Extended Abstract for the 4th International Forum on Seismic Zonation

A SEISMIC MICROZONING TECHNIQUE BASED ON MICROTREMOR DATA

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ABSTRACT

A seismic microzoning technique based on microtremor observation is introduced and an example of its application is demonstrated in this paper. A frequency amplification function in a limited area is necessary in the actual utilization of a seismic microzoning map. A shear wave velocity profiles is identified using an optimization method at the strong motion observation site. Microtremor measurement is also carried out at the same site. Then, the spectral ratio, a ratio of Fourier amplitude spectrum of the horizontal component of a microtremor to the vertical one, is compared with the frequency amplification function calculated from the identified soil profile of the observation site. Then, a technique for microzoning based on microtremor data is verified. Finally, this technique is applied to Kushiro city, Hokkaido Island of Japan where a large earthquake of M=7.8 attacked in 1993.

INTRODUCTION

Fourier amplitude spectrum of the horizontal component of a microtremor is frequently used in the engineering field to detect the natural frequency of a surface soil deposit. However, not only a natural frequency but a frequency amplification factor at a site is indispensable for earthquake engineers to evaluate the extent of ground motions and damage due to an expected earthquake. Recent advances in the research of a microtremor give us the possibility to detect both of them[1),2)].

VERIFICATION OF A MICROZONING TECHNIQUE

Strong motion observation has been conducted since 1984 in the northern-east part of Japan by Kumagai Gumi Co., Ltd. The system is called "KASSEM"[3)]. At the center array sites which are located on an alluvial deposit, microtremor was observed. Fourier amplitude spectra of three directional components of a microtremor were calculated and Parzen's window operation was applied with band width of 0.8. Then, the following spectral ratio $SR(\omega)$ was calculated:

$$SR(\omega) = \frac{F_H(\omega)}{F_V(\omega)} \quad \cdots\cdots\cdots \quad (1)$$

in which, $F_H(\omega)$ and $F_V(\omega)$ denote Fourier amplitude spectrum of the horizontal component of a microtremor and the vertical one, respectively. The author hypothesized that two times of $SR(\omega)$ is approximately identical with frequency response function of a surface deposit. If this approximation is valid, microtremor observations lead to a simple and effective way for seismic microzoning.

In order to show the appropriateness of this microtremor technique, above-mentioned ratio was compared with the frequency response function of an earthquake observation site constituting the center array of "KASSEM". In the first step, identification analysis for a shear wave velocity profile was carried out at the site, using the optimization theory. The target function used in the analysis was the transfer function at the site, which was calculated as the ratio of Fourier amplitude spectrum of accelerogram recorded at surface ground to that in the diluvial gravel and sand layer. Fig.1 illustrates the soil profile, the result of a standard penetration test and shear wave velocity profiles obtained from PS-logging and the identification analysis[4)]. Using the identified shear wave velocity profile in the figure, the frequency response function, which means the amplification factors at ground surface when an incident wave with unit amplitude inputted at the bedrock, was determined based on the reflection theory.

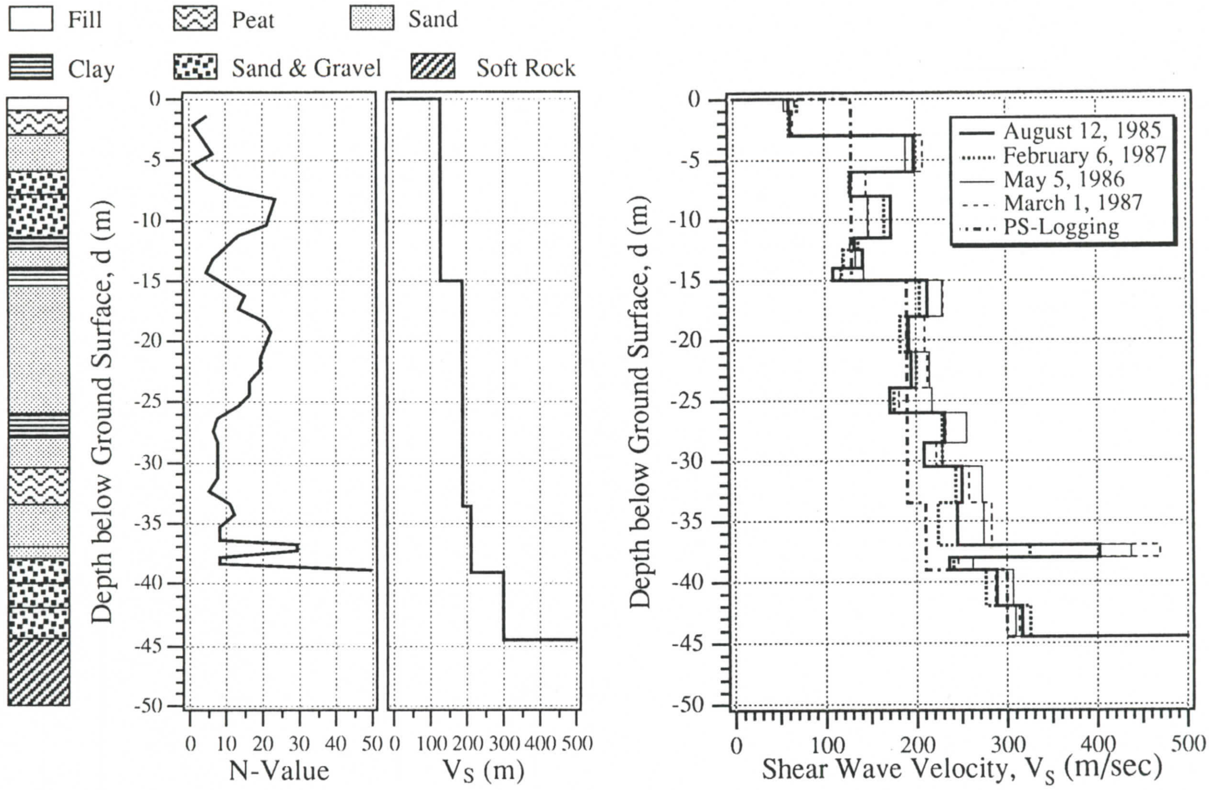

Fig.1 Results of in-situ tests and the identified shear wave velocity profile at the strong motion observation site

Comparison between the frequency response function and the spectral ratio of a microtremor is made in Fig.2. In the figure, two time of the spectral ratio of a microtremor is also plotted together. As shown in the figure, two times of the microtremor spectral ratio is satisfactorily coincident with the frequency response function of the site, in the frequency range of the fndamental mode of vibration. Thus, this techjnique can be approximately used to detect not only the natural frequency but the amplification factor of a surface soil deposit.

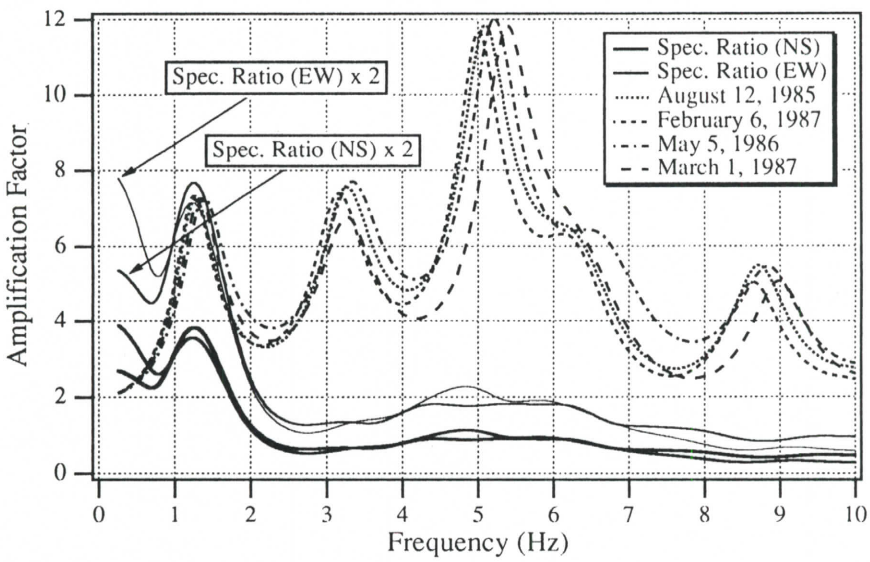

Fig.2 Comparison between the microtremor spectral ratio and the frequency response function

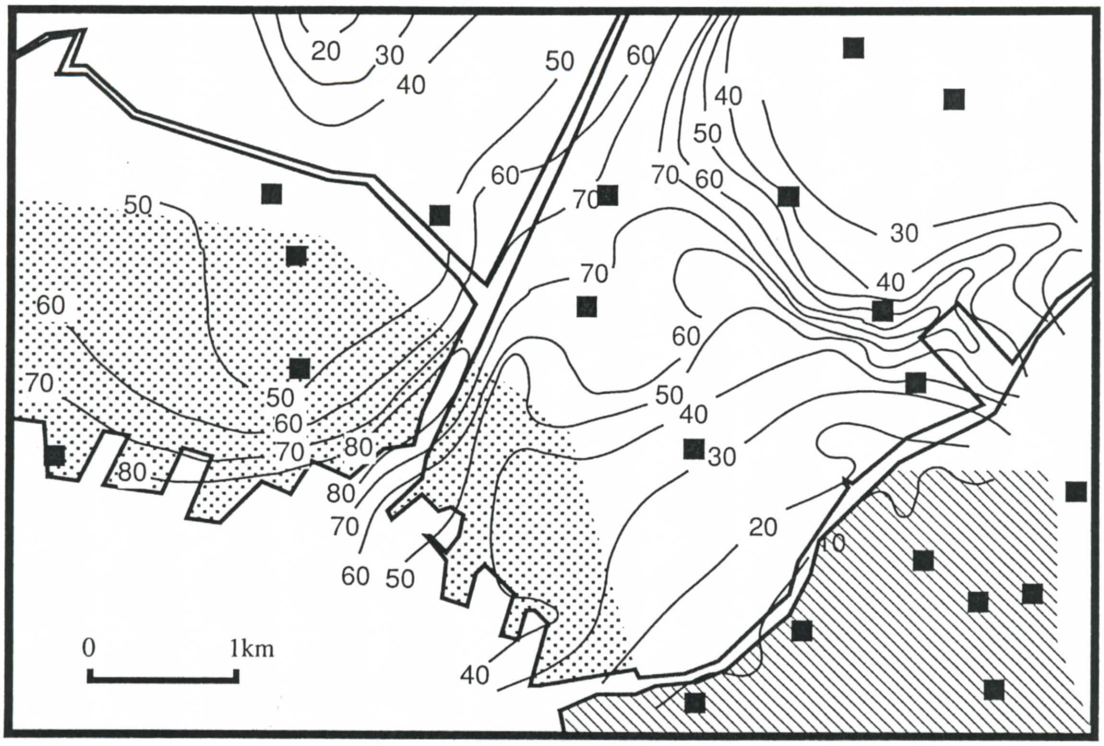

Fig.3 Contour map for the thickness of alluvial deposits in Kushiro City

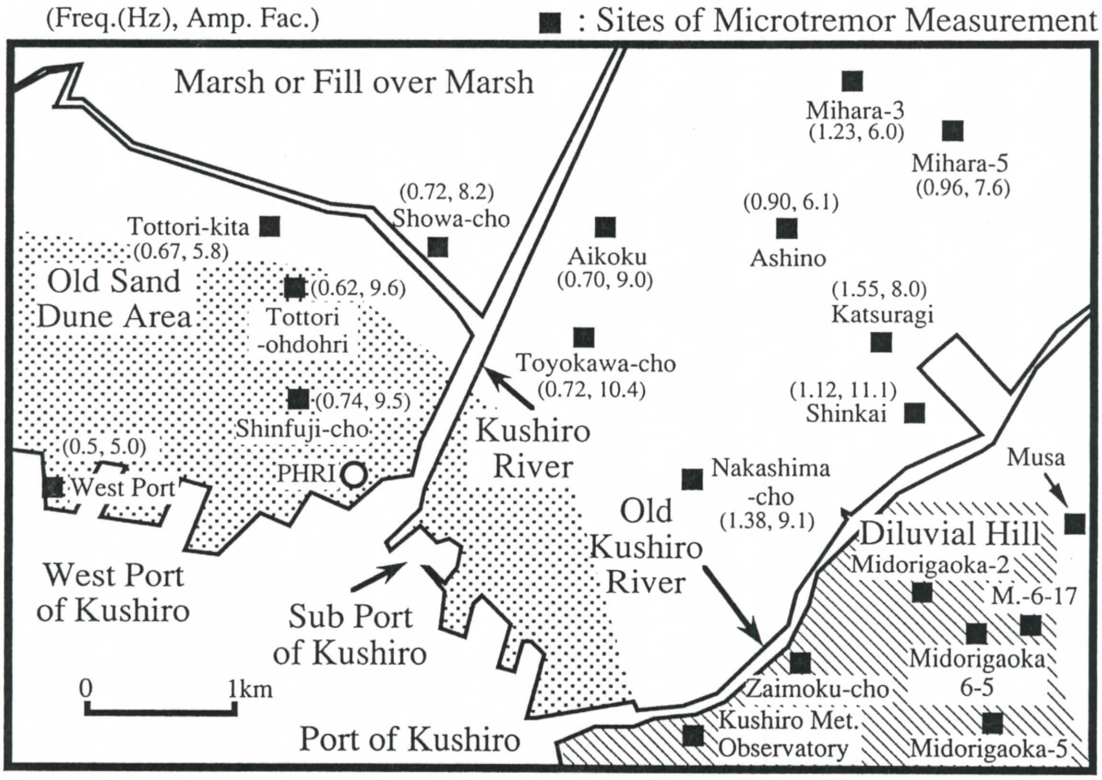

Fig.4 Natural frequencies and amplification factors in the Kushiro Plain estimated by the proposed method

APPLICATION OF TO THE SEISMIC MICROZONG OF KUSHIRO CITY

Microtremor observation was conducted in Kushiro City two moths after the Kushiro-oki earthquake of 1993 took place. The maximum acceleration of 922 gals was recorded on the diluvial hill in Kushiro city, but little severe damage was occurred in the central part of the city where alluvial soft soil is deeply sedimented. The author is interested in this strange phenomenon, which motivated this microtremor observation.

Fig.3 illustrates the contour map of the thickness of alluvial deposits in Kushiro city. 20 sites were selected for microtremor observations, covering three different ground conditions in the city as shown in Fig.4[5]. In the figure, natural frequencies and amplification factors derived from the microtremor observations are listed. Comparing Fig.4 with Fig.3, It is clear that the depth of alluvial deposits in Fig.3 correlates well with the natural frequency in Fig.4., which validates this approach.

CONCLUSIONS

The microtremor spectral ratio proposed in this paper is a simple and effective method to evaluate seismic risks in terms of both natural frequency and amplification factor for seismic microzoning. In addition, this technique can be applied to any place in the world, because it is economical and easy to measure microtremors.

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