Field testing of DAS (Distributed Acoustic Sensing) with a 1 km-long optical fiber

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Recently, seismic observations with optical fibers technology (Distributed Acoustic Sensing, DAS) have been reported. It is based on the technology of coherent optical time domain reflectometry. When a light pulse travels in the core of a optical fiber, a very small level of backscattered light is generated by impurities and defects in the filber. The return light has a time delay according to the reciprocating distance from the incident end to the place where the backscattered light is generated. When light pulses are continuously generated at equal intervals, the time change of pico-strain level occurring in the fiber due to disturbances caused by earthquake, noise, temperature, etc. can be measured at fine points. The light phase reflects strain in the fiber, and the time delay corresponds the distance from the incident end.

The main features of DAS are as follows.
(1) One-dimensional distribution measurement over the entire optical fiber is possible with one measurement.
(2) The distance resolution is determined by the light pulse width incident on the optical fiber, and changes in a range narrower than the light pulse width are observed as averaged values, so it is difficult to measure physical values at points.
(3) The scattered light generated by impurities and defects in the optical fiber is weak, and processing such as averaging is performed to reduce noise.
(4) There is a distance resolution determined by the sampling frequency.
(5) Due to the transmission loss of the optical fiber, the signal strength of the scattered light at a farther distance becomes weaker than that near the device. The maximum measurable distance exists.
If long-distance optical fibers are prepared, array observation can be easily realized. However, the physical quantity of the data observed by the DAS is a strain rate, different from the physical quantity obtained by the seismometer and is an averaged value in a certain section.

Therefore, we investigate whether the vibration intensity is linear to ground motion. A test observation is planned at the Tenryu-Funagira observation station in a tunnel with a length of approximately 900 meters in Hamamatsu City, Shizuoka Prefecture. A single-mode 4-core optical fiber with a total length of 1 km is used. The 4 cables at both ends of the optical fiber have APC polished FC type connectors. An adapter to connect the two connectors on one end is used. The observations are done with a 4 km optical fiber that makes two round trips in the tunnel. The optical fiber is installed by laying it on the ground in a tunnel, burying it, passing it through an FEP pipe, etc. Artificial vibrations are generated during the observation period. A short-period seismometer is installed near the optical fiber. We attempt the same test observation with a few types of instruments.

Keywords: DAS, optical fiber, amplitude linearity

