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Artificial Ground Freezing technique for tunnel stabilizing

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Motivation

Harsh environmental conditions prevailing in northern regions, demand special approach for any construction activity. Combination of high effectivity and low environmental risks are considered crucial in geotechnological projects and particularly in underground construction.
One of the most significant issues in arctic geotechnology is to maintain construction stability. In arctic regions with relatively high permafrost layer this task can be solved by protecting permafrost from thawing during construction and operation. [1]
One of the main advantages of construction in permafrost is absence of water flow in soils. Otherwise, if underground constructions are designed in water saturated soils with average temperature above 0 oC it can be required to freeze a layer of soil around the construction to prevent water leakage inside it. This technique is called Artificial Ground Freezing. The technology was patented more than 100 years ago. Since than it has been modified, but the basic principles remain the same. [2]
Based on this technique, soil with average temperature above 0 oC can be frozen and kept at negative temperature during the construction period and if required also during operation of the geotechnical object. The method is used worldwide – from arctic to subtropics for various geotechnical projects [3].
The current paper describes the feasibility of ground freezing as potential stabilizing measure for tunnelling through a soil filled depression at Bergåsen road tunnel.
The tunnel is planned by Statens vegvesen – Norwegian public roads authority – as a part of European highway E6 (from Trelleborg(Sweden) to Kirkenes(Norway).
The tunnel is located in Grane kommune (Nordland fylke in Northern Norwayregion) and is scheduled for 2018 – 2023. [4]
Based on geotechnical sounding it was found that the 1,3 km long tunnel will cross a depression over a section of approximately 20m, which is filled mostly by water-saturated soils (silt, sand and gravel). To "handle" this section, special methods of soil stabilisation are required.
The aim of the current research is to evaluate the feasibility of artificial ground freezing applied to the current case.

Approach

The analysis implemented in this paper, is based on geological and geotechnical reports with description of mechanical and thermal properties of soil. One of the most important factors is ground water flow, which determines the significance of ground water. This parameter strongly affects the required thickness of artificial frozen ground layer sufficient to protect the tunnel during excavation and permanent lining installation.
The analysis of tunnel stability and support requirement is provided by numerical modelling in FEM software "Rocscience".

Results (expected)

The following issues are expected to be solved during the planned research:

- Design parameters of the Artificial Ground Freezing technique, such as time of freezing, energy consumption and costs for freezing
- Indication of stability and support requirement.

Numerical analysis should prove the assumed advantages of artificial ground freezing in comparison with other methods applicable for the tunnel stabilizing, which are theoretically considered as less effective.

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