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Review

Ground heat exchangers—A review of systems, models and applications

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Abstract

The temperature at a certain depth in the ground remains nearly constant throughout the year and the ground capacitance is regarded as a passive means of heating and cooling of buildings. To exploit effectively the heat capacity of the ground, a heat-exchanger system has to be constructed. This is usually an array of buried pipes running along the length of a building, a nearby field or buried vertically into the ground. A circulating medium (water or air) is used in summer to extract heat from the hot environment of the building and dump it to the ground and vice versa in winter. A heat pump may also be coupled to the ground heat exchanger to increase its efficiency. In the literature, several calculation models are found for ground heat exchangers. The main input data are the geometrical characteristics of the system, the thermal characteristics of the ground, the thermal characteristics of the pipe and the undisturbed ground temperature during the operation of the system. During the first stages of the geothermal systems study, one-dimensional models were devised which were replaced by two-dimensional models during the 1990s and three-dimensional systems during recent years. The present models are further refined and can accommodate for any type of grid geometry that may give greater detail of the temperature variation around the pipes and in the ground. Monitoring systems have been set up to test various prototype constructions with satisfactory results.

Keywords: Ground heat exchangers; Ground temperature; Heat exchanger models; Ground source heat pump

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Contents

1. Introduction

Measurements show that the ground temperature below a certain depth remains relatively constant throughout the year. This is due to the fact that the temperature fluctuations at the surface of the ground are diminished as the depth of the ground increases because of the high thermal inertia of the soil. Also, there is a time lag between the temperature fluctuations at the surface and in the ground. Therefore, at a sufficient depth, the ground temperature is always higher than that of the outside air in winter and is lower in summer. The temperature variation of the ground at various depths in summer (August) and winter (January) is shown in Fig. 1. The graph shows actual ground temperatures as measured in a borehole drilled for this purpose in Nicosia, Cyprus. As can be seen, the temperature is nearly constant below a depth of 5 m for the year round.

The difference in temperature between the outside air and the ground can be utilised as a preheating means in winter and pre-cooling in summer by operating a ground heat exchanger. Also, because of the higher efficiency of a heat pump than conventional natural gas or oil heating systems, a heat pump may be used in winter to extract heat from the relatively warm ground and pump it into the conditioned space. In summer, the process

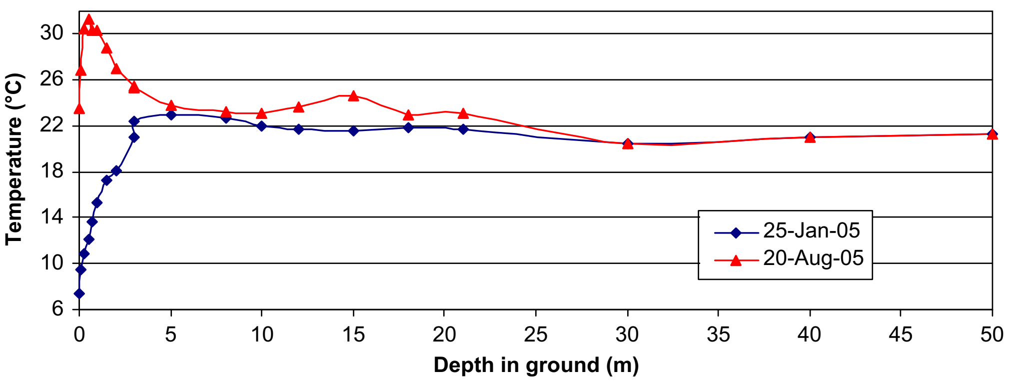

Fig. 1. Temperature variation with depth.