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Soil Thermal Conductivity Study in Western Coastal Zone of Taiwan

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ABSTRACT

The thermal conductivity which governs the flow of heat through the soil is defined as the quantity of heat that flows through a unit area in a unit time under a unit temperature gradient. This characteristic of soil is usually concerned by power cable designer because of copper resistance during power transitions in both underground and submarine circumstance.

The study employed field needle shaped probe to measure 4 points on the beach in Penghuo Island of Taiwan and conduct 12 laboratory tests to measure the thermal conductivity. The soil of beach was categorized to be middle-fine sand with coral skeleton. For simulating the situation of water content of soil on beach varied with the tidal level and the run up of wave, the needle probe instead of micro variation to measure the average thermal conductivity. The results of filed investigation varied from 0.8W/mK to 1.17W/mK, under 27 degree Celsius of circumstance and being similar to Nidal's measurement of sand ranged from 0.58 to 1.94.

KEY WORDS: Thermal conductivity; Thermal resistivity; Water content

INTRODUCTION

In historic engineering study of soil mechanism, the researchers usually focused on soil simple physical properties, which normally contain density, particle size, moisture, which connected to the stresses, strains analysis. The soil temperature, soil heat flux, conductivity, and its related thermal properties, such as soil thermal conductivity (also soil thermal resistivity) are fewer been figured out.
Most of former studies of soil thermal property keens on the plants biology since such properties are the most important factors in controlling the intensity of biophysical, biochemical and microbiological processes (Ghidyal and Triparti; 1987, Brady, 1984).
Even though the thermal properties of soil are very important to the development of soil, they are still properties not widely used and analyzed as often as they should. This can be for various reasons such as cost, time.

Recently, this property of soil has been found important using in engineering, such as soil frozen for preventing water piping during base open cut and burying underground power cable.
When the underground power cable transmits the electric power, some of energy will transfer into heat due to the copper thermal resistance. The heat usually arises surround temperature of copper and damage polyethylene sheath of vicinity, which protects copper avoid oxygenized and water invasion. Normally, the designer would like to enlarge the diameter of cable to prevent high temperature under the cost allowance. However, the consideration criteria changed little in submarine power cable. Apart from landing approach section most portion of submarine power cable is buried under sea bed, where sea water provides enough media to dissipate the heat energy. the designer generally need to care about the economic condition of owner, thus the diameter of submarine power cable is usually smaller than underground power cable. Meanwhile, to treat the section of submarine cable for landing approach, the soil thermal conductivity shall be employed in order to determine the cooling system.
To measure the soil thermal conductivity near the shore where is significantly effected by tide and waves, the study applied a single probe method. The metal probe employs a heat source inserted into the soil whereby heat energy is applied continuously at a given rate. Such metal shall be water proof for working on site and laboratory as well.

THEORY

In concept, the soil thermal properties are difficult to measure in the field because soil temperatures are in a constant state of flux from diurnal and seasonal variations, especially at the tidal zone. Temperature variations are most extreme at the surface of the soil and these variations are transferred to sub surface layers but at reduced rates as depth increases. Additionally there is a time delay as to when maximum and minimum temperatures are achieved at increasing soil depth (sometimes referred to as thermal lag).
Measurement of soil thermal properties is based on Fourier's law,

$$Q = -\lambda \frac{dT}{Dz} \tag{1}$$