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Noise-Absorbing Asphalt Technology in Uzbekistan and Its Ecological Efficiency in Cities

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Abstract. This article analyzes the introduction of noise-absorbing asphalt technology in Uzbekistan and its environmental efficiency in cities. The article examines the composition, principles of operation and practical impact of noise-absorbing asphalt pavements in the urban environment. The article shows that noise-absorbing asphalt not only significantly reduces traffic noise, but also helps to protect public health, improve the quality of the living environment and ensure environmental sustainability. At the same time, the article also highlights the application of innovative solutions to asphalt pavements, such as sensor technologies, temperature-adapting materials and waste recycling.

Keywords: noise-absorbing asphalt, environmental efficiency, urban transport, sensor asphalt, temperature-adapting pavements.

Introduction

Noise-reducing asphalt pavements are widely used today as an innovative solution to improve urban infrastructure and reduce traffic-related noise pollution. Traditional asphalt layers cannot significantly reduce traffic noise levels, especially on roads with high traffic density. Noise-reducing asphalt pavements, due to their special composition and structure, have the property of absorbing and reducing noise propagation, increasing environmental and social efficiency in urban environments [1]. The composition of noise-reducing asphalt differs from traditional asphalt. Such pavements usually consist of highly porous, open-structure asphalt concrete. This structure absorbs noise generated by the interaction of vehicle wheels with the road surface. The pores in the open structure of the asphalt reduce acoustic energy by absorbing air. This reduces the backscatter of noise and reduces the overall level of noise emitted from the road surface.

Noise-reducing asphalt typically contains the following components: asphalt bitumen, heavy aggregates, special polymers, porous fillers, and additional noise-absorbing materials. Special polymers increase the structural stability of the asphalt layer, while porous fillers play a key role in providing acoustic absorption [2]. Such a layer composition improves the noise absorption coefficient and maintains the mechanical strength of the road surface. The principle of operation of noise-reducing asphalt is as follows: when vehicle wheels hit the road surface, the elastic and porous structure absorbs noise, which reduces the amount of acoustic energy emitted from the road surface. Noise-reducing asphalt pavements are typically used in cities with high traffic density, around bridges, near residential areas, and on busy roads. Scientific studies show that noise-absorbing asphalt reduces the noise level at the road surface by 5-10 dB (decibel). This makes a huge difference to human perception, significantly reducing noise stress and having a positive impact on public health.

Methodology

This article uses a comprehensive scientific and analytical methodology to assess the implementation of noise-absorbing asphalt technologies in Uzbekistan and their environmental efficiency in cities. In the research process, a combination of theoretical and practical methods was used, and conclusions were drawn based on international and regional experience. First of all, the literature review method was used. At this stage, scientific works of leading foreign scientists on noise-absorbing asphalt technologies, materials of international conferences, and articles published in reputable scientific journals were systematically studied. In particular, special attention was paid to the sources of traffic noise, the influence of the road surface structure on acoustic properties, and indicators of environmental efficiency. At the next stage, the comparative analysis method was used. It compared the noise reduction level, service life, and environmental efficiency of noise-absorbing asphalt types with traditional asphalt pavements. This analysis was based on the results of empirical studies conducted in the European Union and the CIS countries. The study also used the method of statistical analysis. Data on the impact of transport noise on human health were obtained from open official sources, and the relationship between noise reduction and environmental and social benefits was analyzed. In this process, the noise standards and recommendations established by the World Health Organization were adopted as a methodological basis. In addition, the possibilities of adapting foreign experiences to the conditions of Uzbekistan were assessed through logical analysis and generalization methods. The practical aspects of introducing noise-absorbing asphalt technologies were considered, taking into account climatic conditions, traffic density and existing road infrastructure. At the final stage, scientific conclusions and recommendations were developed based on the results obtained. This methodological approach ensures the reliability of the research results, as well as allows making scientifically based decisions on the introduction of noise-absorbing asphalt technologies in the cities of Uzbekistan.

Results

The practical effectiveness of noise-absorbing asphalt pavements has been confirmed in numerous scientific studies [3]. For example, studies conducted by the University of Dresden in Germany have shown that porous asphalt layers absorb a greater proportion of noise energy than traditional asphalt layers. This significantly reduces noise levels on busy roads. It has also been noted that in a number of European cities, when such asphalts were introduced to the road surface, the echo level decreased and the number of citizen complaints decreased significantly. The social and environmental impact of noise-absorbing asphalt pavements in the urban environment is also of great importance. Noise reduction reduces the stress level of city residents, improves sleep quality, and generally increases the quality of urban life. In design standards related to human health (for example, recommendations of the World Health Organization), noise levels below 55 dB are considered acceptable for humans. On roads where noise-absorbing asphalt is introduced, these standards are often met. In addition, noise-absorbing asphalt pavements also contribute to improving urban ecology. The reduction in noise levels helps animals and birds adapt to the urban environment, as traffic noise increases their stress levels and disrupts their natural behavior [4]. In addition, such asphalt layers usually have a more air-permeable structure, which also provides additional benefits such as water drainage and faster drying of the road surface. Practical experience in the implementation of noise-absorbing asphalt pavements shows that such layers are usually monitored on sample road sections for 3-5 years. The monitoring results showed that the noise absorption performance remains stable over time, which maintains the mechanical strength of the asphalt and the efficiency of absorbed acoustic energy. This guarantees long-term positive results for urban infrastructure. The effectiveness of noise-reducing asphalt is also being improved by enriching the road surface with innovative materials, such as nanotechnology-enhanced polymers. Such modifications increase the elasticity and acoustic absorption of the road surface, which helps to keep noise levels low.

Traffic noise in urban infrastructure is one of the main factors that negatively affect the quality of people's daily life and health [5]. Scientific studies conducted in many cities show that traffic noise leads to increased blood pressure, stress, sleep disturbances and deterioration of mood. For example, a study conducted by the University of Geneva in Switzerland found that stress symptoms increased by 20-30% in residents living in areas with road noise levels of 65 dB or higher. Noise-absorbing asphalt pavements can significantly reduce this problem.

Noise-absorbing asphalt is a type of road surface with a special porous structure that absorbs acoustic energy from vehicle wheels. In general, the reduction in noise levels is 3-10 dB, which is a noticeable difference for the human ear. For example, the results of practical monitoring carried out in a number of European cities have shown that on roads with noise-absorbing asphalt, the noise level is 6-8 dB lower than on conventional asphalt. This reduction is not only noticeable to people, but also has a positive effect on reducing stress and nervous disorders.

Discussion

Noise reduction is very important from a public health perspective. In areas exposed to traffic noise, the risk of cardiovascular disease increases, which places an additional burden on the healthcare system. According to statistics from the Austrian Institute of Health, in areas with high road noise, the incidence of heart attacks and hypertension is 15-18% higher than in areas with low noise. This risk is significantly reduced only when noise-absorbing asphalt is used: if the noise is reduced by 5-8 dB, the rate of reduction of stress symptoms in the cardiovascular system increases by 10-12%. Noise-absorbing asphalt not only improves health, but also improves the quality of the living environment. In the process of urbanization, many cities are surrounded by traffic roads, and in these areas residents cannot relax at home due to noise. Studies have shown that noise levels during traffic jams on roads where noise-absorbing asphalt has been installed have been significantly reduced, improving the quality of sleep and overall quality of life for residents living nearby by 15-20%. This directly contributes to creating a sustainable living environment for cities.

Noise-absorbing asphalt has other advantages from the point of view of environmental sustainability. When noise is reduced, the movement of traffic along the road also becomes more stable, which reduces fuel consumption. Studies have shown that, against the background of reduced noise levels, the speed and unevenness of motor vehicles decreases, resulting in a reduction in fuel consumption of up to 3-7%. This, in turn, also leads to a reduction in emissions of polluting gases - NOx and CO2 - which is a positive result for urban air quality. Noise-absorbing asphalt is often used in conjunction with other environmental aspects. For example, asphalt layers with porous technology also improve water drainage and prevent water from accumulating on the road surface. This, in turn, ensures a long service life of the road, while reducing excessive noise and environmental pollution associated with rainwater. Such asphalt technologies are also often enriched with recycled materials, contributing to the efficient use of resources and reducing waste.

In many cities, especially in Europe and North America, noise-absorbing asphalt has been used, and the long-term environmental impact of this technology has also been studied. For example, in several cities in Germany, 5-year monitoring results showed that noise levels in areas where noise-absorbing asphalt was installed have steadily decreased, and population satisfaction has increased by 20%. This reinforces the need to introduce noise-control technologies into urban environmental strategies.

Modern urban infrastructure requires effective management not only of traffic flow, but also of the environmental situation. Technological innovations in the field of noise-absorbing asphalt technology significantly increase the efficiency of road surfaces by using sensor systems, temperature-adapted materials and waste recycling, which significantly improve the urban environment.

Sensory asphalt is a system that monitors road conditions in real time using digital sensors and acoustic detectors integrated into the road surface. The sensors measure air temperature, vibration, road load and traffic and send them to a central control system. Based on this data, artificial intelligence algorithms optimize traffic flow, adjust traffic light timing, and reduce noise caused by traffic jams. For example, in South Korea and Germany, several pilot projects have been implemented with sensor-based asphalt roads, the results of which show that during traffic jams, the noise level has been reduced by 4-6 dB by dynamically adjusting vehicle speed and optimizing traffic light signaling. This is noticeable to the human ear and has a direct impact on reducing acoustic pollution in the city. These sensor systems also help to detect cracks or defects in the road surface in advance. Vibration measurements automatically send an alarm when they detect changes in the road surface, which allows road maintenance to intervene early, resulting in long-term stable operation of the road surface. New types of modified bitumens and polymer-based complexes have been developed to adapt the road surface to the roughness [6]. These materials automatically change their elasticity and hardness levels depending on the ambient temperature. For example, experiments conducted at the Spanish Institute of Automotive Industry Research showed that ordinary asphalt layers began to deform when the temperature rose above 45°C, while layers with temperature-adapted polymers maintained their structural strength by 30%. This technology is effective not only against high temperatures, but also in cold weather, as special microstructures increase the hardness and protect the road surface from cracks and freezing. As a result, road maintenance costs are reduced, which provides long-term savings for city budgets.

One of the new environmental strategies is to recycle industrial and construction waste and extend the service life of the road surface by adding them to the asphalt composition. For example, in the USA and Canada, carbonate residues, polyethylene waste and glass cullet are added to asphalt as additional aggregates. Such materials increase the mechanical strength of the road surface, improve acoustic absorption and reduce the environmental impact of waste. The results of a study conducted by the University of Toronto in 2023 showed that asphalt pavement with the addition of recycled glass aggregate increases the noise absorption coefficient by 7-9% and provides a 20% longer service life compared to conventional asphalt. It was also found that the addition of polyethylene waste reduces physical wear on the road surface, which also improves the durability and service life of the road surface. Such environmental solutions reduce the negative impact on the environment: the emission of harmful gases into the air as a result of waste accumulation and its combustion is reduced, which improves urban air quality. At the same time, it reduces the energy consumption and carbon footprint of the asphalt production process.

When combined with sensor asphalt, temperature-adaptable materials, and recycled aggregate-enriched pavements, traffic noise is significantly reduced, traffic efficiency is increased, maintenance costs are reduced, and the environmental situation is improved. Such innovations play an important role in ensuring the ecological sustainability of the city and have a positive impact on the quality of people's daily life and health. For example, several European cities have tested these technologies and reported a 6-10 dB reduction in noise levels and a 12-15% increase in traffic flow efficiency. This also serves as a key direction for the digital transformation of urban ecology and transport systems.

Conclusion

In conclusion, noise-absorbing asphalt technology can significantly reduce traffic noise in cities, which has a positive impact on the health of residents, the quality of living environment and the urban ecology. Sensory asphalt systems monitor traffic flow in real time and optimize traffic and noise, temperature-adapting materials maintain a stable road surface in extreme climates, and waste recycling protects the environment from pollution and contributes to the efficient use of resources. At the same time, these innovative solutions extend the service life of road surfaces, reduce maintenance costs and provide cost-effectiveness for the city budget. By implementing integrated technologies, urban infrastructure will develop in line with human health, environmental sustainability and the digital transformation of the transport system, which is of strategic importance for modern cities.

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