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TECHNOLOGY OF LIGHTWEIGHT CONCRETE PRODUCTION

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Abstract. This article examines the technological aspects of lightweight concrete production and evaluates the effectiveness of porous aggregates obtained from industrial waste and local raw materials. Experimental studies were carried out using expanded clay, perlite, foam glass, agloporite, and vermiculite as aggregates. The influence of aggregate type on density, compressive strength, thermal conductivity, and water absorption was determined. The results showed that concrete density decreases to 450–1200 kg/m³ depending on aggregate type, while compressive strength reaches classes B5–B25. The use of hydrophobic admixtures reduced water absorption from 18–25% to 9–12%. The study confirms the feasibility of producing energy-efficient and structurally reliable lightweight concrete based on local raw materials.

Keywords: lightweight concrete, porous aggregates, industrial waste, secondary raw materials.

Аннотация. В статье рассмотрены технологические аспекты производства лёгкого бетона и дана оценка эффективности применения пористых заполнителей, полученных на основе промышленных отходов и местного сырья. Экспериментальные исследования выполнены с использованием керамзита, перлита, пеностекла, аглопорита и вермикулита в качестве заполнителей. Определено влияние вида заполнителя на плотность, прочность при сжатии, теплопроводность и водопоглощение бетона. Установлено, что плотность бетона в зависимости от типа заполнителя снижается до 450–1200 кг/м³, при этом прочность достигает классов B5–B25. Применение гидрофобизирующих добавок позволило снизить водопоглощение с 18–25 % до 9–12 %. Полученные результаты подтверждают возможность получения энергоэффективного и конструкционно надёжного лёгкого бетона на основе местного сырья.

Ключевые слова: лёгкий бетон, пористые заполнители, промышленные отходы, вторичное сырьё.

Inroduction. The development of lightweight concrete with reduced density, sufficient compressive strength, and improved thermal performance remains an important

task for modern construction, particularly under the conditions of Uzbekistan. The use of lightweight concrete makes it possible to decrease the self-weight of structures, improve the energy efficiency of buildings, and expand the application of locally available raw materials and industrial by-products in construction practice. In this regard, the production of structurally reliable and resource-efficient lightweight concrete is of considerable scientific and practical interest.

Previous studies have shown that the technological efficiency of lightweight concrete can be improved through the use of alternative porous aggregates, coal ash, quarry waste, foam-ceramic systems, and geopolymer approaches [1]–[8]. These solutions contribute not only to the expansion of the raw material base and reduction of environmental impact, but also to the improvement of the thermal and mechanical performance of concrete. At the same time, recent investigations have emphasized the importance of microstructural modification, including the use of microsilica, composite mineral admixtures, and hydrophobic modifiers, for increasing strength, reducing water absorption, and improving the long-term durability of lightweight concrete [9], [10], [13].

A particularly promising direction is the production of porous aggregates based on local raw materials. Earlier studies indicated that aggregates derived from Angren clay-based raw materials and industrial waste can achieve relatively low density and sufficient strength, which makes them suitable for lightweight concrete applications [11]. Under the material and technological conditions of Uzbekistan, where expanded clay remains the principal porous aggregate, the search for alternative energy-efficient and resource-saving aggregate systems is especially relevant [12].

The aim of this study was to evaluate the technological aspects of lightweight concrete production using porous aggregates obtained from industrial waste and local raw materials, and to determine the influence of aggregate type on concrete density, compressive strength, thermal conductivity, and water absorption.

Materials and Methods

For the experimental investigations, Portland cement conforming to the requirements of GOST 31108–2020 (CEM I 52.5N) was used as the binder. Artificial porous aggregates, including expanded clay, agloporite, foam glass, perlite, and vermiculite, were employed as the main aggregate components. The granulometric composition, density, water absorption, and thermal conductivity of each aggregate type were determined and evaluated in terms of their influence on the final properties of lightweight concrete.

Experimental specimens were prepared according to a standard procedure including crushing, mixing, molding, and chamber curing. Compressive strength was determined in accordance with GOST 10180–2012, while water absorption was evaluated according to GOST 12730.3–2020. Density was measured by the volumetric method, and thermal conductivity was assessed using a steady-state heat flow apparatus. Experimental testing was carried out using standard laboratory equipment, including a hydraulic testing press with a maximum load capacity of 1000 kN. All measuring devices were calibrated in accordance

with relevant GOST standards, and the obtained results were recorded as average arithmetic values.

Results and Discussion

According to the experimental results, the use of porous aggregates significantly reduced the density of lightweight concrete. Specimens based on expanded clay exhibited densities in the range of 900–1200 kg/m³, whereas perlite-based concrete showed lower values of 450–650 kg/m³. At the same time, the thermal insulation performance of lightweight concrete improved by approximately 2.5–3 times compared with conventional heavyweight concrete. The lowest density values were obtained for perlite-based compositions, which also demonstrated the highest thermal efficiency (Fig. 1).

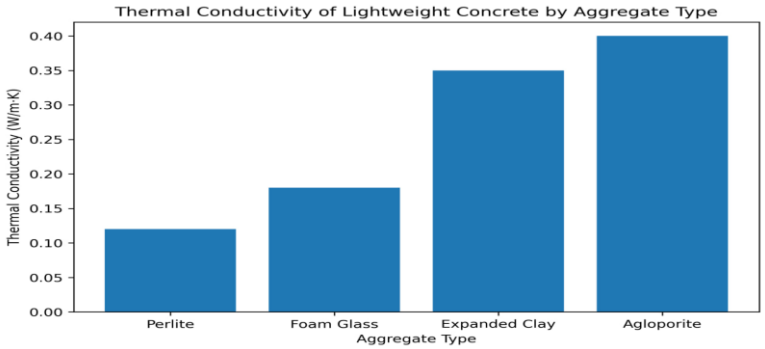

Figure 1. Thermal conductivity of lightweight concrete depending on aggregate type.

The compressive strength of the investigated concretes ranged from classes B5 to B25 depending on the type of porous aggregate, which confirms the possibility of producing structurally reliable lightweight concrete. Measurement uncertainty did not exceed ±5% for density and ±7% for compressive strength based on repeated testing. When hydrophobic admixtures were introduced, water absorption decreased from 18–25% to 9–12%, which is consistent with the results reported by Mordak et al. [10]. In addition, porous aggregates produced from local Angren clay-based raw materials provided densities of 395–690 kg/m³ and compressive strength values of 2.74–6.46 MPa, which agrees with the findings of Kamilov et al. [11]. At the same time, composite compositions modified with microsilica exhibited a 12–18% increase in strength, indicating the effectiveness of microstructural modification in lightweight concrete systems [13]. The obtained relationship between density and compressive strength is shown in Fig. 2.

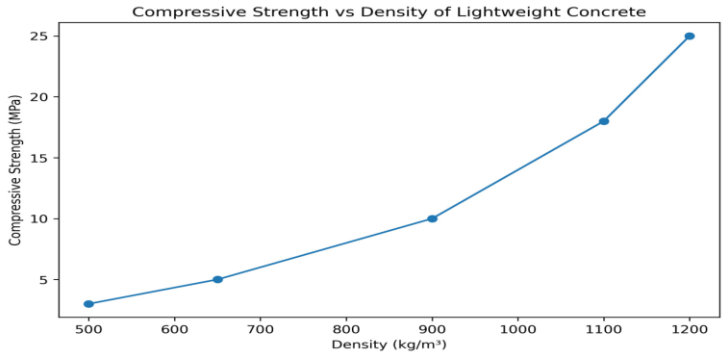

Figure 2. Relationship between density and compressive strength of lightweight concrete.

The obtained results indicate that the mineral composition, pore structure, and type of porous aggregate have a direct influence on the density, thermal conductivity, compressive strength, and water absorption of lightweight concrete. The use of local raw materials and industrial waste not only broadens the raw-material base for lightweight concrete production, but also contributes to improved energy efficiency and reduced material consumption. In general, the results confirm the feasibility of producing energy-efficient and structurally reliable lightweight concrete using porous aggregates based on local resources and modified composite systems.

Conclusion

The study demonstrated that porous aggregates based on industrial waste and local raw materials are suitable for the production of lightweight concrete with a density of 450–1200 kg/m³ and compressive strength within classes B5–B25. The incorporation of hydrophobic admixtures effectively reduced water absorption from 18–25% to 9–12%, whereas microsilica-based modification improved the strength characteristics of the composite system. These findings confirm the technological feasibility of producing structurally reliable and energy-efficient lightweight concrete for practical application in modern construction.

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