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Quality Control of the Technological Process of Surface Treatment for Road Construction

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Abstract: *The article discusses modern technologies for road surface repair, in particular the method of surface treatment using bitumen emulsions. The main defects of road surfaces, methods for their elimination, as well as technical parameters of design and operation are analyzed. Calculations of the strength characteristics of road layers that affect the durability and performance properties of the coating are presented. The importance of choosing the optimal materials and technologies to ensure the safety and economic efficiency of road construction and repair is emphasized.*

Keywords: *road surfaces, bitumen emulsions, surface treatment, road repair, pavement strength, asphalt concrete, performance characteristics, construction technologies and traffic loads.*

Introduction:

When maintaining highways, the main repair is the installation of surface treatments with bitumen emulsion road surfaces. The functionality of highways largely depends on the quality of their maintenance. During the operation of highways, the top layer of the road surface wears out and deteriorates first, causing cracks and potholes, making it difficult for vehicles to move at the estimated speed and causing accidents. When repairing the top layer of the road surface and performing pothole repairs, problems arise in ensuring the integrity and solidity of road surfaces while maintaining their main performance indicators. The top asphalt concrete layer is subject to the greatest loads in the road surface. This is not only about the pressure from moving vehicles, but also about climatic factors. The impact of water and ice, temperature changes, solar radiation - all these are natural "enemies" of road surfaces. Repair of road surfaces can be done by strengthening the road surface structure by gradually building up layers of asphalt concrete, by installing the upper base layer and covering the surface of the existing road or by installing a surface layer. The most common repair method is surface treatment of road surfaces.

Which does not require large expenses, and a huge amount of road inert materials. For repair of upper layers of road surface, bitumen in emulsified state has found wide application. Application of bitumen emulsion for surface treatment. This radically changes construction works. - Finer distribution of bitumen for upper layer of road surface. - Good envelopment of bitumen with mineral material. - Simplicity of technology of application of material in cold state. - Saving of binder. - Saving of transportation. Surface treatment is a method of creation of rough surface of a coating and device of layers of wear and protective layers by pouring on a base of thin layer of organic binder, distribution of high-grade crushed stone and compaction. The composition of the main works includes pouring of bitumen, distribution and compaction of crushed stone. The process of final formation of surface treatment continues about 10 essence. Therefore, the study of such technologies is necessary in innovative task.

Main part:

Surface treatment is carried out depending on the condition of the surface of the moving vehicle, the traffic intensity and the weather and climate factors.

1 Crack formation in the road surface.

2 Less resistance to vehicle loads.

3 Ageing and oxidation of bitumen.

4 There is a high risk of gravel flying off (breaking off) and hitting cars.

These defects provide recommendations on the type of surface treatment technologies using bitumen emulsion composites. Depending on the wear and type of coatings, the required thickness of the wear layer of the coating is determined; the parameters of the roughness of the coating layer should be selected based on the transport and operational characteristics. When designing a surface treatment device, technological solutions should be substantiated that provide the required operational transport properties of road surfaces under positive traffic conditions and exposure to climatic factors.

The operational and transport requirements for individual road sections are determined (ensuring cargo density, maximum noise, light reflectivity of the coating, safe speed of movement). The criterion for the lower layer of the coating is determined from the vehicle loads and climatic factors. So that the underlying layer provides strength and durability while maintaining the operational and transport properties of the upper layer of the road surface. The types of the designed road surface layer and its data are determined:

* Strength and durability properties of the road surface material.

* Service life, degree of deformation of the underlying coating layer.

* Longitudinal and transverse slopes on the road surface.

In the types of deformation, destruction, evenness of the upper layers of destruction there is a coating.

The requirement for the shape of the lower layer of the road surface is regulated by SNiP 3.06.03-85 according to the following criteria: road axis mark, roadway width, roadway width, layer thickness, transverse slopes of the surface (see SNiP 3.06.03-85 Appendix 2, Section 5). The crushing strength is established by Professor N. N. Ivanov.

$$R_{сж} \geq \frac{P \text{ x } K \text{ x } 2 \text{ x } h}{D \text{ x } tg(45^0 + \frac{\varphi}{2})}, \quad (1)$$

where: Rсж - the lowest compressive strength of a sample of the material of the lower layer of the pavement, under conditions that it will not be destroyed under the load of a vehicle upon contact (established) when testing asphalt samples MPa)

P-Pressure from the vehicle tread on the coating. (For vehicle group A - 0.6 MPa;

Load group B - 0.6 MPa);

K - Coefficient that takes into account the impact of horizontal forces and the degree of plasticity of the material of the constructed surface (with easy movement) k = 3/6; in complex areas K = 6/12;

In dangerous areas the movement K=12/18

h - thickness of the bottom coating layer, cm;

D - diameter of the car wheel in contact with the surface (for group A - 37 cm, for group B cars - 32 cm)

φ - friction angle of the underlying layer (determined by shear testing of materials)

The shear stability of the lower layer is determined by:

$$K_1 \text{ x } P \leq P \text{ x } tg\,\varphi + C_1 + C_2 = \tau_{сд}\,, \quad (2)$$

where: K1 - coefficient of transfer of vertical load to horizontal shear forces, (0.6-0.8);

P - Maximum pressure of the car tire on the surface. (A - 0.6 MPa; B - 0.5 MPa) - angle of internal friction (determined by the method of shearing samples.

φ - angle of internal friction, 0 (determined by shear testing of coating material samples;

C1 - Average adhesion to the coating at high temperatures. MPa

C2- Adhesion under short loads MPa.

τсд - total resistance of the treated coating to shear, MPa.

*Tear strength of material from coating

$$O_т \geq 0{,}12 \text{ МПа}, \quad (3)$$

where: Ot - resistance to separation of asphalt particles from the pavement under the impact of the tire on the pavement surface (determined during testing, MPa).

*tensile strength under bending of the road surface.

$$R_и \geq \sigma_r, \quad (4)$$

where Rи is the permissible tensile load in the sample or in the material of the studied layer, MPa.

$$R_и = R \text{ x } (1 - t \text{ x } v_R) \text{ x } K_y \text{ x } K_m, \quad (5)$$

where R is the average value of the resistance of the material of the treated coating layer to stretching under bending, MPa (determined by testing the material for bending);

t- Standard deviation coefficient R, adopted depending on the level of design reliability (Table 1).

Coefficient of standard deviation from design reliability.

Table 1. Dependence of the coefficient of standard deviation on the level of design reliability

Design strength level	0.85	0.9	0.95
Standard deviation coefficient	1.06	1.32	1.71

Vr is the coefficient of variation of the accepted 0.1.

Ky is the coefficient of destruction according to traffic intensity.

Km - coefficient of strength movement due to natural factors.

(adopted for asphalt concrete grades I and II on crushed rock of igneous rocks Km = 1.0 and III grade Km = 0.8; for mixtures of crushed sedimentary rocks and gravel grade I – Km = 0.9; for II and III brands Km = 0.7; for tar concrete Km = 0.7);

Óŕ - maximum tensile stress from the vehicle load, MPa, determined by the formula:

$$\sigma_r = \sigma_r \times P \times K_б, \quad (6)$$

Where: Òŕ is the calculated tensile load from bending under the action of a single load in the surface, the treated coating layer, MPa (determined according to the nomogram of Figure 3.11, 3.12 in CH 46.83)

P - Vertical load on the pavement surface from the contact of the vehicle tire with the pavement, MPa (for load group A - 0.6 MPa; for load group B - 0.5 MPa

Kб is a coefficient that takes into account the loaded state (equal to 0.85).

*The criterion for permitted bending under load, ensuring the tensile strength during bending of the treated road surface. It is determined when the treated surface is significantly damaged.

$$l_{cp} = \frac{P \times D \times (1-\mu)}{E_{тр}} \leq l_{доп}, \quad (7)$$

Where: lcp is the actual rigid deflection on the upper part of the pavement, cm (determined using the method in Appendix 5 of BCH 46-83, using a level or deflection meter under the wheel of the design vehicle, or by calculation using formula 7);

P - vertical maximum pressure with the coating and vehicle tires MPa (for load group A - 0.6 MPa; for load group B - 0.5 MPa);

D is the diameter of the wheel track with coating (for load group A - 37 cm; for load group B - 32 cm);

μ - Poisson coefficient is equal to 0.3;

Etr - the elastic modulus required for the road surface in MPa (determined according to the nomogram in Figure 3.2 BCH 46-83 depending on the traffic intensity, reduced to the design vehicle).

Iдоп - divided deflection of the road surface on the road surface, cm, (for loads of group A it is taken as 0.1 cm; for loads of group B - 0.13 cm)

Requirements for the condition of the road surface layer on which road sections are subject to surface treatment or a wearing layer are established depending on the method of material distribution.

Results and discussions:

There are two methods of material distribution when applying surface treatment. When distributing and leveling the composite on the road surface, the material and bitumen emulsion composites on the road surface fill and level the bottom layer, transforming the smooth layer on the road surface. When pouring the bitumen composite and material twice, copying the bottom layer of the coating becomes smooth, eliminating the unevenness of the coating in the transverse and longitudinal profile direction. The following parameters are regulated by the requirement for the bottom layer of the coating:

* Cleanliness of the top layer of the coating - dust, crushed stone, sand per square meter of coating g/m².

* Surface moisture content of the coating.

* The surface evenness of the road is determined by the clearance of a three-meter rail and by leveling the road surface at 5, 10 and 20 m.

* Combs and mesh are checked with a maximum clearance under a three-meter rail along the strips of the roll mm;

* The defectiveness of a road is determined by the degree of deviation from the design standard (unevenness, cracks, peeling, subsidence, etc.)

The requirements for the above-considered data determining the properties of the lower coating layer are given in Table 2.

In case of discrepancy of the actual position of the processed lower layer of the coating according to table 2, it is necessary to develop the necessary types of work to bring the actual to the required design state. In accordance with the types of defects on the arranged surface treatment of the coating layers, the following table 2 is performed.

The execution of the coating between the connecting layers on the processed layer is carried out in the following order.

1) When installing surface treatment, depending on the category of highways, relief and passenger flow load, traffic intensity, weather and climate factors, the operational layer of the pavement on the road being repaired is divided into sections.

According to Table 1, 2, the types of required repairs and roughness criteria are assigned.

2) When constructing a new pavement or an existing layer of the road pavement in use, the arrangement of surface treatments depends on the equipment of the production and technical base of the road organization. Availability of road building materials and construction machinery and equipment. When installing a new wear layer during new construction or reconstruction of roads to strengthen the pavement, the thickness of the wear layer and the roughness of the pavement must be taken into account. For this, the annual wear of the pavement surface is determined.

The annual wear of the coating layer is determined by the formula:

$$h_r = (a + b \text{ x } Q) \text{ x } K_{Tex}, \qquad (8)$$

Where: hr - road surface wear, mm/year;

a - wear due to climatic influences (depends on the road surface material) mm/year;

b- wear from vehicle load and type of road material mm/million k)

a- cargo flow million kN. year (total load from all axles on the pavement for the year, determined by the formula:

$$Q = 0{,}01 \text{ x } N_{cp}, \qquad (9)$$

where: Ncp - average daily intensity of vehicles, vehicles/essence.

Ktech - The coefficient from the use of technological machines and materials depends on the quality of the road surface.

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Table 2. Requirements for the underlying coating layer being processed

Type of underlying pavement layer being processed, road category	layer and method Planned thickness distribution of rough	Strength characteristics					Condition Characteristics						
		Compressive strength (CSS), MPa	Shear resistance (Ted), MPa	Tensile strength (Tear strength), MPa	(Pи), MPa Tensile strength at bending stress	mm Permissible elastic deflection (1у),	Purity, g/m²	Surface humidity %	Flatness		Rutting, mm	Roughness level	Acceptable defects
									clearance under 3 meters rail, mm	amplitude at 5 m base, mm			
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Asphalt concrete, I, II, III categories of roads	≤25 mm leveling	0.6/0.9*	0.4/0.6	0,12	0.45	1,0	2/30*	2/30	≤14	≤7.0	≤14	2-3	Cracks and cavities up to 10 mm
Same	<25 mm watering	0.6/0.9	0.4/0.5	0.12	0.45	1.0	2/30	2/30	≤10	≤7.0	0	2-3	Cracks and cavities before 5 mm
Same	25-40 leveling	0.5/0.8	0.3/0.5	0.1	0.30	1.0	2/30	2/30	≤20	≤15	≤20	2-3	Cracks and cavities up to 15 mm
Asphalt concrete treated with bitumen III-IV category roads	<25 mm leveling	0.5/0.7	0.3/0.5	0.12	0.30	1.3*	2/30	2/30	≤20	≤10	≤20	2-3	Cracks and cavities up to 15 mm

End of table 2

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Asphalt concrete treated with bitumen, III-IV category roads	<25 mm watering	0.5/0.7	0.3/0.5	0.12	0.30	1.3	2/30	2/30	≤14	≤10	0	2-3	Cracks and cavities up to 10 mm
Same	25-40 leveling	0.5/0.7	0.3/0.5	0.1	0.30	1.3	2/30	2/30	≤20	≤15	≤20	2-3	Cracks and cavities up to 15 mm
Cement concrete of I, II, III categories of roads	<25 mm leveling	≥20	-	-	25.5	1.0***	3/30	3/30	≤10	≤7.0	-	2-3	Cracks and cavities up to 10 mm
Same	<25 mm watering	≥20	-	-	≥25.5	1.0	3/30	3/30	≤7.0	≤7.0	-	2-3	Cracks and cavities up to 5 mm
Same	25-40 mm leveling	≥20	-	-	≥15.5	1.0	3/30	3/30	≤15	≤15	-	2-3	Cracks and cavities up to 15 mm

Conclusion:

The article discusses modern methods of repairing the upper layers of road surfaces using bitumen emulsions, in particular the method of surface treatment. The use of bitumen-emulsion composites can significantly improve the performance characteristics of the road surface, ensuring its durability and resistance to external influences, such as climatic factors and transport loads. Analysis of the considered methods shows that the technology of surface treatment allows achieving significant savings in building materials and labor costs, as well as increasing the adhesion of the surface to vehicles, ensuring traffic safety.

The main defects of road surfaces and methods for their elimination were considered. Important aspects of design are the calculation of the strength characteristics of road layers, determination of stability coefficients and assessment of pavement wear. Key criteria influencing the quality of repair and durability of roads were identified, and parameters regulated by building codes and regulations were considered.

Thus, the use of bitumen emulsions in road construction is an effective solution for extending the service life of road surfaces and improving their performance characteristics. Further research can be aimed at improving the technology and finding new materials that provide even greater durability and cost-effectiveness of road repairs.

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