SEISMIC GROUND MOTION CHARACTERISTICS AT A UNIVERSITY CAMPUS WITH COMPLICATED RELIEF

N. Maeda[1], Y. Nakajima[2], I. Matsuda[3], and N. Abeki[1]

[1] *College of Engineering, Kanto Gakuin University, Yokohama, Japan*
[2] *Institute of Science and Technology, Kanto Gakuin University, Yokohama, Japan*
[3] *College of Economics, Kanto Gakuin University, Yokohama, Japan*

ABSTRACT :

Kanazawa Hakkei Campus of Kanto Gakuin University is located in a seaside, whose size is about 250m by 750m. The greater part of the campus, whose size is about 250m by 500m, is reclaimed land and flat. We have many geological borehole data for building construction in the campus. The area of campus is small, but we have a lot of data to discuss the details of the underground structure. Compiling the materials of borehole data, we found that the campus has complicated relief of basement. We think the campus as a good experimental field for studying seismic ground motion characteristics, and we carried out seismic observation, microtremor observation and elastic wave survey. As the result of the seismic observation, the difference of JMA instrumental seismic intensity is about 1 at most. The result corresponds to the depth of the top surface of the basement at the observation site, and seismograms observed at the sites with the large intensity show long predominant periods of 0.8s, which correspond to the predominant period obtained from the microtremor observation and estimation from velocity model of the campus.

KEYWORDS: seismic observation, predominant period, seismic amplification, surface geology

1. INTRODUCTION

Kanazawa Hakkei Campus of Kanto Gakuin University is located in a seaside, whose size is about 250 m by 700 m. The greater part of the campus, whose size is about 250 m by 500 m, is reclaimed land and flat. We have geological borehole data at 184 points for building construction in the campus (Nokubo and Saito, 2006). The area of campus is small, but we have a lot of data to discuss the details of the underground structure. Compiling the materials of borehole data, we found that the campus has complicated relief of basement. We think the campus as a good experimental field for studying seismic ground motion characteristics.

Nakajima et al. (2000) carried out microtremor observation with a high density in the campus and compared the predominant periods obtained by the microtremor observation with natural periods calculated from the ground surface structure of the campus. One of goals of microtremor observation is to obtain seismic amplification characteristics. From 1996, we continue seismic observation at several points in Kanazawa Hakkei Campus. Maeda et al. (2006) reported JMA (Japan Meteorological Agency) instrumental seismic intensity as an index for seismic amplification characteristics, and compare intensities among the seismic observation points in the campus. In this study, we reviewed the result of the seismic observation and discuss on seismic ground motion characteristics with related to the underground structure of the campus.

2. KANAZAWA HAKKEI CAMPUS

Takahashi and Kawa (2000) compiled the materials of geological borehole data in the campus. After then, several new buildings were constructed and we can obtain new materials of geological data. Nokubo and Saito (2006) added new materials to Takahashi and Kawa (2000)'s work, compiled them together, and made the details of the topography of the basement clear. Figure 1 shows elevation of the top surface of the basement with seismic observation points. The western part, whose size is about 250 m by 500 m, is reclaimed land and flat, and the eastern part is higher place with elevation of 6m to 8m, which consists of sedimentary rocks of the early Pleistocene. The basement of the western part also consists of the sedimentary rocks of the early Pleistocene.

There is a hill area composed of rocks of the early Pleistocene to the south of the campus. The ridges are extended to the underground of the campus, and we can find the several underground ridges. A large valley runs from south by west to north by east. The lowest elevation of the top surface of the basement is about 30 m below the sea.

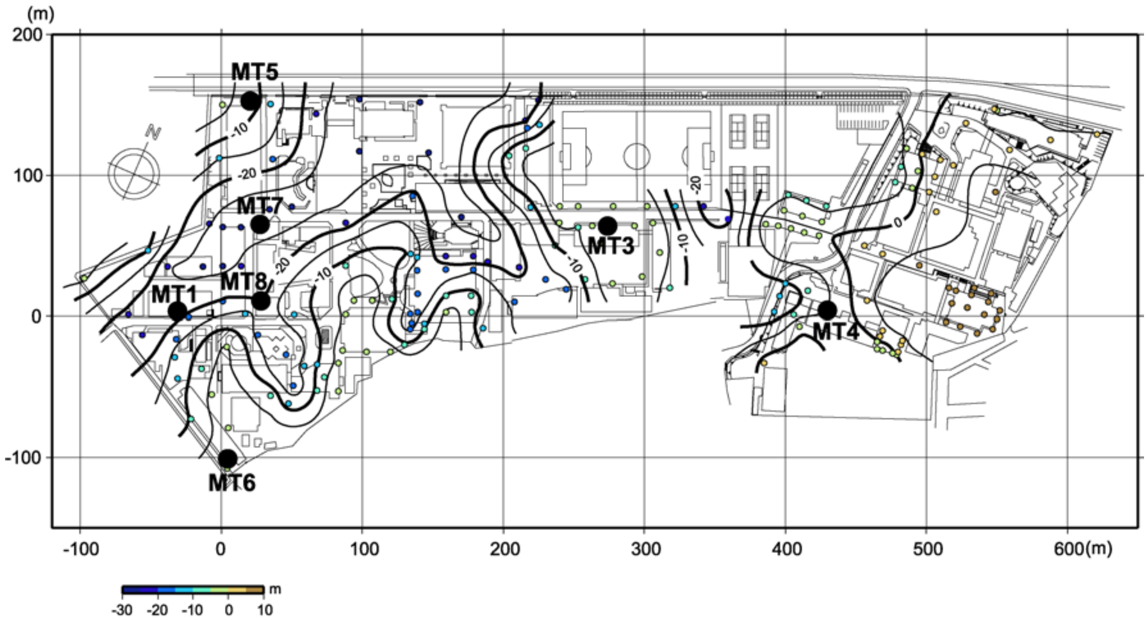

Figure 1 Elevation of top surface of basement with seismic observation points

3. SEISMIC OBSERVATION AND CHARACTERISTICS OF SEISMIC GROUND MOTION

3.1 Seismic observation

Figure 1 shows seismic observation points with elevation of top surface of basement. Seismographs are set on first floor or basement floor of building except MT6. The seismograph has nine channels, consisting of three components of low gain velocity, high gain velocity, and acceleration. Those recordable ranges are up to 100cm/s, 5cm/s, and 1000cm/s^2, respectively. Its frequency characteristic is flat from 0.025Hz to 70Hz. Seismograms are acquired with event trigger recording with a sampling frequency of 100Hz. Periods of observation and setting conditions are summarized in Table 1.

Table 1 Period of observation and setting condition of seismographs

obs. point	period of observation	setting condition
MT1	July, 1996~	1st floor of 5 story building
MT3	Mar., 1999~	1st floor of 2 story building
MT4	Apr., 2000~	basement floor of 2 story building
MT5	May, 2001~Sep., 2005	1st floor of 1 story building
MT6	OCT., 2005~	2nd floor of 2 story building
MT7	Apr., 2006~June, 2006	1st floor of 3 story building
MT8	Apr., 2006~June, 2006	1st floor of 3 story building

3.2. The difference of instrumental seismic intensity

In order to compare, the seismic amplification characteristics among the observation sites, Maeda et al. (2006) calculated JMA instrumental seismic intensity from the seismograms. The values of intensity at MT3 showed the smallest ones among the observation sites. The intensity at MT3 was used as a reference value in the comparison with other stations.

The seismograms for earthquakes with the epicentral distances of 300km or less were used in the calculation of intensities, because there is greater possibility that S wave arrivals are not observed within a record length for the earthquakes with larger epicentral distances. The epicenters used in the calculation of intensities are shown in Figure 2.

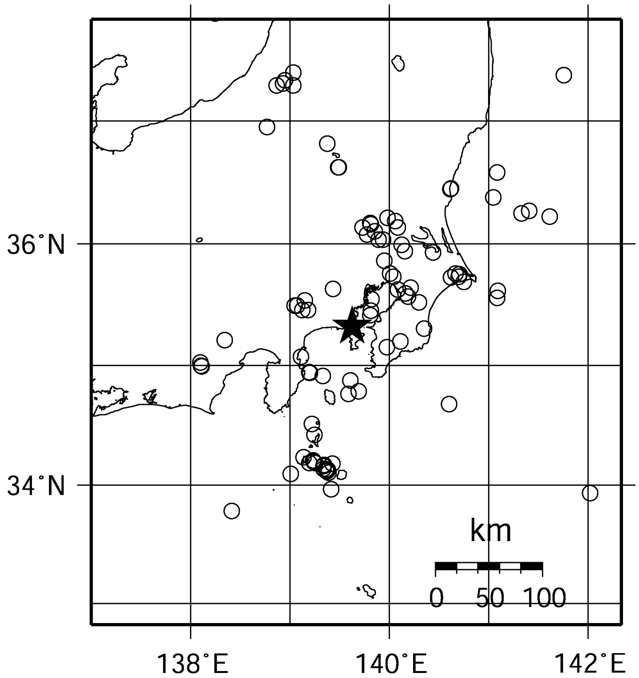

Figure 2 Epicenters (open circles) for which instrumental seismic intensity are calculated. A star symbol represents the location of Kanazawa Hakkei Campus of Kanto Gakuin University. Epicenters are determined by JMA. (Maeda et al., 2006)

Figure 3 shows the intensities at each station versus those at MT3. The intensity at MT1 is about 1 larger than that at MT3 on the average. Although the numbers of data are small, the intensities at MT7 and MT8 are also about 1 larger than that at MT3. The averages of deviations of instrumental intensities at observation points are listed in Table 2.

Table 2 Averages and standard deviations of deviations of instrumental seismic intensities from those at MT3 (Maeda et al., 2006)

obs. point	averages	standard deviations	no. of data
MT1	0.96	0.36	88
MT4	0.41	0.19	62
MT5	0.62	0.16	37
MT6	0.68	0.15	12
MT7	1.19	0.20	4
MT8	0.85	0.18	4

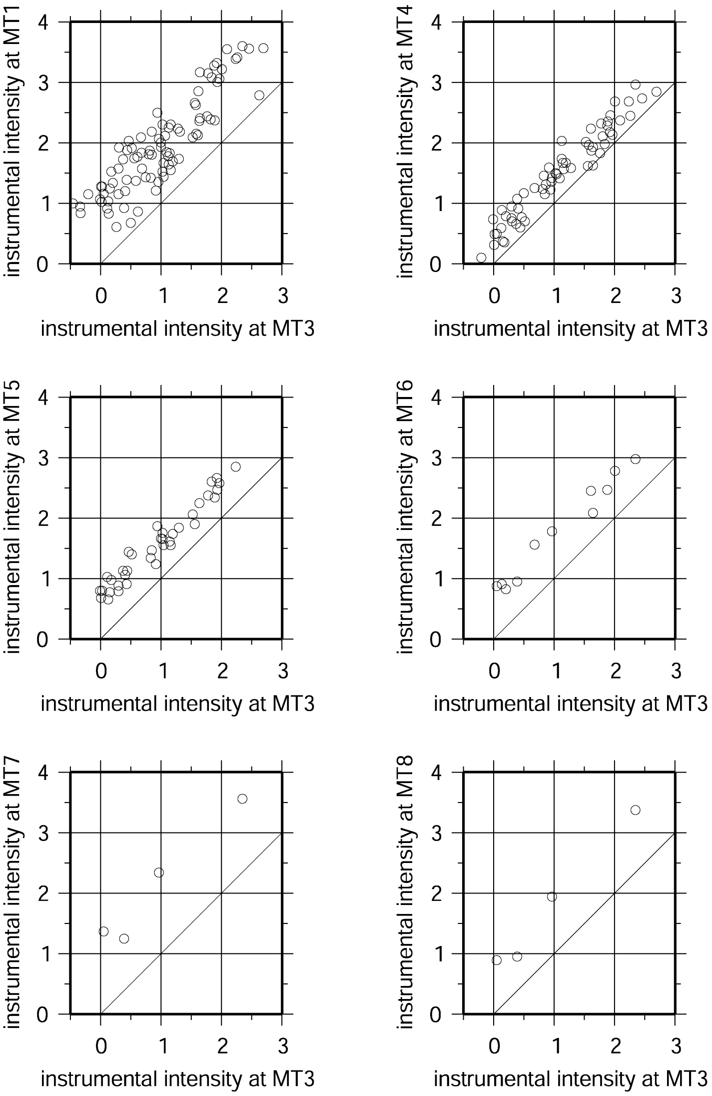

Figure 4 Instrumental seismic intensities at each station versus those at MT3. (Maeda et al., 2006)

3.3. Seismic Intensity and the depth of top surface of basement

Table 3 shows depths of top surface of the basement below the observation stations estimated using Figure 1, taking elevation of surface into account. The top surface of the basement below MT1, MT7, and MT8, where intensities are large, are deeper than those below other stations. The results shown in Table 2 are almost correlated with the depth of the top surface of the basement below the observation points.

Table 3 Depth of top surface of basement at seismic observation points (Maeda et al., 2006)

observation point	MT1	MT3	MT4	MT5	MT6	MT7	MT8
depth (m)	21	2	9	9	4	29	21

3.4. Characteristics of seismograms

Figure 5 and Figure 6 show the seismograms observed at MT3 and MT1, respectively, for the earthquake with magnitude of 5.1 whose epicenter is located in the E off Izu Peninsula Region. The amplitude of horizontal components of the seismograms at MT1 are larger than those at MT3 by a factor of about 4, and the predominant period at MT1 looks longer than those at MT3. Figure 7 shows the velocity response spectra for the horizontal components of seismograms. The predominant period of horizontal components at MT1 is about 0.8s, while that at MT3 is about 0.4s. These values of the predominant period correspond to those obtained from the microtremor observation (Nakajima et al., 2000). We can also find the predominant periods of 0.8s in the seismograms observed at MT7 and MT8, where the deviations of intensity are large.

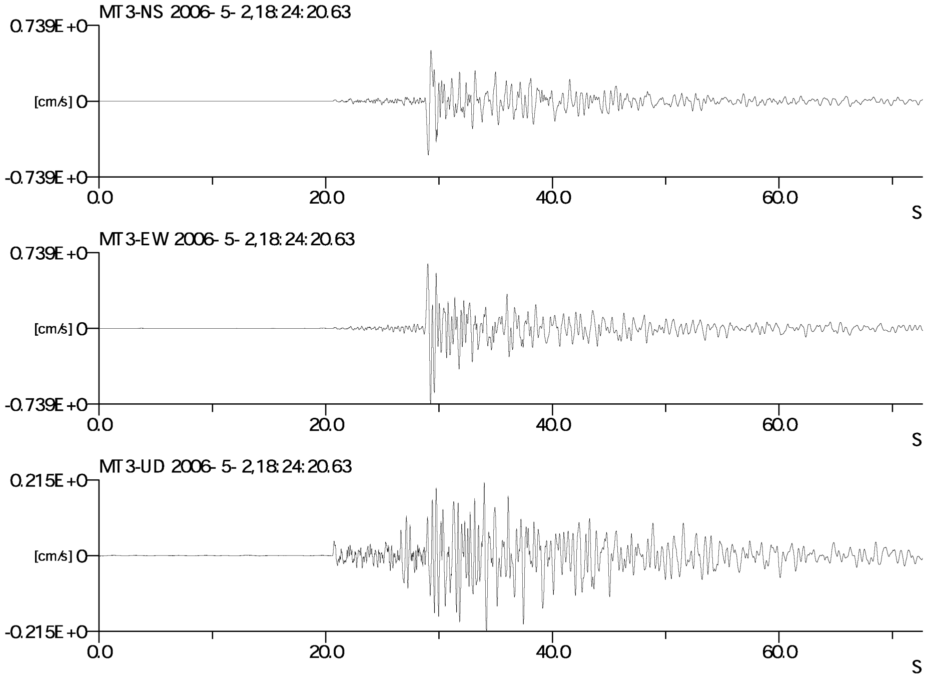

Figure 5 Velocity seismograms observed at MT3 for the earthquake in E off Izu Peninsula Region (Maeda et al., 2006)

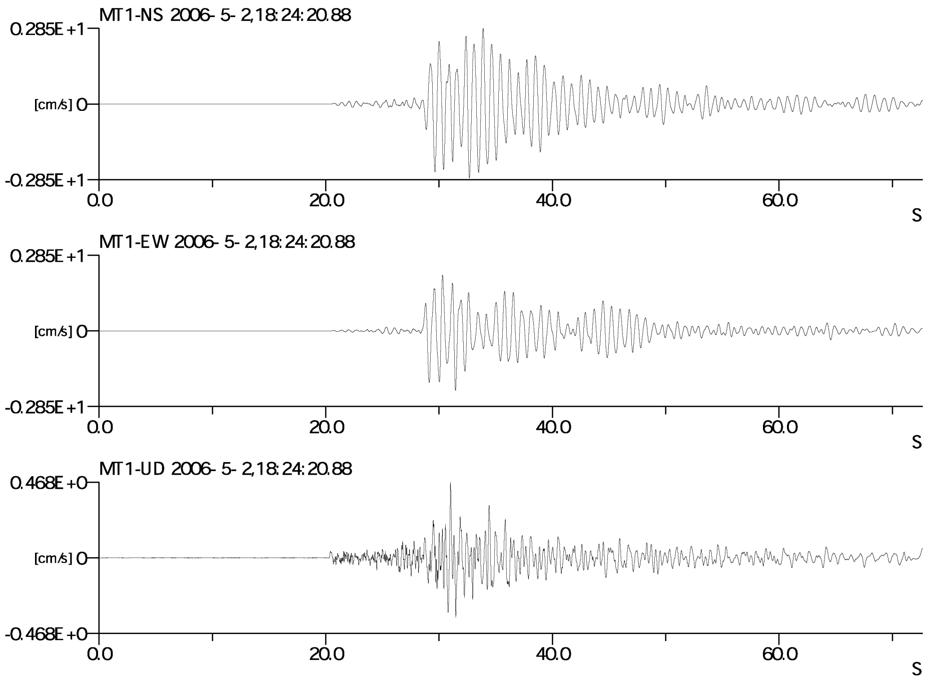

Figure 6 Velocity seismograms observed at MT1 for the earthquake in E off Izu Peninsula Region (Maeda et al., 2006)

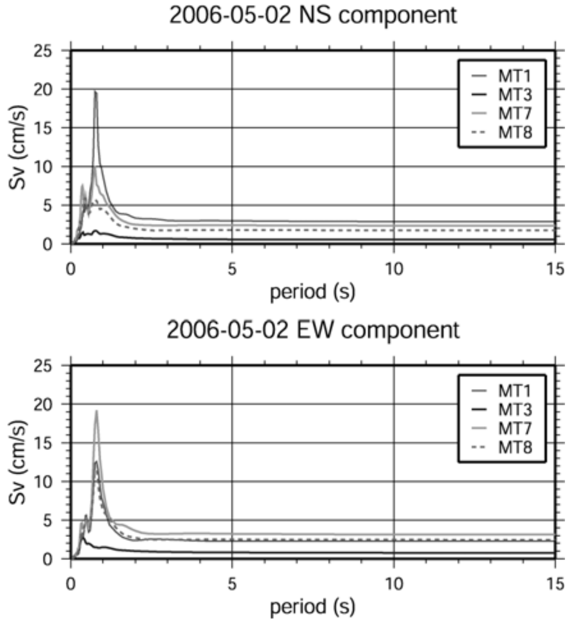

Figure 7 Velocity response spectra for NS components (upper) and EW components (lower) for the earthquake in E off Izu Peninsula Region

Figure 8 shows the velocity response spectra for the horizontal components of seismograms for the Mid Niigata Prefecture Earthquake in 2004. Predominant periods of 0.8s are found at MT1 and MT3.

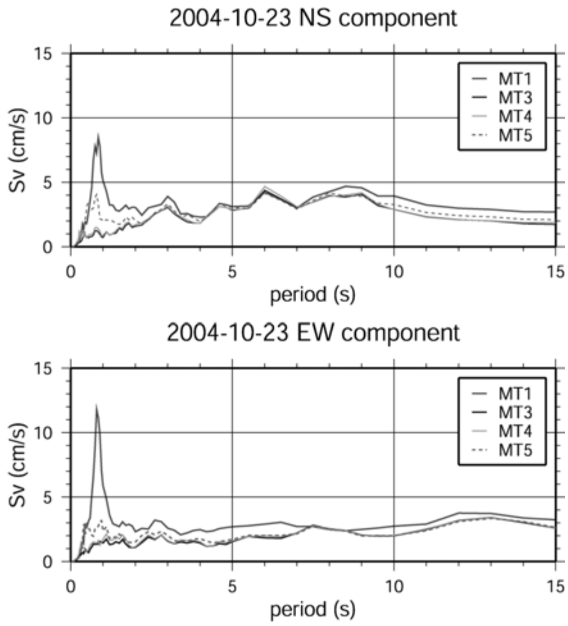

Figure 8 Velocity response spectra for NS components (upper) and EW components (lower) for the Mid Niigata Prefecture Earthquake in 2004

3.5. Estimation of seismic Characteristics

Kamata (2005) constructed a one-dimensional velocity model at the point, where the depth of top surface of basement is 26.4m, by using empirical formulae for the borehole data, and estimated predominant period and seismic amplification at 0.78s and 4.8, respectively, as shown in Figure 9. The value 0.78s of predominant period corresponds to the predominant period of 0.8s at MT1, where the depth of top surface of basement is 21m. But, it seems to be difficult to explain the predominant period of 0.8s at MT5, where the depth of top surface of basement is 9m.

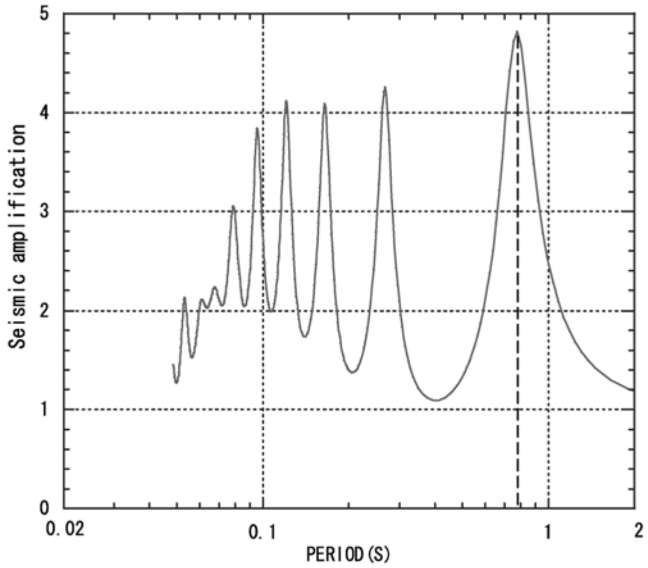

Figure 9 Seismic amplification characteristics calculated using one-dimensional velocity model (Kamata, 2005)

4. CONCLUDING REMARKS

In Kanazawa Hakkei Campus of Kanto Gakuin University, the predominant periods of 0.8s are found at MT1, MT3, MT5, MT7, and MT8. The depths of top surface of basement at MT1, MT5, MT7, and MT8 are larger than 20m. At those sites, the observed predominant periods corresponds the calculated predominant period using by one-dimensional velocity model. The depth of top surface of basement at MT5 is 9m. It, therefore, seems to be difficult to explain the predominant period at MT5 by using a one-dimensional velocity model. It is a possible explanation that MT5 is located on the slope of valley of basement.

We carried out elastic wave survey at several sites in the campus to construct a fine velocity model. We will investigate seismic characteristics at the campus in detail.

REFERENCES

Kamata, Y. (2005). A generation of simulated earthquake ground motion by an empirical method. *Graduation thesis, Dept. Architecture, Faculty of Engineering, Kanto Gakuin University*.

Maeda, N., Nakajima, Y., Matsuda, I., and Abeki, N. (2006). Evaluation of the seismic amplification characteristics at a university campus with complicated relief of basement. *Proceedings of Third ESG Symposium*, 443-451.

Nakajima, Y., Abeki, N., and Watanabe, D. (2000). Study on the stability of H/V spectral ratio of microtremor in short period range for the estimation of dynamic characteristics of surface geology. *12WCEE*, 2094.

Nokubo, Y. and Saito, N. (2006). Surface geology in Kanazawa Hakkei Campus of Kanto Gakuin University. *Graduation thesis, Dept. Civil Engineering, Faculty of Engineering, Kanto Gakuin University*.

Takahashi, M. and Kawa, H. (2000). Microtremor observation in the Mutsu'ura Campus of Kanto Gakuin University -- Correspondence to the surface geology --. *Graduation thesis, Dept. Architecture, Faculty of Engineering, Kanto Gakuin University*.