Rock Physics Digital Library -A data and knowledge base for modeling and interpreting shallow geophysical data -

*Toru Takahashi[1]

1. Fukada Geological Institute

Fukada Geological Institute has opened a database called as Rock Physics Digital Library (RPDL) on its website, which consists of data and information about physical models for modeling and interpreting shallow geophysical data in civil and environmental engineering. Its website address is http://www.fgi.or.jp/rpdl. RPDL is composed of four kinds of data and knowledge that are geophysical and geotechnical datasets obtained in laboratory tests and well loggings, a comprehensive list of empirical relationships between geophysical and geotechnical properties, a guide of procedures for modeling of geophysical data, and a list of literatures on physical models and their applications. These data and information can be viewed on the screen and also downloaded at user’ s preference The RPDL is continuously updated by inputs of new data and information from its users as well as ourselves. This paper demonstrates the data and information available in this database, and also shows a few applications of physical models to shallow geophysical data for solving civil engineering problems.

Keywords: rock physics, database, shallow geophysical data

Detection of surface displacement and landslide blocks in the southwest area of Mt. Hakusan using interferometric SAR analysis

*Yukiyasu FUJII[1], Kazuya Ishitsuka[2], Makoto Kaneko[1], Toru Takahashi[1], Toshifumi Matsuoka[1,3]

1. Fukada Geological Institute, 2. Hokkaido University, 3. Center for the Promotion of Interdisciplinary Education and Research, Kyoto University

It is important to estimate surface displacements of landslides and discriminate active landslide blocks to take counter measures for landslide-related disaster. Interferometric SAR (InSAR) analysis, which utilizes remote sensing technology, would be a suitable method for the purpose, because the spatial distribution of surface displacement can be obtained, and active landslide blocks would be estimated. In this study, we investigated landslide surface displacement in the southwest area of Mt. Hakusan using InSAR analysis. We used SAR data acquired at 8th October 2014 and 15th July 2015 in an ascending orbit, and at 20th September 2015 and 12nd June 2016 in a descending orbit. As a result of analysis, we found landslide displacement up to 10 cm around the Jinnosukedani and Yunotani areas between October 2014 and July 2015. And, significant displacement was not estimated at the Bettoudani area. On the other hand, between September 2015 and June 2016, more broad areas displaced in the Jinnosukedani area. And, displacement was found in the northern part of the Yunotani area. From the result, we interpreted that the Yunotani area consists of several landslide blocks. Our result demonstrates that the effectiveness of InSAR analysis for monitoring around the landslide area.

Keywords: InSAR, Landslide, Monitoring

S-wave velocity structure using seismic interferometry in Zushi area

Shunpei Misumi[1], *Yoshiya Oda[1]

1. Tokyo Metropolitan University

S-wave velocity structure is very important information for earthquake disaster prevention. In recent years, study using seismic interferometry has gained rapidly in popularity. However, there are few studies estimate shallow structure. We applied seismic interferometry to estimate shallow ground structure in Zushi area.

Keywords: S-wave velocity structure, Zushi, Seismic interferometry

Seismic refraction survey on the tunnel pavement and evaluation of seismic velocity of tunnel ground surface

*Kenji OKAZAKI[1], Syusaku YAMAZAKI[1], Toshiyuki KURAHASHI[1], Yoshihiko ITO[1], Hiroumi NIWA[2], Hideyuki MURAYAMA[2]

1. Civil Engineering Research Institute for cold region, PWRI, 2. Fujita Corporation

There have been many reported cases in which deformation, such as tunnel ground heaving and squeezing of sidewalls, occurred in a tunnel days, months or even decades after construction. Therefore, a diagnostic method is required that is able to provide constant and reproducible monitoring from construction stage to maintenance stage. We are carrying out a study to develop a diagnostic method to estimate the soundness of tunnel ground from time-dependent behavior from in an actual two tunnels, the New tunnel and the Old tunnel, with time-dependent deformation. The Old tunnel was conducted after closure after opening of the New tunnel. From the results of a series of laboratory tests and field experiments, we found it is possible to estimate the soundness of tunnel ground using seismic velocity. So, we carried out field experiment of actual tunnel with time-dependent deformation and the result of case study evaluating the soundness of tunnel ground using seismic velocity. The geology of both tunnels in this study is hydrothermally altered pyroclastic rock. Heaving occurred in two sections replaced by timbering in a hydrothermally altered andesite zone in the New tunnel after completion in 2014. The Old tunnel was completed in 1977 using the timbering support method. The Old tunnel has 5 sections of time-dependent deformation. A seismic refraction survey was carried out in both tunnels in order to evaluate the soundness of tunnel ground. We used a hydraulic impactor as the seismic source and MEMS (Micro electro mechanical systems) sensors as seismic receivers. The hydraulic impactor was used to avoid damages to the pavement as a non-blasting seismic source. MEMS sensors enabled down-sizing of the survey equipment and to reduce the hours needed for receiver handling. P-wave generation was achieved using a vertical shot. Each shot is stacked 3 times at each shot point in order to improve S/N ratio. The survey line is 450 m length in the New tunnel, 1,500m in the Old tunnel. The interval of receivers is 6.0m, and the interval of shot points is 3.0m- 6.0m. If the decrease of P-wave velocity due to the time-dependent deformation or the loosening by stress release from the excavated surface, the seismic velocity in the deeper zone may be assumed to be indicate the original seismic velocity of ground because it is far from influence of the excavation. In other words, the surface part having lower seismic velocity originally had higher velocity but it decreased as tunnel excavation work progressed. Based on this assumption, the soundness of tunnel ground can be evaluated by a decrease in the ratio of surface seismic velocity to deep zone. The decrease rate of P-wave velocity of No.1 to No.5 block and non-deformed zone of the Old tunnel and the zone of initial deformation 1 and 2 of the New tunnel. The decrease rate of P-wave velocity of No.1 to No.5 block with time-dependent deformation is estimated 25% to 44%. While, the decrease rate of P-wave velocity of the other zone with no time-dependent deformation is 8% to 16%. Thus, it is confirmed that the decrease rate of P-wave velocity in the zone with time-dependent deformation is higher than that in the other zones. And it is suggested that the threshold of this tunnel ground may exist between 16% and 25%.

Keywords: tunnel, seismic velocity, time-dependent deformation

Dynamic Basement Amplification Characteristics of Dam Site using Reference Site Method

*Junkyoung Kim[1]

1. Semyung University

Observed ground motions are composed of 3 factors such as, seismic source, attenuation, and site amplification effect. Among them, site amplification characteristics should be considered significantly to estimate seismic source and attenuation characteristics with more confidence. Site effect is also necessary to estimate not only seismic hazard in seismic design engineering but also rock mechanical properties. This study applied the method of H/V spectral ratio of observed ground motion between target site and reference site, namely reference site method. In addition to using vertical Fourier spectrum of reference site, this study tried newly to use horizontal Fourier spectrum. This study analyzed H/V spectral ratio of 6 ground motions respectively, observed at 4 nearby sites at Yedang Reservoir. And then, site amplification effects at each site, using 3 kinds of seismic energies, that is, S waves, Coda waves energy, and background noise were compared each other. The results suggested that each site showed similar site amplification patterns among S waves and Coda waves energy. However, site amplification of background noise showed much different characteristics from those of S waves and Coda waves energy, suggesting that background noises at each site has it own developing mechanism. Each station showed its own characteristics of specific resonance frequency and site amplification properties in low, high and specific resonance frequency ranges. Comparison of this study to others using different method can give us much more information about dynamic amplification of sites characteristics and site classification.

Keywords: S wave, Coda wave, background noise, H/V spectral ratio, resonance frequency, reference station

Near surface geophysical survey of the ground in front of a road embankment partially collapsed by a heavy rainfall

*Tomio INAZAKI[1], Hiroshi Kisanuki[1], Takanori Ogahara[1], Kyosuke Onishi[1]

1. Public Works Research Institute, Tsukuba Central Institute

We conducted an urgent but detailed near surface geophysical survey at a site where 8 m high road embankment slope had been partly collapsed by a heavy rainfall along with strong motion of 2016 Kumamoto Earthquake 2 months before. Owing to a geotextile-anchored concrete wall preset at the foot part and 8 m long preventative pile arrays penetrated in front of the road embankment, the slope failure was minimized and debris runoff stayed in a limited zone. Meanwhile, the embankment collapse caused a half-moon shape deformation, 20 m in radius, and upheavals up to 2 m, to the ground in front of the collapse. We set a total of 4 short survey lines in and outside of the deformation zone to identify the extent of the deformation in depth direction. Employed methods were DC resistivity and “Hybrid Surface Wave Survey” recently proposed by the authors. The Hybrid Surface Wave Survey method is characterized as the combination of active and passive surface wave survey simultaneously conducted along the same seismic line. A number of geophones, set along a line at 0.5 m intervals, were used to record active surface hitting waveforms and passive microtremor. Two dispersion curves, one is for a higher frequency part calculated from active survey records, and the other is for the lower frequency part calculated from passive seismic records, were combined to form a single dispersion curve for a specific CMP in a survey line. As a result, DC resistivity measurements provided clear layered structures along the lines. Resistivity sections were concordant with estimated geologic structures but no difference was observed between the sections in and outside the deformation zone. In contrast, S-wave velocity sections showed a characteristic structure in the deformation zone. Namely, the S-wave velocities were as low as 30 m/s in the deformation zone. Thicknesses of the low velocity layer increased toward the major axis of the collapsed body up to 10 m in depth. These features were not obvious along the line set outside of the deformation zone. The field survey results demonstrates that near surface geophysics is helpful for the site characterization of landslides or slope failures on the basis of not only surface evidences but also of near surface structure.

Keywords: Near Surface Geophysics, Embankment Collapse, S-wave velocity, Resistivity

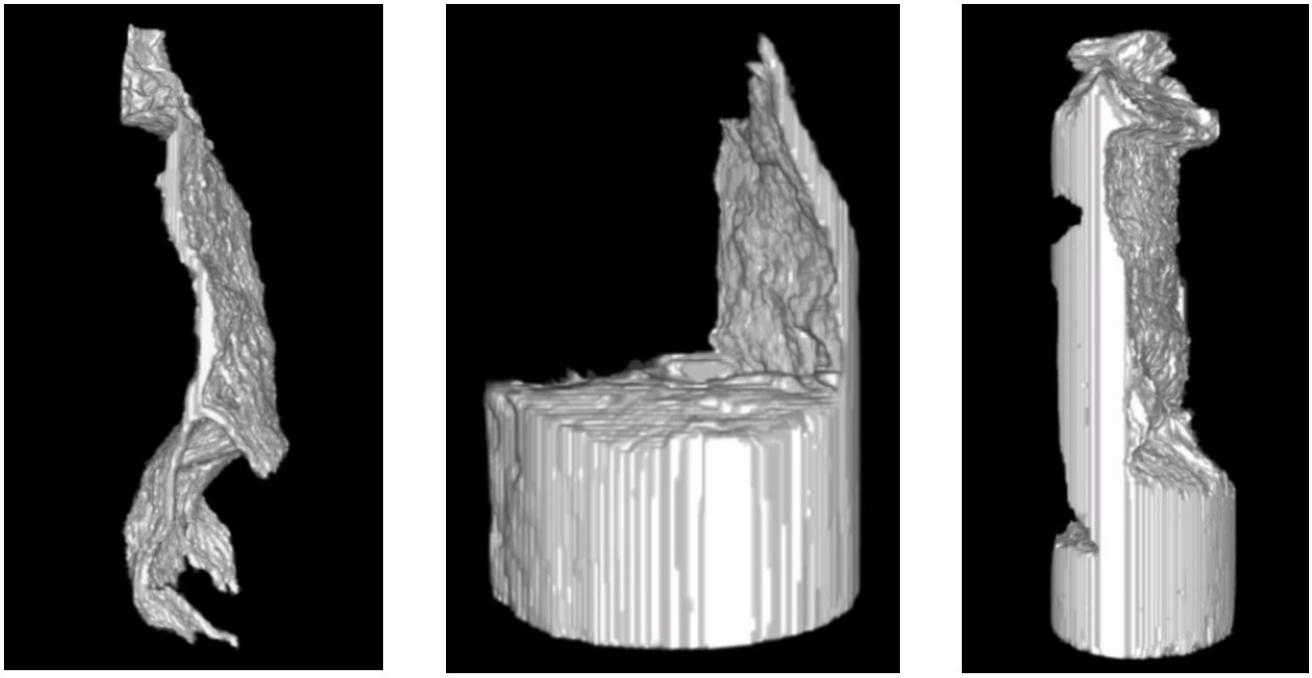
Three-dimensional structures of sand dykes revealed by X-ray computed tomography of boring cores

*Yoshito Nakashima[1], Junko Komatsubara[1]

1. National Institute of Advanced Industrial Science and Technology

Near surface geophysics is employed for the risk assessment of liquefaction induced by earthquakes. The laboratory analysis of boring cores sampled at the liquefied sites is useful for the interpretation of the obtained geophysical data because it contributes to the accurate determination of the occurring depth, spatial extent, and degree of strength of the liquefaction, which is essential for the reliable risk assessment of the sites. Three-dimensional imaging technique such as X-ray computed tomography (CT) is useful to detect the liquefaction-induced sand dykes embedded in the cores without fail. We applied medical X-ray CT to liquefied cores (depth 0 to 10 m) obtained from the Kanto region, Japan, where the 2011 off the Pacific coast of Tohoku Earthquake occurred (Nakashima and Komatsubara, 2016). Sand dykes intruding into silt layers can readily be detected by taking advantage of the significant difference in density and mineral composition between sand and silt. In contrast, sand dykes (i.e., disturbed sand) embedded in undisturbed sandy sediments with laminations were more difficult to detect due to little difference in density and composition between the disturbed and undisturbed sands. However, we successfully extracted the three-dimensional complex structures of sand dykes embedded in the sandy sediments (see attached figure) using a specific digital image segmentation technique (i.e., cellular automaton model) originally developed by Vezhnevets and Konouchine (2005). These results demonstrate that X-ray CT coupled with advanced digital image processing is a promising tool for the liquefaction identification in boring cores.

Reference:
Nakashima, Y. and Komatsubara, J. (2016) Seismically induced soft-sediment deformation structures revealed by X-ray computed tomography of boring cores. Tectonophysics, 683, 138-147 (open access). http://dx.doi.org/10.1016/j.tecto.2016.05.044



Three-dimensional images of sand dykes in a core (diameter, 64mm) obtained by X-ray CT (Nakashima and Komatsubara, 2016)

Development of MASW using Rayleigh wave and Love wave

Kazuya Sugita[1], *Yoshiya Oda[1]

1. Tokyo Metropolitan University

MASW estimates the S-wave velocity from measured dispersion curves of surface waves and in most applications, Rayleigh waves are used. We have developed inversion method using both Rayleigh wave and Love wave to improve the accuracy of MASW in this study.

Keywords: MASW, Rayleigh wave, Love wave

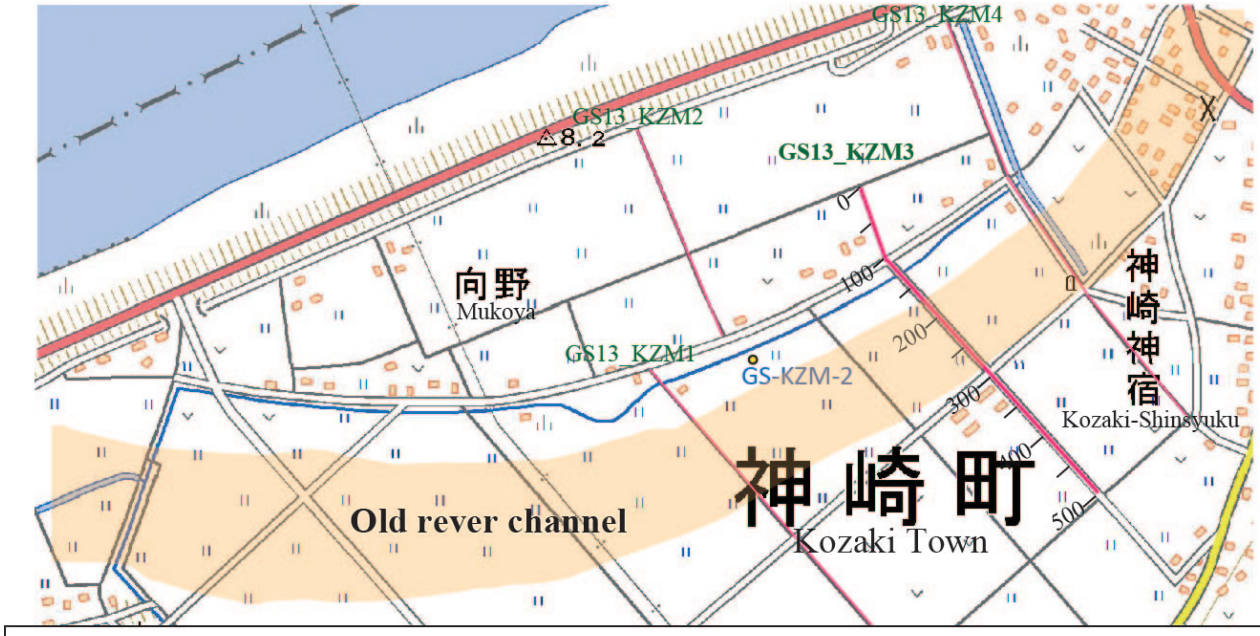
Surface wave surveys in the affected area of liquefaction which was generated by the 2011 off the Pacific coast of Tohoku Earthquake - A case study at Kozaki, Katori, Chiba -

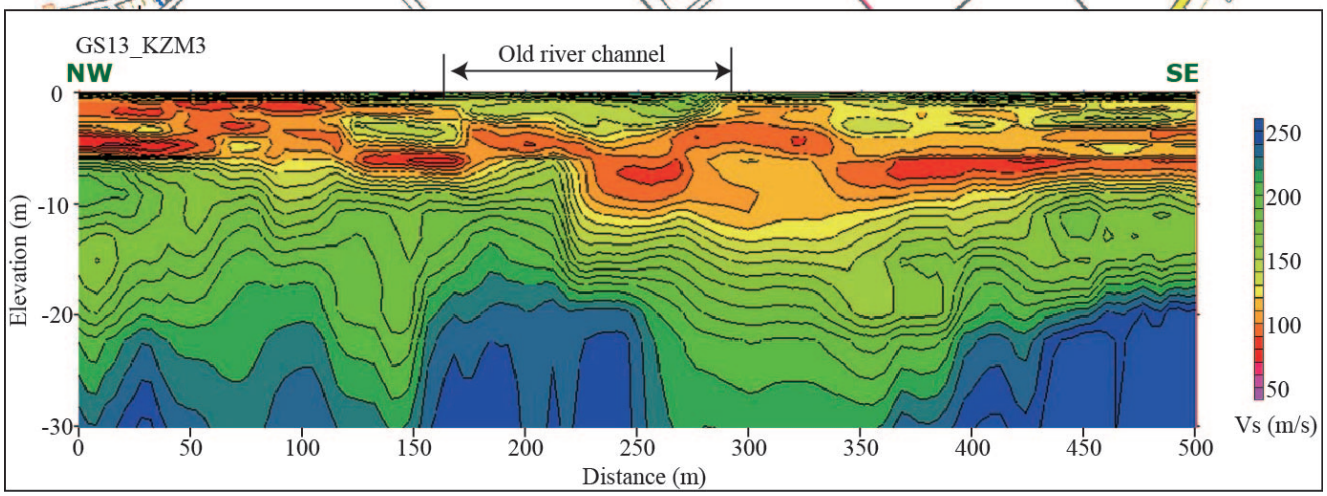
*Tishiyuki Yokota[1]

1. National Institute of Advanced Industrial Science and Technology

Serious liquefaction damage arose according to the 2011 off the Pacific coast of Tohoku Earthquake in the Tone River downstream region. Many of them occurred in the area where water zones were reclaimed until relatively recent years. In the survey area, Mukoya and the Kanzaki-Shinsyuku area, Kozaki, Katori, Chiba, the liquefaction was occurred in case of the 1987 Chibaken Toho Oki Earthquake (Kazaoka, 2003). Liquefaction damage was observed almost the same location in case of the 2011 off the Pacific coast of Tohoku Earthquake, the main reason of the repeated liquefaction damage at the identical location can be explained by the existence of the dredged-sand layer which filled up the old river channel of the Furu-Tone River which was reclaimed in 1963.
In this research, we carried out the surface wave surveys in Mukoya and Kozaki-Shinsyuku area along the four survey lines, GS13_KZM1 (500 m), GS13_KZM2 (300 m), GS13_KZM3 (500 m), and GS13_KZM4 (600 m). We used the land streamer for P-SV wave with a 1-m receiver interval for data acquisition. The central frequency of the receiver was 4.5 Hz, shot-point interval was 2 m, and the maximum offset was 96 m. The acquired data were sorted into the common mid-point gathers as the manner of Hayashi (2001) (the CMPCC method), and processed with the quasi-two-dimensional analysis with assuming the one-dimensional structure (horizontal layered model) beneath each CMP locations. Since the feature of inverse-dispersion nature was observed in the acquired data, both fundamental and higher modes were used in the inversion procedure.
The result of survey-line GS13_KZM3 is shown among the obtained S-wave velocity structures. It is the survey line which crosses the old river channel of the Furu-Tone River, distance of about 100-300 m corresponds to the old river channel portion. Within the 0-100 m interval, the low velocity zone of Vs value is less than 100 m/s can be observed in the shallower portion. We can interpret the low velocity layer as silty layer, and the interpretation agrees well with drilling results. In the section of the old river channel along the survey line GS13_KZM3, we can see the syncline structure of Vs values about 140 to 170 m/s, and another syncline structure of less than 100 m/s can be seen under it. The most probable interpretation of these structures is the existence of the old river channel which were filled with dredged-sand. As considering the interval from the view point of liquefaction, since the silty layer locates beneath the dredge sand layer with homogeneous particle diameter, the water level in the sand layer tends to be kept high, moreover, the shape of the layer tends to enlarge the ground motion when the earthquake happens. From these, liquefaction probably happen in this domain when another big earthquake occurs. In the interval of about 300-500 m, we can see relatively flat alternation of strata with some layers.

Keywords: surface wave survey, the 2011 off the Pacific Coast of Tohoku Earthquake, liquefaction, old river channel





Attempt to Self-potential in shallow groundwater area, Akita prefecture

*Koushou Tanaka[1], Kazuhiro Amita[2], Kyosuke Onishi[3]

1. Graduate School of International Resource Sciences Akita University, 2. Reserch Center for Engineering Science, Akita University, 3. Public Works Reserch Institute

A study is one of the geophysical explorations. It has been used in the volcanic and geothermal areas in order to investigate hydrothermal water convections. The relationship between SP and groundwater flow still is not well studied. It is important to clarify the groundwater flow. It is because the use in groundwater management.
In this study, SP survey was carried out at the shallow groundwater field. And, we examined whether it is possible to observe what kind of SP. It was investigated in a place where there is a lot of groundwater level data and gradient data.
We have selected Rokugo alluvial fan in Akita prefecture, is because of the groundwater level data has been recorded. Rokugo alluvial fan has an area of about 4km from east to west, and approximately 5km from north to south. Its area is 14km². The study was carried out in September-November, 2015.
From the observation result, it was possible to find SP decreases section as the altitude increases. In the case of Rokugo alluvial fan, the topographic effect is -1.0 ~ -3.7mV/m.

Keywords: Shallow ground water, Self-Potential, Streaming potential

Survey for tree root system GPR by synchronized with self-tracking total station

*Kunio Aoike[1], Kazunori Takahashi[1], Yayoi Ishizawa[1], Ishizawa Nobuaki[1]

1. Oyo corporation

A non-destructive inspection for imaging the exact root system of trees under the ground surface is important to assess the healthiness of trees or to evaluate the risk of collapse. The authors applied a GPR (Ground Penetrating Radar) survey to image the distribution of lateral root system in detail. The system used in the surveys was a cart type GPR that is able to synchronize GPR traces with accurate antenna positions obtained by a self-tracking total station using an active target mounted on the GPR antenna. Since the tracking rate of our total station is 2.5 times per a second, it has a nonnegligible delay to determine the position relative to the rate of GPR scanning. The delay causes positioning error that depends on the operation speed. We conducted an experiment to determine the relation between the operation speed and the error and the accuracy was improved by correcting the error using the relation. We applied the system to trees in three different surface conditions: The first case is a Quercus planted in a loam layer. The second case is a Platanus. The ground surface around the tree is paved and layer under pavement is a natural gravel layer. The last case is a Japanese black pine planted in sand near seashore. In all the cases, we could successfully image the detailed root distribution in the near-surface layer, and in the case of the Japanese black pine the horizontal root distribution was identified up to the depth of 1m.

Keywords: GPR, Total station, Root system

Matching locations of survey lines and common reflection points between multi-channel GPR records

*Kyosuke Onishi[1], Takanori Ogahara[1], Hiroshi Kisanuki[1], Tomio INAZAKI[1]

1. Public Works Research Institute

Recent multi-channel ground-penetrating radar (GPR) provides high volume of survey data in short time. Also, high accurate GNSS measurement can be easily used and the combination of GPR and GNSS provides many repeated records in the similar locations. However, repeatedly acquired GPR records cannot be acquired at the exactly same locations and must be surveyed at the slightly different locations. Positioning accuracy of RTK-GNSS is not enough to set survey locations or detect relative survey positions with between two different surveys. On the other hand, repeatedly scanned survey records using multi-channel GPR in a similar survey line have large potential to improve the signal to noise ratios of survey records and detect underground events. Matching locations of survey lines and common reflection points between repeatedly surveyed multi-channel GPR records becomes an important technique for future GPR processing. We will discuss methods of matching two or more different survey records of multi-channel GPR and show results matched with relative positions of records which are actually acquired on paved roads. A set of multi-scanned survey records has high dense information for space and many CMP records which can be useful for making a velocity distribution map.

Keywords: 3D, CMP, velocity analysis

Multi-offset reflection records from point scatterers and velocity analysis

*Kyosuke Onishi[1], Hiroshi Kisanuki[1], Takanori Ogahara[1], Tomio INAZAKI[1]

1. Public Works Research Institute

Ground-penetrating radar records include a lot of reflection events from point scatterers. Soil and ground in near surface includes many stones which are smaller than a typical wave length of propagated electro-magnetic waves of ground-penetrating radar. This relationship is far difference from standard reflection seismic records which include mainly reflection events from continuous layer boundaries. Records of ground-penetrating radar show a lot of diffraction patterns from small scatterers which are frequently main survey targets of the ground-penetrating radar surveys. When applying migration processing for the ground-penetrating radar records, the events from point scatterers sometimes change difficult to be detected in background waves. Therefore, migration processing is frequently skipped in the processing of ground-penetrating radar. The other characteristic issue due to point scatterers in ground-penetrating radar survey is much noise in a semblance panel for velocity analysis. Point scatterers are not normally located just below the survey line. A point scatterer located with the same length of propagation path but not located just below the survey line must be located in a shallower zone from a point scatterer located just below the survey line. Different depth zones frequently have different dielectric constant and the reflection event from a point scatterer not located just below the survey line, which is frequently located in a different velocity zone, makes a strong error event in the semblance panel. We want to discuss this issue and try to avoid it using 3D multi-offset records.

Keywords: GPR, velocity analysis, scatterer

