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EXPLOSION SEISMIC EXPERIMENTS IN THE KYOTO - AWAJI PROFILE

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1. Introduction

Three series of explosion seismic experiments were carried out from the Kyoto area to the South of Awaji Island, from December 12 to 15, 1995. Six explosions were done on December 12, five on December 14 and three on December 15, 1995. These experiments were carried out by the Research Group for Explosion Seismology (RGES). The objective of the field experiments was to reveal the geological structures of the profile from the Kyoto area to the South of Awaji Island. The explosion signals were recorded at many observatory stations, including the four foundations (from North to South: 1A, 2P, 3P and 4A) of the Akashi Kaikyo Bridge. The locations of all shot points and the bridge are shown in Fig. 1. In this paper only the records acquired at these four foundations will be considered.

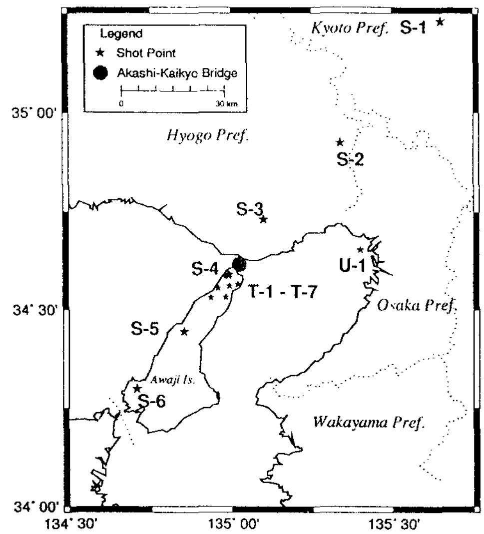

Fig.1 Location of the shot points and the bridge

2. Explosion Signal Enhancement

Only in three explosions out of fourteen done during the three days of experiments, signals could be detected clearly in the raw data. The three events were S-4, T-1 and T-3. Records during the other events did not show any explosion signals in the raw data because they were too noisy. Thus, the signal enhancement was needed to separate the explosion signals from the natural noise in those records.

An explosion is an impulsive load caused by sudden release of energy. Such an impulsive load is expected to have broad band spectrum. The predominant frequencies of the body waves of the explosion signals were identified by taking the Fourier transformation of the explosion signals recorded during the events S-4, T-1 and T-3. The frequencies of the body waves ranged from 16 to 21 Hz and from 4 to 9 Hz. The frequencies of the natural noise could be identified by the same method. The frequency band of the noise was from 8.0 to 13.0 Hz. Since the predominant frequencies of the natural noise and the body waves have been identified, the explosion signals could be separated from the noise by band-pass filtering. The Butterworth band-pass filter was used to enhance the signals. The filter was applied forward and backward over the data for getting zero-phase filtering results.

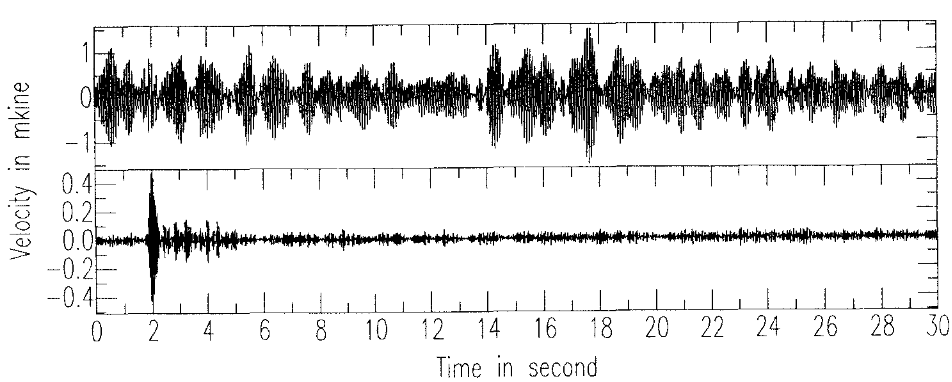

Fig.2 Vertical component of explosion T-7 recorded at 4A station

The vertical component of data recorded at 4A for explosion event T-7 is shown in Fig. 2 (top). Time 0.0 second refers to the time of explosion. The distance between the 4A station and the explosion point was 7.904 km, so it may be estimated that the explosion signals would arrive at the station about two seconds after the explosion. As it can be seen in this figure, no clear explosion signals can be observed because the record was too noisy. Fig. 2 (bottom) shows the signal after being band-pass filtered with passing range from 14 to 22 Hz. This signal shows a clear arrival of the body waves of the explosion.

3. Velocity Model of the Profile

The arrivals of the P waves could be identified from the enhanced records. Fig. 3 shows the travel time of the P waves vs. the distance between the shot points and the stations. The crust of this profile was approximated as a two-layer structure over a half-space. Thus, the distance between the shot points and the stations should be divided into three regions. The linear regressions of the points in each region were done to estimate the velocity of P wave in each layer. The distance regions: 0 - 5 km, 5 - 20 km and 30 - 50 km were adopted because the regressions gave smallest standard deviations. The velocity of the P wave of each layer is given by the slope of the corresponding regression line. The velocities in the first and second layers and the half-space were calculated to be 4.485 km/s, 5.277 km/s and 6.365 km/s, respectively.

The intersection points between two regression lines could be used to estimate the thickness of the corresponding layers. These points are usually referred as the *crossover points*. The crossover distances (X_{c1} and X_{c2}, see Fig. 3) in this model were 4.703 km and 35.182 km. The thickness of the first and second layers were estimated to be 0.711 km and 5.104 km. Figure 4 shows the schematic velocity model of the Kyoto - Awaji profile revealed from the arrivals of P waves in these explosion seismic experiments. The structures proposed by another author [1] is also presented in this figure.

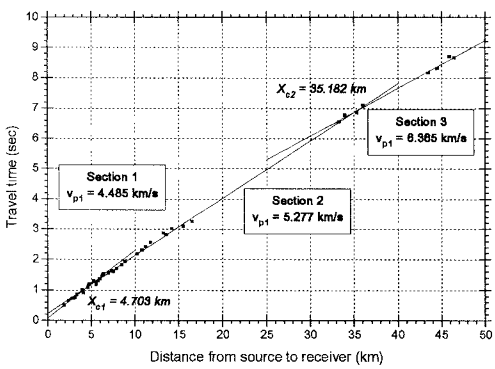

Fig. 3 Travel time of P wave

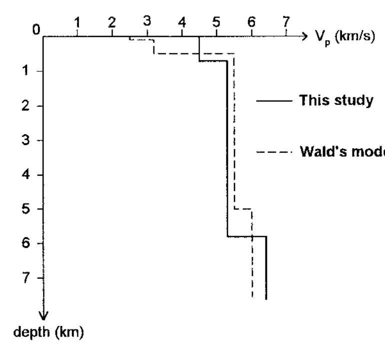

Fig. 4 P wave velocity model

4. Conclusions

The signal enhancement is the first step in analyzing the data recorded during the explosion experiments, especially if the receivers are located in noisy regions. The simple Butterworth band-pass filter was found to be sufficient in the explosion signal processing.

A two-layered structure over a half-space was proposed to model the crust of the profile. The P wave velocity and depth of each layer were found reasonable.

5. Acknowledgment

We wish to express our gratitude to the Honshu Shikoku Bridge Authority for their helpful support and to the firms engaged in the construction of the Akashi Kaikyo Bridge for their assistance in the measurements.

6. Reference

[1] Wald, D. J. (1995). "A preliminary dislocation model for the 1995 Kobe (Hyogo-ken Nanbu), Japan, Earthquake determined from strong motion and teleseismic waveforms." *Seismological Research Letters,* Vol. 66, No. 4, pp. 22-28.