Vital Annex: International Journal of Novel Research in Advanced Sciences (IJNRAS)
Volume: 01 Issue: 03 | 2022 ISSN: 2751-756X
http://innosci.org

The Variety of Factors That Have the Greatest Impact on the Condition of Highways during the Life Cycle

Djumaev Abdusalom Gapparovich
Senior teacher at Tashkent state transport university (TSTU), Uzbekistan, Tashkent

Qurbonov Bobomurod Eshmurodovich
Assistant at Tashkent state transport university (TSTU), Uzbekistan, Tashkent

Annotation: Asphalt concrete as the main material for the construction of road coverings is most susceptible to various operational impacts. At the same time, the asphalt concrete coating comes into operation already with a set of defects acquired at previous stages of the life cycle. Accumulating internal stresses and irreversible deformations associated to a large extent with changes in the structure of the coating material contribute to the appearance of various defects and damages. Multi-factor analysis and the construction of a computer model that takes into account defects that occur at various stages of the asphalt concrete life cycle will solve the problem of high-quality asphalt concrete coatings with improved physical and mechanical properties and increased service life between repairs.

Keywords: asphalt concrete pavement, asphalt concrete life cycle, operational impacts, asphalt concrete defects.

Introduction

The main financial instrument for the development of the country's transport infrastructure is the completion of the program "Modernization of the transport system of Uzbekistan", whose activities provide for more efficient use of the country's transit potential. The need to move from modernization to sustainable development of the transport industry predetermined the development of a new edition of this program – "Development of the transport system of Uzbekistan" [1]. The program is based on the main provisions of the President's Messages, decisions of the State Council, the draft Concept of long-term socio-economic development of Uzbekistan, as well as the Transport Strategy of Uzbekistan for the period up to 2026, approved by the decree of the Government of Uzbekistan dated 29.01.2022.No. UP-60 [2].

The effectiveness of the use of budgetary funds allocated for the development of transport infrastructure is largely determined by the quality of road works, which is emphasized by the program document of the State Road Agency – "The Concept of quality assurance in the road sector", focused on the development of quality-based management in the road sector. In solving this problem, an integrated approach to improving the condition of existing highways and the construction of new ones is extremely important, including: the use of effective innovative technologies and materials, analysis of asphalt concrete defects that occur during the life cycle, theoretical and experimental studies of the properties of materials, the development of recommendations for the stages of the life cycle.

The main part

Asphalt concrete as the main material for the construction of road coverings is most susceptible to various operational impacts (the raw materials used, the conditions for the production of asphalt concrete mixtures at the ACF, the loads of motor vehicles, traffic intensity, natural and climatic operating conditions, the abrasion effect of wheels, hydrological conditions). At the same time, accumulating internal stresses and irreversible deformations, associated to a large extent with changes in the structure of the coating material, contribute to the appearance of various defects and damages (shear deformations, cracking, discoloration and increased wear). The durability of asphalt concrete coatings is determined by the stability of the physical and mechanical properties of asphalt concrete over time. In this regard, taking into account and analyzing possible causes of defects, depending on the degree of influence of one or another operational factor, will allow extending the service life of asphalt concrete road coverings with justification of the duration of the warranty period based on the results of experimental studies at various stages of the life cycle, as well as maintaining the existing road network in a standard condition and timely repair and restoration work.

The variety of factors that have the greatest impact on the condition of highways and on the conditions of movement of vehicles can be divided into ground-geological and hydrological conditions, terrain and landscape, as well as weather and climatic conditions or factors.

From the soil-geological and hydrological factors, the type and characteristics of the soils of the roadbed and the underlying layers, the depth of freezing, the depth and nature of groundwater occurrence, the conditions of surface water runoff are distinguished.

Weather and climatic factors include: atmospheric pressure, solar radiation, temperature and humidity, precipitation (rain, snowfall, wind, blizzard, ice, fog), as well as a combination of these factors. The main sources of humidification of the road structure are precipitation seeping through cracks in the pavement, roadsides (especially at the interface with the roadway); water stagnating on the surface of the canvas, in side reserves and ditches due to obstructed surface runoff and moistening the soil of the roadbed during molecular and capillary movement; underground water rising through the capillaries, especially when the structure is frozen and the occurrence of groundwater close to the road surface; vaporous water moving from warm layers to colder ones. The impact of weather and climatic factors forms the water-thermal regime of the roadbed, which is understood as regular seasonal changes in humidity and temperature in the roadbed and layers of road clothes. Complex processes occur in the road structure: heating, cooling, freezing, thawing, evaporation, condensation, sublimation, oblimation. As a result, diffusive processes of heat and moisture movement, called heat and mass transfer or heat and moisture exchange, can be systematically observed, causing fluctuations in humidity and temperature.

The change in the characteristics of the water-thermal regime significantly affects the strength, durability of the canvas and roads, leads to a decrease in the transport and operational characteristics of highways. At the same time, the degree of environmental impact on the roadbed is ultimately determined by the type and power of the sources of humidification of the road structure and the intensity of temperature influences leading to various deformations.

Deformations and destruction of highways are subdivided [3] into defects and damage to the pavement and pavement as a whole. The defects of the pavement include subsidence and rutting, its destruction – breaks, depths, destruction of edges and cracks. The defects of the coating include shifts, waves and dents, to its destruction – wear, peeling, staining, potholes, cracks and a grid of cracks.

Deformation and destruction of asphalt concrete coatings occur under the influence of vertical and tangential tensile forces (compression, stretching and shear of the layer), natural factors (ambient temperature and humidity, precipitation, solar radiation).

According to L.A. Gorelyshev [3], the appearance of defects that reduce the performance characteristics of the pavement is associated with 3-4 periods of time characterizing the condition of the pavement. The first (initial) period corresponds to the formation of road clothes after construction. At this time, the layers of the pavement are compacted as a result of the opening of the movement of vehicles, physicomechanical and physico-chemical processes are intensively carried out under the influence of climatic conditions, mineral particles of the asphalt concrete skeleton are redistributed. As a result, the thickness of the binder film on the grains of mineral particles and the thickness of the coating as a whole decreases. The condition of the pavement during this period is usually good, but by the end of the period, defects associated with deficiencies in the design or construction of the road may appear.

The second period is the main period of road operation, when there is a more or less uniform formation of deformations over time. The intensity of this process, and, consequently, the duration of the period of operation depend both on external factors, mainly on the characteristics of the movement of vehicles (intensity and composition of traffic), and on the frequency and quality of maintenance and repair work. By the end of this period, the operating conditions begin to affect the condition of the coating: the evenness decreases and the roughness decreases, noticeable wear and individual defects appear in the form of cracks, potholes, coloring, etc.

In the third period, accumulated residual deformations begin to manifest themselves intensively in the form of defects and damage to the coating associated with the aging of the binder, and the strength characteristics of road clothes significantly decrease. During this period, there may be a sharp decrease in the evenness and strength of the pavement, expressed in the appearance of a grid of cracks, potholes and local destruction of the coating (the fourth period).

Factors affecting the durability of asphalt concrete coatings [4] are broadly divided into two groups: technogenic and natural-climatic. Technogenic factors include: dynamic load (vertical and horizontal) from the working bodies of sealing equipment during construction and wheels of transport during the operation of the coating, as well as anti-icing reagents. When exposed to vertical and horizontal loads, the integrity of the films of the structured binder on the grains of mineral particles and the initial granulometric composition of the mineral part due to the crushing of large particles forming the "skeleton" of asphalt concrete pavement and their local destruction in the areas of contact with each other. At the same time, the smallest crushing effect is created by a pneumatic roller, then static and vibrating smooth-rolling rollers go "incrementally". Salt and other anti-icing reagents cause chemical destruction of structural bonds (organic part) between mineral particles and violation of the integrity of bitumen films. Natural and climatic factors include: water, ambient air temperature and its differences, solar radiation and atmospheric oxygen, as well as the action of microorganisms.

During the life cycle of the product "asphalt concrete mix – asphalt concrete", its granulometric composition and the content of bitumen in it change under the influence of various factors. It influences the granulometric composition and the method of sampling asphalt concrete for subsequent analysis. Cutting out a cylindrical sample with an annular cutter (core collector), due to the small volume of the material taken and the large surface area of the cut, most severely violates the granulometric composition and creates a worn side surface with closed pores, which makes it difficult to determine the coefficient of compaction and water saturation. It is more preferable to cut out a piece of the coating with a circular saw, followed by the removal of layers close to the cutting surfaces. Other sampling methods are also known, but without violating the initial granulometric composition, for example, using wire spirals laid on the base in advance (author – engineer B.Z. Shayakhmetov), or metal plates equipped with wire rods extending to the surface of the layer.

According to the authors [4], asphalt concrete pavement of highways comes into operation already with a set of defects acquired at previous stages of the life cycle:

1. Crushing of rocks in the production of crushed stone (bream and microcracks on the surface of crushed stone).
2. Bitumen production (loss of light binder fractions).
3. Preparation of asphalt concrete mixture at the ABZ (bitumen aging and segregation).
4. Laying of asphalt concrete mix by a stacker (segregation, possible slight violation of the initial granulometric composition).
5. Rolling of asphalt concrete mixture (violation of the initial granulometric composition).

Asphalt concrete mix is a complex multicomponent material that changes properties when the composition changes. All technological operations (preliminary dosing of mineral materials, their heating and drying, sorting (screening) and short-term storage of heated stone materials, precise dosing of mineral materials, bitumen or other special binder, mineral powder and additives, mixing of components in a mixer and unloading of the finished asphalt concrete mixture from it, method of delivery of the mixture to the place of laying, the time of its transportation, laying by pavers, compaction modes and the equipment used) have a significant impact on the properties of the asphalt concrete mixture, contributing to the appearance of microdefects and, ultimately, determining the durability of asphalt concrete pavement [5, 6].

During operation, these defects continue to accumulate. Under the wheels of a moving car, asphalt concrete experiences fast-flowing compressive stresses from its weight and at the same time horizontal stresses in the longitudinal direction from traction and braking forces, in the transverse direction from centrifugal forces arising when the car turns. When driving a car with a set of driven and driving wheels, horizontal longitudinal stresses are also alternating. All this leads to a violation of the connection between the particles on bitumen films, their peeling from the particles, crushing of particles with the largest number of initial defects, and local destruction (staining) with violation of the integrity of bitumen films of more durable particles at their points of contact with each other[7,8].

Solar radiation and atmospheric oxygen cause bitumen aging. The negative impact of anti-icing materials further weakens the bonds between mineral particles, and under the action of the wheels of vehicles, the coating surface is painted. Water accumulates in the resulting depressions, which, penetrating into the coating, breaks it during "freeze-thaw" cycles, increasing cracks. The analysis of the operational loads acting on the asphalt concrete coating shows the possibility of a significant extension of its service life due to the management of the structure at the stage of laying and compaction of the asphalt concrete mixture.

Asphalt concrete coatings with prolonged moisture, due to the weakening of structural bonds, can be destroyed due to the staining of mineral grains, which leads to increased wear and the formation of potholes. Water, as a polar liquid, wets all mineral materials well, penetrating under the bitumen film with prolonged contact. At the same time, mineral materials with a positive surface charge potential (calcite, dolomite, limestone) prevent the displacement of the bitumen film by water to a greater extent than materials with a negative surface potential (quartz, granite, andesite).

Water, penetrating into the microdefects of the asphalt concrete structure, leads to a decrease in the strength of the material by reducing the surface energy of the crack walls and weakening the structural bonds at the crack tip as it develops. Moving in the pores, water causes an uneven distribution of stresses, which also leads to destruction. The most destructive effect is caused by alternating freezing and thawing of asphalt concrete in autumn and spring. The frost resistance of asphalt concrete on granite material is significantly lower than on limestone. This is explained by the fact that the nature of the "bitumen-granite" bond forces is physical, while the "bitumen-limestone" bond is physico-chemical. The stresses that arise when water freezes easily destroy physical bonds, but are unable to destroy chemical ones.

Conclusion

Thus, carrying out a multifactorial analysis that takes into account the full range of defects that occur at various stages of the asphalt concrete life cycle, with the construction of a physical model, as well as the development of unified technical and technological solutions and recommendations based on it (with the systematization of domestic and foreign experience in detecting defects at all stages of both the preparation of the initial components of asphalt concrete mixtures, its preparation modes, and the technology of its laying and compaction) will solve the problem of high-quality asphalt concrete coatings with improved physical and mechanical properties and increased service life between repairs.

References:

1. O merax po korennomu sovershenstvovaniyu sistemi gosudarstvennogo upravleniya v sfere transporta Respublike Uzbekistan v 2017-2021 godax.
2. «O strategii razvitiya Uzbekistana 2022-2026 godi» Ukaz Prezidenta Respubliki Uzbekistan, ot 28.01.2022 g. №UP-60.
3. Gorelыsheva L.A. Noviye effektivniye metodы remonta, soderjaniya i sovershenstvovaniya asfaltobetonnых pokrытiy: Obzor. inform. – M.: Informavtodor, 2006. – 104 s.
4. Zaxarenko A.V., Degtyarev A.S., Zaxarenko A.A. Sravnitelniye issledovaniya rezultatov ispытaniya obrazsov asfaltobetonnых smesey i asfaltobetonnix pokritiy s primeneniyem metodov ispitatelnogo oborudovaniya: asfalto analizatorov tipa «Infratest», vijiganiya i ekstragirovaniya po GOST 12801-98. – OAO «Xantimansiyskdorstroy», 2008. – 19 s.
5. Maгыshev B.S., Solovev B.N. Asfaltobetonnыye zavodы i texnologicheskoye oborudovaniye dlya ix osnashyeniya «Dorojnayatexnika», 2004. – 96 s.
6. Ivanchenko S.N., Yarmolinskaya N.I., Parfenov A.A. Obespecheniye kachestva asfaltobetona s uchetom svoystv sostavlyayushix i texnologii uplotneniya: Ucheb. posob. – Xabarovsk: Izd-vo TOGU, 2006. – 237 s.
7. Жумановов Ilyos Begzod o'g'li; Tursoat Jummayevich; Qurbonov Bobomurod Eshmurodovich;, "Асфальт бетон ко пл am ал и йул тушамаларининг муддатидан олдин бузилиш сабаблари." Проблемы архитектуры и строительства (научно-технический журнал), pp. 8–10, 2020.
8. Omonova Sadoqat Rustam qizi; Amirov Tursoat Jummayevich; Qurbonov Bobomurod Eshmurodovich;, "Georeshetka bilan asfaltbeton qoplamalarini armaturalash," Orient. Renaiss. Innov. Educ. Nat. Soc. Sci. Sci. J. Impact Factor Vol. 951–952., vol. 1, no. 5, pp. 5–24, 1967.