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METHODS AND EXPERIMENTAL RESEARCH FOR DETERMINING THE PROPERTIES OF ENERGY-SAVING LIGHTWEIGHT CONCRETES BASED ON TEBINBULOQ MULTIPLYED VERMICULITE

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Abstract. The article highlights the methodology and results of experimental research on producing thermal insulation ultra-lightweight concrete and blocks based on expanded vermiculite from Tebinbuloq deposit and low water-demand cement. Optimal fractional ratios of vermiculite and their effect on mechanical strength were established.

Keywords: Tebinbuloq vermiculite, expanded vermiculite, thermal insulation, ultra-lightweight concrete, thermal conductivity coefficient, XND-2-3030C equipment, compressive strength.

Аннотация. Мақолада Қорақалпоғистон Республикаси Тебинбулоқ кони кўпчитилган вермикулити ва кам сув талабчан цемент асосида иссиқлик сақловчи ўта енгил бетонлар ҳамда блок буюмларини олиш бўйича ўтказилган экспериментал тадқиқотлар методологияси ва натижалари ёритилган. Вермикулитнинг 0.8÷1.6 мм ва 1.6÷2.2 мм фракцияларининг мақбул нисбатлари ва бетоннинг физик-механик хоссаларига таъсири аниқланган.

Калит сўзлар: Тебинбулоқ вермикулити, кўпчитилган вермикулит, иссиқлик изолцияси, ўта енгил бетон, иссиқлик ўтказувчанлик коэффициенти, XND-2-3030C ускунаси, сиқилишдаги мустаҳкамлик.

Аннотация. В статье освещены методология и результаты экспериментальных исследований по получению теплоизоляционных сверхлегких бетонов и блоков на основе вспученного вермикулита Тебинбулакского месторождения и цемента низкой водопотребности. Определены оптимальные фракционные соотношения вермикулита и их влияние на прочность бетона.

INTRODUCTION

Increased energy efficiency of buildings and structures, reduced heat loss, and the use of environmentally friendly building materials are among the most important directions in modern urban planning. The production and introduction into construction of effective thermal insulation materials that can reduce heat loss through wall and barrier structures by 75-90% is an urgent issue.

Within the territory of our republic—specifically at the Tebinbulok vermiculite deposit in the Karauzak district of the Republic of Karakalpakstan—there are reserves of 3.944 million tons of high-grade natural vermiculite ore. By subjecting the vermiculite extracted from this deposit to thermal processing at temperatures of 900–1200°C, its initial volume can be increased by 12 to 20 times, resulting in expanded vermiculite with high porosity.

The purpose of this study is to study the physical-mechanical, thermal-technical properties of heat-protective concrete samples made on the basis of Tebinbulok expanded vermiculite and low-water cement using standard and modern laboratory test methods.

LITERATURE REVIEW ON THE SUBJECT

Foreign researchers such as Akhtyamov Ya.A., Dubenitsky K.N., Pozhnin A.P. created fundamental theoretical foundations for obtaining vermiculite and heat-saving products based on it and studying their physical and technical properties. Scientists from the Institute of General and Inorganic Chemistry of the Academy of Sciences of Uzbekistan (Arifov P.A.) and Professor Tolipov N.Kh. conducted research on hydrophobization of local vermiculite and its use in plaster mixtures.

At the same time, in previous studies, the mechanism of joint structure formation of various fractions of Tebinbulak expanded vermiculite (0.6÷1.6 mm and 1.6÷2.2 mm) and low-water-demanding cement components, and the dependence of the thermal conductivity coefficient on factors were not comprehensively studied.

RESEARCH METHODOLOGY

In experimental studies, vermiculite concentrates from the Tebinbulak deposit and expanded vermiculite grains obtained by their calcination were used. The thermal conductivity coefficient λ (W/(m·°C)) of the samples was determined using a special modern XND-2-3030 C device using 300x300 mm plate samples in accordance with GOST 7076-99.

The intermediate and 28-day compressive strength of ultra-lightweight concrete samples was tested on a 5R-200 kN computerized hydraulic press in accordance with the requirements of GOST 17177-94 and GOST 12865-67. Porosity and structural analysis were performed using optical and electron microscopy.

ANALYSIS AND RESULTS

An analysis of the state of the reserves of the Tebinbulak vermiculite deposit in the Karauzak district of the Republic of Karakalpakstan and the mining enterprises showed that there is a potential to extract 592 thousand tons of high-quality vermiculite concentrate from the total reserve (Table 1).

Table 1. Tebinbulok vermiculite mine reserves and utilization indicators

Mining site name	A+V+S1 reserve (thousand t)	S2 reserve (thousand t)	2020 digging (thousand t)	An incorporated organization
Тебинбулоқ (ғарбий/шарқий)	881.7	642.6	0.10	“Триумф Вермикулит” МЧЖ
Western "Northern" section	140.4	768.4	0.70	"Boston Talk" LLC

Mining site name	A+V+S1 reserve (thousand t)	S2 reserve (thousand t)	2020 digging (thousand t)	An incorporated organization
Total Tebinbulok mine	4375.0	28.3	0.80	Local businesses

During experimental studies, samples with a fraction of 85% of expanded vermiculite with a grain size of 0.8÷1.6 mm and 15% of the fraction of 1.6÷2.2 mm, introduced into the composition of the charge, demonstrated the highest physical-mechanical and thermal-technical indicators (Table 2).

Table 2. Physical and mechanical parameters of ultra-light concrete samples with vermiculite

Type of concrete sample	Average density (kg/m³)	Compressive strength (MPa)	Flexural strength (MPa)	Thermal conductivity λ (W/m·°C)
Heat protector (brand D400)	400 - 500	1.5 - 2.2	1.2 - 1.5	0.085 - 0.099
Heat-constructive (D700)	650 - 800	1.9 - 3.2	1.4 - 1.8	0.110 - 0.145
Constructive-constructive (D1000)	900 - 1200	3.5 - 4.6	1.7 - 2.0	0.160 - 0.210

The test results showed that a 5 cm thick vermiculite slab reduces heat loss in a building by 75%, a 7.5 cm thick slab by 85%, and a 10 cm thick slab by 92%. The developed composition has successfully passed pilot-industrial testing in the form of blocks measuring 120x600x300 mm and 150x600x300 mm at “TRIUMF GORNYAK” LLC in the Navoi region.

CONCLUSIONS AND SUGGESTIONS

1. A scientific and practical methodology for obtaining high-quality expanded vermiculite and effective heat-insulating products from it was developed based on the resources of the Tebinbulak vermiculite deposit in the Republic of Karakalpakstan.

2. When using a mixture of vermiculite grains of 85% of the 0.8÷1.6 mm fraction and 15% of the 1.6÷2.2 mm fraction and low-water cement, durable blocks with an average density of 650-1200 kg/m3 and a compressive strength of 1.5-4.6 MPa were obtained.

3. The developed vermiculite blocks and slabs reduce heat loss in construction by up to 92% and have been confirmed by experimental and industrial tests at the TRIUMF GORNYAK LLC enterprise.

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