THESIS ABSTRACT

on the research topic: "The Research of the Physical and Mechanical Properties of Modified Concrete for Road Construction"
for the degree of Doctor of Philosophy (PhD)
in the educational program 8D07302 – "Production of Construction Materials, Products, and Structures"

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This dissertation is devoted to the study of the physical and mechanical properties of modified concrete for road construction and the development of a complex additive composition.

The purpose of the dissertation is to develop a composition for durable concrete with enhanced performance properties for road construction, incorporating silica-containing complex additives, and to study its physical and mechanical properties.

The research objectives are as following:

- to develop a complex additive (modifier) composition;
- to study the effect of the modifier on the properties of cement stone;
- to develop a modified concrete composition for road construction;
- to study the physical and mechanical properties of modified concrete;
- to conduct pilot production work to produce concrete from modified concrete based on metakaolin, superplasticizer, and wollastonite (dispersed filler);
- to determine the technical and economic efficiency.

Research methods:

The research methodology is based on a combination of theoretical and empirical approaches, including generalization, comparative analysis, experimentation, and the principles of systems thinking, mathematical modeling, and planning and processing of experimental data. We used a systems-based approach in our research on construction materials, taking into account the interrelationships between material composition, structure, and properties. This allows us to optimize production and operational processes more effectively. To conduct our experiments, we used laboratory samples and modern analytical techniques such as electron microscopy, chemical analysis. These methods provide more accurate and reliable results, allowing us to assess material properties and quality with a high level of confidence. All tests were conducted in accordance with the state standards and other relevant regulatory documents of Kazakhstan. They were performed in accredited laboratories.

Scientific statements submitted for the dissertation defense:

- the developed composition of a complex additive for obtaining high-strength modified concrete;

- the effect of the complex additive on the physical and mechanical properties of modified concrete;

- the concrete composition for road construction modified with the complex additive.

The scientific novelty of the dissertation:

- the scientifically substantiated composition of the complex additive that regulates the concrete properties;
- the scientifically substantiated composition of the modified concrete based on metakaolin, superplasticizer, and wollastonite (dispersed filler);
- the theoretical and experimental substantiation of the possibility of using a complex additive consisting of metakaolin, superplasticizer, and wollastonite (dispersed filler). This complex additive improves the strength, deformation properties, density, and durability of road concrete under transport loads;
- the main provisions governing the interaction of the additive components with the cement matrix have been expanded, in particular the role of metakaolin as a pozzolanic activator and wollastonite (dispersed filler) as a microreinforcing and stabilizing element, which are consistent with the scientific research of scientists;
- it was established that due to water the activation in the electrolyzer, metakaolin acquires increased chemical activity, which causes the processes of hydrolysis and hydration of cement grains;
- the resulting modified concrete, compared to the control sample, has a compressive strength 50% higher, a tensile strength in bending greater than 28%; water absorption was 2,6%; water resistance grade was W12 (1,2 MPa); frost resistance was not lower than F400;
- the effectiveness of a complex additive in improving the performance characteristics of road concrete, including increased wear resistance and abrasion resistance, was experimentally confirmed.

The scientific novelty and originality of the results are confirmed by the patent of the Republic of Kazakhstan for the invention "Modified Concrete Mixture" №36733 dated May 3, 2024, certificate № 62583 for objects protected by copyright "The influence of a complex additive on the performance properties of concrete for road construction", as well as 1 publication in the international scientific journal Geomate, included in the Scopus database, 2 publications in a journal recommended by SandHEQAC of the MofSandHE of the Republic of Kazakhstan, as well as at 2 international scientific conferences.

This dissertation was completed within the framework of the Resolution of the Government of the Republic of Kazakhstan "On Approval of the Concept for the Development of Transport and Logistics Potential of the Republic of Kazakhstan until 2030", "National Infrastructure Plan of the Republic of Kazakhstan" until 2029, as well as in accordance with the priority direction of scientific development for 2024-2026 "Energy, Advanced Materials and Transport", the Address of the Head of State K. Tokayev to the People of Kazakhstan "A Fair Kazakhstan: Law and Order, Economic Growth, Public Optimism" and the economic project "One Belt - One Road".

The results of this dissertation allow the use of the raw material base of the Republic of Kazakhstan for the production of modified concrete for road construction, and also allow:

- to develop compositions of complex additives that regulate the physical, mechanical, and performance properties of heavy concrete;

- to develop a modified concrete composition for road construction with a wollastonite (dispersed filler), metakaolin and a superplasticizer;
- to conduct comprehensive studies of the modified concrete microstructure, which revealed the positive impact of the additive components on the structure of the cement stone, the density and homogeneity of the concrete, and its durability;
- to achieve high compressive and flexural strength values, as well as frost resistance, that meet and exceed regulatory requirements. This confirms the effectiveness of the developed composition for use in road construction conditions with increased operational loads.

The research results have been introduced into the educational process of the Abylkas Saginov Karaganda Technical University's "Modern Materials Based on Local Raw Materials" course for the 7M07303 educational program "Production of Building Materials, Products, and Structures".

Pilot testing of the technical solutions was conducted at the production site of ElitTechGroup LLC.

The developed technological solutions can be recommended for widespread practical application in road construction and can also be used in the design, production, and installation of durable concrete road surfaces.

Degree of reliability of the research results.

Laboratory studies were conducted in the following accredited laboratories: the laboratory of Technical Control of Buildings and Structures Safety LLC, Karaganda and the innovative Electron Microscopy Laboratory of E.A. Buketov Karaganda National Research University, both equipped with modern equipment. The laboratory results were confirmed by pilot tests.

The applicant's personal contribution consists in the development of goals and objectives, the choice of research methods, development of the composition of a complex additive, and further development of the composition of modified concrete for road construction, determining the effect of the complex additive on the physical and mechanical properties of modified concrete, conducting pilot tests, and determining the technical and economic efficiency.

Approbation of the work. The main results of the dissertation have been published in the following journals/conferences:

1. The influence of a complex additive on the strength characteristics of concrete for road construction //International Journal of GEOMATE, 2023. - Vol. 25, Issue 110. - p.243-250.
2. The influence of a complex additive on the hydrophysical properties of concrete for road construction //LINDI 2024 6th IEEE International Symposium on Logistics and Industrial Informatics, 2024. – p.169-172.
3. Application of fibrous fillers in cement concrete for road construction // Республиканский журнал Труды универитета, 2022. - 4(89) 2022. - С.235-238.
4. Влияние метакаолина на свойства цементных систем //Республиканский журнал Труды универитета, 2023. - 1(90) 2023. - С.233-239.
5. Перспективы использования цементобетонных покрытий в дорожном строительстве //Труды международной научно-практической online

конференции «Интеграция науки, образования и производства – основа реализации Плана нации» (Сагиновские чтения №13), посвященной 30-летию Независимости Республики Казахстан. – Караганда: Изд-во КарТУ, 2021. – С. 1535-1536.
6. Патент РК на изобретение «Модифицированная бетонная смесь» №36733 от 03 мая 2024 г.
7. Свидетельство о внесении сведений в государственный реестр прав на объекты, охраняемые авторским правом №62583 «Влияние комплексной добавки на эксплуатационные свойства бетона для дорожного строительства», 2025 г.