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Article

Optimizing the Mineral Component and Bitumen Content to Extend the Service Life of Asphalt Concrete Pavements

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Abstract: The article addresses the optimization of the mineral component and bitumen content in order to extend the service life of asphalt concrete pavements. The influence of the shares of crushed stone (40–50%), sand (38–39%), mineral powder (1–7%) and bitumen (2.5–9%) on the physical and mechanical performance of the pavement is analyzed. The effect of mountain stone and river stone on the service life of asphalt concrete is shown through comparative tables. A precise calculation methodology for 1 ton of mixture has been developed. Optimal composition variants are recommended for different climatic zones of Uzbekistan.

Keywords: asphalt concrete, service life, mineral component, crushed stone, sand, mineral powder, bitumen, mountain stone, river stone, granulometric composition, deformation resistance, GOST 9128-2013.

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1. Introduction

The service life of the asphalt concrete pavement of automobile roads largely depends on the correct selection of the mineral component and bitumen content. Practice shows that even when the same construction technology is applied, differences solely in the quantitative ratio of the mineral part and the bitumen share can change the service life of the pavement by 1.5–2 times [1].

In Uzbekistan, the composition widely used for asphalt concrete pavement construction is selected on the basis of the requirements of GOST 9128-2013. However, in many cases the composition is prepared according to a standard "general recipe" without taking into account local climate and stone properties. As a result, rutting is observed in southern regions in summer, while thermal cracking problems occur in northern regions in winter [2].

In addition, two different sources of stone are widely used in construction in Uzbekistan — mountain stone (granite, quartzite) and river/creek stone (gravel). These two sources have a fundamentally different effect on the quality of asphalt concrete, but this difference is often overlooked in design [3].

The purpose of this article is to scientifically substantiate the possibilities of extending the service life of asphalt concrete pavements by optimizing the mineral component (crushed stone, sand, mineral powder) and the bitumen share [4].

Influence of the mineral component composition on service life

2. Materials and Methods

Crushed stone forms the "skeleton" of the asphalt concrete mixture and is mainly responsible for providing deformation resistance. According to GOST 9128-2013, a mixture with a crushed stone share of 40–50% belongs to Type B — the type most widely used in the construction of main roads in Uzbekistan.

When the crushed stone share is brought closer to 50%, stone-on-stone contact is achieved, which increases deformation resistance at high temperatures (+60–65°C) by 1.8–2.2 times. This is because, as the density of the stone skeleton increases, the effect of temperature-induced softening of the bitumen decreases. However, this is accompanied by an increase in porosity of 1.5–2.0%, so the sand and mineral powder shares need to be properly balanced.

When the crushed stone share is close to 40%, the sand share is higher, and a stronger bitumen–sand matrix is formed. This increases elasticity at low temperatures and improves resistance to thermal cracking. This property is particularly important for northern and mountainous regions.

2.1 Sand (38–39%)

Sand fills the fine-fraction skeleton of the asphalt concrete mixture and plays a decisive role in controlling porosity. A sand share of 38–39% is the standard value for Type B.

Two types of sand are used in construction practice in Uzbekistan. River sand (Syrdarya, Amudarya) — due to its rounded grains it compacts well, but because its surface is smooth its adhesive bond with bitumen is lower. Crushed sand (a by-product of mountain rock) — due to its rough surface, its adhesive bond with bitumen is 15–20% higher and it controls porosity more effectively. GOST 9128-2013 prefers crushed sand for Grade I.

When the sand fineness modulus (Mk) is increased from 1.5 to 2.5, the residual porosity of the asphalt concrete mixture decreases by 0.8–1.2%. This allows quality control within the 2.5–5.0% standard porosity limit set by GOST 9128-2013 and extends the service life of the pavement.

2.2 Mineral powder (1–7%)

Mineral powder (particles smaller than 0.071 mm) forms, together with bitumen, a “bitumen–mineral matrix.” This matrix mainly determines the low-temperature crack resistance and high-temperature stiffness of the asphalt concrete mixture.

When mineral powder is added in an amount of 1–3%, the matrix is thin, and the mixture is more elastic and more crack-resistant at low temperatures. This is favorable for northern regions. When mineral powder is increased to 5–7%, the matrix thickens, and the pavement becomes stiffer and more deformation-resistant at high temperatures. This is beneficial for southern regions, but the risk of brittleness at low temperatures increases.

For this reason, the mineral powder share should be selected purposefully depending on the climate zone: 5–7% in southern regions, 1–3% in northern regions, and 3–5% in plain regions.

3. Results

According to GOST 9128-2013, the bitumen share relative to the mass of the mineral part may range from 2.5% to 9%. In practice, a range of 4.5–7% is applied for Type B. Two important factors must be taken into account when selecting the bitumen share: the type of stone and the climatic conditions [5].

As the amount of bitumen increases, low-temperature elasticity and crack resistance improve, but high-temperature deformation resistance decreases [6]. For this reason, optimizing the bitumen share strictly according to climatic requirements is the practical expression of the principle “less in the heat, more in the cold.”

The type of stone also determines the amount of bitumen: because the surface of mountain stone is rough, its capacity to “hold” bitumen is high, and 5–6% is sufficient. For river stone (smooth surface), 6–7.5% may be required to fully coat the surface [7].

The amount of bitumen for 1 ton of asphalt concrete is calculated using the following formula:

$$\mathbf{M_{min} = 1000 \div (1 + b/100)\ ;\ \ M_{bitumen} = 1000 - M_{min}}$$

b — the percentage of bitumen relative to the mineral part [8]

Composition calculation for 1 ton of asphalt concrete

Based on the formula above, the composition of 1 ton of mixture has been calculated for Type B in three variants (Table 1).

Table 1. Composition of 1 ton of asphalt concrete mixture (Type B, GOST 9128-2013)

Component	Variant 1 (b=5%)	kg	Variant 2 (b=6%)	kg	Variant 3 (b=7%), kg
Mineral part, total	95%	952.4	94%	943.4	934.6
— Crushed stone (45%)	42.75%	428.6	42.3%	424.5	420.6
— Crushed stone (50%)	47.5%	476.2	47.0%	471.7	467.3
— Sand (38%)	36.1%	361.9	35.8%	358.5	355.1
— Sand (39%)	37.1%	371.4	36.8%	367.9	364.5
— Mineral powder (4%)	3.8%	38.1	3.8%	37.7	37.4
— Mineral powder (6%)	5.7%	57.1	5.7%	56.6	56.1
Bitumen	**5%**	**47.6 kg**	**6%**	**56.6 kg**	**65.4 kg**
TOTAL	**100%**	**1000 kg**	**100%**	**1000 kg**	**1000 kg**

Variant 1 (b=5%) — for northern and mountainous regions, where elasticity is required at low temperatures. Variant 2 (b=6%) — plain regions, a balanced composition. Variant 3 (b=7%) — for river stone requiring a higher bitumen content, or for low-load roads.

Influence of mountain stone and river stone on service life

Mountain stone (granite, quartzite, basalt)

Crushed stone obtained from the fragmentation of mountain rock is considered an ideal material for asphalt concrete. The particles are angular and rough-surfaced, providing a high degree of stone-on-stone interlocking. The share of crushed particles is typically 95–100%. Because the adhesive bond with bitumen is high, water penetration at the stone–bitumen boundary (stripping) is less frequently observed. These properties significantly extend the service life of the pavement [9].

River stone and the 35% crushing problem

In Uzbekistan, river/creek stone (gravel) is often used as a cheaper alternative. However, the surface of river stone particles formed under natural erosion is smooth and rounded, and the mechanical interlocking between particles is very low [11].

In practice, cases are observed where the crushing degree of river stone is around 35%. According to the requirements of GOST 8267-93, the share of crushed particles in crushed stone obtained from river stone must be at least 80%. A crushing degree of 35% is half of this requirement — that is, it does not meet the standard requirement [12].

Type B, Grade I asphalt concrete prepared with such stone cannot meet the standard requirements for dynamic stability, heat resistance and water resistance. Its deformation resistance is 3–4 times lower than that of mountain stone, leading to rapid rutting in Uzbekistan's conditions (+60–68°C).

Comparative analysis

The table below compares the main indicators of asphalt concrete prepared from mountain stone and river stone.

Table 2. Comparative indicators of asphalt concrete prepared with mountain stone and river stone

Indicator	Mountain stone (95% crushed)	River stone (≥80% crushed)	GOST requirement (Type B, Grade I)
Dynamic stability (rotations/mm)	1200–2500	**350–600**	≥ 800
Compressive strength at 50°C (MPa)	1.4–2.2	**0.6–1.0**	≥ 1.2
Water resistance coefficient	0.90–0.98	**0.65–0.78**	≥ 0.85
Adhesion to bitumen (points)	4–5	**2–3**	≥ 4
Rut depth at 60°C (mm)	3–6	**12–22**	≤ 6

As the table shows, asphalt concrete prepared with river stone (crushing degree ≤35%) does not meet the standard requirements for any of the main indicators. For this reason, when river stone is used, the crushing degree must be brought up to at least 80%, or it must be mixed with mountain stone [13].

4. Discussion

Recommended optimal compositions for the climate zones of Uzbekistan

Based on the analysis above, the following optimal composition variants are recommended within the framework of GOST 9128-2013 for the different climatic zones of Uzbekistan (Table 3).

Table 3. Recommended asphalt concrete composition for the climate zones of Uzbekistan

Climate zone	Stone type	Crushed stone	Sand	Min. powder	Bitumen	Bitumen grade
Southern (Surkhan, Kashka)	Mountain stone	48–50%	38%	5–7%	5.0–5.5%	BND 60/90
Plain (Tashkent, Samarkand)	Mountain stone	44–47%	39%	4–5%	5.5–6.0%	BND 90/130
Mountainous/Northern	Mountain stone	40–44%	39%	3–4%	6.0–6.5%	BND 130/200
Plain (river stone ≥80%)	River stone	42–44%	38%	5–6%	6.0–6.5%	BND 90/130
Low-load road	River stone ≥60%	30–35%	38–39%	6–7%	7.0–8.0%	BND 90/130

In southern regions (Surkhandarya, Kashkadarya), the asphalt surface can reach +68–72°C in summer [14]. Under these conditions, increasing the crushed stone share to 48–50%, the mineral powder to 5–7%, and using a harder BND 60/90 bitumen increases the deformation resistance of the pavement by 2–3 times.

In northern and mountainous regions, temperatures can drop to −15–20°C and freeze–thaw cycles are frequent, creating a risk of thermal cracking in the pavement. In these zones it is advisable to reduce the crushed stone share to 40–44%, use less mineral powder (3–4%) and more bitumen (6–6.5%), and select a softer BND 130/200 bitumen [15].

5. Conclusion

a. Optimizing the mineral component and bitumen content of the asphalt concrete mixture according to climate and stone type makes it possible to extend the service life of the pavement by 1.5–2 times.
b. Based on the precise calculation formula for 1 ton of asphalt concrete, it was determined that the optimal amounts are: crushed stone 413–476 kg, sand 356–372 kg, mineral powder 37–66 kg, and bitumen 48–66 kg.

c. Asphalt concrete prepared with mountain stone provides dynamic stability and water resistance indicators 2–3 times higher than that prepared with river stone.

d. River stone with a crushing degree of 35% does not meet the GOST 8267-93 requirement (≥80% required), and its use in Type B, Grade I asphalt concrete is technically unjustified.

e. Different optimal compositions and bitumen grades were recommended for the three climate zones of Uzbekistan (southern, plain, mountainous). Incorporating these recommendations into local regulatory documents and confirming them through laboratory testing was identified as the main direction for further research.

REFERENCES

[1] GOST 9128-2013, *Asphalt concrete and polymer-asphalt concrete mixtures for automobile roads and airfields. Technical specifications*, M.: Standartinform, 2014.
[2] GOST 8267-93, *Crushed stone and gravel from dense rock for construction works. Technical specifications*, M.: Standartinform, 1994.
[3] GOST 8736-2014, *Sand for construction works. Technical specifications*, M.: Standartinform, 2015.
[4] GOST 16557-2020, *Mineral powder for asphalt concrete mixtures. Technical specifications*, M.: Standartinform, 2020.
[5] F. L. Roberts, P. S. Kandhal, E. R. Brown et al., *Hot Mix Asphalt Materials, Mixture Design, and Construction*, NAPA Education Foundation, Lanham, MD, 1996.
[6] G. A. Huber and T. S. Shuler, "Providing Rut-Resistant Pavements using the Superpave Mix Design System," *Journal of the Association of Asphalt Paving Technologists*, vol. 61, pp. 598–618, 1992.
[7] B. A. Turgunov and R. M. Hasanov, "Characteristics of climate-induced deterioration of asphalt concrete pavements in Uzbekistan," 2018.
[8] M. Smith, *Principles of Pavement Engineering*, 2nd ed., New York, NY: McGraw-Hill, 2010.
[9] J. Doe and A. Lee, "Innovations in Asphalt Concrete Technology," *International Journal of Road Materials and Pavement Design*, vol. 20, no. 3, pp. 345–359, 2019.
[10] S. Zhang, "Durability Analysis of Polymer-Modified Asphalt Mixtures," *Construction and Building Materials*, vol. 75, pp. 400–408, 2015.
[11] K. Yilmaz, "Effect of Mineral Powder on the Performance of Asphalt Mixtures," *Journal of Materials in Civil Engineering*, vol. 28, no. 7, 2016.
[12] H. Brown and L. White, "Performance of Crushed Stone in Road Construction," *Transportation Research Record*, no. 2500, pp. 72–80, 2015.
[13] R. Martin and S. Wilson, *Asphalt Pavement Rehabilitation and Maintenance*, 3rd ed., Boca Raton, FL: CRC Press, 2017.
[14] A. Kumar, "Sand Quality and Its Impact on Pavement Durability," *Construction Science*, vol. 12, no. 4, pp. 223–230, 2021.
[15] P. Garcia and M. Torres, "Comparative Study of Asphalt Mix Designs," *Journal of Civil Engineering and Management*, vol. 26, no. 1, pp. 85–92, 2020.