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IMPACT OF PLATE DIAMETER AND SAMPLE HEIGHT ON THE DETERMINED PRE-COMPACTION VALUE[1]

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ABSTRACT

The objective of the paper was to verify previously obtained results of research on the impact of the plate diameter on the determined value of pre-compaction stress of soil (*NG)* with a wider selection of dimensions of samples. Tests were carried out on samples with a diameter (*D*) of 100 mm and heights (*H*) of 30, 50 or 100 mm produced from the soil material (*M*) or collected (*NNS*) from subsoil with the granulation group of: silt loam, loam, sandy loam, sandy clay loam. The following soil properties were determined: granulation type, density of the solid phase, content of humus and calcium carbonate, reaction, plastic and liquid limit. Properties of samples were described with moisture, dry density of solid particles, porosity of aeration, degree of plasticity and saturation. Samples were loaded with plates of varied diameters. The *NG* value was calculated with the method of searching for the crossing point of tangents with the secondary stress curve and the virgin stresses curve (a traditional method). It was stated that the plate diameter (*d*) and sample height (*H*) do not influence the measurement results when the relation *d/D* is within $0.5 \leq d/D \leq 0.8$ and the ratio *D/H* equals 2. It is possible to omit the condition *d/D* in a situation when soil is low cohesive and its degree of moisture is ca. 0.41-0.44.

Introduction

Excessive soil compaction by machines and tractors leading to unfavorable changes in soil properties is one of the most serious problems of contemporary agriculture (Krasowicz et al., 2011). Soil compaction increases when the pre-compaction resistance to compaction, which can be defined with a pre-compaction stress, is exceeded. It is considered that knowing the value of the stress enables forecasting the pre-compaction loading of soil with driving mechanisms, exceeding of which creates a threat of increase of its compaction (Horn and Fleige, 2003**)**. A utilitarian meaning of the pre-compaction stress causes that this parameter is the object of research in many countries in the world. Complexity of the soil

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environment and changes of its properties cause that no standard method of determination of this parameter has been developed yet (Błażejczak, 2010).

The current research results do not give an explicit answer to the question what conditions are required to carry out the soil loading (Dawidowski et al., 2003; Śnieg et al., 2008; Błażejczak, 2009; Mosaddeghi et al., 2007). Thus, an attempt was made to investigate the impact of the plate diameter on the value of the determined pre-compaction stress of soil (*NG*). Based on the measurements carried out on the model samples made of soil material (*M*) or collected from the subsoil of selected soils (*NNS*) with a varied granulation group, it was found out that the ratio of the plate diameter *(d)* to the internal diameter of the cylinder (*D*) should be within $0.5 \leq d/\mathrm{D} < 0.8$, and that the relation between the value of the determined pre-compaction stress of the sample and the diameter of the plate may affect the soil moisture (Błażejczak and Dawidowski, 2016). Moreover, it was stated that further generalization of the results obtained so far requires further research especially with reference to various heights of samples. It is justified since the soil compaction resistance in a stiff ring is affected both by the manner of sample deformation (Earl, 1997) as well as sample dimensions (Koolen, 1974). A deformation method is related to the proportion of the plate diameter to the sample diameter (*d/D*). In case of the sample size, a relation of the sample diameter to its height (*D/H*) is significant.

Objective, scope and methods of research

The objective of the paper was to investigate the plate diameter effect on the determined value of the pre-compaction stress of soil for samples with a varied height. Simultaneously, the aim was to determine ratios *d/D* and *D/H* at which the impact of the plate diameter or sample height on the determined value of the pre-compaction stress of soil is not reported.

The research material was sampled from the selected soils of Szczecin Lowland *[Nizina Szczecińska]* in the form of loose soil mass with the use of steel cylinders (further called samples with intact structure – *NNS*). The material was sampled from sublayers of subsoil with the thickness of 5 cm located 25 to 60 cm in-depth in the period of spring or autumn field works from the rural areas of: Obojno (*Ob*), Ostoja (*Os*), Skarbimierzyce (*Sk*), Reńsko (*Re*), Nowy Przylep (*Np*), Kurcewo (*Ku*). A depth on which samples were uptaken depended on the actual moisture level, which guaranteed research material of the proper quality, was obtained. In case of *NNS* samples, only those were qualified for further research in which no soil cracks in the cylinder were reported.

Loose soil material was used for determination of the investigated soil properties and for formation of model samples (*M*). Granulometric group acc. to PTG (2009) *[Polish Society of Soil Science]* was determined with Bouyoucosa-Casagrande's method in Prószyński's modification. Density of the solid phase was determined with a pycnometer method and the humus content, soil reaction and calcium carbonate with respective methods: Tiurin's, electrometric and Scheibler's method. The plastic limit was measured with the rolling method and the liquid limit with the use of Cassagrande's apparatus.

Production of model samples (*M*) consisted in collection of soil material from three objects (soils) with clearly varied properties. The next step consisted in sieving the moist material through a 6 mm diameter screen, and in ingle-axis compaction (Fig. 1 a) in steel rings (cylinders) with identical dimensions as during collection of *NNS* samples i.e. with an internal diameter (*D*) equal to 100 mm and heights (*H*) of: 30, 50 or 100 mm. The mass of the sieved soil material used for filling a cylinder was selected in a way that enabled obtaining the volumetric density of the model samples *M* similar to the density of *NNS* samples determined in these soils during previous field research (Błażejczak et al., 2010). However, in relation to the height of samples the soil material was compacted as one layer (*H*30) or divided into 2 (*H*50) or 3 (*H*100) parts and then compacted. It aimed at obtaining samples with a uniform distribution of density in their volume. In *M* and *NNS* samples the following properties were determined: water moisture content and dry density of solid particles, porosity of aeration, plasticity degree, moisture content. Moreover, the ratio of moisture to the moisture corresponding to the plastic limit of the investigated soils was calculated.

Samples *M*, and *NNS* were subjected to the load (Fig. 1b) with the use of a testing machine with plates of varied diameters (*d*). The number of iterations and diameter of plates was determined by analysis of the outcomes of previous research (Błażejczak and Dawidowski 2016b). The *M* samples were loaded in three iterations with plates of the following diameters: 20, 30, 50, 70, 80, 90 and 98 mm. Tests in samples *NNS* were carried out in five iterations with the use of plates with the following diameters: 30, 50, 80 and 98 mm The recorded courses of unit stress of plates from deformation of samples served for determination of their pre-compaction stress (*NG*). The value of *NG* was determined with the so-called classical method (Błażejczak and Dawidowski, 2016a).

a)

b)

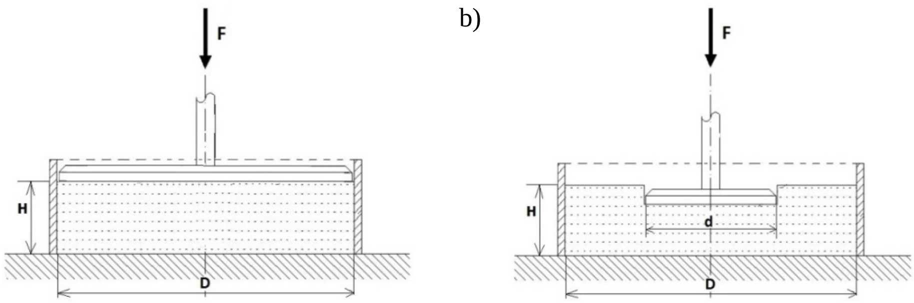

Figure 1. Methods of: a – formation of model samples, b – deformation of model samples (M) and with the so-called intact structure (NNS)

In order to select the range of diameters *d*, for which the plate dimension does not influence the value of the determined pre-compaction stress, and to investigate the impact of the sample height on the *NG* value, a single-factor analysis of variance with post-hoc Tukey's test was carried out. Division into uniform groups was carried out at α=0.05.

Results and analysis

Table 1 includes the results of measurement of the selected properties of the investigated soils. One may notice that they take varied values. Relative density (2.43 – 2.66 $g \cdot cm^{-3}$) is typical for mineral soils. Soil reaction is from weakly acid to weakly alkaline (pH 5.08 –

6.84). The humus and calcium carbonate content, the values of plastic and liquid limit are respectively within: 0.58-3.77%, 0.00-5.00%, 14.1-28.0% moisture weight and 17.0-47.9% of moisture weight %. Moreover, the textural group of soil is varied. The content of sand, clay and dust (not provided in table 1) are changing respectively within 25.0-60.5%, 24.5-52.4% and 8.9-27.0%. Analysis of the values of the above-mentioned properties enables a statement that the research material came from soils which were exposed to permanent and strong deformation during their compaction in the state of high moisture level.

Table 1.
Results of determination of own properties of the investigated soils

Object	Type of samples	Layer	$\rho_{s,}$	Reaction (in KCI)	Z_{pr}	Content of $CaCO_3$	w_P	w_L	Textural group (PTG 2009)
		(cm)	($g \cdot cm^{-3}$)	(pH)	(%)		(% w/w)		
NP	*M, NNS*	35-40	2.46	6,34	2,02	2,5	21,3	31,2	silt loam
Ob	*M, NNS*	35-40	2,49	6,84	3,77	0,04	28,0	47,9	loam
Os1	*M*	35-40	2,66	5,10	0,60	0,00	18,4	27,6	loam
Os2	*NNS*	25-30	2,52	5,08	1,03	0,00	14,1	17,0	sandy loam
Ku	*NNS*	35-40	2,55	6,66	0,58	0,00	15,0	18,9	sandy loam
Re	*NNS*	25-30	2,43	6,21	3,32	5,00	23,5	32,2	silt loam
Sk	*NNS*	25-30	2,50	6,23	1,78	0,00	21,8	39,2	sandy clay loam

Symbols: ρ_s – specific density, Z_{pr} – humus content, w_P – plasticity limit, w_L – liquid limit

Table 2 presents results of determination of properties of samples *M*. It may be noticed that within each object values of particular properties of samples were similar which means that they were uniform. Water content of soils (*w*) was lower than their plastic limit (table 1) and their plastic degree had negative values, which proves that samples in the moment of deformation had solid consistency (Wiłun, 2003).

Table 2.
Results of determination of properties of model samples (M)

Facility	H	w	ρ_d	n_a	I_L	S_r	w/w_p
	(mm)	(% w/w)	($g \cdot cm^{-3}$)	(%)	(-)	(-)	(-)
	30	19.1(0.6)	1.46(0.05)	12.5(2.3)	-0.22(0.06)	0.69(0.05)	0.90(0.03)
NP	50	19.1(0.1)	1.50(0.01)	10.1(0.3)	-0.22(0.01)	0.74(0.01)	0.90(0.01)
	100	19.0(0.4)	1.48(0.00)	11.5(0.5)	-0.23(0.04)	0.71(0.01)	0.89(0.02)
	30	23.1(0.3)	1.43(0.01)	9.3(0.7)	-0.25(0.02)	0.76(0.01)	0.82(0.01)
Ob	50	23.1(0.8)	1.48(0.02)	6.7(0.8)	-0.24(0.04)	0.84(0.02)	0.83(0.03)
	100	22.9(0.9)	1.47(0.01)	7.1(0.6)	-0.26(0.04)	0.83(0.02)	0.82(0.03)
	30	12.7(0.1)	1.46(0.01)	26.5(0.6)	-0.62(0.01)	0.41(0.01)	0.69(0.00)
*Os*1	50	12.8(0.2)	1.49(0.01)	25.1(0.7)	-0.61(0.02)	0.43(0.01)	0.70(0.01)
	100	13.3(0.2)	1.48(0.01)	24.8(0.3)	-0.56(0.03)	0.44(0.01)	0.72(0.01)

Symbols: H – sample height, w – water content, ρ_d – dry density of solid particles, n_a – porosity of aeration, I_L – plastic degree, S_r – moisture degree

Results of *NG* of samples produced in laboratory conditions (*M*) and post-hoc Tukey's test, which was carried out, were presented in table 3. In case of objects *Np* and *Ob* with a relatively high values of ratio w/w_p, which is respectively within 0.89-0.90 and 0.82-0.83 (Table 2), the obtained values of *NG* for particular *H* significantly depended on the plate diameter (*d*). For the facility *Os*1, for which ratio w/w_p was 0.69-0.72, it was found out that the value of *NG* does not significantly depend on *d*, when *H* of samples equals 30 mm and in case of samples *H*50 or *H*100, when *d* it is respectively within *d*30 – *d*80 and *d*20 – *d*80. These results are compliant with the results described in the previous paper (Błażejczak and Dawidowski, 2016b) which proved that the significant impact of the plate diameter on the determined value of *NG* is reported when the moisture of samples is close to their plastic limit value. By analysis of the obtained values of the *NG* and their standard deviations in relation to the height of the sample (*d*) and the plate diameter (*d*) one may also notice (tab. 3) that:

- there is a clear trend except for the object *Os*1, that the *NG* value decreases along with *d* of the plate regardless *H* of the sample;
- there is a clear trend except for the object *NP*1, that the *NG* value decreases along with *H* of the sample regardless *d* of the plate;
- scatter of *NG* values, measured with standard deviation, was often higher for plates *d*20 and *d*30 or *d*90 and *d*98, which was also confirmed by results of calculations of variability of this property;
- *NG* of objects *NP* and *Ob* deformed with plates *d*20 or *d*30, for particular *H*, are often significantly higher than those obtained for *d*50;
- *NG* of investigated objects, for particular *H* often belongs to the same uniform group (*a*) for the following ranges of plate diameters: *d*50 - *d*80 or *d*50 – *d*98;
- *NG* of the investigated objects calculated for *H*50 often (in 13 cases) do not differ significantly from those obtained for *H*30 or *H*100 – uniform groups marked with big letters;
- the highest number of cases of *NG* values which are close to an average value calculated within a particular object were reported for samples with the height of *H*50 mm.

Conclusion of analysis of the results obtained on *M* samples for particular *H* of samples of the investigated objects should lead to a statement that the plate diameter does not affect the measurement results if relation *d/D* is within $0.5 \leq d/D \leq 0.98$ or $0.5 \leq d/D \leq 0.80$. However, when comparing *NG* values obtained for plates *d*80 to *d*90 or *d*98 it may be assumed that relation of *d/D* should be within $0.5 \leq d/D \leq 0.80$, which complies with the results of the previous research (Błażejczak and Dawidowski 2016b). Moreover, it is possible to omit the condition *d/D*in the situation when soil is low-compacted – a difference between w_L and w_P is from 1 to 10% (tab. 1) – and water saturation is relatively low S_r = 0.41-0.44 (Table 2). It was also reported that *D/H ratio* should be close to 2, because it allows reduction of the impact of the sample height on the results of the determined pre-compaction stress of soil (*NG*).

Table 3.
Results of calculations of pre-compaction stress (NG) of model samples (M) of selected objects for their particular heights (H) and applied plate diameters(d)

Object	*H*	*d* (mm)							$\overline{X}_H$
		20	30	50	70	80	90	98	
	(mm)	*NG* (kPa)							
NP	30	318(22) c A	288(17) bc A	258(9) ab A	240(4) a A	246(12) a A	221(14) a A	222(10) a A	257
	50	304(19) b A	278(10) ab A	250(7) a A	267(5) a B	274(7) a B	260(10) a B	253(5) a B	269
	100	297(11) d A	284(8) cd A	241(7) a A	239(11) a A	261(8) abc AB	275(8) bcd B	251(11) ab B	264
	$\overline{X}_P$	306	284	250	249	261	252	242	263
Ob	30	394(10) d B	345(16) c B	309(11) ab C	294(12) ab C	295(9) ab C	316(6) bc C	278(13) a B	319
	50	426(10) d C	342(16) c B	246(9) ab B	236(5) ab B	232(8) a B	267(10) b B	250(15) ab B	286
	100	249(14) c A	219(13) b A	177(7) a A	160(3) a A	174(12) a A	173(13) a A	169(7) a A	189
	$\overline{X}_P$	356	302	244	230	234	252	232	264
*Os*1	30	60(8) a B	64(13) a B	57(5) a C	57(7) a B	59(7) a B	67(9) a B	63(7) a C	61
	50	58(8) b B	50(6) ab AB	42(3) a B	41(4) a B	46(4) ab B	60(8) b AB	47(3) ab B	49
	100	37(5) ab A	30(4) a A	28(3) a A	29(2) a A	30(4) a A	43(5) b A	31(6) a A	33
	$\overline{X}_P$	52	48	42	43	45	57	47	48

Symbols: $\overline{X}_P$ – average value for the column $\overline{X}_H$ – average value for the line; brackets include a value of standard deviation; small letters stand for uniform groups in lines and with capital letters in columns - within a particular object

Table 4 contains results of measurements of soil samples properties collected in field conditions (*NNS*). Within the object, the properties of samples were similar, which means that they can be considered as uniform. Values of the ratio w/w_p of *NNS* samples were more varied that those calculated for samples *M* (Table 2) and were within 0.69 to 1.25. Samples *NNS* were deformed in the solid or plastic consistency since I_L was within -0.44 to 0.96 (Wiłun, 2003).

Table 4.
Results of determination of properties of samples collected in field conditions (NNS)

Object	H (mm)	w (% w/w)	ρ_d ($g \cdot cm^{-3}$)	n_a (%)	I_L (-)	S_r (-)	w/w_p (-)
	30	21.1(1.4)	1.49(0.07)	7.9(5.1)	-0.02(0.14)	0.81(0.11)	0.99(0.06)
NP	50	20.1(0.9)	1.49(0.06)	9.4(3.6)	-0.11(0.09)	0.77(0.08)	0.95(0.04)
	100	20.4(0.7)	1.53(0.04)	6.4(2.2)	-0.09(0.07)	0.83(0.05)	0.96(0.03)
	30	22.4(0.7)	1.52(0.00)	4.9(1.9)	-0.28(0.03)	0.87(0.04)	0.80(0.02)
Ob	50	19.2(2.1)	1.65(0.08)	2.9(2.4)	-0.44(0.11)	0.94(0.07)	0.69(0.08)
	100	22.7(2.1)	1.57(0.05)	1.5(1.0)	-0.27(0.10)	0.96(0.03)	0.81(0.07)
	30	15.3(1.2)	1.63(0.10)	10.2(3.0)	0.40(0.41)	0.71(0.06)	1.08(0.08)
*Os*2	50	14.6(0.1)	1.66(0.06)	10.0(2.5)	0.16(0.33)	0.71(0.05)	1.03(0.07)
	100	14.4(1.1)	1.72(0.04)	6.7(1.5)	0.11(0.39)	0.79(0.04)	1.02(0.08)
	30	17.1(2.3)	1.52(0.06)	14.4(5.5)	0.55(0.42)	0.65(0.13)	1.15(0.17)
Ku	50	18.8(2.0)	1.55(0.04)	9.3(3.1)	0.96(0.11)	0.76(0.08)	1.25(0.09)
	100	18.2(1.7)	1.53(0.05)	11.0(1.7)	0.81(0.10)	0.72(0.04)	1.21(0.08)
	30	25.5(0.8)	1.34(0.10)	10.7(3.4)	0.23(0.10)	0.77(0.07)	1.09(0.04)
Re	50	23.2(0.9)	1.41(0.06)	9.4(3.0)	-0.03(0.10)	0.78(0.06)	0.99(0.04)
	100	23.1(0.4)	1.49(0.02)	3.8(1.2)	-0.04(0.05)	0.90(0.03)	0.98(0.02)
	30	17.0(0.9)	1.65(0.06)	6.2(2.7)	-0.28(0.05)	0.82(0.07)	0.78(0.04)
Sk	50	16.2(0.7)	1.68(0.05)	5.9(1.9)	-0.32(0.04)	0.82(0.05)	0.74(0.03)
	100	15.6(0.8)	1.70(0.05)	5.7(2.1)	-0.36(0.04)	0.82(0.05)	0.71(0.03)

Symbols: see table 2

Table 5 includes results of calculations of the pre-compaction stress (*NG*) of soil samples uptaken in field conditions (*NNS*) and the post-hoc Tukey's test. By analysis of the *NG* value and their standard deviations in relation to the sample height (*H*) and plate diameter (*d*) one may notice (tab. 5) that:

- *NG* values often decrease, except for *Ob* (*H*30) and *Re* (*H*100), along with the increase of the diameter of the plate (*d*) regardless the sample height (*H*);
- *NG* values often decrease except for *d*30 objects *Ob* and *Os*2 and *Sk* also *d*50 and *d*80 of the object *Ob*, along with the increase of the sample height (*H*), regardless the diameter (*d*) of a plate;
- *NG* values obtained on samples deformed with plates *d*30 and *d*50, within all objects differed significantly in 13 cases;
- *NG* values obtained on samples deformed with plates *d*50 and *d*80, within all objects differed significantly in 5 cases;
- *NG* values obtained on samples deformed with plates *d*50 and *d*98, within all objects differed significantly in 11 cases;
- *NG* values obtained on samples deformed with plates *d*80 and *d*98, within all objects differed significantly in 4 cases;
- in 19 cases the *NG* values obtained within all objects on samples *H*50 did not differ significantly from those with values *H*30 or *H*100;

– the highest number of cases of *NG* values which are close to their average value, within a particular object were reported for samples with the height of *H*50 and plate diameter *d*50;
– scatter of *NG* results, measured with a standard deviation was at the average the highest for plates *d*30, but variability coefficient of this property was often the highest for *d*98, which may prove a chaotic course of the soil compaction process in a situation when the plate diameter is close to the cylinder diameter.

Table 5.
Results of calculations of the pre-compaction stress (NG) of samples collected in the field (NNS) for their selected heights (H) and applied plate diameters (d)

Object	H	*d* (mm)				$\overline{X}_H$
		30	50	80	98	
	(mm)	*NG* (kPa)				
NP	30	148(22) b B	83(10) a B	65(7) a B	69(12) a C	91
	50	135(22) c B	78(11) b B	59(8) ab B	44(11) a B	79
	100	92(11) c A	55(10) b A	37(9) a A	27(7) a A	53
$\overline{X}_P$		125	72	53	47	74
Ob	30	136(22) c A	53(8) a A	51(14) a A	95(16) b A	84
	50	160(16) c A	117(14) b B	76(13) a B	68(19) a A	105
	100	148(17) c A	97(15) b B	63(14) a AB	51(11) a A	90
$\overline{X}_P$		148	89	63	71	93
*Os*2	30	129(11) c B	112(18) bc B	98(15) b B	66(19) a B	101
	50	112(12) c A	86(14) b A	64(10) ab A	55(11) a AB	79
	100	112(8) d A	71(7) c A	54(7) b A	36(5) a A	68
$\overline{X}_P$		118	90	72	52	83
Ku	30	71(15) b B	66(8) ab C	54(7) ab C	45(9) a C	59
	50	63(12) b B	42(4) a B	31(4) a B	29(7) a B	41
	100	30(10) b A	24(3) ab A	20(3) ab A	15(3) a A	22
$\overline{X}_P$		55	44	35	30	41
Re	30	119(9) b C	48(8) a B	50(10) a B	36(8) a A	63
	50	50(3) b B	46(9) b B	44(9) b B	28(3) a A	42
	100	35(7) a A	30(7) a A	25(7) a A	26(6) a A	29
$\overline{X}_P$		68	41	40	30	45
Sk	30	134(13) c A	92(13) b B	78(11) ab B	69(9) a B	93
	50	139(12) b A	78(13) a AB	72(8) a B	60(9) a B	88
	100	132(13) c A	71(9) b A	43(7) a A	39(8) a A	71
	$\overline{X}_P$	135	80	64	56	84

Symbols: see table 3

Based on the analysis of results obtained for *NNS* samples it was found that *d*/*D* relation should be within $0.5 \leq d/D \leq 0.80$ or $0.80 \leq d/D \leq 0.98$. However, taking into consideration the scatter of results obtained for samples *d*98 and their values in comparison to samples deformed with *d*50 plate it should be assumed that the relation *d*/*D* should be, similarly to M samples, within the range of $0.5 \leq d/D \leq 0.80$. It was also confirmed that *D/H* should be close to 2, because it favors reduction of the impact of the height (*H*) of a sample on the result of the determined *NG*.

It should be emphasized that the results obtained during this study and in the previous studies (Błażejczak and Dawidowski, 2016a; 2016b) do not exhaust the issue since, for example, we still do not know the participation of forces related to the impact of cylinder walls in the compaction resistance of soil, which may influence the determined value of the pre-compaction stress.

Conclusions

Based on the analysis of results of research obtained in this paper and their comparison to the previously obtained by Błażejczak and Dawidowski (2016a; 2016b) following conclusions can be made:

1. If the value of the pre-compaction stress of plastic soils is determined with cylinders with the diameter of (*D*) 100 mm, one may avoid the impact of the plate diameter (*d*) and sample height (*H*) on the result of measurement, when the relation *d/D* is within $0.5 \leq d/D \leq 0.8$ and the ratio *D/H* equals 2.
2. In a situation when soil is low-compacted and its degree of moisture level is approximately 0.41-0.44 the plate diameter (*d*) does not influence the value of the determined pre-compaction stress when a condition that *D/H* equals 2 is maintained.
3. Further generalization of the results obtained so far requires further research since for example participation of forces related to the impact of cylinder walls in the value of the determined pre-compaction stress of soil is unknown.

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WPŁYW ŚREDNICY STEMPLA I WYSOKOŚCI PRÓBKI NA WYZNACZANĄ WARTOŚĆ NAPRĘŻENIA GRANICZNEGO GLEBY

Streszczenie. Celem pracy była weryfikacja wcześniej uzyskanych wyników badań wpływu średnicy stempla na wyznaczaną wartość naprężenia granicznego gleby (*NG*), w warunkach szerszego spektrum wymiarów próbek. Badania przeprowadzono na próbkach o średnicy (*D*) 100 mm i wysokościach (*H*) 30, 50 lub 100 mm, wytwarzanych z materiału glebowego (*M*) lub pobieranych (*NNS*) z warstwy podornej gleb o uziarnieniach: pyłu gliniastego, gliny zwykłej, gliny lekkiej, gliny piaszczysto-ilastej. Oznaczono następujące cechy gleb: skład granulometryczny, gęstość fazy stałej, zawartość próchnicy i węglanu wapnia, odczyn, granice plastyczności i płynności. Właściwości próbek opisano: wilgotnością, gęstością objętościową szkieletu, porowatością aeracji, stopniem plastyczności i stopniem wilgotności. Próbki obciążano stemplami o zróżnicowanych średnicach. Wartość *NG* wyznaczano metodą poszukiwania punktu przecięcia stycznych do krzywej naprężeń wtórnych i krzywej naprężeń pierwotnych (metoda klasyczna). Stwierdzono, że średnica stempla (*d*) i wysokości próbki (*H*) nie wpływają na wynik pomiaru, gdy stosunek *d/D* zawiera się w przedziale $0,5 \leq d/D \leq 0,8$ a iloraz *D/H* jest równy 2. Możliwe jest pominięcie warunku *d/D* w sytuacji, gdy gleba należy do mało spoistych, a jej stopień wilgotności wynosi około 0,41-0,44.

Słowa kluczowe: gleba, wilgotność, naprężenie graniczne, średnica stempla, wysokość próbki