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Development of plastic deformations and ensuring shear resistance in asphalt concrete road pavements

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Abstract. The operating conditions of roads have deteriorated; the increase in the number of heavy vehicles and the increase in load per axle lead to an increase in plastic deformations on asphalt concrete pavements. This problem reduces the reliability of road layers and increases the costs of their operation and repair, especially during hot periods, when the appearance of rutting and wave-like deformations significantly reduces the strength of the layers. The aim of the study was to identify the causes of plastic deformations in asphalt concrete layers and to determine scientifically based methods aimed at increasing the resistance of road layers to displacement. The use of analytical, comparative and statistical analysis made it possible to achieve the objectives of the study, scientifically assess the resistance of asphalt concrete layers of road pavement to displacement and develop recommendations for practical application. The main results of the study showed that the resistance of asphalt concrete layers to displacement depends on a number of internal and external factors. Internal factors include the structure of the mineral skeleton, the shape and size of aggregates, the viscosity of the bituminous binder, and the degree of mixture density. Sharp and crushed mineral particles contribute to the formation of a mixture

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framework and reduce plastic deformations, while excessive use of bitumen or a grade that does not correspond to climatic conditions, on the contrary, contributes to the formation of rutting. The influence of temperature is also significant: in summer, the layers heat up, the viscosity of bitumen decreases, the relaxation time shortens, resulting in rutting and displacement. Water resistance of layers, adhesion properties and degree of compaction are decisive factors for determining resistance to plastic deformations. The practical significance of the study lies in the fact that its results allow road builders and engineers to optimise asphalt concrete mixtures, improve the quality of layer compaction and ensure long-term and reliable road operation taking into account temperature conditions

■ **Keywords:** rut; resistance to displacement; bituminous binder; mineral aggregates; temperature factors; mixture density; strength of road layers

■ INTRODUCTION

The sustainable functioning of road infrastructure is one of the key factors ensuring the efficiency of the transport system. The operational quality of highways is directly related to the structural strength of the pavement and its resistance to deformation. Asphalt concrete pavements are among the most widely used materials in road construction. However, during operation, such pavements are exposed to various mechanical and climatic factors. In particular, loads from heavy goods vehicles and high temperature conditions lead to the development of plastic deformations in asphalt concrete layers. One of the most common types of such deformation is the formation of wheel ruts on the road surface, i.e. rutting. This phenomenon reduces traffic safety and leads to the deterioration of transport operational performance indicators. In addition, the service life of the pavement is shortened, while maintenance and repair costs increase. A detailed study of the composition, structure, and mechanical properties of asphalt concrete mixtures plays an important role in improving pavement durability. In this regard, identifying the causes of plastic deformations in asphalt concrete layers and investigating methods for their prevention constitutes one of the important scientific problems in the field of road construction.

Plastic deformations and the process of rut formation in asphalt concrete pavements have been examined in the works of numerous researchers. For example, a study conducted by H. Wang *et al.* (2023) analysed the ageing of materials in asphalt pavements and its impact on deformation resistance. The authors noted that long-term operation of road pavements leads to changes in the physical and mechanical properties of the bituminous binder, thereby contributing to an increase in plastic deformations. The study demonstrated that the ageing process of bitumen reduces the structural stability of the mixture and increases the likelihood of rut formation. A number of studies have shown that the granulometric composition and structural framework of mineral aggregates have a significant influence on the durability of asphalt concrete pavements. X. Lu *et al.* (2024) analysed the structural properties of asphalt concrete mixtures using artificial intelligence models. The results indicated that the size of aggregates and their proportions significantly affect the stiffness of asphalt concrete and its resistance to rutting. In particular, mixtures with a higher proportion of coarse aggregates exhibited greater resistance to shear deformation.

Experimental modelling methods are widely used in the study of the deformation behaviour of asphalt concrete pavements. In a study by D.X. Lu *et al.* (2024), the rutting resistance of asphalt concrete was modelled using the discrete element method. The authors proposed a mathematical

model taking into account the visco-plastic properties of the material and analysed the deformation changes in the asphalt concrete structure under the influence of traffic loading (Zhao *et al.*, 2024). The study showed that load intensity and temperature conditions have a significant effect on the development of plastic deformations. The analysis of operational conditions of road layers is also important in studying deformations in asphalt concrete pavements. A study conducted by N.O.A.S. Jourdain *et al.* (2024) demonstrated that rut formation in road pavements is closely related to traffic flow intensity and the type of pavement structure. The statistical model proposed by the authors made it possible to determine the spatial characteristics of deformation along road sections. The study identified traffic load as one of the key factors contributing to rut formation.

In a study by V. Gunka *et al.* (2024), various methods of modifying road bitumen were analysed. The authors noted that bitumen modified with polymer additives contributes to improving the mechanical stability of asphalt concrete mixtures and increases resistance to high-temperature plastic deformations. D.L. Buruiana *et al.* (2023) showed that the use of micro-polypropylene additives improves the resistance of asphalt concrete to high-temperature deformations. Another group of Ukrainian researchers investigated the technological ageing processes of bituminous binders. In a study by M. Donchenko *et al.* (2024), it was shown that the ageing of bitumen alters its structural and rheological properties, thereby affecting the operational durability of asphalt concrete mixtures. The authors noted that antioxidants and special additives can slow down the ageing processes of bitumen. A study conducted by A. Jexembayeva *et al.* (2024) noted that the service life of asphalt concrete pavements is often lower than the design values. The study showed that polymer additives and dispersed reinforcing materials help to improve the mechanical properties of asphalt concrete mixtures. It was also emphasised that the proper formation of the mineral framework and the quality of the bituminous binder play an important role in the long-term performance of the pavement. In another study examining the operational conditions of road structures, P. Dong *et al.* (2024) noted that the loading regimes of asphalt concrete pavements vary depending on road topography and traffic flow characteristics. The authors demonstrated that on uphill and downhill sections of the road, dynamic loads from vehicles are higher, which leads to a more rapid development of deformation processes in asphalt concrete layers.

The studies reviewed above indicate that the deformation resistance of asphalt concrete pavements is determined by the combined influence of multiple factors. The structure of the mineral framework, the properties of the bituminous

binder, temperature conditions, traffic loads, and the characteristics of the pavement structure all have a significant impact on the formation of plastic deformations in asphalt concrete layers. At the same time, optimisation of the structural properties of asphalt concrete mixtures and modification of road materials represent important directions for improving pavement durability. The aim of this study was to analyse the causes of plastic deformation in asphalt concrete road pavements and to scientifically investigate the role of structural and material factors of asphalt concrete mixtures in their prevention.

■ MATERIALS AND METHODS

A set of analytical and statistical methods was employed in the study. The analytical method was used to assess the influence of the physical and mechanical properties of asphalt concrete (mixture density, the shape and size of mineral particles, and the viscosity of the bituminous binder) on the development of plastic deformations. Comparative analysis was carried out on the basis of published data and regulatory documents. Within this approach, scientific publications issued in the period 2022-2024 were examined, including works by M.M. Alamnie *et al.* (2022), A.H. Albayati & G.G. Al Khateeb (2023), Y. Zhao *et al.* (2024), among others. In each publication, the indicators of resistance of asphalt concrete layers to plastic deformation were analysed comparatively.

The statistical method involved the processing of data on the dynamics of pavement deformation for the period 2015-2025 provided by the State-owned enterprise “Kyrgyzavtozhoh-South” (State-owned enterprise “Kyrgyzavtozhoh-South”, n.d.). The data were statistically compiled with regard to potholes, wheel ruts, and the displacement dynamics of pavement layers along road sections. In order to generalise and compare the results, scientific sources

published in 2022-2025 were used. These materials were systematically analysed, and both internal and external factors influencing the occurrence of plastic deformation were identified, including temperature conditions, the structure of the mineral skeleton, the quality of bitumen, and the degree of compaction. The applied set of scientific methods – analytical, comparative, and statistical analysis made it possible to achieve the objectives of the study, to scientifically assess the shear resistance of asphalt concrete road layers, and to develop practical recommendations.

■ RESULTS AND DISCUSSION

The operational conditions of the structural layers of road pavements have undergone significant changes. The number of heavy and multi-axle freight vehicles within traffic flow has been steadily increasing, and the load per axle has exceeded the values specified at the design stage. Statistical data obtained during the study indicate that the number of pavement defects has increased in recent years (2021-2025). According to data provided by the State-owned enterprise “Kyrgyzavtozhoh-South”, the length of road sections affected by various types of deterioration varied over the period 2000-2025 (Fig. 1). In particular, during the period 2021-2025, the share of plastic deformations increased, and a rise in the number of wheel ruts and potholes on the pavement surface was identified. Over the years 2021-2025, this phenomenon showed a gradual upward trend, with especially intensive rut formation observed on sections with a high volume of heavy goods traffic (State-owned enterprise “Kyrgyzavtozhoh-South”, n.d.). This finding is consistent with the conclusions of other studies, which demonstrate that an increase in traffic flow accelerates deformation processes within pavement layers.

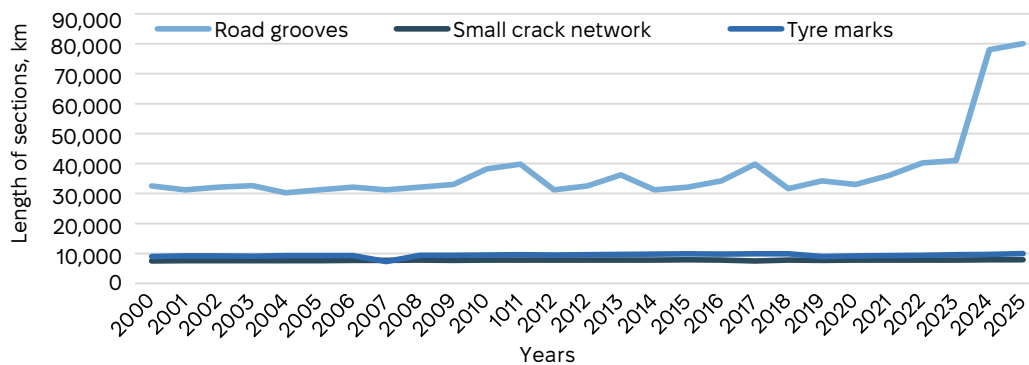


Figure 1. Temporal variation in the length of road sections with various defects, 2000-2025

Source: compiled by the authors using data from the State-owned enterprise “Kyrgyzavtozhoh-South” (n.d.)

The types of plastic deformations observed in the upper layers of asphalt concrete pavements include: shear deformations through the full thickness of the layer, which occur without disrupting surface evenness and are characteristic of layers with high shear resistance; structural changes arising from long-term operation, most often observed in the form of minor curved lines at pedestrian crossings or near “Stop” signs; migrated deformations in the upper layer, caused by the upward movement and accumulation of bitumen from lower layers to a depth of 20-30 mm; transverse wave-like deformations, typically found in braking zones and on sloped sections; deformations caused by insufficient shear

resistance of the layer, developing under the combined effect of high shear forces and elevated temperatures; minor irregularities and undulations, which subsequently contribute to the formation of wave-like deformations; wheel ruts, formed due to the repeated impact of heavy freight and passenger vehicles on specific sections of the road, particularly during peak traffic periods; and flow of the upper layer, observed near road edges, especially on straight sections with transverse gradients.

In summer, the temperature of the upper layer of asphalt concrete pavements may reach +50°C and higher. Prolonged solar radiation increases the temperature of the

material and alters the viscoelastic properties of the bituminous binder. As a result, the pavement softens, and under the passage of heavy vehicles, creep deformation and residual plastic deformation occur (Luan *et al.*, 2023). Asphalt concrete mixtures incorporating higher-viscosity bitumen exhibit greater resistance to rutting (Albayati & Al Khateeb, 2023; Zhao *et al.*, 2024). The shape and characteristics of aggregate particles used in filling voids also influence the formation of the asphalt skeleton.

Angular mineral particles (e.g. crushed stone) increase the shear resistance and strength of asphalt concrete mixtures. The internal friction of angular crushed aggregate particles ensures the integrity of the mixture, whereas particles with smoother shapes reduce the risk of rotational displacement. Asphalt concrete layers are generally recommended to be composed of 100% crushed material. Excessive bitumen content intensifies plastic flow and fatigue of the mixture, thereby reducing its stability. This issue is of considerable importance not only in terms of pavement quality deterioration but also in addressing structural and technological challenges. Rutting is one of the most significant problems requiring both prevention and remediation (Li *et al.*, 2023). It arises due to the visco-plastic behaviour of the material. The strength and deformation properties of asphalt concrete are highly temperature-dependent: as temperature increases, the viscosity of bitumen decreases, the bonding between mineral particles weakens, and the material strength declines; conversely, at low temperatures, bitumen stiffens and the strength of asphalt concrete increases (Shi *et al.*, 2023). The strength indicator varies widely depending on temperature. For example, the compressive strength of standard asphalt concrete specimens (for hot mixes, MPa) is approximately 1-2 at +50°C, 2-5 at +20°C, 8-13 at 0 °C, 10-17 at -10°C, and 18-30 at -35°C (GOST No. 9128-2009, 2010). These values clearly demonstrate the strong dependence of asphalt concrete strength on temperature. Resistance to shear deformation is also closely related to material strength. During hot summer conditions, as strength decreases, the stability of pavement layers deteriorates, whereas increased strength enhances resistance to shear deformation.

Studies by H.F. Tambunan *et al.* (2025) and M.M. Alaminie *et al.* (2022) indicate that naturally rounded mineral particles in asphalt concrete reduce material strength, adhesion, and shear resistance. This is due to their rounded shape and smaller contact surface area. The magnitude of internal friction depends on the gradation of the mineral mixture, as well as the shape and surface characteristics of the particles. Temperature sensitivity is a major drawback of bitumen-mineral mixtures, as they exhibit thermoplastic and coagulative properties. When bitumen binds with mineral particles, the strength of the mineral skeleton decreases, as the bitumen film coating the particles reduces internal friction forces and adhesion within the system. As a result, favourable conditions for rut formation are created. The intensity of rut formation depends on several factors: excessive use of bitumen, the selection of a bitumen grade unsuitable for regional climatic conditions, and a low compaction coefficient of the mixture. Plastic deformations primarily occur when the temperature of asphalt concrete reaches $\geq 40^{\circ}\text{C}$ (Shi *et al.*, 2023). This is associated with phase changes in high-temperature bitumen grades and structural changes in

the mixture (Zhao *et al.*, 2024). During hot summer conditions, the viscosity of the bitumen–mineral mixture decreases sharply, resulting in a reduction of relaxation time. If this time becomes shorter than the duration of load application, conditions are created for the development of plastic deformations. Considering the operating conditions throughout the entire service life of asphalt concrete pavements, it is important to ensure sufficient stiffness at low temperatures while maintaining high viscosity and shear resistance at elevated temperatures.

In winter, bitumen-mineral mixtures exhibit very high viscosity, and the relaxation time significantly exceeds the duration of load application. In contrast, during hot summer conditions, viscosity decreases and relaxation time shortens, sometimes becoming less than the duration of loading. Such conditions lead to the formation of plastic deformations. In addition, the water resistance of asphalt concrete affects both the physical and mechanical properties of the material and the durability of pavement layers. If water resistance is insufficient, premature deterioration occurs, as the bituminous organic binder does not adequately adhere to mineral particles, leading to film failure and layer degradation. The most effective way to address this issue is to improve water resistance through the use of surface-active agents (Buruiana *et al.*, 2023; Zhalaldinov *et al.*, 2025).

Based on the obtained results, a number of practical recommendations have been developed to reduce plastic deformations in asphalt concrete road pavements. Firstly, when designing asphalt concrete mixtures, it is necessary to carefully select the granulometric composition and shape of mineral aggregates (Li *et al.*, 2023). Secondly, it is recommended to use bituminous binders appropriate to climatic conditions and to regulate their content at an optimal level. Thirdly, strict adherence to compaction technology during construction and control of density indicators at the production stage contribute to ensuring the long-term performance of pavements. In addition, consideration of traffic intensity and temperature conditions at the design stage is an important factor in improving operational durability.

The results of this study demonstrate that the occurrence of plastic deformations in asphalt concrete pavements is associated with the combined influence of several factors. In particular, it was established that the increase in traffic loads, the thermal regime of pavement layers, the structure of mineral aggregates, the properties of the bituminous binder, and the degree of compaction of the mixture have a significant impact on the shear resistance of pavement layers. These findings are largely consistent with the works of other authors who have investigated the operational durability of road pavements. For instance, H. Wang *et al.* (2023) examined the ageing processes of asphalt binders and noted that changes in their physico-mechanical properties lead to a reduction in the deformation resistance of road pavements. According to the authors, the ageing of bitumen during service alters its viscosity characteristics and weakens its bonding with the mineral skeleton. This phenomenon contributes to the formation of plastic deformations and rutting in long-term pavement operation. The results of the present study confirm a similar trend, as it was found that under elevated temperatures and increasing traffic loads, the viscosity of bitumen decreases as the temperature of asphalt concrete layers rises, leading to reduced resistance

to shear deformation. This phenomenon was also confirmed by Y. Luan *et al.* (2023), who demonstrated a direct relationship between bitumen properties and rutting resistance.

The structural characteristics of asphalt concrete mixtures were investigated by X. Lu *et al.* (2024) and Y. Mu *et al.* (2020), who reported that the granulometric composition of aggregates and their proportion directly affect the mechanical properties of pavement layers. Using artificial intelligence models, they determined that mixtures composed of coarse and angular mineral particles exhibit higher resistance to shear deformation. The findings of the present study are consistent with this conclusion, as angular and crushed mineral aggregates increase internal friction within the mixture and reduce the likelihood of plastic deformation. Furthermore, D.X. Lu *et al.* (2024) and M. Wei *et al.* (2024), who studied the deformation behaviour of asphalt concrete layers through mathematical modelling, demonstrated that traffic load intensity and temperature factors play a key role in the development of plastic deformations. The discrete element method proposed by these authors enables the investigation of microstructural changes in pavement layers. The results obtained in this study support this perspective, as it was established that an increase in temperature reduces bitumen viscosity and consequently decreases the shear resistance of the material.

The formation of rutting in road pavements is closely related to traffic intensity, as shown by N.O.A.S. Jourdain *et al.* (2024). Using statistical modelling approaches, the authors analysed the dynamics of pavement deformations and concluded that an increase in the number of heavy vehicles leads to a higher rate of pavement deterioration. The findings of the present study confirm this trend, as an increase in freight transport in recent years has resulted in a higher incidence of wheel track formation on road surfaces. The potential for improving the mechanical properties of asphalt concrete through the modification of bituminous binders was investigated by V. Gunka *et al.* (2024). The authors found that polymer-modified bitumen enhances the stability of asphalt mixtures under high-temperature conditions. The results of the present study support this conclusion, as it was established that increasing temperature reduces bitumen viscosity and consequently lowers the deformation resistance of pavement layers. M. Donchenko *et al.* (2024), who studied the technological ageing of bitumen, noted that changes in its rheological properties significantly affect the service life of asphalt pavements. They also demonstrated that antioxidant additives can slow down the ageing process. These findings further confirm that the chemical stability of the binder plays a crucial role in improving the quality of asphalt concrete mixtures.

A. Jexembayeva *et al.* (2024), who investigated the long-term performance of asphalt pavements, reported that the use of polymer additives contributes to improved mechanical stability of road materials. Their study showed that dispersed reinforcing materials enhance the structural stability of asphalt concrete. The results of the present study also confirm that optimisation of the structural composition of asphalt mixtures plays an important role in increasing pavement durability. In addition, P. Dong *et al.* (2024), who examined the operational conditions of road structures, highlighted that road geometry and traffic characteristics significantly influence deformation processes. According

to their findings, dynamic loads are higher on uphill and downhill sections, leading to accelerated deterioration of asphalt concrete layers. The results of the present study also demonstrate the significant influence of these factors on pavement performance.

The analysis of the reviewed studies indicates that the resistance of asphalt concrete pavements to plastic deformation is determined by the interaction of multiple factors. The structure of the mineral skeleton, the quality of the bituminous binder, the thermal regime, traffic loads, and the characteristics of the road structure all have a direct impact on pavement performance. The findings of this study confirm the importance of these factors and demonstrate that optimisation of asphalt mixture composition and modification of road materials are among the key approaches to ensuring long-term pavement performance. Thus, the obtained results substantiate the necessity of comprehensively considering the structural properties of materials and technological parameters in order to enhance the deformation resistance of asphalt concrete pavement layers.

■ CONCLUSIONS

The results of the conducted study indicate that the occurrence of plastic deformations in asphalt concrete pavements was determined by the combined influence of several internal and external factors. Among these, the magnitude of traffic loads, the thermal regime of the pavement surface, the structure of mineral aggregates, the physical properties of the bituminous binder, and the degree of compaction of layers play a key role. In particular, under high summer temperatures, the viscosity of bitumen decreases, leading to a reduction in the structural stability of the mixture. As a result, defects such as rutting, wave-like deformations, and layer displacement occur on the pavement surface. The analysis of analytical, experimental, and statistical data confirmed that the shear resistance of asphalt concrete layers directly depends on traffic load intensity, temperature conditions, the structure of mineral aggregates, the properties of the bituminous binder, and the quality of compaction. The study also demonstrated that the mineral skeleton structure of the asphalt mixture plays a crucial role in the mechanical stability of the material. The use of angular and crushed mineral particles increases internal friction within the mixture and enhances the resistance of layers to shear deformation. Conversely, rounded and smooth particles weaken the structural framework of the mixture. In addition, the content and qualitative characteristics of bitumen are of significant importance. Excessive bitumen content may increase the plasticity of the mixture and reduce the stability of pavement layers. Therefore, the optimal selection of mixture composition is one of the key factors in ensuring the long-term performance of road pavements.

Based on the obtained results, practical recommendations aimed at reducing plastic deformations in asphalt concrete pavements have been developed. These include the proper selection of the granulometric composition and particle shape of mineral aggregates, the use of bituminous binders appropriate to climatic conditions, and the optimisation of their dosage. Furthermore, strict adherence to compaction technology during layer placement and effective density control are essential for ensuring long-term pavement performance. It is also necessary to take into

account traffic intensity and temperature conditions during the design stage of road construction. The implementation of these recommendations can contribute to extending pavement service life, reducing maintenance costs, and improving road safety. Overall, the results obtained demonstrate that the reliability of road pavements can be enhanced through the optimisation of asphalt mixture composition and the improvement of construction technologies for pavement layers. Future research should focus on the use of modified bitumen and the comprehensive modelling of pavement behaviour under various climatic

conditions in order to further improve the deformation resistance of asphalt concrete layers.

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Асфальт-бетон жол төшөлмөлөрүндө пластикалык деформациялардын өнүгүүсү жана жылышууга туруктуулукту камсыз кылуу

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■ **Аннотация.** Жолдордун иштөө шарттары начарлап, оор унаалардын санынын жана октук жүктөмдөрдүн көбөйүшү асфальт-бетон төшөлмөлөрүндөгү пластикалык деформациялардын көбөйүшүнө алып келди. Бул көйгөй жол катмарларынын ишенимдүүлүгүн төмөндөтөт жана аларды эксплуатациялоонун жана тейлөөнүн чыгымдарын көбөйтөт, айрыкча ысык мезгилде, чуңкур жана толкундуу деформациялар катмарлардын бекемдигин бир топ төмөндөтөт. Бул изилдөөнүн максаты асфальт-бетон катмарларындагы пластикалык деформациялардын себептерин аныктоо жана жол катмарларынын жылышууга туруктуулугун жогорулатуунун илимий жактан негизделген ыкмаларын иштеп чыгуу болгон. Аналитикалык, салыштырмалуу жана статистикалык анализди колдонуу изилдөөгө өз максаттарына жетүүгө, асфальт-бетон төшөлмө катмарларынын жылышууга туруктуулугун илимий жактан баалоого жана практикалык колдонуу боюнча сунуштарды иштеп чыгууга мүмкүндүк берди. Изилдөөнүн негизги жыйынтыктары асфальт-бетон катмарларынын жылышууга туруктуулугу бир катар ички жана тышкы факторлорго көз каранды экенин көрсөттү. Ички факторлорго минералдык скелеттин түзүлүшү, агрегаттардын формасы жана өлчөмү, битум байланыштыргычынын илешкектиги жана аралашманын тыгыздыгы кирет. Курч жана майдаланган минералдык бөлүкчөлөр аралашманын каркасынын пайда болушуна өбөлгө түзөт жана пластикалык деформацияны азайтат, ал эми битумду же климаттык шарттарга туура келбеген марканы ашыкча колдонуу, тескерисинче, чуңкурлардын пайда болушуна өбөлгө түзөт. Температура дагы маанилүү ролду ойнойт: жайында катмарлар ысып, битумдун илешкектиги азаят жана релаксация убактысы кыскарат, натыйжада чуңкурлар пайда болот жана жылышат. Катмарлардын сууга туруктуулугу, адгезия касиеттери жана тыгыздалуу даражасы пластикалык деформацияга туруктуулукту аныктоодо маанилүү факторлор болуп саналат. Бул изилдөөнүн практикалык мааниси анын жыйынтыктарында, жол куруучулар жана инженерлер үчүн асфальт-бетон аралашмаларын оптималдаштырууга, катмардын тыгыздалышын жакшыртууга жана температуралык шарттарды эске алуу менен жолдун узак мөөнөттүү жана ишенимдүү иштешин камсыз кылууга мүмкүндүк берет

■ **Негизги сөздөр:** дөңгөлөк изи; жылышууга туруктуулук; битумдук байланыштыргыч; минералдык толтургуч материалдар; температуралык факторлор; аралашманын тыгыздыгы; жол катмарларынын бекемдиги

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■ **Аннотация.** Эксплуатационные условия автомобильных дорог ухудшаются, рост числа тяжеловесного транспорта и увеличение нагрузки на каждую ось приводят к увеличению пластических деформаций на асфальтобетонных покрытиях. Эта проблема снижает надежность дорожных слоев и увеличивает затраты на их эксплуатацию и ремонт, особенно в жаркий период, когда появление колеи и волнистых деформаций значительно снижает прочность слоев. Целью исследования было выявить причины возникновения пластических деформаций в асфальтобетонных слоях и определить научно обоснованные методы, направленные на повышение устойчивости дорожных слоев к смещениям. Применение аналитического, сравнительного и статистического анализа позволило достичь целей исследования, научно оценить устойчивость асфальтобетонных слоев дорожного покрытия к смещению и разработать рекомендации для практического применения. Основные результаты исследования показали, что устойчивость асфальтобетонных слоев к смещениям зависит от ряда внутренних и внешних факторов. К внутренним факторам относятся структура минерального скелета, форма и размеры заполнителей, вязкость битумного связующего, степень плотности смеси. Острые и измельченные минеральные частицы способствуют формированию каркаса смеси и снижают пластические деформации, тогда как чрезмерное использование битума или марка, не соответствующая климатическим условиям, наоборот, способствуют образованию колеи. Влияние температуры также существенно: в летний период слои нагреваются, вязкость битума снижается, время релаксации сокращается, в результате появляются колеи и смещения. Водоустойчивость слоев, адгезионные свойства и степень уплотнения являются решающими факторами для определения устойчивости к пластическим деформациям. Практическая значимость исследования заключается в том, что его результаты позволяют дорожным строителям и инженерам оптимизировать асфальтобетонные смеси, повысить качество уплотнения слоев и обеспечить долговременную и надежную эксплуатацию дорог с учетом температурных условий

■ **Ключевые слова:** колея; устойчивость к смещениям; битумное вяжущее; минеральные заполнители; температурные факторы; плотность смеси; прочность дорожных слоев