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Mechanical properties of reinforced loess soils in road pavements

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Abstract. The modern development of road construction promotes the tasks of not only increasing the strength of road structures, but also the need to effectively use local materials and soils in road construction. During the design and construction of highways, many road scientists of the world have carried out their scientific and research work on soil strengthening based on the road bed. Several methods and techniques have been developed for this. Also, developed countries are producing a lot of surfactants, modifiers and additives for soil strengthening. In this article, research work was carried out in laboratory conditions to study the mechanical properties of soil strengthened with the help of a modifier. Measurement, comparison, experimental laboratory, mathematical statistical analysis in the processing of test results, analytical methods specified in regulatory documents were used in the performance of research work. The results of the conducted laboratory research are specific to loess soils found in the conditions of Uzbekistan. The use of construction work on the foundation of the road bed from reinforced soil allows to reduce the volume of construction work, reduces the consumption of transported sand and gravel materials, and increases the service life of the road.

1 Introduction

Due to the increase in the number of heavy-duty vehicles in the world, the loads on the highways are also increasing. As a result, various deformations occur before the service life of highways. In addition, the shortage of raw materials used for the base layer of the road surface and the transportation costs of transporting the materials lead to an increase in the total cost of road construction. Therefore, in places where there is a shortage of local stone materials, the issue of using primers reinforced with binders is urgent.

Currently, in order to increase the strength of local soils, the implementation of stabilization works by adding various additives and modifiers to the road surface soil is considered as an engineering solution.

In the road sector, several works are being carried out on the development of highways, the design and construction of high-quality highways using resource-saving construction materials.

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The use of stabilized loess soils makes it possible to obtain composite materials for the construction of the road surface of IV and V highways, as a result of which it is possible to reduce the cost of road construction without using expensive crushed stone materials as much as possible.

2 Materials and methods

Foreign scientists have carried out research on strengthening the soil of the road base and base layer [1,5,10,11,13,14]. Also, research works on strengthening of gravels were carried out by scientists of the CIS [2,3,4,6].

In these studies, stabilization of loess soils, structure formation mechanism of cement and modifier in loess soils have not been sufficiently studied.

In the course of the research, a laboratory test was conducted with the soil taken from the 4R20 "Karasuv d. - Boka c. - Bekobad c." highway in the Tashkent region. In laboratory conditions, the granularity of the soil was determined according to GOST 12536-2014 (Table 1).

Table 1. Content of soil fractions.

Content of soil fractions, %, dimensions, mm								
5-2	2-1	1-0.5	0.5-0.25	0.25-0.1	0.1-0.05	0.05-0.01	0.01-0.005	less than 0.005
0.84	2.63	3.36	3.65	10.63	14.27	52.19	7.16	5.27

Then, according to the regulatory documents, the physical parameters of the soil based on moisture were determined (Table 2).

Table 2. The value of physical indicators of soil.

№	**Indicators**	**Values**	**Regulatory documents**
1	Natural humidity, W_n %	12.6	GOST 5180
2	Humidity at the yield point, W_y %	24.6	GOST 5180
3	Humidity at the rolling limit, W_r %	17.3	GOST 5180
4	Plasticity number, I_p	7.3	GOST 25100
5	Optimal humidity, W_{op} %	15.5	GOST 22733
6	Dry soil density, ρ g/cm^3	1.84	GOST 22733

It was established that the type of soil used in laboratory conditions was silty loam.

Currently, many surfactants (modifiers) have been developed for use on highways in developed countries, many of which also have no effect in practice [7,8,9,12]. For this reason, experimental tests were carried out in laboratory conditions on the use of the Akropol GSM modifier, developed by foreign countries and widely used in practice, on the roadbed.

In the preparation of reinforced loess soil samples, research studies were carried out in laboratory conditions on the mechanical index of compressive strength-R_c, bending strength-R_b.

Samples were prepared for research work using a modifier. Samples of Portland cement grade M400 soil were obtained in the amount of 4%, 6%, 8% and 10%, Akropol GSM modifier in the amount of 0.04%, 0.08%, 0.12%, 0.16% 0.2% according to relative to the total weight, as well as using a press mixed with water in an amount of 15% to achieve optimal humidity. Portland cement is one of the most common, versatile and cheap mineral binders used to strengthen soils.

To determine the compressive strength index, samples of soil reinforced with cement and modifier were made in the following order:

- dry soil was sifted through a 5 mm sieve and water was added to achieve optimal moisture;
- after mixing for a certain period, cement and modifier were added;
- in the production of samples from soil processed together with modifier and cement binder, cement was first added to wet soil, and then modifier, for ease of work;
- the moistened soil is kept in a desiccator for 1.5-2 hours for the interaction of soil particles with cement and modifier;
- no less than 6 samples were made, each with a height equal to the diameter of 71.4 mm of prepared cylindrical samples;
- in laboratory conditions, samples were pressed under a load of 15 MPa for 3 minutes.

In order to determine the bending strength, 6 reinforced soil samples were prepared in the form of (40x40x160) mm prisms.

The prepared samples were placed in a desiccator and stored for 28 days before testing. Before determining the compressive and flexural strengths, the sample was saturated with water for 48 hours (6 hours 1/3 of the sample and 42 hours full) and the results were obtained from the Universal Test Machine press.

3 Results and discussion

The obtained results are shown in Figures 1-2.

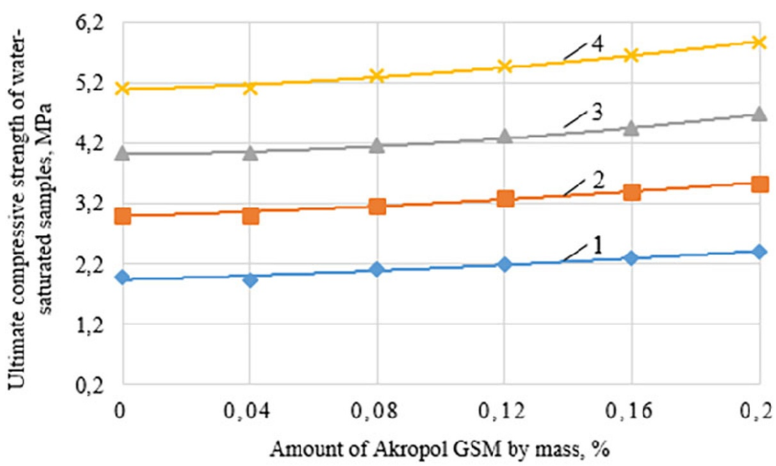

Fig. 1. Akropol GSM and change of the compressive strength limit of dusty lichen depending on the amount of cement, amount of cement: 1-4%; 2-6%; 3- 8%; 4- 10%.

In the results of laboratory research, the compressive strength of the sample increased significantly as a result of adding cement to the soil and increasing its amount. We can see a significant increase of 0.16 and 0.2% in this sample as a result of the introduction of the Akropol GSM modifier. It served to increase the average compressive strength by 10-20%.

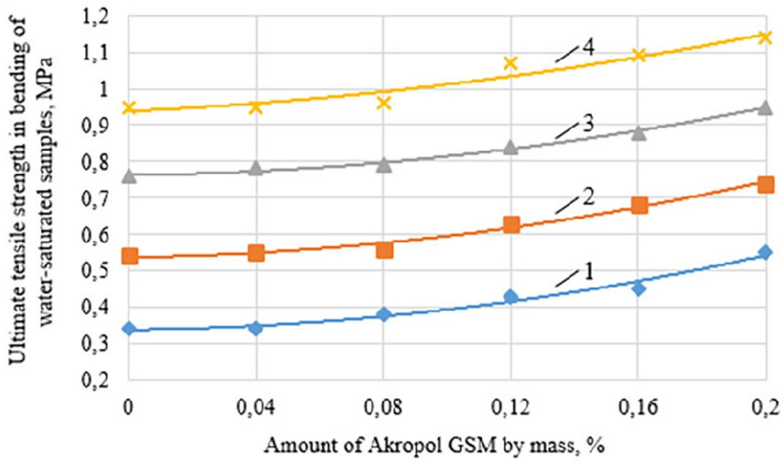

Fig. 2. Akropol GSM and the change of the bend strength limit of dusty lichen depending on the amount of cement, amount of cement: 1-4%; 2-6%; 3-8%; 4-10%.

In the results of the laboratory research, the bending strength of the sample increased significantly as a result of adding cement to the soil and increasing its amount. We can see a significant increase of 0.16 and 0.2% in this sample as a result of the introduction of the Akropol GSM modifier. It served to increase the average bending strength by 20-40%.

4 Conclusion

In the results of research determined in laboratory conditions, the compressive and bending strength of the sample increased significantly as a result of adding cement to the soil composition and increasing its amount. We can see a significant increase of 0.16 and 0.2% in this sample as a result of the introduction of the Akropol GSM modifier. It served to increase the average compressive strength by 10-20%, and the bending strength by 20-40%.

The use of stabilization work on the roadbed makes it possible to reduce the volume of excavation work, reduces the consumption of transported sand and gravel material, ensures the stability of the roadbed slope, reduces uneven subsidence and increases the service life of the road.

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