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USE OF FLY ASHES AND ASH AND SLAG MIXTURES OF PAVLODAR GRES-2 IN ROAD CONSTRUCTION

In the context of increasing environmental load and increasing volumes of industrial waste, the search for effective methods of utilizing ash generated during fuel combustion at thermal power plants is becoming relevant. This work is devoted to the development of an ash-soil composite material designed to strengthen road bases using ash from GRES-2 in the Pavlodar region. The purpose of the study is to create a composition of ash-soil material with high physical, mechanical and operational characteristics. The study included a study of the patterns of formation of the structure and properties of the material depending on the formulation and technological factors, and a technology for its manufacture was developed.

The scientific novelty of the study lies in the theoretical substantiation and experimental confirmation of the hardening processes of ash-soil composites, as well as the structure formation of the ash binder activated by individual and complex activators, depending on the soil moisture and compaction pressure.

The practical significance of the work is manifested in the creation of an environmentally friendly and economically feasible solution for strengthening road bases using industrial waste. The implementation of

the research results will reduce the volume of stored waste, reduce the environmental load and free up land plots used for ash dumps.

The expected result is an increase in the strength and durability of road structures due to the use of ash-soil composite.

Keywords: soil strengthening, cohesive soils, ash and slag mixture, lime, road construction, soil modification, frost resistance.

Introduction

The development of road infrastructure has a direct impact on the economic growth and social mobility of the regions. In the context of rapid wear and tear of road surfaces, especially in regions with sharp climatic fluctuations, there is a need to apply effective and economically feasible solutions in the construction and repair of roads. One of the promising areas is the use of fuel industry waste, in particular fly ash from coal combustion, as binders or modifying additives to strengthen the soils of road pavement bases.

The purpose of this work is to analyze the possibility of using ash from Ekibastuz SDPP-2 in strengthening the bases of road surfaces, taking into account its physical and chemical properties and compliance with the requirements of regulatory documents.

The relevance of the study is due to the need to dispose of large volumes of fly ash, its environmental safety and the potential to replace scarce natural construction resources, which contributes to sustainable development and reducing the cost of road construction works.

The use of fuel industry waste, in particular ash and ash and slag materials, in road construction is actively studied both in domestic and foreign scientific literature. The main attention is paid to their impact on the strength characteristics of soils, as well as the possibility of reducing the cost and increasing the environmental friendliness of construction.

According to a study by Ivanov et al., the use of fly ash as an active mineral additive can improve the adhesion of binders to the mineral part of the soil, increase the strength and frost resistance of road bases [1]. The works of Dubler, Akhtin indicate the effectiveness of stabilization of weak soils using ash and lime, especially in the conditions of the II and III road climatic zones [2]; [3].

The studies of Gorbachev et al. consider the use of ash waste as an independent binder and as part of complex compositions with organic and inorganic components. It was revealed that ash with an active silicate and aluminate component is able to enter into pozzolanic reactions, forming strong hydrate compounds in the conditions of the road base [4].

The Chinese experience, presented in a number of sources by Li and Zhang, Wang et al., demonstrates a model of waste-free production, where ash from

thermal power plants is almost completely used in construction, including in the construction of road foundations. This allows not only to minimize the volume of stored waste, but also to significantly reduce the cost of building materials [5]; [6].

According to Suleimenov et al., the ash of Ekibastuz coals is distinguished by a stable chemical composition, mainly represented by silicon and aluminum oxides, as well as a low carbon content and background radiation [7]. This makes it a promising component in soil strengthening technology. The work of Abishev et al. also emphasizes the importance of pre-grinding of ash and its activation to increase the binding properties, including alkaline activation using water glass or technical caustic soda [8].

World and Kazakh practice confirms the successful use of ash in road construction: as an additive to cement concrete, in the stabilization of weak bases and in the formation of structural layers of the pavement of Nurmakhanov et al [9].

Singh & Siddique also analyzes the potential of ash materials in stabilizing clay soils using alkaline activation, emphasizing the increase in strength and the reduction of deformations. This once again confirms the universality of the approach at the international level [10].

Thus, the analysis of scientific sources demonstrates the high efficiency and prospects of using ash from coal combustion in road construction technology. This direction ensures the stability of the structure, reduces the cost of materials and at the same time contributes to the disposal of industrial waste, which is especially important in the context of sustainable development.

Materials and methods

The following materials and methods were used in the study aimed at strengthening cohesive soils using ash and slag mixture and hydraulic lime to improve the properties of soils used in road construction. For the study, samples of ash ash were taken from different distances from the waste discharge site of 50 m, 100 m, 200 m and 300 m, with an analysis of their granulometric composition. The maximum grain size of the ZShS is 25 mm. Cohesive soils, such as sandy loam and loam, were used. These soils were improved with the addition of SHS in the amount of 40 to 80 % by weight.Hydraulic lime with a CaO+MgO content of 71 % was used to improve the strength characteristics of the soils. Lime was added to mixtures in amounts of 6 % and 8 % by weight. Calcium chloride ($CaCl_2$) hardening activator was used to moisten ash mixtures to optimal moisture.

To assess the properties of ash-soil mixtures, cylindrical samples with a diameter of 35 mm and a height of 50 mm were manufactured. These specimens were used for strength, frost resistance, and flexural tensile tests.

Results and discussion

Determination of optimal moisture content and maximum density.In the laboratory, the selection of optimal moisture and maximum density for various

compositions of ash and soil mixtures was carried out, depending on the addition of ash and lime. These parameters were determined using the standard compaction method GOST 22733 – 2016.Compressive strength in vivo was measured for samples with different concentrations of ash and lime. Each cycle consisted of 4 hours of freezing at – 22 °C and 4 hours of thawing. The tests were carried out after 5 and 10 freeze cycles.

Table 1 – Indicators of strength and frost resistance of reinforced soils

Index	**Class I**	**Class II**	**Class III**
Compressive strength of water-saturated samples (28 days), MPa	≥2,0	≥1,0	≥0,5
Compressive strength of water-saturated samples (90 days), MPa	≥4,0	≥2,0	≥1,0
Frost resistance coefficient after 90 days of hardening	≥0,75	≥0,65	≥0,50

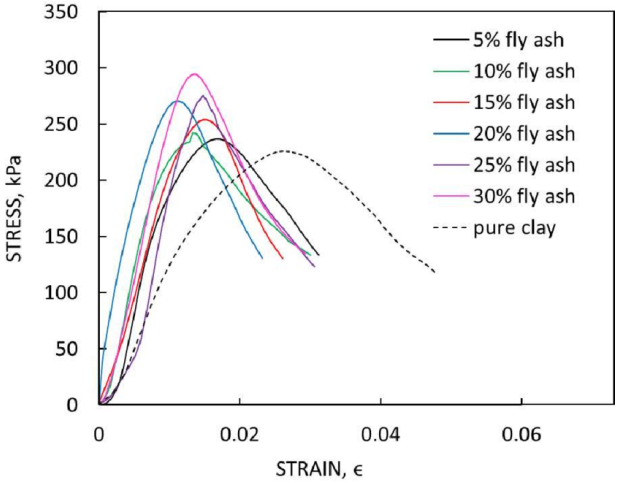

Figure 1 – Compressive Strength Graph

To assess frost resistance, the samples were subjected to freeze and thaw cycles. After each cycle, the compressive strength and excess moisture of the samples were evaluated. Excess moisture was considered to be a moisture content that exceeds the optimal amount.

Tensile strength at bending was measured for specimens with a size of 4×4×16 mm. Standard cement beams manufactured at a pressure of 30 MPa were used

for testing. To assess the compliance of strengthened soils with road construction standards, the results of strength and frost resistance tests were compared with the requirements of SNiP RK 3.03-09-2006. Soils have been classified into strength classes (I, II, III) based on their compressive and tensile strength.

To identify the dependence of strength characteristics on the composition of the mixture (dosage of ash and lime), a regression analysis was carried out, which made it possible to optimize the proportions of the components to achieve the best results.

Conclusion

The introduction of SHS into the composition of the soil significantly increases its strength characteristics. The maximum effect is achieved with a SHF content of 60 %. Soils with this composition demonstrate compressive strength up to 6.0 MPa, which meets the requirements of the first category of reinforced soils according to SNiP RK 3.03-09-2006.

The addition of hydraulic lime in the amount of 6–8 % improves the strength characteristics of soils and contributes to their better frost resistance. Lime activates hardening and increases the resistance of materials to external influences.

Studies have shown that soils with the addition of SHS and lime retain their strength even after 10 cycles of freezing and thawing, which confirms their suitability for use in cold regions.

With an increase in the share of ash ash in the soil, the optimal moisture content decreases, which is due to less water absorption of large fractions of ash ash in comparison with fine ones. This is a factor that must be taken into account when preparing the mixture for maximum density.

Flexural tensile strength: The flexural tensile strength for all the studied specimens meets the requirements for the first category of reinforced soils, which indicates the high deformable properties of these materials.

Recomendation

To achieve maximum strength characteristics, it is recommended to use 60 % of SHS and lime in a dosage of 6–8 %. This will ensure high strength, frost resistance and durability of the material, which makes it suitable for road construction in various climatic conditions.

Additional research is needed to optimize the composition and dosages of ash ash and lime, taking into account the specifics of soils of different types, as well as their use in different climatic zones. This will allow you to more accurately select the composition of the mixture for specific operating conditions.

To improve the deformation stability characteristics of soils, the effects of additional additives, such as organic or synthetic polymers, which can increase tensile strength and reduce material flexural brittleness, should be studied.

Based on the results obtained, it is recommended to introduce reinforced soils with the addition of SHS and lime in road construction, especially in regions with extreme climatic conditions. These materials can significantly increase the durability of road surfaces and reduce the cost of their maintenance.

The use of ash ash as a component for soil improvement contributes to the disposal of waste with minimal impact on the environment. This direction is consistent with the principles of sustainable development and can be recommended for use in environmentally friendly construction projects.

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АВТОМОБИЛЬ ЖОЛДАРЫН САЛУ КЕЗІНДЕ ПАВЛОДАР ГРЭС-2-НІҢ КҮЛІ ЖӘНЕ КҮЛ МЕН ҚОЖ ҚОСПАЛАРЫН ПАЙДАЛАНУ

Экологиялық жүктеменің ұлғаюы және өнеркәсіп қалдықтарының көлемінің ұлғаюы жағдайында жылу электр станцияларында отынды жағу кезінде пайда болатын күлді кәдеге жаратудың тиімді әдістерін іздеу өзекті болып отыр. Бұл жұмыс Павлодар облысындағы ГРЭС-2 күлін пайдалана отырып, жол негіздерін нығайтуға арналған күл-топырақ композициялық материалды әзірлеуге арналған. Зерттеудің мақсаты – жоғары физикалық, механикалық және эксплуатациялық сипаттамалары бар күл-топырақ материалының құрамын жасау. Зерттеу құрамында тұжырымы мен технологиялық факторларға байланысты материалдың құрылымы мен қасиеттерінің қалыптасу заңдылықтары зерттеліп, оны жасау технологиясы жасалды.

Зерттеудің ғылыми жаңалығы күл-топырақ композиттерінің қатаю процестерін, сондай-ақ топырақтың ылғалдығы мен тығыздалу қысымына байланысты жеке және күрделі активаторлармен белсендірілген күлді байланыстырғыштың құрылымын қалыптастыруды теориялық негіздеу және тәжірибе жүзінде растау болып табылады.

Жұмыстың практикалық маңыздылығы өндірістік қалдықтарды пайдалана отырып, жол негіздерін нығайтудың экологиялық таза және экономикалық тиімді шешімін жасауда көрінеді. Зерттеу нәтижелерін енгізу жинақталған қалдықтардың көлемін азайтуға,

экологиялық жүктемені азайтуға және күл үйінділері үшін пайдаланылатын жер учаскелерін босатуға мүмкіндік береді.

Күтілетін нәтиже – күл-топырақ композитін қолдану есебінен жол құрылыстарының беріктігі мен беріктігінің артуы.

Кілтті сөздер: топырақты нығайту, топырақты үйлесімділік, күл және қож қоспасы, әк, жол құрылысы, топырақты модификациялау, аязға төзімділік.

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ПРИМЕНЕНИЕ ЗОЛ-УНОСА И ЗОЛОШЛАКОВЫХ СМЕСЕЙ ПАВЛОДАРСКОЙ ГРЭС -2 ПРИ СТРОИТЕЛЬСТВЕ АВТОМОБИЛЬНЫХ ДОРОГ

В условиях нарастающей экологической нагрузки и увеличения объемов промышленных отходов, актуальным становится поиск эффективных способов утилизации золы, образующейся при сжигании топлива на теплоэнергетических предприятиях. Данная работа посвящена разработке зологрунтового композиционного материала, предназначенного для укрепления дорожных оснований, с использованием золы ГРЭС-2 Павлодарской области.

Цель исследования заключается в создании состава зологрунтового материала с высокими физико-механическими и эксплуатационными характеристиками. В рамках работы проведено изучение закономерностей формирования структуры и свойств материала в зависимости от рецептурно-технологических факторов, а также разработана технология его изготовления.

Научная новизна исследования заключается в теоретическом обосновании и экспериментальном подтверждении процессов твердения зологрунтовых композитов, а также структурообразования золовяжущего, активизированного индивидуальными и комплексными

активизаторами, в зависимости от влажности грунта и уплотняющего давления.

Практическая значимость работы проявляется в создании экологически безопасного и экономически целесообразного решения для укрепления дорожных оснований с применением промышленных отходов. Реализация результатов исследования позволит сократить объемы складируемых отходов, снизить экологическую нагрузку и освободить земельные участки, используемые под золоотвалы.

Ожидаемым результатом является повышение прочности и долговечности дорожных конструкций за счёт использования зологрунтового композита.

Ключевые слова: укрепление грунтов, связные грунты, золошлаковая смесь(ЗШС), известь, дорожное строительство, модификация грунтов, морозостойкость.

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