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THE NEW MUD-PROTECTIVE STRUCTURES AND THEIR CALCULATION METHODOLOGY

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THE NEW MUD-PROTECTIVE STRUCTURES AND THEIR CALCULATION METHODOLOGY

In the works there is considered physical-mechanical, rheological and hydraulical characteristics of mud flows and the new mud-protective structures calculation methodology.

The obtained results may be applied by the scientists, graduate and those students who are interested in problems of nature protective measures.

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To whom it may Concern

Givi Gavardashvli is a candidate of technical sciences from 1987. He has carried out scientific research works since 1981. Mr. Gavardashvili has published more than 42 scientific works, among them 13 inventions. The results of the scientific researches were reported at the conferences in Tbilisi, Tskaltubo (the Republic of Georgia); Moscow (Russia); Alma-Ata (Kazakhstan); Tashkent (Uzbekistan); He took part in the World young Inventors Exhibition in Plovdiv (Bulgaria), the work was noted by the diploma and reward; in Moscow on the Exhibition of National Economy Achievements the work was rewarded with the bronze medal and diploma.

As the object for research was takes the observations of natural characteristics of the active mudflow type rivers on the territory of various. Republics (Georgia, Russia, Armenia, Azerbaijan, Kazakhstan, Kirgizia), and also the natural observation materials issued by the special service of Japan Ministry of Building. While processing were used: many scientific literary sources published in USA, Russia, Switzerland, France, Germany, Japan, England, Netherlands, Austria, Italy, Canada, Spain, etc. The research results are used in the Republic of Georgia (in the regulation project processing of Kharkheti gorg, river Kuro and Samonastro ravine), and also in Uzbekistan in Baisuni, district (Surkandari region), where after carried out measures the influence of the mudflow on the cotton plantation was reduced by 70-80%. As the co-author he has issued: „ELEMENTAL DISASTERS" notes, where are given all the main advices, which are necessary for the population to be followed from the various nature elemental phenomena, METHODICAL DIRECTIONS" The composition of the mountain landscape cadastre by using aerocosmic methods." The main recommendations, necessary for cadastre composition, and also for the precise prognostication of nature elemental phenomena are given in the following work.

Dr. Sc. Prof., V.I. Tevzadze

CONTENTS

N o t a t i o n s

U - velocity in the point;
V – average velocity;
Q – discharge;
Re – Reynolds number;
ν – kinematic viscosity;
R – hydraulic radius;
g – acceleration of gravity;
Fr – Froude number;
S – volume concentration of solids;
τ – tangent strain;
Cr - Currants number;
μ´ - Poison coefficient;
M – Mach’s number;
Sh – Struhals number;
p – density;
μ – dynamic viscosity;
γ – specific weight;
p´ - air density;
$P_{\%}$ - Provision of discharge;
d – average diameter of solid fractions;
H – height of structure;
l_{st} - length of structure;
F_0 – area of catchment basin;
q = Vh, specific discharge;
C_* - shezy coefficient;
h – depth of flow;
K_1 – coefficient of hydraulic friction;
K´ - air resistance coefficient;

I n t r o d u c t i o n

The basic center of erosion and mudflow processes in the Republic of Georgia is the central Caucasus range, extended about 1000 km long from the Republic of Georgia to the Republic of Azerbaijan. The mountain landscapes of Georgia occupy 68% of the republic territory's total area, or 47.8 thousand km^2, the 87 % of the mountain relief of which is characterized with more than 15^0 inclinations, situated on almost equal geographical latitude 40-45^0.

The complex mountain relief and geological structure, geomorphologic and climate conditions of the Republic of Georgia promote the undesirable influence of the surface waters on the environment which often reaches catastrophic point. For example 860 thousand hectares of the agricultural land are under different degree of erosion and they have lost the natural fertility, the total length of active ravine is more than 2 thousand km, the landslide phenomena is registered is 15 thousand lots, it is ascertained that more than 2 thousand basins are characterized by mudflow phenomena, in 1987-1988 years more than 90 thousand hectares of the land were affected by the floods and mudflows.

In connection with the transition to the free market economy the special alarming facts, that ecology crises processes in the mountain ours landscapes and in its different spectrum the damage caused by nature elemental phenomena is not reduced, but vice versa the tendency of considerable growth is noticed, therefore much attention must be paid to the protection of the environment, to the revelation and solution of the contemporary global and regional ecological problems as in the mountain landscapes as well in the plain of the republic of Georgia.

Among the natural elemental phenomena formed in the mountain landscape of Georgia, the special attention must be paid to the mudflow under what influence is more than 26% of the republic territory, the total area of agricultural land is reduced under its affect, they cause the intense erosion of the mountain river beds filling the water reservoirs with mudflow solids, the natural environment, also in case of the mudflow catastrophic discharges cause destructions and human victims.

That is why the regulation of natural and technogenic catastrophes and their opposition is one of the actual problems for the Republic of Georgia, which implies the elaboration and full filament of total national ecological policy programmed together with different measures.

I. THE NEW HYDROTECHNICAL STRUCTURES AGAINST NATURE ELEMENTAL PHENOMENA

The struggle against nature elemental phenomena in the Republic of Georgia began in the early century and has been continued for many years, among them the effective measures against mudflow, particularly in agromelioration, phytomelioration, forest reclamation, hydrotechnical, complex etc. In our item it will discussed hydrotechnical measures.

Taking into the consideration the world experience of the struggle against erosion mudflow processes, the following new hydrotechnical structures were Worked out.

Structures against the erosion of river-beds and mountain slopes [27, 52].

The spring-board type constructions against mudflow [11, 12, 22, 23, 26, 27, 35, 36, 38, 59].

The structures against snow avalanche [30].

The priorities of these new constructions is protected by 10 author's certificates and 3 patens. We will fix attention on two of them, that have been tested at the hydraulic laboratory.

The spring-board type arch-cone structure against mudflow (A.C. N1101499, bull. N25, Moscow, 1984) represents in apace the spring-board in the from of half-cone with arch and beam system which are connected with one another by means of the cone end and make stiff construction. The head of reinforced concrete cone than divides the flow into two parts is directed against the mudflow.

The structure operates this way: while mudflow passes the flow parted by the head of the cone moves on the convexed arch-cone surface of the structure, the small fractions together with the water mass go through the slots of the structure, when the large fractions stay on the surface of the structure (flow bifurcation). The mudflow is moving with residual energy after this process on the reverse inclination of the structure and before it reaches the threshold of the structure the flow stops or passes into the lower bief of the structure, where the complete damping of the flow energy takes place.

The mud-protective, through structure of spring-board type (A. C. N1165736, bull N25, Moscow, 1985) represents the construction with circular arch's and beams, where the slots have the rectangle from. In difference from the former construction the deaf reinforced cone has dosed the river-bed completely, which eliminates the impact of the mudflow on the arch's.

The structure operates as follows: the main destructive impact of the passing mudflow is taken by the cone-shaped head dampening most of the impact energy. Subsequent dampening of the energy in the cylindrical part of the structure occurs in a continuous fashion. Free crosssectional area of rectangular cells ensures optimum energy dampening effect, i.e. it allows to eliminate heavy dynamic (frontal) impact of the mudflow, even catastrophic one, and removes the threat of destruction of the structure which, therefore, may stand up to multiple mudflow impact.

The above discussed structures are erected from concrete and secondary materials (used metal reels, elastic ropes, the defricated autotype, etc) which amount is 70-80 % of the total volume of building materials.

2. THE QUALITATIVE ESTIMATION OF EROSION AND MUDFLOW PROCESSES WITH THE USE OF THE CATASTROPHE THEORY

2.1 The interpretation of Equilibrium of the Mudflow Mass Accumulated in the River-bed

In nature there are fixed such phenomena (weir destruction, pipeline break-downs, avalanche displacement, etc), the movement start of which proceeds not gradually, but stepwise-suddenly during little period of time. The process of mudflow mass displacement is not an exception too, the equilibrium disturbance of which proceeds instantly [46].

Let us discus solid mudflow mass accumulated in mountain river being in the equilibrium state.

In this case the potential energy (Ep) of deformation for a unit of volume of mudflow mass is [33, 37, 70, 71]:

$$E_P = A(a \tan\phi + c)^2 \tag{2.1}$$

where,

$$a \equiv 2\,\gamma_1 h' \cos^2\alpha(1 + 0,\ 01W) \tag{2.2}$$

$$A \equiv \frac{2(\zeta^3 - \zeta^2 + \zeta + 1)}{E \sin 2\alpha(\zeta^3 - \zeta^2 - \zeta + 1)} \tag{2.3}$$

E is a soil module of elasticity (Pa), $\sin\alpha$ - inclination of river-bed, ζ - soil lateral pressure soil coefficient, connected with the Puason coefficient as follows $\mu' = \xi/(\xi + 1)$, γ_1 - mass volume of dry (kg/m^3), h'-height of the soil accumulated in the river-bed (m), W′-dampness, tan ф-inner friction angle of the soil, c- cohesive force of the soil (Pa).

Let us determine the gradient of potential energy in the origin of coordinates. For simplicity let us mark [33]:

$$Y_1 = \phi;\ \ Y_2 = C \qquad \nabla E_P = \left(\frac{\partial E_P}{\partial\gamma_1} + \frac{\partial E_P}{\partial\gamma_2}\right) \tag{2.4}$$

Let us discuss the Taylor series expansion of tany$_1$ – function. First let us learn the third flow J^3 of the tany$_1$ – function, is:

$$J^3 \tan y_1 = y_1 + y_1^3 \qquad (2.5)$$

The potential energy gradient is equal to:

$$\begin{cases} \dfrac{\partial Ep}{\partial Y_1} = 2A\left[a\left(y_1 + \frac{1}{3}y_1^3\right) + y_2\right](1 + y_1)^2 \\ \dfrac{\partial Ep}{\partial Y_2} = 2A\left[a\left(y_1 + \frac{1}{3}y_1^3\right) + y_2\right] \end{cases} \qquad (2.6)$$

As the gradient of the potential energy in the origin of coordinates is equal to zero, is ∇ Ep(0,0)=0, so the use of the theorem about the non-obvious function is not allowed, and it is necessary to examine the condition [49], of Morse lemma, is to determine the so called ,,Hessian” degeneration, bring in the designation:

$$H_* \equiv \left(\frac{\partial^2 E_P}{\partial y_1 \partial y_2}\right)_{i\,j} \qquad i\ j = \overline{1}, \overline{2} \qquad (2.7)$$

After finding the second-order derivative of potential energy the ,,Hessian” value will become equal to zero because of the origin of coordinates and the determinant of the (2.7) equation, is the condition of Morse lemma is not fulfilled and the critical point is the nonisolated degenerated one, or it represents not a Morse critical point. As ∇ Ep=0 and det (H_*) = 0, that’s why we can use the separation lemma, for this we must find ,,Hessian” characteristic equation’s particular value.

After solving the equation we will obtain, that λ_1=0 and

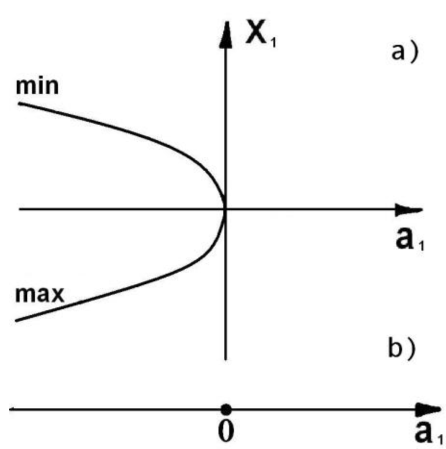

Fig. 2.1

$\lambda_2 = (a^2+1)$, because $\lambda_2 \approx 0$, the refor by local transformation of variables from the two original inner variables (ф and c) only one variable will be degenerated, is the potential function after the transformation (=) will be as follows [37]:

$$E_P = Cat(1{,}1) = X_1^3 + a_1 X_1 \tag{2.8}$$

The obtained catastrophe represents the so called „fold" catastrophe [37] and the critical point value is equal to,

$$X_1 = \pm\sqrt{-(a_1/3)} \tag{2.9}$$

As it is seen from the (2.9) dependence the function's local minimum is $X_1 = \pm\sqrt{-(a_1/3)}$ in which actually the above mentioned phenomenon exists for different values of a_1- parameter. As we see from figure 2.1-a for the negative values of a parameter the potential energy has single local minimum, and for the positive values it has no local minimum at all, that show that in the point a= 0 the gradient of the potential energy undergoes a sudden change and physical phenomenon transfers into another condition, that is not reached by our mathematical phenomenon, starts the mudflow mass motion being in the limited equilibrium. The point (a_1 =0) is called the bifurcation point and in our case it is unique (see Fig. 2.1-b).

2.2 THE ANALISIS OF POSSIBLE BREAK-DOWNS OF SPRING BOARD TYPE MUDFLOW-PROTECTIVE NEW STRUCTURES

Lat us analyze the stiff spring board type arch and beam through structures break-downs according to the units. The calculation scheme of the structures is given in the fig. 2.2.

The mudflow effects the structure with the dynamic striking power, that is equal to [7]:

$$F = kpv^2 wc(a) \tag{2.10}$$

Where k – is a coefficient which is equal to 4.5, W – effected arsa of the mudflow on the structure (m^2) and c(α) search angle, that is equal to [31]:

$$C(a) = V \ \tan\beta + \frac{y^1}{v \ \cos\beta} - \beta \tag{2.11}$$

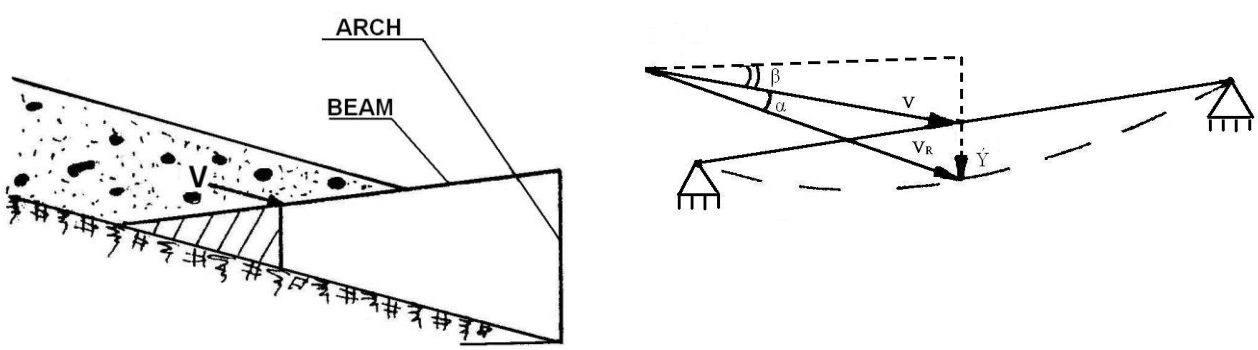

Fig. 2.2

Let us suppose that under the influence of the mudflow of the mudflow the break-down of the spring-board structure occurs as the result of the beam vibration; then if we use the vibration equation and reduce it to transformation we will get [67]:

$$my' + [r + 4{,}5\rho wV]y' + Ky = f(V) \tag{2.12}$$

where m – is mass of the beam; r- vibration damper of the beam; K – characteristic of the elastic spring, and $f(V) = 4.5\rho w v^2 \left(B_0 - B_1 V^3\right)$, where B_0 and B_1 are the coefficients.

If we analyses the obtained equation (2.12) we will see, that the vibration of the beam caused by the influence of the mudflow has the stable focus, is „bifurcation of Chop" takes place, and the beam vibration graph in relation to the time has the fading character, that means that the beak-down caused by the vibration of the beam is not possible, vice versa when designing the spring board type arch and beam structure, if we take into account the optimization elements together with the other indicators, the possible vibrations of the beam could be used for effective dampening of the mudflow energy.

Let us discuss the break-down of the structure in case of arch damage. As the result of the mudflow the arch is effected by the total power (F_{max}), that is equal to [31]:

$$F_{\max} = 4.5\rho w v^2 c(a) + 0.5yB\left[H_1\left(1_{st}^1 - H_1^2\right)^{0.5} + 2\ 1_{st} h\right], \tag{2.13}$$

where H_1- height of the mudflow mass accumulated on the structure (m), B – width of the river-bed.

In the process of the mudflow effect the potential energy excited in the arch, is equal to the sum of bend deformation energy and to the work done by the arch effecting force. Taking the above mentioned into the account and on the basis of the held transformations we will obtain the descriptive excretion of the potential energy as follows [49,67]:

$$E_P = G_0 + \frac{1}{2} G_2 a_2^2 - G_4 a_2^4 \tag{2.14}$$

where G_0, G_2, G_4 - are the coefficients got as the results of transformations, which are equal to,

$$\begin{cases} G_0 \equiv BI'/4(\pi / I')^4 (a_1)^2 \\ 1/2G_2 \equiv 3BI'/4(\pi/I')^4 - 4F\ I/\pi a_1 \\ 1/4G_4 \equiv 4I'F_1/\pi(a_1)^3 \end{cases} \tag{2.15}$$

Where l′ - is the length of the arch and a_1, a_2 - the first and the second coefficient of Fourier series, that show the displacement quantity of the arch deformation.

The obtained (2.14) equation represents the catastrophe of „reversed assembling", that differs from the usual „assembling" catastrophe only the minus mark, but this insignificant mathematical difference causes large physical changes, in particular the descriptive function's minimums and maximums of the potential energy change places. As MSF motion in the nature takes place wavelike, the mudflow static loads increase gradually and tend to that critical power value, when the „indignation" of the second coefficient of Fourier (a_2) series even in the small quantity causes the sudden break-down of arch [67].

Indeed, when the controlling parameters cross the bifurcation line of the fold, the controlling parameters appear in the outer area, where the function will have no minimums altogether, so the immediate catastrophe break-down will occur, furthermore in the case if this load is dynamic.

3. THE DETERMINATION OF MSF VELOCITY FORMS AND THE LOADING EDGE OF FLOW TAKING INTO ACCOUNT THE AIR RESISTANGE

In case of high concentration mudflow (so called Mud Stone Flow- MSF) passing at high speed, where the Mach's number (M) changes M = 0,015…0,073 on the leading edge of the flow, as in the case of snow avalanche [51], the air resistance power occurs, which together with the usual hydraulic resistance is considered as one of the determinates of the mudflow's velocity parameter.

Let us discuss the motion of MSF mass as whole compact flow having the high concentration in the bed inclined under α-angle (see the calculation scheme on Fig. 3.1)

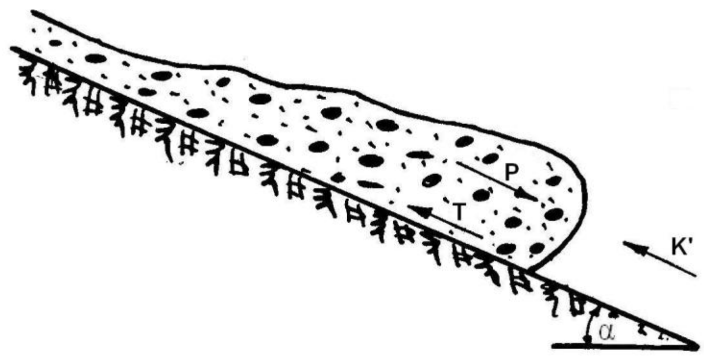

Fig. 3.1

According to the equilibrium of powers:

$$\tau = \tau_0 + \mu \frac{U_{\max}}{h} + \tau a, \tag{3.1}$$

where, μ – is a dynamic coefficient of mudflow viscosity U_{max} and U are the maximum and average velocity in the point of MSF, τ_0 – initial tangent strain (τ_0= K P′ V^2). Let us discuss the two kinds of velocity profile changes while MSF passing: first when the gradient of flow velocity pass has the equal value at the whole depth of the flow is ($U_{max} \doteqdot 2$ V) and second, when the velocity gradient exists in the thin layer at the flow bottom is ($U_{max} \doteqdot$ V).

Taking the above mentioned into the consideration, if we bring in (3.1) equation the first assumption and solve it, we will obtain [66]:

$$V = \frac{\left[\mu^2 + K'yih^2(h - h_0)\right]^{0,5} - \mu}{K'P'h} \tag{3.2}$$

where $h \approx h_0$

the functional relationship between the average velocity of the flow and the air resistance coefficient, when i=0.2, μ=6.0 (gr.p.s/cm^2); γ=2.06 (gr.p.s/cm^3); h=100, 200, 300 and 400 (cm), is expressed on Fig.3.2.

If in (3.1) equation we bring in the second assumption is U_{max}=U, we will obtain likewise (3.2) the expression reduced twice.

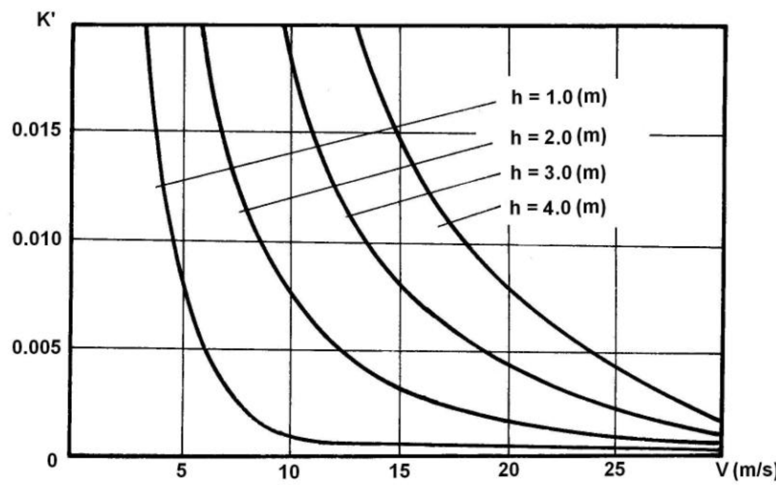

Fig. 3.2

If we consider the flow leciding edge in the passing MSF process, as the object of air shape, the dependence between the forehead resistance coefficient and Reynolds's number according to our calculation will have logarithmic from, such as it is show on the Fig. 3.2, with the ifference that in the MSF pass process the value of air forehead resistance coefficient varies K′= 0…0.02, and that of Reynolds's number Re = 10^3 degree.

If we compare the values of the obtained results with the graphs of the dependence between air forehead resistance and Reynolds's number during the motion of solid we will see that the mentioned graphs have the logarithmic character too, as it is show on the Fig. 3.2, with the difference that K′= 0…1.0 and the Reynolds's number is Re = 10^5 rate [5].

As to the characterization, of K′ = f(Re) function graphs, as being accepted in aerodynamics and hydrodynamic (Nikuradze graphs), it is necessary to carry out the laboratory tests, that can not be done by subjective and objective reasons.

Let us see the more strict scheme of the passing MSF, when the equation of tangent strain is as follows [66].

$$\tau = \tau_0 + \mu \frac{dU}{dy} + \tau_a \tag{3.3}$$

where, $\frac{dU}{dy}$ is a velocity gradient to the vertical y-axis. If as an analogue to the first designation (3.3) we bring in the equation the appropriate values and transforming them we will obtain [66]:

$$\frac{dU}{dy} = \frac{1}{\mu}[\gamma\, i\, (h - h_0) - \gamma\, i\, Y - K' p' U^2] \tag{3.4}$$

(3.2) equation is know in the mathematics as Rikkat equation, that written down as (3.4) has no common solution.

For solving the problem we use the numerical method for differential equation. Take initial data the computer, build the graph $y = f(U, K)$, (see the Fig.3.3)

If we analyse the obtained results, we will see, that when the MSF passes on the low speed, is when in the Mach's number M <0,015, the difference between the obtained and existing dependances is so small that the influence of this factor on the velocity of the MSF may be neglected, is K′=0, and in the case when Mach's number changes 0,015<M<0,2, the difference among them increases and it reaches almost 10-12% and more, from what we can make the following conclusion: when the MSF passes at high speed, we must take into the consideration the air resistance effecting the front flow, which on its side strictly changes the height of the flow's leading edge compared to its depth.

For solving the above mentioned question let us discuss the differential equation of flow's irregular motion considering the air resistance coefficient, when the discharge of the MSF is not constant, is Q ≈ const, the motion equation will be [48].

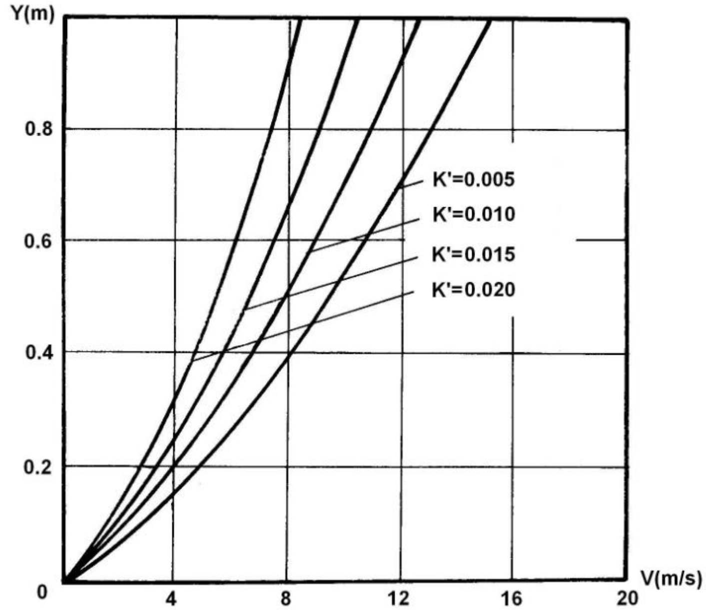

Fig. 3.3

$$\begin{cases} B\frac{\partial h}{\partial t} + B\frac{\partial (hV)}{\partial x} = q_* \\ \frac{\partial V}{\partial t} + V\frac{\partial V}{\partial x} = g\ \sin\alpha - g\cos\alpha\frac{\partial h}{\partial x} - V^2\left(\frac{K_1}{h} + \frac{K'}{l_0}\right) - \frac{q_* V}{W_0} \end{cases}, \tag{3.5}$$

where B- is a width of the river transition section (m), q_* −variable specific discharge, x- length of the river bed (m), $\sin\alpha$ −inclination of the river-bed, l_0- length of the discussed area of the river (m), W_0- the area of the river free section (m^2).

To achieve the purpose, or to solve the (3.5) equation system we use the numerical method for solving the differential equation, in particular the scheme of flow vector Splitting (Steger J.l.; Worming) [55], the equation of which is as follows,

$$Y^{n+1} = Y^n - \tau^{'}[F(Y)_x - 0{,}5\Delta x F(Y)_{xx}] + w, \tag{3.6}$$

where τ' −is a time variation step, Δx - equal space net step, Y- the vector-function velocity of MSF, n – temporary layer number, w- digital analogue of the right part of the (3.5) equation system. For realization of this scheme it is necessary to fulfill the Curant-Fridrich –Levi stability condition [55],

$$\tau \leq \frac{Cr \cdot \min \Delta x}{\max(|V| + C_0)} \tag{3.7}$$

where, Cr - is a, Curant's number, c≡$\sqrt{g\ h}\ \cos\alpha$ is a value of MSF velocity impulse.

The initial date values of the river-bed transitive area varies: I = 0.05…0.7; B = 5.0….25.0 (m); q_* = 500…4000 (kg/s m);

k_1 = 0.1…0.5; 0<K´<0.05; 300≦l_0≦1200 (m). The results of the calculation are on the Fig.3.4.

During the irregular motion of MSF wave as one of the characterizing value is considered the inertion power value, which in aerodynamics is know as Struhal's number (Sh). In natural conditions on the territory of the republic of Georgia in the mudflow type waterfowls [1], the Struhal's number for the passed mudflows changes between the following limits 0<Sh<10. On the Fig.3.5 is given the dependence graphs of the Struhal's number and of the flow depth for the different meanings of the air forehead resistance coefficient.

For determination of the dynamic blow power's value on the mudflow protective structure, one of the main tasks is to define the forms of flow's leading edge, when the last wholly determines the mudflow power.

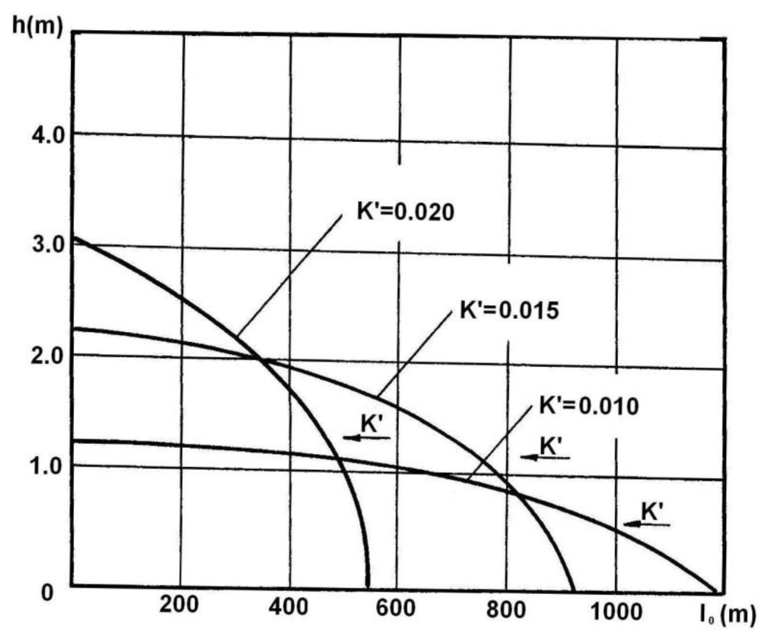

Fig. 3.4.

For solving the question let us discuss the equation system of flow's irregular motion in case of constant discharge (Q=const), [48,54]:

$$\begin{cases} B\dfrac{\partial h}{\partial t}+B\dfrac{\partial (hV)}{\partial x}=q_* \\ \dfrac{\partial V}{\partial t}+V\dfrac{\partial V}{\partial x}=g\sin\alpha-g\cos\alpha\dfrac{\partial h}{\partial x}-V^2\left(\dfrac{K_1}{h}+\dfrac{K^{'}}{\ell}\right)-\dfrac{q_* V}{\omega} \end{cases} \tag{3.8}$$

If we write down the (3.8) equation system for the flow leading edge [58] and simplify it, we will obtain,

$$(V-U_1)\frac{\partial V}{\partial x}= g\ \sin\alpha - g\ \cos\alpha\frac{\partial h}{\partial x}-V^2\left(\frac{K_1}{h}+\frac{K'}{l_0}\right), \tag{3.9}$$

where, U_1 – propagation velocity of front of MSF.

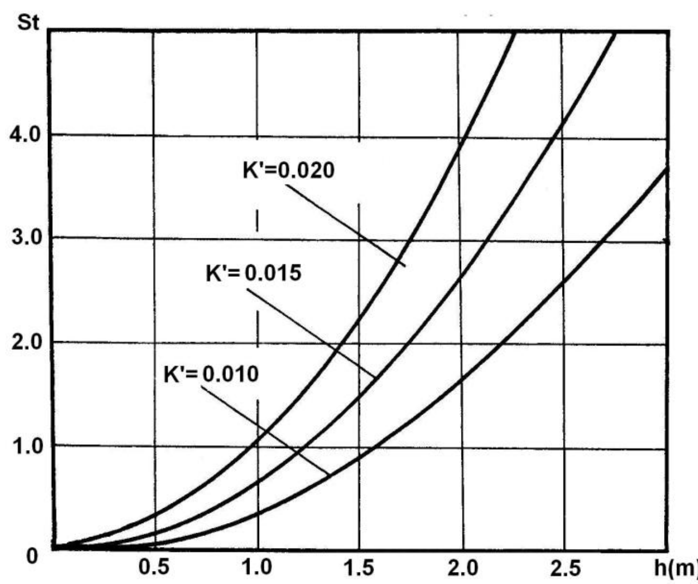

Fig. 3.5.

If we take into account, that the velocities in the flow leading edge are much more that in its back part and consider the initial conditions, (3.9) equation will be,

$$g\cos\alpha\ \frac{\partial \mathrm{h}}{\partial \mathrm{x}}\ =\ g\sin\alpha\ -\ \mathrm{V}^2\left(\frac{K_1}{h}\ +\ \frac{K'}{1_0}\right). \tag{3.10}$$

After solving (3.10) equation and making the transformations we will obtain the dependence, by means of which Kinds of forms of the flow leading edge are calculated, considering the hydraulic friction and air forehead resistance,

$$h + \frac{K_1 V^2}{g\cos\alpha\left[\tan\alpha \text{ - } \mathrm{K}'\mathrm{V}^2/l_0 g\cos\,\alpha\right]}\ in\ \frac{\left|\dfrac{K_1 V^2}{g\cos\alpha\left[\tan\alpha \text{ - } \mathrm{K}'\mathrm{V}^2\ /\ l_0 g\cos\alpha\right]} - h\right|}{\dfrac{K_1 V^2}{l_0 g\cos\alpha\left[\tan\alpha \text{ - } \mathrm{K}'\mathrm{V}^2\ /\ l_0 g\cos\alpha\right]}} =$$

$$= x\left[\tan\alpha \text{ - } \mathrm{K}_1 V^2/l_0 g\cos\alpha\right] \tag{3.11}$$

where, x – distance referring to moving coordinates.

In order to determine the value of dynamic blow power on mudflow structure, we must also define the length of the flow leading edge, the value of which in respect to the depth of the flow is calculatied with the help of the following dependence,

$$X_0 = 6.5h^{0.77} \quad \text{(m)} \tag{3.12}$$

where $0.5 < h < 10$ (m).

The obtained results were compared with the data of Japanese scientist prof. T.Takahashi [58]. The analyses of comparison showed that the values of the obtained results (when Machs number M>0.015) differ from each other by 10-20% and sometimes even more. Mainly, this is caused because, that in our mathematical model during the determination of the flow leading edge front forms, besides the hydraulic friction coefficient, the air forehead resistance coefficient is condidered.

4. THE DETERMINATION OF THE SUPFACE MARKS OF THE SOLIDS ACCUMULATED IN THE UPPER BIEF OF THE STRUCTURE TAKING THE CONFIGURATION OF THE RIVER-BED INTO ACCOUNT

In case of the big inclinations of the river, the inclination of the barrages in the river-bed is considered as one of the effective measures in localization of erosion-mudflow processes, the calculation of which is based on the linear form of the surface of the solids accumulated in the upper bief. On the base of this assumption the distance among cascade structures is being calculated. But the inspections carried out in the nature (1982-1993) have show that the longitudinal section of the surface of the solids accumulated in the upper bief has non-linear character and its length is much more that in the first case.

If we consider the formation of the upper bief structure with the drift and admit that the width of the river in the plan is changing due to the linear low, i.e. $b_x=(b_0+2mx)$, then the current equation will be as follows [60]:

$$\frac{dh}{dx} = \frac{4mh_* b_0^{2/3}}{3(b_0 + 2mx)} \tag{4.1}$$

where, m is a coefficient, that is equal to $m=(B_*-b_0) / 2L$, b_0 – is a width of the river in the initial section (m); B_* - width of the river at the structure threshold mark (m); L – full length of the drift accumulation (m), h_* - variable depth of the current, which depends on m-coefficient.

If we apply the equation of irregular motion for the open river-beds and perform the mathematical transformations envisaging (4.1) equation will get [61],

$$i = \frac{Q^2}{C_*^2 h^3 b_0^2} - \frac{Q^2}{2q}\frac{d}{dx}\left[\frac{1}{hb_0^{4/3}(b_0 + 2mx)^{2/3}}\right] - \frac{4mhb_0^{2/3}}{3(b_0 + 2mx)^{5/3}} \tag{4.2}$$

The marks of the solids accumulated in the structure upper bief are calculated by means of the following famous dependence,

$$Z = -\int i dx \tag{4.3}$$

If we bring the value of (4.2) dependence in (4.3) equation and integrate it, we will obtain the calculation expression of the marks of the solids accumulated in the structure upper bief, when the width of the river-bed in the plan changes according to the linear law,

$$Z_1 = \frac{Q^2}{2\,gh\,b_0^{1.33}}\left[\frac{1}{(b_0+2mx)^{0.67}}\right] + h\left[1-\left(\frac{b_0}{b_0+2mx}\right)^{0.67}\right] - \frac{Q^2x}{C_*^2h^3b_0^2} \quad (m) \qquad (4.4)$$

With similar discussion we will obtain the dependence, when the width in the plan changes according to the parabola low, i.e. $b_x = (b_0+px^2)$, where p= $(B_*-b_0) / L^2$,

$$Z_2 = \frac{Q^2}{2\,gh\,b_0^{1.33}}\left[\frac{1}{(b_0+px^2)^2} - \frac{1}{b_0^2}\right] + h\left[1-\left(\frac{b_0}{b_0+px^2}\right)^{0.67}\right] - \frac{Q^2x}{C_*^2h^3b_0^2} \quad (m) \qquad (4.5)$$

The calculation was carried out on the computer according to the natural data by means of (4.4), (4.5) equations and the following heights of the structure were obtained (see the Tabl. 4.1) and the longitudinal sections of the solids accumulated in the structure upper bief are shown on the Fig. 4.1.

Tabl. 4.1

c o e f f i c i e n t s		height structure (m)	
m	p	$H(Z_1)$	$H(Z_2)$
0,015	0,0002	1,26	3,36
0,035	0,0004	4,20	4,22
0,18	0,003	38,20	11,99
0,25	0,011	44,00	32,98
0,35	0,02	53,00	33,57

When the river-bed width in plan has a prismatic from, i.e. m=p=0, then instead of (4.4) and (4.5) dependences we will obtain,

$$Z_3 = \frac{Q^2x}{C_*h^3b_0^2} \quad (m) \qquad (4.6)$$

The Navie-Stocks's differential system is usedto achieve the purpose in case of high concentration of the MSF consists core, the gradiental layer and also if we envisage that (V =

(q_1+q_2) / h) [6.7] and performs the transformations, in case of changes of the river-bed width in the plan by the linear low, we will obtain,

$$i = \frac{6vQ}{gh^3(b_0 + 2mx)} \quad , \tag{4.7}$$

If we bring the value of the (4.7) equation in (4.3) we will obtain,

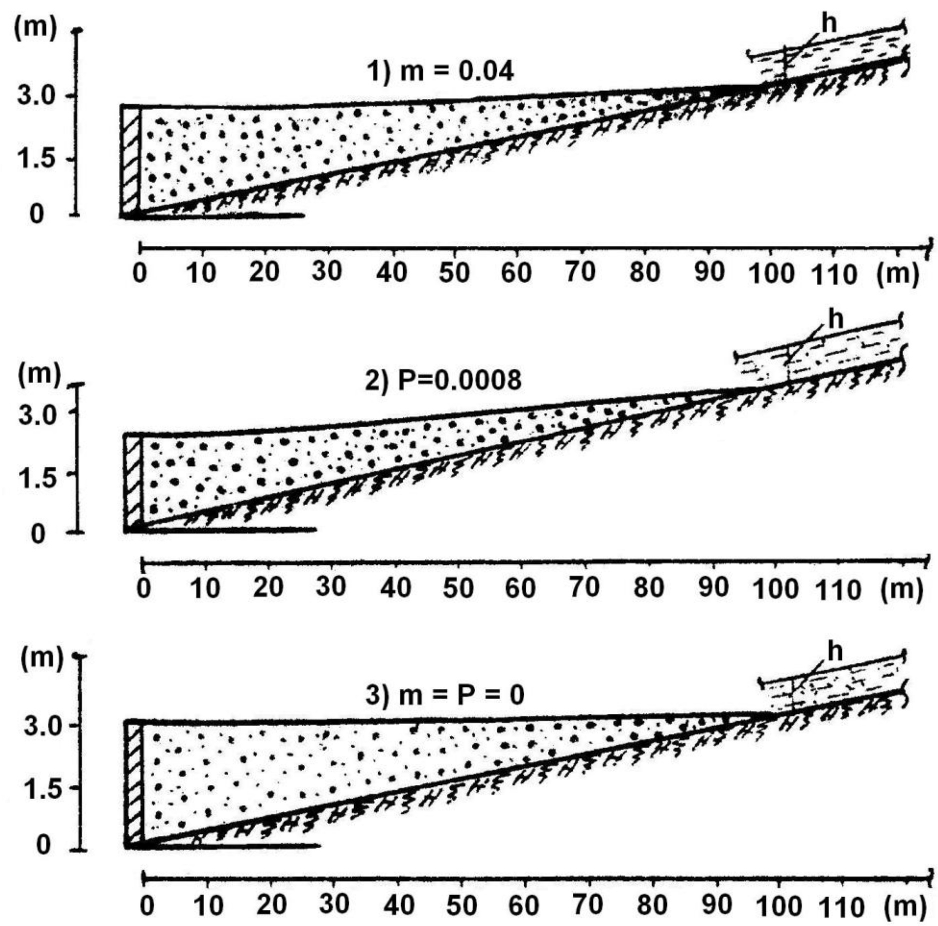

Fig. 4.1

$$Z_4 = \frac{3vQ}{gmh^3} \quad in \quad \left(\frac{b_0}{b_0 + 2mx} \right) \quad \text{(m)} \tag{4.8}$$

And in the case of change of the river-bed width in the olan by the parabola low, instead of the (4.8) dependence we will get:

$$Z_5 = \frac{6vQ\ \mathrm{arctan}\left(\mathrm{p}/\mathrm{b}_0\right)^{0,5} x}{gh^3\left(pb_0\right)^{0,5}} \quad \text{(m)} \tag{4.9}$$

In order to determine the work reliability of the obtained dependences (4.4), (4.5), (4.6), (4.8) and (4.9), they were compared with the natural data of the riv. Duruji, Telavis khevi (Georgia) [39,40] and hydratechnical structures built on the passing active mudflow rivers on Sheki – Zakatala massif (Azerbaijan). The error between the calculated and natural data is the following: when the length (L) of the solids accumulated in the upper bief changes L=(100…500)m the difference with 95% confidence limits doesn't exceed 7-13%, and when 500<L<1500 (m) the difference between them equals to 5-6%, which is quite reliable in view of practical utilization.

5. THE REGULATION OF EROSION AND MUDFLOW PRECESSES BY MEANS OF THE NEW HYDROTECHNICAL STRUCTURES

5.1. The Analysis of the Experimental Research Results

The regulation of the erosion-mudflow processes in the mountain-rivers by means of barrages has the wide practical use in many countries of the world: USA, Japan, Austria, France, Germany, Switzerland etc. when designing such structures, the main problems is the determination of leveling inclination of the solids accumulated in the upper bief of the structure; on the following stage by means of which the length (L) among the structures – barrages is calculated [50].

As the existing transversal hydrotechnical mudflow-protective structures in the nature are characterized by the small period of exploitation, the little reliability and stability of work, the experimental research was carried out in the hydraulic laboratory on two new longitudinal spring-board type mudflow-protective structures (the description of the constructions is given in chapter I), when the turbulent mudflow is passing the hydraulic groove.

The laboratory test was carried out in the groove, the dimensions of which were 18.0x0.6x0.6 (m), the different kinds of inclination being (i=0.01; 0.02; 0.03; 0.04 and 0.05): the water discharge varying Q=15-25 (l/s); the solid fractions were made n the mudflow river-bed with following average diameters: d=0.75; 2.25; 3.75; 5.25 and 6.75 (mm), which were poured into the hydraulic groove from the specially made hopper-meter, the volume of which was equal to 200/kg); the expenditure of the solid fractions varied Q_*=0.20…1.13 (kg/s). To be closer to the natural model (river) the fractions having various diameter value were pasted on the hydraulic groove bottom (i.e. the drag of the river-bed was imitated). The test was held in three series: At first the arch and cone structure was tested, then arch-cylindrical cone and at last both structures, having the deaf from. The total number of test amounted to 75, i.e. for every structure was carried out 25 test. The multiplex correlation method was used during the tests, and the regression equation was as follows [57],

$$U_0\left(\tilde{i}_0\right) = \mathrm{a}_{01} U_1\left(q_s/q_w\right) + \mathrm{a}_{02} U_2\left(i/i_{st}\right) + \mathrm{a}_{03} U_3\left(d/\Delta\right) \quad (5.1)$$

Where, $U_0\left(i_0\right)$ – is a searched value of the leveling inclination; $U_1\left(q_s/q_w\right)$; $U_2\left(i/i_{st}\right)$; $U_3\left(d/\Delta\right)$ – normalized of relative quantities; a_{01}, a_{02} and a_{03} are the coefficients of regression equation; the work percentage of regression equation members was also measured.

The geometric dimensions of the arch and cone spring-board type structure model are the same, but the form of the slots is rectangle with the width – 6.00 (mm), and through is 0.62. The divergence angle of the structure deaf cone amounted 105°.

During the tests on the model, with the due regard of the natural data [1] were met the following conditions: Frud number Fr = idem; inclination i = idem; solids motion V/V_s = idem; resistance coefficient C_n = idem, etc [17];

Obtained as the results of the tests the statistic series after working out on a computer we will get the following equations:

1.The calculating transportability dependence of the solids (fractions) is obtained by the following equation [60],

$$q_s/q_w = Ai^{0.63}\left(K_0/d\right)^{0.35} \tag{5.2}$$

As, $V = q_w/h$ and $V = C_* \sqrt{hi}$ the (5.2) dependence will be as allows:

$$q_s = AC_* \; i^{1.13} \; h^{1.5} \left(K_0/d\right)^{0.35} \tag{5.3}$$

were, A – is a coefficient which is equal to A = 0.2 (kg/m); K_0 – drag bulge height (m), (K_0/d) = 0.27…2.5.

In view of the practical use of the obtained depenences they were compared with those obtained by the varius scientists: R. Asatrian (Armenia); V. Knoroza, A. Kuprin (Russia); R. Pedrol (Switzerland); also compared with natural data made by M. Rukhadze(Georgia). The comparison has show that the laboratory results and the data obtained by the above mentioned scientists corrdates with obtained (5.2) law.

2. The calculating drag coefficient (n_*) of the mountain rivers is obtained by the following equation [64],

$$n_* = \frac{k_n d\left(q_s/q_w\right)^{4.6}}{1^{3.06}} \tag{5.4}$$

where, k_n- is a coefficient which is equal to k_n=1738.0; d = 0.75…6.75 (mm); (q_s/q_w)=0.01…0.034; i = 0.01…0.05.

3. For arch and cone spring-board type structure.

Th regression equation for leveling inclination of the solids accumulated in the upper bief of the structure is as follows [13],

$$U_0(i_0) = 1.38U_1(q_s/q_w) - 0.50U_2(i/i_{st}) + 0.17U_3(d/\Delta) \tag{5.5}$$

Where the relative value (q_s/q_w) plays the main role in forming of the upper bief of the structure, the work percentage of which is 79%, of the relative value (i/i_{st})-17%, and (d/Δ) the work percentage is 4 %.

The correlative coefficient of (5.5) regression equation amounts to 0.98, and the average square error of the correlative coefficient is equal to 0.0175.

By the use of (5.5) regression and graph material we have obtained the empirical dependence, that will be as follows [13],

$$i_0 = \left[1.25 + 0.52d/\Delta - (1.4 + d/\Delta)\, i/i_{st}\right](q_s/q_w)^{1.07}, \tag{5.6}$$

where, i_{st} - is back inclination of spring-board type structure $(i/i_{st}) = 0.063 \ldots 0.32$, and (q_s/q_w) = 0.01…0.034. The correlative coefficient among the data obtained by means of (5.6) equation calculation and laboratory tests is equal to 0.90. The formation of upper bief arch and cone structure is show on the Fig.5.1, and the formed longitudinal and transversal sections of the bief of the same structures is displayed on the Fig. 5.2.

In the formation of the upper bief of the structure the special role has the determination of the solid holding effect (flow bifurcation) of the spring-board type structure.

The results of the tests has enable us to determine the dynamics of filling the structure's upper bief with solids. The empirical dependence is as follows [15],

$$W_t/W_T = (0.95 + 0.05d/\Delta)(t/T)^{0.58} \tag{5.7}$$

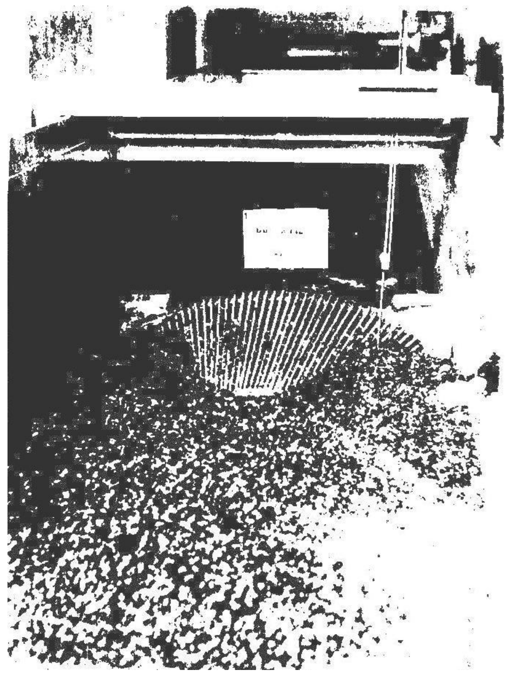

Fig. 5.1

where, W_t and W_T – are the filling volumes of the solid fractions in the structure's upper bief, in the t – elementary period of time and in the T – that is correlated with the duration of total filling of the structure with the solids (t/T) = 0.025…1.0 and (d/Δ) = 0.125…1.125.

4. The second series of the tests

The regression equation of the solids leveling inclination for the spring-board arch and cylinder structure of the upper beef will be as follows [14],

$$U_0\left(i_0^{``}\right) = 0.52U_1\left(q_s/q_w\right) + 0.57U_2\left(i/i_{st}\right) - 0.24U_3\left(d/\Delta\right), \tag{5.8}$$

The work percentage of the relative value (q_s/q_w) is amounted to 51 %, of the value (i/i_{st})- 46,5 %, and (d/Δ) value - 2,5 %.

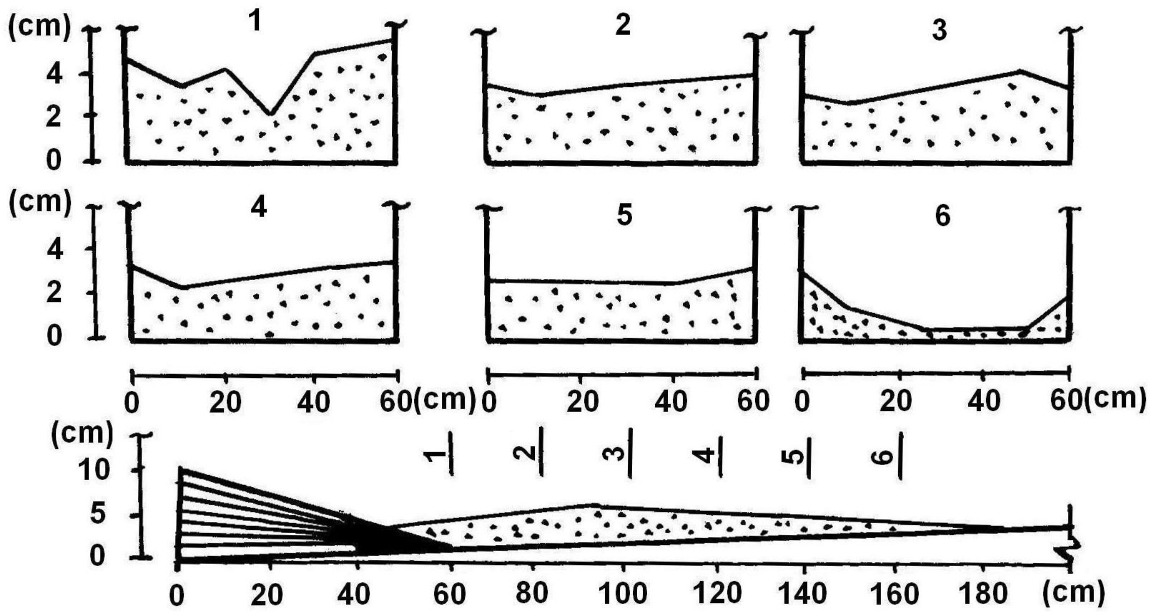

Fig.5.2

The value of the correlative coefficient is equal to 0,98 and the average square error of the correlative coefficient is amounted to 0,023.

The value of the leveling inclination of the solids accumulated by the following dependence [14],

$$i_0 = \left[0{,}10 - 0{,}5d/\Delta + \left(0{,}28 + 0{,}13\, d/\Delta\right) i/i_{st}\right]\left(q_s/q_w\right)^{0{,}46} \tag{5.9}$$

The correlative coefficient between the values calculated with (5.9) dependence and experimental tests is equal to 0,98 and the error among them amounts to 2-5 %, where (q_s/q_w)=0,01…0,03.

With experimental tests we obtained empirical dependence, by means of which the effect of holding the sold franc ions of arch and cylinder spring-board type structure is calculated [10, 21]:

$$W_t/W_T = \left[0.95 + 0.10\left(d/\Delta\right)\right]\left(t/T\right)^{2{,}92} \tag{5.10}$$

Where, (d/Δ) = 8,125…1,125; (t/T) = 0,1…0,9.

5. The third series of the tests.

The results of the laboratory research of the deaf type arch and cone and cylinder structures are the following:

The regression equation of the leveling inclination:

$$U_0(i_0) = 0.97U_1(q_s/q_w) \tag{5.11}$$

The empirical dependence for calculation of leveling inclination is as follows [14]:

$$i_0 = 9{,}29(q_s/q_w)^{1{,}53} \tag{5.12}$$

where, $(q_s/q_w) = 0{,}01 \ldots 0{,}034$.

Correlative coefficient value between the data calculated by (5.12) and the laboratory data is equal to 0.98, and the possible error of the correlative coefficient is amounted to 0.01. As for the solid fractions holding effect of the deaf type constructions of these structures it was 100% before the filling of the structure.

Also during the research process the attention was payed to the question of changing the leveling inclination value in connection with time. After working out the laboratory data we have obtained the empirical dependence as follows [20],

$$i_0 = \frac{0{,}29i}{(d/\Delta)^{0.27}(t/T)^{0.25}} \tag{5.13}$$

where, $i = 0.01 \ldots 0.05$; $(d/\Delta) = 0.125 \ldots 1.125$ and $(t/T) = 0.1 \ldots 0.09$. And after generalization of laboratory tests we obtained the following dependence between the leveling and groove inclinations,

$$i_0 = 0.76\,i \tag{5.14}$$

Our attention has been attracted also by the fact, that in stabilization of leveling inclination of the solids accumulated in the upper bief the significant role has the nonidentity coefficient of solids (d/d_{max}). For solving the problem the natural data from the upper bief of solid holding structures built in active mudflow river-beds in Georgia and Japan were worked out. After the statistic raw elaboration we will obtain the following dependence,

$$i_0 = 0.94(d/d_{\max})^{0.75} i^{1.02} \tag{5.15}$$

where, d_{max} – is a maximal diameter of the solid fractions (m), (d/d_{max}) = 0.2…0.8 and I = 0.02…0.10.

This dependences were compared with: R. Kromer's, I. Bojarski's, S. Fleishman's [6], V. Goncharov's, G. Rojdestvenski's (Russia); A. Daido's (Japan) [4]; S. Valentin's (Italy); L. skatuala's (Poland); I. Kherkheulidze's (Georgia) [39], Ia. Kaganov's (Ukraine); R. Asatrian's (Armenia); I. Mirza-zade's (Azerbaijan) works and with works eleborated by the scientists from the various countries and with the natural data: river Duruji and Telavis Khevi (Khevi – in Georgian means ravine) (Georgia); riv. Pambak (Armenia) and riv. Akjar (Kazakhstan).

The analysis of the comparison has shower us that the difference between the data obtained with the laboratory research and above mentioned data with 95% confidence limits is not more that 10-20%.

So, the dependences obtained as the result of research dearly represent the indicator changes dynamic of the leveling indination of the solids accumulated in the upper bief of the spring-board type mudflow-protective structure as the qualitative, so the quantitive, connected with the type of the structure, the work period, and nonidentity coefficient of the solid fractions, the last determines the stabile quality of the leveling-inclination surface.

5.2. The Hydrological and Hydraulic Calculations for the Designing of the New Spring-board Type Mudflow-Protective Structures

The analysis of the existing literature shows, that the basic mudflow type rivers in the Republic of Georgia are located in climate, soli and forest zones having almost equal characteristics, which quantitative characteristics compared with real (natural) occurrences vaty in so small intervals (climate coefficient 6-7; soli 3-4, foresting coefficient 0.83-0.91), that the use of such characteristics, as the area (F_0) and the water flow inclination (i) of the water-catchment basin is possible only for the turbulent mudflow (i=0.02…0.12; F_0= =5…160 km^2).

As a result of the natural data elaboration we have obtained the dependence, by mans of which the maximal discharge of the turbulent mudflow is calculated taking the corresponding provision coefficient into account [65],

$$Q_{max} = A_0(34 + 400i)F_0^{0.61} \quad (m^3/s) \qquad (5.16)$$

Where, i = 0.02…0.12; F_0 = 5…160 (km^2); A_0 – is a percent provision coefficient of the discharge, which has the following dependence with the percent provision of discharge (P%), see the Table 5.1.

Table 5.1.

(P%)	0.1	1	3	5	10	25	50
(A_0)	2.40	1.0	0.70	0.60	0.50	0.30	0.20

The average and maximal diameters of solid fractions transported by the turbulent mudflows, are calculated on bases of natural data by the following empirical dependence [65],

$$d = \left(0.02 + 6.55\ i^{2.73}\right)Q_{max}^{0.64} \quad (m) \qquad (5.17)$$

where, Q_{max}=10…2000 (m^3/s).

$$d_{max}\left(0.90 + 31.6\ i\right)\ d^{0.62} \quad (m) \qquad (5.18)$$

where, i=0.01…0.10; d=0.1…2.0 (m).

The so called „Rozival" [45] and photo methods jointly were used in order to determine the distribution law of solids diameter function for the mudflow type rivers in natural conditions. The coupled usage of these methods is especially effective for such cases, when the drifts in the river-bed mainly consist of comparably large and average sized diameter solids. For the elaboration of the mentioned question the long statistic series of the natural data was used; the density distribution law of the function of the latter one correlates with the following distribution [64],

$$f(d) = 0.067\exp\ (-\ 0.067\mathrm{d}) \tag{5.19}$$

The obtained (5.19) dependence and the coincidence of the natural data points is controlied by the so called „f^2" – criterion (Pirson's criterion), which is amounted to 60% [68].

By the elaboration of the natural data statistic series on the computer we obtained the calculation dependences of the hydromorphometrical values [53], for such types of mountain rivers (transitive plot), where the turbulent mudflow is mainly formed,

$$\begin{cases} B=3.0\ d^{0.51}Q_{max}^{0.53} & (m) \\ h=0.08\ d^{-0.19}Q_{max}^{0.44} & (m) \\ V=0.16\ d^{0.37}Q_{max}^{0.70} & (m/s) \end{cases} \tag{5.20}$$

To characterize the mudflow river-bed stability the parameters that characterize that characterize the energy of solid loaded and solid-drifted flow, is expressed as – $\gamma\ Q^m\ i$.

By elaboration of the laboratory tests the empirical dependence was obtained that enables us to determine the average velocity of the turbulent mudflow,

$$V = V_w(0.60 + 7.60i - 1.2\ d/h) \tag{5.21}$$

where, V_w ‾ is an average velocity of the water (m/s), (d/h)=0.01…0.24.

The height of the new spring-board type mudflow-protective structure (H) envisaged by the volume concentration of the turbulent mudflow which is calculated by the following dependence,

$$H = h(1.80 + 52.0i - 50\ q_s/q_w) \tag{5.22}$$

To determine the width of the slots between the beams we use the relative value of (d/Δ) value. In the case when the stone addition amounts to S=60% in the mudflow, the interval between the beams becomes $\Delta = d/0.49$ (see Table 5.2).

Table 5.2.

S (%)	10	20	30	40	50	60	70	80	90
d/Δ	0.12	0.21	0.28	0.36	0.42	0.49	0.56	0.66	0.81

To determine the character of the blow power (F_i) value on the mudflow spring-board type structure are of the distribution law of the external load (W_i) weight of the solids accumulated in the upper bief of the structure, experimental research was carried out by the elaboration from which we obtained the distribution laws [25, 44] as follows

$$f(F_i) = 0.0023 \ \exp(- 0.0023F_i) \tag{5.23}$$

$$f(W_P) = 2.857\exp(- 2.857W_P) \tag{5.24}$$

the coincidence among the obtained (5.23) and (5.24) theoretical distributions and the histogram data in the blow power casa amounts to 70%, in the other casa – 80%.

The probability of that, in the case when the external load caused by the solids accumulated in the upper-bief of spring-board type mudflow-protective structure, will be less that the possible load, before the filling of the structure upper bief is equal to [25,44],

$$P(W_P) = \int_0^{1_{st}} f(W_P)dW_P = \int_0^{1,37} 2,857e^{-2,857W_P} dW_P = 0,978 \tag{5.25}$$

The obtained result $P(W_p)$=0.978 points to the high probability of the spring-board type mudflow-protective structure's stability.

To confirm the mentioned result, we have calculated the spring-board type structure according to the modern finite-element method, the results of which prove the high quality of the given new spring-board type structure stabilitys as in the case of dynamic unfluence of the mudflow as well as in the case of the static power of the mudflow mass on the structure.

Knowing the construction dimensions, the formation of the structure's upper bief, there is no difficulty to calculate the distance between the barrages by means of the following dependence [17, 56, 69],

$$L = \frac{H}{i - i_0} \text{ (m)} \tag{5.26}$$

With this the calculation of the spring-board type barrages in the mudflow type river is finished. The structure's situation scheme see on the Fig.5.3.

On the following stage it is necessary to determine the number of the structures, which must be placed cascadely in the river-bed. This question is also calculated by means of the knows formula. The economy of the structure number calculated by our method given on one regulated km of the river-bed 1 or 2 less spring-board type construction. After this the main aim is the calculation of the erosion-mudflow process stabilization effect in the regulated river bed.

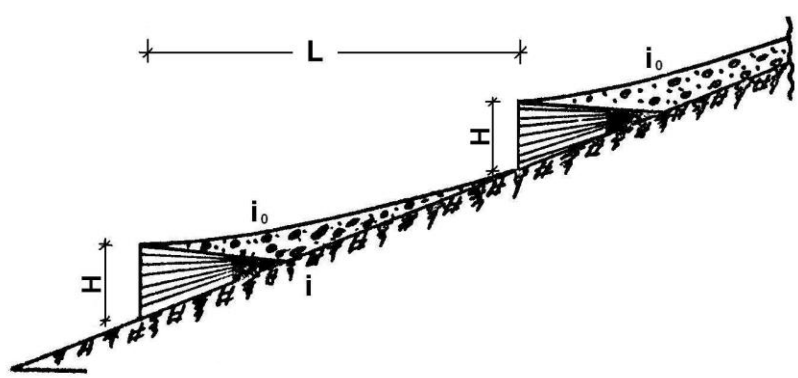

Fig.5.3

For this the qualitative evaluation of the transport ability of the solid fractions in the barrage interval by the mudflow on the solids was accumulated in the structure's upper blef (in the case of filling of the of the upper blef). For this question solving the known method was used – the criterion of displacing the solid fractions from the river-bed, by envisaging the resistance coefficient of the solids in the river-bed.

By means of the above mentioned method the researches were held (1982-1990 y-s) on the solid holding structure upper blef, built in Duruji and Telavis khevi river-beds. The results of the research have shown the qualitative changes of the longitudinal sections of the river-bed, expressed by increasing the height of erosion basis in the upper blef of the barrages and by the stability of the leveling inclination of the solids accumulated in the structure’s upper blef.

6. THE PROGNOSTICATION OF EROSION AND MUDFLOW PROCESSES IN MOUNTAIN LANDSCAPES WITH THE USE OF THE COSMIC AERIAL PHOTOGRAPHS

In formation of mudflow and for their power value and volume determination, the structure and the physicalmechanical characteristics of the solid inert mass accumulated in river-bed has the decisive importance, which is in direct connection with the soil volumes (landslips) slided from mountain slopes, or with the volume of the particles erodes on mountain slopes.

In order to achieve the aim, the aim, the natural ecosystem of the river "Tetri Aragvi'' (Republic of Georgia) was chosen as chosen as an object of observation; the water catchment basin area of which consists of 316 km^2, with average Inch lunation -0.0294 [56].

In 1897-1994 years about 140 catastrophic mudflow passes were registered in natural landscape of the river "Tetri Aragvi'' , which has caused the damages to the population material as well as social, to agricultural lands and to the objects of various destination. After the above brief characterization, it is possible to conclude that the natural landscape of ,, Tetri Aragvi'' for the territory of Georgia may be considered as the characteristic polygon, where both natural phenomena and the erosion of mountain slope proceeds intensively.

In order to determine the dynamics of the mountain slope erosion coefficient (E_0) the cosmic aerial photographs of the river ,,Tetri Aragvi'' were used, carried out in 1958, 1967 and 1987; the total duration of the observation was amounted to 29 tears.

By the photo identification and the elaboration of the obtained statistic series the following empirical dependence was obtained [2],

$$E_0 = \left[0.58 + 1.4\left(F'/F_0\right)\right]\left(t'/T\right)^{0.21}, \qquad (6.1)$$

where, F′ - is a nude area (km^2) of the territory of the water catchment basin of the river, (F'/ F_0) = =0.061…0.24; t′ and T′ - is a duration of elementary and total observations (year), (t′/T′) = 0.04…1.0.

The estimation of erosion processes in water catchment basins of some active mudflow type rivers passing down in the ecosystem of the river "Tetri Aragvi'' is given in the Table 6.1.

The comparison with natural data been showen to us, the difference with 95% confidence limits does not exceed 10-25% [3].

Table 6.1.

Name of the river	Damaged area in the water catchment basin of the river in F′ (%)	Erosion coefficient (F_0)		
		1958	1967	1987
Chadistsikhis khevi	6.1	0.19	0.51	0.62
Chokhelt khevi	6.3	0.22	0.58	0.73
Chabarukhis khevi	20.0	0.26	0.65	0.83
Kvemo Mletis khevi	23.0	0.35	0.71	0.91
Nagvaravis khevi	24.0	0.44	0.79	0.98

So, as we know the variation of the mountain slope erosion coefficient , there is no difficulty in determination of volume of the erosion soli particles, which slides from the mountain slope and accumulates in the river-bed. This enables the precise prognostication of the mudflow and MSF formation and power.

CONCLUSION

The regulation of the erosion and mudflow processes in the mountain rivers by means of new spring-board type hydrotechnical structures is one of the first in this sphere, but it already has opened perspectives for reliable design of spring-board type mudflow-protective structures. For this purpose, the results of theoretical, laboratory and natural research for regulation of erosion - mudflow processes in the mountain rivers by spring-board type mudflow protective structures are represented by the author.

The new dependences have been obtained by means of which the values of the leveling inclination of the solids surface accumulated in the spring-board type mudflow-protective stricter upper blef are calculated, envisaging the type of the structure, the mudflow concentration, the work time of the structure and the other main characteristics.

For the qualitative estimation of the mudflow processes and probable break-downs of the spring-board type mudflow-protective structures an absolutely new approach was elaborated, where the elements of the catastrophe theory were used.

The new dependences have been obtained, by means of which the values of longitudinal section marks of the solids accumulated in the mudflow-protective structures upper bief are calculated by envisaging the configuration of the river-bed.

As the result of the researches new dependences have been obtained by means of which the solidholding effect of the spring-board type structures is determined by envisaging the thoroughness and the fulfillment time of the structure.

Envisaging the increase of hydrotechnical structures working reliability for the protection from elemental phenomena a wide range of new structures were elaborated where more then 50% of the building materials are used the secondary raw materials. These inventions, are protected by 10 author's certificates and 3 patents.

In case of big inclination of river the attention is drawn by both the regular and irregular motions of mudflow, where the velocity value is connected with the hydraulic friction and air resistance coefficient.

With the use of partition scheme of the flow vector the calculation algorithm of MSF unsteady motion was created taking the constant and variable discharge of MSF into account, there was calculated on the computer the velocity of flow motion and the forms of leading edge of MSF mass motion (having the air resistance in view) from the moment of flow formation until its complete damping. The relationship between the depth of flow and length of the leading edge of mass motion is ascertained.

According to the natural data and the experiments held by the author (1981-1995) the empirical dependences have been obtained for the calculation of the hydromorphometric characteristics (river's transitive plot) of the river-bed were the turbulent mudflows are preferably formed.

As a result of the experimental and theoretical research work the dependences have been obtained for calculating the basic hydrological and hydraulic characteristics, necessary to design the new spring-board type mudflow-protective structures.

The long statistic series are obtained by using air and cosmic photos and a new dependence is obtained, by using air and cosmic photos and a new dependence is obtained, by means of which the coefficient values of the mountain slope erosion are calculated in connection with the time, which enables the exact prognostication of are calculated in connection with the time, which enables the exact prognostication of erosion – mudflow processes.

It is stated, that the above discussed results were obtained by hydrological and hydraulic equations, which are solved by means of the traditional admittances, and also by elaborating the laboratory and natural data, the total statistic observation number of which is amounted to 2500. The error of calculated values by obtained dependences is not more than permissible values. which era calculated by means of the error theory, and the comparison of the results which the natural data gives the satisfying coincidence.

The dimensions of the spring-board type mudflow-protective structures and the stability of the construction is calculated by means of modern finite-element method, in the algorithm of which was envisaged a loading, stiffness and also the dynamic matrices of the system.

And finally as UNESCO announced the ten year period 1991-2000 years, as the period of protection from natural catastrophes (IDNDR) and elemental phenomena, as in the republic of Georgia so in the various countries of the world the rate of damage caused by the natural catastrophes is increasing; it would be good if in the world practice of bulling the hydrotechnical structures the reliabls and economic new spring-board type construction would be used more widely. For this purpose the close cooperation and contacts would be necessary.

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THE NEW MUD-PROTECTIVE STRUCTURES AND THEIR CALCULATION METHODOLOGY

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