საქართველოს მეცნიერებათა ეროვნული აკადემიის მოამბე, ტ. 13, №3, 2019
BULLETIN OF THE GEORGIAN NATIONAL ACADEMY OF SCIENCES, vol. 13, no. 3, 2019

Hydrology

Wave Forming as an Active Stimulation of Erosion Processes

Otar Natishvili

Academy Member, Georgian National Academy of Sciences

ABSTRACT. The problem of the impact of waves in the slope shallow water flows on the intensity of soil erosion is considered. The waves appearing on the surface of runoff are often characterized by significant amplitude and become an active stimulation of erosion processes. Methods of the curves of free surface of the wave slope runoff in different planes (*xt, hx*) are recommended. It will give the possibility for effective construction of antierosion measures on the slopes. *© 2019 Bull. Georg. Natl. Acad. Sci.*

Key words: erosion, waves, water flow

Erosion processes intensively occur in mountain and premountain areas, where they reach catastrophic sizes washing out several tons of soil per hectare during a year. According to the data of the international center on integration and development of mountain areas in some cases soil losses deviate from 5 to 2000 ton/he a year [1].

During the motion of liquid flow of small depth along the slopes the wave motion often appears contributing to intensification of erosion processes.

Not taking into account the mechanism of action of slope flow on the process of soil erosion (limit equilibrium of active and passive forces, action of elevating force, etc.), also on determination of critical velocity of raising the soil particles, it should be taken into account not average onlive cross section velocity of the uniform moving flow but the velocity of wave.

Waves in water flows and on the slopes of landscapes change basic hydraulic and hydrologic parameters of the flow (decrease or increase of discharge, velocity, depth) both continuously and step by step.

There are two types of waves: continuous waves and dynamic waves. Continuous waves on the slope surface occur during rainfall. In that case they are characterized by significant amplitude, which increases washed out and transport capability of hard particles by the flow often not taken into account while evaluating the velocity of washing out. It is natural that wash out capability of the flow at wave regime must be bigger than that of the uniformly moving flow. Similar waves can be observed in the slope streets during rainfalls and even in the streets with slight gradients with shallow depths of the flow. The well known equation of continuity with variable discharge along the way has the form:

$$q = \frac{dh}{dt} \quad (1)$$

q – intensity of the discharge change of the surface flow per unit of length and width;
t – time;
h – depth of the flow.

Suppose q=const. then integration (1) gives:

$$h - h_0 = q(t - t_0). \quad (2)$$

Index 0 refers to primary conditions of the task. The velocity for the concrete wave in wave regime motion V_w=1.5V [1], V – average velocity in uniform regime of the motion [2]:

$$V = C\sqrt{Ri}\,, \quad (3)$$

where C coefficient of Chézy (velocity);
R – hydraulic radius;
i – average gradient of slope plane.

Then velocity of the wave is:

$$V_w = 1.5C\sqrt{Ri}. \quad (4)$$

For concrete wave taking into account (4), when axe Ox coincides with the direction of the wave motion:

$$\frac{dx}{dt} = 1.5C\sqrt{Ri}. \quad (5)$$

Joining (1) and (5) we get

$$\frac{dh}{dx} = \frac{dh/dt}{dx/dt} = \frac{q}{1.5C\sqrt{Ri}}. \quad (6)$$

After integration of (6), taking into account that $R \cong h$ (as width of the slowpe B>>h) gives:

$$(h - h_0)1.5Ch^{0.5}i^{0.5} = q(x - x_0). \quad (7)$$

Dependence (7) characterizes the profile of trajectory of the wave surface in the plane *hx*.

Index *O* in the introduced dependences and in the following formulas means primary conditions of the parameters.

Determining h from (1) and inserting into (7) we can get the form of distribution of the waves in the plane *xt* in the function of primary parameters:

$$\left[q(t - t_0) - h_0\right]^{1.5} = h_0^{1.5} + \frac{q(x - x_0)}{C_{cp} i^{0.5}}. \quad (8)$$

Dependence (8) defines the form of wave distribution in the plane xt.

Taking off h_0 from (1) and (7) we can define „h” depending on „x” in the necessary moment of the time, i.e. profile of the wave surface. From (2) it follows

$$h_0 = h - q(t - t_0). \quad (9)$$

Taking into account (9) instead of (7) we get:

$$h^{1.5}\left[h - q(t - t_0)\right]^{1.5} + \frac{q(x - x_0)}{C_{cp} i^{0.5}}. \quad (10)$$

When the motion begins at $t_0 = 0$ from initial position x=0, we deal with the first family of waves at different values h. Then from dependence (7) it follows:

$$h^{1.5} = h_0^{1.5} + \frac{qx}{Ci^{0.5}}. \quad (11)$$

The distribution line in the plane *xt*, as is seen from dependence (8), will be:

$$(qt + h_0)^{1.5} = h_0^{1.5} + \frac{qx}{Ci^{0.5}}. \quad (12)$$

As for the profile of the surface, according to dependence (10) when $t_0 = 0$ and $x_0 = 0$ we get:

$$h^{1.5} = (h - qt)^{1.5} + \frac{qx}{Ci^{0.5}}. \quad (13)$$

For the second family of waves the following moments of time are counted from the conditions $x_0 = 0$ and $h_0 = 0$. Then the distribution lines of waves and surface profile of the second family of waves are described by one equation, i.e. from (7) we get:

$$h^{1.5} = \frac{qx}{Ci^{0.5}}. \quad (14)$$

Dependence (14) characterizes by the profile of wave in the established condition of the flow.

Distribution line of the wave in plane *xt* according to dependence (10) will be:

$$t = t_0 + \sqrt[1.5]{\frac{x}{q^{0.5}C}}. \qquad (15)$$

The given dependences allow us to judge about curved free surfaces at wave regime of the motion of surface flow. The wave regime can be considered as active stimulant of erosion processes as the velocity (as it was mentioned) of wave is 1.5 times more than the average onlive cross section velocity of the flow at uniform motion regime, which should be taken into consideration for projecting of anticorrosion measures.

ჰიდროლოგია

ჩამონადენის ტალღური მოძრაობა ეროზიული პროცესების გააქტიურებაში

ო. ნათიშვილი

აკადემიის წევრი, საქართველოს მეცნიერებათა ეროვნული აკადემია

გაანალიზებულია ჩამონადენის ტალღის ზეგავლენა ნიადაგის ეროზიული პროცესების გააქტიურებაზე. დადგენილია, რომ ტალღის სიჩქარე ერთნახევარჯერ აღემატება ნაკადის საშუალო სიჩქარეს, რომლის მიხედვითაც დღეისთვის წარმოებს ეროზიული პროცესების პროგნოზირება. შემოთავაზებულია ჩამონადენის თავისუფალი ზედაპირის წირის აგების მეთოდიკა ტალღის პარამეტრების გათვალისწინებით, რომლის მხედველობაში მიღება აუცილებელია ეროზიის საწინააღმდეგო ღონისძიებების შემუშავებაში.

REFERENCES

1. Natishvili O.G., Urushadze T.F., Gavardashvili G.V. (2014) Volnovoie dvizhenie sklonovogo stoka i intensivnost' erozii pochvogruntov. M., 162 p. (in Russian).
2. Sterenlicht D.V. (1984) Gidravlika. 640 p. (in Russian).

Received May, 2019