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GEOSPATIAL-GEOTECHNICAL DATABASE OF BORING AND DENSE MICROTREMORS DATA FOR KANAGAWA PREFECTURE, JAPAN.

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ABSTRACT

Japan has suffered greatly from natural destructive events such as 1923 Kanto earthquake. Numerous geological data have been collected from local governments and municipalities in Kanagawa prefecture, Japan in order to be applied on studies for the effect of surface geology on seismic motions as well as micro-zoning projects. Further more data from array measurements have been added to the database since the Vs data are not adequate in Sagami plain and in some locations of Yokohama city. Microtremors measurements were deployed at two major sedimentary basins; Ashigara and Sagami Plains and Yokohama city on a square mesh size 250m. The H/V Spectral ratio was used to obtain the predominant periods. All three kinds of data and the related analysis were stored on a geospatial database using a GIS platform. Distribution maps was provided for each characteristic parameter for example; predominant period, amplification factors, and so on. The database is being used for disaster management applications and studies.

Introduction

Developed countries, such as Japan can suffer greatly from a natural destructive event such as 1923 Kanto earthquake. In this paper, as a part of the “Academic Frontier Research Project”, we collected numerous geotechnical data about the ground to be applied in micro-zoning studies. Boring data used for civil projects have been collected from local governments and municipalities in Kanagawa prefecture, Japan. We introduced the data into an application independent database for further studies on the effect of surface geology on seismic motions. However the main obstacle for us was the lack of suitable information for accurately estimating the Vs profile from the popular N-Values since the vertical profiles of Vs and P velocities as well as soil density are needed for estimation of dynamic behavior of ground. Therefore we deployed array measurements in Sagami plain and in some locations of Yokohama city in order to obtain a basis to refine out estimations.

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Microtremors measurement also proved to be a convenient method for obtaining ground's basic dynamic characteristics in mass quantities. At two major sedimentary basins, Ashigara and Sagami Plains we applied microtremors measurements as well as Yokohama City on a mesh size of 250m×250m. The H/V Spectral ratio were used to obtain the predominant periods. All three kinds of data and the related analysis were stored on a geospatial database using a GIS platform. Distribution maps provided for each characteristic parameter, e.g., predominant period, amplification factors. The database is suitable for disaster management applications and studies.

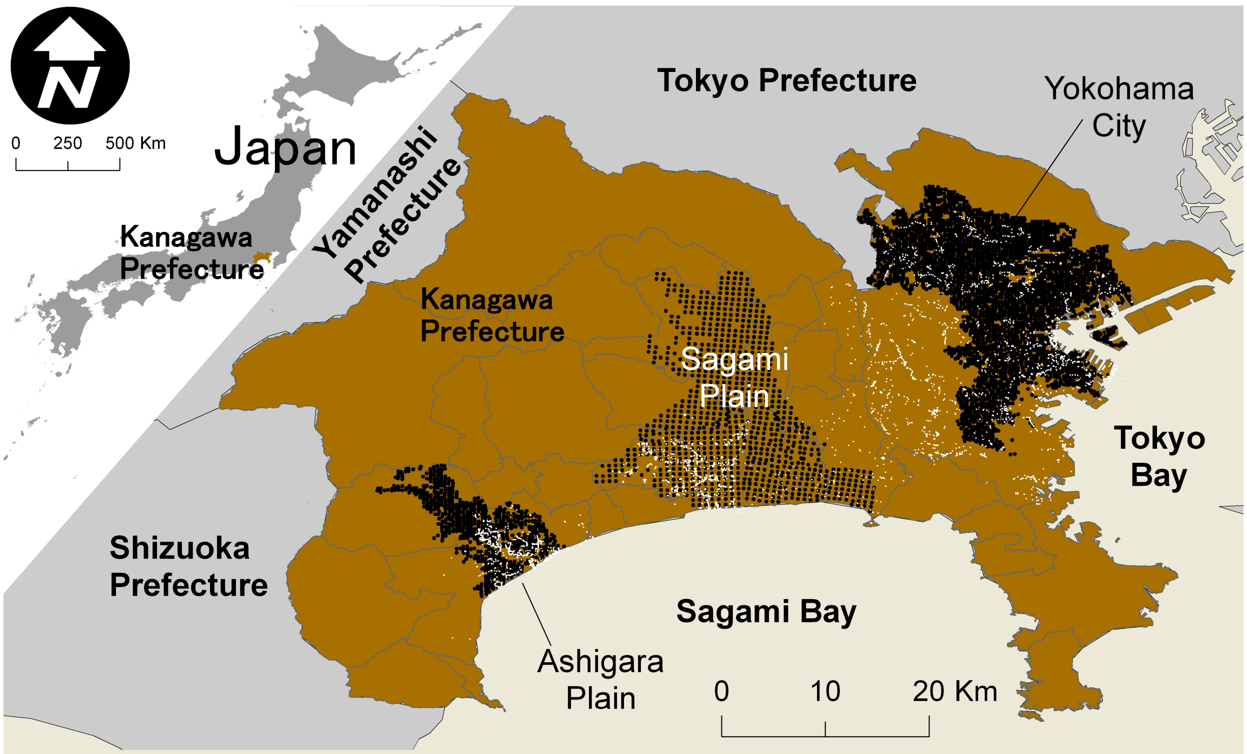


Figure 1. Dense microtremors measurements (Black circles) and boring data (white circles).

Area of Coverage

Kanagawa Prefecture, with 2,415.84 square kilometers, is ranked 47th in area and with a population density 3,711 people per square kilometer is ranked the second in Japan. This prefecture is stretched from Kawasaki City on East to Ashigara area on west and Sagamihara City at North to the Pacific Ocean in south. The prefecture can be divided into roughly three regions by topographic features; the mountainous region in the west with the 1,500 m high mountains of the Hakone and Tanzawa ranges, the plain and plateau in the central part with Sagami River that runs through it, and the hilly and coastal area in the east.

Many historic and large earthquakes hit Kanagawa Prefecture which is located at very complex crustal combination with four tectonic plates. Pacific Ocean Plate is sub-ducting under North American and Philippine Sea Plate, and North American plate is sub-ducting under Eurasian Plate while colliding with Philippine Sea plate in so called Izu collision zone.

High-Density Microtremors Observations

A three components SPC-51 seismometer were used to observe the microtremors on very dense (231m by 285m), grid points. At each point recording was made in two horizontal, NS and EW and vertical (UD) directions at a sampling rate of 100 Hz for three minutes (18000 data points). Figure 1 also shows the location of the measurement points in Kanagawa Prefecture. The measured microtremors data were analyzed for about 4 cities in Kanagawa prefecture.

There are many discussions (e.g. Field and Jacob 1995) over the application of H/V ratio first introduced by Nogoshi (1978) and made popular by Nakamura (1989) but recent studies (Lachet et al. 1994 and 1996) shown very good confident on the results of this method. Enomoto et al. (2000) confirmed that the predominant period of H/V spectra and corresponding amplitude of H/V spectrum shows very good correlation with characteristics of surface geology such as amplification factors. Rahimian (2002) also confirmed the same for soft sediments by comparing H/V with conventional site to reference spectral ratio obtained from strong motions.

A software have been developed (SAMR) to automatically trace, identify and eliminate the short period transient noises and then identify the possible numbers of segments with 2048 data points. A sample calculation procedure is shown in Fig 2. The possible numbers of samples (in this Fig. two samples) have been chosen automatically by the software then the Fourier spectra of identified records are calculated and smoothed by a log window with 15% bandwidth. Then horizontal vector component calculated using the following formula

$$H = \sqrt{NS \times EW} \qquad (1)$$

where NS, EW and UD are the spectra of the three recorded velocity data in directions of North-South, East-West and vertical, respectively. H is the estimated spectra for the Horizontal vector and finally by dividing the Horizontal to the Vertical component in the following formula

$$H/V = H/UD \qquad (2)$$

H/V is calculated which is the well known spectral ratio as mentioned before. The mean spectrum for all components H and H/V would be calculated. Finally we estimate the site predominant periods by tracking the peak values in these mean spectra. The results are plotted into a multi-page post-script file which is then converted to a PDF file suitable for a GIS platform use.

Separate spread-sheets are provided after careful assignment of predominant periods from PDF files and then used for distribution maps by GIS platform.

Geotechnical Borehole Database

Currently a large amount of borehole data is kept in each region by the local self-governing bodies and the amount continues to increase each year. These soil data are very hard to organize, as they are largely paper-based, and information retrieval is not easy. Also, despite a strict sharing system, information losses would be inevitable. In many cases companies are refraining from releasing their soil information and it would stay within the company as records of construction projects and never made public.

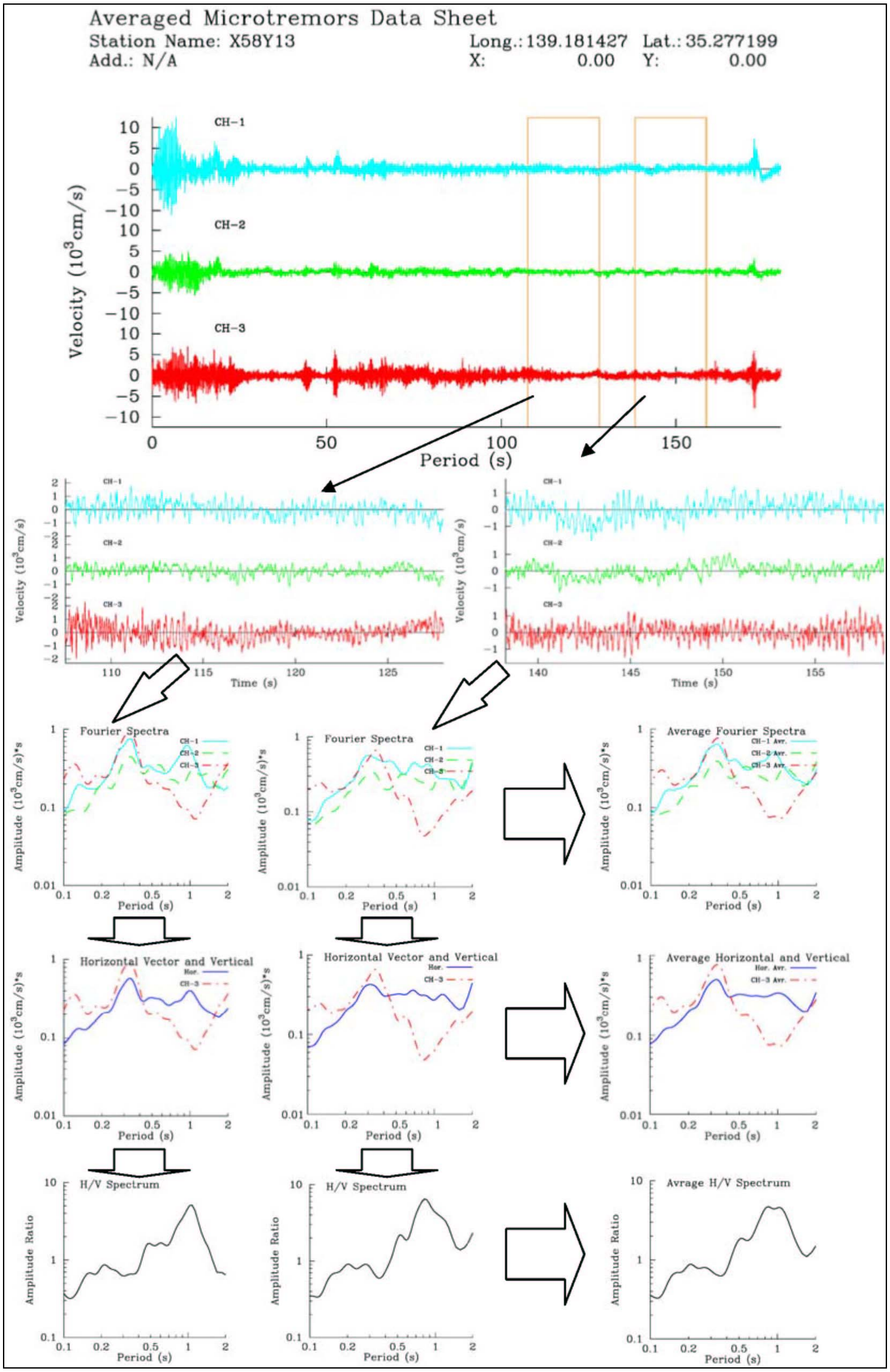


Figure 2. The sample flow of the analysis of the microtremors records

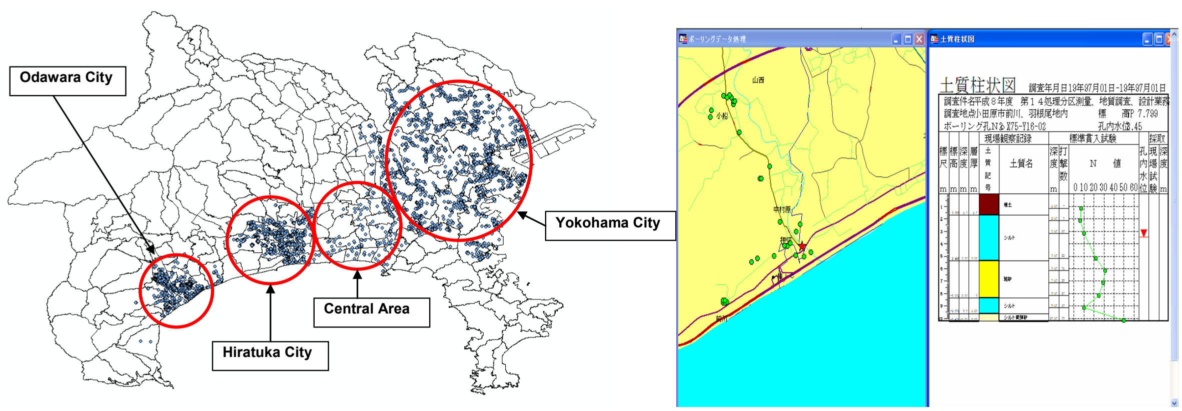
On the other hand the available soil related info and data are stored inconsistently, as analogue or digital formats. The integration and planning for joint owner-ship of this information is a major challenge for research activities in universities that are in need for such asset.

In order to compile a soil survey report including all fundamental soil information, for scientific research purpose, the existing paper-based data, such as columnar sections, soil test results, and PS logging data were gathered or borrowed from the administrative bodies in several cities and towns within Kanagawa Prefecture from year 2002.

Procedure and Collection Criteria

Boring data which were collected from the municipalities and local governments were in different quantities, detailing and formats. The first step was to check the credibility and usefulness of the information. Only the collected data that includes all of the following five types of sections were collected to be included in our database:

1) Outline of investigation,
2) Information map,
3) Detailed map of investigation location,
4) Columnar sections of boreholes,
5) Soil test results.



a) b)

Figure 3 a) Distribution of borehole data in Kanagawa Prefecture b) Sample illustration of borehole info in GIS platform. Click on the left map results in a pop-up plot of the soil profile (right)

Total of 5678 borings were collected in this study (Fig. 3a) that can be divide roughly into 3000 from eastern Kanagawa including the Yokohama City and 1500 boreholes from Central Kanagawa that includes the Hiratsuka city and from West Kanagawa we obtained 1178 borehole data Including Odawara, and Minami Ashigara cities.

The collected information then compiled in uniform digital report indicating the “Local name”, altitude, latitude, longitude and standard penetration test results, as shown in Fig. 3b. The database was compiled, and organized in a GIS platform.

GIS Illustration

All the data obtained for the site investigation of the Kanagawa prefecture are gathered in a GIS platform for easy illustrations. The database is for disaster management applications. Combined with the local site data from Boreholes or geological or geotechnical digital data in a GIS platform. Spatial illustration of the collected information and analyzed spectra has been addressed from a digital database. Fig. 4 shows the predominant period distribution map for Odawara city in west Kanagawa. We provided access for each station to illustrate the geographical location, predominant period, and a hyperlink to a file (PDF format) containing all the waveforms and spectra that are provided in preparation for database. Using this database we are able to present the result quickly and efficiently. Fig 5 shows a sample for accessing such file. This database is only accessible from within the network and is not opened to public use yet.

Array Measurements Data

The main obstacle we observe was the lack of accuracy in estimating the Vs profile from the N-Values. The P and S wave profiles are needed for almost all dynamic site response analysis of the soil. Yokohama city has the most dense city-wide seismic network in Japan provided us with PS profiles for the seismic stations. However we made array measurements for comparisons between the commonly used modified SPatial Auto-Correlation method (Aki, 1957) SPAC method, and regular PS logging in playgrounds of 6 schools in Yokohama city with the details given by Ishii et al. (2006). For other cities we needed to deployed array measurements in order to obtain a basis to refine our estimations. For Sagami-plain array measurements of microtremors deployed at nine sites in Hiratsuka city near the banks of the Sagami River. The measurements need wide flat areas. Therefore the playgrounds of 8 elementary schools and one park (listed in table 1) were used.

A seven channel double triangle of vertical servo-velocity-meter sensors were used in arrays with max radius 15 to 40 meters to cover a range of pair distance from 5m to 70m. Recordings were made for at least 20min with 100Hz sampling rate. Inversion of zero order Bessel function of SPACs was used to obtain the phase velocity dispersion curve and estimated Vs profile (shown in Fig. 6).

Table 1. List of the Array locations in Sagami Basin

Location Name	Max R(m)	Mid R(m)	Min R(m)
Toyoda E.S.	30	15	7.5
Matsuoka E.S.	30	15	7.5
Ohno ES	30	15	7.5
Fujimi E.S.	30	15	7.5
Souzen E.S.	30	15	7.5
Matsubara E.S.	40	20	10
Nadeshiko E.S.	30	15	7.5
Hanamizu E.S.	30	15	7.5
Shonan Kaiger Park	40	20	10

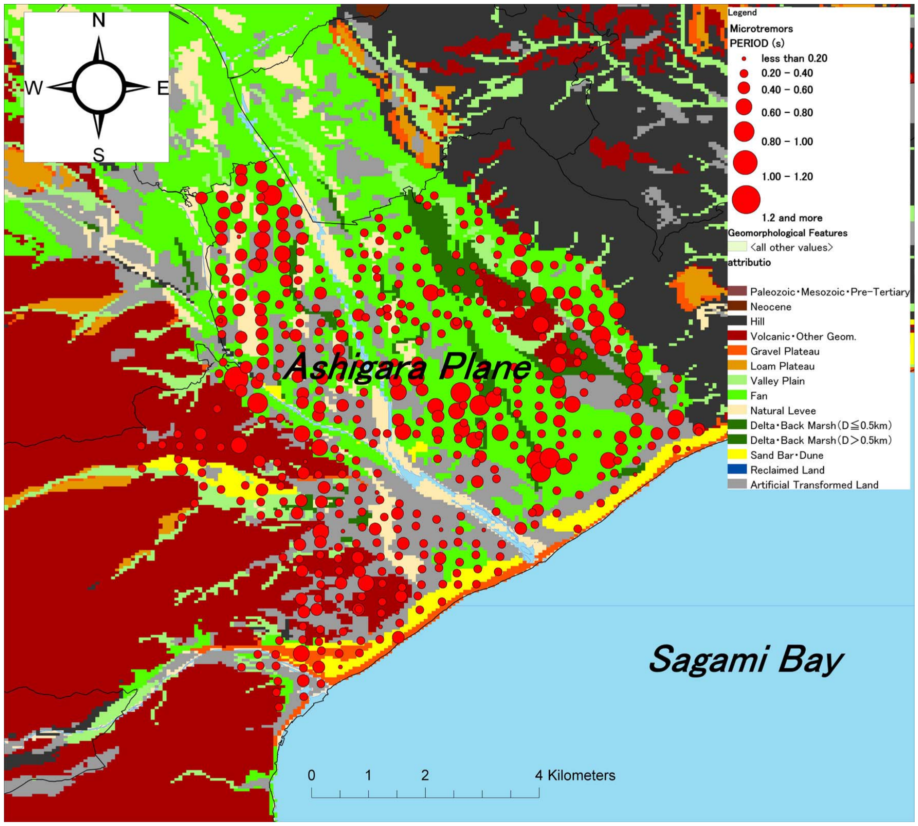


Figure 4. Distribution map for predominant period in Odawara city west of Kanagawa.

Application of Databases

Currently three sets of data are independently stored in GIS system and further discussion on relationship among these data will be presented in near future, including comparisons between boring data and array results with microtremors. However the data have been applied partially as they were collected.

Tanaka (2003) used the database to estimate the soil profiles along Northern Ashigara Valley in Odawara City. Matsuzawa (2003) compared the Borehole data and Microtremors for northern Ashigara valley. Yamamoto (2004) and Matsuzawa (2004) continued the work for southern part of the valley.

The average shear wave velocity of the upper 30m of the ground (AVS30) is a very popular method of site characterization among engineers. This method is used as a measure for indexing the stiffness of the ground. Enomoto used the collected boring data to calculate AVS30 and compared to other empirical methods and mapped them for Yokohama City (2009a) and Kanagawa Prefecture (2009b).

Hashimoto (2009) also used the database of both microtremors and boreholes to produce an earthquake disaster prevention map for the Sagami basin in the border of Hiratsuka and Chigasaki cities.

Distribution Maps of Microtremors Measurement Results have been produced by Ochiai et al. (2006, 2007, 2008) and Yamamoto et al. (2007, 2009) for several wards in Yokohama city.

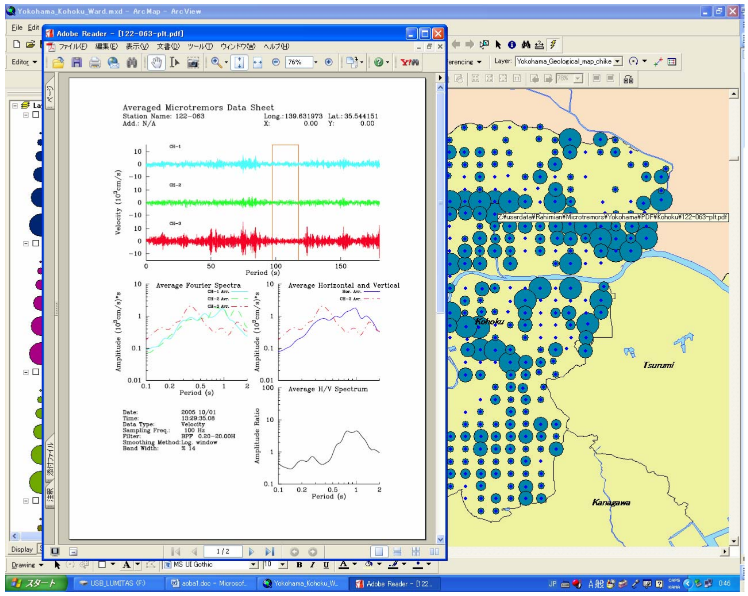


Figure 5. Typical hyperlink to the GIS maps pops-up the detailed info files e.g. microtremors analysis, boreholes, array analysis, etc.

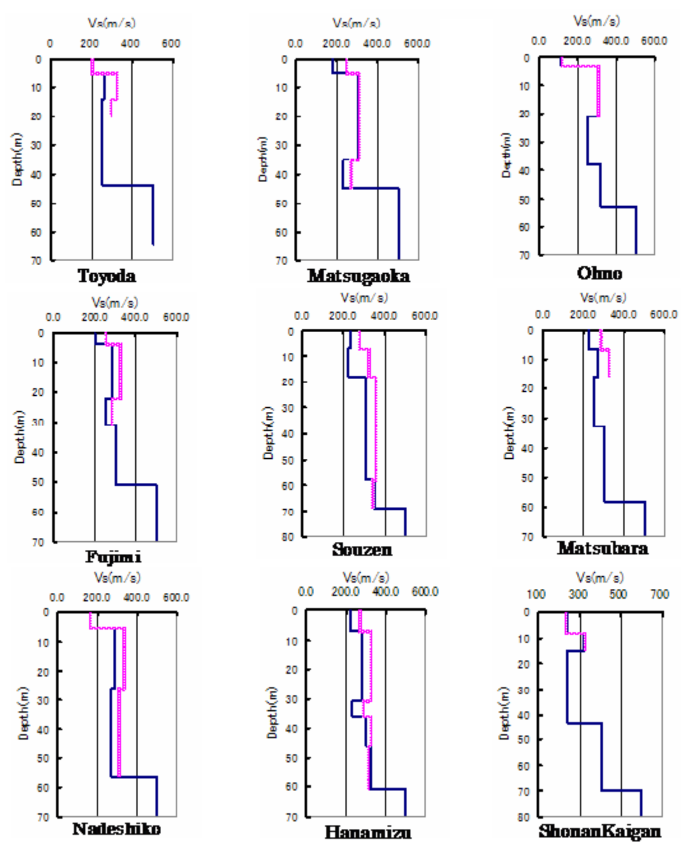


Figure 6 Comparison between the array results (Blue) and nearby borehole profile (Pink) in terms of shear wave velocity (m/s)

Conclusions

The shallow soil condition has a great influence on earthquake and an important point of this research is to reach a full representation of the soil characteristics for earthquake disaster prevention studies when it is complete. In this regards it is essential to build a geoinformatic database for the management and effective application of fundamental and important soil information, which digitizes and stores data using state of the art computer technology.

A large amount of soil information acquired, and prepared on a GIS platform to be used according to the need of researchers in the area. Currently, three sets of data are independently stored in GIS system and further discussions are needed on relationship among these data such as comparisons between boring data and array results with microtremors in near future.

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