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# METHODS FOR INCREASING THE SERVICE LIFE OF MODERN ASPHALT CONCRETE PAVEMENTS ON HIGHWAYS

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**Abstract**
This article analyzes methods for increasing the service life of modern asphalt concrete pavements used on highways. The study examines the causes of pavement deterioration, physical and mechanical properties of asphalt concrete, the effectiveness of polymer-modified bitumen, geosynthetic materials, and modern drainage systems. In addition, the advantages of innovative monitoring technologies and environmentally sustainable road construction methods are scientifically substantiated. The research results are important for improving road durability, reducing maintenance costs, and ensuring traffic safety.

**Keywords** Asphalt concrete pavement, highways, service life, polymer-modified bitumen, geosynthetic materials, deformation, drainage system, road construction, monitoring technologies, durability.

## Introduction

At present, road transport is considered one of the main components of the global economy. The efficiency of the transport system is closely related to the level of a country's economic development, logistics capabilities, industrial production, and the quality of life of the population. Therefore, the construction of modern highways, their high-quality operation, and the extension of their service life are among the most urgent issues of today[1].

Highways are the main element of transport infrastructure and play an important strategic role in the economic development of countries. In particular, the development of international transit corridors, major highways, and intercity transport networks is causing a sharp increase in the load applied to road pavements. As a result, there is a growing need to maintain the technical condition of highways at a high level, improve pavement durability, and ensure long-term service performance.

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Today, many countries, including Uzbekistan, are carrying out large-scale projects aimed at reconstructing highways, building new motor roads, and developing transport and logistics systems. In our republic, the construction of highways that meet international standards and the modernization of existing roads are considered priority directions of state policy. In recent years, special attention has been paid to the introduction of innovative technologies into road construction, the use of high-quality construction materials, and the application of modern machinery[2].

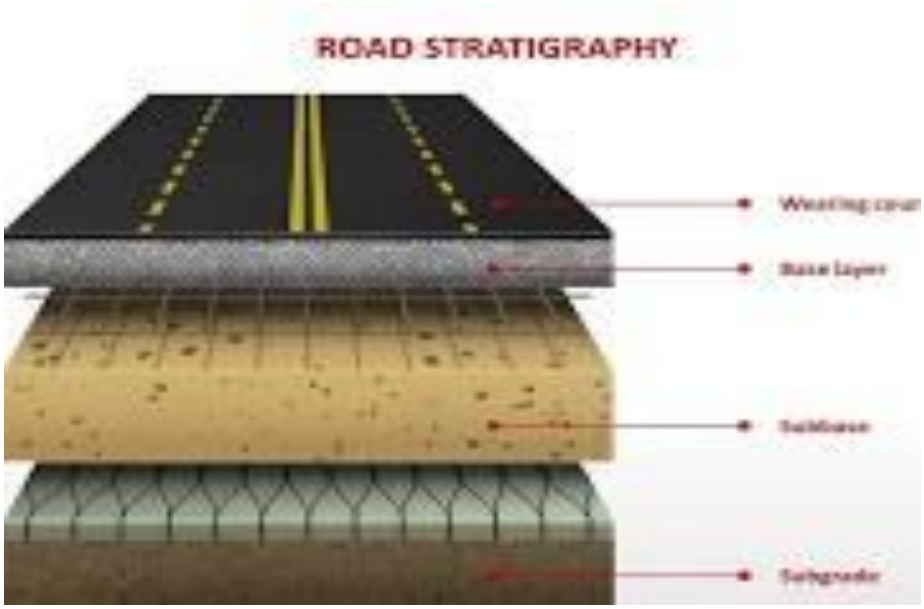


**Fig1.** Road stratigraphy

Asphalt concrete pavements are the most widely used type of pavement in highways. This is due to their elasticity, convenience for vehicle movement, noise reduction properties, and relatively high economic efficiency of construction technology. Asphalt concrete pavements are capable of partially absorbing dynamic loads generated by vehicle traffic, thereby creating comfortable and safe conditions for transportation. Nevertheless, asphalt concrete pavements are subjected to various types of deformation during long-term operation. In particular, cracks, rutting, settlements, delamination, and slippage may occur on pavements. The appearance of such defects is caused by increased traffic flow, the growth in the number of heavy vehicles, sudden climate changes, moisture effects, and shortcomings in construction

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technology. Especially during the summer season, high temperatures soften asphalt, while in winter, freeze-thaw cycles negatively affect pavement quality[3].

Rapid deterioration of road pavements causes significant economic losses. This is because road repair and reconstruction works require substantial financial resources. In addition, poor-quality roads negatively affect the technical condition of vehicles, increase fuel consumption, reduce driving speed, and raise the risk of traffic accidents. Therefore, extending the service life of asphalt concrete pavements is not only a technical issue but also an important economic and environmental task. In recent years, developed countries have widely introduced modern innovative technologies to improve the эксплуатацион characteristics of asphalt concrete pavements. In particular, the use of polymer-modified bitumen, geosynthetic materials, fiber additives, nano-modifiers, and intelligent monitoring systems significantly increases pavement strength and durability. Furthermore, the application of digital diagnostic systems, drone technologies, and artificial intelligence-based pavement monitoring systems is continuously expanding[4].

The quality of the road base, the efficiency of drainage systems, and the physical and mechanical properties of construction materials also play an important role in increasing the service life of asphalt concrete pavements. The penetration of water into pavement layers reduces pavement strength and accelerates the deterioration process. Therefore, the design and implementation of effective drainage systems are of great importance in road construction. This scientific article analyzes the operational condition of modern asphalt concrete pavements used on highways, the factors affecting their service life, the causes of pavement deterioration, and innovative methods for extending pavement durability. In addition, the effectiveness of polymer additives, geosynthetic materials, drainage systems, and modern monitoring technologies is scientifically substantiated.

The main purpose of the research is to study modern technologies and engineering solutions for extending the service life of asphalt concrete pavements on highways and to develop practical recommendations. The results of this study contribute to improving efficiency in road construction and operation, reducing maintenance costs, and enhancing traffic safety[5].

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## RESEARCH METHODOLOGY

Structural Design and Working Principle of Asphalt Concrete Pavements. Asphalt concrete pavements used on highways are considered complex multilayer structures. These pavements receive static and dynamic loads generated by vehicles and distribute them evenly to the road base. The durability and long-term service life of asphalt concrete pavements largely depend on the proper design of their layers and the use of high-quality materials. An asphalt concrete pavement consists of the following main layers: surface layer; binder layer; base layer; sub-base layer; soil foundation. The main function of the surface layer is to withstand wheel loads from vehicles and ensure traffic safety. This layer must possess high strength, smoothness, and wear resistance.

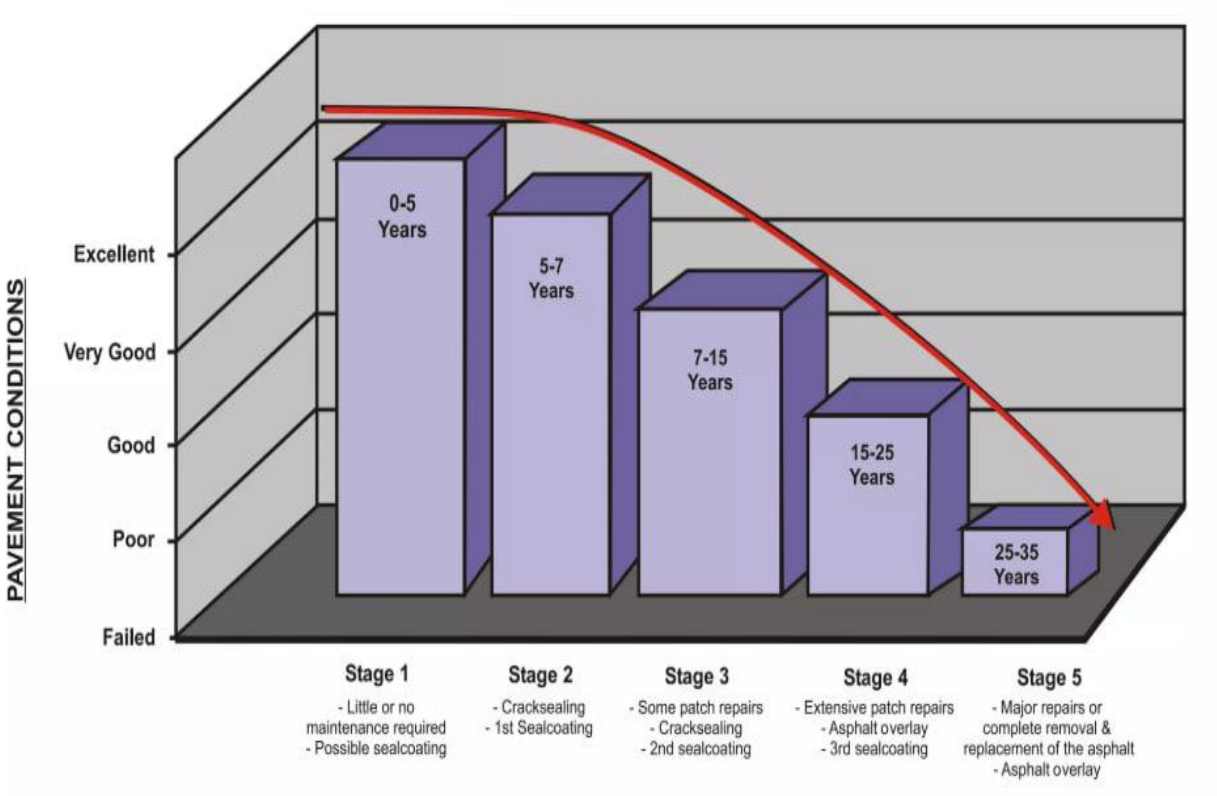


**Fig2.** Pavment conditions

The binder layer connects the upper layer with the base layer and ensures uniform load distribution. The base layer provides pavement stability and prevents deformation.

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The long-term performance of road pavement directly depends on the quality of each structural layer. If the base layer does not have sufficient strength, cracks and settlements may occur even when high-quality asphalt is laid[6].

Asphalt concrete is an artificial construction material composed of mineral aggregates and bitumen. Crushed stone, sand, and mineral powder are used as mineral materials, while bitumen acts as a binding agent. The main physical and mechanical properties of asphalt concrete include: strength; elasticity; water resistance; wear resistance; heat resistance; frost resistance.

The strength of the pavement determines its ability to withstand traffic loads. Elasticity ensures that asphalt does not crack under temperature changes. High temperatures soften asphalt, which leads to rut formation under the influence of heavy vehicles. At low temperatures, asphalt hardens, becomes brittle, and develops cracks. Water resistance is one of the most important characteristics of asphalt concrete. When moisture penetrates the pavement, the bond between bitumen and mineral aggregates weakens, resulting in rapid pavement deterioration[7].

During operation, various defects appear in asphalt concrete pavements. These defects shorten pavement service life and negatively affect traffic safety. Cracks are among the most common pavement defects. They are classified into the following types:

longitudinal cracks; transverse cracks; alligator cracks; thermal cracks.

The main causes of crack formation are: temperature changes; increased traffic load; deformation of the base layer; poor-quality materials. Water penetrates through cracks into the pavement structure and accelerates deterioration. Rutting occurs on roads frequently used by heavy vehicles. This phenomenon is caused by asphalt softening under high temperatures. Rutting leads to: reduction of vehicle speed; accumulation of water; increased accident risk[8].

Settlements and Deformations. Insufficient compaction of the road base or excessive soil moisture causes pavement settlements. In some cases, uneven deformation of asphalt layers leads to surface irregularities. The separation of asphalt layers from one another is called delamination. This mainly occurs when there is insufficient adhesion between layers. The main causes of delamination are: violation of technological requirements; use of low-quality bitumen; excessive moisture.

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Today, polymer-modified bitumen is widely used to increase the service life of asphalt concrete pavements. Polymer additives improve the physical and chemical properties of bitumen. The most commonly used polymers include: SBS; EVA; APP; crumb rubber. Advantages of polymer-modified asphalt include: high elasticity; crack resistance; deformation resistance; waterproofing properties; resistance to high temperatures. According to research, the service life of polymer asphalt pavements can be 1.5–2 times longer than that of conventional asphalt pavements.

Efficiency of Geosynthetic Materials. Geosynthetic materials are widely used in road construction as innovative solutions. These materials are produced from synthetic polymers and serve to reinforce pavement structures. The main types of geosynthetic materials are: geotextiles; geogrids; geomembranes; geocomposites. Geotextile Materials. Geotextiles are used for separation, filtration, and reinforcement of soil layers. They prevent mixing of soil layers and improve the stability of the base layer. Geogrids distribute loads over a larger area and reduce deformation. They are especially effective in areas with weak soils. Geomembranes limit water penetration into pavement layers, thereby reducing the rate of asphalt concrete deterioration.

Water is considered one of the main enemies of asphalt concrete pavements. Therefore, the organization of effective drainage systems plays a crucial role in extending pavement service life. The main functions of drainage systems are: removing rainwater; reducing soil moisture; minimizing freeze-thaw damage. Modern road construction uses the following drainage systems: open drainage systems; closed drainage systems; perforated pipes; geocomposite drainage materials.

## CONCLUSION AND RECOMMENDATIONS

Highways are one of the most important components of transport infrastructure, playing a crucial role in ensuring the uninterrupted functioning of the national economy, logistics systems, and interregional transport connections. In modern conditions, the increasing number of vehicles, the growing movement of heavy trucks, and rapid climate changes are significantly intensifying the loads applied to road pavements. As a result, various types of deformations, cracks, rutting, and surface deterioration occur in asphalt concrete pavements. This leads to a reduction in road service life and an increase in maintenance and operational costs.

During this scientific research, the main factors influencing the service life of asphalt concrete pavements were comprehensively analyzed. The results of the study showed

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that the durability and long-term performance of pavements largely depend on the quality of construction materials, compliance with technological processes, the efficiency of drainage systems, and operating conditions.

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