Importance of Wintertime Phase Change in Modeling Moisture Dynamics in Road Systems, Sweden

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Abstract

Moisture in road systems is important for a better understanding of pavement design as well as road hydrology [1]. In high latitude regions, the moisture dynamics in road systems is more complicated due to freezing/thawing. A better understanding of moisture dynamics in road systems in cold regions is essential for a stable road structure design and also for a sustainable road hydrologic environment. An observation system was installed in a highway in Sweden to detect water, heat and solute dynamics during wintertime. Moisture dynamics has shown to be tightly coupled to the temperature in road systems.
Two numerical models were set up to compare the influences of soil freezing/thawing on modeling of water dynamics in road systems. Part of the E18 highway has been modeled, with control points in base material and under the shoulder (Figure 1). The first model was built in COMSOL Multiphysics® using the Richards Equation interface and Heat Transfer in Porous Media interface. Then the second model was set up in COMSOL by coupling water, heat and solute transport during freezing/thawing using a PDE interface.
Results showed that phase change is very important in modeling water dynamics in road systems and model performance was significantly improved by considering coupled transport of water, heat and solute during freezing/thawing. Some initial results included here are the modeling of temperature changes in different layers (Figure 2) and liquid volume fraction (Figure 3). Further detailed results will include a comparison for short period simulations using two models. The influences of phase change on modeling of road systems will be fully discussed in this part
This study shows the importance of wintertime phase change considering in modeling of water and heat transfer in road systems. Results can be utilized in future research to build a new application or tool in COMSOL for this specific case of transport phenomena in unsaturated road material with phase change considerations. Further work would be necessary by applying the coupled model to similar road systems.

Reference

[1] Dawson A. (Editor), 2009. Water in road structures – Movement, Drainage & Effects. Springer. Nottingham.

Figures used in the abstract

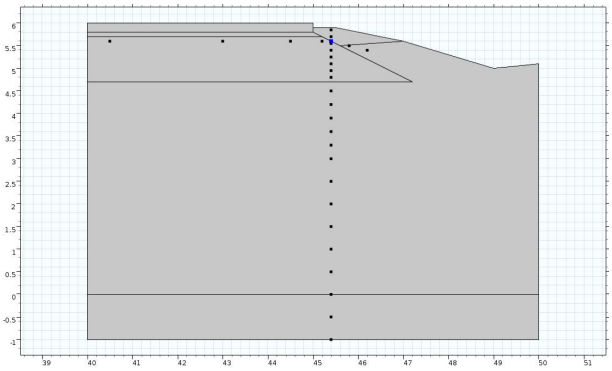

Figure 1: Section of modeled road showing the control points at different layers.

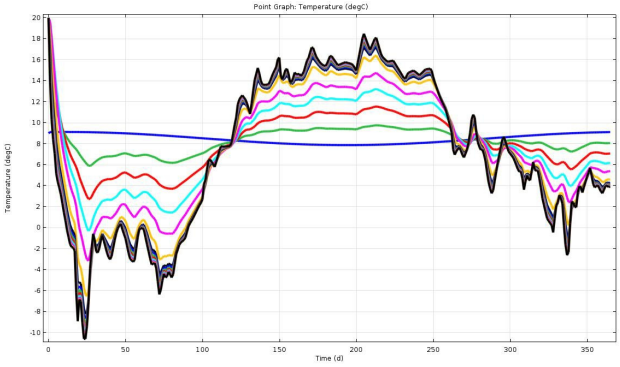

Figure 2: Modeled temperature changes at points beneath the road shoulder at different depth.

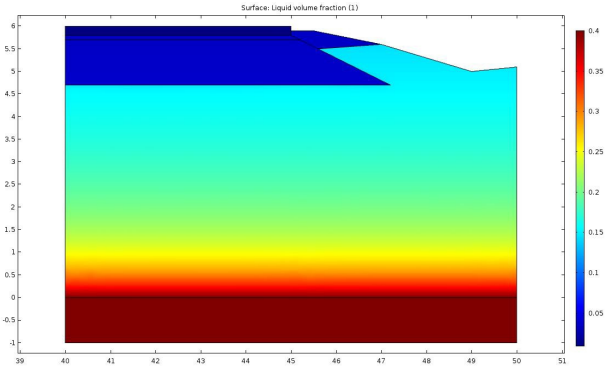

Figure 3: Liquid volume fraction.