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Physic-Mechanical Properties of Petroleum Road Bitumen Modified with Styrene-Butadiene Rubber, Butyl Rubber and Nano-Sized Dolomite

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Abstract In the provided article 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 improve the mechanical strength and adhesive properties of road bitumen. Thus, the resulting polymer bitumen is an excellent bindingsystem for the resulting asphalt-bitumen mixture.
Key words: bitumen, modification. styrene butadiene rubber, butyl rubber, dolomite

Intrduction

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].

petroleum road bitumen, used in the production of asphalt concrete mixtures for the construction of highways and gluing waterproofing, is a residue from the distillation of petroleum products. This is a hard-looking black shiny mass, which, under prolonged loads, retains plasticity even at low temperatures [5-7]. Over time, during storage and operating conditions under the influence of sunlight and climatic conditions, the properties of crude bitumen change. Basically, the content of hard and brittle components in them increases and, accordingly, the adhesive and mechanical properties decrease [6-9]. Therefore, to improve the basic properties of road bitumen, the modification process is very relevant [10-112]. For the modification of bitumen, elastomers and crumb rubber obtained from worn tires are very suitable [13-15]Thus, we argue that 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 [16-19].

Meted And dissertation

Modification of bitumen with polymers and rubber crumbs, as well as a polymer-asphalt concrete mixture were prepared at a temperature of C for 24 hours using mixing equipment

We carried out the modification of various road oil bitumen with elastomers and rubber crumbs and the data obtained and their composition and characteristics are given in Tables 1.2 and 3.

Table 1: formulation of a composition based on bitumen and polymers

Name of components	№ samples					
	1	2	3	4	5	
	The content of the mass parts					
Bitumen	100	100	100	100	100	

BR+BSR+rubber waste (2%+3%+8%)	2	4	6	8	10
Sulfur+	1,5	1,5	1,5	1,5	1,5
nano-sized dolomite	2,0	2,0	2,0	2,0	2,0

The dolomite we used was obtained from the Dash-Salakhli deposit in Azerbaijan - a sedimentary rock that includes dolomite itself - $CaCO_3 \cdot MgCO_3$, with admixtures of clayey, ferruginous, siliceous and other substances. The hardness of this dolomite is much lower than others and the density was 1.9 - 2.3 g/cm3, and the tensile strength ranges from 190 - 270 MPa. (table 2)

Table 2: Composition Of Dash-Salakhli 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 composition of the composition based on the components we use is given in Table 3

Table 3: Composition of bitumen-polymer compositions

Composition components	Contents of components, parts by mass								
	1	2	3	4	5	6	7	8	9
Rubbercrumb+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 bitumen leads to a doubling of its softening temperature, while the frost resistance and elasticity of asphalt concrete increase.

Modification of road bitumen with an elastomeric material with a unique set of properties only increases 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 into the composition of bitumen and asphalt leads to a sharp increase physical and mechanical properties of asphalt concrete mixtures (Tables 4 and 5).

Table 4: Physico-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 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 prototypes	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
Hardness Shore A, conventional units	63	50	35	58	20	45	43	40	45
Polymer flow temperature 190 °C, pressure 4 MPa	18	20	40	35	100	30	35	30	25

Adding crumb rubber to bitumen makes it possible to obtain a binder that provides a significant improvement in the deformability and crack resistance of asphalt concrete. (Table 6)

Table 6: Physico-mechanical properties of crushed stone-mastic asphalt concrete with the introduction of crumb rubber

№	The name of indicators	Norms on standard	0 %	0,1 %	0,2 %	0,3 %	0,5 %
			rubber crumb				
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	3,35	2,95	2,95
3	Water saturation, % by volume	,5–4,0	2,82	2,33	2,23	2,16	2,01
4.	Tensile strength in compression, MPa	7	8	14	12	11	9
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	,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

Subsequently, we studied the structural and rheological constants established as a result of testing the samples (Table 7).

Table 7 : Structural and rheological constants of samples

t^0, C	Coating 1 (bitumen)				Coating 2 (polymer bitumen)			
	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	2,5-10^6	2,18-10^6	4,6-10^2	4,3-10^2	5,76-10^6	5,02 -10^6	1,4-10^2	2,95-10^4
+10°C	6,3-10^6	5,45-10^6	11,1-10^2	-	7,9-10^6	6,84 -10^6	3,39-10^2	-
0°C	1,55-10^7	1,15-10^7	27,2-10^2	-	1,41-10^7	1,05 -10^7	8,3-10^2	-
-10°C	3,9-10^7	2,94-10^7	1,51-10^3	-	2,59-10^7	1,95 -10^7	1,55-10^3	-
-20°C	9,9-10^7	2,07-10^7	5,7-10^4	-	3,08-10^8	6,45 -10^7	1,74-10^3	-
Thunderstorm during rain	6,3-10^6	6,3-10^6	11,1-10^2	-	7,9-10^6	6,84 -10^6	3,39-10^2	-

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

In the course of the work, further research consisted of determining the durability of the resulting polymer-polymerbitumen 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 stress summation). 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 various temperatures depending on operating stresses, the overall durability of materials was determined using the formulas

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

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 $T_1, T_2 \ldots T_n$.

Result

This paper presents the results of modification, computational and experimental studies of petroleum road bitumen with elastomers and rubber crumbs.

It has been shown that in order to improve the performance characteristics of highways and their durability, it is necessary to modify them with polymers and rubber crumbs.

Nano-sized dolomite was used as a modifier and filler in the work.

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