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Freeze -Thaw Resistance and Increased Strength of Cohesive Soils Modified with a Cationic Surfactant

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Abstract

The problem of adequate load carrying capacity of the base coarse layer of road surfaces or load-bearing layer of industrial floors or building foundations arises during the realization of every investment undertaking. The article presents the issue of stabilizing poor soils with cement along with applying a hydrophobizing agent. The aim of the work was to present new means of improving the physical and mechanical parameters of cohesive soils.

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Keywords: hydrophobizing agent, cement, freeze-thaw resitance, cohesive soil, load-carrying capacity of soil.

1. Introduction

The subsoil is the native or man-made soil material, found directly under the base coarse layer of the road surface or load-bearing layer of industrial floors or building/machine foundations. The main role of the subsoil is to carry loads and fulfill the following conditions: ensure adequate load-carrying capacity and serviceability, as well as resistance to freeze-thaw damage and drainage of groundwater. Soils characterized by weak or non-load bearing properties are frequently encountered in areas were building or road structures are to be constructed. Situating buildings or linear facilities on such soils can generate problems with their use and endanger the safety of their users. In the case of road construction, shallow building foundations, or industrial floors in unheated production halls and warehouses, the subsoil has to be secured against the negative effects of moisture down to the freezing depth of the ground.

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An effective method for permanently strengthening, hardening and securing the ground against the effects of water is to stabilize native or man-made soil (including the use of local materials). Depending on the parameters and the type of soil, as well as the designed load, the most commonly applied methods of stabilizing soil are: degranulation and stabilization with the use of hydraulic binders (cement, hydraulic calcium, fly ash). Very good results are obtained when the material subjected to stabilization is non-cohesive soil of full granulation. Non-cohesive soils stabilized in such a way gain high load carrying capacity, and are characterized by good compactability and freeze-thaw resistance. However the results of the stabilization of cohesive soil (e.g.: of low cohesion - including loamy sand, clay, sandy and silty loam) are not fully satisfying. Cohesive soil that is full of moisture is not suitable for mechanical compaction. Nevertheless, it turns out that the parameters of cohesive soil can be significantly improved by the addition of a hydrophobization agent. Anion chemical solutions for the hydrophobization of soil are currently available on the market, but the authors' experience has shown that the anion components of these substances are not attracted to negatively charged minerals contained within the soil. Their effect is not satisfactory, as they do not change the hydrophilic character of the soil.

The aim of the study was to find a hydrophobization agent for cohesive soils which will evenly penetrate the structure of the soil, changing its character from hydrophilic to hydrophobic. Modified cohesive soil should not absorb moisture, but it should retain cohesion and not undergo plastification, and should be suitable for mechanical compaction. It turns out that the desired effect is obtained with the use of cationic surfactants.

2. Research methodology

Cohesive soil taken from a heap found on a building site in the suburban area of Poznan was used (Fig. 1). The main features of this soil have been presented in Tabs. 1 and 2, as well as Fig. 2.

a. b. c.

Fig. 1. Loamy sand after 10-day submersion in water with the addition of a hydrophobization agent in the amount of: a) 7%; b) 5%, c) 3%.

Table 1, Table 2 and Fig. 2 present the results of the sieve analysis and aerometric analysis of the collected soil samples.

Table 1. Results of granulation analysis - sieve and aerometric analyses.

AREOMETRIC ANALYSIS								SEIVE ANALYSIS			
Duration of Sedimentation T	Temp of Suspension t [ºC]	Shortened Indicator of Reading R	Correction for Meniscus R_1=R+c	Correction for Areom. Graduation.□R	Substitute□ of Particles d_T [mm]	Percentage of Particles Z_T Ř□□<d_T [%]	Percentage of Particles Z_T Ř□□□>d_T [%]	Side of Sieve Opening [mm]	Sieve Residue [g]	Sieve Residue [%]	Fine Fraction [%]