Geotechnik im Bauwesen
Geotechnical Engineering
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Geotechnical Engineering

RWTH AACHEN UNIVERSITY

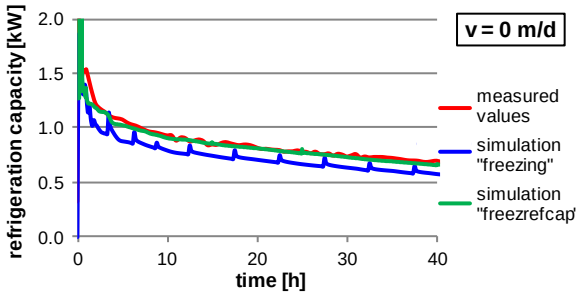
Optimization of Artificial Ground Freezing Applications

Aim of the research project

A systematic use of the ground freezing method often fails due to the energy costs that are expected to be excessively high. Therefore numerical simulations have been carried out at the Institute of Geotechnical Engineering at RWTH Aachen University to optimize artificial ground freezing applications. Former investigations of Baier showed that the freezing time can be significantly reduced by flow adapted freeze pipe arrangements. Our current research work deals with the optimization of the energy consumption. In this context not only the freezing phase but also the operating phase need to be considered due to their high impact on the total energy consumption of artificial ground freezing applications.

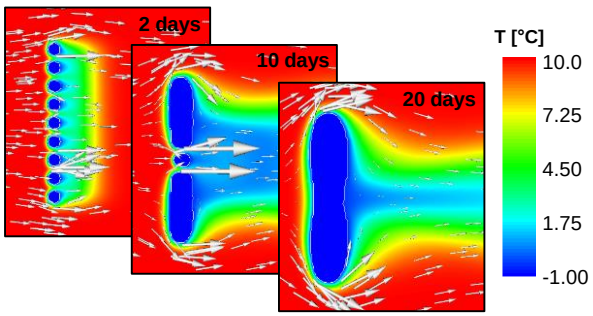
Approach and results

To achieve a realistic determination of the refrigeration capacity both a simplified approach and a detailed numerical model have been developed and implemented in the program SHEMAT-Suite. In contrast to the simplified approach („freezing“) the detailed approach („freezrefcap) considers the freeze pipe structure as well as the flow conditions and heat transfer processes inside the freeze pipe. Both approaches resp. modules have been validated by the recalculation of a laboratory test and a real construction project.

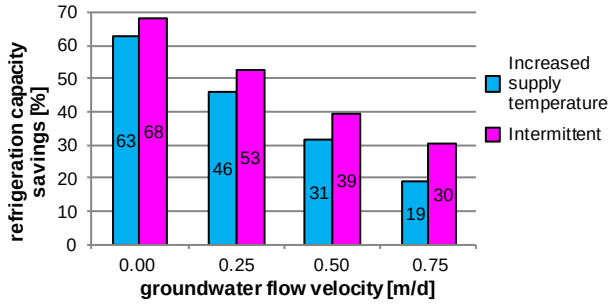


Refrigeration capacity of laboratory test

Subsequent to the validation of both modules the energy saving potential for an excavation pit freezing has been examined. The optimization of the energy consumption during the operating phase can be realized with different modes, an increased supply temperature mode or an intermittent mode. The results showed that both operating modes can achieve significant energy savings compared to an operating mode with a constant supply temperature of -35°C. The possible energy savings decrease with an increasing groundwater flow velocity due to the convective heat flow. The results indicate that an intermittent mode can achieve higher energy savings due to the individual control of the freeze pipes, especially for higher groundwater flow velocities. A further advantage of an intermittent mode can be seen in the minimization of detrimental frost heave in cohesive soil.



Frost body development (v = 0.75 m/d)



Energy savings in operating phase

Bundesamt für Bauwesen und Raumordnung

w&f Wayss & Freytag Ingenieurbau

GEOPHYSICA Beratungsgesellschaft mbH

ZÜBLIN

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