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EVALUATION OF THE AMPLIFICATION CHARACTERISTICS OF SUBSURFACE USING MICROTREMOR AND STRONG MOTION - THE STUDIES AT MEXICO CITY -

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SUMMARY

This paper examined the relationship between the H/V spectral ratio of strong motion and the amplification characteristics or the H/V spectral ratio of microtremor. Both the data of strong motion and microtremor have been recorded at the lake, transition and hill zones in Mexico City. As a result, in case of strong motion, the amplification characteristic agreed with the H/V spectral ratio approximately. Moreover the H/V spectral ratio of strong motion agreed with that of microtremor at the same site. However, at some sites of soft ground on irregular basement, the shape of the H/V spectral ratio of microtremor and the strong motion are almost similar for each other but the H/V spectral ratio of microtremor is less than the other. At such a site, microtremor contains Rayleight wave component and also strong motion contains relatively less Rayleigh wave component. It suggests that Rayleigh wave has influenced to this situation.

INTRODUCTION

In recent years, microtremor is measured as a useful tool to estimate easily the vibration characteristics of surface ground in the various places. And H/V spectral ratio made use of the analysis of microtremor and strong motion is noticed as an analysis method to describe simply and dynamic characteristics of the ground or the structure accurately. H/V spectral ratio was developed from an analysis of strong motion data on the various ground conditions.

It is supposed that because the body wave mainly contributes the seismic damage, ground amplification occurred by multi reflection of SH wave in the superficial layer. Spectral ratio of the surface and basement (H_s/H_b) is large value generally disturbed by the influence of surface wave. And so, Nakamura considered V_b/V_s as revised spectra to remove the influence of Rayleigh wave, predominant from mixed various waves. It is expected that if Rayleigh wave doesn't exist, the V_b/V_s of microtremor will be 1 in the frequency range of horizontal vibration predominating and be smaller than 1 in the frequency range of Rayleigh wave energy predominating. Nakamura et al. suggested that more certain amplification

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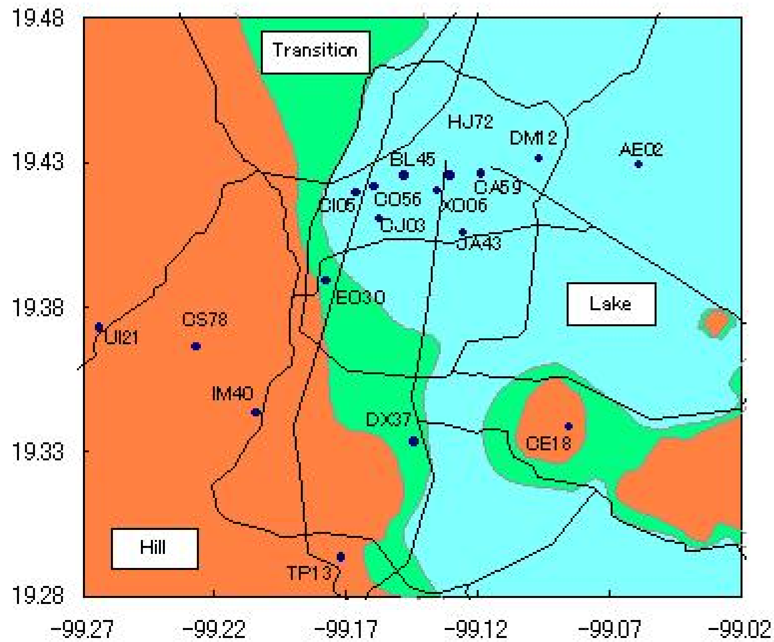

Fig.1 The target observation points for strong motion in Mexico City

characteristic estimated by H_s/H_b spectral ratio multiplied by V_b/V_s. However, H_b/V_b actually is almost 1 in the wide range of frequency, so strong motion characteristics of surface ground can be estimated only from the H_s/V_s ratio on surface. This is the H/V spectral ratio.

This paper examined that it can be estimated the amplification characteristics of strong motion from H/V spectral ratio of microtremor, and is pointed an attention to use microtremor for estimating strong motion characteristics.

STUDY AREA FOR THE INVESTIGATION OF GROUND MOTION CHARACTERISTIC

The investigated area is central Mexico City as shown in Fig.1. Mexico City has developed on a reclaimed lake since 16th century. Therefore, almost all the central city locates on soft sedimentary ground. The represented earthquake (1957, 1979 and 1985 Michoacan) caused a sever damage to this area. And also, although it didn't cause heavy damage, an earthquake (2003, Mw7.8) occurred near Colima City, 400 kilometers away from Mexico City. At this time the maximum acceleration about 50 Gal on the soft ground was recorded in Mexico City.

ANALYSES AT THE EACH OBSERVATION POINTS FOR STRONG MOTION

Microtremor measurement was conducted to confirm whether it was possible to estimate a dynamic characteristic of surface ground from microtremor at several strong motion sites in Mexico City, gathered the strong motion data recorded before, and analyzed with measured microtremor data as follow.

1. Comparing the horizontal to vertical spectral ratio (H/V spectral ratio) of strong motion with the amplification characteristics of strong motion.
2. Comparing the H/V spectral ratio of strong motion with the H/V spectral ratio of microtremor.
3. Confirming to be able to estimate an amplification characteristic of strong motion from H/V spectral ratio of microtremor, based on the similarity of the H/V spectral ratio of strong motion and H/V spectral ratio of microtremor at the same site.

Fig.1 shows some observation points of strong motion we measured microtremor in Mexico City. Table 1 shows maximum acceleration of each observation points at Colima earthquake (Jan. 22, 2004). The analyzed points in this study were total 17 points located typical grounds (Lake, Transition and Hill) in Mexico City. These points have been installed and managed by CIRES (Centro de Instrumentacion y Registro Sismico). Totally 84 observation points are installed in Mexico City.

Microtremor was recorded 3 times at about 41 seconds (4096 data in 100Hz sampling) on each site. A three component (NS, EW and UD direction) sensor installed on the basement for seismometer. After taking H/V spectral ratio on each site, it was compared with H/V spectral ratio of strong motion recorded at same site. On strong motion records, besides of taking H/V spectral ratio, amplification characteristics was estimated using CS78 site at Hill zone for a reference site.

Table1 The maximum acceleration of Colima earthquake (Mw7.8, 2003) at each observation points for strong motion in Mexico City

(Gal)

observation point	UD	NS	EW	division
UI21	2.9	4.8	4.5	hill
CS78	2.8	5.8	2.7	hill
IM40	2.7	4.7	3.6	hill
TP13	2.1	5.4	3.6	hill
CE18	2.1	3.7	2.3	hill
EO30	2.4	4.9	5.3	transition
DX37	2.7	10.7	12.4	transition
CI05	4.6	14.8	24.9	lake
CO56	5.0	22.4	22.8	lake
BL45	3.9	14.4	17.1	lake
XO06	5.9	24.8	23.4	lake
HJ72	7.8	19.8	31.6	lake
CA59	7.5	19.7	35.7	lake
DM12	4.1	24.5	15.7	lake
AE02	7.1	28.3	17.6	lake
CJ03	3.5	11.7	18.9	lake
JA43	3.6	14.0	17.4	lake

COMPARISON OF EACH SPECTRA

Fig.2 shows the results of comparison of the amplification characteristics (reference site: CS78) with the H/V spectral ratio of strong motion of Colima earthquake. The amplification characteristics of strong motion and the H/V spectral ratio at all site are similar on the shape and amplitude value approximately. Four sites at Hill zone show small amplification characteristics on flat spectral form, and the spectral forms at Lake and Transition zone represent high amplification at low frequency as the depth of surface ground become deeper. It agrees with the maximum acceleration shown in Table1. More specifically, Fig.2 represents that an amplification characteristic of strong motion at surface ground is estimated well by the H/V spectral ratio of strong motion without reference site.

Fig.3 shows the result of comparison of strong motion of Colima earthquake and a microtremor at each site using H/V spectral ratio. From Fig.3, the H/V spectral ratio of strong motion and the microtremor agreed with the shape and amplitude approximately. However, the peak value of H/V spectral ratio at Lake zone is smaller than the one in Transition zone. Although the shapes of H/V spectral ratio at double

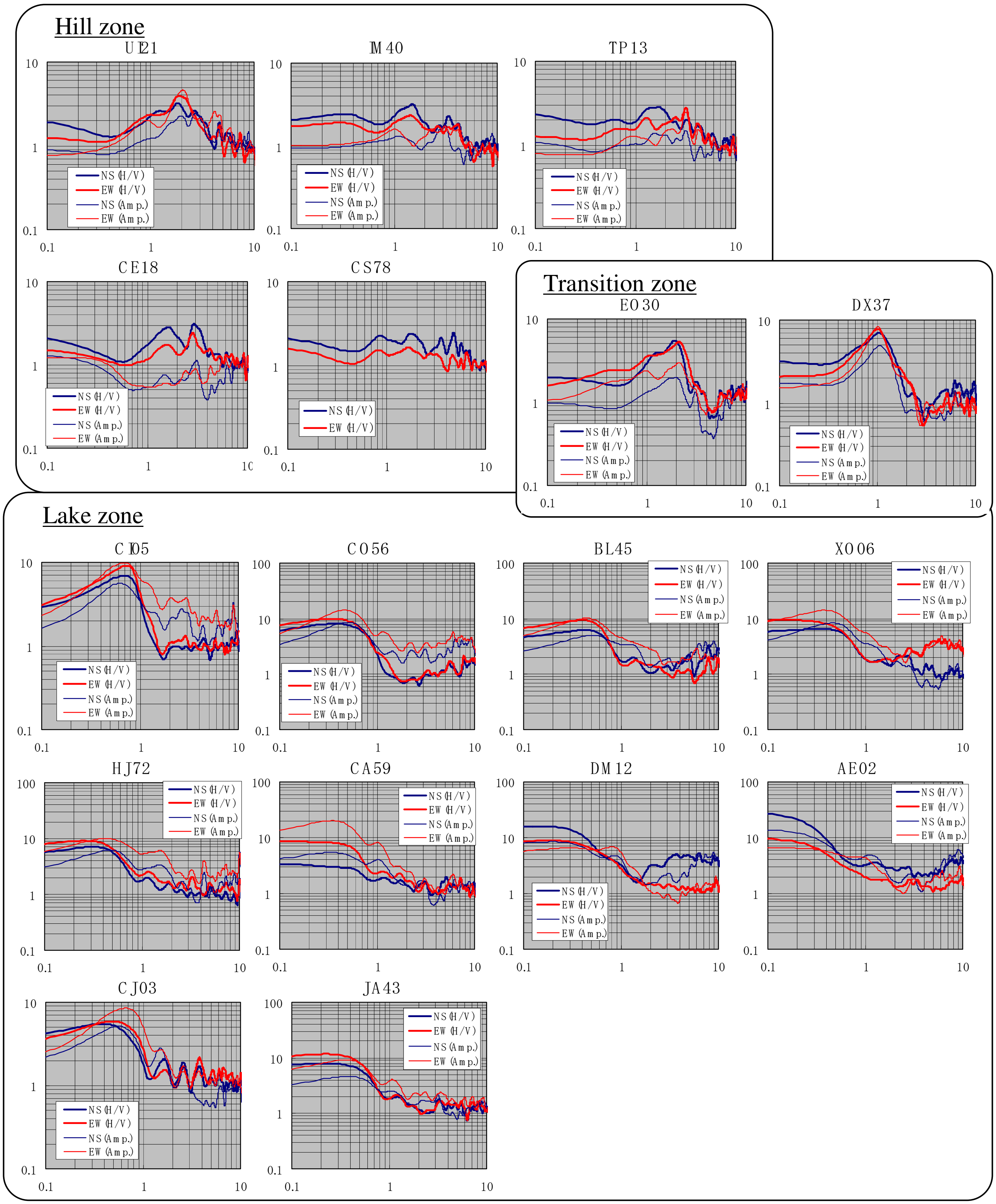

Fig.2 The comparison with the amplification characteristics and the H/V spectral ratio of microtremor on each observation points for strong motion

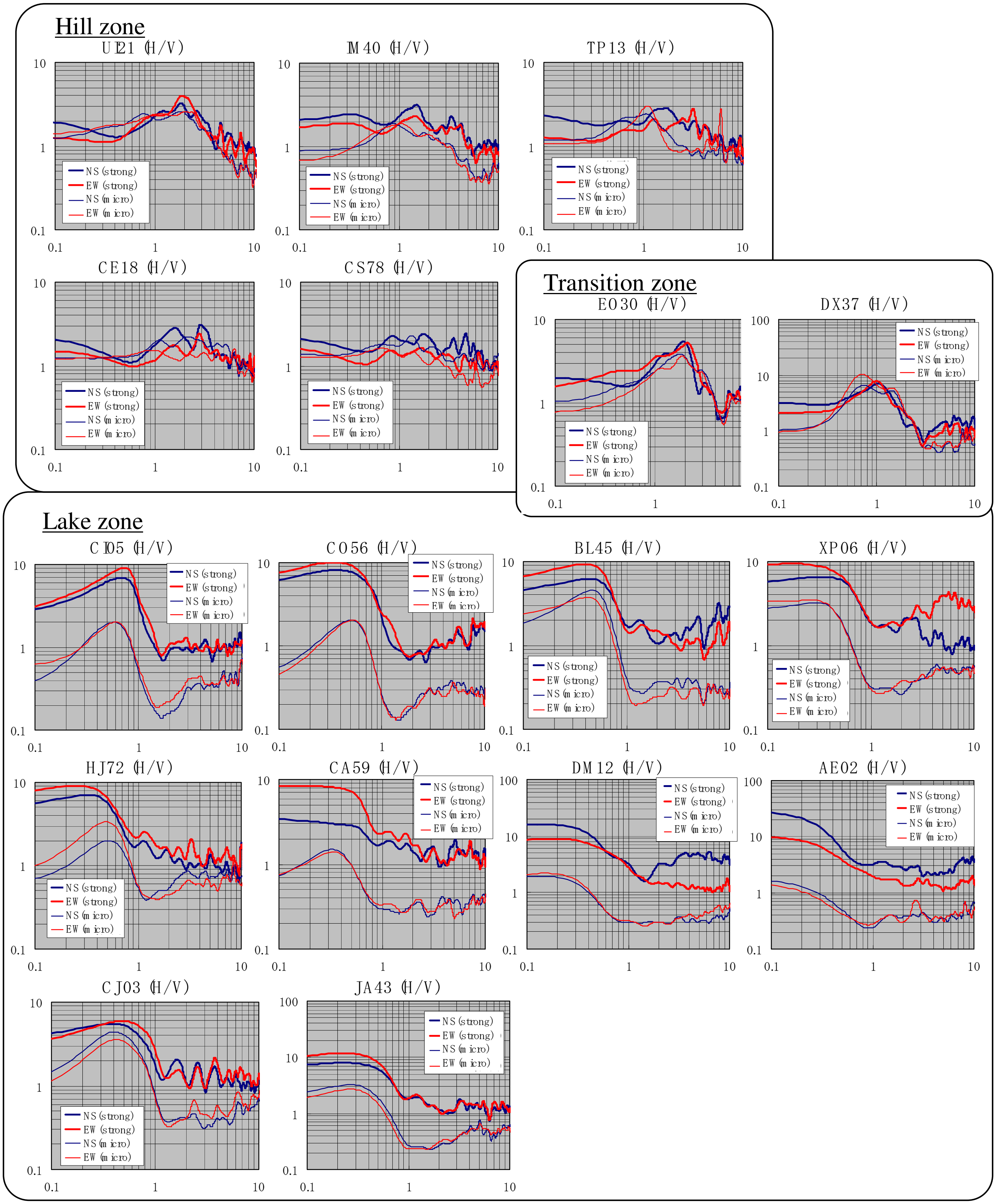

Fig.3 The comparison with the H/V spectral ratio of strong motion and the H/V spectral ratio of microtremor on each observation points for strong motion

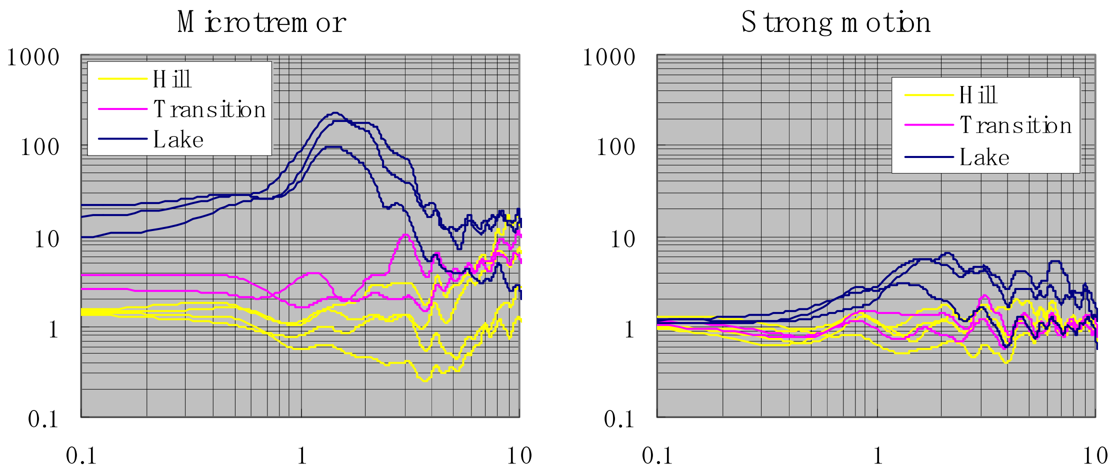

Fig.4 The amplification characteristics of vertical component at each observation points for strong motion

logarithmic chart are similar, the values of amplitude are different. It indicates that the UD component of microtremor has large value.

Using microtremor and strong motion records at basement ground, it is able to estimate the influence of Rayleigh wave at the observation points. In this study, the behavior of Rayleigh wave in sedimentary ground inferred from the microtremor and the strong motion of reference site instead of basement ground of each observation site.

Fig.4 shows the amplitude ratio of UD-component at each site as reference site of CS78. In Fig.4, both figures of a microtremor and a strong motion separated Hill, Transition and Lake zone. From the figure of strong motion, the amplitude of the ratio is almost same value compared with CS78 for all frequency range though the amplitude is slight high or low value at Transition and Hill zone. However, at Lake zone, the amplitude is almost similar and 3-6 times compared with CS78 around predominant frequency F_0 (0.4Hz-0.8Hz) and $2F_0$, respectively. If CS78 and the basement of each site have a same vertical motion characteristic, it is considered to exist the potent influence of Rayleigh wave around about 0.8Hz-1.6Hz at Lake zone though influence of Rayleigh wave is slight at Transition and Hill zone. Rayleigh waves way affect for microtremor at upper frequency range because of high amplitude at Transition zone. In a soft sedimentary ground like Lake zone, the amplitude of UD component is 10 times more than CS78 on almost all the frequency range, the contrast is extremely high compared with that of strong motion. The microtremor of sedimentary ground is thought to be consisted of Rayleigh wave occurred from traffic or other noise. Though the H/V technique aims to reduce the influence of Rayleigh wave, the thick and soft sedimentary ground in Mexico City has high amplification of vertical component around predominant frequency of horizontal component. And it is considered that it is sometimes difficult to estimate an amplification characteristic of surface ground effectually with ordinarily H/V technique. It way occurs at not only Mexico City but also the other place like this ground condition.

CONCLUSION

This paper examined the relationship between the H/V spectral ratio of strong motion and the amplification characteristics of strong motion, and between the H/V spectral ratio of strong motion and that of microtremor recorded at Mexico City. Mexico City has been built on very soft sedimentary ground filled on a lake. It emerged as follows from the results of comparing with microtremor and strong motion recorded on Hill, Transition and Lake zone in the city.

1. In case of strong motion, the H/V spectral ratio as reference site agreed with estimated amplification characteristic from hard ground approximately.
2. The H/V spectral ratio of strong motion is similar to that of microtremor without the site Rayleigh wave exceeding extremely.
3. Therefore, the amplification of strong motion around first predominant frequency could be estimated by the H/V spectral ratio of microtremor approximately.
4. However, in a case that of large amplitude of vertical component caused by Rayleigh wave exceeding extremely, it is difficult to estimate an amplification characteristic of surface ground because of lower shifted H/V spectral ratio.

It is necessary to consider the techniques to eliminate influence of Rayleigh wave. And henceforth, the study aims to find the technique to estimate an amplification characteristic in case of 4.

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