Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

HDS030-01 Room:101 Time:May 26 16:30-16:45

Performance of Earthquake Early Warning of JMA ? present status and improvement

Toshihiro Shimoyama[1*], Kazuyuki Hirano[1], Yasuyuki Yamada[1], Mitsuyuki Hoshiba[2], Kazuo Ohtake[2], Kazuhiro Iwakiri[2]

[1]Japan Meteorological Agency, [2]Meteorological Research Institute

Japan Meteorological Agency(JMA) started to provide EEW to a limited number of users from August 2006, and started to the public through TV and radio in October 2007. The Meteorological Law amended in December 2007 was provided that EEW should be as forecast or warning of strong ground motions caused by an earthquake.

From October, 2007 to December, 2010, JMA issued 17 warnings to the public and issued 1756 forecasts. For 7 cases for which maximum seismic intensity ”5 lower” was actually observed, JMA did not issue warnings because of underestimation of the strong ground motion. .

In 2010, warnings were issued for 5 events - M7.2 earthquake occurred at Near Okinawajima island on 27,February, M6.7 earthquake occurred East off Fukushima prefecture on 14 March, M5.7 earthquake occurred Western Fukushima prefecture on 29,September, M4.7 earthquake occurred Mid Niigata prefecture on 3,October and M4.6 earthquake occurred Ishikari depression on 2 December. For Western Fukushima prefecture event, EEW system estimated focal depth deeper than the actual one. (depth of JMA catalogue:8km -> depth of EEW Warning:120km) Therefore, EEW system overestimated its magnitude (magnitude of JMA catarlogue:M5.7 -> magnitude of EEW warning:M6.6), and issued Warning including area where observed intensity was much smaller than ”5lower”.

JMA has been enhancing seismic observation network, and improving the method in order to issue more accurate and more rapid EEW.

For example, until March 2011, JMA is going to apply empirically estimated site amplification factors for predicting seismic intensities. JMA is going to use new seismic stations - 10 free surface stations in Nansei-shoto Islands in Kagoshima and Okinawa prefecture , Niijma island in Tokyo prefecture and Beppu in Oita prefecture.

In addition, we are planning to use data from NIED’s seismometers installed in boreholes at depth of more than 1000m from surface in Tokyo metropolitan area.

In this presentation, we will present evaluation of the performance of EEW issuance, problem and various efforts to improve EEW of JMA.

Keywords: Earthquake Early Warning, Warning event

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Examination of the On-site Earthquake Warning System by Boring Seismograph Data

Kiyoshi Takano[1*], Yusuke Awata[2]

[1]III and ERI, theUuniversity of Tokyo, [2]Graduate School of Frontier Sciences,The

In our country, a lot of public earthquake observation facilities are maintained. If the data of these seismographs will be used for the on-site earthquake warning system, we will be able to build up the ideal early warning system that can apply from the near regional large earthquakes to the far great earthquakes by combining with the JMA EEW.

In the public earthquake observation facilities, there are a lot of observation facilities where the boring seismograph set up under the soil.

The noise of these boring seismograph are very low compared with the ground level seismograph, and the earthequake detection time can be earlier if the seismobraph was set in the very deep well of about 1000m class.

However it is not easy to forecast a strong shake of the ground level from the underground observational data by the influence of the subsurface layer.

We examined the technique for forecasting a strong shake of the ground level from the P wave part of the underground observational data.

We are adopted the simple seismic intensity which can obtain by real-time processing as a predictive index.

We examined the effectiveness by using the data of the ground level and underground level strong motion record of Tokyo Electric Power Company Kashiwazaki and KiK-net of the NIED, and obtained the forecasting formula of the underground seismograph.

It is thought that it is possible to offer the on-site earthquake warning for the regional area of the site by making the similar forcasting formula for each borehole seismograph.

Keywords: Boring Seismograph, On-site Earthquake Warning, Earthquake Early Warning

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HDS030-03 Room:101 Time:May 26 17:00-17:15

Development of the new EEW method available for the area near hypocenter

Shuichi Taya[1*], Satoshi Kodama[1], Shigeru Nakajima[1], Satsuki Shimono[2], Kentaroh Ohba[3], Hiroshi Nakamura[4]

[1]Central Japan Railway Co.,Ltd., [2]ANET Co.,Ltd., [3]MSS Co.,Ltd., [4]RION Co.,Ltd.

1. Introduction

The Earthquake Early Warning system is expected for earthquake disaster mitigation. However, the method on this system has a problem that warning for the area near the hypocenter is not in time for the arrival of the strong ground motion.To solve the problem, we proposed the new seismic intensity (called 'Iap') computed from the vertical acceleration and the new EEW method using this intensity (Taya, et.al (2007)). This report is described the best threshold level of Iap warning and new methods of judging whether detected-shake is the earthquake (called 'Earthquake-Noise Judgment').

2. The best threshold level of Iap warning

In this analysis, 84 K-NET waveform data (for events of Ijma >= 4.5 and hypocentral distance < 30km) were used. The warning thresholds were set by 3.0~3.4. Timings of Iap warning were calculated. It was found that the new method could warn earlier than old one and could reduce unnecessary warnings if the warning threshold level was set by 3.4.

3. The new methods of Earthquake-Noise Judgment

The EEW seismograph might detect an abnormal shake that causes the false warning. To prevent the false warning, it must judge whether the detected-shake is the earthquake within very short time. In addition, waveforms of abnormal shake have some types. Therefore, the EEW seismograph must have some methods of Earthquake-Noise Judgment adapted to each waveform type. One of the feature of abnormal shake, the amplitude of the initial part of wave exceeds thousands Gals so rapidly. Aiming at this feature caused by electric noises, it was found that the detected-shake was considered to be a noise if the amplitude of the initial part of the wave exceeded the certain limit, defined by the maximum amplitude of the initial part of earthquakes.

4. Development of the new EEW seismograph

The new EEW seismograph based on SM-27 (made by RION Co.,Ltd.) was developed. Now it has been tested in the factory. It will be set up on the wayside of the Tokaido Shinkansen.

Keywords: Earthquake Early Warning, seismograph, Iap, Earthquake-Noise Judgment

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HDS030-04 Room:101 Time:May 26 17:15-17:30

A new method for estimating epicentral distance using very initial phase of single station data

Shunroku Yamamoto[1*], Shunta Noda[1], Masahiro Korenaga[1], Shinji Sato[1], Naoyasu Iwata[1]

[1]Railway Technical Research Institute

Since estimation of epicentral distance using single station data plays is an essential part of the Shinkansen EEW system or the JMA EEW system, its accuracy and rapidness are expected to be improved. The B-delta method (Odaka et al., 2003) adopted by the present systems assumes that amplitude envelope of initial P-wave is effected by both epicentral distance and magnitude. On the other hand, Yamamoto et al. (2010) pointed out amplitude envelope of very initial phase (0.0 - 0.5 sec) has little relationship with magnitude by an analysis of real-time seismic intensities. Here, a new method for estimating epicentral distance is proposed on the basis of the result mentioned above.

The proposed method uses a fitting function, $y(t) = C\,t$, where y, t and C are amplitude envelope, time after P-wave detection and coefficient corresponding to epicentral distance respectively. Once coefficient C is obtained by fitting the function to observed envelope of the very initial phase, epicentral distance can be estimated from empirical relation between C and the distance. Band pass filter (10 - 20 Hz) is applied to recorded wave as a pre-process in order to reduce effects of surface amplification or rupture process.

To confirm performance of this method, estimation errors (RMS in log scale) are calculated by using 2237 waves of 23 earthquakes recorded by K-NET. Estimation errors are 0.303 and 0.316 for 0.5-sec and 2.0-sec time window respectively. The estimation error by this method using 0.5-sec time window is reduced by 4 % comparing with the error by the B-delta method using 2.0-sec time window. This result demonstrates very high potential of the method for EEW.

Keywords: earthquake early warning, single station, epicentral distance

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HDS030-05 Room:101 Time:May 26 17:30-17:45

Estimation of epicentral distance taking account of the effect of viscous attenuation for single station method of EEW

Shunta Noda[1*], Shunroku Yamamoto[1], Naoyasu Iwata[1], Masahiro Korenaga[1], Shinji Sato[1]

[1]Railway Technical Research Institute

1. Introduction

A single station method (an on-site method), which can estimate earthquake parameters (epicenter locations and magnitude) by using single station data, is now in use for the present Earthquake Early Warning system of JMA and Shinkansen. Although the method has higher rapidness, lower accuracy to estimate earthquake parameters is pointed out compared to multi station methods (network methods).

The B-Delta method (Odaka et al., 2003) is used as one of components of the single station method to estimate epicentral distance. In the method, a function Bt∗exp(-At) is fitted to the initial phase of P-wave in order to estimate epicentral distance (Delta), which negatively correlates with the coefficient B. The coefficient B represents increasing ratio of amplitude of the initial phase. On the other hand, Yamamoto et al. (2010) proposed a new method using a simple function Ct for fitting, called the C-Delta method. The coefficient C also represents the increasing ratio of initial phase.

In the conventional B-Delta method, relationship between B and Delta is expressed as LogB=a∗Log(Delta)+b taking account of only geometrical attenuation. Since the coefficient B or C have high correlation with amplitude, it is natural to take viscous attenuation into account. Therefore, we propose the following equation to express the relationship between B (or C) and Delta, LogB=c∗Log(Delta)+d∗(Delta)+e (B can be replaced by C). The first and second term of right side of the equation indicate geometric and viscous attenuation, respectively. In general, the farther the epicentral distance is, the greater the effect of viscous attenuation relatively is. In this study, we investigate effect of the viscous attenuation term on estimation accuracy.

2. Analysis and Result

First, B and C are calculated from K-NET acceleration records for M>5.0 earthquakes. The functions Bt∗exp(-At) and Ct are fitted to the initial phase of P-wave which is filtered by 10-20 Hz band-pass. 2-second and 0.5-second data from P-wave arrival are fitted by Bt∗exp(-At) and Ct, respectively.

Second, regression analysis is carried out by fitting equations, a∗Log(Delta)+b and c∗Log(Delta)+d∗(Delta)+e, to B or C. In this analysis, data are selected according to Fukushima and Tanaka(1990) to avoid the problem due to S/N ratio.

We calculate errors (RMS) between true Delta and Delta estimated from the relationship obtained above. As results, in case that epicentral distance is less than 100km, errors taking account of viscous attenuation are almost same to ones without viscous attenuation. However, in case that epicentral distance exceeds 100km, errors taking account of viscous attenuation are decreased by 25% compared to ones without viscous attenuation. We have the same results for both the case of B and the case of C.

Those results demonstrate that the equation c∗Log(Delta)+d∗(Delta)+e which includes viscous attenuation is more appropriate to estimate epicentral distance accurately for the B-Delta and the C-Delta methods.

Keywords: Earthquake Early Warning, single station method, on site method, B-Delta method

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HDS030-06 Room:101 Time:May 26 17:45-18:00

Estimation of extended source area from vertical PGA saturation during a great earthquake for upgrading the EEW system

Susumu Kurahashi[1*], Masaki Kazuaki[1], Irikura Kojiro[1]

[1]Aichi Institute of Tecnology

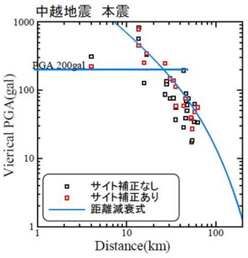
1. Introduction

The Earthquake Early Warning (EEW) system by JMA in Japan provides the coordinate of the starting point, the origin time and the magnitude of target earthquakes based on a point source assumption. The seismic intensity at each site is calculated by using an attenuation distance relation and site amplification from the magnitude and hypocentral distance provided from the EEW. However, during large earthquakes, the calculated seismic intensity might be underestimated in comparison with the observed one. Because a large earthquake has not a point but an extended source, the distances from the earthquake rupture area to observed sites are different from the hypocentral distances assuming a point source. In the Tokai area, the calculated seismic intensity might be about one or two scales smaller than the observed one as long as the Tonankai earthquake would occur off Shionomisaki. It is effective to estimate the rupture extension of the large earthquake from real-time observed records close to the rupture area to prevent underestimation of the seismic intensity in the Tokai area. We have examined to estimate the rupture extension of large earthquake from attenuation distance relation peak ground acceleration (PGA) of P-waves. As a result, we can provide the information about the rupture extension before the arrival of the S-waves (Kurahashi et al., 2009). However, the PGA so far used did not exclude the site effect. In this study, we try to obtain site effects of vertical component for estimate absolute saturation levels of PGA near rupture areas. The site effects were defined as the ratio of the observed PGA and the calculated PGA from the attenuation distance relation.

2 Attenuation distance relations of vertical motions

First, we estimated the attenuation distance relations of vertical motions. We used the observed records of the mainshocks and aftershocks in the 2004 Chuetsu earthquake and 2008 Iwate Miyagi nairiku earthquake. The observed records were used within 120 km in hypocentral distance to exclude the influence of the reflected waves from the moho on the motions. Regression equation for attenuation distance relations of vertical motions is expressed as (1). This equation corresponds to a simple point source with geometrical spreading and constant Q. Therefore this equation is appropriate for small earthquakes. The coefficients of regressions were estimated by two step method (Joyner and Boore, 1981). Next, the site effects were calculated the ratio of observed PGA and calculated PGA. As a result, there is no great distinction between the site effects of horizontal PGA and those of vertical PGA. The absolute saturation levels of PGA are obtained from the attenuation distance relations of vertical motions by removing the site effects. Figure1 shows the attenuation distance relations of PGA during the 2004 Chuetsu earthquake correcting the site effects of vertical motions. The absolute saturation levels of PGA during the 2004 Chuetsu earthquake were estimated about 200gal. However, a detailed examination is necessary for determining the absolute saturation levels because the number of data is not many.

$$\log(PGA) = aMw - \log(r) - br + c \qquad (1)$$



HDS030-07 Room:101 Time:May 26 18:00-18:15

Expectation of ground motion using real time data of neighbor and front stations

Mitsuyuki Hoshiba[1]*

[1]Meteorological Research Institute

Earthquake Early Warning(EEW) has been operated nationwide in Japan by Japan Meteorological Agency(JMA). JMA EEW basically adopts a network method, in which hypocenter and magnitude (source parameters) are determined quickly, and then issue warnings. In this method, though we can expect ground motions using a few parameters (location of hypocenter, magnitude, site factors), error of source parameters leads directly to the error of the expectation, and it is not easy to take the effects of rupture directivity and source extent into account. In this presentation, we propose a method which uses real time waveform data of neighbor and front stations, In the method, though real time data is needed, relatively precise prediction is expected even when effects of rupture directivity or source extent are dominant.

For the analysis, we use borehole data (depth of borehole ranges 500 to 3500m), and also data from 2003 Tokachi Oki Earthquake (M:8.0) and 1994 Sanriku Haruka Oki Earthquake(M7.6).

Regarding the borehole, at SITH01, for instance, the accelerometers are located at surface and at a depth of 3500m. The borehole accelerometer detects S waves 3 sec earlier than the surface. The difference of site factors corresponds 1.3 on JMA intensity. The intensity at surface is expected 3 sec earlier by simply adding 1.3 to the observed intensity at borehole in real time manner. Regarding the Tokachi Oki Earthquake, the intensity is expected 7 sec earlier by using data at station which located 30km apart. For Sanriku earthquake, we try to modify the fault extent.

Acknowlegments. Data from K-NET, KiK-net of NIED, and JMA seismic intensity meters are used.

Keywords: Earthquake Early Warning, Expectation of seismic intensity, Deep borehole, real time manner, source region

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Utilization of Earthquake Early Warning and On-Site Strong Motion to disaster mitigation for High-Rise Building

Tomohiro Kubo[1*], Yoshiaki Hisada[1], Masahiro Murakami[1]

[1]Kogakuin University

The building manager must make not only the fire scheme for the large-scale building such as a high-rise building, but also the disaster prevention plan, due to Fire Service Act gone into effect on June 1, 2009. However, many high-rise buildings do not have the disaster prevention plan and system.

After a major earthquake, the about 10 security officers have to manage to rescue trapping people in the elevator and respond to the people in the building, gather the damage information of the building.

According to the above problems, we developed the Initial Response Support System for High-Rise Building using Earthquake Early Warning and On-site Strong Motion Data in order to carry out the initial response during a major earthquake. Furthermore, we applied the system to a high-rise building and studied the utilization of the system based on the PDCA (Plan Do Check Action) cycle.

As the result of the disaster drill, we found many people ignored the earthquake early warning announcement and did not avoid from the hazardous area and material. Therefore, we disseminate the response when people heard the earthquake early warning and confirm the necessity of the public outreach and education to utilize the information and warning.

Keywords: Earthquake Early Warning System, On-Site Strong Motion, Earthquake Disaster drill, Initial Response Plan