

EFFICIENCY OF USING CEMENT CONCRETE FOR ROAD CONSTRUCTION

Vinnitsia National Technical University

Анотація

В роботі проаналізовано світовий та вітчизняний досвід будівництва та експлуатаційного утримання цементобетонних дорожніх покриттів, можна зробити висновок про те, що цементобетон є ефективним матеріалом, який дозволить вирішити проблеми сьогодення в дорожній галузі України. Його успішно можна використовувати для будівництва бетонних покриттів на дорогах із напруженим рухом і високою інтенсивністю руху з метою забезпечення пропуску сучасних транспортних засобів без обмежень в теплу пору року, а також високої якості та довговічності доріг.

Ключові слова: автомобільні дороги, цементобетонне покриття, будівельні матеріали.

Abstract

The paper analyzes the global and domestic experience in the construction and operational maintenance of cement concrete road surfaces, and it can be concluded that cement concrete is an effective material that will solve today's problems in the road industry of Ukraine. It can be successfully used for the construction of concrete surfaces on roads with heavy traffic and high traffic intensity in order to ensure the passage of modern vehicles without restrictions in the warm season, as well as high quality and durability of roads.

Keywords: highways, cement-concrete covering, building materials.

Introduction

In terms of road coverage per 1000 km² of territory and per 1000 inhabitants, Ukraine ranks one of the last among European countries. The existing network of public roads with a length of 169.4 thousand km currently satisfies only the basic national needs of the economy and the needs of the population in transportation. At the same time, the existing low level of provision of public roads in Ukraine has practically not changed for a long time, due to the very small volume of construction of new roads. Thus, over the past ten years, only 1460 km of public roads have been built [1-2]. To ensure the economic and social development of Ukraine in the coming years, it is necessary to ensure and bring the transport and operational condition of Ukrainian roads in line with European standards and requirements

Research results

The road network is one of the main components of the transport system of Ukraine, which largely satisfies the needs of society in passenger and freight transportation by road. The gradual integration of Ukraine into the European and world economies, the expansion of trade and economic ties with countries of near and far abroad, the further development of economic sectors, and the improvement of the standard of living of the population against the background of the unsatisfactory transport and operational condition of most roads lead to the need to develop the domestic road network.

Insufficient operational quality of road surface causes a decrease in the operating speeds of vehicles, an increase in fuel and lubricant consumption and an increase in the share of the transport component in the cost of production. The fact that the cost of transportation is 1.5 times, and fuel consumption is 30% higher than similar indicators in developed European countries, also has a significant impact on the road component [3-4]. All this, together with the insufficient development of infrastructure, does not attract foreign carriers, restrains the growth of domestic transport and leads to the fact that transit transportation on Ukrainian roads increases very slowly. Non-rigid type roads do not withstand even reduced maintenance service life to a sufficient extent. According to the analysis of the State Agency of Motor Roads of Ukraine, as of today, about 80% of the total network of roads require urgent repair, and more than 60% of road bridges require major repairs and reconstruction, the level of wear of artificial structures on the roads is 43.7% [5-6]. Today, up to 40 thousand km. of roads require major repairs in Ukraine. Ukraine annually loses about 20 billion UAH from the unsatisfactory technical and economic condition of roads, which is a logical result of the lack of new technologies, optimal methods of calculation and implementation of modern road construction materials that appear on the construction market of Ukraine when arranging road surfaces in the 21st century.

A significant territory of Ukraine is located on soils with low bearing capacity. Soils, mainly clayey in nature. According to the road classification, they are classified as heaving and very heaving [7-8]. These are soils that heave in the winter, when wet, and subside in the spring under the influence of solar radiation. Heave is also promoted by: high groundwater levels, prolonged autumn and spring rains, mild winters with slow freezing of the soil and frequent thaws alternating with frosts, sharp temperature fluctuations in spring, precipitation during the thawing of the road surface of highways and city roads and streets. Such adverse climatic conditions do not contribute to the regulatory state of highways for a long period. In the conditions of urban highways, the problem of unfavorable soils is complicated by the presence of an extensive network of engineering communications, which have a negative impact on water-thermal processes in the base soils of road pavements of highways [9-10].

The construction of modern highways requires the use of expensive materials. As the requirements for the durability and safety of highways increase, road industry specialists around the world are studying and implementing new technologies that create conditions for improving quality characteristics and the process of saving money and material resources.

In recent years, in Ukraine and throughout the world, there has been a dynamic increase in the intensity of traffic and the load of trucks. Modern grain trucks can transport from 60 tons to 100 tons of cargo. The structures of existing roads and bridges are not designed for such a load, in addition, the climate of Ukraine in recent years has been characterized by the presence of a long period in the summer when the air temperature exceeds $+30 - 35^{\circ}\text{C}$. At such an air temperature, even in the northern zone of Ukraine, asphalt concrete heats up to a temperature above $+60^{\circ}\text{C}$, despite the fact that the design temperature of asphalt concrete layers according to the standards for the design of road surfaces should not exceed $+40^{\circ}\text{C}$. At such a temperature, the strength of asphalt concrete is less than 1.0 MPa. As a result, asphalt concrete road surfaces, which make up more than 95% of the surfaces in Ukraine, operate in extreme operating conditions. To preserve roads, traffic restrictions are introduced during the daytime, which is a forced measure and does not solve the problem.

The authors in their work [11-12] listed the main advantages of cement concrete pavements compared to asphalt concrete: greater strength and durability; absence of rutting; ensuring greater traffic safety; less surface heating; the ability to ensure a lower noise level during road construction.

The economic aspects of concrete pavement construction are important. Until now, road construction experts believe that structures with cement concrete pavement are more expensive than asphalt concrete. But current realities refute this thesis. The cost of bitumen has increased 10 times over the past decade and continues to grow rapidly. The cost of cement has increased 4.7 times and has practically not changed over the past three years. The cost of asphalt concrete has increased 6-8 times, and that of poured asphalt 11 times. The cost of cement concrete has increased only 3.5 times over the decade. It should be noted that in recent years, Ukraine has experienced a shortage of its own raw materials and insufficient production of road bitumen to meet construction needs, which is why there is a need for imports. Cement production in Ukraine is practically unlimited in terms of raw materials and resources

In works [12-13], the authors established that the construction with cement concrete pavement is 1.6-1.7 times cheaper when compared with asphalt concrete. The service life before major repairs for a category II road with asphalt concrete pavement does not exceed 11-12 years, and with cement concrete it is 25 or more years. That is, the service life of cement concrete pavement is 2.27 times longer than asphalt concrete. In addition, asphalt concrete pavements require higher annual costs for current and emergency repairs. The total annual maintenance costs for asphalt concrete pavement are 36.45 UAH/m², for cement concrete pavements – 15.14 UAH/m² [13].

Most cement concrete pavements in Ukraine were built in the 50s-70s of the last century. Almost all of them need repair or have already been repaired using asphalt concrete layers. Of the approximately 170 thousand km of public roads, only 2.4 thousand km have cement concrete pavement, which is only 1.4%. In European countries, the share of cement concrete roads is constantly increasing. For example, in Germany, Austria and the UK, the share of concrete roads is more than 62%.

Conclusions

From the above, we can conclude that the main advantages of roads with cement concrete pavement are:

- high strength, low surface wear, long service life. low maintenance costs;
- cement concrete pavements do not change their bearing capacity during sharp seasonal fluctuations in temperature and humidity.

The total annual maintenance costs for asphalt concrete pavements are more than two times lower than for asphalt concrete pavements.

References

1. Hladyshev, D., et al. Prospective directions of scientific research in engineering and agriculture. International Science Group, 2023.
2. Glovyn, N., et al. Technical, agricultural and physical sciences as the main sciences of human development. International Science Group, 2024.
3. Lemeshev, M., et al. Applied, technical and agricultural sciences: introduction of the latest technologies into use. International Science Group, 2024.
4. Wójcik, Waldemar, and Małgorzata Pawłowska, eds. Biomass as Raw Material for the Production of Biofuels and Chemicals. Routledge, 2021
5. Stadniychuk, M., Obtaining active mineral additives from industrial waste. Національний університет" Львівська політехніка", 2023.
6. Lemeshev, M., O. Bereziuk, and K. Sivak. "Features of the use of industrial waste in the field of building materials." Scientific foundations in research in Engineering. 1.2: 25–32. (2022).
7. Stadniychuk, M. Modified building materials based on industrial waste. Харківський національний університет міського господарства імені ОМ Бекетова, 2020
8. Hladyshev, D., et al. Technical and agricultural sciences in modern realities: problems, prospects and solutions. International Science Group, 2023.
9. Stadniychuk, M., Modified multi-component fast-hardening construction composites. Національний університет" Львівська політехніка", 2021.
10. Beresjuk, O., et al. Theoretical and scientific foundations in research in Engineering. Vol. 1. International Science Group, 2022.
11. Stadnijschuk, M. Composite materials using metal sludge. Харківський національний університет міського господарства імені ОМ Бекетова, 2020.
12. Sivak, K. Use of industrial waste for increased experimental properties in construction. Львів: Національний університет" Львівська політехніка", 2023.
13. Стаднічук, М. Ефективність використання цементобетону для будівництва автомобільних доріг. ВНТУ, 2024.

Стаднічук Максим Юрійович, аспірант кафедри будівництва, міського господарства та архітектури, Вінницький національний технічний університет, м. Вінниця, e-mail: b15.stadniychuk@gmail.com

Stadniychuk Maksym - graduate student of the Department of Construction, Municipal Economy and Architecture, Vinnytsia National Technical University, e-mail: b15.stadniychuk@gmail.com.