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COMPARATIVE ANALYSIS OF THE EFFECT OF POLYMER ADDITIVES ON THE PHYSICAL AND MECHANICAL PROPERTIES OF ASPHALT CONCRETE MIXTURES

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Abstract. In light of the current problems in the road construction industry related to technological violations during the laying of asphalt concrete mixtures and their negative impact on the physical and mechanical properties of the coating, special attention is paid to the quality of organic binder in asphalt concrete mixtures. In this article we will focus on studying the effect of polymer additives on the compaction of asphalt concrete mixtures.

Problems associated with technological violations during the laying of asphalt concrete not only reduce the durability of the pavement, but can also lead to serious operational problems. Our research focuses on solving these problems through the use of polymer additives that have the potential to increase the compaction of mixtures, hence improve the characteristics of the road surface.

Within the framework of the work, not only the influence of polymer additives on the physical and mechanical properties of asphalt concrete was considered, but also their influence on the stability and durability of the pavement was analyzed. The results obtained can serve as a basis for the development of effective strategies for improving the technology of laying asphalt concrete mixtures and improving the quality of road surfaces in general.

Keywords: polymer, organic binder, asphalt concrete mixture, physical and mechanical properties.

Introduction

Modern Kazakhstan is facing serious problems in the field of road construction related to the low quality of organic binder. The insufficient quality of bitumen and the limited volume of supplies create difficulties affecting the quality of the road surface and leading to disruptions in the construction of highways.

As part of laboratory studies conducted at «KazdorNII» JSC, a reference sample was prepared in accordance with the standards. This sample was manufactured under laboratory conditions using BND 100/130 bitumen at a load of 160 kN (40 MPa) and a temperature of 160 °C and subjected to tests followed by determination of the initial density.

In the course of the research, the effect of the use of polymer in the composition of crushed stone-mastic asphalt concrete (SMAC) was analyzed, both with and without the addition of polymer. The experiment included a change in the density of the samples, a decrease in the load and a decrease in the temperature of the mixture. Particular attention was paid to the determination of the physical and mechanical properties of the samples, which allows us to draw conclusions about the effect of additives on the characteristics of asphalt concrete mixtures under various operating conditions.

The results obtained can have an important practical application, providing a basis for developing recommendations for improving the quality of road materials and optimizing construction processes under conditions of variable factors.

Methodology

The methodological basis of the research is a comparative analysis of the results of laboratory tests of asphalt concrete samples with a polymer additive and without a polymer additive and an assessment of their compliance with the requirements of ST RK 1225-2019 "Mixtures of asphalt concrete road, airfield and asphalt concrete. Technical specifications" and ST RK 1223-2019 "Mixtures of polymerasfalt concrete road, airfield and polymerasfalt concrete. Technical conditions".

Indicators of physical, mechanical and operational properties of asphalt concrete were determined by testing samples in accordance with the requirements of ST RK 1218-2003 "Materials based on organic binders for road and airfield construction. Test methods".

The preparation of asphalt concrete mixtures was carried out by weighing the calculated amount of raw materials, heating stone materials in a drying cabinet to the required temperature, mixing in a laboratory paddle mixer, introducing mineral powder and bitumen. The mixing time was determined visually. The temperature of the finished control mixture was 160 °C.

Preparation of mixtures in the laboratory

During the preparation of mixtures in the laboratory using hot technology, the materials crushed stone, mineral powder and slag crushed stone were pre-dried in a SNOL drying cabinet (Figure1) at a temperature of 160 degrees.

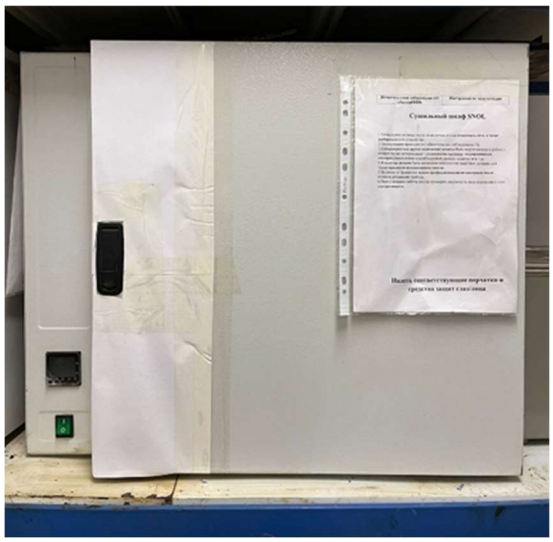

Figure 1 – SNOL drying cabinet

In a separate container heated to 170 ° C on a heating plate, organic binder bitumen BND 100-130 with a modifying additive was prepared, which was stirred mechanically for 30 minutes using a stirring screw (Figure 2).

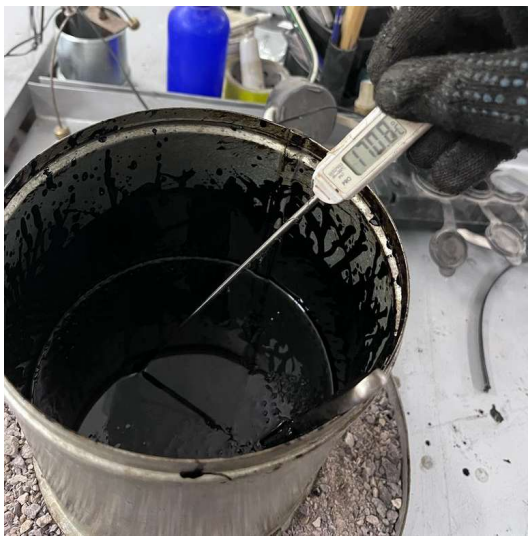

Figure 2 – Container with organic binder

Materials in quantities specified by composition, modified bitumen was added to the pre-dried volume. The composition was mixed manually to a state of uniformity of composition, where all mineral grains are evenly coated with a binder. The composition of the asphalt concrete mixture with polymer is shown in Table 1, without polymer in Table 2.

Table 1 - Composition of asphalt concrete mix with polymer additive

№	Name of materials	The composition of the mineral part of the asphalt concrete mixture (bitumen over 100%)	The composition of the mineral part of the asphalt concrete mixture (bitumen in 100%)
1	Crushed stone fr.10-20 mm q.Volgodonovka	59,0	56,0
2	Crushed stone fr.5-10 mm q.Volgodonovka	13,0	12,3
3	Screening fr.0-5 mm q.Volgodonovka	17,0	16,1
4	mineral powder of "TUTAS" LLP	11,0	10,4
5	Viscous bitumen of the BND 100/130 brand	5,3	5,0
6	Polymer additive from the bitumen mass	4,5	0,2

Table 2 - Composition of asphalt concrete mix without polymer additive

№	Name of materials	The composition of the mineral part of the asphalt concrete mixture (bitumen over 100%)	The composition of the mineral part of the asphalt concrete mixture (bitumen in 100%)
1	Crushed stone fr.10-20 mm q.Volgodonovka	59,0	56,0
2	Crushed stone fr.5-10 mm q.Volgodonovka	13,0	12,3
3	Screening fr.0-5 mm q.Volgodonovka	17,0	16,1
4	Mineral powder of "TUTAS" LLP	11,0	10,4

5	Viscous bitumen of the BND 100/130 brand	5,3	5,2

Production of samples

Samples with a diameter and height of 71.4 ± 1.5 mm of cylindrical shape for determining the physico-mechanical properties of mixtures were made by compacting mixtures using a hydraulic press with a load of up to 500 kN (Figure 3).

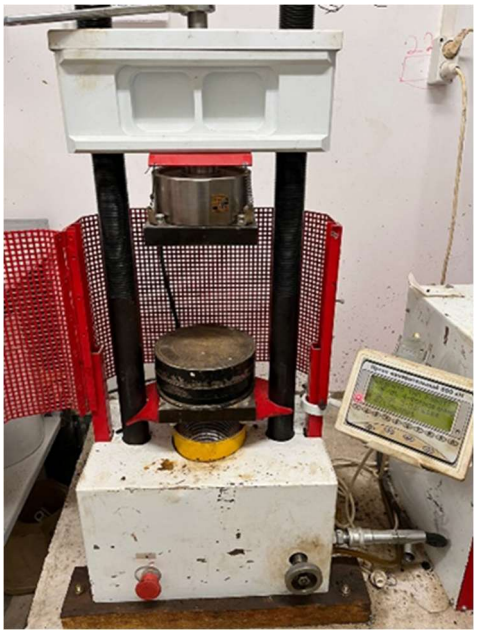

Figure 3 – Hydraulic press

During the manufacture of samples from hot mixtures, the molds and liners were preheated to 100 degrees (Figure 4).

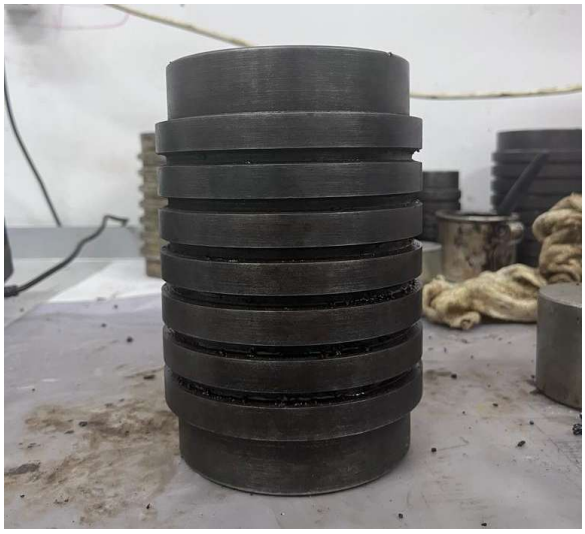

Figure 4 – Sample preparation mold

An upper liner was inserted onto a mixture evenly distributed in a mold with a spatula and the mixture was pressed onto the lower plate of the press for sealing, the upper plate of the press

was brought into contact with the upper liner and the electric motor of the press was turned on (Figure 5).

Figure 5 – The process of forming a sample on a hydraulic press

The pressure on the compacted mixture was brought to 160 kN for 5-10 seconds and after 3.0 minutes the load is removed.

The samples were extracted from the mold using a decompressor (Figure 6).

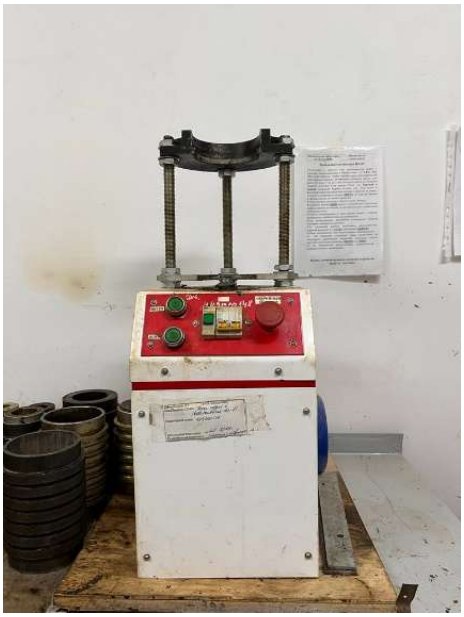

Figure 6 – The decompressor

The height of each sample was measured using a caliper with an error of 0.1 mm.

Physico-mechanical properties of crushed stone-mastic asphalt concrete without polymer and with polymer

The indicators of physico-mechanical asphalt concrete were determined by testing samples in accordance with the requirements of ST RK 1218-2003 "Materials based on organic binders for road and airfield construction. Test methods".

The test results of asphalt concrete with and without polymer additive are shown in Table 3.

Table 3 - Test results of asphalt concrete with and without polymer additive.

№	Name of indicators	The norm according to		SMAC without polymer additives	SMAC with a polymer additive
		GOST 31015-2002	ST RK 2373-2019		
1	2	4	5	6	7
1.	Residual porosity, %	from 2,0 to 4,5	from 2,0 to 4,5	2,43	3,46
2.	Water saturation, % by volume	from 1,0 to 4,0	from 1,0 to 4,0	3,06	1,71
3.	Compressive strength at temperature 50 °C, MPa	at least 0.7	at least 1,0	1,3	1,8
4.	Compressive strength at temperature 20 °C, MPa	at least 2,5	at least 2,8	3,5	6,1
5.	Shift tolerance by: - coefficient of internal friction; - by adhesion during shear at temperature 50 °C, MPa	 at least 0,94 at least 0,20	 at least 0,94 at least 0,25	 0,96 0,43	 0,98 0,51
6.	Crack resistance is the ultimate tensile strength when split at temperature 0 °C, MPa	at least 3,0 no more 6,5	at least 3,0 no more 6,5	3,17	4,51
7.	Average track depth, mm, no more	it is not standardized	3,0	4,94	1,74

The tests were carried out in laboratory conditions and based on the presented data, the following conclusions can be drawn:

- A mixture with a polymer additive exhibits higher compressive strength compared to a mixture without a polymer additive. The compressive strength is significantly higher for a mixture with a polymer additive.
- The mixture with a polymer additive has better shear stability, which is expressed in higher values of the coefficient of internal friction and shear adhesion.
- The crack resistance of a mixture with a polymer additive is superior to a mixture without a polymer additive in terms of tensile strength when split at a temperature of 0o. This indicates a higher crack resistance in low temperature conditions.
- The average track depth is significantly lower for a mixture with a polymer additive, which indicates a higher resistance to deformation.
- Both types of mixtures comply with established standards, but taking into account all indicators of physical and mechanical properties, a mixture with a polymer additive shows an average 1.5 times higher characteristic compared to a mixture without a polymer additive.

Conclusion

Based on the laboratory tests conducted, important conclusions can be drawn that emphasize the need to use high-quality bitumen binders in Kazakhstan and the role of a polymer additive in improving its properties.

Research clearly indicates the need for the use of high-quality bitumen binders in Kazakhstan. The polymer additive is an effective means to improve the physical and mechanical properties of bitumen, which in turn contributes to the creation of durable and stable road surfaces. These studies support the importance of innovative methods in the construction industry to ensure high standards of safety and sustainability of road surfaces.

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Contribution of authors (indicate the respective contribution of each author):

[1]Zhumamuratov M. – analyzed the results, compared them with known data and formulated conclusions.

[2]Pirshayev D. – conducting laboratory tests

[3]Omirbekova Z. – processed the data, performed calculations and visualization

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ПОЛИМЕРЛІ ҚОСПАЛАРДЫҢ АСФАЛЬТБЕТОН ҚОСПАЛАРЫНЫҢ ФИЗИКАЛЫҚ-МЕХАНИКАЛЫҚ ҚАСИЕТТЕРІНЕ ӘСЕРІН САЛЫСТЫРМАЛЫ ТАЛДАУ

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Аңдатпа. Асфальтбетон қоспаларын төсеу кезіндегі технологиялық бұзушылықтарға және олардың жабынның физикалық-механикалық қасиеттеріне кері әсеріне байланысты жол құрылысы саласындағы қазіргі проблемаларды ескере отырып, асфальтбетон қоспаларындағы органикалық байланыстырғыштың сапасына ерекше назар аударылады.. Бұл мақалада біз полимерлі қоспалардың асфальтбетон қоспаларының тығыздалуына әсерін зерттеуге тоқталамыз.

Асфальтбетонды төсеу кезіндегі технологиялық бұзушылықтарға байланысты проблемалар тротуардың беріктігін төмендетіп қана қоймайды, сонымен қатар күрделі пайдалану проблемаларына әкелуі мүмкін. Біздің зерттеуіміз қоспалардың тығыздалуын арттыруға, демек, жол жамылғысының сипаттамаларын жақсартуға әлеуеті бар полимерлі қоспаларды қолдану арқылы осы мәселелерді шешуге бағытталған.

Жұмыс аясында полимерлі қоспалардың асфальтбетонның физикалық-механикалық қасиеттеріне әсері ғана емес, сонымен қатар олардың тротуардың тұрақтылығы мен беріктігіне әсері де талданды. Алынған нәтижелер асфальтбетон қоспаларын төсеу технологиясын жетілдірудің және жалпы жол төсемдерінің сапасын жақсартудың тиімді стратегияларын жасауға негіз бола алады

Түйінді сөздер: полимер, органикалық байланыстырғыш, асфальтбетон қоспасы, физикалық-механикалық қасиеттері.

СРАВНИТЕЛЬНЫЙ АНАЛИЗ ВЛИЯНИЯ ПОЛИМЕРНЫХ ДОБАВОК НА ФИЗИКО-МЕХАНИЧЕСКИЕ СВОЙСТВА АСФАЛЬТОБЕТОННЫХ СМЕСЕЙ

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Аннотация. В свете современных проблем в дорожно-строительной отрасли, связанных с технологическими нарушениями при укладке асфальтобетонных смесей и их негативным влиянием на физико-механические свойства покрытия, особое внимание уделяется качеству органического вяжущего в асфальтобетонных смесях. В этой статье мы сосредоточимся на изучении влияния полимерных добавок на уплотнение асфальтобетонных смесей.

Проблемы, связанные с технологическими нарушениями при укладке асфальтобетона, не только снижают долговечность дорожного покрытия, но и могут привести к серьезным эксплуатационным проблемам. Наши исследования направлены на решение этих проблем за счет использования полимерных добавок, которые потенциально могут повысить плотность смесей и, следовательно, улучшить характеристики дорожного покрытия.

В рамках работы было рассмотрено не только влияние полимерных добавок на физико-механические свойства асфальтобетона, но и проанализировано их влияние на устойчивость и долговечность дорожного покрытия. Полученные результаты могут послужить основой для разработки эффективных стратегий совершенствования технологии укладки асфальтобетонных смесей и повышения качества дорожных покрытий в целом.

Ключевые слова: полимер, органическое вяжущее, асфальтобетонная смесь, физико-механические свойства.