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Measurement of electromagnetic property of soils (part 2)

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Electromagnetic (EM) property is important factor on ground penetrating radar (GPR). EM property is consisting of three component i.e. dielectric permittivity, electrical conductivity and magnetic permeability. The dielectric permittivity is most important parameter to determine EM wave velocity in GPR frequency range.

It is conducted recently that an estimation of soil classification or hydrate condition attributed from the EM wave velocity or the dielectric permittivity of soils. These trials are however remained the relative or qualitative estimation. It had not discussed the EM properties of the soil sample at GPR wide frequency range. This report shows the method of the EM properties measurement and these results which were added new data to last results.

Dielectric permittivity of air and water takes the value 1 and 80 respectively. Of these two values, air is the minimum and water is the maximum in underground medium. Dielectric permittivity of mineral particles takes the value about 4 to 5, which is between air and water values, except like mica with anisotropy caused by crystal structure. As the water content is increased, the dielectric permittivity will become large value because the soil consists of air, water and mineral particles.

Impedance was measured by the network analyzer using S parameter method in reflection mode at the surface of the soil sample using coaxial line and waveguide. It can be calculated the dielectric permittivity, electrical conductivity and magnetic permeability from the measured impedance. Frequency range of the measurement was selected 50 MHz to 3GHz including almost GPR frequency range.

Measured soil samples are loam, organic loam, scoria and peat in last report. New data were made up for the samples of decomposed granite and dune sand in this report.

The samples must be picked up non-disturbed but the samples could not installed non-disturbed condition because the coaxial wave guide was too small. Consequently sample's bulk density was reproduced the same density as non-disturbed condition compacted inside the coaxial wave guide. Bulk density was measured by 'Test method for soil density by the sand replacement method: JIS-A-1214-2001'. Density of soil particles and weight water content were measured by 'Test method for density of soil particles: JIS-A-1202-1999/JGS-T111-2000' and 'Test method for water content of soils: JIS-A-1203-1999/JGS-T121-2000' respectively. Volumetric water content calculated from the bulk density, the weight water content and the density of soil particle.

Our results confirmed that (1) dielectric permittivity had frequency dependence (dielectric dispersion), (2) dielectric permittivity value was decreased with the increase of frequency, (3) dielectric dispersion was remarkable appeared with increase of the volumetric water content.

The measured dielectric permittivity and the electrical conductivity were correlated approximately proportional of independent frequency. The dielectric permittivity and the volumetric water content were correlated exponentially regardless of soil types.