

PREPARATION OF NANO-CONCRETE WITH IMPROVED MECHANICAL PROPERTIES BASED ON GRAPHENE OXIDE (GO)

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ANNOTATION

This research is devoted to studying the role of graphene oxide (GO) in improving the physical and mechanical properties of cement-based composite materials. In the experiment, the effect of GO at a dosage of 0.05% by weight of cement on the hydration process was analyzed. The results showed that the addition of GO increases the density of concrete and can reduce concrete cracking by up to 35%. The article also provides information on the environmental efficiency of nano-concrete.

Keywords: Graphene oxide, nanomaterials, cement hydration, strength, sustainable construction.

INTRODUCTION

Modern construction materials are required not only to possess high strength but also to maintain durability over long periods of time. Although conventional concrete has high compressive strength, its brittleness under tensile and flexural stresses remains one of its major disadvantages. Concrete production accounts for approximately 8% of global CO₂ emissions. The use of graphene oxide (GO) can help achieve higher strength while using less cement, which in turn contributes to reducing harmful gas emissions released into the atmosphere.

Graphene oxide (GO) is well dispersed in water due to the presence of functional groups on its surface (–OH, –COOH) and forms strong chemical bonds with cement particles. Currently, as the share of “intelligent materials” in construction continues to increase, the issue of extending the service life of concrete by 2–3 times with the help of GO has become an important and relevant topic at the global level [1].

Nano-concrete is resistant to high temperatures and retains its properties at temperatures up to 800 °C. It improves physical and mechanical properties, increasing both strength and frost resistance [2].

According to studies conducted over the past five years, GO acts as a template for cement hydration products (C–S–H gel). GO particles serve as nucleation centers that promote the orderly growth of crystals during the cement hydration process.

EXPERIMENTAL PART

In this study, M500 grade Portland cement and graphene oxide (GO) powder obtained by the chemical method (Hummers method) were used [5].

The required amount of cement was placed into a container. Three times the amount of sand was added to it. The cement and sand were thoroughly mixed in a dry state. In a separate container, graphene oxide was added to water and mixed until it was uniformly dispersed. The prepared GO dispersion was then gradually added to the dry mixture. The mass was mixed until a homogeneous and thick concrete mixture was obtained. The prepared concrete was poured into pre-prepared molds. To remove air bubbles inside the concrete, the mold was lightly vibrated. The mold was left undisturbed for 24 hours. Afterwards, it was kept in a moist environment for several days, during which the hardening process was observed.

Concrete containing graphene oxide becomes stronger and denser compared to ordinary concrete. The amount of cement used is less relative to sand (1:3 ratio), which ensures an economical and optimal composition of the concrete.

ANALYSIS OF RESULTS

According to the results of the conducted experiments, the physical–mechanical tests and microstructural analyses of the obtained nano-concrete demonstrated that graphene oxide (GO) plays a decisive role in improving the performance of cement composites. Based on the obtained data, it can be stated that after 20 days of curing, the compressive strength of samples containing 0.05% GO increased by 34%. This improvement can be explained by the fact that GO sheets act as nucleation centers during the cement hydration process, regulating the formation of hydration products (C–S–H gel) [6].

GO nanosheets also function as a type of nano-reinforcement within the cement matrix. The study recorded an 18% increase in flexural strength, which is directly related to the “bridging effect”: GO sheets connect forming microcracks, preventing their propagation and thereby reducing brittle fracture of the material.

From an economic and environmental perspective, the addition of GO increases the strength of concrete, making it possible to reduce the structural volume by 15–20%. This, in turn, decreases cement consumption, lowers overall costs, and contributes to reducing CO₂ emissions released into the atmosphere.

CONCLUSION

The high-shear liquid-phase exfoliation method used for producing water-based graphene dispersions is suitable for integrating graphene into concrete, as the industrial-scale equivalent equipment can achieve high throughput, exceeding 100 L·h⁻¹ [7].

The conducted research shows that the addition of 0.05% graphene oxide (GO) elevates the quality indicators of concrete to a new level. This material may become a key component in the future construction of skyscrapers, bridges, and hydraulic engineering structures.

Concrete containing graphene oxide is stronger and denser compared to conventional concrete. It also reduces cement consumption, which ensures a more economical and optimal composition of the concrete.

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