

Effect of Ore and Finely Dispersed Fractions of Wollastonite From the Koytash Deposit on The Structure and Strength of Non-Autoclaved Foam Concrete

Allanazar Ilyasov

Professor at Karakalpak State University, Doctor of Technical Sciences (DSc), Uzbekistan

Javlon Xamrayev

Independent Researcher at Karakalpak State University, Uzbekistan

Timur Begjanov

Student of Karakalpak State University, Uzbekistan

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Abstract

The article investigates the possibility of using ore and finely dispersed fractions of Koytash wollastonite from the Jizzakh region as a structure-modifying additive in non-autoclaved cement-fly ash foam concrete. The objective of the study was to determine the effect of the fractional state and dosage of wollastonite on the aggregative stability of the mix, the density of inter-pore partitions, compressive strength, and thermal conductivity. Compared with the control composition, the ore fraction was found to reduce the settlement of the mix from 14 mm to 9–11 mm, while the finely dispersed fraction reduced it to the range of 6–8 mm. When 1.0–1.5% finely dispersed wollastonite was used, the 28-day compressive strength increased from 1.30 MPa to 1.78–1.92 MPa, and the 90-day strength increased to 2.05–2.25 MPa. At the same time, the thermal conductivity coefficient decreased from 0.135 to 0.128–0.130 W/(m·°C). The results were explained by the role of wollastonite as a microfiller, a nucleation center, and a factor promoting the densification of inter-pore partitions.

Keywords: Non-autoclaved foam concrete, Koytash wollastonite, ore fraction, finely dispersed fraction, inter-pore partition, compressive strength, thermal conductivity.

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1. Introduction

In the cellular concrete market, a key objective is to increase the share of materials that provide a balance between thermal insulation and structural properties

while relying on the local raw material base [1-4]. In the production of non-autoclaved cement-ash foam concrete, the problem of strengthening inter-pore partitions while maintaining a low density remains one of the most complex challenges.

Due to the presence of Ca-Si minerals, the elongated shape of its particles, and its well-developed surface area, Koytash wollastonite is prone to forming a spatial-mechanical bond with the cement stone [2]. Therefore, it can serve not only as an inert micro-filler but also as an additional nucleation center for hydration products.

In practice, wollastonite can be used in the form of ore and enriched/dispersed fractions. This article provides a comparative assessment of the technological effectiveness of these two forms in non-autoclaved cement-ash foam concrete.

2. Methods

The base composition of foam concrete, based on a Portland cement–fly ash system, was adopted for the research. A protein-type foaming agent was selected as the technical foam. Wollastonite was introduced in ore and dispersed fractions in the range of 0.5–2.0%. All tests were performed under the same foaming regime and at the same water-to-solid ratio.

The aggregate stability of the mixture was evaluated by signs of settlement and stratification at 60 minutes, while the properties of the hardened material were assessed based on average density, compressive strength, and thermal conductivity. To determine the mechanism of the modifying effect, structural data on porosity parameters and the quality of the inter-pore partitions were analyzed.

Table 1 – Effect of wollastonite fraction and dosage on mixture settling

Wollastonite Type	Dosage, %	Settlement after 60 min, mm	Signs of Segregation
Control	0.0	14	Moderate
Ore wollastonite	0.5	11	Low
Ore wollastonite	1.0	9	Low
Ore wollastonite	1.5	10	Low
Dispersed wollastonite	0.5	8	Almost absent
Dispersed wollastonite	1.0	6	Absent
Dispersed wollastonite	1.5	6	Absent
Dispersed wollastonite	2.0	7	Low

Table 2 - Main indicators of compositions modified with wollastonite

Composition	ρ , kg/m ³	λ , W/(m·°C)	Compressive strength (28 days), MPa	Compressive strength (90 days), MPa	Shrinkage, mm/m
T0 (control)	560	0.135	1.30	1.55	1.12
T2 (dispersed wollastonite)	538	0.130	1.78	2.05	0.98
T3 (dispersed wollastonite + fiber)	532	0.128	1.92	2.25	0.82

3. Results

The fractional state of wollastonite had varying effects on the aggregative stability of the mixture. While the control sample exhibited 14 mm of settling over 60 minutes, the ore fraction reduced this figure to 9–11 mm, and the dispersed fraction reduced it to 6–8 mm. Stratification was almost non-existent, particularly within the 1.0–1.5% range of the dispersed additive.

Although the ore fraction reduced settling, it was less effective than the dispersed fraction in terms of final strength. With the dispersed fraction, the 28-day compressive strength increased by 36–48%, which can be attributed to the densification of inter-pore partitions and the narrowing of the macropore spectrum.

The introduction of wollastonite led to a decrease in thermal conductivity, alongside a slight decrease in average density. This is due not only to the reduction in mass but also to an increase in the proportion of closed porosity and a shortening of the open capillary network.

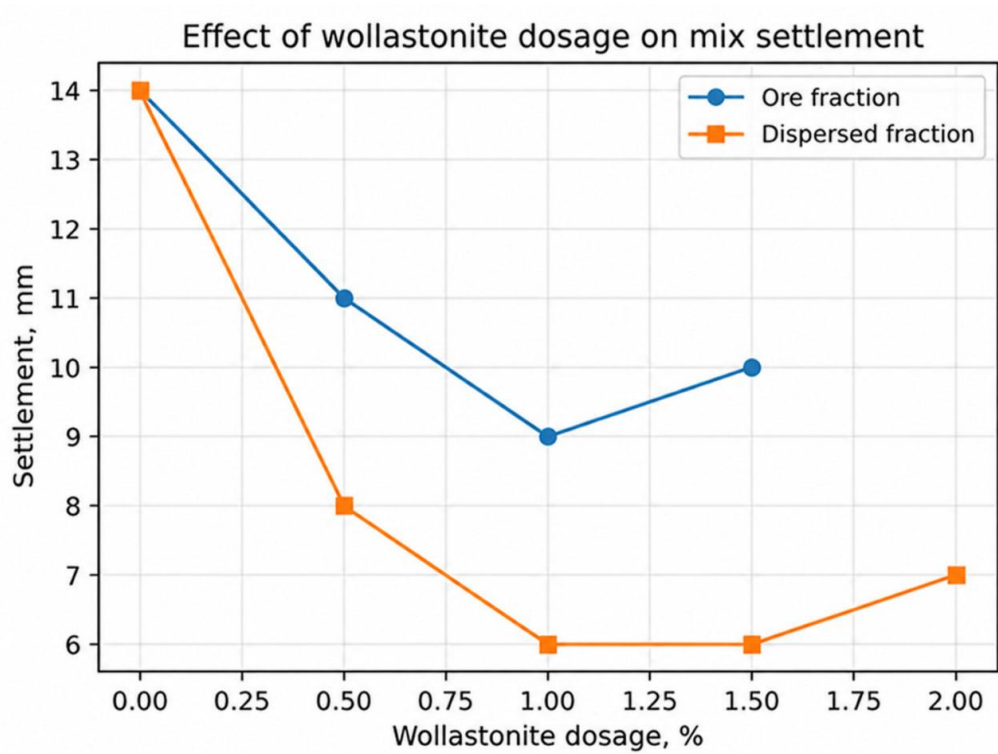


Figure 1 – The effect of wollastonite dosage on mixture settlement

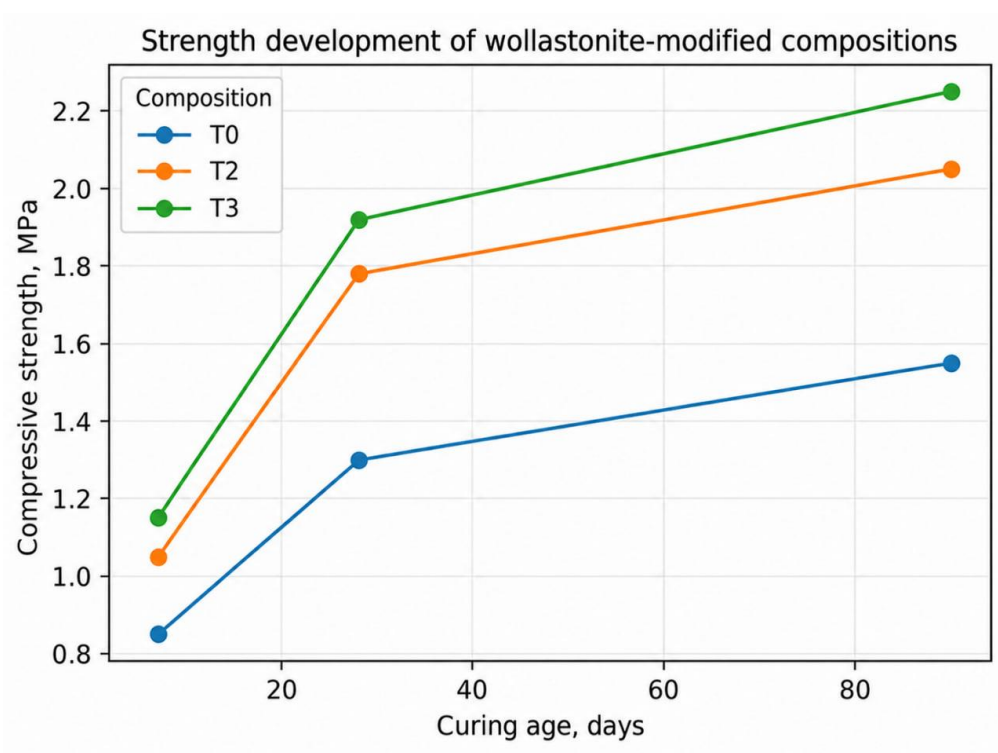


Figure 2 – Strength dynamics of compositions modified with wollastonite

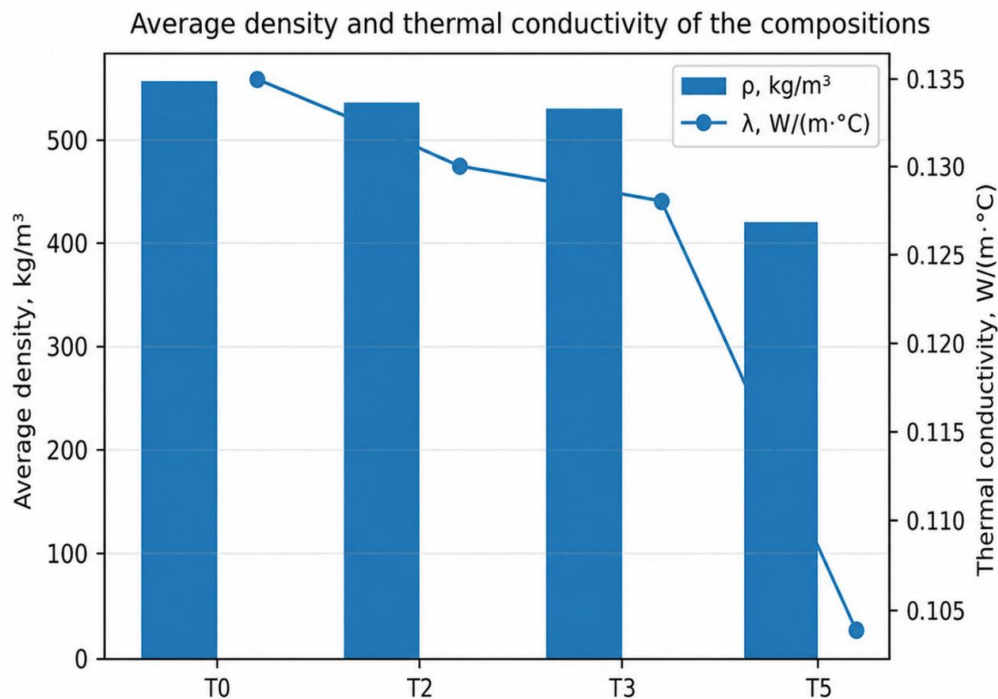


Figure 3 – Average density and thermal conductivity of the compositions

4. Discussion

Because the ore fraction contains carbonate and other associated minerals alongside wollastonite, its modifying effect was primarily manifested through micro-filling and improved particle packing. In the dispersed fraction, however, the developed surface area and favorable particle shape accelerated the formation of the cement stone's spatial framework during the early stages of hardening.

It was experimentally confirmed that the optimal range for dispersed wollastonite is 1.0–1.5%. As the concentration approaches 2.0%, the mixture's water demand increases and its rheology deteriorates, which limits further positive results.

The results demonstrate that the problem of structural modification in non-autoclaved foam concrete can be solved using local raw materials. This approach aligns with reducing import dependency and utilizing waste materials (fly ash).

5. Conclusion

1. The dispersed fraction of Koytash wollastonite more effectively enhances the aggregate stability of the foam concrete mixture compared to the ore fraction.

2. The 1.0–1.5% range of dispersed wollastonite is considered optimal for densifying the inter-pore partitions, increasing 28- and 90-day strength, and reducing thermal conductivity.

3. The use of local wollastonite enables a comprehensive improvement in the thermal insulation and performance properties of non-autoclaved cement-ash foam concrete.

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