Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SSS25-P01 Room:Convention Hall Time:May 25 18:15-19:30

Characteristic of Strong Motion in Sanriku Tsunami of 1896 by the point of view of seismic intensity distribution

AIZAWA, Koji[1*]

[1]Administration Division, Seismology and Volcanology Department

It is thought that the Sanriku Tsunami of 1896 which occurred on June 15, 1896 is a ”tsunami earthquake” with a large scale of tsunami compared with the magnitude of the earthquake presumed from the size of earthquake motions, such as a surface wave (Kanamori, 1972; Abe, 1989).

Seismic intensity distribution of a Sanriku Tsunami of 1896 has two reports. The Central Meteorological Observatory (1896) has reported that seismic intensity of the northern Tohoku district is weak. Omori (1901) illustrated the observed seismic intensity. Omori (1901) has reported that the strong seismic intensity was observed by the area of the weak of seismic intensity. I contrasted the seismic intensity described by the earthquake investigation original register of JMA, and the seismic intensity which Omori (1901) reported. As a result, it turned out that two reports are almost the same. For this reason, I considered distribution of the seismic intensity observed on the basis of Omori (1901). The seismic intensity observed in the west side of backbone range of northern Tohoku district was strong compared with seismic intensity of Kitakami mountain district. The attenuation of seismic intensity by the distance from the epicenter is not clear. Moreover, in the point of strong seismic intensity, a primary natural period is distributed over the area for natural period of 2 seconds or more, and the area for natural period of 1 second or less has many points of weak seismic intensity.

The earthquake investigation original register and Omori (1901) have reported the character of a shake to be ”slow.” Noda (2000) – expression of a shake of 1.5 seconds or more of periods – ”slowly” – it have reported. A Sanriku Tsunami of 1896 is considered that the periodic ingredient beyond periodic 1.5 second, at least. In the northern Tohoku district, the point where an earthquake intensity scale is big is similar with the point to relativity where long period ground motion class (Aizawa et al.,2014) is large.

It is thought that the seismic intensity in a Sanriku Tsunami of 1896 shows the physical feeling by the long period ground motion of about 5 seconds or more of periods together with the character of the observed earthquake motion from the above result.

Keywords: Seismic Intensity, Long-term Period Ground Motion, Tsunami Earthquake, Strong Motion

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SSS25-P02 Room:Convention Hall Time:May 25 18:15-19:30

Reproducing the short-period seismic surface waves from subduction zone earthquakes based on large-scale simulation

OKAMOTO, Taro[1*] ; TAKENAKA, Hiroshi[2] ; HARA, Tatsuhiko[3] ; NAKAMURA, Takeshi[4] ; AOKI, Takayuki[1]

[1]Tokyo Institute of Technology, [2]Okayama University, [3]Building Research Institute, [4]JAMSTEC

The seismic-wave propagation from shallow subduction zone earthquakes is strongly affected by the heterogeneous structure: there are the thick layers with low-seismic wave velocities, such as the oceanic water and the sedimentary layers, and these layers are separated with three-dimensionally irregular interfaces. These heterogeneities affect both the excitation and propagation of the seismic waves. Therefore they must be considered in generating the synthetic waveforms for the waveform analysis of the earthquake sources and structural heterogeneities, otherwise the analysis could result in erroneous solutions [1,2]. In this paper we study the effect of the structure of the Japan trench on the strong-motion seismic waveforms, especially the surface waves, from a shallow subduction zone earthquake in connection with the analysis of the 2011 Tohoku-Oki earthquake (Mw9.1). We selected an small event (2003/11/1, Mw5.8) because this event occurred in the source area of the 2011 Tohoku-Oki earthquake, and has a similar mechanism (inter-plate thrusting) as that of the 2011 Tohoku-Oki earthquake. The strong-motion records (K-NET, KiK-net) were integrated to obtain velocity components. We assumed a three-dimensional structure model for the Japan trench by compiling models for topography [3], sediments [4], crust, and subducting plates [5,6]. We applied a GPU-accelerated finite-difference program developed by ourselves [7,8]. We used the TSUBAME-2.5 supercomputer in Tokyo Institute of Technology for the finite-difference computation. By using the 3D structure model, the strong-motion seismograms were well reproduced for a period band of 12-40 s. For periods shorter than around 10 s, however, the misfit of surface waves was large: the amplitudes of the synthetic surface waves were smaller than that of the observations. That is, the excitations of the short period surface waves from shallow earthquakes were not sufficient in the assumed 3D structure model. As an experiment we reduced the S-wave velocities of the oceanic sediments by 30 % and re-computed the synthetics. However, the fit between the observed and synthetic waveforms were not improved. We will discuss these results and present findings based on further experiments (e.g., results by modifying the thickness of the sediments).

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Keywords: subduction zone earthquake, waveform modeling, short period wave, GPU computing

Japan Geoscience Union Meeting 2015
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SSS25-P03 Room:Convention Hall Time:May 25 18:15-19:30

On National Seismic Hazard Maps of Japan 2014 edition

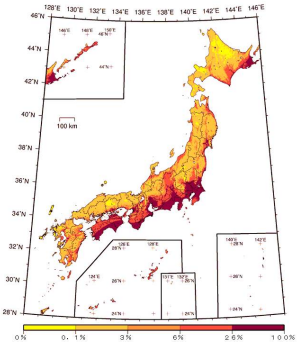
JISHINHONBU, Jimukyoku[1*]

[1]Ministry of Education, Culture, Sports, Science and Technology

Since its establishment in 1995, the Headquarters for Earthquake Research Promotion (HERP) has conducted long-term evaluation and strong ground motion prediction of inland and subduction-zone earthquakes.Based on those results, HERP compiled the first edit of National Seismic Hazard Maps of Japan (NSHMJ) in March 2005. Since then, HERP has revised and released NSHMJ on an annual basis. In July 2009, HERP made overall revision to NSHMJ and its name was changed.Although HERP was planning to release NSHMJ in 2011, the 2011 off the Pacific coast of Tohoku Earthquake suspended the release of the year because of the earthquake revealed considerable number of issues in probabilistic hazard maps※ of NSHMJ. This became one of the primary motives of validity confirmation of fundamental framework of the probabilistic hazard maps and resolution of revealed problems.HERP carried out the necessary studies and released the revised probabilistic hazard maps of NSHMJ in 2012 and 2013.HERP continued efforts to improve NSHMJ in 2014, and accomplished certain progress in the creation of probabilistic hazard maps, which reflected the studies, since 2011. HERP publicized the 2014 edition of NSHMJ with aforementioned probabilistic hazard maps. In our presentation, the outline of NSHMJ 2014 edition will be shown.

※ Probabilistic hazard map shows the estimated strength of ground motion at individual places, in and around Japan with probabilities, during a given period of time. This map is made based on the information on location, magnitude, and occurrence period of earthquakes in Japan.

Keywords: National Seismic Hazard Maps of Japan 2014 edition, seismic hazard, Earthquake research committee



An example of Probabilistic Seismic Hazard Map:
The probability of ground motions equal to or larger than seismic intensity 6 Lower, occurring within the next 30 years from the present.

Japan Geoscience Union Meeting 2015
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SSS25-P04 Room:Convention Hall Time:May 25 18:15-19:30

Simulation of long-period ground motion using 3D structure model of the Kanto Basin

YOSHIMOTO, Kazuo[1*] ; TAKEMURA, Shunsuke[1] ; KAJIKAWA, Kengo[1] ; MASUDA, Kei[1] ; TAMAKI, Taishi[1] ; KITAZAWA, Rana[1] ; KOBAYASHI, Keika[1]

[1]Yokohama City University

Introduction

The development of a more realistic seismic structure model of the Kanto Basin is required for the precise evaluation of the long-period ground motions in the Tokyo metropolitan area. In this study, on the basis of the three-dimensional (3D) finite difference simulation, we validated the effectiveness of the currently developed seismic structure models of the Kanto Basin for long-period ground motions using observed seismic waveforms of shallow moderate earthquakes.

3D finite difference simulation of long-period ground motions

We conducted 3D finite difference simulation of long-period ground motions during two shallow moderate earthquakes: the northern Tochigi earthquake on February 25, 2013 (Mw 5.8) and the Mid. Niigata earthquake on October 27, 2004 (Mw 5.8). Both earthquakes were occurred on the north of the Kanto Basin. The 3D structure model of finite difference simulations covered a zone of 201.6 $\times$ 127.5 $\times$ 60 km^3, which was discretized by grid intervals of 0.15 km in horizontal directions and 0.075 in vertical direction. A staggered-grid finite difference method with fourth-order and second-order in space and time, respectively, was used in our simulations. We conducted simulations using three structure models: JIVSM (Koketsu et al., 2008), SBVSM (Masuda et al., 2014, SSJ; Takemura et al., 2015) and SBVSM2, which was constructed by incorporating local S-wave velocity structures around the northern edge of the Kanto Basin estimated by waveform modeling (Takemura et al., 2014, SSJ). To construct a subsurface structure beneath the sediment of the Kanto Basin, we adopted JIVSM structure for all structure models.

Simulation result

It was verified that the observed long-period ground motions in the northern area of the Kanto Basin were practically well simulated by SBVSM, compared to JIVSM. The reproducibility of observed long-period ground motions was further improved when SBVSM2 was used for 3D finite difference simulations. This result indicates that a method proposed by Takemura et al. (2014) is practically useful for the improvement of the sedimentary structure model of long-period ground motions. This improvement may help us to better understand the characteristics of the excitation and propagations of surface waves at the edge of sedimentary basin. In addition to these findings, it was realized that the reproducibility of observed long-period ground motions by three structure models was not high enough in the western area of the Kanto Basin, where the past geophysical investigations are insufficient to construct a precise basin structure model. In our poster presentation, we will summarize the characteristics of SBVSM and SBVSM2 in more detail and discuss the relation between the characteristics of surface waves and sedimentary structure around the basin edge.

Acknowledgement

We acknowledge the National Research Institute for Earth Science and Disaster Prevention, Japan for providing the K-NET/KiK-net waveform data. SK-net waveform data were provided by the Earthquake Research Institute at the University of Tokyo. The computations were conducted on the computer system of the Earthquake and Volcano Information Center at the Earthquake Research Institute, the University of Tokyo.

Keywords: long-period ground motion, Kanto Basin, simulation of seismic ground motion

Japan Geoscience Union Meeting 2015
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SSS25-P05 Room:Convention Hall Time:May 25 18:15-19:30

Study on Spatial Distribution of Response Duration Time of Earthquake Motions in Tokyo Metropolitan Area

ARAI, Kensuke[1*] ; ISHII, Toru[1] ; HIRATA, Naoshi[2]

[1]Shimizu Corporation, [2]University of Tokyo

1. Background and Objective

Ishii (2012) paid attention to the spectral characteristics of duration times of earthquake ground motions, newly defined the response duration time spectra in order to evaluate it quantitatively, and by using the proposed spectra, the ground motions recorded at Etchujima in Tokyo during the 2011 Off the Pacific Coast of Tohoku earthquake, its foreshock, aftershocks, and induced earthquakes, are examined. It was pointed out that the duration times of ground motions in the period range especially more than 1 second could be much longer than the ones in shorter period range or the ones evaluated by several past studies. It has been assumed that such characteristics are affected by the long period surface waves which generate and propagate in the deep underground structure of Tokyo metropolitan area.

The Metropolitan Seismic Observation Network (MeSO-net) is composed of more than 300 stations in Tokyo metropolitan area and observes broadband long-duration spatial records of earthquake ground motions. Arai et al. (2014) calculated and examined the response duration time spectra of the earthquake motions recorded at the MeSO-net stations during fourteen earthquakes including the 2011 Off the Pacific Coast of Tohoku earthquake, its foreshock and aftershocks. Continuously this paper examines the spatial characteristics of the recorded time histories, of its response spectra and of its response duration time spectra especially in rather longer period range, discussing with the deep underground structure of Tokyo metropolitan area and with the azimuth or the depth of the earthquakes.

2. Data and Analyses

The response spectra SV [cm/s] and the response duration time spectra TSV [s] of ground motions during six earthquakes which occurred since March 11 to April 12, 2011, including the 2011 Off the Pacific Coast of Tohoku earthquake and its aftershocks, are examined in this paper. According to Ishii (2012) and Arai et al. (2014), the spectral parameters are as follows; h = 0.05, p1 = 0.03 and p2 = 0.95. By picking up a few linear array data from the spatially distributed MeSO-net data, the characteristics of the spectra are examined and discussed comparing with the deep underground structure model presented by J-SHIS, Japan Seismic Hazard Information Station of National Research Institute for Earth Science and Disaster Prevention.

3. Discussion

The characteristics of the response duration time spectra of earthquake ground motions in Tokyo metropolitan area are affected by the deep underground structure. Especially in the longer period range, TSV seems to have simple spectral peaks where the deep underground structure is also simple, however TSV seems to have several spectral peaks where the deep underground structure is composed of several sedimental layers. It is supposed that the characteristics of the response duration time spectra highly depend on not only the magnitude and the distance of the earthquake but also the azimuth and the depth of the earthquake, and affected by the characteristics of surface waves propagating in the sedimental layers.

Acknowledgement

The authors express gratitude to the Special Project for Earthquake Disaster Mitigation in Tokyo Metropolitan Area for supplying the data recorded by the Metropolitan Seismic Observation Network (MeSO-net).

Reference

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J-SHIS, National Research Institute for Earth Science and Disaster Prevention ; http://www.j-shis.bosai.go.jp/

Keywords: Tokyo, Earthquake Motion, Duration, Surface Wave, Structure

Japan Geoscience Union Meeting 2015
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Possible quantification of earthquake size using strong motion duration and displacement amplitude

HARA, Tatsuhiko[1*]

[1]IISEE, BRI

Hara (2014) showed the correlation between strong motion duration and duration of high band-pass filtered tele-seismic P waves. In this study, we investigated the possibility to quantify earthquake sizes using strong motion durations and displacement amplitudes referring to Hara (2007), who showed that it is possible to determine magnitude for huge earthquakes using high frequency energy radiation durations and displacement amplitudes from tele-seismic P waves. We used horizontal components of strong motion seismograms from the KiK-net borehole stations for nine large earthquakes that occurred in and around Japan since 2003, which were retrieved and processed by Hara (2014). We obtained displacement records by integration of strong motion seismograms and measured amplitudes after applying high-pass filter with the corner frequency of 0.01 Hz. We used the strong motion durations obtained by Hara (2014), who used high band-pass filter with the corner frequencies of 5 and 10 Hz. He suggested the duration dependence on epicentral distance. We calculated the logarithms of the products of the strong motion durations and displacement amplitudes divided by the epicentral distance twice and compared them to the moment magnitudes. Although the scatter is large, they correlate well, which suggests the possibility to quantify the earthquake size using durations and displacement amplitudes measured from strong motion seismograms.

Acknowledgements. We used strong motion seismograms recorded by the KiK-net of the National Research Institute for Earth Science and Disaster Prevention. We used the hypocenters of the unified hypocenter catalog of the Japan Meteorological Agency.

Keywords: strong motion duration

Japan Geoscience Union Meeting 2015
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Relations between seismic intensity by linear and nonlinear site responses using empirical transfer functions

SATOH, Toshimi[1*]

[1]Shimizu Corporation

In order to estimate broadband source models or predict strong motions to agree with intensity scale of historical earthquakes such as the 1923 Great Kanto earthquake and Nankai Trough earthquakes, intensity scale or seismic intensity should be calculated considering into nonlinear site responses. However, strong motions calculated by the stochastic Green's function method using empirical site responses derived from weak motions or the empirical Green's function method are not considered into nonlinear site responses. The site responses estimated by nonlinear seismic response analyses depend on subsurface structure models and the dynamic property models as well as the methods. In this study we develop an empirical relation between seismic intensity by linear and nonlinear site responses using many KiK-net records.

Firstly, we select strong motion records with peak ground accelerations greater than 300 cm/s^2 of 68 earthquakes observed at 124 KiK-net stations and the weak motion records of 520 earthquakes there. Then we remove some records affected by rocking or uplifting vibrations of seismometers, basements or structures from the selected records. The record most strongly affected by such vibration was the strong motion records observed at KiK-net Haga with equivalent intensity scale of 7 during the 2011 Tohoku earthquake.

Then we calculate empirical transfer functions which are defined by spectral ratios of ground motions at a surface to vertical motions at a borehole for weak motions to those for strong motions. The strong motions by linear site responses are estimated from strong motion records multiplied by the empirical transfer functions, which are complex Fourier spectra, in the frequency domain. The strong motions in the time domain are calculated by the Fourier inverse method. This idea means that we use empirical transfer functions instead of theoretical transfer functions by the one-dimensional linear and equivalent linear analyses. The empirical transfer functions are not influenced by the assumptions of dynamic property models and subsurface structure models.

The seismic intensity by nonlinear site responses I_{NON} is modeled by seismic intensity by linear site responses I_{LIN} and the equivalent predominant frequency fe=PGA_{LIN} /($2\pi PGV_{LIN}$). Here PGA_{LIN} and PGV_{LIN} are the calculated peak ground acceleration and the peak ground velocity. The regression relation derived by the constrained least square method with $I_{LIN} \geqq I_{NON}$is,

$I_{NON} - I_{LIN} = 6.155 - 1.669\, I_{LIN} + 0.110\, I_{LIN}^2 - 0.688 \log_{10} fe$.

Figure shows the relation between I_{NON} and I_{LIN} and the regression relations. The maximum I_{NON} of data was 6.6 observed at KiK-net Hino during the 2000 Tottoriken Seibu earthquake. The range of I_{LIN} used in the regression analysis is from 4.5 to 7.0. The number of transfer functions is 192. In the empirical equation, I_{NON} becomes smaller than I_{LIN} beyond I_{LIN} of about 5.0. We show that fe is better than Vs30 as a parameter of the equation because fe is influenced by not only site effects but also source and path effects. The higher fe is, the bigger the difference between I_{NON} and I_{LIN} is. This feature reflects that amplification factors in the high frequency range decrease stronger than those in the low frequency range by the increase of damping factors due to nonlinearity of soil. In the obtained equation, INON is 6.4 in the case of I_{LIN} =7.0 and fe=5Hz. I_{NON} is 6.7 in the case of I_{LIN} =7.0 and fe=2Hz. Since I_{LIN}^2 term is added in the equation in order to represent the saturation of dynamic properties on the strain, the empirical equation of I_{NON} has the slight saturation effect on I_{LIN}.

Acknowledgments: This research is supported by JSPS KAKENHI Grant Number 26242034 and 23241054. We use KiK-net records and P-S loggings by NIED and the hypocenter information by JMA.

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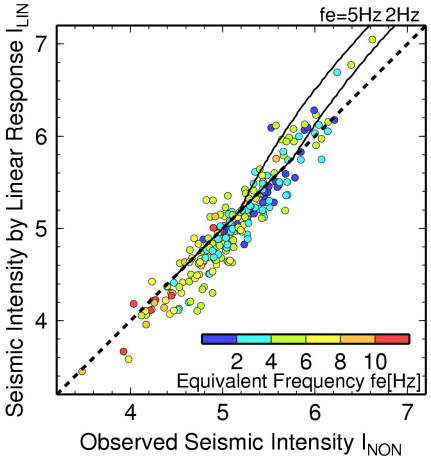

Japan Geoscience Union Meeting 2015
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SSS25-P08 Room:Convention Hall Time:May 25 18:15-19:30

Nonlinear Site Response Analysis in Tokyo Meteropolitan Area Using Equivalent Linear Approach

IBRAHIM, Rami[1*] ; MASUDA, Tetsu[1] ; KOKETSU, Kazuki[1] ; HIROSE, Takeshi[2]

[1]Earthq. Res. Inst., Univ. Tokyo, [2]East Nippon Expressway Company Limited

Nonlinear site effect analysis was carried out for 210 simulated strong ground motion records in the Tokyo Metropolitan area. The simulated strong motion records synthesized for two scenario earthquakes, i.e. plate-boundary and intra-slab ones, were the outputs from the Special Project for Earthquake Disaster Mitigation in Tokyo Metropolitan Area. Fault plane of plate boundary earthquake extends along the surface of subducting Philippine Sea Plate (PHS), located beneath the northern part of Tokyo bay area. Its presumed magnitude of M_w 7.3. The fault plane of intra-slab earthquake is expected within the PHS at a focal depth of 50 km, extended beneath Chiba and Ibaraki prefectures. Its presumed magnitude of M_w 7.1. All waveforms were synthesized on engineering base of shear-wave velocity 500 m/s.

Site response analyses were achieved by an equivalent linear method using DYNEQ program developed by Yoshida and Suetomi (1996). G-γ and h-γ relationships of Central Disaster Mitigation Council are recognized to express the shear deformation of soil (clay, sand, and gravel). Resultant waveforms on free surface shows a systematic dependence on thickness of the soft structure above the engineering base. Large amplification is dominant at corresponding short periods above shallow soft structure, whereas the peak amplitudes shifted to longer periods for sites located above deep soft structure. Nonlinear site effects were typically obvious at short periods of approximately 0.2 s and shorter. The deformations mostly concentrated in the shallow 20 m of the soil inferred from maximum shear strains analysis. Our analysis showed the considerable effects of the non-linear response of surface layers to large seismic inputs on the engineering base.

Keywords: Nonlinear site effect, Plate boundary earthquake, Intra-slab earthquake

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Relation between smallest microtremor amplitudes and largest seismic oscillations observed by TRIES

TANAKA, Torao[1*] ; OKUBO, Makoto[1]

[1]NOTHING

In order to investigate the relation between the smallest spectral amplitudes of microtrmors and largest seismic spectral amplitudes, we started data analysis of microtremors and seismic data at 02TRIES and 00Togari. By the discrete Fourier transform we calculated the spectral amplitudes and frequencies of microtremors recorded at 00Togari just before the first arrival of seismic waves in the frequency range of 0.1Hz from 2.0 to 4.0 Hz. Similarly we calculated the spectral amplitudes and frequencies of seismic waves by the discrete Fourier transform in the same frequency range of 0.1Hz from 2.0 to 4.0Hz. We obtained the ratio of relative amplitudes of the smallest amplitude of microtremors and largest amplitude of seismic waves to those at the station 02TRIES. By taking the relative amplitudes of microtremors and largest seismic amplitudes to those at the station 02TRIES, we can separate the site effects at 00Togari caused by the ground soil from the amplitude, modifications caused by the magnitude, source mechanism and position, lay path, and so on. Preliminary results show that the smallest amplitude of microtremors might generate large seismic amplitudes which will increase the amplitude by the magnitude, source mechanism, wave path, the distance to the hypocenter and so on in future.

Keywords: microtremor, seismic waves, discrete Fourier transform, ground soil, maximal amplitude, site effect

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SSS25-P10 Room:Convention Hall Time:May 25 18:15-19:30

Microtremor surveys for S-wave velocity structure in Okinawa and Amami islands, Japan

YAMADA, Nobuyuki[1*] ; TAKENAKA, Hiroshi[2]

[1]Fukuoka University of Education, [2]Okayama University

We conducted microtremor array measurements at six sites in four islands of the Nansei islands area: Northern part of Okinawa main island, Yoron island, Okinoerabu island and Tokunoshima island, to estimate the vertical (1D) S-wave velocity profiles of deep sedimentary layers over the basement with a Vs about 3.0 - 3.5 km/s. In this presentation, we will report the result of the analysis and the obtained S-wave velocity profiles at the six sites. These 1D velocity profiles may be available for making a 3D structure velocity model over the Nansei islands area for the strong ground motion simulations.

This work was supported by JSPS Grant-in-Aid for Scientific Research (B), Number: 26282105.

Keywords: Okinawa, Yoron, Okinoerabu and Tokunoshima island, S-wave velocity structure, Microtremor array measurement

Japan Geoscience Union Meeting 2015
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Estimation of surface wave group velocities beneath the Beppu bay, western Japan, using a dense broadband array

HAYASHIDA, Takumi[1*] ; YOSHIMI, Masayuki[2] ; TOKUMARU, Tetsuyoshi[3] ; SUGIYAMA, Takeshi[4]

[1]IISEE, Building Research Institute, [2]Geological Survey of Japan, AIST, [3]Tokumaru Professioal Engineer's Office, [4]Free

S-wave velocity structure beneath the Beppu bay is evaluated with seismic interferometry, using newly observed ambient-noise data. We have already determined surface-wave group velocities beneath central Oita prefecture using the NIED Hi-net data (Hayashida and Yoshimi, 2014 SSJ Fall meeting). The results show importance of higher-density broadband seismic array observations to evaluate detailed spatial variation of deep subsurface structure beneath the bay. We have developed a dense seismic array consisting of 12 broadband stations around the bay area after late August 2014. Each station is equipped with a Hakusan DATAMARK LS-8800 data logger (24bit A/D, sampling at 100Hz) and a Nanometrics Trillium Compact seismometer (T=120s). The power spectral density functions of ambient noise have peaks at frequencies of 0.08Hz-0.1Hz, 0.15Hz-0.25Hz and around 0.5Hz among all stations. We used the continuous ambient-noise data to extract Green's functions between two receivers (66 station pairs) for vertical (Z-Z), horizontal (R-R, T-T) and vertical-horizontal (Z-R, Z-T) components in the frequency range of 0.05Hz-2Hz after the signal processing of Bensen et al. (2007). The stacked cross-correlation functions show distinct wave trains for every pair of stations. However, it is still difficult to estimate surface-wave group velocity dispersions in a wide rage of frequency band due to low S/N ratios (<2) and the preliminary results suggest the need for continuous seismic observations.

Acknowledgements:
This research is conducted as a part of Comprehensive Research on the Beppu-Haneyama Fault Zone by the Ministry of Education, Culture, Sports, Science and Technology (MEXT).

Keywords: ambient noise, seismic interferometry, surface wave, group velocity, beppu sedimentary basin

Japan Geoscience Union Meeting 2015
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SSS25-P12 Room:Convention Hall Time:May 25 18:15-19:30

Microtremor array survay in Oita and Beppu area

YOSHIMI, Masayuki[1*] ; HAYASHIDA, Takumi[2] ; TOKUMARU, Tetsuyoshi[3] ; SUGIYAMA, Takeshi[4]

[1]Geological survey of Japan, AIST, [2]IISEE, Building Research Institute, [3]Tokumaru Professioal Engineer's office, [4]Free

We conducted microtremor array survey in Oita plain and Beppu area, Kyusyu, Japan, to estimate subsurface S-wave velocity structure. Each observation is comprised of six equilataral arrays, with aparture of 20 to 1000 meters. Velocity seismometers with natural period of 10 sec. are deployed connected with 24bit A/D, GPS time-calibrated data loggers to obtain night-long data. Each continuous data are segmented to hourly data sets, and are analyzed with SPAC method, V method (Tada et al,2007) and CCA method (Cho et al. 2006) to estimate phase velocity using BIDO 2.0 software (Tada et al, 2010, http://staff.aist.go.jp/ikuo-chou). We successfully obtained phase velocities in the frequency about 0.2 to 5 Hz.

1D S-wave velocity structure for each observation site is estimated using GA algorism to fit observed phase velocity data.

This research is a part of "Research for Beppu-Haneyama Fault Zone" funded by MEXT.

Keywords: velocity structure, beppu sedimentary basin, ambient noise

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Estimation of Subsurface Structure based on Microtremor and Gravity Survey in the Shikano Area, Tottori Prefecture

NOGUCHI, Tatsuya[1*] ; KAGAWA, Takao[1] ; TSUYOSHI, Yusuke[1] ; OGURA, Kohei[1] ; YOSHDA, Shohei[1]

[1]Tottori University

Shikano and Yoshioka earthquake fault occurred on the surface by the 1943 Tottori earthquake. In this study, subsurface structures were determined and we grasped characteristics of ground motion by microtremor and gravity survey in the Shikano area, Tottori Prefecture. Microtremor single-point 3-components observations and array observations were carried out at 156 and 12 sites respectively. As analysis of microtremor surveys data, we estimated S-wave velocity structures by using phase velocities obtained from array observations and thickness of sedimentary layer by using predominant periods of H/V spectrum obtained from single-point 3-components observation records. Gravity observations were carried out at 38 sites. As analysis of gravity surveys data, gravity anomalies with assumed density in 2.4t/m^3 were obtained by using gravity databases, existing data in the east-part of Tottori Prefecture and this study data. We estimated 2D and 3D density structures from the distribution of gravity anomalies.

Keywords: microtremor survey, gravity survey, subsurface structure, hikano area in Tottori Prefecture

Japan Geoscience Union Meeting 2015
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SSS25-P14 Room:Convention Hall Time:May 25 18:15-19:30

Estimation of Subsurface Structure from Microtremor and Strong Ground Motion Evaluation of the 1943 Tottori Earthquake

YOSHDA, Shohei[1*] ; KAIZAKI, Tatsunori[1] ; NOGUCHI, Tatsuya[1] ; KAGAWA, Takao[1]

[1]Tottori University

September 10, 1943. The Tottori earthquake occurred in the east of Tottori prefecture, and gave serious damage to Tottori city. In this study, subsurface structures at damaged site were estimated for evaluating strong ground motion of the Tottori earthquake in Tottori city. Single site 3-components observation and array observation were carried out at the school points. Predominant period of H/V spectrum was obtained from 3-components observation records. The predominant period were not have related with natural period of school building. S-wave velocity structures were obtained from array observation records. Thickness of S-wave velocity 100m/s˜200m/s layer was estimated 30m at observation sites. We calculated engineering bedrock waveforms using Stochastic Green's function method and surface waveforms using equivalent linearization method. It was found that large damage schools tended to high response value in periodic band of 1.0 second.

Keywords: Microtremor observation, Tottori Earthquake, S-wave velocity structure, H/V

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Evaluation of Rayleigh-wave group velocities using seismic interferometry in the vicinity of Tachikawa fault zone

ISHIGE, Hirokazu[1*] ; CHIMOTO, Kosuke[1] ; SAGUCHI, Koichiro[1] ; YAMANAKA, Hiroaki[1] ; SAKAI, Shin'ichi[2] ; KURASHIMO, Eiji[2] ; HIRATA, Naoshi[2]

[1]Interdisciplinary Graduate School of Science and Engineering, Tokyo Institute of Technology, [2]Earthquake Research Institute, the University of Tokyo

Recently, seismic interferometry has attracted the attention as one of the geophysical exploration methods. In this study I evaluated the surface-wave group velocities in the vicinity of Tachikawa fault zone in Kanto basin, Japan, using seismic interferometry for continuous earthquake data. First, I analyzed the dispersion of the surface-wave group velocity from estimated Green's function based on cross-correlation function between each pair of observation points. Next, I conducted the slowness tomography analysis of the surface wave arrival times, using criteria on the application range of the seismic interferometry proposed by Chimoto and Yamanaka (2013). Apparent differences in the tomography maps of group velocity were observed in the southwest side and the northeast side of the Tachikawa fault. In the southwest side of the Tachikawa fault, longer period surface-wave has wider area with high group velocity. I finally compared the group velocities observed from seismic interferometry with those calculated from existing subsurface structure model. The results show that the high group velocity area found in the southwest side become wider at shorter period band than those in the existing model. This suggests that the thickness of the surface layer is thinner than the existing model.

Keywords: Tachikawa fault zone, Seismic interferometry, Rayleigh wave, surface-wave group velocities

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Characteristics of Spatial Variation of Short-Period Ground Motion in the Vicinity of Tachikawa-Fault

TSUNO, Seiji[1*] ; SAGUCHI, Koichiro[2] ; CHIMOTO, Kosuke[2] ; SATO, Hiroaki[3] ; MATSUSHIMA, Shinichi[4] ; MICHIKO, Shigefuji[5] ; TAKAI, Nobuo[5] ; KANNO, Tatsuo[6] ; YAMANAKA, Hiroaki[2] ; KAWASE, Hiroshi[4]

[1]Railway Technical Research Institute, [2]Tokyo Insitute of Technology, [3]Central Research Institute of Electric Power Industry, [4]Kyoto University, [5]Hokkaido University, [6]Kyusyu University

Inhomogeneity of shallow soil structure often causes earthquake damage and extreme large acceleration concentrated locally. To understand the phenomena for singular distribution of earthquake ground motions, therefore, we evaluated the characteristics of spatial variation of short-period ground motions. We performed an earthquake observation at the site locating in Musashimuraya city, Tokyo, for 4 days during June 17 to 20, 2014. 8 seismic stations were installed temporally within a linear array of about 650m crossing the Tachikawa-Fault. In this study, we evaluated the characteristics of spatial variation of earthquake ground motions by applying spectral analyses to seismic data recorded during the Chiba-ken Hokuseibu earthquake (Mj 4.6, 2014/July 20) and the Off Ibaraki-ken earthquake (Mj 3.9, 2014/July 20). In the near future, we will evaluate those characteristics quantitatively by the method of goodness-of-fit considering time and frequency.

Keywords: short-period ground motion, spatial variation, shallow soil structure, earthquake observation, Tachikawa-Fault

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Estimation for velocity structure of shallow sediments using microtremor array observation in Furukawa, Japan

MITSUNAGA, Hitoshi[1*] ; IIYAMA, Kahori[1] ; MORIKAWA, Hitoshi[1] ; GOTO, Hiroyuki[2] ; INATANI, Masayuki[2] ; HADA, Koji[3] ; IKEDA, Takaaki[2] ; TAKAYA, Toshiyasu[2] ; KIMURA, Sayaka[2] ; AKIYAMA, Ryohei[2] ; SAWADA, Sumio[2]

[1]Tokyo Institute of Technology, [2]Kyoto University, [3]Newjec INC.

On March 11, 2011, the Tohoku earthquake (Mw 9.0) brought the large ground motion and tsunami in the eastern part of mainland Japan. As a result, many buildings were seriously damaged and many people were killed. Furukawa of Miyagi prefecture is one of the most seriously damaged areas by the earthquake ground motion. The anomaly of the damage distribution was observed in this area. It is considered that the anomaly caused by difference in ground motion characteristics, and especially shallow ground structure affects ground motion characteristics. To identify the characteristics, some observations have been carried out in Furukawa, for example, very dense seismic array observations (Goto ea al., 2012) and so on. The observation covers 2?3km^2 area by 23 sensors and provides the relative information on depth to ground basement. However, it is still difficult to determine the absolute values of the depth to the basement.

In order to clarify the shallow ground structure in the area, the array observation of microtremors was carried out from December 13 to 16, 2014. The three components seismometer was adopted, that is, moving-coil type velocity sensor with the natural frequency of 2 Hz. We set three arrays in the north-western area of Furukawa station, which were the equilateral triangle arrays with radii of 2.9 m to 45 m.

The microtremor data were analyzed by the spatial auto-correlation (SPAC) method (aki, 1957). In the surface layer of ground, the shear-wave velocity is approximately 100 m/s at all the sites and the depth is 10 or 15 m. Also, the depth to the ground basement is around 35 m at all the sites. On the other hand, the differences of the ground properties are found in middle layers. It, however, is difficult to recognize the differences on the horizontal-to-vertical spectral ratios (H/V), because of the similarity of the predominant frequencies.

The estimated S-wave velocity structures suggest that the properties of middle layers affect to the anomaly of damage distribution. This means that the impedance ratio between middle layer and basement plays the important roles to the amplification of the ground motions in this area.

Reference

Goto et al. : Very dense seismic array observations in Furukawa district, Japan, Seism. Res. Lett., 83(5), pp.765-774, 2012.

Aki : Space and time spectra of stationary stochastic wave, with special reference to microtremor, Bull. Earthq. Res. Inst., 35, pp.415-456, 1957.

Keywords: microtremor, velocity structure, array observation, Furukawa, ground motion, spatial auto-correlation method

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Super dense microtremor observation evaluating shallow ground structure in Furukawa area

GOTO, Hiroyuki[1*] ; INATANI, Masayuki[2] ; HADA, Koji[3] ; IKEDA, Takaaki[4] ; TAKAYA, Toshiyasu[4] ; KIMURA, Sayaka[2] ; AKIYAMA, Ryohei[2] ; SAWADA, Sumio[1] ; IIYAMA, Kahori[5] ; MORIKAWA, Hitoshi[5]

[1]DPRI, Kyoto Univ., [2]Eng. Dept., Kyoto Univ., [3]Newjec Inc., [4]Eng., Kyoto Univ., [5]Science Eng., Tokyo Inst. Tech.

During 2011 Tohoku earthquake, structure damages due to ground motion occurred in inland of Tohoku area. In Furukawa area, residential structure and lifeline systems were severely damaged. The damaged area did not spread in whole the downtown of Furukawa area, but the damages were concentrated in a particular spot. In order to investigate the reason why the damage spot exists, we conduct dense observation of strong ground motions via seismometer network (Goto et al., 2012).

Ground motion records observed by the network investigate the shallow ground structure in the area. The structure implies deep deposit soil structure beneath the damage spot. However, more detailed spatial information is required to discuss the spatial distribution, because the structure is interpolated over the data at the seismic stations.

We performed denser survey of single station microtremor in the Furukawa area. The spatial interval in the downtown area is planed to about 50m. We totally collect mocrotremor records at 527 sites. H/V spectra ratio is calculated at each site, and the peak frequency is picked up. The distribution of peak frequency in the downtown, Furukawa area, is well correlated with the shallow ground structure based on the ground motion records.

Reference
Goto et al.,: Very dense seismic array observations in Furukawa district, Japan, Seism. Res. Lett., 83(5), pp.765-774, 2012.

Keywords: micrtoremor observation, H/V spectral ratio, site factor, Furukawa area

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Construction of underground structure model in the fault neighborhood(An example of Fukaya fault and Ayasegawa fault).

SENNA, Shigeki[1*] ; MATSUYAMA, Hisanori[2] ; JIN, Kaoru[2] ; FUJIWARA, Hiroyuki[1]

[1]NIED, [2]OYO Corp

Sophisticated predictions of strong ground motion are vital when constructing structure models that enable us to evaluate broadband ground motion features. In this study, we have created a subsurface structure model applicable from seismic bedrock to ground surface for individual Japanese individual prefectures, e.g., South Kanto Area, in attempts to sophisticate subsurface structure models.An essential issue in sophisticated prediction of strong ground motion is constructing structure models that enable us to evaluate broadband ground motion in a range from 0.1 to 10 seconds. It then becomes essential to integrate subsurface model and deep structure models, which used to be modeled separately, to enable us to reproduce observation data. Previous studies do not seem to have verified ground motion in 3D structure models. We therefore prepared an initial structure model for entire prefectural areas.

Using the initial structure models initial values, we obtained S-wave ground velocity, Q values and amplification features, i.e., spectral amplification factors, from seismic data at seismic observation points from K-NET, KiK-net, JMA, municipalities, and from numerous array and single-point survey data on microtremors collected area-wise. We worked out area-wise interpolation and created subsurface structure models from seismic bedrock to ground surface in 250-meter meshes. In creating the above subsurface structure model, we verified results at each stage in reference to seismic observation and site amplification by using one-dimensional(1D) multiple reflection for periods shorter than two seconds and referencing seismic observation data by using the finite difference for periods longer than two seconds in order to check whether created models were more sophisticated than previous structure models.

The final goal of this study is to facilitate and promote studies creating new structure models based on the above subsurface structure models, so we decided to construct standard structure models for predicting broadband ground motion in Japan and to make them available to the general public. This paper focuses on results of our study on standard structure models for test sites in Chiba and Ibaragi Prefectures.

Keywords: microtrmor observation, active fault, strong motion prediction, underground structure model

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A study for detection of the site on inclined engineering bedrock based on microtremor observation

SAKAI, Kimitoshi[1*] ; TANAKA, Kohei[1] ; USAMI, Atsuhiro[1] ; KOBAYASHI, Kaoru[2] ; HIRABAYASHI, Masaya[2]

[1]Railway Technical Research Institute, [2]East Japan Railway Company

The local site amplification is seen in the ground motion observed at site on inclined engineering bedrock. So, the site is the important point from the view of the seismic design. In this study, the feasibility of detection of the site on inclined engineering bedrock based on microtremor observation is verified. As the result, the ratio of vertical Fourier spectrum between two point shows the harmonic tendency of the degree of the slope of the engineering bedrock.

Keywords: microtremor, surface wave, irregular ground