ remain independent of the free surface fluctuations?

If in a plane problem the stability of a straight slope channel is disturbed by a random excitation hiving a wavelength equivalent to the stream depth, then in the case of a three-dimensional problem, the stability of the prismatic channel bed of a straight slope is disturbed by excitation having a wavelength proportional to the channel width [1]. From here, one can arrive to a conclusion that the average velocity of the channel along the run can be practically constant in a section proportional to the channel width. It has been proved that if the free surface fluctuations occur sufficiently slow, then the water movement in the prismatic channel of the constant gradient angle, regardless of the stream depth remains quasi-constant, that is, it can only be changed if the output is changed [1].

Conflict settings

To implement bank-protection and channel training measures a problem is posed to develop a technique able to predict channel deformations.

Research results

The method for determining a stable longitudinal profile involves in a system of differential equations characterizing the channel processes equations of the nonuniform flow of the fluid and the deformations of the channel [3, 4]. Thus, we get

$$\frac{dh}{dx} + \frac{dz}{dx} = -\frac{d}{dx}\left(\frac{U^2}{2g}\right) - \frac{U^2}{C^2 h}, \qquad (1)$$

$$\frac{dG}{dx} = 0 :$$

To solve this system it is necessary to have G output expression of the solid particles. A good many empirical dependence devoted to the solution of this problem are available in the special literature. Analyzing these dependences K.V.Grishanin [1] found that all formulae determining output of the solid particles are the same in the sense that they all point to the same factors affecting the amount of silt, such as flow kinetics, particles' mobility, hydraulic resistance of the channel, etc. [1]. For the G output expression we have

$$G \sim Fr\left(\frac{V_*}{W_0}\right)^n \left(\frac{C}{\sqrt{g}}\right)^m \qquad (2)$$

The size of the fixed particles and the resistance of the channel are mutually depend. As a proof of that is revelation of regular alteration of ***n*** index as compared with the ***m*** one. For example, formulae having a high value of ***n*** index have a lower value of ***m*** index. And since all of these formulas the indices are determined empirically, their correlated changes reflect the objective reality. Based on this, K.V.Grishanin obtained that interrelationship directly [2]

$$n = 1.25 - 0.25m: \qquad (3)$$

When the channel bed is assumed stable in the current of solid particles should take place sedimentation. That is, the hydraulic size of the moving particles should become equal to the hydraulic size of the bottom silts. When ***n*** = 0, then m = 5. In this case, the following relationship can be used to determine the output of solid particles

$$G \sim Fr\left(\frac{C}{\sqrt{g}}\right)^5 : \qquad (4)$$

or taking into consideration the following dependence

$$G \sim K_1\left(\frac{h}{d}\right)^{1/6} : \qquad (5)$$

for solid particles, we get

$$G \sim \frac{U^2}{d(h/d)^{1/6}} : \qquad (6)$$

Taking into account Eq.(6) in case of stationary flow the equation of the channel deformation will have the following view

$$u^2 = kd\left({}^{h}/_{d}\right)^{1/6} \qquad (7)$$

The velocity determined by Eq.(7) is the non-washing-up velocity measure of unbound particles of ***d*** diameter on the channel bottom at the ***h*** depth. Therefore, to ensure stability of the channel it is necessary that the flow velocity be not greater than that measure. In that case, taking into account Eq.(5) and (7), we get

$$\frac{dz}{dx}=\frac{d}{dx}\left[-h-\frac{k}{2g}d\left(\frac{h}{d}\right)^{1/6}-\frac{k}{k_1^2}\int_0^x\frac{d(x)dx}{h\left(h/d\right)^{1/6}}\right]: \tag{8}$$

Integrating Eq.(8), we have

$$z=-h-\frac{k}{2g}d\left(\frac{h}{d}\right)^{1/6}-\frac{k}{k_1^2}\int\frac{d(x)dx}{h(x)\left(h/d\right)^{1/6}}+k_2 \tag{9}$$

Let us assume that in the source course of the river the average depth of the stream and the self-evenning diameter of the solid particles are the following

$$x=0;\, z=z_0;\, h=h_0;\, d=d_0. \tag{10}$$

Taking into account Eq.(9) and (10), we get the equation of the stable channel's cross-section

$$z=z_0+(h_0-h)+\frac{k}{2g}\left[d_0\left(\frac{h_0}{d_0}\right)^{1/6}-d\left(\frac{h}{d}\right)^{1/6}\right]-\frac{k}{k_1^2}\int\frac{d(x)dx}{h(x)\left(h/d\right)^{1/6}} \tag{11}$$

The obtained relationships show that the stable shape of longitudinal cross-section of the channel being washed-up depends not only on the change in the depth of the current along the course, but also on the self-leveling diameter of the solid particles and the change of roughness of the channel. Given the regularity of these magnitudes change in accordance of the river length, we will get the longitudinal section of the channel.

In particular, when the depth of the current and the self-evenning diameter of solid particles along the length do not change, whereas do in lowland rivers, from Eq.(11) one can arrive at a conclusion that the longitudinal cross-section of the stable channel bottom is a straight line and its gradient is determined by the equation of the water uniform movement.

The flow in the mountainous rivers is always nonuniform. Some researchers suggest taking it constant [1], that is

$$h=h_0: \tag{12}$$

Such an approach is unacceptable and leads to sensible errors.

The average diameter of self-evenning solid particles can be determined from the following regularity

$$d=d_0e^{-\alpha x} \tag{13}$$

Taking into consideration Eqs.(12) and (13) for a stable channel longitudinal cross-section we have

$$z_p^*=z_0+\frac{k}{2g}d_0\left(\frac{h_0}{d_0}\right)^{1/6}\left(1-e^{-\frac{5}{6}\alpha x}\right)-\frac{6k}{7\alpha k_1^2}\left(\frac{d_0}{h_0}\right)^{7/6}\left(1-e^{-\frac{7}{6}\alpha x}\right) \tag{14}$$

The movement of the mountain in the mountainous rivers is uneven. On the other hand, the slopes of these rivers, as a rule, are smaller and the width increases. As a result, the depth of power decreases in length. Given that we use the exponential connection to determine the bottom self-evenning particles (13), from the point of view of convenience, a similar connection can be used to determine the depth of the current

$$h=h_0e^{-\beta x} \tag{15}$$

The analysis of experimental results enables to conclude that there always is the following inequality $\alpha>\beta$, that is diameters of self-evenning particles are decreasing more quickly than the current depth. As a result, when Eqs(13) and (15) are taken into account and some simplifications are made Eq.(11) will have the following view

$$z_p^* = z_0 + h_0\left(1 - e^{-\beta x}\right) + \frac{k}{2g} d_0 \left(\frac{h_0}{d_0}\right)^{1/6} \left(1 - e^{-\frac{(5\alpha+\beta)}{6}x}\right) - \frac{6k}{7(\alpha-\beta)k_1^2}\left(\frac{d_0}{h_0}\right)^{7/6}\left(1 - e^{-\frac{7(\alpha-\beta)}{6}x}\right) \quad (16)$$

In this case, one more β index is added to previous conditions set for the river.

Conclusion

1. The suggested technique enables to predict possible channel deformations while implementing bank-protection and river training measures. In the latter case, as a rule, the bottom gradient of channel increases.
2. In designing it is necessary using a calculation method to determine the gradient of the stable channel bottom and compare the obtained results with original values. At the same time if data on current depth change along the water run then one can make use of Eq.(16), and in case of absent of such data – of Eq.(`4).
3. Taking into account that when the channel's time stability is evaluated and the fluctuation caused by the channel bottom movement is neglected, it is suggested to use the "time pseudo-stability of the channel" concept.

Used designations

u- average flow velocity
C- Shezy coefficient
R- hydraulic radius
n- roughness factor
Fr- Froud's number
Q - fluid outlet
G- output of solid particles
h- average depth of the stream
h_0 - depth of the stream at the beginning of the section
d - average self-evenning diameter
d_0- diameter at the beginning of the section
x- axis
U_0 - not wash-up speed
g- free fall acceleration
Z_{p_*}- calculated height of the bottom, in case of variable depth;
Z_p - calculated height of the bottom, in case of unchanged depth
Z_H- calculated actual height of the bottom
Z_0- the height of the bottom at the beginning of the section
α - degree of self-absorbing particles
β- degree of the stream depth decrease
V_* - average hydraulic size of bottom silts
W_0 - average hydraulic size of moving particles;
K, K_1, a- constants.

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ՀՈՒՆԻ ԿԱՅՈՒՆ ԵՐԿԱՅՆԱԿԱՆ ՊՐՈՖԻԼԻ ՈՐՈՇՄԱՆ ՄԱՍԻՆ

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1- Շուշիի տեխնոլոգիական համալսարան
2- "Պասկալ" ՍՊԸ

Հունային գործընթացների կանխատեսման հիմնական խնդիրներից է հունի կայուն երկայնական պրոֆիլի որոշումը: Դրա հետ են կապված նաև գետերի միանդրացման խնդիրները: Հունային գործընթացների կանխատեսման առաջարկվող մեթոդը հիմնված է տվյալ տեղամասում գետի կայուն երկայնական պրոֆիլի և իրական երկայնական պրոֆիլի հետ համեմատության վրա: Այս երկու պրոֆիլների համեմատումը թույլ է տալիս գնահատել, գետի տրված տեղամասում, հունային դեֆորմացիաների ամբողջ նկարագիրը: Հիմնավորվում է,թե որ դեպքում է նպատակահարմար իրականացնել գետերի հուների ուղղում, իսկ որ դեպքում է պետք սահմանափակվել հին գետի հունի վրա ափապաշտպան միջոցառումներով:

Բանալի բառեր. գրունտ, հուն, հունի ողղում, հիդրոգրաֆ, ափապաշտպան միջոցառում, հիդրավլիկական խոշորություն

ОБ ОПРЕДЕЛЕНИИ ПРОДОЛЬНОГО ПРОФИЛЯ УСТОЙЧИВОГО РУСЛА

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Одной из основных задач прогнозирования русловых процессов является определение продольного профиля устойчивого русла. С этим связаны также вопросы меандрирования рек. Предлагаемый метод прогнозирования русловых процессов основан на сравнении продольного профиля устойчивого русла со существущим профилем дна, что позволяет оценивать русловые деформации на данном участке реки. Обоснованы случаи, когда предпочтительно проводить выпрямление русла река, и когда можно обойтись берегозащитными мероприятиями.

Ключевые слова: грунт, русло, гидрограф, берегозащитные мероприятия, гидравлическая крупность