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DYNAMIC ANALYSIS AND MEASUREMENT OF GROUND MOTION FOR THE SOLARIS - NATIONAL SYNCHROTRON RADIATION CENTRE IN CRACOW

D. Ziemianski†, Cracow University of Technology, Cracow, Poland
M. Nowak[1], National Synchrotron Radiation Centre SOLARIS, Cracow, Poland

Abstract

The paper presents the results of the ground motion measurements and dynamic analysis performed in The Polish synchrotron radiation facility Solaris. The analysis has been carried out within the framework of the installation experimentals lines inside SOLARIS bilding and accelerator tunnel. The equipment used in this study consists of 4 seismic, high sensitivity, ceramic flexural ICP accelerometer. Models 393B31. (PCB) , which performed measurements in one vertical directions. The first analysis was to evaluate the power spectral density for each sensors and event. The power spectral density is calculated from the auto power spectrum. The power spectral density shows a typical curve with the micro seismic peak between 0.2 and 0.4 [Hz]. It is important to point that ground vibrations should not be ignored in planning accelerator facility. All over the measurement, the RMS integrated level in the vertical direction at 1 [Hz] were calculated and presented in paper.

SENSORS

Four mono-axial seismic accelerometers were used to measure the ground motion, with a sensitivity of about 1000 [mV/m/s2].The mass of each transducer is 635 [g] and 771[g] (PCB 393831, ENDEVCO 86). The usable frequency range of a sensor is from about 0.1 Hz up to 1/3 to 1/2 of the natural resonance frequency (700/370 [Hz]). In order to increase the frequency, either the stiffness should be increased or the mass decreased. Since decreasing mass also decreases sensitivity, increasing stiffness is preferable. In most cases, a combination of the two approaches is required.

The accelerometers were glued on the floor with wax. The natural frequency of an umounted sensor is different from that of a mounted sensor, because the mounted sensor has a stiffness determined by the stiffness of the structure in which it is mounted. Attaching the sensor to a structure can lower the natural frequency by a substantial amount.

EVOLUATION OF ACCELEROMETER

In addition to seismometers, seismic accelerometers can be a suitable motion transducer for the SOLARIS measurement. The signal and noise of two different seismic accelerometers has been evaluated. These are PCB393831 (Figure 1) and Endevco Model 86 (Figure 2).

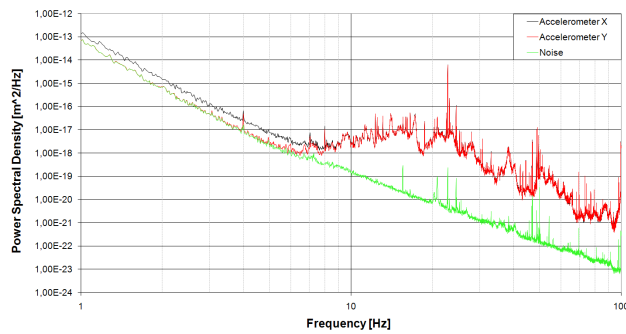

Figure 1: Integrated RMS signal and noise PCB393831.

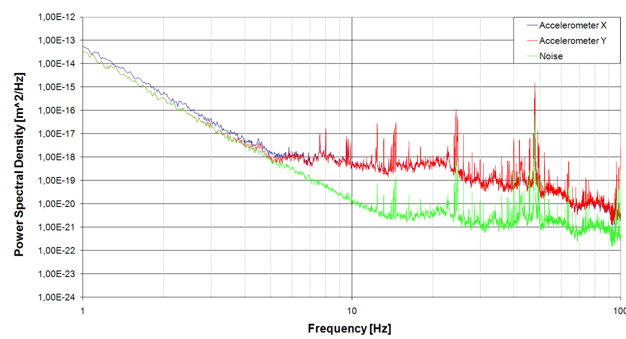

Figure 2: Integrated RMS signal and noise Endevco Model 86.

Two curves show that all accelerometers tested are able to measure above 7 Hz according to the signal to noise ratio. For the SOLARIS measurement this is not sufficient. The motion should be measured down to 1 Hz. However, seismic accelerometers can be used as a supplement to seismometers at high frequencies.

INTEGRATED RMS VALUES

Integrated RMS is used to sum up the total vibration in a spectrum. As the name indicates it give the RMS (Root Mean Square) value of the total vibration.

$$\sigma_\omega = \sqrt{\sum_{k_1}^{k_2} \Phi_\omega(v)\,dv} \tag{1}$$

† dziemianski@pk.edu.pl

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Integrated RMS is a function of k, the frequency, k_1 is the lower value for the summation and k_2 is the upper value for summation. It is usual to plot the integrated RMS as a graph where k_2 is a fixed upper value and k_1 is gradually reduced while the integrated RMS is plotted for each value of k_1. Then it is possible to see the total summation of vibrations from a frequency and down to every lower frequency.

The integrated RMS ground motion at vertical direction for several locations are plotted (Figure 3).

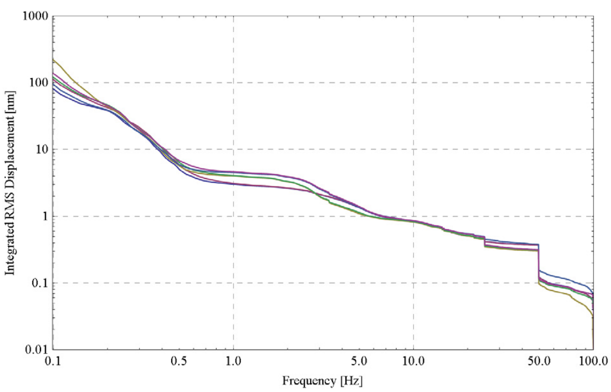

Figure 3: Integrated RMS displacement at vertical direction.

CONCLUSIONS

The power spectral density shows a typical curve for the geophones with the micro seismic peak between 0.2 and 0.3 [Hz]. The amplitude of this peak has a good correlation with ocean wave height and depends also on the distance from the ocean.

Table 1: The value Integrated RMS value at 1 and 10 [Hz]

Location	**1 Hz [nm]**	**10 Hz [nm]**
SOLARIS	5,1	0,9
CLEX experiment (Bld.2013)	13,3	11,6
AEGIS experiment (Bld.193)	13,0	12,4
PSI particle accelerator	11,8	11,0
CERN surface	11,7	10,1
CMS experiment	6,8	1,5
CesrTA particle accelerator	3,8	3,0
SOLARIS	5,1	0,9
CLEX experiment (Bld.2013)	13,3	11,6

All over the measurement, the RMS integrated level in the vertical direction at 1 [Hz] do not exceed a maximum of 5.1 [nm]. The values obtained from these measurements do not differ as to the value of the results obtained during the measurements in other locations (Table 1).