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METHODOLOGY OF DETERMINATION OF THE INTERNAL FRICTION COEFFICIENT OF GRAIN LAYER AT INCREASED STRAINS

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The single-phase harvesting and transportation to stores silos of a large amount of grain of differentiated physical parameters creates many new technological problems. It requires the knowledge of the phenomena occuring in grain layer during storing.

One of the basic mechanical properties of grain mass is the friction among the particles, in the mechanics of soils and granular bodies called the interial friction. The value of the friction is determined on the basis of the cutting resistance of the medium

$$\tau = \sigma \operatorname{tg}\varphi + c,$$

where

τ — the cutting strains,
σ — normal strains,
$\operatorname{tg}\varphi$ — the internal friction coefficient,
φ — the angle of internal friction,
c — cohesion.

Experimentally it is possible to obtain this relation using the direct compression test [3—6, 8, 10] or the triaxial compression test [1, 3—5, 8, 9].

The most common and accepted in the mechanics of soils is the method of triaxial compression. In the triaxial compression test (Fig. 1) a cylindrical sample of granulated material *1* in a membrane of thin rubber *2* is placed inside a cylinder *3* closed at both ends with plates *4* fastened after the insertion of the sample with screws *5*. The interior of the cylinder is filled with a liquid or gass under a certain pressure *p*. During the measurement the sample is axially loaded with an increasing force *F*. The value of the force *F* is recorded in relation to the movement of the piston *6*. After the force *F* reaches a certain value there occurs the destriction of the sample, usually by a characteristic cutting along

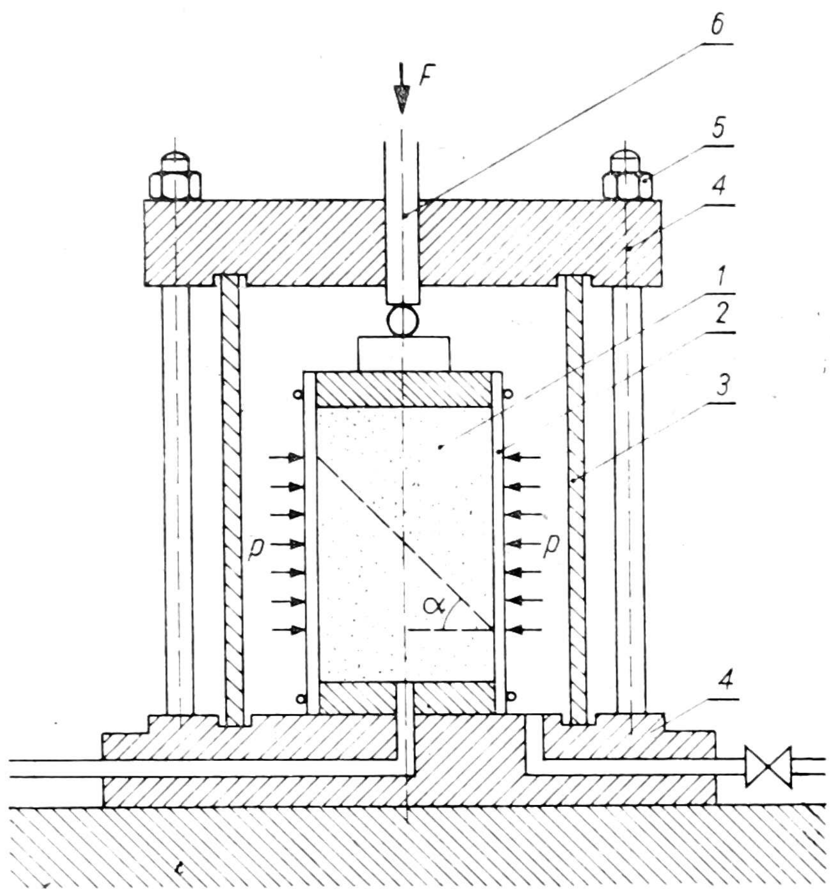

Fig. 1. Diagram of the triaxial compression chamber: *1* — sample, *2* — rubber membrane, *3* — cylinder, *4* — cover of the cylinder, *5* — screw, *6* — piston

a plane inclined at the angle α. Knowing the value of the force F, of the pressure p, and the surface of the intersection of the sample at the moment of cutting it is possible to draw the Mohr circle describing the states of strains occuring during the measurement.

The tangent to the Mohr circles determines the limit values of the cutting strains, and its inclination determines the internal friction coefficient.

The theoretical justification, practical routine of measurement and the interpretation are extensively described in the literature [1, 3, 5, 8].

The angle of internal friction of loose materials is also determined with other methods [2, 6, 10], ex. from the angle of heaping of slope, the angle off offset, etc. These methods cannot be applied for the determination of friction at increased strains in grain layer.

METHODOLOGY OF INVESTIGATIONS

Investigations of the resistance of grain layer to cutting (on the basis of which the values of the internal friction coefficient were determined) were carried out in a specially constructed chamber of triaxial compression. The cutting of a cylindrical sample of the diameter of 68 mm and the length of 136 mm (about 450 cm^3) was done with the help of the resistance apparatus Instron model 1253. The strains and deformations were recorded in a recorder. The pressure in the measurement chamber was obtained with the help of compressed gass.

For the investigations winter wheat of the Grana variety from the crops of 1975 was used. At the moisture of 14.5% the volume weight of the grains was 743 g/l, and the porosity was 49%.

In order to obtain results in different ranges of moisture grain was moistened or dried, and then stored for 7 dys in closed containers [7, 9]. The samples were formed by preliminary compacting with the force of $1+2 \cdot 10^4$ N/m². The cutting was made at five states of side strain: $5 \cdot 10^4$, 10^5, $2 \cdot 10^5$, $3 \cdot 10^5$ and $4 \cdot 10^5$ N/m², at the speed of 0.084 m /sec (0.5 m/min), recording the strains and deformations.

According to the methodology applied in the mechanics of soils [1, 5, 8] the Mohr circles and their tangents were drawn, and the value of the internal friction coefficient as the tangent of the angle of inclination of these tangents was determined for all the values of moisture and side strains. The obtained values of the friction coefficient are presented graphically in Fig. 2.

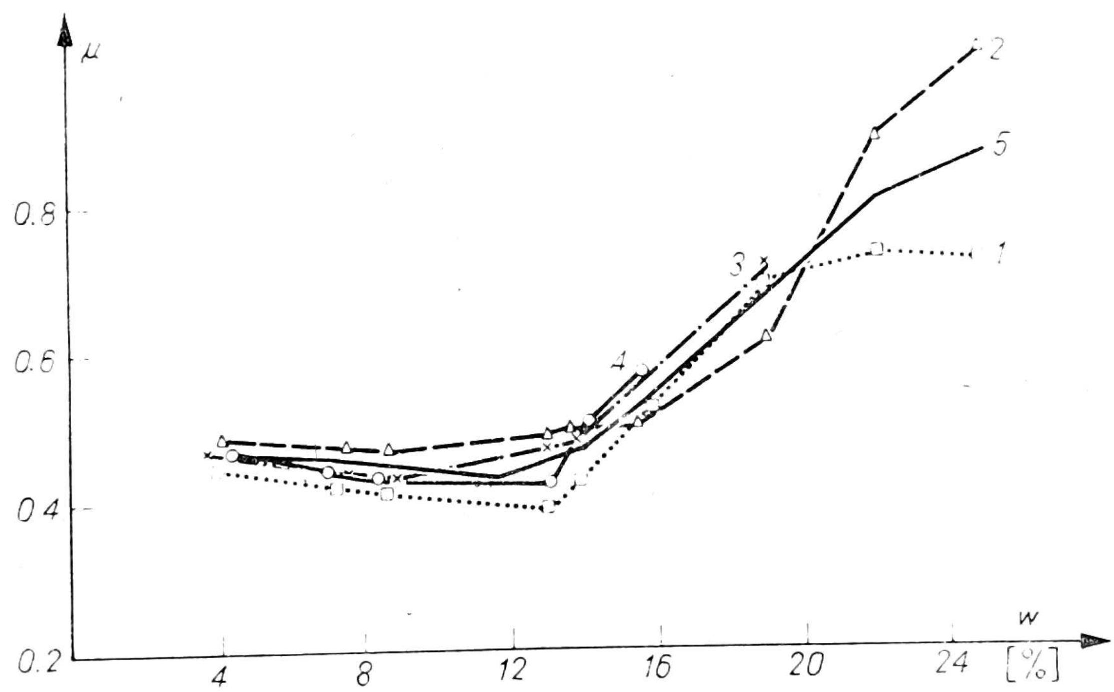

Fig. 2. The dependence of the internal friction coefficient of grain layer μ from the moisture of grains w at different side strains σ_3 determined in the triaxial compression chamber: 1) from 5 to $10 \cdot 10^4$ N/m², 2) from 10 to $20 \cdot 10^4$ N/m², 3) from 20 to $30 \cdot 10^4$ N/m², 4) from 30 to $40 \cdot 10^4$ N/m² 5) from 5 to $40 \cdot 10^4$ N/m²

In order to compare the obtained results the internal friction coefficient was determined for the same mass of grain with the method of direct cutting [3, 5] at the sample sizes of 60×60×40 mm. The calculated values of the coefficient are presented in Fig. 4.

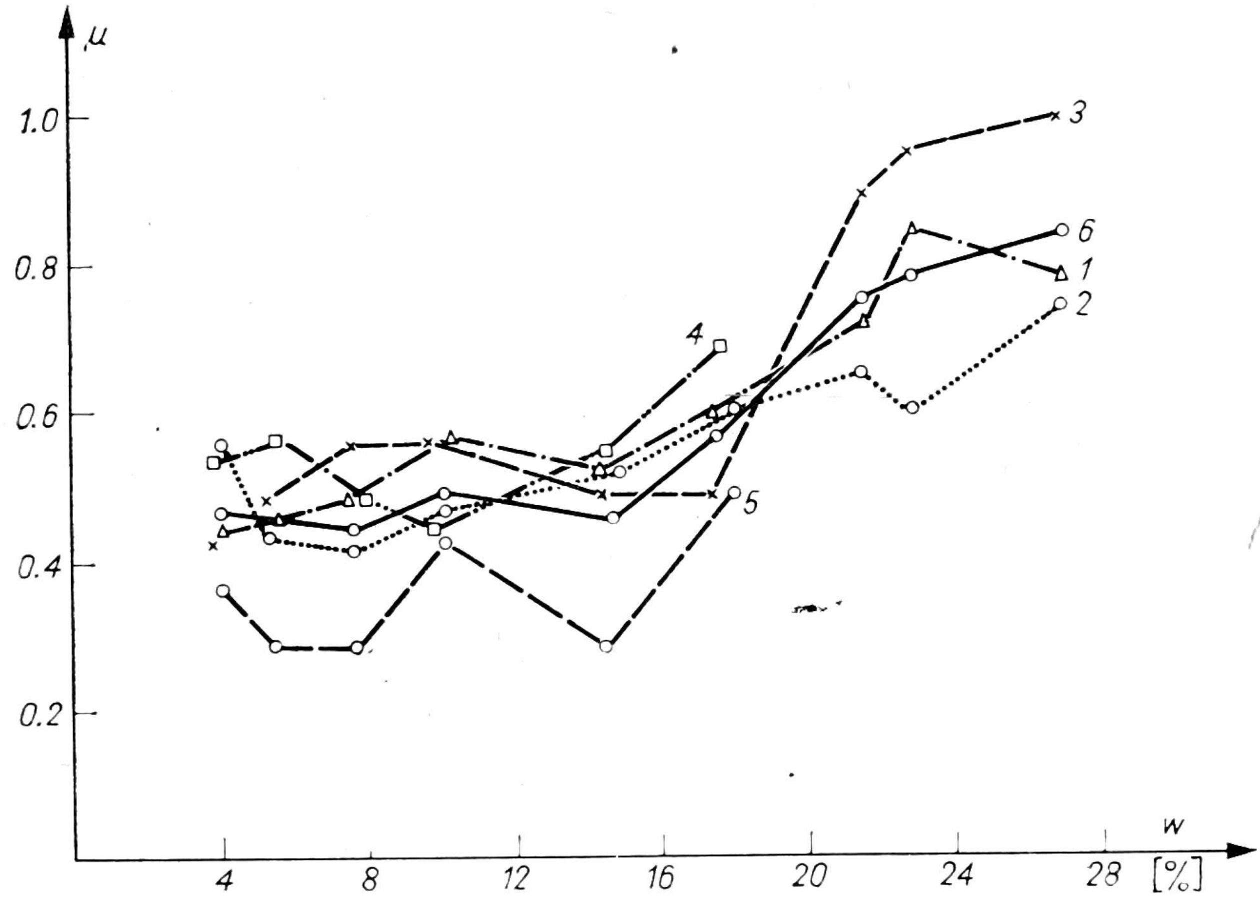

Fig. 4. The dependence of the internal friction coefficient of grain layer μ from the moisture of grains w at different normal strains σ determined in the triaxial compression apparatus: 1) from 2.5 to $7.5 \cdot 10^4$ N/m^2, 2) from 7.5 to $12.5 \cdot 10^4$ N/m^2, 3) from 12.5 to $17.5 \cdot 10^4$ N/m^2, 4) from 17.5 to $22.5 \cdot 10^4$ N/m^2, 5) from 22.5 to $27.5 \cdot 10^4$ N/m^2, 6) from 2.5 to $27.5 \cdot 10^4$ N/m^2

cient for dry grain does not change. For moist and wet grain it increases with the increase of moisture.

The values of the internal friction coefficient of grain layer obtained with the help of triaxial compression apparatus and the direct cutting apparatus are very close. However, the distribution of the obtained results is considerably greater in the case of the direct cutting apparatus (Fig. 2 and 4).

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OKREŚLANIE WSPÓŁCZYNNIKA TARCIA WEWNĘTRZNEGO WARSTWY ZIARNA ZBÓŻ W WARUNKACH ZWIĘKSZONYCH NAPRĘŻEŃ

Streszczenie

Wielkość współczynnika tarcia wewnętrznego w warstwie ziarna w zależności od zmiennych warunków składowania i czynników klimatycznych ma szczególne znaczenie przy budowie urządzeń transportowych, magazynów, silosów oraz maszyn rolniczych.

W opracowaniu dokonano adaptacji metodyki i aparatu trójosiowego ściskania (stosowanego w gruntoznawstwie) do określania naprężeń występujących w warstwie ziarna.

Na podstawie uzyskanych wyników określono zakres zmienności współczynnika tarcia wewnętrznego i naprężeń w zależności od parametrów geometrycznych ziarna, warunków klimatycznych i grubości warstwy.

Wielkość współczynnika dla pszenicy zmieniała się w granicach od 0,42 do 0,86.

Wyniki pomiarów porównano z innymi metodami aktualnie stosowanymi w badaniach agrofizycznych.

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ОПРЕДЕЛЕНИЕ КОЭФФИЦИЕНТА ВНУТРЕННЕГО ТРЕНИЯ СЛОЯ ЗЕРНА ЗЕРНОВЫХ КУЛЬТУР В УСЛОВИЯХ УВЕЛИЧЕННЫХ НАПРЯЖЕНИЙ

Резюме

Величина коэффициента внутреннего трения в слое зерна в зависимости от переменных условий хранения и климатических факторов имеет особенное значение в строительстве транспортных устройств, хранилищ, силосов и сельскохозяйственных машин.

В работе были адаптированы методика и прибор трехосного сжатия, применяемый в грунтоведении, для определения напряжений, выступающих в слое зерна.

На основании полученных результатов были определены пределы изменчивости коэффициента внутреннего трения и напряжений в зависимости от геометрических параметров зерна, климатических условий и толщины слоя.

Величина коэффициента для пшеницы колебалась в пределах 0,42-0,86.

Результаты измерений сравнивались с другими методами, актуально применяемыми в агрофизических исследованиях.

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