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ABSTRACT

In this work, road petroleum bitumen was modified with styrene butadiene rubber, butyl rubber and nano-sized dolomite. As a result of the modification, the basic physical, mechanical and chemical characteristics of the resulting composition were improved. It has been shown that the penetration, softening temperature and adhesive properties of bitumen as a result of modification with polymers are improved by 1.3 times compared to standard unmodified bitumen. The use of rubbers such as butyl rubber, styrene butadiene rubber and dolomite improves the mechanical strength and adhesive properties of road bitumen. Thus, the resulting polymer bitumen is an excellent binding system for the resulting asphalt-bitumen mixture.

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I. INTRODUCTION

Petroleum road bitumen change their physical and chemical parameters in a wide range (temperature, frost resistance, ductility, elasticity, adhesive bond, resistance to aggressive environments, high dielectric strength, etc.) and, compared to their low cost, allow them to be used in various areas.

Petroleum bitumen can be used in agriculture, construction and many other industries [1-4].

The bitumen used when gluing waterproofing is a residue from the distillation of petroleum products. It is a hard-looking, black, shiny mass that, under prolonged loads, retains its ductility even at low temperatures [5-7].

Over time, during storage and under operating conditions under the influence of sunlight and oxygen, the composition and properties of bitumen change: the relative content of solid and brittle components in them increases and, accordingly, the amount of oily and resinous fractions decreases, therefore the amount of oily and resinous fractions decreases. resinous fractions. increased fragility and hardness (aging process). Therefore, the process of bitumen modification is very relevant [8-10].

The properties of bitumen can be improved by combining them with polymer additives [11]. Currently, in the construction of roads for the production of asphalt concrete pavements, bitumen-polymer compositions are used as a binder, and for this purpose the expensive polymer thermoplastic elastomer DST-30 is used [12-13]it is necessary to find more economically beneficial modifiers for road bitumen [14-16].

Typically, road petroleum bitumen has a plasticity range, as a rule, no higher than 60-65 C, which is clearly not enough for the construction of outer layers of coating in the climatic conditions of most regions. In addition, viscous road bitumen practically does not have elastic properties that determine the resistance of composite materials, such as asphalt concrete, to destruction under cyclic loading. Therefore, bitumen binders fundamentally require modification and improvement of physical and mechanical properties, since by their nature they cannot provide the necessary durability of asphalt concrete road surfaces under conditions of increasing traffic loads [17-19].

Based on a set of indicators, polymers and their waste have the greatest potential for improving the properties of bitumen binders.

II. METED AND DISSERTATION

To modify oil bitumen grades ROB 25/40, TB 70/30 and Baku 85/25, rubber, rubber waste and nano-sized dolomite were used. The recipe and composition of the components are given in Tables 1, 2 and 3, and the physical and mechanical properties of the bitumen used are given in Table 4.

Subsequently, based on the obtained compositions, an asphalt concrete mixture was prepared using mixing equipment

Table 1: The composition of the composition based on rubber crumb (RC)

Name of Components	№ Samples					
	1			4	5	
	The content of the mass parts					
Bitumen	100	100	100	100	100	
BR+BSR+rubber waste (2%+3%+8%) Sulfur+ nano-sized dolomite	2 1,5 -	1,5 2,0	1,5 2,0	8 1,5 2,0	10 1,5 2,0	

Dolomites are a sedimentary rock that includes dolomite itself - CaCO3·MgCO3, with admixtures of clayey, ferruginous, siliceous and other substances. Dolomites come in granular, politic and crystalline structures. The hardness of dolomite is slightly higher than the hardness of limestone, its density is 2.0 - 2.8 g/cm3, and its tensile strength ranges from 120 - 300 MPa. Dolomite has a white, greenish-brown, brown and reddish-brown color. Taking into account the above, it must be assumed that it can be more effective than limestone materials when constructing structural layers of road and airfield pavements.

Different quantitative ratios of calcium carbonates in sedimentary rocks are one of the reasons for the wide variety of mineral-petrographic and physical-mechanical characteristics of these rocks, the name of which depends on the percentage of calcium carbonate in them, which is clearly shown in Table. 2.

Table 2: Content (% by weight) of calcium carbonate in limestone and dolomite

Name of Mineral	Standard for carbonate, in % by weight					
	Pure Limestone	Dolomite Limestone	Dolomite Limestone	Calcareous Dolomite	Calcareous Dolomite	Pure Dolomite
$CaCO_3$	90-100	75-95	50-75	25-50	5-25	0-5
$CaCO_3$ $MgCO_3$	0-10	5-25	25-50	50-75	75-95	95-100

The mechanical properties of limestones play a significantly important role in road and airfield construction, since these properties depend on the strength and cementing ability of the carbonate rocks they contain, as well as on the presence of non-carbonate impurities, which, in each individual case, are characterized by the chemical composition of the specific limestone material .

The composition of the composition based on the components we use is given in Table 3.

Table 3: Composition of bitumen-polymer compositions

Composition Components	The Content of Components, Mass. H. By Examples								
	1	2	3	4	5	6	7	8	9
Rubber crumb+Br+BSR	-	5	10	15	20	25	30	35	40
Bitumen	200	200	200	200	200	200	200	200	200
Filler	200	200	200	200	200	200	200	200	200
nanoclay+wooden stone(1+1)	150	-	-	-	10	10	10	10	10
The mixing temperature of the components in the mixer, ° C	100	70	90	100	160-180	70	90	70	100
Mixing time, min	15	10	12	15	65-120	10	12	10	15

As laboratory studies have shown, the introduction of 2 wt.% active rubber powder into grade A asphalt with good properties leads to a doubling of its softening temperature, while the frost resistance and elasticity of asphalt concrete increase.

Rubber, being an elastomeric material with a unique set of properties, only improves the durability of polymer-asphalt concrete.

In our work, the main attention was paid to improving the properties of domestic low-quality oxidized bitumen. The introduction of polymers and their waste leads to a sharp increase in the properties of Indicators of physical and mechanical properties of asphalt mixtures.

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The introduction of polymers and their waste leads to a sharp increase in the properties of bitumen (Tables 4 and 5).

Table 4: Physic-mechanical properties of a composition based on polymers and bitumen

№	Indicators	Samples				
		1	2	3	4	5
1.	Penetration of a needle at 25 ° C	38	72	100	71	96
2.	Softening point, ° C	49	68	82	56	75
3.	Fragility temperature, ° C	-10	-10	-26	-8	-20
4.	Tensile at 25 ° C	40	60	70	55	60
5.	Density, g / cm 3	2,34	2,36	2,38	2,2	2,4
6.	Temperature changes at T = 65 ° C for 5 hours	7	6	6	6	6
7.	Tensile strength at 20 ° C at 50 ° C	2,4 0,9	3,0 1,0	3,5 1,2	3,1 1,1	3,4 1,3

Table 5: Indicators of physical and mechanical properties of asphalt mixtures

Indicators	Indicator Values for Examples								
	1	2	3	4	5 prototype	6	7	8	9
Tensile strength, MPa	4,5	10,0	6,0	6,5	Breaks without load	7,0	8,0	5,0	9,5
Elongation at break,%	650	850	1100	780	-	900	900	700	830
Shore A hardness, Con, unit, усл. Ед	63	50	35	58	20	45	43	40	45
Polymer fluidity T=190 °C, P=49 H, q/10 min	18	20	40	35	100	30	35	30	25

The introduction of crumb rubber in bitumen allows to obtain a binder, which provides a significant improvement in the deformability and crack resistance of asphalt concrete.

Table 6: Physical -mechanical properties of crushed stone-mastic asphalt concrete with the introduction of Thermoplastic Polyethylene on stone materials

№	The name of indicators	Norms on Standard	0 %	0,1 %	0,2 %	0,3 %	0,5 %
			Thermoplastic Polyethylene				
1.	Density (bulk density), g / cm3	-	2,39	2,40	2,40	2,41	2,41
2.	Residual porosity, %	2,0–4,0	3,761	3,358	3,358	2,956	2,956
3.	Water saturation, % by volume	1,5–4,0	2,82	2,33	2,23	2,16	2,01
4.	Tensile strength in compression, MPa at temperature: 200 ° C 500 ° C	- 2,5-0,70	3,29 0,75	3,52 0,87	3,67 1,00	3,99 1,11	4,12 1,12
5.	Water resistance coefficient	-	0,86	0,92	0,94	0,95	0,97

6.	The coefficient of water resistance during prolonged water saturation (15 days.)	0,75	0,79	0,86	0,88	0,91	0,92
7.	Fracture resistance - tensile strength at split at a temperature of 0 ° C, MPa	3,0 – 6,5	3,48	3,82	3,99	4,21	4,16
8.	Coefficient of internal friction tg	0,94	0,89	0,90	0,92	0,92	0,91
9.	Shear grip at 500 ° C, MPa	0,20	0,18	0,33	0,57	0,60	0,65
10.	The binder runoff index,%	0,20	0,24	0,19	0,18	0,15	0,13

The values of structural and rheological constants were established as a result of testing coating samples and constructing rheological curves (Table 7).

Table 7: Structural and rheological constants

	Coating 1 (bitumen)				Coating 2 (polymerbi Bumen)			
t^0, C	E_y, Po	E_3, Po	θ, c	α_k, 1/degrees	E_y, Po	E_3, Po	θ, c	α_k, 1/degrees
+20°C	2,5-10⁶	2,18-10⁶	4,6-10²	4,3-10²	5,76-10⁶	5,02-10⁶	1,4-10²	2,95-10⁴
+10°C	6,3-10⁶	5,45-10⁶	11,1-10²	-	7,9-10⁶	6,84-10⁶	3,39-10²	-
0°C	1,55-10⁷	1,15-10⁷	27,2-10²	-	1,41-10⁷	1,05-10⁷	8,3-10²	-
-10°C	3,9-10⁷	2,94-10⁷	1,51-10³	-	2,59-10⁷	1,95-10⁷	1,55-10³	-
-20°C	9,9-10⁷	2,07-10⁷	5,7-10⁴	-	3,08-10⁸	6,45-10⁷	1,74-10³	-
Thunderstorm during rain	6,3-10⁶	6,3-10⁶	11,1-10²	-	7,9-10⁶	6,84-10⁶	3,39-10²	-

Calculations of temperature stresses arising in coatings at different temperatures are given in table 8

Table 8: Temperature stresses in coatings

Stress σ_t	σ_t in the temperature range, Pa					
Type Covered	+20°C	+10°C	0°C	-10°C	-20°C	Thunderstorm
Oil Polymer bitumen 70/30)	4,86	12,24	27,7	70,24	90,7	62,5
Polymer bitumen "The cream"	5,57	7,62	12,5	2,14	43,36	38,17

: n the work, the further study was to determine the durability of the resulting polymer-phaltobitumen system. The calculation is based on assumptions under which temperature and stress change continuously, and the destruction process is irreversible according to the Bailey criterion (the principle of summation of stresses). Under the influence of various stresses, the material loses a certain amount of strength each time, and when the amount reaches unity, it collapses.

After determining the durability values of coatings at different temperatures depending on the operating stresses, the overall durability of the materials was determined using the formula

$$\tau_{(\sigma, t)} = \frac{100}{\frac{P_1}{\tau_1} + \frac{P_2}{\tau_2} + \ldots + \frac{P_n}{\tau_n} + \frac{g}{\tau_g}}$$

where $P_1, P_2 \ldots P_n$ is the percentage of days in a year with a temperature of $T_1, T_2 \ldots T_n$;

$\tau_1, \tau_2 \ldots \tau_n$ -durability of the material,

respectively, at temperatures $T_1, T_2 \ldots T_n$.

III. RESULT

Thus, the computational and experimental method for predicting the durability of a coating comes down to an experimental study of the properties of the coating material under various test conditions and further calculation of the durability of these coatings.

This paper presents the results of computational and experimental studies of the durability of coatings made of various materials:

Since the most common cause of destruction of asphalt concrete is the formation of cracks due to the difference in temperature deformations of the coating and the base or the coating layer and the base, Comparison of standard properties of asphalts with polymer-bitumen coating mass was reduced to determining changes in structural-rheological and physical-mechanical properties, including weather resistance and water resistance, and, as a consequence, service life and reliability. of these materials has been determined.

It has been shown that to improve the performance of highways and their durability it is necessary to modify them with polymers such as BR and BSR.

REFERENTS

1. Belyaev P.S., Zabavnikov M.V., Malikov O.G., Volkov D.S. / Bulletin of the Tambov State Technical University. -2005.-T. 11. - No. 4. -FROM. 923-930.11.
2. Timofeev A.G. The effect of complex modification by processing products of secondary rubber materials and polymer waste (PET) on the properties of road bitumen // Vestnik TSTU. - Tver, -2017, - issue 4.-C.7-11.
3. Zolotarev V.A. About quality indicators of bitumen modified with polymers - Kiiv, -2006 r - (Zbirnik of scientific articles); - sleep. 5; -C.200-231.
4. Amirov Fariz Ali., Shixaliyev Kerem Sefi., Obtaining and application of rubber mixtures based on isoprene and functional group polymers. Austrian Journal of Technical and Natural Sciences Vienna. 2017.-№3-4.- P.274 technology journal Kemerovo. -2017., - 46 p.
5. Shikhaliev K.S. Modification of petroleum bitumen with polymer waste. Exact science and 15. Shykhaliev K. S. Alieva Z. N., Modification of petroleum bitumen with plastic waste. Problem of modern science and education 2017. 58p.
6. Kerem Shixaliyev Investigation of the subsequent use of lands along the Araz River contaminated with heavy metals, JOURNAL OF AERONAUTICAL MATERIALS ISSN: 1005-5053, Vol. 43, Issue-01, 2023pp. 102-111
7. Kerem Shixaliyev, RESEARCH AND APPLICATION OF THE PROCESS OF MODIFYING OIL ROAD BITUMEN WITH POLYMERS FOR USE AS A BINDER, ION EXCHANGE AND ADSORPTION ISSN: 1001-5493, Vol. 23, Issue-01, 2023 pp.248-255.

8. Kerem Shixaliyev Research New Ways of Processing Polymer Waste that was Formed as a result of Operation, *Novel Perspectives of Geography, Environment and Earth Sciences Vol. 1*2022, Page 25-35.
9. *Kerem Shixaliyev. PROPERTIES OF THE COMPOSITION BASED ON MODIFIED POLYETHYLENES,* Eur. Chem. Bull. *ISSN 2063-5346, 2023; Volume -12, Special Issue-5 : Page: 242-258.*
10. *Kerem Shixaliyev.* Study of the Properties of the Composition Obtained Based on Mixtures of Polyvinyl Chloride and Ethylene-Propylene Copolymers, International Journal of Current Science Research and Review ISSN: 2581-8341 *Vol 6 No 1 (2023): Volume 06 Issue 01 January 2023,pp314-318.*
11. *Kerem Shixaliyev.* Studies of the physical and mechanical properties of the composition obtained based on polyvinyl chloride, synthetic rubber ethylene propylene terpolymer, and plasticizer, Qeios Ltd. All rights reserved. Qeios, CC-BY 4.0 Article, March 21, 2023pp.1-9
12. *Kerem Shixaliyev.* DİSCONTİNUED HİGH-DENSİTY AND LOW-DENSITY POLYETHYLENE PURCHASE OF ENVİRONMENTALLY FRİENDLY ROAD SURFACES, European Chemical Bulletin ISSN 2063-5346, Section A-Research pape2023,12(Special Issue 1), 654-662.
13. *Kerem Shixaliyev.* Environmental Damage Of Polymer Products That Have Been Turned Into Assembly After Being Out Of Use, European Journal of Molecular & Clinical Medicine ISSN 2515-8260, Volume 09, Issue 08, 2022 pp. 1965–1980.
14. *Kerem Shixaliyev.* ENVIRONMENTAL DAMAGE OF POLYMER PRODUCTS THAT HAVE BEEN TURNED INTO ASSEMBLY AFTER BEING OUT OF USE, *Environmental Issues: Innovations in Life Sciences in Today's World,* 3First Impression: January 2023 pp32 – 39.
15. *Kerem Shixaliyev.* Investigation of the Properties of a Composition Obtained based on Mixtures of Polyvinylchloride and Synthetic Rubber Ethylene Propylene Terpoliymer, Medicine editor *special issue eurchembull,* Vol. 11: Number 1, 2023 JCLMM 1/11 (2023) |2653–2658.
16. *Kerem Shixaliyev.* DİSCONTİNUED HİGH-DENSİTY AND LOW-DENSITY POLYETHYLENE PURCHASE OF ENVİRONMENTALLY FRİENDLY ROAD SURFACES, European Chemical Bulletin ISSN 2063-5346, Section A-Research pape 2023, 12(Special Issue 1), 654-662.
17. *Kerem Shixaliyev.* eneralization of the temperature dependence of some physical properties of high-strength polyethylene using the method of given parameters/ Journal of Harbin Engineering University ISSN: 1006-7043. *Link1:* https://harbinengineering journal.com/index.php/journal/article/view/ 2429, Vol 45 No. 1 January 2024 *Page* 431 – 438.
18. *Kerem Shixaliyev.* Discontinued High-density and Low-density polyethylene purchase of environmentally friendly road surfaces, Journal of Harbin Engineering University ISSN: 1006-7043 Vol 45 No. 1 January 2024 *Page № 1:* 422 – 430.
19. *Kerem Shixaliyev.* DETERMINATION OF RUBBER-CORD CONNECTION ON THE BASIS OF LATEX SYNTHESIZED ON THE BASIS OF ETHYLENE-PROPYLENE RUBBER, China Petroleum Processing and Petrochemical Technology, Catalyst Research Volume 24, Issue 1, March 2024 Pp. 117-126ISSN: 1008-6234. https://zgsyjgysyh-gjs.cn/index.php/reric/article/view/2024-117.html