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Water retention curves and thermal insulating properties of Thermosand

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The heat loss and the efficiency of isolating material surrounding heat supply pipes are essential issues for the energy budget of heat supply pipe lines. Until now heat loss from the pipe is minimized by enlarging the polyurethane (PU) - insulation thickness around the pipe. As a new approach to minimize the heat loss a thermally insulating bedding material was developed and investigated. Conventional bedding sands cover all necessary soil mechanical properties, but have a high thermal conductivity from λ =1,5 to 1,7 W/(m K). A newly developed embedding material ”Thermosand“ shows thermal properties from λ=0,18 W/(m K) (dry) up to 0,88 W/(m K) (wet). The raw material originates from the waste rock stockpiles of a coal mine near Fohnsdorf, Austria. With high temperatures up to nearly 1000 ˚C and a special mineral mixture, a natural burned reddish material resembling clinker arises.

The soilmechanical properties of Thermosand has been thoroughly investigated with laboratory testing and in situ investigations to determine compaction-, permeability- and shear-behaviour, stiffness and corresponding physical parameters. Test trenches along operational heat pipes with temperature-measurement along several cross-sections were constructed to compare conventional embedding materials with “Thermosand”. To investigate the influence of varying moisture content on thermal conductivity a 1:1 large scale model test in the laboratory to simulate real insitu-conditions was established. Based on this model it is planned to develop numerical simulations concerning varying moisture contents and unsaturated soil mechanics with heat propagation, including the drying out of the soil during heat input. These simulations require the knowledge about the water retention properties of the material. Thus, water retention curves were measured using both steady-state tension and pressure techniques and the simplified evaporation method. The steady-state method employs a tension table (sand box) at tensions below 100 hPa and a pressure extractor at tensions between 300 hPa and 15,000 hPa; the water content is measured by weighing after the sample has equilibrated at the tension value set on the table or plate. In the transient evaporation method two tensiometers with a measurement range between 0 and 850 hPa are installed at a depth of 1.25 cm and 3.75 cm in a sample of 5 cm in height; the mean values of the two tensiometers and the water contents measured by weighting are used to obtain the water retention curve. First results of both methods show that the Thermosand samples release water over the entire tension range measured above 10 hPa. Because of the limited measurement range of the tensiometers used for the evaporation method, the measured curve must be extrapolated between 850 hPa and 15,000 hPa, to allow comparison with the steady-state method. To this end, it was attempted to match the Van-Genuchten and a bimodal Van-Genuchten retention function to the data from the evaporation experiments. This involves a simultaneous fit of both the water-retention and the hydraulic-conductivity function. As one first result only the Van-Genuchten model was found to be able to produce satisfactorily fits to the data. The extrapolated water retention curves (above 850 hPa) however do not match the data from the steady-state method. This suggests that alternative soil hydraulic functions are needed to provide an adequate representation of the water retention characteristics of the Thermosand. It has to be considered that especially for the heat flow simulation water retention and hydraulic conductivity functions above 15,000 hPa have to be determined.