Applicability of the fiber optic DAS(Distributed Acoustic Sensor) to the calculation of surface wave dispersion curves.

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Introduction

Recently optical fiber DAS (Distributed Acoustic Sensor) technology has been introduced in oil and gas industries. However, the applications of DAS have mostly involved vertical seismic profile (VSP) data, there have not been many attempts to target the near surface area. DAS measures seismic waves using Rayleigh mode backscattering of laser light input into a fiber. To evaluate the applicability of DAS to near surface structures, we performed a field test. In this test, we used the Schulenburg hDVS, which senses the strain rate along the elongation direction of the fiber (Hartog, 2017), as opposed to the vertical velocity sensed by an ordinary geophone. A comparison of DAS and geophones has been made by Hasada et al. (2018) for this assembly.

Field test and data processing

We performed a field test on the CRIEPI campus in September 2017. The experimental outline and the DAS data obtained are reported by Kasahara et al. (2018) in this session. The total survey line was 100m long. Three parallel optical fibers were buried at a depth of 20 cm along the survey line. To compare the optical fibers to geophones, 100 4.5Hz geophones were installed every 1 m, along the survey line. To obtain surface waves, hammer shots were used at 5m intervals. Surface wave dispersion images were calculated via the phase-shift-method (Park et al. 1998). None that the DAS data were obtained at every meter, however the average over 5m distances for each 1m grid was used due to the constrains of the DAS acquisition system. In addition, we used the seismic interferometry technique for the geophones, seismometers, and DAS.

Results

We obtained nearly comparable seismic records from all sensors, even though the method for sensing physical quantities for seismometers, geophones and DAS are different. The signal-to-noise(S/N) ratio of the DAS shot record generated by the hammer blows was slightly lower than that of the geophone records, however, the dispersion image calculated from the DAS data sensing the radial vibrations showed a rough dispersion curve similar to that obtained by the vertical geophones. To eliminate the averaging problem of the DAS data, we applied an interferometry technique to the DAS data. Ambient noise cross correlations (CCFs) were calculated for each station pair with a reference station, which was located at the end point of the survey line. The calculated CCFs show distinct wave trains up to 60m. Dispersion curves were calculated using the phase shift method (Park et al. 1998), and these images show clear results compared to those from the hammer blows.

Discussion and conclusions

We tested DAS for a surface wave analysis. Because the measured physical quantities and sensing directions are different between vertical and horizontal seismometers geophones and DAS,which senses vibrations along the fiber elongation,a direct comparison of the S/N ratios between the three method is difficult.In addition, the measuring spacing of DAS was 5m on average and it might be difficult to use raw DAS data for phase velocity analyses of very shallow structures. According to the interferometry technique result, however, CCFs of the DAS record show high S/N ratios and these dispersion curve images are consistent with the results of conventional surface wave methods.
This suggests that the application of CCFs to the DAS data is an effective method to detect surface waves.

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Keywords: DAS, near surface layer, surface wave, Rayleigh wave, dispersion curve

