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The Calculation of the Parameter of Friction in Border Layer Not Fixed Flow

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ABSTRACT. In the article, according to the results of literature analysis, empirical relations are proposed for determining the friction parameter of a not washing away turbulent boundary layer, which plays an important role in the design of earth channels.

KEYWORDS: Stationary flow, boundary layer, orbital velocity, friction parameter, wave flow.

I. INTRODUCTION

When deciding the problems, referring to the forecast of the transport alluvium at the presence of the different sort of the wave motion, the leading place is occupied with the question about shaping not stationary turbulent border layer. Because of this not accidentally the study of erosion processes, connected with the wavy flow in most cases begins with the studies of the structured particularities of border layer, which in natural condition have mainly turbulent nature at present, due to fundamental studies of some authors [1, 2, 4] in border layer is reached enough greater successes. However, in view of greater mathematical difficulties of the description of the process of the shaping border layer in condition of the oscillatory nature of the motion, on modern stage, on former, exists the gaps that worth to pay attention and first of all, in the field of reliable quantitative estimation parameter of the not stationary layers, which much defines the correctness of taking the design decisions at hydro technical construction.

II. SIGNIFICANCE OF THE SYSTEM

In the article, according to the results of literature analysis, empirical relations are proposed for determining the friction parameter of a no stationary turbulent boundary layer, which plays an important role in the design of earth channels. The study of literature survey is presented in section III, methodology is explained in section IV, section V covers the experimental results of the study, and section VI discusses the future study and conclusion

III. LITERATURE SURVEY

One of the first models of the oscillating boundary layer is the solution [8]. The author used the concept of turbulent viscosity to create a three-layer model; In a thin inner layer, the turbulent viscosity was assumed constant, in the intermediate layer it was assumed linearly dependent on the distance to the bottom, and finally, at some distance from the bottom, it was again assumed to be a constant (outer layer). Using the equation of conservation of the moments of motion in [8] a very complex numerical-analytical solution was obtained. Later, Brevik [6] greatly simplified the solution [8] by eliminating the inner layer from the analysis. Both authors compared their theoretical results with the experimental data of Johnson [7] and obtained a fairly good agreement.

Some of these shortcomings were eliminated later in the models of Johnson and Carlsen [7]. Using also the equation of conservation of momentum and assuming that the velocity distribution in the boundary layer obeys a logarithmic law, the authors obtained an expression for the friction parameter for the case of fully expressed roughness. However, since the equations were integrated during the wave period, detailed (within the wave cycle) changes in tangential stresses and phase shifts between the maxima of the orbital velocity and tangential stresses were not described. In addition, changes in the boundary layer over time were considered negligible and the integration constant was determined from experimental data.

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Further, it is advisable to mention the development of Bakker [5], who introduced the hypothesis of the path of mixing (like the Prandtl hypothesis for unidirectional flow). Combining with the equation of motion the theory of the path of mixing, the author obtained a second-order nonlinear differential equation in the form:

$$\frac{\partial u_*}{\partial t} = \aleph Z \frac{\partial^2 (u_* |u_*|)}{\partial Z^2},$$

u_* - where is dynamic speed; Z - vertical coordinate; $\aleph = 0{,}4$ - Carman constant. This numerical development is very complex, and the used notion of a mixing path for oscillating motion can be considered at least questionable.

However, as disadvantages of these theories, the following can be noted: 1) they do not take into account the nonstationarity of the turbulent viscosity coefficient; 2) the thickness of the boundary layer was assumed to be independent of time and 3) the change in tangential stress was assumed sinusoidal.

IV. METHODOLOGY

The Existing mathematical model of border layer and majority of the events is founded on equations that were accepted after a string of simplified general system of the equations Navie - Stoks, and being of the form of:

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + w\frac{\partial u}{\partial t} = -\frac{1}{\rho}\frac{\partial p}{\partial x} + \nu\frac{\partial^2 u}{\partial z^2}, \quad (1)$$

$$\frac{\partial u}{\partial x} + \frac{\partial w}{\partial z} = 0, \quad (2)$$

Where u, w - corresponding to vector velocities in border layer, along the axis X and Z; P - pressure; ν – kinematic factor of viscosity; ρ - specific density of water.

Usually, the border condition serves:

$$u = w = 0 \text{ at z=o; } u = \vartheta(x,t) \text{ at z =}\infty. \quad (3)$$

The System (1) - (3) is identified the equations Prandial for border layer.

In none stationary event, when motion has oscillatory nature, and it is necessary account appearing under greater number of Reynolds turbulent pulsation, the system (1) - (3) is mutated.

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + w\frac{\partial u}{\partial t} = -\frac{1}{\rho}\frac{\partial p}{\partial x} + \frac{\partial}{\partial z}\nu_*\frac{\partial u}{\partial z}, \quad (4)$$

$$\frac{\partial u}{\partial x} + \frac{\partial w}{\partial z} = 0, \quad (5)$$

The condition of border:

$$u = w = 0 \text{ at } z = z_0; u = \vartheta(x,t) \text{ at } z = z_0 + \delta, \quad (6)$$

where ν_* – kinematic factor of turbulent viscosity. $z_0 = K_S / 30$ level of the zero velocities; K_S - a height of equivalent roughness by Nikuradze; δ - thickness of border under layer. $\vartheta(x,t)$ the velocity not viscose of the external current, connected with pressure in border layer by correlation:

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$$-\frac{1}{\rho}\frac{\partial p}{\partial x}=\frac{\partial \vartheta}{\partial t}+\vartheta\frac{\partial \vartheta}{\partial x} \quad , \tag{7}$$

Uniting (4) and (7) we get the main system of the equations, about describing motion in not stationary border turbulent layer:

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+w\frac{\partial u}{\partial z}=\frac{\partial \vartheta}{\partial t}+\vartheta\frac{\partial \vartheta}{\partial x}+\frac{\partial}{\partial z}v_*\frac{\partial u}{\partial z}, \tag{8}$$

$$\frac{\partial u}{\partial x}+\frac{\partial w}{\partial z}=0 \quad , \tag{9}$$

In most cases, considering small vertical sizes of border layer and small action of the near the bottom of the nonlinear members, systems (8) and (9) brings to this feature:

$$\frac{\partial u}{\partial t}=\frac{\partial \vartheta}{\partial t}+\frac{\partial}{\partial z}v_*\frac{\partial u}{\partial z} \quad , \tag{10}$$

$$\frac{\partial u}{\partial x}+\frac{\partial w}{\partial z}=0 \quad , \tag{11}$$

V. EXPERIMENTAL RESULTS

Such a (or like) type of system was analyzed by many researchers. The Qualitative defect of majority existing theory one possible refer the followings;

1. They do not take into account not stationary factors of turbulent viscosity.
2. The Thickness of border layer was taken as in the manner of independent from time of the immensity.
3. Change the tangential tension was taken as sinusoidal.

Not jutting out mathematical niceties of existing models of border layer it worth to note the followings: in each of enumerated theoretical developments were undertaken attempts (more or less success) and was taken the dependencies from the point of view of the most important of transport of alluvium values - parameter of friction $f=2u_{*m}^2/u_m^2$ (here u_{*m} – maximum importance of dynamic velocity in wavy flow; u_m - maximum importance of the orbital velocity of external edge turbulent border layer). Herewith in the row of the events as they were already spoken earlier that researchers managed to get the dependencies, residing in enough good correspondence to the experimental facts (fig.1).

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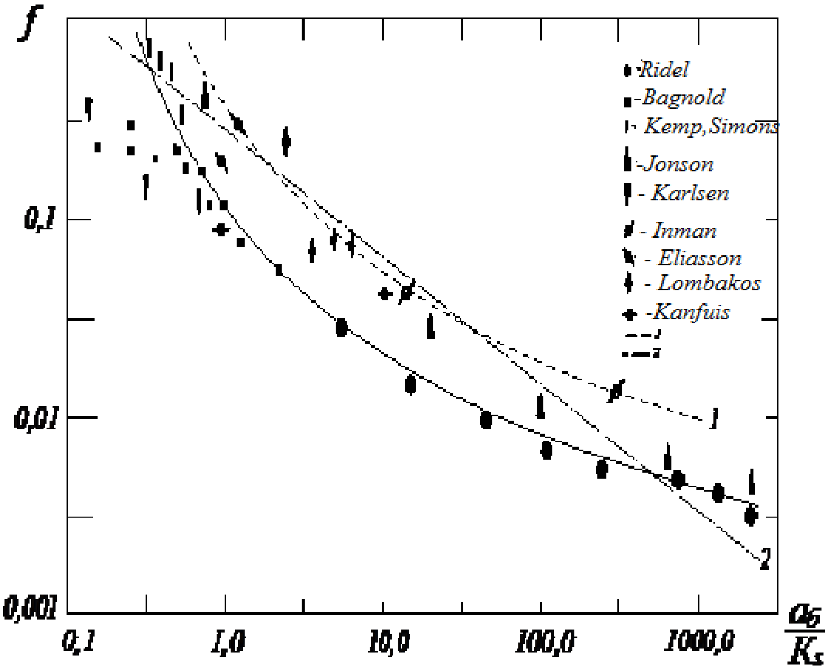

Fig.1. Communication schedule $f=fct(a_\delta/K_s)$: 1- Johnson connection, 1976; 2- Kajiura connection, 1968.

However, from our point of view this correspondence is insufficient for development of the reliable methods of the forecast of the transport alluvium at wavy condition. So purpose of our work is a generalization of existing laboratory and natural facts for getting enough reliable electric dependency of calculation of the parameters of friction, including the most important thing for making decision is the problem of the transport alluvium in wavy flow u_{*m}.

VI. CONCLUSION AND FUTURE WORK

As a result of analysis of the modern literatures [3] the received facts 51 measurements of the change of the parameter f and a_δ / K_S (where $a_\delta = u_m / w$). $f=fct(a_\delta/K_s)$, submitted in figure 1 and from our point of view this seems usefully from earlier gotten analytical relationships. As a matter of convenience practical use got empirical relationship was approximated accurately to 2% series of the dependencies in the manner of:

$$200 < \frac{a_\delta}{K_s} \qquad f = 0{,}05\left(\frac{a_\delta}{K_s}\right)^{-0{,}308} \qquad (11.a)$$

$$25 < \frac{a_\delta}{K_s} \le 200 \qquad f = 0{,}105\left(\frac{a_\delta}{K_s}\right)^{-0{,}444} \qquad (11.b)$$

$$2{,}5 < \frac{a_\delta}{K_s} \le 25 \qquad f = 0{,}204\left(\frac{a_\delta}{K_s}\right)^{-0{,}650} \qquad (11.c)$$

$$0{,}4 < \frac{a_\delta}{K_s} \le 2{,}5 \qquad f = 0{,}279\left(\frac{a_\delta}{K_s}\right)^{-0{,}978} \qquad (11.d)$$

$$\frac{a_\delta}{Ks} \le 0{,}4 \qquad f = 0{,}214\left(\frac{a_\delta}{K_s}\right)^{-1{,}270} \qquad (11.e)$$

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The Dependencies (11a) – (11d) is possible to use in calculation of the transport alluvium in erosion processes in the condition of wind waves.

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