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NONHOMOGENEITY OF THE PHYSICAL PROPERTIES OF GLACIAL TILLS

1. Introduction. Soils usually represent nonhomogenic material due to variable environment of their origin and later post-sedimentation changes. Particularly high variability of sedimentation environments occurs during the origin of glacial tills. Therefore parameters of these soils are characterised by a high variability of values. Analysis of parameters variability has a crucial meaning in engineering geology and geotechnics, because tills commonly cover the surface of Poland. They are also frequently the soil basis for engineering objects.

Analysis of variability is presented for chosen physical parameters of tills within types and sub-types of microstructures. The variability of these parameters is characterised by a statistical parameter – the coefficient of variation. Values of arithmetic means of the parameters are also presented.

2. Lithogenesis and microstructures of tills. Geological conditions of the origin and occurrence of tills, as well as their microstructures are presented by [2].

3. Physical characteristics of tills. The physical characteristics of tills from 83 sampling sites have been subject to investigations [1, 3]. The location of these sampling sites is presented on fig. 1 in [2]. Several physical parameters have been determined: water content, bulk density, porosity, free swell and soaking. These parameters largely depend on the soil microstructure [3]. The analysis of the parameter values were carried out 1) for each microstructure type occurring in tills (skeletal, matrix and matrix-turbulent), 2) for three sub-types (A, B, and C) of the matrix microstructure, and 3) for the microstructure types treated as a whole.

The analysis of physical properties of tills reveals that (tab.):

1. the water content reaches similar values for tills with different types of microstructures. This parameter decreases in tills with the matrix microstructure from sub-type A to sub-type C,
2. the bulk density reaches the smallest values in tills with the skeletal microstructure. The values of this parameter increase for tills with the matrix microstructure, and are the highest in tills with matrix-turbulent microstructure. In tills with the matrix microstructure the bulk density increases from sub-type A to sub-type C,
3. porosity is the highest in tills with the skeletal microstructure, decreases in tills with the matrix microstructure, and is the lowest in tills with the

matrix-turbulent microstructure. In tills with the matrix microstructure the value of this parameter decreases from sub-type A to sub-type C,

4. tills with the skeletal microstructure soak to the largest degree and in the shortest period of time. Tills with matrix microstructure sub-type A soak more intensely and faster that tills with the matrix microstructure sub-type C. For tills with air dry humidity the obtained relations are similar, and soaking processes take place in shorter periods of time and to a larger degree.

The physical properties of glacial tills

Type/sub-type of microstructure	Skeletal		Matrix		Matrix						Matrix-turbulent		Micro-structures (All types)	
					sub-type A		sub-type B		sub-type C					
Properties of glacial tills	$\overline{X}$	ν	$\overline{X}$	ν	$\overline{X}$	ν	$\overline{X}$	ν	$\overline{X}$	ν	$\overline{X}$	ν	$\overline{X}$	ν
Water content w %	**13.5**	39	**13.3**	27	**14.6**	27	**13.6**	23	**10.9**	20	**13.4**	10	**13.3**	27
Bulk density ρ Mg/m^3	**1.90**	5	**2.01**	6	**19.4**	6	**2.00**	5	**2.15**	4	**2.14**	1	**2.01**	6
Dry density ρ_d Mg/m^3	**1.68**	6	**1.78**	8	**1.70**	8	**1.75**	6	**1.94**	6	**1.88**	1	**1.77**	8
Porosity n %	**38.0**	14	**33.6**	17	**36.4**	16	**34.5**	14	**27.8**	15	**29.3**	10	**33.9**	17
Void ratio e	**0.62**	16	**0.52**	27	**0.58**	24	**0.53**	23	**0.41**	29	**0.42**	12	**0.53**	26
Free swell FS %	**0.6**	83	**1.6**	144	**2.2**	127	**1.2**	117	**1.5**	193	**0.2**	100	**1.4**	150
Final water content of free swell w_f %	**24.3**	22	**21.6**	24	**24.2**	22	**21.5**	22	**18.9**	23	**17.6**	13	**21.8**	24
Soaking (with water content) SO_w %	**81**	27	**73**	45	**77**	36	**76**	42	**61**	62	**36**	125	**72**	46
Time of soaking (with water content) h	**12.2**	101	**15.5**	69	**16.8**	61	**13.5**	81	**18.3**	54	**21**	29	**15.2**	71
Soaking (air dry soil) SO_d %	**98**	6	**91**	22	**97**	8	**93**	16	**78**	41	**56**	71	**91**	23
Time of soaking (air dry soil) h	**2.6**	288	**5.9**	164	**4.1**	214	**4.8**	185	**10.8**	104	**18.2**	63	**6.0**	163

$\overline{X}$ – arithmetic average, ν – coefficient of variation, number of samples – 83.

4. Variability of physical properties of tills. Physical parameters of tills present a high nonhomogeneity (tab. 1). The coefficient of variation exceeds sometimes 100%, sporadically even 200%. Nevertheless, for over half (50%) of the investigated parameters, this coefficient does not exceed 25%, and is the lowest for the bulk density.

Typically, nonhomogeneity of physical parameters is the highest for all the microstructures treated as a whole, and decreases for the particular types. A similar relation can be observed for the matrix microstructure treated as a whole. For this microstructure treated as a whole the variability is higher than the variability within the particular sub-types A, B and C.

5. Conclusions. The carried out analysis of physical parameters variability reveals that:

1. the nonhomogeneity of physical properties of tills is often considerably high and may reach 100%; in some cases exceeds 200%,
2. for over half (50%) of the investigated parameters the nonhomogeneity does not exceed 25%,
3. the values of the coefficient of variation for particular types of microstructures are smaller from values of this coefficient for the microstructure treated as a whole. A similar relation exists in the matrix microstructure treated as a whole and its sub-types,
4. the nonhomogeneity of microstructure parameters of tills is usually higher from nonhomogeneity of physical parameters of these soils (see [2]).

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НЕОДНОРІДНІСТЬ ФІЗИЧНИХ ВЛАСТИВОСТЕЙ ЛЬОДОВИКОВИХ ҐРУНТІВ (ВАЛУНОВИХ ГЛИН)

Обрані фізичні параметри льодовикових глин у межах типів/підтипів мікроструктур проаналізовано щодо змінності. Змінність параметрів характеризується коефіцієнтом змінності. Дослідженнями фізичних властивостей охоплено льодовикові глини з 83 місць. Вивчали такі фізичні параметри: вологість, об'ємна густина, поруватість, розмокання. Зазначені параметри суттєво залежать від мікроструктури глини. Для глин з матрицевою мікроструктурою підтипів від A *до* C *вологість і поруватість зменшуються, а об'ємна густина збільщується. Глини з матрицевою мікроструктурою підтипу* A *розмокають більше і за коротший час порівняно з відповідними глинами підтипу* C. *З проведеного аналізу змінності фізичних властивостей випливає, що* 1) *величина неоднорідності фізичних властивостей льодовикових глин може бути значною і часом сягати* 100%; 2) *для понад половини* (50%) *досліджуваних параметрів величина неоднорідності не перевищує* 25%; 3) *значення коефіцієнта змінності фізичних властивостей для окремих типів мікроструктур є меншим від значення цього коефіцієнта для всіх досліджуваних типів мікроструктур, узятих разом.*

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