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IMPROVING THE QUALITY OF SALTED SOILS SOILS DURING THE CONSTRUCTION OF TRANSPORT FACILITIES

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Abstract
This article presents the results of observations of the effect of capillary humidification on the dynamics of the density of dispersed, in particular saline and loess soils in the bed of a transport structure. Studies show that the nature and degree of soil decompression during humidification depends on the degree of compaction and the nature of salinization; at maximum density, the height of capillary rise of water decreases; soils with optimal humidity equal to the maximum molecular moisture capacity are practically not subjected to decompression.

Keywords: transport facilities, saline soils, stability, durability, road bed, compaction, optimum humidity, maximum density, capillary moistening.

Аннотация
В настоящей статье излагаются результаты наблюдений влияния капиллярного увлажнения на динамику плотности дисперсных, в частности засоленных и лёссовых грунтов в полотне транспортного сооружения. Исследования показывают, что характер и степень разуплотнения грунтов при увлажнении зависит от степени уплотнения и характера засоления; при максимальной плотности уменьшается высота капиллярного поднятия воды; грунты, у которых оптимальная влажность равна максимальной молекулярной влагоемкости, практически не подвергаются разуплотнению.
Ключевые слова: транспортные сооружения, засоленные грунты, устойчивость, прочность, земляное полотно, уплотнение, оптимальная влажность, максимальная плотность, капиллярные увлажнение.

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Introduction

The growth of intensity, carrying capacity of vehicles, the speed of cars and trains imposes increased requirements on transport facilities. In particular, the evenness of the pavement surface is of great importance. Currently, road construction is developing in the direction of increasing the strength and durability of roads, which leads to the use of expensive materials for the construction of pavement and complicates the technology. However, the money invested and the efforts expended are in vain if the subgrade is not sufficiently stable. In these cases, the evenness of the road surface given during the construction process is also quickly lost. Therefore, in the conditions of modern construction, especially great attention is paid to the device of a durable and stable subgrade, which is the foundation of a transport structure.

One of the most important measures to ensure the stability of the transport structure, including the subgrade, is compaction. The condition of the road largely depends on the degree of compaction of the subgrade soil. The density of the soil directly affects the water-thermal regime of the subgrade and the strength of the soil base [1].

Long-term observations in the field on roads (Table 1), such as "4P33 Dashtobod-Naiman (Guliston-Gagarin, 20 km)", "4P161 Urgench-Chalish-Beruniy -Bustan, 15-16 km", "M-37 Samarkand-Turkmanboshi (section Bukhara-Jondor, 10-22 km) "(Fig. 1)," M-39 Almaty-Bishkent-Tashkent-Termez (section Kagan-Karaulbazar, 9-22 km and Bukhara-Kagan, 5-9 km)", "4P175Khalkabad-Kegeyli, 3 and 5 km (Fig. 2); "Nukus-Khalkabad 20.3 km"; Chimbay-Tahta-Kupyr, 7.2 km; "Khojeyli-Shumanay, 5.1 km"; "Khalkabad-Chimbay, 14.8 km" and numerous laboratory experiments show that with a high degree of soil compaction, the movement of moisture slows down sharply due to the blockage of soil pores by bound water films. As a result of soil compaction, their water resistance increases, water permeability and the height of the capillary rise of water decrease [2–5]. The speed of movement and the height of the rise of capillary water in compacted soils were studied by Bezruk V.M. [6]. Experiments carried out with clay, loam and sandy loam showed that at optimal moisture and maximum density (standard compaction), the capillary movement of water almost stops. I.A. Nosich, who studied the water resistance of silty chernozem soils of various moisture content and density, compacted with an effective number of impacts of a standard weight, as well as the time and degree of possible wetting of the subgrade from side ditches, also came to the conclusion that soils compacted at optimal moisture content to standard density have the highest water resistance. [7].

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Table 1 Characteristics of observation sites

№	Road	km	Road category	Terrain type according to moisture conditions	Depth of groundwater from the bottom of the trough, m	Embankment height, m	Subgrade condition
1.	Khalkabad-Kegeyli diameter 1 Khalkabad-Kegeyli diameter 2	3 0,5	II II	3 3	>3,0 >3,0	1,2-1,5 1,5	Stable, no precipitation. There are no slips of slopes and roadsides, no erosion was observed
2.	Nukus-Khalkabad	20,3	II	3	>3,2	1,2-1,5	Stable, slope slipping and roadside erosion are not observed.
3.	Chimbay-Takhta-Kupir	7,2	II	3	>2,5	0,3	Stable, slope slipping and erosion of roadsides are not observed.
4.	Khodjeili-Shumanai	5,1	II	3	>2,5	1,2-1,5	Stable, no precipitation. There is no slippage on the side of the road, no washouts were observed.
5.	Khalkabad-Chimbay	14,8	II	3	>2,0	0,8-1,0	Stable, no precipitation.

Laboratory studies [8], carried out with soils of different granulometric composition and genesis, proved that soils of standard compaction are not only moistened to a minimum degree, but also in the case of flooding with water, the longest period is required for their wetting and destruction.

The degree of decompaction turned out to be the greater, the more the moisture content of the formation differed from the optimal moisture content. The results of these laboratory studies indicate that in terms of ensuring the stability and therefore the stable strength of compacted soils, one should strive for standard compaction in laboratories and compaction with rollers in production conditions.

Fig. 1. Section of the Bukhara-Jondor highway, 22 km

Fig. 2. Section of the Khalkabad-Kegeyli highway, 3 km

Uzbekistan, where freezing is absent or insignificant, this phenomenon is not observed [9]. Decompression of subgrade soils occurs mainly under the action of groundwater (Fig. 3). Groundwater is fed by seepage through the thickness of the soil part of precipitation and irrigation water. With a close occurrence, groundwater can wedge out directly to the surface of the earth or be pulled up to the upper layers of the subgrade due to capillary rise.

To calculate the elevation of the bottom of the pavement, we propose a method based on the following assumptions. When erecting a canvas on a site with a close level of groundwater, a moisture gradient appears in the soil. Due to fluctuations in the groundwater level, the minimum gradient, and, consequently, the curve of soil moisture in the h_v layer change (Fig. 3).

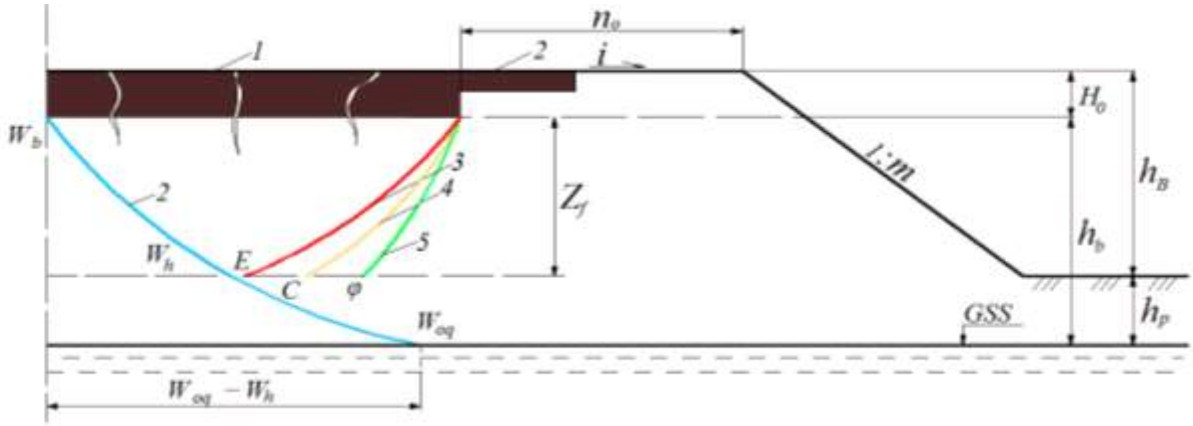

Fig-3. Calculation scheme - constructive solution of the road embankment:

W_b–initial moisture content, equal to the optimal moisture content during compaction of the subgrade soil,%. W_h –calculated humidity,%. W_{oq}–moisture at soil fluidity,%. E is the modulus of elasticity, MPa. C–specific adhesion, MPa. φ - angle of internal friction, deg. Z_a –active zone, m. n_O–shoulder width, m. i–shoulder slope. GWL–groundwater level.

In the areas under consideration, the minimum W_O-W_1 gradient corresponds to the end of the warm period with the maximum depth of groundwater. Due to precipitation in autumn and winter periods and a decrease in the intensity of evaporation from the surface, the groundwater level rises and the humidity in the layer h_v gradually increases.

In the presence of a moisture gradient, a bottom-up flow of two-phase moisture is formed: liquid-like (capillary and film) and vaporous. Moisture migration significantly depends on the moisture conductivity of the soil. Since the canvas does not freeze through and the temperature gradient in the h_v layer is relatively small, the intensity of moisture migration due to thermal moisture conductivity is insignificant and can be neglected. From the upper part of the roadway, moisture is removed into the atmosphere due to the diffusion of steam through the layers of pavement, which, including even asphalt concrete and cement concrete pavement, are air and vapor permeable. In this case, the loss of moisture in the sheets is replenished by two-phase moisture migrating from below.

With a close occurrence of groundwater, artificial soil compaction in many cases is not durable. Decompression of the subgrade by capillary groundwater, as a rule, is also observed in areas where it is built from highly saline soils. An increase in the moisture content of subgrade soils above the optimum causes a decrease in their density.

Taking into account the existing ideas about the nature of soil decompaction in the conditions of Uzbekistan, it was necessary to experimentally test the effect of capillary moisture on artificially saline soils.

This article presents the results of observations of the effect of capillary moisture on the density dynamics of saline soils.

When carrying out the corresponding experiments, it was necessary to establish: at what distance of the compacted layer from the water, the density decreases, how much and in what soils; reveal the dependence of capillary rise on soil density; whether it is possible to reduce the height of the embankment due to the increased density and whether it will be preserved.

Determination of the degree and nature of decompaction of variously saline soils was carried out in metal columns, made up of individual rings 10 cm high and 9.5 cm in diameter. A series of experiments was carried out at 0.96; 0.98; 1.00 and 1.02 from the maximum density and optimal moisture content with soils of varying salinity, both in qualitative and quantitative terms, i.e. in the following options:

Control - non-saline heavy silty sandy loam.

Heavy sandy loam + 5% Na_2SO_4;
“ “ “ +5% NaCl;
“ “ “ +2,5% Na_2SO_4 +2,5% NaCl;
“ “ “ +1% Na_2SO_4 +4% NaCl;
“ “ “ +1% Na_2SO_4.

These options for artificial salinization were taken from the considerations that in the natural conditions of Uzbekistan, highly saline and excessively saline soils of sulfate and chloride-sulfate salinity are most often found.

The preparation of the soil for the experiments consisted in the fact that non-saline heavy silty sandy loam was crushed with a wooden pestle and sifted through a 1 mm sieve, then, thus prepared, the soil was salted. Salts were introduced into the air-dry soil in the form of solutions. After drying in air, the saline soil mixtures were ground and sifted through a 1 mm sieve. For all series of experiments, the saline soil was pre-soaked. The columns were loaded with saline soil at the optimal moisture content pre-set using the standard compaction method.

The prepared soil was poured into a metal cylinder to about 1/3 of the height and compacted with a 2.5 kg load falling from a height of 30 cm. seals (for clay soils - 120). After the metal cylinder was filled with compacted soil, the next cylinder was screwed on and the soil was compacted in the same way as in the previous one.

The continuity of the soil column was ensured by loosening the previous layer by 0.5 cm before compacting the next layer.

For the first series of experiments, the upper and lower rings of each column were loaded with non-saline heavy silty sandy loam, compacted to 0.6-0.7 of the maximum density. To reduce evaporation, the upper rings were additionally closed with a barrier-barrier.

Soils compacted in this way were placed in columns with their lower ends in vessels with water. Humidification was carried out through a mesh bottom. Hole diameter - 1 mm. A paper filter was placed on the mesh bottom to prevent the soil from being washed out of the cores.

The columns were unloaded after 30, 50, 75, 120, 135 and 240 days. During unloading, in each ring, the volumetric weight, humidity, testing by a Road Research Institute (RRI) striker were determined, and samples were taken for chemical analysis in order to study the quantitative composition of salts after capillary moistening of soils. Laboratory experiments were carried out in conditions of positive temperatures, considering that in the conditions of Uzbekistan soil freezing is insignificant and does not affect the density of the soil of the active layer.

Heavy silty sandy loam was taken for laboratory experiments. The content of carbonates in the soil reaches 22%. According to the content of easily soluble salts, the soil should be considered non-saline. Analyzing the results of a series of experiments, it can be seen that in the columns loaded with non-saline heavy silty sandy loam, the greatest change in moisture occurred in the lower horizon (9-19), counting from the water level, the bulk density in the same horizon changed by 2-3%. The greatest height of the capillary rise of moisture was observed during the period of 240 days of moistening (30 cm). In the overlying horizons, the moisture content did not change and the bulk density remained equal to the maximum obtained in the standard compaction device.

The results of observations of the distribution of moisture in soils compacted at optimal moisture to maximum density showed that the capillary movement of water occurs very slowly or almost completely stops. As V.M. Bezruk points out, at optimal humidity and maximum density, the pores are filled with physically bound water. The absence of free pore volume prevents the movement of capillary water, resulting in a stable state of humidity even after prolonged capillary wetting. In the experiment with non-saline heavy silty sandy loam, for 240 days of capillary moistening, a change in moisture content on the horizon 19-29 was only 1.7%.

In a column loaded with heavy silty sandy loam, which contains 1% Na_2SO_4, after 240 days of capillary wetting, there was no change in moisture content, and hence the volumetric weight. Moderately saline soil behaves similarly to non-saline heavy silty sandy loam. A significant change in soil moisture and bulk density occurred in experimental cores with 5% Na_2SO_4. The moisture content of the excessively saline soil after 30 days of moistening changed by 5%, and the bulk density by 4%. After 240 days of capillary moistening, there was a change in humidity to a height of 60 cm with a decrease in bulk density, i.e. there was a partial decompaction over the entire height of the column. The volumetric weight decreased from 1.76 to 1.66 g/cm3, and the testing of impacts by the DorNII striker showed low strength. The humidity and density in the cores loaded with heavy silty sandy loam with 5% NaCl did not change over the entire observation period.

Considering the state of humidity at different times, with intensive capillary moistening of soils that are maximally compacted at optimal moisture content, containing 2.5% Na_2SO_4 + 2.5% NaCl and 1% Na_2CO3 + 4% NaCl, we can say that practically detectable changes in moisture and density during 240 days did not happen.

The experiments of capillary moistening of soils with different salinity showed that the greatest decompaction occurred in the column with soil containing 5% Na_2SO_4. This can be explained by the fact that with excessive sodium sulfate salinity (5% Na_2SO_4), part of the salt will be in a dissolved state, and part will be in a crystalline state. In this case, with the solubility of Na_2SO_4=16.1%, 2.5 g of Na_2SO_4 will dissolve in the optimal humidity corresponding to 15.59%. And, if we take into account that part of the water will be in a bound state, having a lower ability to dissolve salts [7], then there will be much more salts in the crystalline state.

With capillary moistening of excessively saline soils, capillary water, having thrown into the pores of the soil, dissolves the crystals of sodium sulfate salt that have not dissolved at optimal humidity. In this case, the dissolution of salt can cause decompaction of the soil.

The release of pores during the dissolution and leaching of salt from the soil is the cause of the increase in moisture noted in the experiments and the decrease in the volumetric weight of the soil. In this case, decompaction is expressed in a decrease in volumetric weight against the maximum.

Excessively saline soils containing 5% Na_2SO_4, with capillary moistening, decompacted to a height of 50 cm from the water horizon by about 7% in 240 days.

In columns filled with soils containing 5% NaCl and 2.5% Na_2SO_4 + 2.5 NaCl, salt migration also occurred, but the change in salt concentration did not affect the volumetric weight. In this case, this is explained by the fact that with such high-quality salinity, the total salt content does not exceed the amount that can be dissolved in a volume of water corresponding to the optimum moisture content at the maximum soil density.

The experiments carried out with saline soils with intensive capillary moistening allow us to draw the following conclusions:

1. The nature and degree of decompaction of soils depends on the degree of compaction and the nature of salinization.
2. The more the density of the soil approaches the maximum density, the lower the height of the capillary rise of water.
3. Excessively saline soils with a sulfate character of salinization, with capillary moistening, decompacted within 240 days to a height of 60 cm. cm, at a density of 0.96 - to a height of 20 cm.
4. Highly saline soils with a chloride character of salinization, over a period of 120 days of capillary moistening, decompacted to a height of 40 cm at a density of 0.98 and to a height of 60 cm at a density of 0.96.
5. Soils containing 2.5% Na_2SO_4 + 2.5% NaCl, compacted to 0.96 at optimal moisture content, over 130 days of capillary moistening, decompacted to a height of 40 cm, counting from the water level.
6. Soils are not subjected to decompaction, in which all salts are in a dissolved state at optimal moisture content and maximum density.
7. Soils, in which the optimal moisture content is equal to the maximum molecular moisture capacity, are also not subject to decompaction.
8. When constructing a subgrade from excessively saline soils, it is necessary to compact to a density of at least 1.00-0.98.
9. With a compaction coefficient of 1.00-1.02 of the subgrade of a transport facility, backfilled from excessively saline soils, it is possible to reduce the height of the embankment by 0.3 meters against the standard.

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