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The “Engineer” publishes the most significant results of scientific and applied research carried out in universities of transport profile, as well as other higher educational institutions, research institutes, and centers of the Republic of Uzbekistan and foreign countries.

The journal is published 4 times a year and contains publications in the following main areas:

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- Mechanical Engineering;
- Mechanics of Materials;
- Safety, Risk, Reliability and Quality;
- Media Technology;
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- Architecture.

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Improvement of pavement concrete by industrial waste microfillers

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Abstract: Determination of the composition of pavement concrete using industrial waste in the most optimal options, determination of its flow limit, surface activity, and other properties of the composition, such as water separation, are presented.

Keywords: Pedestrian road surface, concretes, paving slabs, microfillers, putty

1. Introduction

Pedestrian pavement has long been firmly established in the image of a modern city. ¬A distinctive feature of the pavement made of composite material with concrete coating is its diverse properties and various configurations. At the same time, the strength and frost resistance of concrete are of great importance for road pavements. However, the tendency to use vibrocompression concrete products in areas where heavy vehicles move, combined with the aggressive effect of freezing and thawing on the properties of the pavement concrete, leads to a decrease in these physical and mechanical properties. The use of composite binders is an effective tool in eliminating this problem. At the same time, the multi-component composition of the pavement concrete is a product based not on reducing the amount of clinker in the mixture, but on effectively controlling the processes of structure formation, ensuring high quality of the resulting concrete.

At the same time, current trends in building materials science today are reducing the energy intensity of building materials production and the use of man-made raw materials in their production. From this point of view, one of the effective materials in terms of saving cement is crushed high-calcium oxide slag. The advantages of binders made from this type of slag and cement compared to Portland cement binders are greater resistance to chemical influences, hydration at low temperatures, and cost-effectiveness. Adding slag to Portland cement is an effective means of combating the harmful effects of hydroxide oxides. Therefore, it is proposed to use a composite slag-cement binder for the production of vibropressed roadbed slabs.

Today, the amount of PM particles in the air around the world is increasing, polluting the air. The main reason for this is the large amount of industrial waste, its non-recycling, the expansion of waste areas and the dumping of large amounts of waste into water resources. These harmful substances are causing widespread diseases among humanity.

In this article, we propose a simple, inexpensive, and safe method for disposing of slag waste.

Although slag is a waste product resulting from the melting of various substances, it can be used as a binder in the building materials industry.

Literature analysis shows that, based on previous studies, binder granules are crushed fractions of slag, the specific surface tension of which should not exceed at least 2000 m2/kg and a maximum of 3000 m2/kg. Slags with this surface tension are optimal for use in road construction and pavements.

Figure 1. Various types of pavement slabs

Currently, in developed foreign countries, natural stone and cement-based paving slabs are used in the construction of pedestrian crossings, squares and other road structures, and they have become very widely used in our country. Decorative concrete paving elements are increasingly used on sidewalks in city centers, playgrounds, pedestrian recreation areas, and pedestrian walkways of civil buildings. The main reason for this is their variety of configurations and rich colors (Figure 1). Also, the resistance of the paving slabs to various climatic conditions, frost and various climate changes ensures a long service life even in urban conditions [1-6].

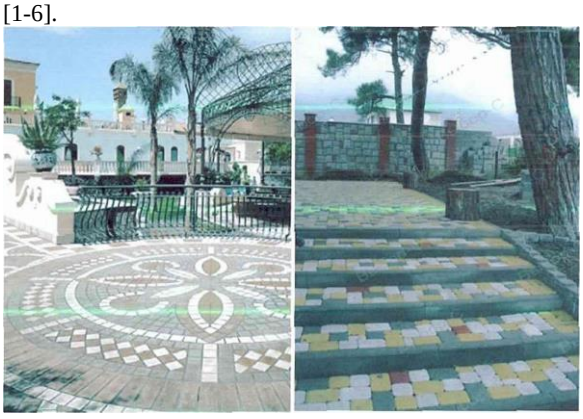

Figure 2. Types of paving slabs

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Pedestrian paving slabs add a cultural and aesthetic appeal to urban or suburban areas, and replacing cobblestone and gravel pavements with concrete pavements has many advantages (Figure 2). The advantages of this type of pavement are ease of installation with minimal labor, attractive appearance, absence of small water puddles, and durability of paving slabs compared to other coatings [7].

At the same time, this type of pedestrian pavement can be used in the construction of highways. In this case, replacing asphalt concrete with concrete pavement helps to eliminate one of the current pressing environmental problems. Thus, the effect of evaporation on asphalt concrete surfaces, which increases in our region, especially on hot summer days, is often not taken into account. It is known that during the preparation and laying of hot asphalt concrete mixtures, this concrete releases polycyclic hydrocarbons. To improve the adhesive properties of the binder, surface-active additives, such as toxic coal tar products, are added to them during surface treatment. During operation, they are partially washed out and evaporated, thereby polluting the environment [8-10].

2. Materials and method

Experimental studies Laboratory tests using waste materials from copper mining at the Almalyk Mining and Metallurgical Combine were carried out using non-standard methods developed by scientific research specialists according to generally accepted standards.

The average density and water absorption of cement stone were studied in cubic samples measuring 2x2x2 cm in accordance with GOST 12730.1-78 and 12730.3-78, and the above-mentioned properties of cement-sand mixture and heavy concrete were studied in prisms measuring 4x4x16 cm and cubic samples with sides of 10 cm after drying to constant mass at a temperature of 105ºC.

Determination of water release of the components was carried out in accordance with GOST310.6-2020 “Cement. Method for determining water release”. When conducting research, 350 g of cement and 350 g of water are weighed. Cement is weighed to an accuracy of 1 g, and water is weighed to an accuracy of 0.5 g or measured in a beaker with a volume of 0.5 cm3.

Water is poured into a beaker, then the measured cement is added for 1 minute, the contents are continuously stirred with a metal spatula for another 4 minutes, and carefully poured into a graduated glass cylinder.

The cylinder is placed on a horizontal surface and the volume of the cement paste is marked on the cylinder scales (cm3). During the study period, the cylinder should be placed in a stationary position in a place free from air currents, vibrations, and other external factors.

The grinding process of mineral raw materials was carried out in the impact-erosion mode of a ball mill. The dispersion of the obtained minerals was evaluated by the relative surface area on the PSX-11A device. The relative surface area on the PSX-11A device is determined based on the Kozeni-Karman method (via the air permeability and porosity of the compacted powder layer). The granulometric composition of microfillers was studied by laser particle diffraction on the MicroSizer 201 device. This method allows for a complete distribution of particle sizes and obtaining accurate results. The MicroSizer 201 device allows for the study of particles from 0.2 to 600 microns and dividing the specified range into 40 fractions.

3. Results and discussion

The transition to the construction of rigid road structures using cement as a binder reduces the total emissions of dust particles and toxic substances released during the asphalt concrete production process (Table 1) [11].

Table 1

The amount of harmful gases emitted from surfactants

The substance name	Concentration, g/m
Inorganic dust	12-40
Sulfur dioxide	0.016
Carbon oxide	0.0008
Nitrogen oxides	0.00007

A decisive factor in favor of expanding the construction of cement-concrete pavements in the future is the indispensability of bitumen in the repair of almost all types of pavements. Unlike bitumen, the raw material reserves for the production of cement are almost unlimited [12-13].

One of the important properties of concrete mixtures for monolithic structures is not only viscosity, but also flowability and its change over time. For this reason, the change in flowability of concrete mixtures over time for composites was studied (Figure 3).

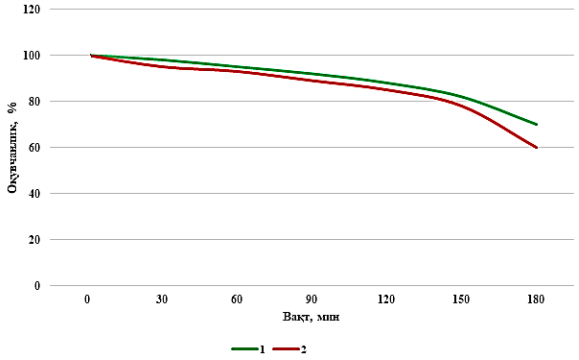

Figure 3. Change in flowability of concrete mix over time (1-Cement + OKMK microfiller; 2-cement)

Analysis of the obtained data shows that the control compositions of the concrete mix with a KCH of 4-6 cm lose their initial fluidity after 20-30 minutes. The addition of the SP modifier extends the period of formation of the coagulation structure and maintains the fluidity of the concrete mix for a long time. After 2 hours, the fluidity index of this composition is 85-88% of the initial value.

The finite element method uses a numerical approach to solve complex engineering problems. It allows you to approximate complex geometric structures and materials by dividing them into simpler elements. This method is widely used in various fields such as mechanics, heat transfer, electromagnetism, etc. We will consider the basic principles of the finite element method, its advantages and disadvantages, as well as examples of its application.

The finite element method (FEM) is a numerical method used to solve various mathematical modeling and analysis problems. It is based on dividing a complex geometric domain into simpler subdomains called finite elements. Each finite element represents a small part of the domain for which the mathematical model can be easily defined and solved analytically or numerically.

The finite element method is widely used in various fields such as mechanics, heat transfer, electromagnetism, fluid dynamics, etc. It allows modeling and analyzing the

behavior of complex systems such as mechanical structures, electrical circuits, thermal processes, etc.[1]

The basic idea of the finite element method is to approximate the solution of the problem over the entire domain by combining the solutions of individual finite elements. To do this, each finite element is described by a set of equations that relate the values of the desired function and its derivatives at the boundaries of the element under consideration.

4. Conclusion

It was found that using 12% micro aggregate is sufficient to obtain a self-compacting concrete mix with a low viscosity value. Using 8% slag increases the effect of reducing the viscosity of the concrete mix.

The use of microfiller admixture and binary microfiller allows maintaining the flowability of the concrete mix for 100-120 minutes, which helps to increase the efficiency of the self-compacting mix for monolithic pedestrian pavement.

Mathematical models were obtained that depended on the strength of concrete, microfiller additives, cement consumption, recipe, and technological factors, based on which the composition of the concrete mix was optimized.

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