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VESTNIK
Kyrgyz National Agrarian University named after K.I. Scriabin

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STRESS STATE OF MOUNTAIN SLOPE WITH A STEP UNDER EXTERNAL LOAD WITH DECLINING TRIANGULAR EPURA

Abstract: *In this article description is given and calculations are carried out using the computer system of the soft MATCAD, the stress state of a mountain slope with a ledge under the action of gravitational, horizontal tectonic forces and a distributed external load with a decreasing triangular diagram, this conclusion is described by analytical relations.*

Regularities of stress distribution in the massifs of a mountain slope with a scarp from the action of an external load have been established, where the actions of gravitational, horizontal tectonic forces were taken into account each separately.

The general stress state of a mountain slope with a scarp from all the listed forces is determined by preliminary summing only the ratios $BN(\varsigma) + B(\varsigma)$, $AN(\varsigma) + A(\varsigma)$ and calculations of stress components were performed using the functions $\Phi(\varsigma)$ u $\Psi(\varsigma)$.

Keywords: *Stress state, rock massifs, ledges, gravitational forces, horizontal tectonic forces, stress distributions, Muskhelishvili relations, isolines.*

1 Introduction

The stress state of the crustal massifs as an urgent problem attracts the attention of many researchers [1,6]. The influence of the relief [1] on the stress state of the massif within the framework of the method [3] was considered in works [4,7]. The influence of an external load with a triangular diagram on the stress state of the river canyon walls was studied in [7]. The effect of a uniformly distributed load on the stress state of mountain slope massifs with ledges has been studied in recent years in works [8,10]. Below, in a similar setting [8,10], the problem of the influence of an external load with a linearly decreasing triangular load on the stress state of a mountain slope with one ledge is considered.

2 Materials, methods and results

Massifs of a mountain slope with a scarp undergo in natural conditions the combined action of the force of gravity and horizontal tectonic compression and are in conditions of plane deformation.

The force of gravity is determined by the volumetric weight of rocks $\gamma=\rho g$. Here: ρ- rock density; g- gravitational acceleration. Tectonic force Tx, directed horizontally and has a constant intensity along the depth of the mountain massif with a ledge. In plane XOY the topography of a slope with symmetrical ledges is modeled using a display function [11]:

$$\omega(\xi,\eta) = \alpha\zeta(\xi,\eta) + \omega_0(\xi,\eta) \quad \omega p_1(\xi,\eta) = \omega_0 p_1(\xi,\eta) + \alpha$$
$$\omega_0(\xi,\eta) = a_1 / \zeta(\xi,\eta) - i + b_1 / \zeta(\xi,\eta) + tb - i \quad ,$$
$$\omega_0 p_1(\xi,\eta) = a_1 /(\zeta(\xi,\eta) - i)^2 - b_1 /(\zeta(\xi,\eta) + tb - i)^2 \tag{1}$$

To simulate a mountain slope with symmetric ledges in (1):

$$a = 160,\ a_1 = 500,\ b_1 = 250,\ d_1 = 250,\ tb = -2,$$

The shape of the mountain slope with ledges looks like in Fig. 1.

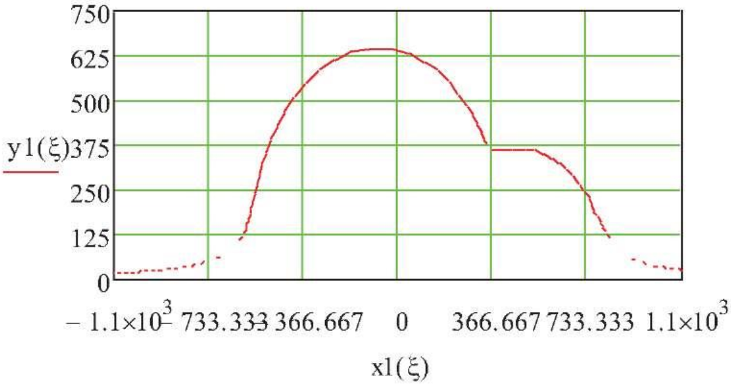


Figure: 1. Mountain slopes with one ledge

External load N(ξ) distributed on the contour points of the ledge and graphically shown in Fig. 2.

It is customary to designate the area of action of the load: L_3 and L_4 the beginning and end of the section of the contour, where the load diagram decreases; P_0 is the maximum load value. Figure 2.

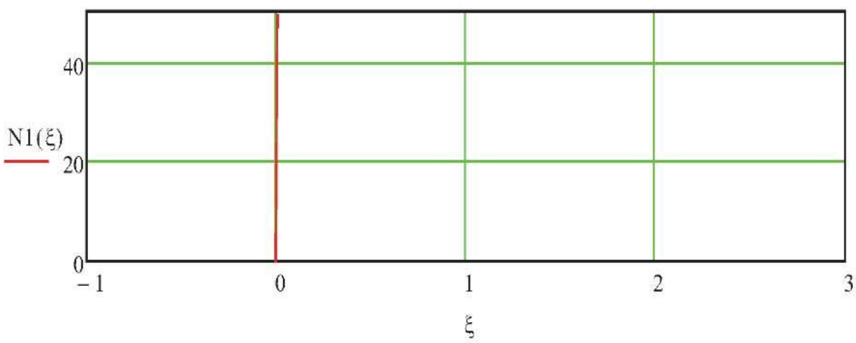


Figure: 2. Diagram of the distributed load, for illustration, conditionally assigned

L_3=0, L_4=2

According to the accepted works [1] two-dimensional theory of elasticity at an arbitrary point of the massif for stresses, it is customary to denote by $(\sigma_x, \sigma_y, \tau_{xy})$. These components are at the same point in the array in the adopted transformed coordinate system (1) indicated through $(\sigma_\xi, \sigma_\eta, \tau_{\xi\eta})$.

There is a connection between the components in Cartesian and curvilinear coordinates in the form [8]:

$$\sigma_\xi + \sigma_\eta = \sigma_x + \sigma_y, \;\; \sigma_\eta - \sigma_\xi + 2i\tau_{\xi\eta} = e^{2i\alpha}(\sigma_y - \sigma_x + 2i\tau_{xy}), \tag{2}$$

$$\text{where} \quad e^{2i\alpha} = \frac{\omega'(\zeta)}{\overline{\omega'(\zeta)}}, \tag{3}$$

Stress components $(\sigma_\xi, \sigma_\eta, \tau_{\xi\eta})$ defined through functions Φ(ζ) и ψ(ζ), as proved by N.I. Muskhelishvili [8], from the boundary conditions following from the relations:

$$\sigma_\eta + i\tau_{\xi\eta} = \Phi(\zeta) + \overline{\Phi(\zeta)} + \frac{\left[\overline{\omega(\zeta)}\Phi'(\zeta) + \omega'(\zeta)\Psi(\zeta)\right]}{\overline{\omega'(\zeta)}}$$

$$\sigma_\eta - i\tau_{\xi\eta} = \Phi(\zeta) + \overline{\Phi(\zeta)} + \frac{\left[\omega'(\zeta)\overline{\Phi'(\zeta)} + \overline{\omega'(\zeta)\Psi(\zeta)}\right]}{\overline{\omega'(\zeta)}} \tag{4}$$

in ζ=ξ=t, η=0 и $\sigma_\eta(\xi,0) = N(\xi)$, $\tau_{\xi\eta}(\xi,0) = T(\xi)$.

The quantities T(ξ) and N(ξ) normal and tangent lines on the contour of the studied load area. The initial stress state of a mountain massif with a symmetrical scarp in natural conditions is formed under the combined action of gravitational, horizontal tectonic forces and external distributed loads with a triangular diagram (see Fig. 1). It is required to find the stress distribution laws if the differential equilibrium equations are satisfied at each point of the array:

$$\frac{\partial\sigma_x^{II}}{\partial x} + \frac{\partial\tau_{xy}^{II}}{\partial y} + \rho_x = 0, \quad \frac{\partial\tau_{xy}^{II}}{\partial y} + \frac{\partial\sigma_{xy}^{II}}{\partial y} + \rho_y = 0, \tag{5}$$

Where, $\rho_x=0$, – horizontal and vertical $\rho_y=\gamma=\rho*g$ volumetric force components; integrals of (5) have the form: $\sigma_x^n = A_1 * y + T_x;\;\; \sigma_y^{II} = A_2 y;$ (6)

Where, the notation $A_1=\lambda\gamma$; $A_2=\gamma$; λ – coefficient of lateral thrust according to Dinnik [1,5]; tectonic force T_x directed horizontally [2,5]; y- the vertical distance of the point in question in the array. In the absence of external loads at the contour points, the stress components will be equal:

$$\sigma_\eta(\xi,0) = 0, \tau_{\xi,\eta}(\xi,0) = 0. \tag{7}$$

Determination of stresses from the action of an external load, when the distribution law has the form (see Fig. 1**):**

$$N(\xi) = \frac{L_4 - \xi}{L_4 - L_3} * p_0 \qquad (L_3 \leq \xi \leq L_4) \tag{8}$$

Taking into account in (8), where on sections of the contour the load N(ξ)=0. Then we use the following (4) boundary conditions equalities [3];

$$\Phi(t) \cdot \overline{\omega^{/}(t)} + \overline{\Phi(t) \cdot \omega^{/}(t)} + \overline{\omega(t)}\Phi^{/}(t) + \omega^{/}(t)\Psi(t) = \overline{\omega^{/}(t)}[N(t) + iT(t)]$$

$$\Phi(t) \cdot \omega^{/}(t) + \overline{\Phi(t)} \cdot \omega^{/}(t) + \omega^{/}(t)\overline{\Phi^{/}(t)} + \overline{\omega^{/}(t)\Psi(t)} = \omega^{/}(t)[N(t) - iT(t)], \tag{9}$$

Integrals of the Cauchy type [1] taken in the range from "-" infinity to "+" infinity from the boundary conditions (9) have the following form:

$$\Phi(\xi,\eta) = \frac{(B(\xi,\eta) - G(\xi,\eta)}{\omega p_1(\xi,\eta)}, \Phi p_1(\xi,\eta) = \frac{Bp_1(\xi,\eta) - Gp_1(\xi,\eta) - \Phi(\xi,\eta) \cdot \omega_0 p_2(\xi,\eta)}{\omega p_1(\xi,\eta)}, \tag{10}$$

$$\omega(\xi,\eta) = \alpha\zeta(\xi,\eta) + \omega_0(\xi,\eta) \quad \omega p_1(\xi,\eta) = \omega_0 p_1(\xi,\eta) + \alpha$$

$$\omega_0(\xi,\eta) = a_1 / \zeta(\xi,\eta) - i + b_1 / \zeta(\xi,\eta) + tb - i$$

$$\omega_0 p_1(\xi,\eta) = a_1 /(\zeta(\xi,\eta) - i)^2 - b_1 /(\zeta(\xi,\eta) + tb - i)^2$$

$$G_1(\xi,\eta) = \frac{-\overline{K}_1}{(\zeta(\xi,\eta) - i)^2} + \frac{-\overline{K}_2}{(\zeta(\xi,\eta) + tb -)^2}$$

$$G_1 p_1(\xi,\eta) = \frac{2\overline{K}_1}{(\zeta(\xi,\eta) - i)^3} + \frac{2\overline{K}_2}{(\zeta(\xi,\eta) + tb -)^3} \quad K_1 = a_1\Phi_0 \;\; K_2 = \overline{b}_1\Phi_0 tb \;\; \Phi_0 = \wedge_{0,0}$$

$$\Phi_0 tb = \wedge_{1,0} \;\; BN(\xi,\eta) = BBn(\xi,\eta)(L_4 - \zeta(\xi,\eta))$$

$$BBn(\xi,\eta) = Nc2\omega p_1(\xi,\eta) \cdot \ln\left(\frac{L_3 - \zeta(\xi,\eta)}{L_4 - \zeta(\xi,\eta)}\right)_{-} bd_1 L(\xi,\eta) + bd_2 L(\xi,\eta)$$

$$BN_1(\xi,\eta) = -BBn(\xi,\eta) + (L_4 - \zeta(\xi,\eta)) \cdot Bn_1(\xi,\eta)$$

$$Bn_1(\xi,\eta) = Nc_2 \cdot (\omega p_2(\xi,\eta) \cdot u_{21}(\xi,\eta) + bd_{11}L(\xi,\eta) + bd_{21}(\xi,\eta),$$

$$u_2(\xi,\eta) = \ln\left(\frac{L_3 - \zeta(\xi,\eta)}{L_4 - \zeta(\xi,\eta)}\right) \;\; u_{21}(\xi,\eta) = \frac{-1}{L_3 - \zeta(\xi,\eta)} + \frac{1}{L_4 - \zeta(\xi,\eta)},$$

$$AN_1(\xi,\eta) = An_1(\xi,\eta) \cdot (L_4 - \zeta(\xi,\eta)),$$

$$An_1(\xi,\eta) = Nc2\omega p_1 cL(\xi,\eta) \cdot \ln\left(\frac{L_3 - \zeta(\xi,\eta)}{L_4 - \zeta(\xi,\eta)}\right) + bd_1 cL(\xi,\eta) + bd_2 cL(\xi,\eta)$$

$$bd_1L(\xi,\eta)=\frac{ha_2L}{(\zeta(\xi,\eta)-i)^2}+\frac{ha_1L}{(\zeta(\xi,\eta)-i)},$$
$$bd_2L(\xi,\eta)=\frac{hb_2L}{(\zeta(\xi,\eta)+tb-i)^2}+\frac{hb_1L}{(\zeta(\xi,\eta)+tb-i)},$$

$$bd_{11}L(\xi,\eta)=\frac{-2ha_2L}{(\zeta(\xi,\eta)-i)^3}+\frac{-ha_1L}{(\zeta(\xi,\eta)-i)^2}$$
$$bd_{21}L(\xi,\eta)=\frac{-2hb_2L}{(\zeta(\xi,\eta)+tb-i)^3}+\frac{-hb_1L}{(\zeta(\xi,\eta)+tb-i)^2}$$

To determine the constants K_1 and K_2 in the first equation (10), we successively represent that $\varsigma_1=i$ и $\varsigma_2=-tb-i$. As a result, we will have a system of two linear equations with complex coefficients. Let's add two more conjugate equations to them. The resulting system of four linear equations with coefficients $M_{к,м}$ in the left and $M_{0к}$ on the right and look like:

$$M_{0,0}=\omega p_1(0,-1),\ M_{0,1}=0,\ M_{0,2}=n_1(0,-1),\ M_{0,3}=nb(0,-1),$$

$$M_{1,0}=0,\ M_{1,1}=\omega p_1(-tb,-1),\ M_{1,2}=n_1(-tb,-1),\ M_{1,3}=nb(-tb,-1), M_{2,0}=\overline{M_{0,2}},$$
$$M_{2,1}=\overline{M_{0,3}},\ M_{2,2}=\overline{M_{0,0}},\ M_{2,3}=\overline{M_{0,1}},\ M_{3,0}=\overline{M_{1,2}},\ M_{3,1}=\overline{M_{1,3}},\ M_{3,2}=\overline{M_{1,0}},$$
$$M_{3,3}=\overline{M_{1,1}}$$

The right side of the system are:

$$M_{0,0}=B(0,-1)\ \ M_{0,1}=B(-tb,-1)\ \ M_{0,2}=\overline{B(0,-1)}\ \ M_{0,3}=\overline{B(-tb,-1)},$$

For the coefficients of the system, we denote by:

$$n_1(\xi,\eta)=\frac{-a_1}{((\zeta(\xi,\eta)-i))^2}\quad nb(\xi,\eta)=\frac{-b_1}{(\zeta(\xi,\eta)+tb-i)^2}$$

The functions sought from the boundary conditions (9) then have the form:

$$\Phi(\xi,\eta)=\frac{(B(\xi,\eta)-G(\xi,\eta))}{\omega p_1(\xi,\eta)},\ \Phi p_1(\xi,\eta)=\frac{Bp_1(\xi,\eta)-Gp_1(\xi,\eta)-\Phi(\xi,\eta)\cdot\omega_0 p_2(\xi,\eta)}{\omega p_1(\xi,\eta)},\qquad(11)$$

где $G(\xi,\eta)=n_1(\xi,\eta)\overline{\Phi_0}+nb(\xi,\eta)\overline{\Phi_0}tb$

$$Gp_1(\xi,\eta)=n_1p_1(\xi,\eta)\overline{\Phi_0}+nbp_1(\xi,\eta)\overline{\Phi_0}tb$$

$$n_1 p_1(\xi,\eta) = \frac{2a_1}{(\zeta(\xi,\eta)-i)^3} \quad nbp_1(\xi,\eta) = \frac{2b_1}{(\zeta(\xi,\eta)+tb-i)^3}$$

$$G_1(\xi,\eta) = \frac{-\overline{K}_1}{(\zeta(\xi,\eta)-i)^2} + \frac{-\overline{K}_2}{(\zeta(\xi,\eta)+tb-i)^2}$$

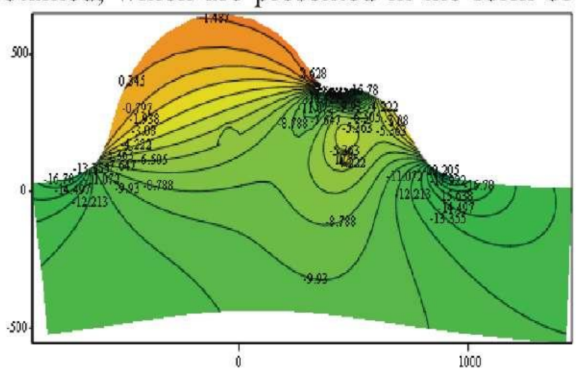
$$G_1 p_1(\xi,\eta) = \frac{2\overline{K}_1}{(\zeta(\xi,\eta)-i)^3} + \frac{2\overline{K}_2}{(\zeta(\xi,\eta)+tb-i)^3}, \quad \Psi(\xi,\eta) = \frac{D_3(\xi,\eta)+D\Psi_3(\xi,\eta)}{\omega p_1(\xi,\eta)} \tag{12}$$

Relations (12) due to the presence of poles in the vicinity $\varsigma_1=i$ и $\varsigma_2=-tb-i$ calculated by alternative relations. To check the boundary conditions with a load of a decreasing triangular diagram (see Fig. 1), the stresses were calculated for the contour points in the vicinity of the loaded section of the contour.

Table 1 - Calculation of stress with load

#	«x(ξ,0)»	«y(ξ,0)»	«σ η(ξ, -0)»	«τ ξ η (ξ, -0)»
1	379.1	378.5	$-1.6*10^{-12}$	$1.2*10^{-12}$
2	386.5	377.4	-47.6	$-7.2*10^{-15}$
3	394.4	376.7	-45.1	$2.2*10^{-14}$
4	402.9	376.4	-42.5	$8.3*10^{-15}$
5	412.1	376.4	-39.9	$-1.2*10^{-14}$
6	422	376.6	-37.4	0
7	432.7	376.8	-34.8	$5.5*10^{-15}$
8	444.1	377	-32.3	$-1*10^{-14}$
9	456.2	377	-29.7	$-1.3*10^{-14}$
10	469	376.7	-24.6	$11*10^{-15}$
11	482.5	375.9	-22.1	$-6*10^{-15}$
12	496.5	374.5	-19.5	$2.9*10^{-14}$
13	511.1	372.5	-16.9	0
14	525.9	369.7	-14.4	$-1*10^{-14}$
15	541	366.1	-11.8	$3.6*10^{-15}$
16	556.1	361.7	-9.3	$4.6*10^{-15}$
17	571.2		-6.7	$-2.9*10^{-15}$
18			-4.2	$3.9*10^{-15}$
19			-1.6	0
20		…	$1*10^{-14}$	$1.4*10^{-14}$
21				$4.3*10^{-15}$

From Table 1. in the columns for stress components, which are perpendicular to the contour points of the mountain slope massif, it can be seen that the numerical values decrease linearly and duplicate the law of variation of the external load diagram (Fig.1), where the tangent component at all points of the contour is zero. The calculation of the stress components was also performed and the regularities of the stress distribution were obtained, which are presented in the form of



isolines in Fig.3.

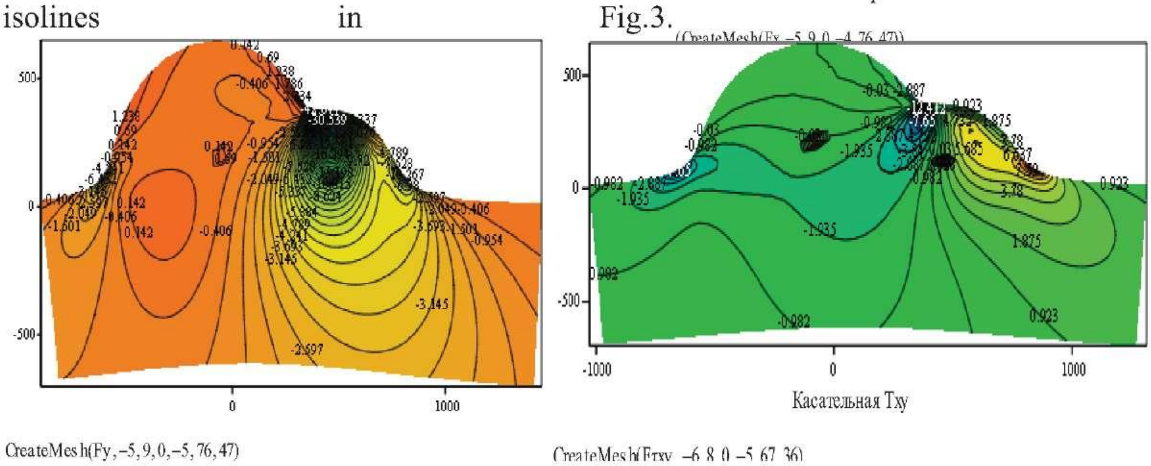


Fig. 3. Isolines of stress distribution

Fig. 3. It can be seen that the stress isolines indicate the influence of the mountain slope protrusion, where the law of distribution of external load leads to a very complex stress distribution law, which is difficult to predict without performing calculations with specific parameters of the mountain slope with a protrusion at the places of external load application.

The primary stress state of the mountain slope is a ledge.

The initial stress state of the mountain slope massif with a ledge experiencing the action of the forces of gravity and tectonic compression (without external loads) satisfy the equilibrium equations (5) and the boundary conditions (7) at all points of the mountain range. In order for conditions (7) to be satisfied at all points of the array contour, it is necessary to apply fictitious loads N and T, which arise from stress fields (6). Fictitious loads are calculated by the ratios:

$$\mathrm{N}+\iota\mathrm{T}=\frac{\overset{n}{\sigma}_x+\overset{n}{\sigma}_y}{2}+\frac{\overset{n}{\sigma}_y-\overset{n}{\sigma}_x}{2}*\mathrm{e}^{2\iota\alpha}\quad \mathrm{N}-\iota\mathrm{T}=\frac{\overset{n}{\sigma}_x+\overset{n}{\sigma}_y}{2}+\frac{\overset{n}{\sigma}_y-\overset{n}{\sigma}_x}{2}*\mathrm{e}^{-2\iota\alpha} \tag{13}$$

For contour points $e^{2\iota\alpha}=\dfrac{\omega'(\xi)}{\overline{\omega'(\xi)}}$ $e^{-2\iota\alpha}=\dfrac{\overline{\omega'(\xi)}}{\omega'(\xi)}$ $y=(\omega(\xi)-\overline{\omega(\xi)})/(2*\iota)$.

we introduce the notation: $T_1 = T_x / 2$ $T_2 = \alpha * i * A_2 / 2$ $T_3 = i * (A_1 + A_2) / 4$ $T_4 = -i * (A_1 - A_2) / 4$

Relationships for Ф(ς) and Ψ(ς) will be determined from functions (11) and (12), if we replace AN (ς) to A(ς) and BN(ς) to B(ς).

Calculations of the initial stress state of a mountain slope massif with a ledge were performed according to the above accepted scheme, first for the contour points of the massif, where the boundary conditions (7) must be met, and then for the entire mountain slope massif with a ledge. The values of the contour stress components are listed in Table 2.

The first column 0 contains the values of the variable ξ; the second and third columns are the coordinates of the contour points x and y; the fourth and fifth columns contain the values of the main normal stress components; the sixth and seventh columns contain the normal and tangential stresses contour; the eighth column shows the values of the maximum shear stress.

Table 2 - Values of contour stress components

#	«ξ»	«x»	«y»	«σ1»	«σ2»	«N»	«T»	«Tmax»
1	-5-	-899,7	27,9	$2,1*10^{-14}$	-122	$8,4*10^{-15}$	$4,4*10^{-14}$	-118,7
2	-4	-780,8	41,7	$1,4*10^{-14}$	-207,6	$1,4*10^{-14}$	$4,3*10^{-14}$	-186,1
3	-3	-676,8	69,1	$2,8*10^{-14}$	-418,2	$2,8*10^{-14}$	$2,8*10^{-14}$	-204,2
4	-2	-596,9	133,7	$5,7*10^{-14}$	-540,6	$2,8*10^{-14}$	$7,1*10^{-14}$	-92,9
5	-1	-522,1	322,9	0	-156,7	$7,1*10^{-15}$	0	-77
6	0	-95,6	644,5	$5,7*10^{-14}$	-59	$5,4*10^{-14}$	$-4*10^{-15}$	-58,5
7	1	326,2	407,6	$8,5*10^{-14}$	-208,8	$8,5*10^{-14}$	$4,2*10^{-14}$	-24,8
8	2	503,3	364,5	$2,1*10^{-14}$	-69,4	$2,5*10^{-14}$	$2,2*10^{-14}$	-67,7
9	3	753,4	205,1	$2,8*10^{-14}$	-142,5	$3,6*10^{-14}$	$1,8*10^{-14}$	-16,8
10	4	845,8	91,8	$8,5*10^{-14}$	-349,1	$8,5*10^{-14}$	$-5*10^{-14}$	-33,2
11	5	943,5	50,8	$7,1*10^{-14}$	-216,2	$8,2*10^{-14}$	$7,1*10^{-15}$	-170,9
12	6	$1,1*10^3$	32	$2,1*10^{-14}$	-125,1	$2,4*10^{-14}$	$1,8*10^{-14}$	-119,5
13	7	$1,2*10^3$	22,2	$1,4*10^{-14}$	-83,1	$1,6*10^{-14}$	$1,6*10^{-14}$	-82
14	8	$1,3*10^3$	16,3	$7,1*10^{-15}$	-60,9	$8,6*10^{-15}$	$4,4*10^{-15}$	-60,6
15	9	$1,5*10^3$	12,5	$1,4*10^{-14}$	-47,7	$1,7*10^{-14}$	$2,3*10^{-14}$	-47,6
16	10	$1,6*10^3$	9,9	0	-39,2	$3,5*10^{-15}$	$10*10^{-15}$	-39,1
17	11	$1,7*10^3$	8,1	$3,6*10^{-15}$	-33,3	$2,3*10^{-15}$	$1,6*10^{-14}$	-33,3
18	12	$1,9*10^3$	6,7	$3,6*10^{-15}$	-29,1	$4,4*10^{-15}$	$9,1*10^{-15}$	-29,1
19	13	$2*10^3$	5,6	$1,8*10^{-15}$	-25,9	0	$4,7*10^{-15}$	-25,9
20	14	$2,2*10^3$	4,8	$1,8*10^{-15}$	-23,5	$1,7*10^{-15}$	$3,3*10^{-15}$	-23,5
21	15	$2,3*10^3$	4,2	$1,8*10^{-15}$	-21,6	$3,8*10^{-15}$	$1,5*10^{-14}$	-21,6
22	16	$2,5*10^3$	3,6	$1,8*10^{-15}$	-20,1	0	$7,5*10^{-15}$	-20,1
23	17	$2,6*10^3$	3,2	$3,6*10^{-15}$	-18,9	$1,6*10^{-15}$	$1,5*10^{-14}$	-18,9
24	18	$2,7*10^3$	2,8	0	-17,8	0	$1,3*10^{-14}$	-17,8
25	19	$2,9*10^3$	2,5	0	-17	0	$1,2*10^{-15}$	-17

The contents in the fourth, fifth, sixth and seventh columns indicate that the boundary conditions in (7) are satisfied very accurately, where the error is not more than ten to the thirteenth power (10^{-13}).

The distribution patterns of the initial stress state of a slope massif with one step are shown in Fig.4, for each stress component in the form of stress isolines.

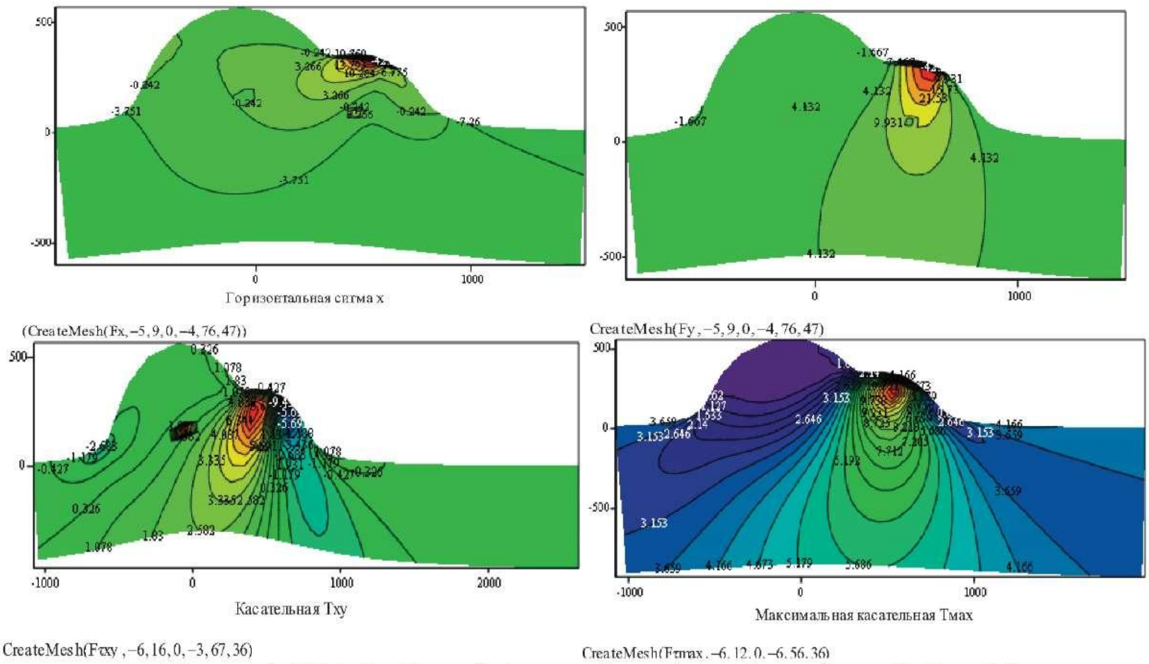


Figure: 4. Distribution of stresses from the action of gravitational forces

Thus, all calculations were carried out and the distribution patterns of the initial stress state of a slope massif with one step were obtained.

3 Conclusions

- The stress state of a mountain slope with a scarp under the action of gravitational, horizontal tectonic forces and a distributed external load with a decreasing triangular diagram are described by analytical relationships.
- Regularities of stress distribution in the massifs of a mountain slope with a scarp from the action of external load by a decreasing triangular diagram and from the action of gravitational, horizontal tectonic forces were established each separately.
- The general stress state of a mountain slope with a scarp from all the listed forces is determined by preliminary summing only the ratios $BN(\varsigma) + B(\varsigma)$, $AN(\varsigma) + A(\varsigma)$ and calculated stress components using the functions $\Phi(\varsigma)$ и $\Psi(\varsigma)$.
- The computer soft MATHCAD was used to calculate the stresses [11].

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НАПРЯЖЕННОЕ СОСТОЯНИЕ СКЛОНА ГОРЫ С УСТУПОМ ПРИ ДЕЙСТВИИ ВНЕШНЕЙ НАГРУЗКИ С УБЫВАЮЩЕЙ ТРЕУГОЛЬНОЙ ЭПЮРОЙ

Кыскача мазмуну: *Бул макалада MATCAD программасынын компьютердик тутумун, гравитациялык, горизонталдык тектоникалык күчтөрдүн таасири астында тоо боорунун стресстик абалын жана кыскарган үч бурчтук диаграмма менен бөлүштүрүлгөн тышкы жүктөмдү колдонуу менен сүрөттөмө берилген жана эсептөөлөр жүргүзүлгөн, бул тыянак аналитикалык талдоолор менен сүрөттөлгөн. Тыш каптаган тоо массивдериндеги стресстин тышкы жүктүн таасиринен скарп менен бөлүштүрүлүшүнүн закон ченемдүүлүктөрү белгиленди, мында гравитациялык, горизонталдык тектоникалык күчтөрдүн иш-аракеттери ар бири өзүнчө эске алынган. Бардык келтирилген күчтөрдүн скарп менен тоо боорунун жалпы стресстик абалы BN (ς) + B (ς), AN (ς) + A (u) катыштарын гана алдын-ала суммалоо менен аныкталат жана стресс компоненттеринин эсептөөлөрү Ф (ς) жана Ψ (функциялары) аркылуу жүргүзүлгөн. ς).*

Негизги сөздөр: *Чыңалуунун абалы, тоо тектери, тоо кыркалары, тартылуу күчтөрү, горизонталдык тектоникалык күчтөр, чыңалуунун бөлүштүрүлүшү, Мусхелишвили мамилелери, изолиндер.*

Баялиева Жамиля Аскаровна, Жумабаев Бейшен, Аскаралиев Бакытбек Океновиич

НАПРЯЖЕННОЕ СОСТОЯНИЕ СКЛОНА ГОРЫ С УСТУПОМ ПРИ ДЕЙСТВИИ ВНЕШНЕЙ НАГРУЗКИ С УБЫВАЮЩЕЙ ТРЕУГОЛЬНОЙ ЭПЮРОЙ

***Анотация**: В данной статье дано описание и проведены расчеты с помощью компьютерной системы программы MATCAD, напряженного состояние склона горы с уступом при действии гравитационных, горизонтальных тектонических сил и распределенной внешней нагрузки с убывающей треугольной эпюрой, данный вывод описан аналитическими соотношениями. Установлены закономерности распределения напряжений в массивах склона горы с уступом от действия внешней нагрузки где учитывались действия гравитационных, горизонтальны тектонических сил каждые в отдельности. Общее напряженное состояние склона горы с уступом от всех перечисленных сил определяются предварительным суммированием только соотношений $BN(\varsigma) + B(\varsigma)$, $AN(\varsigma) + A(\varsigma)$ и выполнены расчеты компонентов напряжений с помощью функций $\Phi(\varsigma)$ и $\Psi(\varsigma)$.*

***Ключевые слова:** Напряженное состояние, горные массивы, уступы, гравитационные силы, горизонтальные тектонические силы, распределения напряжений, соотношения Мусхелишвили, изолинии.*

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