

An Optimal Bituminous Impregnating Compound for Asphalt Coat Protection in the Russian Federation

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Currently, to strengthen and extend the durability of the bituminous macadam pavement surface compositions are used-impregnating composition (emulsions, solutions). These compositions are effective, but they have several disadvantages: instability to temperature changes; high water saturation; low water loss when applied, because of which the service life of the surface layer and of the pavement are reduced, and resource consumption is quite high; long drying time and others. This paper presents a brief overview of the main components included in the protective impregnating compositions for road pavements in Russian Federation, as well as the optimal in its purpose, and its components, the composition of the impregnating composition to protect the pavement from the negative effects of natural and manmade factors.

Keywords: Bitumen, Binder, Road pavement, Impregnating composition, Modifying agent, Solvent.

Since the second half of the twentieth century, the most widespread in industrialized countries, including the Russian Federation (RF), is bituminous macadam pavements. They are applied to any load intensity of the road. This is due to a number of positive qualities:

- a) Sufficient mechanical strength;
- b) The ability to perceive the elastic and plastic deformation;
- c) Good grip with the tires of vehicles to provide conditions for road safety;
- d) Evenness of the coating provides a comfortable and quiet for high-speed vehicles and convenience to passengers;
- e) Hygienic, making it easy to wash and clean

the surface;

- f) Damping capacity, allowing dampen fluctuations and vibration caused by traffic;
- g) Manufacturability and maintainability, which provide ease repair work and the elimination of defects;
- h) Possibility of full mechanization of work in the preparation, construction and repair¹.

The traffic intensity on Russian roads and the increased exploitation of goods transport results in a fast wear of an upper pavement layer and a violation of its waterproofing properties. This in turn leads to wheel tracking, holes, potholes, and cracks of road pavement. Aging of oil bitumen in the upper layer under climatic factors is also believed to be one of the causes of premature destruction of road pavement. Road pavements in Russia are characterized by specific features and firstly it is associated with the use in different climatic conditions of Russia². The upper pavement

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layer is especially destructible.

A destructive process on the road pavement can be slowed (or stopped) if a surface is treated with special agents. Often bitumen-based compounds are used as protective compounds, because bitumen is the main component of asphalt pavements. In most cases, protective bitumen compounds are used as impregnation solution (adhesives), emulsions³ and sealants⁴⁻⁵. All types of protective bitumen-based compounds consist of bitumen (binder), solvent, plasticizer and modifying agents.

Certain state standards, construction rules and regulations, and recommendations are applied in Russia for preventive works on road pavement protection and repair.

The concept of asphalt mixes for road pavement in the Russian Federation

Bitumen concrete mix (BCM) is a mixture of a mineral additive with bitumen (binder), taken in certain proportions, heated and mixed in accordance with Russian Federation GOST 9128-2009.

Usually crushed stone or sand is used as a mineral additive. Residues of crushed marble, granite and diabase, with certain grain fineness, for example, of 10 mm, are used as crushed stone⁶. Fine powder of grinded limestone, dolomite, chalk, asbestos, blast furnace slag, and etc are typically used as an additive in road pavement compounds. According to GOST 9128-2009⁷, the asphalt mixtures are divided into the following types depending on the mineral component content:

- a) Type A - 50-60% of crushed stone in a mixture;
- b) Type B - 40-50% of crushed stone in a mixture;
- c) Type C - 30-40% of crushed stone in a mixture;
- d) D and E types contain sand of crushing residues or mixture with natural sand if content of the latter is not more than 30% by mass.

According to this GOST mix (BCM) can be classified by size of mineral grains:

- a) Coarse-grained (grain size up to 40mm);
- b) Fine-grained (grain size up to 20mm);
- c) Sand (grain size up to 5mm).

Asphalt binder

As mentioned above, the main

component of road pavements is bitumen. Almost all properties of road pavement correspond to bitumen properties and quality. Bitumen is widely used in civil construction due to its versatility and low cost. One of the main areas of bitumen application is the road construction; also bitumen is used as a part of the roof coat, at sealing of cracks in buildings and so forth.

Bitumen is a petroleum product with a colloidal structure. It is a viscous product of dark color.

The main requirement for the road bitumen quality in Russia is their meeting of GOST 22245-90⁸. Road bitumen manufactured by Russian petroleum refineries often do not meet the standards by binder index such as resistance at low temperatures, characterized by brittleness temperature and melting point (known from experience). This bitumen has poor adhesive properties, thereby the fracture strength of coatings and resistance to dynamic loads are reduced.

Currently, a wide range of road bitumen with different compounds is manufactured in Russia. (Table 1)

The road climate zone of asphalt pavement use in the Russian Federation determines the choice of bitumen for asphalt mix. (Table 2). Properties of road bitumen are characterization by many parameters 9. Table 3 shows only some of them.

Modifying additives

Different modifying additives are added to improve the performance properties of road pavement (to increase the mechanical strength and water resistance in bituminous compounds):

- a) Organosilicon compounds: organoaminosylons and etc⁶;
- b) Sulfur compound^{10, 11};
- c) Various derivatives of monocarboxylic acids¹²;
- d) Phosphorus containing compound¹³;
- e) Lithium salts of fatty acids¹⁴;
- f) Rubber¹⁵⁻¹⁶;
- g) Thermoplastic¹⁷;
- h) Copolymers and plasticizers, and polymeric additives¹⁸.

Choosing certain modifying additives, attention should be paid to their compatibility with bitumen. But these additives may reduce binder

adhesion with mineral components of bitumen concrete mix, may lower the melting temperature and extensibility (elasticity) of the pavement when applied. Also the additives for modifying additives may impair penetration.

Solvent

It is known that to improve the bitumen compound fluidity and the asphalt pavement impregnation, their use is increased in a form of emulsions, solutions, suspensions or gels¹⁹⁻²¹, where water (emulsions, suspensions, gels) or organic solvents (impregnation) are used as solvents.

Compounds to protect asphalt road pavements in the Russian Federation

The bituminous compounds as solutions are very interesting for the use. This is due to

convenient solution applying onto the surface and a square of the treated road pavement surface. A benefit of the impregnated compound as solution is quick formation of a protective layer. This decreases in repair work on the roads.

The studied subject is widely covered and protected by many patents both in the Russian Federation and abroad. The quality of the applied coatings has been improved and the applying technology optimization has been developed for the last 20-30 years.

A few examples of such compounds are shown below.

Since the compound¹⁴ used as a binder of cold applying includes from 0.1 to 25 mass percent of elastomer, from 0, 1 to 40 mass percent of solvent, 30 to 99 mass percent of bitumen and from 0.1 to 30

Table 1. Classification of bitumen produced in the Russian Federation

Group	Subgroup	Brand
Petroleum viscous bitumen	Road	BND-200/300, BND-130/200, BND-90/130, BND-60/90, BND-40/60, BN-200/300, BN-130/200, BN-90/130, BN-60/90
Petroleum liquid bitumen	Road	BG-25/40, BG-40/70, BG-70/130, SG-40/70, SG-70/130, SG-130/200, MG-25/40, MG-40/70, MG-70/130, MG-130/200
Shore bitumen	Road and roofing	BS-0, BS-1, BS-2, BS-3, BS-4, BS-5, C-6
	Road and paint and insulation	BS-I, BS-II, BS-III
Shore liquid bitumen	Road and roofing	C-1, C-2, C-3, C-4, C-5, C-6

Table 2. Dependence of the brand choice for road pavement on the road climatic zone in the Russian Federation

Road climatic zone in the Russian Federation	Average monthly temperature of the coldest season, °C	Brand of used bitumen
I	Not higher -20	BND 90/130, BND 130/200, BND 200/300
II- III	from -10 to -20	BND 60/90, BND 90/130, BND 130/200, BND 200/300
II,III,IV	from -5 to -10	BND 40/60, BND 60/90, BND 90/130, BND 130/200, BN 90/130, BN 130/200, BN 200/300
IV-V	Not lower +5	BND 40/60, BND 60/90, BND 90/130, BN 60/90, BN 90/130

Table 3. Indicators properties of bitumen according to certain European standard (EN 12591)

Property	Reduction	Units	Measurement standard
Needle penetration at 25°C	P ₂₅	1/10 MM	EN 1426
Softening Point by Ring and Ball method	RBSP	°C	EN 1427
Fraassen's breaking point	FBP	°C	EN 12593

mass percent of lithium salts of fatty acids. Furthermore, the compound may contain extender as well. This bitumen compound contains polymer-based elastomers of diene type butadiene and isoprene and copolymers of the mentioned dienes with styrene-type vinyl aromatic compounds. Esters with the boiling temperature of 120-160°C are used as the bituminous binder solvent in this invention. The compound with 5-15% solvent is applied with a spatula or a manual cylinder or an injector for precise application. However in case of 15-30 solvent (for total compound), the bitumen compound is applied by spraying. When applied this way, the solvent evaporates and the compound hardens. The time of hardening depends on a width of the applying compound and makes from 7 to 60 days.

According to the description, the compound and its application method are not good for fast treatment of bitumen pavement, especially, for repairing of exploited roads.

The requirements for protective impregnating compositions for bitumen pavements:

- a) Quick drying and protective layer formation;
- b) Low water saturation of treated bitumen pavements;
- c) Increased term of road operation, increased coefficient of coupling of wheels and road surface by slowing down the aging of bitumen pavements.

Bitumen-based impregnating compositions form a durable, stable, resistant to temperature fluctuations, non-toxic, vapor-permeable, rough, water-repellent layer on the basis of cheap natural or artificial materials - bitumen.

To meet the requirements to the protective impregnating compositions in the Russian patent²² of FSUE "IREA", a method of impregnation of the upper layer bitumen pavement with penetrating compound of the modified bitumen binder containing 30-85 mass percent of bitumen, 15-20 mass percent of petroleum resin, and optionally, 0-40 mass percent mineral oil, and 0-5 mass percent of surface-active substances (surfactants). This composition is applied to bitumen surface in a form of solvents in organic solvent with a boiling temperature of 155-200°C, at a weight ratio to the modified bitumen binder equal to 70/30-50/50. The modified bitumen on the pavement is applied at a

rate of 0.1-0.40 l/m² and at -6 - +40°C.

The choice of an organic solvent and its amount for the used binder play a significant role in the effectiveness of applying of the modified polymer-bitumen compound. The organic solvent with a boiling temperature of 155-200°C is used as this kind of solvent in this invention, including, for example, known and widely used solvents such as white-spirit (nefras), petroleum ether, LotoxaneFast© and etc.

These solvents are related to fast drying, as well as to those providing the protective compound with such technic properties as viscosity.

These solvents are ecologically safer comparing to the aromatic hydrocarbon solvents, previously used for this purpose: benzene, toluene, xylene.

Weight ratio of components of the polymer-bitumen compound to the amount of the solvent used affects both the quality of the protective coating and its resistance to aging, and the efficiency of the prepared impregnating compound. The conducted tests of the efficiency of the asphalt pavements treatment by the offered method revealed that the weight ratio of solvent to the binder compound equal to 70/30-50/50 should be used for full transformation of a binder compound into liquid state, after which it can be applied to the road pavement by filling.

To guarantee a full coverage of the road pavement surface with protective impregnating compound and its penetration to a depth of 1 to 3 mm, a modified bitumen solvent is applied onto road pavements by filling at a rate of impregnating compound 0.10-0.40 l/m². In this case, old bitumen fractions lost due to road pavements aging during exploitation pavement are replaced and replenished.

Decreasing of an application rate below declared reduces protective functions of the compound, and increasing of an application rate higher declared increases the time of surface drying. Compounds with 80% of bitumen and 20% of resin, and petroleum ether or other similar solvent as a solvent - a weight ratio of binder and solvent equal to 50/50 is optimal.

This compound has benefits comparing to other well-known compounds of similar purpose: once the impregnating compound is formed (prior

to application) it does not polymerize for sufficient time, which ensures its fluidity during the filling and fast penetration into the asphalt pavement pores, even at low temperatures.

An important advantage of this compound is a fast formation of a protective layer (no more than 0.5 hours) on the road pavement, reducing repairing works on the roads.

This compound has a number of advantages before other analogues and may be the most optimal for the protection of road pavements in the Russian Federation.

CONCLUSION

- 1 The paper contains a brief overview of components of protective compounds for road pavements in the Russian Federation.
- 2 The paper stipulates the most optimal compound to protect the road pavement of various purposes in modern Russia.

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