

The use of modern data about the composition and properties of soils for the development of transport infrastructure of Tyumen

Dmitry Eremin¹

¹The State Agrarian University of Northern Zauralye, Republic Street, 7, Tyumen, 625003, Russia

E-mail: soil-tyumen@yandex.ru

Abstract. Sedimentary properties territory Tura-Pyshma interfluvium, where Tyumen is located are determined by the general course of ancient and especially the newest tectonic movements. Active development of the transport network on the territory of the Tura-Pyshma interfluvium has created the need for a contemporary study of regional peculiarities of grounds. This will allow you to create roads with the quality meet the international standards. The use of average values of indicators of the properties of silty-clay soils during the development of the transport infrastructure projects of the city of Tyumen and its environs is ineffective due to the genetic characteristics of the rocks located at the depth of 1.5-5.0 meters. Detailed analysis showed that the studied soil belongs to the covering carbonate loams and clays, differing in its characteristics from loess-like sediments of the European part of Russia. The thickness of the covering rocks is not more than 5 meters. It's low-carbonate, non-saline and often has a layered structure. The upper three meters of sediments contain the minimum quantity of water-soluble salts (dry residue less than 0.1%). Studied covering loams are characterized by favorable physical properties: the density of the bulk and the particle is 1.44 to 1.62 and 2.70-2.78 g/cm³, respectively. Water permeability is high – the filtration coefficient varies from 3.4 to 6.4 m/day, the minimum water velocity observed in the clay types of soil. The presence of sand layers adversely affects the permeability of soil. Therefore, the design and construction of transport infrastructure of the city and the surrounding territories it is necessary to consider regional features of grounds.

1. Introduction

Tyumen region in the last decades is characterized by a high rate of industrialization. The emergence of new plants and factories with hundreds of thousands of jobs led to the need for large-scale building of cities and adjacent territories.

Most actively conducted construction work in the city of Tyumen, which may already in the next decade obtain the status of one of the largest cities of Russia with population over a million people. Construction companies and investors decided to move away from the strategy of spot building in the Central districts of the city, focusing on the development of the suburbs of Tyumen. It plans to build new neighborhoods and residential areas there. To date, almost on 2,000 hectares various stages of work are actively being carried out – from geodetic to delivery of houses in operation.

The geological structure of Tyumen and its suburbs are located on the covering carbonate loams and clays with a peculiar granulometric composition; physical, chemical and water properties. The depth of the sediments of these rocks reaches up to 5 meters [1,2]. Current knowledge of regional



peculiarities of composition and properties of soils, allow optimizing the work on the foundation for the roadway with high strength characteristics [3-5].

2. The purpose of researches

The study of the physical, chemical properties and granulometric composition of grounds on the territory of large-scale building of the city of Tyumen.

3. Methods

The study of grounds was carried out in the construction sites of the Tyumen and surrounding areas. The drilling was conducted to a depth of 5 meters. When sampling, has identified the depth of each layer. Analysis of the physical and chemical properties of selected soils was conducted in accordance with the state standards. As a result of analysis were determined: granulometric composition – laser granulometer Analisette-22; bulk and particle density – method Kaczynski; filtration coefficient; hygroscopic moisture content; total porosity; salinity; organic carbon – with dichromate of potash with spectrometric end.

4. Results and discussion

As shown by visual analysis, the presented grounds have a yellow-fawn color, fine pores addition, poorly compacted. Sandy or clay layer is ubiquitous; pebbles are present in the scattered state. The content of the granulometric composition of the covering rocks of this region differ from loess grounds, to which some researchers try to relate them. The loess and loess-like grounds of the European part of Russia have very high dust content (0.05-0.001 mm) – 60 to 80 %, including coarse dust (0.05-0.01 mm) – 30-50% composed of secondary minerals.

Analyzed covering loams are characterized by a very low content of dust fraction – from 10 to 40 %, of which the fraction of coarse dust accounts for not more than 20 % (Figure 1). Such coarse dust content does not allow the analyzed soil to be classified as loess type. In addition, this ground in contrast to the loess and loess-like loams of the European part of Russia includes 2 times less carbonate and bicarbonate of calcium and also is characterized by a high degree of sandy. Light and medium loams in the majority belong to the group slimy-sandy ground. Heavy loamy grounds are usually sandy-silt, and the clay ground is characterized by slimy-silt of granulometric composition.

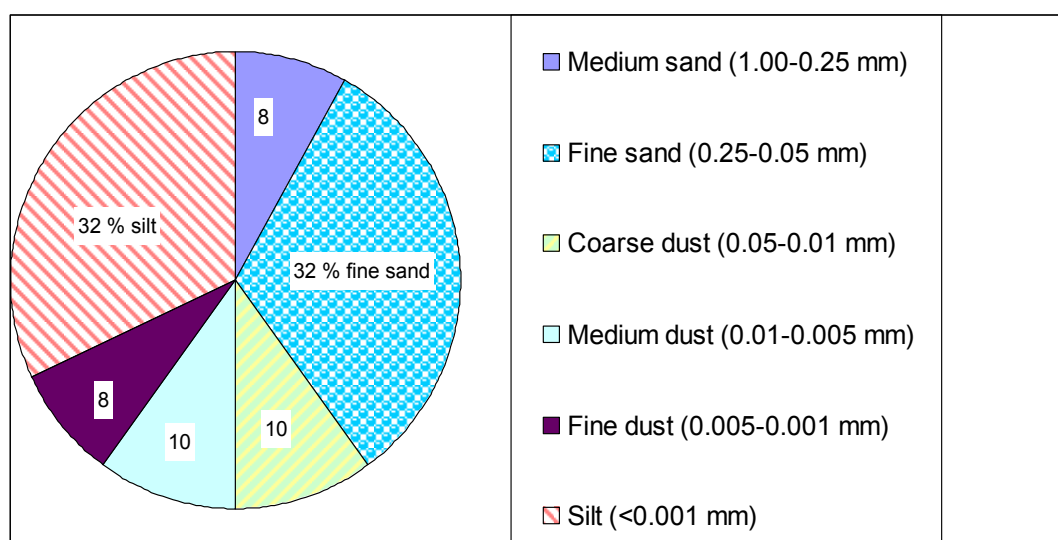


Figure 1. Granulometric composition of covering loams the city of Tyumen. Number of definitions – 25. Depth selection – 3-5 meters

After analyzing the data of granulometric composition to a depth of 5 meters and after a visual analysis of the samples identified 4 different types of grounds with different characteristics and properties. This is the result of the ancient influence of the rivers Tura and Pyshma flowing in the immediate vicinity of the city. We did not find homogeneous by granulometric composition profiles of ground in the development territory of the city of Tyumen.

Covering loam and clay, common in urban areas not salted (table.1 and 2). The maximum sum of ions is 0.266% in clay ground. In light loams the sum of ions decreases, reaching 0.131% of the mass of ground. The dry residue is predominantly represented by bicarbonate calcium. The studied soils are characterized by the absence of carbonates (CO₃), which can be found in minimal quantities (no more than 2 mg/100 g) in clay ground taken from a depth of 4.0 to 5.0 meters.

Table 1. Analysis Data of water extract of ground of different granulometric composition

Grounds	Ions	Depth of selection, m					
		1.5-2.0		3.0-3.5		4.5-5.0	
		mg/100 g	%	mg/100 g	%	mg/100 g	%
Light loam (*n=15)	HCO ₃	72	0.072	83	0.083	92	0.092
	CO ₃	0	0	0	0	0	0
	Cl	17	0.017	18	0.018	24	0.024
	SO ₄	7	0.007	7	0.007	12	0.012
	Ca	25	0.025	31	0.031	38	0.038
	Mg	6	0.006	5	0.005	6	0.006
	Na+K	4	0.004	5	0.005	7	0.007
	HCO ₃	82	0.082	84	0.084	92	0.092
	CO ₃	0	0	0	0	0	0
	Cl	18	0.018	17	0.017	25	0.025
Medium loam (n=22)	SO ₄	4	0.004	5	0.005	8	0.008
	Ca	28	0.028	35	0.035	37	0.037
	Mg	5	0.005	6	0.006	6	0.006
	Na+K	5	0.005	6	0.006	8	0.008
	HCO ₃	120	0.120	31	0.031	37	0.037
	CO ₃	0	0	0	0	0	0
	Cl	11	0.011	11	0.011	12	0.012
	SO ₄	3	0.003	4	0.004	3	0.003
	Ca	30	0.030	40	0.04	40	0.040
	Mg	7	0.007	7	0.007	8	0.008
Heavy loam (n=18)	Na+K	50	0.050	50	0.050	6	0.006
	HCO ₃	160	0.160	18	0.018	21	0.021
	CO ₃	0	0	0	0	2	0.002
	Cl	12	0.012	12	0.012	16	0.016
	SO ₄	40	0.004	50	0.050	50	0.050
	Ca	40	0.040	50	0.050	50	0.050
	Mg	8	0.008	8	0.008	9	0.009
	Na+K	6	0.006	1	0.001	2	0.002
Clay (n=10)							

n – the number of samples

Light loamy and medium loamy soils to a depth of 4.0 meters contain a minimum number of water-soluble salts, which do not significantly accumulate in the layer of 4.5 to 5.0 meters. This is due to the partial washing out of them by the downward flow of water, due to the high permeability of these soils. In heavy loams and clay varieties the process of salts migration is less noticeable. Their content is gradually increased already at a

depth of 3 meters. However, in this layer the salt of sodium and potassium are almost absent, which makes possible the use of analyzed grounds to create soil-concrete with desired strength characteristics by means of jet cementation [6,7]. Also seized soil can be used for artificial soil-ground in the accomplishment and dumping of urban areas [8-11].

The content of the ground, taken from a depth of 1.5-5.0 meters was discovered the organic carbon that goes into the composition of humic substances. It should be noted that these substances are found mostly in the layer of 1.5-2.0 meters heavy loam and clay grounds, where their content reaches 0.27-0.35 % of the mass. In the soils with more light granulometric composition water-soluble humic substances are found at a depth of 3.0-3.5 meters. Discovered carbon is a part of mobile fulvic acids, the salts of which are water soluble and are able to migrate inland under the action of water [6]. These acids usually react with the cations of alkaline earth metals, which are part of the bicarbonate and do not have a negative effect on the concrete or building structures.

The presence of hydrocarbonate of calcium causes a slightly alkaline reaction of the grounds, reaching in heavy loam and clay of 7.9 units. In the varieties of the soil lighter on granulometric structure pH has no significant differences (7.8 units). The studied soil of the city of Tyumen on its physical parameters is significantly different from loessial rocks of the European part of Russia. The particle density is much higher due to the specific mineralogical composition. In light and medium loam it is – 2.72 of 2.70 g/cm³; while in the heavy loam and clay – 2.77-2.78 g/cm³. However, the bulk density in comparison with European analogues of grounds, in contrast, is smaller and is 1.44 to 1.62 g/cm³. It should be noted that the strong correlation between density and granulometric composition are not detected. The obtained values of the particle density to characterize the ground are as good for building the base objects with high bearing capacity.

Table 2. Chemical and physical properties of grounds of different granulometric composition

Variety grounds	Sum of ions, %	The organic carbon, %	pH, units	The density		Total porosity, % of volume	Hygroscopic moisture, % by weight	The filtration coefficient, m/day
				Bulk	Particle			
Light loam	0.131	0.12	7.8	1.44	2.70	45.4	2.5	6.3
Medium loam	0.142	0.12	7.8	1.56	2.72	42.3	2.9	5.7
Heavy loam	0.221	0.27	7.9	1.62	2.78	40.5	4.4	4.2
Clay	0.266	0.35	7.9	1.54	2.77	45.2	4.6	3.4

The total volume of voids (porosity) is quite large, especially considering the fact that the ground is at a depth of 1.5-5.0 meters. Porosity ranges from 40.5 to 45.4 % of the volume of the ground. Usually at a depth of 4-5 m. these voids are filled with water. This should be considered in the design of foundations, because in Siberia there is a possibility of freezing.

The content of hygroscopic moisture, and, consequently, maximum hygroscopicity correlates with the content of physical clay. In light loamy and medium loamy ground the content of hygroscopic moisture is 2.5-2.9% of the mass. In the heavier types of ground it increases to 4.6 % of the mass.

Water permeability was determined at several points in grounds with different granulometric composition. The maximum water permeability have light loamy grounds, filtration coefficient is 6.3 m/day. The minimum water permeability was observed in clay – 3.4 m/day. Based on the data, it is possible to establish the presence of a high correlation between filtration coefficient and water permeability. This is true for homogeneous grounds. However, as we have already pointed out, the rocks on which is located the city of Tyumen and its environs are layered, that making them in some cases

waterproof. The reason for this is the creation of a layer of capillary-backed-suspended moisture. In addition, during the spring period (sometimes up to mid-June) in the profile of the rock remains the permafrost layer, the water permeability of which is equal to zero. Given these factors, we can conclude that the water permeability of soil on the territory of Tyumen is quite changeable, so it is recommended to define it directly on each stage of construction.

5. Conclusions

1. Covering loam and clay on the territory of building of the city of Tyumen have a capacity of up to 5 meters, low-carbonate, layered. Granulometric composition is mostly sandy-silt. Low content of silt fraction does not allow attributing them to a group of loess-like sediments.
2. The soil to the full depth of their occurrence is not salted (dry residue less than 0.1%). Of salts is dominated by bicarbonate of calcium. The upper three meters of sediments are characterized by minimal content of ions, due to their migration to a depth of 5 meters.
3. Covering loams have the favorable performance of the physical properties that are different from European counterparts. The water permeability of grounds classified as good, but only if the homogeneous addition. In the presence of sand interlayer correlation between the filtration coefficient and granulometric composition is violated. The water permeability of such grounds is dramatically reduced, and in some areas completely absent.

References

- [1] Eremin D I 2016 Agrogenic change of granulometric composition of leached black soil in the forest steppe zone of Zauralye *Agri-food policy in Russia* **9(33)** pp 35-37.
- [2] Khomentovsky V V, K.E.Nagovitsin K E, Postnikov A A 2008 *Russian Geology and Geophysics* **49** pp 1-22 DOI: 10.1016/j.rgg.2007.12.001
- [3] Forcelini M, Garbin G R, Faro V P and Consoli N C 2016 Mechanical Behavior of Soil Cement Blends with Osorio Sand *Procedia Engineering* **143** pp 75-81
- [4] Vinogradov V V, Zaytsev A A, Frolovsky Y K 2017 *Procedia Engineering* **189** pp 767-773 DOI: 10.1016/j.proeng.2017.05.120
- [5] WU Jonathan T H, Kevin Z Z L, Sam B H, Kanop K 2016 Design and Construction Guidelines for Geosynthetic-Reinforced Soil Bridge Abutments with a Flexible Facing *WASHINGTON, D.C.* pp 132
- [6] Zege S O and Broid I I 2007 Design features of soil-concrete structures built by means of jet geotechnology *Soil Mechanics and Foundation Engineering* **44** (4) pp 143-145
- [7] Pinto A, Tomasio R and Marques G Ground *Procedia Engineering* **143** pp 1495-1502
- [8] Eremin D I and Eremina D V 2016 *Procedia Engineering* **165** pp 788-793
- [9] Iglovicov A V 2016 *Procedia Engineering* **165** pp 800-805
- [10] Eremin D I and Eremina D V 2017 *MATEC Web Conf.* **106** DOI:10.1051/mateconf/2017106010
- [11] Eremin D I 2016 *Eurasian Soil Science* **49 5** pp 538–545 DOI: 10.1134/S1064229316050033