

## OBTAINING ASPHALT BASED ON BITUMEN COMPOSITION

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**Abstract.** The paper presents the results on obtaining asphalt compositions based on bitumen composition and the addition of crumb rubber, river sand, stone dust, cement, crushed stone, gravel, polyethylene production waste and M-40 fuel oil, which can be used for pavements with high performance indicators. The obtained composition has been used to produce pavements by compounding compositions with road bitumen of BND 60/90. The proposed asphalt pavements have advantageous properties: the ability to be stored at elevated temperatures under the impact of the separation temperature of the constituent compositions. The produced pavements are recommended for use in the construction of highways and inside city roads, sidewalks, bridge decks and others.

**Keywords:** Asphalt composition, bitumen, river sand, stone dust, gravel, crushed stone, pavement, penetration, extensibility, softening temperature, polymer waste, road bitumen.

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**Received:** 15 September 2023; **Accepted:** 5 December 2023; **Published:** 18 December 2023.

### 1. Introduction

Asphalt pavement compositions are used in the production of pavements due to their performance at extreme temperatures.

Polymers can increase the strength of asphalt, making the pavement more resistant to load such as traffic of motorcars and trucks. The addition of polymers can help reduce material fatigue and increase its service life by reducing the probability of crack formation. Polymers can increase resistance of asphalt to water, which is important for preventing water and freeze damage. Polymers can also improve tire grip and reduce noise, making the road safer and more comfortable for drivers. Some polymers can protect asphalt from ultraviolet rays, which helps extend the service life of the pavement (Zolotarev, 2006; Yang *et al.*, 2022; Pugin *et al.*, 2022).

Asphalt based on a bitumen composition was obtained at Oil Refinery Plant named after Heydar Aliyev, at which time modifying additives (polyethylene by-product, rubber crumbs, fuel oil, bitumen) were added to it, and its physical and mechanical properties were checked (Mammad Hasan-zada, 2019; Mammad Hasan-zada *et al.*, 2019; 2022; Mammad Hasan-zada & Ibrahimov, 2020).

The results of researches on the production of polymer-bitumen compositions by involving clods of high-density polyethylene production waste in the composition are presented. In comparison with a bitumen composition, the modified bitumen, composition containing clod, rubber crumbs, fuel oil with improved properties for

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#### How to cite (APA):

Mammad Hasan-zada, D.S. (2023). Obtaining asphalt based on bitumen composition. *New Materials, Compounds and Applications*, 7(3), 219-225.

pavements that meets the requirements of bitumen of BND 60/90 according to SS 22245-90, was obtained. It was established that the introduction of a bitumen composition into the composition as a modifying additive of polymer waste from the production of high-density polyethylene - clods, along with rubber crumbs, makes it possible to obtain a bitumen composition of improved quality. It was found that the greatest influence on the extensibility of the mass is exerted by the proportion of clods in the composition and their softening and needle penetration temperatures are influenced by the proportion of bitumen in the mass (Zou *et al.*, 2020; Wieser *et al.*, 2021; Li *et al.*, 2022).

Obtaining polymer-bitumen compositions by introducing polymer additives into the composition makes it possible to expediently regulate the structural and mechanical properties of the final product, since bitumen modified in this way is characterized by both the properties of bitumen and the properties inherent in polymers, namely high elasticity, heat resistance, transparency and frost resistance (Samedov & Allahverdiev, 2007; Khristoforova *et al.*, 2008; 2011).

### **The objective of the research work**

The objective of the research work is the use of polyethylene waste as an additive to attract a new direction of research, protect the environment from pollution by polymer waste, as well as determine the conditions for obtaining polymer-bitumen compositions with improved quality indicators, suitable for use as pavements (Zolotarev, 2006; Rasman, 2018; Gu *et al.*, 2021; Mashaan, 2022).

The performance properties of compositions obtained using polymer waste were improved; asphalt and products for various purposes can be recommended for use as a protective solution for copper roofing, oil pipelines and foundations of buildings.

## **2. Experimental part**

The bitumen taken to obtain asphalt compositions has the following properties: softening temperature according to KiSh 110<sup>0</sup>C, penetration at 25°C 16x0.1 mm, extensibility at 25°C 3 n. s. (Patent 2194729, 2004; Patent 6569351, 2003). The following asphalt compositions were prepared based on bitumen and components.

Mineral compositions were prepared as follows. River sand is usually very stable and contains no impurities. River sand is an indispensable material for road construction. Stone dust is a material obtained by processing river stone in thermal centrifuges.

Gravel is a building material obtained by crushing and passing rocks through sieves.

The chemical formula of cement is 67% calcium oxide, 22% silicon oxide, 5% aluminum oxide, 3% iron oxide and 3% other substances.

The compositions were prepared as follows: bitumen was heated in a thermostat to 100°C.

Then the ingredients were added to it in parts. The temperatures were raised to 170°C and the mixture was stirred. After this, the physical and mechanical properties of the resulting mixture were determined.

As additives to bitumen, we used crumb rubber, which is a waste from rubber production (waste tires in accordance with SS 1293) and a clod - a waste from polyethylene production (Samedov & Allahverdiev, 2007; Khristoforova *et al.*, 2008; 2011).

When preparing the bitumen composition, the quantities of rubber crumbs and clods were changed. Fuel oil (M-40) was added to the composition.

The content of the bitumen compositions contained a waste from the production of high-density polyethylene (HDPE) - a clod with a molecular weight of 700-1100. The polyethylene content in the composition was 99%, the concentration of double bonds was 2-10% and the thermographic indicator was 150°C. Crumb rubber had a diameter of 0.06 mm of SS (1293) and was a waste from the production of rubber products. The use of rubber crumbs as a modifier of road bitumen is justified both by their organic composition with bitumen components and by increasing the performance properties of the final product. The introduction of rubber crumbs ensures increased adhesion of tires to the surface and reduces dust formation.

**Table 1.** Physical and mechanical properties of used fuel oil M-40 according to SS 10585-99

No	Name	Indicators
1	Kinematic viscosity, at 80 °C, mm <sup>2</sup> /C	43
2	Density at 20°C, kg/m <sup>3</sup>	922,1
3	Pour temperature, °C	-12
4	Flash point, °C	184
5	Ash content, %	0,0228
6	Mass fraction of sulfur, %	0,23
7	Mass fraction of water, %	Not

The molecular weight of the polymer and the technology for preparing the bitumen composition is of great importance (5, 6). The raw material is bitumen, which has a softening temperature (“KiSh”) of 110°C. (SS 11506-73), needle penetration depth or penetration of 16x 0.1 mm at 25°C (SS 11505-75).

### 3. Results and discussion

When the amount of the specified polymer waste is 1.8% per unit mass of bitumen, the melting point of the composition is reduced by 57°C according to “KiSh”, which is 53°C versus 110°C for raw materials. At the same time, the penetration depth of the needle increases from 16×0.1 mm to 100×0.1 mm, as well as the extensibility at 25°C from 3 to 8 cm. As can be seen, judging by the softening temperature, the resulting polymer-bitumen composition meets the requirement for bitumen of BND 60/90 (Table 2). For comparison, the effect of introducing only polymer waste clods into the bitumen composition, in amounts of 2.0 and 4.0% by weight, was investigated. The results are presented in Table 2.

As our researches showed, with an increase in the amount of polymer additive above 4% by weight, obtaining a homogeneous bitumen composition becomes somewhat more complicated. The best results are obtained by introducing polymer waste in an amount of 2% by weight. The resulting bitumen composition fully complies with the construction data, which confirmed the advantages of pavements based on polymer-modified bitumen compared to conventional road bitumen in terms of elasticity strength, softening point, durability, etc.

Adhesion is the property of a material to adhere or “stick” to another surface. In the case of pavements, adhesion refers to the ability of a bituminous surface (or asphalt) to adhere to a road base such as concrete or asphalt and form a strong bond. High adhesion is important to prevent the coating from peeling off from the base, cracking and other pavement defects (Mukhamaddinov & Galimullin, 2017).

Polymers can improve adhesion in bituminous coatings. They promote better adhesion between the bitumen and the road base, which makes pavements more reliable and durable. This is especially important in conditions of high traffic and extreme temperature fluctuations, when the safety and stability of pavements becomes a priority. The adhesive ability of polymer bitumen coating is higher than that of road bitumen (Patent 6569351, 2005; Kaligin, 2006).

**Table 2.** Physical and mechanical properties of polymer-bitumen compositions

No	Name	Softening temperature according to KiSh °C,ГОСТ 11506-73	Penetration depth of needle at 25°C × 0,1 mm of SS 11501-73	Extensibility cm, at 25°C n.s. SS 11505-75
	Oil road bitumen of BND 60/90 of SS 22245-90	n.s. 47	61-69	55
	High-melting bitumen (raw material)	110	16	3
I.	Bitumen 60,6%	53	100	8
	Clod - 1,8%			
	Fuel oil - 36,4%			
	Rubber crumb -1,2%			
II.	Bitumen -49,02%	46	71	13
	Clod -1,96			
	Fuel oil-49,2%			
III.	Bitumen -48,07%	80	51	4
	Clod-3,85%			
	Fuel oil -48,08%			

The conducted research established that the introduction of polymer waste from the production of high-density polyethylene - clod - along with rubber crumb into the bitumen composition as a modifying additive ensures the production of a bitumen composition of improved quality that meets the requirements of SS 22245 - 90 for bitumen of BND 60/90

The possibility of recycling polymer waste from the production of polyethylene and used tires helps reduce the cost of pavements and solve environmental problems.

Asphalt is prepared from heavy oil residues and is natural asphalt. Artificial asphalt is a mixture containing mineral substances: crushed stone, sand, sandstone, limestone and viscous-binding elements.

Asphalt concrete is a complex mixture containing bitumen, which is used in road construction, pothole repair, etc.

This work is dedicated to the preparation of asphalt compositions for their further use for pavements.

The first composition (Table 2) had poor adhesion to bitumen. The second composition was hard and also had poor adhesion. The best composition was the third composition, which had good adhesion to road bitumen. We conducted experiments to investigate the impact of the amount of added asphalt composition on some qualities of the resulting road bitumen.

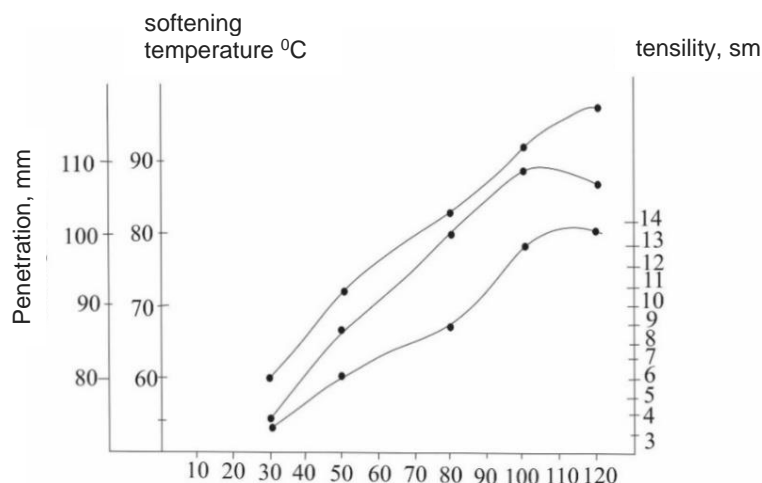
When comparing the data given in table 3, it is clear that the proposed composition has improved performance, namely, a softening temperature according to KiSh was obtained that meets the requirements for bitumen of BND 60/90 and the needle penetration depth and extensibility at 25°C also increased, ensuring the use of the composition under different climatic conditions.

**Table 3.** Physical and mechanical properties of bitumen compositions

No	Name	Softening temperature according to KiSh, °C, SS 11506-73	Penetration depth of needle, at 25°Cx0,1 mm	Extensibility, cm, at 25°C, n.s. GOST11505-75
1	SS 22245-90 for oil road bitumen BND of 60/90	47	61-90	55
2	High-melting bitumen (raw material)	110	16	3
3	Bitumen composition: Bitumen- 77% Rubber crumb - 1, 5% Clod – 1,4% Fuel oil-19,8%	54	134	9
4	Bitumen composition: Bitumen - 73,5% Rubber crumb - 2,2% Clod –2,2% Fuel oil-22,1%	47	139	13,5
5	Bitumen composition: Bitumen - 77,96% Rubber crumb - 3,5% Clod– 7,8% Fuel oil-11,9%	43	143	3,0

**Table 4.** Content and properties of compositions

1	Bitumen - 17% Clod - 23,4% River sand - 36,5% Stone dust - 8,8 % Crushed stone - 5,0%	110°C	58	8
2	Bitumen - 14% Clod - 23,4% River sand - 36,5% Stone dust - 8,8 % Cement - 8,8 % Crushed stone - 5,0% Gravel - 4,0 %	115	60	10
3	Bitumen - 30,8% Clod - 10,54% River sand - 7,7% Stone dust - 20,5 % Cement - 10,3% Crushed stone - 10,3%	90	75	13



**Figure 1.** Change in the penetration softening temperature and extensibility of the obtained road bitumen depending on the amounts of the asphalt composition added

#### 4. Conclusion

The research of the ratio of the bitumen mixture, asphalt and polymer waste is a new direction and is of great scientific and practical importance.

These questions have been investigated quite thoroughly and very important results have been obtained.

The introduction of waste rubber into the composition of the road composite road pavements, in addition to environmental benefits, increases the slip resistance of asphalt concrete pavements, which is a very important condition for the safety of road transport.

The slip resistance of roads with rubber waste has been investigated and good results have been obtained.

It is this direction that further determines the essence of research work.

The addition of oil products into composite materials prepared for road pavement gives additional quality to the softening and polishing of pavement materials. Taking all this into account, we can conclude that the work is a multifaceted and complex research work.

Depending on the amounts of mineral components and bitumen, asphalt compositions are divided into several classes: a) sand (for sidewalks and pedestrian roads); b) fine-grained (for roads with heavy traffic), rubber-bitumen for covering stadiums and bicycle roads, etc.

Asphalt contains oil-derived asphalt and asphalt oil. These compositions contain asphaltenes, resins, cyclic compounds and saturated hydrocarbons. The compositions obtained by us can be used to obtain asphalt road surface compositions.

For this purpose, we added the resulting asphalt compositions to road bitumen of BND 60/90.

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