Soil thermal behavior in different moisture condition: an overview of ITER Project from laboratory to field test monitoring

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Abstract

The thermal properties of soils can be considered one of the most important parameters for many engineering projects designing. In detail, the thermal conductivity plays a fundamental role when dimensioning ground heat exchangers, especially very shallow geothermal (VGS) systems, interesting the first 2 m of depth from the ground level. However, the determination of heat transfer in soils is difficult to estimate, because depends on several factors, including, among others, particle size, density, water content, mineralogy composition, ground temperature, organic matter.
The performance of a VSG system, as horizontal collectors or special forms, is strongly correlated to the kind of sediment at disposal and suddenly decreases in case of dry-unsaturated conditions in the surrounding soil. Therefore, a better knowledge of the relationship between thermal conductivity and water content is required for understanding the VSG systems behavior in saturated and unsaturated conditions.
Key challenge of ITER Project, funded by European Union, is to understand how to enhance the heat transfer of the sediments surrounding the pipes, taking into account the interactions between the soil, the horizontal heat exchangers and the surrounding environment.
In order to obtain reliable data for modelling, an interdisciplinary approach is used. In laboratory the physical-thermal properties of more than 15 soil mixtures, consisting in (i) natural soil, (ii) pure sand and (iii) mixtures of pure sand and clay additives, have been tested under different water content percentages and different consolidation degree. Then the same parameters are monitored in the project case study, in Eltersdorf, (Germany), where five helix collectors are installed in horizontal trenches filled in with five different mixtures already tested in laboratory. In addition, a monitoring system allows to record every 15 minutes, by means of devoted sensors, values related to ground temperature (undisturbed, inside and outside each helix), fluid temperature and flow running in the collectors, volumetric water content at 20 and 60 cm depth. Moreover, a meteorological station provides climatic data acquisition as rainfall, wind speed, relative humidity and air temperature.
The main results achieved until now are useful for future modeling because shed new light (i) on the differences between data collected in laboratory and in the field and (ii) on the influence of the technical solution adopted in situ to fill in the trenches, able to create a non-homogeneous distribution of the soil bodies around the helix.