Site responses and sediment structures in metropolitan Beijing from microtremor array measurement

Qi-fu Chen[1], Weijun Wang[1], Lanbo Liu[2]

1. Institute of Earthquake Science, China Earthquake Administration, China, chenqf@seis.ac.cn
2. Department of Civil & Environmental Engineering, University of Connecticut, USA, lanbo@engr.uconn.edu

ABSTRACT

Using the ambient noise (microtremor) measurements to delineate local site effects and sediment structures represents a fast and low-cost way to provide high-resolution maps of the predominant resonance frequency, the thickness of the soft sediments, and the ground motion amplifications. A campaign of microtremor measurements with 30 three-component seismometers was conducted in summer 2007 for assessing local site effects of seismic strong ground motion in metropolitan Beijing. We have collected microtremor arrays data at more than 1,000 sites with approximately 1-2 km spacing covering the entire area inside Beijing's 5th Beltway. The collected data are processed with both the horizontal to vertical spectral ratio method (H/V) and space correlation method to extract information on ground motion fundamental frequency and amplification factor.

From the analyses of the H/V ratios for these data we found that the predominant resonance frequency has a range of 0.5-8 Hz. The high resonance frequencies (close to 8 Hz) tightly concentrated in a small area west of central Beijing near Babaoshan (Babao Hill), a topography high with bedrock outcrops; whereas the lowest frequencies were found in a much vast area east of central Beijing that is the SW end of the Shunyi Depression. The H/V amplification factor at different frequencies and the peak resonance frequency are in good agreement with ground shaking intensity distribution in Beijing area caused by the Tangshan earthquake.

The inferred soft sediment thickness is in the range of zero (the Babaoshan area west of the City) to ~400 m (east of the City center) with an average of about 100 m. The relatively thicker sediment (about 250 m) in the NW corner between the 4th and the 5th Beltways on the map coincides with the location of the Kunming Lake in the Summer Palace, the largest surface water body inside the 5th Beltway. In the inner city, the thicker sediments seem to be following the ancient surface water system around the 2nd Beltway, the location of the ancient city wall with guardian canal filled with water. The microtremor-derived soft sediment thickness is generally in agreement with previous results based on much sparser borehole data, with the revealing of more short-wavelength undulations, which coincide with major geomorphological and neotectonic expressions in metropolitan Beijing.

This study demonstrates that the wide availability of microtremors provides additional valuable information to the earthquake-resistant design of civil infrastructures and seismic hazard response in metropolitan Beijing. It also provides a feasible geophysical approaching to explore the 3-D structure beneath metropolitan cities.

Key words: Beijing, microtremor, site effect, sediment structure

PRESENTER'S BIOGRAPHY

Dr. Qi-fu Chen is a research professor of Institute of Earthquake Science, China Earthquake Administration. He earned his B.Sc. degree in computational mathematics in 1984 from Fudan University and Ph.D. degree in geophysics in 1997 from Institute of Geophysics, China Earthquake Administration. He was awarded the Science and Technology Award for Chinese Young Scientist by China Associate for Science and Technology in 1997. He was awarded the Special Government Allowance issued by the State Council of China in 2006. He worked at the International Seismological Centre (ISC) in 2000 as a Royal Society fellow. From August to November 2006, he was a visiting professor in the Earthquake Research Institute, University of Tokyo. His research interests focus on the structure of fault zones and mechanisms of earthquakes, earthquake prediction research and seismic risk analysis.

Amplifications of Ground Motion in Different Regions of South Africa

Artur Cichowicz[1] Eldridge Kgaswane[2] Jayson Ramperthap[3] Mayshree Singh[4]

1. Council for Geoscience,South Africa, e-mail artur@geocience.org.za
2. Council for Geoscience,South Africa, e-mail ekgaswane@geocience.org.za
3. Council for Geoscience,South Africa, e-mail jasonr@geocience.org.za
4. Council for Geoscience,South Africa, e-mail mayshree@geocience.org.za

The objective of this evaluation is to determine the amplification factors of the seismic signal for different geological provinces in South Africa. Seismic hazard assessment projects in South Africa are utilising attenuation equations mostly from the central and eastern US. This is done on the assumption that both areas are intraplate regions characterised by low seismic activity. The strong ground motion is affected significantly by the top 2 to 3 km of the crustal structure. The top 10 km of the crustal structure influence signal amplification at the low frequency range. The quantification of similarities and differences between the South African and other crust models is vital for the prediction of the strong ground motion.

The crust parameters that provide an indication of the ground motion amplification are the S-wave velocity and the quality factor Q. Most observations of shear wave velocity profiles are derived using a joint inversion method. Joint inversion of the receiver function and surface wave is applied to obtain the S-wave velocity models for more than 80 sites, using teleseismic earthquakes. The controlling mechanism for the spectral content of the ground motion is the attenuation in the shallow part of the crust. The shear wave quality factor Q is based on surface wave attenuation measurements. Tectonically stable regions are usually characterised by high values of Q that vary from 800 to 1200. The Q values obtained for the Kaapvaal craton are about 600. The region of low Q is the Cape Fold Belt at the southern tip of Africa. Data analysis was carried out by applying cluster analysis in order to determine groupings within the velocity profiles. Hierarchical clustering with the average linkage method was selected. The cluster results show quite clearly the grouping of velocity profiles of neighboring sites, i.e. there is a large degree of homogeneity of neighbouring sites with respect to their velocity profiles. The results from the modelling transfer function of the upper crust indicate that, in order to model crustal amplification in South Africa, a model of the S-wave and Q- factor has to be determined.

Microtremor soil-structure resonance study in the Bovec basin (NW Slovenia) related to 1998 and 2004 damaging earthquakes

Andrej Gosar[1,2]

1. Environmental Agency of Slovenia, Slovenia, andrej.gosar@gov.si
2. University of Ljubljana, Faculty of Natural Sciences and Engineering, Slovenia

ABSTRACT

The Bovec basin, which is filled with glacial and fluvial sediments, has been struck in the last ten years by two strong earthquakes (M_w=5.6 in 1998 and M_w=5.2 in 2004) which caused extensive damage of VII-VIII European Macroseismic Scale intensity. Strong variations in damage to buildings were observed within short distances in the whole basin. They cannot be explained by changes in the epicentral distance or by differences in building vulnerability, since the building typology is similar throughout the area, but must be related to local site effects. Previous studies have also shown that observed site effects cannot be explained by the surface variation in Quaternary sediments or by subsurface structures known from rather sparse geotechnical and geophysical data.

The microtremor horizontal-to-vertical-spectral-ratio (HVRS) method was therefore applied to a 200 m dense grid of free-field measurements at 124 points to assess the fundamental frequency of the sediments in the whole basin and the iso-frequency map was drawn. This map shows large variations in the sediments frequency (3-22 Hz), but the range 6-12 Hz prevail. The observed frequencies cannot be related to the total thickness of Quaternary sediments (mainly sand and gravel), which is up to 100 m, but can be explained by the presence of conglomerate or lithified moraine at shallow depths. The extent of these layers inside sand and gravel was not known before.

The main building frequencies (longitudinal and transverse) were assessed by microtremor measurements performed inside the characteristic houses of various heights. Measurements in 20 two and some three and four storey houses (masonry with RC floors), which prevail in the Bovec basin, have shown that the main building frequencies in the area are in the range 7-11 Hz. Comparison of building frequencies with the iso-frequency map of sediments has shown similar values in several cases. This indicates that damage to houses in some parts of the basin was enhanced by soil-structure resonance. Identified areas of possible soil-structure resonance correspond good to the distribution of the heaviest damage in both earthquakes.

Microtremor investigations have proved to be an effective tool for assessment of site effects in cases of complex geological structures commonly encountered in young Alpine basins filled with glaciofluvial sediments which are partly cemented. Cemented layers can considerably change the fundamental frequency and, consequently, the site effects. By taking additional measurements in buildings the danger of soil-structure resonance can be identified.

Key words: microtremors, horizontal-to-vertical-spectral-ratio (HVRS), site effects, soil-structure resonance

ANDREJ GOSAR

Andrej Gosar obtained his Ph.D. in geophysics from the University of Ljubljana. He has been working for nine years at the Department of geophysics of the Geological Survey of Slovenia and eleven years at Seismology and Geology office of the Environmental Agency of Slovenia. He is also teaching geophysics at the University of Ljubljana. His research interest include: applied seismic methods, deep seismic crustal studies, seismic hazard, site effects and seismotectonics. He was involved in several international projects related to assessment of seismic hazard for a nuclear power plant, deep seismic crustal studies, effects of local geology on seismic ground motion and microtremor method. He is a national representative of Slovenia to IASPEI.

Statistical site amplifications and their standard deviations based on the spectral inversion of strong motion data in Japan

Hiroshi Kawase[1] and Yusuke Nejime[2]

1. DPRI Kyoto Univ., Japan, Kawase @ zeisei.dpri.kyoto-u.ac.jp
2. Kagoshima City Office, Japan

ABSTRACT

Thanks to the advent of the nationwide strong motion networks in Japan, we have now plenty of weak motion data, enough to construct statistical Green's functions. Since the site amplification effects on the sediment sites in an urbanized environment tend to be so large that we need to extract site amplification ratios in a statistical manner and construct amplification models for different site categories. In this study we perform first the spectral analysis to separate the so-called source spectra, attenuation coefficient, and the site amplification factors from about 18,825 K-NET, KiK-Net, SK-net, CEORKA net, and JMA Intensity meter network records observed at more than 1,700 stations in Japan. The separation method is the well-established one of Andrews (1980). As a reference site we use one rock station of KiK-Net in Yamaguchi Prefecture, from which we remove amplification due to the shallow weathered rock formation.

Once we obtain site amplification factors, we try to reproduce them by using one-dimensional S-wave velocity structures below each site of K-NET and KiK-Net (in total, 1,300). We use Genetic Algorithm to invert the S-wave structures with fixed S-wave velocities in the shallow part. We succeed to reproduce site amplification factors at about one half of the sites (namely, 668 sites) very well. We then calculate average S-wave velocities for top 30 m, the so-called Vs30. We also perform the same kind of separation analysis for three ground motion strength indexes, namely, PGA, PGV, and JMA Seismic Intensity. The standard deviations (STD) of site amplification factors are calculated based on the residuals derived from the averaged source spectrum and the attenuation value for each record.

As a result, we found that 1) the influence of a nonlinearity of the soil amplification starts to appear when PGA become more than 200 Gals, 2) when we see STD for every frequencies, they are around 1.8/1.8-1 times on average, 3) STD of inland earthquakes is larger for all frequencies than those in the subduction zone earthquakes. 4) when we classified 668 sites into 4 bins based on their Vs30 (0-200m/s, 200-400m/s, 400-800m/s, 800 m/s and larger), STD for sites with Vs30$\leqq$ 200m/s is slightly larger (~0.3) than other bins (~0.26) but the difference is small and frequency independent, 5) when we use averaged site characteristics for 4 bins of Vs30 as a substitute of individual site amplification, STD become larger; 0.36 at low frequency and 0.45 at high frequency, which means about 1.3 times (at low freq.) or 1.6 times (at high freq.) larger than the individual amplification case.

Since the benefit to use individual site amplifications (i.e., reduction of STD) does not seem so large, for simplicity, we can use the average site amplifications for 4 bins if we tolerate to use site amplifications considering average+1 STD.

Key words: site amplification, statistical Green's function, strong motion, attenuation, Fourier spectra

PRESENTER'S BIOGRAPHY

Prof. Kawase graduated from Faculty of Engineering, Kyoto University in 1978 and then got his master's degree successively in 1980 and then he got his Doctor's degree again from Kyoto University in 1990. He joined to Shimizu Corp. in 1980 and then he had been working at Ohsaki Research Laboratory for 18 years. In 1998 he moved to Kyushu University as an associate professor and then promoted himself to full professor in 2000. In 2008 he moved to the current position at DPRI, Kyoto University. He had been a visiting scholar at Department of Geological Sciences, University of Southern California, from 1986 to 1988 working with late Prof. Kei Aki. His research interest is site amplification studies, geophysical exploration, strong motion prediction, structural response, and seismic damage prediction. He has been serving as a co-chairman of the Joint Working Group of IASPEI/IAEE for Effect of Surface Geology on Strong Motions.

Effect of subsurface characteristics on ground shaking inferred from aftershocks of 17 August 1999 Kocaeli Earthquake

Asli Kurtulus[1], Atilla Ansal[2], Gokce Tonuk[3]

1. Bogazici Univ., Kandilli Observatory and Earthquake Research Institute, Turkey, asli.kurtulus@boun.edu.tr
2. Bogazici Univ., Kandilli Observatory and Earthquake Research Institute, Turkey, ansal@boun.edu.tr
3. Bogazici Univ., Kandilli Observatory and Earthquake Research Institute, Turkey, gokce.tonuk@boun.edu.tr

ABSTRACT

Effects of local site conditions in central part of Adapazari during 17th August Kocaeli earthquake are investigated using strong motions recorded by the temporary accelerometer array after the main earthquake. Temporary accelerometer array, deployed by Kandilli Observatory and Earthquake Research Institute (KOERI) for investigating aftershock motions in Adapazari, included nine accelerometer stations founded at sites with varying soil conditions. Stations were located on a line through the city from South to North, with spacing of ~1–2 km. Two stations were located on stiff ground at Maltepe (IMAR) and Serdivan hill (SERDIVAN), to record free-field earthquake ground motions to be used as reference motions. IMAR station located primarily on greywacke (location coincides with Sakarya station where main shock of Kocaeli Earthquake is recorded) was thought to be the best representative of the accelerations that took place in the bedrock of the Adapazarı plain. Five stations were located in the central city on deep alluvial soil. Several aftershocks with magnitudes ranging between 3.6 to 5.8 were recorded at the array stations. Three of the larger of these events (Mw=5.8, 5.2 and 4.6) with epicenters in Kocaeli recorded at two stiff sites and three of the alluvial sites are considered in this study. Peak accelerations of the records used in the study vary between 0.005 and 0.086g. Available geotechnical data, which included cone penetration (CPT), standard penetration (SPT), spectral-analysis-of-surface-waves (SASW), soil index tests and microtremer array studies are used to generate representative soil profiles at the sites of stations.

Shake91 (Idriss and Sun, 1992), a one-dimensional site response analysis program is performed to predict the seismic response. Recordings at the IMAR station are used as outcrop bedrock motions. Predicted responses are found to be in general agreement with those that were actually recorded though calculated responses are somewhat smaller in amplitude. Comparisons are made between records to evaluate the effect of subsurface characteristics on ground shaking. It is shown that at smaller events, the alluvial sites show amplification factors of 2-4, while deamplification and shift of peak frequencies is evident at the largest event.

Others who have also studied the site effects in central part of Adapazari inferred similar results. Beyen and Erdik (2004) analysed the same array recordings using a 2D site model of Adapazari plain. They concluded that alluvial sites amplify the motion at all events but the magnitude 5.8 event, where deamplification was observed. Bray et al. (2004) did a comprehensive site investigation study for soils in Adapazari and used similar soil profiles as used in this study and performed 1D site response analyses with Shake 91 followed by liquefaction triggering analyses to predict the seismic response at sites where ground failures were observed during the 17 August 1999 Kocaeli Earthquake. The case studies they presented demonstrated that much of the observed failures were due to site conditions.

The results from this study yet provide another example that demonstrates the influence of geological and geotechnical site conditions on strong motion characteristics on the ground surface underlining the need for incorporating site specific response analyses in earthquake hazard studies of engineering analyses and design.

Key words: site effects, site response analysis, aftershock records, 1999 Kocaeli Earthquake, Adapazari.

PRESENTER'S BIOGRAPHY

Dr. Asli Kurtulus was born in 1975 in Istanbul, Turkey. She received her MSCE in Civil Engineering from Istanbul Technical University in 1997, and her Ph.D. in Geotechnical Engineering from The University of Texas at Austin in 2006. She is currently working for the Earthquake Engineering Department of Kandilli Observatory and Earthquake Research Institute at Bogazici University. She has been working in the areas of in situ and laboratory seismic field testing, installation and monitoring of strong motion arrays, seismic microzonation and earthquake scenarios.

Theoretical Investigation of the ellipticity of Rayleigh waves in the light of seismic hazard assessment in the region of the Dead Sea Transform (DST)

Peter G. Malischewsky[1], Yuli Zaslavsky[2], Vladimir Pinsky[3], Frank Scherbaum[4], Tran Thanh Tuan[5]

1. Friedrich-Schiller University Jena, Institute of Geosciences, Germany, p.mali@uni-jena.de
2. Geophysical Institute of Israel, Seismology Division, Lod, Israel, yuli@ seis.mni.gov.il
3. Geophysical Institute of Israel, Seismology Division, Lod, Israel, vlad@ seis.mni.gov.il
4. University Potsdam, Institute of Geosciences, Germany, Frank.Scherbaum@geo.uni-potsdam.de
5. Friedrich-Schiller University Jena, Institute of Geosciences, Germany, tuan.vanh.nguyen@gmail.com

ABSTRACT

The Dead Sea Transform (DST), constituting part of the boundary between African and Arabian plates, has been the locus of ongoing seismic activity and surface displacements with a long history. In the framework of an interdisciplinary study of the internal structure and crustal deformation in the DST with applications to seismic hazard in the region measurements of propagating ambient noise by short-period and broad-band seismometer arrays are carried out. It is well-known that ground motion amplification due to soft soils, common in urban areas, is a major contributor to increasing damage and number of causalities. Indirectly, the study of Rayleigh-wave ellipticities has recently gained considerable popularity in the context of studying ambient seismic vibrations for seismic hazard analysis. The output can be integrated into the inversion process for velocity structure. Due to the strong impedance contrast in the shallow subsurface structure, local site effects are often fairly well predicted by simple models. Therefore, a thorough theoretical understanding of even a single layer over half-space (LOH) is not only of theoretical but also of considerable practical interest. Adding to this argument is the fact that an accepted theoretical model for the interpretation of H/V-measurements from ambient vibrations, still has to be developed. A useful starting point for the theoretical investigation of the ellipticity of Rayleigh waves is the exact formula derived by Malischewsky and Scherbaum (2004). It can be shown that already the simple LOH model is able to produce a great variety of H/V-versus-frequency curves with different character. Several observations in Israel demonstrate the occurence of two maxima of the H/V-curves. This phenomenon is usually contributed to an additional layer, where the first maximum is connected with the shear-resonance frequency of the first layer and the second maximum with a resonance frequency of a deeper layer. We demonstrate that already the simple LOH model is capable to produce two maxima in a certain range of Poisson's ratio in the layer (ν between about 0.26 and 0.28). We compare this with the occurence of two maxima in the case of an additional layer and obtain constraints for the velocity inversion from H/V-data. Another constraint concerns the character of particle motion: retrograde-prograde: We have theoretically derived the range of prograde Rayleigh motion in dependence on the shear-wave contrast and Poisson's ratio in the layer. It turns out, for example, that for the Kiryat Shmona test site prograde motion is possible within the almost whole frequency region between the site frequency and double-site frequency. In conclusion, such theoretical investigations of analytical or half-analytical character are necessary for a better understanding of the behaviour of the ellipticity of Rayleigh waves and its use for seismic hazard assessment.

Key words: Ellipticity, Rayleigh waves, *H/V* method

Peter G. Malischewsky

Born May 9, 1945 in Geising (Germany) as son of Baltic parents. Graduation in physics (diploma) at Friedrich-Schiller University Jena 1968. Dr. rer. nat. in Geophysics from the German Academy of Sciences, Potsdam 1974. Title of the dissertation: Propagation of seismic surface waves in media with vertical discontinuities. Dr. sci. nat. in geophysics from the German Academy of Sciences, Potsdam 1989. Dr. rer. nat. habil. in theoretical physics from Friedrich-Schiller University Jena 1994. Positions held: Scientific aspirant in Central Institute Physics of the Earth Jena (1968-1973); scientific research fellow in Central Institute Physics of the Earth Jena (1973-1991); private docent in Institute of Geosciences, Friedrich-Schiller University (since 1992); head of the Seismological Observatory Moxa (1993-1996); visiting professor at Universidad Nacional Autónoma de México (UNAM) (1999-2000, 2004); professor for geophysics at Friedrich-Schiller University (since 2000). Author of the monograph "Surface Waves and Discontinuities", Elsevier 1987.

SITE SPECIFIC GROUND MOTION SIMULATION USING STOCHASTIC METHOD

Adel M. E. Mohamed [1], Abuo El-Ela A. Mohamed [2] , Sayed S. R. Moustafa [3]

1. Researcher of Seismology, Egypt, geotec_04@yahoo.com
2. Professor of Seismology, Egypt, amin@nriag.sci.eg
3. Researcher of Seismology, Egypt, sayed.moustafa@nriag.sci.eg

ABSTRACT

In Northern part of Egypt, quantitative statements on strong ground motion suffer from the lack of instrumental strong motion data although the historic catalogue indicates that events of moment magnitudes up to six are conceivable. This is the situation in the northern tip of the Gulf of Suez area, where moderate earthquakes with high impact caused by the significant aggregation of infrastructure and industrial facilities, are expected to toke place. We have developed scenario of crustal earthquake with moment magnitude M_W =5.2 for a source region of Wadi Hagoul fault, itself being struck by earthquake in 1984 with an intensity of up to VI (MMS). In order to synthesize strong ground motion seismograms, we are using a stochastic modeling technique proposed by Boore (1983, 2003). In this approach, the ground-motion amplitudes are simulated as a summation of stochastic point sources. The applied methodology is tested against its ability to predict site-specific strong-motion records by the incorporation of use of site-specific amplification function estimated by the horizontal-to-vertical ratios technique. The maximum simulated PGA value in the area is 38.9 gal at the bedrock and 73.2 gal at the surface. We compare the Peak Horizontal Acceleration (PHA) and response spectra in terms of spectral accelerations with the attenuation laws proposed for Egypt as well as the macroseismic intensity map of the 1984 Hagoul earthquake. Our results encourage the application of the approach as a supplementary tool for site-specific strong ground motion prediction.

Key words: 1 Stochastic simulation; PGA; Response spectra; Synthetic seismograms.

PRESENTER'S BIOGRAPHY

Full Name	: **Sayed Shaban Refaie Moustafa**
Nationality	: Egyptian citizen.
Occupation	: **Senior Researcher**. Department of Seismology. Egyptian National Seismic Network Lab. (ENSN). National Research Institute of Astronomy and Geophysics (NRIAG). El-Marsad street, Helwan, 11421, Cairo, Egypt.
Correspondence	Prof. Samir Riad
RESEARCH INTERESTS	▪ Earthquake Rupture Mechanics. ▪ Numerical Methods for Wave Propagation. ▪ Spectral Element Method. ▪ Seismic Hazard. ▪ Characterization of Sedimentary Basins and Simulation of Their Seismic Response.

Quick Seismic Risk Evaluation Using Soil Amplification Ratio in Northern Morocco

T. Mourabit[1)], A. Dwiri [1)], A. Ouazani [2)], K. Seo [3)],

1- Dept. of Geology, Abdelmalek Essaadi University, Tangiers, Morocco
2- Dept. of Geology, Abdelmalek Essaadi University, Tetouan, Morocco
3- Tokyo Institute of Technology, Yokohama, Japan

Abstract

It is very well known that soft surface soils like alluvial deposits produce soil amplification in shacked areas. Severe damages to structures are caused by the amplified seismic motion. So, we are developing an approach on quick risk evaluation using soil amplification ratio in northern Morocco. This study is applied to different urban areas with different soil conditions, namely Tangiers, Tetouan and Imzouren.
We measured microtremors in several directions in order to confirm the difference of soil characteristics and to compare deduced amplification with 1994 and 2004 Alhoceima earthquakes damage distributions.
At the first step, we gathered all the geological and geo-technical data including bore holes and superficial seismic refraction profiles. Soil amplification is estimated using microtremor records and Nakamura method.
We think that this approach is very simple and effective to recognize and understand the distribution of seismic risk potential at before and after the earthquake occurrence and also very useful for the quick response of local government.

Contact Person : Taoufik Mourabit; tmourabit@gmail.com
B.P 383, Tanger principal, 90000, Tanger ; Morocco

Assessments of Site Amplification, Structural Dynamic Characteristics and Structural Vulnerability Evaluation of Aqaba

Mohammad Dawoud Fandi Naser

Natural Resources Authority (NRA), Jordan Seismological Observatory (JSO), P. O. Box 7, 11118, Amman-Jordan, mfandi@nra.gov.jo

ABSTRACT

Many geological studies have been integrated with seismology in the Middle East but only a few of them have attempted to find a correlation between the dynamic engineering response of structures and the local surface geology. In this study 18 frame wall structures and 17 nearby ground sites located a few meters from each structure were subjected simultaneously to 2-Hz free vibrations direct recording. Three component seismometers were used to record the structural response at the top of each structure and the free-field ground motion. These records and their spectra provided a basis for determining the structural response with respect to the longitudinal and transversal directions of the structure. The relative site response caused by changes in the physical properties of the local site geology was obtained using the H/V ratios of the spectra. The FFT spectra derived from each record were used to estimate the fundamental mode of structural response in the longitudinal and transversal directions. Amortization factors for each horizontal mode were calculated using the half–width band method.

Analysis of the structural response and the spectra in the framework of a generalized structural classification of the city showed that Aqaba city is comprised mostly of short-period (high-frequency) structures that are also susceptible to short-period local site amplification that correlates well with the local geology. Except a few structures, results showed that the fundamental period T is T = N/18 and the amortization factor is found around 0.1. The H/V ratios indicate that the dominant ground response in the range of 0.86-1.59 Hz and the corresponding H/V amplification found in the range 2.01-4.85.

Determination Site Effect of Zarqa City-Jordan Based on Microtremors Field Measurements: A microzonation Study

Waleed Eid Olimat

Natural Resources Authority (NRA)
Jordan Seismological Observatory (JSO)
11118 , P.O.Box # 7, Amman - Jordan
E-mail: waleedolimat@yahoo.com

Zarqa governorate is one of the important governorates in Jordan. It is the second populated after the capital Amman, the location of Zarqa gives the city a great importance because it lies on the main high ways leading to Syria, Iraq and Saudi Arabia, most of Jordan's industries, power plants and strategic projects are located in Zarqa, which gives this city a special importance.

The Nakamura's technique is applied in this study for both areas; Zarqa city and Hashemite University Campus in order to determine the resonance frequencies and amplification factors for each site then draw there maps which will be of a great use in the field of civil and structural engineering by enriching the building codes.

The results of our study show that; values of resonance frequency F are not affected by the time of recording. While values of amplification factor A can vary accordingly. Results also show that the amplification factor A varies from 0.8 to 8.55 in Zarqa city and the resonance frequency (F) also varies between 0.37 Hz and 2.98 Hz in Zarqa city , that means some constructions in the study area, in case of a major earthquake, may experience minor damages respectively.

Estimation of relative amplification factors for the Legnica Glogow Copper District area in Poland using response spectra.

Dorota Olszewska

AGH University of Science and Technology, Faculty of Geology, Geophysics and Environmental Protection, Poland, dolszewska@seismo.geol.agh.edu.pl

ABSTRACT

Earthquakes and seismic events caused by human activity trigger ground motion which can have a disadvantageous influence on the surface of the Earth. Within the area of Poland the induced seismicity is among others connected with underground mining works in the Legnica Glogow Copper District (LGCD), and especially in the area of the town of Polkowice. The seismicity of this area is characterized by a considerable activity, whose amount and strength are demonstrated by the number and scale of events – yearly about 2.5 thousand events are registered with energy above 10^4J. The influence of local conditions on the surface is a crucial factor conditioning the size of the seismic effect. This influence appears as an amplifying effect of ground motion and is probably connected with different geological conditions in place of the localization of the registration station. The possibility of predicting ground motion is essential for protecting the building against the destructive effects of seismic events. Such predictions of ground motion come up based on attenuation relations for the given parameters of motion and the influences of local conditions should be taking into consideration.

Attenuation relations for peak ground acceleration (PGA) are most often worked out. Indeed, with regard to protecting objects, we are interested in the motion of building as a response to the ground motion. This problem is examined by analysis of a response spectrum. Prediction of the response spectrum is realized by estimating their value, i.e. spectral amplitudes (SA). Spectral amplitudes are one of the ground motion parameters and the attenuation relation for them can be successfully obtained. Site effect as a crucial factor of seismic effect should be taking into account with identification of the attenuation relation. This permits a more accurate prediction of ground motion. A model of ground motion for LGCD was suggested in which free parameters refer to individual stations. As a result the obtained attenuation relations include information about the local effects of positions where the stations are localized. There were analysed attenuation relations for PGA, PGV and SA for chosen frequency. That why, relative amplification factors where the stations are localized for those parameters were obtained. Knowledge of local conditions is essential for predicting ground motion using those relations. For this reason a way to recognize relative amplification factor for any specified place on this area was proposed based on analysis of normalized response spectra.

Relative amplification factors for localization of 10 registration station from the area of the LGCD are known thanks to free parameters of obtained attenuation relations. Those 10 stations are treated as permanent. Estimation of relative amplification factors for the specified place was suggested by comparing the average spectrum calculated on the basis of measurements carried out in the specified place with the average spectrum from permanent stations. Relative amplification factor for localization of other 5 registration station were found. That gives possibility to recognize local condition in new places and also permits for more accurate prediction of ground motion using obtained attenuation relations.

Key words: site effects, site amplification, attenuation relation, response spectra, induced seismicity.

PRESENTER'S BIOGRAPHY

Dorota Olszewska

Dorota Olszewska is a final year PhD student of geophysics in the Faculty of Geology, Geophysics and Environmental Protection in AGH University of Science and Technology in Krakow, Poland. Her research is connected with mining-induced seismicity and engineering seismology on mining areas, being strongly supported by mathematical statistics. In her already prepared and positively reviewed PhD dissertation Dorota undertakes the problem of estimating and incorporating site effects into attenuation relations of ground motion caused by mining seismic sources. She is an author or co-author of 12 research papers and conferences presentations from the field of mining seismology.

Site amplification from S-waves of intermediate-depth Vrancea (Romania) earthquakes

Adrien Oth[1], Stefano Parolai[2], Dino Bindi[3], Friedemann Wenzel[4]

1. European Center for Geodynamics and Seismology, Luxembourg, adrien.oth@ecgs.lu
2. GFZ German Research Center for Geosciences, Germany, parolai@gfz-potsdam.de
3. Istituto Nazionale di Geofisica e Vulcanologia, Italy, bindi@mi.ingv.it
3. Universität Karlsruhe (TH), Geophysical Institute, Germany, friedemann.wenzel@gpi.uka.de

ABSTRACT

The intermediate-depth earthquakes occurring in the Vrancea seismogenic zone pose a serious threat to Romania and its neighboring countries. During the last century, four large events with magnitude > 6.5 occurred here. The Vrancea events show the peculiarity that they occur in a narrowly confined focal volume with an epicentral area of about 30 x 70 km^2 and their depths range between 70 and 200 km.

Site amplification effects, besides radiation strength of the source and attenuation of the seismic waves on the travel path, are a key factor determining the severity of ground shaking. To assess these effects on the territory of Romania, seismograms from 55 Vrancea earthquakes recorded at 43 stations of the accelerometric network deployed in the framework of the Collaborative Research Center (CRC) 461 'Strong Earthquakes' are analyzed in this study. Using the generalized inversion technique (GIT), the frequency-dependent attenuation characteristics beneath Vrancea are determined in a first step and the attenuation-corrected spectra are then split into source and site contributions in the second one. The site amplification functions are determined for both horizontal and vertical components. Contrary to wide-spread expectation, the results of the GIT for the vertical component show significant amplification effects at high frequencies. The H/V ratios derived from the GIT results (i.e. dividing the amplification function of the horizontal component by the vertical component one) compare well with those derived directly from the S-wave windows. Yet, the basic assumption for the determination of site effects using H/V ratios from the S-wave window is that the vertical component is not or only little amplified. For Vrancea earthquakes, this assumption is incorrect and consequently, site effects should not be estimated from H/V ratios calculated from the S-wave windows of earthquake recordings in this case.

Key words: Vrancea, site amplification, generalized inversion technique, H/V ratio

PRESENTER'S BIOGRAPHY

Adrien Oth

Adrien Oth studied geophysics at the Universität Karlsruhe (TH), Germany, and obtained a PhD in geophysics in 2007. He works as a researcher at the European Center for Geodynamics and Seismology (ECGS) in Luxembourg. His main research interests are the spectral analysis of strong motion recordings to separate source, attenuation and site effects, strong ground motion simulations as a tool for deterministic seismic hazard assessment, earthquake source physics and earthquake early warning.

Earthquake hazard for the Czech Republic corrected to local geology

Vladimír Schenk and Zdeňka Schenková

Institute of Rock Structure and Mechanics, v.v.i., Academy of Sciences, Czech Republic
schenk@irsm.cas.cz, zdschenk@irsm.cas.cz

ABSTRACT

The Czech Republic belongs to an area of relatively low seismicity, which is affected occasionally by stronger earthquake. Seismogenic zones are located either in surrounding of the Alpine-Carpathian orogenic system or on the boundaries of rigid geologic blocks of the Bohemian Massif. In the present days users, designers, land and urban planners follow the Czech National Application Document of the EUROCODE 8 when one value of the effective peak acceleration was determined for each administrative district. Local geology can influence drastically the site hazard values and thus a new on-line approach to the earthquake hazard assessment in terms of macroseismic intensities for individual sites in the Czech Republic was elaborated. Shapes of isoseismal depend closely on earthquake source properties, lithosphere structures, tectonic zone orientations, site geology and topography. The isoseismals of higher intensities are often shaped in accordance with local rupture zones and their seismotectonic characteristics and the isoseismals of lower intensities reflect generally broad regional structural features of the shaken area. Great attention was paid to occurrences of less consolidated geological formations (soil, sands, etc.) because even if they are located in large epicenter distance they can influence significantly site intensity values. In the delivered approach the standard earthquake hazard values were determined by the similar way which was used in the Global Seismic Hazard Assessment Project (GSHAP). Contrary to the GSHAP approach, hazard calculations had to be realized in denser mesh to allow more precise site corrections to local geological effects to be implemented. Then the hazard values were corrected by relations evaluated between the seismic wave characteristics and physical parameters of geological media, especially those for sedimentary covers. As geological background the latest version of the digitized geological map of the Czech Republic, on the scale 1:500 000, compiled by the Czech Geological Survey was used. The corrected values of earthquake hazard are now under procedure to create ~~a~~ one GIS layer in the Czech Geological Survey server. This research was supported by the Targeted Research Program of the Academy of Sciences CR (Project 1QS300460551), by the Czech Science Foundation (Project 205/05/2287) and by funds of the Ministry of Education, Youth and Sport (Projects LC506 and 1P05ME781).

Key words: earthquake hazard, local geology corrections, seismic intensity, the Czech Republic

Vladimír Schenk - RNDr (geophysics, geology), CSc. (seismology), Dr.Sc (seismology) - graduated at the Faculty of Sciences, Charles University, Prague, Czech Republic, and held the CSc. and Dr.Sc. degrees at the Geophysical Institute, Academy of Sciences, Prague. After university studies he joined the Institute of Applied Geophysics, Brno, where he works in geophysical research, in 1964 he left to the Academy of Sciences, the Geophysical Institute (1964-1995) and then to present Institute. His research activities are: geodynamics and seismotectonics, earthquake hazard and seismic risk, seismicity and time-variable activity of seismogenic zones and strong ground motion. He has been in positions of the national and international organizations, lector in UNESCO and IAEA-Training courses and he is editor of Natural Hazards journal, Springer. He is author more than 250 articles, editor of 12 special issues in professional journals, author of more than 70 research reports and holder of 1 patent.

Shallow Crustal Structure of Ponta Delgada (Azores)

Graça Silveira[1,2], **Paula Teves-Costa[2,3]**, Idalina Veludo[2,3], Maria Escuer[4]

1. Instituto Superior de Engenharia de Lisboa, Portugal, gsilveira@dem.isel.ipl.pt
2. Centro de Geofísica da Universidade de Lisboa, Portugal, ptcosta@fc.ul.pt
3. DEGGE-Faculdade de Ciências da Universidade de Lisboa, Portugal, idalina.veludo@gmail.com
4. Instituto de Meteorologia, Ponta Delgada, São Miguel, Açores, mescuer@notes.uac.pt

ABSTRACT

One of the purposes of COMICO project is the identification of the most vulnerable zones inside Ponta Delgada (Azores) town. To achieve this purpose, several tasks have been developed; among them, the cartography of the upper crust shear-wave velocity, by using the long wave's content of the natural seismic noise. In fact, the knowledge of the shallow crust shear-wave velocity profiles is essential for the estimation of seismic site response.
It has been demonstrated that the cross correlation of seismic noise between a pair of stations contains, at least partially, the Green's function between the two stations. This Green's function can be used to extract the group velocity between each stations pair and, after that, inverted to retrieve shear wave velocity profiles for the shallow structure.
First, seismic noise analysis has been applied only to a few sites in Ponta Delgada, to evaluate the method capability in such a geographical area. The cross-correlation between each stations pair has been computed for different frequency bandwidths to better understand the noise origin.
The analysis of the correlograms, obtained without filtering, only reflect the presence of a low frequency noise, probably induced by the sea. For frequencies between to 2 and 4 Hz, the noise reveals, mainly, human activity and it is not possible to obtain a Green's function. Between 0.8 and 2 Hz, we have been able to retrieve a good Green's function. The results also revealed that a continuous recording of 10 days is enough to attain correlation stability.
A second mission was then planned for Ponta Delgada region, using an array of 8 short period seismic stations Hathor LEAS equipped with Lenhartz LE-3D/1Hz sensors. The array geometry and recording period was decided considering the results obtained in the first experiment.
We will present here the first results of the application of the seismic ambient noise analysis method to short period seismic data for Ponta Delgada. We applied a frequency-time analysis to the extracted surface wave signals and we measured group and phase velocities in the period range between 0.5 and 1.5 seconds. The short-period information from this network can enhance resolution of the subsurface structure at depths within a few kilometers. These results can be further used to perform the site response analysis of the different surface formations present in this town.

Key words: seismic noise, shallow crustal properties, surface waves, group velocity, Azores

PRESENTER'S BIOGRAPHY

Paula Teves-Costa is professor at the Faculty of Sciences of the Lisbon University. She teaches Solid Earth Geophysics, Seismology and Seismic Engineering. Since many years her research field is devoted to 1D and 2D site effects estimation. During the last years she used ambient vibration analysis to estimate the physical properties of the surface layers. She applied this methodology for microzonation purposes for several towns in Portugal. She also used these results on the estimation of damage seismic scenarios for some towns in Portugal, in particular, in the Azores. She has been involved in several research projects, at national and international levels, concerning the estimation of the seismic response of the shallower formation. She is Vice-President of the Portuguese Society of Earthquake Engineering (SPES) looking always for a close collaboration between seismic engineers and seismologists.