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RHEOLOGICAL INDICES FOR VERTOSOLS AND PELLOSOLS IDENTIFICATION

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Abstract. *Theories of soil mechanics were concerned with calculating soil loads on masonry retaining walls. Both the cohesive and non-cohesive soils require determinations of soil behavior in the conditions of application of compression strengths, cutting deformation, shear, and penetration. For the Soil Science, mainly for soil survey, has been elaborated in the course of the year 1980, 2003 and 2012 the new Romanian Taxonomy Soil System (SRTS), which are similar with the World Reference Base for Soil resources (WRB), 2014, but not identic. In accordance with SRTS-2012, Vertisols class comprises soil with shrinkage - swelling properties (z), which are manifested from the first 25 cm pending above to 100 cm, and contain ≥ 45% clay. There are two soil types in this class: Vertosol and Pelosol, both of them with z horizon – shrinking and swelling and a vertic horizon, Bzy, namely Vertosol but also Pelosol. For a better identification of the two soil types from the Vertisols Class, respectively Vertosol and Pelosol, the present thesis proposes some rheological indices. we have selected only these indexes which don't need special equipment: Free swelling (UL), (vertic horizon >140%, pelic horizon 100 - 140%); Plastic index, (Ip), (Ip=25-45 pellic horizon, Ip≥45 vertic horizon); lower plastic limit (wp); indexes: volume contraction, Cv, (Cv = 75 - 100 – pellic horizon, Cv > 100 – vertic horizon); activity index, IA, (IA 1,00 – 1,25 – pellic horizon, IA > 1,25 – vertic horizon).*

Keywords*: smectites, slickenside, Vertisols, Rheological index*

INTRODUCTION

In the course of the time, especially beginning from the 20th century, the researches of the soil has been diversified according to the mode of use, respectively as mode of agricultural and silvicultural production, or on the other side the use of soil as raw materials for building and as foundation. In the first case has been developed a lot of methods in order to determine the biological – physical and chemical characteristics and also mineralogical methods. Soil science or Pedology has been developed methods for soil survey and soil evaluation.

In the second case, an ample development for the knowledge of the mechanical characteristics of the earth respectively the soil. Theories of soil mechanics were concerned with calculating soil loads on masonry retaining walls (BERTICI, 2013). Both the cohesive and non-cohesive soils require determinations of soil behavior in the conditions of application of compression strengths, cutting deformation, shear, and penetration (ROGOBETE, 2015)

The analysis in Soil Science and the establish the rheological properties in Soil Mechanics need complicated apparatus. There are used standard methods for all type of analysis and trials, in the laboratory or in the field.

It can be appreciated that between the Soil Science and Soil Mechanics there is not a good communication. The both branch of the research became a great development in the latest decades. For the Soil Science, mainly for soil survey, has been elaborated in the course of the year 1980, 2003 and 2012 the new Romanian Taxonomy Soil System (SRTS), which are

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similar with the World Reference Base for Soil resources (WRB), 2014, but not identic. At the Romanian Soil System have collaborated as co-author Professor Gh. Rogobete and D. Țărău.

The soil cover from the plaine of Banat has inherited a large area with water excess and a great quantity of clay inherited from the existing swamps which covered about 800000ha (GRISELINI, 1779). These soil types has been named "lăcoviști asfaltoide" Oprea C.V (1960) and "smolnița" Teaci (1964).

A scientific paper published in the year 1998 of Rogobete and collaborators, emphasized the evolution of the classification system for soils in the Low Plain of Banat, in the conditions in which the whole plaine has evaluated during the centuries (Ianoș, 1994). The complexity process which appear as a result of the drainage works have been discussed about subsidence phenomena (ROGOBETE, 1992).

A study of the territory Uivar (1:10000), effectuated with OSPA – Timis, reveals a plot with a high content of mobile P (828 ppm) and K mobile (840 ppm). A group of archeologists have identified a tell site Radiocarbon dating of charcoal embedded ages of 5726-5862 years BP of the inner ditch system (DRASOVEAN, 2004). The sedimentation rate was 0.7m at each 900 years. Numerous researches were dedicated for fine – textured soils, named also heavy soils (PUSCA, 1987, ROGOBETE, 1972). Because the clay, in the Low Plaine are very rich in clay mineral, especially smectite. The wetting and drying cycles cause these clays to expand and contract, generating the soil type – Vertisols. As a result of shrinking and swelling the vertic structure has either slickensides or wedge – shaped with shiny surfaces (vertic horizon) (TEACI, 1990, ROGOBETE, 1979). In accordance with SRTS – 2012, Vertisols have shrinkage – swelling properties in the first 100 cm and contain ≥ 45 % clay < 2μ. There are two soil types in this Soil Class: Vertosol and Pelosol. The difference between these soil types is difficult to establish at the soil profile. A trial was made in a paper (BERTICI, 2005). It has been used 290 soil profiles from the Aranca Plain (SV Romania). The main conclusion is that Vertosol has a high cation exchange, > 35 me and Pelosol a CEC < 30 me.

A great number of papers relates to the behavior soil as foundation for building (DRON 1984, MAIOR, 1973, ROGOBETE, 2005).

The land improvement specialization of the Polytechnical University Timisoara has imposed to concern in the soil studies with the rheological properties. During the many years have been effectuated geotechnical study for antennas height above average terrain and also for civil building in the varied soil conditions (ROGOBETE, 2005, 2016), about 30 – 40 studies, for example Timișoara, Jebel, Mașloc, Bătrâna etc.

The methods used in these studies are content either in the books (PĂUNESCU, 1974, ROGOBETE, 1999, DUMITRU, 2009). For the Vertosol – Pelosol differentiation, the methods were modified and accommodated to the rheological properties, especially to understanding the results of the determination. In this manner have been calculated some indexes like swelling index, activity index, contraction index, plastic index (ROGOBETE, 2016), (SRTS, 2012).

In fact, the rheological behavior depends of the content of mineralogical clay, respectively smectite or illite (ROGOBETE, 1979).

The problem is caused by the Vertic Pelosols, which has and Bzy and by the Pelosols which are formed on the fluvic materials rich in humus, with a croma ≤ 2.

Romanian System (2012) proposes a quantitative define for the shrinkage - swelling horizon (page 32) with the rheological indexes, like free swelling (ROGOBETE) and coefficient of volume expandable COVE (Mocanu și Florea).

WRB (2014) proposes two types of vertic horizons: protovertic and vertic:

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- protovertic horizon with ≥ 30% clay, and one or more of wedge shaped soil aggregates, or slickensides, or shrink-swell cracks, or a COLE of ≥ 0,06, and a thickness of ≥ 15 cm
- vertic horizon, with ≥ 30% clay, and one or both of wedge shaped and aggregates with longitudinal axis tilted between ≥100 and ≤ 600 from the horizontal, or slickensides, and shrink-swell cracks, and a thickness of ≥25 cm.

WRB specifies that the wetting and drying cycles cause the smectitic clays to expand and contract. In the subsoil, expansion and contraction causes slickensides on the parallelepiped structure faces.

MATERIAL AND METHODS

For a better identification of the two soil types from the Vertisols Class, respectively Vertosol and Pelosol, the present thesis proposes some rheological indices, frequently used in Soil Mechanics and utilized of the paper authors in the construction foundation and also for the soil researches.

The proposed method follows the standards, and the understanding of the analytical results relies on the own scientific researches with clayey soils utilized for agriculture or constructions.

RESULTS AND DISCUSSIONS

The rheological indexes which have presented in the scientific paper (Rogobete, 2005) can be analyzed throughout of all laboratory experiment from the Agrochemical and Pedological Studies Offices from Romania, because we have selected only these indexes which don't need special equipment.

1. Free swelling (UL)

The trial relies on the properties of colloidal system to sedimentation, namely the setting the colloidal particles in the gravitational field.

In the liquid dispersium medium, like distillated water, the colloidal particles named "lyosols" are complied with gravitational forces and viscosity resistance.

From a soil sample of 100 – 150 g, oven dry at 1050C, grinded and sieving by 0.5 mm sieve, we will take 13 g soil with medium compaction, corresponding with 10 cm3 volume.

In a graduated cylinder of 100 cm3 will be introduced 80 cm3 distillated water and the 13 g soil sample. After a short stirring. After 4 - 5 hours it must restirring the cylinder and add with water until 100 cm3, but must be involved entire quantity of soil sample. On the next day it will be reading the final volume (Vf).

For every determination must be effectuated 5 repetitions, the value of free swelling is the average of the 5 repetitions.

$$U_L = 100(V_f - 10)$$

where the: U_L – free swelling

V_f – final volume (cm^3)

The significance of results:
- vertic horizon >140%
- pelic horizon 100 - 140%

2. Plastic index, Ip

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Between certain conditions of moisture content the soil behaves as a plastic body, namely suffer an irreversible deformation beneath action some external loadings, without to change the volume.

The moisture contents which delimit lower and upper the plastic behavior are named plastic limits.

Lower plastic limit (wp) or kneading limit, represents the minimum moisture content at which the behavior of soil passes from the semisolid state to the plastic state.

Upper plastic limit (wL), or flow limit, represents the maximum moisture content, up to which the clayey soil has a plastic behavior and demarcate passes to the flow state.

Plastic index, (Ip) results from the difference between upper plastic limits and lower plastic limit.

$$I_p = w_L - w_p$$

a) Determination of upper plastic limit (w_L)

The determination needs a piece of laboratory apparatus named Cassagrande (fig. 1) which is composed of a bowl from copper and a lever which raise or descend the bowl on 10 mm height and fall down on an ebonite support with a frequency of 120 fallings/minute.

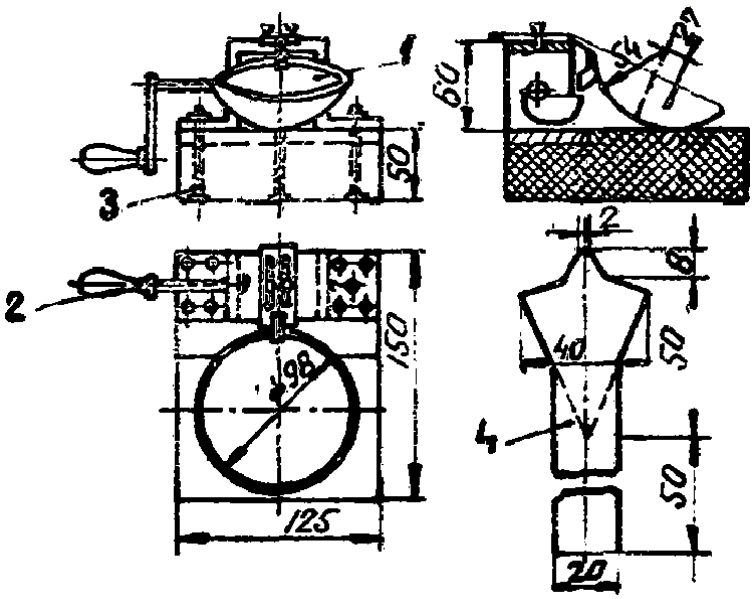

Figure 1. Cassagrande apparatus

The soil sample, air dry, grinded and sieved of 0.2 - 0.5 mm sieve, will be pestled and kneaded with so much water how the sample needs to become a soft paste.

The paste will be introduced into the bowl (2/3 from the bowl volume) and leveled. With the spatula we make a cut deep until the base of bowl. Wind the lever until when the deep cut of 12 mm is closed, counting the fallings.

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Leveling the surface of the paste, and the method must be repeated until when the cut is closed after an equal number (± 1) of falling and determine the water content of the paste. The result express the value of upper plastic limit (w_L) after correction with the date of from table 1.

Table 1

Values of K - correction coefficient

n	K	n	K	n	K
20	-1,4	30	+1,2	40	+3,1
21	-1,1	31	+1,4	41	+3,2
22	-0,8	32	+1,6	42	+3,4
23	-0,5	33	+1,8	43	+3,5
24	-0,3	34	+2,0	44	+3,7
25	0,0	35	+2,2	45	+3,8
26	+0,2	36	+2,4	46	+4,0
27	+0,5	37	+2,5	47	+4,1
28	+0,8	38	+2,7	48	+4,2
29	+1,0	39	+2,9	49	+4,4
				50	+4,5

where: n-number of falling
and:

$$w_L = w_n + K$$

where:

w_L-upper plastic limit;

w_n-water content (%) of the soil paste corresponding with the number of fallings;

K – correction coefficient

Interpretation

$$I_p = 25 - 45 \text{ pellic horizon}$$
$$I_p > 45 \text{ vertic horizon}$$

b) Determination of the lower plastic limit (wp)
Method of soil cylinder

The soil sample, air dry, grinded and sieved of 0.2 – 0.5 mm, sieve, will be pestled and kneaded, and shaped rolled on a panel made of glass, in order to form cylinders with 3 – 4 mm diameter and 40 – 50 mm length. Operation must be repeated until when the cylinders are fissured.

The moisture content will be determined exactly in this moment. For each soil sample must be made three trials. The obtained result represents the lower plastic limit (w_p)

3. Calculated rheological indexes

a) Volume contraction, Cv

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$$C_v\,\% = 100 \cdot \frac{V_i - V_f}{V_f}$$

where:

- V_i - initial volume of saturated soil sample, cm^3;
- V_f - final volume after dry of soil sample, cm^3

C_v = 75 - 100 – pellic horizon

C_v > 100 – vertic horizon

b) Activity index, I_A

$$I_A = \frac{I_P}{A}$$

where:

- I_P – plastic index;
- A – content of clay <2µ, %

I_A 1,00 – 1,25 – pellic horizon

I_A > 1,25 – vertic horizon.

CONCLUSIONS

In SRTS – 2012, there is the Class Vertisols, with two soil types, respectively Vertosol and Pelosol.

Nearby, WRB – 2014 has two type of horizons with shrink – swell properties, namely protovertic and vertic.

The difference between Vertosol and Pelosol sometimes is difficult to establish Vertic horizon, Bzy can be present of both of soil types, and also there are Pelosols with A horizon with black color.

For this reason, we have considered that is necessary to introduce in the SRTS – 2012 some rheological indices, which are possible to measure in the Soil Physics Laboratory from OSPA. These rheological indices can make the difference, respectively: U_L - free swelling, I_p - plastic index, C_v – volume contraction, I_A - activity index.

Finally conclusions:

Index	Vertosol (Vertisols)	Pelosol (Chromic Vertisols)
Free swelling U_L	>140	100 - 140
Plastic index I_p	>45	25 - 45
Contraction volume C_v	>100	75 - 100
Activity index, I_A	>1.25	1.00 - 1.25
Clay < 2µ, %	>40	>30

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