DESIGNING AND CONSTRUCTION OF ROADS, SUBWAYS, AIRFIELDS, BRIDGES AND TRANSPORT TUNNELS

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FEASIBILITY OF APPLICATION OF BITUMINOUS BINDER IN CAST ASPHALT CONCRETE MIXTURES FOR LAYING AND REPAIRING ROADWAY SURFACING OF A HIGHWAY BRIDGE

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Statement of the problem. We consider the problem of the justification of the use of bitumen and the development of compositions of cast asphalt-concrete mixtures for the installation and repairs of roadway surfacing of highway bridges.

Results. The experimental results and their analysis for the determination of physical and mechanical properties of cast mixtures with the use of different bitumen binder are shown. The analysis of physical and mechanical properties of cast mixtures using different grades of bitumen and polymer-bitumen binder was performed. The role of bitumen in improving the quality of cast asphalt concrete used for the repair and paving of the roadway of a road bridge is indicated. The optimal prescription indicators of cast asphalt are provided. The optimal composition of the cast mixtures for the installation and repairs of roadway surfacing layers of highway bridges is identified.

Conclusions. It is established that the main factor influencing the characteristics of the cast asphalt concrete mixture is the viscosity of the asphalt binder and to the use of modifying polymer additives in it. It is shown that there is the most significant difference in the characteristics of the cast mixtures of Type I and II depending on their physical and mechanical properties and particularly on that applied to the bitumen binder.

Keywords: highway bridge, cast mixture, asphalt, bitumen, polymer-bitumen binder.

Introduction. In the Russian Federation, as in many other countries, roads have an asphalt concrete surfacing. The most road mixes that are used for asphalt concrete surfacing of roadways and pavements of highway bridges are hot high-density or dense asphalt concrete mixes of class A, B according to the GOST (ГОСТ) 9128-2009.

Lately in order to lay out and repair asphalt concrete surfacing of roadways of highway bridges, poured asphalt has been generally used.

Poured asphalt is a hot mix with a doughy consistency where the main component is mastic (an asphalt binder) that consists of a highly viscous bitumen and a great amount of mineral powder as well as sand from grinding sifts and fine crushed stone as a filler. Poured asphalt might contain up to 13 % of bitumen and up to 30—35 % of mineral powder, i.e. a proportion of an asphalt binder might be over 1/3 of a specified material, which makes it considerably more expensive than traditional dense or high-density asphalt concrete mixes. Based on the above feature of poured asphalt, the temperature of its laying should be rather high, about 200—215 °C [1, 3, 13].

According to modern studies, a poured asphalt concrete mix is a mix of ratios of mixed and heated crushed stone, sand, mineral powder, bitumen (or modified bitumen) and if necessary, modified additives so that the amount of a bitumen binder was the same or even higher than that of pores in a mix of mineral components [1, 3].

The drawbacks of traditional technology of using poured asphalt concrete mixes for laying out and repairing surfacing of highway bridges are the following:

— a high consumption of mineral powder for necessary heat resistance of poured asphalt;

— high temperature (215—230 °C) necessary for preparing and laying out (200—215 °C) poured asphalt due to a high concentration of mineral powder in it. A high temperature gives rise to accelerated aging of road bitumen in a structured state;

— insufficient stability against residual plastic deformations, which is particularly the case for poured mixes with a low content of crushed stone in the mineral component;

— insufficient roughness and cohesive properties of repaired areas of rodway bridges due to low rigidity of poured asphalts.

Lately there has been some positive experience repairing and laying asphalt concrete surfacing of roadways of highway bridges by Ltd. Lemminkainen Dorstroy using a fine-grained poured mix Lempruf by means of a polymer bitumen binder. In the upper layer of a roadway surfacing from a poured mix Lempruf with the thickness of 40 mm is laid and then black crushed stone with the fraction of 12—16 or 10—20 mm. Works are performed in compliance with the requirements of the Roadway Guidelines (CTO) 49976959-001-2011 “Laying out surfacing of bridge structures using the Lemminkainen Technology”. The characteristics of poured asphalt concrete mixes “Lempruf” and their composition are protected by Ltd. Lemminkainen Dorstroy.

According to the GOST (ГОСТ) P 54401-2011, the classification of poured mixes is presented with three types with a grain composition being most detailed. Additional requirements for

mixes used for designing surfacing (I and II type) are introduced and those pertaining to particular types of poured asphalt concrete according to a stamping depth have become more strict.

In the above document technological parameters (temperature of preparation) of a poured mix using a polymer bitumen binder are identified, but the no effect on the physical and mechanical properties of poured asphalt concrete after the use of the above binder as well as the improved road bitumens is shown in the GOST (ГОСТ) P 54401-2011. Given that the central role played by the properties of a bitumen binder in the properties of asphalt concrete used in construction of road surfacing has been proved by scholars in this country and abroad [1—20], the effect of the characteristics of a polymer bitumen binder on the properties of poured mixes recommended for laying out and repairing surfacing of roadways of highway bridges.

1. Justification of the use of a bitumen binder and development of compositions of poured mixes using oil road and modified bitumen. Through the course of studies of poured mixes for laying and repairing surfacing of highway bridges, a different bitumen binder was used. These were oil bitumens BND 60/90 according to the GOST (ГОСТ) 22245-90 and a polymer bitumen binder PBB 60, PBB 90 according to the GOST (ГОСТ) 52056-2003. Poured mixes of type I and II were prepated with a grain composition meeting the requirements of the GOST (ГОСТ) P 54401-2011. The composition of poured mixes is presented in Table 1, the physical and mechanical indices of the poured mixes are in Fig. 1—5.

Table 1

Compositions of poured mixes

№	Name of the material	Type I	Type II
1	Granite crushed stone with the fraction 5—20, %	44	21
2	Grinding sifts of granite, %	22	50
3	Mineral powder, %	34	29
4	Binder, % per 100 % of the mineral component	9.5	9

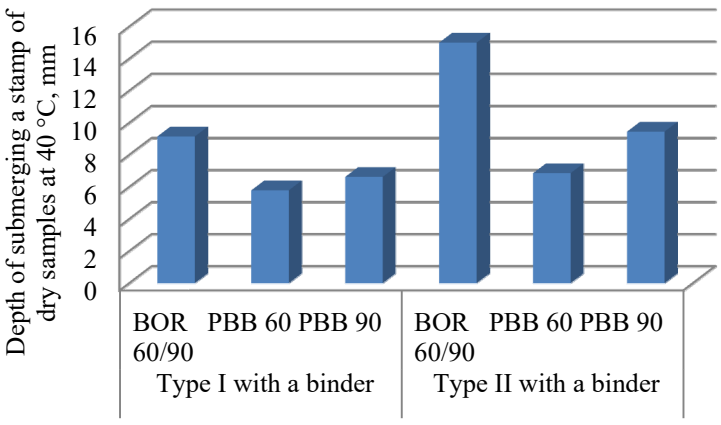

Fig. 1. Dependence of the depth of submerging a stamp of dry samples at 40 °C of poured asphalt concrete, mm, after 30 min on a used bitumen binder: Type I, Type II

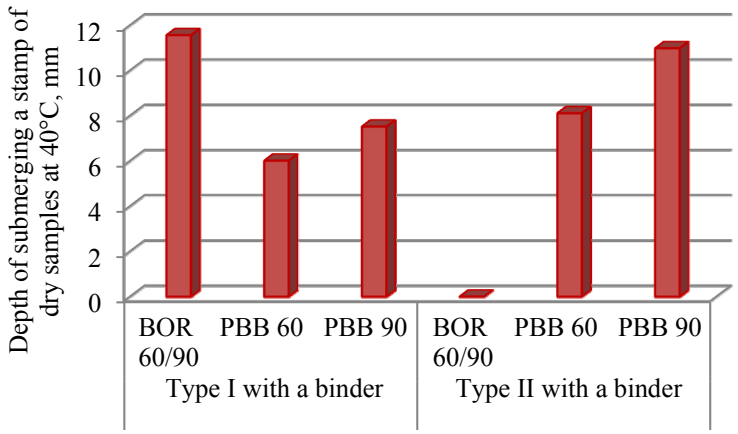

Fig. 2. Dependence of the depth of submerging a stamp of dry samples at 40 °C of poured asphalt concrete, mm, poured after 60 min on a used bitumen binder: Type I, Type II

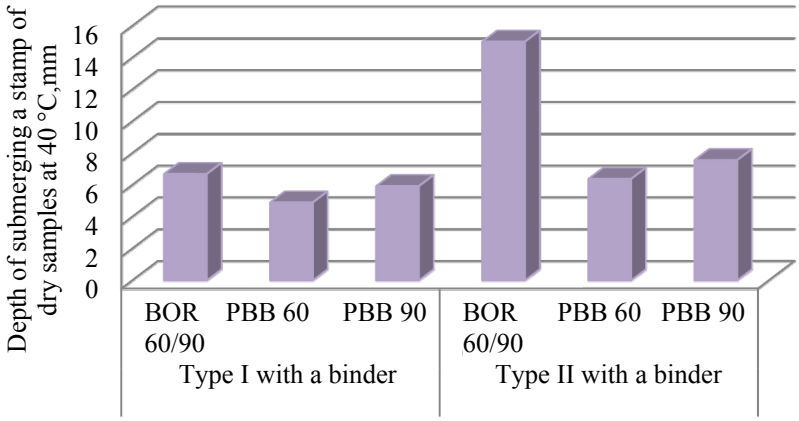

Fig. 3. Dependence of the depth of submerging a stamp of water saturared samples at 40 °C of poured asphalt concrete, mm, poured after 30 min on a used bitumen binder: Type I, Type II

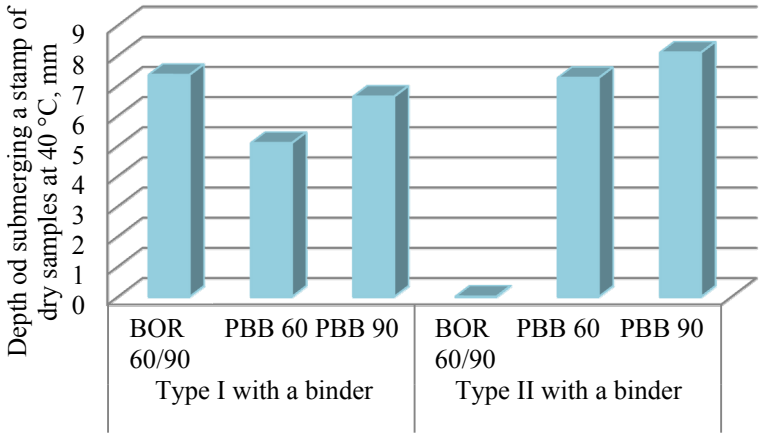

Fig. 4. Dependence of the depth of submerging a stamp of water saturared samples at 40 °C of poured asphalt concrete, mm, poured after 60 min on a used bitumen binder: Type I, Type II

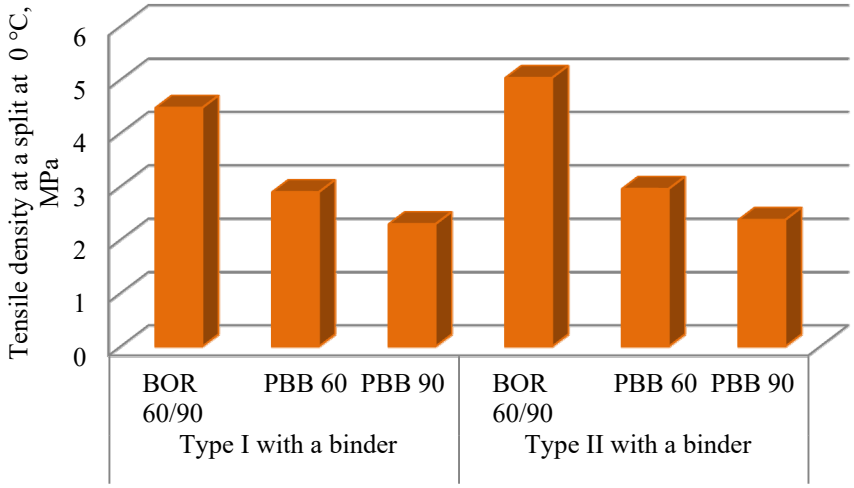

Fig. 5. Dependence of the depth of submerging a stamp of water saturared samples at 0 °C of poured asphalt concrete, mm, Type I and Type II

The results of the studies of poured mixes of Type I and II on oil road bitumen BOR 60/90, polymer bitumen binder of the class PBB 60 and PBB 90 allowed one to identify a strong dependence of the physical and mechanical properties of asphalt concrete on a type of a poured mix and particularly on a used binder. For poured mixes of Type I both bitumen BOR 60/90 as well as a polymer bitumen binder of the class PBB 60 or PBB 90 should be used for repairing and laying asphalt concrete surfacing of a roadway of highway bridges. For poured mixes of Type II the required physical and mechanical indices should be achieved only by using a polymer bitumen binder of the class PBB 60 or a more viscous one. As the results of the experiment suggest, the use of a less viscous binder (e.g., PBB 90 or oil bitumen BOR 60/90) will lead to poured asphalt concrete with insufficient resistance to plastic deformation. An advantage of using a poured mix of Type II according to the GOST (ГОСТ) P 54401-2011is that it can be prepared using only the crushed stone fractions of 5—10 mm, which allows them to be employed at a damage depth of roadway surfacing of a highway bridge of 1 to 3 cm.

2. Developing compositions of poured mixes using oil road bitumen in compliance with TP TC 014/2011. Due to the use of new guidelines according to TP TC 014/2011 “Highway Safety”, when asphalt concrete mixes are prepared, road bitumen should be used in compliance with GOST (ГОСТ) 33133-2014. In the experiment where oil bitumen BOR 35/50, BOR 50/70, BOR 70/100 were used as binders for preparing poured mixes of Type I according to the GOST (ГОСТ) 33133-2014 as well as a polymer bitumen binder of the class PBB 60, PBB 90 according to the GOST (ГОСТ) 52056-2003, a dependence of the properties

of poured asphalt concrete on the viscosity of a used binder. The composition of the investigated poured mixes of Type I is presented in Table 2, the physical and mechanical indices of the above mixes are in Fig. 6—10.

Table 2

Composition of poured mixes

№	Materials	Type I
1	Granite crushed stone with the fraction 5—20, %	43
2	Grinding sifts of granite, %	31
3	Mineral powder, %	26
4	Binder, % per 100 % of the mineral component	9.5
Total		109.50

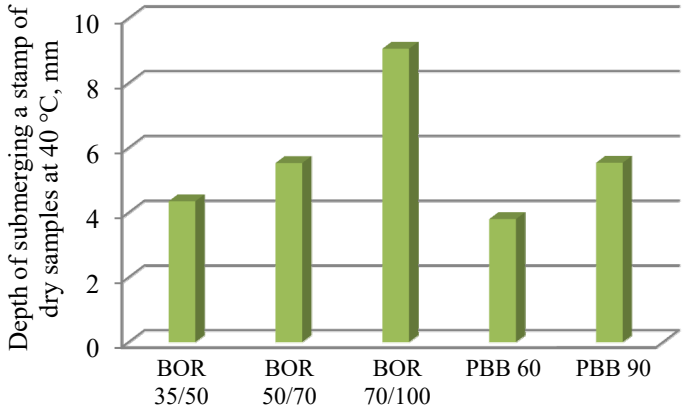

Fig. 6. Dependence of the depth of submerging a stamp of dry samples at 40 °C of poured asphalt concrete of Type I, mm, following 30 minutes on a used bitumen binder

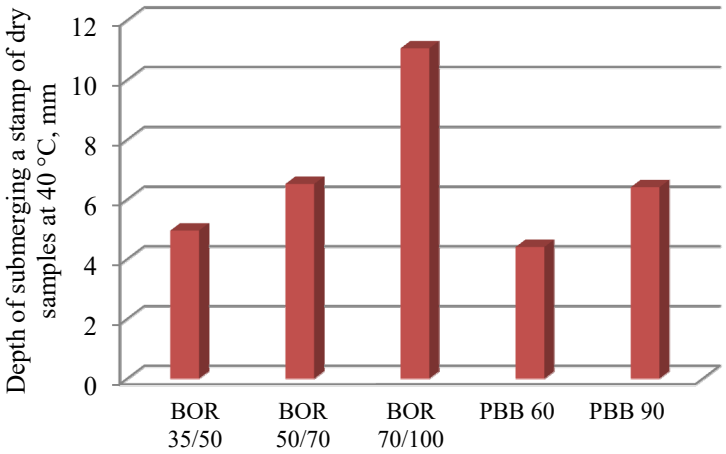

Fig. 7. Dependence of the depth of submerging a stamp of dry samples at 40 °C of poured asphalt concrete of Type I, mm, following 60 minutes on a used bitumen binder

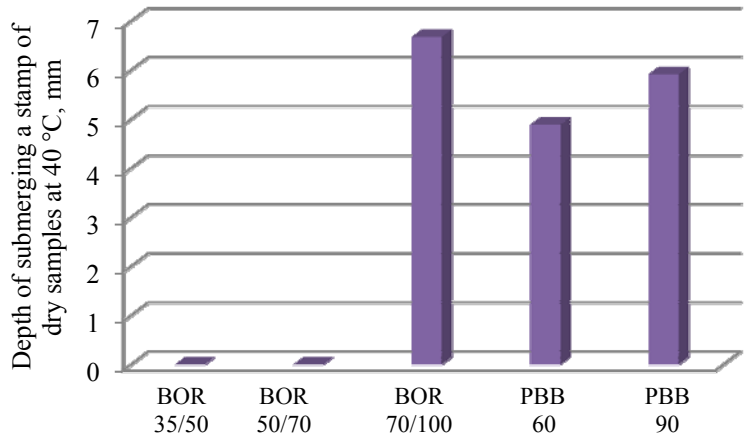

Fig. 8. Dependence of the depth of submerging a stamp of water-saturated samples at 40 °C of poured asphalt concrete of Type I, mm, following 30 minutes on a used bitumen binder

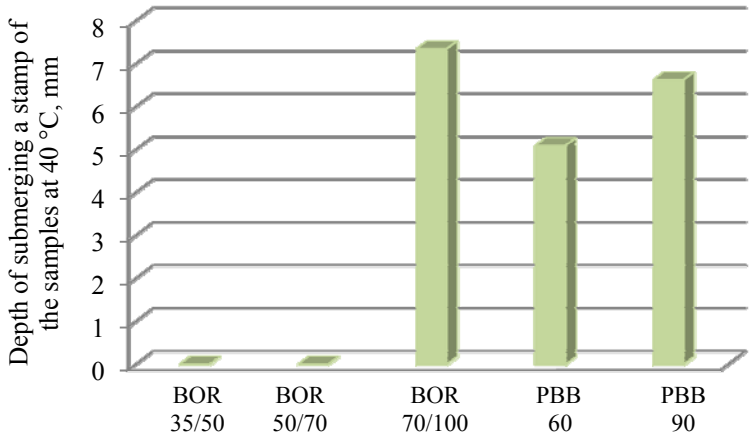

Fig. 9. Dependence of the depth of submerging a stamp of water-saturated samples at 40 °C of poured asphalt concrete of Type I, mm, following 60 minutes on a used bitumen binder

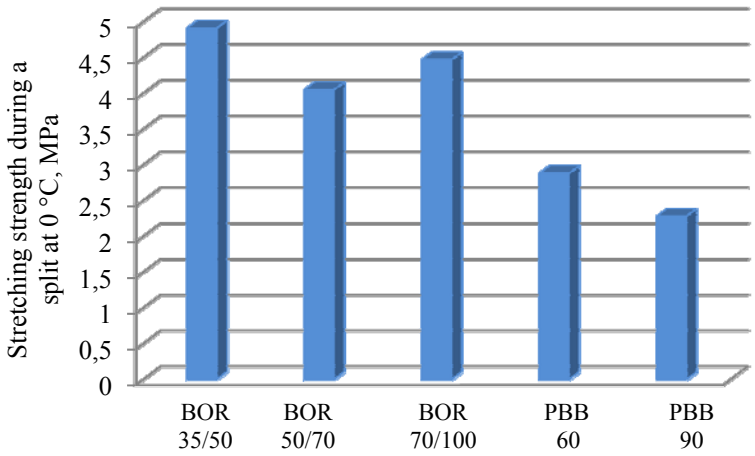

Fig. 10. Dependence of the shear strength for a split at 0 °C of poured asphalt concrete of Type I on a used bitumen binder

Conclusions

1. The results of the tests of poured mixes of Type I prepared using oil bitumen BOR 35/50, BOR 50/70, BOR 70/100 as well as a polymer bitumen binder of the class PBB 60 and PBB 90 showed a significant dependence of the physical and mechanical indices on the viscosity of a used bitumen binder.

2. It is possible to use poured mixes of Type I based on oil bitumen BOR 35/50 or a polymer bitumen binder of the class PBB 60 for repairing and laying roadways of highway bridges as the above compositions of poured asphalt concrete showed the best physical and mechanical indices and a stronger resistance to plastic deformations.

3. According to the results of the experiment, the use of a less viscous bitumen binder (e.g., PBB 90 or oil bitumen BOR 50/70 and particularly of the class BOR 70/100) would lead to poured asphalt concrete with a low resistance to plastic deformations, which makes it impossible to use for repairing and laying a roadway of a highway bridge.

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