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RESEARCH ON VIBRATION STABILITY OF SAPS FOUNDATION

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Abstract

With the development of science and technology, the technology of synchrotron radiation light source is further developed. As the fourth generation synchrotron radiation light source, Southern advanced photon source forward more stringent requirements on the beam stability. The foundation vibration is the main factor affecting the beam stability. In this paper, the foundation vibration characteristics of the proposed site of Southern advanced photon source are studied, and the foundation vibration test is carried out. The data analysis is carried out from the aspects of different locations, day - night vibration variation characteristics, vibration source frequency, vibration attenuation, and the influence of Expressway on the foundation vibration. This paper provides guidance for the follow-up construction and anti micro vibration foundation vibration treatment of Southern advanced photon source

PREFACE

With the improvement of science and technology, the performance of large scientific devices is constantly developing towards higher requirements. Southern advanced photon source (SAPS) is the fourth generation synchrotron radiation light source to meet the new development requirements. As the fourth generation synchrotron radiation source, South light source needs higher performance, and beam stability is a very important index. Beam stability needs a stable and non-interference equipment environment. The settlement of the ground, the movement of the surrounding ground, the vibration caused by the fluid and the change of the ambient temperature will affect the mechanical stability of the equipment itself. The foundation vibration is transmitted to the magnet, BPM and other beam equipment through the equipment girder, which eventually leads to the degradation of beam stability. In order to meet the requirements of beam stability, it is necessary to carry out a detailed study on the foundation vibration of the proposed site of the South light source, and clarify the characteristics of the foundation vibration, so as to lay the foundation for the subsequent construction of the light source.

MEASUREMENT CONTENT AND ANALYSIS METHOD

Southern advanced photon source is located on the west side of China spallation neutron source. The experimental measurement system uses 3ESPCDE seismograph to obtain the velocity signal of foundation vibration. In order to grasp the overall foundation vibration situation of Southern advanced photon source, the vibration measurement is divided into six areas, each area is arranged with 5 measuring points, and the 24-hour vibration measurement is carried out in three directions of east-west, north-south and elevation. The layout of each point is shown in Fig. 1. Because the survey area is mountain forest area, the surface layer is soft soil, and the bottom layer is hard rock. In order to get the ground vibration results more accurately, each measuring point is dug to remove the loose soil on the surface, and the concrete with the thickness of 100 mm is poured to make the measured value of the seismograph closer to the real situation of the foundation, as shown in Fig. 2.

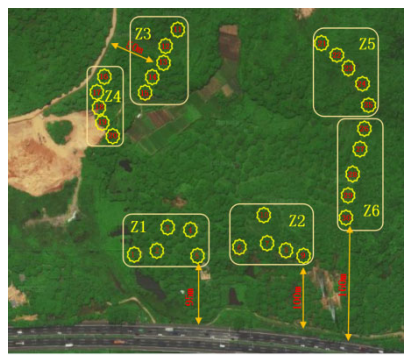

Figure 1: Distribution points of vibration measurement.

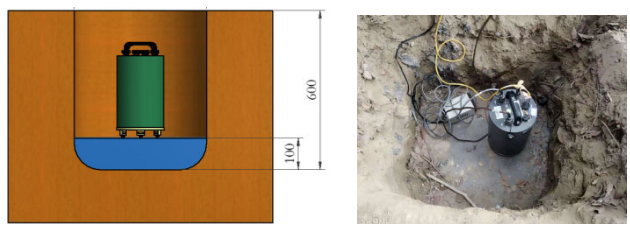

Figure 2: Installation method of seismograph.

Time domain analysis, frequency domain analysis and wavelet analysis are often used in vibration data analysis [1]. In this study, the vibration data are analyzed and evaluated by root mean square (RMS) and power spectral density (PSD), and the time domain RMS value is used to evaluate the energy of foundation vibration signal. The calculation formula of RMS value is shown in Formula 1, In frequency domain, the power spectral density is taken as the evaluation standard, and the calculation formula is formula 2. Considering the measurement accuracy of the seismograph, and the artificial vibration interference in the environment is mainly within 1-100hz. For the evaluation of foundation vibration, the RMS value of 1-100hz is taken as the evaluation standard, and formula 3 is used for calculation [2] .

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$$\mathrm{RMS} = \sqrt{\frac{1}{k+1}\sum_{i=0}^{k} y_i^2} \quad (1)$$

$$\mathrm{PSD} = \frac{\Delta t}{N}\left|\sum_{n=0}^{N-1} u(n) e^{-i2\pi kn/N}\right|^2 \quad (2)$$

$$\mathrm{RMS} = \sqrt{\frac{A_0 \Delta f}{2} + \sum_{i=1}^{k-1} A_i \Delta f + \frac{A_k \Delta f}{2}} \quad (3)$$

ANALYSIS OF VIBRATION MEASUREMENT RESULTS

In order to simulate the vibration of the storage ring of Southern advanced photon source, the vibration measuring points are distributed in six areas, each of which has five measuring points. Among them, the vibration of Z3 and Z4 area is affected by the traffic flow of forest path, and the vibration of Z1 and Z2 area is affected by the traffic flow near the expressway. Z5 and Z6 areas are deep in the forest, and are less disturbed by the outside, which can better reflect the vibration of the whole mountain forest. Taking the average RMS value of 1-100 Hz amplitude as the vibration measurement index, the vibration analysis results of daytime and late night are counted respectively, and the RMS values of each measuring point in vertical, east-west, north-south directions are listed. The results are shown in the Fig. 3 below. The influence of traffic flow on foundation vibration is obvious. Zone Z1 and zone Z2 area are close to the expressway, and the vibration value is significantly higher than that of other areas, The RMS value of vibration is 100-200nm. The vibration values of Z3 and Z4 area affected by forest mountain road are 15-70nm. The vibration of Z5 and Z6 area is the lowest, and the RMS value is 20-40nm.

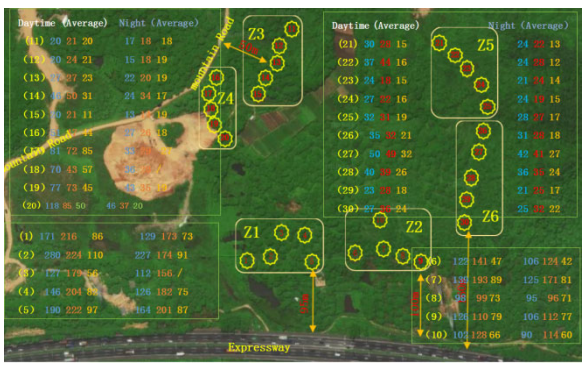

Figure 3: RMS value of the proposed site.

The measuring points of area Z5 and area Z6 are perpendicular to the expressway, and the vibration value distribution of the measuring points reflects the vibration attenuation from near to far away from the expressway, as shown in Fig. 4. From the change of measuring point 21 to 30, it can be seen that the vibration increases gradually, and the vibration amplitude increases gradually. At the same time, the vibration of the whole area at night is slightly lower than that during the day, as shown in Fig. 5.

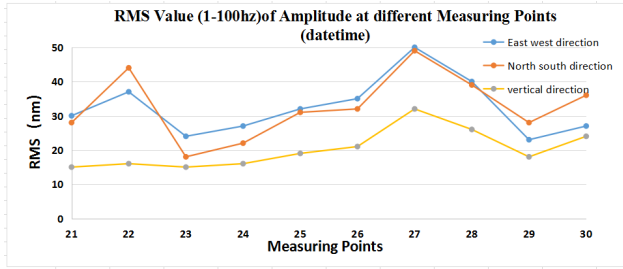

Figure 4: RMS value of different Measuring Points (datetime).

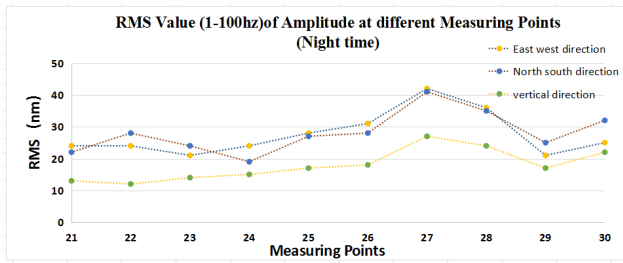

Figure 5: RMS value of different Measuring Points (nighttime).

The RMS values of the above measuring points are the average values of 12 hours in day and night respectively. In order to better grasp the variation trend of the foundation vibration of Southern advanced photon source with time, the RMS statistical values of each measuring point per minute are carried out, and the scatter diagram of 24-hour vibration measurement is drawn. Take No. 17 measuring point as an example, as shown in Fig. 6. Under the influence of traffic flow in the daytime, the RMS value of foundation vibration can reach more than 500 nm, while in the case of less human activity at night, most of the vibration value is less than 30 nm. The large-scale change of the vibration reflects the influence of Road on the foundation vibration. The subsequent treatment of the foundation of Southern advanced photon source should consider the isolation of the surrounding human activities (the vibration value of 500nm), rather than reduce the vibration of the whole foundation plate itself (the vibration value of 30nm). It can be seen from the figure that the RMS value in the vertical direction of the three directions is smaller than that in the east-west direction and north-south direction, so the vibration isolation needs to consider the horizontal vibration more seriously.

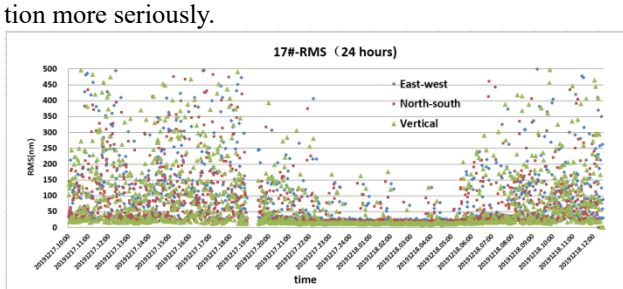

Figure 6: RMS value of 24-hour vibration.

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The vibration frequency of traffic and industrial production activities is mainly in lhz-100hz. In order to study the RMS contribution value of different frequency bands, the RMS value statistics of four frequency bands are carried out, as shown in Fig. 7, the RMS value of 1-100hz frequency band is close to that of 4-100hz, and the RMS value contribution value of 15-100hz frequency band is very low, which indicates that the foundation vibration mainly comes from the low frequency band of 4-15hz. As the high-frequency vibration decays rapidly in the stratum, the low-frequency vibration signal is mainly felt on the surface [3]. This conclusion is also obtained from the power spectral density analysis of the measuring points, as shown in Fig. 8.

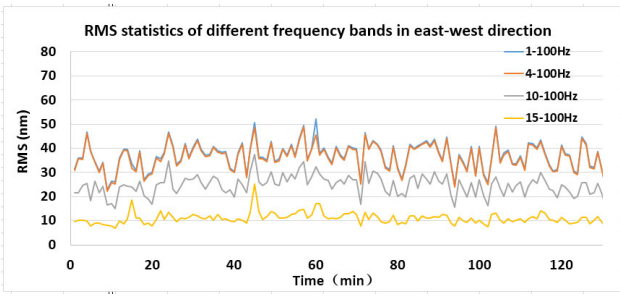

Figure 7: RMS statistics of different frequency bands.

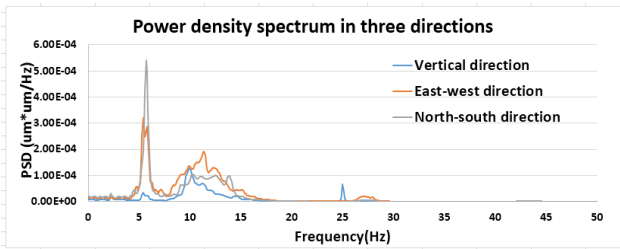

Figure 8: Rower density spectrum in three directions.

Analyze the power density spectrum change of a measuring point for 24 hours, as shown in Fig. 9. The frequency below 15Hz is the main frequency component, and the frequency band with 5Hz highlight has the largest contribution, which runs through the whole day of measurement, indicating that there is still a high traffic flow on the expressway at night. 60Hz frequency is the frequency of industrial machinery, which only appears in the daytime and disappears at night.

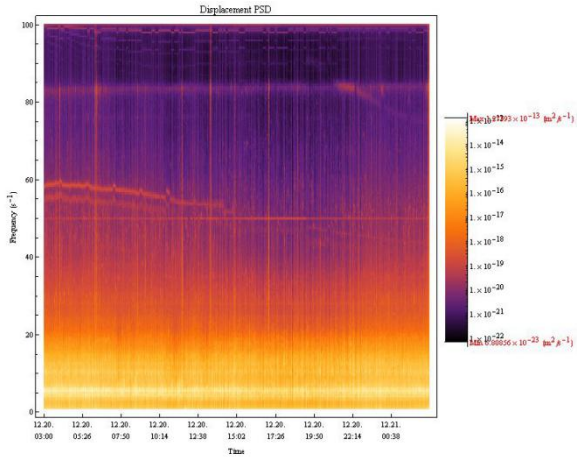

Figure 9: Power Spectral Density in 24-hour.

CONCLUSION

Through the above analysis, we can draw the following conclusions: (1) the foundation of the South light source is located in the mountains and forests, and the RMS is mainly within 30nm, but some areas are affected by the high speed, reaching more than 200nm.(2)The vibration value in horizontal direction is greater than that in vertical direction, and the horizontal vibration isolation measures should be considered in later engineering.(3)The main part of foundation vibration is the low frequency part of 1-15Hz, and the influence of 5Hz expressway is the most obvious. Isolating the influence of Expressway vibration is helpful to reduce the RMS value of the whole area.

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