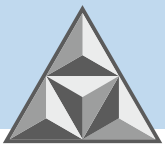

RESEARCH PAPER
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Application of gabbro-diabase for preparation of asphalt mixtures

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The significant increasing of both road traffic and loads on the vehicle axle led to unavailability of asphalt concrete to provide the necessary durability of road surfaces. The durability of road surfaces is directly related to the quality of the construction materials used and, above all, to the roadstone aggregate used to form the asphalt concrete. The quality assurance and control of road products re-quires a systematic approach, which is ensured primarily by having a proper quality assessment sys-tem, methods and instruments for testing the properties of road materials, products and structural layers, in accordance with the established standards, indicators. The paper considers the issues of optimizing the choice of a large aggregate (crushed stone) for asphalt concrete in terms of the best adhesion with bitumen used by road construction companies of the Vladimir region. For laboratory testing we use the roadstone aggregate by various manufacturers in order to produce a durable, shear-resistant and crack-resistant road surface material. By the experimental results, crushed gab-bro-diabase crushed stone is the most suitable for the preparation of hot asphalt mixtures. The paper contains a crushed stone test report, information on gabbro-diabase crushed stone selection of as-phalt concrete composition and results of asphalt concrete testing.

Key words: coarse aggregate, crushed stone, gabbro-diabase, asphalt concrete

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НАУЧНАЯ СТАТЬЯ
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Применение габбро-диабазов при приготовлении асфальтобетонных смесей

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Значительное повышение интенсивности автомобильного движения и возросшие нагрузки на ось транспортных средств на дорогах привели к тому, что асфальтобетоны не в состоянии обеспечить необходимую долговечность дорожных покрытий. Долговечность асфальтобе-тонных покрытий напрямую связана с качеством используемых материалов и, прежде всего, с каменными материалами, формирующими структуру асфальтобетона. Задачи обеспечения качества дорожной продукции и его контроль требуют системного подхода, что обеспечива-ется, прежде всего, наличием надлежащей системы оценки качества, методов и приборов для проведения испытаний свойств дорожных материалов, изделий и конструктивных сло-ев, в соответствии с установленными нормативными документами, показателями. В работе рассмотрены вопросы оптимизации выбора крупного заполнителя (щебня) для асфальтобе-тона из условия наилучшей адгезии с битумом, применяемого в дорожных организациях Владимирской области. Выполнялись лабораторные испытания каменного материала раз-личных производителей для получения прочного, сдвигоустойчивого и трещиностойкого материала дорожных покрытий. Результаты испытаний показали, что наиболее пригодным для приготовления горячих асфальтобетонных смесей является щебень из габбро-диабаза. Приводится протокол испытаний щебня, подбор состава асфальтобетона на габбро-диабазом щебне и результаты испытаний асфальтобетона.

Ключевые слова: крупный заполнитель, щебень, габбро-диабаз, асфальтобетон

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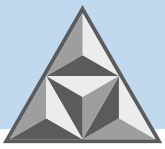

INTRODUCTION

Roads are an essential part of infrastructure contributing to economic growth, achieving of social objectives and providing the national security. The development of roads in terms of increasing economic activity and intensive motorisation of the population should provide access to settlements, match the capacity of the road network to road traffic flows and meet the challenges of transport system in future.

Despite the recent emergence of modern highways, the traffic conditions of the most automobile roads can be regarded as unsatisfactory. More than half of them have insufficient road surface durability and more than a third of the trunk roads need upgrading to a higher technical category [1-5].

Their low technical level, inconsistency of road parameters with the volume and traffic structure, regular overloading of certain road sections do not allow the performance qualities of modern vehicles to be realised: average speeds in Russia are more than half those in European countries. The unsatisfactory condition of road surfaces on a significant number of roads causes the increasing of the shipping operations costs. These factors increase the transport costs and time costs of delivery of goods and passengers of Russian manufacturers and consumers, reduce the defense capability and security of the country, the competitiveness of domestic goods, especially goods produced in regions remote from the borders of the Russian Federation [2].

A particular issue is the improving of road surface conditions in order to reduce the rate of wear and increase the permissible stress (only about a quarter of all paved roads are designed for axle loads of 10 tonnes and the European limit requires roads to be designed for 11.5 tonnes). Analysis of the Russian Federation roads condition shows the high percentage of the road under repair and the shortage of working life of built and major repaired asphalt concrete road surfaces. Erosion and cracks often appear at the first year of use, whereas abroad road surfaces can be exploited up to 15 years. Largely the low quality of road surfaces is due to their insufficient water resistance and frost resistance as a consequence of the low adhesion of road bitumen to the aggregate. Therefore, special attention needs to be paid to the issue of road surface condition, as it determines the condition of the transport network as a whole [6].

By the experience of a number of countries, the issues of road network developing can only be accomplished through the government programmes defyning the main directions and measures for road development and their funding providing. The national project “Safe and High Quality Roads” is currently being implemented in 84 regions of the Russian Federation.

It includes works to ensure the safety of federal and regional public highways, improve the transport and operational condition of the road network and reduce the slippage rate of federal and regional public highways in terms of repair schedules. Improving the transport and operational condition of roads, increasing the technical level and length of the road network will increase the speed, comfort, safety and efficiency of road transport and ensure a 15-20% reduction in the cost of road freight and passenger transport across the country, contributing to economic growth [7].

Reducing transport costs will increase the competitiveness of products in various sectors of the economy and decrease costs in the social sphere, which will contribute to increased production and better living standards of the population.

In this regard, the quality assurance of road construction, and of all the structural elements of roads, is also becoming increasingly important. The quality assurance and control of road products requires a systematic approach, which is ensured primarily by having a proper quality assessment system, methods and instruments for testing the properties of road materials, products

and structural layers, in accordance with the established standards, indicators.

The purpose of this work is to analyse the test results of crushed stone used in the Vladimir region and provide a background for choosing one or another material for use in the production of asphalt mixtures by road construction companies.

It is very important to identify any inconsistencies of road construction materials or structural layers during the initial stages of road construction. This requires both skills and a short timeframe for conducting the analysis. In order to meet both criteria at once, it is necessary to develop additional documentation not conflicting with normative one, but rather supplements and clarifies it, which would serve to assist professionals working of the industry and enable optimal solutions to be applied based on an option comparison. This paper examines the issue.

EXPERIMENTAL PART

One of the main challenges in achieving a dense and durable asphalt concrete meeting the requirements of the regulations is to ensure the quality of the input materials and, most importantly, to maintain compatibility of the constituents when mixing, laying and compacting the asphalt mixture. The most important condition for the asphalt concrete quality is good adhesion of the bitumen to the surface of the mineral materials, including the coarse aggregate - crushed stone.

The research was carried out on the basis of the Laboratory Control and Implementation of New Technologies Department of GUP VO “DSU-3”.

During selecting the composition of the asphalt mixtures, a large number of materials of the mixture were tested. Road construction companies of the Vladimir region use limestone, crushed stone from the Vladimir Karieroupravlenie (VKU), crushed stone from the Brykovy Mountains de-posit in the Alexandrov district of the Vladimir region, gabbro-diabase from deposits of Ranta-Myaki, “KP-Gabbro”, Iron Mountain, Holodai Mountain, VKU, Zhukov Kamen, etc.

Diabase-gabbro crushed stone of 11.2- 16 M1400 grades, produced by “KP-Gabbro”, Petrozavodsk, is the most widely used at the moment and it was taken as the basis for testing and selection of asphalt concrete mixture.

Testing of the initial crushed stone, according to [8-15], used to select the composition of the asphalt mixture and its manufacture includes determining (Fig. 1):

1) aggregate gradation composition;
2) aggregate packed density;
3) natural moisture content of the material;
4) brand by crushing capacity;
5) grains of flaky aggregate and needle shaped;
6) gritty and clay particles content;
7) medium density.

Experimentally it was found the gabbro-diabase rock of “KP-Gabbro” is the most suitable for the production of asphalt mixtures according to GOST R 58406.2-2020, as the best values of all the tested materials of the similar group are observed. We use this material for our further work.

The study was carried out on asphalt-concrete mixture A16Vn used in the top layer of the pilot section during the repair of the road in Kolchuginsky district of Vladimir region. Also we made a selection of asphalt concrete mixture composition (Table 1).

Fig. 1. Testing of crushed stone gabbro-diabase gr. 11,2-16 M1400 "KP-Gabbro"

The next step of the research is the development of an asphalt concrete mixture formula with the selection of the grain composition of the asphalt concrete and the optimum amount of bitumen, followed by the moulding and testing of the samples produced. The following materials were used to prepare the mixture:

– crushed stone gabbro-diabase gr. 11,2-16 M1400 “KP-Gabbro”
– crushed stone gabbro-diabase gr. 8-11,2-16 M1400 “KP-Gabbro”;
– crushed stone gabbro-diabase gr. 4-8 M1400 “KP-Gabbro” “Karieroupravlenie No. 1, Iron Mountain deposit”;
– crushed sand, gabbro-diabase, M1400 “Karieroupravlenie No. 1, Iron Mountain deposit”;
– MP-2 mineral powder by “CAPITAL MAGNESIT”.

Table 1. Selection of asphalt concrete mix composition

"___"_____ 2021			23 November 2021								
Composition of asphalt-concrete mixture											
A16Vn by GOST R 58406.2-2020(TWA-160)											
For construction of top layer jf the road surface											
For road repairing in Kolchugino district, Vladimir region											
Contract # 27, 7 June 2021											
1. Construction materials											
N	Name of the material	Composition of asphalt-concrete mixture (bitumen over 100%)	Average and true specific gravity, g/cm^3	Particle-size distribution (passed through a sieve with holes mm), % by mass							
				22.4	16	11.2	8	4	2	0.125	0.063
1	crushed stone gabbro-diabase gr. 11,2-16 M1400 "KP-Gabbro"		2.99	100.0	93.3	5.16	2.14	0.00	0.00	0.00	0.00
2	crushed stone gabbro-diabase gr. 8-11,2-16 M1400 "KP-Gabbro"		2.99	100.0	100.0	92.82	9.72	1.02	0.00	0.00	0.00
3	crushed stone gabbro-diabase gr. 4-8 M1400 "KP-Gabbro", "Karieroupravlenie No. 1, Iron Mountain deposit"		3.00	100.0	100.0	100.0	92.82	7.86	1.17	0.00	0.00
4	crushed sand, gabbro-diabase, M1400 "Karieroupravlenie No. 1, Iron Mountain deposit"		3.04	100.0	100.0	100.0	100.0	92.36	67.03	12.97	8.01
5	MP-2 mineral powder by "CAPITAL MAGNESIT"		2.83	100.0	100.0	100.0	100.0	100.0	100.0	98.32	84.78
2. Grain composition of asphalt concrete mixture											
	Mixture composition	%		22.4	16.0	11.2	8	4	2	0.125	0.063
1	crushed stone gabbro-diabase gr. 11,2-16 M1400 "KP-Gabbro"	25.0		25.0	23.3	1.3	0.5	0.0	0.0	0.0	0.0
2	crushed stone gabbro-diabase gr. 8-11,2-16 M1400 "KP-Gabbro"	15.0		15.0	15.0	13.9	1.5	1.2	0.0	0.0	0.0
3	crushed stone gabbro-diabase gr. 4-8 M1400 "KP-Gabbro", "Karieroupravlenie No. 1, Iron Mountain deposit"	17.0		17.0	17.0	17.0	15.8	1.3	0.2	0.0	0.0
4	crushed sand, gabbro-diabase, M1400 "Karieroupravlenie No. 1, Iron Mountain deposit"	38.0		38.0	38.0	38.0	38.0	35.1	25.5	4.9	3.0
5	MP-2 mineral powder by "CAPITAL MAGNESIT"	5.0		5.0	5.0	5.0	5.0	5.0		4.9	4.2
6	Total	100.0		100.0	98.3	75.2	60.8	41.6	30.7	9.8	7.3
7	Grain composition by GOST R 58406.2-2020			100.0	100.0	85.0	-	58.0	40.0	20.0	10.0
				100.0	90.0	70.0	-	37.0	25.0	7.0	5.0
8	**Actual grain composition**			**100.0**	**98.3**	**75.2**	**60.8**	**41.6**	**30.7**	**9.8**	**7.3**

The mixture preparation technology included the following processes:

1) Preparation of asphalt concrete mixture based on the initial binder - modified bitumen grade BND 70/100, under laboratory conditions in a mixing plant (Fig. 2).

Fig. 2. Production of asphalt concrete mixture of the specified composition

2) Preparation of laboratory samples of the required size and quantity for the study (Fig. 3).

Fig. 3. Preparation of asphalt concrete samples by GOST R 58406.2-2020

3) Testing of the samples obtained.

4) Analysis of the samples obtained.

RESULTS

During the testing, a laboratory sample of the material, prepared from a composite assay, was formed for all laboratory tests for this type of crushed stone. This assay was used to prepare an analytical sample from which individual samples were taken in accordance with the test procedure. According to [8] it is allowed to use one analytical sample for more than one type of test.

The test results are shown in Table 2.

One of the most important quality parameters is the adhesion of the binder to the surface of the aggregate providing almost all the technological and performance parameters of asphalt surfaces.

By the results of the experiments, a strong bond between the binder and the gabbro-diabase stone material is ensured. The cohesion and adhesion to mineral materials increases, as well as resistance to oxidation and ageing. The asphalt mixture was prepared with the using of modified bitumen.

Table 2. Test report for crushed stone gabbro-diabase gr. 11,2-16 M1400 "KP-Gabbro"

Test report for crushed stone gabbro-diabase Name of the material: crushed stone gabbro-diabase gravel 11.2-16 M1400 (brand 90/100) Sampling point: Ulybyshevo railway station Date of sampling:15 November 2021 Manufacturer: "KP-Gabbro"							
Laboratory testing results							
N	Name	Unit of measurement	GOST requirements 32703-2014	Actual value			
1	bulk density	g/cm^3	-	1.62			
2	moisture	%	-	0.75			
3	brand by crushing capacity		-	M1400 (gr.=1.44%)			
4	grains of flaky aggregate and needle shaped	% by mass	-	5.6 (L10)			
5	gritty and clay particles content	% by mass	less than 1	0.34			
6	medium density	g/cm^3	-	2.99			
Grain composition							
N	Amount of balance	Grain size, mm					
		31.5	22.4	16	11.2	5.6	Less than 5.6
		2 D	1.4 D	D	d	d/2	
1	Private, g	0	0	670	8814	302	214
2	Private, %	0.00	0.00	6.70	88.14	3.02	2.14
3	Total, %	0.00	0.00	6.70	94.84	97.86	100.0
4	Total, %	100.0	100.0	93.30	5.16	2.14	
5	GOST requirements 32703-2014 to total, % (brand 90/100)	100.0	100.0	900-100	0-10	0-2	
Conclusion: crushed stone gabbro-diabase gravel 11.2-16 M1400 (brand 90/100) corresponds to GOST requirements 32703-2014							

The "KP Gabbro" asphalt mix on crushed stone gabbro-diabase gravel 11.2-16 M1400 also show good results. The study was carried out on samples of a given type of asphalt concrete mixture prepared on the basis of petroleum road bitumen [16, 17].

Test results of asphalt mix A16Vn are shown in Table 3.

CONCLUSIONS

The use of crushed gabbro-diabase stone as a coarse aggregate for the preparation of asphalt mixtures makes it possible to obtain a strong, durable, shear-resistant and wear-resistant surface material, reliable in operation during the entire normative service life.

1) A rationality of use of crushed gabbro-diabase in asphalt-concrete mixtures on modified road

bitumen used by road constructing companies of the Vladimir region is proved.

2) Increased cohesion and increased adhesion, as well as resistance to oxidation and ageing, which also improves the physical and mechanical properties of the asphalt concrete and increases the life between repairs of the road surfaces.

Table 3. Test results of asphalt concrete mixture A 16Vn. Key indicators

Indicators name	Unit of measurement	Permissible variation of individual indicators from the formula	GOST requirements P 58406.2-2020	Results by formula	The actual results BND 70/100
Bulk density	g/cm^3	-	-	2.650	2.655
Air void	%	± 1,2	2.5 to 4.5 included	3.3	3.21
Air void in mineral aggregate	%	-	at least 12.0	16.2	16.0
Air void filled with asphalt binder	%	-	67-80	79.7	79.95
Average track depth	mm	-	max 4.5	2.4	2.41
Waterproofing		-	at least 0.85	0.86	0.86
Maximum density	g/cm^3	-	-	2.740	2.743

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