COMPARISON OF MICRO TREMOR BETWEEN KEKB AND SPring-8

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Abstract

Stability of ground is preferable for accelerator beam operation. We have measured micro tremor of ground at the KEKB and SPring-8 site, where the ground has quite different characteristics each other.

In this paper, some of analysis results are shown, and the characteristics of the ground motion at the KEKB site and those at the Spring-8 site are compared.

INTRODUCTION

Stability of ground is preferable for accelerator beam operation. For example, position errors of quadrupole magnets are required to be less than 5nm in the acceleration area and even 1nm at the collision point in GLC (Global Linear Collider)[1]. In general, the hard rock bed is stable and has less seismic noise. It is very important to know the characteristics of the ground motion to select the site for an accelerator facility such as GLC. We have measured micro tremor of ground at the KEKB and SPring-8 site, where the ground has quite different characteristics each other. KEKB is located on the diluvium ground in Kanto plain, and SPring-8 on the Kamigori meta-gabbro rock area. The KEKB tunnel is buried 10m deep in the ground, and the SPring-8 ring is placed on the ground surface.

Measurement executed in the accelerator structure is reported. Some analysis results on vertical ground motion are shown, and those for the KEKB tunnel and those for the SPring-8 ring are compared. Effect of traffic noise to the ground motion is also discussed.

OUTLINE OF THE MEASUREMENT

Measurement points

Measurement points in the KEKB tunnel are shown in Figure 1, and those in the SPring-8 ring in Figure 2.

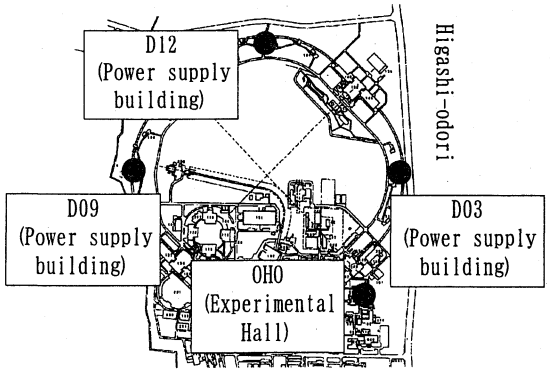

Figure 1: Measurement points in the KEKB tunnel

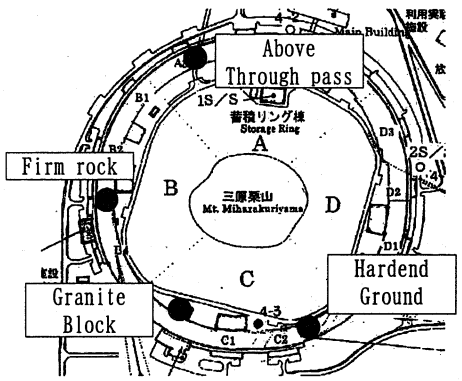

Figure 2: Measurement points in the SPring-8 ring

The measurement points were selected to understand the influence from utilities and traffic. Four measurement points were selected along the KEKB ring, one of which is close to the main street, Higashi-odori, and the others are far from it. At the SPring-8 ring, four points were also selected. Accelerator ring structure is placed on the firm rock bed at first point, and it is on the hardened ground by filling gravels at second point. At third point, there is an through path under the ring structure. The sensor was placed on a granite block in a building at fourth point.

Condition of Measurement

The measurement was executed during the machine shutdown period. The sampling frequency was set to be 100Hz. The condition of measurement is listed in Table 1.

Table 1: Condition of measurement

Facility	Number	Measuring period
KEKB *	4	24hours from 13:00 Dec. 27, 2002
SP-8**	4	24hours from 21:00 June 14, 2003

*10 minutes duration in every hour for 24 hours at KEKB
**30 min. consecutive duration for 24 hours at SPring-8

Measurement instruments

In this measurement, we used the servo type velocity meter VSE355G2 (Resolution: 10e-6 gal, Frequency band: 0.012-70Hz) and the data logger SAMTAC802H. These are manufactured by Tokyo Sokushin Co.,Ltd. Before accumulating data, VSE355G2 and STS-2 were compared on the same granite block, and the comparison authorization was executed.

RESULTS OF THE MEASUREMENT

Comparison by RMS value in time history

The measured data is time history in velocity. We calculated the RMS of them, and observed the variation according to time of the day. We pay attention to the vertical component. Results for the KEKB tunnel are shown in Figure 3, and those for the SPring-8 ring in Figure 4.

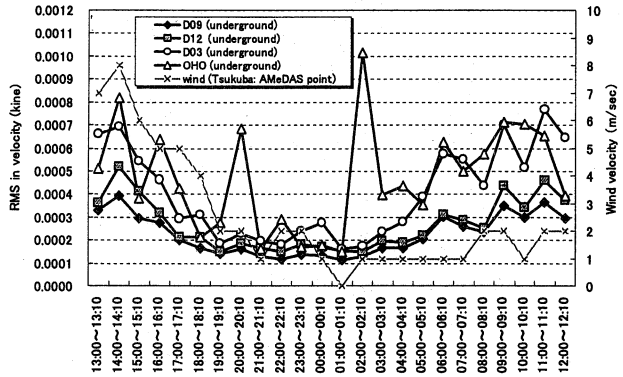

Figure 3: RMS of vertical velocity of ground motion in the KEKB tunnel.

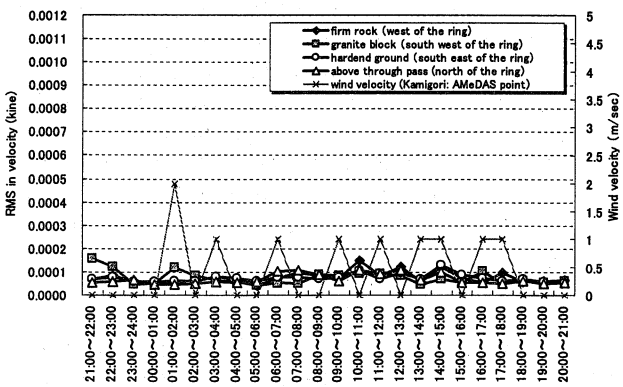

Figure 4: RMS of vertical velocity of ground motion in the SPring-8 ring.

It can be seen in Figure 3 that the seismic noise is small at night and large in the daytime. Dividing one day into two time zones, daytime (9:00-15:00) and night time (19:00-2:00), mean RMS value for each time zone was calculated. Results are shown in Table 2 (KEKB) and Table 3 (SPring-8).

Table 2 : Mean RMS for daytime and night time (KEKB tunnel)

	Day-time (kine)	Night-time (kine)
D09 (underground)	3.26×10^{-4}	1.34×10^{-4}
D12 (underground)	4.04×10^{-4}	1.63×10^{-4}
D03 (underground)	6.23×10^{-4}	2.04×10^{-4}
OHO (underground)	6.02×10^{-4}	3.65×10^{-4}
Average of 4 points	4.89×10^{-4}	2.17×10^{-4}

Table 3 : Mean RMS for daytime and night time (SPring-8)

	Day-time (kine)	Night-time (kine)
Rock	9.23×10^{-5}	6.32×10^{-5}
Granite rock	7.90×10^{-5}	8.65×10^{-5}
Improved ground	8.80×10^{-5}	6.17×10^{-5}
Above under passing	7.98×10^{-5}	5.31×10^{-5}
Average of 4 points	8.48×10^{-5}	6.61×10^{-5}

The mean RMS value in the daytime is 2.25 times larger than that at night at KEKB. On the other hand, this ratio between daytime and night time is only 1.28 at SPring-8. And the mean RMS value in the day time at KEKB is 5.77 times larger than that at SPring-8. At night, this ratio between KEKB and SPring-8 is 3.28. It is thought that the vibration level at SPring-8 is very low because the accelerator ring is located on the stiff bedrock and isolated from heavy traffic noise. At KEKB, the site is close to heavy traffic, which causes the difference in the magnitude of ground motion between daytime and night time. Although the wind is said to be some source for seismic noise, it is not clear in Figure 3. The main source looks to be heavy traffic.

Spectral analysis

The spectra for 24 measurements at KEKB and 48 measurements at SPring-8 for 24 hours were analysed.

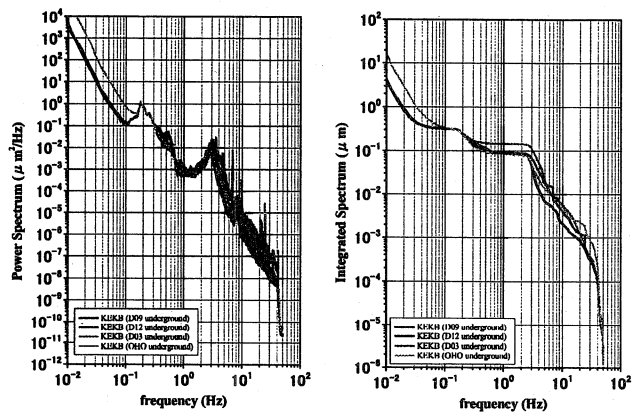

Figure 5: Spectra of vertical ground motion at KEKB tunnel

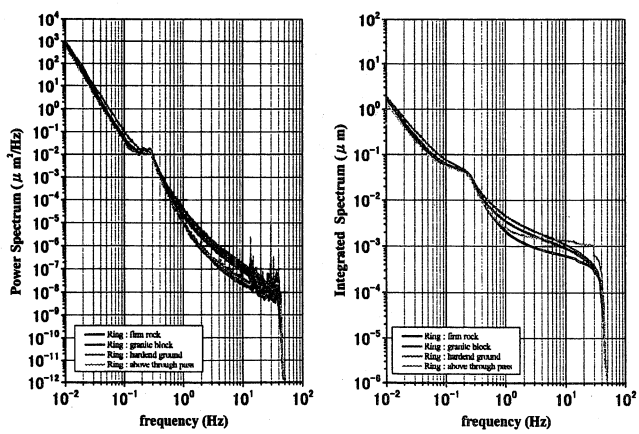

Figure 6: Spectra of vertical ground motion at SPring-8

The duration of measurement is 10 minutes at KEKB and 30 minutes at SPring-8. Those spectra were averaged. The averaged spectra of vertical ground motion over 24 hours are shown in Figure 5 for KEKB and Figure 6 for SPring-8..

From these results, the level of the ground motion is found to be extremely lower in the SPring-8 ring than that in the KEKB tunnel.

COMPARISON OF THE GROUND MOTION BETWEEN KEKB AND SPring-8

The spectra were classified into two groups, daytime (9:00-15:00) spectra and night time (19:00-2:00) spectra. And the spectra in each group were averaged.

The spectra for daytime are shown in Figure 7 and those for night time in Figure 8. In the figures, two spectra, the one is the highest one and the other the lowest one, for each KEKB and Spring-8 site are shown. The spectra are valid in the frequency region less than 25 Hz which is the Nyquist frequency corresponding to the sampling rate 100Hz.

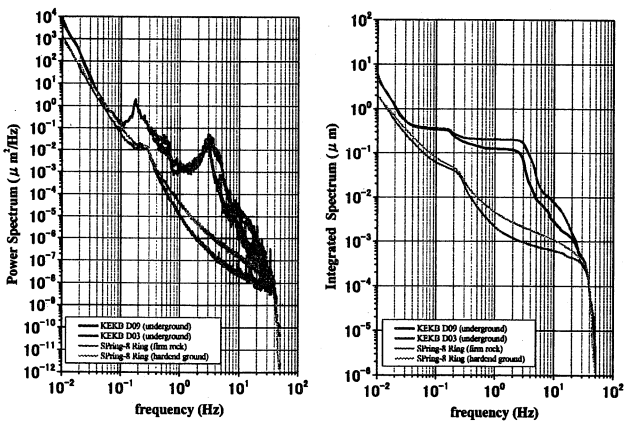

Figure 7: Comparison of the spectra for vertical ground motion in the daytime between KEKB and SPring-8.

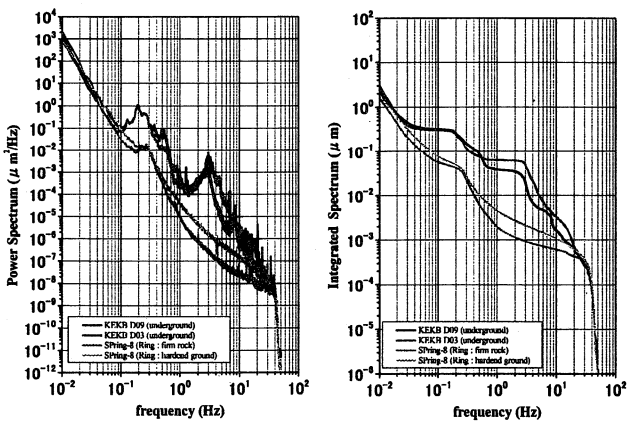

Figure 8: Comparison of the spectra for vertical ground motion in the night time between KEKB and SPring-8.

In the spectra, two peaks are observed. One is around 0.2-0.3 Hz, which is said to be caused by some natural phenomena such as ocean swells and wind. The other is around 2-3 Hz, which is said to be caused by some artificial noise such as traffic noise and machine noise in factories. At KEKB, the difference in the amplitude between the daytime and night time is remarkable around 2-3Hz peak, but this difference is not seen around 0.2-0.3Hz peak. The spectra in the daytime and night time looks almost the same at SPring-8. Comparing the spectra at KEKB and those at SPring-8, the ground vibration in the KEKB tunnel is much larger than that in the SPring-8 ring. The amplitude at night at KEKB is larger by about three orders in the power spectra and by about one order in the integrated spectra than those at SPring-8. In the daytime, the amplitude at KEKB is larger by about five orders in the power spectra and by about two orders in the integrated spectra than those at SPring-8.

SUMMARY

The micro tremor measurement was executed in the KEKB tunnel and in the SPring-8 accumulation ring. The followings are observed in the analysis of the data.

- The level of the vibration in the KEKB tunnel is much higher than that in the SPring-8 accumulation ring.
- The magnitude of the peak around 2-3 Hz in the spectra in the daytime is different from those at night at KEKB. This difference does not appear at SPring-8.
- The peak around 0.2-0.3 Hz does not vary through 24 hours both at KEKB and SPring-8.

ADDRESS OF THANKS

We deeply thank to Professor Kumagai of SPring-8 because this measurement was achieved by his cooperation. We also thank to the staff of Electric Power Development Co., Ltd. who helped us in setting instruments and accumulating data during the measurement period.

REFERENCES

[1] ACFA, JHEPC and KEK, "JLC Project, Linear Collider for Tev Physics", JLC Project Report, March 2003.

[2] Y. Nakayama, *et al.*, Characteristics of micro tremor in KEKB (Tsukuba), Proceedings of the 14th Symposium of Accelerator Science and Technology, Tsukuba, Nov. 11-13, 2003.

[3] Y. Nakayama, *et al.*, Characteristics of micro tremor in SPring-8 (Harima), Proceedings of the 14th Symposium of Accelerator Science and Technology, Tsukuba, Nov. 11-13, 2003.