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

SSS25-01 Room:A04 Time:May 25 09:00-09:15

Relationships between building damage and characteristics of strong ground motions during the M6.5 Zhaotong Earthquake-I

WANG, Xin[1*] ; MA, Qiang[2] ; SI, Hongjun[3] ; DANG, Ji[4] ; WU, Hao[5] ; KURAHASHI, Susumu[6]

[1]IRIDeS, Tohoku University, [2]Institute of Engineering Mechanics, China Earthquake Administration, [3]Earthquake Research Institute, The University of Tokyo, [4]Saitama University, [5]DPREC, Aichi Institute of Technology, [6]Aichi Institute of Technology

Magnitude 6.5 inland earthquake happened at the Longtoushan town which is located on the northeast side of the Yunnan province of China on 16:30 August 3rd, 2014 (CST). The biggest seismic intensity is estimated to be IX in China seismic intensity scale (equal to 5+ in JMA seismic intensity scale) at the Longtoushan town with the recorded peak ground acceleration (PGA) of 949 gal. As of 8 August 2014, 617 persons were killed by this earthquake, in which almost 85% (526 persons) of the death are happened at the Longtoushan town. The reason of death should be attributed to the seismic capability of residential houses and the characteristics of ground strong motions.

In order to make clear the building damage condition and the ground amplitude and period characteristics, we performed the onside investigation of building damage and the microtremor measurement from November 9th ˜12th, 2014. The places which have been investigated are marked with red dots in Fig 1. The PGA of investigated places are, 15 gal at Zhaotong city, 45 gal at Ciyuan town, 137 gal at Qianchang, and 135 gal at Mashu town. Based on the attenuation relations of PGA, it has been known that the accelerations attenuated fast with the increasing of fault shortest distance.

Masonry houses and buildings are commonly used in the disaster area. In the Longtoushan town, the collapse of masonry buildings can be widely seen. Based on the vulnerability functions of the 2008 Wenchuan earthquake, which was proposed by Wang 2011, the predicted collapse ratio of the Longtoushan town is 79%, which is almost the same with the result of onsite investigation. However, the building collapse cannot be seen in other places. Some slight damage, such as the crack in masonry walls, can be seen in the Qianchan town and Mashu town. Generally, no damage happened to buildings in the Zhaotong city.

We measured the ground microtremor of these onsite investigated places using high-sensitive velocity seismometers with sampling rate of 100 Hz and duration of 30 min in each place. Based on the H/V spectra, the predominant period of Longtoushan is about 4 Hz which is almost the same with results of other places. Furthermore, it has been known that the building damage in Longtoushan town relates to the ground condition of mountain side and the river side.

Keywords: Zhaotong Earthquake, Onsite Investigation, Ground Microtremor Measurement, Masonry Buildings

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

SSS25-02 Room:A04 Time:May 25 09:15-09:30

Relationships between building damage and characteristics of strong ground motions during the M6.5 Zhaotong Earthquake-2

KURAHASHI, Susumu[1*] ; IRIKURA, Kojiro[1] ; WANG, Xin[2] ; SI, Hongjun[3] ; MA, Qiang[4] ; WU, Hao[1]

[1]Aichi Institute of Technology, [2]IRIDeS, Tohoku University, [3]Earthquake Research Institute, The University of Tokyo, [4]Institute of Engineering Mechanics, China Earthquake Administration

On 3 August 2014, an Ms6.5 earthquake occurred at the Longtouchan town located on the northeast side of the Yunnan province of China. As of 8 August 2014, 617 persons were killed by this earthquake, in which almost 85% (526 persons) of the death happened in the Longtoushan town. During this earthquake, the strongest peak acceleration of 949 gal was measured in the Loungtouchan station (LLT station). The observed record at the station also had two impulsive waves (figure (b)). Explication of generation mechanism of the large acceleration is needed to clear the relationship between seismic ground motion and damage. In this study, we construct the strong motion generation area (SMGA) as the short-period source model of this earthquake using the strong-motion records, and elucidate generation mechanism of the large acceleration.

The aftershock distribution of this earthquake is shown in Figure (a). Two possible fault planes from the distribution are considered to be southeast ? northwest (plane A) and southwest ? northeast (plane B).

Most of building damge and landslide disasters were along the plane A. On the other hands, although the slip distribution on each plane was inverted by the teleseismic data, we do not understand which plane is better from the results.

Therefore, we try to estimate the short-period source model using the empirical Green's function method. In the first trial, we did not use the LLT station's data too close to the source fault because the rupture plane is not clear. The earthquake information about the hypocenter of the mainshock and aftershocks is not enough todetermine the rupture planes correctly. Thenre, the seismic moment of the element event used as the empirical Green's function is calculated from magnitude, and the seismic mechanism of the element event is assumed to the same as the mainshock. The scaling parameters N and C are determined for SMGA from the observed source spectral ratio between the mainshock and the element event.

The synthetic ground motions explain well the characteristics of observed ground motions for either plane. The area and stress drop of the SMGA were about 100km2 and about 10 MPa, respectively. However, we do not understandwhich plane is better.

Next, we discussed the arrival direction of seismic waves by the particle motion diagrams of the two pulsive waves using the observed record at LLT station.

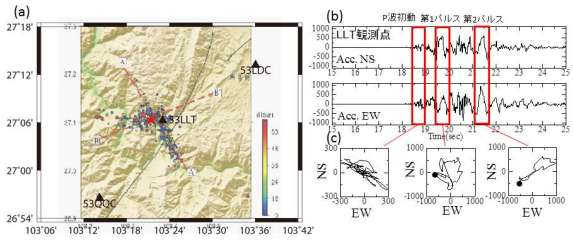
The NS and EW particle motion of P-waves in the horizontal plane oscillate in northwest-southeast direction. Namely, the azimuth of the starting point of fault rupture is assumed to be northwest direction (Fig(c) left figure).

Similarly, the particle motion diagrams of the first pulse and second pulse of S-wave oscillate in northwest-southeast and northeast-southwest direction, respectively. If these pulses mainly consist of SH wave, the propagation directions from those two pulses seem to be different. As a result, the first and second pulses are assumed to be generated from plane A and plane B, respectively to satisfy the relation between the aftershock distribution and the location of observation station (LLT).

Hereafter, we try to estimate the strong-motion generation areas using LLT station's record.

Keywords: Zhaotong Earthquake, large acceleration, strong-motion generation area

SSS25-02 Room:A04 Time:May 25 09:15-09:30



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

SSS25-03 Room:A04 Time:May 25 09:30-09:45

Relationships between building damage and strong ground motions characteristics during the 2014 Zhaotong Earthquake-III

WU, Hao[1*] ; WANG, Xin[2] ; SI, Hongjun[3] ; DANG, Ji[4] ; MA, Qiang[5] ; LIN, Guoliang[6] ; IRIKURA, Kojiro[1] ; KURAHASHI, Susumu[1]

[1]Aichi Institute of Technology, [2]Tohoku University, [3]The University of Tokyo, [4]Saitama University, [5]China Earthquake Administration, IEM, [6]Yunnan Province Earthquake Administration

Many of the buildings near the Longtoushan (LTS) strong-motion station were heavily damaged or collapsed during the 2014 Zhaotong earthquake (Ms 6.5) which occurred on Aug. 3, 2014. The largest PGA with approximately 1 g was recorded at LTS during the mainshock. In contrast, the damage of buildings was minor near other stations, and the strong-motion records there were lower than 150 gal.

We conducted an almost three-day field survey near five strong-motion stations around the epicenter. We found that the causes for heavy damage of buildings near the LTS station were complicated, such as geological failure (e.g. landslide), insufficiently seismic resistant structural design, inappropriate construction, and site effect (transfer function and nonlinear effect), and so on. We also found that the collapse of many buildings in the EW direction was obviously heavier than that in the NS direction near the LTS station. It can be explained by the higher pseudo-velocity response spectrum in the range of 0.5 s to 1.0 s in the EW direction.

We also conducted microtremor measurement at six sites around the LTS station to examine the variation of site effects in this area. We found that the predominant periods at heavily damaged sites were similar, i.e., 0.25 s, while the predominant periods at light damaged sites were about 0.15 s.

In addition, we obtained several aftershock records as well as mainshock record, and the boring data near the LTS station. These data can be used to clarify the site effect characteristic at the LTS station.

Keywords: Zhaotong Earthquake, ground motion, microtremor, site effect

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

SSS25-04 Room:A04 Time:May 25 09:45-10:00

STRONG GROUND MOTION SIMULATION of THE 24 MAY 2014 NORTH AEGEAN SEA EARTHQUAKE (Mw 6.9) in TEKIRDAG and SURROUNDING AREA

KARAGOZ, Ozlem[1*] ; CHIMOTO, Kosuke[1] ; YAMANAKA, Hiroaki[1] ; OZEL, Oguz[3] ; CITAK, Seckin ozgur[4]

[1]Department of Environmental Science and Technology, Tokyo Institute of Technology, Tokyo, Japan, [2]Department of Geophysical Engineering, Canakkale Onsekiz Mart University, Canakkale, Turkey, [3]Department of Geophysical Engineering, Istanbul University, Istanbul, Turkey, [4]JAMSTEC

The Marmara Region (NW Turkey) was affected from destructive earthquakes since historical times. The North Anatolian Fault with 1,200 km length is the main source of the earthquakes in the region. The most recent 1999 Kocaeli Earthquake (Mw 7.4) damaged residential and industrial areas of the large cities in Marmara. The future earthquake is expected on the north-western segment of the fault close to the city of Tekirdag.

In this study, we simulated strong ground motion records of the 24 May 2014 North Aegean Sea Earthquake (Mw 6.9) in Tekirdag and surrounding area. We used one-dimensional homogeneous horizontal layer model at each AFAD (Republic of Turkey Prime Ministry Disaster & Emergency Management Presidency Earthquake Department) strong motion station site in Tekirdag and surroding area (i.e. 5904, 5902, 5907, 5906), Canakkale (i.e. 1701, 1710), Gokceada (1711), Edirne-Enez (2201). We combined our shallow model (0-250 m) that obtained from our previous microtremor explorations (Karagoz et al., 2014) and the deeper parts were taken from pervious crustal studies in the region. The outer fault parameters of the mainshock (seismic moment, strike, dip, and rake) were determined by previous focal mechanism solutions studies while the inner fault parameters were estimated by following the recipe of Irikura and Miyake (2011).

The fault plane (background) and asperities were divided into several subfaults that were assumed as single double-couple point source. We defined appropriate Kostrov-like slip-velocity function (modified by Nakamura and Miyatake, 2000) for the asperity areas to simulate high frequency ground motions. The synthetic seismograms were obtained using a deterministic discrete wave number method for each sub-fault and were summed to get full waveform at the station around the epicentre in a broadband frequency range (0.1-10Hz).

The simulated peak ground velocities at the ground surface were estimated by multiplying the simulated ground motion at the top layer of Vs=780 m/s from the discrete wave number method with 1D amplification factors of S-waves in the shallow soil layers derived from the microtremor explorations. For validation, the results converted accelerations and were compared with S-wave portions of the recorded acceleration waveforms at the strong motion stations.

Keywords: Discreete wave form method, earthquake waveform simulation, Gokceada, site effect, Tekirdag

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

SSS25-05 Room:A04 Time:May 25 10:00-10:15

Source Rupture Process of the 2014 Northern Nagano Earthquake Estimated by Strong Motion Data

ASANO, Kimiyuki[1*] ; IWATA, Tomotaka[1] ; KUBO, Hisahiko[1]

[1]Disaster Prevention Research Institute, Kyoto University

A large inland crustal earthquake occurred in the northern Nagano prefecture, central Japan, on November 22, 2014 (M_{JMA} 6.7). According to the moment tensor solutions by Global CMT Project and F-net (NIED), this earthquake was a reverse-slip type event. This event has been reported to be related to an active fault, the Kamishiro fault of the Itoigawa-Shizuoka Tectonic Line (e.g., HERP, 2014). The surface rupture is observed along the Kamishiro fault. We estimated the source rupture process of this earthquake by the kinematic waveform inversion analysis using strong motion data.

We used strong motion data from 12 strong motion stations of K-NET, KiK-net, JMA, and Nagano prefecture. The S-wave portion of the velocity waveform in 0.05-1 Hz are used in the inversion analysis. Since the underground velocity structure in this region seems complex, it is not good strategy for calculating Green's functions that single one-dimensional velocity structure is applied to all stations. We assumed individual one-dimensional velocity structure model for each station, which is extracted from the nation-wide three-dimensional velocity structure model, Japan Integrated Velocity Structure Model Version 1 (JIVSM, Koketsu *et al.*, 2012). The Green's function was calculated by the discrete wavenumber method (Bouchon, 1981) and the reflection and transmission matrix method (Kennett and Kerry, 1979).

The fault model consists of two fault planes, which have different dip angle between the north and south plane based on the aftershock distribution by NIED (2014) and the surface fault information. The south fault plane has relatively steep dip angle compared to the north fault plane. The top of the south fault plane corresponds to the Kamishiro fault. The total length and width of the fault plane is 22 km and 14 km, relatively. The fault plane is divided into subfaults of 2 km $\times$ 2 km. The moment function of each subfault is represented by a series of six smoothed ramp function.

The kinematic waveform inversion method is based on the multiple time-window linear waveform inversion method by Hartzell and Heaton (1983). The relative strength of the smoothing constraint (Sekiguchi *et al.*, 2000) and the first time-window front triggering velocity were determined to minimize Akaike's Baysian Information Criteria.

The estimated source model has a large slip area in a slightly deep portion approximately 5 km north to the rupture starting point. Its largest slip is 1.8 m. It is consistent with the centroid location of the CMT solutions by GCMT and JMA. The aftershock activity in this large slip area is relatively low compared to the other area on the fault. The slip amount of the shallowest subfaults are approximately 0.3-0.5 m, and this slip would be related to the surface rupture observed after this earthquake. The total seismic moment is 3.85×10^{18} Nm (MW 6.3), and the average slip is approximately 0.4 m. Comparing these source parameters with previous inland crustal earthquakes in Japan, this earthquake is not an unusual earthquake.

Acknowledgments: The strong motion data of K-NET and KiK-net of NIED, JMA, and Nagano prefecture government which is released through SK-net of the Earthquake Research Institute, University of Tokyo, are used in this study.

Keywords: the 2014 northern Nagano earthquake, source process, strong motion data

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

SSS25-06 Room:A04 Time:May 25 10:15-10:30

Site amplification in Hakuba from microtremor and aftershock observation of the 2014 Northern Nagano Earthquake

CHIMOTO, Kosuke[1*] ; YAMANAKA, Hiroaki[1] ; SAGUCHI, Koichiro[1] ; TSUNO, Seiji[2] ; MORIKAWA, Hitoshi[1] ; IIYAMA, Kahori[1] ; GOTO, Hiroyuki[3]

[1]Tokyo Institute of Technology, [2]Railway Technical Research Institute, [3]DPRI

During the 2014 Northern Nagano Earthquake on 22 Novermber, the maximum seismic intensity of 6 lower, buildings in Horinouchi or Mikkaichiba in Hakuba located at about 5km south to K-NET Hakuba were heavily damaged. We then carried out the aftershock observation and microtremor measurements from 24 November to 4 December to investigate the site amplification due to subsurface structure.

We carried out the aftershock observation with 13 temporal stations using accelerometer JEP6A3 with Data logger of LS7000XT and LS8800. We observed about 30 events with the seismic intensity of above 1, the highest peak ground motion was about 30 gal. In Horinouchi and Mikkaichiba, where the damage was heavy, we observed high accelerations and long later phases. The response spectrum shows high value between the periods of 0.5 and 1 second. The spectral ratios to the aftershock observed at the base of mountain in Mikkaichiba shows the peaks in the periods of 0.5 to 1 second.

We conducted microtremor measurements at all aftershock observation stations with the array size of less than 20m and applied SPAC method to estimate Rayleigh wave phase velocity. Near Horinouchi, we also conducted microtremore measurements with the large array size of about 680m at the west and east of Kamishiro Fault. We estimated dispersion curve of phase velocity in the range from about 3 to 30 Hz from the array size of about 20m. It was highest in K-NET Hakuba, and about 100 to 200m/s in Horinouchi and Mikkaichiba. We also estimated phase velocity of more than 1000m/s at above 1 second from large array. The S-wave velocity structures were estimated from an inversion of phase velocity. The layer with the S-wave velocity of 300m/s was less than 10m in K-NET Hakuba, while the layer with the S-wave velocity of below 200m/s was about 10m depth and about 50m thickness of the layer with 400m/s. The S-wave velocity structure obtained from the analysis of large arrays revealed that it was deeper in the west of the fault than the eastern part. The depths to the layer with the S-wave velocity of above 1000m/s were about 700m in the west and about 400m/s in the east. Since the depth to such layer in the KiK-net site, about 1km west to K-NET Hakuba, is below 100m, the heavily damaged area has deep structure in around the region.

We calculated the S-wave site amplification factor using the estimated S-wave velocity structure. The site amplification of shallow structure exhibits a peak at about 0.1 second in K-NET Hakuba, while it was about 1 second in Horinouchi and Mikkaichiba. The comparison between the spectral rations and calculated site amplifications show similarity in terms of dominant periods. However, the spectral ratios have higher values in general, suggesting the effects of deep structures.

Keywords: 2014 Northern Nagano Earthquake, Site Amplification, Aftershock observation, Microtremors, Kamishiro Fault

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

SSS25-07 Room:A04 Time:May 25 10:30-10:45

Damages of Stone Lanterns at Zenkoji Temple, Nagano, Caused by Northeastern Nagano Earthquake, November 22, 2014

KATO, Mamoru[1*]

[1]GSHE, Kyoto University

Stone lanterns at Zenkoji Temple, Nagano, are severely damaged by the ground shaking caused by Northeastern Nagano Earthquake, November 22 2014. Damages of the residential houses in downtown Nagano is minor compared that in Hakuba Valley, and the damages at Zenkoji appear to be the result of characteristic ground shaking in downtown Nagano.

An M 6.7 earthquake occurred at the northern portion of Itoigawa-Shizuoka Tectonic Line on November 22, 2014. Seismic shaking in the vicinity of epicenter is as severe as JMA Intensity 6-minus, which caused moderate damages of the residential houses and geomorphology damages such as movement of surface ground mass.

Nagano Zenkoji Temple is located in downtown Nagano, approximately 30 km east of the epicenter. Strong shaking by this earthquake cause a number of stone lanterns at Zenkoji to collapse but the damages in the surrounding residential area is minor. Similar damages of stone lanterns are recorded at the previous large earthquake in this epicentral area in 1714. Collapse of stone lanterns often is interpreted as the strength of shaking is as strong as JMA Intensity 5 Reported Seismic Intensities are 5-plus and 4 at JMA Nagano and 4 at K-net, respectively..

We surveyed damages at Zenkoji Temple and investigate characteristics of strong motion in downtown Nagano. Our focus is on directions of collapse of stone lanterns which would be used to study direction of strong shaking. Our field surveys took place on November 23, the next day of the earthquake, and November 30 and December 1, one week later. Previously we have surveyed stone lanterns of Zenkoji Temple in 2013 to study whether these lanterns have recorded damages by 1847 Zenkoji Earthquake, and by using this result we are able to distinguish old and new damages of these lanterns.

Our results indicate that approximately one-thirds of the stone lanterns at Zenkoji Temple fell down by the strong shaking. Damages appear to occur in the entire Zenkoji area, and it is not successful to relate these damages to local site effects within Zenkoji. Stone lantern most frequently fell down toward south. Characteristic periods of typical stone lanterns are often assumed to be 0.2 or 0.5 second, and our results imply that shaking at high frequency is particularly strong in north-south direction at Zenkoji.

Keywords: String Motion, Northern Nagano Earthquake, 2014

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

SSS25-08 Room:A04 Time:May 25 11:00-11:15

Age-dependent Mortality in the 2011 East Japan Giant Earthquake (5) Additional Revision of the Current Equation

OHTA, Yutaka[1*] ; SHIGAKI, Tomoko[2] ; KOYAMA, Maki[3]

[1]Tono Res. Inst. Earthq. Science, [2]Inst. Elderly Housing Sci., [3]Medical Inst.,Kyoto Univ.

1. Preface

This paper reports an additional revision for the current age-band specific mortality equation, though known as the traditional one, via critical examinations conducted in a series of previous studies. The current equation defined so as to describe Age-band specific mortality is effective enough to describe the deaths of elderlies, but lesser effective at evaluation of the deaths for infants and children, which suggests strongly the necessity of revision of the current equation.

What we attempted was to introduce two independent equations; one was made via slight revision of the Ozaki method commonly known in Medical Science and the other was made by developing a new equation based on an opinion by Sen in economics as earlier deaths such as either by starvation or poverty is nothing but the deprivation of all of capability. Those new equations brought better outcomes for the cases in the 2011 East Japan Earthquake. But, the first one revised starting from the Ozaki method was still insufficient for the direct comparison with the current mortality, since the first one produces a better figure for the absolute number of deaths but was not enough to produce mortality itself.

2. Additional Revision of the Ozaki method

In the revised equation of the Ozaki method, therefore, the values in the vertical axis were as just the number of deaths until the previous study and therefore no direct comparison with the currently known equation was incapable. In this paper we attempted additional revision by which the age-dependent mortality can directly be expressed and therefore a parallel comparison with current and traditional age-specific mortality equation is to be made. Our proposal at present is to introduce our newly revised mortality equation, having an equation composed under the proposal by Sen as a supporting equation.

3. Singularities in Mortality Curves among Prefectures and Municipalities

In comparison of such additionally revised equation and regarded curves with those smoothed ones, we are easy to recognize significant gaps between observed and smoothed ones, which suggest additional reasons over the main reason of the age-dependency due to the degeneration of behavioral performance of residents.

Here, we can point out a few singular cases; the most peculiar gap is seen at age-intervals of 0 up to 14, as has been known in a word called such as a Miracle in Kamaishi city in the curve of Iwate pref. Another remarkable gaps can be seen at 20-30 and 60-70 years old; for these unusual phenomena we have still been conducting the insight studies.

4. Concluding Remarks

We arrived at a conclusion that the age-dependent characteristics should be described in a manner different from the traditional and called current equation. And, in this way of thinking, we developed new equation sets which are more logical and effective at elucidating the mortality which may suffer in natural disasters as earthquakes and/or tsunamis. It is needless to say that the similar investigation is expected to be made for the other pattern than ones described

in the English J character types.

References

1) Ohta and Koyama; Mortality in the 2011 East Japan Earthquake (2, 3 and 4).
2) Katada; Hito ga shinanai bousai (Disaster Preparedness for Minimizing Death Toll, 2012,
Shueisya Publishing Co., (in Japanese).
3) Ozaki; kousei no shihyou, 59, 2012 (in Japanese).
4) Amartya Sen, Retrieve via Wikipedia, giving his name as a serching string.

Keywords: East Japan Earthquake, Age-band specific Mortality, Revision of Evaluation Equation, Disaster-Vulnerable Persons

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

SSS25-09 Room:A04 Time:May 25 11:15-11:30

Multiple Seismic Origins of the 2011 Tohoku Earthquake Analyzed by S-Wave Peak and Regions

NUMAKURA, Masayuki[1*]

[1]Last position Sakura Higashi High School

1, Introduction

Within the field of research on the 2011 Tohoku earthquakes, analyses of the vicinity of the ocean trench axis have made remarkable progress. In contrast, opinion is divided regarding regions closer to land. One example concerns the question of whether tremors that reached the Kanto region originated from the ocean trench axis. Many studies emphasize land-based seismic origins for these tremors, but the precise locations from which these tremors originated remains to be determined in detail. Considering that this earthquake was a ones-in-several-hundred-years event, it can hardly be said that our understanding of the earthquake as a whole has progressed to a fully satisfactory state.

The S-wave and P-wave data available for this earthquake are mixed together and hence difficult to use. Multiple large-amplitude contributions following S-wave initial shocks, S-wave peaks, were present. These data may be used for analyses, despite their mixed nature, if they can be well separated. Due to the paucity of previous research on this subject, we have tested our methods on other large earthquakes in Japan. Method is indicated to 3-1-2 Results of validation.

2, Method

2-1 We determined epicenters by following the Omori method of drawing three circles on map.

2-2 We use Omori's formula. (However, we use distant-dependent velocities.)

r=k×t k1=(Vp×Vs)/(Vp-Vs)

2-3 We used S-wave peak travel times and velocities. The method is indicated to 3-1-2.

3, Results

3.1 Validation.

3-1-2 2004 Niigata Chuetsu earthquake

Epicenter 37.29N 138.87E Depth 12km Start ; 17:56:00

Ojiya Distance13.9km Traveltime S-wave peak 8.73s

Velocity peak3.19km/s Acceleration0.365 Constant1.16Time arrival 56:08

Tokamachi Distance24.1km Travel time S-wave peak 12.60s

Velocity peak 3.83km/s Acceleration 0.304 Constant1.16 Time arrival 56:12

Kashiwazaki Distance31.0km Travel time S-wave peak 14.90s

Velocity peak4.16km/s Acceleration 0.280 Constant1.16 Time arrival 56:14

Travel time is peak time at many stations. (2)r=1/2×a×tˆ2 (3)r=1/2 √ (ktˆ3)

(4) r=1/2×v×t (5)k=v×a k=4rˆ2/tˆ3 (6)v=2r/t v=dr/dt (7) a=2r/tˆ2 a=dv/dt

It is sufficiently possible to calculate in this equation (2), but coefficient ″ a ″ is not constant. Therefore, I prepare the equation (3). The equations (2) and (3) are function that the distance and time of the hypocenter and observation point. In those equations, the function (5), which is in inverse proportion to ″ v ″ and ″ a ″ , is contained.

3-2 Seismic origins of 2011 Tohoku Earthquake

P-1-2 (Epicenter announced by United States Geological Survey)

Epicenter 37.291N 138.867N Depth 30km Start: 46minites, 24 seconds

Oshika Distance 81.5km Travel time S-wave peak 43.3s

Velocity peak 3.76km/s Acceleration 0.0868 Constant 0.327

Time arrival 47:07

Utatsu Distance 94.1km Travel time S-wave peak 47.6s

Velocity peak 3.95km/s Acceleration 0.0829 Constant 0.327

Time arrival 47:11

Tsukidate Distance 130.9km Travel time S-wave peak 59.3s

Velocity peak 4.41km/s Acceleration 0.0744 Constant 0.327

Time arrival 47:23

P-3, Epicenter 38.045N141.47E Depth30km Start: 47minites, 37 seconds

Oshika Distance 41.8km Travel time peak 20.0s

Velocity peak 4.18km/s Acceleration 0.209 Constant 0.873
Time arrival 47:57
Kamaishi Distance 143.6km Travel time peak 45.4s
Velocity peak 6.33km/s Acceleration 0.139 Constant 0.873
Time arrival 48:22
Hitachi Distance 180.2km Travel time peak 53.0s
Velocity peak 6.80km/s Acceleration 0.128 Constant 0.873
Time arrival 48:30
P5 (May be divided into 5 epicenters in all)
In the first phase, P1-2 and P1-3 gave a strong motion to Miyagi and Iwate. In the third phase, Max acceleration of Tsukidate and Oshika was observed by P3. It is both epicenter third phase and trench axis that gave a strong motion to Kanto.

Keywords: S-Wave Peak, 2011 Tohoku Warthquake

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

SSS25-10 Room:A04 Time:May 25 11:30-11:45

Simulation of strong ground motions from the Evaluation of the 2011 Mw 9.0 Tohoku earthquake

IRIKURA, Kojiro[1*] ; KURAHASHI, Susumu[1]

[1]Aichi Institute of Technology, Disaster Prevention Research Center

The 2011 Mw 9.0 Tohoku earthquake occurring in the subduction zone off the Pacific coast of Tohoku, Japan was observed by dense networks of geophysical instruments including strong-motion, teleseismic, tsunami, and geodetic sensors. Long-period source models have been constructed from separate and joint inversions of long-period data including long-period strong motion data. On the other hand, short-period source models have been done from the back-projection method using short-period teleseismic data and the empirical Green's function method using strong motion data. Most of slip distribution inverted from long-period records such as geodetic and tsunami data are placed at depths shallower than the hypocenter toward the trench. On the other hand, short-period seismic energy obtained by the back-projection method was generated mainly from the down-dip areas near the coasts of Pacific coast. The observed strong motions have five wavepackets that correspond to specific strong-motion generation areas (SMGAs). The origins of the wavepackets were retrieved from the original seismograms using a semblance analysis. Then, we estimate a short-period source model for generating strong ground motions from this earthquake by comparing the observed records from the mainshock with synthesized motions based on a sperity/SMGA(strong motion generation area) source model and the empirical Green's function method. We find that five small-asperities in the down-dip areas generate short-period motions of engineering interest but large asperities in the shallower area east of hypocenter generate mainly long-period ground motions. We call such small asperity SMGA. Another problem is that the short-period source models with such SMGAs cannot simulate impulsive waves with high acceleration and velocity seen at onsets of the wave-packets in strong motion records observed near the source fault. To generate the impulsive waves, more heterogeneous model is needed with higher stress parameters within a small sub-area inside the SMGAs. Then we propose multi-scale heterogeneous model as a recipe of predicting strong ground motions for mega-thrust subduction earthquakes. Recent other Mw 9.0 class subduction earthquakes such as the 2004 Mw 9.1 Sumatra earthquake and the 2010 Mw 8.8 Maule earthquake are known to have almost the same period-dependent source model mentioned above. However, the M 8 class earthquakes such as the 1978 Mw 7.8 Miyagi-oki earthquake and the 2003 Mw 8.3 Tokachi-oki earthquake seem to have different characteristics, showing that the strong motion generation areas locate inside large slip areas considered to be "asperity" . Then, the asperity areas have two to four times larger than the strong motion areas.

Keywords: the 2011 Tohoku earthquake, subduction earthquake, strong ground motion, characterized source model, strong motion generation area, the empirical Green's function method

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

SSS25-11 Room:A04 Time:May 25 11:45-12:00

Field Survey for the Memorial Matters from the 1923 Great Kanto Earthquake in Western Kanagawa Prefecture, Japan

TAKEMURA, Masayuki[1*]

[1]Disaster Mitigation Research Center, Nogoya-Univ.

Many memorial towers and monuments have been contracted for the heavy toll of life and for the restoration of villages or cities in Southern Kanto district. Death claimed a toll of about 105000 totally from the 1923 Great Kanto earthquake. These towers and monuments must be forever witnesses to the tragedy of the earthquake damage and spokesmen for the victim's dying wish "don't repeat such damages". However, most of them have been already forgotten by the citizens. We thought it's sacrilege and must use them for the public education of earthquake disaster prevention. This manuscript is a report on the field survey for the memorial matters from the Great Kanto earthquake in Western Kanagawa Prefecture and Atami, Ito Cites. The number of the matters is 170. This survey will be continued to the next year in Eastern Kanagawa Prefecture. The survey in Central Kanagawa Prefecture had been summarized in the last year.

Keywords: Great Kanto Earthquake, Memorial tower, Kanagawa Prefecture

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

SSS25-12 Room:A04 Time:May 25 12:00-12:15

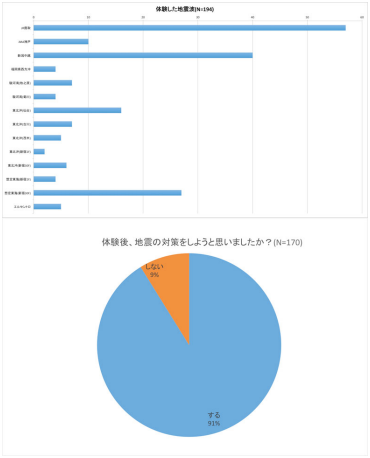
Effects on disaster prevention by The Portable Earthquake Simulator ”Jishin-The-Vuton”

AZUMA, Hiroki[1*] ; NAITO, Shohei[1] ; FUJIWARA, Hiroyuki[1]

[1]NIED

This page is intentionally blank.

Keywords: ”Jishin-The-Vuton”, Strong motion experience, measurement on countermeasure



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

SSS25-13 Room:A04 Time:May 25 12:15-12:30

Wave features Theory and Liquefaction

NISHIZAWA, Masaru[1*]

[1]none

Large liquefaction have an effect on many many house and building.

Conclusion
(1) Large-scale liquefaction, the building is greatly influenced rolation because of a phase shift.
(2) The main point of liquefaction, look carefully wave features of principal shock.
(3) In case of large-case liquefaction, wave mechanics theory is necessary.

Keywords: Wave Features Theory, Liquefaction, Phase, Rolation

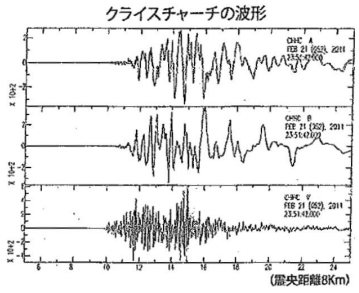


図-1

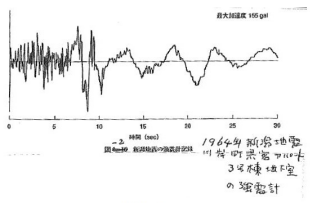


図-2

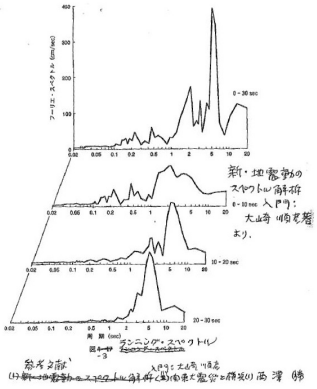


図-3

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

SSS25-14 Room:A04 Time:May 25 12:30-12:45

An additional correction term of ground-motion prediction equation for intra-plate earthquakes

MORIKAWA, Nobuyuki[1*] ; FUJIWARA, Hiroyuki[1]

[1]NIED

Intra-slab earthquakes, which occur in a subducted ocean plate, radiates short-period seismic waves strongly compared with an inter-plate earthquakes with the same magnitude. It is pointed out that the strength of short-period seismic waves depends on the focal depth of the earthquake or has a difference by the plate. On the other hand, it is also pointed out that the radiation of short-period seismic waves from an outer-rise earthquake is as strong as that from an intra-slab earthquake whose focal depth is deep.

These things mean that it is important to model radiation characteristic of short-period seismic waves appropriately in the prediction of strong ground motions for intra-plate earthquakes. We propose a new ground-motion prediction equation (GMPE), but focal depth and/or plate dependence of the ground motion intensities are not considered. So we analyze strong ground motion records to investigate a new additional correction term of our GMPE for intra-plate earthquakes.

First we calculate the difference between observed amplitude and predicted one by using our GMPE for each records. And then we obtain ”the source value” by averaging the difference for each earthquake and ”the site value” by averaging the difference for each observation site. We examine the relation between ”the source value” and the focal depth or difference in plates.

The ”source value” of an intra-plate earthquake in the Pacific plate is large compared with an earthquake in the Philippine Sea plate. In addition, ”the source value” becomes larger so that the focal depth becomes deeper. However, it is difficult to distinguish the effects of focal depth and/or different plates, because focal depths of intra-plate earthquakes in the Pacific plate are deeper than those in Philippine Sea plate in general. Therefore we think that it is better to model only one of these as the additional correction term of our GMPE.

Keywords: intra-slab earthquakes, outer-rise earthquakes, ground-motion prediction equation

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

SSS25-15 Room:A04 Time:May 25 14:45-15:00

Attenuation characteristics of strong ground motions in Chugoku, Shikoku and Kyushu distrints

IKEURA, Tomonori[1*]

[1]Kajima Tech. Res. Inst.

I investigated attenuation characteristics of strong motions using data of K-NET and KiK-net in the southwest Japan. First, I evaluated relative site factors of 630 sites of K-NET and KiK-net in the area using adjacent sites network method[Ikeura and Kato,2011]. Secondly I converted spectra observed at those sites during large earthquakes to ones of base rock motions by cancelling site amplification effect using the relative site factor of each site. The converted high frequency amplitudes from the 2000 Western Tottori earthquake clearly show linear attenuation curves in the distance range of 10 to 500km. The converted amplitudes of the 2001 Geiyo earthquake, which occurred at the depth of 46 km in Philippine sea plate, also shows almost linear distribution in the distance range of 50 to 400km. In contrast with these events, the converted amplitudes of the 2014 Iyo-nada earthquake, which occurred at the depth of 78 km in Philippine sea plate, showed widely dispersed distribution, indicating complex attenuation characteristics due to tectonic setting beneath these area. Lower limit of the wide distribution is characterized by western sites beyond volcanic zone in Kyushu district, while upper limit is characterized by eastern sites in the fore arc area of Chugoku district and in Shikoku district.

Keywords: strong motions, attenuation characteristics, site factor, southwest Japan

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

SSS25-16 Room:A04 Time:May 25 15:00-15:15

Study on frequency and hypocentral distance dependent radiation coefficient

NAGASAKA, Yosuke[1*] ; NOZU, Atsushi[1]

[1]Port and Airport Research Institute

Modeling radiation coefficient is important because radiation coefficient transits from theoretical to average value at the frequency range that is important for structures.

We have investigated the records of the 2000 Western Tottori Earthquake and modeled frequency and hypocentral distance dependent radiation coefficient. We modeled the radiation coefficient as a weighted average of the theoretical and average radiation coefficient and the weighting coefficient is modeled so that it depends on frequency and hypocentral distance. We propose a weighting coefficient alpha expressed as α=exp(-πfr/$Q_R V_S$). This means that the radiation coefficient approaches to the average value as the number of waves between the hypocenter and a station increases. Q_R is a coefficient that determines the dependence on frequency and hypocentral distance.

In this study, we apply the model to smaller earthquakes in order to eliminate the effect of complex source process that prevents from setting one theoretical radiation coefficient for each station.

Keywords: radiation coefficient, strong ground motion simulation

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

SSS25-17 Room:A04 Time:May 25 15:15-15:30

Effects of Accretionary Prisms on Long-Period Ground Motions Associated with Velocity Structure Models and Sources

GUO, Yujia[1*] ; KOKETSU, Kazuki[1] ; MIYAKE, Hiroe[1]

[1]Earthquake Research Institute, University of Tokyo

Subduction earthquakes along the Nankai Trough can generate significant long-period ground motions in the Osaka, Nobi, and Kanto basins. Accretionary prisms along the Nankai Trough play an important role to excite and prolong long-period ground motions. Yamada and Iwata (2005), Yoshimura *et al.* (2008), and Watanabe *et al.* (2014) reported that accretionary prisms can reduce amplitudes of direct waves and prolong durations of later phases. Goto and Nagano (2013) and Watanabe and Kato (2013) implied that the source location can control accretionary prism effects. Three-dimensional velocity structure models have been constructed for ground motion simulations in Japan. However, these models contain a larger uncertainty at the ocean region rather than the land region. There are only a few studies to validate S-wave velocity structure models, which affect seismic waves significantly. To evaluate precisely accretionary prism effects on long-period ground motions, we should take into account not only the uncertainty of velocity structure models but also the source diversity of subduction earthquakes. Furthermore, it is important to discuss accretionary prism effects in different frequency ranges, since long-period ground motions with different dominant periods are excited in the Osaka, Nobi, and Kanto basins.

We here performed three-dimensional simulations of long-period ground motions for the event (M_w 7.2) that occurred off the Kii peninsula at 10:07 on 5 September 2004 (UT), to clarify the variation of accretionary prism effects resulting from different accretionary prism models. Our simulations used three kinds of velocity structure models that are composed of a different accretionary prism model: (A) the Japan Integrated Velocity Structure Model (Koketsu *et al.*, 2008. 2012); (B) the model where the accretionary prism layer in the Model A is replaced with accretionary prism layers presented by the previous studies as Takahashi *et al.* (2002), Fujiwara *et al.* (2009, 2012), and Tsuji *et al.* (2011, 2014); (C) the model without accretionary prisms by replacing the S-wave velocity with 3.2 km/s. Long-period ground motions simulated for these models were compared in several frequency ranges. A finite element method with voxel meshes (Ikegami *et al.*, 2008) was used for simulations, and topography, ocean water as well as an attenuation with constant Q-value were implemented into the code. The valid frequency range was 0.05-0.3 Hz. We assumed the point source of Yamada and Iwata (2005) and used the source time function of Yagi (2004).

We then focused on the dependence of accretionary prism effects on seismic source as pointed out by previous studies, and investigated the performance of accretionary prism effects in terms of source location and rupture propagation effect using the above method and velocity structure models. We assumed several finite source models estimated by the Cabinet Office of Japan (2012).

Our simulations suggested that amplitudes of direct waves are not always smaller than those for the model without accretionary prisms, which is not consistent with the previous studies. In the Osaka and Nobi basins, the amplitude of peak ground motions at sites where sedimentary layers are thick is sensitive to the change of accretionary prism models. On the other hand, in the Kanto basin, such sensitivity is not significant and peak ground motions are attenuated because the main arrivals to the Kanto basin propagate through the accretionary prisms. We confirmed a difference in propagation characteristics at the eastern edge of the accretionary prisms between the Models A and B: for the Model B, later phases with periods of 9-12 sec at the Izu peninsula and the Kanto basin have a potential to be developed. We also indicated that the amplification effect of accretionary prisms on later phases is enhanced in the forward direction of rupture propagation for shallow sources located near the trough axis.

Keywords: Long-period ground motion, Accretionary prism, Nankai Trough, Subduction earthquake, Ground motion simulation, Velocity structure model

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

SSS25-18 Room:A04 Time:May 25 15:30-15:45

Long-period ground-motion observations and simulations in the Nankai Trough, southwest Japan

NAKAMURA, Takeshi[1*] ; TAKENAKA, Hiroshi[2] ; OKAMOTO, Taro[3] ; OHORI, Michihiro[4] ; TSUBOI, Seiji[1]

[1]Japan Agency for Marine-Earth Science and Technology, [2]Okayama University, [3]Tokyo Institute of Technology, [4]University of Fukui

We deployed a dense-array seafloor seismic observatory in the source area of great subduction earthquakes in southwest Japan in 2010. We observed the development of long-period motions in the seafloor strong-motion data at a moderate inland event (Mw 5.8) occurred in April 2013. The observed seismic waveforms are significantly prolonged and amplified, which does not agree with an empirical relation of amplifications for epicentral distances. We reproduce these features of waveforms at the seafloor stations in the period range of 10-20 s with FDM simulations and demonstrate the significant effects of seawater and sediment structures in ocean area on seismic wavefields. The long-period motions are predominantly caused by the propagation of surface waves developed within sediment layers in the subduction area. For the motions of the vertical component, the presence of a seawater layer also contributes to the developments. The snapshots in the cross section in depth show more trapped seismic energies and slower seismic-wave propagation in the subduction area than those in the land area, which produces the amplified and prolonged long-period motions at the seafloor stations. The snapshots in the horizontal plane show the distortion of concentric wave trains propagating from the source, indicating significant lateral variations of seismic velocity structures between land and ocean areas. The long-period range we analyzed is very important for magnitude estimations and moment tensor and finite-source analyses at great subduction earthquakes. Our observation and simulation results highlight the importance of ocean-specific structures for the seismic wave propagation and would contribute to advancing the seismic source studies and the strong-motion prediction by using seafloor station data.

Keywords: Long-period ground motion, strong motion, Nankai Trough, seafloor observation, DONET

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

SSS25-19 Room:A04 Time:May 25 15:45-16:00

Approach to broaden the period-range of long-period ground motion evaluation based on theoretical method

MAEDA, Takahiro[1*] ; IWAKI, Asako[1] ; MORIKAWA, Nobuyuki[1] ; IMAI, Ryuta[2] ; AOI, Shin[1] ; FUJIWARA, Hiroyuki[1]

[1]NIED, [2]Mizuho Information & Research Institute, Inc.

We have simulated long-period ground motions generated by megathrust earthquakes using various source models and 3D velocity structure model by the 3D finite difference method. To consider the influence of simulated ground motions on buildings, the analyzing period range of our simulation (3 - 20 seconds) was too long for most buildings. In this study, we examine the effects of more detailed velocity structure and seismic source models to broaden the analyzing period range.

As for the structure model, we used a newly constructing subsurface structure model (Senna et al., 2013, JDR) for the southern Kanto area. This model includes not only a deeper structure model but shallower layers than the engineering bed rock. By constructing deep and shallow structure model simultaneously, it is expected to improve ground motion simulation for period from 0.5 to 2 seconds. We assume two velocity structure models; one has shallow structure (Vs=250m/s) as a surficial layer (SD model) and other includes only the deep structure model (surficial layer has Vs of 500m/s) (D model). By comparing the simulated results assuming a point source, peak amplitude and duration for SD model are larger than those of D model. Simulated Fourier spectra indicated that the difference of two models is dominant at period shorter than about 2 second.

As for the source model, we used a characterized source model and uniform rupture velocity was assumed. In this study, we introduce a multi-scale heterogeneity (Sekiguchi and Yoshimi, 2006) to rupture propagation. We construct 274 source models for the Sagami Trough megathrust earthquake assuming different source area, hypocenter and asperity configuration and put the rupture heterogeneity on these source models. Influence of the rupture heterogeneity seems larger for shorter period range and is vary with hypocenter and asperity configuration.

To broaden a valid period range of long-period ground motion simulation, the shallow slower velocity layers and multi-scale heterogeneity of source model are worth taking it consideration. In addition, considering the appropriate simulation method is important, especially for long-period ground motion simulation, which needs a long-duration calculation.

This study was supported by the Support Program for Long-Period Ground Motion Hazard Maps by the Ministry of Education, Culture, Sports, Science and Technology (MEXT).

Keywords: long-perido ground motion, FDM, velocity structure model, multi-scale heterogeneity

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

SSS25-20 Room:A04 Time:May 25 16:15-16:30

Broadband ground motion simulation techniques applied to megathrust earthquakes in the Sagami trough

IWAKI, Asako[1*] ; MAEDA, Takahiro[1] ; MORIKAWA, Nobuyuki[1] ; FUJIWARA, Hiroyuki[1]

[1]NIED

Long-period (~1s and longer) ground motion are generally evaluated by a theoretical computation method based on appropriate models of rupture process and three-dimensional (3D) wave propagation process. We have been working on seismic hazard assessment for long-period ground motion of various scenarios of the megathrust earthquakes in the Sagami trough (e.g. Iwaki et al. 2014, JEES). The period range of the analysis was limited to 3s and longer due to the resolution of the source and velocity structure models.

On the other hand, it is necessary to include shorter-period ground motion to the seismic evaluation as the source fault on the Sagami trough lies directly beneath the metropolitan area. In order to achieve this goal, Maeda et al. (2015, this meeting) apply short-scale source and velocity structure models in the ground motion simulation by theoretical computation method. This paper presents alternative approach: broadband ground motion simulation techniques that include stochastic or semi-empirical methods.

We apply the “hybrid method” for broadband ground motion simulation by NIED (e.g. Senna et al. 2004) to M8 class earthquakes in the Sagami trough. It is the hybrid of finite-difference method (FDM) and the stochastic Green’s function (SGF) method in the long- and short-period ranges, respectively. In addition, we try another method proposed by Iwaki and Fujiwara (2013) and compare the methods. The latter method simulate high-frequency (short-period) ground motion using low-frequency (long-period) ground motion and the empirical “envelope ratio function (ERF)” between high- and low-frequency acceleration envelopes.

For both methods, the long-period ground motion is computed by a 3D FDM (GMS; Aoi et al., 2004) and combined with the short-period ground motion at the cross-over period 2s.

We compared the methods in terms of the computed velocity waveforms and Fourier spectra at several sites within the Kanto plain. The amplitude levels of the main motion for the two methods are similar to each other. However, the considerable difference is observed at some sites in the later phases where hybrid method produces smaller short-period components.

In order to compare and investigate the appropriateness of the two methods, it is necessary to compare the resulting ground motion with the GMPEs. We aim to utilize these methods in broadband seismic hazard evaluation.

Keywords: megathrust earthquake, long-period ground motion, broadband ground motion, Sagami trough, Kanto plain

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

SSS25-21 Room:A04 Time:May 25 16:30-16:45

Simulation of irregular wave generation due to fault formation by an elasto-plastic finite deformation analysis

YAMADA, Shotaro[1*] ; NODA, Toshihiro[1] ; ASAOKA, Akira[2]

[1]Nagoya University, [2]Association for the Development of Earthquake Prediction

The authors, in the past study[1)], simulated shear bands formation in ground due to strike-slip fault by using a soil-water coupled finite deformation code taking into inertia force, ***GEOASIA***[2)]. In the present study, the analysis code was employed to simulate formation of normal and reverse faults and wave generation due to the formation assuming a ground composed of a highly brittle soil. The analysis code mounts the SYS Cam-clay model[3)] as an elasto-plastic constitutive model which can describe a wide variety of soils within the same theoretical framework. Also, since the rate-type equation of motion is precisely time-integrated, progressive failure will be analyzed as a nonlinear dynamic problem, and then generation and/or propagation of waves induced by shear bands formation will also naturally be developed in the analysis[4),5)]. Making use of this characteristic, wave generation induced by fault formation was focused on. When the ground was compressed from lateral faces by displacement control under plane strain condition, a reverse fault-like failure was generated as a progressive failure with strain localization (Figure 1). At that time, elastic energy accumulated on the non-destructive area at the compression stage was released at once. In the case of a horizontally stratified ground, as failure progresses rapidly, acceleration motion was reached to the max. at first motion and decayed exponentially with time in a similar way that artificial earthquake shows (Figure 2). On the other hand, in the case of a ground with initial random imperfections, as some small failure events exist in a large failure event, an irregular wave like a natural seismic wave was generated (Figure 3). On the other hand, when the ground with the initial random imperfections was extended from lateral side by strain control, a normal fault was generated and another irregular wave was generated.

1) Noda, T., Yamada, S., Asaoka, A. and Kawai, Y. (2014): Numerical simulation of shear bands formation in ground due to strike-slip fault, *Japan Geoscience Union Meeting 2014*, SSS31-08.
2) Noda, T., Asaoka, A. and Nakano, M. (2008): Soil-water coupled finite deformation analysis based on a rate-type equation of motion incorporating the SYS Cam-clay model, *Soils and Foundations*, **48(6)**, 771-790.
3) Asaoka, A., Noda, T., Yamada, E., Kaneda, K. and Nakano, M. (2002): An elasto-plastic description of two distinct volume change mechanisms of soils, *Soils and Foundations*, **42(5)**, 47-57.
4) Noda, T., Xu, B. and Asaoka, A. (2013): Acceleration generation due to strain localization of saturated clay specimen based on dynamic soil-water coupled finite deformation analysis, *Soils and Foundations*, **53(5)**, 653-670.
5) Asaoka, A., Yamada, S. and Noda, T. (2013): Numerical analysis of failure of soil ground due to surface loading and generation of vibration induced by the failure, *Japan Geoscience Union Meeting 2013*, SSS28-18.

Keywords: natural fault, reverse fault, seismic wave, strain localization, inertial force, elasto-plastic body

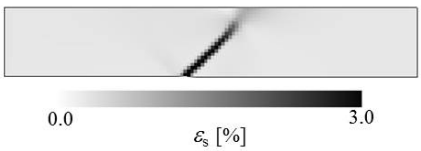


Figure 1. Reverse fault-like failure (shear strain distribution)

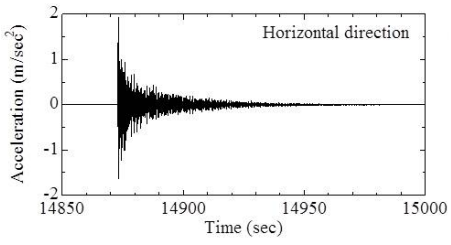


Figure 2. Wave generated in a horizontally stratified ground

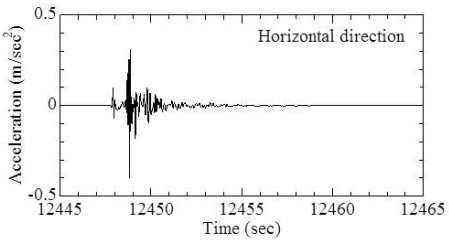


Figure 3. Wave generated in a ground with initial random imperfections

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

SSS25-22 Room:A04 Time:May 25 16:45-17:00

Estimation of shallow shear wave velocity in Bandung basin, Indonesia using horizontal to vertical (H/V) spectral ratio

PRAMATADIE, Andi muhamad[1*] ; CHIMOTO, Kosuke[1] ; AFNIMAR, Afnimar[2] ; YAMANAKA, Hiroaki[1]

[1]Tokyo Institute of Technology, [2]Bandung Institute of Technology

Bandung, the third populous city in Indonesia with population of around 2.7 million, is located in the western part of Java island. The city lies on a basin structure called Bandung basin. The concern of seismic risk in this area becomes important as existing of 24 km-long Lembang fault in the northern part. As part of potential seismic hazard estimation, Microtremors measurement is one of effective tool to estimate shear wave velocity profile and site amplification factor, especially in the urban area. A 3 component microtremors measurement is conducted in 76 sites to observe horizontal-to-vertical (H/V) spectral ratio that reflected to the ground characteristic. In the previous work, the obtained shear wave velocity models from Spatial Autocorrelation (SPAC) are used as reference model. Estimation of the ground structures are using the tuning factor to fitting the observed H/V spectrum with the theoretical ellipticity of fundamental mode of Rayleigh wave from the velocity model. From the obtained velocity model, we observed the thicknesses of soft layer (<500 m/s) from north to south of basin are changing from around 8 to 12 m in edge of basin area and around 40 m at the central of basin. The obtain profiles provide detail structure information in Bandung basin. Also the calculation of AVS30s and site amplification factor were conducted in each site, to understand the potential seismic hazard in the area. We also discuss a spatial variation of the amplification of earthquake ground motion using the obtained profiles.

Keywords: H/V spectral ratio, S-wave velocity, shallow soil, Bandung basin, amplification

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

SSS25-23 Room:A04 Time:May 25 17:00-17:15

An evaluation to trace phase of surface wave using the seismic interferometry

MOTOKI, Kentaro[1*] ; KATO, Kenichi[1]

[1]Kobori Research Complex

Using seismic interferometry, group velocities between 2 sites have been successfully evaluated from microtremor long term records by previous researches. If seismic interferometry can reproduce Green's function, we can estimate not only group velocities but also phase traces. In this study, we propose a method to evaluate propagation of surface waves, confirm the validity through the numerical test, and show application to the observed data.

We calculate deconvolution waveform against cross correlation at the end of the target area, in order to trace the propagation of surface waves on the target area. In numerical test, the waves from the surrounding sources were calculated using the reciprocity theory to represent the equipartition wave field. We set subsurface structure the 2 layer models, which are stratified model, 2 dimensional irregular model and 3-dimensional irregular model. The Green's function, which was regarded as a correct result, was calculated by the point force with FDM, and we confirmed the validity of the result of seismic interferometry.

The result of seismic interferometry of the stratified model corresponds to the result of Green's function. With the 2 dimensional and 3 dimensional irregular models, the result of the seismic interferometry successfully reproduced the Green's function only for the propagation from the rock area to the sedimentary area, and it is necessary to pay an attention about the direction in calculation of deconvolution and seismic interferometry.

We apply this method to Hi-net stations whose codes are N.ICWH and N.ICEH. The results using 2 reference sites are consistent each other and correspond to the results using 3 dimensional subsurface model.

For future works, we will apply this method near the edge of the Kanto basin to trace the generation of the surface wave induced by basin edge.

Keywords: seismic interferometry, deconvolution

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

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

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).

References

[1] Okamoto, T. and Takenaka, H., *Advances in Geosciences*, **13** (Solid Earth), p.215-p.229, World Scientific Pubishing, 2009.
[2] Okamoto, T. and Takenaka, H., *Earth Planets Space*, **61**, e17-e20, 2009.
[3] Kisimoto, K., *Geological Survey of Japan, Open-file Report*, No. 353, 2000.
[4] Fujiwara, H. et al., *Technical Note of the National Research Institute for Earth Science and Disaster Prevention*, No.337, 2009.
[5] Baba, T. et al., *Abstr. Japan Geoscience Union Meet.*, S111-006, Makuhari, Japan, 2006.
[6] Nakamura, T. et al., *Abstr. Seism. Soc. Japan*, P1-06, Hiroshima, Japan, 2006.
[7] Okamoto, T. et al., *Earth Planets Space*, **62**, 939-942, 2010.
[8] Okamoto, T. et al., *GPU Solutions to Multi-scale Problems in Science and Engineering*, 375-389, Springer-Verlag, 2013.

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

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

SSS25-P03 Room:Convention Hall Time:May 25 18:15-19:30

On National Seismic Hazard Maps of Japan 2014 edition

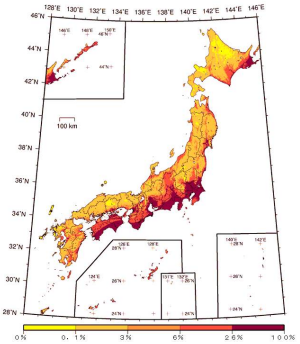
JISHINHONBU, Jimukyoku[1*]

[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
(May 24th - 28th at Makuhari, Chiba, Japan)

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
(May 24th - 28th at Makuhari, Chiba, Japan)

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

T. Ishii (2012): Journal of Structural and Construction Engineering (Transactions of AIJ), Vol.77, No. 676, pp.843-850
K. Arai et al. (2014): 2014, Fall Meeting, The Seismological Society of Japan, S16-P19
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
(May 24th - 28th at Makuhari, Chiba, Japan)

SSS25-P06 Room:Convention Hall Time:May 25 18:15-19:30

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
(May 24th - 28th at Makuhari, Chiba, Japan)

SSS25-P07 Room:Convention Hall Time:May 25 18:15-19:30

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.

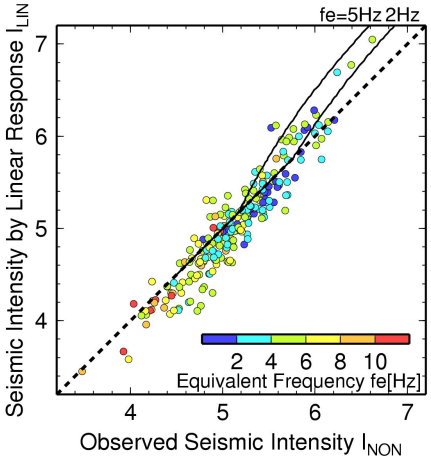
The seismic intensity by nonlinear site responses I_{NON} is modeled by seismic intensity by linear site responses I_{LIN} and the equivalent predominant frequency fe=PGA_{LIN} /($2\pi PGV_{LIN}$). Here PGA_{LIN} and PGV_{LIN} are the calculated peak ground acceleration and the peak ground velocity. 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.

SSS25-P07 Room:Convention Hall Time:May 25 18:15-19:30



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

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

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

SSS25-P09 Room:Convention Hall Time:May 25 18:15-19:30

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

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

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
(May 24th - 28th at Makuhari, Chiba, Japan)

SSS25-P11 Room:Convention Hall Time:May 25 18:15-19:30

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
(May 24th - 28th at Makuhari, Chiba, Japan)

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

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

SSS25-P13 Room:Convention Hall Time:May 25 18:15-19:30

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
(May 24th - 28th at Makuhari, Chiba, Japan)

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

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

SSS25-P15 Room:Convention Hall Time:May 25 18:15-19:30

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

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

SSS25-P16 Room:Convention Hall Time:May 25 18:15-19:30

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

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

SSS25-P17 Room:Convention Hall Time:May 25 18:15-19:30

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

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

SSS25-P18 Room:Convention Hall Time:May 25 18:15-19:30

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

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

SSS25-P19 Room:Convention Hall Time:May 25 18:15-19:30

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

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

SSS25-P20 Room:Convention Hall Time:May 25 18:15-19:30

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