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The assessment of the possibility debris flow influence on the pass through type debris flow against construction in the river Jokhtaniskhevis basin

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Abstract
In the article is determined the maximum discharge of the possibility debris flow in the river Jokhtaniskhevi basin with various percentage insurance. Also is purposed pass through type debris flow against construction built on the surrounded principle, on which has been implemented theoretical research for evaluate possibility debris flow influence in the river Jokhtaniskhevi basin.
As a result of our implemented calculation has been established, that during influence of possibility debris flow on the construction in the river Jokhtaniskhevi basin, number value of the loading at the cylinder shape elements of construction, that gives bases, that purposed construction considered as a effective debris flow against construction.

Keywords: erosion, landslide, debris flow, ecological risk

Introduction
Recently, due to climate changes running on the Earth significantly changed existing climate on the various continent, because have become more frequent floods caused with intensive rains, also became more active the process of melting glaciers, Erosion, landslide debris flow phenomena creates damage for the people who lives in the ecological disabling zone, under the risk falls strategic importance transport corridors and energetically objects safety functionality, suffering the country economy.
From the natural disaster which are distributed on the territory of Georgia one main is debris flow phenomena, which has place approximately every mountain and pre-mountain region. This problem especially is actual on spring and summer, when is frequent rain and snow melting intensively. Due to debris flow origin unpredictable and action short time and also as a result of its characteristic big destroyed power, fight against them often is not only material side, its cover also social field, because often is necessary evacuation of population not only temporary, but in the long time, and their settlement some less dangerous places.

The main part
The above-mentioned circumstances, due to various genesis debris flow activated in debris flow nature river catchment basin in Georgia, there should be implement debris flow against resources saving measures, for minimizing ecological risks [1].
By taking into account above mentioned our research object is catchment basin (see graph 1) of Jokhtaniskhevi, which is debris flow characteristic tributary of the river Gldaniskhevi, where according to recent data, froms erosion debris flow genesis phenomena by 5 years interval, that accompanied destroyed of local population plot and houses, expected loss of human [2].

Graph 1: The catchment basin of the river Jokhtaniskhevi

By taking into account above mentioned, for receive necessary data for forecast expectable debris flow maximal discharges, implemented field researches in the Jokhtaniskhevi (see photos 1, 2, 3, 4,).

Photo 1: The general view of erosion-landslide genesis debris flow tributary Jokhtaniskhevi drains and its adjacent degraded slope

Photo 2: The sediment debris flow material in the bed of Jokhtaniskhevi

Photo 3: The process of measure of charachteristic parameters of Jokhtaniskhevi bed

Photo 4: On the left side of the Jokhtaniskhevi bed is fixed trace of debris flow by height 1.2 (m)

By use of data received as a result of field researches implemented in the catchment basin of Jokhtaniskhevi and empirical independence[1] received by Prof. Givi Gavardashvili it has been determined maximal discharges of the predictable debris flow in the catchment basin of Jokhtaniskhevi by various percentage insurance (see table 2):

$$Q_{max.} = A(34 + 400i) \cdot F_0^{0.61} (m^3/sec); \qquad (1)$$

Where, i – average inclination of tributary;
F_0- area of catchment basin of the river (km^2),
A – discharge coefficient, which linkage with insurance coefficient (P %) is given in table 1.

Table 1: Independence of discharge coefficient (A) and insurance coefficient (P %)

($P_{\%}$)– insurance coefficient	0.1	1	3	5	10	25	50
A – discharge coefficient	2.4	1	0.7	0.6	0.5	0.3	0.2

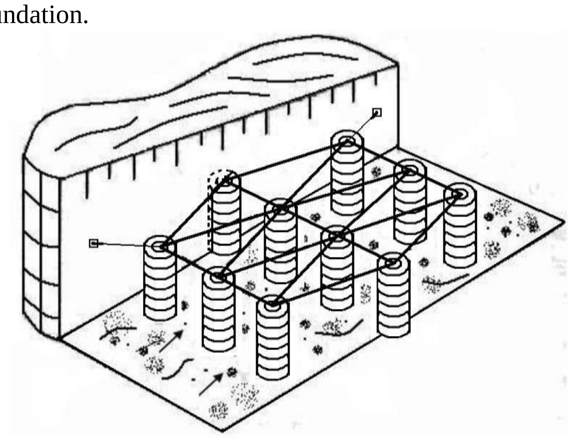
Table 2: The various percentage insurance maximal discharges of the predictable debris flow in the catchment basin of the Jokhtaniskhevi

#	Name of tributary	Area of catchment F_0 (km^2)	Height of tributary from the sea level H (m)		Length of tributary L (km)	Inclination i	Various percentage insurance maxima discharges of the debris flow $Q_{max.}$(m^3/sec)		
			originate (m)	tributary (m)			0.1%	1%	10%
1	2	3	4	5	6	7	8	9	10
1	Jokhtaniskhevi	10,6	1120	580	4,2	0,128	863,2	359,6	179,8

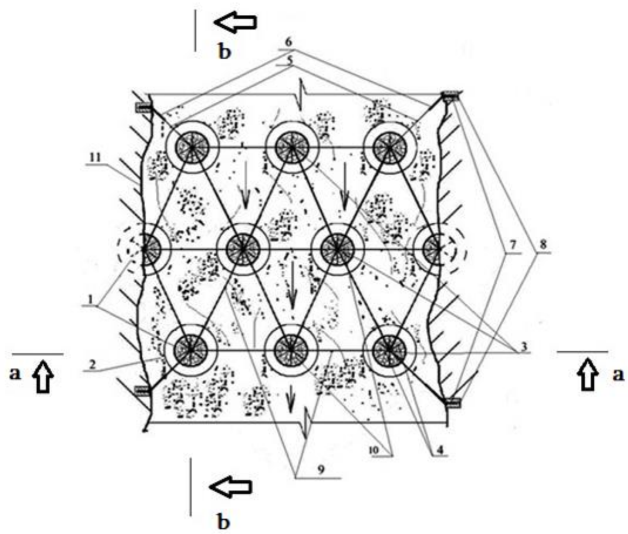
As seems from the table 2 the maximal discharge of predictable debris flow with 1 % insurance is 359,6 m^3/sec, that is dig danger for local population and is necessary implementation of effective engineering measures for decrease predictable ecological disaster.

For this purpose, we have developed, resources saving through type debris flow against construction [3], built on base of surrounded principle of power, which consist checkerboard pattern knotted cylindrical elements, which are metal pipes with the metal axis, full's of inert mass of riverbed, which have been fitted with tires, they are fixed on Reinforced concrete base (see pic. 2, 3, 4, 5).

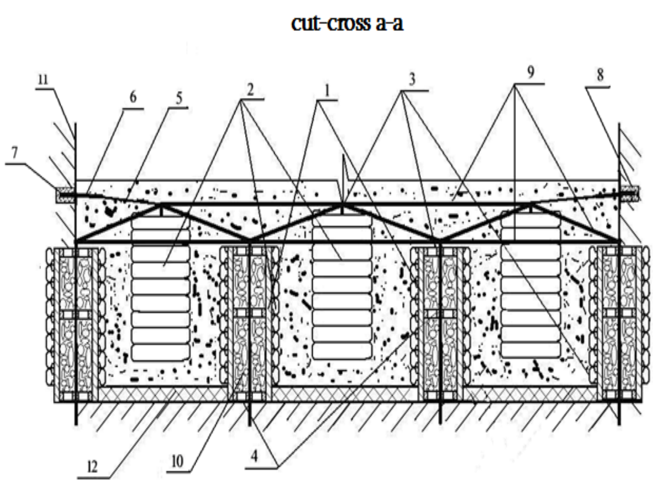
Among the elements of the scheme of through type debris flow against construction, developed by us:(1)metal pipe, (2) tyres, (3) metal axis, (4) angled bar for connecting metal pipe and metal axis, (5) ropes for fixing on the river bed slope cylindrical elements component of the debris flow against construction, (6) ropes clamps, (7) anchors for attach ropes clips on the river bed slopes, (8) reinforce for attach anchors on the river bed slopes, (9) metal angled bar, for connection cylinder elements of the construction to each other, (10) inert mass placed in the tube, (11) slopes of river bed, (12) the building of reinforced concrete foundation.



Pic 1: General view of the through type debris flow against construction

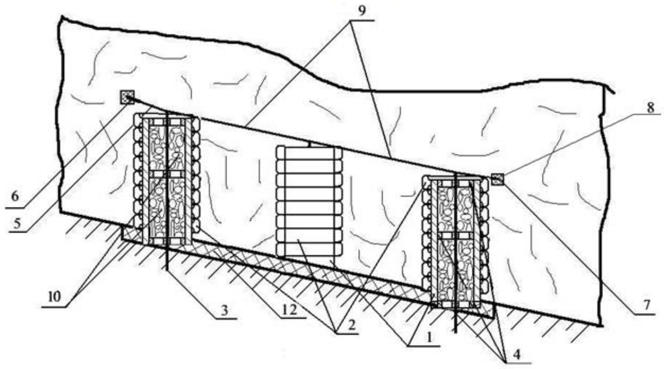


Pic 2: Plan of the through type debris flow against construction



Pic 3: Front view of the construction (from the tailrace)

cut-cross b-b



Pic 4: The view of the construction site

For assessment of debris flow impact on the above noted through type debris flow against construction it is given follow calculation with recieved data as a result of field researches implemented in the Jokhtaniskhevi and specific assumptions [4]:

Initially, it should be noted, that distance between rows of cylinder elements of our construction L=10 m, because, due to lack of L, in calculation is not provided energy losses in the length of the debris flow during debris flow through from I row to III row of the construction cylinder elements. Deaf building case, when construction creates to bed base 90^0 corners, debris flow power impact on the construction is equal:

$$P = K_1 \frac{\gamma \cdot Q^2}{g \cdot \omega}, \qquad (2)$$

Where, K_1 – is experimental coefficient;

γ – debris flow volume weight kg/m^3;

Q – discharge od debris flow;

g – gravity acceleration (m/s ^{2});

ω – Live sectional area of m^2.

Due to model of flow motion is received meaning of K_1 [8].

$$K_1 = 1{,}5 \cdot \left[\cos\alpha \cdot tg\varphi + \frac{h_0}{2 \cdot H} \cdot \left(\frac{1-\sin\varphi}{\cos\varphi}\right)\right], \qquad (3)$$

Where h_0 – cohesive equivalent to the height;

φ – internal friction angle;

H – height of debris flow ;

α –inclination of bed.

Taking into account the above indicates, calculating formula of size of debris flow attacking force on the construction has follow view:

$$P = \frac{1{,}5 \cdot \gamma \cdot \omega \cdot v^2}{g} \cdot \left[\cos\alpha \cdot tg\varphi + \frac{h_0}{2 \cdot H}\left(\frac{1-\sin\varphi}{\cos\varphi}\right)\right], \qquad (4)$$

Meaning of debris flow attacking force on the construction It is the cross-cutting function of capacity. Therefore, in the first place, calculation takes place on the analogical deaf construction, which considering, force of linkage debris flow impact on the construction, when is given characteristics of bed and flow, so when width of debris flow bed B=25 m, flow height H=6.5 m, Flow rate V = 1.8 (m/s), Volumetric mass of 2000 kg/m^3, Internal friction angle – 300 and inclination of duct 0.128.

$$P = \frac{1{,}5 \cdot \gamma \cdot \omega \cdot v^2}{g} \cdot \left[\cos\alpha \cdot tg\varphi + \frac{h_0}{2 \cdot H}\left(\frac{1-\sin\varphi}{\cos\varphi}\right)\right] = \frac{1{,}5 \cdot 2000 \cdot 205 \cdot (1{,}8)^2}{9{,}81}\left[0{,}991 \cdot 0{,}577 + \frac{5{,}5}{2 \cdot 6{,}5}\left(\frac{1-0{,}5}{0{,}866}\right)\right] = 1626{,}1\ k.n.$$

Because submitted construction is trough, off road coefficient calculating by formula.

$$K_2 = \frac{\omega_{through}}{\omega}, \text{ or } K_2 = \frac{(B - n \cdot d) \cdot H}{B \cdot H} = 1 - \frac{n \cdot d}{B},$$

Where $\omega_{through}$- in the construction row through area between cylinder shape elements;

n –amount of cylinder elements in construction row, In our case, due to the structures of theconstruction $n = 3$.

d – diameter of cylinder elements, so

$$K_2 = 1 - \frac{3 \cdot d}{25} = 1 - 0{,}12d; \; K_2 = 1 - 0{,}12d, wherefore\ d = \frac{1 - K_2}{0{,}12};$$

As for, on the first row of through construction, as attracting force current on the every next row, compare to deaf construction, in case of various assumptions (total 5 access, m=1,…,5), as by percentage, also partially functionality

$$\frac{P_{m\ deaf}}{P} = f\ (K_2)$$

<u>I access</u> $K_2 = 0{,}8$; then

$$\frac{P_{1deaf}}{P} = 20\ \% = 0{,}2,$$

$$P_{1\ deaf\ I\ row} = P \cdot 0{,}2 = 1626{,}1 \cdot 0{,}2 = 325{,}2 \text{ k.n.}$$

$$d_1 = \frac{1 - 0{,}8}{0{,}12} = 1(6)m$$

In case of diameter of cylinder shape elements of through type debris flow against construction 1,(3) m, after impact of debris flow at the first row elements o the construction, residual attract force on the second row elements of the construction $P_{1\ residual\ I\ row}$ is equal:

$P_{1\ residual\ I\ row} = P – P_{1\ deaf\ I\ row} = 1626{,}1 – 325{,}2 = 1300{,}9$ k.n.,

but $P_{1\ residual\ II\ row} = P_{1\ residual\ I\ row} \bullet 0{,}2 = 1300{,}9 \bullet 0{,}2 = 260{,}2$ k.n.

After the impact of debris flow at the second-row elements o the construction, residual attract force on the third-row elements of the construction $P_{1residual\ II\ row}$ is equal:

$P_{1\ residual\ I\ row} = P – P_{1\ deaf\ I\ row} = 1300{,}9 – 260{,}2 = 1040{,}7$ k.n.,

but $P_{1\ deaf\ II\ row} = P_{1\ residual\ I\ row} \bullet 0{,}2 = 1040{,}7 \bullet 0{,}2 = 208{,}1$ k.n.,

Finally will recieve: $P_{1\ residualIII\ row} = P_{1residualII\ row} – P_{1deaf\ III\ row} = 1040{,}7 – 208{,}1 = 832{,}6$ k.n.

From above calculation seem, that in the case of diameter of cylinder shape elements of through type debris flow against construction 1,(3) m, the initial force of the debris flows front P=1626,1 k.n. impacted on the construction, decreases after through the construction approximately twice ($P_{1\ residual\ III\ row}$ =832,6 k.n.).

<u>II access</u> $K_2 = 0{,}6$ then,

$$\frac{P_{2\ deaf}}{P} = 40\ \% = 0{,}4 \text{, but}$$

$P_{2\ deaf\ I\ row} = P \cdot 0{,}4 = 1626{,}1 \cdot 0{,}4 = 650{,}4$ k.n.,

$$d_2 = \frac{1-0{,}6}{0{,}12} = \frac{0{,}4}{0{,}12} = 3(3)\text{m.}$$

In case of diameter of cylinder shape elements of through type debris flow against construction 3,(3) m after impact of debris flow at the first row elements o the construction, residual attract force on the second row elements of the construction $P_{2\ residual\ I\ row}$ is equal:

$P_{2\ residualI\ row} = P - P_{2\ deaf\ I\ row} = 1626{,}1 - 650{,}6 = 975{,}5$ k.n.,
But $P_{2\ deaf\ II\ row} = P_{2\ residualI\ row} \bullet 0{,}4 = 975{,}5 \bullet 0{,}4 = 390{,}2$ k.n.,

After impact of debris flow at the second row elements o the construction, residual attract force on the third row elements of the construction $P_{2\ residual\ II\ row}$ is equal:

$P_{2\ residual\ II\ row} = P_{2\ residualI\ row} - P_{2\ deaf\ II\ row} = 975{,}5 - 390{,}2 = 585{,}3$ k.n.,
but $P_{2\ deaf\ III\ row} = P_{2\ residualII\ row} \bullet 0{,}4 = 585{,}3 \bullet 0{,}4 = 234{,}1$ k.n.,

Finally will recieve: $P_{2\ residuaIII\ row} = P_{2\ residuaII\ row} - P_{2\ deaf\ III\ row} = 585{,}3 - 234{,}1 = 351{,}2$ k.n.,

From above calculation seem, that in case of diameter of cylinder shape elements of through type debris flow against construction 3,(3) m, initial force of the debris flow front P=1626,1 k.n. impacted on the construction, decreases after through the construction approximately 4,6-times and equal : $P_{2\ residual\ III\ row} = 351{,}2$k.n.

III access $K_2 = 0{,}4$ and,

$$\frac{P_{3\ deaf}}{P} = 60\ \% = 0{,}6 \text{, but}$$

$P_{3\ deaf\ I\ row} = P \cdot 0{,}6 = 1626{,}1 \cdot 0{,}6 = 975{,}7$ k.n.

$$d_3 = \frac{1-0{,}4}{0.12} = \frac{0{,}6}{0.12} = 5{,}0m.$$

In case of diameter of cylinder shape elements of through type debris flow against construction 5 m, after impact of debris flow at the first row elements o the construction, residual attract force on the second row elements of the construction $P_{3\ residual\ I\ row}$ is equal:

$P_{3\ residualI\ row} = P - P_{3\ deaf\ I\ row} = 1626{,}1 - 975{,}7 = 650{,}4$ k.n.,
but $P_{3\ deaf\ II\ row} = P_{3\ residualI\ row} \bullet 0{,}6 = 650{,}4 \bullet 0{,}6 = 390{,}2$ k.n.,

After impact of debris flow at the second row elements of the construction, residual attract force on the third row elements of the construction $P_{3\ residual\ II\ row}$ is equal:

$P_{3\ residualII\ row} = P_{3\ residualI\ row} - P_{3\ deaf\ II\ row} = 650{,}4 - 390{,}2 = 260{,}2$ k.n.,
But $P_{3\ deaf\ III\ row} = P_{3\ residualII\ row} \bullet 0{,}6 = 260{,}2 \bullet 0{,}6 = 156{,}1$ k.n.,

Finally will receive:$P_{3\ residualIII\ row} = P_{3\ residual\ II\ row} - P_{3\ deaf\ IIIrow} = 260{,}2 - 156{,}1 = 104{,}1$ k.n.,

From above calculation seem, that in case of diameter of cylinder shape elements of through type debris flow against construction 5 m, initial force of the debris flow front P=1626,5k.n. impacted on the construction, decreases after through the construction approximately 15,6-times $P_{3\ residual\ III\ row} = 104{,}1$k.n.

IV access $K_2 = 0{,}2$ and,

$$\frac{P_{4\ deaf}}{P} = 80\ \% = 0{,}8 \text{, but}$$

$P_{4\ deaf\ I\ row} = P \cdot 0{,}8 = 1626{,}1 \cdot 0{,}8 = 1300{,}9$ k.n.

$$d_4 = \frac{1-0{,}2}{0{,}12} = \frac{0{,}8}{0{,}12} = 6,(6)m.$$

In case of diameter of cylinder shape elements of through type debris flow against construction 6,(6) m, after impact of debris flow at the first row elements the construction, residual attract force on the second row elements of the construction $P_{4\ residual\ I\ row}$ is equal:

$P_{4\ residual\ I\ row} = P - P_{4\ deaf\ I\ row} = 1626{,}1 - 1300{,}9 = 325{,}2$ k.n.,
but $P_{4\ deaf\ II\ row} = P_{4\ residual\ I\ row} \bullet 0{,}8 = 325{,}2 \bullet 0{,}8 = 260{,}2$ k.n.,

After impact of debris flow at the second row elements o the construction, residual attract force on the third row elements of the construction $P_{4\ residual\ II\ row}$ is equal:

$P_{4\ residual\ II\ row} = P_{4\ residual\ I\ row} - P_{4\ deaf\ II\ row} = 325{,}2 - 260{,}2 = 65{,}0$ k.n.,
but $P_{4\ deaf\ III\ row} = P_{4\ residual\ II\ row} \bullet 0{,}8 = 65{,}0 \bullet 0{,}8 = 52{,}0$ k.n.

Finally will receive: $P_{4\ residual\ III\ row} = P_{4\ residual\ II\ row} - P_{4\ deaf\ III\ row} = 65{,}0 - 52{,}0 = 13$ k.n.

From above calculation seem, that in case of diameter of cylinder shape elements of through type debris flow against construction 6,(6) m, initial force of the debris flow front P=1626,2k.n. impacted on the construction, decreases after through the construction approximately 125 - times $P_{4\ residual\ III\ row} = 13$ k.n.

V access $K_2 = 0$ and,

$$\frac{P_{5\ deaf}}{P} = 100\ \% = 1{,}0 \text{, but}$$

$P_{5\ deaf\ I\ row} = P$

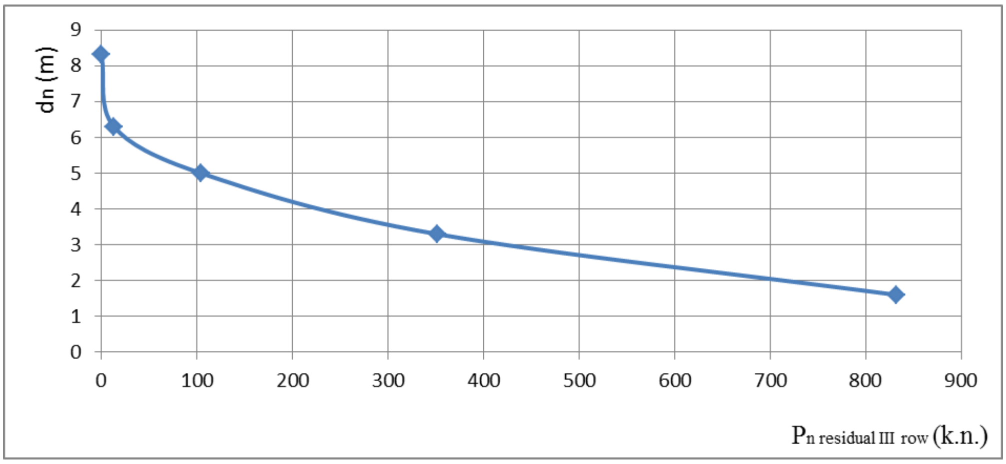
$$d_5 = \frac{1-0}{0{,}12} = 8,(3)\text{m.}$$

In case of V assess, when diameter of the cylinder shape elements of the through type debris flow against construction d=8,(3) their amount is 3, then width of the construction is 3×8,(3)=25 m, therefor construction is deaf construction, so width of construction elements becomes equal of debris flow duct width B=25 m.

After through debris flow against construction (third row) connection between residual attacking force and changeable diameter of cylinder shape elements of construction is equal:

$d_1 = 1,(6)$ In case $P_{1residual\ III\ row} = P_{1\ residual\ II\ row} - P_{1\ deaf\ III\ row} = 1040{,}7 - 208{,}1 = 832{,}6$ k.n.,
$d_2 = 3,(3)$ In case $P_{2\ residual\ III\ row} P_{2\ residual\ II\ row} - P_{2\ deaf\ III\ row} = 585{,}3 - 234{,}1 = 351{,}2$ k.n.,
$d_3 = 5{,}0$ In case $P_{3\ residual\ III\ row} = P_{3\ residual\ II\ row} - P_{3\ deaf\ III\ row} = 260{,}2 - 156{,}1 = 104{,}1$ k.n.,
$d_4 = 6,(6)$ In case $P_{4\ residual\ III\ row} = P_{4\ residual\ II\ row} - P_{4\ deaf\ III\ row} = 65{,}0 - 52{,}0 = 13$ k.n.,
$d_5 = 8,(3)$ In case $P_{5\ residual\ III\ row} = 0$ k.n.,

It is presented follow functional dependence dn=f ($P_{n\ residual\ III\ row}$), where amount of assumptions change into 1÷5 points (see graph**.** 5).



Graph 5: The functional defendence between changeable diameter of cylinder shape elements and residual attacking force of debris flow action on the deaf section of the construction after pass through type debris flow aginst construcion

After through debris flow against construction (deaf part) connection between residual attacking force and changeable diameter of cylinder shape elements of construction is equal:

d_1=1,(6) In case $P_{1\ deaf}$ =P – $P_{1\ residual\ III\ row}$ =1626,1 – 832,6=793,5 k.n.,

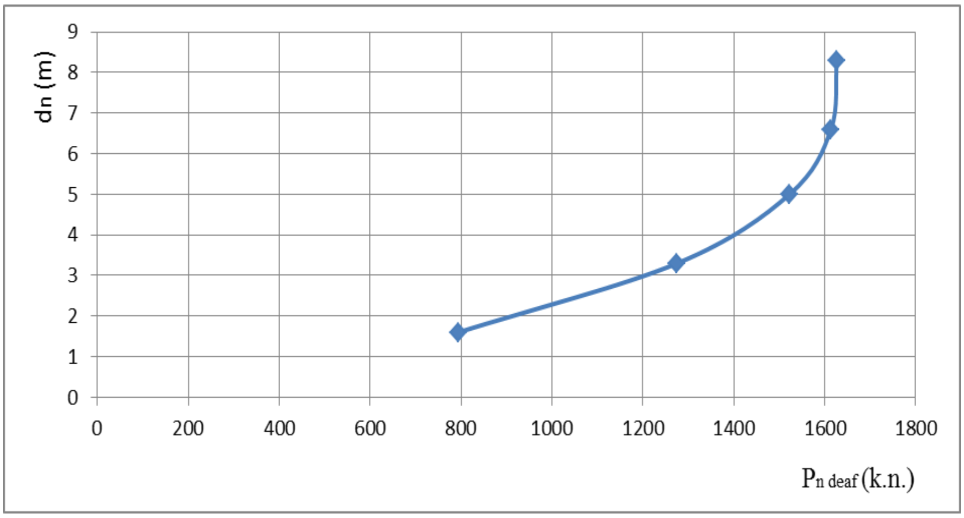
d_2=3,(3) In case $P_{2\ deaf}$ =P – $P_{2\ residual\ II\ row}$ =1626,1 – 351,2 =1274,9 k.n.,

d_3=5,0 In case $P_{3\ deaf}$ =P – $P_{3\ residual\ III\ row}$ =1626,1 – 104,1=1522,0 k.n.,

d_4=6,(6) In case $P_{4\ deaf}$ =P – $P_{4\ residual\ III\ row}$ =1626,1 – 13 =1613,1 k.n.,

d_5=8,(3) In case $P_{5\ deaf}$ =P – $P_{5\ residual\ III\ row}$ =1626,1 – 0=1626,1 k.n.,

According to received results draw follow functional independence graph $d_n=f(P_{n\ deaf})$, where n changes 1-5 (see graph**.** 6).



Graph 6: The functional defendence between changeable diameter of cylinder shape elements and residual attacking force of debris flow action on the deaf section of the construction after pass through type debris flow aginst construcion

Conclussion

As a result of implemented research has been established, that in the catchment basin of river Jokhtaniskhevi is expected 1% insurance 359.6 m^3/sec maximal discharge debris flow, that is big danger. For decrease noted ecological danger is purposed effective-resources saving through type debris flow against construction, from implemented calculation seems, that during influence of maximal discharge debris flow expected in the catchment basin of river Jokhtaniskhevi on the construction it significantly reduce kinetic energy of debris flow and suitable it is effective engineering measure for fight to debris flow and its implementation is perspective as for Jokhtaniskhevi, also other analogical debris flow beds regulation.

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