The investigation of soils by using laboratory freezing system

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ABSTRACT

In cold regions of Kazakhstan has long winter season. On average, the ice freezes is in early December and the end of March. In this study, investigate the different type of soil, 4 specimen of soil with different physical and mechanical properties and soil classification by unified classification method. Freezing test was carried out for 4 sort of classified samples by the Unification Classifications (USCS). The temperature change of the specimens and change condition of the outside freezing temperature, appear the amount of frost heaving. During the experiments used sample of soils is marine clay contain chemical agent – ash 4%, 8% and only clay. The frost test equipment consists of a sample loading part, water supply part and a measuring device for heaving amount and atmospheric pressure. The measuring part is load cell for measuring the pressure and holder Linear Variable Differential Transformers (LVDT) for measuring the swelling amount of the same phase. The boundary temperature condition was at -12 ℃. During several days observe the temperature of 1 cm deep at the surface of the specimen was 0 ℃ and the inside temperature of the experiment was changed to -3 ℃. As a results, for TRRL standard it was found that the minimum heaving amount is 0.5 mm during 48 hr, which have clay with chemical agent ash 8%, and maximum heaving amount is 4 mm during 48 hr, contain clay without chemical additives.

Keywords: temperature, freezing soil; heaving amount

1 INTRODUCTION

The development of the natural resources of Kazakhstan requires the construction of new facilities, which leads to the use of seasonally freezing soils as bases. During construction in such regions there is a need to solve issues to ensure the reliability, stability and durability of buildings and structures that are being built on heaving soils. And also as questions of the negative impact of frost heaving on the foundations during freezing are the main tasks for engineers. In the frozen state, the soil has the same properties as concrete, but with change temperature, the properties of the soil ground change. The purpose of the paper is to study samples of the frozen properties of the soil with additives ash to determine the most durable frozen soil that can be used as the foundation of roads, and in other projects Zhussupbekov, Shakhmov and Tleulenova (2017); Tleulenova (2018), Tsytovich (1973); Karlov (2007); Shin (2012); Zhussupbekov, Shin, Shakhmov and Tleulenova (2018); Nevzorov (2000); Shakhmov (2014); Shakhmov (2013); Anderson (1989); Zhussupbekov, Omarov (2017); Shin, (2012), Shakhmov (2016).

2 EXPERIMENTAL METHOD

The study on geotechnical properties of frozen soil was carried out through indoor and field tests such as the characteristics of heaving amount. However, although GOST, ASTM, JGS, and TRRL methods are currently being used for the determination of statistical sensitivity, there is a need to establish an appropriate test method for the domestic environment conditions and establishment of the statistical sensitivity criteria. Therefore, in this research, the frozen soil temperature change, frozen water amount, floating water, and amount ice lens were measured for four kinds of soil samples by using the frozen soil sensitivity test method which is currently applied by using the produced room frozen experiment apparatus (freezing camera)

2.1 Geotechnical properties of samples setup

First, the mechanical characteristics and freezing test were carried out for 4 kinds of classified samples by the Unification Classification (USCS). The temperature change of the sample depends of the continuous condition of the freezing temperature, the amount of frost heave, moisture of soil. The sensitivity of the images was evaluated by analyzing the characteristics. Specific gravity tests, liquid and plastic tests, sieving tests, and compaction tests were carried out in accordance with the standard test methods to

determine the physical properties of each classified soil sample. In particular, the maximum dry unit weight and the optimal water content were calculated with a maximum grain size of 10mm for the compaction method used in the roadside compaction management. Poor particle size, or a small amount of fine clay.

In this research use 4 kinds of samples clay with different chemical agent content was used. And also analyzed the behavior of clay samples during the freezing test.

3 EXPERIMENTAL PROCEDURE

All four samples were placed, and the temperature, the amount of swelling, the swelling pressure, and the floating water content were measured. The boundary temperature condition of the room temperature experiment was maintained at -12 ℃ until the temperature of 1 cm above the specimen of the specimen reached 0 ℃ after the start of the in situ coincidence test. The temperature of 1 cm deep at the surface of the specimen was 0 ℃ and the internal temperature of the experiment was changed to -3 ℃, and the experiment was performed for 96 hours after the start of the experiment. In order to maintain the inflow water temperature constant at 4 ℃, the temperature was controlled through the cooling system and the thermal insulation system.

Fig. 2 presented equipment for monitoring and checked displacement freezing soil in samples.

In addition, as shown in Fig. 1, Fig. 3 the freezing method was one-sided warm-tempering method, and the freezing direction of the sample was frozen from the top to the bottom as in the ASTM method and the TRRL method. However, when it is frozen from top to bottom, the top is frozen, and there is a cohesive force between the mold and the sample, and the frost is frozen. In order to overcome this disadvantage, in this experiment, a silicone material pad with elasticity was inserted between the mold and the sample to minimize the adhesion between the mold and the sample.

3.1 Experimental measurement

Device and the whole view of the room sampler system, which was constructed to evaluate the characteristics of the frost the soil type. The frost test equipment consists of a sample loading part, a water supply part for supplying water, and a measuring device for measuring the expansion amount and the atmospheric pressure.

A total of four specimens can be inserted into the loading section of the sample, and a porous stone having a thickness of 6 mm and a diameter of 100 mm is placed on the bottom of the loading section.

The measuring part is composed of a holder for mounting a load cell for measuring the in-phase expansion pressure and a holder for mounting LVDT (Linear Variable Differential Transformers) for measuring the swelling amount of the same phase. TRIME-FM, a model of time domain reflectormetry (TDR), was installed inside the specimen. The temperature of each specimen was measured using a thermocouple installed at 1 cm intervals. LVDT check settlement soil in the samples.

Fig. 1 Four samples in freezing box

Soil properties are determined by the size of the component particles. Dusty-clay soils, in which particles less than 0.05 mm in size predominate, are plastic and have low water permeability. Capillary raising of moisture is typical for clay soils.

Many properties of soils are determined by the amount of coherent water contained in them.

As the temperature decreases, the amount of ice increases, and as the temperature increases, the ice partially melts.

Fig. 2. Monitor to check displacement freezing soil

Fig.3. Prepare soil in samples for freezing test

The sensors of the decal and thermocouple were connected to the data logger automatic measuring equipment. In addition, the TDR prove floating water was measured by connecting to a laptop and measured

by a measuring program. All the data were measured at intervals of 1 hour.

In this experiment, the specimens were weighed at 100% degree of compaction using the maximum drying unit weight and the optimum water content, in the soil compaction test method.

The system is equipped with an open system to generate a phase due to the rise of the capillary tube. In general, the water supply system uses open and closed methods according to the groundwater conditions when testing the field samples. However, in this case, the experiment was carried out in an open method to reproduce the condition of the area vulnerable to frostbite because the groundwater level was low. The specimens were plumbed into 3 layers and the specimens were soaked for 2 days after compaction to induce saturation.

4 TEST RESULTS

The amount of swelling is an important parameter used to estimate the frost heave rate used for the determination of the isosceles sensitivities.

In general, soil properties increase steadily when the supply of sufficient water is maintained at a constant zero temperature. Such a frost heaving characteristic can be obtained by varying the amount of in-phase expansion during a unit time which is used as an index to judge statistical sensitivity.

Fig. 5 shows the amount of in-phase expansion depending on the type of soil.

The temperature of 1 cm deep at the surface of the specimen was 0 ℃ and the inside temperature of the experiment was changed to -3 °C. As a results, for TRRL standard it was found that the minimum heaving amount is 0.5 mm during 48 hr, which have clay with chemical agent ash 8%, and maximum heaving amount is 0.4 mm during 48 hr, contain clay without chemical agent.

In table 1 presented results of heaving ratio during 24 hour different types of clay samples. Clay with chemical agent 8% is 0.4 mm, it is less than comparable other type soils.

Table 1 Value heaving rate of different kind of freezing of soil

Heaving ratio	clay	clay +chemical agent 4%	clay +chemical agent 6%	clay +chemical agent 8%
mm/day/ 24 hour	2.5	1.0	0.6	0.4

Swelling soils are called frost - dangerous.

The intensity of the flow of moisture to the front of freezing depends on many factors: the composition of the soil, the shape and size of pores, the presence of salts in them.

In table 2 illustrated displacement freezing soil, clay with chemical agent 8% has 0.5 mm.

Table 2 Value heaving rate of different kind of freezing of soil

Descrip-tion	clay	clay +chemical agent 4%	clay +chemical agent 6%	clay +chemical agent 8%
Displace ment (mm)	15	2.5	0.7	0.5

4.1 Results of ice lens characteristics

When water is present in the bottom soil at a temperature below 0°C, the water rises along the surface of the soil constantly due to the capillary phenomenon, and flows into the upper part to cause frostbite. In stationary frost heaving, the freezing of pore water gradually increases and the amount of in-phase expansion increases with the increase of ice crystals in the sample.

The formation of the pieces was remarkable, and the enlargement of the area of the ice lens portion could be confirmed with the naked eye. However, CL, which are not susceptible to frostbite, are very small in shape and cannot be visually confirmed.

In Figure 5 illustrated different type of samples. So, much better physical characteristics is clay with chemical agent 8% has piece ice lens.

Fig. 6 presented results heaving amount (mm) and elapsed time (hr). Samples clay with chemical agent 8% has 0.5 mm during 36 hours, and maximum heaving amount is 0.5 mm during 48 hours.

Fig. 5. Results freezing test of different type of clay samples.

On the basis of research for these frozen samples, in construction as the ground or pavement, you should use the play + chemical additives 8%.

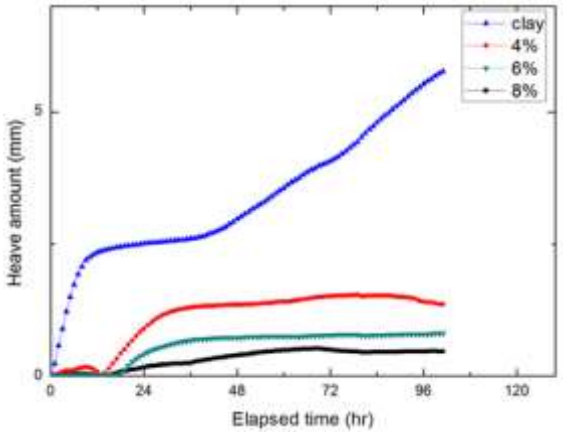

Fig. 6. Graphs of samples of freezing test.

5 CONCLUSION

In this case, the freezing soil temperature change, frozen water amount, floating water, and ice lens were measured for four types of soil samples using the currently used frost susceptibility test method. The main conclusions are as follows CL, which were found to be highly susceptible to the same phase among the 4 samples used in the experiment. When the temperature characteristics, swelling amount, and floating water characteristics are analyzed, it can be seen that the most important factor affecting the isothermal sensitivity at the same temperature is the rise of the soil capillary. The amount of 200 sieves passing through the soil, the particle size distribution, and the permeability coefficient interact with each other to affect the frost heave characteristics. In other words, clay with chemical additives 8% content, but less clay content, tends to be more susceptible to frostbite.

As a result of comparing GOST, ASTM, JGS, and TRRL method with the method applied in this experiment, different test results were different from each other according to each test standard and same phase sensitivity criterion. Because the different phases are generated according to the experimental condition, the appropriate experiment is applied according to the temperature and moisture characteristics of the region.

The temperature change of the specimens and change condition of the outside freezing temperature, appear the amount of frost heaving. During the experiments used sample of soils is marine clay contain chemical agent– ash 4%, 6%, 8% and only clay. The frost test equipment consists of a sample loading part, water supply part and a measuring device for heaving amount and atmospheric pressure. The measuring part is load cell for measuring the pressure and holder (LVDT) for measuring the swelling amount of the same phase. The boundary temperature condition was at -12 °C. The temperature of 1 cm deep at the surface of the specimen was 0 ℃ and the inside temperature of the experiment was changed to -3 °C. As a results, for TRRL standard it was found that the minimum heaving amount is 0.5 mm during 48 hr, which have clay with chemical agent ash 8%, and maximum heaving amount is 2.8 mm during 48 hr, contain clay without chemical additives.

ACKNOWLEDGEMENTS

This work was supported by the Incheon National University, Geotechnical Laboratory (Incheon, South Korea) and authors are grateful of Prof. Eun Chul Shin for carry out investigations freezing soil ground.

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