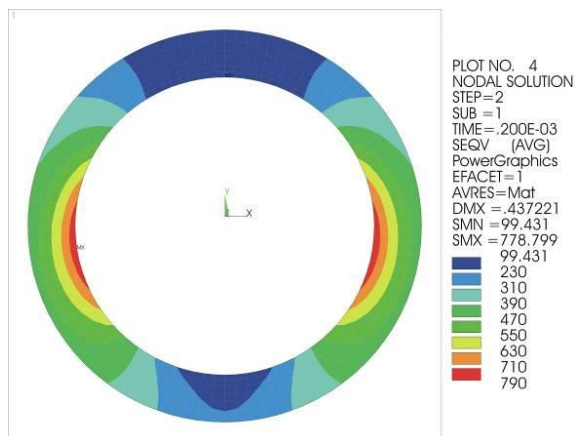
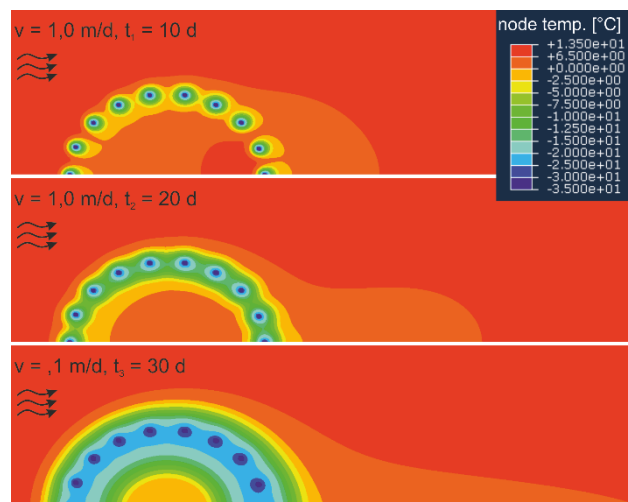


Artificial Ground Freezing as a Multiphase Process – Coupling with Mechanics

In the past few years the artificial ground freezing method is more often used for urban underground engineering projects in various kinds of application. Hereby, the frost body usually has a sealing and/or stabilizing function. To map and calculate the realistic freezing and thawing process of frozen soil the multiphase system of soil, water and air must be taken into account. The freezing and thawing process of water within the soil is described by numerical models. In these models the different constitutive laws of the individual phases must be coupled. Furthermore, the coupled problem of convection by groundwater flow within the soil has to be considered. Especially in urban areas the groundwater flow is often disturbed by underground engineering, which can lead to an acceleration and/or diversion. For the realistic simulation of the freezing and operating process it is essential to consider the convection in the numerical model. The coupling of the flow and heat transport as well as the physical and thermal material properties of the multiphase system soil have already been realised and implemented at the Department of Geotechnical Engineering of RWTH Aachen University. To represent the multiphase process in a realistic way, the implementation of the viscous temperature-dependent mechanical behaviour and the coupling with the flow and heat transport must be added.



Stresses in the frost body
(after freezing phase)



Temperature development due to groundwater flow
(during freezing Phase)

Based on known laboratory tests and literature data a constitutive law for the viscous, temperature-dependent mechanical behaviour of a frozen soil should be developed. The constitutive law should be validated by the results of the laboratory tests. Subsequently, the constitutive law has to be combined with the flow and heat transport. A validation of the coupled numerical model should be carried out by simulating a model experiment and/or an actual ground freezing application.