Investigating the Impacts of Hydrogeological Parameters on DSI Efficiency Through Numerical Simulation

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Abstract

DSI (Düsensauginfiltration), literally translated as 'nozzle-suction-infiltration', is an innovative method for construction at dewatering sites. Unlike in conventional installations, water is not withdrawn from the subsurface [4] but injected (back) into the porous medium in the lower part of the borehole. The concept of this method is referred as 'single borehole pump & inject' (Figure 1) and described in detail in [1], [3] and [5]. Currently, the DSI method has been practically applied in Germany and the Netherlands. Nevertheless, the impacts of hydrogeological parameters on its efficiency are yet to be systematically assessed. The significance of these parameters (i.e. anisotropy, hydraulic conductivity, porosity) for the efficiency of DSI is obvious.

We used COMSOL Multiphysics® for the development of 2D model that simulate groundwater flow in an unconfined aquifer. Groundwater flow equation derived from Darcy's Law and fluid mass conservation was solved in the model [2]. Particularly, we gave the focus on capturing the movement of the groundwater table (free-surface) by using the arbitrary Lagrangian-Eulerian (ALE) method. The model was validated by comparison against the results obtained from respective analytical solutions [6]. However, this model was limited in considering the ideal cases, which assume homogenous and isotropic conditions for an aquifer, only. To consider more realistic constitution of an aquifer, we developed 2D and 3D models taking non ideal conditions, into account (i.e. anisotropy, heterogeneity). Moreover, the influence of typical hydrogeological parameters (i.e. hydraulic conductivity), on DSI set-up was evaluated. When parameters such as ambient groundwater flow are considered, a 3D model set-up is required. The simulation results are also expected to be validated with field observations.

The parametric sweep feature in COMSOL Multiphysics® allows us to perform extensive study on the selected hydrogeological parameters as well as the various types of DSI borehole settings. As an example of the simulation results, figure 2 demonstrates the influence of anisotropy on drawdown when DSI technique is applied. The result shows enlarged drawdown yielded by the decrease of vertical anisotropy ratio. Similar analysis has been conducted for different types of DSI borehole set-up. We found that higher pumping and injection rate of DSI installation contributes deeper drawdown. Moreover, deeper drawdown can be achieved

alternatively by lowering the position of the injection section in the borehole (see: Figure 3).

The simulation results not only show the potential of the DSI method, but also direct the borehole design considering the demands from a dewatering site. We intend to compare our simulation results with the field observations and provide more comprehensive instruction for DSI method.

Reference

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[5] Y. Jin et al., Simulation of a novel groundwater lowering technique using arbitrary Lagrangian-Eulerian method, COMSOL Conference, Stuttgart (Germany), 2011.

[6] Y. Jin et al., Y., Simulation of pumping induced groundwater flow in unconfined aquifer using arbitrary Lagrangian-Eulerian method, COMSOL Conference, Milan (Italy), 2012.

Figures used in the abstract

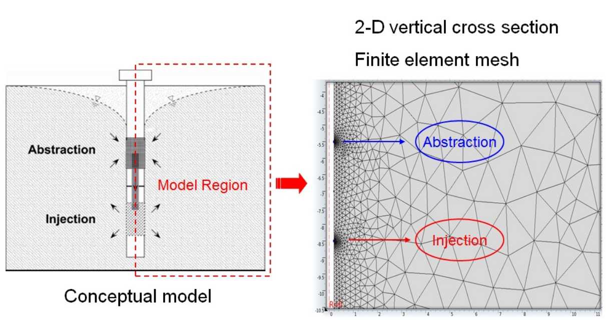

Figure 1: The conceptual model sketch (left) and the model region meshing (right) of DSI method.

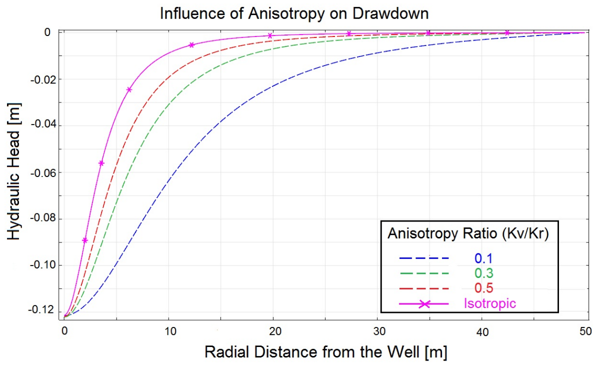

Figure 2: The influence of anisotropy on drawdown with DSI set-up. The black line with mark indicates drawdown achieved by the conventional pumping.

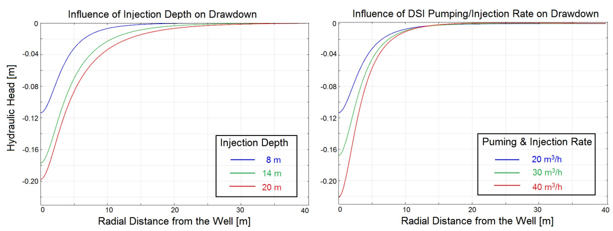

Figure 3: The influence of DSI well settings, i.e. depth of injection section (left), pumping and injection rate (right), on drawdown.