APPLICATION OF NANOTECHNOLOGIES IN THE FIELD OF TRANSPORT

Djumabayev Dilmurad Kutlimuratovich
Assistant of the Department of Sciences,
Tashkent State University of Transport, Scientific supervisor
Djumabaev0508@gmail.com
Kasimova Gulnora Abaydullayevna
Associate professor of the Department of Sciences,
Tashkent State University of Transport, Scientific supervisor
Saidaliyeva Shaxlo Samikovna
Assistant of the Department of Sciences,
Tashkent State University of Transport, Scientific supervisor

Abstract: Nanotechnology is a technique used in the design and construction of structures by utilizing the properties of materials at the nanoscale. In the past, this technology was mainly applied in fields such as medicine, biochemistry, and microelectronics for micro-level operations. However, developments in the field of nanotechnology have transformed our capabilities and expectations for modifying material properties, making it applicable in various industries. Nowadays, the use of nanotechnologies in road construction engineering is steadily increasing. Materials used in nanotechnology possess specific properties at the nanoscale. These nanoscale properties of materials are employed in the preparation of nanocomposites.

Keywords: Nanotechnology, cement-concrete, bitumen, nanophosphor.

Some materials exhibit unique properties that cannot be observed at the macroscopic scale. Nanotechnology utilizes the properties of materials at the nanoscale, typically ranging from 1 nm to 100 nm. Road construction is carried out on a kilometer scale, which raises the question of how nanoscale properties relate to such large-scale projects. The answer lies in the fact that nanoscale properties can be used to improve the quality of traditional road construction materials. A small amount of nanomaterials can enhance large quantities of conventional materials. Nanomaterials are used in road construction to improve durability, safety, cost-efficiency, and other road performance characteristics. Nanotechnology involves the use of nanomaterials that upgrade cement-concrete/bitumen products, making them more sustainable and reducing environmental pollution.

Nanotechnology is an emerging field of research, and the unique properties of materials developed with nanotechnology can be effectively utilized in road construction. Controlling materials at the nanoscale allows for remarkable

improvements. Carbon nanotubes (CNTs) are a good example, with tensile strength up to 100 times greater than that of steel. Nanotechnology can be applied to enhance road durability, safety, and efficiency. It can be implemented in various aspects of road construction, including repair works. Using nanotechnology can lead to faster road construction and increased road performance. Road construction generally includes the following types of works:

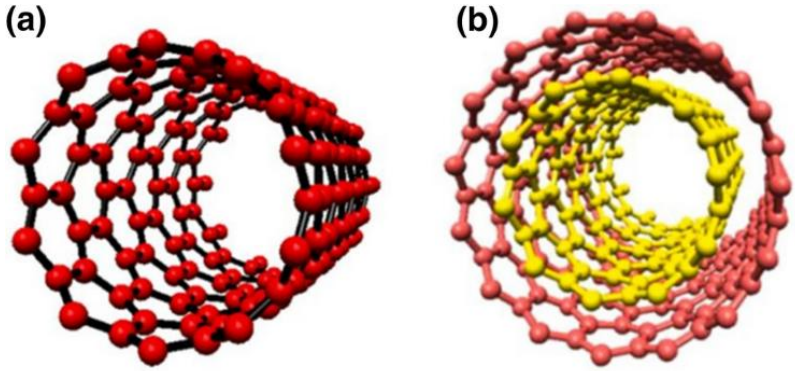
- Cement-concrete road works
- Bitumen roads
- Steel works
- Other miscellaneous tasks

Nanotechnology for Cement-Concrete:

Cement-concrete is an important material for road construction. The significance of cement-concrete roads is increasing. Chemistry, physics effects, materials science, construction engineering, and other fields can modify the properties of cement using nanotechnology. When a small amount of nanoparticles is uniformly mixed with cement-concrete, the cement particles attract the nanoparticles, accelerating the cement hydration process. Nanoparticles fill the nanoscale pores in the cement. Calcium hydroxide promotes the generation of C-S-H (calcium silicate hydrate) in the cement. The hardness of cement is improved by C-S-H, which also enhances the durability of cement-concrete.

Nanomaterials used in cement-concrete:

Some important nanomaterials used in cement-concrete include:



SWCNT DWCNT

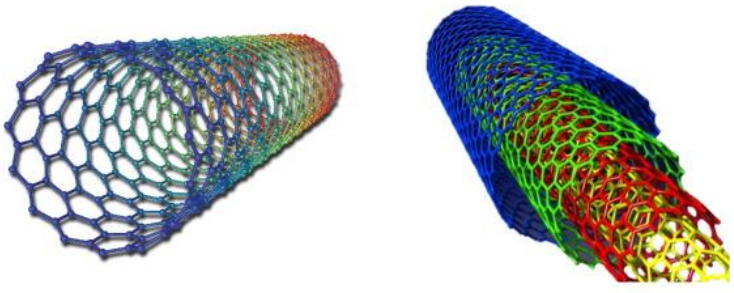
 Carbon Nanotubes (CNTs): These are nano-sized tubes made from graphite carbon. They can be either single-walled (SWNT) or multi-walled (MWNT).

 Properties:

(I) CNTs are highly flexible.(II) CNTs are mechanically strong.(III) They are the hardest and strongest fiber known.The addition of CNTs leads to faster hydration of cement-concrete. It creates a strong bond between the cement-concrete and the CNTs themselves. When CNTs are added to concrete, the compressive strength of the concrete can increase by up to 70%. Adding CNTs to cement-concrete can reduce its

thermal conductivity by up to 12%. A key property of CNTs is their resistance to corrosion in corrosive environments, making them especially useful in marine conditions.

 Nanosilica: Compared to traditional pozzolanic materials used in concrete, nanosilica provides higher workability with a lower water-cement ratio. It fills micro-pores and micro-voids in cement-concrete, allowing for up to 35-40% cement savings.



(a) (b)

Use of Nanotechnology in Roads

Roads have long been constructed using bitumen as a binder.

The quality of bitumen can be improved using nanotechnology. Various nanomaterials can be used to modify bitumen quality. Some of them are listed below:

Improving Bitumen Quality through Nanoclay:

Polymer modifiers used to enhance the mechanical and physical properties of bitumen are quite expensive, leading to high costs in road construction. To reduce construction costs, researchers have recently proposed using nanoclay to modify asphalt. Nanoclay is abundant in nature, making its production cost very low. Only a small quantity of nanoclay is needed for asphalt modification, so it is possible to improve bitumen properties at a low cost. Montmorillonite (MMT) is the most widely used nanoclay for asphalt modification. This nanoclay has a layered silicate structure composed of a single octahedral alumina layer sandwiched between two tetrahedral silica sheets. A small amount of nanoclay can significantly enhance the physical properties of bitumen. Nanoclay-modified bitumen increases the stiffness of bitumen and improves its resistance to degradation. Additionally, it improves Marshall stability and indirect tensile strength of bituminous concrete.

Nanophosphors:

Proper road surface illumination is crucial for traffic safety and nighttime visibility, especially in rural areas. Nanophosphors can solve the road lighting problem when used with road surface materials like cement concrete, paints, etc. Nanophosphors with crystalline structures can have size-dependent band gaps that cause changes in emitted light color (Kelsall et al.). By incorporating nanophosphors into construction materials, roads can emit light from their surface, enhancing road safety. Research has been conducted on mixing nanophosphors with concrete, bitumen, or even road paint. These materials remain luminescent under light exposure.

Nanotechnology for Roads in Waterlogged Areas:

Nanotechnology can be applied in road construction in waterlogged areas. It helps create water-resistant soil by increasing the CBR (California Bearing Ratio) value of the soil under wet conditions. Preventing capillary rise of water is also beneficial. The added benefits include extending the road's service life and minimizing maintenance costs. A salty, nano semi-solid paste dissolves in water. When applied, it forms a waterproof layer between the flexible pavement and natural soil. In this method, a 50 nm saltwater solution and a 100 nm acrylic copolymer are used. This technique can increase the lifespan of roads by 1 to 3 years. In a practical design study (Jay et al.), the thickness of the flexible pavement was successfully reduced from 710 mm to 600 mm using the CBR method. The CBR value of wet soil significantly increased with saline treatment.

REFERENCES:

1. Introduction to Nanotechnology – http://nano-edu.ulsu.ru/w/index/php
2. C. Goodall, *Ten Technologies to Fix Energy and Climate*, Profile Books, 2012.
3. N.I. Pugachenko, *Nanomaterials and Nanotechnologies: Problems and Perspectives*, "Science and Education" Scientific Journal, Volume 1 Issue 2, May 2020, www.openscience.uz
4. Hessian Ministry of Economy, Transport, Urban and Development (2008), *Application of Nanotechnologies in the Energy Sector*, http://www.hessen-nanotech.de/mm/NanoEnergy_web.pdf
5. Nanoforum, *European Nanotechnology Gateway* (2004), *Nanotechnology Helps Saving the World's Energy Problems*, http://www.nanoforum.org
6. *Nanoscience Research for Energy Needs*, National Nanotechnology Initiative, 2004, https://public.ornl.gov/conf/nanosummit2004/energy_needs.pdf
7. *Nanotechnology: Energizing the Future*, *Nanofrontiers Newsletter*, Fall 2008, Woodrow Wilson International Center for Scholars, Project on Emerging Nanotechnologies, http://www.nanotechproject.org
8. Zach, M., Hagglund, C., Chakarov, D., Kasemo, B., *Nanoscience and Nanotechnology for Advanced Energy Systems*, Current Opinion in Solid State and Materials Science, 10 (2006) 132–143