11 WCEE

Paper No. 2062. (quote when citing this article)
Eleventh World Conference on Earthquake Engineering
ISBN: 0 08 042822 3

APPLICATION OF MICROTREMORS TO EARTHQUAKE DAMAGE SCENARIOS - LESSONS LEARNED FROM RECENT DAMAGING EARTHQUAKES -

Kazuoh SEO

Tokyo Institute of Technology
4259 Nagatsuta, Midori-ku, Yokohama 226, Japan
Tel & Fax: +81-45-924-5502

ABSTRACT

In recent years, measuring microtremors is well-known as a convenient tool to confirm the effect of surface geology on seismic motion without knowing other geologic information. It is becoming very popular since the 1985 Mexico earthquake, because the measured microtremors in Mexico city after the earthquake reflected the soil condition of the area very well. But in general, it is not so easy to get enough conclusion only from microtremor measurements. A matter of importance will be to examine how microtremors can be used with successful and unsuccessful cases under different conditions. After reviewing such fundamental characteristics about microtremors, the nearest goal will be to provide a practical guideline when we apply microtremors to engineering purposes, such as evaluating geologic site condition, surveying seismic wave velocity profiles, predicting strong motion characteristics, etc. We believe that this type of preparedness will be meaningful as one of international cooperative research activities among earthquake countries.

The final goal of earthquake engineering should be the minimization of earthquake disaster, and therefore, the management of every kind of research works will be required. Among a lot of subjects, the most fundamental one must be how to extend the information from observed or expected strong motion into neighboring district. Then we expect measured microtremors to play an important role as a substitute of earthquake ground motion, because we cannot expect densely distributed strong motion data so often. In recent studies, measured microtremors have been examined for several purposes with different approaches.

1) Kanai et al.(1961) defined their microtremors as ambient motions due to human activities such as traffic and machinery noise. They found out very useful information that microtremors obtained the similar predominant periods as earthquake ground motions. Then they proposed a practical idea to classify site soil conditions with only measured microtremors.

2) Kagami et al.(1982) has tried to get spectral ratios of microtremors between arbitrary sediment site and referential rock site by a simultaneous measurement. The discussion is mainly made in the period range longer than a few seconds. And as results, such amplitude ratio provides an information about site conditions even if the predominant period is not clear.

3) Horike(1985) and Okada et al.(1990) are making array measurements of microtremors with several sets of vertical components. Inversion analysis of soil layers by F-K spectra and dispersion characteristics provides a seismic wave velocity profile as results. Where the principal component of microtremors is considered as Rayleigh-waves.

4) Nakamura(1989) presented his unique idea that the spectral ratio of microtremors between its horizontal and vertical components fit with amplification factor (transfer function) at a site. Where the vertical motion on a free surface is assumed as a substitute of horizontal motion at the basement.

5) Kobayashi et al.(1986) tried to obtain spectral ratio of microtremors between arbitrary site and referential strong motion site. In this case, the referential site should be installed in the similar soil condition with other sites. And the product of the ratio and the spectrum of strong motion at the reference site makes predicted strong motion at arbitrary site.

As mentioned above, there are so many ideas to apply measured microtremors for engineering use. On the other hand, it is true there are different opinions that microtremors contain unstable and unreliable features because origin source and propagation mechanism of microtremors are not so clear. Then all we have to do before making a guideline (an instruction manual) will be to confirm the basic characteristics of microtremors.

Ambient motions in free field, so-called microtremors, are classified into "microtremors" due to human activities and "microseisms" due to ocean waves, as defined by Dr.Kanai. The microtremors will contain stable predominant period as well as earthquake ground motions, although the level of amplitude is changeable between daytime and nighttime. On the contrary, the features of the microseisms not only amplitude but period characteristics will be affected by the weather condition. In spite of such different characteristics between microtremors and microseisms, a very important thing is that we are going to find applicabilities in both of them. For example, microtremors are being discussed in the procedures 1), 4) and 5) mentioned above, microseisms are mainly used in the procedure 2), and the both in the procedure 3).
When we measure microtremors at a new site, the continuous measurements to confirm the stability of microtremors will be required. If we find stable predominant periods and daily variation in their amplitudes, we are sure that it is Kanai's microtremors. Usually microtremors are measured and discussed in the period range shorter than one or two seconds. The only exception has been noticed in Mexico city (Kobayashi et al., 1986), where very long period microtremors up to five seconds were excited by human activities because of existing very soft sediments. Most of all, the stability checking will be required when we carry out the procedure 5), where we take the spectral ratio of microtremors in the area without simultaneous measurements.

Now the preliminary trials to prepare a guideline for measuring microtremors are being made in the research activity of "The Effects of Surface Geology on Seismic Motion, ESG". We have already carried out the joint measurements of microtremors in the Ashigara valley of Kanagawa prefecture, around the Kushiro area of Hokkaido, and in the Hanshin district including Kobe city, to find out the basic characteristics about microtremors. After the further consideration with sufficient data about soil conditions and damage distribution (mainly in Kushiro and Kobe districts), we will reflect the results into the guideline that we are going to prepare in this work.

As we discussed already, a well-organized arrangement of all the individual works will provide good countermeasures for earthquake disaster mitigation. A very important thing is that such countermeasures are not common for every district or country, because the natural circumstances like seismicity and geological site conditions, and social background will not be the same. The idea in this work is to prepare a common tool as a scale to measure soil condition objectively. The further consideration will be made to make sure "what is common and what is different among the districts?" and "what should be done for each district?".

REFERENCES

Horike,M.(1985): Inversion of Phase Velocity of Long Period Microtremors to the S-Wave Velocity Structure down to the Basement in Urbanized Areas, *J.Phys.Earth*, **33**, 59-96.
Kagami,H., C.M.Duke, G.C.Liang, and Y.Ohta(1982): Observation of 1- to 5-Second Microtremors and their Application to Earthquake Engineering. Part 2. Evaluation of Site Effect upon Seismic Wave Amplification due to Extremely Deep Soil Deposits, *Bull.Seism.Soc.Am.*, **72**, 987-998.
Kanai,K. and T.Tanaka(1961): On Microtremors.VIII, *Bull.Earthq.Res.Inst.*, **39**, 97-114.
Kobayashi,H., K.Seo, and S.Midorikawa(1986): Report on Seismic Microzoning Studies of the Mexico Earthquake of September 19, 1985. Part 2. Estimated Strong Ground Motions in Mexico City due to the Michoacan, Mexico Earthquake of Sept.19, 1985 Based on Characteristics of Microtremor, *Tokyo Inst.Tech.*, 1-34.
Matsushima,T. and H.Okada(1990): Determination of Deep Geological Structures under Urban Areas, *Butsuri-Tansa (Geophysical Exploration)*, **43**, 21-33.
Nakamura,Y.(1989): A Method for Dynamic Characteristics Estimation of Subsurface using Microtremor on the Ground Surface, *Quarterly Report of Railway Tech.Res.Inst.*, **30**, 25-33.
The Research Group on Microtremor Joint Measurements Related to the 1993 Kushiro-oki Earthquake, Coordinator; Seo,K.(1994): A Study on Application of Microtremors to Evaluate the Characteristics of Ground Motions during Earthquakes, *A Technical Report by the Grant-in-Aid for Developmental Scientific Research, the Ministry of Education,Science and Culture*, 1-194.

KEYWORDS

microtremors, ambient motion, predominant period, site condition, microseisms, the 1985 Mexico earthquake