TYPE 557: VERTICAL GROUND HEAT EXCHANGER

General Description

This subroutine models a vertical heat exchanger that interacts thermally with the ground. This ground heat exchanger model is most commonly used in ground source heat pump applications. This subroutine models either a U-tube ground heat exchanger or a concentric tube ground heat exchanger. A heat carrier fluid is circulated through the ground heat exchanger and either rejects heat to, or absorbs heat from the ground depending on the temperatures of the heat carrier fluid and the ground.

In typical U-tube ground heat exchanger applications, a vertical borehole is drilled into the ground. A U-tube heat exchanger is then pushed into the borehole. The top of the ground heat exchanger is typically several feet below the surface of the ground. Finally, the borehole is filled with a fill material; either virgin soil or a grout of some type.

In typical concentric tube heat exchanger application, the borehole is just slightly larger than the outer pipe of the ground heat exchanger, but the same process applies. The borehole is drilled into the ground, and the heat exchanger is pushed into the borehole.

The two types of ground heat exchangers available in this subroutine are shown in Figures 1 and 2. Figure 1 shows one U-tube per borehole; although this subroutine allows the user to have up to 10 U-tubes per borehole.

The program assumes that the boreholes are placed uniformly within a cylindrical storage volume of ground. There is convective heat transfer within the pipes, and conductive heat transfer to the storage volume. The temperature in the ground is calculated from three parts; a global temperature, a local solution, and a steady-flux solution. The global and local problems are solved with the use of an explicit finite difference method. The steady flux solution is obtained analytically. The temperature is then calculated using superposition methods.

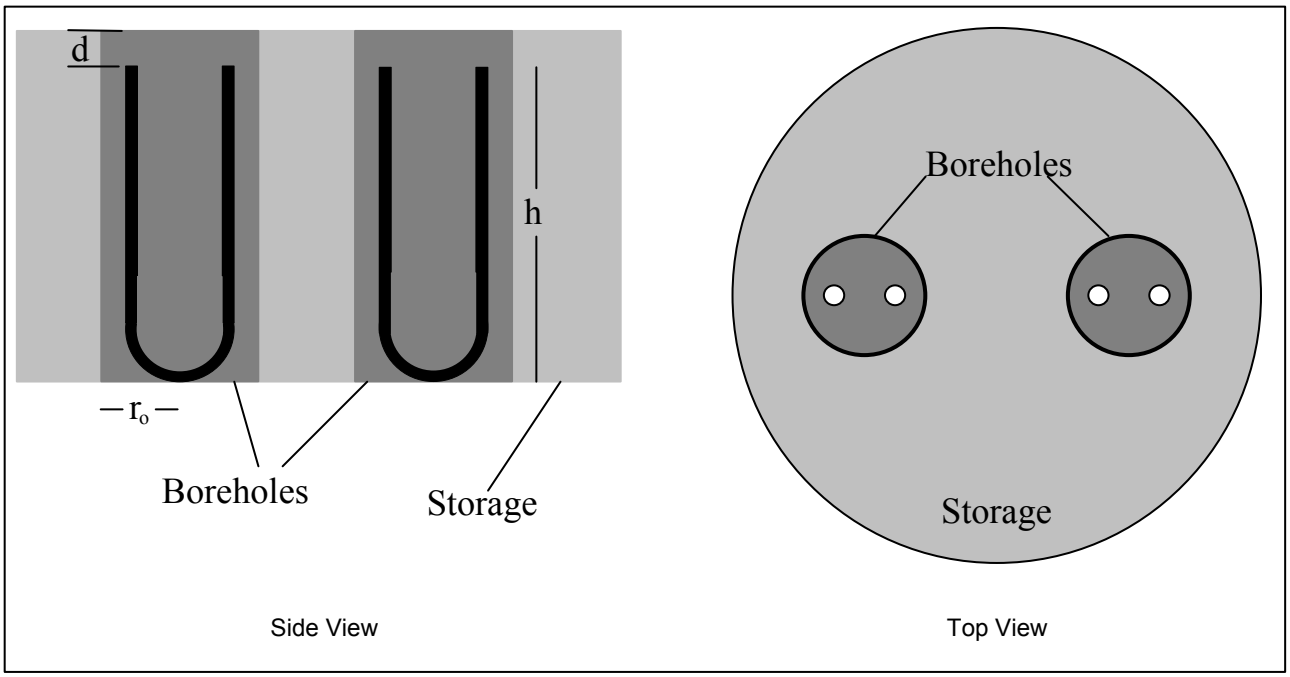


Figure 1: U-Tube Ground Heat Exchanger

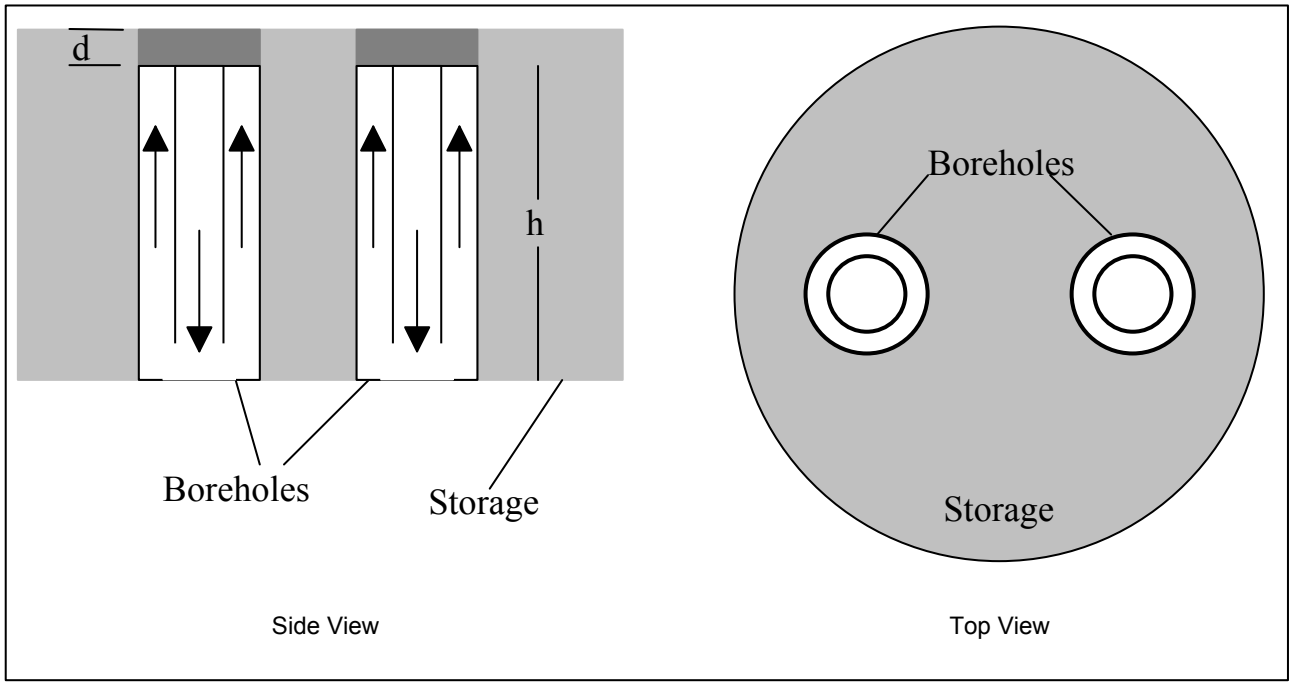


Figure 2: Concentric Tube Ground Heat Exchanger

Mathematical Description

The subroutine at the heart of Type557 was written by the Department of Mathematical Physics at the University of Lund, Sweden and is considered to be the state-of-the-art in dynamic simulation of ground heat exchangers. Instead of duplicating information already available, a portable document format (PDF) version of the original subroutine manual has been provided. The document is called DST_manual.pdf and is taken verbatim from the following reference:

Hellstrom, Goran, "Duct Ground Heat Storage Model, Manual for Computer Code", Department of Mathematical Physics, University of Lund, Sweden.