GROUND VIBRATION MEASUREMENT AT NSRRC SITE

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Abstract

For the future TPS project in the NSRRC, ground vibration would be important for this new machine. We have monitored the ground vibration under various experimental conditions at NSRRC site. Sensors were installed in different sites, on the ground and underground in different depth up to 40 meters. From the collected data, we compare the effect of day and night, traffic effect, and internal machine vibration. Specific vibration sources and their propagations are also discussed.

INTRODUCTION

In the future TPS project, this machine is designed as features of low emittance, high brightness, high stability etc. Above parameters are sensitive to the vibration issues. In one tentative design with 518meters storage ring circumference, the building is plotted in the blue circle as shown in the Figure 1. Around BH8, the ground level is 6 meters lower than the average. The nearest point of the building to the public road (Park Avenue III) is only 25 meters. The shortest distance from storage ring to public road is only 45 meters. Ground vibration and building vibration seems a challenge to this project. In this paper, we performed the ground vibration measurement at different locations of TPS site in different underground levels to understand the vibration source and distribution. We also measured vibration at different distance from the public road to understand the traffic effect.

MEASUREMENT METHOD

The measurement were made using seismometers of Guralp CMG 6TD and Tokyosokushin VSE-15D for the ground measurement; Tokyosokushin VSE-355D for the underground measurement. The above sensors were all velocity types in three axes direction with flat response from 0.1 Hz upwards. Suitable recorder or build-in hard disk performed the programmed recording with sampling rate in 200Hz. The sensors were calibrated with laser interferometer and assumed within 10% error. We selected three measurement points within the TPS planning building site as shown in the Figure 1. For the underground measurement we prepared three down holes in different depth and measured underground 5meters for BH10, 15meters for BH11, and 40 meters for BH8.

The measurements data were taken once or twice each hour. After loading time domain data from recorder, we select one time interval of 2048 data point for FFT analysis and we took 10 time intervals for calculating the average of power spectrum density. The integrated RMS displacement was integrated PSD from specific frequency to 100Hz and takes square root [1,2].

MEASUREMENT RESULT

Power spectrum density

Figure 2 shows a typical PSD measured at bare ground in vertical directions. We can find a peak around 3 Hz, which is often found in the Taiwan island. The mechanism is not clear yet. Integrated displacement from 1 Hz to 100 Hz in vertical direction was 108 nm, from 2Hz to 5Hz the integration was 56nm. For this strong 3 Hz peak, it is difficult to damp it by civil or mechanical methods. From the simulation of the beam dynamics [3], the amplification factor of beam motion by the ground vibration below 4 Hz was less than that at higher frequency.

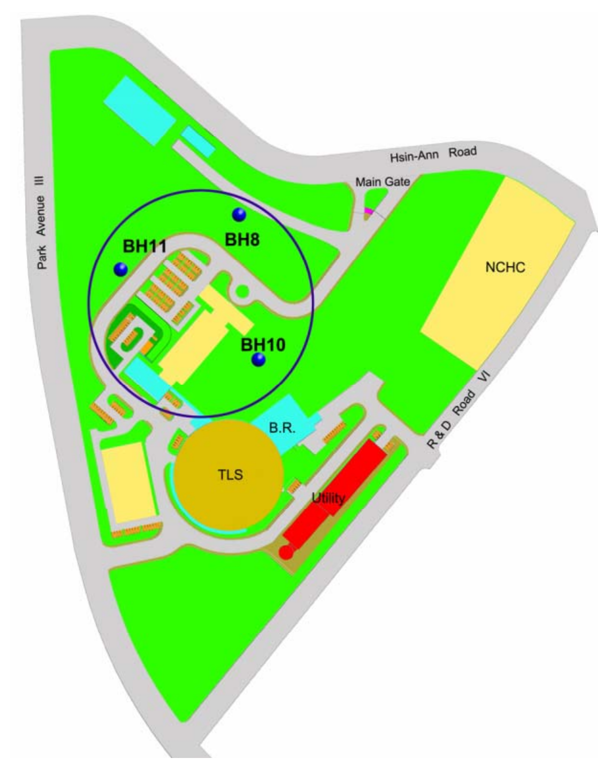

Fig. 1: Layout of ground vibration measurement

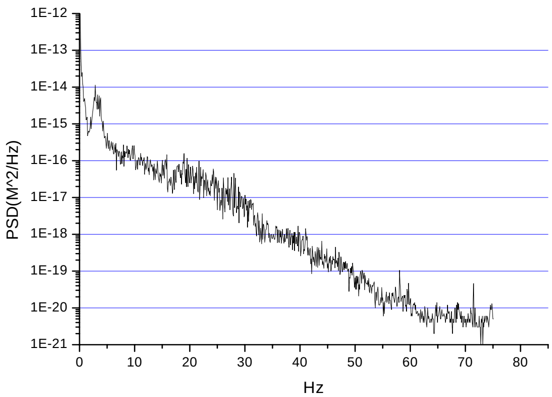

Fig. 2: A typical power spectrum density of ground vibration in vertical direction.

Integration displacement of ground vibration at different locations.

For the 3 selected measurement points, BH8 was near the public road, BH10 was near the staff and utility building, BH11 was close to the NSRRC internal road. Table 1 shows the average of 24 hours measurement at different locations on 2005,10/19 19:00 to 10/20 18:30 [4]. Data was taken twice per hour.

Table 1 Average of ground vibration measurement at different locations (unit: nanometer)

	1.12 HZ upwards			3.35 HZ upwards		
	BH8	BH10	BH11	BH8	BH10	BH11
N-S	139	97	223	42	51	54
E-W	146	110	166	47	58	48
V	113	105	101	46	53	46

We can find transverse vibration (N-S, E-W) was sometimes higher than that in vertical for displacement from 1.12Hz upwards but almost same as vertical's from 3.5 Hz upwards. It seemed the 3 Hz peak was not so isotropic in three directions. For the vertical vibration displacement from 1.1Hz upward, BH8 was highest about 10% above average; BH10 was highest from 3.5 Hz upwards. It suggested the internal noise contribute somewhat.

Vibration at different level of underground

Before comparing the vibration at different depth, sea level height of BH8, BH10, BH11 was 109,118,119 meters individually. Table 2 shows the summary of one day's measurement at different level of underground. We can compare the displacement from 3.5 Hz upwards at different depth. There was a decaying trend as the depth going deep. But there was no significant decay in displacement between 1.1 Hz to 3.5 Hz. It seemed the higher frequency part generated from the ground surface and decayed as it propagated further. It could reduce to half amount as it propagated 40 meter deep. Comparing with Table 1, on the ground with different sea level, the vibration was not so big different, it suggested the vibration propagating is surface wave dominant.

Table 2 Summary of vertical vibration in different level of underground.

	1.12 Hz upwards	3.55 Hz upwards
0M (BH8)	113nm	46nm
-5M (BH10)	101nm	50nm
-15M (BH11)	87nm	28nm
-40M (BH8)	81nm	20nm

Traffic effect.

In order to study the traffic effect we measured a point about five meters near the public road (Hsin-Ann Road). Figure 3 shows the measurement result in vertical direction for one day. At nine o'clock of rush hour, vibration increased up to two times of average; in the middle night, amplitude was reduced significantly. From Figure 3, we can say that traffic effect increased not only the low frequency part (1 Hz upwards) but also high frequency (4 Hz upwards) part. Another measurement was with different distance away from another public road (Park Avenue III). Result is shown in Figure 4. We can see the amplitude from 4 Hz upwards have peak at nine o'clock and dropped to nearly average level as the distance was 15 meters away from the public road. From Figure 3 and 4 for a whole day measurement we also found the peak was always in the rush hour at nine o'clock rather than at six PM. One possible reason was these roads with slope of 3-5meters per one hundred meters. At nine o'clock most cars was going upwards, more momentum impact to the ground.

The result of BH8, which was about 40 meters from the road, is shown in Figure 5. We can find the 1-4 Hz decayed significant compared with Figure 3.

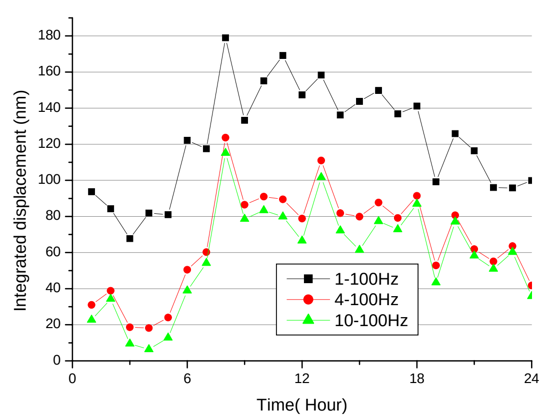

Fig. 3: Vertical vibration at 5 meters away from the Hsin-Ann public road.

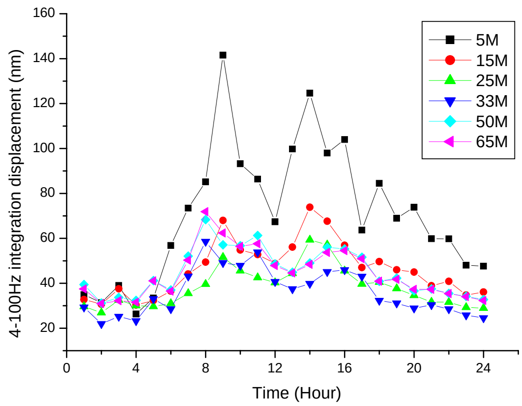

Fig.4: Vertical vibration at different distance from the Park Avenue III public road.

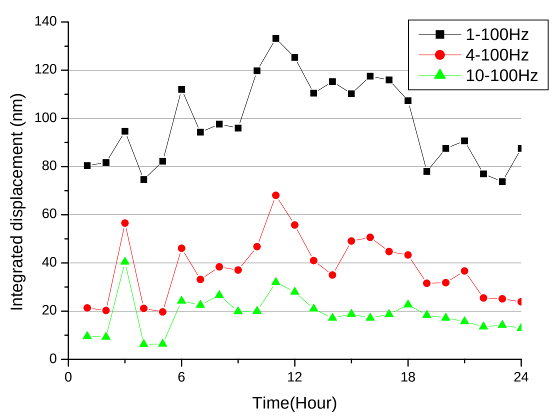

Fig. 5: Vertical vibration at BH8, about 40 meters from Hsin-Ann public road.

Internal source

Besides the above-mentioned outside source there was also internal sources such as utility vibration and some pumps etc. Rough estimation is as following. BH8 stands for the outside traffic contribution. Let's compare the lowest background; the quiet period in the midnight of Figure 3 or 4 was about 20nm from 4 Hz upwards. Figure 6 shows the vertical displacement in a point near the TLS tunnel. In the midnight the vibration level was about 30nm from 4 Hz upwards. It seemed the 10nm was from the internal source such as utility, water or air-condition flow. Comparing the midnight of Figure 4 and 5, we also find from 10Hz upwards the difference bare site and tunnel in the midnight was about 8nm. One of internal source has been reported [5].

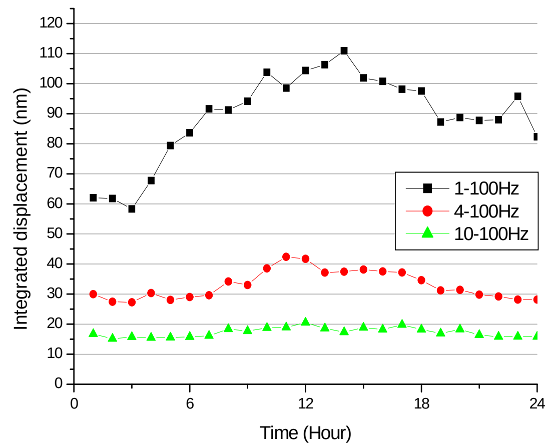

Fig. 6: Vertical vibrations near the TLS tunnel.

SUMMARY

The measurement of vibration at TPS site is summarized as following:

- Vibration level in vertical direction was about 50nm from 4 Hz upwards in the three measurement points with different sea level.
- Vibration level in vertical direction decreased as the underground measurement going deep, 40 meters underground is only 20nm from 4 Hz upwards.
- At five meters away from public road showed a vibration peak in the rush hour at nine o'clock, from 15 meters away the peak dropped down to nearly average level.
- The estimated internal noise was estimated about 10nm from 4 Hz upwards in the TLS tunnel.

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