ISSN 2518-170X (Online)
ISSN 2224-5278 (Print)

NEWS OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN, SERIES OF GEOLOGY AND TECHNICAL SCIENCES

№4
2025

ISSN 2518-170X (Online)
ISSN 2224-5278 (Print)

CENTRAL ASIAN ACADEMIC
RESEARCH CENTER

N E W S
OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN, SERIES OF GEOLOGY AND TECHNICAL SCIENCES

4 (472)

JULY – AUGUST 2025

THE JOURNAL WAS FOUNDED IN 1940

PUBLISHED 6 TIMES A YEAR

ALMATY, 2025

«Central Asian Academic Research Center» LLP is pleased to announce that "News of NAS RK. Series of Geology and Technical sciences" scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of Geology and Technical Sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

«Орталық Азия академиялық ғылыми орталығы» ЖШС «ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Web of Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

ТОО «Центрально-азиатский академический научный центр» сообщает, что научный журнал "Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

N E W S OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN, SERIES OF GEOLOGY AND TECHNICAL SCIENCES
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Owner: «Central Asian Academic research center» LLP (Almaty).
The certificate of registration of a periodical printed publication in the Committee of information of the Ministry of Information and Social Development of the Republic of Kazakhstan **No. KZ39VPY00025420,** issued 29.07.2020.
Thematic scope: *geology, hydrogeology, geography, mining and chemical technologies of oil, gas and metals*
Periodicity: 6 times a year.
http://www.geolog-technical.kz/index.php/en/

N E W S OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN, SERIES OF GEOLOGY AND TECHNICAL SCIENCES
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Меншіктеуші: «Орталық Азия академиялық ғылыми орталығы» ЖШС (Алматы қ.).

Қазақстан Республикасының Ақпарат және қоғамдық даму министрлігінің Ақпарат комитетінде 29.07.2020 ж. берілген **№ KZ39VPY00025420** мерзімдік басылым тіркеуіне қойылу туралы куәлік.

Тақырыптық бағыты: *Геология, гидрогеология, география, тау-кен ісі, мұнай, газ және металдардың химиялық технологиялары*

Мерзімділігі: жылына 6 рет.

http://www.geolog-technical.kz/index.php/en/

NEWS OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN, SERIES OF GEOLOGY AND TECHNICAL SCIENCES
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Собственник: ТОО «Центрально-азиатский академический научный центр» (г. Алматы).

Свидетельство о постановке на учет периодического печатного издания в Комитете информации Министерства информации и общественного развития Республики Казахстан **№ KZ39VPY00025420,** выданное 29.07.2020 г.

Тематическая направленность: *геология, гидрогеология, география, горное дело и химические технологии нефти, газа и металлов*

Периодичность: 6 раз в год.

http://www.geolog-technical.kz/index.php/en/

CONTENTS

Sh.K. Aitkazinova, B.B. Imansakipova, O.O. Sdvizhkova, D.M. Kirgizbaeva, A.B. Imansakipova
Localization of the sinkhole hazard of the earth's surface during underground mining........8

T.M. Almenov, R.K. Zhanakova, G.E. Askarova, M.R. Shautenov, K. Amantayuly
Comprehensive assessment of ore losses and dilution impacting Vasilkovsky gold deposit profitability........27

K.A. Bashmur, V.V. Bukhtoyarov, N.N. Bryukhanova, R.V. Kononenko, V.V. Kondratyev
Intelligent diagnostics and prediction of wear of drilling equipment elements using LSTM and GRU models........46

A.Z. Bukayeva, V.V. Povetkin
Development of thermal jet tool for preparation and combustion of pulverized coal fuel........59

A.Z. Darkhan, A.A. Anarbayev
Study of the process of producing ceramic granite based on mineral raw materials and silica production waste........74

G.K. Dzhangulova, T.V. Dedova, O.P. Kuznetsova, N.Z. Bashirova, A.A. Kalybekova
Dam break flooding simulation using a dem constructed from lidar data........92

B.T. Zhumabayev, A.A. Altaibek, A.T. Sarsembayeva, M. Nurtas
Space weather influence on seismic activity: analyzing the May 1, 2011, MW 5.1 earthquake in Kazakhstan........109

S. Zhussupbekov, L. Abzhanova, Y. Orakbaev, S. Sagyndykova, A. Kuanyshbayeva
Network hydrodynamic model of underground uranium leaching........125

G.I. Issayev, I.G. Ikramov, N.A. Akhmetov, G.Zh. Turmetova, R. Izimova
The impact of lead production on the nature of the distribution of slag waste in the environment........137

B. Isakulov, D. Zhumamuratov, H. Abdullaev, Z. Tukashev, A. Issakulov
Increasing the durability of deep impregnation arbolite with gray petrochemical wastes........153

Israa J. Alhani, Wael M. Albadri
Developing prediction equation for the swelling and swelling pressure of swellable clay based on experimental data..169

A.G. Kassanova, G.M. Efendiyev, I.A. Piriverdiyev, M.K. Karazhanova, N.M. Akhmetov
Assessment of the characteristics of the geological section of wells based on complex geophysical and technological information.....................................184

S.Zh. Kassymkhanov, K.K. Tolubayeva
Rheological model of molding mixtures in foundry machines............................199

A. Kuttybayev, O. Khayitov, L. Saidova, A. Umirzokov, Y. Makhat
The influence of chloride ions on uranium sorption from productive solutions of sulfuric acid leaching of ores...211

A.N. Munaitpassova, A.K. Zheksenbaeva, A. Zhadi, A. Zhanat
Regional climate changes in Almaty region under global climate change..........222

M.N. Mussabayeva, T.K. Salikhov, Sh.K. Musabayeva, Y.K. Shulghaubaev, G.K. Baimukasheva
Natural resource potential of the lake geosystem of Akmola region...................242

A. Mustafina, Zh. Inkarova, G. Baimukasheva, M. Jexenov, Zh. Tukhfatov
Impact of oil and gas fields on atmospheric air and public health in Atyrau region (a case study of Zhylyoi district)...260

K.G. Satenov, Ye.M. Suleimen, G.K. Mamytbekova, A.S. Kalauova
Development and modeling of a resource-saving process for methanol extraction by the example of X oilfield...280

D.Kh. Sunakbaeva, D.Kh. Yuldashbek, K. Aitekova, S.M. Nurmakova, M. Waris
Assessment of the effectiveness of biostabilization in improving the geotechnical properties of degraded soils in the arid regions of Kazakhstan..........................295

E.V. Khudyakova, V.V. Kukartsev, A.A. Stupina, S.V. Pchelintseva, K.S. Muzalev
Machine learning for modelling the impact of geo-environmental factors on natural resource allocation...312

NEWS OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC
OF KAZAKHSTAN, SERIES OF GEOLOGY AND TECHNICAL SCIENCES
ISSN 2224–5278
Volume 4. Number 472 (2025), 153–168

https://doi.org/10.32014/2025.2518-170X.536

IRSTI 67.09.55
UDC 691.34

© B. Isakulov[1], D. Zhumamuratov[2], H. Abdullaev[3], Z. Tukashev[3], A. Issakulov[3]*, 2025.
[1]Institutions Baishev University, Aktobe, Kazakhstan;
[2]Nukus Mining Institute at Navoi State Mining and Technology University, Nukus, Uzbekistan;
[3]Aktobe Regional University named after K. Zhubanov, Aktobe, Kazakhstan.
E-mail: mr.baizak@mail.ru

INCREASING THE DURABILITY OF DEEP IMPREGNATION ARBOLITE WITH GRAY PETROCHEMICAL WASTES

B. Isakulov — Doctor of Technical Sciences, Research Professor, Department of “Science and Innovations” institutions “Baishev University”, Aktobe, Kazakhstan,
E-mail: mr.baizak@mail.ru, https://orcid.org/0000-0002-4597-2028;
D. Zhumamuratov — Candidate of Technical Sciences, Associate Professor, Deputy Director of Nukus Mining Institute at Navoi State Mining and Technology University, Nukus, Uzbekistan,
E-mail: daniarjk@mail.ru, https://orcid.org/0009-0009-8824-0255;
Kh. Abdullaev — Candidate of Technical Sciences, Associate Professor of the Department of “Transport Engineering, Organization of Transportation and Construction”, Aktobe Regional University named after K. Zhubanov, Aktobe, Kazakhstan,
E-mail: hamit_66@mail.ru, https://orcid.org/0000-0001-7490-6241;
Z. Tukashev — Candidate of Technical Sciences, Associate Professor of the Department of “Transport Engineering, Organization of Transportation and Construction”, Aktobe Regional University named after K. Zhubanov, Aktobe, Kazakhstan,
E-mail: Tukashev291955@mail.ru, https://orcid.org/0009-0000-5804-5197.
A. Issakulov — PhD, senior lecturer of department “Transport engineering, organization of transportation and construction” of Aktobe regional university named after K. Zhubanov, Aktobe, Kazakhstan,
E-mail: issakulov.abilkhair@gmail.com, https://orcid.org/0000-0002-2462-6185.

Abstract. The article deals with the study of increasing the durability of arbolite concrete products by means of deep impregnation with sulfur from petrochemical waste. As the composition of arbolite-concrete composites includes various vegetable wastes (wood chips, crushed stalks of cane and cotton, corn cob wastes, crushed walnut shells, etc.) and it has low strength and has a small average density. For this reason, deep seasoned impregnation of molten liquid sulfur of samples of arbolite concrete composites should lead to an increase in physical and mechanical characteristics and durability of lightweight concrete and will also protect against the effects of aggressive external factors. The impregnation of porous arbolite-concrete composites is made by the contraction method, when the penetration of the impregnating liquid into the freshly molded arbolite-concrete mixture occurs due to the vacuum caused by physical and chemical processes of the cement binder dough. For making arbolite-concrete composites we used porous wastes of shredded corn cob with sizes ranging from 10 to 40 mm. To compare the results, we used denser wastes of crushed walnut shells with sizes from 10 - 20mm and crushed cotton stalks with sizes 10-25mm. For the study adopted the method of complete impregnation of arbolite concrete samples with liquid molten sulfur. As impregnation material sulfur - waste of oil refinery of Atyrau region of Kazakhstan was used. We have established that the physical and mechanical properties of impregnated arbolite concrete samples are very high and they can be recommended for use in underground and engineering structures.

Keywords: Sulfur waste, contracting method, impregnation of samples, porous aggregates, durability, aggressive factors, ultimate strength

© Б. Исакулов[1], Д. Жумамуратов[2], Х. Абдуллаев[3], Ж. Тукашев[3], А. Исакулов[3*], 2025.

[1]Баишев университеті мекемесі, Ақтөбе, Қазақстан;
[2]Науайы мемлекеттік тау-кен технологиялық университеті жанындағы Нөкіс тау-кен институты, Нөкіс, Өзбекстан;
[3]Қ. Жұбанов атындағы Ақтөбе өңірлік университеті, Ақтөбе, Қазақстан.
E-mail: mr.baizak@mail.ru

МҰНАЙ-ХИМИЯ ӨНДІРІСІ ҚАЛДЫҒЫ ТЕХНИКАЛЫҚ КҮКІРТТІ ТЕРЕҢ СІҢІРУ ӘДІСІМЕН АРБОЛИТТІҢ ҚАСИЕТТЕРІН АРТТЫРУ

Б. Исакулов — техника ғылымдары докторы, профессор, Баишев университеті мекемесінің «Ғылым және инновация» департаментінің зерттеуші профессоры, Ақтөбе, Казақстан,
E-mail: mr.baizak@mail.ru, https://orcid.org/0000-0002-4597-2028;
Д. Жумамуратов — техника ғылымдары кандидаты, Науайы мемлекеттік тау-кен технологиялық университеті жанындағы Нөкіс тау-кен институтының директоры орынбасары, Нөкіс, Өзбекстан,
E-mail: daniarjk@mail.ru, https://orcid.org/0009-0009-8824-0255;
Х. Абдуллаев — техника ғылымдары кандидаты, Қ. Жұбанов атындағы Ақтөбе өңірлік университетінің «Көлік техникасы, тасымалдауды ұйымдастыру және құрылыс» кафедрасының доценті, Ақтөбе, Казақстан,
E-mail: hamit_66@mail.ru, https://orcid.org/0000-0001-7490-6241;
Ж. Тукашев — техника ғылымдары кандидаты, Қ. Жұбанов атындағы Ақтөбе өңірлік университетінің «Көлік техникасы, тасымалдауды ұйымдастыру және құрылыс» кафедрасының доценті, Ақтөбе, Казақстан,
E-mail: Tukashev291955@mail.ru, https://orcid.org/0009-0000-5804-5197;
А. Исакулов — PhD, Қ. Жұбанов атындағы Ақтөбе өңірлік университетінің «Көлік техникасы, тасымалдауды ұйымдастыру және құрылыс» кафедрасының аға оқытушысы, Ақтөбе, Казақстан,
E-mail: issakulov.abilkhair@gmail.com, https://orcid.org/0000-0002-2462-6185.

Аннотация. Мақалада мұнай-химия өндірісінің қалдығы техникалық күкіртті арболитобетон құрамына терең сіңіру арқылы арболитті бетон бұйымдарының ұзақ уақыт өмір сүруін және беріктігін арттыруды зерттеу мәселелері талқыланады. Арболитті бетон композиттердің құрамына өсімдіктің әр түрлі қалдықтары (ағаш жоңқасы, ұсақталған мақта сылдырмағы, жүгері собығының қалдықтары, ұнтақталған жаңғақ қабықтары, т.б.) кіретіндіктен, олардың беріктігі және орташа тығыздығы төмен болып келеді. Сол себептен балқытылған сұйық күкіртті арболитті бетон композиттерінің үлгілеріне көп уақыт ұстап терең сіңіру, жеңіл бетонның физикалық-механикалық сипаттамалары мен беріктігін арттыруға және сондай-ақ агрессивті сыртқы факторлардың әсерлерінен қорғануға зор көмегін тигізеді. Кеуекті арболитті бетон композиттеріне күкіртті сіңіру, сіңдіру сұйықтығының жаңадан пайда болған арболитті бетон қоспасына енуі, цемент байланыстырушы пастаның физикалық-химиялық процестерінен пайда болған вакуум есебінен түзілген кезде, жиырылуы арқылы жүзеге асырылады. Арболит-бетон композиттерін жасау үшін өлшемдері 10мм-ден 40мм-ге дейінгі өлшемде болған ұсақталған жүгері құлақтарының кеуекті қалдықтары пайдаланылды. Зерттеу нәтижелерін салыстыру үшін біз сондай-ақ өсімдіктердің тығызырақ қалдықтарын, яғни өлшемдері 10-нан 20 мм-ге дейін ұсақталған жаңғақ қабығын және өлшемдері 10-25 мм аралығында ұсақталған мақта сабақтарын алдық. Зерттеуді жүргізу үшін арболит бетон үлгілерін сұйық балқытылған күкіртпен толық сіңдіру әдістері қабылданды. Сіңдіру материалы ретінде Қазақстанның Атырау облысындағы жоғары күкіртті мұнайды өңдеу және тазарту жөніндегі мұнай өңдеу зауытының күкірт-қалдықтары пайдаланылды. Зерттеу барысында біз техникалық күкірт сіңдірілген арболит-бетон үлгілерінің физикалық-механикалық қасиеттері мен коррозияға төзімділігі өте жоғары екенін анықтадық және бұл деректер оларды жерасты және инженерлік ғимараттарды құру құрылыстарда кең көлемде қолдануға ұсынуға болатындығын дәлелдейді.

Түйін сөздер: күкірт қалдықтары, контракциялық әдіс, үлгілерді сіңдіру, кеуекті толтырғыштар, беріктік, агрессивті факторлар, беріктік шегі

© Б. Исакулов[1], Д. Жумамуратов[2], Х. Абдуллаев[3], Ж. Тукашев[3], А. Исакулов[3*], 2025.

[1]Учреждение Баишев университет, Актобе, Казахстан;
[2]Нукусский горный институт при Навоийском государственном горно-технологическом университете, Нукус, Узбекистан;
[3]Актюбинский региональный университет имени К. Жубанова, Актобе, Казахстан.
E-mail: mr.baizak@mail.ru

ПОВЫШЕНИЯ ДОЛГОВЕЧНОСТИ АРБОЛИТА ГЛУБОКОЙ ПРОПИТКИ СЕРОЙ ОТХОДОМ ПРОИЗВОДСТВ НЕФТЕХИМИЙ

Б. Исакулов — доктор технических наук, профессор-исследователь департамента «Наука и инновации» учреждений «Баишев университет», Актобе, Казахстан,
E-mail: mr.baizak@mail.ru, https://orcid.org/0000-0002-4597-2028;
Д. Жумамуратов — кандидат технических наук, заместитель директора Нукусского горного института при Навоийском горно-технологическом университете, Нукус, Узбекистан,
E-mail: daniarjk@mail.ru, https://orcid.org/0009-0009-8824-0255;
Х. Абдуллаев — кандидат технических наук, доцент кафедры «Транспортная техника, организация перевозок и строительства» Актюбинского регионального университета имени К. Жубанова, Актобе, Казахстан,
E-mail: hamit_66@mail.ru, https://orcid.org/0000-0001-7490-6241;
Ж. Тукашев — кандидат технических наук, доцент кафедры «Транспортная техника, организация перевозок и строительства» Актюбинского регионального университета имени К. Жубанова, Актобе, Казахстан,
E-mail: Tukashev291955@mail.ru, https://orcid.org/0009-0000-5804-5197;
А. Исакулов — PhD, старший преподователь кафедры «Транспортная техника, организация перевозок и строительства» Актюбинского регионального университета имени К. Жубанова, Актобе, Казахстан,
E-mail: issakulov.abilkhair@gmail.com, https://orcid.org/0000-0002-2462-6185.

Аннотация. В статье рассматриваются вопросы повышения долговечности арболитобетонных изделий методом глубокой пропитки серой — отходом нефтехимического производства. Так как в состав арболитобетонных композитов входят различные растительные отходы (древесная щепа, измельчённые стебли тростника и хлопчатника, отходы кукурузных початков, измельчённые скорлупы грецкого ореха и др.), они обладают невысокой прочностью и небольшой средней плотностью. По этой причине глубокая выдержанная пропитка образцов арболитобетонных композитов расплавленной серой должна привести к повышению их физико-механических характеристик и долговечности, а также обеспечивать защиту от воздействия агрессивных внешних факторов. Пропитка пористых арболитобетонных композитов производилась контракционным способом, при котором проникновение пропиточной жидкости в свежеотформованную арболитобетонную смесь происходит за счёт вакуума, создаваемого физико-химическими процессами вяжущего цементного теста. Для изготовления арболитобетонных композитов использовались пористые отходы измельчённых кукурузных початков размером 10–40 мм. Для сравнения результатов исследований применялись более плотные отходы растительности — измельчённые скорлупы грецкого ореха размером 10–20 мм и измельчённые стебли хлопчатника размером 10–25 мм. В исследовании применялся метод полной пропитки арболитобетонных образцов расплавленной серой. В качестве пропиточного материала использовалась сера — отходы нефтеперерабатывающего завода по переработке и очистке высокосернистой нефти Атырауской области Казахстана. В ходе исследования установлено, что физико-механические свойства и коррозионная стойкость пропитанных арболитобетонных образцов значительно повышаются, что позволяет рекомендовать их для применения в подземных и инженерных сооружениях.

Ключевые слова: сера-отходы, контракционный способ, пропитка образцов, пористые заполнители, долговечность, агрессивные факторы, предел прочности

Introduction. In Kazakhstan, especially in the cities of Atyrau and Pavlodar oil refineries for processing and purification of high sulfur oil with a capacity of up to 12 million tons of oil per year, which is expected to allow from oil refining to obtain annually from 220 to 230 thousand tons of technical sulfur. Technical sulfur began to be used as a binder in the production of building materials in the early 30s of the twentieth century in England, the United States and then it began to be used in the former Soviet Union in the construction industry. This innovation is based on the properties of technical sulfur, which melts at temperatures from 112 to 115 ° C, and when cooled to a temperature of 100 ° C crystallizes and prevails increased strength (Kasimov et al, 1981; Parfenyuk, 1987; Paturoev, et al, 1985). In the 30s of the twentieth century, technical sulfur was used for fixing metal bolts in concrete foundations, for iron posts of staircase railings and balcony railings (Orlovskiy et al, 1995; Kasimov et al, 1981; Abdykalykov et al, 2024; Abdul et al, 2024; Athira et al, 2021; Mohammad, et al, 2025). The disadvantage of these studies is that in the process of impregnation sulfur-containing arbolite concrete composites melt and lose geometric shapes.

Recently, in Kazakhstan and in the countries of the Commonwealth of Independent States of the CIS, as well as in foreign countries, considerable attention of scientific researchers is particularly focused on the method of sealing the pore inter-grain space of concrete by impregnating it with monomers, oligomers and also waste products of the oil and gas industry, molten liquid technical sulfur (Sokolova et al, 2021; Sokolova et al, 2022). To increase the durability and improve the physical and mechanical characteristics of building materials and products used in various aggressive environments, methods of impregnation with monomers, oligomers and molten sulfur are used for their subsequent polymerization in the pore structure of concrete (Vyshar et al, 2023; Stanevich et al, 2023; Rakhimova et al, 2023; Roman et al, 2025; Chen et al, 2022).

The works show methods of impregnation of building materials and products of organic and inorganic origin possessing a system of closed-open capillaries. Systematic search for new ways of their antifiltration protection shows that the existing methods for one reason or another do not fully satisfy the requirements to them. In our opinion, that at contact with solid surface of dispersoid grains or solid matrix molecules of impregnating liquid under the action of physical and chemical phenomena penetrate into voids and remain there in initial form or under the influence of temperature, catalysts and radiation pass into irreversible state.

To date, several methods of impregnation of building materials and products of organic and inorganic origin possessing a system of closed-open capillaries have been developed. The systematic search for new methods of their antifiltration protection shows that the existing methods for one reason or another do not fully satisfy the requirements imposed on them. The process of impregnation of skeleton-matrix can be represented in the following form: at contact with the solid surface of dispersoid grains or solid matrix molecules of impregnating liquid under the action of physical and chemical phenomena penetrate into voids and remain there in their original form or under the action of temperature, catalysts and radiation pass into irreversible state. The interaction between the impregnating liquid and the solid surface can be divided very conditionally into physical-mechanical, physical-chemical and purely chemical (Orlovskiy et al, 1990). Arbolite concrete composites are varieties of lightweight concrete made on the basis of various vegetation wastes and composite binders (Sokolova et al, 2021). Arbolite concrete composites, depending on the constituent components, have an average density in the range from 400 to 1200 kg/m^3 and strength from 1.5 MPa to 6.0 MPa (Bazhirov et al, 2018; Cheng et al, 2021). The disadvantages of these arbolite concrete composites can be attributed to their low strength and low resistance to aggressive environments. To protect against the effects of aggressive external factors and also to increase the construction and technical parameters of porous arbolite concrete products of plant origin can be impregnated with technical sulfur and other monomers.

To protect against the effects of aggressive external factors and also to increase the construction and technical properties of low-strength and porous arbolite concrete products of plant origin, it is possible to use impregnation methods with molten liquid sulfur. Thus it is possible to increase physical and mechanical characteristics of lightweight concrete and the set ecological and economic tasks become actual for the Republic of Kazakhstan.

Research materials and methods. For the manufacture of arbolite concrete composites we used porous wastes of corn cob crushed with sizes from 10 to 40 mm. For comparison of research results we also adopted more dense waste vegetation shredded stalks of cotton and crushed walnut shells with sizes from 10 to 30 mm. At the time of experimental works the moisture characteristics of cellulosic organic aggregates were 3-5%. Chemical compositions of cellulose organic aggregates in the composition of arbolite concrete are presented in Table 1.

Table 1 - Chemical composition of organic cellulose aggregates in the composition of arbolite concretes

No. by/order	Name of composition	Chemical formula	Number, in %
Chemical composition of corn waste			
1	Cellulose	$C_6H_{10}O_5$	46,17
2	Lignin	$C_{41}H_{40}O_{15}$	29,76
3	Pentosan	$C_5H_8O_4$	22,00
4	Resins and soluble components	-	2,07

Portland cement of 400 grade from Kyzylkum cement plant of Navoi region of Navoi region of the Republic of Uzbekistan was also used for the manufacture of arbolite concrete composites. The chemical composition of cement is given in Table 2.

Table 2 - Chemical composition of Kyzylkum cement plant

Content, %									
Basic oxides						Major minerals			
CaO	SiO_2	$A1_2O_3$	Fe_2O_3	R_2O	SO_3	C_3S	C_2S	C_3A	C_4AF
61,48	23,38	6,38	6,09	0,38	0,60	57,60	17,40	7,90	13,10

As an active mineral additive fly ash from Aktobe Heat and Power Center was used, which meets the requirements of GOST 10181-2000 (2000). Interstate standard. Concrete mixtures test methods. The chemical composition of fly ash is presented in Table 3.

Table 3 - Chemical composition of fly ash mineral additive

Losses on ignition, wt. %	Oxide content, wt. %						
	SiO_2	$AI_2O_3+TiO_2$	Fe_2O_3	CaO	MgO	NaO_2	SO_2
7,33	48,3	23,92	5,94	9	1,9	0,18	0,52

In the experimental and research work as impregnation material we used waste high-sulfur oil of Atyrau petrochemical plant of the Republic of Kazakhstan. Technical sulfur is a solid crystalline substance with yellowish color shade and melting point from 115 to 119°C. When the temperature rises to 200 ° C passes into a viscous state and at 450 ° C passes to the process of boiling, from then sharply burns. Table 4 shows the chemical composition of technical sulfur grade No. 9998.

Table 4 - Chemical composition of technical sulfur of grade No. 9998

No. by/order	Name of the share of substances in the composition of sulfur, %	Number, %
1	Share of net technical sulphur	99,060
2	Ash fraction	0,400
3	Proportion of different organic matter	0,053
4	Water fraction in sulfur composition	0,010

Three series of cemented arbolite specimens with different compositions were manufactured for experimental work. Each series consisted of four sample cubes with dimensions 100x100x100mm with different binder compositions. The first series of samples were made using porous corn cob waste with dimensions of 15-30mm and the second series of samples were made using shredded cotton stalks with dimensions of 18-25mm and the third series were made based on shredded walnut shells with dimensions of 18-20mm. All these arbolite-concrete samples were manufactured in strict technological sequence and tested in accordance with the State Standard 19222-84 (1984). Arbolite and products made of it. General technical conditions.

After all testing procedures, we impregnated all these sample cubes with molten liquid sulfur at a temperature of 115 to 120°C. Since the purpose of our study was to investigate the effect of molten liquid sulfur on the physical and mechanical properties of less durable arbolite concrete composites, so for impregnation we prepared three series of simple cement arbolite concrete composites with different compositions and physical and mechanical properties. Impregnation of capillary-porous arbolite-concrete composites was carried out by capillary suction and contraction methods. Compositions and properties of arbolite-concrete composites prepared for impregnation with sulfur-waste are given in Tables 5, 6 and 7.

Table 5 - Compositions and properties of arbolite-concrete samples of series №1

Name of indicators	Unit of measurement	Indicator values for arbolite
Cement consumption	kg/m^3	325
Corn cob waste consumption	kg/m^3	235
Water consumption for preparation of arbolite concrete mixes	l/m^3	350
Fly ash consumption	kg/m^3	90
Density of samples in dry states	kg/m^3	600–630
Compressive strength	MPa	2,1-2,9
Water absorption by mass	%	67
Frost resistance of samples	cycle	50
Heat transfer coefficient	W/m^{2}K	0,10

Table 6 - Compositions and properties of arbolite-concrete samples of series № 2

Name of indicators	Unit of measurement	Indicator values for arbolite
Cement consumption	kg/m^3	350
Consumption of shredded cotton stalks	kg/m^3	250
Water consumption for preparation of arbolite concrete mixes	l/m^3	370
Fly ash consumption	kg/m^3	90
Density of samples in dry states	kg/m^3	610–660
Compressive strength	MPa	3,1-3,5
Water absorption by mass	%	45
Frost resistance of samples	cycle	75
Heat transfer coefficient	W/m^{2}K	0,135

Table 7 - Compositions and properties of arbolite-concrete samples of series № 3

Name of indicators	Unit of measurement	Indicator values for arbolite
Cement consumption	kg/m^3	350
Consumption of walnut shells	kg/m^3	250
Water consumption for preparation of arbolite concrete mixes	l/m^3	370
Fly ash consumption	kg/m^3	90
Density of samples in dry states	kg/m^3	620–750
Compressive strength	MPa	3,5-3,7
Water absorption by mass	%	45
Frost resistance of samples	cycle	75
Heat transfer coefficient	W/m^2K	0,135

Determination of physical and mechanical properties, impregnated with sulfur-waste arbolite samples were carried out according to standard methods. Impregnation of arbolite concrete samples with molten liquid technical sulfur can be carried out in the following technological sequence. To carry out dehydration in the capillary-porous structures of arbolite-concrete composites should be pre-drying with heating for 6 to 10 hours at a temperature of 125-145 °C.

For arbolite-concrete composites dried to a constant mass, impregnate with molten sulfur at a temperature of 125 to 185 ° C for 2 to 10 hours. Gradual uniform cooling of impregnated molten liquid sulfur impregnated arbolite-concrete samples at the required depth brings to the ambient temperature within 2 to 4 hours. Given all these factors technology impregnation of arbolite with molten liquid sulfur can be argued that the entire technological cycle of impregnation of arbolite concrete samples with liquid sulfur will last from 2 to 10 hours.

Results and discussion. During the study of sulfur-waste impregnation of samples of arbolite concrete composites with different compositions and also different organic cellulose aggregates we obtained the following results:

From the results of the study shown in Table 8, it can be seen that in all samples impregnated with liquid molten liquid sulfur increased the average density of the samples by 10-15%. In arbolite concrete samples based on corn waste for 1-4 compositions (series № 1) density of samples increased depending on the initial state of 14-16% was from 624.6 to 707.04 kg/m^3.

And in arbolite-concrete samples based on crushed cotton stalks (series №2) density of samples after impregnation increased depending on the initial state by 12-15% and ranged from 634.4 to 715.04 kg/m3. We also found that the average density of all arbolite-concrete samples based on walnut shells (series №3) increased 10-15% depending on the initial state and respectively ranged from 634.4 to 775.04 kg/m^3.

Table 8 - Variation of average density of different arbolite concrete samples after sulfur impregnation

Series of prototypes prototypes	Types of arbolite concretes	Impregnation time, hour	Average density of samples before impregnation, kg/m^3	Average density of samples after impregnation, kg/m^3
1-series of samples	Arbolite concrete samples on the basis of corn waste	2	600	624,6
		5		653,92
		10		677,04
2-series of samples		2	610	634,5
		5		663,92
		10		687,04
3-series of samples		2	620	644,7
		5		673,92
		10		697,04
4-series of samples		2	630	654,9
		5		683,92
		10		707,04
1-series of samples	Arbolite concrete samples based on shredded cotton stalks	2	610	634,4
		5		653,92
		10		677,04
2-series of samples		2	620	644,5
		5		653,92
		10		672,04
3-series of samples		2	640	660,7
		5		683,92
		10		711,04
4-series of samples		2	660	681,9
		5		709,92
		10		715,04
1-series of samples	Arbolite concrete samples based on walnut shells	2	620	634,4
		5		653,92
		10		677,04
2-series of samples		2	650	664,5
		5		673,92
		10		682,04
3-series of samples		2	700	714,7
		5		723,92
		10		731,04
4-series of samples		2	750	761,9
		5		769,92
		10		775,04

As can be seen from the results of the study shown in Table 9, it can be seen that in all samples impregnated with molten liquid sulfur, the average density by 12-16% and mechanical strength increased 2-3 times.

In arbolite-concrete samples (series №1) based on corn waste 1 series at densities of 624.6; 653.92; 677.04 kg/m^3 the strength increases 3.7; 4.8; 5.9 MPa depending on the impregnation time. Also in series 2-4 specimens at average densities of 634.5; 663.92; 687.04; 644.7; 673.92; 697.04; 654.9; 683.92; 707.04 kg/m^3, the strength increases 4.3; 5.1; 6.8; 4.7; 6.5; 7.9; 4.9; 6.9; 8.7 MPa, respectively, depending on the impregnation time.

In arbolite concrete specimens (series № 2) based on shredded cotton stalks 1-4 series at densities of 634.4; 653.92; 677.04; 644.5; 653.92; 672.04; 660.7; 683.92; 711.04; 681.9; 709.92; 715.04 kg/m^3 depending on the duration of impregnation with molten liquid sulfur, the strength of the specimens increased 3.7; 3.8; 3.9; 4.3; 4.9; 5.8; 5.1; 6.5; 7.1; 6.5; 7.1; 8.3 MPa, respectively. The results are summarized in Tables 8 and 9.

In arbolite-concrete samples (series №3) based on crushed walnut shells 1-4 series at densities of 634.4; 653.92; 677.04; 664.5; 673.92; 682.04; 714.7; 723.92; 731.04; 761.9; 769.92; 775.04 kg/m^3 depending on the duration of impregnation with molten liquid sulfur, the strength of the specimens increased 3.5; 3.7; 3.9; 4.1; 4.5; 4.7; 4.3; 5.5; 6.9; 4.5; 6.7; 7.7 MPa, respectively. The results are summarized in Tables 8 and 9.

Also by the results of experimental and experimental works it was found that with in all arbolite concrete composites there is a significant increase in sulfur weight gain from 4.2 to 10.2% of lightweight concrete depending on the duration of sulfur-waste impregnation.

Table 9 - Change in strength of different arbolite concrete specimens after impregnation with sulfur

Series of prototypes prototypes	Types of arbolite concretes	Impre-gnation time, hour	Average density of samples before impregnation, kg/m^3	Compressive strength of samples before impregnation, MPa	Compressive strength of samples after impregnation, MPa	Coefficient hardening factor, MPa $\frac{R_{csols}}{R_{csous}}$
1-series of samples	Arbolite concrete samples on the basis of corn waste	2	600	2,5	3,7	1,48
		5			4,8	1,92
		10			5,9	2,36
2-series of samples		2	610	2,6	4,3	1,65
		5			5,1	1,96
		10			6,8	2,6
3-series of samples		2	620	2,7	4,7	1,74
		5			6,5	2,4
		10			7,9	2,92
4-series of samples		2	630	2,8	4,9	1,75
		5			6,9	2,46
		10			8,7	3,10

1-series of samples	Arbolite concrete samples based on shredded cotton stalks	2	610	2,6	3,7	1,42
		5			3,8	1,46
		10			3,9	1,5
2-series of samples		2	620	2,9	4,3	1,48
		5			4,9	1,69
		10			5,8	2,0
3-series of samples		2	640	3,1	5,1	1,64
		5			6,5	2,09
		10			7,1	2,29
4-series of samples		2	660	3,5	6,5	1,86
		5			7,1	2,02
		10			8,3	2,37
1-series of samples	Arbolite concrete samples based on walnut shells	2	620	2,9	3,5	1,2
		5			3,7	1,27
		10			3,9	1,34
2-series of samples		2	650	3,3	4,1	1,24
		5			4,5	1,36
		10			4,7	1,42
3-series of samples		2	700	3,7	4,3	1,16
		5			5,5	1,49
		10			6,9	1,86
4-series of samples		2	750	4,1	4,5	1,09
		5			6,7	1,63
		10			7,7	1,88

Note: R_{csois} - *compressive strength of impregnated specimens,* R_{csous} - *compressive strength of unimpregnated specimens*

Weight gain and increase in the average density of impregnated arbolite concrete samples can be explained by the content and change in the structural porosity of cellulose organic aggregates in the composition of impregnated lightweight concrete. On this value and also the change of physical and mechanical properties of impregnated arbolite concrete samples is significantly influenced by the duration and methods of impregnation. It can be noted here that in all impregnated specimens there is an increase in mechanical strength and average density. Test impregnated with sulfur waste arbolite concrete samples in compression showed that all samples without exception increased their mechanical strength from 1.5 to 3.5 times.

We found that with increasing the time and duration of impregnation from 2 to 10 hours there is an intensive increase in strength of impregnated samples (Tables 8 and 9). Further impregnation and exposure of arbolite concrete samples in molten sulfur does not significantly affect the physical and mechanical characteristics of arbolite concrete composites. Growth of the compressive strength of arbolite concrete in the process of impregnation with sulfur-waste showed that the greatest relative increase in the compressive strength of arbolite concrete samples made on the basis of porous waste corn cob and they increased to 8.7 MPa.

The obtained research results are shown in Tables 8 and 9. At the same time, the value of the hardening coefficient for all types of arbolite concrete samples from each other differs significantly. In the arbolite concrete specimens based on corn waste, the hardening coefficient ranges from 1.48 to 3.10. And the other two arbolite concrete specimens have hardening coefficients ranging from 1.42 to 2.37 and 1.2 to 1.88. The lowest coefficient of hardening has arbolite concrete composites based on crushed walnut shells, and the highest coefficient of hardening has arbolite concrete composites based on corn waste.

By comparing the results of research we found that from all tested arbolite concrete samples after impregnation with molten sulfur-waste, the strongest index has arbolite concrete composites based on corn waste. After 10-hour sulfur impregnation, the average density of the arbolite concrete specimens increased from 630 to 707.04 kg/m3 and the strength reached up to 8.7 MPa. The research results are shown in Tables 8, 9 and Figure.

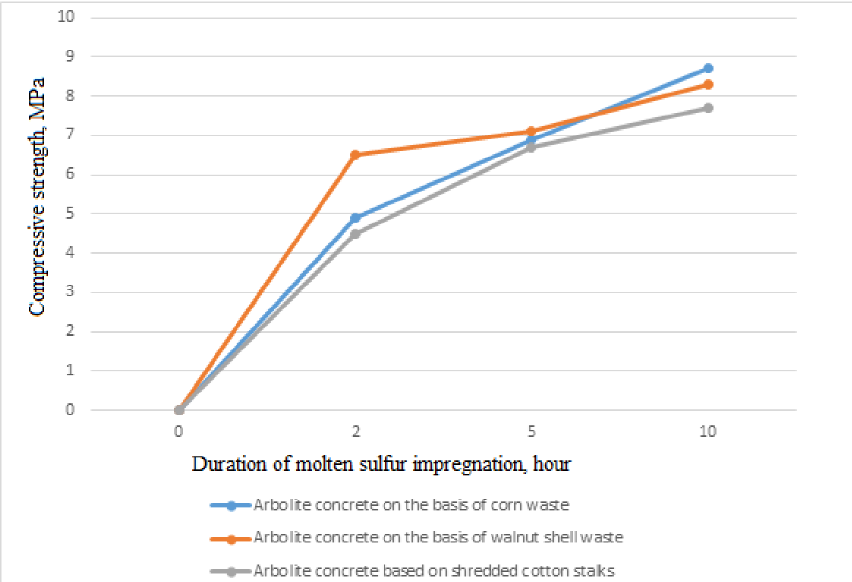

Figure. Change of strength of arbolite concrete composites depending on the duration of impregnation with molten sulfur

The impregnation of arbolite concrete composites with molten liquid sulfur shows the high capacity qualities of the studied lightweight concrete. The character of structure formation of arbolite-concrete composites to some extent obeys the laws of “binder - cellulose organic aggregate”. After impregnation of arbolite concrete samples with molten liquid sulfur in the contact “arbolite concrete composite - impregnation material” there are physical and chemical processes that determine the bonding characters between porous lightweight arbolite concrete and liquid technical sulfur. In this case, a very significant influence has porous structure of arbolite concrete, causing suction of liquid sulfur by arbolite immediately after its impregnation, which leads to strengthening its bonding properties between molten liquid sulfur and uneven rough surfaces of organic aggregate.

Our experimental studies also lead to the conclusion to clarify the hypothesis on structure formation of strength of arbolite concrete composites impregnated with monomers, oligomers and also technical liquid sulfur. Based on our developed data and theories of numerous authors (Kasimov et al, 1981; Parfenyuk, 1987; Paturoev et al, 1985; Sokolova et al, 2023), we came to the conclusion that in the case of using technical liquid sulfur as an impregnating material, the most significant are the presence of three-dimensional framework in porous organic aggregates of arbolite concrete composite. While increasing the bonding strengths of the contact zone of organic aggregates and binders, due to the joint adhesive effect of arbolite and technical sulfur, which contribute to the volumetric filling of pores and cracks with molten liquid sulfur and leading to the strengthening of the contact zone of the developed materials.

The novelty of the research work is that our proposed method of impregnation of low-strength porous arbolite concrete composites based on vegetation waste with technical sulfur led to an increase in physical and mechanical properties of the studied materials. After impregnation with sulfur, the density of the studied samples increased up to 775 kg/m^3 and the strength increased up to 8.7 MPa. The dependence between its cubic strength and the strength of concrete-matrix of arbolite concrete composites was also established. The practical significance of this study is the results obtained during the research, which can be recommended for structures, which in the process of operation are subject to increased requirements for frost resistance, water permeability, water resistance and chemical resistance.

Although the study on impregnation of low-strength arbolite concrete composites with gray waste covers important aspects of the topic, this study only addresses a limited area of the construction industry for underground construction. Despite the significance of the findings, more extensive research is needed to set up additional experimental work to investigate the strength and deformability of arbolite concrete products.

Conclusions. In accordance with the goal and objective of our study it was found that molten liquid sulfur has a very significant effect on improving the physical and mechanical properties and durability of low-strength porous arbolite concrete products. It was found that in all arbolitobetonnyh products observed a significant increase in the weight of sulfur from 4.2 to 10.2% in the composition of lightweight concrete, depending on the duration of impregnation and all samples without exception increased their mechanical strength from 1.5 to 3.5 times.

We also determined that the optimal arbolite concrete products with higher physical-mechanical and construction-technical indicators is arbolite concrete composites made on the basis of corn waste. After impregnation with gray waste the density of the studied samples increased up to 755 kg/m3 and the strength increased up to 8.9 MPa. These results are explained by the fact that the porous structure of organic aggregates in the composition of arbolite concrete, causing the suction of liquid sulfur of corn waste immediately after its impregnation and leading to the strengthening of its physical and mechanical properties. Based on this research, impregnation methods can be developed for low-strength lightweight concrete based on different formulations. The results of the study provide valuable ideas in practical terms for their use in the construction industry in the construction of underground structures. Such structures can be manholes, flumes, pipelines, cooling towers, pavements, desalination plants, elements of marine structures, and others.

References

Abdykalykov A., Bolotov T., Kurbanbaev A., Matyeva A., Zhumabaev R. (2024) Optimisation of composition and strength properties of slag-alkali binders based on fuel slags. Architectural Studies. 2024. 10 (1). — P. 125-135. DOI: 10.56318/as/1.2024.125 (in Eng.).

Abdul F., Adachi K., Ho H.-J., Iizuka A., Shibata E. (2024) Magnesium recovery from ferronickel slag by reaction with sodium hydroxide. Journal of Environmental Chemical Engineering, 12(3). DOI: 10.1016/j.jece.2024.112516 EDN: AFICWY (in Eng.).

Athira V., Charitha V., Athira G., Bahurudeen A. (2021). Agro-waste ash based alkali-activated binder: Cleaner production of zero cement concrete for construction. Journal of Cleaner Production, 286, article number 125429. DOI: 10.1016/j.jclepro.2020.125429 EDN: GJSTVS. (in Eng.).

Bazhirov N.S., Dauletiyarov M.S., Bazhirov T.S., Serikbayev B.E., Bazhirova K.N. Research of waste of aluminum production as the raw components in technology of composite cementing materials. News of the national academy of sciences of the Republic of Kazakhstan. Series of geology and technical sciences. ISSN 2224-5278. 2018. — Vol. 1, N 427. — P. 93-98. (in Eng.).

Chen J., Xing Y., Wang Y., Zhang W., Guo Z., Su W. (2022) Application of iron and steel slags in mitigating greenhouse gas emissions: A review. Science of the Total Environment, 844. DOI: 10.1016/j.scitotenv.2022.157041. (in Eng.).

Cheng Y., Awan U., Ahmad Sh., Tan Zh. (2021) How do technological innovation and fiscal decentralization affect the environment? A story of the fourth industrial revolution and sustainable growth. Technological Forecasting and Social Change. — P. 162. DOI: 10.1016/j.techfore.2020.120398. (in Eng.).

Kasimov I.K., Fedotov E.D. (1981) Impregnation of cement stone with organic binders. L., Stroyizdat. — P.168. ISBN: 66-94-058-678-06. (in Eng.).

Mohammad N. Akhtar, Abdulaziz Alotaibi, Nadim I. Shbeeb. (2025) River Sand Replacement with Sustainable Sand in Design Mix Concrete for the Construction Industry. Civil Engineering Journal. — Vol. 11, No. 01. — P. 201-214. Doi: 10.28991/CEJ-2025-011-01-012. (in Eng.).

Orlovskiy Yu.I., Semchenkov A.S., Khorzhevskiy V.I. Concrete and products based on sulfur-containing wastes. Concrete and Reinforced Concrete, 1995. — № 3. — P. 21-24. (in Eng.).

Orlovskiy Yu.I. Polymersulfur concretes. Application of sulfur and sulfur-containing wastes in construction industry, 1990. — P. 3-5. (in Eng.).

Paturoev A.N., Volgushev Yu., Paturoev A.N., Volgushev Y.I., Orlovsky Yu.I. Properties and prospects of application of sulfur concrete. Concrete and Reinforced Concrete, 1985. — № 5. — P. 16-17. (in Eng.).

Parfenyuk S.A. Experience of using sulfur and sulfur-containing wastes in asphalt concrete pavement construction. Automobile roads, 1987. — № 2. — P. 16-20. (in Eng.).

Roman Shults, Gulnur Seitkazina, Andriy Annenkov, Roman Demianenko, Saule Soltabayeva, Zhenis Kozhayev, Gulizat Orazbekova. (2025). Complex Geodetic Monitoring of the Massive Sports Structures by Terrestrial Laser Scanning. Civil Engineering Journal. Vol 11. — No 3. — P. 884-909. Doi: 10.28991/CEJ-2025-011-03-05. (in Eng.).

Rakhimova G., Stolboushkin A., Vyshar O., Stanevich V., Rakhimov M., Kozlov P. Strong

Structure Formation of Ceramic Composites Based on Coal Mining Overburden Rocks (2023) Journal of Composites Science, 7(5), 209. DOI 10.3390/jcs7050209. (in Eng.).

Sokolova Y., Akulova M., Isakulov B., Sokolova A., Isakulov A. (2022) The Study of the Impact of Iron and Sulfur Containing Additives on the Strength Properties of Sulfur Containing Binders. Solid State Phenomena, 2022, 334. — P. 195–201. DOI: 10.4028/p-25n3i8. (in Eng.).

Sokolova Y.A., Akulova M.V., Isakulov B.R., Kul'sharov B.B., Isakulov A.B. (2021) The study of creep and deformation properties of sulfur-containing arbolit exposed to various compression stresses. Key Engineering Materials, 2021, 899 KEM. — P. 137–143. DOI: 10.4028/www.scientific.net/KEM.899.137 (in Eng.).

Stanevich V.T., Bulyga L.L., Vyshar O.V., Girnis S.R., Rakhimova G.M. (2023) Analysis of Energy Efficiency of Building Envelopes of JSC "Station EGRES-2" (2022) AIP Conference Proceedings, 2559, 050006, DOI 10.1063/5.0100151. (in Eng.).

Vyshar O., Stolboushkin A., Rakhimova G., Stanevich V., Rakhimov M. Study of the properties of overburdened rocks from coal mining: overburden – as a raw material in the production of ceramic bricks (2023) International Journal of GEOMATE, 25 (107). — P. 86–94. DOI 10.21660/2023.107.377 (in Eng.).

GOST 10181-2000 (2000). Interstate standard. Concrete mixtures test methods. (in Eng.).

GOST 19222-84 (1984). Arbolite and products made of it. General technical conditions. (in Eng.).

Publication Ethics and Publication Malpractice in the journals of the National Academy of Sciences of the Republic of Kazakhstan

For information on Ethics in publishing and Ethical guidelines for journal publication see http://www.elsevier.com/publishingethics and http://www.elsevier.com/journal-authors/ethics.

Submission of an article to the National Academy of Sciences of the Republic of Kazakhstan implies that the described work has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis or as an electronic preprint, see http://www.elsevier.com/postingpolicy), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder. In particular, translations into English of papers already published in another language are not accepted.

No other forms of scientific misconduct are allowed, such as plagiarism, falsification, fraudulent data, incorrect interpretation of other works, incorrect citations, etc. The National Academy of Sciences of the Republic of Kazakhstan follows the Code of Conduct of the Committee on Publication Ethics (COPE), and follows the COPE Flowcharts for Resolving Cases of Suspected Misconduct (http://publicationethics.org/files/u2/New_Code.pdf). To verify originality, your article may be checked by the Cross Check originality detection service http://www.elsevier.com/editors/plagdetect.

The authors are obliged to participate in peer review process and be ready to provide corrections, clarifications, retractions and apologies when needed. All authors of a paper should have significantly contributed to the research.

The reviewers should provide objective judgments and should point out relevant published works which are not yet cited. Reviewed articles should be treated confidentially. The reviewers will be chosen in such a way that there is no conflict of interests with respect to the research, the authors and/or the research funders.

The editors have complete responsibility and authority to reject or accept a paper, and they will only accept a paper when reasonably certain. They will preserve anonymity of reviewers and promote publication of corrections, clarifications, retractions and apologies when needed. The acceptance of a paper automatically implies the copyright transfer to the National Academy of Sciences of the Republic of Kazakhstan.

The Editorial Board of the National Academy of Sciences of the Republic of Kazakhstan will monitor and safeguard publishing ethics.

Правила оформления статьи для публикации в журнале смотреть на сайтах:

www:nauka-nanrk.kz

http://www.geolog-technical.kz/index.php/en/

ISSN 2518-170X (Online),

ISSN 2224-5278 (Print)

Директор отдела издания научных журналов НАН РК *А. Ботанқызы*

Редакторы: *Д.С. Аленов, Ж.Ш.Әден*

Верстка на компьютере *Г.Д.Жадыранова*

Подписано в печать 15.08.2025.

Формат 70x90$^{1}/_{16}$. Бумага офсетная. Печать – ризограф.

20,5 п.л. Заказ 4.

РОО «Национальная академия наук РК»

050010, Алматы, ул. Шевченко, 28, т. 272-13-19