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Methods for Preserving Soil Moisture when Constructing the Earth Weave

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Abstract. The arid regions of Uzbekistan are characterized by an acute moisture deficit in the hot period of the year, which as practice shows, is often not considered in the construction of the subgrade. Underestimation of the low natural moisture content of soils in these areas leads to under-compaction of the embankments of the subgrade, as a result of which the quality of construction deteriorates.

To increase the moisture content, the existing regulatory documents for the construction of the roadbed of roads and railways provide for moistening the soil before compaction. However, moistening is associated with high costs and labor for transporting water and its distribution in the ground. One of the promising ways to solve this issue is to compact non-moistened soils to the required density at their natural moisture content. Therefore, the issue of improving organizational and technological solutions to reduce the intensity of evaporation and maximize the use of the natural moisture of atmospheric precipitation is put forward.

Summarizing the results of laboratory experiments, we can conclude that all materials used to create screens, except clay, reduce the rate of evaporation, and the greatest effect was obtained while maintaining moisture in the soil with a vapor-tight screen made of polyethylene film.

INTRODUCTION

A significant volume of transportation of national economic goods is carried out by the road. The cost of freight transportation depends to a large extent on the speed of movement of transport, which, in turn, is determined by the evenness of the road surface. One of the main factors affecting the evenness of the road surface is the strength of the subgrade, which is in direct proportion to the density of the soil. To achieve the required density of the subgrade, building codes and regulations [1] provide for compaction of soils at a moisture content close to optimal. In this case, the maximum sealing effect is achieved at the lowest cost [2].

However, vast territories of our country are occupied by areas with an arid climate characterized by an acute moisture deficit in the summer. A feature of arid regions is the low natural moisture content of the soil during most of the year when the main work on the construction of the subgrade is carried out. To link the existing discrepancy between the low natural moisture content of soils and the required one, building codes and regulations [1] provide for artificial moistening of soils. Still, they do not give specific recommendations on technology before moistening [3, 10-15].

In the design documentation, to increase the moisture content, it is proposed to water the soil with water before compaction. However, high-quality moistening of soils using this technology is not achieved because the depth of soaking (5-10 cm) is much less than the thickness of the compacted layer. It is economically unprofitable to fill the embankments in layers of less than 10 cm since this sharply decreases work productivity and increases the cost of construction. In addition, the delivery of the required amount of water to moisten the soil is associated with high costs. They are since in arid regions, road construction objects are often located at great distances from water supply sources, and the volume of water for the moisture is 10-25% of the volume of soil [3, 10, 13-17].

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At different times Yu.L. Motylev [4], P.V.Sobolev [5], N.Ya. Kharkhuta [2], N.P. Ivlev [3], M.I. Nayte [6], P.O. Morris, A.E. Tainen [7], E. Leflev [8], A.D. Kayumov [9]. As a result of their research, the subgrade design from half-moistened soils was proposed, the fundamentals of the technology of artificial moistening of the soil in the embankment and the soil quarry were developed, the optimal parameters and modes of soil compaction with various rollers were established. However, these proposals and developments did not fully solve the issues of building embankments in arid regions due to the significant expenditures of labor and funds for the implementation of the proposed structures and artificial soil moistening [16,18,19].

The study aims to substantiate rational methods for maintaining soil moisture in reserves during the construction of a subgrade in arid regions.

METHOD

To qualitatively assess the effectiveness of methods for retaining moisture in the soil, laboratory experiments were carried out, the program of which provided for the identification of the most promising materials in production conditions for creating screens that reduce evaporation. From binders in laboratory studies, crude oil (organic binder), liquid glass (mineral binder), and clay were tested as the most accessible materials in their extraction and production regions. Of the hydrophobizing and structure-forming substances, the most interesting research was the waste of chemical processing of wood (sulfate-alcohol stillage) and widespread hygroscopic salts (calcium chloride). In concentrated reserves, with a relatively small open pit area, to reduce the evaporation of moisture from the soil, it may be rational to use a polyethylene film [20].

Soil columns with various evaporation depressors served as models of reserves in laboratory experiments. Glass measuring cylinders with a volume of 1000 cm^3 were used as vessels for the columns.

In the process of preparing for the experiments, the soil, moistened to the optimum moisture content, was layered in cylinders and compacted to a compaction coefficient equal to 0.8, which approximately corresponds to the natural density of the soil in the reserves.

The soil columns prepared for the experiments were installed in a container. The space between the cylinders was filled with dry sawdust to create thermal insulation of the lateral surfaces of the columns. It was assumed that heat exchange between the soil and the environment occurs only through the soil surface [20,21].

The air temperature during laboratory tests varied from 17.6 to 30.5 ° C with an average value of 24.5 ° C, which corresponds to the average daily air in the summer period for arid regions Uzbekistan. The relative air humidity during the experiments ranged from 70 to 80%.

In the first series of laboratory experiments, the effectiveness of screens made of binders and clays to reduce moisture evaporation was determined. The model contained four pairs of columns, the first of which served as a control [19].

The study was carried out on light sandy loam having the following indicators: yield point Wt = 21%; rolling border Wp = 16%; plasticity number Wp = 5; the content of sand particles with a size of 2-0.05 mm = 74.6%; optimum humidity Wo = 12.5%; maximum density of dry soil δst = 1.77 g/cm^3.

On the surface of the soil, laid in cylinders, screens were arranged. The material for the screens was crude highly resinous oil in the second pair of columns, liquid glass with a density of 1.17 g/cm^3 in the third, and silt clay (semi-bold) with a plasticity number of 20 in the fourth pair. The consumption of binders in the experiments was 0.1 g/cm^2.

RESULTS AND DISCUSSION

The results of laboratory experiments in the first series are shown in Fig. 1, where by the nature of the curves, it is possible to trace the course of moisture evaporation from the soil. Thus, in the initial period of experiments, more intensive evaporation of moisture occurred from soil columns with an oil coating than from soil isolated by the liquid glass. However, by the end of the experiment, the total water losses for evaporation in these columns were the same.

The calculations showed that during the observation period (110 days) in experiments with screens made of oil and liquid glass, moisture evaporation decreased compared to evaporation from control columns by 18% and 15%, respectively. In the experiment with sandy loam coating, the evaporation rate from the columns was practically the same as from the control columns. This indicates that, on the one hand, a thin layer of clay located at the interface between the soil and the atmosphere is exposed to its temperature effect and is unable to keep moisture from evaporation. On the other hand, the drying clay layer absorbs moisture well, immediately consumed for evaporation. Thus, it can be concluded that the clay surface shield does not fulfill its function of reducing evaporation [21].

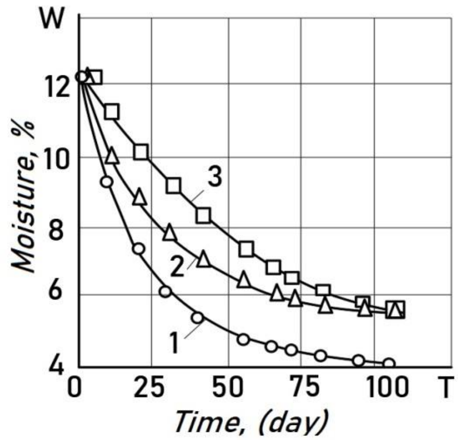

FIGURE 1. Influence of screens made of binding materials on soil moisture.
1 is control, 2 is oil screen, 3 is liquid glass screen, 4 is clay screen

In the next three series of laboratory experiments, the possibility of using calcium chloride salt and sulfate alcohol stillage as depressants of moisture evaporation was investigated.

The characteristics of the soils in these experiments are given in Table 1.

TABLE 1. Characteristics of soils in laboratory experiments

Batch number	Variety of soil	Fluidity limit, %	Rolling border, %	Plasticity number	Standard compaction rate		Sand particle content, 2-0.05 mm, %
					W_o, %	δ_{ct}=1.77 g/cm^3	
2	Light silty loam	26	18	8	14.9	1.80	12.90
3	Light sandy loam	24	18	6	11.9	1.98	57.7
4	Light silty loam	27	19	8	14.3	1.82	16.9

The laboratory models in the second series of experiments consisted of twelve soil columns. In the first six columns, a 20% solution of sulfate-alcohol stillage served as the material for creating the screens. In the first column, the consumption of vinasse was 0.3 g / cm^2, in the second column - 0.5 g / cm^2, and in the third - 1 g/cm^2. In these columns, screens were arranged on the ground surface.

In the fourth, fifth, and sixth columns, the flow rate of vinasse was also equal to 0.3, 0.5, and 1 g / cm^2. However, the screens were arranged at a depth of 10 cm from the ground surface.

By analogy with the first six, the next six columns were modeled. The only difference was that calcium chloride salt was added to the vinasse, the consumption of which for all columns was 0.1 g / cm^2. Experiments show that with an increase in the consumption of the binder, a slowdown in the process of evaporation of moisture from the columns is observed. The addition of calcium chloride salt to sulphate-spira vinasse had practically no effect on moisture evaporation.

At a low consumption of vinasse, a decrease in the evaporation intensity from the columns, where the screens are located under the soil layer, was observed.

CONCLUSION

Summarizing the results of laboratory experiments, we can conclude that all materials used to create screens, except for clay, reduce the rate of evaporation. The greatest effect was obtained with moisture preservation in the soil by a vapor barrier made of polyethylene film.

Similar results were obtained when using screens made of crude oil, liquid glass, sulfate alcohol stillage, and calcium chloride with the same material consumption. Increasing the thickness of the screen increased the efficiency of the evaporation depressors. However, increasing material consumption can lead to high costs. In addition, sulfate alcohol stillage and calcium chloride are readily water-soluble materials, which can lead to disruption of the integrity of the screen during rainy periods. Based on these considerations, sulfate-alcohol stillage and calcium chloride can be attributed to unpromising materials for creating screens to preserve moisture in reserves.

Liquid glass also dissolves in water, but it takes a certain time to dissolve the dried liquid glass crust. Consequently, the destruction of the liquid glass screen will depend on the duration of the rains. Therefore, the question of the effectiveness of using liquid glass to retain moisture requires verification in the field.

REFERENCES

1. ShNK 3.06.03-08. *Automobile roads. State Committee of the Republic of Uzbekistan for Architecture and Construction*, 86 (2008)
2. N. Ya. Kharkhuta, Yu. M. Vasiliev, *Strength, stability and compaction of soils of the road bed of highways*, p.288 (1975)
3. S.V. Aleksikov, in International Conference on Industrial Engineering, **150**, 1729-1732 (2016)
4. S.V. Aleksikov, in Proceeding of Engineering problems of the building material science, geotechnical and road construction, II-nd scientific and technical conference, 141-144 (2009)
5. Zh. S. Mustafaev, A. T. Kozykeeva, L. K. Zhusupova, *Technology of development of saline lands with hydroecological restrictions*, Scientific works of SKFNTsSVV **17**, (2018)
6. Zh. S. Mustafaev, Ecosystem substantiation of saline land development methods Agroecology, **2(4),** 4-9 (2015)
7. Y. Wen, W. Zhang, Y. Luo, X. Liu, B. Li, and L. Wang, Journal of Qinghai University **36**(4), 17–23, (2018)
8. W. Li and S. Chai, Journal of Engineering Geology, **26**(2), 407–415, (2018)
9. Kayumov A.D. Design characteristics and compaction technology for loess soils, p. 132, (2006)
10. Guideline on the Use of Sand in Road Construction in the SADC Region AFCAP/GEN/028/C., **81** (2013)
11. Geotechnical, Geological and earthquake engineering. Water in road structures Movement, Drainage ettects andrew dawson editor.(University of Nottingham, UK, 2008), p. 436
12. X. Zhang, Q. Wang, G. Wang, W. Wang, H. Chen, Z. Zhang, Mathematical Problems in Engineering **2**(1), 2017
13. R. M. Khudaykulov, *Justification of the design characteristics of saline soils of the subgrade*, (2018)
14. L. Qingfeng, G. Zhou, S. Wang, Z. Huo, and B. Ma, Rock and Soil Mechanics, **40**(1), 245–249 (2019)
15. A. D. Kayumov, R. M. Hudaykulov, Structural mechanics of engineering structures and structures, **2**, 65-78 (2016)
16. G. P. David, *Engineering Geology principles and practice*, (Springer-Verlag Berlin Heidelberg, 2009), p. 450
17. Roads and Salinity ISBN:0734753772//Department of Infrastructure, Planning and Natural Resources-26 b (2003)
18. The Prevention and Repair of Salt Damage to Roads and Runways ISBN 99912-0-380-/Guide to the Prevention and Repair of Salt Damage to Roads and Runways-24 b (2001)
19. International Journal of Pavement Researchand Technology ISSN 1996-6814//Pavement Mechanic Response of Sulfate Saline Soil Subgrade Section Basedon Fluid-Structure Interaction Model **9(1)**, 19 (2016)
20. V. D. Kazarnovsky Fundamentals of engineering geology, road soil science and soil mechanics, **284** (2007)
21. E. M. Dobrov, Soil mechanics, **272** (2008)
22. A. D. Kayumov, R. M. Hudaykulov, D. A. Makhmudova, Bulletin of the Kyrgyz State University of Construction, Transport and Architecture named after I. N. Isanova, **1(51)**, 66-70 (2016)
23. R. M. Hudaykulov, T. L. Mirzaev, The use of stabilizers to improve the strength of the soil base of highways, Transport structures, **1** (2019)