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DİSCONTİNUED HİGH-DENSİTY AND LOW-DENSİTY POLYETHYLENE PURCHASE OF ENVİRONMENTALLY FRİENDLY ROAD SURFACES

Kerem Shixaliyev Seyfi

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Abstract

This work, in order to improve the main indicators of oil-road bitumen, it is dedicated to the modification of polymer materials that have been decommissioned and turned into waste. For this purpose, "Baku 85/25" brand bitumen was selected and modified. After that, polymeasphaltoconcrete mixture obtained on the basis of changed "Baku 85/25" brand bitumen was prepared and its physical and mechanical properties were studied. The results of the analysis showed that by adding 3-5 mass parts of polymer waste to bitumen, it is possible to increase its viscosity by 2 times and its strength by 4 times.

The obtained results show that the penetration of the prepared sample is 1.4 times higher than the standard, its elasticity is 4 times higher, and it is proved that the mixture has high deformation properties.

As a result of our scientific research works, a new processing technology for the environmental protection of out-of-service polymer products was developed, polymer scraps of 0.16-0.18 mm size were purchased, and "Baku 85/25" brand bitumen was modified with this polymer scrap.

Thus, the most critical environmental problem was solved and very valuable raw materials were obtained.

Based on the obtained results, it was proposed to use "Baku 85/25" brand bitumen modified with polymer in the preparation of the asphalt-concrete mixture.

Keywords: temperature, polymer waste, Oil-road-bitumen, composition, penetration, softening mechanical force, heat energy. Low-density polyethylene (LDPE), High-density polyethylene (HDPE) Doctor of Technical Sciences, Professor-Academician of the European Academy of Natural Sciences

Professor, Department of Organic substances and technology of macromolecular compounds, Azerbaijan State Oil and Industry University, Baku, AZ1010, Azerbaijan, 20 Azadlig Avenue kerem_shixaliyev@mail.ru

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Introduction

Bitumen is a colloidal system belonging to dispersed systems of oil. Paramagnetic molecules are the center of power in the bitumen colloidal system. The properties of bitumen depend on the colloidal particles and their stability over time. In order to create this stability and adapt the main indicators of bitumen to the requirements of the standard, it should be modified with bitumen-polymer waste [1-5].

Since the softening temperature of road bitumen produced on an industrial scale is 38-40°C, it softens without continuing at a temperature of 45-50°C in the summer months, the asphalt coating collapses, and the toxic gases in the bitumen evaporates and spread into the atmosphere, creating environmental problems[6-9]. Taking into account all this, in this study, an environmentally friendly polymer-bitumen composition with high physical and mechanical properties was obtained by modifying the oil-road bitumen with low properties with polymer waste [6-10].

The wide range of different properties of bitumen (resistance to heat and cold, plasticity, adhesion-cohesion, resistance to aggressive environment, high dielectric properties, etc.), and its relatively cheap price, allow the scope of its use to increase. It has become necessary to use bitumen in construction, industry, and agriculture [11-13].

The use of bitumen in road construction is of particular importance. Road pavements prepared on the basis of bitumen are advantageous in comparison with concrete pavements from the point of view of both strength and safety and are 2.0-2.5 times cheaper [14-15].

During the long-term use of liquid road bitumens, due to the influence of temperature and air oxygen, the process of evaporation of low-boiling fractions and hardening of high-molecular compounds occurs. The strength of road bitumens depends not only on their properties but also on the technology of their use. Bitumens have a unique role in the field of hydraulic engineering. They are used in the preparation of valuable coatings as a waterproof, non-toxic material. Oxidation bitumens with penetration from 85 to 40·0.1 mm are also used for waterproofing purposes. In order to increase the durability of coating bitumens against heat and moisture, the addition of a small amount of small-molecule polyethylene to them has also found a positive solution in practice. [16-17].

Method

When mixing bitumen with a polymer, the following law is obtained: chemical reaction does not occur because in most cases the polymer is inert to the bitumen/ At high temperatures (200-250°C), the polymer turns into a molten bitumen, which causes it to mix with the bitumen and dissolve.

Mixing of bitumen and polymer requires mechanical force and heat energy, which indicates the incompatibility of polymer and bitumen with each other. Directly, when the hot mixture of polymer and bitumen (T≥200°C) is cooled, it forms polymer associates.

We can consider the polymer-bitumen system as three-component, these components consist of bitumen, polymer, and solvent (bitumen solvents). The triangular diagram method is used to look at such systems.dur/

Asphaltenes are better soluble in bitumen than polymers. However, it can be said that the amount of asphaltenes and polymer dissolved in bitumen at a temperature of 200°C is constant.

Thus, the production of polymer-bitumen composition in bitumen at a temperature of 200°C continues until a certain hardness of the polymer, and then it is divided into separate phases. Therefore, the amount of polymer in bitumen should not exceed 25%. Three types of solid, semi-solid, and liquid bitumen are produced at the Baku Oil Plant. The main properties of the bitumen used in the dissertation work are given in table 1.

Properties that determine the quality of solid and semi-solid bitumen and separate them into brands are its viscosity, softening temperature, brittleness temperature, and plasticity.

Table .1.

Main indicators of used oil bitumen

Name of indicators	Type of bitumen		
	semi solid	hard	Liquid
Softening temperature, ºC	25 - 50	60 - 90	-
Penetration (the depth at which the needle penetrates the bitumen layer in 5 seconds as a result of the impact of 100 grams of load), 0.1mm	4 - 20	0 - 5	-
Extension (25ºC), sm	40 - 60	1 - 5	60

The viscosity of bitumen is characteristic of its structure and mechanical properties, it depends on temperature and group composition. The bitumen is selected, the density of the bitumen is determined, and the mixing temperature is found by determining its viscosity at different temperatures. The viscosity of bitumen is 170±20 centistokes (0.17±0.02 Pa·s) and the viscosity of bitumen at compression temperature is 0.28Pa·s.

The following values of kinematic viscosity are determined with the help of a capillary viscometer. These values are determined at temperatures of 60, 135, and 1590C. Viscosity is 2.8x10 sts, 498 sts, and 219 sts.

Kinematic viscosity is found by the following equation:

$$\lg \eta = A - VTS \lg T$$

where: - kinematic viscosity of bitumen, sts; T-temperature, 0C; VTS - sensitivity of viscosity to temperature change (VTS-0.868); A-parameter (A=2.28).

Sample preparation for testing

Standard dimensions of the sample: diameter-102 mm, height 64 mm, 15-18 compressed samples are prepared. In addition, 3 soft samples are prepared. Using these samples, the density of the two-phase system is determined. This indicator is called the actual density of asphalt concrete.

Determination of asphalt-concrete volume indicators

In a soft sample, the true density of asphalt concrete is determined at a temperature of 600C. In the compressed sample, the average density is found. Porosity is determined for each sample. (VTM-Wolds-total-mix), the porosity of mineral composition (VTM-Wolds in mineral aggregates) and distance between grains filled with bitumen (VFA-Wolds filled with asphalt).

Results and Discussions

We determined the physical and mechanical parameters of high-pressure and low-pressure Polyethylenes produced on the basis of Industrial waste used in this work, and the results are given in tables 2 and 3

Table 2

Physical and chemical indicators of polyethylene waste

№ sır.	Characteristics	Brands of polyethylene waste:					
		A-1	A-2	A-3	B-1	B-2	B-3 B-4
1	Primary raw material	Household waste, caps, packaging materials, plastics			Low-pressure polyethylene waste, production waste		
2	Density, g/cm3	0,915	0,915	0,915	0,945	0,945	0,945
3	Alloy flow index: 21.17 H (2.16 kg \force) at load 49.0 H (5.0 kg\force) in cargo	0,1-10 -	0,1-10 -	0,1-10 -	- 0,1-35	- 0,1-35	- 0,1-2,0
4	Mass fraction of volatile substances, %	0,30	0,30	0,30	0,30	0,30	0,30
5	Mass fraction of sol, %	5,0	5,0	7,0	5,0	5,0	0,1
6	Tensile yield strength, MPa	8,0	8,0	8,0	15,0	15,0	15,0
7	Relative elongation at break, MPa	300	300	300	250	250	250
8	Compaction density kg/m3	400	400	250	400	400	400

Table 3.

HDPE and LDPE formed on the basis of industrial waste physicochemical properties of waste

№ sır.	Characteristics	Industrial waste consisting of mixtures of HDPE and LDPE					
		Brands:					
		B-1	B-2	B-3	Q-1	Q-2	Q-3
1	Primary raw material	Industrial waste of PE			Industrial waste based on mixtures of HDPE and LDPE		
2	Density, g/cm3	0,915	0,915	0,915	0,915	0,915	0,915
3	Flow index of the alloy, g/10 min. Loads: 21,17 H in Holland At 49.0 H	 0,1-35 0,1-35	 0,1-35 0,1-35	 0,1-35 0,1-35	 0,1-35 0,1-35	 0,1-35 0,1-35	 0,1-35 0,1-35
4	Mass fraction of volatile substances, %	0,30	0,30	0,30	5,0	5,0	5,0
5	Mass fraction of sol, %	5,0	5,0	5,0	7,0	7,0	7,0
6	Tensile yield strength, MPa	8,0	8,0	8,0	8,0	8,0	8,0
7	Relative elongation at break, MPa	8,0	8,0	8,0	8,0	8,0	8,0
8	Compaction density kg/m3	300	300	300	250	250	250
9	Density of scattering and pouring (ball formation), kg/m3	400	400	400	300	300	300

HDPE and LDPE formed on the basis of industrial waste

"Baku 85/25" brand bitumen was modified after sorting, washing, drying, and grinding. For this purpose, the "Baku 85/25" brand bitumen we used was mixed intensively for 1 hour at 150-180°C, then 3-15 parts by mass were added to the mixer. The main indicators and composition of the composition obtained by giving % polyethylene waste are given in table 4.

Table 4

Based on "Baku 85/25" brand bitumen and Polyethylene waste composition and characteristics of the obtained polymer-bitumen composition

"Baku 85/25" brand bitumen, mass part	Bulk fraction of polyethylene waste	Temperature, °C		Penetration, 0.1m		Uzanma, sm	
		Softening	fragility	At 0°C	At25°C	At13°C	At25°
100	–	51	-5	16	65	14	60
95	3	49,5	-5	15	60	12	70
90	6	49,5	-9	13	59	8	85
85	8	49,5	-12	12	59	8	>100
80	15	41	-12	8	39	5	>100

When 6% resin is given, the main indicators of the composition correspond to the indicators of the standard. its production time can be added to bitumen. Thus, it can be said that by adding Polyethylene waste to bitumen, its properties can be improved.

To improve the basic properties of bitumen, HDPE and LDPE are added to them.

was more profitable to add. The obtained results are given in Table 5

Table 5

Polymer-bitumen composition prepared on the basis of used high and low-density PE alloy and bitumen

Polymer-bitumen composition	The amount of polymers in the composition, mass part	Penetration, 0,1 mm		Temperature , °C		Elongation at 25°C, cm
		25°C-də	0°C-də	softening	fragility	
«Bakı 85/25» markalı bitum	–	61	14	45,5	-6	43
Example I	5	62	15	46,5	-9	45
Example II	10	85	20	46	-16	60
Example III	20	155	30	37	-19	64
I Example V	30	220	43	32	-27	64

The obtained results show that the following indicators of the bitumen-polymer composition have increased: brittleness temperature -16°C, elongation 62 cm, penetration 20·0.1 mm at 0°C, as a result of these indicators, it has been confirmed that bitumen has high plasticity and cold resistance properties.

Thus, HDPE and LDPE by adding, it is possible to improve the main indicators of low-quality "Baku 85/25" brand bitumen.

3 and 6 mass fractions were prepared using recycled HDPE

the macrostructure of bitumen at 180ºC was studied (Figures 1 and 2). The obtained results showed that if a polymer that is insoluble or partially soluble in bitumen is taken, the size of the particles in the mixture depends on the ratio of viscosities and the intensity of mixing. With such a mixture, they are emulsified at high temperatures. The low viscosity of the polymer causes it to disperse better in the bitumen. By increasing the density of used HDPE in the mixture by 15 mass parts, the homogeneity of the system is disturbed and a new phase is formed in the system. If we mix used HDPE with a concentration of 15 parts by mass in bitumen, then a continuous system is formed in bitumen.

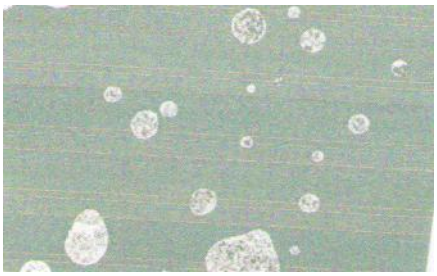

Figure 1. 3-6 mass fractions prepared using high-density PE used macrostructure of bitumen at 180ºC

Figure 2. 15 parts by mass prepared using recycled high-density PE macrostructure of bitumen at 180ºC 6% by mass of recycled high-density polyethylene

The results obtained by studying the physical and mechanical properties of the polymer-bitumen composition are shown in table 6.

Table 6

Polymer-bitumen modified with polyethylene waste physical and mechanical properties of its composition

Name of indicators		according to standard 52056-2003	LDPE+ HDPE in polymer-bitumen composition quantity, mass part .		
			mass part 3 .	mass part 6	mass part 8 .
epth of penetration of the needle into the sample, 0.1 mm					
	at 25°C	40	74	43	41
	at 0°C	25	25	22	20
Uzanması, sm	At 25°C	15	20	18	16
	At 0°C	8	3,5	10	9
Softening temperature,, °C		56	64	68	72
Brittleness temperature, °C		-18	-22	-26	-40
Elasticity, %	At 25°C	80	85	95	60
	At 0°C	70	Not checked		
Change in softening temperature after heating, ºC		5	3	2	1
Ignition temperature, °C		210	300	320	350
Kinematic viscosity at 135°C		-	455	4768	5940

Polymer asphalt concrete based on modified "Baku 85/25" brand bitumen preparation and application

The properties of polymer asphalt concrete and asphalt concrete were studied in a comparative manner. For this purpose, BND and modified bitumen, which are currently used in the preparation of asphalt concrete, were used. The main properties of asphalt concrete prepared on the basis of modified and unmodified bitumen are revealed only during use. The polymer-asphalt concrete tested in service conditions fully meets the standard DÜIST 28-97 bitumen indicators. Compared to asphalt concrete, polymer asphalt concrete has high deformation, strength, and water and mine resistance.

One of the most important indicators is its tolerance to temperature changes. The physical Properties of polymer asphalt concrete and mechanical properties of polymer asphalt concrete prepared on the basis of bitumen modified with DÜIST 28-97 were mainly determined and the obtained results are given in table 3.8. The deformation of asphalt concrete and polymer asphalt concrete was studied under both static and dynamic loading modes.

Polymer asphalt concrete has been shown to have better deformation properties than asphalt concrete at 20ºC (Fig. 7).

In the mechanical process, Mu P-100 research conducted under dynamic conditions (piston travel speed 1200 mm/min) showed that the temperature at which the brittle disintegration of asphalt concrete takes place is indeed in the negative temperature region.

Table .7.

Name of indicators	Yükün təsir etmə vaxtı, san	Temperatur, ºC	Used connector			
			Neft bitumu **БНД 60/90**	Istifadə olunan bitum	3 LDPE+ HDPE	6 LDPE + HDPE
Balance module $E_m\left(\frac{kq\cdot s}{sm^2}\right)\cdot 10^{-3}$	- -	+20 -20	1,09 36,5	0,77 8,5	1,57 5,92	3,13 19,5
Deformation module	10 0,02	+20 -20 -20	0,24 18,3 133	0,16 4,7 32,2	0,36 3,4 22	0,96 9,4 50,5
Plasticity, P	- -	+20 -20	0,34 0,151	0,39 0,149	0,34 0,142	0,28 0,107
The highest viscosity of the conditional-dispersion structure $\eta_o^x\cdot 10^{-10}\frac{kqs\cdot s}{sm^2}$	- - -	+20 -20 -	11,6 488 42	7,6 270 35	15,6 340 22	31,2 1300 42
Aging factor α_0 - before aging α_1 - after aging	-	-20	1,76	1,73	1,39	-

In this case, the bending strength of polymer asphalt concrete is greater than that of asphalt concrete at a positive temperature.

Polymer asphalt concrete prepared on the basis of bitumen modified with LDPE + HDPE has more deformation properties at negative temperatures and good brittleness and high dynamic stability at positive temperatures.

To determine the aging of polymer asphalt concrete, we heated it and determined its acoustic indicators.

As an indicator of aging, it is calculated according to the ratio of the attenuation coefficients of the sound waves in the sample before and after heating at 120ºC for 40 hours.

The elastic-viscous-plastic characteristics of polymer asphalt concrete samples at 50ºC were determined. The obtained results are given in table 8.

Table 8.

Polymeric asphalt prepared on the basis of bitumen modified with LDPE+ HDPE

indicators of brittle-viscous-plastic characteristics of concrete

Göstəricilərin adı	**БНД 60/90** brand bitumen (prototype)	Polymer – bitumen-based binder (suggested)
The highest plastic viscosity $\eta_o 10^{-4}$, Pa· sec	8,5	54,0
The lowest plastic viscosity $\eta_m 11^1$, Pa· sec	4,9	23,7
Dynamic displacement limit, $P_{1<2}$, Pa	4,4	24,0
Equilibrium fragility modulus Gm, Pa when P < P1<2	139	463
Voltage reaction cycle q· η_o /Gm· sec	611	1166

The analysis of the rheological characteristics shows that the modified bitumen can be used in the construction of road surfaces.

Conclusion

with polyethylene (HDPE+ LDPE) coating. As a result, we received a high-quality polymer-bitumen composition.

2. By adding polymer waste to bitumen, it was possible to increase its viscosity by 2 times and its strength by 4 times.

3. After modifying the bitumen with polymer waste, we studied the properties of the obtained composition. The obtained results show that the penetration of the prepared sample is 1.4 times higher than the standard, and its elasticity is 4 times higher.

3. Since the physical and chemical properties of bitumen are very low, the asphalt-concrete road surfaces made of them soften in high-temperature conditions in the summer months and release toxic chemicals into the atmosphere. In order to prevent all this, we managed to obtain ecologically clean bitumen by modifying road-oil bitumen with polymer-based waste. It has been proven by the results of our scientific research that the eco-friendly bitumen we offer is 4 times more flexible than the bitumen currently produced on an industrial scale, and it is possible to increase its heat resistance up to 120°C, which creates fertile conditions for its application in the industry.

4. Based on the obtained results, we suggest the use of "Baku 85/25" brand bitumen modified with polymer waste in the preparation of the asphalt-concrete mixture.

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