KTH Architecture and the Built Environment

ARTIFICIAL GROUND FREEZING IN CLAYEY SOILS

LABORATORY AND FIELD STUDIES OF DEFORMATIONS DURING THAWING AT THE BOTHNIA LINE

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Abstract

Artificial ground freezing as a method to temporarily stabilize and create hydraulic sealing in urban as well as in rural areas has been used in a number of Swedish construction projects, particularly during the last decade.

One problem with the freezing of soil and rock is that fine-grained clayey types of soils have showed a tendency to under certain circumstances, during the thawing process, create a pore water overpressure and to consolidate, despite a change in the external loading conditions. In certain cases, this condition can be a desired effect as the soil mass after a freeze- and thaw cycle acquires overconsolidated properties.

The main objectives of this study are, to describe and review the knowledge and current state of practice of artificial ground freezing, to increase the understanding about the conceptual behaviour for prognosis of the vertical deformation concerning artificial ground freezing and to compare and discuss results from laboratory and field studies concerning vertical deformation during thawing process for Bothnia soil.

The field studies and the laboratory tests in this research study have been performed with soil from the freezing of the Bothnia Line in the vicinity of Stranneberget. The Bothnia Line is the railway link between Nyland, north of Kramfors, and Umeå.

This thesis relates to a part of the Bothnia Line. It deals with the behaviour of soil during thawing by means of temporary stabilization and hydraulic sealing of fine-grained soil through artificial freezing using brine as the cooling agent. However, the reason behind the problem consists of the final deformations due to the thawing process.

The general conclusions of this study are;

- the Bothnia soil water content decreased in mean approximately 14 % after a freeze-thaw cycle, which approximately corresponds to; $w_{th} = 0.8w - 1.5$
- the decrease of the water content has no correlation to the depth below ground surface, in contrast, there is a strong correlation between the undisturbed soil water content and the magnitude of the decrease in water content
- the soil liquid limit decreases after a freeze-thaw cycle, simultaneously as the relative share of clay and fine silt grains decreases while the relative share of more coarse grains increases
- the coarser and denser soil created after a freeze-thaw cycle obtains an increased preconsolidation pressure and an increased undrained shear strength.

Keywords: Artificial ground freezing, AGF, deformation, thawing, heaving, Bothnia Line.