Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS33-01 Room:103 Time:May 19 09:15-09:30

Estimation of underground structures using microtremors in the southern part of the Osaka Plain

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It is essential to evaluate an underground structure properly or validate previously proposed underground models based on the geological data and/or boring exploration data with observed ground shaking, in order to obtain highly precise estimation of strong ground motions in urban areas.

In this study, we observed microtremors in the southern part of the Osaka Plain in Japan where detailed geological information are comparatively less than the other areas of the Osaka Plain. We calculated H/V spectral ratio of microtremors (HVRM hereafter) from observed data and compared the predominant peak frequencies and amplitudes at these frequencies with theoretical HVRM calculated from our initial model. We searched for the better 1-D structure at each site based on these predominant frequencies and amplitudes.

In our identification approach we used the code that calculates theoretical HVRM for a given underground structure based on a newly proposed theory (Sanchez-Sesma *et al*., 2011). In this theory, HVRM at a site can be expressed in terms of a ratio of the imaginary part of the Green's function components at the site if the site is in the diffuse field.

First we calculated theoretical HVRM from the underground models at three strong motion stations of NIED using the code. By comparing the theoretical HVRMs with the observed HVRMs, we validate the theoretical calculation scheme and our estimation approach for an underground structure. As a result, we found that both theoretical and observed HVRMs show fairly good agreement, except for a site in a hilly zone with highly irregular topography. Therefore it is shown that if an observation point is on an alluvial plain with soft sediments, we are able to identify an underground structure close to the real structure at the point by fitting the theoretical HVRM to the observed HVRM.

Next, we identified both thicknesses and S-wave velocities of underground layers together. We used the grid-search method to identify the best underground structure that yields minimum residual between theoretical and observed HVRMs. As a result, theoretical HVRMs of the proposed models are a better match to those of observed HVRMs in both the predominant frequencies and the amplitudes at these frequencies than theoretical HVRMs of the initial models at all the observation stations.

After finishing our identification, we compared our results to previously proposed studies such as microtremor array observation conducted by the Headquarters for Earthquake Research Promotion, and H/V spectral ratio obtained from Rayleigh-wave ellipticity (HVRR hereafter), in order to validate the appropriateness of the newly proposed theoretical HVRM based on the diffuse field theory.

Finally we further studied a way to apply our identification results for estimation of strong ground motions. Considering the results of our modified underground models, which have different Vs structures at each site (that is, different-Vs models), we identified again underground models with the common Vs values in each layer at all the sites (that is, same-Vs models). As a result we found that we can use the same-Vs models as models for estimation of strong ground motions instead of the different-Vs models since the differences in 1-D amplification characteristics between them seem insignificant.

In this study, following the newly proposed theoretical HVRM based on the diffuse field theory, we could precisely identify the best underground structure by comparing observed HVRM and theoretical HVRM for an assumed underground structure.

We would like to estimate strong ground motions for hypothesized scenarios of earthquakes in future based on the underground structures proposed in this study. We also would like to extend our approach of microtremors for estimation of complex underground structures around faults with much dense sampling in space.

Keywords: microtremors, H/V spectral ratio, Osaka Plain, diffuse field theoy

Japan Geoscience Union Meeting 2013
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SSS33-02 Room:103 Time:May 19 09:30-09:45

Estimation of variation in site amplification due to uncertainty of shallow Vs profile from microtremor exploration

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Many model parameters are involved in strong motion simulations, and some of the parameters are difficult to determine in advance for future major earthquakes. The variations of estimated ground motion have been often discussed from numerical simulations considering effects of fluctuation of the parameters for fault models. Uncertainty in subsurface structural parameters, such as S-wave velocity, also affects the variation of the ground motion characteristics. However, ground motion variation due to uncertainty of subsurface structure has not been deeply discussed. One of the reasons can be caused from a difficulty to estimate an uncertainty for the model parameters of subsurface structural model from geophysical or seismological investigations.

In this study I estimated an uncertainty of shallow S-wave velocity profiles from microtremor array explorations using Markov Chain Monte Carlo method (MCMC method in the following). The estimated uncertainty was used to know the variation of the amplification from the sampled S-wave profiles. The MCMC inversion method does not determine one model unlike to conventional inversions. It can provide models whose parameter distributions are proportional to their probability density functions. Therefore we can estimate the variation of the amplifications for soil model parameters from the sampled models with the MCMC method.

I used the results of the shallow microtremor explorations conducted in Monzen-machi in Ishikawa prefecture after the 2007 Noto Hanto earthquake (Yamanaka et al., 2008). The MCMC method by Yamanaka (2011) was applied to the Rayleigh wave phase velocity data at periods of less than 1 second from the microtremor explorations. The sampled shallow S-wave velocity models over the engineering bedrock were used to obtain an average and a standard deviation of the S-wave velocity and the thickness of the shallow soils at each site. Furthermore, 1D amplifications of S-wave were also calculated from the sampled models. The variations of the amplification factors are almost the same (about 30%) at all the periods including fundamental peak period. The average amplification factors become much smoother at short-periods than those at long-period. Since the sampled models have different peak periods for the higher mode amplifications, such higher-mode peaks and troughs are smoothed in averaging operation. I also calculated amplification for a model derived in conventional inversion of the phase velocity. The S-wave velocity model from the conventional inversion shows peaks and troughs of higher-mode in short period range. However, these peaks and troughs are not so accurate considering the uncertainty of S-wave velocity profiles from the microtremor explorations.

Keywords: amplfication, shallow soil, microtremor exploration, S-wave velocity profile, inversion, Markov chain Monte Carlo method

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SSS33-03 Room:103 Time:May 19 09:45-10:00

Soil structure inversion and strong motion estimation based on H/V spectral ratio for earthquakes

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During the 2011 Off the Pacific Coast of Tohoku earthquake which occurred on March 11, 2011, the maximum acceleration of 585.7 cm/s^2 and JMA seismic intensity 6 upper was observed at the K-NET Furukawa (MYG006) station, in Osaki City, Miyagi Prefecture. Near the K-NET Furukawa several buildings were collapsed or heavily damaged due to strong motion and subsequent ground liquefaction. We investigated underground structures at and near the K-NET site by using aftershock records to delineate site amplification effects on the strong motions during the main shock.

We deployed five temporary aftershock observation sites around MYG006 on June 2011, and measured ground motions continuously for six months. Among the 63 aftershocks triggered at MYG006 the observed earthquake data at the temporary aftershock observation sites were used. Average Fourier spectra were computed for the NS and EW components to determine the HVRs of NS/UD and EW/UD. As for the aftershock HVRs, a peak was observed at around 0.2 Hz at all six observation sites including MYG006, and all of the sites recorded similar HVRs in the frequencies below 1.5 Hz, which is believed to be the effect of the deep soil structure.

The strong motion HVRs for the main shock and the aftershock that occurred at 23:32 on April 7 (M7.1) and weak motion HVRs calculated as the average of other small aftershocks were compared. The HVRs were almost the same between the two major events but they were different from those of weak motions, which shows the effect of nonlinearity on the strong motion HVRs. During the strong motion, due to the effect of nonlinearity, the frequencies that are said to cause severe damages to buildings, namely 0.5-2 Hz, were greatly amplified and this is believed to be one of the causes for the severe building damages in Furukawa. If we focus our attention to the troughs around 8 to 10 Hz, we can see weak frequency shift from the average HVRs of small aftershocks to the two strong motion HVRs by half at most.

Identification of the soil structure immediately below each observation site was attempted based on the HVRs of weak motion data recorded at each site. For the initial model the results of the previous study (Kawase and Matsuo, 2004) with two more layers for better characterization were used. The theoretical HVRs were calculated based on the concept of Kawase et al. (2011), and were identified by changing both shear wave velocities Vs and thicknesses of assumed layers. We used Hybrid heuristic method (Yamanaka 2007) and minimized the misfit between observed and theoretical HVRs. First we identified common deep soil layers for all observation sites to much all the HVRs in the longer period than 1.0 s. Next we determined shallow soil layers to fit observed HVRs at each observation sites for period range from 10 s to 0.05 s. The identified velocity structures reproduced the observed HVRs quite nicely in a wide period range.

One-dimensional deconvolution analysis was applied to derive the incident seismic wave on the seismic bedrock using the equivalent linear analysis, taking the nonlinearity of the soil structure into consideration. We calculated the incident waves for the main shock record in the frequency range from 0.1Hz to 20Hz. The maximum acceleration of NS bedrock wave was found to be 159.5 m/s^2 and the maximum acceleration of EW bedrock wave was 454.2 m/s^2 . The latter is high because of large amplification in high frequency range over 10Hz.

We computed the seismic motion at the temporary observation site near MYG006 during the main shock by using the above inverted bedrock motions. The maximum acceleration of calculated wave was almost the same as the observed wave at MYG006. The transfer function between the bedrock and the surface shown strong peak shift to longer period due to the effect of soil nonlinearity with the same degree as the shift observed at MYG006.

Keywords: H/V spectral ratio, strong motion, defuse field theory

Japan Geoscience Union Meeting 2013
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SSS33-04 Room:103 Time:May 19 10:00-10:15

A new development in shallow explorations using microtremors based on a practical use of a CCA method

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We have continued development of a CCA method (Centerless Circular Array) for nearly 10 years as a tool to determine phase velocities of Rayleigh waves by using vertical-component microtermor arrays. The initial development was characterized by the applicability of a CCA method to irregular arrays consisting of three seismometers (Cho et al. 2004). Later, we found the potential of a CCA method to deal with a very long-wavelength range relative to an array size (Cho et al., 2006). Recently, we showed that wavelengths more than 100 m are analyzable using miniature arrays having radius less than 1 m, by adopting a CCA method and a noise-compensated CCA method (Cho et al., 2013). This time, we have examined the practical use of a CCA method and its application.

We replaced the cross spectra that are involved in a fundamental equation of a CCA method with coherence functions (Hereafter, we call it a coherence CCA method). A comparison between the analysis results of coherence-SPAC and CCA methods indicated that the coherence CCA method can produce confidential and robust results. In particular, the noise-compensated CCA method for miniature arrays were significantly stabilized by the use of coherences, producing performances much higher than that of the SPAC method. We expect that the use of the coherence CCA method with miniature arrays ($r < 1$ m), together with small irregular arrays consisting of three seismometers ($r < 10$ m) depending on the necessity, enables shallow subsurface explorations (to the depth of about several tens of meters) more practical than ever before, from view points of the mobility of observations, broadness of the analyzable wavelength ranges, and the reliability and robustness of the analysis results.

Incidentally, the amplitudes of microtremors, as well as the phase data by an array analysis, have information on the subsurface structure. A peak frequency of H/V spectra is related to either the thickness or the elastic-wave velocity of a surface soft soil, while the height of the peak is related to the impedance ratio between the soft-soil and basement layers. However, we cannot constrain the depth scale corresponding to the peak of a H/V spectrum due to the tradeoff between the velocity and thickness.

This problem can be solved by conducting a miniature-array observation adjacent to a single-point observation. Obtaining a relation between frequency and wavelength from an array observation, we can apply it to the H/V spectra to obtain a relation between the wavelength and the HV ratio. By using some conversion equation from a wavelength to a depth, we can have a plot of depth vs. H/V ratio. We call a subsurface structure obtainable in this way a H/V structure.

We propose an integrative interpretation of H/V section, together with a pseudo shear-wave velocity section (Ling et al., 2003; Haraguchi, 2010), obtainable by adopting miniature arrays for phase velocities and single-point observations for H/V spectra. Miniature arrays for the CCA method have high mobility and high horizontal resolution owing to the array size. A combination of the CCA and H/V methods enables to obtain more information from microtermors in a easier way than before.

We are planning to increase application examples and to validate the usefulness of the method proposed above. A seismometer JU-215, which was co-developed by the NIED and Hakusan Co. (Senna et al., 2006), is best suited for our purpose from a view point of the portability, the simple handling, and the capacity of providing with high-quality data. Fig. 1 shows H/V and pseudo shear-wave velocity sections along a measurement line about 10 km. The data were obtained by a single researcher, who conducted a two-day observation, including a preliminary inspection, using JU215 seismometers. In the presentation, showing analysis results of the data obtained using JU215 (at Tsukuba, Kashiwa, Urayasu, Itako, ... etc), we will discuss the usefulness and problems of the proposed method.

Keywords: microtremor, velocity structure, surface waves, phase velocity, expolation method, array

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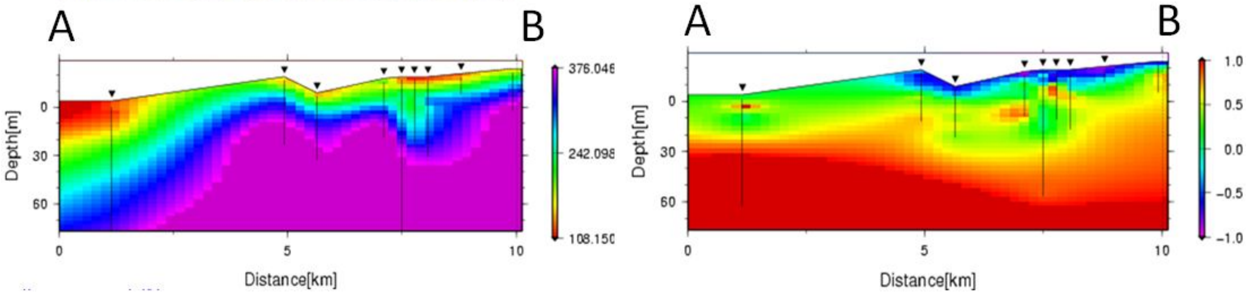
Figure 1
Upper : A measurement line at Kashiwa (about 10 km)
Lower : a pseudo shear-wave velocity section (Left) and a H/V section (Right)



Japan Geoscience Union Meeting 2013
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SSS33-05 Room:103 Time:May 19 10:15-10:30

Statistical properties of strong ground motions based on the spectral inversion method

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Studies to separate strong motion properties (source, path, and site properties) from Fourier spectra of observed strong motions by the generalized spectral inversion method have been attempted for several decades (e.g., Iwata and Irikura, 1986; Kawase and Matsuo; 2004). However, there is barely any research to separate strong motion properties using response spectra because the physical meaning of these properties in the separated response spectra is not clear. However, similarities are identified between acceleration Fourier spectra and the velocity response spectra, and so investigation using response spectra seems worth attempting. In addition the data used in Kawase and Matsuo (2004) was those observed from 1996 to 2002 for three nation-wide strong motion networks, namely, K-NET, KiK-net, and Japan Meteorological Agency's seismic intensity-meter network. Since then more than ten years have passed, and vast amount of data has been accumulated. Thus we separated and analyzed strong motion properties for both the Fourier and response spectra of strong motion data between 1996 and 2011 (with Mj 4.5 and over) and summarizes findings on newly obtained strong motion properties.

Strong motion properties separated from acceleration Fourier spectra agreed well with those by Kawase and Matsuo (2004) regardless of earthquake types and regions. The Q values tend to be more linear and stable than their results. The Q values of crustal earthquakes in Hokkaido were obtained for the first time. Site amplification properties show a good match with Kawase and Matsuo (2004). The source properties represented by the so-called Brune's stress drop were also not so significantly different.

The Q values from acceleration response spectra agreed very well above 1 Hz with those from the Fourier spectra. In contrast, different trends were observed below 1 Hz, where the Q values from response spectra showed linear frequency dependence. The site amplification properties matched well with those from Fourier spectra; however, many sites below 1 Hz tend to show a flat trend with high amplitude. As for the source properties, we compared source terms of the pseudo-velocity spectra with those from acceleration Fourier spectra. Basically levels were similar for frequencies higher than 1 Hz, but again data separated from response spectra again maintained a high value below 1 Hz. The differences below 1 Hz would be due to higher response spectral values by prominent peak amplitudes in Fourier spectra in the higher frequency range.

Source properties separated from acceleration Fourier spectra were statistically analyzed. We applied t tests to the Brune's stress drop estimates before and after the Off the Pacific Coast of Tohoku Earthquake of March 11, 2011, to realize that they were not significant for all earthquake scales and types. This means that there are barely any effects of the Off the Pacific Coast of Tohoku Earthquake on the stress drops of small earthquakes including aftershocks in the source region in Tohoku.

We also compared the short-period level A, which is one of the important indicators that determine the area of asperities in the so-called empirical Green's function method, with the generally used scaling relationships by Dan et al. (2001) and Satoh (2003). The obtained data was not considered to be the same as those by Dan et al. (2001), although the regression line for subduction-zone earthquakes is close to their work. The obtained distribution of the short-period level A was also tested against those by Satoh (2003) to find that the distribution for subduction-zone earthquakes and intraslab earthquakes can be considered as the same data; however, the data was not the same for crustal earthquakes because the standard deviation in our study was larger than that by Satoh (2003). On the other hand direct comparison of short-period level A with Sato (2003)'s results showed correlation coefficients higher than 0.8 for all earthquake types.

Keywords: response spectrum, strong motion properties, Q value, stress drop, short-period level A

SSS33-06 Room:103 Time:May 19 10:30-10:45

TOWARD BETTER ESTIMATIONS OF GROUND-MOTION VARIABILITY

Fabrice Cotton[1*], Rodriguez-Marek Adrian[2], Archuleta Ralph[3], Causse Mathieu[4]

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The random ground-motion-prediction variability strongly influences the seismic hazard curve computation, in particular for long return periods. One of the key challenges of seismology is to be able to calibrate and analyze the physical factors that control the ground-motion variability. The exponential growth of seismological near-field records provides the opportunity to separate the source, propagation, and site factors controlling the ground-motion variability (Al-Atik et al., 2010; Rodriguez et al., 2011). Ground-motion variability is usually divided into between-events variability and within-event variability. We describe and discuss some recent results and analysis performed on these two variability components. In a recent study (Rodriguez-Marek et al., 2013) we estimate the within-event variability for five databases from different regions worldwide (California, Switzerland, Taiwan, Turkey, and Japan). We investigate the potential dependency of the within-event variability on region, Vs30, distance and magnitude. The results show that the variability of the within-event variability across the different regions is small when compared with the within-event standard deviation. In other words, the event-corrected single-station standard deviation is remarkably stable across tectonic regions. Our results also suggest that moderate earthquakes are more variable for a given magnitude than large ones and that some stations are also showing larger variability of ground motions than others. Our analysis of the between-event variability shows (Cotton et al., 2013) that the between-event ground-motion variability gives an upper boundary to the earthquake stress-drop variability. This quantification of stress-drop variability offers a new way to calibrate future earthquakes ground-motion simulations.

Keywords: strong-ground motion, seismic hazard, stress drop, variability

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SSS33-07 Room:103 Time:May 19 11:15-11:30

Source model of the 2011 Ibaraki-oki earthquake by the empirical Green's function method using strong-motion data

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The 2011 Ibaraki-oki (M_w 7.9) earthquake occurred off the east coast of the Kanto region, the south-eastern part of Japan at 15:15 on 11 March 2011 (JST). It is the largest aftershock of the 2011 Tohoku earthquake (M_w 9.1) which occurred approximately thirty minutes before this event. Kubo *et al.* (2012) estimated the kinematic source-rupture process of the 2011 Ibaraki-oki earthquake by jointly analyzing strong-motion data (0.2-0.02 Hz) and static displacements obtained from GPS data. In this study, we estimate the source model composed of strong motion generation area (SMGA, Miyake *et al.*, 2003) for the 2011 Ibaraki-oki earthquake based on modeling of broadband strong-motion data (0.1-10 Hz) using the empirical Green's function (EGF) method, and compare it with the source model of Kubo *et al.* (2012)

The strong-motion records of the 2011 Ibaraki-oki earthquake shows that several seconds of small amplitude arrival followed by the main rupture phase. This indicates that there was an initial rupture during the 2011 Ibaraki-oki earthquake. Therefore we assume a source model that the rupture of SMGA occurred as main rupture several seconds after the initial rupture started at hypocenter.

The location of the rupture starting point of SMGA and the delay time of SMGA are estimated after the procedure of Takenaka *et al.* (2006) and Suzuki and Iwata (2007) using the arrival-time differences between the initial and main rupture phase. The source parameters of SMGA (spatial dimensions, rise time, rupture starting subfault, and rupture propagation velocity) are estimated based on broadband strong ground motion simulations using the empirical Green's function method (Irikura, 1986). The best set of the parameters is estimated by minimizing the sum of the residuals of the acceleration envelope and displacement waveform fitting (Miyake *et al.*, 1999, 2003) through a grid search. For this analysis, the records at six KiK-net stations are used. The ratios of the source dimension and the stress drop between the large and small events are obtained by the source spectral ratio fitting method (Miyake *et al.*, 1999, 2003) using observed source spectral ratios. The seismic moment ratio between the large and small events is estimated from the source spectral ratio at two F-net stations. As EGF, we adopt the records of an M_w 6.3 event, which occurred at 20:44, on October 10 2005.

The estimated location of the rupture starting point and the delay time are approximately 10 km southeast of the hypocenter and 9s, respectively. The estimated SMGA is located at the deep side of the large slip area obtained from source inversion (Kubo *et al.*, 2012) and partly overlaps with the large slip area. The spatial dimension of SMGA is 28 km$*$28 km and it is smaller than the spatial dimension of the large slip area (60 km$*$60 km). The rise time, seismic moment, and stress drop of SMGA is 2.8s, $3.4*10^{20}$ Nm (M_w 7.6), and 42 MPa, respectively. The rupture within SMGA mostly expands towards the southwest direction at 4.0 km/s. This differs from the result of Kubo *et al.* (2012) where the rupture propagates towards the southeast direction.

Based on the results of this study and Kubo *et al.* (2012), we conclude that the entire source process of the 2011 Ibaraki-oki earthquake was as follows: Approximately 10s after the initial rupture started, the main rupture started at the deeper side of the initial rupture point. At the early stage of the main rupture, short-period seismic waves are mainly radiated. The whole main rupture with a large slip extends toward the southeast direction.

Acknowledgement: The strong-motion data recorded by KiK-net and F-net of NIED was used for this analysis.

Keywords: The 2011 Ibaraki-oki earthquake, Source process, Strong motion generation area, The empirical Green's function method

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Source Modeling of Sanriku-oki 2011(Mw7.6) Outer Rise Earthquakes Using the Empirical Green's Function Method

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1. Introduction

Just after the Tohoku Pacific ocean earthquake, at 15:26JST outer-rise earthquake (Mw 7.6) occurred in Sanriku?oki area. Outer-rise earthquakes frequently occurred in this area after this. The largest outer-rise earthquake is the 1933 Sanriku-oki earthquake in this area. It was difficult to recognize the character of strong ground motion of outer-rise earthquakes before this earthquake. However after this earthquake, we can study with rich strong ground motion data. It is important to grasp the seismic source characteristics of this earthquake not only for understanding the 1933 Sanriku-oki earthquake but also for next large outer-rise earthquake. In this study, we make the source model of this earthquake using the Empirical Greens Function (EGF) method and compare the parameters with empirical formulas.

2. Data

We use an outer-rise earthquake (05 May 2011 23:58JST Mw6.1) as element earthquake of EGF. Reason of this selection is this earthquake occurred near from target and it has similar source mechanism. Strong motion data which we use is delivered from KiK-net and Institute of Seismology and Volcanology, Faculty of Science, Hokkaido University.

3. Source modeling of EGF

We assume a rectangle strong ground motion generation area with a constant slip and stress drop to simulate wide-band strong-motion with simple fault model. In this case, seismic waves are generated only from strong motion generation area (SMGA) not from background area. The fault plane is determined based on focal mechanism of the target event and aftershocks distribution (Obana et al., 2012). The number to divide the SMGA into subfaults (=N) and the ratio of the stress drop of the target event to the element one (=C) are estimated with Yokoi and Irikura (1991). Under these setting we carry out grid-search analysis to get the size of SMGA, epicenter, rise time and rupture velocity. The epicenter is determined in south part of fault plane. This fact is related to directivity effects owing to the northward propagation of rupture understanding from observed wave forms. The model explains the envelope of acceleration, velocity and displacement records.

4. Combined SMGA and Stress Drop

We compare the SMGA parameters between this outer-rise earthquake and the shallow intraplate earthquakes in the Pacific Plate. The relationship between the combined SMGA and the total seismic moment is similar to the intraslab earthquakes (Sasatani et al., 2006). The stress drops for this earthquake are also similar to those for the intraslab earthquakes. Therefore the SMGA parameters of the outer-rise earthquake are similar to those of the intraslab earthquakes despite the shallow focal depths of the former events.

Acknowledgement

We use strong motion data from NIED (National Research Institute for Earth Science and Disaster Prevention) and Institute of Seismology and Volcanology of Hokkaido University. And we use the focal mechanism from GCMT.

Keywords: Outer-rise Earthquake, Source Characteristics, Empirical Green's function method

SSS33-09 Room:103 Time:May 19 11:45-12:00

Development of a new ground motion prediction equation applicable up to Mw9 (2)

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We examine a new ground motion prediction equation (GMPE) of instrumental seismic intensity in JMA scale, peak acceleration, peak velocity, and acceleration response spectrum for the purpose of application to seismic hazard assessments. In the last year, we develop a new GMPE which is directly applicable upto Mw9 using the strong-motion records of the 2011 Tohoku-oki earthquake in the last year. However, the new GMPE have a tendency that overestimates the amplitude at near source region. Therefore, we perform the examination towards improvement.

The improving point from the last examination is as follows.
(1) Add the strong-motion records by the earthquake which occurred in 2011 and 2011 to our database.
(2) Introduce the magnitude saturation of the amplitude to the model with a quadratic magnitude term.
(3) Give a larger weight to the data from near source region.
(4) Distinguish the interplate and the intraplate earthquakes for subduction eathquakes.

We confirm that the predicted ground motion amplitudes near the source region becomes small according to the above point (3) compared with the last result. However, the uncertainty of the prediction at near source region for large earthquakes (distance<30km, Mw>7) still remains. The examination using overseas records may be required.

Acknowledgement: The strong-motion records were operated and provided by a large number of organizations in Japan, especially NIED, JMA and PARI.

Keywords: ground motion prediction equation, strong ground motion, seismic hazard assessment

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How to construct a recipe for predicting strong ground motions from great subduction earthquakes

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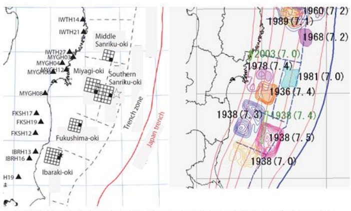
Source models related to strong ground motions have been integrated in the waveform inversion analysis to better characterize rupture processes of inland crustal earthquakes and subducting mega-thrust earthquakes. Generation of strong ground motion is related to slip heterogeneity inside source areas, i.e. strong motion generation areas (SMGAs). High frequency motions are generated from SMGAs which are almost coincident with large slip area for inland crustal earthquakes. On the other hand, ground motions from subduction earthquakes clearly show differences in wave radiation at various frequencies. The short-period generations obtained from the backprojection method using short-period teleseismic arrays from subduction earthquakes are located on deeper down-dip areas. Most of slip distribution inverted from long-period records such as geodetic and tsunami data are placed at shallower depths near the trench. We estimate a source model for generating strong ground motions from the 2011 Tohoku earthquake by comparing the observed records from the mainshock with synthesized motions based on a characterized source model and the empirical Green's function method. We obtained a short-period source model consisting of five SMGAs with large slip velocity or high stress drop. The SMGSs distributed in dip direction west of the hypocenter and in strike direction north and south of the hypocenter, along the down-dip portion of the source fault of this earthquake. These results indicate that great earthquakes on inland active faults and on subduction earthquakes have different source characteristics, especially in the short-period range related to strong ground motions. We developed a recipe for predicting strong ground motions for inland crustal earthquakes (Irikura and Miyake, 2010). Earthquake scenarios based on the recipe successfully estimate ground motions. Then, we propose an improved idea for recipe of predicting strong ground motions for subduction earthquakes.

Keywords: great subduction earthquakes, strong ground motions, short-period source model, strong motion prediction recipe



(Left) The short-period source model and source segments used for the long-period forecast by the ERC. (Right) Source segments for the long-period forecast and the slip distributions of past earthquakes (Earthquake Research Committee 2009).

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Study on a recipe for strong ground motion prediction for large inland earthquakes along long strike-slip faults

Atsuko Oana[1*], Toru Ishii[1], Kazuo Dan[1], Hiroyuki Fujiwara[2], Nobuyuki Morikawa[2]

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It has been pointed out that an application of 'the recipe' for predicting strong ground motion to the case of faults with great length leads to negative amount of slips on the background area of the fault model (Headquarters for Earthquake Research Promotion (HERP), 2005). In order to solve the problem, Dan et al. (2011) proposed the new idea of asperity model that can set the fault parameters without having negative slip on the background area for the strike-slip crustal earthquakes even with great length.

In this study, fault models for a scenario earthquake along the Median Tectonic Line faults with overall length of 360 km are established based on the methods by Dan et al. (2011) and the ones by HERP (2005). The spatial strong ground motions are simulated based on the fault models by the stochastic Green's function method. The results of the simulations are examined discussing the adequacy and the problem for each method to establish fault models.

In the cases with reference to the examinations by HERP (that is, the asperity area on the fault plane is calculated by the empirical regression related to the short-period spectral level), it was confirmed that the fault models could not be set due to the negative slip on the background area. For this problem, two fault models ('reference case A') were developed based on the improved method by HERP (2005) in order to set the fault parameters successfully. The ratios of the asperity area to the whole fault area were assumed to be 22 % (Somerville *et al*., 1999). The averaged stress drop of 'reference case B' was calculated by the equation derived from a circular crack model, and that of 'case C' was set to be 3.1 MPa (Fujii and Matsu'ura, 2000). Another fault model ('case D') based on the method by Dan et al. (2011) was also developed.

In order to discuss the simulation results, the peak ground velocities of simulated ground motions are compared to the ones calculated by using the attenuation relationship by Si and Midorikawa (1999). In the 'reference case B', the simulated peak ground velocities reached about 300 cm/s near the source fault and became much greater than the ones by the attenuation relationship since the short-period spectral level was about three times of the other two models. In the 'case C', while most of the results of the simulated ground motions are in the range of the dispersion of the attenuation relations, in the near-field of the source fault, the simulated peak ground velocities reached about 150 cm/s and became a little greater than the ones by the average attenuation relationship. In the 'case D', the simulated peak ground velocities reached about 100 cm/s near the source fault and corresponded well to the attenuation relationship. Therefore, it is concluded that the method by Dan et al. (2011) is the most appropriate to evaluate strong ground motions of a large earthquake along a very long strike-slip fault.

Keywords: very long fault, fault model, strong motion prediction

SSS33-12 Room:103 Time:May 19 12:30-12:45

Short-period radiation properties of intra-slab earthquakes in the subducting Pacific plate from seismic intensity data

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Intra-slab earthquakes occurring in the subducting oceanic plate radiate more short-period seismic energy than shallow inland and interplate earthquakes and often cause a wide area of strong ground motion. Three damage intra-slab earthquakes in Miyagiken-oki and Kishiro-oki in the Pacific plate are analyzed. Their properties of short-period energy radiation are revealed from JMA seismic intensity data. Seismic intensity inversion analysis is carried out to obtain high-frequency radiation area on their fault planes.

Recently, two damage intra-slab earthquakes occurred in Miyagiken-oki, the 2003/5/26(MJ7.1, D=72km) and 2011/4/7(MJ7.2, D=66km). 6 minus of JMA intensity was observed in Miyagi and the south of Iwate with 174 of the injured and 2 collapsed houses during the 2003 event. Meanwhile, 6 plus of JMA intensity was observed in Miyagi with 4 casualties and 296 of the injured during the 2011 event. The attenuation relationship and site correction factors of seismic intensity are estimated based on recent seismic intensity data. The relationship between focal depth and residual term of attenuation equation for each earthquake shows depth-dependency of short-period radiation. We also find the discrepancy of short-period radiation between the 2003 and 2011 events. It may be due to the Q-value structure in the mantle wedge above a subducting ocean plate. The short-period radiation area of fault plane almost corresponds to a large slip area from waveform inversion analysis.

The 1993/1/15 Kushiro-oki earthquake (M7.5, D=101km) occurred with 6 of JMA intensity at Kushiro-city and caused 966 of the injured and 53 collapsed houses. The Seismic intensity data of intro-slab earthquakes in the vicinity of Kushiro-city are analyzed in the same way as the Miyagiken-oki events. The short-period radiation properties is similar to those of the Miyagiken-oki events and depend on focal depth. The short-period radiation area of the 1993 Kushiro-oki earthquake spread in the rupture direction from the hypocenter.

Keywords: seismic intensity inversion, short-period energy radiation, the 1993 Kushiro-oki Earthquake, off Miyagi Prefecture, intra-slab earthquake, focal depth

SSS33-13 Room:103 Time:May 19 14:30-14:45

Strong ground motion prediction of the Uemachi fault zone using dynamic rupture scenarios

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Strong ground motion prediction needs realistic earthquake scenarios with characteristics of earthquakes occurring on source faults. We have proposed that physically reasonable dynamic rupture models under a fault geometry and stress fields based on geological or geomorphological data are used as earthquake scenarios for strong ground motion prediction. We apply our method to possible sources of earthquake occurring on the Uemachi fault zone using 3-D geometry of the fault plane and average uplift rate distribution along the fault trace based on the Comprehensive Research on the Uemachi Fault Zone, and calculate ground motion distributions.

The Uemachi fault zone runs just underneath the central part of Osaka plain, extends about 48 km, and the fault plane dips about 60 degrees to the east in the seismogenic zone. The stress conditions for dynamic rupture simulations are presumed based on a large-scale slip distribution on the fault and small-scale heterogeneities of static stress drop. First, a spatially varied cumulative slip distribution along the strike of the Uemachi fault zone was estimated from reflection surveys, borehole data, the subsurface structure model of the Osaka sedimentary basin (Horikawa et al., 2003), and the detailed topography around the fault trace. The borehole data at a site along the fault showed that the vertical slip on the earth's surface due to the last event was about 1.3 m (Kondo et al., in this meeting). Combining these data, we presume a prototype of the slip distribution along strike. A slip distribution along dip is modeled through simulations of spontaneous ruptures under vertically depth-dependent stress conditions to realize spontaneously stopping rupture near the bottom of the seismogenic zone. The large-scale heterogeneous slip distribution is composed of the slip distributions along strike and dip. Second, a stress change caused by the large-scale heterogeneous slip on a 3-D geometry of the fault plane (Kimura et al., 2012), which is a large-scale heterogeneous distribution of static stress drop, is calculated by the formulation of Okada (1992). Onto the large-scale static stress drop model, we add fractal heterogeneities in small-scale created from different random numbers. Finally, the strike and dip components of stress drop are converted to shear and normal stresses, assuming that the heterogeneity of stress drop is caused by a local geometry of the fault plane. We calculate dynamic rupture processes by the finite-difference method (Kase, 2010), assuming the slip-weakening friction law. We run the rupture simulations, changing hypocenter locations within relatively high stress drop area on the fault. The ruptures propagate not smoothly, and some regions remain locking. The rupture area and rupture time on each point depend on the stress model and the hypocenter location. The calculated earthquake scenarios are slightly smaller (Mw6.5-7.0) than an earthquake (Mw 7.1) presumed from the fault length based on "Recipe" of HERP. Predicted ground motion due to one of the largest scenarios is large especially in the northern part of the fault system where slip is relatively larger. The ground motion level along the fault in the northern area exceeds 100 cm/s.

Acknowledgment: This research was funded by the Ministry of Education, Science, Sports and Culture, Grant-in-Aid for Scientific Research (C) 21510190 and the Comprehensive Research on the Uemachi Fault Zone (in FY2012) by MEXT.

Keywords: dynamic rupture, the Uemachi fault zone, ground motion prediction, geomorphology, geology

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS33-14 Room:103 Time:May 19 14:45-15:00

Diffracted P and S Waves Excited by Shallow Inland Earthquakes

Michiko Shigefuji[1*], Tsutomu Sasatani[1], Nobuo Takai[1]

[1]Hokkaido University

We investigate effects of subsurface structure on diffracted P and S waves excited by shallow inland earthquakes. A shallow earthquake (Mw4.6) occurred on December 2, 2010 beneath the Ishikari plain. The record sections of velocity waveforms along a profile in the NNW direction from the epicenter (NNW profile) show conspicuous later phases at about 2 sec and 4 sec after the direct P and S waves. Both of the direct and later phases have apparent velocities of about 6 km/s and about 3 km/s for P and S waves, respectively; these values are nearly the same as P and S wave velocities of the seismic basement. The amplitudes for the direct and later phases attenuate with L^{-2}, where L is the epicentral distance, beyond a certain distance, but the amplitudes of the later phases are larger than those of the direct waves. These conspicuous later phases are also visible on the observed aftershock records along the NNW profile. However these phases are not visible on the records at stations with the different directions.

Ben-Menahem and Singh (1981) obtained approximate solutions for the wave field from a point source in a layered half-space; these solutions were derived from manipulation of integral paths in the complex wavenumber plane. The solution for a point source in the layer is well known as generation of head waves (or conical waves). They also showed the solution for a point source in the half space generates diffracted waves when the source is located very near the interface. The latter case is similar to our observation, because the source is laid beneath the sediment-seismic basement interface as shown below. In this case, the ray of the later phase is reflected 2 times inside the layer before it reaches the observer; the 2 times reflection points are the free surface and the interface. Shigefuji et al. (2012) made theoretical consideration of the wavefield from a point source in the layered half space. They concluded the direct and later phases mentioned above are diffracted waves. Here, to understand the generation mechanism of the conspicuous later phases on the observed records along NNW profile, we make the finite difference method simulation (Aoi and Fujiwara, 1999; Pitarka, 1999) using the 3D velocity structure model of deep sedimentary layers after AIST (Yoshida et al., 2007) and the source parameters after Shigefuji et al. (2012). The seismic basement of the NNW profile is roughly flat and the thickness of the sedimentary layer is about 4 km, and the focal depth is set at a depth of 5 km.

The synthetic waveforms well reproduce the features of the observed waves along the NNW profile. On the basis of the above considerations, we revealed that the direct waves and the conspicuous later phases on the NNW profile are the direct and reflected diffracted P and S waves generated when the source is located near the sediment-seismic basement interface. These also indicate that the AIST velocity structure along this NNW profile is reasonable. The analysis of the diffracted wave is important to verify the structure.

Acknowledgements

We used the strong motion data by NIED, the seismic intensity network of Sapporo city, JMA, Hokkaido Gas Corporation, Ueyama Corporation, and Hokkaido University.

Keywords: Diffracted P and S waves, Shallow Inland Earthquakes, Three dimensional simulation, Deep subsurface structure

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SSS33-15 Room:103 Time:May 19 15:00-15:15

Nonlinear behavior of soft soil deposits in wide area during the 2011 Tohoku earthquake

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In order to understand the effects of strong ground motions on engineering structures, it is important to evaluate the effects of soil nonlinearity on strong ground motions. In this report, based on strong motion records obtained in wide area during the 2011 off the Pacific coast of Tohoku earthquake, degree of soil nonlinearity was evaluated based on the shift of peak frequencies from linear site amplification factors to observed Fourier spectra during the Tohoku earthquake. Then, the relation between the degree of soil nonlinearity and ground motion indices such as PGA, PGV and PSI was investigated. It was found that the degree of soil nonlinearity was best correlated with PGV and the relation can be approximated with a hyperbolic curve. In addition, it was found that the deviation from this empirical formula is correlated with the peak frequencies of linear site amplification factors.

Keywords: nonlinearity, strong motion, the 2011 Tohoku earthquake, empirical equation

Japan Geoscience Union Meeting 2013
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SSS33-16 Room:103 Time:May 19 15:15-15:30

Improvement of Three-Dimensional Velocity Structure Model of the Osaka Sedimentary Basin

Masayuki Yoshimi[1*], Kimiyuki Asano[2], Haruko Sekiguchi[2], Takumi Hayashida[1], Haruo Horikawa[1], Hidetaka Saomoto[1], Tomotaka Iwata[2]

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1. Introduction

In the Osaka sedimentary basin, southwest Japan, the three-dimensional velocity structure has been modeled by many studies (e.g., Kagawa et al., 2002; Horikawa et al., 2003; Osaka pref., 2005; Iwata et al., 2008) based on the geophysical and geological surveys and waveform modeling. For reliable and detailed strong motion prediction, precise or reasonable basin velocity structure model is indispensable because of its remarkable effects on the strong ground motions. We improved the basin velocity model by adding new observations and applying newly developed methodology to describe the model (Sekiguchi et al., 2012, 2013) under the Comprehensive Research Project on the Uemachi Fault Zone by MEXT. In this presentation, we report the improvement of the three-dimensional velocity structure model of the Osaka sedimentary basin.

2. Observations and Analyses

We have conducted the microtremor array observation for obtaining phase velocities at 6 sites in southern part of the Osaka basin (Yoshimi et al., 2012), single-station microtremor observation for obtaining H/V spectra at 100 strong motion stations (Asano et al., 2012a), continuous microtremor observation at 15 stations and seismic interferometry (Asano et al., 2012b), and the reflection survey along 2 lines (Iwata et al., 2012, 2013). We also collected strong motion records from seismic intensity observation network by Osaka prefectural government and other strong motion networks (CEORKA, K-NET, KiK-net, etc.), and used them to estimate PS-P travel time by the receiver function analysis (Horikawa, 2012) and to compare with the synthetic waveforms of moderate size events (Sekiguchi et al, 2012). We found that the velocity structure model needed improvement especially in the southeast of the basin, southern part of the Osaka Bay area, and northern edge of the basin.

3. Improvement of Vp and Vs Relationships

The P-wave velocity profile in Horikawa et al. (2003) is estimated by the empirical relationships among age of sediments, burial depth, and P-wave velocity. The age of sediments is estimated by the interpolation of six key layers (Ma10, Ma3, Ma-1, Fukuda tephra, Gauss-Matsuyama reversal, and top of Kobe group) and bedrock depths. We confirmed the empirical relationships proposed by Horikawa et al. (2003) by comparing the P-wave reflection survey data. The S-wave velocity and density profiles are estimated from the porosity and the P-wave velocity with the Gassmann's (1951) equations. The porosity is empirically given by the P-wave velocity and the burial depth following Matsumoto et al. (1998). We reviewed previous studies on the relationship between P-wave and S-wave velocities of the Osaka group, and found that the empirical relationship proposed by Nakagawa et al. (1996) fits well the PS logging data in the Osaka basin. In our final model, the P-wave velocity is given by the empirical relationship of Horikawa et al. (2003), the S-wave velocity profile is given from its P-wave velocity by the empirical relationship of Nakagawa et al. (1996), and the density is given based on Gassmann's equations.

We also include a new correction parameter of burial depth describing the effect of the erosion of the Osaka group. The S-wave velocity profile at near surface is improved especially in the southeast of the basin judging from the observed high frequency phase velocity of the microtremor survey.

4. Revising the Bedrock and Key Layer Model

After reconstructing the initial model following the method proposed by Sekiguchi et al. (2013), we revised the bedrock and key layers depths to fit the observed phase velocities, dominant period of H/V spectral ratios, and PS-P travel times. We will check the improved model based on the three-dimensional ground motions simulations of the moderate size events and the inter-station Green's functions.

Acknowledgements: This study is a part of the Comprehensive Research on the Uemachi Fault funded by the MEXT, Japan.

Keywords: S-wave velocity, strong ground motion prediction, Uemachi fault, H/V spectra, ambient noize survey, receiver function analysis

SSS33-17 Room:103 Time:May 19 15:30-15:45

Description of 3D velocity structure: Osaka Basin

Haruko Sekiguchi[1*], Hidetaka Saomoto[2], Masayuki Yoshimi[2], Kimiyuki Asano[1], Haruo Horikawa[2], Takumi Hayashida[2], Tomotaka Iwata[1]

[1]DPRI, Kyoto Univ., [2]AFERC, AIST

1. Introduction

Three dimensional subsurface structure model of the Osaka sedimentary basin is revised with additional survey data conducted under Comprehensive Research on the Uemachi Fault Zone (FY2010-2012) by MEXT. In addition to revision of velocity structure (Yoshimi et al., 2013, this meeting), we explore the way of description of the 3D velocity structure model.

2. Former 3D velocity structure models of Osaka sedimentary basin

3D velocity structure models have been developed for the Osaka sedimentary basin from relatively early time thanks to relatively dense data of underground structure surveys compared to other areas. Former 3D models are classified to two types. One, we call them J-type here, includes Kagawa et al.(1993), Miyakoshi et al.(1997), Miyakoshi et al.(1999), Kagawa et al.(2002), Iwata et al.(2008) and Iwaki and Iwata (2011). Another one, H-type, includes AIST model (Horikawa et al., 2003) and Osaka Prefecture model (Osaka Prefecture, 2004). These two types adopt quite different description of their 3D structure. J-type models divide the sediments into three layers with constant Vp, Vs and densities and adopt spline-function to model the layer boundaries, which make it easy to derive medium properties at arbitrary point. This property of these models has advantage when being applied to numerical computations. H-type models are given in fixed 3D grids to express complex heterogeneity and steep material-boundaries like overhang faults. Medium properties are given by empirical formulas depending on the depth and the depositonal age and the depositonal age is assigned by six key layers modeled in the sediments.

3. Description of our 3D velocity structure

In this study, we aimed to model the layers and medium property structure as faithful as possible to survey data (like H-type models) and to describe the layer boundaries by interpolation functions so that we can get the model in arbitrary mesh (like J-type models). To realize this, we construct our 3D velocity structure model with the following way.

1) Divide the model area by extreme boundaries like faults
2) Describe the layer boundaries by appropriate interpolation functions
3) Prepare the empirical formula for medium properties which depends on depth, depositional age and regionality
4) Prepare dataset and tools to calculate relative location of arbitrary points to layer boundaries and block boundaries and to calculate physical properties for given point or given arbitrary mesh.

We explain more about 2) in the following.

4. Description of layer boundaries by interpolation function

In the Osaka basin, many geophysical explorations such as seismic reflection method, borehole drilling and microtremor survey have been performed to reveal both the three-dimensional depositional structure and the faults configurations. These efforts have also accumulated the data about the depth of sedimentary layers. By virtue of the abundant data, we can construct the sedimentary layer boundaries precisely.

We here tried to construct some representative sedimentary layer boundaries by using the radial basis function (RBF) interpolation. The RBF method has advantages compared to the conventional way based on the spline curve:(1)The RBF method incorporates a parameter concerning the smoothness of the interpolated surface. (2)The RBF method holds robustness in extrapolation operations.

As shown in Figure, we have got the accurate three-dimensional depositional structure.

Keywords: layer boundary, key layer, Radial Basis Function, interpolation

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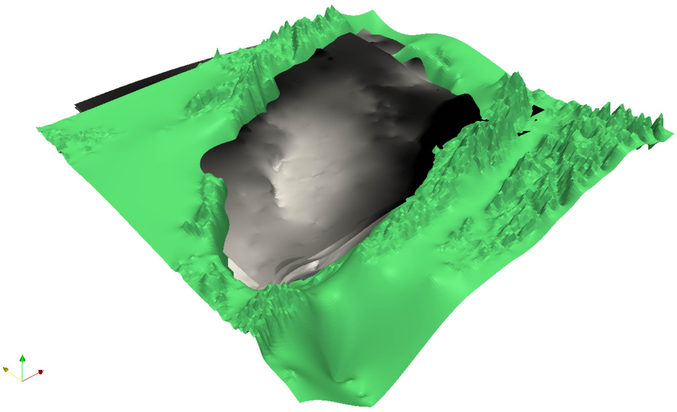

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SSS33-18 Room:103 Time:May 19 15:45-16:00

Overview of the studies on bedrock depth distribution beneath Istanbul, Turkey by microtremor measurements

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On August 17, 1999, a devastating earthquake with a moment magnitude of Mw=7.4 struck the Kocaeli and Sakarya (Adapazari) provinces, and part of suburbs of Istanbul in the northwestern of Turkey, a very densely populated region in the industrial heartland of Turkey. This earthquake is considered to be the largest event to have devastated a modern, industrialized area since the 1923 Great Kanto earthquake. This earthquake caused about 30.000 losses of life and collapsed thousands of buildings. Thus, total loss figure amounted to about $16 Billion. Following the losses during this large earthquake, there has been a broad recognition among Turkey governmental, non-governmental and academic organizations of the need for extensive response planning based on detailed risk analysis of likely seismic hazard, microzonation studies and ground-motion researches in Turkey, in general, and Istanbul particular. In this frame, several studies are performed to map the bedrock depth distribution in the west part of Istanbul. Local S-wave velocity-depth profiles and bedrock depth distribution are key factors in assessing seismic hazard and earthquake ground motion characteristics since they allow determination of the amplification potential of geological formations overlying bedrock. In a project supported by Istanbul University, S-wave velocity structure beneath the European side of Istanbul is determined. One of the aims of the project is to improve the knowledge about the influence of local geology on the expected earthquake ground motion. In this project, both array measurements and single station microtremor measurements at 40 sites are conducted. In another study by Birgoren etal. 2009, an empirical relationship between the thickness of Tertiary?Quaternary sediments overlying Palaeozoic bedrock and their resonance frequencies is calculated for the ?stanbul region and the bedrock depth distribution beneath the city is presented. The bedrock distribution beneath populated areas of ?stanbul is obtained by applying the derived relationship from this study to 86 strong-motion sites, where the resonance frequencies are known. Picozzi etal. 2008, have investigated the site characterization by seismic noise in Istanbul. Single station seismic noise measurements were carried out at 192 sites in the western part of Istanbul, Turkey. This extensive survey allowed the fundamental resonance frequency of the sedimentary cover to be mapped, and identify areas prone to site amplification. There sults obtained by this study are in good agreement with the geological distribution of sedimentary units, indicating a progressive decrease of the fundamental resonance frequencies from the northeastern part, where the bedrock outcrops, towards the southwestern side, where a thickness of some hundreds meters for the sedimentary cover is estimated. From these studies and the other studies, not mentioned here, the conclusion is that the bedrock dips towards SW from NE and S-wave velocity structure shows the presence of strong impedance contrast being responsible of seismic ground motion amplification. On the other hand, the particular distribution of fundamental resonance frequencies indicates that local amplification of the ground motion might play a significant role in explaining the anomalous damage distribution in the west part of Istanbul after the 17 August 1999 Kocaeli Earthquake.

Keywords: Earhquake disaster, Microtremor, Dominant frequency, Istanbul

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SSS33-19 Room:103 Time:May 19 16:30-16:45

The Relationship between Soliton in GPS Wave gage and Seismic Wave of 2011 the Tohoku District Pacific Ocean Earthquake

Masaru Nishizawa[1*]

[1]none

Japanese only

Japan Geoscience Union Meeting 2013
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SSS33-20 Room:103 Time:May 19 16:45-17:00

Severity of Mortality in the 2011 East Japan Earthquake (3) Examination of Age-dependency Part II

Yutaka Ohta[1*]

[1]Ohta, Yutaka

1. Introduction

We started to expand our attention to age-dependency as the third paper of the series studies. It has been known that most probable one is a shape resembling U character in English, as rates are high both at the infant-child ages and the senior ages as 60 or over and low in the middle ages. But we are not yet certain whether such age-dependent characteristics are generally valid or not. So, in this point of view and in comparison with significant past inland and oceanic earthquakes we conducted a study focusing on this age-dependency problem.

2. Surveyed Earthquakes

There is no much available data even now in case when we desire somewhat deeper analysis good for age-dependent characteristics. After careful and in-depth retrievals we obtained 4 domestic earthquakes; the 1933 Sanriku, the 1993 Hokkaido-nansei-oki, the 1995 Kobe and the 2011 East Japan Tsunamigenic earthquakes, and the 3 overseas earthquakes as 2 Turkish earthquakes plus the 2004 Indian Ocean tsunamigenic earthquakes. Especially for the 2004 Indian Ocean earthquake, regarded and significant data were retrieved via papers from US PubMed Database. The dataset of 2 earthquakes in Turkey are based on our own field surveys on due years.

3. Analytical Comparison and Characterization of Age-dependency

After a careful data processing on age-dependent characteristics for each earthquake, we arrived at the conclusion that those are well classified into three principal types.

3.1) U type in English character Typical cases are earthquakes of the 1933 Sanriku-oki, the 1993 Hokkaido-nansei-oki, the 1970 Gediz and the 1976 East Turkey, and northern seaside areas of Indonesia due to the 2004 Indian Ocean Tsunami. In these earthquakes the mortality rate pattern shows typical U shaped type as is high for both of infants-children and senior people of 60 or more. And, this can naturally be accepted as the direct reflection of either humans undeveloped for infants-children or deteriorated for seniors of behavioral performance in case when no assistance by neighbors is expected.

3.2 J type in English character Another pattern we see often is the one expressed as J type in English character. This is somewhat simpler case as increasing age gives increasing rate of mortality; The 1995 Kobe, the 2011 East Japan earthquakes are typical cases. This J type age dependency can be interpreted as a variation when an earthquake occur during day time and then children were outdoors and/or under teachers control and/or they were under care by their parents etc. so, we should be keen to when the event comes. Those above two cases seem typical pattern in somewhat higher mortality rates, but in the initial case as in low mortality rate the pattern might be different and is likely to make age-independent characteristic; Let us call this as Flat type.

4. Results

For the change of age-dependency, we can therefore summarize as in the initial situation of low external force of either seismic shaking or tsunami inundation high, mortality rate seems low and age-independency is as F type and in case when the external force is strong enough the most probable

pattern would be U type, which means higher mortalities for the age-extremities of infants-children and the seniors as of 60 or older, giving a concave as a function of age. So, this pattern can be most probable, if no assistance is available by nearby people, nor recognition for protection is not prevailed.

Keywords: 2011 East Japan Earthquake, Inland and Ocernic Earthquake, Mortality, Age-dependency

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SSS33-21 Room:103 Time:May 19 17:00-17:15

Development of J-SHIS Web APIs provide seismic hazard information via REST scheme.

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[1]National Research Institute for Earth Science and Disaster Prevention, [2]Mitsubishi Space Software Co.,ltd.

Glossaries are..
J-SHIS : Japan seismic hazard information station.
REST : REpresentational State Trransfer.
API : Application Program Interface.

Japan Geoscience Union Meeting 2013
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SSS33-22 Room:103 Time:May 19 17:15-17:30

Regional Disaster Information System by using IT Kyoshin Seismometer for Buildings : Making the Regional Earthquake Earl

Kiyoshi Takano[1*], Takamori Ito[1]

[1]III & ERI, University of Tokyo

We have developed the IT Kyoshin Seismometer for Buildings(Takano et.al 2005) and installed these sensors for some buildings of the university (Takano et.al 2012, etc).

On the other hand, in order to examine the possibility of utilization as regional disaster prevention information system, we have installed the sensors in several private housings at the local area with the cooperation of the local community.

On the other hand, in order to examine the possibility of utilization as regional disaster prevention information system, we have installed the sensors in several private housings at the local area with the cooperation of the local community in Chigasaki city.

And we have developed the earthquake early information of the housing and regions by e-mail for the users.

In this presentation, we will discuss about the earthquake early information of the housing and regions by e-mail for the regional users.

When an earthquake occurred, the earthquake early information e-mai was sent to the users of the housing installed the sensors.

This information includes the shaking of the ground around the house, first and second floors and ceiling obtained by sensors by using the simple seismic intensity (K-value).

This e-mail may be sent to some mobile phones of the users and their families etc.

As how to take advantage of the this e-mail, we can consider as follows.

1. It will help ease knowing about the shake of the own housing compared to the average of the surrounding housings and help to do the disaster prevention activities.

2. When the major earthquake ocurred, it will help to make rapid response for the status of damage in own house and regions.

And since it can send some mobile phones, we can consider more as follows.

3. By this mail, users can found shaking of the home from office.

4. Can help to watch house of the elderly.

5. Can help the establishment of the regional self-preventing community for disaster prevention organization.

In this report, a presentation on the overview of the system and issues such as this.

Keywords: IT Kyoshin Seismometer, Regional Disaster Information, earthquake early information

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SSS33-23 Room:103 Time:May 19 17:30-17:45

Relationship between damage ratios and ground motion characteristics during 2011 Tohoku Earthquake

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The relationship between ground motion indices, e.g., PGA, PGV,I_{JMA},SI, and three different building damage ratios, i.e., total collapse ratios(TCRs), collapse ratios(CRs) and damage ratios(DRs), were constructed for the 2011 off the Pacific coast of Tohoku Earthquake. It was found that DRs relate better with ground motion indices than TCRs or CRs. It was also found that PGA was sensitive to predominant period of velocity response spectrum. Large PGA was not related with high DR if the predominant period is shorter than 0.4s or longer than 2.0s. However, the damage ratios are calculated based on an administrative unit, large variability can be seen from the fragility curves. It is necessary to examine the variability of ground motions within a small district, if the ground motions are estimated properly.

As the earthquake motions H/V can be represented theoretically, in proportional to the ratio of transfer funcitons between S- and P-wave, it has been suggested that H/V of earthquake motions can be used to determine the velocity structures. It implies that the microtremor H/V can also be used to estimate the velocity structures at damaged sites, if the consistency of H/V spectral ratios between microtremors and earthquakes can be confirmed there. The ground motions at some damaged sites are estimated by using the underground velocity structures inverted from the microtremor H/V spectra ratios. Then the estimated ground motions are used to be related with damage ratios at the damaged sites.

Keywords: building damage ratio, H/V spectral ratio, velocity structure, estimated ground motions

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Strong ground motion observation network in Himalaya, India

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It is pointed out that acquisition and analysis of data on the natural hazard and social conditions are fundamental to the disaster mitigation scheme, and that information about disaster impact is essential for the first aid and recovery planning. However, the technical issues and the environment for actual use are not yet established. It is a universal subject. 'Information Network for Natural Disaster Mitigation and Recovery' is a project of 'Science and Technology Research Partnership Sustainable Development (SATREPS) International Collaborative Research Program' supported by JST and JICA. The participants are Keio University, the University of Tokyo, Indian Institute of Technology Hyderabad, CSIR:National Geophysical Research Institute, Indian Institute of Technology Kanpur, Indian Institute of Technology Madras, International Institute of Information Technology Hyderabad, India Meteorological Department Hyderabad, and India Meteorological Department Pune.

In India, heavy rains and floods are causing thousands of casualties and building damages, for example 2001 Gujarat earthquake and 2005 Kashmir earthquake killed thousands of people. In Japan too, heavy rains and floods caused severe damages, and recent inland earthquakes and 2011 Tohoku earthquake caused tremendous damages.

From a view point of disaster mitigation, the infra-structure in India is still in infancy stage. and thus recovery will be hindered in case of such disasters. In Japan, information technology is recognized as useful in case of emergency and has been occasionally utilized. However, 1995 Kobe earthquake, 2004 Hukui and Niigata floods, and 2011 Tohoku earthquake revealed that a lot of issues remain unsolved in handling information.

The objectives of the project are to construct seismic and meteorological observation networks, data acquisition and analysis systems by means of global information network, to develop necessary technology to help effective performance of the first aid and recovery by means of preparing the information infra-structure in case of emergency, and to establish the basis for disaster mitigation and recovery by applying our experiences to Indian conditions.. The project contains studies on earthquake disaster mitigation, basis for meteorological observation, sustainable communication system, and platform of information in case of emergency and for disaster mitigation.

The study on earthquake disaster mitigation aims at observation networks for strong ground motion, crustal movement by GPS, and building performance to understand the seismic hazards and risks, and contribution to earthquake disaster mitigation from future earthquakes in Indo-Gangetic plain near the seismic active region. The present report introduces some achievements on the strong ground motion observation network. India has a warm and humid climate. The equipments are required to operate under such a circumstance. They are also required to be feasible for the infra-structure environment in India. Furthermore, it is desired that the sensor is able to record long period waves as well as short period motions. The velocity type strong motion seismometer was selected according to these conditions. The equipments were deployed at 26 sites in the seismic active region in Himalaya. Networking of the observation sites is on progress. The precise seismic activity, propagation characteristic of seismic waves, and effects of seismic waves to the buildings will be studied in the following years.

Keywords: strong ground motion, observation, network, Himalaya