Asphalt Concrete Preparation and Placement Monitoring

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***Abstract*:** Asphalt concrete quality depends on many factors, each of which can have a decisive impact on the strength and durability of the road surface. Therefore, adherence to optimal process conditions and well-established monitoring at all stages of raw material preparation, placement, compaction, and structure formation guarantees the stability of asphalt concrete.
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Introduction

Quality control of the produced asphalt concrete mixture is performed by the process control department or the plant laboratory. The control system includes:
- incoming quality control of materials arriving at the plant;
- operational monitoring of process operations;
- control of the release of the finished mixture.

Main Part

Incoming Inspection. The quality of incoming mineral materials and binders is regulated by state standards and is specified in the data sheet and certificate for these materials, issued by the manufacturer. However, the factory laboratory still checks the key parameters of this material. Particularly careful quality control should be exercised for materials arriving from a non-specialized facility, directly from a crushing plant or from the asphalt concrete plant workshop.

Crushed stone quality is determined based on an average sample taken from each batch of material received at the plant. The following parameters are critical for crushed stone: petrographic characteristics, particle size distribution, strength, wear resistance, content of lamellar grains, dust and clay impurities, and frost resistance. The same data is used to monitor the flow of the crushing and screening plant. In this case, the density and porosity of the original crushed stone may also be determined. Sand quality is determined by testing an average sample taken from all incoming batches. The main sand characteristics tested are petrographic characteristics, particle size distribution, dust, clay, and organic impurity content.

The quality of the mineral powder is assessed based on parameters such as particle size distribution, bitumen content, porosity, and petrographic characteristics.

The quality of the bitumen arriving at the plant is tested in each batch. The following properties are determined: penetrometer needle penetration depth, tensile strength, softening point, mass loss, and softening point change upon heating. Liquid bitumen is tested for relative viscosity in a standard viscometer, particle size distribution, flash point, and the properties of the viscous residue—yes, after the evaporation of the thinner (penetration, tensile strength, softening point).

When bitumen is produced at an asphalt concrete plant or when various additives are added to it, all of these parameters are tested.

All material quality parameters obtained during testing must be compared with the requirements of the relevant standard or the manufacturer's data.

If the results specified in the data sheet do not match the actual results, the supplier must be immediately notified so that they can take prompt action to bring the product into compliance with the required level. If agreement cannot be reached, the materials may be submitted for testing to an independent accredited laboratory. If a resolution cannot be reached between the consumer and the supplier of the defective product, the dispute must be resolved by arbitration.

Operational monitoring is carried out at all stages of the technological process, as good source material can produce poor-quality asphalt concrete mixes and asphalt concrete from it.

Operational monitoring is carried out:

- during the stages of crushed stone and sand drying and binder heating;

- during the heating of the heated crushed stone-sand mixture;

- during the material dosing stage;

- during the mixing of the composition.

During the crushed stone and sand heating stage, their moisture content is monitored as they enter and exit the drying drum. Before drying, their ratio is controlled by dosing equipment.

During the drying process, it is necessary to completely remove moisture from the aggregates, and their temperature at the exit of the drying drum must comply with technical standards. If the operating temperature deviates too low, the extraction of filler grains into the binder is impaired, while if the temperature rises, there is a risk of binder overheating and an unacceptably high temperature in the finished mixture.

When heating the binder in the bitumen melting kettle, the temperature and heating time are monitored. Overheating the binder, as well as prolonged heating, negatively impacts its properties. The evaporation and oxidation of light hydrocarbon fractions alters the binder's group composition, resulting in its properties in the asphalt concrete mixture differing from those it had during laboratory testing.

During the firing stage of the heated gravel-sand mixture, the homogeneity of the fractions is monitored. This results in the coarse gravel being converted into finer gravel, which was not separated from the rest of the gravel mass at that point. This phenomenon is observed either due to an excessively high flow of gravel-sand mixture from the drying drum or as a result of a faulty grate—that is, due to high rotation speed, insufficient grate cross-section length, a large grate tilt angle relative to the horizontal, etc.

Incomplete separation of the gravel-sand mixture into individual fractions leads to significant deviations in the particle size distribution of the mineral mixture in the asphalt concrete, which negatively impacts its properties such as strength, porosity, durability, etc.

During the dosing stage, the dosing device and the accuracy of the materials being dosed are systematically checked to ensure compliance with the asphalt concrete **composition.**

When preparing asphalt concrete mix, the mixing time of the mineral mixture is monitored, and after adding bitumen, the remixing time is monitored. It is essential that the finished mix is thoroughly mixed and free of lumps, bitumen deposits, and mineral grains not coated with bitumen.

Production control includes acceptance testing and periodic inspection. Acceptance testing is conducted for all batches of asphalt concrete mix. A batch is defined as the quantity of hot asphalt concrete of a single composition produced per shift by a single machine, but not exceeding 600 tons. For cold mixes, the quantity per batch does not exceed 200 tons.

Depending on the capacity of the mixing unit, 3-4 samples are taken from the mix discharged from the mixer at 15-30 minute intervals and then averaged. The amount of mix for each sample depends on the maximum thickness of the mineral grains and the type of asphalt concrete and ranges from 2.5 kg to 17 kg.

Samples are prepared from the averaged sample to test the following parameters:

- temperature of the mix upon exiting the mixer;

- particle size distribution of the mineral component of the mix; - water saturation;

- compressive strength at 20°C, including in the saturated state of the cold mix;

- compaction of the cold mix (2-3 times per shift).

Periodic Monitoring. Periodic monitoring of the asphalt concrete mix is performed at least once a month, as well as with each change of materials.

During periodic monitoring of the mix, the following parameters are determined:

- porosity of the mineral component;

- residual porosity of the asphalt concrete;

- water resistance during prolonged saturation with water;

- Compressive strength at 20^{0}C and after prolonged water saturation for cold mixtures;

- Compressive strength at 0°C for hot mix;

- Bitumen adhesion to mineral components of the mix.

The specific activity of natural radionuclides in the mix and asphalt concrete is determined by the maximum content of the mineral materials used. This data is specified in the supplier's quality documentation. If this data is not available, the asphalt concrete mix manufacturer is required to conduct incoming inspection of these parameters in a specialized laboratory in accordance with the state standard.

Depending on the specific effective activity of natural radionuclides, asphalt concrete mix can be used in road and airfield construction without restrictions if the AEF of mineral materials is up to 740 Bq/kg, and in uninhabited areas and in prospective construction zones – from 740 to 2800 Bq/kg.

Monitoring during the laying and compaction stage includes checking the temperature of the mix delivered to the site, the thickness of the laid layer, and the quality of compaction. The layer thickness is controlled by the compaction factor – 1.15–1.2 for hot mixes and 1.6–1.7 for cold mixes. During compaction, it is important to monitor the compactor speed: no more than 3–5 km/h in static mode and 2–3 km/h in vibration mode. The temperature drop of the compacted layer is also monitored, especially in cold and windy weather. It is important to avoid prolonged idle time for the laid but uncompacted mix. Thus, if a loose, uniformly laid mix cools by 1–5 °C/min in summer, the same mix after compaction begins will cool by only approximately 0.5 °C/min.

Asphalt concrete pavement quality control is performed by comparing the properties of a hollowed-out cylindrical core or a cut-out sample with a molded sample. The core diameter for asphalt concrete samples should be at least 50 mm, 70 mm for fine-grained asphalt concrete, and 100 mm for coarse-grained asphalt concrete. Three intact samples are taken from the cut. The average density, water absorption, shrinkage, and compaction coefficient are determined on the molded samples.

Molded samples are prepared by heating the core or cut in a sand bath or thermostat to the required temperature corresponding to the viscosity of the binder used, and then compacting them in cylindrical molds at a pressure of 40 MPa.

The compaction coefficient $K_ə$ is calculated as the ratio of the average density of samples taken from the construction layer to the average density of the molded samples. The compaction coefficient must not be less than that obtained in accordance with the regulatory and technical documentation. If the difference in the properties of the molded and design samples is significant, the asphalt concrete composition of the pavement is verified by bitumen extraction (solubility) and sieving of the mineral fraction.

Conclusion

To produce asphalt concrete that is durable and resistant to dynamic loads, water, temperature, freezing and thawing, chemical reagents, and other factors, it is necessary to control the source mineral materials and binders, as well as their supply, use, frequency, and commissioning during the mixing and curing stages.

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