

On the educational program 8D07366-“Production of building materials, products and structures”

Abstract

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to obtain the degree of Doctor of Philosophy (PhD) on the theme “Technology of production of paving slabs from fine-grained concrete on the basis of local raw materials”.

Relevance of the work. The main ways to increase the efficiency of construction are the use of secondary resources in the production of building materials and products and the reduction of material intensity. This can be achieved by using progressive scientific and technical achievements, resource and energy-saving technologies, and the reduction of labor and fuel energy resources per unit of output.

The high efficiency of using ash waste from combined heat and power plant (CHP) in the production of building materials was proven by numerous scientific studies and experiments. This is reflected in the reduction of raw material consumption, fuel and energy reserves, and the shortening of technical cycle of manufactured product. Another solution is to save materials by eliminating ash heap. The transportation of ash to heap and using heap requires a large amount of funds.

Fine-grained concrete FGC is widely used in the construction industry. Among them are paving slabs and slabs for various road surfaces. However, as we have seen in practice, fine-grained concrete is exposed to aggressive environmental influences, salts are formed on its surface, which deteriorates the appearance of the product and leads to its destruction. Another disadvantage is that fine-grained concrete has a higher consumption of Portland cement than conventional heavy concrete. One of the possible ways to solve this problem is to improve the properties and structure of fine-grained concrete by adding various additives. The use of multi-ton waste from combined heat and power plants directly responds to the problem of processing and implementing resource-saving technologies. Thus, using combined heat and power plant ash allows the production of a new effective type of building material with improved construction properties, simultaneously reducing capital and operating costs, the composition of ash heaps, which significantly reduces the product. The use of ash heaps in the production of building materials will, firstly, improve the environmental situation in the region, and secondly, solve the problem of disposing of large-tonnage waste.

The studied scientific work was carried out within the framework of the State Program of Industrial and Innovative Development of the Republic of Kazakhstan for 2020-2025.

The object of the research. Paving slabs made from fine-grained concrete based on local raw materials.

The scope of the research. Study of the structure of FGC developed for road pavements and its effect on the strength of these concretes, technology development of the production of paving slabs from fine-grained concrete based on local raw materials.

The utilization of industrial waste and its use in the field of building materials is considered one of the urgent issues to save natural resources. Such a program will undoubtedly affect the expansion of nomenclature of building composites produced at a new technical level. Accordingly, it is possible to produce ceramic materials, fly ash concrete, and arbolite products through these directions using ash from ash heaps with local raw materials. The use of fly ash in the production of building materials and the utilization of fly ash heaps are both economically and environmentally beneficial. One of the most effective directions for this is its use as a raw material in the production of building materials. It is worth noting that there is a shortage of effective building materials, especially low-cost and low-quality materials in the Kyzylorda region today. In this regard, fly ash heaps will be used of in the field of building materials, in particular, concrete, ceramics, lightweight aggregates, etc.

The idea of thesis research. The main scientific and technical idea of the thesis work is to obtain various building materials for the production of building materials, depending on chemical mineralogical, phase composition and distribution area of the ash of the Kyzylorda CHP.

The use of multi-ton waste from combined heat and power plants directly responds to the problem of processing and implementing resource-saving technologies. Thus, using ash from combined heat and power plants allows to produce a new effective type of building material with improved construction technical properties, simultaneously reduce capital and current costs, the composition of ash heaps, which significantly reduces product cost.

The purpose of thesis work is the technology of manufacturing road products from fine-grained concrete based on local raw materials.

The following tasks were set to achieve the purpose of work:

- to research the composition, properties and structural features of fly ash from the Kyzylorda combined heat and power plant (CHP);
- to determine and research of optimal composition of FGC for road pavements with CHP ash waste addition;
- to develop the technology of production of FGC road pavement slabs with addition of highly active metakaolin (HAM) and C-3 to CHP ash waste;
- to determine the economic efficiency of FGC pavement slabs production based on local raw materials and organomineral additives.

Methods of achieving set tasks

The solution of set tasks is carried out in accordance with generally accepted methodology of implementation of scientific research, which includes generalization and analysis of previous research, analytical, laboratory and industrial-experimental testing of technological developments. The solution of set tasks was carried out in accordance with generally accepted methodology of implementation of scientific research, which includes the generalization and

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Submitted for protection:

* Optimal composition and properties of fine-grained concrete based on organomineral (CHP ash–C-3, FGC) additives.

* Results of physicochemical analysis of the structure of fine-grained concrete based on organomineral (CHP ash–C-3, FGC) additives..

* Technology of fine-grained concrete production based on organomineral (ash – C-3, FGC) additives.

* Calculation of economic efficiency of using concrete for road pavements based on organomineral mixtures.

Scientific novelty of work.

Effective fine-grained concrete for road products with high homogeneity and reduced capillary porosity was obtained by unique grinding of local raw materials, CHP ash and C-3 mixture and adding FGC.

During the hardening process of cement stone in the FGC composition, low-basic hydrosilicates, plomberite minerals (C₅S₆H_n), and gyrolite minerals are formed, which contribute to an increase in the hydration degree, acceleration of the crystallization processes of hydrosilicates, and an increase in the strength of fine-grained concrete.

FGC with improved properties for road pavements was obtained by introducing an organomineral mixture consisting of metakaolin modifier and CHP ash, which contributes to reducing capillary porosity, increasing density, obtaining stable new formations in the form of low-basic calcium hydrosilicates, as well as strengthening the contact zone between cement stone and aggregate.

The practical significance of work.

The use of Kyzylorda CHP ash heap waste in the production of road paving slabs is not only beneficial for the construction industry, but also the most rational way to solve economic and environmental problems.

The optimal composition of Kyzylorda CHP ash, by adding HAM and C-3, was determined to develop FGC composition necessary for the production of road paving slabs.

Economic benefits of obtained results. The developed compositions and methods of obtaining paving slabs were tested at the production base of LLP “NurBestStroyService” in Kyzylorda. An experimental batch of 10,000 pieces was produced. A new composition for paving slabs was obtained.

The economic efficiency of the production of 1 m³ of paving slabs using proposed technology compared to the known technology is approximately 5910 tenge, and with a production volume of 10,000 m³ per year - more than 59 million tenge.

The personal contribution of researcher.

- The characteristics of raw materials of the preparation of organomineral admixtures for fine-grained concrete were determined experimentally;

- The current state of production technology of paving slabs from fine-grained concrete was analyzed in the works of domestic and foreign scientists.
- the optimal composition of fine-grained concrete based on organomineral (ash-C-3) and HAM aggregates was determined and its properties were studied;
- The optimal composition of binder and fine-grained concrete with addition of organomineral admixture was determined by mathematically planning experimental work. Nomograms of optimal composition were created.
- The microstructure of cement stone in fine-grained concrete with the addition of organomineral admixtures and HAM was studied and specific conclusions were drawn.
- The structure of fine-grained concrete with proposed organomineral admixture and HAM was analyzed by X-ray phase analysis.
- The composition and physical and mechanical properties of fine-grained concrete with addition of organomineral admixtures and HAM were determined and analyzed.
- The economic efficiency of production technology of paving slabs from fine-grained concrete based on local raw materials was calculated.

Approbation of work.

The materials of thesis research were presented and discussed at the following international and domestic scientific and practical conferences: Study of properties of fine-grained concrete for road pavement products. IV World Science and Innovations 2019: Central Asian International Scientific and Practical Conference. January 21, 2019. pp. 270-274; “Study of ash collected from the Kyzylorda combined heat and power plant for using as raw materials for fine-grained concrete”. IX International Scientific and Practical Conference “Science and education in the modern world: challenges of the XXI century”. Technical Sciences. Volume I. Nursultan-2021. pp. 22-25; Abstracts of IV International Scientific and Practical Conference “Preparation of organo-mineral additives for fine-grained concrete based on local raw materials”. Milan, Italy (January 31-February 02, 2022).

Publication of research results.

12 scientific works were published on the thesis theme, including: 1 article in publications indexed by Scopus and Web of Science databases; 3 articles in journals included in the list of publications of the Committee for Quality Assurance in the Field of Science and Education; 2 articles in international scientific and practical collections of conferences; 1 article in other international publications, 1 article in other publications of the Republic of Kazakhstan, as well as 5 patents for utility patents were obtained.

Structure and scope of work:

The thesis work consists of introduction, four parts, conclusion, a list of references, and appendices in accordance with content and objectives of research. The volume of the work is 127 pages of texts, 37 figures, 27 tables, 9 appendices (10 pages) and 116 references (8 pages).

The validity and correctness of scientific principle, the conclusions and recommendations were confirmed:

- Organomineral admixture, namely highly active metakaolinite, superplasticizer C-3, and ash from Kyzylorda CHP plant was used in fine-grained concrete;
- Optimal composition of binder and fine-grained concrete composition with addition of organomineral admixtures was determined by mathematical planning of experimental work.
- Economic efficiency of production technology of paving slabs from fine-grained concrete based on local raw materials.
- The research results were published in high-impact journal included in Scopus database and protected by patents.