Soft rock of perm as the base of pile foundations soils

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ABSTRACT: Building and designing on soft rocks is problematic for many countries in the world. In particular, in Russia the problems of building on soft rocks are not given clearly enough in national construction norms and standards. In that paper laboratory research methodology and some results of experimental analysis of soft rocks are presented.

1 INTRODUCTION

Today high-rise buildings is actively constructed in the central districts of Perm. It leads to the foundation depth and load increase on the soils the as well. Under these conditions foundations interact with geological Lower Permian deposits are the most effective and sometimes the only possible type of foundations. Therefore in the conditions of building in Russia it is important to know the real properties of Lower Permian soft rocks for the forecast of the settlement and bearing capacity of the foundations based on them (Bartolomey 2007, Ponomarev 2010).

2 LABORATORY RESEARCH METHODOLOGY

2.1 *Initial information*

The study of physical and mechanical properties of soft rocks was carried out for following samples: sandstone (depth of burial – 19.5 – 23.0 meters) and argillite (depth of burial – 25.0 – 30.0 meters).

2.2 *Physical properties determination methodology*

In the course of study following physical properties of argillite samples were determinated: density of soil ρ, density of soil particles ρ_s, water content ω, plasticity index I_P, liquidity index I_L, according to GOST 5180-84. Moreover, next calculated parameters were determinated: unit weight γ, density of dry soil ρ_d, porosity n, void ratio e, degree of saturation S_r. Statistical treatment of tests results was carried out according to GOST 12248-96.

In the course of study following physical properties of sandstone samples were determinated: density of soil ρ, density of soil particles ρ_s, water content ω, according to GOST 5180-84, and granulometric composition, according to GOST 25100-95.

2.3 *Deformation properties determination methodology*

In the course of study following deformation properties of argillite and sandstone samples were determinated: oedometric modulus E_{oed}, deformation modulus E. Laboratory tests were carried out by means of oedometer. The device is allowed to create a vertical pressure 1.5 MPa to the sample. The height of samples was 20 mm, and the diameter of samples was 71.5 mm. Loading of samples was done by device with load steps equal 50 kPa each, from 25 kPa till 1000 kPa, according to GOST 12248-96. Treatment of test results was carried out by means of software.

2.4 *Strength properties determination methodology*

In the course of study following strength properties of argillite and sandstone samples were determinated: angle of internal friction φ; effective cohesion intercept c. Laboratory tests were carried out by means of shear box. The height of samples was 40 mm, and the diameter of samples was 71.5 mm. Study was carried out by consolidated-drained scheme, without water saturation. Normal pressure took following values 400 kPa, 500 kPa and 600 kPa. Before shear test began, each sample was compressed in the device of preliminary compression, by appropriate normal pressure. Time periods of preliminary compression load steps corresponded to requirements of

GOST 12248-96. In course of tests tangential load increased continuously, and velocity of slice took following values: for sandstone – 0.5 mm per minute, for argillite – 0.02 mm per minute. The final criterion of shear test included one condition: the common slice deformation could be more than 5 mm. Treatment of shear test results was carried out by means of software.

3 RECEIVED RESULTS

3.1 *Physical properties of argillite samples*

Physical properties of argillite samples are presented in the Table 1.

Table 1. Normative values of argillite samples physical properties.

Properties	Depth of burial, m			
	13.0	16.0	20.0	27.0
ρ, g/cm^3	1.97	2.10	2.12	2.10
γ, kN/m^3	19.31	20.58	20.78	20.58
ρ_s, g/cm^3	2.76	2.75	2.77	2.76
ρ_d, g/cm^3	1.64	1.78	1.80	1.81
ω,	0.20	0.18	0.18	0.16
I_P,	0.19	0.15	0.20	0.16
I_L	-0.08	0.09	0.10	0.01
e	0.68	0.55	0.54	0.52
n, %	40.52	35.29	31.15	34.41
S_r	0.81	0.91	0.92	0.84

According to plasticity index I_P and liquidity index I_L argillite samples were classified as hard loam.

3.2 *Deformation properties of argillite samples*

Oedometric modulus Eoed in interval 0.5-0.6 MPa of argillite samples with natural water content changed in following limits 5.03 – 7.00 MPa.

Oedometric modulus E_{oed} calculation results of argillite samples from depth of burial 25.0-30.0 m are presented in the Table 2.

Table 2. Normative values of oedometric modulus E_{oed} for argillite samples with different water saturation

Sample number	S_r	$E_{int\ 0.5\text{-}0.6}$, MPa*	Average value $E_{int\ 0.5\text{-}0.6}$ MPa
70	0.89	6.16	
72	0.89	7.00	
76	0.89	5.03	6.16
200	0.89	5.60	
207	0.89	6.23	
212	0.89	6.93	
120	1.00	6.94	
175	1.00	5.14	
176	1.00	5.84	5.53
194	1.00	3.76	
195	1.00	6.86	
196	1.00	5.02	

* Deformation modulus in interval E_{int} 0.5-0.6 MPa

Compression curves for argillite samples are presented at Figure 1 and Figure 2.

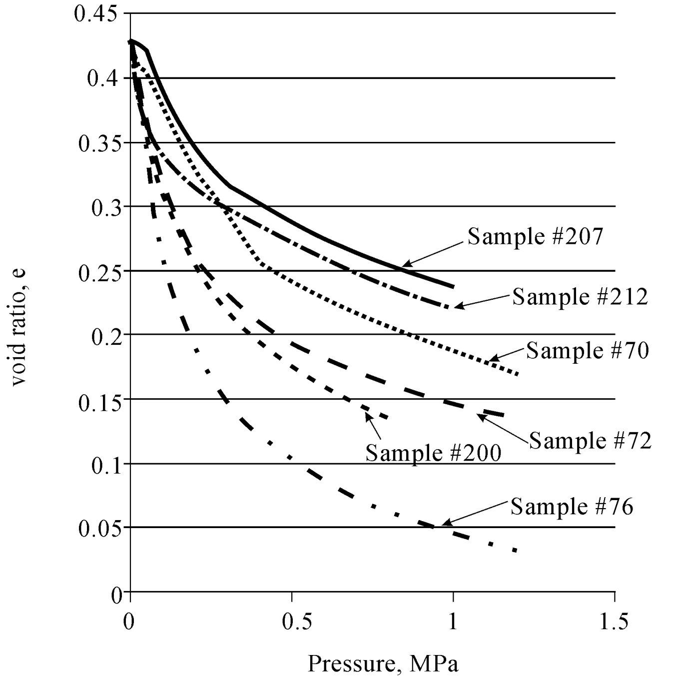

Figure 1. Compression curves for argillite samples (without water saturation)

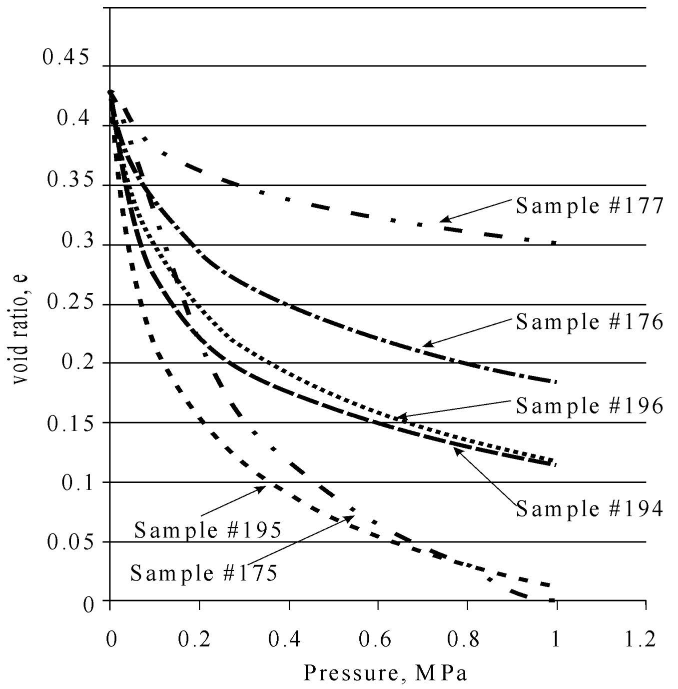

Figure 2. Compression curves for argillite samples (with full water saturation)

Therefore, in the scheme without water saturation the oedometric modulus E_{oed} average value of argillite samples in interval 0.5-0.6 MPa was 6.16 MPa, and in the scheme with full water saturation the oedometric modulus E_{oed} average value of argillite samples in interval 0.5-0.6 MPa was 5.53 MPa. So, decrease of oedometric modulus E_{oed} value in the scheme of full water saturation was 10.2 %.

3.3 *Strength properties of argillite samples*

Strength properties of argillite samples, from depth of burial 25.0-26.0 m, are presented in the Table 3, strength straight lines are presented at Figure 3.

Table 3. Strength properties of argillite samples, with depth of burial 25.0-26.0 m

Strength properties	φ	c
	º	MPa
Effective	29.23	0.043
Residual	30.17	0.031

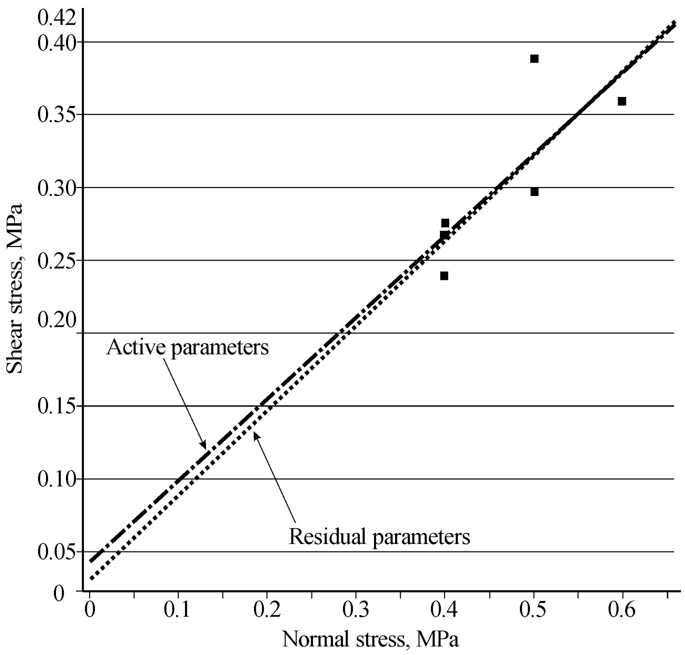

Figure 3. Argillite samples strength straight lines

4 CONCLUSIONS

As the result of laboratory tests, properties of soft rocks were investigated. Also was proved that strength properties of soft rock samples depend on the rate of water saturation. Therefore strength properties of the samples decreased on 10.2 %. A number of laboratory and especially field experiments are required in order to find an integrated solution of the problem under discussion.

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