ORIGINAL ARTICLE

INTERNATIONAL JOURNAL OF ARTIFICIAL INTELLIGENCE

ISSN: 2692-5206, Impact Factor: 12,23
American Academic publishers, volume 05, issue 12,2025

Journal: https://www.academicpublishers.org/journals/index.php/ijai

ASSESSMENT OF THE INFLUENCE OF MECHANICALLY ACTIVATED NATURAL MINERAL COMPONENTS ON THE PROPERTIES OF ASPHALT CONCRETE COMPOSITIONS

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Abstract: This article presents the results of a comprehensive scientific study aimed at evaluating the effects of mechanically activated natural mineral sands and other mineral ingredients on the performance characteristics of asphalt concrete compositions. Mechanical activation enhances the specific surface area of mineral particles, increases their surface energy, and improves adhesion between the mineral filler and bitumen. These effects contribute to significant improvements in strength, deformation resistance, and overall durability of asphalt concrete road pavements. The study highlights the relevance of using local and secondary raw materials to develop advanced asphalt concrete formulations suitable for harsh climatic conditions.

Keywords: Influence of adsorption additives, tar concrete, bituminous mastics, physical-mechanical properties, heat resistance, composition, fillers, river and dune sands, mechanical activation of ingredients, shear resistance, crack resistance, workability, durability, asphalt concrete compositions, specific surface area.

The quality and longevity of road pavements remain a critical issue for many countries, especially those experiencing extreme temperature fluctuations and rapidly growing transportation demands. In Uzbekistan, large-scale reforms in transport infrastructure have increased the need for high-performance asphalt concrete materials capable of resisting deformation, cracking, and thermal stresses. Despite the abundance of local mineral resources, conventional asphalt concrete compositions often fail to meet modern mechanical and operational requirements.

Recent advances in material science emphasize the importance of mechanical activation as an effective method for modifying mineral fillers used in asphalt mixtures. Mechanical activation alters the microstructure, surface properties, and energy state of particles, enabling improved interaction with bitumen and enhanced structural integrity of the resulting composite. Therefore, investigating the role of mechanically activated natural sands as fillers is an important step in developing durable and cost-effective road pavement materials.

The main objective of this research is to study the influence of mechanically activated natural mineral components-primarily river and dune sands-on the physical, mechanical, and operational properties of asphalt concrete compositions.

The research utilized natural river sands collected from the Chinaz and Chirchik regions, as well as dune sands from Yazyavan, Jamashuy, Boz, and Yangiyer. These sands were subjected to mechanical activation using high-energy impact-shear equipment designed to increase particle fragmentation, introduce structural defects, and enhance surface reactivity.

The following parameters were investigated:

Specific surface area of mineral particles;

Thermal stability coefficient of mixtures;

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Compressive strength and shear strength of asphalt concrete compositions;
Adhesion quality between mineral filler and bitumen.

Mechanical activation was performed under controlled conditions to achieve maximum enhancement of particle surface properties without causing excessive pulverization or undesirable shape modifications.

The findings of the study demonstrated that mechanical activation plays a significant role in modifying the behavior of mineral fillers within asphalt concrete mixtures. The specific surface area of sands increased substantially after activation, resulting in better bitumen coating and stronger interfacial bonding. The improvement in surface energy was particularly beneficial for strengthening the asphalt mastic structure.

One of the most important observations was that the compressive and shear strength of asphalt concrete increased steadily with higher specific surface area values. Maximum strength characteristics were observed when the activated sand reached a specific surface area of approximately 550 cm^2/g. This indicates an optimal activation threshold beyond which additional increases in surface area may not yield proportional benefits.

The enhanced adhesion between activated mineral particles and bitumen can be attributed to microstructural changes such as lattice distortions, formation of surface defects, and development of heterogeneous dipole moments. These phenomena contribute to stronger hydrogen bonding and van der Waals interactions, resulting in improved cohesion within the asphalt mixture.

The results also confirmed that both river and dune sands are suitable candidates for use as mechanically activated fillers. Despite natural differences in mineralogy and grain morphology, all sands demonstrated improved performance when mechanically activated. This supports the argument that local mineral resources can be effectively utilized to produce high-quality, durable asphalt concrete mixtures.

The study provides strong scientific evidence supporting the use of mechanically activated natural mineral components-particularly river and dune sands-in asphalt concrete production. Mechanical activation significantly enhances the specific surface area and surface reactivity of mineral particles, resulting in higher strength, improved deformation resistance, and increased durability of asphalt concrete pavements.

Given the climatic challenges and heavy load demands faced by modern road networks, the adoption of mechanically activated fillers can contribute to the development of stronger, longer-lasting, and more reliable road surfaces. The use of abundant local raw materials also reduces production costs and supports sustainable infrastructure development.

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