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COMPOSITION AND PHYSICAL AND MECHANICAL PROPERTIES OF FOAM CONCRETE

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Abstract. In this research work, Portland cement of the PC 400 D20 grade from JSC “Qizilqumsement” was added to compositions No. 1, 2, 3, and 4 during the preparation of foam concrete mixes. In all compositions, the foaming agent “PB-2000” was used with a consumption rate of 600 ml/m³. Based on the compositions given in the table, samples with dimensions of 100×100×100 mm were prepared and cured under normal conditions, i.e., in an environment with more than 95% humidity. The compressive strength at 3, 7, 14, and 28 days was determined using a hydraulic press. For each curing period, three samples were tested and the average value was obtained. In addition, the average density of each composition was determined.

Keywords: Portland cement, foam concrete, mixture, compressive strength, hydraulic press, average density, high-grade binder, flexural strength, compressive strength, slag, dune sand, macrostructure.

Annotatsiya. Ushbu tadqiqot ishida 1, 2, 3 va 4-chi tarkiblarga AJ “Qizilqumsement” ning PS 400 D20 markali portlandsement ko‘pik beton qorishmasini tayyorlanayotganda solindi. Barcha tarkiblarda “PB-2000” markali ko‘pik hosil qiluvchi ishlatildi va uning sarfi 600 ml/m³ bo‘ldi. Jadvalda keltirilgan tarkiblar asosida 100x100x100 mm o‘lchamdagi namunalar tayyorlandi, normal sharoitda, ya’ni namligi 95% dan yuqori bo‘lgan sharoitlarda saqlandi va 3, 7, 14 va 28 kunlik siqilishga bo‘lgan mustahkamlik chegarasi gidravlik pressda aniqlandi. Har bir muddatga 3 tadan namunalar sinalib o‘rtacha miqdori topildi. Bundan tashqari har bir tarkibning o‘rtacha zichligi aniqlandi.

Kalit so‘zlar: portlandsement, ko‘pik beton, qorishma, mustahkamlik chegarasi, gidravlik press, o‘rtacha zichlik, yuqori markali bog‘lovchi, egilishdagi mustahkamligi, siqilishdagi mustahkamligi, shlak, barxan qumi, makrostruktura.

Аннотация. В данной исследовательской работе портландцемент марки ПЦ 400 Д20 производства АО «Кызылкумцемент» вводился в составы № 1, 2, 3 и 4 при приготовлении пенобетонных смесей. Во всех составах использовался пенообразователь «ПБ-2000» с расходом 600 мл/м³. На основе составов, представленных в таблице, были изготовлены образцы размером

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100×100×100 мм, которые твердели в нормальных условиях, т.е. в среде с влажностью более 95%. Прочность при сжатии определялась на гидравлическом прессе в возрасте 3, 7, 14 и 28 суток. Для каждого срока твердения испытывались по три образца и выводилось среднее значение. Также определялась средняя плотность каждого состава.

Ключевые слова: портландцемент, пенобетон, смесь, прочность при сжатии, гидравлический пресс, средняя плотность, высококачественное вяжущее, прочность на изгиб, прочность при сжатии, шлак, дюнный песок, макроструктура.

INTRODUCTION.

In recent years, various changes occurring in solid raw materials during mechanical treatment (grinding), their influence on physical and mechanical properties, and the resulting impact on the technology of building materials-especially cement-have been extensively and thoroughly studied. Mechanical processing of inorganic powders does not affect the entire particle volume but contributes to the formation of stress fields on the contact surfaces with a grinding body or another particle. During mechanical activation, the formation of stress fields varies depending on mechanical impacts at local points. Moreover, the occurrence of solid-phase processes inside the working body of the mechanical activator may change the physical state, chemical composition, and properties of the material being ground.

High-grade binders belong to the class of binders produced through such mechanical activation and modification techniques. Therefore, when preparing them, the type and properties of chemical and mineral additives used for modification must be taken into account.

For the research, foam concrete with an average density of 300 – 600 kg/m³ was selected, as this density range is the most commonly used in construction. If another density is required, it can be regulated by adjusting the amount of sand used as filler.

Portland cement PC 400 D20 from JSC “Qizilqumsement” was added to compositions No. 1–4 during the preparation of foam concrete mixes. The foaming agent “PB-2000” was added to all compositions at a dosage of 600 ml/m³. Based on the compositions provided in the table, 100×100×100 mm samples were prepared, cured under normal conditions (relative humidity above 95%), and tested for compressive strength at 3, 7, 14, and 28 days using a hydraulic press. Three samples were tested for each period, and the average value was obtained. The average density of each composition was also determined.

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The selected foam concrete compositions for the research are presented in Table 1. Zarafshan river sand was used as filler.

Foam concrete prepared using high-grade binders was tested for strength after heat-treatment curing and after 28 days of hardening. The obtained results are shown in Table 1.

Table 1.

Composition and properties of foam concrete based on high-grade binders

№	Average density kg/m^3	The composition of the binder, %		W/C	PB-2000 l/m^3	Compressive strength, MPa				Weight after drying, gr
		Cement	High-grade binder			3 days	7 days	14 days	28 days	
1	300	100	0	0,4	0,6	-	-	0,25	0,55	350
2	400	100	0	0,4	0,6	-	0,32	0,6	0,66	420
3	500	100	0	0,4	0,6	0,35	0,45	0,86	1,25	550
4	600	100	0	0,4	0,6	0,5	1,0	1,5	1,8	640
5	300	0	100	0,3	0,6	0,0	0,82	1,22	1,55	350
6	400	0	100	0,3	0,6	0,4	1,3	2,1	2,65	440
7	500	0	100	0,3	0,6	0,8	1,65	2,25	2,8	560
8	600	0	100	0,3	0,6	1,0	1,9	2,5	3,25	620

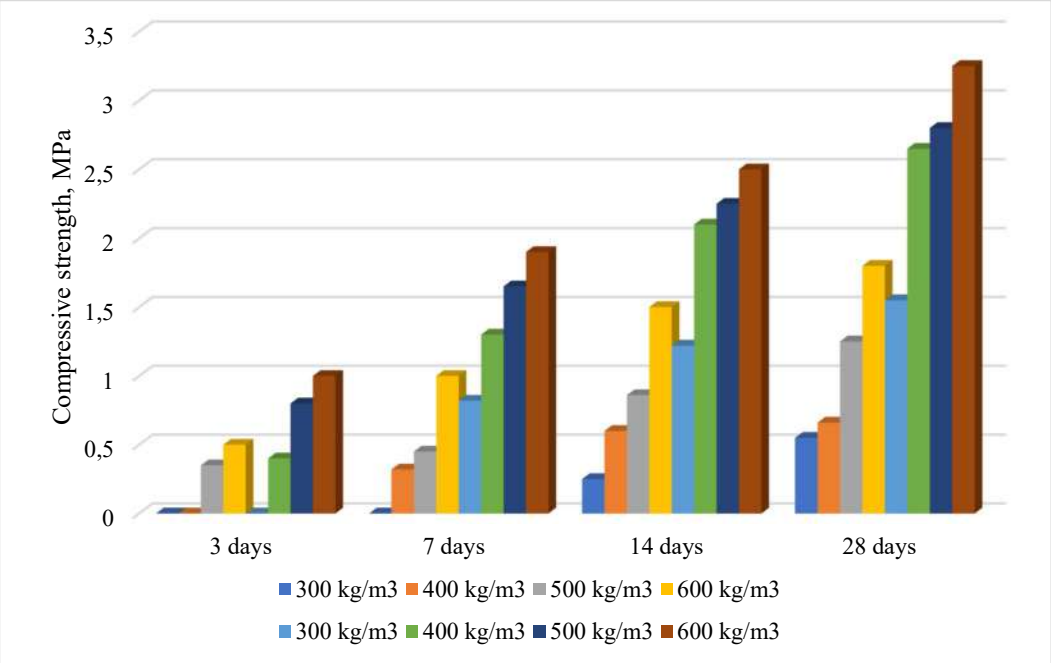


Figure 1. Compressive strength of foam concrete.

The presented table makes it possible to compare foam concrete samples prepared with high-grade binders at different densities, examine the differences in their compositions, and evaluate their physical-mechanical properties. The results

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show how sensitive foam concrete is to binder type and average density in terms of strength, mass, and hydration behavior.

The first four samples were prepared with cement-based binder only, without high-grade binder. However, in samples 5 – 8, cement was completely replaced with high-grade binder. The same foaming agent (PB-2000) was used in all samples, which minimizes structural variability in the foam and allows strength differences to be attributed solely to binder type.

The results indicate that in cement-based foam concrete, the 28-day compressive strength increases steadily with density: from 0.55 MPa at 300 kg/m³ to 1.8 MPa at 600 kg/m³. This is associated with the reduction of porosity and formation of a denser structure.

Foam concrete based on high-grade binder showed significantly higher strength 2 – 3 times greater than cement-based analogs. For example, at a density of 600 kg/m³, the cement-based composition reached 1.8 MPa, while the high-grade binder sample reached 3.25 MPa. This is due to the enhanced hydration process, compact crystalline structure, and higher binding capacity of the high-grade binder.

Additionally, samples with high-grade binder demonstrated high early-age strength (7-day strength ranging from 1.3 to 1.9 MPa), confirming rapid hardening-advantageous for fast-construction applications.

Dry sample weight increases proportionally with density, which confirms consistency in foam concrete structure and correctness of the technological process. For samples of equal volume, mass increased from 350 g (300 kg/m³) to 640 g (600 kg/m³).

Analysis of the test results indicates that high-grade binders demonstrate flexural and compressive strength values exceeding those of ordinary Portland cement regardless of curing conditions. For example, after 28 days, Portland cement shows 25 MPa (flexural) and 35 MPa (compressive) strength, while high-grade binders produce 33 MPa and 35 MPa, and when slag is used, strength reaches 66 MPa.

Similar patterns appear when 45% cement clinker is added. For instance, in composites of slag and dune sand (55%) and cement (45%) subjected to heat treatment, flexural and compressive strengths reached 4.5 and 42 MPa, whereas after 28 days they were 4.4 and 44 MPa. Meanwhile, slag–dune sand (45%) and cement clinker (55%) compositions exhibited 6.7 and 66 MPa after heat treatment and 6.5 and 65.3 MPa after 28 days.

In all compositions, heat-treated samples showed higher strength than samples hardened for 28 days without heat treatment. This corresponds with

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literature on high-grade binders, finely-ground cements, and low-clinker cements used in foam concrete.

As a result of the research, high-grade binders equivalent to cement grades 500 and 600 were obtained using selected raw materials. The main reason such high grades can be achieved lies in the new structural formations created in finely-ground and chemically modified binders. Therefore, microscopic and physico-chemical analyses were conducted to study the new structures of hardened artificial stone based on electrothermophosphorus (ETP) slag, dune sand, and superplasticizer.

Thus, the high strength observed in high-grade binders is explained by the new structural formations created during hydration. The artificial stone produced from such binders possesses high strength, sulfate resistance, frost resistance, and other advantages. Foam concrete based on high-grade binders exhibits significantly higher strength, faster setting, and improved structural stability compared to cement-based analogs. In particular, samples with densities of 400–600 kg/m³ are suitable for practical applications as lightweight structural foam concretes. Therefore, high-grade binder technology makes it possible to design and produce efficient cellular concrete materials.

The analysis of the obtained results shows that using the foaming agent PB-2000 in high-grade binders enables the production of durable foam concrete, as the foam bubbles generated in the highly alkaline cement environment remain stable for several hours.

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