Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

SSS23-01 Room:211 Time:May 1 09:00-09:15

Study on long strike-slip fault model with heterogeneous dynamic stress drops on asperities

OANA, Atsuko[1*] ; ISHII, Toru[1] ; DAN, Kazuo[1] ; FUJIWARA, Hiroyuki[2] ; MORIKAWA, Nobuyuki[2]

[1]Institute of Technology, Shimizu Corporation, [2]National Research Institute for Earth Science and Disaster Prevention

Oana *et al*. (2013) has established the long strike-slip fault model for a scenario earthquake along the Median Tectonic Line fault zone using the procedure for evaluating the fault parameters by Dan *et al*. (2011), and has simulated the strong ground motions. On that fault model, the dynamic stress drops on the asperities have been homogeneous. However, this is unnatural because the all stress drops on the asperities must be inhomogeneous in the actual earthquakes. How we consider the heterogeneity of the fault rupture is very important subject on the strong motion prediction, because the heterogeneity will have great effects on the spatial distribution of strong ground motions along a fault, especially along a very long fault. The uncertainty of the fault parameters also should be considered into the evaluation of the fault parameters.

In this study, for the strike-slip fault, the procedure for establishing the fault model which takes into account the heterogeneity of the dynamic stress drops on the asperities is examined, and then the spatial strong ground motions are simulated using the fault model based on the procedure. And also, some fault models with the uncertainty of the rupture starting point, the layout of the asperities, and the relationship between the asperity area and the dynamic stress drop on the asperity are established, and then the spatial strong ground motions are simulated using these fault models.

First, the procedure for establishing the fault model to give each asperity the heterogeneous dynamic stress drop is examined. Concretely, first, the probability density distribution of the stress drop is calculated based on the data of the stress drops on the strong motion generation areas of the past earthquakes by previous studies. And then, the procedure is proposed, that gives each asperity the dynamic stress drop corresponding to the frequency of the midpoint of the probability density distribution which is equally divided by the number of the asperity. Here, to satisfy the all relationships among the fault parameters of the asperity model is impossible. So we preceded satisfaction of the relationship formula of the seismic moment, and allowed an error between the obtained short period spectral level and the relationship formula of the short period spectral level. But the error became smaller than about 6 % of the short-period level of the fault model with the homogeneous dynamic stress drops on the asperities. As one of the ideas, we assumed that the relationship between the ratio of the asperity areas and the ratio of the dynamic stress drops on the asperities is random.

Next, for a scenario earthquake along the Median Tectonic Line fault zone, we established the long strike-slip fault model with the heterogeneous dynamic stress drops on the asperities based on the above proposed procedure, and also simulated the strong ground motions by the stochastic Green's function method. As a result, the deviation for the average of the attenuation relation by Si and Midorikawa (1999) of PGA became 0.20 and that of PGV became 0.16. Each deviation is smaller than 0.25, 0.23, which are derived from Si and Midorikawa (1999). It is concluded that this result is relevant, because the attenuation relation is based on a lot of observed records of various earthquakes and sites, while this study targets for the specific earthquake, the local pass, and the local site condition.

Finally, we examined the effect of the uncertainty of the source parameters for the strong ground motions. In the cases of the various rupture starting points, the deviation for the average of the attenuation relation of PGA became 0.23 and that of PGV became 0.21. In the cases of the various layouts of the asperities, those became 0.22 and 0.17, respectively. In the cases of the various relationships between the asperity area and the dynamic stress drop on the asperity, those bacame 0.20 and 0.17, respectively.

Keywords: Very long fault, Heterogeneity, Strong motion prediction

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

SSS23-02 Room:211 Time:May 1 09:15-09:30

Establishing procedure of evaluating fault parameters for predicting strong motions from intra-slab earthquakes with M8

ARAI, Kensuke[1*] ; DAN, Kazuo[1] ; ISHII, Toru[1] ; HANAMURA, Masaki[1] ; FUJIWARA, Hiroyuki[2] ; MORIKAWA, Nobuyuki[2]

[1]Shimizu Corporation, [2]National Research Institute for Earth Science and Disaster Prevention

For precise prediction of strong motions from intra-slab earthquakes, it is necessary to establish a new procedure of evaluating fault parameters based on the characteristics of intra-slab earthquakes. Although such studies had been conducted by Sasatani et al. (2006) and Dan et al. (2006), procedures of evaluating fault parameters were not fully validated by reproduction of the actual earthquake records. So, Arai et al. (2013) simulated the ground motions of the intra-slab earthquake that occurred off the coast of Miyagi Prefecture on April 7, 2011, and they pointed out the problem of existing procedures of evaluating fault parameters and suggested the ideas to overcome the problem. Hence, in this study, we simulated the ground motion of the intra-slab earthquakes with M8, the 1993 Kushiro-oki earthquake of January 15 (Mw 7.6) and the 1994 Hokkaido Toho-oki earthquake of October 4 (Mw 8.2), using the procedures of evaluating fault parameter proposed by Arai et al. (2013) and we pointed out the problem of the procedure.

In the case of the intra-slab earthquakes of the 1993 Kushiro-oki earthquake and the 1994 Hokkaido Toho-oki earthquake, there was a possibility that the results of evaluation of strong ground motions using the equation of the short period spectral level proposed by Sasatani et al. (2006) or Dan et al. (2006) became too small. So, we tried to use the procedures of evaluating fault parameter proposed by Arai et al. (2013). But, the fault model of the 1994 Hokkaido Toho-oki earthquake was unnatural because the short period spectral level of the earthquake estimated by Morikawa and Sasatani (2004) was too large. For this problem, we developed the new fault model using a method to reduce the fault area while increasing the short period spectral level. We also developed the fault model using a crack model.

We set fault models of the intra-slab earthquakes of the 1993 Kushiro-oki earthquake and the 1994 Hokkaido Toho-oki earthquake, which were derived from the relationships of intra-slab fault parameters by Sasatani et al. (2006), Dan et al. (2006), Arai et al. (2013), and the procedure developed here. And we also set the fault model using a crack model. By using these five fault models, we evaluated strong ground motions by the empirical Green's function method. As a result, in the case of the 1993 Kushiro-oki earthquake, ground motion evaluation results by using Sasatani et al. (2006) and Dan et al. (2006) were smaller than the actual records. On the other hand, ground motion evaluation results by using the Arai et al. (2013), the procedure developed here, and the procedure of using a crack model showed better agreements with the actual records. In the case of the 1994 Hokkaido Toho-oki earthquake, ground motion evaluation results by using Sasatani et al. (2006) and Dan et al. (2006) were smaller than the actual records. And ground motion evaluation results by using Arai et al. (2013), the procedure developed here, and the procedure of using a crack model were larger than the actual records especially in the period of 0.5 seconds or less. This may result from overestimation of the short period spectral level obtained by estimating the S-wave acceleration source spectrum by Morikawa and Sasatani (2004). Actually, the short period spectral level calculated from the fault parameters by Morikawa and Sasatani (2004) is smaller than the short period spectral level obtained by estimating the S-wave acceleration source spectrum. So, we will reconsider the short period spectral level of 1994 Hokkaido Toho-oki earthquake for setting fault models. In this study, we targeted the intra-slab earthquakes of the Pacific Ocean plate. The study on intra-slab earthquakes of the Philippine Sea Plate remains as a future subject.

Keywords: Intra-slab earthquakes, Strong motion prediction, Fault model

SSS23-03 Room:211 Time:May 1 09:30-09:45

Source effects of the intraslab and interplate earthquakes in Miyagi-ken-oki region based on spectral inversion

KASATANI, Naoya[1] ; KAKEHI, Yasumaro[1]*

[1]Faculty of Science, Kobe University

Previous studies showed that intraslab earthquakes generate stronger high-frequency waves than interplate earthquakes. For example, Satoh (2004) estimated the high-frequency levels of acceleration source spectra for seven intraslab earthquakes and four interplate earthquakes in Miyagi-ken-oki region. Their result showed the high-frequency level of intraslab earthquake is 3 to 4 times higher than that of interplate earthquake on the average. On the other hand, Katoh et al. (1999) estimated the excitation strength of high-frequency strong motions for intermediate-depth earthquakes based on the peak ground accelerations (PGA). Their result showed the focal depth is a key parameter controlling the PGA amplitudes rather than the difference of tectonic environments, such as intraslab or interplate earthquakes. Thus, the reason for the excitation strength of high-frequency waves of slab earthquake varies among studies, and this problem requires more precise investigation.

In this study, spectral inversion of NIED K-NET strong motion data is done to evaluate source effects of the intraslab and interplate earthquakes in Miyagi-ken-oki region. Then, seismic moments and corner frequencies are estimated from the evaluated source effects, and the high-frequency levels of the earthquakes are determined.

From the comparison between the intraslab and interplate earthquakes, the high-frequency levels of the former are 2 to 3 times higher than those of the latter. On the other hand, from the viewpoint of source depth, a clear trend is found that deeper earthquakes have higher high-frequency spectral levels. Here, it should be noted that the source depths of intraslab earthquakes are systematically larger than those of interplate earthquakes. Additionally, we find no significant difference between the spectral levels of intraslab and interplate earthquakes that have almost the same source depths. This is also seen for the difference between the spectral levels of upper-plane and lower-plane intraslab earthquakes.

Based on these results, we conclude (1) the trend that intraslab earthquakes have higher- high-frequency level than interplate earthquakes is apparent due to the fact that the former have systematically deeper source depths than the latter, and (2) the high-frequency level does not depend on the difference of tectonic environments, such as intraslab or interplate earthquakes, but on the source depth, and deeper earthquakes have higher high-frequency spectral levels. Difference of 4 times is seen between the high-frequency levels of deeper (~80 km depth) and shallower (~30 km depth) earthquakes for the depth difference of ~50 km.

Finally, we pick up two factors, other than source-originated ones, that may effect the evaluation of the high-frequency level: effect of the waveform difference depending on source depth and depth-dependent Q-value structure. These effects are evaluated quantitatively, and we conclude that they cannot bring such biases as can change the above-mentioned trend of the high-frequency level. Thus, we have successfully enhanced the reliability of our interpretation that deeper earthquakes have higher high-frequency spectral levels.

Acknowledgments: The strong ground motion data recorded by K-NET, KiK-net, and F-net of National Institute of Earth Science and Disaster Prevention and the hypocenter data of the unified hypocenter catalogue by the Japan Meteorological Agency were used for the analysis.

Keywords: spectral inversion, high-frequency level, intraslab earthquake, interplate earthquake, focal depth

SSS23-04 Room:211 Time:May 1 09:45-10:00

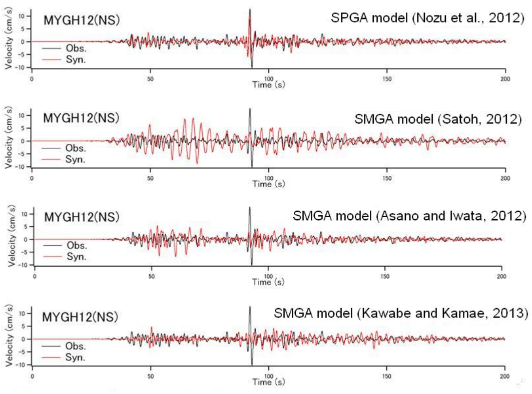
Comparative study of the performance of source models for the 2011 Tohoku earthquake

NOZU, Atsushi[1*]

[1]Port and Airport Research Institute

The 2011 Tohoku, Japan, earthquake is obviously the first M9 earthquake which was recorded by dense strong motion networks such as K-NET, etc. Several source models have been proposed to explain strong ground motions from this earthquake. It is significantly important to evaluate the relative performance of these models, especially in the frequency of engineering importance. From engineering point of view, the most striking feature of strong ground motions of the Tohoku earthquake is the generation of strong-motion pulses in the frequency range from 0.2 to 1 Hz observed at many sites along the coast of Miyagi through Ibaraki Prefecture. It is significantly important to consider the generation of such pulses in the strong-motion prediction for mega earthquakes, especially when the prediction is aimed at seismic design of structures. To model strong motion pulses from the Tohoku earthquake, a source model including nine subevents with relatively small size (on the order of several kilometers) was developed (Nozu et al., 2012). The model is called the 'SPGA model'. On the other hand, several 'SMGA models' have been proposed for the same earthquake, in which larger subevents (on the order of several tens of kirometers) are considered. In this study, the errors between the synthetic and the observed ground motions are evaluated for each of these source models. The result clearly indicates that the SMGA model cannot reproduce strong ground motions in the frequency range from 0.2 to 1 Hz, which is characterized by strong-motion pulses. In this frequency range, the performance of the SPGA model is significantly better than the SMGA models. The SPGA model also reproduces the seismic intensity proposed by Sakai et al. (2002), which is in good agreement with the building damage. Based on such results, the author concludes that the SPGA model should be used to calculate strong ground motions for a future mega earthquake as long as the strong motion prediction is aimed at structural safety.

Keywords: mega earthquake, the Tohoku earthquake, source model, strong ground motion, SPGA model, SMGA model



Observed (black) and synthetic (red) velocity waveforms (0.2 -1 Hz)
MYGH12, surface, NS

SSS23-05 Room:211 Time:May 1 10:00-10:15

A pseudo point-source model for off Miyagi intraslab earthquake on May 26, 2003

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

[1]Port and Airport Research Institute

In a recent research, a pseudo point-source model, which is a simplified version of the conventional characterized source model, was proposed and it was verified that the source model can be applied to the 2011 Tohoku earthquake, Japan. In the source model, the spatio-temporal distribution of slip within each subevent is not modeled. Instead, the source spectrum associated with the rupture of each subevent is modeled. For the future application of the source model, it is important to investigate its applicability to other destructive earthquakes.

In this study, the off Miyagi intraslab earthquake on May 26, 2003 is taken as an example, and the applicability of the pseudo point-source model is investigated. It was revealed that the source model can reproduce the waveforms and the Fourier spectra at least as well as the conventional characterized source model.

Keywords: pseudo point-source model, intraslab earthquake, strong ground motion, the 2003 off Miyagi earthquake

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SSS23-06 Room:211 Time:May 1 10:15-10:30

Strong ground motion simulation for the July 23, 2005 northwestern Chiba earthquake by pseudo point-source model

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

[1]Port and Airport Research Institute

We propose a pseudo point-source model (Nozu, 2012) of the July 23, 2005 northwestern Chiba earthquake. The model is developed for the benchmark test (Hisada *et al*., 2013) in which various strong ground motion generation methods are compared.

In the pseudo point-source model, detailed spatiotemporal slip distributions within a subevent are not considered. Instead, the source spectrum associated with the rupture of each subevent is specified and it is assumed to follow the omega square model. This model has been applied for some earthquakes and shows good agreement with observations.

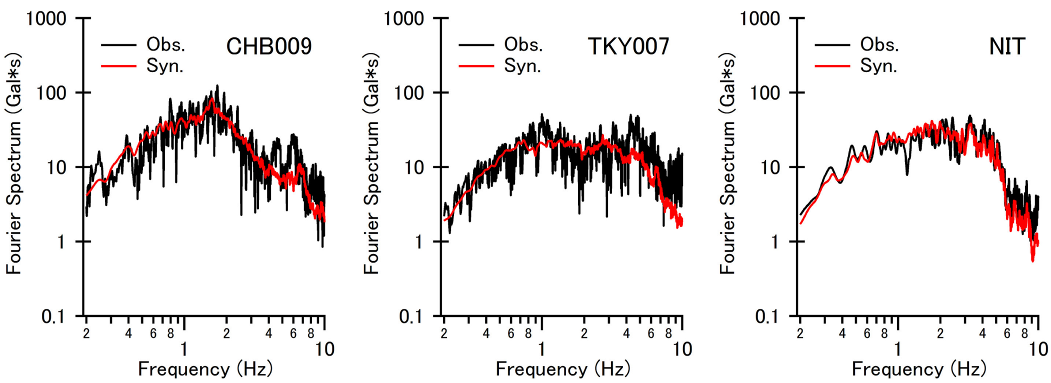
With this simplificationi, each subevent involves only six parameters, namely, longitude, altitude, depth, seismic moment, corner frequency and rupture time. In addition to these parameters, strike, dip and rake angles of the subevent are considered in this study in order to investigate the effect of radiation pattern while average value has been used in the previous studies. In this study, it is assumed that the theoretical radiation pattern becomes less evident with the increase of the hypocentral distance divided by the wavelength. This means that when the hypocentral distance is large of the wavelength is short, the radiation pattern is close to the average value rather than the theoretical value and vice versa. A new parameter Q_R is introduced to express this effect that determines how slowly the radiation pattern converges to the average.

The parameters for this particular earthquake are determined as follows. The hypocenter and the mechanism are from Koketsu and Miyake (2005). The seismic moment (=9.11×10^{17}Nm), the density (=3.2g/cm^3) and the S wave velocity (=4.46km/s) in the source region are from the F-net. The corner frequency (=0.75Hz) and Q_R(=10π) are determined so that the synthetic velocity waveforms and the Fourier spectra become consistent with the observations.

The site amplification factor for the K=net or KiK-net sites is from Nozu and Nagao (2005). For other sites (Building Research Institute and UR sites), the site amplification factors are newly determined by using the spectral ratio of the observed records between the target site and neighboring K=net or KiK-net stations. In terms of the Fourier phase information, we pick up 3 earthquakes before the main shock and chose the best one for each site.

As an example of the result, the synthetic Fourier spectra at 3 sites are compared with the observations (see the Figure).

Keywords: pseudo point-source model, benchmark test, the 2005 northwestern Chiba earthquake, radiation pattern, site amplification factor



Comparison of acceleration fourier spectrum
(CHB009 and TKY007: K-NET station, NIT: BRI station)

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SSS23-07 Room:211 Time:May 1 10:30-10:45

Three-dimensional grid modeling based on analysis of borehole data

KIMURA, Katsumi[1*] ; HANASHIMA, Yuki[2] ; NISHIYAMA, Shoichi[3] ; ISHIHARA, Yoshiro[4] ; SEKIGUCHI, Haruko[5]

[1]AIST, Geological Survey of Japan, [2]Smart Solution Corporation, [3]OYO Corporation, [4]Fukuoka University, [5]Kyoto University

The article presents a 3D geologic modeling method and applies it to build a subsurface 3D geologic model in the northern Tokyo and southern Nakagawa lowlands and the adjacent upland area. The modeling method, using borehole data for ground survey consists of (1) the surface modeling of the base of the Chuseki-so (the latest Pleistocene to Holocene incised-valley fill) , which has been improved by interpolating borehole data and (2) the 3D grid modeling of lithofacies and N-values constrained by the above surface model. The 3D grid model is very useful for not only geologic expression, but also the ground model of seismic response characteristics, because this can be converted to be S-wave velocity and density models.

Keywords: 3D model, ground, grid model, basal surface of the Chuseki-so, Tokyo lowland, borehole data

SSS23-08 Room:211 Time:May 1 11:00-11:15

Three-dimensional structure model for modeling strong motion around the Ryukyu arc

FUJIOKA, Akira[1] ; TAKENAKA, Hiroshi[2*] ; YAMADA, Nobuyuki[3] ; NAKAMURA, Takeshi[4] ; OKAMOTO, Taro[5] ; FUJIWARA, Hiroyuki[6]

[1]Kyushu Univ., [2]Okayama Univ., [3]Kyushu Univ. of Education, [4]JAMSTEC, [5]Tokyo Institute of Technology, [6]NIED

The Ryukyu Islands have frequently been damaged by large earthquakes and tsunamis since ancient times. For instance, in 1771, gigantic tsunamis are occurred from an earthquake and more than 12000 people died in Yaeyamya Islands. From the point of view of disaster prevention, it is also important to improve the precision of strong ground motion prediction. Here we build a 3D numerical structure model for modeling of strong ground motion, which includes land and ocean-bottom topographies and a seawater layer as well as subsurface structures of the arc side and the PHS slab, partially based on the J-SHIS model for near-surface structure (NIED) and a slab-top depth model of the PHS (Headquarters for Earthquake Research Promotion, Japan). We then try to improve the near-surface structure model in the islands using our original microtremor surveys. We also conduct numerical simulations of seismic motions for three sub-oceanic earthquakes occurring near the Amami Islands, Okinawa Island and Miyako Island to confirm the applicability of the constructed structure model and to check the improvement of the near-surface model.

Keywords: Ryukyu arc, strong motion, simulation

SSS23-09 Room:211 Time:May 1 11:15-11:30

3-D sedimentary layers model and simulation of seismic motions around the Tachikawa fault zone

SAGUCHI, Koichiro[1*] ; CHIMOTO, Kosuke[1] ; YAMANAKA, Hiroaki[1]

[1]Interdisciplinary Graduate School of Science and Engineering, Tokyo Institute of Technology

Tachikawa fault is one of the most activity faults in the western part of the Tokyo metropolitan area. Strong motion estimation is necessary to know the possible damage due to rupture of the fault considering effects of geological structure. However, a three-dimensional subsurface structural model is not well tuned in the vicinity of the fault.

In this study, we estimated a three-dimensional structure of deep sedimentary layers around the Tachikawa fault zone using Rayleigh wave phase velocity and horizontal-to-vertical spectrum obtained from microtremor explorations and receiver functions from the obtained records of the K-NET, KiK-net and SK-net. And we simulated seismic ground motions around the Tachikawa fault zone using the three-dimensional finite difference method to validate of a three-dimensional structure of deep sedimentary layers.

To accomplish it, we first conducted the array observations of microtremors at 12 sites around the Tachikawa fault. Rayleigh-wave phase velocity at periods from 0.5 to 5.0 seconds was estimated from a frequency-wave number spectral analysis of the microtremors. We next conducted the observations of microtremors at 268 sites on nine lines across the Tachikawa fault zone. Predominant periods of the H/V spectrum clearly indicated differences of subsurface structure across the Tachikawa fault.

Then, we conducted the joint inversion of the phase velocity and the receiver function to a P and S-wave velocity profile based on the simulated annealing method. P-wave velocities, S-wave velocities and thickness of individual layers are inverted very well, and the S-wave velocities of the inverted profile are 0.5, 0.9, 1.5, 2.4 and 3.2km/s. We constructed a three-dimensional structures of the deep sedimentary layers in this area from integrating the 1-D S-wave velocity profiles at all the stations. The basement depth at hanging-wall side of the Tachikawa fault is larger than that at foot-wall side with a difference of about 1.7km in the 3-D model.

Finally, we simulated seismic ground motions around the Tachikawa fault zone using the three-dimensional finite difference method considering three-dimensional velocity structure down to 50km. The results indicate that the maximum accelerations in simulated waveforms were similar to the observed one.

Keywords: Tachikawa fault zone, array microtremor exploration, Rayleigh wave phase velocity, 3-D sedimentary layers model, 3-Dfinite difference method

Japan Geoscience Union Meeting 2014
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SSS23-10 Room:211 Time:May 1 11:30-11:45

DETERMINATION OF S-WAVE VELOCITY STRUCTURE BY MICROTREMOR ARRAY OBSERVATION IN TEKIRDAG AND ZEYTINBURNU (TURKEY)

KARAGOZ, Ozlem[1*] ; CITAK, Seckin ozgur[2] ; CHIMOTO, Kosuke[1] ; YAMANAKA, Hiroaki[1] ; OZEL, Oguz[3] ; YALCINKAYA, Esref[3] ; ZANEIH, Hussam[1] ; ASKAN GUNDOGAN, Aysegul[4] ; KAOURU, Kojima[1] ; TOMOHIRO, Tsuchiya[1] ; AKSAHIN, Behiye[3] ; ILKAY, Sena[3] ; SISMAN DERAN, Fatma[4]

[1]Interdisciplinary Graduate School of Science and Engineering, Tokyo Institute of Technology, [2]Japan Agency for Marine-Earth Science and Technology (JAMSTEC), [3]Istanbul University,Department of Geophysical Engineering, Turkey, [4]Middle East Technical Uni.,Dept .of Civil Engineering and Dept. of Earthquake Studies,Turkey

The use of environmental vibration recordings (microtremors) is cost effective and easily collected data for site characterization that is a component of microzonation mapping and has become very popular around the world in the last years.

Local site conditions have a major effect on the level of ground shaking. For this reason we carried out microtremor measurements by using circular small array configuration at twenty one locations in Tekirdag, four locations in Zeytinburnu and one location in Yesilkoy. In addition to eight large array measurements for estimating S-wave velocity structures of shallow deeper soil formations for site effect analysis. These sites were selected by considering the different geological units (i.e. recent landfill, clay stone, silt stone, alluvium, lime stone, sand) in the cities. We also collected data on five buildings in Tekirdag in order to understand dynamics properties of buildings.

We estimated the phase velocities of Rayleigh waves at each site from the vertical components of recorded microtremor data by using Spatial Autocorrelation (SPAC) method. Obtained phase velocity dispersion curves are varied from area to area. The obtained phase velocities range from 100 m/s to 750 m/s along the coastline in Tekirdag while, they range from 200 m/s to 500 m/s for Zeytinburnu area.

Genetic Simulated Annealing Algorithm technique was applied for inversion of phase velocities to estimate 1-D S-wave velocity structures beneath the sites. The inverted Vs profiles are not uniformed. The preliminarily results show that similar phase velocity changes have been seen at the low and the high periods on the different geological units along the parallel direction of the coastline. When we check the velocity changes from coastline toward the inland, we can see the different phase velocities on the different geological units.

Keywords: Microtremor, Spac, S-wave velocity, Tekirdag, Zeytinburnu, Turkey

Japan Geoscience Union Meeting 2014
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SSS23-11 Room:211 Time:May 1 11:45-12:00

Characteristics of long-period strong ground motion in the Keihin-area during the 2011 Tohoku earthquake

UETAKE, Tomiichi[1*]

[1]Tokyo Electric Power Company

The velocity response spectra of 5% damping calculated from the observed data in the Keihin area during the 2011 Tohoku Earthquake had no significant peak at period of around 8 s and had peak over 100cm/s at period of around 3 s. The acceleration seismograms had spindle-shaped envelope and peak accelerations were recorded about 120 s after S-wave on-set. The maximum velocity response at period of around 3 s was recorded in the first half part of waveforms. It is important to realize the difference of wave propagation characteristics between in the first half part and the later part of the waveforms. In this article, the propagation characteristics of long-period strong ground motions during the 2011 Tohoku Earthquake were studied by semblance analysis using the data observed in the Keihin area.

Sixteen strong motion observatories in the Keihin area were used for array analysis. The major axis of the array area is about 18 km and minor axis is about 9km. Distance between adjacent observation points is from 0.6km to 5km. We performed semblance analysis using narrow-band pass filtered waveforms and evaluated the phase velocity for each time sections from the peak point of semblance in slowness plane. The center periods of the filters were 1, 2, 2.5, 3, 4, 5, 6, 7, 8, 9, 10, 12, 15 and 20 s. The length of time window for analysis was 20 s and the time windows were opened every 10 s in wave traces.

The peak semblance values were high for longer period waveforms and were lower value for short period waveforms. The value at period of 1 and 2s were lower than 0.5. The values calculated from large array data were lower than those from small array data. The semblance values in first part of waveform were high but the values in the later part show lower value. The phase velocities in first half part are over 3 km/s for all case. The phase velocities in later part were 1 to 2 km/s and showed the dispersion characteristics. The back azimuths of wave propagation in the first part indicated the epicenter direction but those in later part did not indicate constant direction especially in short period range.

To examine the relation between this dispersion characteristics and underground structure, we calculated phase velocities of surface waves using the underground structure model. The phase velocities evaluated in the first part were faster than phase velocity of the fundamental mode. The phase velocities evaluated for several last time windows in the later part coincided with the phase velocity of the fundamental mode. These characteristics are similar to the results from the data observed the Tokyo lowland area [Uetake (2013)].

Judging from the property of the acceleration waveform and a result of the semblance analysis, the waves caused large response in a period of 2-3 s were more likely to be a body wave not a surface wave of the fundamental mode.

The strong ground motion data used in this study were observed by TEPCO, K-NET of NIED, ERI, JMA, Tokyo Metropolitan office and Yokohama-City. I appreciate these organizations for making the data be available.

Keywords: Long-period strong ground motion, the 2011 Tohoku earthquake, Semblance analysis, Phase velocity, Keihin area

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SSS23-12 Room:211 Time:May 1 12:00-12:15

Characteristics of Long-period Ground Motion in the Osaka Sedimentary Basin due to the 2011 Great Tohoku Earthquake

SATO, Kayoko[1*] ; IWATA, Tomotaka[1] ; ASANO, Kimiyuki[1] ; KUBO, Hisahiko[1] ; AOI, Shin[2]

[1]Disaster Prevention Research Institute, Kyoto University, [2]National Research Institute for Earth Science and Disaster Prevention

The 2011 great Tohoku earthquake (Mw 9.0) occurred on March 11, 2011, and the largest aftershock (Mw 7.7) occurred in the Ibaraki-oki region, adjacent to south boundary of the mainshock's source region. Long-period ground motions (2?10s) of large amplitude were observed in the Osaka sedimentary basin about 550-800km away from the source regions during both events. We collected the strong motion records in and around the Osaka basin and analyzed the long-period ground motions. The amplitude of horizontal components of the ground motion at the site-specific period is amplified at each sedimentary station and its duration is prolonged. The predominant period is around 7s in the bayside area inside the Osaka basin where the largest pSv among the stations inside the Osaka basin were observed. The pSvs at the bedrock sites surrounding the Osaka basin also have their peak values around 7s.

Then, we focus on the propagation characteristics from the source region to the Osaka basin. We compared the pSvs of 7s at the sedimentary stations in the Osaka basin with those in the Kanto basin. The maximum pSv among the Osaka basin is comparable to the maximum pSv among the Kanto basin whose fault distance is about 500km nearer than the Osaka basin. Moreover, the amplitude of observed pSvs is systematically larger than prediction from the empirical attenuation relationship by Kataoka et al. (2008) at non-sedimentary stations in the region between the Nobi and Osaka basins. The large long-period ground motions in the Osaka basin might be generated by the combination of propagation-path and basin effects.

Thus, we simulate ground motions due to the largest aftershock using the three-dimensional Finite Difference Method (GMS; Aoi and Fujiwara, 1999). The reason we use the largest aftershock is that this event has a relatively small rupture area and simple rupture process compared to the mainshock. The size of the model space is 730km (EW) x 330km (NS) x 100km (Vertical) including the source region and the Osaka basin. A three-dimensional velocity structure model based on the Japan Integrated Velocity Structure Model (Koketsu et al., 2008, 2012) is assumed. The minimum S-wave velocity is 350m/s and the grid spacing in the sedimentary layers is 200m for horizontal direction and 100m for vertical direction, respectively. The minimum effective period in this computation is 3s. We estimated a point source using the long-period ground motions (4-10s) at a station close to the source region (KiK-net CHBH14) and used it for our simulation.

We compared the synthetic and observed waveforms in the periods of 4-10s. As well as the observed ones, the amplitude of synthetic waveforms was amplified and the durations were prolonged at the sedimentary stations in the Kanto basin, the Nobi basin and the Osaka basin. The feature of the attenuation relations in the region between the Nobi basin and the Osaka basin was qualitatively reproduced. At the period of 7s, the amplitudes of synthetic waveforms were little underestimated in the Osaka basin.

Finally, we simulate the ground motion during the mainshock. The model space is 730km (EW) x 400km (NS) x 100km (Vertical). The grid interval and velocity structure model are same as those for the largest aftershock. We assume two point sources based on the two southern SMGAs of the four SMGAs estimated by Asano and Iwata (2012). As a result of the simulation, the synthetic waveforms reproduced the observed ones qualitatively. Therefore, we conclude that the large long-period ground motions in the Osaka basin during both events mainly resulted from the combination of those two SMGAs, propagation-path and basin effects.

ACKNOWLEDGEMENTS

We used strong motion data recorded by K-NET, KiK-net and F-net of NIED, CEORKA, BRI, JMA, and Osaka prefecture. GMS provided by NIED is used for the computation.

SSS23-13 Room:211 Time:May 1 12:15-12:30

Long-period ground motion evaluation for the Nankai Trough megathrust earthquakes

MAEDA, Takahiro[1*] ; MORIKAWA, Nobuyuki[1] ; AOI, Shin[1] ; FUJIWARA, Hiroyuki[1]

[1]NIED

We evaluate long-period ground motions associated with the Nankai Trough earthquakes (M8~9) in southwest Japan. Large interplate earthquakes occurring around the Nankai Trough have caused serious damages due to strong ground motions and tsunami. Such large interplate earthquake potentially causes damages to high-rise and large-scale structures due to long-period ground motions. The long-period ground motions are amplified particularly on sedimentary basins, where big cities have been established. Therefore it is important to evaluate long-period ground motions as well as strong motions and tsunami for the anticipated Nankai Trough earthquakes.

The long-period ground motions are evaluated by the finite difference method (FDM) using " characterized source models " and the 3-D underground structure model. The parameters of the characterized source model are determined based on a " recipe " for predicting strong ground motion [Earthquake Research Committee (ERC), 2009]. We construct various source models (more than 300 scenarios) assuming various possible source parameters, including rupture area, asperity configuration, and hypocenter location. Each source region is determined by " the long-term evaluation of earthquakes in the Nankai Trough " published by ERC. The asperity configuration and hypocenter location control the rupture directivity effects. These parameters are important because our preliminary simulations are strongly affected by the rupture directivity (Maeda et al., 2013). We apply the system called GMS (Ground Motion Simulator) for simulating the seismic wave propagation based on 3-D FDM scheme using discontinuous grids (Aoi and Fujiwara, 1999) to our study. The 3-D underground structure model used in the FD simulation is the Japan integrated velocity structure model (ERC, 2012).

We evaluate the long-period ground motions using the peak ground velocity (PGV) and velocity response spectra (Sv). The simulation shows a large variation of PGV and Sv at a site. The large variation is important to understand the seismic hazard. The variation at the Kanto region, an eastern extension of the source area, seems larger than those at the Nobi and Osaka regions. The scenarios with wider source area have larger PGV and Sv than those with smaller source area. The large number of simulations of this study allows us to select scenarios that correspond to representative (e.g. average and maximum) response spectra at each site.

Keywords: Nankai Trough, long-period ground motion, megathrust earthquake, hazard assessment, GMS

Japan Geoscience Union Meeting 2014
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SSS23-14 Room:211 Time:May 1 12:30-12:45

Long-period ground motion evaluation for the Sagami Trough megathrust earthquakes

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

[1]National Research Institute for Earth Science and Disaster Prevention, [2]Mizuho Information & Research Institute, Inc.

It is important to assess seismic hazard in consideration of uncertainty and occurrence frequency in order to mitigate disasters from future earthquake. Iwaki et al. (2013) examined the influence of the long-period ground motion on uncertainty of asperity (strong motion generation area) or hypocenter location, and the heterogeneity of rupture velocity or slip direction for megathrust earthquakes occurring at the Sagami Trough region. They showed that the asperity or hypocenter location largely affects to the amplitude and predominant period of simulated long-period ground motions. Based on their results, we simulate long-period ground motions by a large number of source models considering the uncertainty of asperity or hypocenter location, and we try to assess long-period ground motion due to megathrust earthquakes occurring at Sagami Trough by evaluating the simulation results statistically.

We set ten source regions containing Taisho and Genroku earthquakes by changing those from Iwaki et al. (2013) referring the model by Central Disaster Council (2013). The range of moment magnitude (Mw) is 7.9 to 8.6 and total number of source model is more than 150. We use a ”characteristic source model” and source parameters are evaluated by following the method in ”Recipe” by Headquarters of Earthquake Research Promotion of Japan. We use a velocity structure model by Earthquake Research Committee (2012) but we revise the topography of the Philippine Sea plate based on recent researches. The long-period ground motions are simulated using a 3D finite difference method with discontinuous grid coded by Aoi and Fujiwara (1999). As long-period-ground motion hazard assessment, we first calculate average and slightly large (i.e. +1 sigma; sigma is the standard deviation) amplitude of peak velocity and velocity response spectrum whose natural period is 5, 7 and 10 seconds respectively on engineering bedrock for every ten source region. And then we integrate them by assuming the ”weight” which corresponds to occurrence frequency of each source region.

Although a large number of source models are set up in this study, the uncertainty on the megathrust earthquake occurring at Sagami Trough cannot be covered completely. So it should be required to examine much source models. On the other hand, the source region of magnitude 8-class earthquake at Sagami Trough extends to beneath the metropolitan area. In addition, it is said that the occurrence of the magnitude 7-class earthquake, which does not take in this study, is imminent in southern Kanto region. It is necessary to advance broadband ground motion hazard assessment also including a short-period ground motion.

Keywords: long-period ground motion, seismic hazard assessment, Sagami Trough, megathrust earthquake, GMS

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SSS23-15 Room:211 Time:May 1 14:15-14:30

Emplical ground motion model for long period motions and for long distance -Distance dependent geometrical spreading ter

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

[1]Kobori Research Complex Inc.

The GMPEs have been proposed by Sato et al.(2012), Kataoka et al.(2008), and Yuzawa and Kudo(2011). For predictions of long period ground motions on Kanto Plain for the Nankai Trough mega earthquake, the proposed GMPEs cannot be adopted because of the deficiency of applicable distance ranges. In order to establish an adoptable GMPE for long distance, we investigate the distance dependent geometrical spreading term.

We used records for magnitude equal to or greater than 5.0 and distance less than 1000 km. The dataset used in this study is provided by F-net, because of high sensitivity for long period motions and continuous recordings. Since the F-net stations can be regarded as hard rock sites, the site term was not taken into account in the regression.

First, we use a constant geometrical spreading and anelastic attenuation for distance. The regression curve at the 20sec of period decays more slowly than the average of records in the short distance less than 100km, and decays more steeply than records in the longer distance. It implies that the GMPE with a constant geometrical spreading term may underestimate near the source region and in the longer distance.

In the long period range, the dominance of seismic wave changes from the body wave to the surface wave according to the travelling distance, and the slope of the geometrical spreading depends on distance. We will evaluate the geometrical spreading term in the separated distance range to reveal how the geometrical spreading changes.

Keywords: long period motions, long distance, geometrical spreading

SSS23-16 Room:211 Time:May 1 14:30-14:45

Long-Period Ground Motion Prediction Equations and Their Application to the Magnitude Estimation of Large Earthquakes

IBRAHIM, Rami[1*] ; SI, Hongjun[1] ; KOKETSU, Kazuki[1] ; MIYAKE, Hiroe[1]

[1]Earthq. Res. Inst., Univ. Tokyo

We developed long-period ground motion prediction equations (GMPEs) for peak ground velocities (PGVs) and peak ground displacements (PGDs) in a period range of 5-30 s. We only used strong motion data of KiK-net downhole stations located in layers of shear-wave velocities equal to or greater than 2000 m/s. We confirmed that the site effects due to surface geology for long-period PGVs and PGDs can be ignored at these observation stations. The dataset consists of 20 earthquakes of $6 \leq M_w \leq 9.1$ occurred in and around Japan. Two-stage regression analyses were carried out to derive the GMPEs. We fit the data with bilinear regression lines bending at M_w 7.5. Additional factors of focal depth and earthquake type were found to enhance the fitting with the observed data. Our developed long-period GMPEs predict the PGVs and PGDs of crustal earthquakes are larger than those of inter-plate and intra-plate earthquakes. The attenuation coefficients presented in the current study indicate that the long-period PGVs and PGDs increase by increasing depth.

We used the long-period GMPEs developed in this study to estimate the moment magnitude by fitting observed PGVs and PGDs at period range of 5-30 s with GMPEs. We estimated the magnitudes of the same 20 earthquakes and the 2013 Awaji Island earthquake (M_w 5.8) recorded by downhole accelerometers of KiK-net. The results are consistent with the moment magnitudes from the Global CMT project. The method is useful to estimate the magnitude of giant earthquakes such as the 2011 Tohoku earthquake (M_w 9.1). The proposed method can estimate the moment magnitude quickly if information of source area is available.

Keywords: long-period ground motion, ground motion prediction equation, moment magnitude, PGV, PGD

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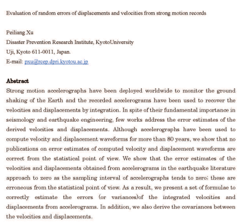
SSS23-17 Room:211 Time:May 1 14:45-15:00

Evaluation of random errors of displacements and velocities from strong motion records

XU, Peiliang[1*]

[1]Disaster Prevention Research Institute, Kyoto University

Strong motion accelerographs have been deployed worldwide to monitor the ground shaking of the Earth and the recorded accelerograms have been used to recover the velocities and displacements by integration. In spite of their fundamental importance in seismology and earthquake engineering, few works address the error estimates of the derived velocities and displacements. Although accelerographs have been used to compute velocity and displacement waveforms for more than 80 years, we show that no publications on error estimates of computed velocity and displacement waveforms are correct from the statistical point of view. We show that the error estimates of the velocities and displacements obtained from accelerograms in the earthquake literature approach to zero as the sampling interval of accelerographs tends to zero; these are erroneous from the statistical point of view. As a result, we present a set of formulae to correctly estimate the errors (or variances)of the integrated velocities and displacements from accelerograms. In addition, we also derive the covariances between the velocities and displacements.


Evaluation of random errors of displacements and velocities from strong motion records

Peiliang Xu
Disaster Prevention Research Institute, KyotoUniversity
Uji, Kyoto 611-0011, Japan.
E-mail: pxu@rcep.dpri.kyotou.ac.jp

Abstract

Strong motion accelerographs have been deployed worldwide to monitor the ground shaking of the Earth and the recorded accelerograms have been used to recover the velocities and displacements by integration. In spite of their fundamental importance in seismology and earthquake engineering, few works address the error estimates of the derived velocities and displacements. Although accelerographs have been used to compute velocity and displacement waveforms for more than 80 years, we show that no publications on error estimates of computed velocity and displacement waveforms are correct from the statistical point of view. We show that the error estimates of the velocities and displacements obtained from accelerograms in the earthquake literature approach to zero as the sampling interval of accelerographs tends to zero; these are erroneous from the statistical point of view. As a result, we present a set of formulae to correctly estimate the errors (or variances)of the integrated velocities and displacements from accelerograms. In addition, we also derive the covariances between the velocities and displacements.

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SSS23-18 Room:211 Time:May 1 15:00-15:15

Earthquake detection from strong ground motion observation network in Himalaya, India

MASUDA, Tetsu[1*] ; KOKETSU, Kazuki[1] ; TAKANO, Kiyoshi[2] ; FURUMURA, Takashi[2] ; OKI, Satoko[3] ; ITO, Takamori[3] ; CHADHA, Rajender kumar[4] ; SRINAGESH, Davuluri[4] ; SRINIVAS, Dakuri[4]

[1]Earthquake Research Institute, [2]University of Tokyo, [3]Keio University, [4]National Geophysical Research Institute

It is an important subject to establish the technical issues and environment of data acquisition and analysis of natural hazards for the disaster mitigation, the first aid and recovery planning. The Indo-Japanese collaborative project on 'Information Network for Natural Disaster Mitigation and Recovery' of 'Science and Technology Research Partnership Sustainable Development International Collaborative Research Program' supported by JST and JICA, Japan initiated strong ground motion observation, crustal movement measurement, and building vibration measurement in Indo-Gangetic plain and foot hills of Himalaya, India.

We started the strong ground motion observation network with deployment of broadband velocimeters and digital equipments at 26 sites near the seismic active region in Himalaya, India by October 2012. The continuous time history of ground motion is digitally recorded with high resolution. Because of the broadband response of the sensor and the high resolution of the recorder, it is expected that the long- period motions or weak ground motions from small local earthquakes and distant earthquakes will be recorded as well as the short-period strong ground motions. It is a necessary task for the seismic data analysis to detect earthquakes using continuous records from the network. In this paper, we present a method developed for fast and precise earthquake detection from continuous records of the network.

The stations of the network are located in the compounds of local schools. The ambient noise is not always low but it changes as well as contains abrupt increases. We developed a detection method with simple algorithm adequate for the noisy circumstances. We compared our detections with the earthquakes reported in the NEIC catalogue. Our results show that the network detected all earthquakes of magnitude 7 or more, more than 90% of magnitude 6.5 through 6.9, more than 50% of magnitude 6.0 through 6.4 regardless of epicentral distances, and more than 80% of magnitude 6 or more from epicentral distances less than 100 degrees.

Several local earthquakes with short S-P times which were not reported in the NEIC catalogue were also detected by the network. Local seismicity is an index of the stress status, and detection of local earthquakes is important to understand the stress distribution in a small region. The preliminary results show that the network will provide data from local and global earthquakes to study the local seismic activity in the Himalayan region, the propagation path effects from the source to the stations, amplification effects at sites, the physical process of the seismic source, and subsurface velocity structure.

Keywords: strong ground motion, observation, network, earthquake detection

SSS23-19 Room:211 Time:May 1 15:15-15:30

Liquefaction damage expansion caused by the generation of surface waves from base end section

NAKAI, Kentaro[1*] ; NODA, Toshihiro[1] ; MURASE, Kotaro[1] ; ASAOKA, Akira[2] ; SAWADA, Yoshihiro[2]

[1]School of Engineering, Nagoya University, [2]Association for the development of earthquake prediction

The 2011 off the Pacific coast of Tohoku Earthquake caused liquefaction to occur in reclaimed lands in Urayasu City and in other wide areas of reclaimed land along Tokyo Bay. One of the important characteristic of the observed liquefaction damage is that the level of liquefaction damage was nonuniform spatially, and the variation in the damage levels was large. The difference in damage levels in various parts has often been explained by the presence/absence of past ground improvement and by the difference in the dates of reclamation work. From the boring survey at Urayasu, thin layer of soft alluvial clay is located directly under the liquefiable layer on the inland side where liquefaction damage was small. However, the basement layer is inclining towards coast side and alluvial clay layer is increasing in thickness as approaching to the coast where liquefaction damage was severe. This paper examines the cause of extensive and nonuniform liquefaction damage observed in Urayasu City by focusing attention on the stratum inclination at the deeper part of the liquefiable layer with the use of 2D elasto-plastic seismic response analysis of the multi-layer ground. The analysis code employed in this report was the soil-water coupled finite deformation analysis code GEOASIA (Noda et al. 2008), which incorporates an elasto-plastic constitutive model (SYS Cam-clay model; Asaoka et al. 2002) that allows description of the behavior of soils ranging from sand through intermediate soils to clay under the same theoretical framework.

Fig.1 (a) illustrates the velocity vector distribution 50 sec after earthquake occurrence. Only the area around the sloped part is shown in this figure, and the scale in the vertical direction has been magnified by 2 times. Surface waves generate at the base end section of the inclination which shows orbit in a counterclockwise direction with ongoing wave propagation to the right-hand side. Excess pore water pressure ratio at the liquefiable layer is shown, superimposing the result of 1D analysis with same stratigraphic composition at the point. 2D analysis result shows liquefaction (excess pore water pressure ratio is greater than 0.95), even 1D analysis did not liquefy (Fig.1 (b)). In the case of 2D analysis, in addition to the magnitude, duration time of the oscillation increases in subsurface layer accompanied by the generation of surface waves (Fig.1 (c)). Excess pore water pressure ratio of 2D analysis continues to increase for a long period even after the primary earthquake motion. Fig.1 (d) illustrates the shear strain distribution 200 sec after earthquake occurrence. Although shear strains are small in the non-inclined horizontal strata, large strains are produced in the subsurface liquefiable layer. Furthermore, this strain distribution is nonuniform and localized even assuming homogeneous initial conditions for subsurface layer. The nonuniform, localized shear strain are due to the existence of the sloped boundary. In other words, in addition to the vertical component of seismic movement being generated by the stratum slope, multi-dimensional propagation is also exhibited because of complex reflection behavior in the diluvial layer. Moreover, in sloped layers such, the danger of liquefaction is increased compared with the one-dimensional model. The actual liquefaction damage observed in Urayasu City was heavy in the sloped stratum locations where midterm reclamation work had been executed. This behavior resembles the results of the analysis carried out here. The current analysis shows that even in the case of homogeneous geomaterials, stratigraphic nonhomogeneity results in large variations in ground deformation behavior and that such deformation becomes particularly large in sloped strata locations. These things cannot be taken into consideration in one-dimensional analysis and highlight the necessity of performing multi-dimensional effective stress analysis.

Keywords: liquefaction, stratum inclination, surface wave, effective stress analysis

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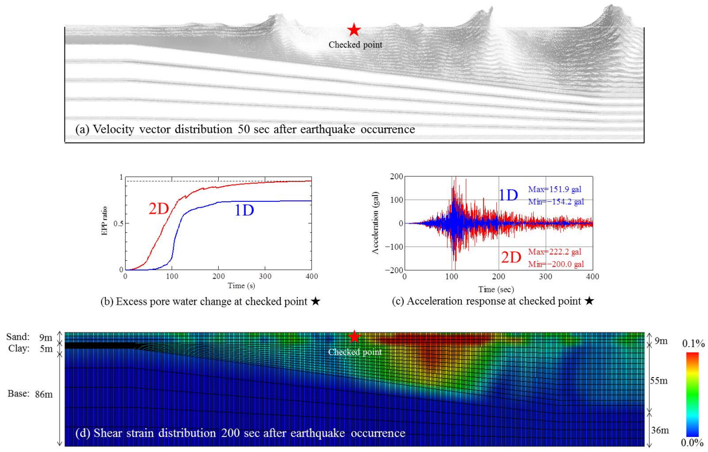

Japan Geoscience Union Meeting 2014
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SSS23-20 Room:211 Time:May 1 15:30-15:45

Relationship between liquefaction occurrence ratio and strong ground motion duration for the 2011 off the Pacific coast

SENNA, Shigeki[1*] ; WAKAMATSU, Kazue[2] ; MATSUOKA, Masashi[3]

[1]NIED, [2]Kanto Gakuin University, [3]Tokyo Inst. Tech

In this study, We first reorganized the points of liquefaction in the 2011 off the Pacific coast of Tohoku Earthquake and plotted the number of liquefaction points in 250m mesh units, because many areas had not been investigated or were insufficiently investigated, as revealed in the information on liquefaction points disclosed and summarized by December 2011.

Next, using the reorganized liquefaction data, the seismic intensity were calculated and the 'real-time seismic intensity' noted by Kunugi et al.(2008) based on the waveforms recorded by seismographs of K-NET, KiK-net, the Meteorological Agency, and the municipalities and examined the effects of earthquake duration on liquefaction using the data on liquefaction points and the method of Matsuoka et al.(2011) to calculate the liquefaction occurrence, so that the liquefaction occurrence can be examined with consideration of the effect of the duration of seismic motion in the March 11 earthquake.

Keywords: Occurrence of liquefaction, Continuation time of strong ground, Geomorphologic classification, Fragility curve, Regional peculiarity

Japan Geoscience Union Meeting 2014
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SSS23-21 Room:211 Time:May 1 15:45-16:00

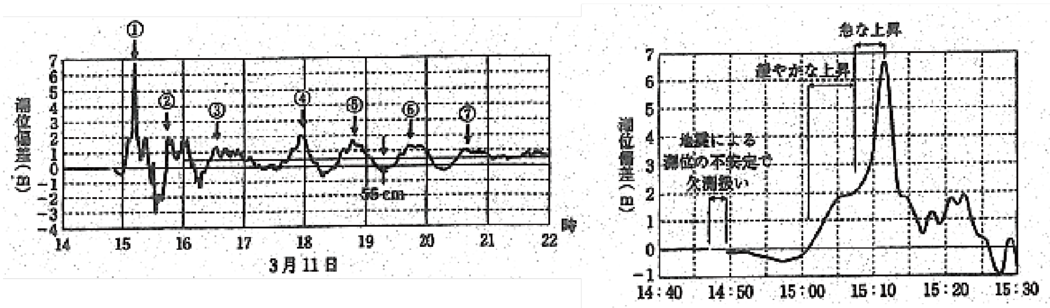
The Wave Features Theory and Soliton

NISHIZAWA, Masaru[1]*

[1]none

1. The eye of Writers under the title “ The Great Kanto Earthquake (of 1923) ” correctly spotted, the demolished style difference between the large and small structure.
2. Fourier Spectrum of Earthquake Motion near the observatory forms The Normal Distribution (Gaussian Distribution). And The further near the observatory. And The Sharp shape of Normal distribution mean densely the frequency.

Keywords: Wave Features Theory, Soliton, KDV Equation, Nonlinear waves



Kazuo OIKE
「Massive earthquake in Japan archipelago」
(Iwanami Library of Science 185, P10)
①: Soliton
②～⑦: Break down of Solitary wave Solitons
Reference：Mikio HINO「流体力学」
(Asakura Publishing Co., Ltd. (1992))

岩手県南部沖のＧＰＳ波浪形の記録（左）と最初の部分の拡大図（右）
国土交通省のデータをもとに作成

Japan Geoscience Union Meeting 2014
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SSS23-22 Room:211 Time:May 1 16:15-16:30

Seismic hazard karte : A Tool for distribution of seismic hazard information with Multi-index

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

[1]National Research Institute for Earth Science and Disaster Prevention

1. Overview of seismic hazard karte

NIED distributed the "seismic hazard karte(chart)" in July, 2013. An "seismic hazard karte" is what summarized the earthquake hazard information for every point, arbitrary places can be searched and the diagnosis of the earthquake hazard about the place can be drawn up. A result displays many indices, such as various foundation information, hazard curves, etc. about the danger of an earthquake, like the notice of a medical examination by the view format summarized to A41 sheet using many charts and graphs.

2. Purpose of Development

It was thought possible to spread the recognition to seismic hazard by using for the user itself the form of diagnosing a certain point with the connection as a starting point, from the investigation by HERP, the argument in a comprehensive sectional meeting, etc. Although the seismic hazard karte was dispatch fundamentally turned to the whole average citizen like other seismic hazard information, when it decomposed into use-cases, it assumed roughly dividing and being used in the following domains. For insurance and real estate, as customer-oriented service data. As the teaching materials which teach the tool for advancing a measure at a workshop or a home to the local resident engaged in disaster prevention educational persons concerned and disaster prevention, and the view of the seismic hazard information on the area. It developed by being that it is easy to carry out use, respectively conscious as a sample of the way of expressing a response using J-SHIS Web API which is open API, and designing to IT persons concerned and developers.

3. Distributed Result

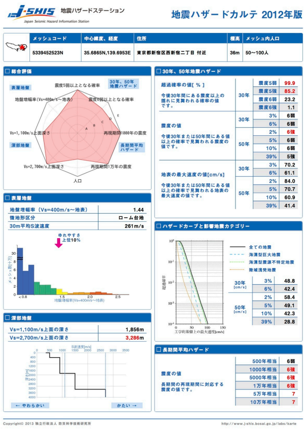
There are many echoes from the exhibited beginning and it is thought that effect fixed as one of the how to show the seismic hazard information evaluated across the board by the country was achieved. Nothing new as contents have in the information offered as seismic hazard karte this time, and it is already J-SHIS seismic hazard station offered, was only visualized in a different form. However, receiving a karte "it may be very intelligible. From the thing of having also let the family know who lives in the distance"as a positive thing, many reactions "worth of the possessions affair of our company will be influenced and it will be troubled by it if such a thing comes out" were seen by the negative thing, like when the hazard information is released newly.

4.References.

Seismic hazard karte |http://www.j-shis.bosai.go.jp/labs/karte/ (Japanese only)
Manual |http://www.j-shis.bosai.go.jp/karte-manual (Japanese only)
Description |http://www.yullege.jp/?p=282 (Japanese only)
J-SHIS Web API |http://www.j-shis.bosai.go.jp/api-list (Japanese only)
Hiroki Azuma, Shinichi Kawai and Hiroyuki Fujiwara, 2013, Development of J-SHIS and Applications Using API, Journal of Disaster Research, Vol.8 No.5, 869-877.

Keywords: Seismic hazard, information tool

SSS23-22 Room:211 Time:May 1 16:15-16:30



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SSS23-23 Room:211 Time:May 1 16:30-16:45

JMA intensity distribution of the 1943 Tottori earthquake derived from immediately conducted questionnaire survey

NAKAMURA, Mariko[1] ; KAGAWA, Takao[2*] ; NOGUCHI, Tatsuya[2] ; NISHIDA, Ryohei[2]

[1]Okayama City Office, [2]Tottori University

Questionnaire surveys were conducted by university of Tokyo immediately after five disastrous earthquakes in 1940s to evaluate modified Mercalli (MM) intensity scale. The raw data of the surveys had been stored long time without following analyses. We have studied explanation of each item in the Questionnaire sheet and developed the relational expressions between MM and JMA intensity scales. Finally, we derived JMA intensities at 1935 sites in southwest Japan, and estimated JMA intensity distributions with almost same resolution as modern intensity observation network. The distribution map suggests radiation pattern of strike slip fault and effect of surface geology. The result is worth of basic information for earthquake disaster prevention.

Keywords: the 1943 Tottori earthquake, questionnaire survey, JMA intensity scale, modified Mercalli scale

SSS23-24 Room:211 Time:May 1 16:45-17:00

Mortality in the East Japan Great Earthquake (4) Infants and elderlies should always suffer heavy rate of deaths?

OHTA, Yutaka[1*] ; KOYAMA, Maki[2]

[1]TRIES, ADEP, [2]Engr. Fac. Kyoto Univ.

With the aim of clarifying age dependency of mortality in earthquakes we have been conducting a series of studies, just employing a simple division of number of deaths over population in age intervals of 5 or 10 years from area to area in devastated region. What we have found up to now is that there are 2 dominant types approximated by the capital U and J letters in English on the 2 dimensional coordinates of X axis as increasing ages and Y axis as mortality. In case of the 2011 East Japan earthquake, the age dependency in terms of J letter type dominates in most of devastated areas, which suggests that the mortality gets heavier with increasing ages but for infants it stays milder. Such result on age-dependency looks to be apart from our general recognition as infants are very much vulnerable in mortality at many disasters. The discrepancy requests further in-depth studies. In order to settle this issue we attempted two different approaches, that is, 1) comparing natural deaths of certain population with number of accidental deaths by an earthquake (Ozaki. 2012) and 2) introducing a way of evaluating the loss of life expectancy as an weighting factor inversely changing with increasing ages.

Consequently, we succeeded to make clear that infants are still very vulnerable in the meaning of bringing heavy rate of deaths.

Reference

Ozaki; kousei no shihyou, 59, 2012 (in Japanese)

Keywords: East Japan Earthquake, Mortality, Age-dependency, Life Expectqancy