SATBAYEV UNIVERSITY

Architecture and Civil Engineering

Volume 1 (2024), Issue 3, 30-34

https://doi.org/10.51301/ace.2024.i3.05

Quality control of compaction of asphalt concrete layers of road pavements

A.M. Zhangabylova[1*], I.S. Bondar[2], G.O. Sarsenbayeva[1], S.A. Abdiqodirov[3], A.L. Komilov[3], F. Adilzanov[1]

[1]*Satbayev University, Almaty, Kazakhstan*

[2]*Academy of Logistics and Transport, Almaty, Kazakhstan*

[3]*Termez Institute of Engineering and Technology, Termez, Uzbekistan*

**Corresponding author:* *zhangabylova82@mail.ru*

Abstract. The article discusses a destructive method for determining the actual compaction coefficient of asphalt concrete layers of road pavement. General concepts and provisions, the procedure for performing the work are given. The compaction quality of hot mix asphalt concrete is assessed by the average coefficient of compaction of the material (density) and its homogeneity (compaction variation coefficient). The values of these characteristics depend on the type of mixture, the type of road compaction equipment used, its operating modes, etc. The characteristics of the devices and equipment used, as well as the values of the required compaction coefficient, are given.

Keywords: *highway, asphalt concrete mixture, asphalt concrete, compaction coefficient*.

1. Introduction

A highway is an object of transport infrastructure intended for the movement of vehicles and includes land plots within the boundaries of the right of way of the highway and structural elements and road structures located on or under them, which are its technological part, protective road structures, production facilities, elements of road construction. The quality of roads determines traffic safety, the comfort of passenger transportation, the efficiency of road transport, and the service life of road structures. Particular attention must be paid to improving the quality and safety of the transport network, the level of which must meet modern standards and requirements. The problem of the quality of road construction exists and requires a solution.

The role of soil compaction in ensuring the stability of the subgrade and the strength of road pavements. Soil compaction in the roadbed structure is one of the most critical technological operations. The quality of soil compaction in an embankment or in the working layer of excavations determines the stability of the subgrade, which ultimately ensures the reliability, strength and durability of the road pavement. The reasons for the violation of the stability of the roadbed may be insufficient density of the soil, given to it during construction or obtained during operation due to the negative impact of factors of the water-thermal regime of the roadbed and loads from vehicles. The main technological measures that ensure the stability of the roadbed include: layer-by-layer and uniform compaction of the soil using compacting machines and mechanisms, the implementation of measures to regulate the water-thermal and technological regimes of the roadbed.

High-quality compaction of subgrade soils allows you to increase their strength and thereby reduce the thickness of the road pavement. This ensures the operation of the structure in the elastic stage, regardless of the season of the year and the geographical conditions of the area where the highway is laid, and also reduces its cost.

1.1. Data

Asphalt concrete mixture - is a rationally selected mixture of mineral materials (crushed stone/gravel and sand with or without mineral powder) with bitumen, taken in certain proportions and mixed in a heated state.

Asphalt concrete - is a compacted asphalt concrete mixture. Mixtures and asphalt concrete, depending on the indicators of physical and mechanical properties and the materials used, are divided into grades: Hot (High-density - I); dense (types: A - I, II; B, D - I, II, III; C, D - II, III); porous and highly porous - I, II; Cold (types: Bx, Bx - I, II; Gx - I, II).

2. Materials and methods

Depending on the viscosity of the bitumen used and the temperature during installation, mixtures are divided into: *hot*, prepared using viscous and liquid petroleum road bitumen and laid at a temperature of at least 120°C; *cold*, prepared using liquid petroleum road bitumen and laid at an air temperature of at least +10°C in autumn and +5°C in spring [1].

Compliance with the technology of laying and compacting asphalt concrete mixtures is the basis for the quality of asphalt concrete in the bases and coatings of highways and bridges. The role of compaction is undeniable. This compaction process is the final stage of coating formation. As a result, an asphalt concrete structure is formed that can withstand traffic loads and withstand atmospheric factors during the service life of the pavement.

The essence of the compaction process is that, under the influence of mechanical forces, mineral grains are rearranged relative to each other, as a result of which small particles fill the voids between larger ones. At the same time, redistribution (squeezing out) of the asphalt binder and free bitumen occurs, which leads to the displacement of trapped air and a decrease in the porosity of the asphalt concrete mixture. After compacting the asphalt concrete mixture, the coating acquires the necessary density, strength, water resistance and water resistance.

Quality control of the compaction of asphalt concrete layers can be carried out both by non-destructive methods (using radioisotope and ultrasonic devices) and destructive methods (cutting method), which are discussed in this work.

Instruments and equipment used: core sampler, heating cabinet, spoon or spatula, hydraulic press, mold and two liners, squeezing device, caliper, vibrating platform, vessel with water, laboratory scales of the 4th accuracy class with a device for hydrostatic weighing (for cuttings).

The quality of compaction of the asphalt concrete layer is determined by the indicators of cores (cuttings) in three places per 7000 m^2 of pavement. Cuttings, or cores, should be taken in layers from hot asphalt concrete 1-3 days after compaction, and from cold ones – after 15-30 days, at a distance of at least 1 m from the edge of the pavement.The characteristics of the samples depend on the composition. In sandy asphalt concrete, the sample must have a size of at least 50 mm in diameter and a total mass of 1 kg. If it is a fine-grained material, then you need to use 70 mm and 2 kg. Coarse grain requires 100 mm and 6 kg. From the samples for experiments, 3 parallelepiped-shaped samples are selected. Side length is 50-100 mm.

To determine what coefficient of compaction of asphalt concrete will be in this case, use the following algorithm: First, dry the samples to constant masses, then cool and hang in the air. Then the actual density is calculated. Next, calculate the average value for 3 samples. Samples with cores are heated in thermal cabinets. The temperature for this procedure is determined separately for each type of mixture. Then the samples are crushed, distributed into molds, compacted under a press with a pressure of 40 MPa, and then the height is measured. Samples of hot mixtures are compacted by vibration, and then additionally compacted under a press. Based on the data obtained, the density of the deformed samples is determined. Average standard indicators are calculated. Compaction coefficients are calculated from the actual density to the standard one.

If it turns out that the value is insufficient, then it is considered that the calculation of asphalt concrete compaction is incorrect: the surface is poorly compacted.

The compaction coefficient of the structural layers of the road pavement on the site under construction (actual) must not be lower than the values of the required compaction coefficient: – 0.99 – for dense hot-mix asphalt concrete of types A and B; – 0.98 – for dense asphalt concrete from hot mixtures of types B, G and D, porous and highly porous asphalt concrete; – 0.96 – for asphalt concrete from cold mixtures [2].

The compaction coefficient $K_{упл}$ is calculated accurate to the second decimal place using the rounding method using the formula:

$$K_{УПЛ} = \frac{\rho_m}{\rho'_m}, \tag{1}$$

where is ρ_m - the average density of the sample from the structural layer (actual density), g/cm^3; ρ'_m - average density of the remolded sample (standard density), g/cm^3.

To take samples from the structural layers of the road pavement, select a section of the pavement at a distance of at least 1.0 m from the edge of the pavement or the axis of the road and with a size of no more than 0.5×0.5 m. Sampling is carried out in the form of rectangular cuttings or drilled cylindrical cores (Figure 1).

Figure 1. Appearance of the core sampler

Core sampling is carried out at a distance of at least 1 meter from the edge of the coating or the axis of the road and at least 0.2 m from the seam. Core sampling is carried out over the entire thickness of the coating with further separation of layers in the laboratory. Sampling is carried out at the rate of: 1 sample from every 3000 m^2 or 3 samples from every 7000 m2 of coverage. Asphalt samples are taken using a special apparatus - a core sampler. It cuts small cylinders (cores) from the road surface. To check the thickness of the asphalt, no special instruments are required - the cylinder is measured with a simple ruler. And to check the quality, the cores are taken to the laboratory. The asphalt layer on busy highways should be at least 80 mm, and on large highways up to 100 mm. In this case, asphalting of large highways is carried out layer by layer with a thickness of the first coating of 40-80 mm, the second - 40-60 mm.

Quality control of road base layers. When installing additional base layers, it is necessary to monitor the compliance of the quality of the materials used with current regulatory and technical standards and project requirements:

Cylindrical cores are drilled through the full thickness of the coating (top and bottom layers together) using a drilling rig and the layers are separated in the laboratory.

3. Results and discussion

The dimensions of the cutting and the number of drilled cores from one place are set according to the maximum grain size and based on the number of samples required for testing. In this case, the mass of cuttings or cores taken from one place must be at least kg: 1.0 – for sand mixtures; 2.0 – for fine-grained mixtures; 6.0 – for coarse-grained mixtures. The diameter of the cores must be at least, mm: 50 – for samples of sandy asphalt concrete; 70 – for samples of fine-grained asphalt concrete; 100 – for samples of coarse asphalt concrete [3].

Cutting samples (cores) and remolded samples (Figure 2) are tested to determine the actual compaction coefficient of mixtures in the structural layers of road pavements.

Figure 2. Appearance of remolded samples

Three samples with an undisturbed structure are cut or cut from the cutting to determine the actual coverage density of the structural layers of the road pavement. The samples must have a shape approaching a cube or rectangular parallelepiped with sides from 5 to 10 cm. The presence of cracks in the samples is not allowed. Core samples are tested entirely. If necessary, cores can be sawed or cut into pieces.

Before testing, samples are dried to constant weight at a temperature of no more than 50°C. Each subsequent weighing is carried out after drying for at least 1 hour and cooling at room temperature for at least 30 minutes.

The actual density of the asphalt concrete pavement is determined by the formula:

$$\rho_m = \frac{m}{V}, \tag{2}$$

where m - is the mass of the sample, *g; V* – sample volume, cm^3.

The mass of the sample is determined by weighing it on a balance. The volume of the core sample is calculated using geometric formulas for determining the volume of a cylinder. The volume of samples obtained from cuttings and having an irregular shape is determined by hydrostatic weighing. The essence of the method is to determine the volume of displaced water when a sample is immersed in it.

The result of determining the average value of the actual density is taken as the arithmetic mean value of the results of determining the average density of three samples, rounded to the second decimal place. If the discrepancy between the largest and smallest results of parallel determinations exceeds 0.03 g/cm^3, then repeat tests are carried out and the arithmetic mean of six values is calculated [4].

The tested cores and samples from the cuttings, as well as the remaining parts of the cuttings and the remaining cores are used to make remolded samples.

To determine the standard density of the material, cylindrical samples are made by reshaping cores or parts of cuttings brought from the work site. The cuttings, or cores, are heated in a sand bath or in a heating cabinet to a temperature of 200°C, and then crushed with a spoon or spatula.

Compaction of samples from mixtures containing up to 50% crushed stone by weight is carried out by pressing under pressure (40.0±0.5) MPa on hydraulic presses in molds. When compacting, two-way application of the load must be ensured, which is achieved by transferring pressure to the compacted mixture through two liners that move freely in the mold towards each other.

When making samples and hot mixtures, molds and liners are heated to a temperature of 90-100°C. When making samples from cold mixtures, the molds are not heated. A test sample is made. The mold with the bottom liner inserted is filled with an approximate amount of mixture in accordance with the Table 1.

Table 1. Approximate amount of mixture per sample

Sample dimensions, mm		Approximate amount of mixture per sample, g
diameter	height	
50.5	50.5±1.0	220–240
71.4	71.4±1.5	640–670
101.0	101.0±2.0	1900–2000

The mixture is evenly distributed in the mold by bayoneting with a knife or spatula, the upper liner is inserted and, pressing the mixture with it, the mold with the mixture is placed on the lower plate of the press for compaction (Figure 3), while the lower liner should protrude from the mold by 1.5-2.0 cm.

Figure 3. Compaction of the mixture on the press

The upper plate of the press is brought into contact with the upper liner and the electric motor of the press is turned on. The pressure on the compacted mixture is brought to 40 MPa for 5-10 s, after (3.0 ± 0.1) minutes the load is removed, and the sample is removed from the mold with a squeezing device and its height is measured with a caliper with an error of 0.1 mm (Figure 4).

Figure 4. Measuring the height of the remolded sample with a caliper

If the height of the sample does not correspond to that given in the Table 1, then the required mass of the mixture m' for forming the sample is calculated using the formula:

$$m' = m_0 \frac{h}{h_0}, \quad (3)$$

where m_0 - is the mass of the test sample, g; h – required sample height, mm; h_0 – height of the test sample, mm.

Samples with edge defects and non-parallelism of the upper and lower bases are rejected. Compaction of samples from hot mixtures containing more than 50% crushed stone by weight should be done by vibration, followed by additional compaction by pressing.

In this case, when making samples, the molds, heated to 90-100°C, are filled with the mixture, placed on a vibrating platform, and firmly strengthened on it with a special device (the design of the device for strengthening depends on the type of vibration platform). The inserts should protrude from the mold by 2-2.5 cm. The mixture in the mold vibrates for (3.0±0.1) minutes at a frequency of (2900±100) min-1, amplitude (0.40±0.05) mm and vertical load on the mixture (30±5) kPa, which is transmitted to the mixture by a load freely hung on the upper mold liner.

At the end of vibration, the mold with the sample is removed from the vibration platform, placed on the press plate for additional compaction under pressure (20.0±0.5) MPa and maintained at this pressure for 3 minutes. Then the load is removed and the sample is removed from the mold using a squeezing device.

Molded samples - cylinders are weighed and their volume is found to determine the standard density:

$$\rho'_m = \frac{m'}{V'} \quad (4)$$

The compaction coefficient $K_{упл}$ is calculated accurate to the second decimal place using the rounding method according to formula (1).

The value of the actual compaction coefficient is compared with the required value and a conclusion is given about the degree of compaction of the asphalt concrete pavement.

Determination of compaction coefficient of asphalt concrete mixture. Determining the compaction coefficient of asphalt concrete most directly affects the subsequent characteristics of the surface. It is used both in the repair of coatings and in their construction. At the moment, advanced technologies and formulas for calculating the compaction coefficient of asphalt concrete make it possible to most often complete the task of constructing a road successfully. The coating is smooth and quite dense. The average compaction coefficients of asphalt concrete, for example, for the city of Almaty over the past 5 years were 0.98-0.99. Seal defects rarely exceeded 3-5%.

List of requirements:

The compaction coefficient of asphalt concrete according to GOST 9128-09 must meet a number of requirements. Among them are the following indicators:

More than 0.96 – for cold mixtures.

More than 0.98 – for hot mixtures of type B.

More than 0.99 – for hot mixtures of types A and B.

It is important and correct to use the technological scheme for compacting the road surface [5-6].

4. Conclusions

If the actual compaction coefficient is lower than the required one, the reasons that caused the under compaction of the layer are analyzed: the compaction temperature is below the critical value (give the critical temperature value for this composition); insufficient number of rollers passes (give the recommended number of passes); insufficient weight of the roller, etc.

So, quality control of work at all stages of construction requires special attention and strict compliance with the requirements of regulatory documents and the project. A lot depends on the quality of work, for example, traffic safety and comfort, the service life of the road, construction and repair costs, etc.

It is necessary to follow the path of mandatory improvement of the soil properties of the subgrade and underlying foundation, maintaining their stable properties throughout the entire period of operation of the road. From an economic point of view, costs for improving soil properties can have an effect in reducing the thickness of road pavements. Moreover, the additional costs will be offset by a reduction in operating costs for major repairs of road pavement, as well as replacement of subgrade soils during operation on problem sections of roads.

Acknowledgements

The authors express their gratitude to the management of the Almaty regional branch of the joint stock company «National Company «KazAvtoZhol» for organizational and technical assistance in conducting research in this area.

References

[1] GOST 9128-09. (1997). Smesi asfal'tobetonnye dorozhnye, ajero-dromnye i asfal'tobeton. Tehnicheskie uslovija. *Moscow*

[2] SNiP RK 3.03-09-2006. Avtomobil'nye dorogi. *Astana*

[3] GOST 12801-98. (1999). Materialy na osnove organicheskih vjazhu-shhih dlja dorozhnogo i ajerodromnogo stroitel'stva. Metody ispytanija. *Moscow*

[4] Bondar', I.S., Kvashnin, M.Ja. & Ajymbetov, A.Sh. (2020). Ocenka prochnosti grunta v osnovanii zemljanogo polotna avto-mo-bil'nyh dorog. *Vestnik KazATK, 4(115), 26-31*

[5] Bondar', I.S. & Madiev, Zh.D. (2019). Ocenka sostojanija dorozhnyh odezhd pri dinamicheskom vozdejstvii. *Sbornik materia-lov XIX ezhegodnoj Respublikanskoj nauchnoj studencheskoj konferencii, KazGASA*

[6] Bondar', I.S., Kvashnin, M.Ja. & Kan, E.G. (2021). Metodika uprochne-nija nezhestkih dorozhnyh odezhd. *Materialy I Mezhduna-rodnoj nauchno-prakticheskoj konferencii «Innovacionnye tehnologii na transporte: obrazovanie, nauka, praktika», Almaty: ALiT*

Жол жабындарының асфальтбетон қабаттарын нығыздау сапасын бақылау

А.М. Жанғабылова[1*], И.С. Бондар[2], Г.О. Сарсенбаева[1], С.А. Әбдіқодиров[3], А.Л. Комилов[3], Ф. Әділжанов[1]

[1]*Satbayev University, Алматы, Қазақстан*
[2]*Логистика және көлік академиясы, Алматы, Қазақстан*
[3]*Термез инженерлік-технологиялық институты, Термез, Өзбекістан*

**Корреспонденция үшін автор: zhangabylova82@mail.ru*

Аңдатпа. Мақалада жол жабынының асфальтбетонды қабаттарының нақты тығыздалу коэффициентін анықтаудың деструктивті әдісі қарастырылады. Жалпы түсініктер мен ережелер, жұмысты орындау тәртібі келтірілген. Ыстық аралас асфальтбетонның нығыздалу сапасы материалдың орташа тығыздалу коэффициентімен (тығыздығы) және оның біртектілігімен (нығыздаудың вариация коэффициенті) бағаланады. Бұл сипаттамалардың мәндері қоспаның түріне, пайдаланылатын жолды тығыздау жабдығының түріне, оның жұмыс режимдеріне және т.б. байланысты екенін анықтайды. Қолданылатын құрылғылар мен жабдықтардың сипаттамалары, сондай-ақ қажетті тығыздау коэффициентінің мәндері, беріледі.

Негізгі сөздер: *тас жол, асфальтбетон қоспасы, асфальтбетон, тығыздау коэффициенті.*

Контроль качества уплотнения асфальтобетонных слоёв дорожной одежды

А.М. Жангабылова[1*], И.С. Бондар[2], Г.О. Сарсенбаева[1], С.А. Абдикодиров[3], А.Л. Комилов[3], Ф. Адилжанов[1]

[1]*Satbayev University, Алматы, Казахстан*
[2]*Академия логистики и транспорта, Алматы, Казахстан*
[3]*Термезский инженерно-технологический институт, Термез, Узбекистан*

**Автор для корреспонденции: zhangabylova82@mail.ru*

Аннотация. В статье рассмотрен разрушающий способ определения фактического коэффициента уплотнения асфальтобетонных слоев дорожной одежды. Приведены общие понятия и положения, порядок выполнения работы. Качество уплотнения горячих асфальтобетонных смесей оценивается по среднему коэффициенту уплотнения материала (плотность) и его однородности (коэффициент вариации уплотнения). Значения данных характеристик зависят от типа смеси, вида применяемой уплотняющей дорожной техники, режимов ее работы и др. Даны характеристики используемых приборов и оборудования, а также значения требуемого коэффициента уплотнения.

Ключевые слова: *автомобильная дорога, асфальтобетонная смесь, асфальтобетон, коэффициента уплотнения.*

Received: 14 April 2024
Accepted: 15 September 2024
Available online: 30 September 2024