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EARTHQUAKE DISASTER MITIGATION IN LOCAL CITY

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SUMMARY

After the Great Hanshin Earthquake, disaster mitigation planning in megalopolis (large city) is progressive in Japan. However, it is difficult to obtain some effective method for disaster mitigation in small cities or villages because of limitation of financial affairs, boring data for estimating dynamic soil properties and so on. It is urgently important to prepare new method for decrease of natural disaster not only in huge cities but also in local/rural area at this time when strong earthquake may soon occur in the oceanic trench in West Japan. From this point of view, this report will deal with the restoration process, estimation of dynamic characteristics of surface soil by H/V spectra from micro-tremor and self-organized mitigation systems in small city such as Hikone in Shiga Prefecture.

INTRODUCTION

After the 1995 Hyogoken-Nanbu Earthquake, a lot of survey papers were published in Japan, where most of researchers focused in the damage in big city, Kobe[1)]. There happened many general and important problems solved in modern city, for instance, risk management system, new building code, strengthening of infrastructure, insurance system for collapsed houses, and so on. However, local cities or small towns have also different problems to be solved.

Damage and restoration process of small town such as Ichinomiya, Hyogo Prefecture due to the 1995 Earthquake showed the importance of daily communication among citizens as well as local government. They could quickly rescued neighborhood and constructed some community center for aged person or weak person who could not rebuild a house by themselves[2)]. Damages in Hino town, Tottori Prefecture due to the 2000 Western Tottori Earthquake in mountain area were not so severe in spite of similar magnitude as the former Earthquake because houses built in this area were to be stronger due to local construction technique[3)] and heavy snow fall area.

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In this paper, four kinds of disaster mitigation methods for local cities or small towns are discussed; communication, dispersion of village, lack of fund and specialist and lack of important data for risk mitigation. Finally, a method of depth estimation of alluvial soil is proposed.

CHARACTERISTICS OF THE EARTHQUAKES AND DAMAGES CONSIDERED IN THIS RESEARCH

The 1995 Hanshin-Awaji Earthquake with magnitude of 7.2 occurred January 17, 5:46 beneath the modern city, Kobe and seismic intensity 7 were recorded in many wards in Kobe, satellite city Ashiya, Nishinomiya, Takarazuka and Hokutan town,Ichinomiya town, Tsuna town in Awajishima Island. More than 6 thousands of people died, 44 thousands were injured, more than a hundred thousand houses were collapsed. The reason of death was mainly collapse of wooden houses because of early morning. Total ratio of death person to Number of collapsed houses is 15%. While the ratio is 2% in Ichinomiya town. Figure 1 shows the location of Ichinomiya in Awajishima Island, from here fault rapture started to North-East.Why the ratio in Ichinomiya was so small ?
The 2000 Western Tottori Prefecture Earthquake occurred October 6, 13:30 with magnitude 7.3 similar to the 1995 Earthquake. Maximum seismic intensity of 6+ was measured in Hino town in mountain area[4]. Populations in Ichinomiya and Hino town are 10 thousand and 5 thousand respectively.

Fig.1 Ichinomiya town in Awajishima

Fig.2 Hino town in Tottori Prefecture

DAMAGE CHARACTERISTICS IN SMALL TOWN AND SOME PROBLEMS TO BESOLVED

Problem-1. Communication

Six years after the Earthquake, we visited Ichinomiya town, where we found heartful three types of community houses as shown in Fig.3. 75% of houses were completely collapsed in this area. However, local government organized town regenerate committee with citizen by a lot of discussion and questionnaire to citizen. Finally, three type of community houses were constructed with aged person’s residences and public bath as well as commercial shop for damaged store.
In the case of the damage due to the 2000 Earthquake, Tottori local governor decided to offer the fund for reconstruction of private houses by public fund. It was the epoch-making judgment in Japan. Recently governor’s committee agreed with the proposal of mutual support system from Hyogo Prefecture.
Citizens living in small towns or villages have reliable partnership in daily life and cooperate each other when some affairs occurred. Figure 4 shows the relationship between the ratio of self organized disaster

mitigation system and number of family in some city or town in Shiga Prefecture as shown later. The larger the population, the person does not contact familiar each other.

Fig.3 Community house in Ichinomiya

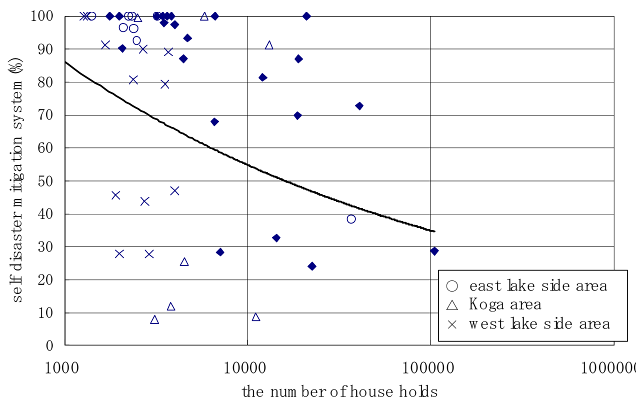


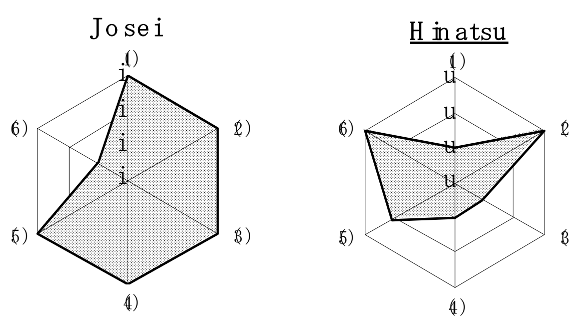
Fig.4 Self Disaster Mitigation System

Problem-2. Dispersion of a village

In small town like Hino we investigated, sometimes villages are separately distributed on the border of mountain and river where road was often closed due to land slide as shown in Fig.5. Not only emergent vehicles but important information can not enter the town area. Above mentioned self organized disaster mitigation network is effective for decrease of damage in such area. Six items related to the seismic safety were discussed in 16 zone in Hikone, Shiga, that is, construction age of house, risk of fire spread, dense house area, narrow road ratio, ratio of aged population and refuge capacity.

Fig 6 shows typical example of dangerous zone (Josei), neighborhood of Hikone castle and safe zone (Hinatsu), new residential zone[5)]. We must survey where the dangerous zone is and where aged person or weak person for disaster is living. Counter measure for disaster mitigation must take care in advance.

Fig.5 Land slide in Hino Town



(1) construction age
(2) wooden house ratio
(3) building coverage ratio
(4) narrow road ratio
(5) ratio of aged population
(6) refuge capacity

Fig.6 Estimation of dangerous zone in Hikone

Problem-3. Lack of fund and specialist

Trench survey of active fault, examination of surface soil due to deep boring and simultaneous earthquake observation network are progressive in large city after the 1995 Earthquake. High quality estimation of seismic damage can be obtained by using such a precise data. However, it is difficult to promote such project in small cities or villages because of lack of funds to be used in disaster mitigation and lack of specialist for those managements. For instance, statistics in Kyoto city is as follows: population-1,465,381, total budget-655 billion, fire service and disaster prevention budget-28 billion, engineers-17. Statistics in Hikone: population-108,928, total budget-3.55 billion, fire service and disaster prevention budget-2.13 billion, engineers-1. Percentage of fire service and disaster prevention budget/total budget is a little larger than Kyoto but absolute fund is quite small in small city, Hikone. In order to obtain effective deta for disaster mitigation, additional support from Prefecture and national government must be necessary, especially when some disaster occurred. Investigators living near the city or village are requested to follow local governments.

Problem-4. Lack of fundamental data

Shiga Prefecture is located at the center of main Island of Japan, where the largest lake, Biwa is located in the center of the Prefecture as shown in Fig.7. There are some of active faults along the west coast of Biwa, estimated Magnitude of 7.3. Probability of occurrence is estimated rather higher than the Nojima fault in the 1995 Earthquake. We also have the other fault in East side of Lake Biwa, where our campus, the university of Shiga Pref. is located in Hikone city. As mentioned before, Hikone city is a small city and has population of a handred thousand persons. Red Mark in Fig.7 shows a intensity meter location. Fig.8 shows observation network in USP (The University of Shiga Prefecture) and KJY (Mt.Kojin), where we have a boring data of –100m and –16m. We have another two observation point; Meteorological Agency of Hikone and Nishiima fire station. We don’t have effective boring data in Hikone area because there are no tall building in the city area. It is necessary to estimate dynamic characteristics of surface soil and amplification factor in each site for damage estimation in Hikone.

As shown in Figs.9 and 10 there are two hills Mt. Kojin and Mt. Hikone along the Lake. From the micro-tremor measurement along the coast and perpendicular to the coast, H/V spectra were calculated. Additional observation points are selected so as to distribute evenly in Hikone area.

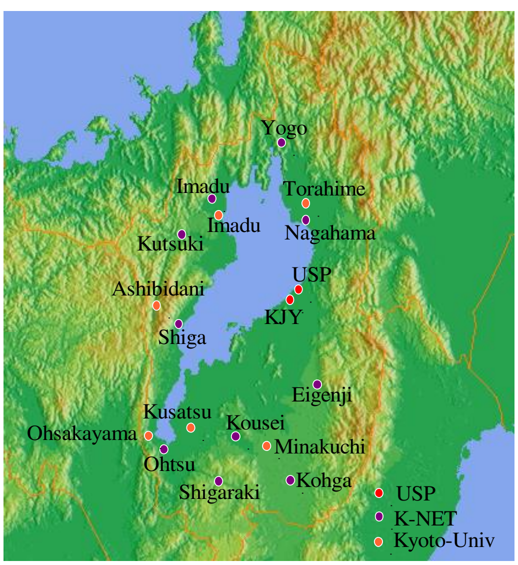


Fig.7 Shiga Prefecture and Lake Biwa

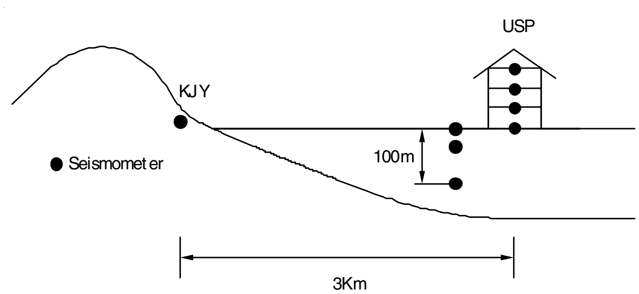


Fig.8 Observation network in the Univ. of Shiga Prefecture

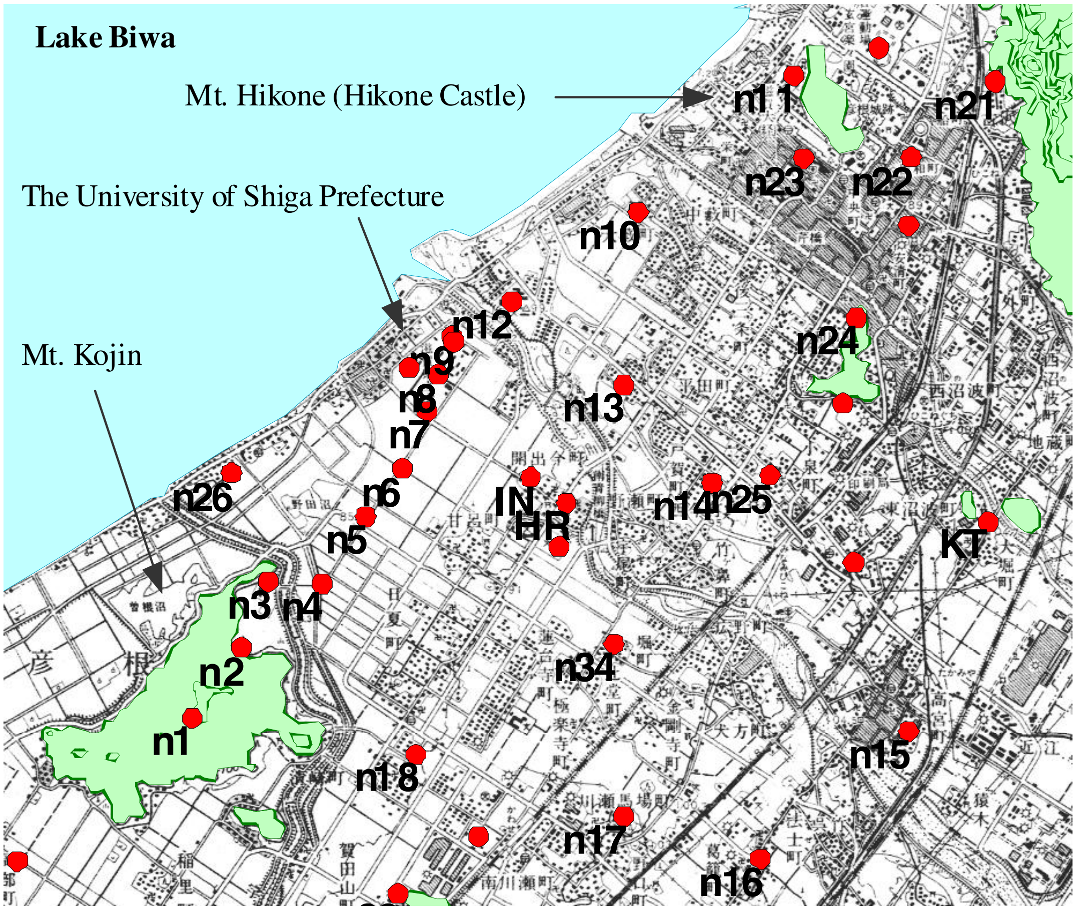


Fig.9 Geographical feature in Hikone. Circle point is an observation

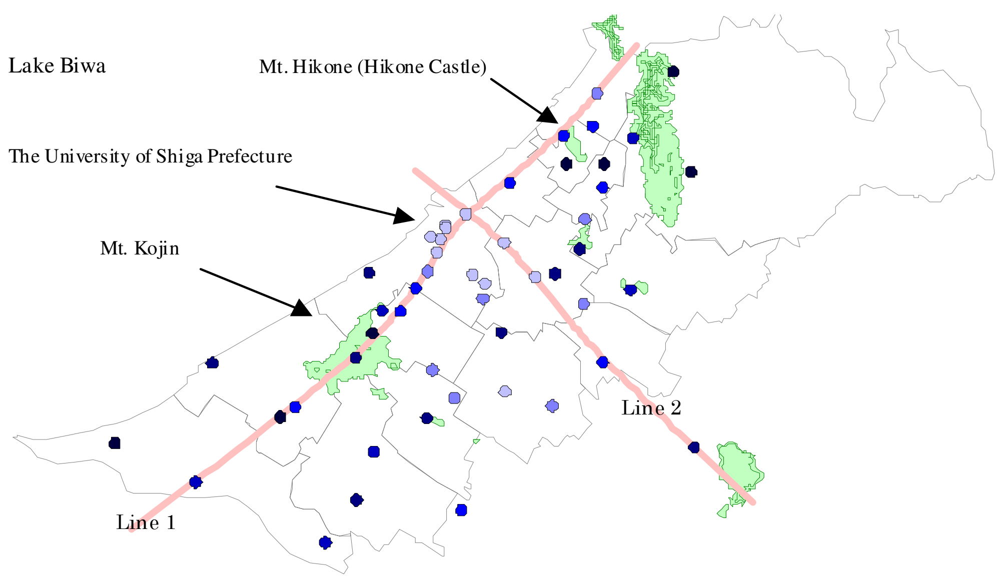
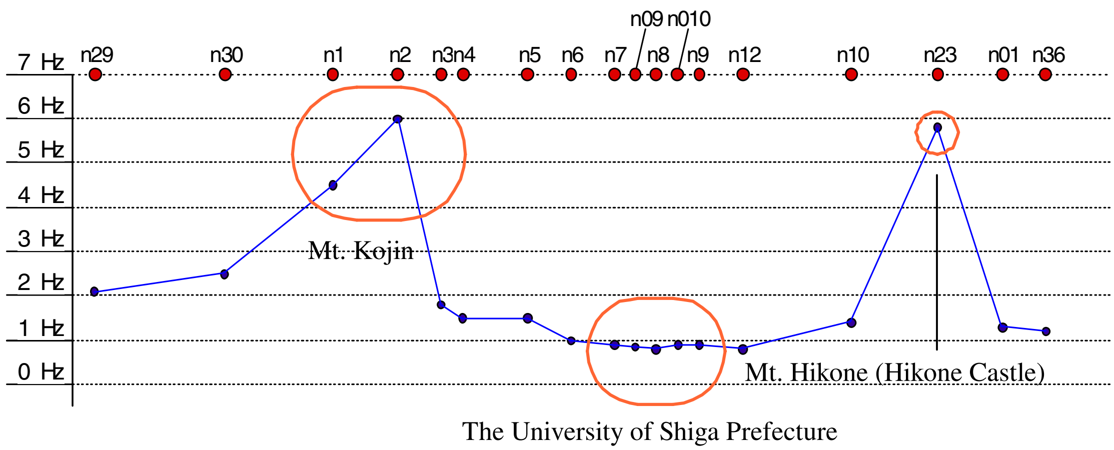
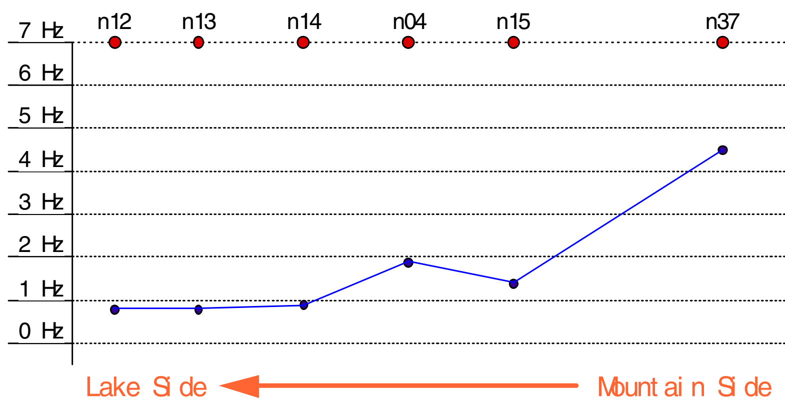


Fig.10 Observation Line 1 is from Mt.Kojin(n1) to Mt.Hikone(n23). Observation Line 2 perpendicular to the coastal line is from the point near USP(n12) to the mountain area (n15,n37).

Figure 11 shows predominant frequency of each point along the coastal line. We can see high predominant frequency close to the mountain area and USP is most low predominant frequency, where is the alluvial fan of the river Inukami. On the other hand, predominant frequency is gradually higher from coastal zone to mountain zone along the observation line 2 perpendicular to the coast as also shown in Fig.11.



(a) Line 1 (the coastal line)



(b) Line 2

Fig.11 Predominant frequency of observation points along line 1 and line 2

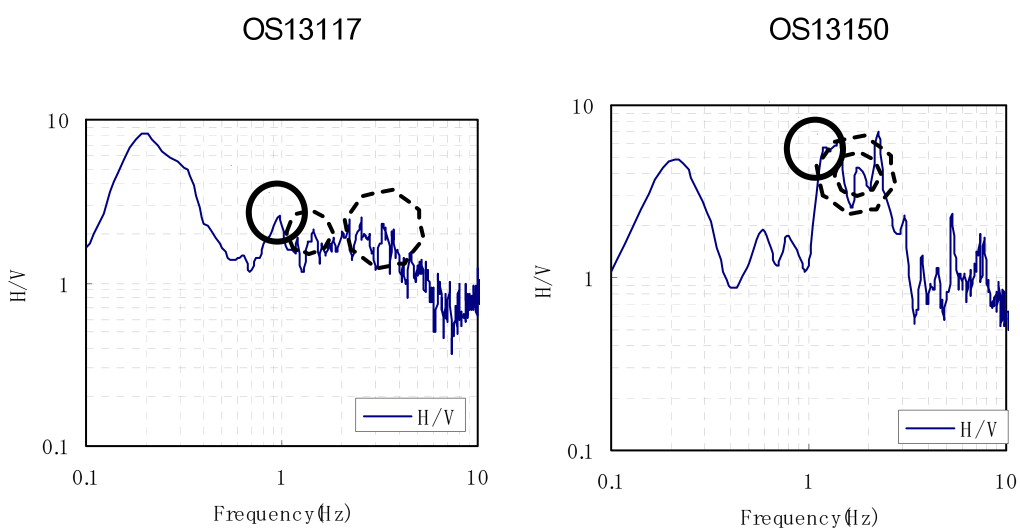


Fig.12 Example of H/V spectra OS13117, OS13150

We defined engineering foundation as the N value greater than 50. There is few boring data containing both N value and velocity of S-wave, for instance, data at USP with Vs only, data at Mt.Kojin with N and Vs value, others with N value only. Then we obtained some deep boring data of Osaka, which were known both the N value and Vs, and the micro-tremor also measured in the same point. We used estimation method to estimate Vs value from N value[6~8], the results were verified by using 4 boring data with N value and Vs value obtained in Osaka. We also used 9 data, which contain N, Vs as well as the result of micro-tremor measurement and estimated depth of surface soil H defined as strata of 400m/s. Predominant frequency obtained from one dimensional wave theory were compared with the frequency from H/V spectra from micro-tremor measurement. Figure 12 shows H/V spectra, in which f_{obs} was predominant frequency calculated from the result of the micro-tremor measurement with solid circle, theoretical frequency f_N was predominant frequency calculating the layer from a surface to N= 50 or more as one layer with small broken circle, and theoretical frequency f_{Vs} was predominant frequency calculating the layer from a surface to Vs=400m/s as one layer with broken circle. Generally, the frequency f_{obs} is lower than theoretical value f_{Vs} If observation frequency may be real value, additional depth of Vs=400m/s must be introduced. Relationship of total depth adding imaginary depth and the observed frequency were shown in Fig.13, where 13 sites in Shiga Prefecture and 4 sites in Osaka Prefecture were used.

Comparing Figs. 7 and 8 to Figs. 14 and 15, distribution of predominant frequency is quite similar to the distribution of estimated alluvial depth in observation lines 1 and 2 in Hikone. Since there is a boring data with observed Vs in n8 (USP), priority was given to the calculation result using it. Even if there are Micro-tremor measurement and shallow boring data, it can be possible to estimate alluvial soul structure using Fig. 13. It is also useful for amplification on specific location subjected to strong earthquake. We can estimate more precise damage in each site where is risky region in objective district by using above mentioned risk analysis.

Anyway, It is most important to make plan and carry out the strengthening as soon as possible.

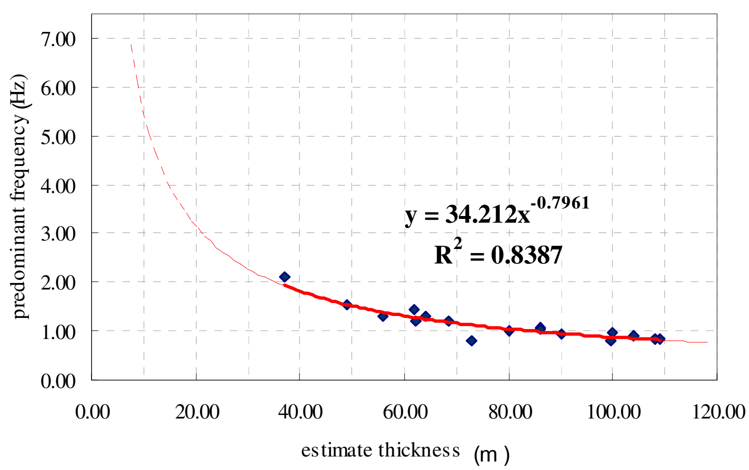


Fig.13 Relationship between estimated depth of Vs=400 and frequency ratio of observation to theory

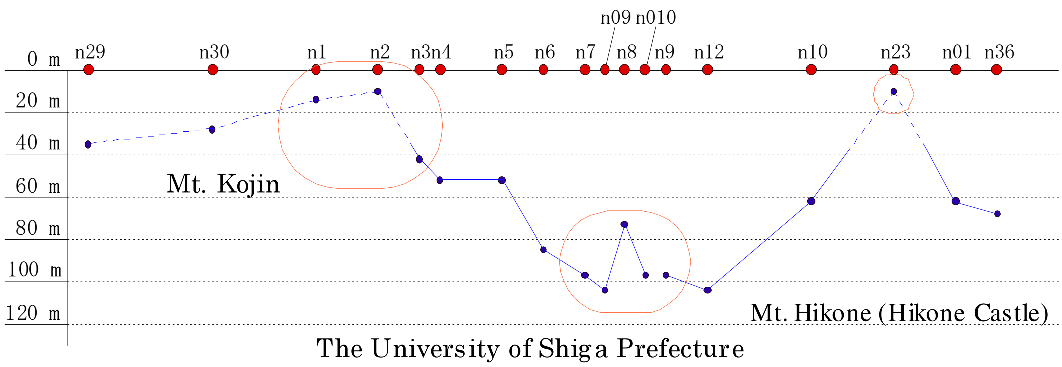


Fig.14 Estimated surface depth along observed line1

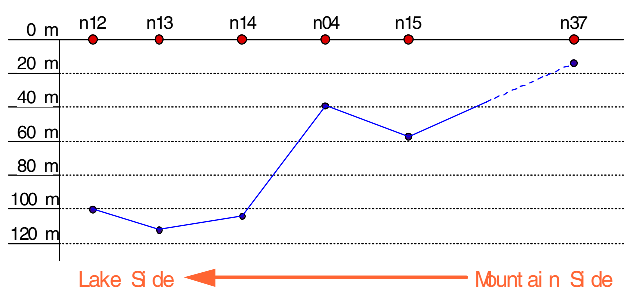


Fig.15 Estimated surface depth along observed line 2

CONCLUDING REMARKS

Great Hanshin-Awaji Earthquake occurred beneath the modern city, Kobe and many fragility in the big city were pointed out. However, in small cities or small villages also had peculiar problems. Here we discussed particularly on the disaster mitigation in local cities. The following concluding remarks were obtained:

/ Communication system in local cities fulfilled emergency rescue and rehabilitation of after disaster.

/ Small villages are distributed along the river or mountain area. Sometimes, landslide produced traffic damage. Daily communication among citizen and local governing is necessary, Self organized disaster mitigation system must be functional in such places.

/ Not only economical situation but specialist for disaster prevention in small village is very poor. They can not keep effective data for disaster estimation. It is important to support prefecture government and national government when emergency happened. Projects for disaster mitigation must be daily organized by investigators of some university, citizen and staffs of local government.

/ Estimation of dynamic soil characteristics is very important for disaster estimation in some region. We investigated the soil profile in Hikone area by using H/V spectra due to micro-tremor observation, where we verified the adequacy of estimated depth of alluvium by analyzing and comparing to the results of tremor observation for the precise boring data with N value and Vs. This method is useful and easy for the estimation in small cities or villages.

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