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INVESTIGATIONS OF SCRAPING RESISTANCE OF A COHESIVE SOIL

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Mining process can be generally present in the form of the scheme (Fig. 1).

Each of the elements forming the system "Tool-Scraping parameters--Soil" is described by many factors having various influence on the value of mining resistance with that a soil stands in opposition during the action of a tool on it.

Assuming at the given moment, that the system is stabile, i.e. internal agents (temperature, moisture of a soil) do not change it, and parameters of a tool and soil are constant, then the value of the mining resistance will be dependent only upon mining parameters.

It allows to change mining parameters during the mining process to obtain wilful effect such as: minimalization of mining resistance, defined change of a structure of a mineolsoil etc.

A factor determining defineol, wilful choice of mining parameters will be costs of mining, tools as well as costs of energy necessary for mining of a defined volume of a virgin soil.

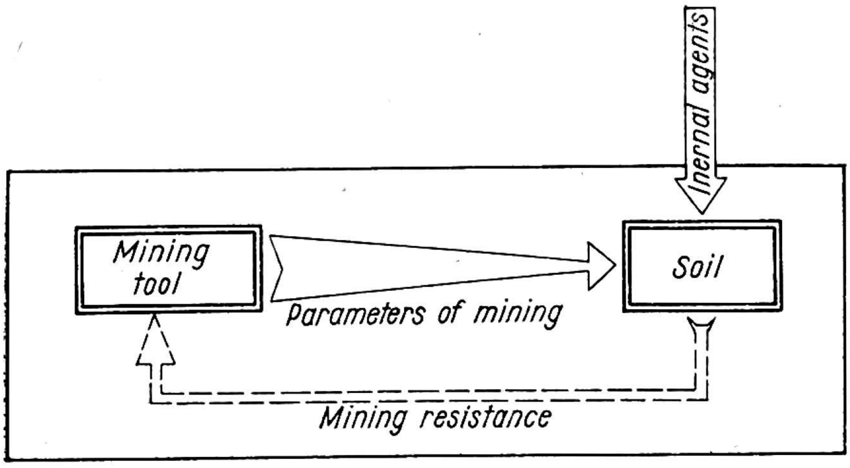

Fig. 1. Mining process

The purpose of investigations carried out *in situ* was to explicitly determine the cutting resistance of a soil with a vertical cutter as well as scraping resistance one and two-sidedly combined. Parallel with this, observations on deformation of the soil in the process of scraping and cutting of it have been carried out.

The investigations were performed with the help of a portable measuring device consisting of the truck to which bow-shaped cutters are fastened, chuck for fastening straight cutters, construction of a running track of a truck, supports bracing in a soil and power transmission system (transmission gear and engine of power 4 KW) straining at a rope fastened to the truck.

Between the rope and truck a dynamograph was placed to record the scraping resistance or cutting resistance. The soil under investigion was the heavy dusty clay with following geotechnical parameters:

— bulk density $\gamma_0 = 1.95$ G/cm³,
— weight density $\gamma = 2.68$ G/cm³,
— internal friction angle $\varphi = 15°32'$,
— cohesion $c = 4.87$ kG/cm²,
— moisture $w = 22.64\%$.

In the course of investigations, testing of the soil by resistance-meter Dor NII have been performed.

An average indication $C = 15.5$ on a resistance-meter Dor NII have been obtained.

As a first, the measurement of the cutting resistance of the soil by a flat cutter have been carried out having $s = 10$ mm in thick and $d = 170$ mm in width, by cutting angle of $\alpha = 90°$ and cutting speed of $V_p = 0.2$ m/s.

The results of the investigations are presented in Fig. 2.

To compare the results obtained with empirical methods, dependence of a cutting force of a soil by a straight cutter is presented according to the Zelenin's [5] formula

$$P = c \cdot h^{1.35}$$

and Brach's [2] formula

$$P = 2.65\, c\, (h - 1.2).$$

From figures presented it follows that the Brach's formula gives values nearer to those obtained in the course of investigations, while the Zelenin's formula together with the growth of depth of cutting of

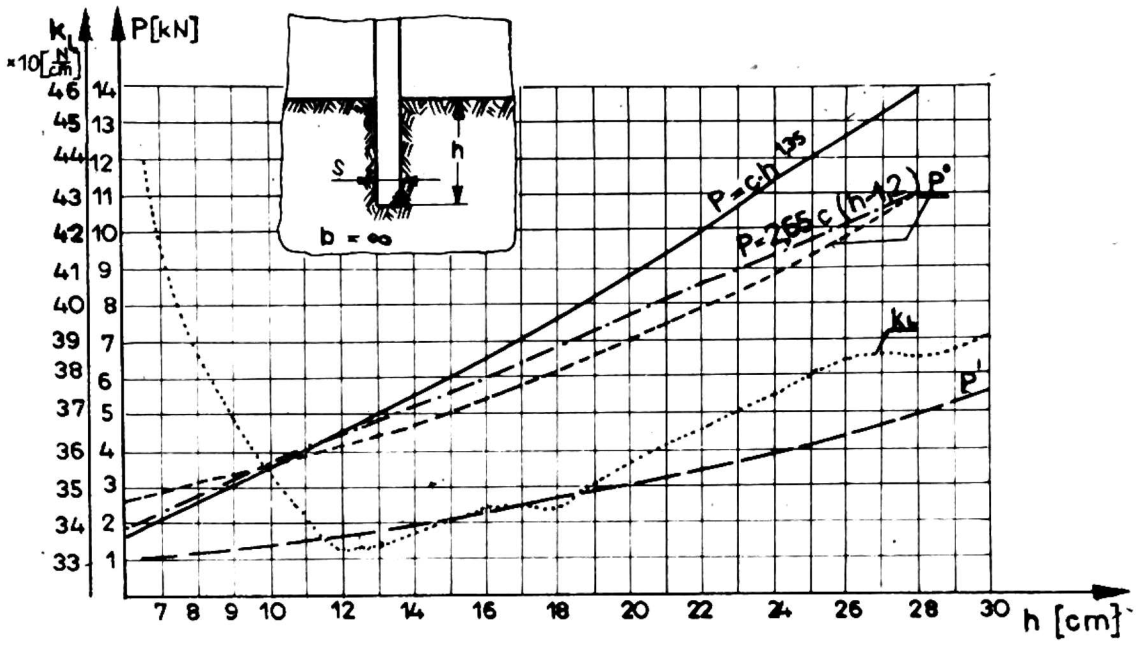

Fig. 2. Value of cutting resistance of a soil in dependence on a depth of cutting $P = c \cdot h^{1.35}$ — according to Zelenin's formula, $P = 2.65\, c\, (h - 1.2)$ — according to Brach's formula, P — cutting resistance, P' — resistance for a successive passage of cutter in the groove made during soil cutting

a soil gives result's more and more exceeding the values obtained during investigations.

Parallel to the investigations of a cutting resistance of a soil investigations have been performed depending on the determination of a resistance which gives a soil by a repeated passage of a cutter in the grobove previously done during cutting a soil.

A curve P' in the Fig. 2 ilustrates the result obtained. A distinct relationships is seen between cutting a soil (curve P°) and the resistance, which gives a soil by a repeated passage of a cutter.

To determine the resistance produced by a soil by passage in the groove previously done, the investigations were extended on multiple passage in the same groove.

The results of investigations are presented in Fig. 3.

A constant decrease of resistance with successive passages is seen, on condition that the resistance asymptotically is getting on to a certain limit, which can be defined as a resistance of wholly reversible deformations P°_{C}.

A curve of a unitary linear scraping resistance K_L is also drawn.

$$K_L = \frac{P^{\circ}}{h}$$

where

P° — cutting resistance of a soil,

h — cutting depth.

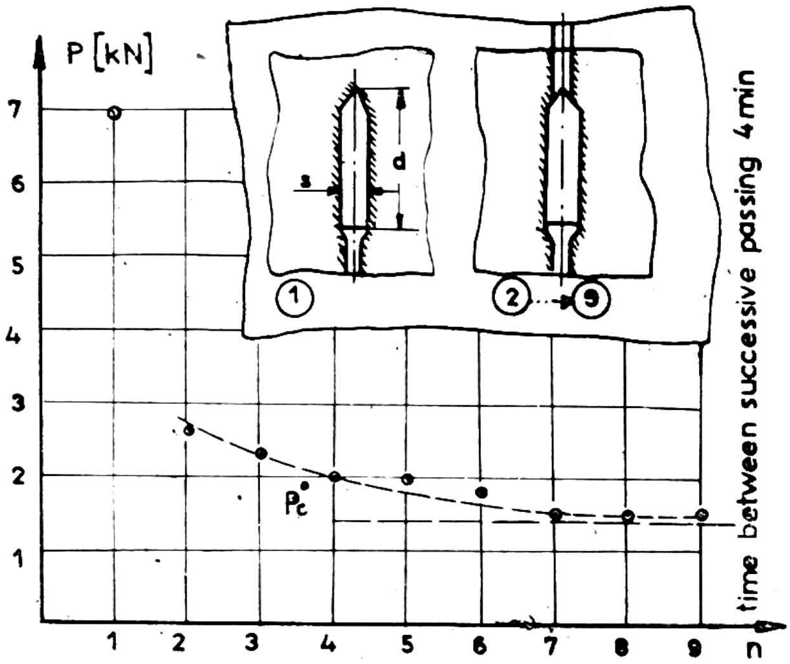

Fig. 3. Dependence of resistance, by passage in the groove made during soil cutting, from a number of passages: n — number of successive passage, o — cutting of a soil

Distinct minimum of this function exist for depth $h = 12$ cm of cutting a soil. It should be emphasized that this value refers only to the kind of a soil under investigation as well as cutting parameters and dimensions of a tool.

None the less, existence of a distinct minimum shows on the fact of existing the most "effective" depth of cutting for which the resistance of a soil on a unit depth of cutting is minimum.

Measurements of tightening of the groove made after cutting of a soil have been also performed in dependence on time, which passed away since passage of a cutter, by different thicknesses of a cutter. The results obtained are shown in Fig. 4.

On the basis of run of graphs it is possible to state, that for greater thicknesses of a cutter the value of tightening a groove is greater and time of tightening shorter.

Simultaneously, investigations of a cutting resistance of a soil with a cutter of $d = 100$ mm in thick have been carried out. The results obtained illustrate curves in Fig. 5. To compare, the curve of a cutting resistance of a soil by a cutter of $d = 170$ mm in thick have been also drawn.

An analysis of run of both curves allows to state an influence of the width of a cutter on value of the cutting resistance after going beyond a certain depth of cutting, which in case in question was $h = 10$—12 cm.

By smaller depths an influence of the width of cutter on value of cutting resistance of a soil have not been observed.

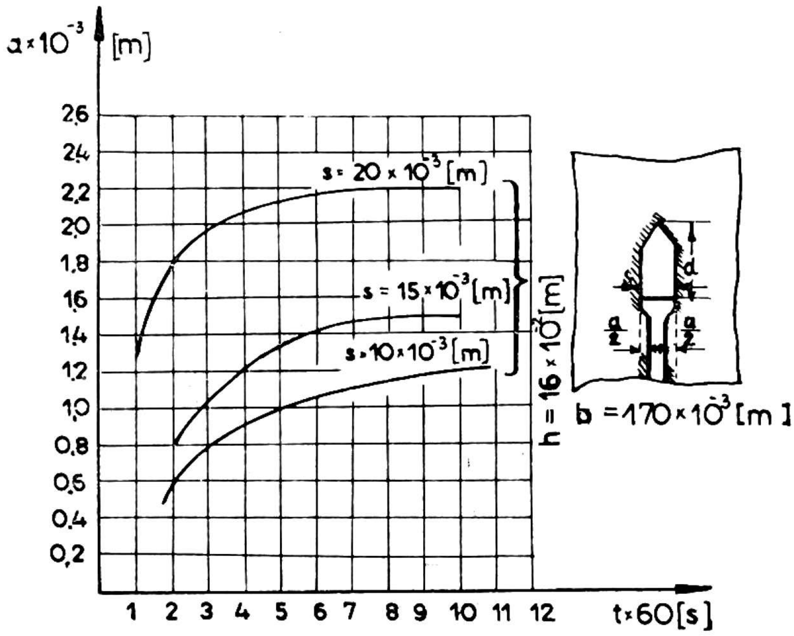

Fig. 4. Tigthening a gap by cutting with a straight cutter as a function of time and width of a cutter

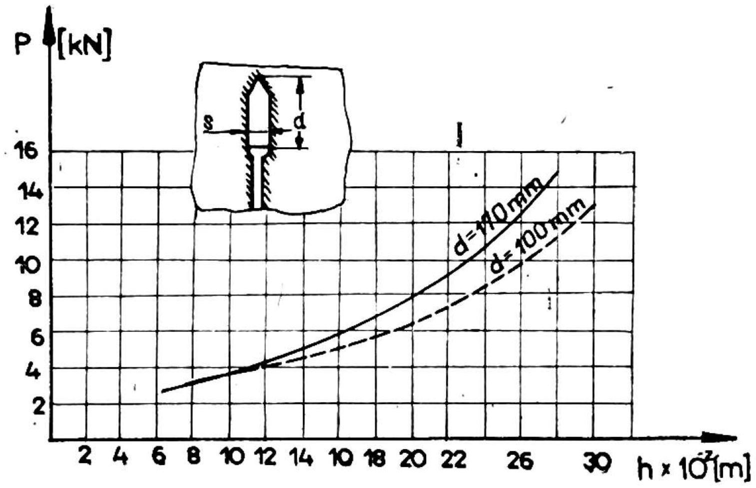

Fig. 5. Dependence of cutting resistance on the width of a cutter

The reason of smaller cutting resistances when a cutter of smaller width is used are smaller values of friction resistances on active flanks of a cutter. Together with the growth of a cutting depth increase a difference between value of cutting resistance of a soil with a cutter of smaller width and this one but of greater width. The reason of more quick growth of cutting resistance of a soil a wider cutter by increase of a cutting depth, is larger and larger influence of friction resistance on active flanks of a cutter with the growth of cutting depth.

The next problem was the determination of an influence of existing the bare lateral surface on value of the cutting resistance of a soil. From graph in Fig. 6 it follows that with the growth of a cutting depth h of a soil, an influence range of the bare lateral surface on decreasing the cutting resistance also increase. In the course of investigations it has

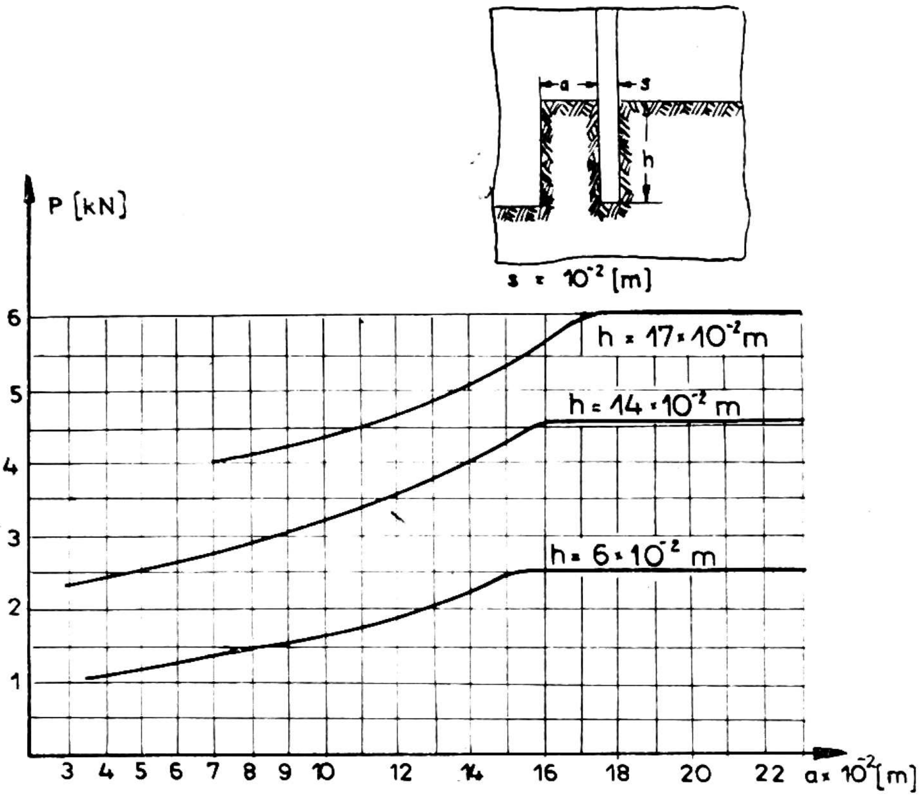

Fig. 6. Influence of distance from the bare lateral surface on the value of cutting resistance

been observed that with the growth of distance from bare lateral surface decrease a lateral force which causes deflection of cutter in the lateral surface direction.

From the measurement carried out it follows that for the ratio $\frac{a}{h} < 1$ a soil from the side of bare lateral surface is destroyed along the surface lying on the cutting depth (Fig. 7*a*).

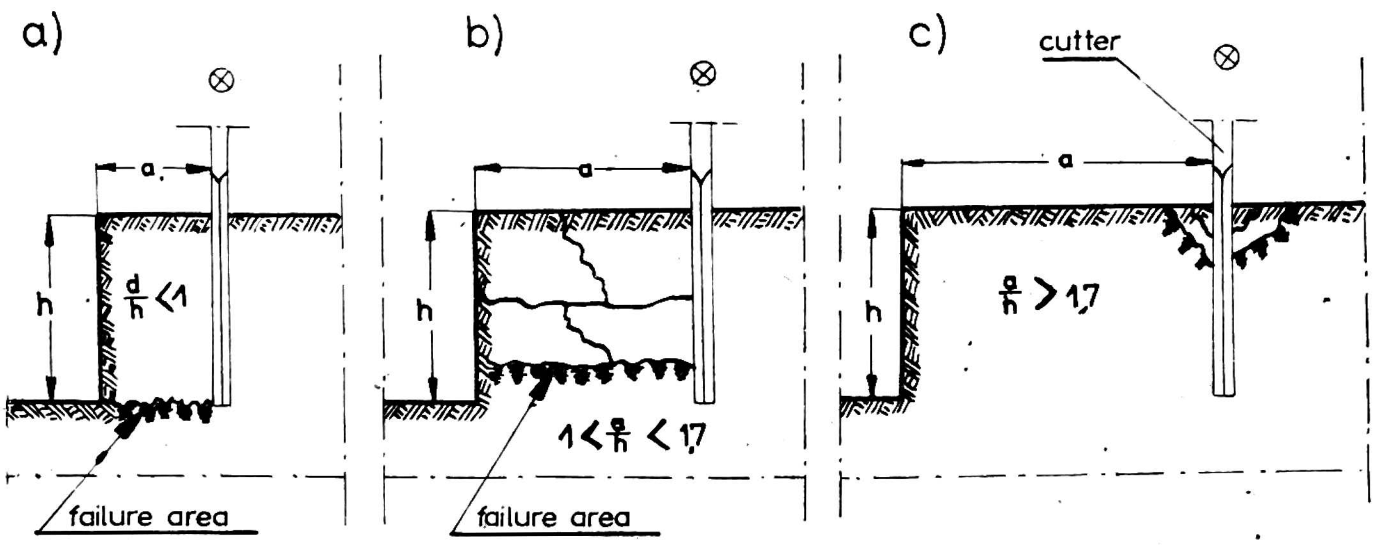

Fig. 7. Destruction of a soil structure independence on a distance from the bare lateral surface and depth of cutting

— within the interval $1 < \frac{a}{h} < 1.7$ follows partial destruction of soil structure in a manner shown in Fig. 7*b*,

— after going beyond the ratio $\frac{a}{h} > 1.7$ an influence of the bare surface on increasing the cutting resistance does not appear and destruction of soil around cutter takes a similar course as in the case of indefinite distance from the lateral surface (Fig. 2).

Range of influence of bare lateral surface depends on cutting depth and thickness of a cutter. With the growth of these values the range of influence of lateral surface also grows.

SCRAPING ONE-SIDEDLY COMBINED

The purpose of investigations given up to the scraping one-sidedly combined was to determine a dependence of scraping resistances upon dimensions of a cutting off chip. Investigations have been performed by means of a bow-shaped cutter having following dimensions:

— thickness of a cutter $s = 10$ mm,
— spacing of lateral walls $b = 295$ mm,
— radius of curvature of a tool point $r = 60$ mm,
— angle of a tool point $\alpha = 15°$,
— angle of scraping $\beta = 23°$.

Results of investigations are presented in Fig. 8. With the growth of width of a chip the scraping resistance decreases quicker than proportionally. It should be interpreted by a decreasing influence of bare lateral surface.

Unitary superficial scraping resistance K_F decreases with the section growth of a chip, on the understanding, that for the constant width of a chip the growth of a scraping depth from $h = 6$ cm to $h = 20$ cm involves decreasing the unitary superficial scraping resistance K_F.

With further growth of a scraping depth the value K_F decreases, attaining by $h = 25$ cm the value numerically equals to the unitary scraping resistance for a depth $h = 12$ cm. Minimum K_F is for $h = 20$ cm.

Examining the variability of unitary linear scraping resistance K_L an existence of distinct minimum has been stated, moving to smaller widths of a chip with the growth of its thickness (Fig. 8).

Increments of unitary linear scraping resistance from the minimum value with the growth of a chip depth are smaller when compared with increments for decreasing the chip depth.

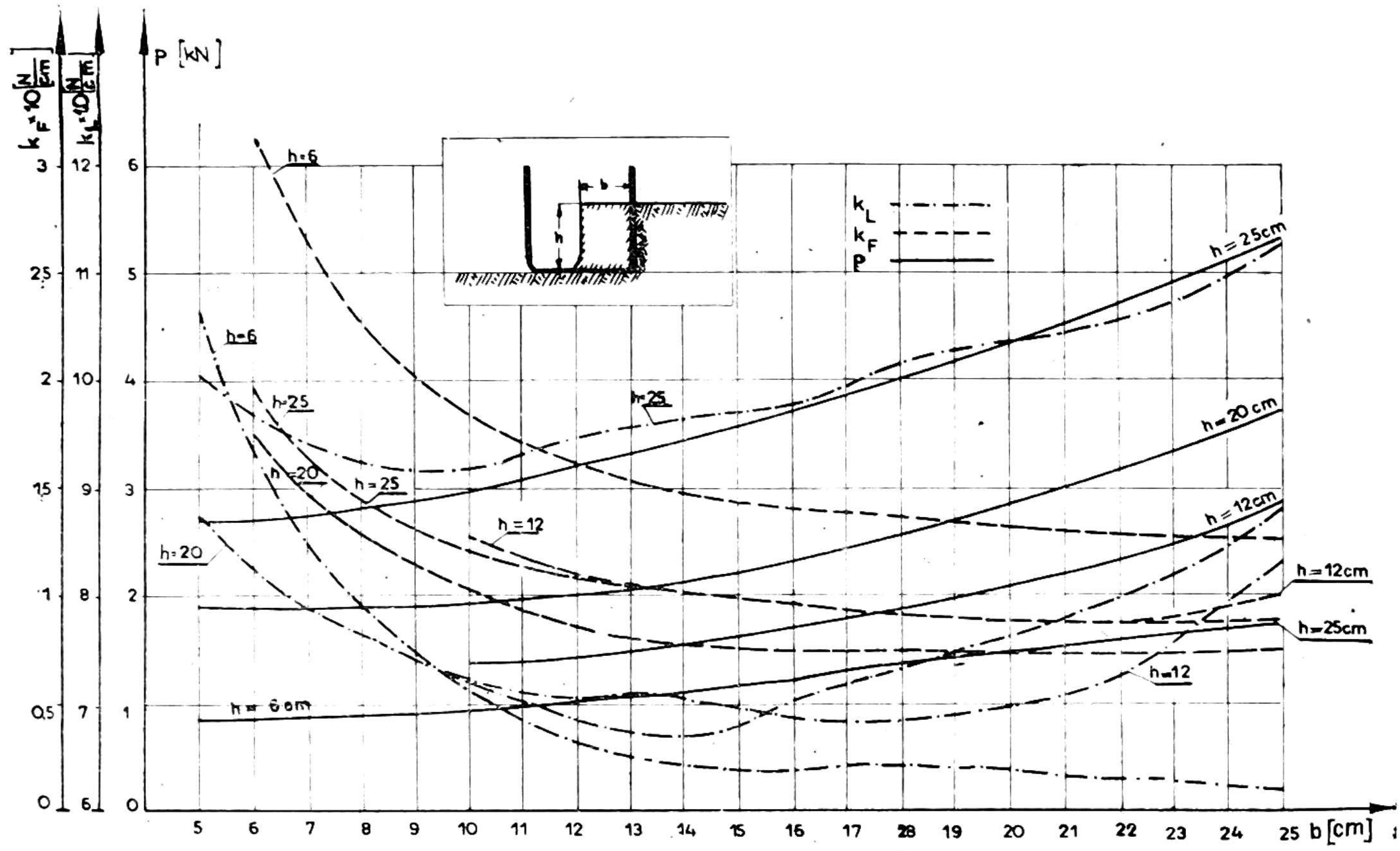

Fig. 8. One-sidedly combined scraping. Dependence of unitary scraping resistance and the scraping resistance from dimenions a chip

SCRAPING TWO-SIDEDLY COMBINED

Series of investigations closed measurements of two-sidedly combined scraping resistance.

Results of the investigations are presented in Fig. 9. Width of a chip on account of one cutting tool was constant, but the depth of scraping was changing. Character of changing the scraping resistance and unitary linear scraping resistance K_L with growth of the depth of scraping is identical.

However, unitary superficial scraping resistance shows distinct minimum, existing in case in question for h = 14 cm, that goes to make about 0.5 of the chip width.

Process of two-sidedly combined scraping differs essentially from one-sidedly combined scraping. The difference lies in a destruction of a soil structure by lateral walls, in consequence of smaller tool width on the input side of a chip in comporison with the tool width on the output side of a chip, with that the tool cut off a soil from a virgin soil.

One can to conclude that the position of minimum K_F depends upon the bow-shaped cutter width, angle of scraping and chip width for the same kind of soil and unchanging other parameters.

It follows a conclusion from this, that in case in question, K_F on

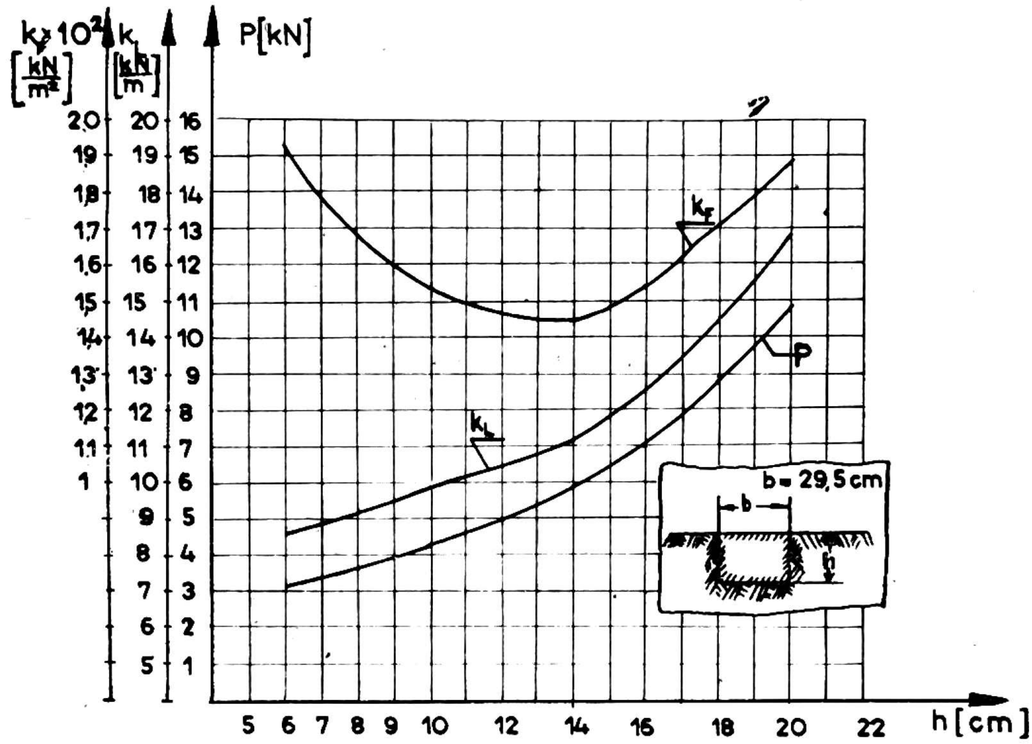

Fig. 9. Dependence of the two-sidedly combined scraping resistance from the thickness of a chip and curves of unitary scraping resistance K_L and K_F

account of his changeability is a more stabile value as the workability factor and thereby numerically better characterizes the workability of a soil.

However, for the scraping one-sidedly combined a similar property shows the unitary linear scraping resistance K_L.

In the light of investigations performed, to evaluate the soil workability in one-sidedly combined scraping more advisable is to use index K_L, however, by two-sidedly combined scraping to use index K_F. This problem needs further studies, which are the subject of investigations actually carried out.

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OPÓR SKRAWANIA GRUNTÓW SPOISTYCH

Streszczenie

W artykule przedstawiono wyniki badań terenowych oporu skrawania gruntów spoistych. W celu wyjaśnienia zjawisk towarzyszących procesowi skrawania gruntu w zakres badań weszły pomiary oporu przecinania gruntu nożem prostym i pałąkowym dla różnych wymiarów geometrycznych wiórów. Podjęto próbę wyjaśnienia przydatności jednostkowych oporów skrawania K_F i K_L dla oceny urabialności gruntu w zależności od rodzaju skrawania.

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СОПРОТИВЛЕНИЕ СРЕЗУ ПЛОТНЫХ ПОЧВОГРУНТОВ

Резюме

В статье рассматриваются результаты территориальных исследований сопротивления плотных почвогрунтов срезу. С целью изучения явлений сопутствующих процессу срезывания почвогрунта, в исследованиях учитывали измерения сопротивления почвогрунта резанию прямым и кривым (дугообразным) ножом для различных геометрических размеров стружек. Предпринята попытка определения пригодности единичных сопротивлений срезу k_F и k_L для оценки обрабатываемости почвогрунта в зависимости от вида среза.