Experience in the installation of coatings of warm asphalt mixes in the first road-climate zone

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Abstract. This article describes in detail the technology of production of low-temperature mixes (warm asphalt-concrete mixes) of type A, B and C using viscous bitumen and the method of its foaming, as well as the construction of road coatings from them in the first road-climatic zone and the results of laboratory studies of mixtures. A schematic diagram of the operation of the foaming equipment for the production of warm asphalt concrete mixes and the principle of its operation are given. The expediency of foaming viscous oil road bitumen was substantiated and confirmed by spraying an asphalt mixing plant in a mixer with a specified amount of water through the nozzles of the dispenser-dispenser of DRV-001 water. This technology is especially relevant for regions with a short duration of the construction season.

Introduction

Low-temperature mixes (hereinafter referred to as warm asphalt concrete mixtures) imply a variety of methods and technologies for their production and can significantly increase the pace in the construction, reconstruction and major repairs of highways. This is due to the fact that warm asphalt mixes can be prepared and laid at lower temperatures compared to classic hot mixes, and accordingly - to extend the construction season, which is important for road climate zone I. Based on these advantages, it is obvious that
the use of warm asphalt mixes in road construction is the most promising activity [1].

In the production of asphalt mixes, one of the most important indicators of quality is the uniformity and completeness of the coating with an organic binder mineral fill. When using viscous bitumen, this condition is achieved by reducing the viscosity of the organic binder by heating it, of the order of 140-150°C. Also in the process of producing asphalt mixes, it is necessary to maintain the high temperature of the stone material. This entails large energy consumption in the production of asphalt concrete mixes according to the classical hot technology, contributes to the intensive oxidation of organic binder, which leads to a decrease in its physical and mechanical properties and, as a result, a decrease in the durability of asphalt concrete pavements. In addition, high fuel consumption leads to an increase in pollutant emissions.

Hot asphalt mixes are laid and compacted at a temperature of 120-150 °C, this temperature provides the required workability and workability of asphalt concrete mixes, and completes the compaction at a temperature not lower than 80°C [2].

The technology of warm mixes is a significant reduction in temperature regimes during production, laying and compaction. Warm asphalt mixes have a number of advantages over hot ones [3]:
- Saving energy when cooking;
- Reducing pollutant emissions;
- Less intense oxidation of bitumen;
- Increase the distance of transportation and the possibility of laying and compacting the mixture at low temperatures;
- Improving working conditions in the preparation of asphalt mixes, as well as in the implementation of road construction works.

Materials and Methods

To date, there are several methods for obtaining warm asphalt mixes [2, 3]:
1. The use of chemical additives that alter the viscosity of the bituminous binder;
2. Using the two-phase mixing method;
3. Application in the production of asphalt concrete mixtures of foamed bitumen.

The first method involves the use of chemically active substances that can significantly improve the properties of an organic binder, increasing its oper-
ating temperature range and reduce the viscosity of bitumen for a certain time.

Also widely known is the two-phase mixing method used in the production of warm asphalt concrete mixes [4]. It consists in the alternate introduction of bitumens of different viscosity into the asphalt mixing plant. At the beginning of the preparation, bitumen with a lower viscosity is introduced, which provides a coating of mineral aggregate in thin films and helps reduce surface stresses. During the second phase, bitumen having a higher viscosity is introduced into the mixing plant. This method allows to reduce the temperature of the produced mixture, however, increases the cooking time.

The most promising direction, in our opinion, is the use of foamed bitumen.

Binding in the foamed state is characterized by high surface energy, low viscosity and, consequently, high activity when interacting with mineral materials, which provides the best coating of mineral aggregate grains with a bitumen film [5].

In addition, when using foamed binders, bitumen consumption and material mixing time are reduced, which makes it possible to consider this method as a material and energy saving technology for preparing asphalt concrete mixes [5].

In the period from 2016 to 2017, three experimental plots with various types of asphalt concrete paving were arranged using the technology of foaming a bituminous binder by simultaneously supplying water and bitumen to the mixer of the asphalt mixing plant. All experimental plots belong to the I climatic zone.

Bitumen was introduced according to the standard scheme of its supply, and water was supplied using the DRV-001 water dispenser-dispenser and air-water nozzles inserted into the agitator body.

This system provides foamed bitumen which has a lower viscosity at lower process temperatures, and also allows to achieve a high degree of homogeneity of the mixture, to ensure high-quality adhesion of bitumen to the surface of the mineral aggregate and, as a result, to ensure the required physical and mechanical properties of asphalt concrete mixtures at lower process temperatures [6].

DRV-001 is installed at the working site of the asphalt mixing plant, next to the agitator, and is connected to the compressed air system and the control of the asphalt mixing plant (Fig. 1).
Figure 1. Device for the production of asphalt concrete mixes.

During preparation of warm asphalt concrete mix by this method temperature of heating of mineral materials in the dryer drum decreases to 140 °C, temperature of organic knitting is maintained at the same temperature level as well as at preparation of hot asphalt concrete mixes, for ensuring better foaming of organic knitting. Warm asphalt concrete mixes prepared with use of bitumens of the BND 90/130 and BND 100/130 brands. During process of production of warm asphalt concrete mixes for foaming of bitumen from 3.0 to 3.5% of water of the mass of bitumen were pumped, foaming was carried out directly in the ACS mixer, and time of hashing was from 45 seconds to 1 minute 10 seconds [7].

Results

In August 2017, in the Tyndinsky district of the Amur region, on the section for the reconstruction of the M-56 Lena federal highway from Nevers to Yakutsk km 155 - km 165, the company Trud JSC acted as a contracting organization. An experimental plot was built from warm asphalt concrete mixes of type A grade II according to the presented technology. The work was carried out at a temperature of +22 to +26 °C, the range of wagon was 8 km. At the outlet of the mixer, the mixture had a temperature of 120-135 °C. Comparative data of hot and warm asphalt mixes are given in table 1 [8].

Table 1. Physical and mechanical properties of asphalt concrete mixture type A using foaming installation DRV-001.

| №  | The name of indicators | Indicators | Reference hot asphalt concrete mix type A grade II | Experimental warm asphalt concrete mix type A grade II |
|----|------------------------|------------|--------------------------------------------------|-----------------------------------------------------|
| 1  | Density, gr / cm³      | not standard-ized | 2.39                                              | 2.39                                                |
### Properties

| Property                                      | Requirement                   | Value 1 | Value 2 | Value 3 |
|-----------------------------------------------|-------------------------------|---------|---------|---------|
| 2 Water saturation, % by volume              | from 2.0 to 5.0               | 2.2     | 2.1     |         |
| 3 Strength at compression, MPa, at:          |                               |         |         |         |
| 0°C                                           | not more than 10.0            | 4.9     | 5.8     |         |
| 20°C                                          | not less than 2.2             | 2.9     | 3.0     |         |
| 50°C                                          | not less than 0.8             | 1.1     | 1.3     |         |
| 4 Water resistance                            | not less than 0.90            | 0.93    | 0.95    |         |
| 5 Water resistance for long-term water saturation | not less than 0.85        | 0.88    | 0.88    |         |
| 6 Shear resistance to coefficient of internal friction | not less than 0.86 | 0.91    | 0.93    |         |
| shear adhesion at a temperature of 50 °C, MPa | not less than 0.22           | 0.39    | 0.29    |         |
| 7 Fracture resistance according to tensile strength at cleavage at 0 °C and strain rate 50 mm / min | from 2.5 to 6.0 | 3.2     | 2.8     |         |

Laying the mix was carried out at a temperature of from 120 to 100 °C, and the beginning of compaction was carried out at temperatures: 120 and 100 °C.

The compaction was carried out by two smooth-drum rollers with a mass of 10.3 and 11.9 tons, following one after another, one after the other using the vibration effect after preliminary compaction (rolling).

An express method for assessing the quality of compaction was the use of a PQI 301 asphalt concrete density meter. The measurements were carried out after each pass of the roller on one track and were carried out until the increase in density of asphalt concrete stopped.
For the final assessment of the quality of compaction of warm asphalt concrete mixes, cutting samples were taken, the compaction coefficient of which corresponded to the requirements of regulatory documents.

In September 2017, in the Barguzinsky district of the Republic of Buryatia, a site of 215 - km 230, where the Ust-Barguzinsky branch of Trud JSC acted as a contractor, was constructed at the site of the reconstruction of the regional motorway Ulan-Ude - Turuntaevo - Kurumkan - Novy Uoyanna warm asphalt mix type B mark II.

The mix was prepared in the same way as in the first case. The range of the wagon was 16 km, the ambient air temperature was + 11 ° С.

The temperature of the mix at the outlet of the mixer was 120-130 ° C.

The compaction was initiated by two rollers: a smooth-drum weight of 12 tons and a pneumowheel roller of 18 tons at a temperature of from 120 to 100 ° C.

After 6 passes in one track, the required compacting ratio was achieved, which indicates good compactibility of warm asphalt concrete mixes.

The PQI 301 asphalt concrete density gauge was also used as an express method for determining the quality of compaction. Measurements were taken after each pass of the roller.

The compaction coefficient at the experimental site was 0.98-0.99.

Comparison of physicomechanical indicators of hot asphalt concrete mix and warm asphalt concrete mix of types V mark II are presented in table 2.

*Table 2. Physical and mechanical properties of asphalt concrete mix type V using foaming installation DRV-001.*

| №  | The name of indicators | Indicators | GOST 9128-2013 | Reference hot asphalt concrete mix type V grade II | Experimental warm asphalt concrete mix type V grade II |
|----|------------------------|------------|----------------|-----------------------------------------------|-----------------------------------------------|
| 1  | Density, gr / cm³      |            | not stand-ardized | 2.34 | 2.34 |
| 2  | Water saturation, % by volume | from 1.0 to 4.0 | 1.1 | 1.1 |
| 3  | Strength at compression, MPa, at: |          |                | 5.7 | 5.8 |
|    | 0°C                    |            | not more than 10.0 | 3.3 | 3.5 |
|    | 20°C                   |            | not less than 2.2 |      |      |
On October 20, 2016 at the Solovievsky branch of AO "Trud" at the object "Reconstruction of the Lena highway M-56 from Never to Yakutsk km 4 - km 38" an experiment was conducted on laying warm asphalt concrete type B mark II. The experimental warm mix is identical in composition and characteristics to the hot asphalt concrete mix used.

Comparative data of the warm asphalt concrete mix type B mark II and hot asphalt concrete mix type B mark II are given in table 3.

**Table 3.** Physical and mechanical properties of asphalt concrete mix type B using wet mineral powder.

| №  | The name of indicators                        | Indicators                              |
|----|----------------------------------------------|-----------------------------------------|
|    |                                              | GOST 9128-2013                          | Experimental warm asphalt concrete mix type B grade II |
| 1  | Density, gr / cm³                            | not standardized                        | 2.41                                      |
| 2  | Water saturation, % by volume               | from 1.5 to 4.0                         | 3.4                                      |
| 3  | Strength at compression, MPa, at:           |                                        |                                          |
|    | 0°C                                          | not more than 10.0                      | 8.2                                      |
|    | 20°C                                         | not less than                           | 4.3                                      |
|    |                                              |                                         |                                          |
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| Property                                      | Value  |
|-----------------------------------------------|--------|
| Water resistance                              | 0.90   |
| Shear resistance to coefficient of internal friction | 0.86   |
| Shear adhesion at a temperature of 50 °C, MPa | 0.31   |
| Fracture resistance according to tensile strength at cleavage at 0 °C and strain rate 50 mm/min | from 2.5 to 6.0 |

Laying this mix occurred at air temperature of -7 °C. After the mix was distributed by an asphalt paver, it was rolled, the temperature of the start of rolling was 120 °C, at the completion of compaction the temperature of the mix was 80-90 °C. The compaction factor was 0.99, asphalt concrete mix meets the requirements of GOST 9128-2013 in all respects [9].

**Conclusion**

The environmental friendliness of this technology is confirmed by data on pollutant emissions measurements made by FBU Center for Laboratory Analysis and Technical Measurements in the Siberian Federal District, based on the Tulun branch of Trud JSC on the MARINIRS-1800 asphalt mixing
plant (Fig. 2).

Figure 2. Diagram of polluting emissions in the production of warm asphalt concrete mix.

So in comparison with the classic hot mixes, emissions of pollutants have decreased:
- sulfur dioxide 3.15 times (68%);
- nitric oxide by 30%;
- soot by 58% [10].

Based on the research and work performed, the following conclusions can be made:
1. The physicomechanical properties of warm asphalt concrete mixes of types A, B, and C mark II are not inferior to the regulatory requirements imposed on hot asphalt concrete mixes;
2. Warm asphalt mixes have a significantly better index of workability and compactibility;
3. Warm asphalt concrete mixes of types A, B, C can be produced, laid and compacted at lower temperatures (up to -10 °C), which allows to increase the duration of the construction season in road-climatic zone;
4. Fuel economy in the preparation of warm asphalt mixes based on one ton of production is 1.6 liters or 20-30%;
5. Reducing emissions of pollutants in the production of warm asphalt mixes is reduced from 30 to 68%, which contributes to the improvement of the environmental situation and provides more favorable working conditions for workers at the ABZ and work sites;
6. Reduction of aging (oxidation) of bitumen due to short-term temperature exposure, which increases the service life of asphalt concrete pavements;

7. The developed equipment of the DRV-001 water dispenser-sprayer is easy-to-mount at ABZ, simple enough in operation, reliable and has low cost;

8. This technology is universal for asphalt concrete mixes of types A, B, C of various grades and can be used on all installations of cyclic action.

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