Proposal of a Seismic Exploration Method using an AM Elastic Wave

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1.Introduction

Recently, a bore-hole type crustal-deformation meter developed by Prof. Ishii has detected increase of crustal deformation as a precursory phenomenon of an earthquake in Izu peninsula. The phenomenon started from about one day before the earthquake. This fact shows semi-real time and routine observations to detect the phenomenon are effective.

A dynamites explosion and a vibrator for an artificial seismic source are employed for seismic physical explorations. However these methods have week points: such as which the explosion is destructive, non-routine operation, and an uncertain source function, and the vibrator is for a short distance from the seismic source to the observation point. To complement these week points, an artificial seismic source ACROSS using a rotational mass has been developed. This method that generates a sinusoidal signal is routinely operative and has a clear source function. A high S/N ratio is achieved by stacking the signals. Nevertheless, there are week points: such as which the method can not instantly distinguish a direct wave form the source to the observation point, and a reflection wave from the surface of crustal discontinuity in experiments. Furthermore, to distinguish them by a calculation, the certain model of crustal structure is necessary.

A method that we propose is to solve the problems of the above exploration methods.

2. Crutal exploration method using an AM elastic wave

A seismic exploration method using an AM (Amplitude Modulation) elastic wave is shown in Fig. 1. An artificial seismic source of this method uses a rotational mass synchronized by a standard signal form GPS. The source generates a single frequency (carrier) signal with amplitude modulated by changing the center mass position. At an observation point, a seismometer, having a pendulum natural frequency tuned to the source frequency by adjusting the restoring force of the pendulum by a magnetic spring, is used. The natural frequency is also calibrated by the signal of GPS. To realize highly sensitive signal detection in the seismometer, a lock-in amplifier is used for narrow frequency-band synchronized detection that removes the carrier wave from the AM signal. The rotational frequency pulses of the source for the synchronized detection are also generated from the GPS signal.

The special future of this method is as follows. The pulses with the carrier wave are emitted from the seismic source. Therefore, the method in the observation can instantly distinguish a direct signals form the source to the observation point, and a reflection signal from the surface of crustal discontinuity. A transfer function between the source and the point can be estimated by controlling the source function such as the shape and the width of the pulse. This method can employ a burst pulses operation that the vibrator seismic source usually uses. To improve S/N of detected signal in the seismometer, stacking the bust pulses for a short time is effective. The synchronized detection is also effective to improve S/N of the signal. Adjusting the pendulum natural period, to the seismic source frequency, synchronized to GPS is useful to remove the effect from an environmental change to the detection characteristics of the seismometer.

3. Summary

The AM artificial seismic source modified from ACROSS has been built. It was installed in to the tunnel of the Kazunogawa electric power plant operated by Tokyo Electric Power Company. Now, the basic operational functions of the seismic source are being checked in experiments. Observation instruments, such as bore-hole seismometers and optical fiber cables connected from the source to the observation points, were also equipped in the tunnel. The cables can transmit the pulses for the synchronized detection. From the above development status, near future, we could start experiments on feasibility study of the seismic exploration using AM elastic waves.

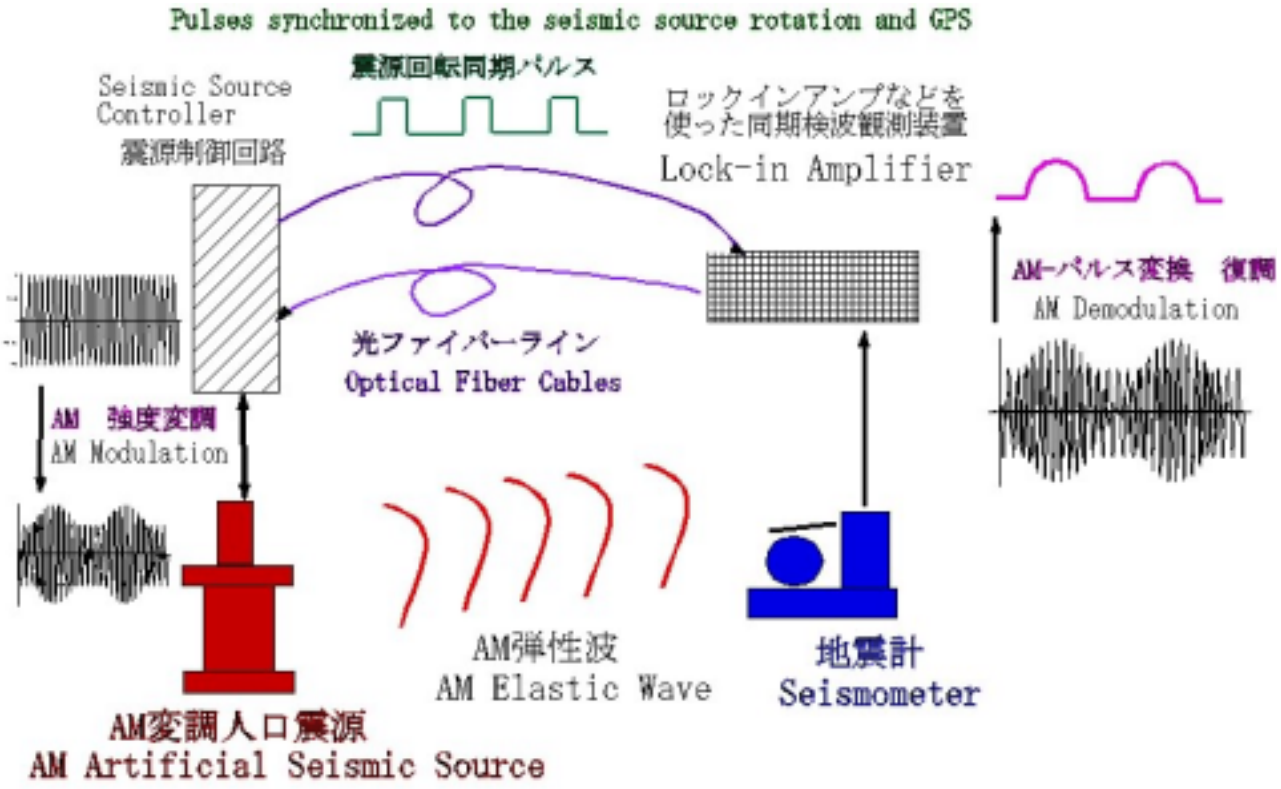

Fig. 1. A seismic exploration method using an AM elastic wave