Simulation of Heat and Mass Transfer During Artificial Ground Freezing in Saturated Saline Groundwater

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Abstract

With the extensive application of ground freezing method in coastal areas, the groundwater environment during ground freezing has been changed. Especially in seawater intrusion areas, groundwater salinity is high (even salinity equivalent to sea water (ca. 35g/L)). Engineering experience shows that the presence of saline groundwater will affect the formation of freezing wall. High groundwater salinity will reduce the ground freezing point, affect unfrozen water content and freezing soil thermal parameters such as thermal conductivity, and even delay the formation of freezing wall[1-3]. In this work, we quantitatively analyze the effect of groundwater salinity on the formation of freezing wall.

In the previous work[4], our team has simulated the heat transfer process during artificial ground freezing combined with groundwater flow by using COMSOL Multiphysics®. This time, in order to focus on the discussion of the salinity factor, we ignore the groundwater flow to focus on the effect of salinity changes on the temperature field. Using the Heat Transfer in Porous Media physics interface, firstly, we establish the function of salinity and other parameters such as freezing point, thermal conductivity of freezing wall, etc.. Secondly, we build a 2D freezing temperature field model with phase transition by using Heat Transfer in Porous Media physics interface. This model is validated by two analytical solutions of Lunardini's and Trupak (reference) respectively.

The geometrical model, same as in the last work, is simplified to a two-dimensional model with a profile perpendicular to the tunnel axial direction. The size of this model is up to 50m × 50m. The diameter of the freezing pipe is 108mm and the hole spacing is 1.1m. Now, we have obtained the following results: (1) the results of numerical solution and the analytical solution are very consistent and (2) with increasing TDS, the freezing wall thickness gradually reduces (Fig. 1).

In the further study, we will quantify the effect of salinity on the thickness and closure time of the freezing wall and consider the migration process of solutes during artificial ground freezing.

References

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Figures used in the abstract

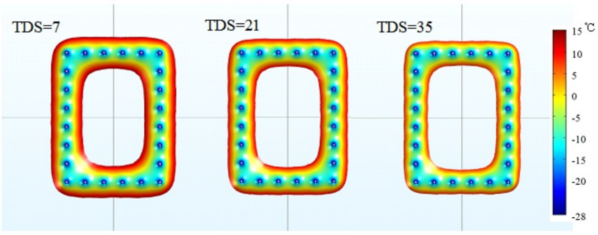

Figure 1: Calculated temperature field on the 40th day (TDS=7, 21 and 35 g/L).