

The SSRF Ground Vibrations Measurements and the Beam COD Calculations

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Abstract

Vibration measurements have been carried out at SSRF bare site before and during construction, and at storage ring tunnel and experimental hall during commissioning and regular operation. Comparison between the different measurement results has been made. The beam COD's caused by the vibrations have been calculated, with and without the consideration of the seismic correlation. It reflects the comprehensive measures to improve the noise circumstances both through the building base reinforcement and careful magnet support design.

Key Words: Vibration measurements, Synchrotron radiation, power spectral density, COD

1. Measurement results

1.1 Measurement results of SSRF site

Two measurement points were located at the concrete slab of experimental hall area. The distance between them is about 30 meters. The total data taking time at SSRF site is approximately 48 hours during ongoing construction work. In order to avoid the noises caused by the construction work, it was stopped for 24 hours. The example results of vertical component power spectral density and integrated RMS displacements ($f \geq 1\text{Hz}$) for quiet and noisy time are shown in Figure 1-2. The RMS displacement versus time is shown in Figure 3.

Figure 1-2 show that the site features (1) clear microseismic peak at 0.64Hz, (2) typical sharp peaks around 1.3Hz (one or two), the frequency is not constant, and it is hard to explain their origin, (3) strong cultural noise above 1.5 Hz, the amplitude of the noise at daytime(noisy time) is much larger than that at night(quiet time), the 2.5Hz peak is the main peak of the cultural noise which caused by heavy traffics, see table 1. (4) RMS displacement is "quiet" during the night, maximum in the morning and has large fluctuations during noisy times(Fig.3).

Table 1 Frequencies and Integrated displacement at quiet and noisy time

	Frequencies(Hz)	Integrated displacement(μm)
Quiet time	0.23,0.64,1.3,2.5	0.122
Noisy time	0.23,0.64,1.3,2.5	0.481

2 The comparison of correlation between the different measurements

Ground vibration is harmful to the beam stability only if it causes the magnets to sway at random, which means if all the magnets sway "in phase", there will be no meaningful effect on the beam. That is why the correlation measurement is so important. The followings are two coherence functions we got at different measurement time, from Fig 6-7, it can be seen that "good correlation" has extended from 2Hz during construction to approximately 10Hz after the completion of the construction.

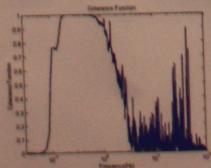


Fig 6 The coherence function measured at the construction site in Nov. 2005

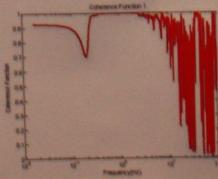


Fig 7 The coherence function measured at the storage ring tunnel in March, 2009

3 The predicted effect of the vibration on beam

The closed orbit distortion (COD) caused by the random vibrations can be calculated by

$$\Delta x_i = (a)_{rms} \frac{\sqrt{\beta_i}}{2\sqrt{2} \sin \theta} \sqrt{\sum_j (k_j)^2 \beta_j}$$

There are total 200 quadrupoles at the storage ring which can be grouped into ten kinds with different strength (Table 2). Figure 8 is the beta function.

Table 2 SSRF storage ring quadrupole parameters

	Length(m)	k
Q1L	0.320	-1.04370
Q2L	0.580	1.36330
Q3L	0.320	-1.22420
Q4L	0.260	-1.07460
Q5L	0.320	1.39810
Q1	0.320	-1.33860
Q2	0.580	1.53070
Q3	0.320	-1.04420
Q4	0.260	-1.35670
Q5	0.320	1.46050

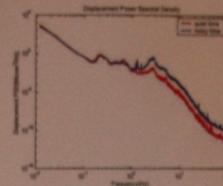


Fig 1 Displacement Power Spectral Density for vertical component at quiet time and noisy time

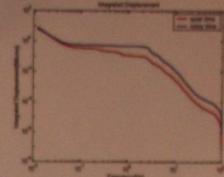


Fig 2 Integrated Displacement at quiet time and noisy time

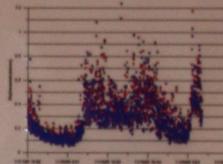


Fig 3 RMS displacement versus time

1.2 Measurement in storage tunnel

Several measurements have done during the commissioning and regular operation in the storage tunnel and experimental hall. Figure 4-5 are the typical results of PSD and integrated displacement. The characteristic frequencies in the PSD are different from those in PSD of Fig. 1, which reflects the effect of the building foundation. And the 1-100Hz and 5-100Hz integrated displacement during day are around 0.12 and 0.01 micron, respectively.

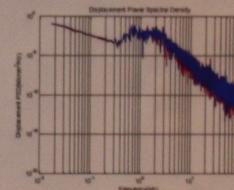


Fig 4 Displacement PSD at the storage ring

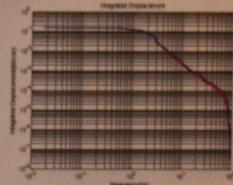


Fig 5 Integrated displacement of Fig 4

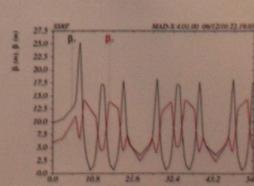


Fig 8 The beta function of the storage ring

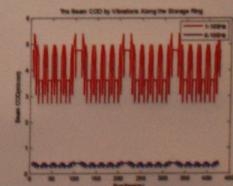


Fig 9 COD caused by the 1-100Hz vibrations (red), and 6-100Hz(blue).

Suppose the vibrations in the 1-100Hz frequency range are totally random, the maximum COD is 5.4 micron (Fig. 9, red). Since the vibrations below 5Hz are in good correlation, they have no meaningful effect on the beam. The vibrations in the 6-100Hz frequency range have an integrated displacement of 0.01 micron, the corresponding maximum COD is around 0.44 micron (Fig. 9, blue).

4. Conclusion

The above analysis is evidences of substantial improvement of the stiffness from the soil to the concrete foundation. The commissioning and regular operation show the beam orbit sub-micron stability has been achieved, which reflect the comprehensive measures to suppress the noise both from the building foundation and magnet support design, as well as vibration isolation and damping measures.