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Debris flow density and their effect on debris flow regulation buildings

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A B S T R A C T

The regulation of debris flow, the issue of their energy dissipation, the selection of calculation models and the design of regulatory measures are related to the selection of the elements that determine the interaction with the flow of anti-flood buildings. In this scientific paper, innovative methods are used to determine and evaluate the criteria of debris flow behaviour at the point of origin, evaluating energetical specifications, and determining its density/bulk. In conjunction with rheology, we can determine energetic characteristics (of a debris flow) and for regulatory purposes, new regulatory constructions are being processed. Great attention should be paid to the latest debris flow regulatory elastic barrage which we received copyright and patent for. The project parameters have been calculated, for example, determining the required number of computational dependencies of the flow striking force acting on them in the plan.

Keywords: *Debris flow, Density bilk, Natural anomalies, Landslide regulation, Pronounced zone, Flow structure.*

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Introduction

Natural anomalies and their impact on the environment is very important, and the risks they pose, to effectively use natural resources and advance the economy.

Based on the analysis of the existing debris flow control measures, the environmental condition still fails to meet the high risks of natural infrastructure. Priority is given to the creation of new forms of innovative countermeasures, as well as the improvement of the calculation methodology. This is due to the genesis and dynamics of Debris flows, as well as the complexity of designing buildings.

Main Part

The study, which deals with the problems of landslide regulation, is focused on refining the methodology for calculating regulatory measures and perfecting the full redistribution of the impact force of the flow on the pressure surface of the building. The study also discusses the possibilities of changing the flow modes and density caused by the complexity of the bed shape on the transit sections of the floodplains. Especially the issue of flood regulation and the critical impact on buildings should be taken into account in sections of the pipeline where they have a pronounced complexity of the shape of the transverse section, so the duct experiences a change in the size of the flow it either expands or contracts according to the flow direction; also the density of the flow is changed. Assessing the impact of flow on the obstacles encountered under such conditions and selecting regulatory measures are associated with completely different approaches and the selection of calculation methodologies [1-3].

An analysis of the causes, of the loss, of the existing debris flow regulatory structures, confirms that the cases of failure of each of them are considerably different from each other. When selecting a model for the impact of flow on buildings, it is necessary to specify the main factors determining the durability of the building along with the issue of energy dissipation, and the layout, quantity and dimensions of the building plan should be based on these factors [4-8].

Approaches to assessment of debrisflow behaviour, sustainability, change in energy performance and methods and methodology for the assessment of criterion indicators are given in scientific papers [9-13].

Based on the methods and methodology for assessing Debris flow behavior, resilience, changes in energy characteristics, and criterion parameters, when Debris flow acceleration is recorded over a short period of time, its magnitude is not related to body deformation and is estimated by impact force and accuracy of deformation [14].

When evaluating stability, analogues of Debris flow deformation within the proportionality limits can be used when the magnitude of the tensile-compression velocity model is less than or equal to the similar magnitude of the sound propagation. n the case of a complete evaluation of the process, the possibility of disruption of the flow structure and the expected cessation of mass are taken into account during the impact.

The possibility of creating a pronounced zone of disturbance during a blow is due to the rate of deformation and at the same time depends on the concentration of tension, the shape and size of the striking flow. When studying the impact of Debris flows on oncoming obstacles, the paper discusses a case where both the potential and kinetic energies of the Debris flow in action are known. The possibilities of equal energy between tension and deformation are preserved. The connection between them is linear. The values of the deformation under dynamic and static impact are equal to each other, for example in the case of a transition to the kinetic energy to potential energy; the values of the deformation are equal to each other.

Disruption of flood resistance, the formation of free surface shape, continuous or gradual change of hydraulic elements, is caused by the influence of many interrelated factors.

The model of a rolling mound in a long cylindrical flow bed having the shape of a rectangular cross-section in the form of a calculation scheme is given in the first scheme.

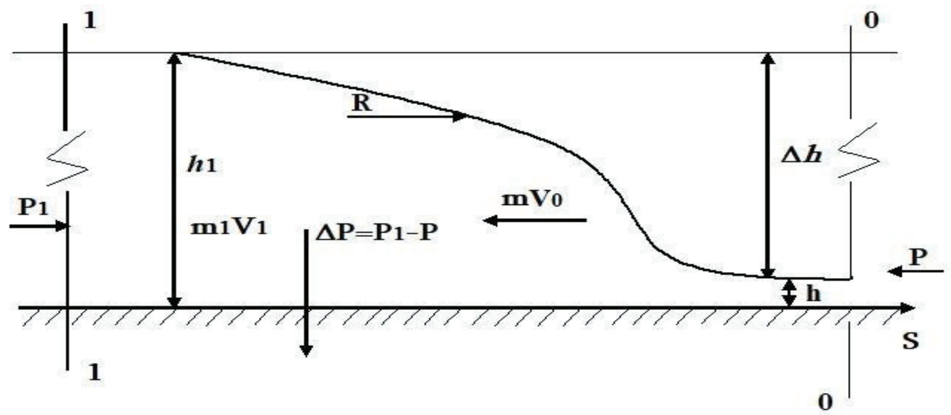


Fig. 1. *Longitudinal cross-section of debris flow wave*

Under the influence of rheological characteristics, an analytical relation is established between the debris flow wave characteristic and the force pulse based on the given scheme. From section 1-1 the mass $m_1 = \rho Q$ does not change in the direction of the wave, and therefore, when the velocity is equal to V_1, the amount of motion is represented by the magnitude $\alpha V_1 \rho Q$, and the sum of the amount of flow motion has a force dimension. Similarly to the cross-section of 1-1, in cross-section 0-0 if the wave propagates at a velocity of V_0, the amount of flow motion will be $\alpha V_1 \rho Q$ Costs represented by such assumptions have a dimension of force, and the magnitude of their projections, when the S-axis has an anti-displacement direction, can be negatively represented.

When the depth h_1 of the Debris flow mass decreases to a depth h, the magnitude of the flow in the control sections is equal to Q, and the change in force from P to P_1 occurs as an impulse, the equation of the balance of the number of seconds motion will be as follows:

$$\rho QV - \alpha\rho QV_0 = P_1 - P \quad (1) \qquad (1)$$

In the selected sections, when the volumetric weight of the trough, the width of the transverse section B, and the change in momentum of the force are equal to ΔP, Equation (1) can be represented as follows:

$$\frac{\gamma Q}{g}\frac{B}{\Delta P} = \frac{h_1 h}{h_1 - h} \quad (2)$$

In the case of debrisflow in the form of a wave corresponds to the non-stationary nature of the flow motion.In the case of wave motion in the form of a wave corresponds to the non-instability of the flow motion.

When determining the energy characteristics of a flood in the transit section of a duct, when the free surface has the face given in the diagram (Fig. 1), the magnitude of the pressure loss can be represented by a differential equation.

$$\frac{dh}{d\ell} = \frac{i_c \dfrac{Q^2}{a^4\omega^2c^2h}\left(1 - \dfrac{a\alpha c^2 h\partial\omega}{g\omega\partial\ell}\right)}{1 - \dfrac{\alpha Q^2 B}{ga^3\omega^3}} \quad (3)$$

Where i is the slope of the duct;

Q - flood consumption;

ω - cross-section area;

α - coefficient of rheology;

c - speed resistance coefficient;

μ - viscosity coefficient;

g - gravity force acceleration;

h - depth of flow.

When a torrent moves at a variable flow rate (Q) and its specific magnitude from the 1 longitudinal meter of the channel is equal to $q = \frac{Q}{\ell}$

$$\frac{dh}{d\ell} = \frac{i_c - \dfrac{QV}{gBf(\beta)}\left(1 - \dfrac{ghf(\beta)}{2K^3B}\right)}{1 - \dfrac{\alpha Q^2 B}{ga^3\omega^3}} \quad (4)$$

To simplify the calculation of the f-s and the values of the members of differential equations (3) and (4) fig. 3 and fig. 4 – Dependency $f(\beta) = \frac{h_0}{2h}\left[\left(\frac{h_0}{h}\right)^2 - 1 + \frac{1}{3}\left(1 - \frac{h_0}{h}\right)^3\right]$, $\alpha' = f(\varphi)$ and $\alpha'' = f\left(\frac{h_0}{h}\right)$; a graphs are given.

In the case of motion in the form of a longitudinal wave of a debrisflow, when the change of its hydraulic elements is slow, the velocity of the wave propagation is 3 times higher than the average velocity [15, 16].

The binding mass is characterized by the ability to resist external stresses whose shape change is completely different from that of Newtonian liquids. The change in the shape of the torrent body is related to the possibility of impact resistance and the tense state of the flow.

h o/h	0	0.2	0.4	0.6	0.8	1
f(β)	0.33	0.23	0.144	0.069	0.018	0

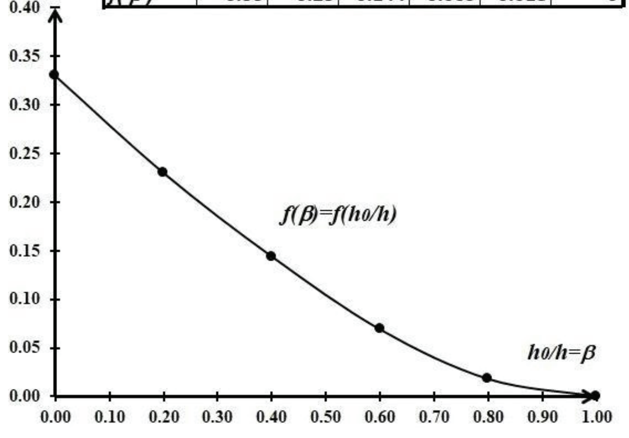


Fig. 2. *Graphical Dependency* $f(\beta) = f(h_0/h)$

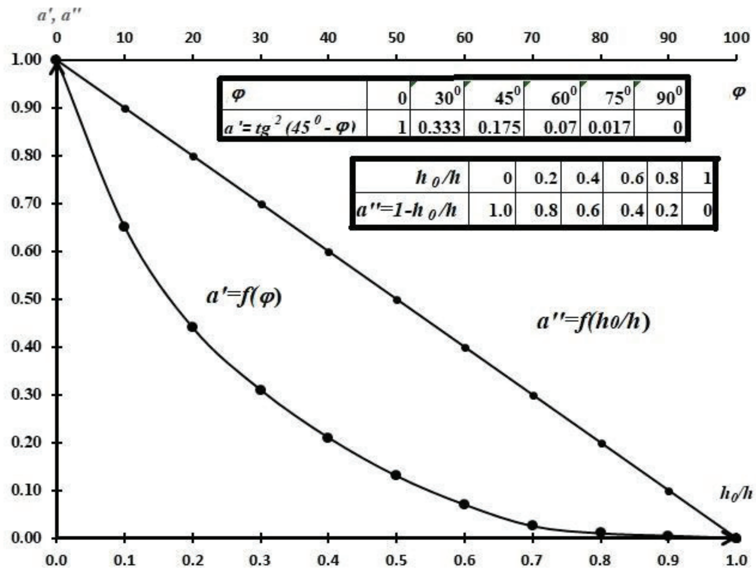


Fig. 3. *Graphical Dependency* $a' = f(\varphi)$ *and* $a'' = f(h_0 / h)$

Gradual, leapfrog, and gentle changes in the dynamic characteristics of the flow are expected when overcoming the obstacles encountered in the duct by a torrent. The classical approaches in the form of Lagrange dependencies are widely used in estimating the dynamic velocity wave (V_0) in the duct. Based on the analysis of the differential equations (1) and (2), when the magnitude $1-\frac{\alpha Q^2}{g}\cdot\frac{\omega^3}{B\alpha^3}$ of the right-hand side is equal to 0, the cross-sectional energy is minimal in magnitude and the wave propagation velocity C is equal to the average velocity $\overline{V}$. Based on continuous wave studies, in the case of a constant flow forward flow rate, the characteristics can be used to estimate the contact wave velocity, duct mode regimes, and pressure changes in the duct. In particular, in the case of a change in pressure - the flow velocity, and in the case of a disturbance characteristic - the elasticity parameters of the change in mass and volume [15-17].

The risks of floods and the impact on oncoming obstacles are related to the perfection of the methods of correct assessment of the criteria defining the movement and stopping capacity of their formation.

Particular attention is paid to cases of impacts on flood resistance, which are associated with the prediction of changes in its structure, concerns with the flow resistance in the body, changes in the geometry of the flow body, and the shape of the free surface obtained during stopping. Each specific task, depending on the above, depends on the types of floods and each case of energy extinction is due to the cases of effective deployment of regulatory measures.

In the case of the well-known morphometry of the duct, the possibility of breaking the structure of the moving flow is possible with points located on its free surface. The flow maintains a continuous appearance of the free surface without hydraulic jump when the bottom is turned. In the event that the duct slopes are less than critical and when this condition is violated, its stability is lost. There is a free surface crossing of the critical and the generation of a wave [9,15,17].

Stability forecasting and estimation of regime change is possible only when the shape of the free surface of the flow motion is known. Representing the flow in this way and constructing its free surface circle is possible by selecting the length of the small section of the pipeline, using hydraulic dependencies, compiling the differential equation of motion, simplifying it for convenience of integrations, calculating free surface coordinates based on the equation and building the surface profile.

When assessing debrisflow resilience it is necessary to consider the role of the influence of oncoming resistances in the regularity of the change in flow stability, along with the possibilities of changing the flow dynamics and the stress state.

By changing, narrowing or expanding the deformation of the Debris flow mass, it changes the shape of its body, as well as the electromagnetic and thermal state. At the same time, there is a transition of spent energy into potential and the formation of a free surface flow in the form of a wave.

The lateral expansion of a semi-unloaded debris flow is estimated by lateral expansion coefficient. When the Debris flow mass is bounded by a horizontal surface and the stress element is characterized by height h, volumetric mass γ, angle φ of internal friction, equivalent depth of bond h_0, the lateral expansion change picture can be estimated based on the relative magnitude of the main stresses or the lateral expansion coefficient.

$$\frac{\sigma_2}{\sigma_1}=\frac{\gamma h\left(1-\frac{h_0}{h}\right)\tan^2\left(45^0-\frac{\varphi}{2}\right)}{\gamma h}=\left(1-\frac{h_0}{h}\right)f=\frac{\mu^*}{1-\mu^*} \quad (5)$$

The magnitude of the relative deformation coefficient of the Debris flow mass, when the amplitude of the Debris flow mass is B, the height is h, and the corresponding values of the deformations are equal to ΔB and Δh,

$$\mu^*=\frac{\frac{\Delta B}{B}}{\frac{\Delta h}{h}}=\frac{\left(1-\frac{h_0}{h}\right)f}{1+\left(1-\frac{h_0}{h}\right)f}=\frac{\alpha}{1+\alpha} \quad (6)$$

According to the 6th dependence analysis, the magnitude of the relative deformation is a function of the rheological characteristics and a clear picture of its change is presented in Figure #4. Reducing the flow width corresponds to increasing its depth and breaking the parallelism of the flow cycles. When the width of the flood is equal to B and the lateral narrowing is equal to ΔB, the value of the width bounded by the narrowing of the width $B_{mar.}$ is equal to $B-\Delta B \le B_{mar.}$ (7)

The magnitude of the lateral deformation of the flow width $\frac{\Delta B}{B}=1-\frac{B_{mar.}}{B}$ (8)

ho/h	0.2	0.4	0.6	0.8	1	*f*
0.0	0.167	0.285	0.375	0.44	0.5	
0.2	0.188	0.24	0.324	0.39	0.44	
0.4	0.107	0.19	0.264	0.132	0.375	
0.6	0.079	0.137	0.194	0.24	0.285	
0.8	0.038	0.074	0.107	0.137	0.166	
1.0	0	0	0	0	0	

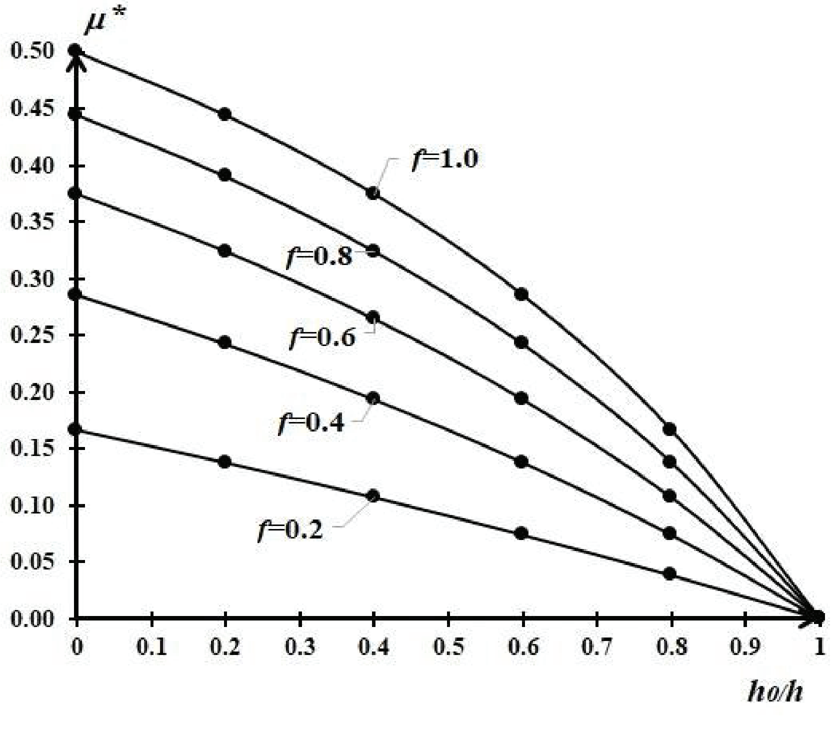


Fig. 4. *Graph of the relation of the relative deformation to the rheological characteristics of the flood*

Ability to increase the height of the flooding mass caused by lateral constriction $h_1 = \Delta h + h$ (9)

The magnitude of the cross-sectional contraction of the flow from the (6) dependence $\frac{\Delta B}{B} = \mu \frac{\Delta h}{h} = \frac{\alpha}{1+\alpha} \cdot \frac{\Delta h}{h}$ (10)

The relationship of the magnitude of the transverse contraction of the flow to the rheological characteristics is given fig. 5.

Bmar./B	0	0,0127	0,0548	0,1220	0,2080	0,3120
a=(1-h0/h)f	0	0,2	0,4	0,6	0,8	1

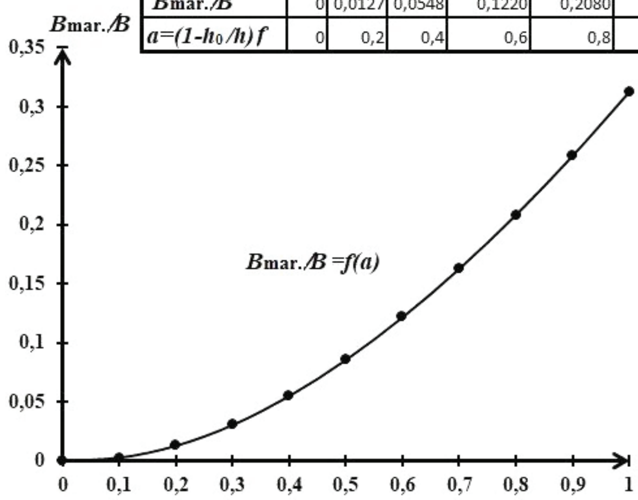


Fig. 5. *$B_{mar.}$/B=f(a) Dependency Graph*

If we consider the case of dam rupture or core collapse as a model of a stopped wave of displacement of the Debris flow mass, based on the magnitude of the flow q resulting from the deformation in such a case and the value in decreasing the fall velocity in case of changes in Debris flow height from h_1 to h. $V = 2\sqrt{gh_1} - 2\sqrt{gh}.$ (11)

Debrisflow energy expenditure

$$q = h\left(2\sqrt{gh_1} - 2\sqrt{gh}\right) \quad (12)$$

According to the analysis, the minimum magnitude of the Debris flow cross-sectional energy corresponds to the condition when the ratio of the average kinetic energy to the potential is equal to 1, respectively, based on Equations (1) and (2). $\frac{dh}{d\ell} = \infty$

$$1 - \frac{\alpha Q^2}{g} \cdot \frac{B}{\alpha^3 \omega^3} = 0$$

When = 1, flow Q = ωV-1, mean flow velocity is equal to wave velocity,

$$C = V = \left(1 - \frac{h_0}{h}\right) fC \sqrt{\left(1 - \frac{h_0}{h}\right) fgh} = C\alpha\sqrt{\alpha gh} \quad (13)$$

Accordingly debrisflow energy expenditure

$$q = \alpha h \sqrt{\alpha gh}\,. \quad (14)$$

Based on the result obtained above,

$$h\left(-2\sqrt{gh} + 2\sqrt{gh_1}\right) = \alpha h \sqrt{\alpha gh}\,. \quad (15)$$

Accordingly the magnitude of the deformation

(16) Considering this in (9)

$$\frac{\Delta h}{h} = \frac{\alpha^3 + 4\alpha\sqrt{\alpha}}{4}. \quad (16)$$

$$\frac{B_{mar.}}{B} = \mu * \frac{\alpha^3 + 4\alpha\sqrt{\alpha}}{4} = \frac{\alpha}{\alpha+1} \cdot \frac{\alpha^3 + 4\alpha\sqrt{\alpha}}{4(\alpha+1)} \quad (17)$$

The magnitude of the relative deformation with respect to (10)

$$\frac{\Delta B}{B} = 1 - \frac{\alpha}{\alpha+1} \cdot \frac{\alpha^3 + 4\alpha\sqrt{\alpha}}{4} = \frac{4(\alpha+1) - \alpha\left(\alpha^3 + 4\alpha\sqrt{\alpha}\right)}{4(\alpha+1)} \quad (18)$$

When the rheological characteristics do not affect the deformation e.g. $h_0 = 0$ and $\alpha = 1$, respectively, $\frac{\Delta B}{B} = 0{,}375$ and the obtained result fully confirms the results of the research [14].

The magnitude of the relative elongation of the stretch by contraction and lateral constriction of the debris flow mass

$$\frac{\Delta h}{h} = \frac{h_1 - h}{h} = \frac{h_1}{h} - 1 \quad (19)$$

Accordingly (16) - in (19)

$$\frac{h_1}{h} = \frac{4\alpha + \alpha^3 + 4\alpha\sqrt{\alpha}}{4}$$

When $a = 1$, $\frac{h_1}{h} = 2{,}25$. The values of the ratio of longitudinal and transverse deformations of the flow in the control sections if we express the extension or contraction with the initial value. $\frac{h_1}{h} = f(\beta)$

$$f(\beta) = \frac{\left(\alpha^3 + 4\alpha\sqrt{\alpha}\right)\left(2+\sqrt{\alpha}\right)^2}{16} \quad (21)$$

Accordingly the magnitude can be determined $\frac{h_1 - h}{h_1 h}$ by dependence (21) An illustration of the relative magnitude $\frac{h_1}{h}$ is given in connection with rheology fig. 6.

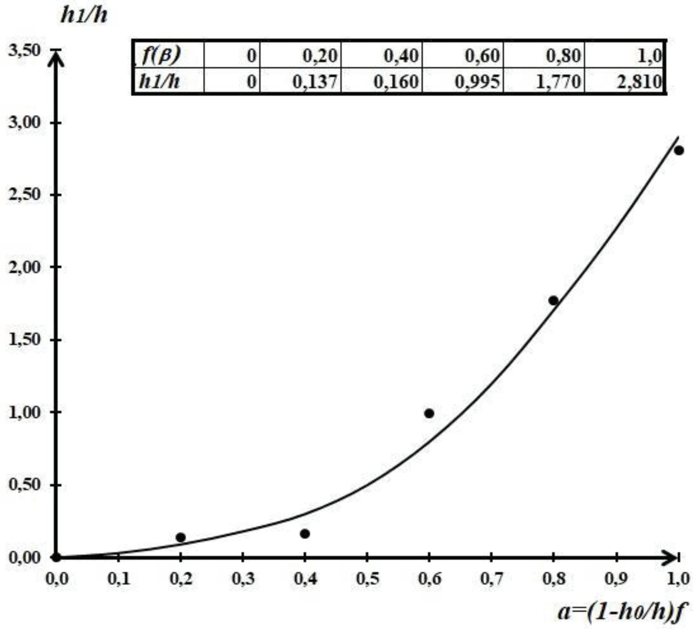


Fig. 6. *Graph of h_1 / h dependence in relation to debris flow rheological characteristics*

Flood risks and impact on various facilities are related to its capacity and energy performance. Among the regulation tasks, it is important to balance the free surface equilibrium of the flow created by the opposing resistances working in dynamic strikes in the flow and the flow-free balance created by the resistance forces. The layout in the engineering action plan is related to the appearance of a flow-free surface and the existence of many such anomalies in nature. The impulse of the dynamic impact of the flood on oncoming resistances.

$$\Delta P = \left(\rho C V + \rho V^2\right)\omega \quad (22)$$

When C>>V-moving debris is equal to $\sin\alpha$

$$\Delta P = \frac{Q\gamma\omega V^2}{g}\sin\alpha \frac{16 - \left(\alpha^3 + 4\alpha\sqrt{\alpha}\right)\left(2+\sqrt{\alpha}\right)^2}{\left(\alpha^3 + 4\alpha\sqrt{\alpha}\right)\left(2+\sqrt{\alpha}\right)^2}. \quad (23)$$

In Equation (23) because hence the value of the striking coefficient: $f(\alpha) = \left(\alpha^3 + 4\alpha\sqrt{\alpha}\right)\left(2+\sqrt{\alpha}\right)^2$,

$$m = \frac{16 - f(\alpha)}{f(\alpha)}. \quad (24)$$

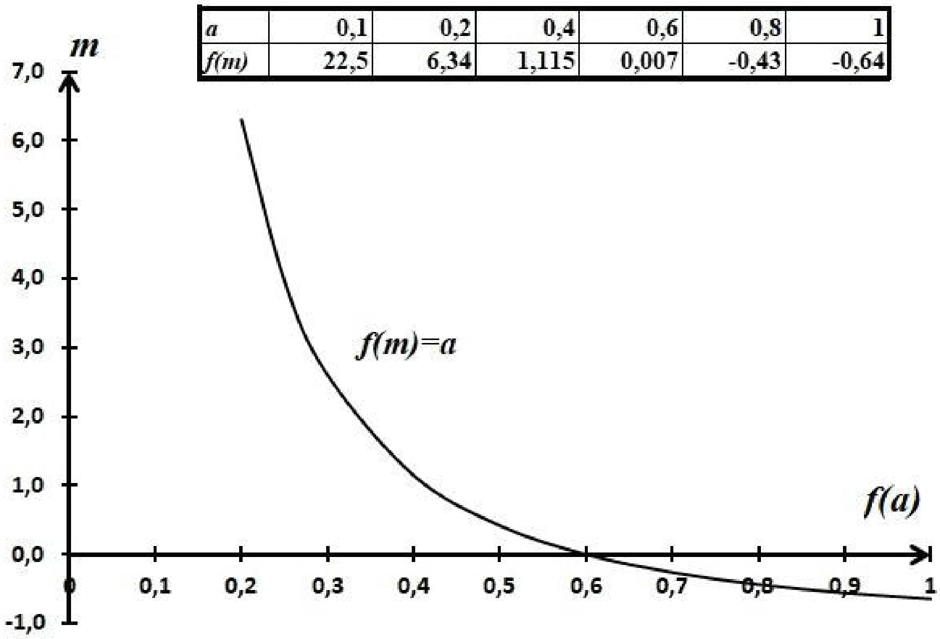
The magnitude of the impact force of the Debris flow/debrisflow

$$P = m\frac{\alpha\omega V^2}{g}\sin\alpha \quad (25)$$

As the dependence analysis (22) confirms, the magnitude of the functionally striking force coefficient is related to the rheology of the Debris flow and the nature of its change depends on the face of each particular Debris flow. When a value of a> 0.60 in such a case corresponds to the condition of the immobility of the Debris flow and the probability of impact resistance is equal to 0. Function 1 is equal to the case when $\alpha = \left(1 - \frac{h_0}{h}\right)\cdot f$

The value of the impact force coefficient is a function of the rheological characteristics and its magnitude is given graphically in Fig.7.

Flood-regulating measures in the environment according to the purpose, according to the con-



a	0,1	0,2	0,4	0,6	0,8	1
f(m)	22,5	6,34	1,115	0,007	-0,43	-0,64

Fig. 7. *Graph Dependency* $m = f\left[f(\alpha)\right]$

structive solutions of the constituent elements, are divided into flood-transit, flood-management and debris flow buildings. The function of each of them is diametrically different from each other and the possibilities of failure are caused by the specificity of the impact of the floods. Based on the above, the paper presents an innovation compared to the existing flood control by changing the direction of the strategy of application of regulatory measures and the longitudinal change of structural solutions of transverse structures. In this regard, the types of buildings on which copyright certificates have been obtained have been processed. The patent for the recently created elastic barrier stands out (P20207068B) – invention [18-26].

The effect of impact on floodplains is related to their permeability when regulated by copyrighted buildings. According to the permeability coefficient and the types of buildings, the strong impact of floods according to the types of buildings is given in the form of calculation dependence:

1. Semi-conical permeable structure;

$$\Delta P = \frac{\alpha\omega V^2}{g}\sin\alpha\left[\left(0{,}215 + 0{,}785\left(1 - \frac{h_0}{h}\right)\right)^2\right]\frac{16 - f(\alpha)}{f(\alpha)}; \quad (26)$$

2. Pyramidal permeable structure;

$$\Delta P = \frac{\alpha\omega V^2}{g}\sin\alpha\left[\left(0{,}5 + 0{,}5\left(1 - \frac{h_0}{h}\right)\right)^2\right]\frac{16 - f(\alpha)}{f(\alpha)} \quad (27)$$

3. Semi-cylindrical building;

$$\Delta P = \frac{\alpha\omega V^2}{g}\sin\alpha\left(0{,}5 - 0{,}5\frac{d}{H}\right)\frac{16 - f(\alpha)}{f(\alpha)}; \quad (28)$$

4. Flood regulating elastic barrier

$$\Delta P = \frac{\alpha\omega V^2}{g}\sin\alpha\frac{1}{\left(1 + \frac{d}{H}\right)^2}\cdot\frac{16 - f(\alpha)}{f(\alpha)} \quad (29)$$

In the case of a prismatic intersecting channel, when the volumetric volume of the flood and the velocity correction coefficient are represented by a, the velocity of the flow motion is V, the velocity of the wave propagation on the flow surface is C, and the magnitude of the impact of the momentum P is on the opposing resistances. S equals, breaking the condition of sustainability and its loss can be expressed by inequality:

$$V_0 \geq V + C \quad (30)$$

In Equation (30), taking into account the values of V and C, with respect to the corresponding transformations and simplifications, the flood resistance in the case of its slope is equal to:

$$i \leq 0{,}00067 \frac{\sqrt[3]{\frac{d}{h}}}{\alpha^2} \ . \ (31)$$

When the magnitude of the slope of the Debris flow is known, the distance between the Debris flow elastic
dams in the case of the L-balancing I slope

$$L = \frac{H}{I} \cdot \frac{\alpha^2}{\alpha^2 I - 0{,}00067} . \ (32)$$

Table. *The report of the member (a) included in the formula*

$\frac{h_0}{h}$ \ f	**0**	**0,4**	**0,6**	**0,8**	**1,0**
0	0,04	0,16	0,36	0,64	1,0
0,2	0,0256	0,102	0,234	0,409	0,64
0,4	0,0144	0,0576	0,1296	0,264	0,36
0,6	0,0064	0,0258	0,00576	0,1024	0,16
0,8	0,0016	0,0064	0,0144	0,0254	0,04
1.0	0	0	0	0	0

Conclusion

Based on the analysis of the impact of debris flows on the existing debris flow regulation facilities and based on the selection of regulatory measures, innovative construction solutions are presented to the debris flow regulation building and a new methodology for their calculation is proposed;

Based on the dynamics of floods, the potential for their reliability/strength is assessed, and innovative reporting models are adapted to the event to clarify the criteria for determining reliability/strength. Based on the use of the corresponding inequality in the definition of reliability/strength, the possible conditions of reliability/strength are specified;

According to the theoretical characteristics, the strain mass and deformation possibilities are evaluated;

An innovative model for the impact on flood defences is proposed, based on which the calculation ratios of the impact force are derived taking into account in the types of buildings;

Different design strategies are used in terms of flood risk neutralization, building design solutions, rigidity and regulatory potential. Innovative methods and methodology are used to derive the calculation dependencies of the striking force of the flow, the loss of stability, the determination of the distance between buildings.

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