CHARACTERISTICS OF GROUND MOTION AT KEK AND SPRING-8

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Abstract

In the next generation accelerator, construction of the machine on the stable ground is preferable for accelerator beam operation. We have measured ground motion at the KEKB and SPring-8 site, where the ground has quite different characteristics each other. In this paper, some of observed results are shown, comparing the characteristics of the ground motion at the KEKB site and those at the Spring-8 site.

INTRODUCTION

Stable ground is preferable for accelerator beam operation. For example, vertical position errors of quadrupole magnets are required to be less than 5nm in the frequency region more than 10Hz 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.

Our research group has measured ground motion 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 [KEK] is buried 10m deep in the ground, and the SPring-8 ring [SP8] is placed on the ground surface.

In this paper, we report the results concerning the ground motion in the existing accelerator facilities. Especially, analyzed results on vertical ground motion are shown, and those for KEK and SP8 are compared and discussed.

GROUND MOTION IN THE EXISTING ACCELERATOR FACILITIES

Measured points in the accelerator facilities

Measured points in the KEK are shown in Figure 1, and those in the SP8 in Figure 2. Those points were selected to understand the influence from utilities and traffic. Four 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. The first point is on the firm rock, and the second is on a granite block in a building. The third is on the hardened ground by filling gravels, and the fourth is on the floor over the through path being under the ring structure.

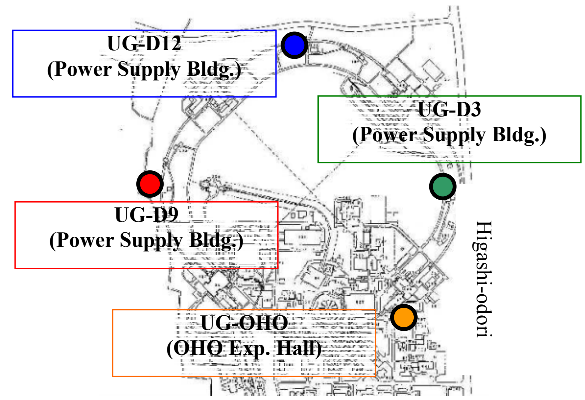

Figure 1: Measurement points in the KEKB tunnel

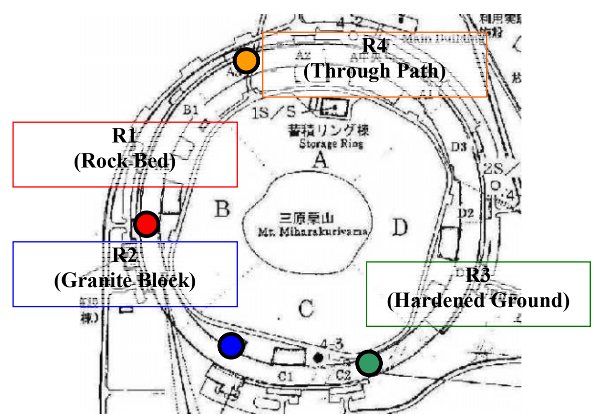

Figure 2: Measurement points in the SPring-8 ring

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 and their calibration

In the present measurements, we used the servo type velocity meter VSE355G2 (Resolution:10e-6 gal, Frequency band: 0.012-70Hz) and the data logger

SAMTAC802H manufactured by Tokyo Sokushin Co.,Ltd. Before accumulating data, calibrations for all instruments were done. In KEK, we have confirmed all the measuring instruments being operated equally to STS-2. We have found, however, that the observed coherence by the present instruments was deteriorated from STS-2 at SPring-8. This result indicates that we should pay attention to the level of the vibration whether being below the measurable limit or not, since the level of ground motion at SPring-8 is critical for this limit.

Standard deviation values in velocity

All the measured data are time series in velocity. We calculated the standard deviation of the data to know the variations according to the time of a day. Dividing one day into two time zones, daytime (9am-5pm) and night-time (7pm-3am), the standard deviation value for each time zone was calculated for vertical ground motion. Results for representative points are shown in Table 2.

Table 2: Standard Deviation for daytime and night-time

		Day-time	Night-time
		(cm/sec)	(cm/sec)
KEK	UG-D9	$3.18*10^{-4}$	$1.29*10^{-4}$
	UG-D3	$6.06*10^{-4}$	$2.01*10^{-4}$
	Averaged	$4.62*10^{-4}$	$1.65*10^{-4}$
SP8	R1	$7.51*10^{-5}$	$5.48*10^{-5}$
	R3	$6.50*10^{-5}$	$5.74*10^{-5}$
	Averaged	$7.01*10^{-5}$	$5.61*10^{-5}$

The mean standard deviation value in the daytime is 2.8 times larger than that at night for KEK. On the other hand, this ratio between daytime and night-time is only 1.25 for SP8. The mean standard deviation value in the daytime of KEK is about 6.59 times larger than that of SP8. At night, this ratio between KEK and SP8 is 2.94. It is thought that the vibration level at SP8 is much lower than KEK 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.

Power Spectrum Density

The observed Power Spectrum Density [PSD] was classified into two groups, daytime (9am-5pm) and night-time (7pm-3am). The PSDs in each group were averaged. The duration of measurement is 10 minutes at KEKB and 30 minutes at SPring-8. The PSDs for daytime and night-time are shown in Figure 3. These figures are concerning for vertical ground motion.

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 50 Hz which is the Nyquist frequency corresponding to the sampling rate 100Hz. From these results, the level of the ground motion is found to be extremely lower in the SP8 than that in the KEK. In these spectra, there are obvious two peaks. 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. On the case of KEK, 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 show almost the same at SPring-8. Comparing the spectra of KEK and those of SP8, the ground vibration in the KEK is much larger than that in the SP8. When we pay attention to 2-3Hz peaks, the amplitude at night of KEK is larger by about three orders in the power spectra than those of SP8. In the daytime, the amplitude of KEK is larger by about five orders in the power spectra than those of SP8.

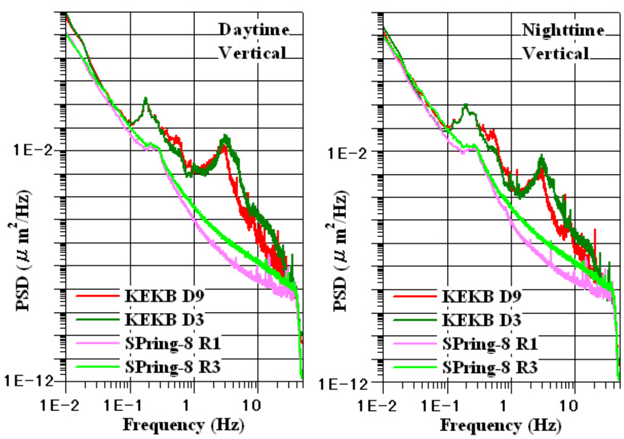

Figure 3: PSDs of vertical ground motion in the daytime and night-time for KEKB and SPring-8.

Integrated Spectrum

We calculated the integrated spectra by using observed PSDs. The integrated spectra were also classified into daytime and night-time and are shown in Figure 4. These figures are also concerning for vertical ground motion.

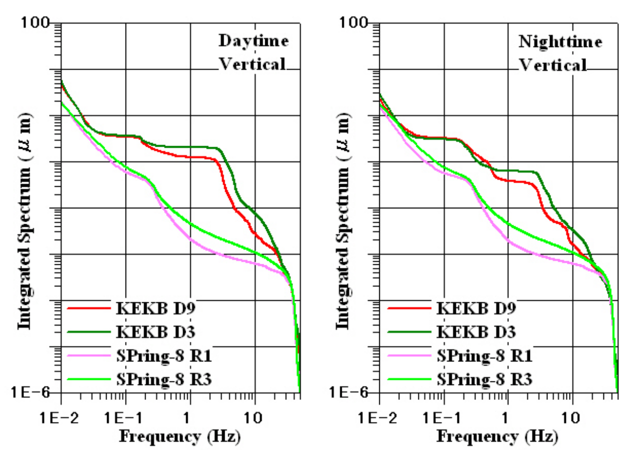

Figure 4: Integrated spectra for vertical GM in the daytime and night-time at KEKB and SPring-8 (Vertical)

We can clearly find out that the amplitudes at night of KEK is larger by about one order than those of SP8 around 3Hz where the maximum differences are there. In the daytime, the amplitudes of KEK are larger by about two orders than those of SP8. From these spectra we can say that characteristics of their ground are very different each other.

In order to clear the time serial spectrum densities, we classify the integrated spectra into three groups according as the frequency increases, those are larger than 0.1Hz, larger than 1Hz and larger than 10Hz. The results are shown in Fig. 5 for KEK and in Fig. 6 for SP8.

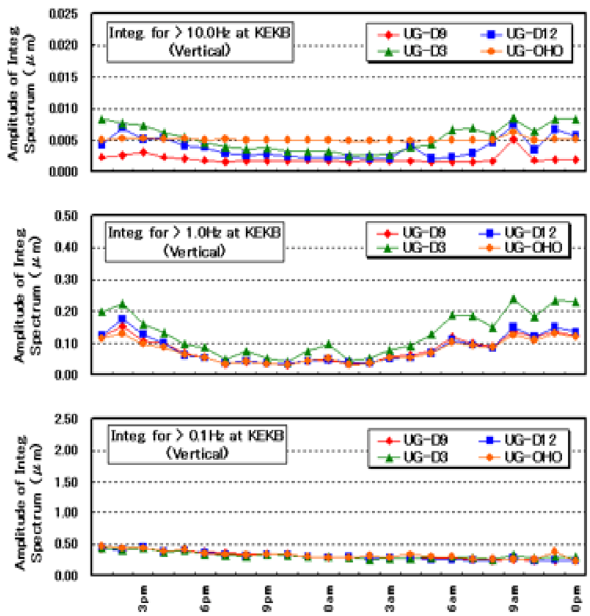

Figure 5: The time serial spectrum densities of KEK.

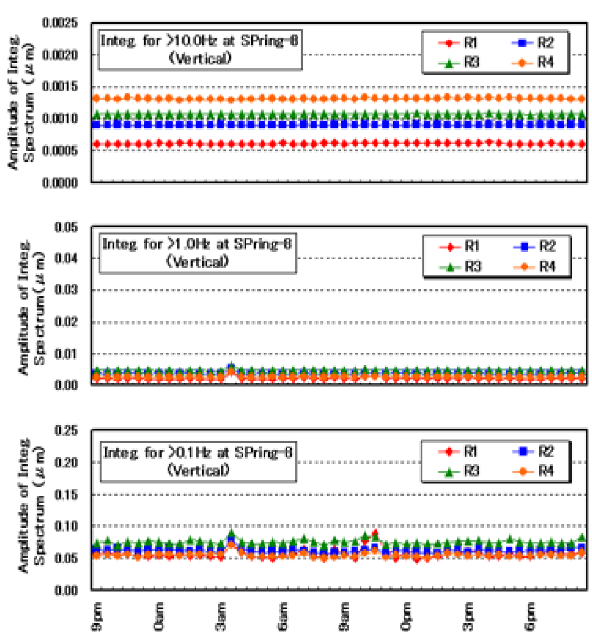

Figure 6: The time serial spectrum densities of SP8.

The difference in the amplitude between daytime and night-time can be seen in the frequency region more than 1Hz for KEK. This is specified by influences of some artificial noises. But we cannot see the difference for ground motion in the frequency range more than 0.1Hz, since the effect of meteorological conditions such as ocean-swells is main component. The measuring point UG-OHO (Oho experimental Hall) shows almost the same amplitude in the frequency range more than 10Hz. It seems to be some influences by accelerator utility noise. The amplitude of UG-D3 is larger than all other measuring points of KEK in the frequency range > 1Hz. The point UG-D3 is close to the main street Higashi-Odori, and has been influenced by heavy traffic. On the other hand, the time serial spectrum densities of SP8 show always flat and much lower values than those of KEK.

SUMMARY

The ground motion has been observed in the KEKB tunnel and in the SPring-8 ring. The followings are clearly shown by the observed and analyzed data.

- The amplitudes of the ground motion of KEK are much higher than those of SP8.
- The magnitude around 2-3 Hz of the spectra in the daytime is different from those at night in KEK. Such difference does not appear in SP8.
- The peak around 0.2-0.3 Hz does not vary through 24 hours both at KEK and SP8.
- KEK shows clear variation for the time serial spectrum densities, though SP8 does not show.

ACKNOWLEGEMENTS

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