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ENHANCING THE STABILITY OF SOFT SOIL FOUNDATIONS IN TRANSPORTATION INFRASTRUCTURE THROUGH THE APPLICATION OF LIME AND XANTHAN GUM

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Abstract. *This paper investigates the improvement of road subgrade stability by employing lime and the biopolymer xanthan gum. The study identifies these materials as effective solutions for enhancing the resilience of road foundations. Laboratory experiments were conducted to determine the optimal concentrations of lime and xanthan gum required to achieve the best results. The findings reveal that the use of biopolymers, particularly xanthan gum, offers an environmentally friendly alternative for soil stabilization.*

Key words: *stability, soft soil, road subgrade, transportation infrastructure, lime, biopolymers, xanthan gum, soil stabilization.*

Introduction.

The global quest for cost-effective and environmentally sustainable materials for reinforcing weak-soft soils, which are unsuitable as road subgrade in their natural state, is ongoing [1]. Replacing such soils can significantly escalate the costs of construction, reconstruction, and major overhauls. Using reinforced soils as a substitute for high-strength soils in the foundation layers of road pavement structures can considerably reduce these costs. Enhancing road subgrade stability can be achieved through the application of geosynthetic materials or the incorporation of lime and biopolymers [2].

In Ukraine, the need to restore, reconstruct, and strengthen pavement structures, especially under challenging engineering and geological conditions, is critical. The predominance of clay soils, which lose bearing capacity when waterlogged, presents a significant challenge. Therefore, improving the stability of water-saturated clay soils is an urgent issue in Ukraine [3].

Main text.

The most prevalent methods for increasing the stability of water-saturated clay soils include the use of cement, lime, and polymers as stabilizing additives. Among these, biopolymers are considered the most environmentally friendly. Although cement is widely used, it is less sustainable than biopolymers. This study focuses on examining soil mixtures enhanced with lime and the biopolymer xanthan gum [4].

When lime or biopolymer is introduced to waterlogged soil, it interacts with moisture and fine soil particles, acting both as a drying agent and a chemical modifier that alters soil properties. These additives also function as binders, forming relatively strong and water-resistant bonds with soil components.

To determine the optimal amount of lime for soil stabilization, various soil-lime ratios were tested in the laboratory. Existing methods for selecting mixture compositions rely on an approximate lime content, which is then fine-tuned by assessing the quality characteristics of the soil-lime mixture.

The global trend in geotechnical engineering is moving towards the use of biopolymers like xanthan gum to enhance the physical and mechanical properties of water-saturated clay soils [5]. Xanthan gum, a natural polysaccharide produced by the microorganism Xanthomonas campestris, is known for its high shear resistance, even at low concentrations (e.g., 0.2%) in soil [6]. The optimal concentration of xanthan gum in clay soil ranges between 2% and 4%. The effectiveness of xanthan gum depends on several factors, including soil type, moisture content, xanthan gum concentration, and the method of mixing.

Although the use of biopolymers in soil stabilization is gaining popularity, standardized methodologies are still in development. Ongoing research is essential to establish clear guidelines for their application.

In this study, laboratory tests were conducted using a compression device to assess the effectiveness of lime and xanthan gum. Samples were prepared with varying soil liquidity indices (LI=0.5-0.7).

The research findings, illustrated in Figure 1, demonstrate that the inclusion of 4% xanthan gum in clay soil (LI=0.5-0.7) enhances soil stability by a factor of 1,6-

2,1 compared to the use of 4% lime, depending on the soil mixture's liquidity index.

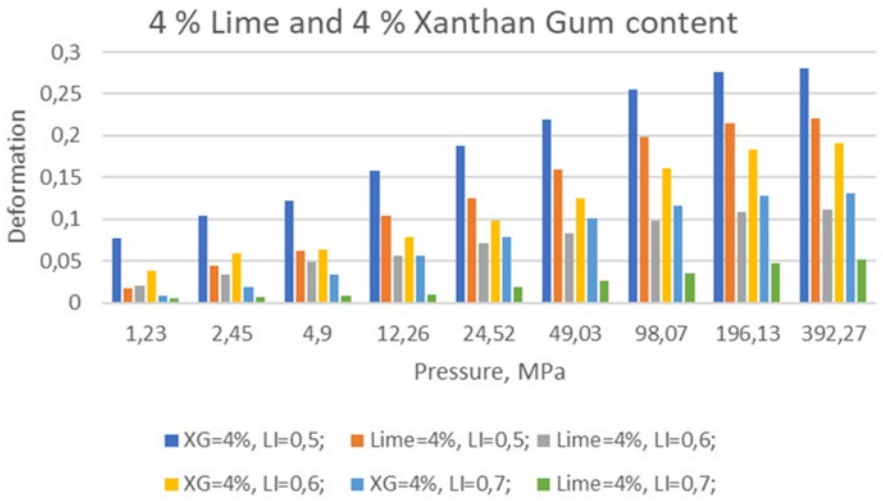

Figure 1 - Deformation Test Results for Clay with 4% Lime and 4% Xanthan Gum Additions

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Summary and conclusions.

1. The study was conducted to identify the most effective and environmentally sustainable method for enhancing the characteristics of clay soils using lime and biopolymer.

2. Laboratory models of clay soil with varying moisture levels and liquidity indices were prepared using 2-4% lime and xanthan gum.

3. The research concluded that xanthan gum is the most effective and eco-friendly material for consolidating soft soils and enhancing their stability.

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