Problem of the action of frozen soil to sustainability of the foundation

Zhanbolat Shakhmov[1], A. Zhussupbekov[1], and G. Tleulenova[1]

[1] Department of Design of buildings and structures, L.N. Gumilyov Eurasian National University, 2, Satpayev str., Astana 010008, Kazakhstan.

ABSTRACT

Kazakhstan is located in the seasonally frozen soil climatic region. The temperature is seasonally changing from negative to positive degree during calendar year. The temperature could reach -45 ºC in winter and +45 ºC in summer seasons. The soil types is different in territory of Kazakhstan because of the large size and different landscape. Many buildings and structures are built in Kazakhstan associated with the growth of cities such as Astana, Almaty, Shymkent (Zhussupbekov et al.2012). There are also many infrastructure projects such as roads, railways a n d b i i d g

Keywords: frozen soil; soil ground; Kazakhstan, frost depth, frost heaving

1 INTRODUCTION

The deformation of underground structures of buildings is main geotechnical problem in seasonal freezing ground of Kazakhstan. Inappropriate laying of the soil ground of foundations can lead to loss of stability or to large uneven deformations of the latter. So according to freezing-thawing of soil ground there are important to predict frost heaving, freezing force. There are tangent frost heaving, vertical frost heaving, horizontal frost heaving which influence underground structures and could deform those structures. There are many examples in construction when it led to disappointing results in Kazakhstan, for example, such construction projects as: The Besoba residential complex in Karaganda, the Astana-Karaganda highway built and commissioned in 2017, and others. Frost heaving of soil directly depend on moisture content of soil, type of soil, chemical composition. Especially soil has high frost susceptibility if pores of soil fulfilled with water (Zhussupbekov et al.2017).

Hydrodynamical forces of frost heaving tend to move up foundation with relegation soil. If statical relegation links between soil and foundation will be less than weight of foundation and structures, so after that begin to slip a frozen soil layer with lateral surface of foundation. The resistance to those slippage in freezing of soil and foundation define tangent forces of frost heaving. There is a regelation of soil with lateral surface of underground structure during the freezing of soil ground by depth (Nevzorov A.L. (2000)).

2 SOIL GROUND PROPERTIES AND FREEZING EXPERIMENTS

It is important to know soil ground properties for defining freezing susceptibility, which is important for design and construction of the buildings. Frost susceptibility could be estimated roughly by freezing soil normative according to soil properties (Zhussupbekov et al.2018).

The special mold which can eliminate the side friction between soil and wall is used in the laboratory freezing test. Prior to the laboratory freezing test, geotechnical properties of the soils are determined throw the basic tests (Shakhmov et al. 2018). The geotechnical properties of soil specimens are presented in Table 1.

Table 1. Properties of the soil specimens

Soil number Description	I CL	II SP	III SM
Specific gravity (G_s kN/m^3)	2.62	2,63	2,67
Natural water content (w_n,%)	21	N.P	N.P
Particle size passed #200 (%)	52	19,6	1,9
Liquid limit (LL, %)	27.01	N.P	N.P
Plastic limit (PL, %)	17.75	N.P	N.P
Maximum dry unit weight (γ_{dmax}, kN/m^3)	1.79	1,92	1,93
Optimum water content	15.9	11,5	12,4

(w_{opt} , %)			
USCS	CL	SP	SM

The specimen is remolded and prepared in mold which is appropriate for freezing chamber. Only after saturation, they were putted in the freezing apparatus. General view of freezing chamber filled in with soil and freezing equipment is presented in Figure 1.

Figure 1. Freezing camera

The grain size distribution curves of the soils are presented in Figure 2. The first 24 hours is a conditioning period. Both the top and bottom plates are kept the temperature at 3 ^{0}C. The first freeze starts at the beginning of the second 24-hours period. The temperature of the top plate was lowered and hold it up at -3 ^{0}C. The temperature of the bottom plate was kept at 3 ^{0}C for 8 hours.

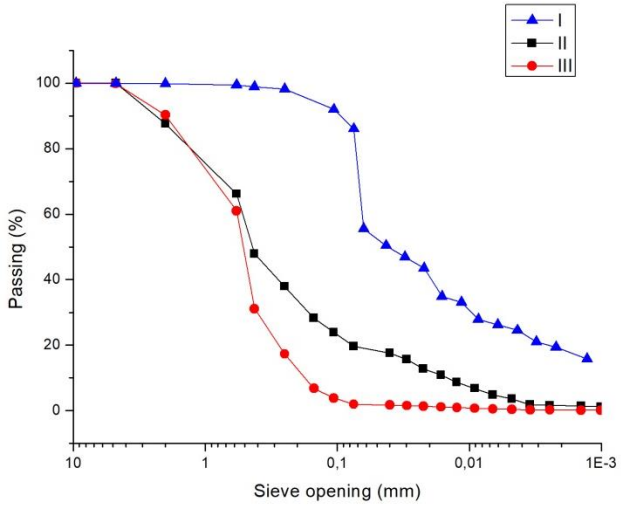

Figure 2. Grain size distribution curves of soil specimens

3. RESULTS AND DISCUSSIONS

The experimental freezing tests were performed for understanding frost susceptibility of the soil and predetermination possible frost action to the structure. The frost heaving results of soil specimen after freezing test are presented in Figure 3. There are some curves which show frost different frost heaving resulted by freezing test.

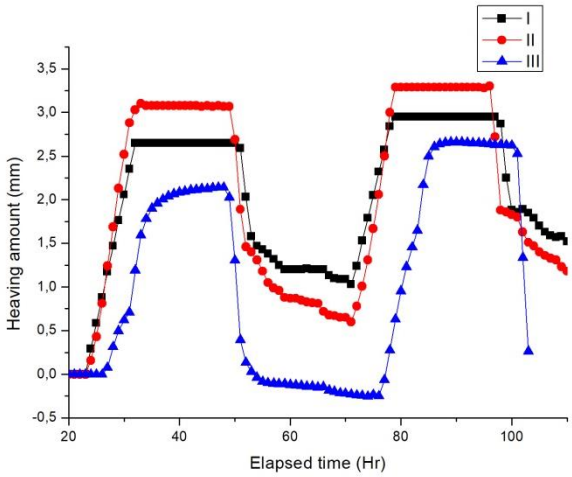

Figure 3. The frost heaving amount of the soil specimens by ASTM

Also freezing test according ASTM for comparison with TRRL testing provided by experiments throw freezing chamber. The results shows some differences and pasted below in Figure 4.

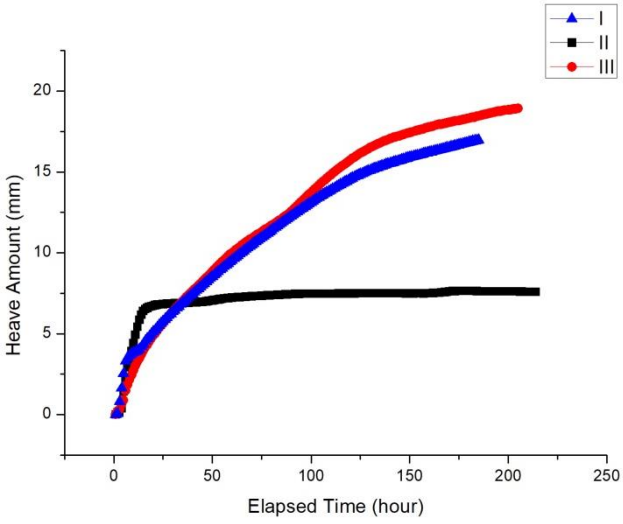

Figure 4. The frost heaving amount of soil specimens by TRRL

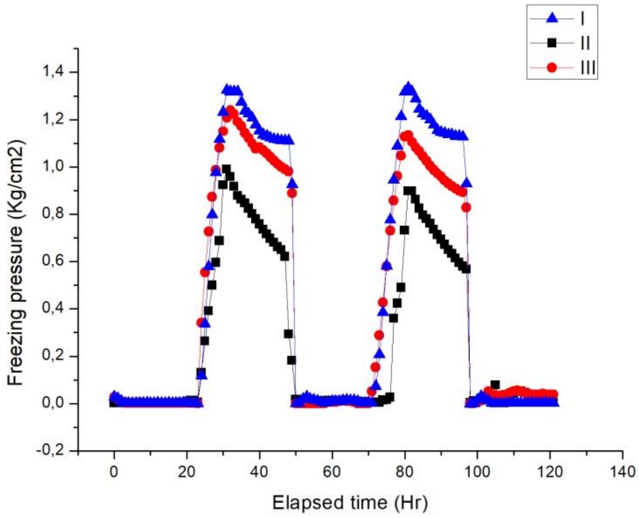

Figure 5. The freezing pressure curves of soil specimens by ASTM

The freezing pressure, heaving amount of soil specimens gives different results which show frost susceptibility of the soil specimens. According to the results TRRL frost susceptibility properties like frost heaving could reach more than 18 mm and heaving pressure 400 kPa. These results could damage roads and another light-weight constructions.

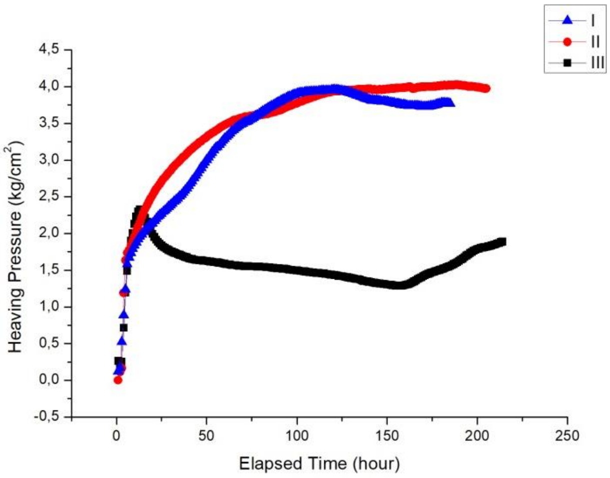

Figure 6. The freezing pressure curves of soil specimens according TRRL

4. Conclusions

Freezing experiments show high frost susceptibility criteria for silty-clay soil types. Heaving amount for silty-clay soil ranging from 8mm to approximately 20 mm. While heaving pressure ranging from 1 to 4 kg/cm2. These results indicate sensibility of silty-clay soils to freezing process. Especially its important to consider frost susceptibility results during design low depth structures. Also the results of freezing tests show dangerous data for light-weight structures in condition of Kazakhstan.

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