UWB measurement of dielectric permittivity of lossy medium

Hai Liu[1], Motoyuki SATO[2]
([1]Graduate School of Environmental Studies, D1; [2]Center for Northeast Asian Studies, Tohoku University) (Poster)
[1]liuhai@cneas.tohoku.ac.jp
Key words: ground penetrating radar (GPR); dielectric constant; attenuation

Radar wave propagated in homogeneous medium meets the following equation:

$$E_r = E_i e^{-\alpha r} e^{-i\beta r} \quad (1)$$

Where E_r and E_i are respectively received wave and incident wave, r is propagation distance, α is attenuation coefficient, and β is the phase constant that related to the dielectric constant of medium under test.

The objective of this experiment is to test the dielectric constant and frequency-dependent attenuation of bentonite specimen, which is expected to store the radioactive waste underground due to its high attenuation characteristic. But it is difficult to collect the transmission radar signal with high quality by directly placing transmitter and receiver on two sides of bentonite specimen because the transmission signal is very weak and even overwhelmed by the air lateral signal outside the specimen.

HP 5071B Vector network analyzer (VNA) and two Vivaldi antennae are employed to transmit and receive ultra-wideband transmission radar wave in dry bentonite and wet bentonite with 20% moisture content firstly. The two antennae were buried in bentonite to avoid the air lateral signal. The transmission signals were collected at the antenna separation of 5cm, 10cm, 15cm, 20cm and 25cm. Fig.1 shows the attenuation at different frequency. The relative dielectric constant of dry and wet bentonite were estimated to be 2.67 and 5.07 respectively and from them the dielectric constant of bentonite specimen could be calculated to be 10.2 and 12.4 respectively according to their moisture content and porosity by complex refraction index model (CRIM) .

Table 1. Estimated dielectric constant

	Dry bentonite	Wet bentonite	Bentonite Specimen
Density (g/cm^3)	0.96	0.93	1.95
Moisture content	10%	17%	20%
Dielectric constant	2.69	5.07	10.2/12.4

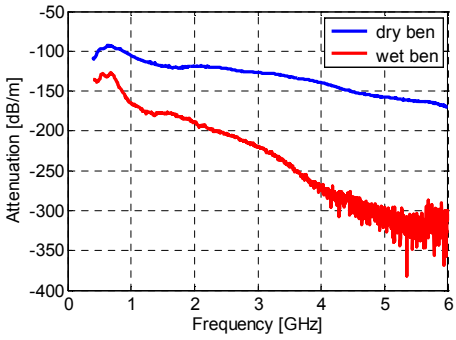

Figure 1. Frequency dependency of attenuation