CEMENT ASPHALT CONCRETE WITH ENHANCED PHYSICAL AND MECHANICAL CHARACTERISTICS

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ABSTRACT

The main type of road surfaces in Kazakhstan, as well as abroad, are asphalt concrete pavements. Most of the financing in the road sector (up to 80 %) is spent on repairs. This is due to the low inter-repair service life of the coatings due to increased traffic intensity and underfunding of repair activities in full.

The problem of ensuring the durability of asphalt concrete pavements is one of the most urgent. Its solution requires significant expenditure of material and labor resources. Due to the high cost of road construction materials, the issues of using new technologies, efficient and non-traditional materials, waste and by-products of industry in road construction are of particular importance. First of all, this applies to such technologies and materials that could improve the quality of asphalt concrete coatings, reduce the consumption of expensive binders of petroleum origin. The technologies under consideration also provide opportunities for the use of high-tonnage waste and industrial by-products as part of asphalt concrete mixtures. The issues of using high-tonnage waste and by-products of industry are also important because they allow simultaneously solving the problem of the environmental plan - to free up huge territories of land occupied by waste, to prevent environmental pollution.

KEYWORDS:

cement asphalt, fly ash, waste, development of the road construction, industry, building materials

INTRODUCTION

Increasing the durability and ease of operation of highways can be achieved by using semi–rigid organomineral composite materials – cement asphalt concrete, obtained on the basis of a complex of binders - Portland cement and bitumen emulsion. The use of various types of fuel ash as mineral additives in the composition of each type of binder will allow to regulate the operational properties of the final composite with a reduced content of the main structure–forming component - Portland cement.

The main task of modifying bitumen emulsions used in road construction materials is to structure the film formed by the bitumen emulsion directly in the composition of the final composite in order to improve its physical and mechanical characteristics. This makes it possible to vary its qualitative characteristics.

Considering the fact that the structure of semi–rigid organomineral composites is formed by a complex of binders of various types of hardening (Portland cement – hydration type, bitumen emulsion - coagulation type), the bitumen film formed on the surface of crushed stone grains is of interest. The positive experience of using fuel ash to improve the structural and mechanical characteristics of viscous road bitumen suggests the possibility of their use in bitumen emulsions. The use of fuel ash for the purpose of modifying bitumen in the structure of cement asphalt concrete will allow the creation of movable (so-called «hinged») elements due to the structure of ash particles. This will make it possible to increase the damping capacity of the material, which will positively affect its durability.

According to the theory of stabilization of emulsions by solid particles, the stability of emulsions is determined by the stability of the interfacial layer of the stabilizer on the surface of the droplets and the stability of the emulsion layers of the dispersion medium between the droplets. Insoluble powders represent a special class of stabilizers of dispersed systems, primarily emulsions and foams. Solid particles are adsorbed on the water/oil surface, forming an interfacial (adsorption) layer that protects the emulsion droplets from coalescence, which inevitably leads to decomposition.

The stabilization of emulsions by solid particles is provided by several factors:

1) strong adsorption of particles and formation of a dense interfacial layer of particles on the surface of droplets;

2) capillary pressure in an emulsion film stabilized by solid particles;

3) steric or electrostatic repulsion between the adsorption layers;

4) mechanical strength and elasticity of the mesh, a structure formed by solid particles in a dispersion medium.

In addition, the smaller the particle radius, the lower the adsorption energy, which expresses the strength of the particle's fixation on the interfacial surface. Therefore, too small particles are not fixed to the surface. Along with the particle sizes, the stable position of a solid spherical particle on the interface of the two phases is determined by the equilibrium edge angle. Thus, hydrophilic particles with an edge angle from 0 to 90 ° C (such as metal oxides, silica) form direct emulsions.

THE MAIN PART

The article «Temperature sensitivity of mechanical properties of cement-asphalt mortar with nanoparticles» was published in the journal «Advances in civil engineering». The purpose of this article is to evaluate the ability of nanoparticles to reduce the temperature sensitivity of the mechanical properties of cement-asphalt mortar and to study the mechanism of influence of nanoparticles on thermal characteristics. First, bending and compression tests of cement-asphalt mortar with nano-SiO2 and nano-TiO2 were carried out at five different temperatures ranging from -20 °C to 60 °C, and flexural and compressive strength were measured. Based on the experimental results, the type, number of nanoparticles, and the effect of temperature sensitivity on flexural and compressive strength were investigated. In addition, changes in the composition and microstructure of the cement-asphalt mortar were studied using a scanning electron microscope, and the temperature-related behavior of the cement-asphalt mortar is explained based on experimental observations. [1]

The article «Asphalt Portland cement concrete composite - laboratory assessment» was published in the Journal of Transportation engineering - asce. Asphalt-Portland cement concrete composite is asphalt concrete with a hot mixture with a high content of air voids (25-30 %) filled with cement mortar modified with resin. It has unique properties of both Portland cement concrete and hot asphalt concrete, such as the absence of deformation characteristics of rigid coatings, as well as the susceptibility of flexible coatings and coatings of asphalt concrete with a hot mixture to abrasive wear

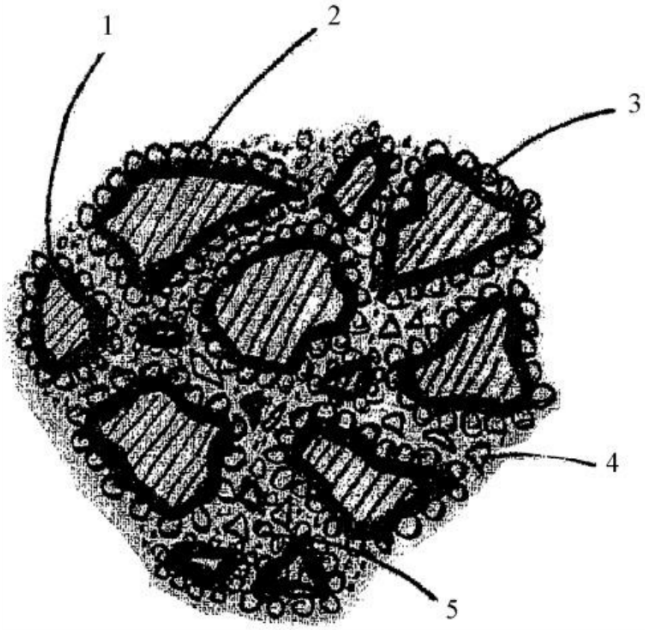
The raw material mixture consists of Portland cement, fly ash, sand, water and additives. The resulting concrete has the properties of both flexible and rigid concrete. A laboratory study was conducted to evaluate the effectiveness of an asphalt-Portland cement concrete composite under controlled conditions. The program included the following tests: stability, indirect tensile strength, compressive strength, modulus of elasticity, sensitivity to water, freezing and thawing, as well as resistance to chloride penetration. The tests were carried out at three levels of wet curing: no wet curing, one-day wet curing and three-day wet curing. The samples were tested for 28 days. The results were compared with the results of control samples of hot-mix asphalt concrete and Portland cement concrete. The study concluded that the strength and durability properties of the asphalt-Portland cement concrete composite are better than those of asphalt with a hot mixture. It was found that chloride penetration into the samples is less than in ordinary Portland cement concrete. The study shows that asphalt-Portland cement concrete composite is an effective alternative material for use as a bridge flooring coating. [2]

The article «The effect of cement kiln dust on the low-temperature durability and fatigue life of hot mix asphalt concrete» was published in the Journal «Cold regions science and technology» Cement kiln dust is waste that is largely formed in large volumes during the cement production process. In this study, the effect of cement kiln dust as a filler on the low-temperature characteristics of hot mix asphalt concrete was investigated. A laboratory program consisting of evaluating the durability of asphalt concrete of a hot mixture in freeze-thaw cycles using indirect tensile strength testing and fatigue behavior analysis at four temperatures of 20, 0, -10 and -20 °C using a four-point bending fatigue test. In addition, an environmental assessment was carried out with respect to the presence of heavy metals in the dust compounds of the cement kiln by applying a leaching toxicity test. According to the results obtained, mixtures containing cement kiln dust filler demonstrated better resistance to freeze-thaw cycles compared to the control mixture containing limestone. In addition, mixtures containing cement kiln dust showed higher fatigue life compared to the control mixture, and for all mixtures, fatigue life decreased due to a decrease in temperature. However, at lower strain levels of 150 microstresses, the fatigue life of the studied mixtures was largely similar, and even higher fatigue life was obtained by reducing the test temperature. In addition, the results of the leaching toxicity test showed that the amount of heavy metals in the asphalt concrete filtrate of the hot mixture containing cement kiln dust was low and met the required criteria. [3].

At The International Airfield and Highway Pavements Conference, an article «Evaluation of coal combustion products in hot asphalt concrete mix» was published. The combustion products of fine coal are a by-product of coal combustion in the production of electricity. Fly ash is commonly used in Portland cement concrete. However, some fly ash was used in hot mix asphalt concrete as mineral fillers. Due to current changes in environmental emission requirements, large volumes of fly ash containing sulfur cannot be used in traditional concrete. Therefore, this study was undertaken in order to find out whether some of the smaller evils could be usefully used in hot mix asphalt concrete. In this project, fly ash was mixed with asphalt binder PG 58-28 in various percentages (5%, 10% and 15%). A rotational viscosity test was performed on the mixture to determine what percentage of fly ash by weight of the asphalt binder would be acceptable. All percentages were found to be viable. Then the Hamburg tests were carried out tracking these mixtures of asphalt concrete hot mix. Based on the results of the Hamburg test, the most effective mixture with 15% fly ash was selected for further tests, such as the modified Lottman, dynamic module and S-VECD test, and comparison with the control group (without fly ash). In this article, these results showed a positive trend. [4]

Patent «Method of preparation of cement-asphalt concrete mixture and its composition» by the authors Yevtushenko S.V., Miroshnichenko S.I., Stepashov N. E. The composition of cement-asphalt concrete mixture is characterized in the invention. Technical result: reduction of the amount of complex binder while improving the physical and mechanical properties of the resulting material: increased water resistance and long-term water resistance, resistance to alternate freezing and thawing, increased modulus of deformation and strength. [5]

Patent «Ultrahigh strength asphalt» by the author of Servin Holding APS. This invention relates to a method for preparing a dry material for use as an ultra-high strength road surface. A specific property of ultra-high strength asphalt is that all aggregates, such as fillers, sand and stones, are coated with a thin or thick layer of bitumen, depending on the desired properties. The thickness of the layer is determined in the initial stages of the preparation of the mixture after heating the stone and sand aggregates and applying bitumen. Technical result: reduction of labor intensity, reduction of time during the construction of asphalt pavement.[6] Figure 1 shows a section of the asphalt concrete mix.



1 – bitumen layer;
2 – filler 8-16 mm;
3 – cement;
4 – placeholder;
5 – filler 5-8 mm

Figure 1 – Section of asphalt concrete mix

CONCLUSIONS

Thus, as a result of the analysis of domestic and foreign literature, the possibility and expediency of using finely dispersed mineral materials of various natures in the composition of emulsion systems for their stabilization have been established, and the main criteria for mineral materials have been identified. One of the promising types of mineral raw materials for the modification of bitumen emulsions are fuel ashes, however, due to the lack of experimental data, determining the effectiveness and expediency of their use is one of the most important tasks. This will expand the range of modifying additives for stabilization of emulsion systems and increase the use of fuel ash.

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