УДК 625

ENHANCING THE STRENGTH OF ASPHALT CONCRETE THROUGH RHEOLOGICAL PROPERTIES

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Abstract: *This article is devoted to the improvement of the rheological properties of asphalt concrete and its strength based on the addition of surfactants, secondary industrial waste and polymers. Additives used to increase the strength of asphalt concrete through the rheological properties of bitumen or asphalt concrete mixture, surfactants and polymers, were carried out in laboratory conditions and the results of the research are presented.*

Keywords: *Bitumen, asphalt concrete, surfactants, secondary industrial waste, polymers, production technologies, testing, physical and mechanical parameters, sample testing methods, etc.*

Asphalt-concrete pavements make up the majority of public highways in Uzbekistan. Ensuring the service life and durability of asphalt concrete pavements is one of the main problems. In recent years, the daily increase in the number of cars with high load carrying capacity in the traffic flow and the increase in the anomalous temperature in the summer season in Uzbekistan in the last 4 years, especially in the southern part of the republic, the temperature of the asphalt concrete surface has risen to 75-78 ^{0}C is a heavy burden. as a result of the impact of their cars, it causes various deformations and premature breakdown. In addition, the resulting deformations have a negative impact on road quality indicators and safe movement, and lead to a decrease in the speed of cars, which is the main indicator.

In order to prevent such situations, it is necessary to carry out research on the quality indicators of asphalt concrete with additional surfactants,

secondary industrial waste, polymers and their mixtures. It is planned to increase the durability of asphalt concrete in two ways:

- addition of surface-active substances to improve the physical and mechanical properties of bitumen added to asphalt concrete;
- adding surfactants to the asphalt concrete mixture.

To do this, we select the following additional substances:

Alfadob, "Honeywell 7686", "Titan 7686", mixture of crushed rubber powder with polymer, Topcell, Ekotop and Chrysopro were studied.

Alfadob, "Honeywell 7686" and "Titan 7686" are added to improve the physical and mechanical properties of bitumen.

The tolerance of the rheological properties of asphalt concrete is increased by mixing crushed rubber powder with polymer, and adding Topcell, Ekotop, and Chrysopro to the asphalt concrete mixture as a surface-active substance.

Alfadob is a liquid surface-active bituminous additive for improving the adhesion of bitumen to stone material based on organic ethers and industrial waste vegetable oils. Alfadob is added to the asphalt-concrete mixture in the proportion of 0.1-0.3% compared to bitumen. Alfadob provides extreme thermal stability (2-3 weeks in hot bitumen) and improves water absorption and crack resistance properties of the pavement surface [2].

Alfadob retains its quality indicators regardless of the physical and mechanical characteristics of the stone material. It creates a strong hydrogen bond between the bitumen and the limestone and provides perfect adhesion. It works not only with acid rocks (e.g. quartz, granite, porphyry, etc. / basic silicates), which form negatively charged SiO_32 - ions along with the moisture that is always present on their surface, but also with all the main types of rocks (e.g. dolomite , limestone, etc.) gives good results when used [3].

One of the multifunctional road construction composite materials made from polymer waste used in industry is the polymer "Honeywell 7686" containing polyethylene, titanium and wax. Honeywel specification 7686 is a low molecular weight, multi-functional, polyethylene-based wax optimized for effective bitumen modification. The viscosity of the polymer solution is very low. Therefore, the use of the surfactant "Titan 7686" allows manufacturers to significantly increase adhesion and save polymer.

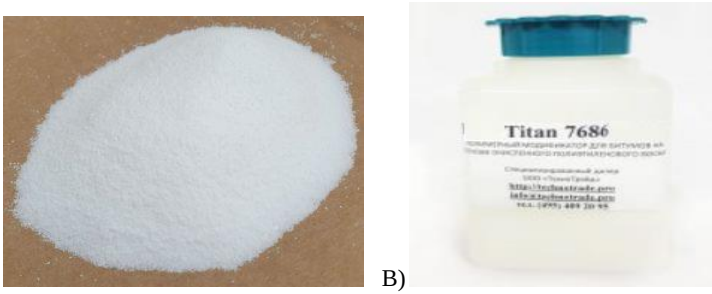


Figure 1. Appearance of the additive used to improve bitumen quality:
A) "Honeywell 7686" polymer B) Packaged view of "Titan 7686" surfactant

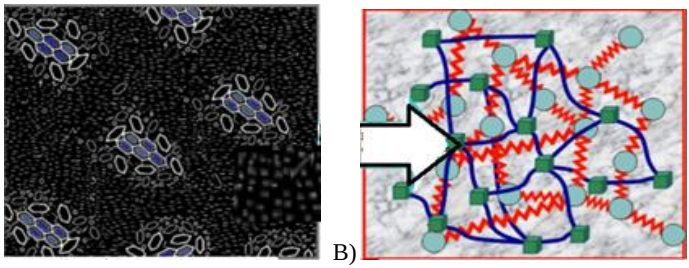


Figure 2. A) Structural structure of asphalt concrete mixture without polymer B) Structural structure of asphalt concrete with "Honeywell 7686" polymer and "Titan 7686" surfactant added to bitumen

Advantages:

It ensures compliance with "GOST-9128-2013", increases cold resistance, improves elasticity, reduces the occurrence of cracks, enhances water resistance. By using a simple blending agent, the polymer is added to the bitumen and easily melts at 150ºC. Additionally, after the asphalt concrete mixture is laid, it reduces the release of carbonate and anhydrite gases under hot climate conditions. It is possible to prepare the asphalt concrete mixture without any additional additives or directly add polymer-bitumen to the bitumen.

Additionally, one of the most common and promising projects in world practice is the enrichment of bitumen composition with thermoplastics, which combine the properties of thermoplastics and elastomers. By using these thermoplastics, it is possible to improve the quality of bitumen. In order to increase the quality of bitumen, it is advisable to add polymer in the proportion of 2.5-6% of the total mass of bitumen.

Figure 3. A) The process of pouring bitumen samples enriched with "Honeywell 7686" polymer into molds for testing in the laboratory

In this case, the quality indicators of asphalt concrete will be improved to some extent. We can see it in the table below [4].

Table 1. Physico-mechanical properties of "Honeywell 7686" polymer-added asphalt concrete

Name of indicators	Amount
Average density of asphalt concrete, kg/m3	2360
Water absorption	3,5
Porosity	0,1
Compressive strength at a temperature of 20 °C	3,8
Water resistance coefficient	1,21

In order to increase the durability of asphalt concrete, in order to enrich the bitumen composition with the help of surfactants, taking into account the above actions, we carry out the following works.

For this, the selected bitumen sample is placed in a metal container with a volume of about 10 liters and placed in a thermal cabinet with a thermometer. The bitumen sample is heated to a temperature of 145-155°C, while the temperature should not exceed 160°C. The reason is that

overheating of the temperature can change the properties of bitumen and materials added to it. When the bitumen is heated to the temperature indicated above, it is removed from the heating furnace and poured into the laboratory mixer. In addition, a 13% rubber solution and pre-crushed polyethylene are added in the required amount of gasoline [5]. The mixture is stirred at a temperature of 160-180°C for 1-1.5 hours until all components are completely combined. When the composition becomes homogeneous, it is poured into test molds and tested according to GOST-33137-2014. And the results are compared in Table 2 below.

Table 2
BND 60/90 bitumen from modification previous and keying results

No. k/k	Indicators names	Measurement unit	In practice results		
			According to GOST	Bitumen real value	Modification when done value
1	Needle sunset depth At 25 °C At 0 °C	0.1 mm	61-90 from 20 less it's not	66.3 27	43 21
2	Softening temperature (people and ball by)	°C	from 47 less it's not	48.4	52.9
3	Elongation at 25 °C At 0 °C	cm	from 55 less it's not	72 3.7	59.4 3.9
4	Mortality temperature	°C	-15	-12.4	-14.6
5	Flash temperature	°C	230	from 230 high	from 230 high
6	Penetration index	-	(-1) to 1	-1	-0.7

In addition, pieces of rubber, which remain the main problem as secondary industrial waste, can be used in road construction. In this case,

only pieces of rubber can be added to the mixture after processing with polymer. In this case, pieces of rubber as shown in Figure 4 are prepared and processed with polymer (polybutadiene) under special conditions. And it comes in the following form.

This piece of rubber is mixed with limestone and bitumen at a temperature of 170-180 °C in a special mixer for 40-45 minutes. We will prepare 2 different samples based on the requirements of GOST-9128 for testing in the laboratory. The first sample is ordinary asphalt concrete, and the second is asphalt concrete with polymer-treated rubber particles. In this case, rubber is added in the amount of 12.5% of total bitumen and the following content is selected for sample preparation. In addition, asphalt concrete samples enriched with surfactants such as Topcell, Ekotop, Chrysopro are prepared.

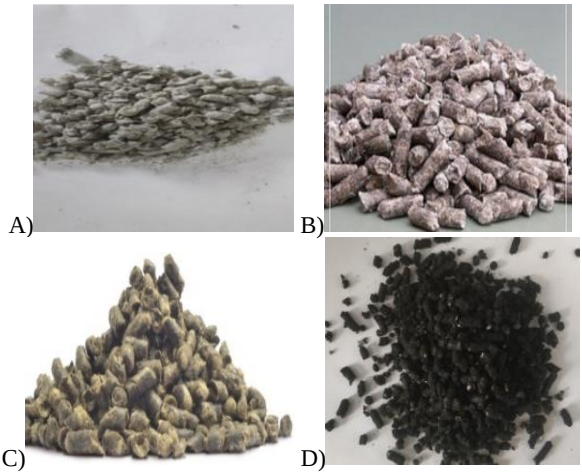
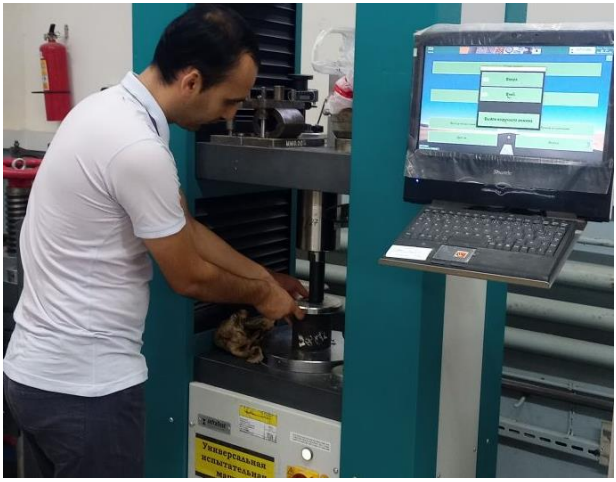


Figure 4. Surfactant additives. A) Topcel, B) Chrysopro C) Ecotop D) Rubber pieces treated with polymer

Based on the selected composition, samples are prepared for testing in the laboratory and the tolerance of its rheological properties is checked. In this case, its resistance to displacement is tested as follows. In this process, a sample in a water bath at a temperature of 50 °C, a test stamp of a universal press is made in a transverse view, and research is carried out according to the Marshall scheme [6].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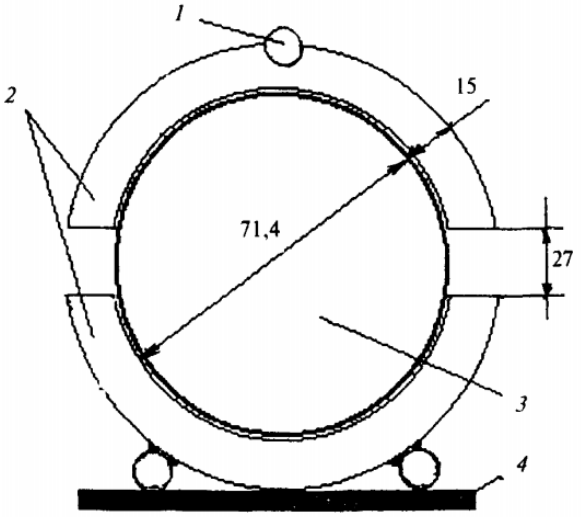

Figure 5. The process of checking the compressive strength of an asphalt concrete sample in a universal pres: A) Anti-slip strength inspection process B) Scheme of the compressing device according to the Marshall scheme in a universal press; 1-hinge, 2-cylinder surface, 3-place for sample, 4-bottom plate.

In this process, the tension is checked by applying a tension of 20 (50)KN at a speed of 50 mm/min [7].

Then the following accounting work is done [7].

$$A = \frac{Pl}{2} \quad (1)$$

A- Marshall unit for compression [Joule]

P-supplied voltage

l-test sample size in compression [mm]

Then the coefficient of internal friction of asphalt concrete tg ph is calculated according to the formula [7].

$$\mathrm{tg}\varphi = \frac{3(A_m - A_c)}{3A_m - 2A_{c)}} \quad (2)$$

A_m , A_c , - the average work of deformation of asphalt concrete tone samples when tested according to the Marshall scheme and uniaxial compression

After calculating these, we calculate the shear strength [7].

$$C_l = \frac{1}{2}(3 - 2\mathrm{tg}\varphi)\mathrm{R_C} \quad (3)$$

Rc - sample compression limit [15 MPa].

After completing the above work, we compare according to GOST-9128-2013, GOST-31015 [6-7-8]. And we come to the following result [9-10]:

On the basis of the results of research conducted in laboratory conditions, based on the data presented in the tables, we can conclude as follows:

1. In order to increase the strength of asphalt concrete by enriching the bitumen composition with various surfactants listed above, it is implemented by increasing its rheological properties.
2. By adding additives prepared by mixing polymers with secondary industrial waste to the asphalt concrete mixture, it is possible to improve its rheological properties and increase its quality indicators and durability

Table 4
Comparison of physical and mechanical properties of asphalt concrete according to test results

No	The name of indicators	Unit change	According to GOST-9128	Actual Results				
				Without additives	Top cell	Rubber pieces	Ekotop	Xriz opro
1	Water saturation	%	1.5 - 4.0	1.5	2.9	3.3	3.5	3.3
2	Porosity of the mineral part	%	horse 14 do 19	17.2	16.7	13.7	14.6	14.2
3	Residual porosity	%	St. 2.5 do 5.0	4.2	3.6	4.8	1.9	1.5
4	Ultimate compressive strength at a temperature of 50 °C , not less than	MPa .	0.7	1.2	1.8	2.2	1.2	0.96
5	Ultimate compressive strength at a temperature of 20 °C , not less than	MPa	2.5	2.4	6.0	7.0	3.7	3.3
6	Ultimate compressive strength at 0 °C , no more	MPa	3.0-6.5	3.2	4.2	3.8	4.4	4.2
7	Water resistance, no less	-	0.75	0.79	0.83	0.99	0.80	0.96
8	Average density	g/cm3	-	2.35	2.35	2.39	2.39	2.40

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