

THE CRUSHING STRENGTH OF LOESS SOIL AGGREGATES IN RELATION TO SOIL
DENSITY AND MOISTURE

J. Lipiec, S. Tarkiewicz

Institute of Agrophysics, Polish Academy of Sciences, Lublin,
Poland

S y n o p s i s. The authors carried out experiments to determine the crushing strength of loess soil aggregates 1 cm^3 in volume and 1 cm high. The aggregates, of various densities, were taken from fields subjected and not subjected to tractor traffic kneading. The crushing strength of the aggregates was determined by means of an Instron strength testing apparatus. The paper presents and discusses the results of the crushing strength of soil aggregates as a function of soil moisture and density.

INTRODUCTION

The crushing strength of soil aggregates is an important parameter characterizing the susceptibility of soil to compaction [1, 2, 4]. Dominant factors determining this characteristic are the density and moisture of aggregates.

It has been shown [4] that changes in the density of spherical aggregates of 2.5 cm in diameter, caused by tractor wheel traffic, found a reflection in an over 300% increase in their crushing strength as determined at a moisture content corresponding to the field water capacity. Moisture affects the crushing strength of aggregates mainly through changes in their cohesion, the values of which depend on the density of the aggregates. The effect of both moisture and density on the crushing strength of aggregates depends on the size of soil aggregates [2].

The present paper discusses the effect of moisture and density in the crushing strength of soil aggregates, of constant size, taken from a loess soil.

METHOD

The study was carried out on a brown soil developed from loess of the following granulometric composition: 1.0-0.1 mm - 2%, 0.1-0.02 mm - 56%, below 0.02 mm - 42%, below 0.002 mm - 13%, and a humus content in the arable horizon - 1.48%. Moisture content corresponding to field water capacity is 23.2% by weight, and the moisture content corresponding to the wilting point - 6.4% by weight.

Cylindrical soil aggregates, 1 cm³ in volume and 1.128 mm in diameter, were cut from the soil by means of a device described by Rząsa and Owczarzak [3]. The known volume of the aggregates permits an easy calculation of their density.

Various states of soil compaction were obtained in compacted and non-compacted plots by means of single, triple, and eightfold passes of a tractor weighing 5230 kg (inflation pressure of rear tyres - 160 kPa, of front tyres - 200 kPa). Aggregates were taken, moist, from a depth of 5-10 cm.

Measurements of crushing strength were made at various moisture contents of the aggregates, using an Instron strength-testing apparatus in which the aggregates were subjected to crushing force.

Disintegration products, obtained as a result of crushing of soil aggregates, were screened air dry through sieves of 10, 7, 5, 3, and 1 mm mesh, after which the percentage content of particular products of disintegration was determined. These measurements were made for aggregates crushed at the lowest moisture levels.

RESULTS

The results of the crushing strength of aggregates as a function of moisture are presented in Fig. 1. The results indicate that the effect of the examined densities of aggregates on their crushing strength depended on the moisture content of the aggregates, and increased with decreasing moisture. At moisture contents close to the field water capacity the crushing strength values of aggregates of various densities were alike. At a moisture content corresponding to the wilting point (6.4% by weight) the crushing strength of aggregates of a density of 1.338 kg dcm⁻³ was 0.381 MPa, and increased with increasing density to 1.562, 1.598, and 1.655 kg dcm⁻³, by 76, 103, and 153%, respectively.

The effect of moisture on crushing strength increases together with increasing density of the aggregates. Values R² of regression equations (Fig. 1) indicate that moisture is the principal factor determining the crushing strength of aggregates.

The data in Table 1 indicate that more compacted aggregates disintegrate, during the crushing strength measurement, to a greater degree into smaller fragments

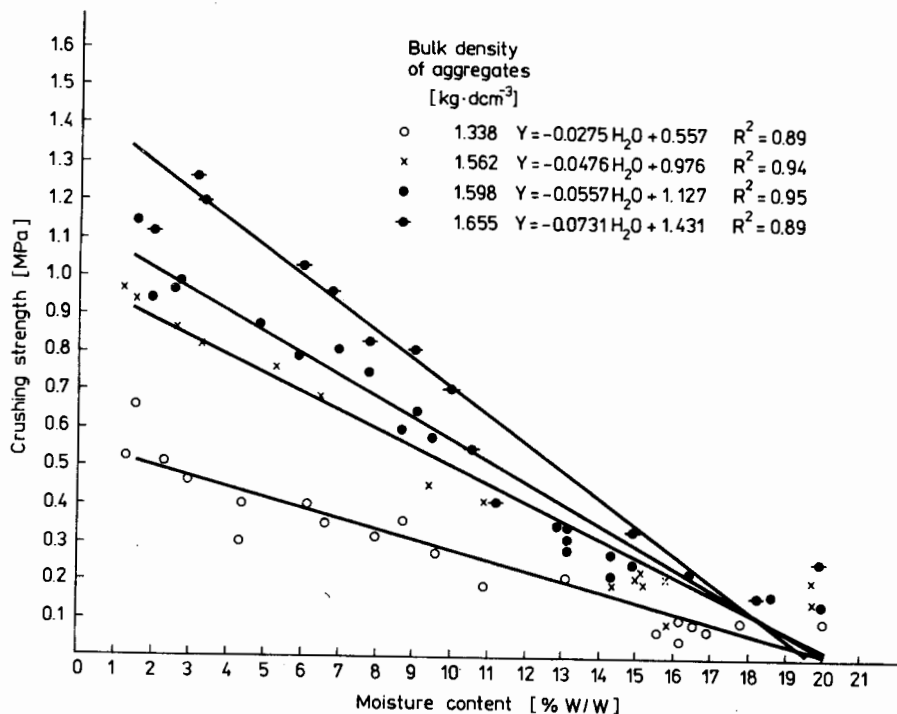


Fig. 1. Crushing strength of soil aggregates of different density as a function of moisture content

Table 1

Products of disintegration obtained as a result of aggregates crushing at moistures of 2-2.8% by weight

Density of aggregates kg dcm ⁻³	Percentage content of aggregates				
	10-7 mm	7-5 mm	5-3 mm	3-1 mm	1 mm
1.338	81.0	6.9	4.9	4.3	2.9
1.562	54.8	18.4	11.9	9.8	5.1
1.598	20.4	31.6	19.3	14.3	14.4
1.655	24.8	12.6	23.8	16.1	22.7

than aggregates from reference plots. This indicates a different character and a different number of bonds between soil particles per a volume unit of particular aggregates.

CONCLUSIONS

The crushing strength of cylindrical aggregates of loess soil, 1 cm^3 in volume decreases in a linear progression together with increasing moisture, and increases with increasing density. The effect of moisture, especially in the range of its lower values (less than 20% by weight), on the crushing strength of aggregates, increases with increasing density of the aggregates. The effect of density of aggregates on their crushing strength increases with a decrease in their moisture.

REFERENCES

1. Lipiec J., Tarkiewicz S.: Sensivity of soil to compaction as a factor of rye root distribution. Trans. of the XIII Congr. of ISSS, Hamburg 1986, III, 106-107.
2. Lipiec J., Tarkiewicz S.: Influence of water content on crushing strength loamy soil aggregates of various bulk density. Polish J. Soil Sci. (in press).
3. Rząsa S., Owczarzak W.: Modelling of soil structure and examination methods of water resistance, capillary rise and mechanical strength of soil aggregates. Annales of Poznań Agric. Univ. Scientific Dissertations 1983, 135, 3-35.
4. Voorhees W. B., Senst C. G., Nelson W. V.: Compaction and soil structure modification by wheel traffic in the Northern Corn Belt. Soil Sci. Soc. Am. Proc. 1978, 42, 344-349.

Translator: T. Bylica

J. Lipiec, St. Tarkiewicz

WYTRZYMAŁOŚĆ NA ZGNIATANIE LESSOWYCH AGREGATÓW GLEBOWYCH W ZALEŻNOŚCI
OD GĘSTOŚCI I WILGOTNOŚCI GLEBY

S t r e s z c z e n i e

Przeprowadzono badania wytrzymałości na zgniatanie agregatów gleby lessowej o objętości 1 cm^3 i wysokości 1 cm , pobranych z poletek o różnej gęstości gleby poddanej wcześniej zabiegom ugniatania. Wytrzymałość na zgniatanie oznaczono przy pomocy aparatu do badań wytrzymałościowych Instron. Praca omawia wyniki wytrzymałości agregatów na zgniatanie w funkcji wilgotności i gęstości.

Е. Липец, С. Таркевич

ПРОЧНОСТЬ НА РАЗРУШЕНИЕ ЛЕСОВЫХ ПОЧВЕННЫХ АГРЕГАТОВ
С УЧЕТОМ ВЛАЖНОСТИ И ПЛОТНОСТИ ПОЧВЫ

Р е з ю м е

Провели исследования прочности на разрушение агрегатов лессовой почвы объемом 1 см^3 и высотой 1 см , взятых с дежанок с разной плотностью почвы, подвергнутых раньше уплотнению. Прочность на разрушение определили при помощи прибора для прочностных исследований „INSTRON”. Работа рассматривает результаты прочности агрегатов к разрушению в функции влажности и плотности.