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Hydrology

Simplified Method of Construction of Free Surface Curves at Wave Motion Regime of Debris Flow with Variable Rate along the Way

Otar Natishvili

Academy Member, Georgian National Academy of Sciences, Tbilisi, Georgia

The introduced dependences give us the possibility to judge about the free surface curves of slope debris flow at wave motion regime with variable rate along the way. The suggested method can depict the intensity of erosion processes in slope flows and can help to develop effective methods to fight against negative processes. *© 2020 Bull. Georg. Natl. Acad. Sci.*

Debris flow, wave regime, free surface curves

Erosion processes intensively occur in mountain and in premountainous regions, where they often reach catastrophic sizes of several tones of soil per hectare during a year. While pouring rains very often wave motion flows occur, contributing to intensification of erosion processes. Not talking about the mechanism of slope flow impact on the process of slope erosion and also on defining critical rate of particle separation from ground soil, the wave rate should be taken into account and not the average on live cross section rate of uniformly moving flow.

It is established that variable wave rate is 1.5 time more than average on live section rate of the flow at uniform motion regime [1,2]. In the mentioned works methods of predicting the continuous waves on free surface are suggested.

Analogous to [3] the motion of debris flow with variable rate along the way will be considered.

Suppose, the rate per unit of length $q = const$. In this case for each concrete wave the well-known equation of continuity will have the form:

$$\frac{dh}{dt} = q, \tag{1}$$

where h is variable depth of the flow; t is time.

After integrating (1) we get:

$$h - h_0 = (t - t_0), \tag{2}$$

where index 0 means primary condition.

The rate of continuous wave V_w for the given wave will have the form [1,2]:

$$\frac{dx}{dt}=\frac{gh^2}{\nu}, \qquad 3)$$

where g is accelerated gravity force;

$\nu=\dfrac{\mu}{\rho_x-\rho}$ coefficient of kinematic viscosity of debris flow;

μ – the coefficient of dynamic viscosity of water;

ρ_x,ρ – correspondingly densities of debris and water.

Combining (1) and (3) we get:

$$\frac{dh}{dx}=\frac{dh/dt}{dx/dt}=\frac{q\nu}{gh^2}. \qquad (4)$$

After integration of (4) we get:

$$\frac{\left(h^3-h_0^3\right)g}{3\nu}=q\left(x-x_0\right). \qquad (5)$$

Dependence (5) gives the possibility to construct the curve over free surface wave in the plane „hx" (when OX is located on the bottom of the river bed).

If to exclude „hx" from (2) and (5) we get the equation for characteristics of waves surface in the plane „xt":

$$\left[h_0+q\left(t-t_0\right)\right]^3=h_0^3+\frac{3\nu q\left(x-x_0\right)}{g}. \qquad (6)$$

Dependence (6) gives the possibility to judge about to wave families:

The first one, which are formed in $t_0=0$ и $x_0=0$

$$h^3=h_0^3+\frac{3\nu qx}{g}. \qquad (7)$$

For description of the wave surface in the plane „xt" we have:

$$\left(h_0+qt\right)^3=h_0^3+\frac{3\nu qx}{g}. \qquad (8)$$

The profile of the surface can be written according to dependence:

$$h^3=\left(h-qt\right)^3+\frac{3qx\nu}{g}. \qquad (9)$$

The second one: the wave family is written by one equation:

$$h^3=\frac{3qx\nu}{g}. \qquad (10)$$

Equation (10) describes the curve of free surface wave in the final --- where motion becomes stable.

From (6) it fallows that in the plane „xt" in the lines of wave distribution are parallel

$$t=t_0+\sqrt[3]{\frac{3x\nu}{gq^2}} \qquad (11)$$

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