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Organic-Mineral Aggregate for Sandy Subsoil Strengthening

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Abstract

The article evaluates the possibility of using organic-mineral aggregate for strengthening sandy subsoil. As an organic component of the organic-mineral aggregate, glyoxal is used. To ensure uniform polymerization throughout the required thickness of the sandy subsoil a mineral component was admixed into the aggregate. The above component is saponite containing pulp waste produced in the industrial ore benefication tailing dump of the diamond deposit named after M.V. Lomonosov. It was found that glyoxal is a surface-active substance. The tailored content of glyoxal was identified by the OWRK method (Owens–Wendt–Rabel–Kaelble). In the paper the results of research on the strength properties of sandy subsoil modified by the organic-mineral aggregate are presented. It is shown that the tailored aggregate content allows increasing the specific cohesion of sandy subsoil by up to 50 times.

Keywords: Sandy subsoil, organic-mineral aggregate, glyoxal, saponite containing waste, strength characteristics

1 Introduction

Nowadays the transport system development of any country is a prerequisite for the economic growth model implementation and for the improvement of the quality of life of the population, e.g. the Russian Federation is implementing the Federal purpose oriented program "Development of the transport system in Russia (2010-2020)". The purpose of the program is to develop a modern and efficient transport infrastructure [1].

To achieve this goal it is necessary to ensure the reliability and durability of roads and their structural elements: subgrade, pavement, and other engineering structures. Subgrade serves as the basis for pavement therefore the durability and riding characteristics of the road depend on its strength and stability.

The Russian Federation is characterized by a variety of geotechnical conditions, e.g. the ones of the Arkhangelsk region are unfavorable for construction activities due to the prevailing water-bearing dispersive soils such as fine sand, sandy silt, loam soil, sludge and peat. Moreover, flat terrain and

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high level of subsoil water are specific features of natural and climatic conditions of the Arkhangelsk region contributing to considerable water accumulation, deep seasonal frost penetration and intensive frost heave thus increasing water content and decreasing density of the subsoil while thawing out in spring. It reduces the bearing capacity of the whole road structure [2].

To solve this problem various methods of subgrade strengthening are used. There are mechanical and chemical technologies. Currently, nanomaterials, which are added in the construction of roads, are widely used. Due to the size, nanoparticles have more developed specific surface and, consequently, high reaction activity. Even a minimal content of nanoparticles affects such properties of subsoil as strength, permeability and resistance to various impacts [3]. Thus the research [4] investigated properties of sandy subsoil modified with highly dispersed aggregate consisting of fine sand and saponite-containing material and proved it to increase subsoil specific cohesion by up to 9 times.

However, the production of nanodispersed material involves significant power consumption while grinding. Therefore, a method of subsoil stabilization using nanomaterials is not considered to be cost effective.

According to the current hypothesis, glyoxal should be introduced into subsoil as an aggregate; its supplier is "Novokhim PRO" (Tomsk, RF).

Glyoxal is a dialdehyde of ethane diacid. The chemical name is ethanedial. The molecular formula is $C_2H_2O_2$. Figure 1 demonstrates the structural formula of the compound. Table 1 shows the specific characteristics of glyoxal.

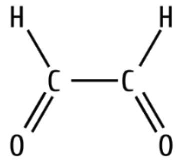

Figure 1: Structural formula of glyoxal

Mass fraction of glyoxal	0.4
Density of glyoxal solution (40%; 20^{o}C), g/cm^3	1.20-1.35
Molecular mass (a.m.u.)	58.04
Melting point, °C	15
Boiling point, °C	51
pH	2-3.5

Table 1: Glyoxal properties

The selection of glyoxal is due to its properties: it polymerizes quickly and easily even at low temperatures; soluble in water; its inclusion into polymeric materials provides moisture resistance and increases adhesion; under certain conditions, glyoxal forms a decorative and protective film on the surface of the modified materials. In addition, taking into consideration the glyoxal structure it could be assumed that the substance is a surface active surfactant. As after the source studies having been done no data on surface activity of glyoxal were revealed, one of the aims of the research is to specify the surface activity of the substance and compare it with that of sodium lignosulfonate which is widely used as an additive for composite materials. The maximum surface activity of sodium lignosulfonate is achieved at 10 g/l and 0.180 N·m^2/g [5]. Plants producing cellulose by sulfite pulping are the main suppliers of the lignosulphonate. Sulfite pulping prevailed since the late XIXth to the mid XXth century. At that time the method was the only one used to identify pulping wood grades, and the emission of the unprocessed boiled off cooking liquor in water heavily polluted the environment. Nowadays, sulfite cooking takes only a small segment of the pulp market and is gradually being superseded by other pulping methods, so the production of lignosulfonate is reducing. Thus, actually