ZESZYTY PROBLEMOWE POSTĘPÓW NAUK ROLNICZYCH 1976, z. 168

UNITARY MINING RESISTANCES AS THE INDICES OF WORKABILITY OF SOILS FOR ESTIMATION OF INTERNAL LOADS OF MINING ELEMENTS

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To determine the internal loads of mining elements of machines for earth works we used unitary mining resistances: linear K_L and superficial K_F, i.e. the resistance referred to the unit length of a cutting nose or resistance referred to the unit cross-section area of a chip cut off.

Mining resistance is an index defining simultanously workability of a given soil and value characterizing a tod as well as parameters of cutting. This connection and the relationship of the above-mentioned factors limit the value of unitary resistance empirically determined to the narrow area of changes of the parameters in question.

The dependence of unitary mining resistances upon changes of the chip cross-section and the active length of a cutting nose is known and consist in the fact, that together with the growth of a cutting-off chip cross-section the unitary superficial resistance decrease and with the growth of length of a cutting nose the unitary linear mining resistance increase.

The problem still in the small part recognized is an influence of shape and dimensions of a chip on the value of instantaneous loads of mining elements of wheed-milling excavators.

Pilot investigations upon this problem have been performed in the Brown Coal-Mine „Turów" on the wheel excavator $SR_S - 1200 \cdot \frac{24}{4} \cdot 12$ during mining heavy, dusty clay having following parameters:

— bulk density $\gamma = 2.68$ G/cm³,
— weight density $\gamma_0 = 1.98$ G/cm³,
— content of loamy fraction $I = 28\%$,
— natural moisture $W = 22.64\%$.

Grain composition is presented in Fig. 1.

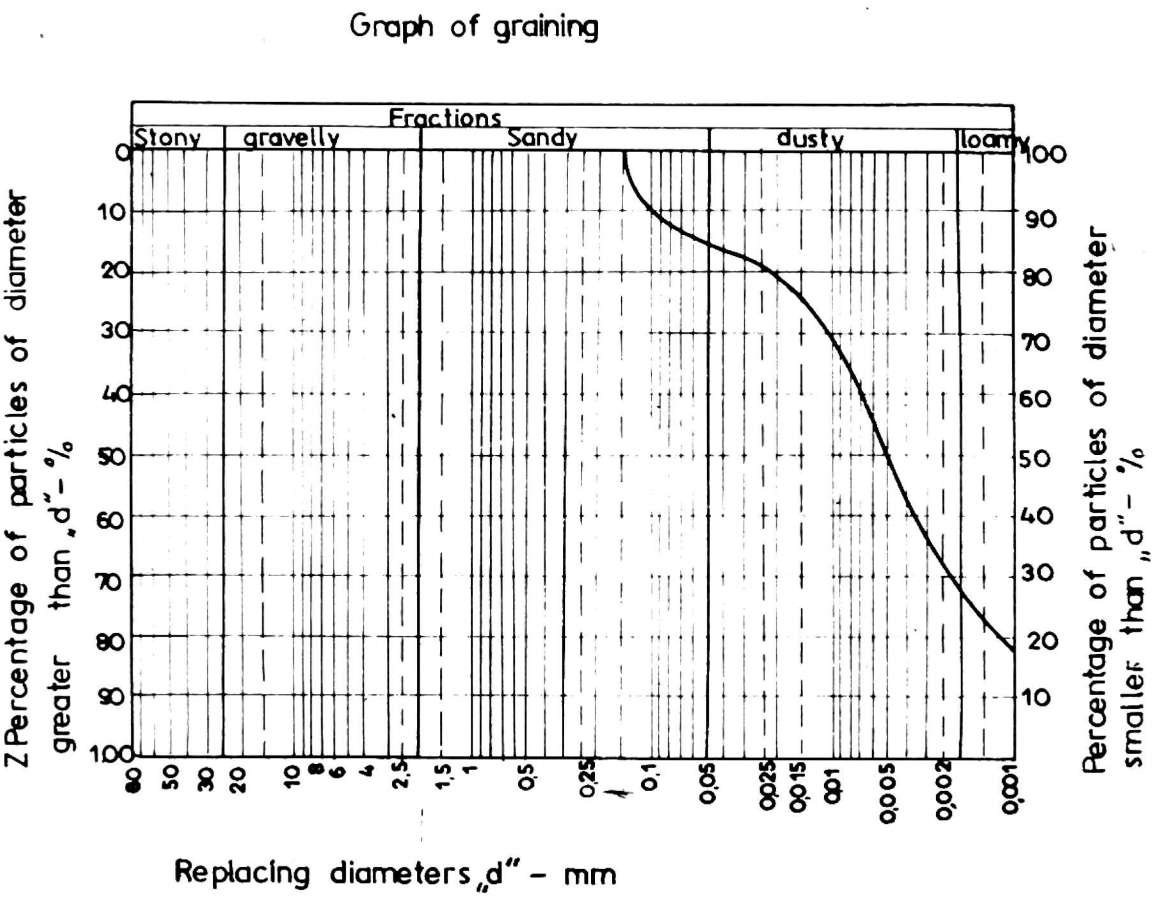


Fig. 1. Graph of graining of a soil being examined

On the basis of results obtained from investigations the strength parameters of the soil have been determined:

— cohesion $c = 4.87$ KG/cm³,

— internal friction angle $\varphi_{ev} = 15°32'$.

Limits of the paper do not allow to present all details of the manner of realization of measurements and elaboration of results. We limit ourselves to the informing the main assumptions and the way of conduct taken up.

Examination of the mining resistance have been performed by reduced number of buckets on a mining wheel, from 8 to 2 units. It allowed to record an instantaneous mining resistance acting on a single bucket in time of cutting-off a chip.

In the course of the measurement power of current input by a propulsion motor of a mining wheel has been recorded and dimensions of chips cut off — the thickness, width and heigth — have been measured (Fig. 2).

On the basis of recorded power of current input by an engine the value of circumferential force has been defined from the formula

$$P_{o_\varphi} = \frac{3060 \cdot e}{\pi \cdot R \cdot i} \cdot N_\varphi \cdot \eta_\varphi, \tag{1}$$

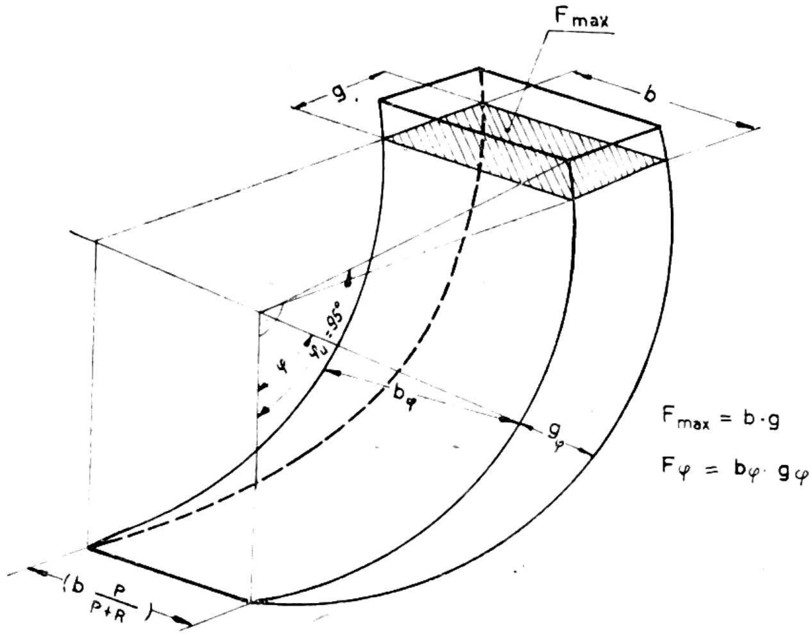


Fig. 2. Dimensions of a chip cutting off by a wheel excavator in the course of investigations

where

P_{o_φ} — instantaneous value of circumferential force by angle of rotation $_\varphi$,

e = 8 — number of buckets settled on a mining wheel,

π = 3.1415 ...,

R = 4.1 m — radius of a mining wheel,

$i = 50 \frac{1}{\text{min}}$ — number of emptying the buckets in time of 1 min,

N_φ — power of current input by an engine, by angle of rotation $_\varphi$,

η_φ — coefficient of efficiency of an engine and transmission gear, by a power N_φ.

Scraping resistance P_{o_φ} is equal to the circumferential force P_{s_φ} reduced by a force P_{p_φ} of lifting a soil being in a bucket (Fig. 3).

$$P_{s_\varphi} = P_{o_\varphi} - P_{p_\varphi} \tag{2}$$

where

$$P_{p_\varphi} = \gamma_\circ \cdot R \cdot b \cdot g\,(1 - \cos\varphi)\,\frac{R_{G_\varphi}}{R} \cdot \left[\frac{2P^\circ + R\sin\varphi}{2(P^\circ + R)}\right] \sin\varphi,$$

γ_0 — weight density of a soil,

b — width of a chip,

g — thickness of a chip,

φ — angle of rotation of a mining wheel,

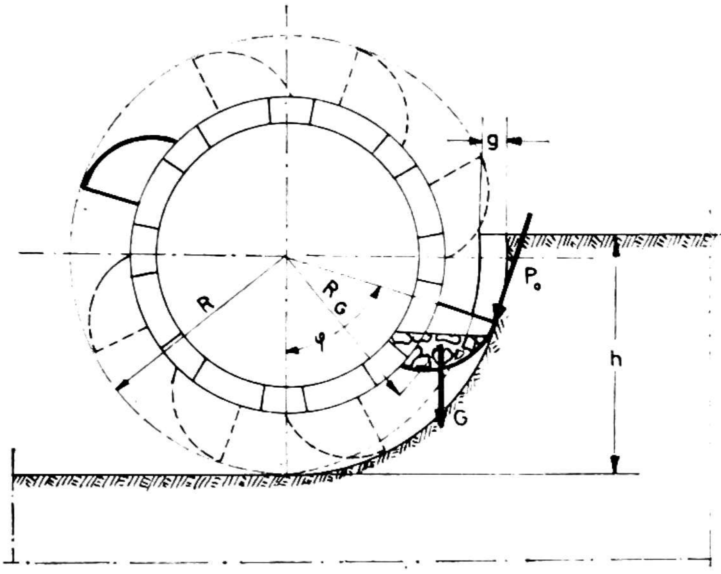


Fig. 3. Scheme of action of forces in the process of loosening a chip by a single bucket

$R_{G\varphi}$ — instantaneous radius of action of gravity force of a soil being in a bucket,

P^o — distance from axis of rotation of an excavator to axis of rotation of a bucket wheel — radius of mining.

Investigations carried out shown that maximum of the mining resistance exists before output of a bucket from a virgin soil. For the constant, in the course of investigations, mining angle $\varphi_u = 95°$, maximum of mining resistance exists within the range of angles from $\varphi = 70°$ to $\varphi = 75°$ and than vidently grows less attaining at the moment of output of a bucket from a virgin soil value ten times smaller (Fig. 4).

Value of average mining resistance P_{av} for the whole range of mining angles to the maximum instantaneous value of resistance results from 0.512 to 0.527 for presented three series of measuring results.

For the purpose of acquaintance with the mechanism of destruction of a cohesive soil structure in the process of its scraping o pilot series of laboratory model investigations has been performed of the process of mining with a bucket having circular trajectory of motion.

This investigation has had a qualitative character in which the process of mining have been photografically recorded in te plane corresponding with the position of a side wall of a tod.

A material submitted to the mining process was a sandy day of plastic consistency and moisture of 29%. The photos inserted presenting successive stages of the mining process and the results obtained allow a modest qualitative interpretation of the mining process of a cohesive soil to be done.

In the initial phase, destruction of a soil runs in the forced plane compatible with the trajectory of a cutting tool point and is assisted by

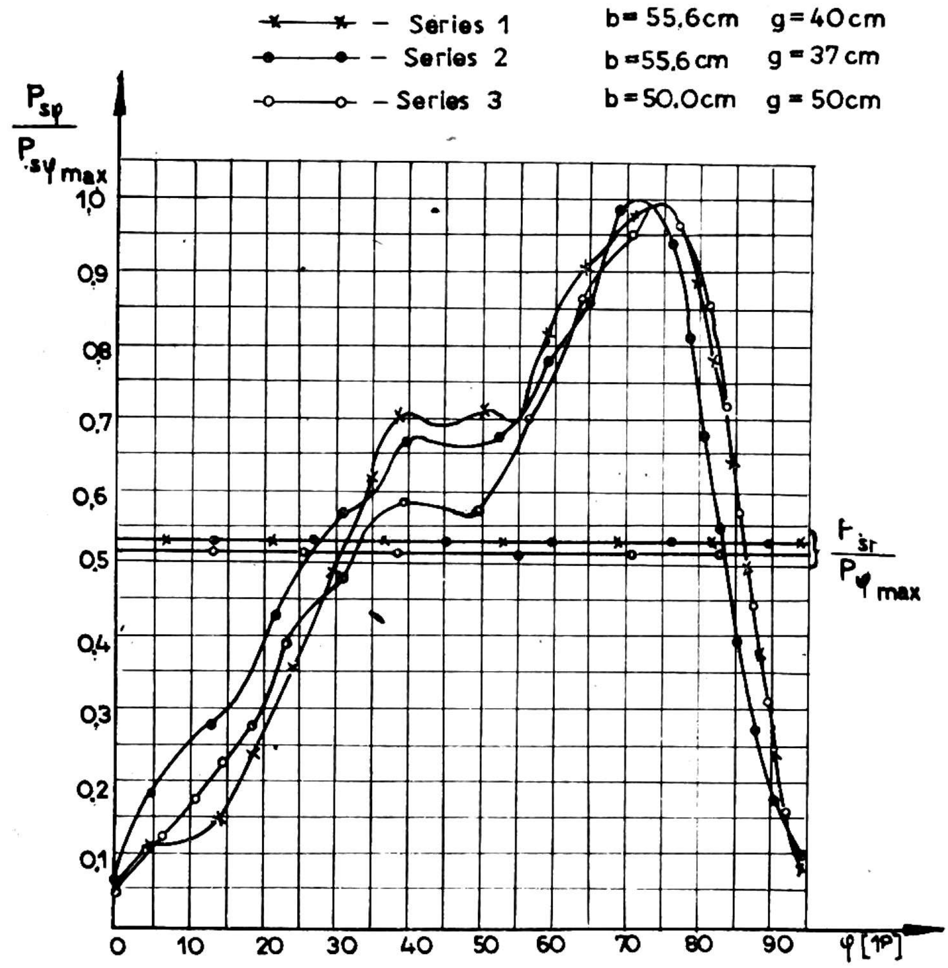


Fig. 4. Run of instantaneous values mining resistance in dependence on angle of rotation of a mining wheel, for a single bucket

the defined deformation of a chip cut off corresponding to the shape of tool (Figs. 5 a, b, c). In the next phase, in addition, we observe an effect of formation of „partial" wedges due to the action of load resulting from the passive chip pressure leaning against the back wall of tod (Figs. 5 d, e).

In the succeeding phase of the process (Figs. 5 f, g) very quickly detachment of the remaining part of a chip from a virgin soil take place.

The last phase (Fig. 5 h) is the „pure" lifting of the loosed soil.

In Fig. 6 changing the values of the unitary linear mining resistance K_{L_φ} is presented together as a function of angle of rotation of a mining wheel with which opposes a soil in the process of its mining by a single bucket.

Run of values $\frac{K_{L_\varphi}}{K_{L_{\varphi\max}}}$ has a similar character of changing as the ratio $\frac{P_{s_\varphi}}{P_{s_{\varphi\max}}}$, and ratio of the average value of unitary linear mining resistance to the maximum instantaneous value is $\frac{K_{L_{av}}}{K_{L_{\varphi\max}}} = 0.68$ to 0,69.

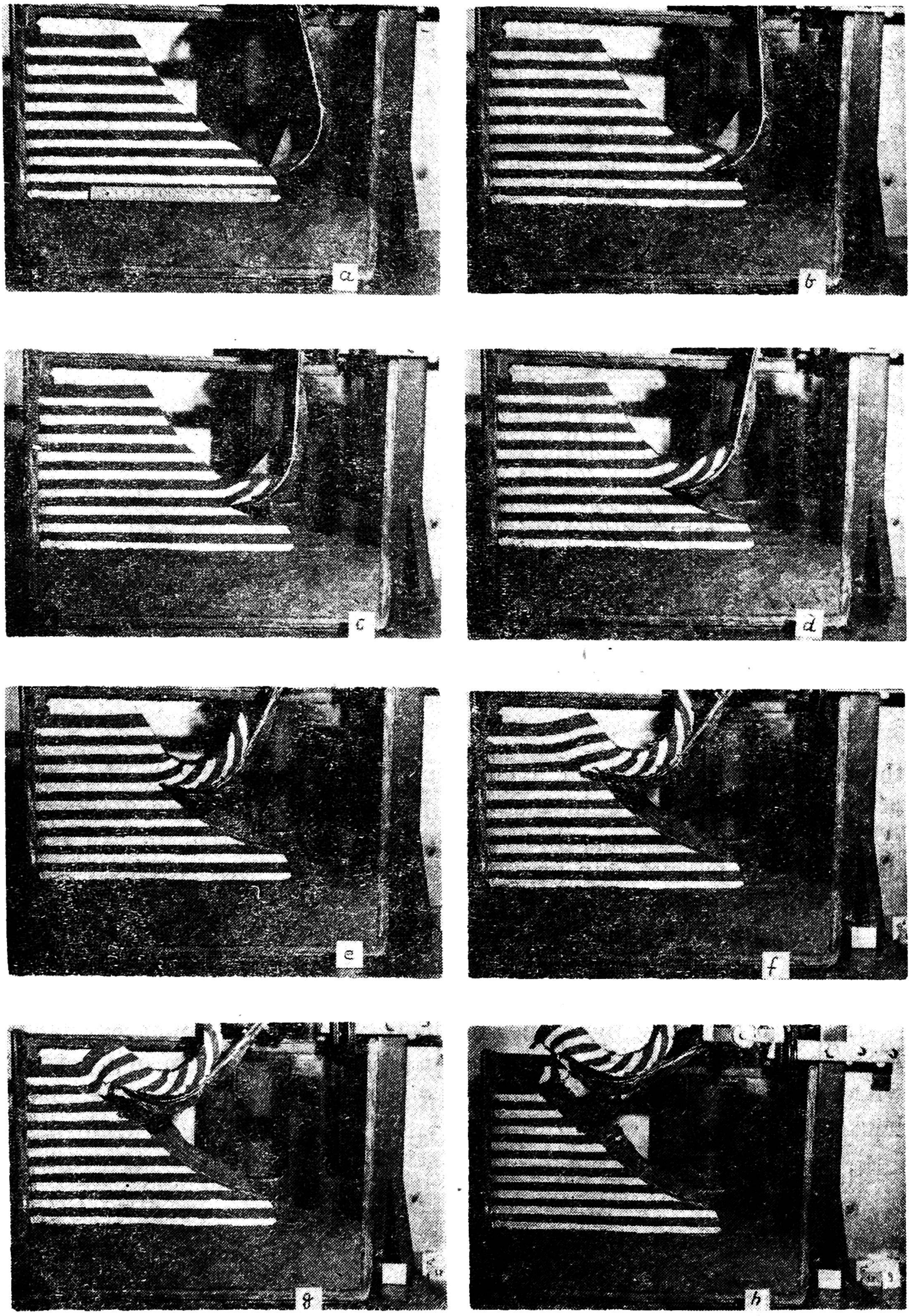


Fig. 5. Successive phases of the process of mining (pilot series)

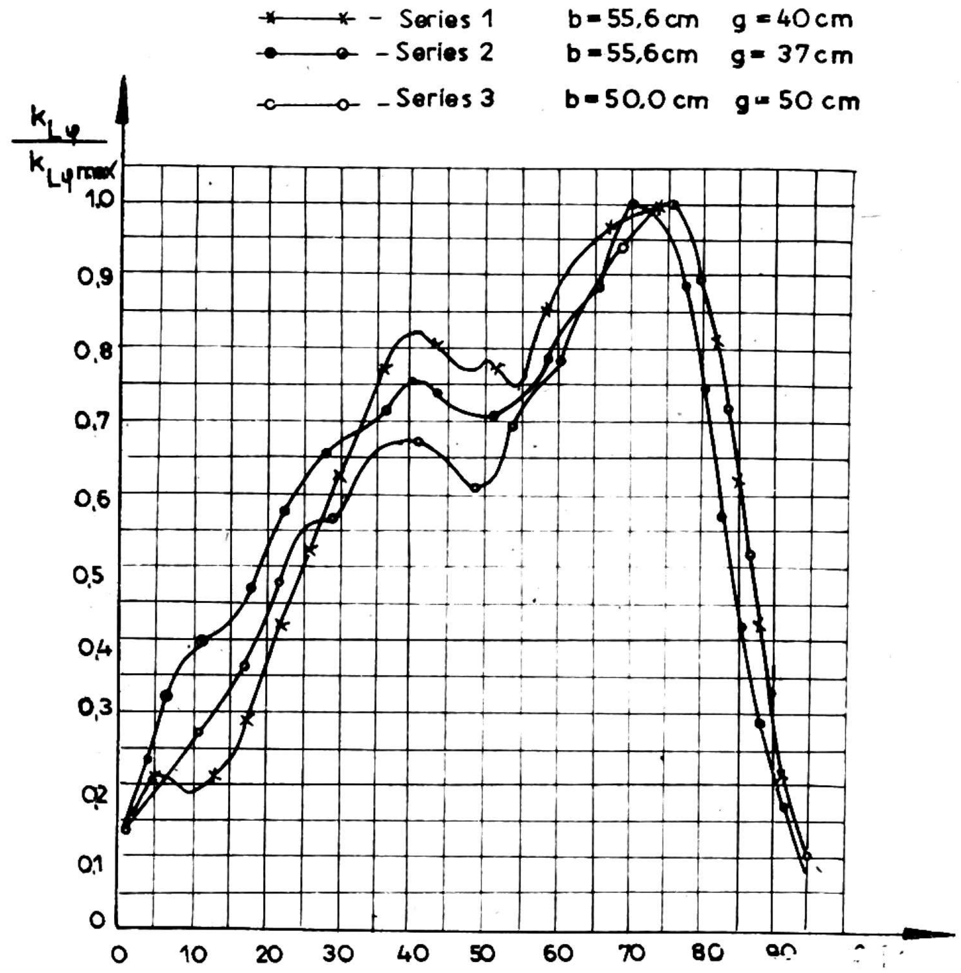


Fig. 6. Instantaneous values of unitary linear mining resistance in dependence on angle of rotation of a mining wheel, for a single bucket

Run of values of instantaneous superficial mining resistances have been also determined. Dependence $\frac{K_{F_\varphi}}{K_{F_{\varphi\max}}}$ (Fig. 7) shows smaller changing with the growth values $\frac{K_{L_\varphi}}{K_{L_{\varphi\max}}}$.

The interesting results have been obtained by comparison of values of mining resistance determined in measurements and these ones calculated from formulae

$$P = K_{\mathrm{Lav}} \cdot L \text{ and } P = K_{\mathrm{Fav}} \cdot F. \text{ (Figs. 8a, b, c)}$$

A conclusion follows from that, that unitary superficial mining resistance K_F better characterizes workability of a soil and the values of maximum mining resistance determined on the basis of this index are nearer to the real values.

The suitable ratios of mining resistances have been determined for designation the superiority of one of the unitary mining resistance indices as a determinant of workability of a soil and the following have been obtained:

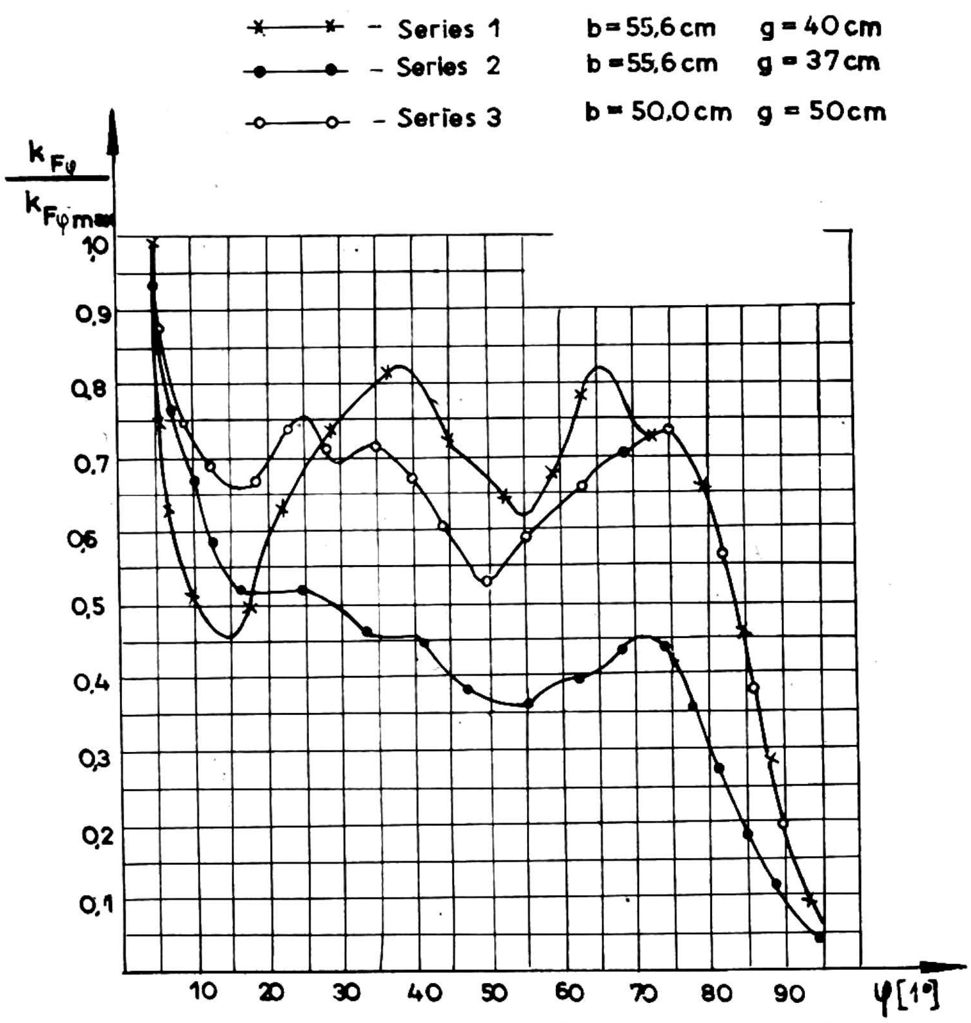
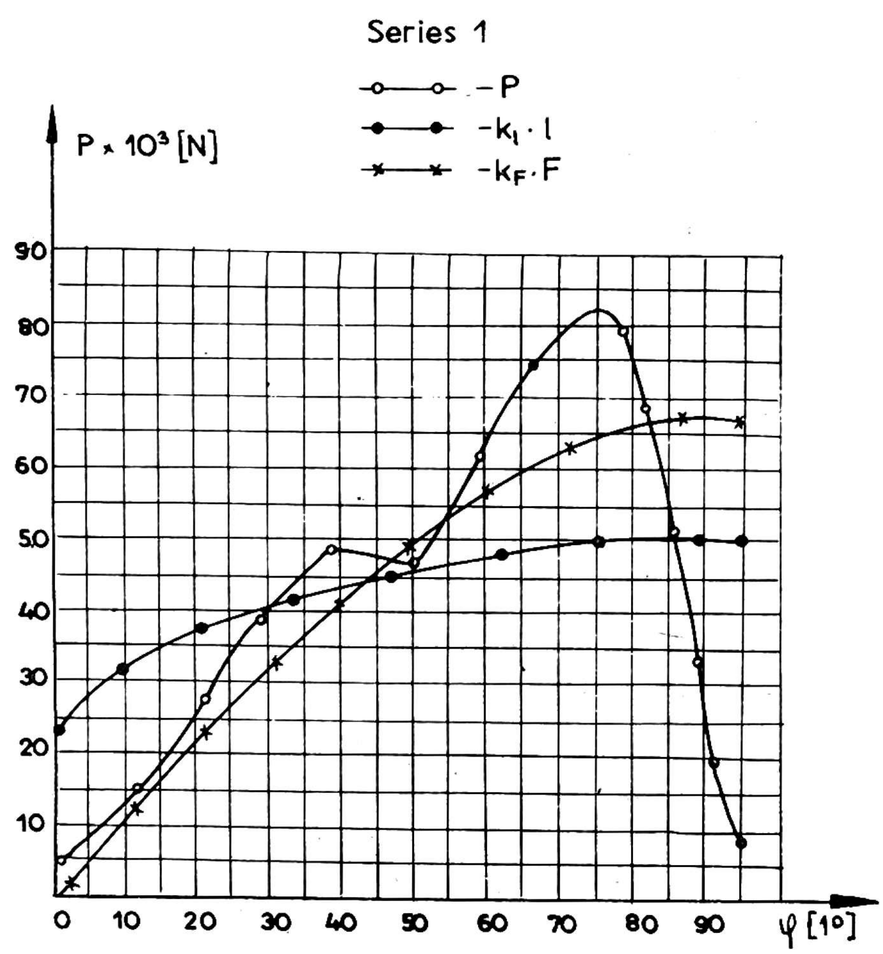
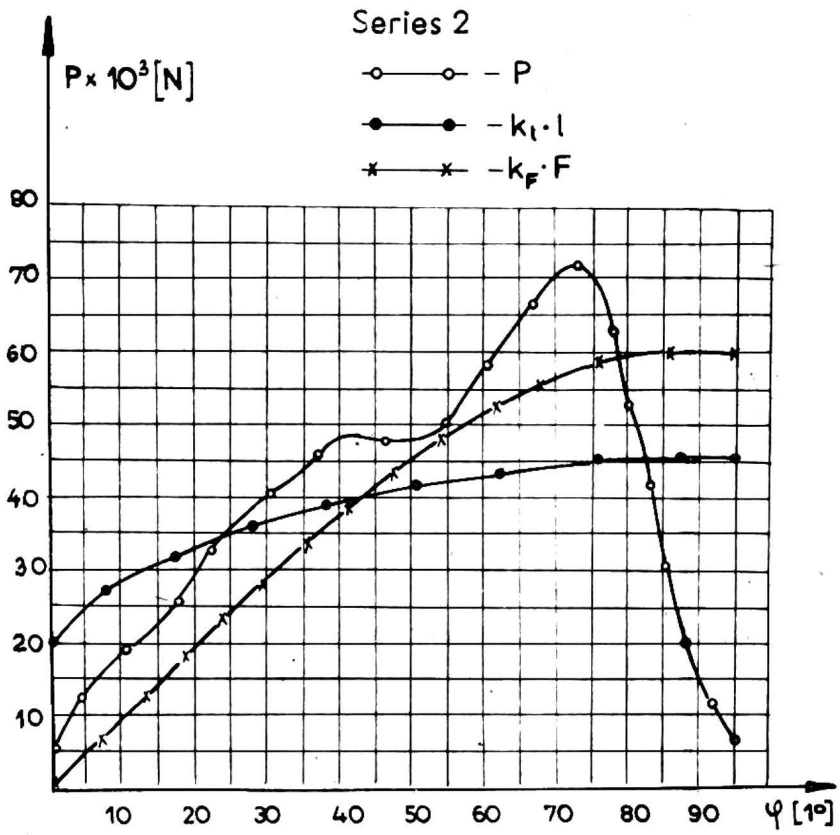


Fig. 7. Instantaneous values of unitary superficial mining resistance in dependence of angle of rotation of a mining wheel, for a single bucket





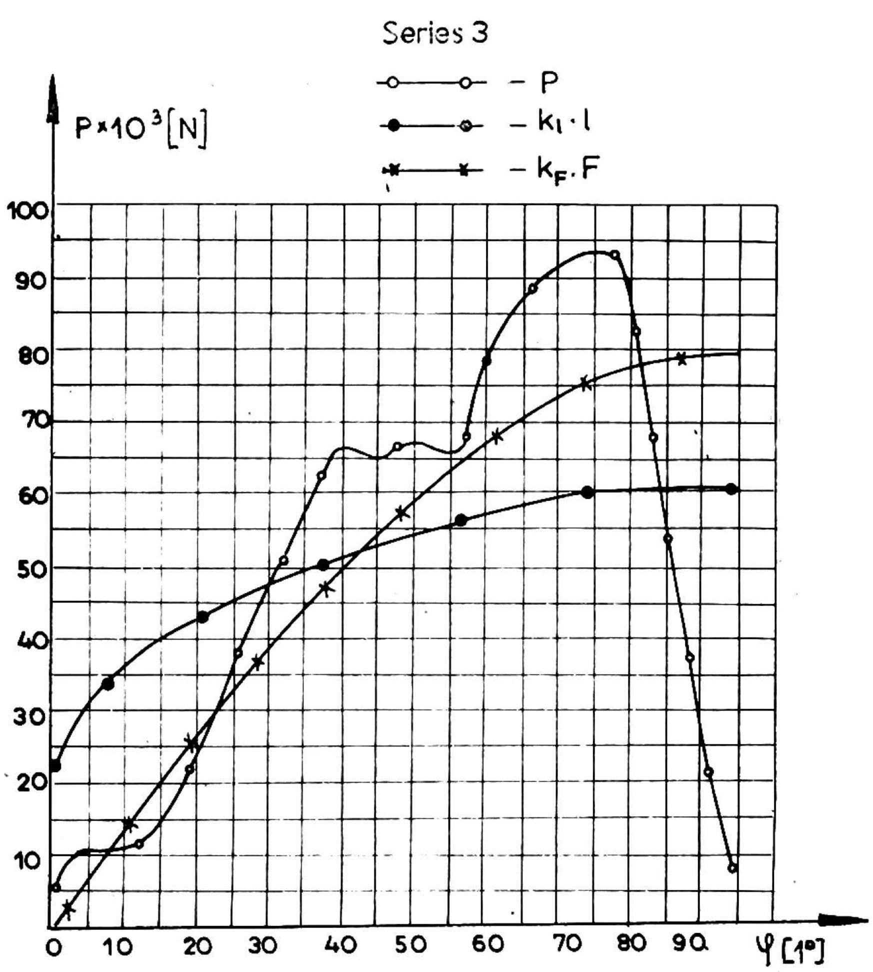


Fig. 8. Comparison of instantaneous values of mining resistance determined from investigations with those obtained from relations $P_L = K_L \cdot L$ and $P_F = K_F \cdot F$

$$\frac{P^P_{max}}{K_{Fav}F_{max}} = 1.19 \text{ to } 1.24, \text{ and} \frac{P^P_{max}}{K_{Lav}L_{max}} = 1.55 \text{ to } 1.64,$$

where

$P^P{}_{max}$ — maximum instaneous value of mining resistance from measurements,

F_{max} — maximum instantaneous chip section,

L_{max} — maximum instantaneous active length of a scraping point.

At this point once more it should be emphasized, that all conclusions drawn on the basis of investigations performed refer to the conditions which existed in the course of investigations and to the kind of a soil being examined.

Using the dependence, that the instantaneous load acting on drive of the mining wheel having 8 buckets is equal to the sum of instantaneous mining resistances acting on several buckets moved towards to each other at angle of $\frac{\Pi}{4}$, the graphs of following dependences have been determined:

$$\frac{P_{s_\varphi}}{P_{s_{\varphi max}}} \text{ (Fig. 9)}; \quad \frac{K_{L_\varphi}}{K_{L_{\varphi max}}} \text{ (Fig. 10)}; \quad \frac{K_{F_\varphi}}{K_{F_{\varphi max}}} \text{ (Fig. 11)}$$

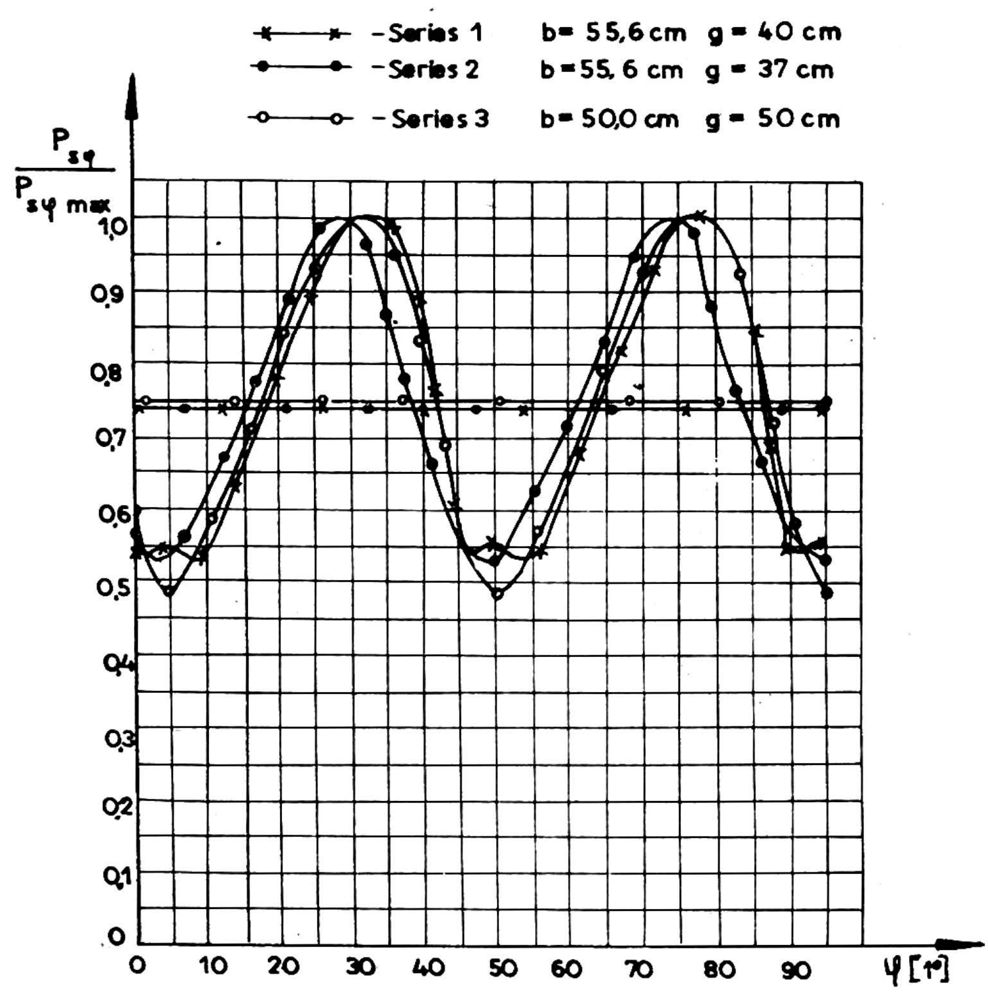


Fig. 9. Run instantaneous values of mining resistance in dependence on angle of rotation of a mining wheel for 8 buckets

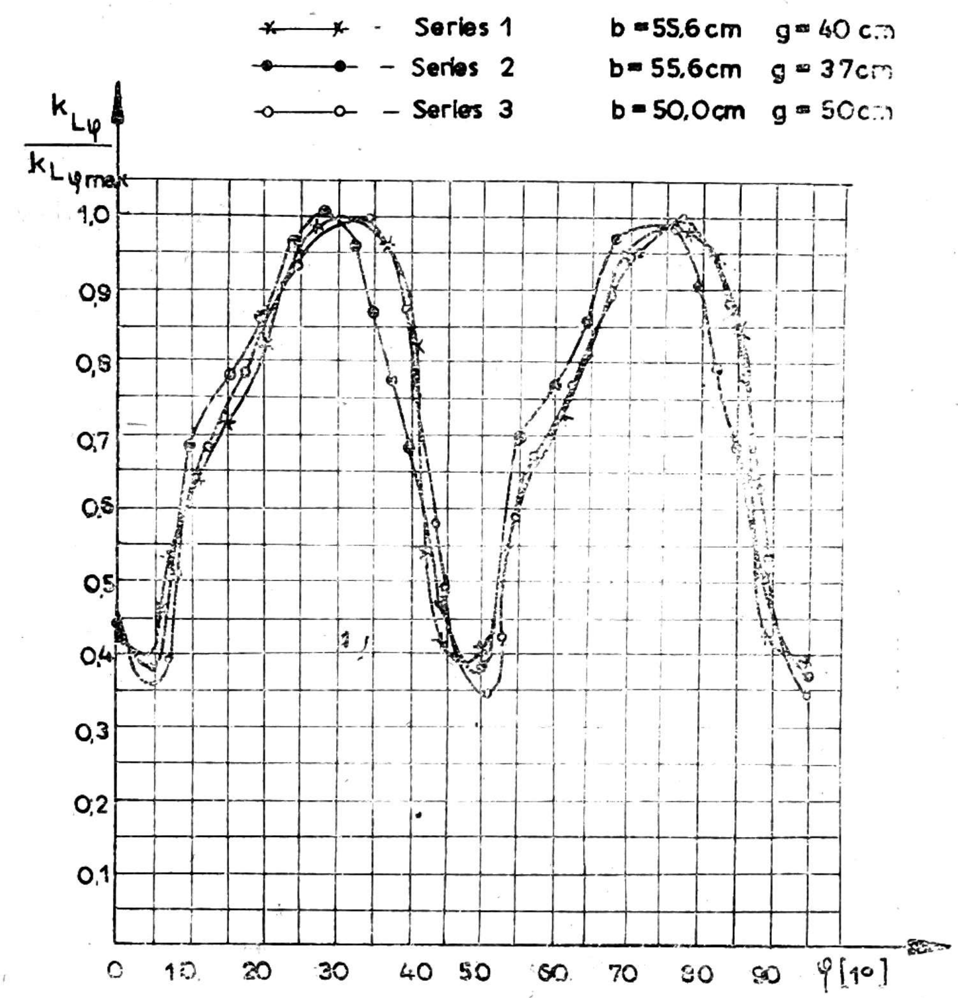


Fig. 10. Instantaneous values of unitary linear mining resistance in dependence on angle of rotation of a mining wheel for 8 buckets

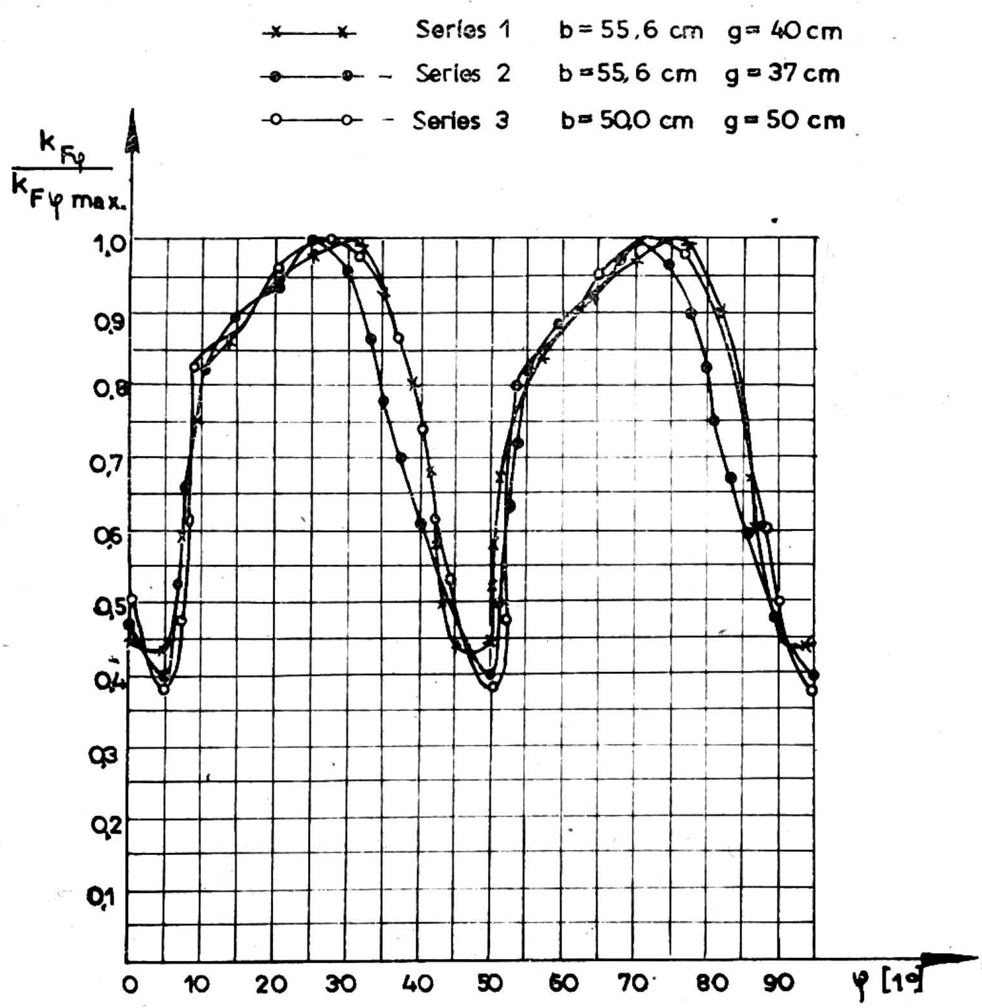


Fig. 11. Instantaneous values of unitary superficial mining resistance in dependence on angle of rotation of a mining wheel for 8 buckets

Comparing values of mining resistance obtained from formulae:

$$P = K_{\mathrm{Lav}} \cdot L \text{ and } P = K_{\mathrm{Fav}} \cdot L,$$

with the resistance determined on the basis of investigations (Fig. 12) and the assumption allowing to determine its value for 8 buckets, it is possible to formulate a following conclusion: the nitary linear mining resistance better characterizes workability of a soil for the purposes of determining the maximum loads in the process of mining.

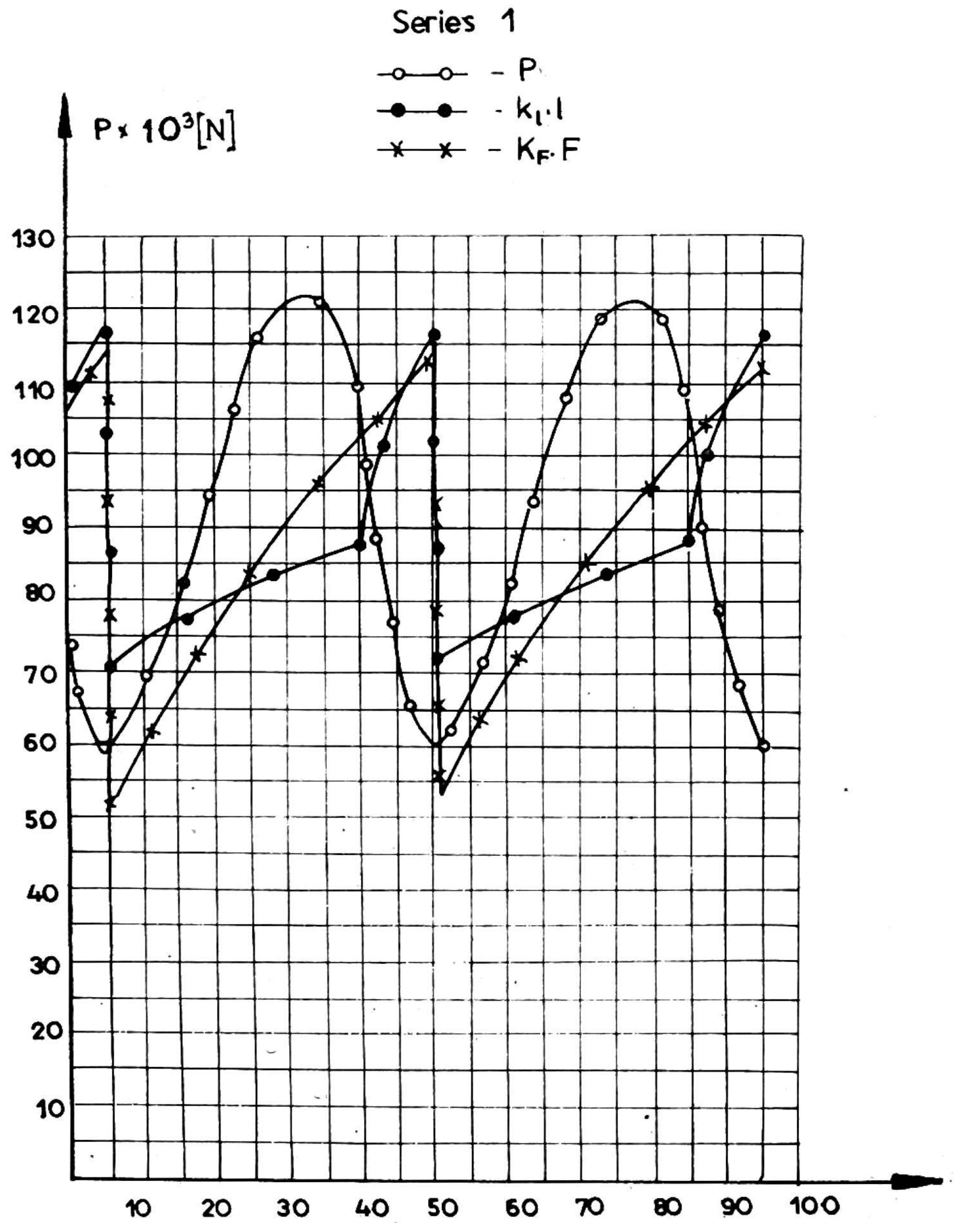


Fig. 12. Comparison of instantaneous values of mining resistance determined in investigations with those obtained from relations $P_L = K_L \cdot L$ and $P_F = K_F \cdot F$ for 8 buckets

H. Wojtkiewicz in the paper „Investigations of scraping resistance of a cohesive soil" also emphasized, that in case of scraping two-sidedly combined an index K_F better characterizes workability of a soil, however, in case of one-sidedly combined scraping the better is index K_L. On the basis of these two papers one can state that in case of mining with the help of single-bucket excavators having a circular trajectory of scraping two-sidedly combined, an index K_F will be best one to characterize workability of a soil and in case of bucket ladder excavators having a circular trajectory of scraping one-sidedly combined — an index K_L.

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JEDNOSTKOWE OPORY URABIANIA JAKO WSKAŹNIKI URABIALNOŚCI GRUNTÓW W CELU PROGNOZOWANIA OBCIĄŻEŃ ZEWNĘTRZNYCH ELEMENTÓW URABIAJĄCYCH

Streszczenie

Wykorzystując wyniki badań wykonanych w terenie na wielonaczyniowej koparce kołowej przeprowadzono analizę stosowalności jednostkowych liniowych i powierzchniowych oporów urabiania dla określenia urabialności gruntu oraz prognozowania obciążeń zewnętrznych elementów urabiających. Na podstawie uzyskanych wyników proponuje się stosowanie wskaźnika K_F do prognozowania obciążeń zewnętrznych pojedynczych elementów urabiających maszyn o kołowej trajektorii skrawania. Natomiast wskaźnik K_L lepiej charakteryzuje opór urabiania w przypadku współdziałania kilku elementów urabiających.

М. Хаврыш, Б. Шимловска, Г. Войткевич

ЕДИНИЧНЫЕ СОПРОТИВЛЕНИЯ ОБРАБОТКИ КАК ПОКАЗАТЕЛИ ОБРАБАТЫВАЕМОСТИ ПОЧВОГРУНТОВ ОПРЕДЕЛЯЕМЫЕ С ЦЕЛЬЮ ПРОГНОЗИРОВАНИЯ ВНЕШНИХ НАГРУЗОК ОБРАБАТЫВАЮЩИХ ЭЛЕМЕНТОВ

Резюме

Используя результаты проведенных в поле исследований с многоковшовым колесным экскаватором, авторы анализируют применяемость единичных линейных и поверхностных сопротивлений обработке для определения обрабатываемости почвогрунта и прогнозирования внешних нагрузок обрабатывающих эле-

ментов. На основании полученных результатов автор предлагают использовывать показатель K_F для прогнозирования внешних нагрузок отдельных элементов машин по обработке, с круговой траекторией среза. Показатель же K_L лучше характеризует сопротивление обработке в случае совместного действия нескольких обрабатывающих элементов.