ASSESSMENT OF SLOPE STABILITY IN OPEN-PIT MINES WITH CONSIDERATION OF EXPLOSIVE WORKS

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Abstract
The article discusses the analytical method for calculating the coefficient of stability of quarry slopes taking into account the seismic impact of technological explosions. Offers computer program that implements this method. Are graphic dependence between the conventional height of the slope H slope angle of the slope α built using the program.

Key words: stability of slopes, seismic impact, «angle of attack» seismicical forces, technological explosions, provisional height of the slope angle of inclination of the slope, factors-UNT stability

Stability of slopes quarries in the areas of earthquakes was considered in works [1-4] for surfaces slides in the form of a line segment logarithmic spiral and round cylinderly surface.
For the conditions of stability of slopes of the ledges and the pit walls under seismic impact SC technological explosions P.S.. Mironov has developed a scale of levels [5] based on the capacity of the blasting process unit, which allows for a qualitative assessment of the impact of explosions for sustainability of slopes.
In Belgorod state University the method of calculation of slope stability in open pits with regard to explosive works, based on the model and method of assessing the impact of dynamic forces on the slopes used in seismically active areas has been developed [6]. This model allows the quantification of the impact of seismic vibrations on the stability of slopes taking into account the scale levels P.S.. Mironov.
On Fig. 1 presents the scheme of calculation of factor of a stability on round cylinderly slip surface for under sole landslide. Factor of stability of slope determined by the formula:

$$n = \frac{\mathrm{tg}\varphi\left[\sum P_i \cos\delta_i + P_0 \sin\mu - k_C\left(\sum P_i \sin(\delta_i - \beta) + P_0 \cos(\mu - \beta)\right)\right] + c(l + l_1)}{\sum P_i \sin\delta_i + P_0 \cos\mu + k_C\left(\sum P_i \cos(\delta_i - \beta) + P_0 \sin(\mu - \beta)\right)};$$

$$\int_0^{\theta^*} P_i \cos\delta_i d\theta = \rho\int_0^{\theta^*} h_i \cos^2\delta_i d\theta;$$

$$\int_{\theta^*}^{90-\alpha} P_i \cos\delta_i d\theta = \rho\int_{\theta^*}^{90-\alpha} h_i \cos^2\delta_i d\theta;$$

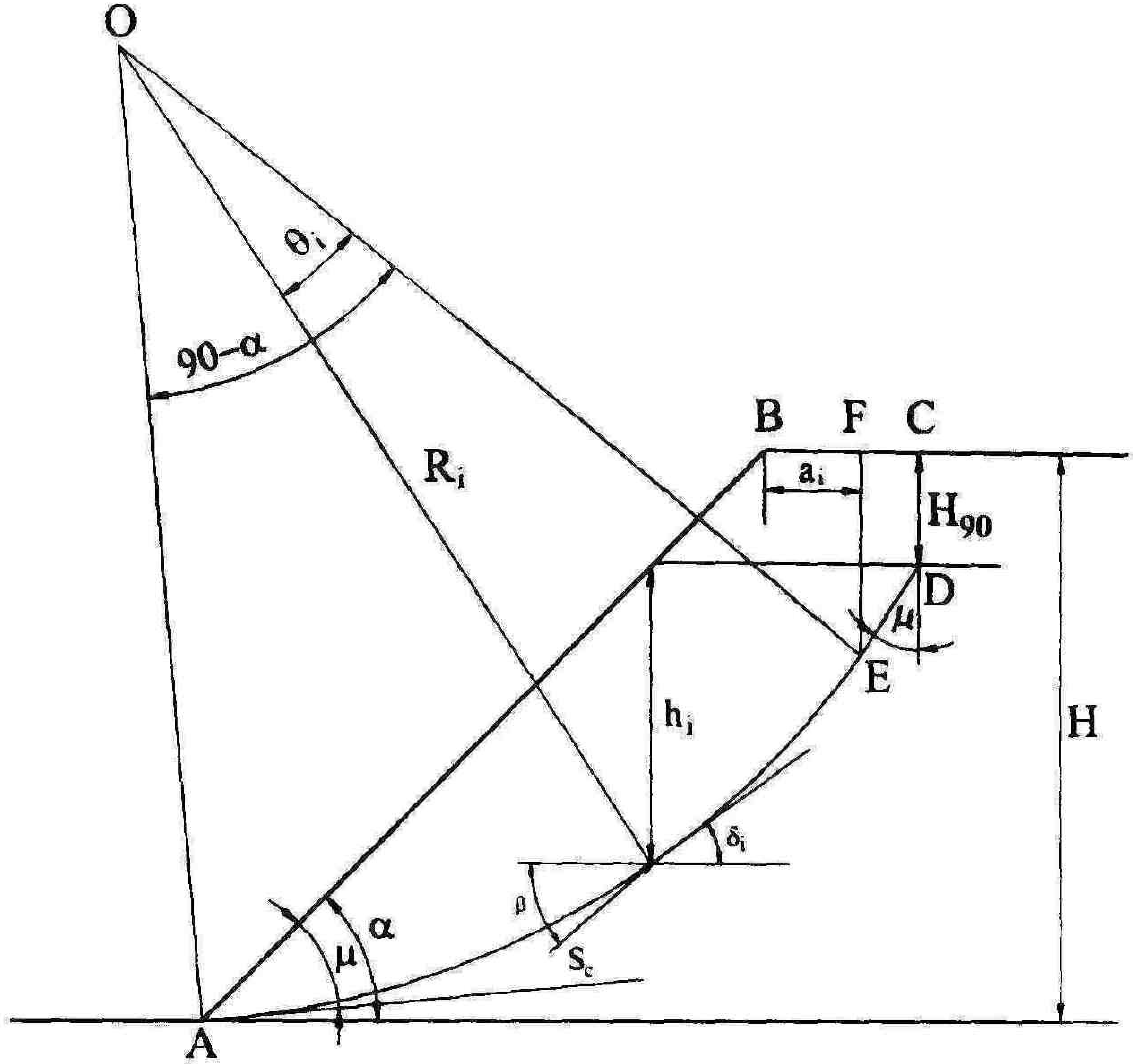

Fig. 1: Scheme of defining factor of stability of slopes with a view of the seismic impact

$$\int_0^{\theta^*} P_i \sin\delta_i d\theta = \rho \int_0^{\theta^*} h_i \sin\delta_i \cos\delta_i d\theta \,;$$

$$\int_{\theta^*}^{90-\alpha} P_i \sin\delta_i d\theta = \rho \int_{\theta^*}^{90-\alpha} h_i \sin\delta_i \cos\delta_i d\theta \,;$$

$$P_0 = \rho(H_{90}(R\sin\mu - R\cos(\alpha-\mu) + H - H_{90}) + \\ + 0{,}5(R\sin\mu - R\cos(\alpha-\mu) + H - H_{90})^2)\cdot tg\mu \,;$$

$$H_{90} = \frac{2c}{\rho} ctg\mu$$

$$\mu = 45^\circ - \frac{\varphi}{2}$$

$$R = \frac{Hctg\alpha + a}{\cos\mu - \sin(\alpha-\mu)}$$

$$l = R\frac{(90^o - \alpha)\pi}{180^o}$$

$$l_1 = \frac{R\sin\mu - H_{90} - R\cos(\alpha-\mu) + H}{\cos\mu},$$

where P_i - is the mass of an elementary column in the i-th point of the curvilinear the sliding surface;

δ_i - is the angle of inclination of the elementary site sliding to the horizon in the i-th point.

h_i - height of the elementary unit in the i-th point.

k_C - coefficient of seismicity;

β - «angle of attack» seismic forces;

H_{90} - the height of the vertical cracks tear CD;

R - is the radius of the sliding surface;

P_0 - is the weight of the block the collapse of the CDEF;

c - specific grip rock, composing slope;

φ - the angle of internal friction rocks, composing slope;

ρ - the density of rocks, composing slope;

l - length of the shape of the surface area of sliding EA;

l_l - the length of the straight line of the surface area slip DE;

a_i - auxiliary value equal to the section of the BF.

The value of a_i is, ranging from a_{min} to a_{max}.

$$a_{i\,min} = \frac{(Hctg\alpha(\cos(\alpha-\mu) - \sin\mu) - H + H_{90})(\cos\mu - \sin(\alpha-\mu))}{(\cos\mu - \sin(\alpha-\mu))(tg\alpha(\cos\mu - \sin(\alpha-\mu)) - \cos(\alpha-\mu) + \sin\mu)};$$

$$a_{i\,max} = \frac{(\cos\mu - \sin(\alpha-\mu))(H - H_{90})}{\cos(\alpha-\mu) - \sin\mu} - Hctg\alpha.$$

For realization of this method for the evaluation of stability of slopes of taking into account the seismic forces has been developed computer software «KRUG-2». In the proposed scheme surface consists of straight and curve line segments. Width prism of a possible collapse B exhaustive search in the range from 0 to Bmax. For each of the defined values of Bi built surface and is determined by the factor of stability of slopes n. In the assessment of slope stability in the conditions of seismic-economic impact of the proposed method of calculation taken into account the coefficient of seismicity kC, depending on rating of technological explosion, and the «angle of the attack» seismic forces β, determining the direction of a seismic forces SC. The program for computer «KRUG-2» allows under certain physico-mechanical properties of rocks, composing slope, and the parameters of the seismic impact of kC and β to solve a number of tasks:

- determined in the light of the seismic impact factor of stability of slope n at the set height H and angle of the slope α;

- calculated with the account of the seismic impact of the height of the embank-ment H the set of normative ratio of the stock of the sustainability of the n and the angle of the slope α;

-identify with the consideration of the seismic impact of the angle of inclination of the slope α at the given normative ratio of the stock of the sustainability of the n and the height of the embankment of the H.

Use of the software «KRUG-2» has allowed to build graphics for profile of the conditional height of the embankment H from the angle of inclination of the slope α for the representation ratio is the stock sustainability n=1, presented in Figure 2.

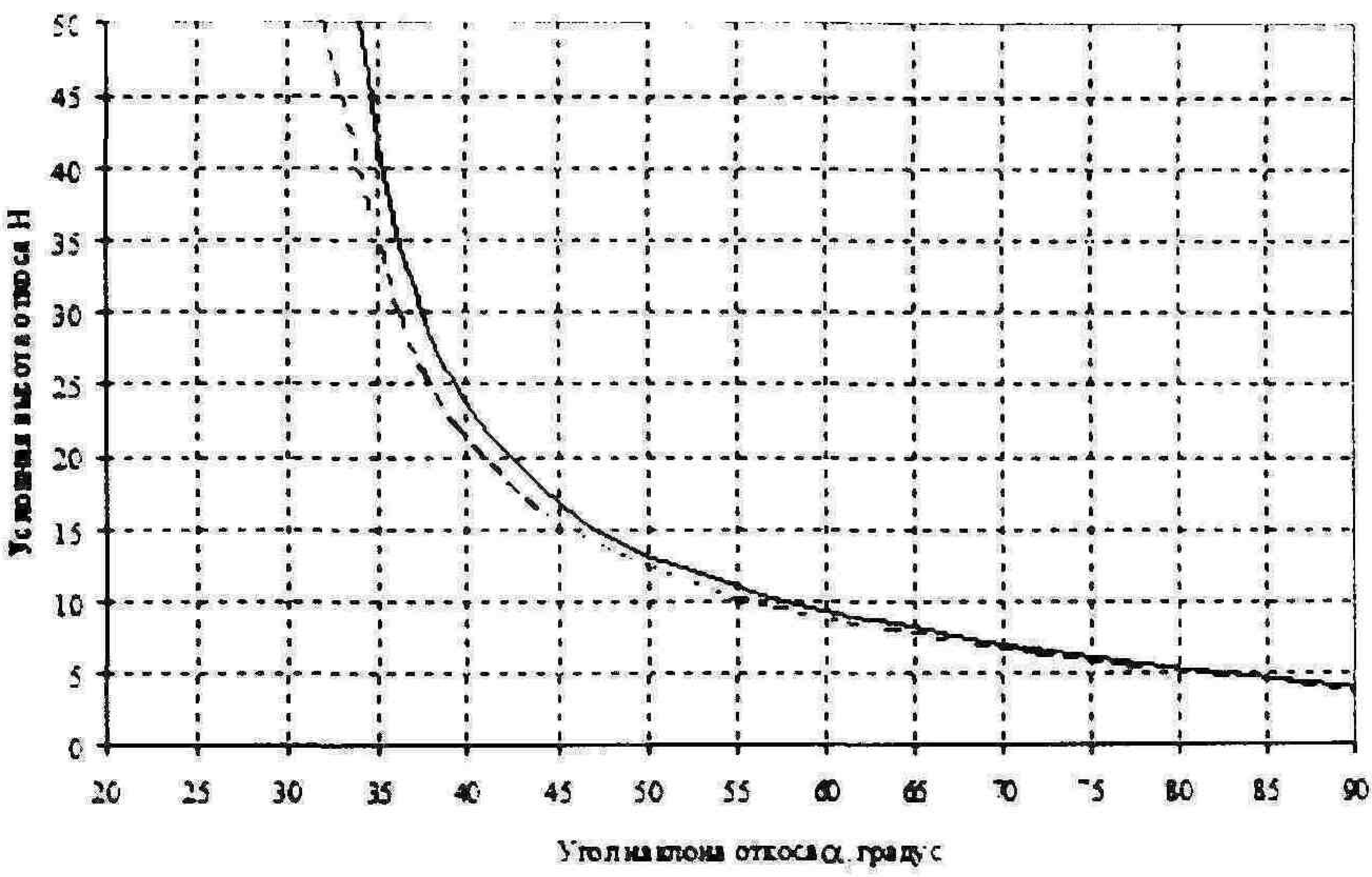

Fig. 2: Dependence of the conditional height of the embankment *H* from the angle of inclination of the slope *α*

- - - - with into account the seismic impact;

—— excluding seismic impact

From Figure 2 it should be, that in determining the parameters of sustainable quarry slopes must take into account that in the conditions of the seismic impact of technological explosions values of sustainable angles of inclination of the slope is reduced by 2-3°, and the height value to 5-10%.

References

1. Abdul Baten Abdul Zahir Influence of seismic impact on the sustainability of the boards and benches and quarries: abstract of PhD thesis. Kabul, 1987

2. Khramtsov B.A. Evaluation of stability of slopes of the boards and benches and quarries in the areas of earthquakes // Inter scientific thematic collection: Problems of higher effectiveness of mine-surveyor works at the mining enterprises. - Sverdlovsk. SGI.-1989

3. Khramtsov B.A. Action of explosions on the stability of pit walls, Izv. Mining magazine. - 2007. - №1
4. Gordeev V.A. Evaluation of the sustainability of quarry slopes on extremely method of equi-librium. Curved sliding surface, Izv. Mining magazine. - 2008. - № 2
5. Mironov P.S.. Action of explosions on the stability of pit walls, Izv. Mining magazine. - 1967. - №11
6. Pokrovsky G.I. The action of the impact and explosion in the deformable - M.: Promstroyizdat, 1957