DETERMINING THE RELATIVE EFFECTS OF VOLUMETRIC WATER CONTENT AND DRY DENSITY ON THE DIELECTRIC CONSTANT OF SOILS

Shane M. Rasch

Dr. John J. Bowders Jr., Thesis Supervisor

ABSTRACT

Non destructive subsurface investigation using electromagnetic (EM) waves is a growing technique in geotechnical engineering (Mohamed 2006). The ability to "see" under the Earth's surface without having to excavate is important since the soil remains intact and undisturbed.

When there is a discontinuity in dielectric constants, a portion of the EM energy is reflected and the remainder is refracted into the next material. The reflected EM wave indicates detection of an object, a change in material, or a void or crack in the subsurface.

The composition of a soil-water system (i.e. how much water or air is in the soil) will control the reflection and refraction of an EM wave traveling through the soil-water system. Pure water at 20 degrees Celsius has a dielectric of around 80 and air at one atmosphere pressure and 20 degrees Celsius has a dielectric of 1, thus relative volume of water in the soil is hypothesized to have a greater effect than the dry unit weight on the dielectric constant of the soil-water system.

The overall project goal is to better understand the dielectric constant of soil (including the soil-water system) in order to improve subsurface detection methods. Predictive models for dielectric constant of a soil as a function of the EM wave frequency transmitted to the soil as well as a multitude of soil properties, including but not limited to soil water content and dry unit weight (also referred to as dry density), are to be investigated.

It is hypothesized that effects of volumetric water content will dominate the effects of dry density on the dielectric constant of a soil water system. The relative influence of these soil properties on the resulting dielectric constant is to be evaluated through dielectric constant testing in this study.

Through an extensive series of testing, volumetric water content was found to have up to 525 times more impact on the dielectric constant than dry density, but typical results show this quantifiable difference is more reasonably between 7 and 15 times greater effect for volumetric water content than dry density on the dielectric constant of sand.