THE INFLUENCE OF MINERAL POWDER ON THE HIGH TEMPERATURE SLIDER RESISTANCE INDICATORS OF ASPHALT CONCRETE COATING

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Abstract*. In the article, scientific-research works were carried out on the effect of types of mineral powder on the strength of the asphalt-concrete mixture. By grinding shale rocks, limestone material, and ozokerite material into powder under the same conditions with the help of a centrifugal impact mill, their mutual properties were compared. Experiments were conducted to study the adhesion of mineral powders crushed with the help of a centrifugal impact mill to flint by forming a binder with bitumen. Laboratory tests on the compressive strength and shear resistance of fine-grained hot asphalt concrete mixtures with the addition of these three types of mineral powders were conducted and the results are presented.*

Keywords*: centrifugal impact grinding mill, technological processes, fine-grained hot dense asphalt concrete, shale, limestone, ozokerite, activated mineral powder from shale rocks.*

In the construction of highways, various defects occur in the same type of pavements during the summer months when the air temperature rises. These defects are mainly ruts and ruts, as well as longitudinal and transverse irregularities in the pavement. One of the main reasons for this is the decrease in the compressive strength and shear strength of the fine-grained hot dense asphalt concrete mixture being laid on the pavement at high temperatures. The types of inert materials, binding materials and mineral powders affect the physical and mechanical properties of fine-grained hot dense asphalt concrete mix. One of the main elements in the production of asphalt concrete mixture is mineral powder.

A lot of scientific and research work has been carried out on the influence of the types of mineral powders on the strength of the asphalt-concrete mixture. It is important to choose the types of mineral powders based on the climatic region of our country, i.e. taking into account that the temperature in the coating is 80-85oC as a result of the increase in air temperature in the summer months. Currently, the design and construction of highways is carried out on the basis of road-climate regionalization in order to ensure its effective operational period. "Region" was adopted as a road-climate districting unit in the middle of the last century [1]. A "region" is usually characterized by a specific combination of heat and humidity [2].

The weather and climatic conditions of the region (air temperature, solar radiation, precipitation, etc.) have a great influence on the performance of highways and, in particular, of asphalt-concrete pavements. Their effect causes shear deformations at high temperatures and cracks at low temperatures [3,4].

Calculation of the maximum and minimum temperatures of road surfaces is carried out on the basis of formulas 1 and 2 used in the Superpave system. Formula (1) derived from the heat flow and energy balance model is used to set the maximum design temperature of the coating:

$$T_{max}^{qop} = 54{,}32 + 0{,}78 \cdot T_{max}^{o'r} - 0{,}0025 \cdot Sh^2 - 15{,}14 \cdot \log_{10}(H + 25) + Z \cdot (9 + 0{,}61 \cdot s^2)^{0,5} \quad (1)$$

The minimum design temperature of the coating is determined by the formula (2).

$$T_{min}^{qop} = -1{,}56 + 0{,}72 \cdot T_{min}^{o'r} - 0{,}004 \cdot Sh^2 + 6{,}26 \cdot \log_{10}(H + 25) - Z \cdot (4{,}4 + 0{,}52 \cdot s^2)^{0,5} \quad (2)$$

Determining the values of the extreme temperature criterion, which is the PG index, in the Superpave asphalt pavement design system corresponds to four main steps:

1. Analysis of climatic data.
2. Determination of coating temperature.
3. Determination of temperature. Asphalt concrete functional type indicator values (PG or EHM).
4. Correction of the received values.

As a result of the regionalization of the territory of the republic, various measures are adopted as an effective solution in the regions, including:

– restricting the movement of heavy goods vehicles at a certain time of the day according to the temperature value;

– determining the minimum speed of movement of the cargo vehicle according to the type of axles;

– choosing the type of asphalt-concrete coating according to the temperature region and carrying out construction and repair works.

Asphalt-concrete mixture was tested on the type, quantity and degree of fineness of the mineral powders used in its composition according to the temperature region. The properties of mineral powders obtained by grinding into powder under the same conditions using a centrifugal impact mill were compared in laboratory conditions. We can see the results in Table 1 below.

Table 1

Indicator names	**Unit of measure ment**	**Indicator value**		
		Standard value	Average value obtained	**Regulatory compliance**
Activated mineral powder from shale rocks				
Natural humidity	%	0-1,0	0,8	-
Grain composition, mm	1,25	at least 100	100,0	fits
	0,315	at least 90	91,7	fits
	0,071	at least 80	81,2	fits
Density	g/sm3	is not regulated	2,60	-
Porosity, at least	%	30 (MP-1 activated)	28,9	fits
Reproduction of a sample of a mixture of bitumen with mineral powder	%	1,8 (MP-1 activated)	1,6	fits
Bitumen capacity	g	-	62	fits
Limestone mineral powder				

Natural humidity	%	0-1,0	1,0	-
Grain composition, mm	1,25	at least 100	100,00	fits
	0,315	at least 90	94,8	fits
	0,071	at least 80	80,5	fits
Density	g/cm^3	is not regulated	2,66	-
Porosity, at least	%	35 (MP-1 not activated)	32,1	fits
Reproduction of a sample of a mixture of bitumen with mineral powder	%	2,5 (MP-1 not activated)	1,93	fits
Bituminous	g	-	76,2	fits
Ozokerite mineral powder				
Natural humidity	%	0-1,0	0,4	-
Grain composition, mm	1,25	at least 100	100,00	fits
	0,315	at least 90	97,1	fits
	0,071	at least 80	82,9	fits
Density	g/sm3	is not regulated	2,71	-
Porosity, at least	%	35 (MP-1 not activated)	35,5	does not match
Reproduction of a sample of a mixture of bitumen with mineral powder	%	2,5 (MP-1 not activated)	2,4	fits
Bituminous	g	-	70,0	fits

The test results of activated mineral powder obtained from shale rocks meet the requirements for activated mineral powders used in the production of fine-grained asphalt concrete mixtures. We can see that activated mineral powders obtained from Slaney rocks have lower bitumen capacity indicators than mineral powders obtained from limestone and Ozycrete.

Experiments were conducted to study the adhesion of mineral powders crushed by a centrifugal impact mill to flint by forming a binder with bitumen. According to the test results, bituminous binder mixed with activated mineral powders obtained from shale rocks forms a thin film on the surface of the stone (Fig. 1).

Figure 1. Bonding test of bituminous binder with three different types of mineral powder on limestone

Activated mineral powder from shale rock increases the activity of the binder. As a result, the binder forms a bond with the inert material in the form of a thin film.

Laboratory tests were conducted on the compressive strength and shear resistance indicators of small-grained hot asphalt concrete mixes with three different types of mineral powders. Granite pebbles with inert materials M1200 were used in the mixture. We can see the physico-mechanical indicators of asphalt concrete mixes with three different types of mineral powders in Table 2.

Table 2

Content	**Compressive strength, MPa**				**Shear strength, MPa**
	20°C	50°C	60°C	70°C	
Ingredient 1: mineral powder obtained from ozokerite material is added	2,78	1,25	0,96	0,71	0,72
Ingredient 2: mineral powder obtained from limestone material is added	2,58	0,95	0,92	0,738	0,75
Ingredient 3: mineral powder obtained from shale rock is added	3,15	1,22	1,13	0,89	0,84

Tests on shear strength and compressive strength were carried out depending on the test temperature and bitumen content. We can see the test results in the graphs below.

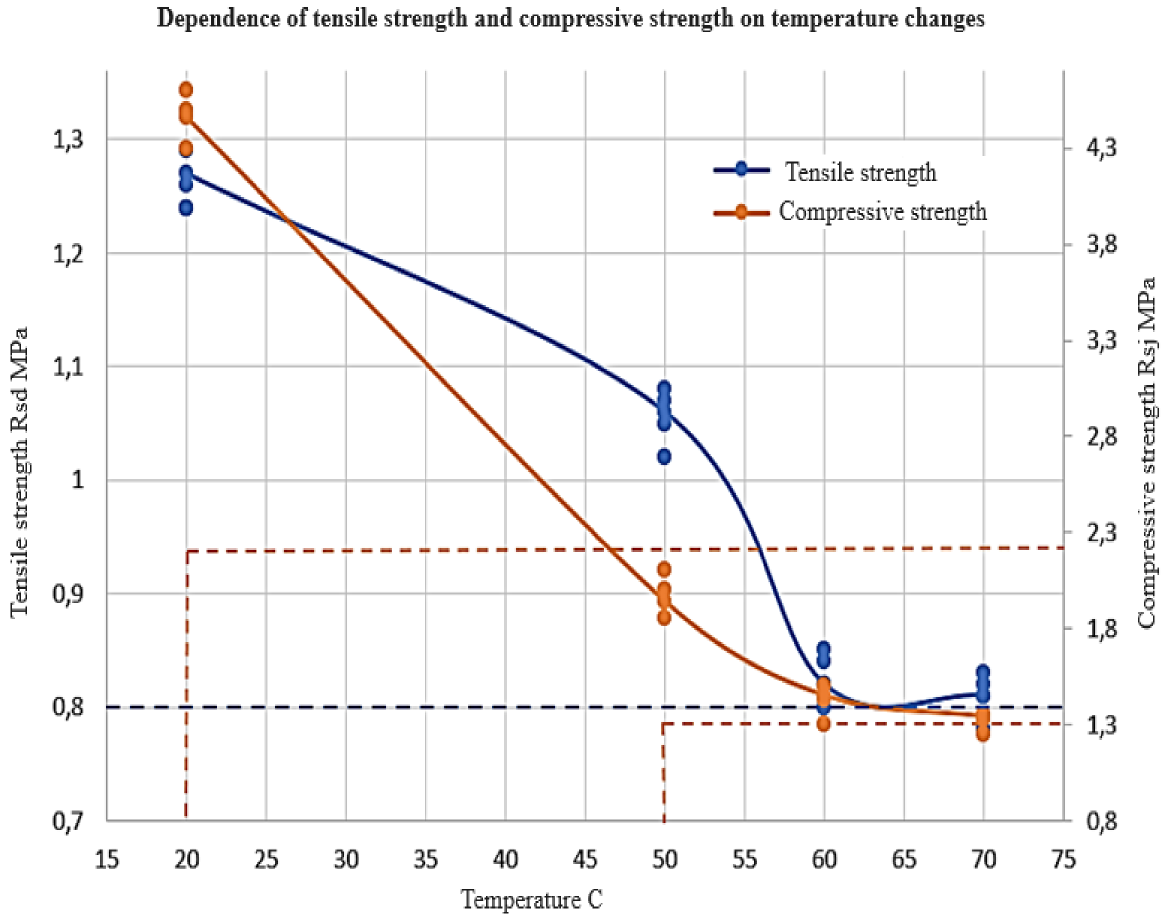

Figure 2. Dependence of tensile strength and compressive strength on temperature changes

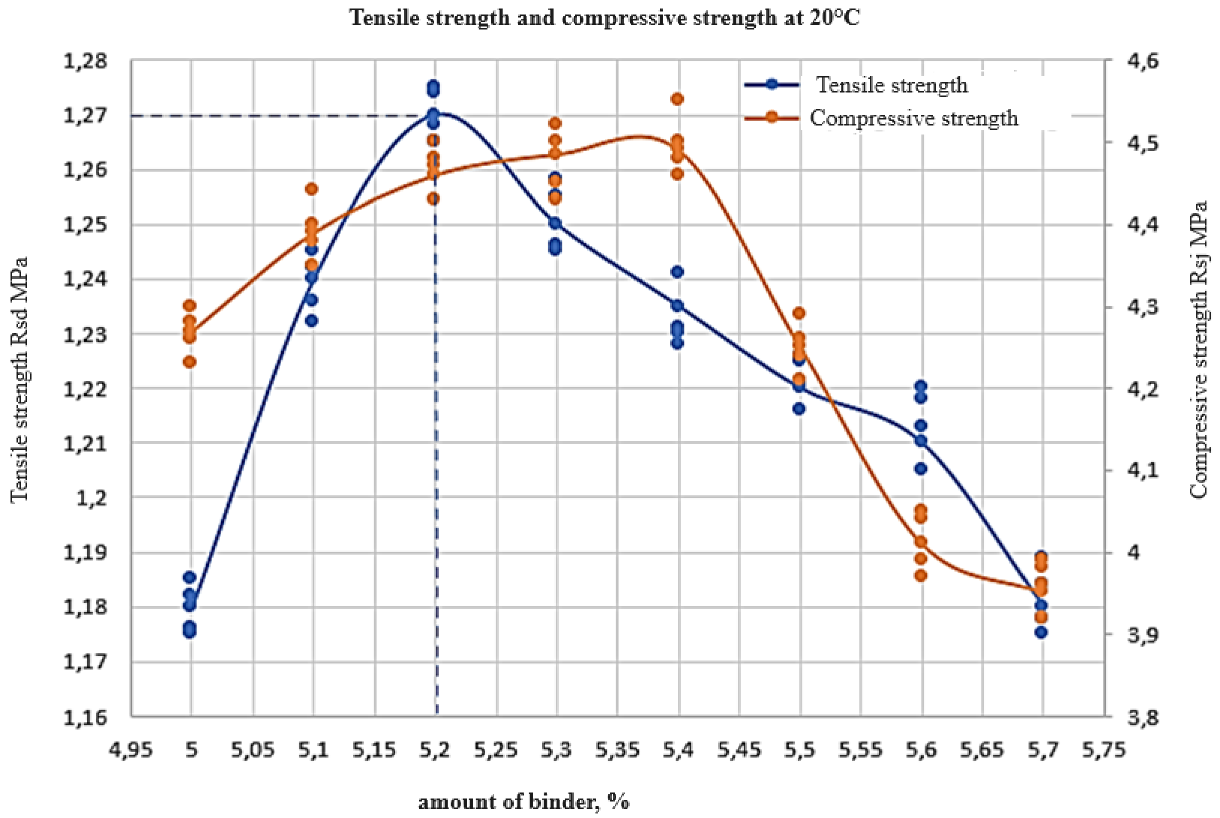

Figure 3. Temperature dependence of tensile strength and compressive strength at 20 °C

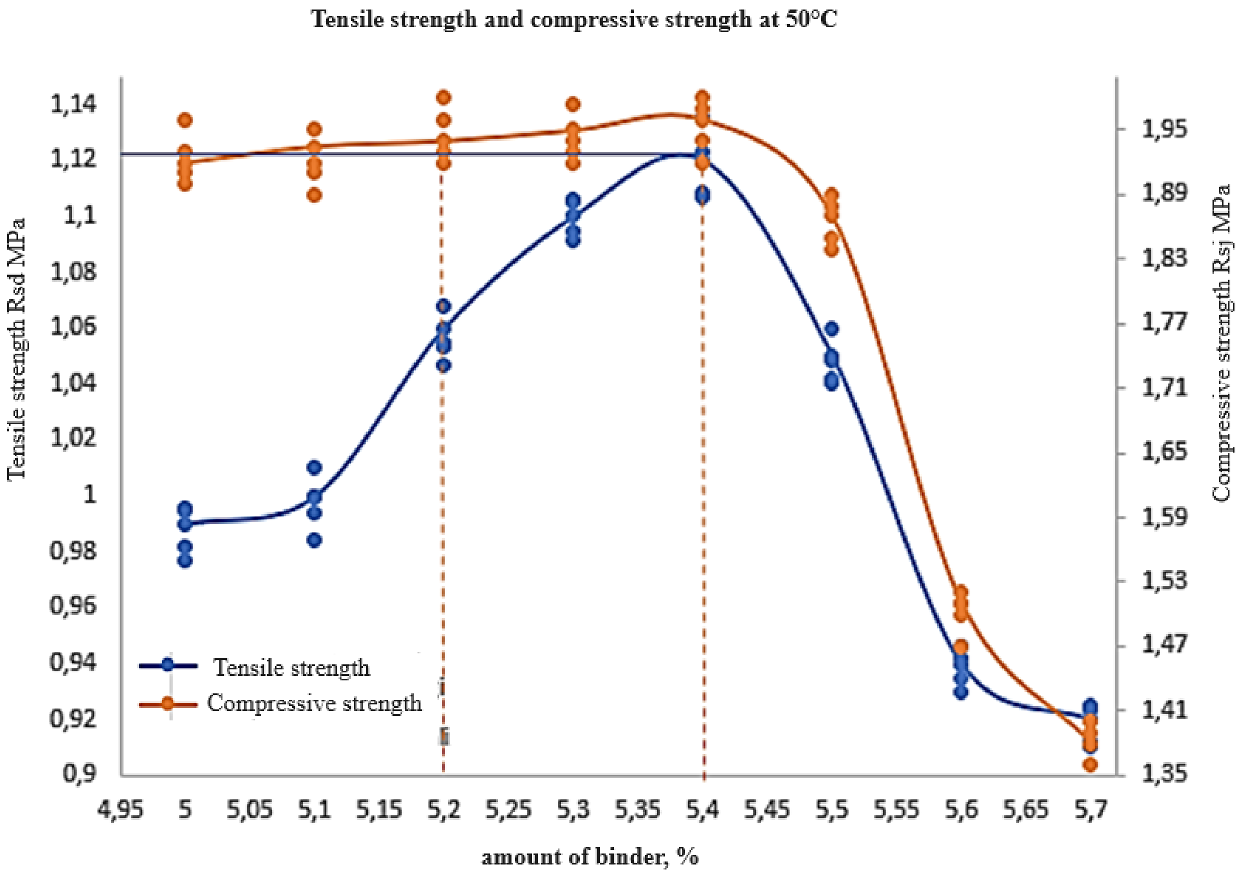

Figure 4. Temperature dependence of tensile strength and compressive strength at 50 °C

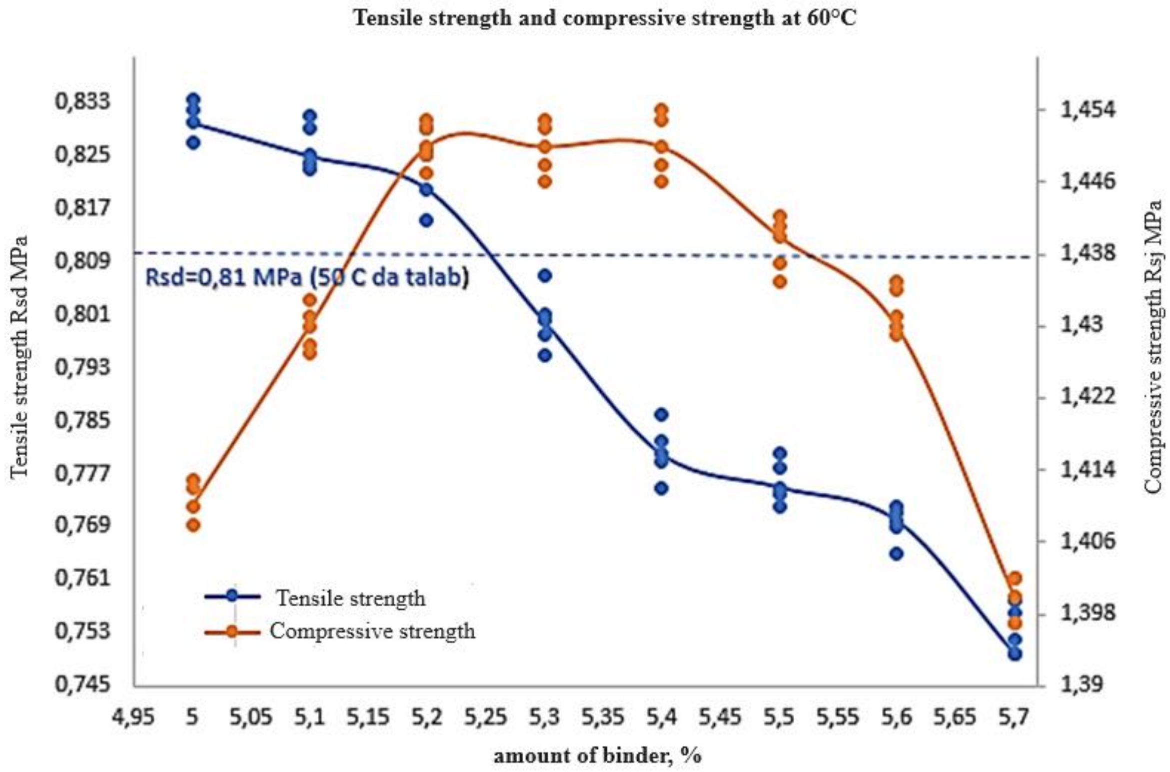

Figure 5. Temperature dependence of tensile strength and compressive strength at 60 °C

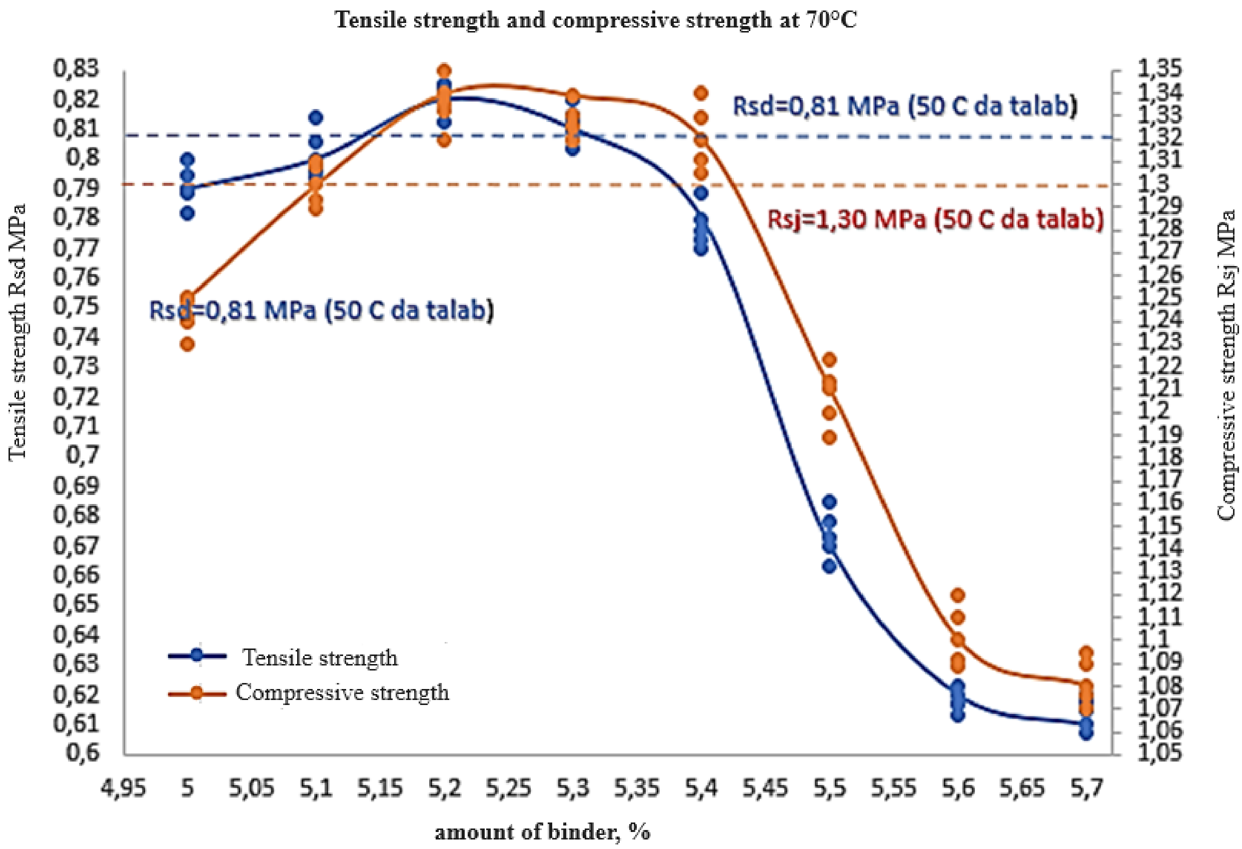

Figure 6. Temperature dependence of tensile strength and compressive strength at 70 °C

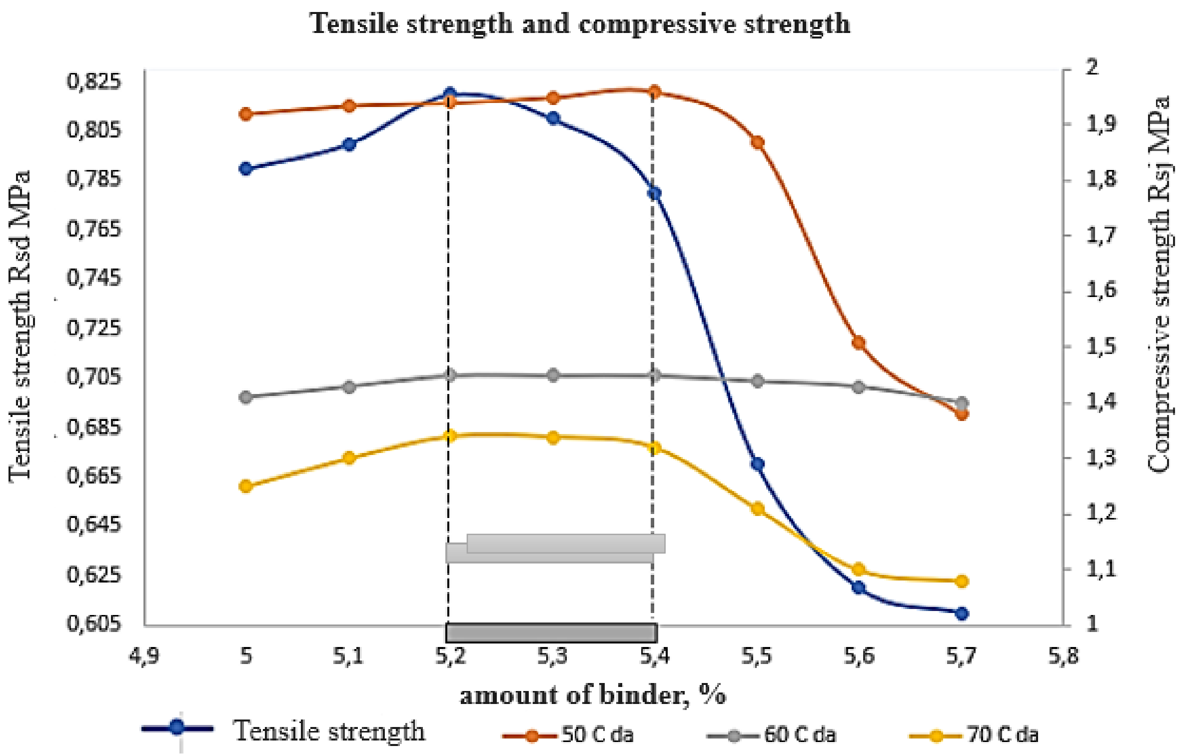

Figure 7. Comparison of temperature variation of tensile strength and compressive strength at 20 °C, 50 °C, 60 °C, 70 °C

Conclusion: In the production of asphalt concrete pavement suitable for high-temperature operating conditions, mineral powders obtained from shale rocks are included in the mixture. The powders used in the production of fine-grained hot dense asphalt concrete mixture of type B, grade I have passed 100% of the 0.071 mm sieve in terms of fineness, granularity, form 8 - mineral powder obtained from shale rocks in the proportion of 4.5% to the composition of the cube-shaped asphalt concrete mixture increases its activity with the binding bitumen material in the mixture, filling the small pores between the small and large aggregates, binding bitumen - mineral powder - inert materials increase the shear resistance and compressive strength of an asphalt concrete mixture at high temperatures.

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