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ESTIMATIONOF FROST HEAVING IN SEASONALLY FREEZING SOIL GROUND

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For more than 100 years, many local and foreign scientists have been studying frost heaving, the amount of water in the seasonally frozen soil. This phenomenon is one of the main in the design of buildings and structures in seasonally frozen soils, and can lead to negative consequences (cracks in the foundations, exterior and interior walls of buildings and structures). The aim of this paper is to evaluate the frozen frost heave of the experimental soil ground.

When designing buildings and structures, engineers should understand the important role that frozen soils and thawing soils play. The phenomenon of frost heaving leads to a change in the geotechnical characteristics of the soil.

The ground contains droplets of moisture that freeze, form ice lenses, ice expands and expands the ground - this causes soil swelling, the formation of waves, cracks, and these forces are so strong that they can easily squeeze out of the ground or break heavy monolithic structures.

The definition "frost susceptibility soil" is used most often in reference to freezing soil materials that are sufficient fine-grained to have large specific surface areas and pore-size distributions and water content in soil [1].

When water freezes in soils, not only the properties of the soils themselves dramatically change (adhesion increases, as well as resistance to external forces), the volume of frozen soil increases significantly, and it is unevenly distributed. Humidity during freezing is fixed by lowering the temperature. The redistribution of humidity depends on the area of construction, the geology of the soil foundation, on the temperature of soil freezing. The effect of migration during soil freezing is the release of water from the freezing soil zone, the influxe of water and the increase in ice content near the freezing zone. Water migration in freezing soils occurs under the influence of various forces that determine the mechanism of moisture transfer. The mechanism of water migration during freezing of various soils can be different depending on many factors, the effect of molecular forces on the surface of mineral particles of soil and ice. In assessing the mobility migration, the temperature regime and the different state of the soil phases had particular significance. Water migration in freezing wet soils is a process of moisture transfer, which constantly occurs with any imbalance of the soil phases and changes in external influences (changes in temperature, humidity, pressure, mineral particles) [2-8].

Non-balance frozen ground affects the structure during thawing. The processes occurring in the soil is change in the precipitation of the soil and the carrying capacity of the soil.

Frost soil swelling is determined by standards GOST, ASTM. These methods allow to obtain the results of frost heaving at different temperatures and from different soils.

Based on long-term observations, there are two indicators that determine the initial heaving conditions. The first indicator is the humidity limit of the swelling (W_h). It characterizes the extremely humid state, in which the pores are filled with ice and frozen water, there is no swelling. The second indicator is the critical humidity (W_{cr}). It characterizes the limiting state in which the water content in frozen ground does not affect its mobility in the soil layer located below the freezing limit.

The swelling rock in seasonally freezing soil is increase volume in freezing process is uneven. The increment of the amount of the deposit (9%) of the total volume, which is included in the data in freezing soil,due to the freezing of new volumes of water, pulled up to the front of freezing in the process of moisture migration.Due to the heterogeneity of the composition of the soil, the uneven distribution of moisture in them, the difference in hydrogeological conditions - a uniform increase in the volume of soil during freezing is not observed. An uneven increase in the volume of soils during freezing, i.e., the swelling of soils, is observed quite often and is a harmful process (especially for road and airfield pavements), resulting in unavoidable damage to the coating. If ground swelling occurs during freezing only due to pore moisture without water inflow from the outside, although in the presence of moisture redistribution, this swelling is called heaving in a closed or closed system (S. Taber, M. I. Sumgin and etc.).This swelling, as a rule, is small and is measured by a value of the order of several percent of the thickness of the layer of soil freezing. The freezing of sands (with the exception of only very fine dusty) has the peculiarity that, with free flow of water, their volume during freezing remains almost unchanged, since the water pressure that occurs when ice crystals grow quickly spreads to adjacent volumes of sand, and excess water is squeezed out. side, dehydrating the freezing area. When water flows from the outside when the groundwater level is located at a depth less than the height of the soil intake, i.e. when the soil freezes in the so-called open system, vertical heaving of soils associated with the migration of moisture to the freezing front and fixation (F. G. Bakulin) in the form of ice in the frozen layer, it increases significantly, reaching tens of percent or more of the depth of frost penetration [7].

In this regard, many theories of moisture migration have been put forward, explaining the physical causes of its occurrence and development. The rate of freezing affects the heaving of the soil. With rapid freezing, it may turn out that the process of migration of moisture to the freezing front, although it does occur, will not have time to develop fully. In this regard, swelling during rapid freezing of the soil is usually less than with slow freezing. The load applied to the soil layer exposed to freezing significantly reduces its swelling. In order to completely eliminate the increase in the volume of the soil during freezing, it is necessary to apply a significant load, since the forces of frost heaving reach very large values. The amount of migrating water, and, consequently, a significant part of the magnitude of the swelling is proportional to the temperature gradient in the freezing layer of the soil, i.e. depend on the temperature on the surface of the freezing soil.

The stresses arising from the heaving of soils are so significant that they can cause deformations of buildings and structures, destruction of the roads, etc. The swelling soils are characterized by a deformation of frost heaving h_f, equal to the height of the elevation of the surface of the frozen ground, as well as relative heaving f, determined by the ratio

$$f = \frac{h_f}{d_f}$$

d_f – layer of freezing ground

This formula (1) allows to calculate the frosty swelling of the soil, taking into account the depth of freezing. The total value of frost heaving of the soil depends on many factors, among them: the grain and mineralogical composition of the soil; the density and humidity of the soil during the period of frosty moisture accumulation and freezing; the ability of the soil to resist freezing (thermal, thermal insulation properties); geological and hydrological conditions of the area; climatic conditions of the area; moisture gradient in the thawed zone of freezing soil.

At Incheon National University (Incheon, South Korea), a series of frozen soil experiments were conducted in the geotechnical laboratory to determine the amount of frost heaving of the soil. In the period from October to December, 2017, observations were made of the experimental soil at a temperature T = -10 ^{o}C, T = -5 ^{o}C. Laboratory experiments demonstrated segregated ice lenses in soil at negative temperature.

The experiments were carried out according to the ASTM standard. As a result, graphs of frost heaving of the soil were obtained.

A diagram illustrating different situations, behavior of freezing soil changes of ground temperature below 0°C, -5°C, -10°C.

According to the results of the graph, it is clear that the lower the soil freezing temperature, the lower the strain, and the lower the soil freezing rate.

Most researchers agree that when freezing, water, increasing in volume by about 9,5%, is the cause of frost heaving of the soil, which, in turn, may increase in volume by 5-6 %. However, the amount of frost heaving of soils can reach 10% or more (over-luffing soils), which means that the freezing.

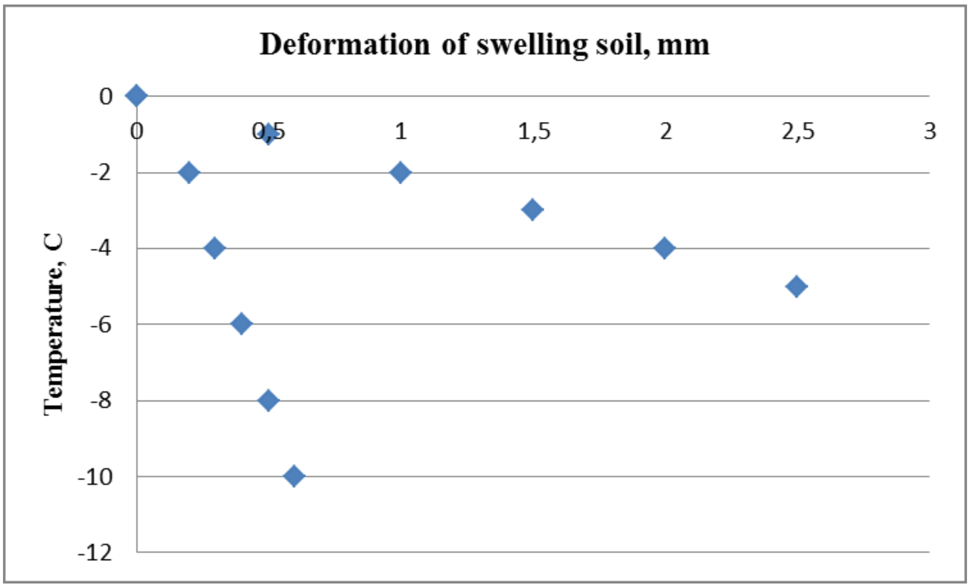

Figure 3 – Graphs of deformations of swelling soil

layer is fed with additional moisture from the warm underlying layers. Scientists have called this process the migration of moisture to the front of freezing. The mechanisms of such migration are physically complex and diverse.

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