Development of a New Early Earthquake Detection and Alarm System

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The Railway Technical Research Institute (RTRI) has developed an urgent earthquake detection and alarm system (UREDAS) and put it into practical use mainly for Shinkansen. Valuable knowledge is being accumulated to issue an urgent alarm for earthquakes due to the development of the real-time seismology in recent years. The Japan Meteorological Agency (JMA) and other governmental organizations are improving the nationwide earthquake observation network and planning to distribute prompt earthquake information (now-cast earthquake information). Under the circumstances, RTRI is studying new methods to predict seismic source parameters based on the P-wave and urgently estimate earthquake damage, and promoting the development of a new early earthquake detection and alarm system to utilize the prompt earthquake information provided by governmental organizations jointly with JMA.

NEW EARLY EARTHQUAKE DETECTION AND ALARM SYSTEM

A New Method to Predict Seismic Source Parameters. The conventional system roughly estimates the magnitude and the epicenter by observing the period and the maximum amplitude of the initial P-wave measured at a observation point, and issues an alarm before the arrival of the main shock. RTRI has discussed a method to predict seismic source parameters based on the P-wave by utilizing the latest knowledge in seismology and other scientific fields, and developed a new method to estimate the magnitude and the distance to the epicenter from the maximum amplitude and the amplitude increasing rates of the initial P-wave (Fig. 1). The relationship between the rate of increase in the envelope of the initial P-wave and the distance to the epicenter from observation points is illustrated in Fig. 2. When compared with the conventional method, the new method estimates the magnitude at higher precision (Fig. 3) while less affected by the noise of ground motion.

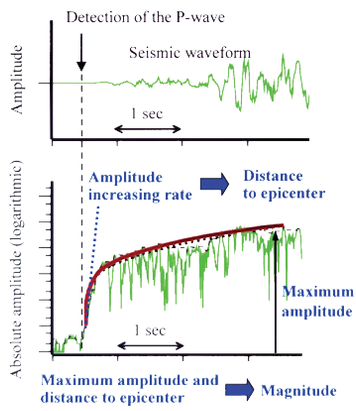

Figure 1. New method to predict seismic source parameters.

Seismograph for the New System. RTRI has developed a seismograph for the new system by applying the new method to detect seismic source parameters (Fig. 4), and by assuming the application to observation points of railway operators. Since it applies the latest information technology, it has several merits when compared with the conventional system, in addition to the aforementioned improved precision in the detection of source parameters. A built-in PC, for example, makes the seismograph compact and lightweight and enables parallel processing and remote operation with a real-time OS. Circuits are designed to incorporate countermeasures against electromagnetic noise. This makes it possible to use the seismograph at observation points in wayside substations.

Now-Cast Earthquake Information. JMA has a plan to measure the seismic waves near the epicenter at 180 observation points across the country and prepare the information on the epicenter, magnitude, main shock arrival time and predicted seismic intensity, which is called the now-cast earthquake information, before the main shock arrives. The now-cast information will be distributed when the P-wave has arrived at the observation point nearest the epicenter and repeatedly thereafter at certain time intervals. The information which is created first (the 0^{th} information) is on the seismic source parameters estimated from the data of the P-wave which is caught at an observation point in a few seconds. The new method mentioned above will be used to process this information. After that, more precise information (the 1^{st} information, the 2^{nd} information and so on) will be distributed, as the seismic motion is observed at other observation points. The new system uses the now-cast information (mainly the 0^{th} information) provided by JMA in addition to the information obtained by railways. It is thought, therefore, that the function of the UREDAS for Shinkansen will significantly be improved. It will also be possible to apply it to narrow-gauge lines at low costs.

FUTURE PLAN OF RTRI

RTRI has constructed a prototype compound system to combine the new early earthquake detection and alarm system and the post-earthquake operation restart support system on its premises in 2002 autumn for operation tests, based on which it will propose the specifications for a practical compound system at the end of fiscal 2002. In 2003 autumn, it will start a test of the normal operation of the compound system based on the now-cast information and two-dimensional information on the seismic intensity estimated by JMA.

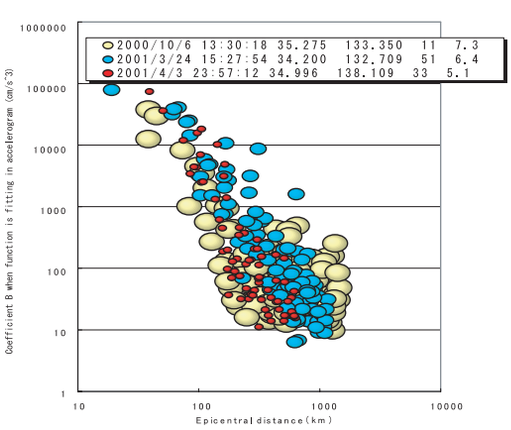

Figure 2. Relationship between the rate of increase in the envelope of the initial P-wave and the distance to the e picenter.

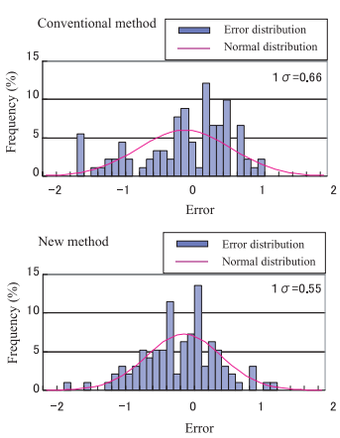

Figure 3. Comparison of the precision of the estimation of magnitude.

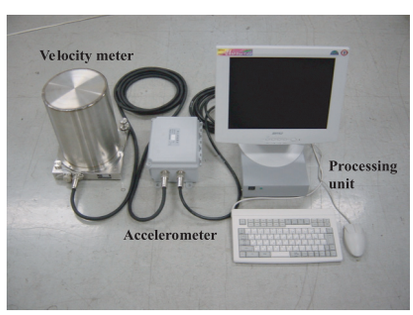

Figure 4. Seismograph for the new system (prototype).