Use of Brick Waste in the Production of Energy-Efficient Lightweight Concrete

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Abstract This article discusses the potential use of brick waste in the production of energy-efficient lightweight concrete, considering the climatic conditions of Georgia. The study demonstrates that the use of crushed brick waste as a partial replacement for natural aggregates reduces the density of concrete and improves its thermal insulation properties. At the same time, water absorption increases and compressive strength decreases to a certain extent, depending on the replacement ratio. The research highlights the prospects of using this material in energy-efficient and environmentally sustainable construction.

Keywords: brick waste; lightweight concrete; energy efficiency; construction waste; thermal insulation; circular economy

Introduction

The intensive development of the construction industry has significantly increased the amount of construction and demolition waste, which has become one of the major environmental problems of the modern world.

In the modern construction sector, particular importance is attached to the recycling of construction waste and the development of environmentally sustainable materials, which are associated with the conservation of natural resources and the reduction of negative environmental impacts.

The issue of brick waste management is especially relevant, since the demolition of old buildings generates large volumes of ceramic waste, the disposal of which adversely affects the environment. One of the most effective solutions to this problem

is the recycling of brick waste. The porous structure of brick creates the possibility of its use in the production of lightweight and thermally efficient concrete, which is particularly important for the climatic conditions of Georgia.

Recent studies have shown that crushed brick waste can be used in the production of lightweight concrete as both coarse and fine aggregate. The porous structure of brick contributes to the reduction of concrete density and bulk weight while improving thermal insulation properties, which is especially important for the construction of energy-efficient buildings.

The climatic conditions of Georgia, characterized by both humid and sharply continental zones, require the use of construction materials that ensure thermal efficiency, structural durability, and reduced energy consumption. In this regard, lightweight concrete based on brick waste represents a promising alternative to traditional heavyweight concrete.

In addition to its technical advantages, the reuse of brick waste creates significant economic and environmental benefits, as it reduces the consumption of natural aggregates, decreases waste generation, and lowers CO_2 emissions. This approach fully corresponds to the modern concepts of sustainable development, circular economy, and green construction.

According to international studies, the use of crushed brick aggregate in concrete reduces its bulk density and improves thermal insulation properties. This material is particularly effective in the production of lightweight concrete, where reducing structural self-weight and increasing energy efficiency are important factors.

Research also indicates that the partial replacement of natural crushed stone with brick waste causes a certain reduction in concrete strength; however, acceptable mechanical properties can be maintained at optimal replacement ratios. At the same time, the porous structure of brick aggregate significantly increases water absorption, which

requires consideration of additional waterproofing measures.

Studies conducted in European and Asian countries also indicate that the use of recycled brick contributes to reducing the consumption of natural aggregates and promotes environmentally safe management of construction waste, which is especially important under conditions of urban development.

Main Part

In Georgia, brick construction played a significant role in previous centuries. Therefore, conducting modern and innovative research on brick waste is highly relevant today, as demolition waste from brick structures is currently considered one of the major environmental challenges.

According to international studies, the use of crushed brick waste in concrete reduces its density and improves thermal insulation properties. Nevertheless, the use of this material somewhat decreases the mechanical strength of concrete, depending on the level of replacement. Research also indicates that the use of brick waste contributes to the conservation of natural resources and the reduction of construction waste.

The scientific novelty of this study lies in the comprehensive assessment of the possibility of using brick waste in the production of energy-efficient lightweight concrete, considering the climatic conditions of Georgia. Within the framework of the research, the influence of crushed brick waste on the physical-mechanical characteristics as well as the thermal and energy-efficient properties of concrete is examined for the first time in relation to local environmental conditions.

Research Methodology

The study is based on an experimental laboratory method, within which lightweight concrete samples are prepared with different percentages of brick waste replacement.

Concrete samples are produced using different percentages of brick waste replacement (0%, 10%, 20%, 30%, and 50%). The samples are molded into standard cubes measuring 150×150×150 mm and cured in a humid environment for 28 days. Subsequently, density, compressive strength, water absorption, and thermal properties are determined (Table 1).

The following materials were used in the study:

- Cement (Grade 400);
- Natural sand;
- Natural crushed stone;
- Crushed brick waste (fraction 5–20 mm);
- Water.

Brick waste is obtained through the mechanical crushing of old ceramic bricks followed by sieving.

Density is determined according to the mass and volume of the samples. Replacing part of the natural heavy aggregate with brick waste leads to a reduction in concrete density. This is due to the porous and lightweight nature of brick material, which has a lower bulk density compared to natural crushed stone. Consequently, the concrete becomes lighter and the self-weight of the structure decreases, which is particularly important for seismically active zones.

Compressive strength is determined using a hydraulic press according to the standard testing method. Brick aggregate has lower mechanical strength and a porous structure, which increases the probability of internal defects. The addition of brick waste in moderate amounts (e.g., 10–30%) causes a partial reduction in strength; however, this depends on the replacement ratio. At higher replacement levels, the strength decreases significantly.

For water absorption testing, samples are weighed in both dry and water-saturated conditions. Since brick is a highly porous material and easily absorbs water, the use of brick waste significantly increases the water absorption of concrete. As a result, the porosity of concrete increases, requiring additional waterproofing measures.

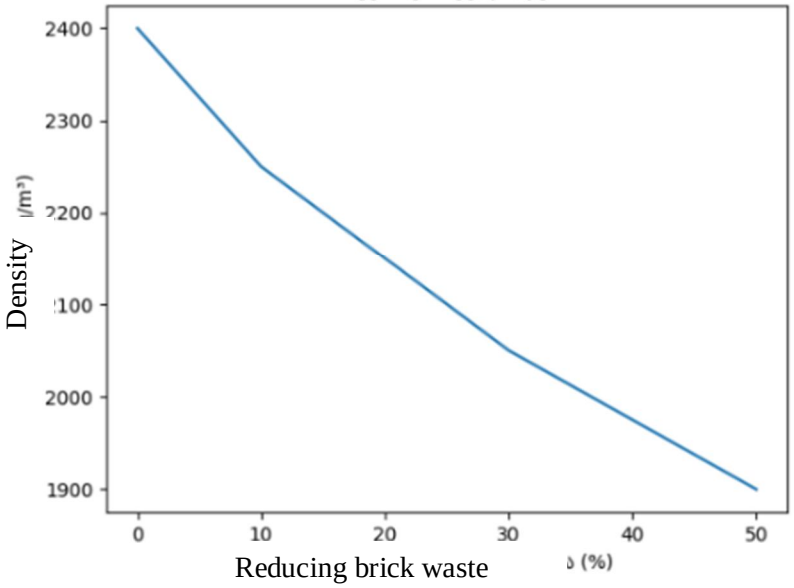
Thermal conductivity is determined using a thermal analysis device. Concrete produced with brick waste is characterized by low thermal conductivity. Its porous structure contains air voids, and air is a poor conductor of heat. As a result, energy efficiency increases both in winter and summer, since concrete retains heat more effectively.

Table 1. Effect of Brick Waste on Lightweight Concrete

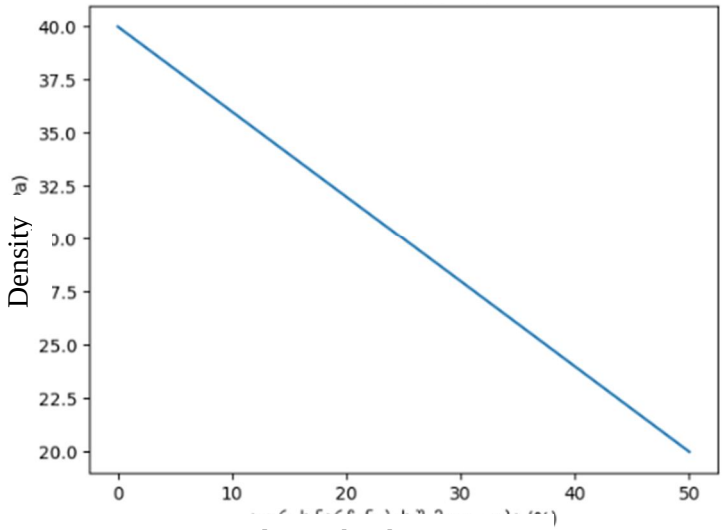
brick %	Density	Strength	Water absorption	Thermal conductivity
0	2400	40	5	1,7
10	2250	36	7	1,5
20	2150	32	9	1,3
30	2050	28	12	1,1
50	1900	20	16	0,9

Based on the analysis of the research results, it was determined that the use of brick waste in concrete composition leads to a reduction in density and an improvement in thermal insulation properties. At the same time, the water absorption rate increases and the compressive strength of concrete decreases to a certain extent, depending on the replacement ratio of the brick aggregate. These changes indicate that concrete modified with brick waste represents an effective material for lightweight and energy-efficient construction structures

Density change

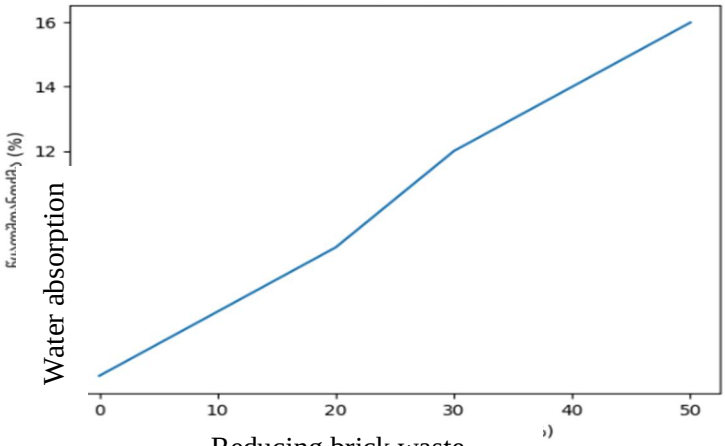


Change in strength



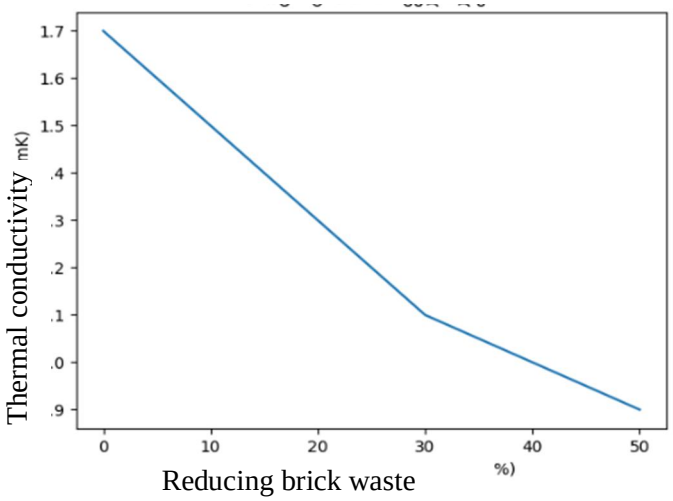
Reducing brick waste

Change in water



Reducing brick waste

Change in thermal conductivity



Reducing brick waste

The obtained data are processed using a comparative analysis method, in which the influence of brick content on the physical and thermal properties of concrete is evaluated.

Conclusion

The use of brick waste in the production of lightweight concrete represents an effective approach to reducing construction waste and increasing energy efficiency. The research results indicate that the application of this material ensures a reduction in concrete density and an improvement in thermal insulation properties, which is particularly important for the climatic conditions of Georgia.

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