DYNAMIC PERFORMANCE OF A SUPPORT SYSTEM FOR BBA COMPONENTS IN SXFEL

F. Gao†, Y.X.Dong, R.B. Deng, Y.M.Wen, S. Sun, Z.Q. Jiang, X. Hu, L.Wang,

Shanghai Institute of Applied Physics, CAS, Shanghai, 201204 China

Abstract

The electron beam orbit stability is very important for the Free Electron Laser (FEL) facility. The high beam position stability requirement results in the high position stability for the FEL key components, such as quadruple magnet (Q) and beam position monitor (BPM). This work focus on the research of the dynamic performance of a mechanical support system composed of mechanical supports（including sheets and adjustments）and a granite block mounted on them. It will be applied for the beam based alignment (BBA) Q magnet and BPM for the Soft X-ray FEL project (SXFEL). The Finite-element（FE） calculations of the model characteristics were carried out to guide the subsequent tests. The test results show that the support system can meet the requirement of the SXFEL project.

INTRDUCTION

Shanghai Soft X-ray FEL (SXFEL) and the Dalian Coherent Light Source project (DCLS) are significant national science and technology infrastructure. The electron beam stability is one of the most important factors that influence the properties of FEL. The increasing demands of beam position stability result in the higher position stability requirement for the FEL key parts such as undulator and quadruple magnet. Since the mechanical support system for the FEL provides supporting, location and position adjustment, the high mechanical stability of the supports is indirectly expected.

Soft X-ray Free Electron Laser (FEL) light in the SCSS project developed a new support-stand composed of cordierite body with low thermal expansion rate attached with two flanges at top and bottom used in undulator line [1]. Sand-filled insulated steel support pedestals were used in undulator line of LCLS (Linac Coherent Light Source) [2]. Swiss FEL also developed a new mechanical support with low thermal expansion for BBA [3].

For the DCLS&SXFEL projects, granite blocks with produced from Shandong Province of China have been used as the main component of the support for BBA. In this work, several kinds of mounting method between granite block with mechanical components and Ground were designed and discussed. The first eigenfrequency is an important index for the stability and performance of supports [4].This paper describes an attempt to understand and increase the first eigenfrequency of different kinds of support for BBA to improve its stability, which based on the fact that the ground vibrations at the SXFEL(SSRF site) are larger than at other light sources [5].

This paper presents two different kinds of support prototype for Beam Based Alignment (BBA). Modal hammering experiments and FE analysis of prototypes are discussed in this work. Finally, vibration measurement result about the final support for BBA mounting in the tunnel is shown in this paper.

PROTOTYPES DESIGN

Design of Prototype 1 (See Figure. 1)

- Prototype1 support contains two components of a granite block with a low thermal expansion coefficient and three dimensional adjustments.
- 3 welding bases are fixed on ground with 12 anchor bolts and non-shrinkage cement having high strength.
- 3 direction adjusting can be done by adjustments located on 3 welding bases and M42 Screws.

Design of Prototype 2 (See Figure. 2)

- Prototype2 support contains two components of a granite block with a low thermal expansion coefficient and three layers of steel.
- The bottom steel is fixed on ground with 4 anchor bolts and non-shrinkage cement having high strength.
- 3 direction adjusting can be done by adjusting blocks located on steel and 4 M16 jack screws.

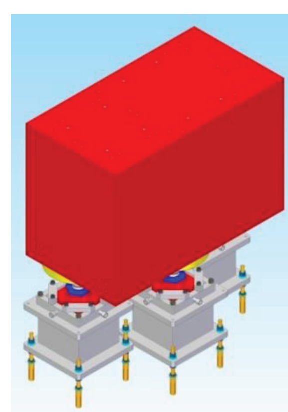

Figure 1: 3-D modal of prototype1.

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† gaofei@sinap.ac.cn

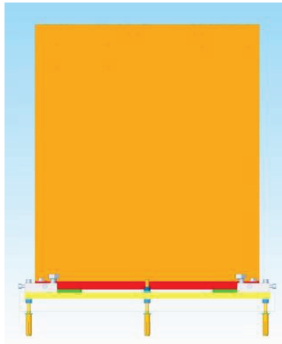

Figure 2: 3-D modal of prototype2.

FE ANALYSIS&MODAL HAMMERING MEASUREMENT OF PROTOTYPES

Table 1: First Eigenfrequency (Hz) of Two Prototypes

Type	Prototype1	Prototype2
FE analysis	29.12	90.32
Modal measurement	28.74	94.28

FE Analysis and Modal Analysis

In order to investigate the dynamic performance and improve the initial mechanical design, FE analysis (ANSYS Workbench14.0) and dynamic measurements (Device:DH5927N Data Collector system，Donghua Testing Technology. Co.,LTD and PCB333B30Acceleration sensors) have been performed on two prototypes.

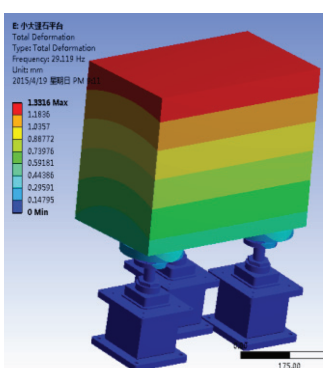

Figure 3: FE analysis of prototype1.

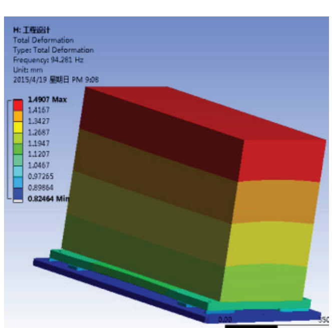

Figure 4: FE analysis of prototype2.

From the results shown in Table 1 we can see that it is very close between FE calculation and modal measurement. Figure3-6 show that the first modal shape of two prototypes is consistent in lateral direction. However, the first eigenfrequency of prototype 2 is much higher than prototype1. Base on the above FE and modal analysis, the structure of prototype2 and connection between a granite block and ground is proposed to improve the first eigenfrequency of the support for BBA.

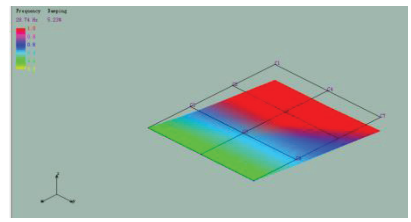

Figure 5: First modal shape of prototype1.

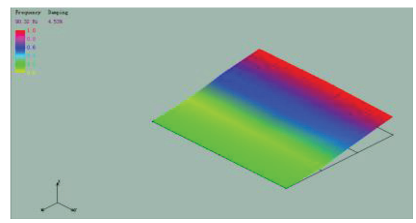

Figure 6: First modal shape of prototype2.

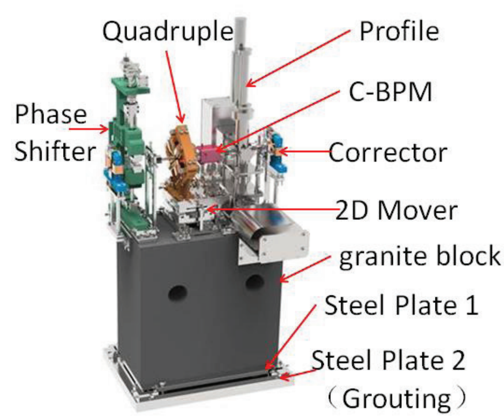

Figure 7: Support system for BBA.

VIBRATION MEASUREMENT OF FINAL SUPPORT INSTALLED IN DCLS

Vibration Measurement

Four measurement points (Top of Q, mover, granite block and ground) were located at the support system (See Figure 7 and 8). The total data taking time in tunnel is approximately 12 hours (quiet time) at night.

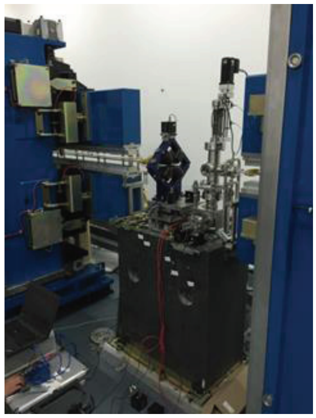

Figure 8: Vibration measurement in DCLS tunnel.

Table 2: Results in Vibration Measurement

	rms(nm)	Ratio(*/ground)
Ground	10.1	1.0
Granite	12.1	1.2
Mover	12.4	1.23
Quadrupole	14.3	1.43

Vibration Analysis

The result of power spectral densities and integrated RMS displacement (*f*: 4-100Hz band) are shown in Figure.9 and Figure.10. The rms average ratio of Quadrupole/ground, Granite/ground and Mover/ground can be seen in table 2. Based on the vibration results, we can see that the most of important average ratio of Quadrupole/ground is 1.43，which is low and can meet the requirement of the SXFEL and DCLS .

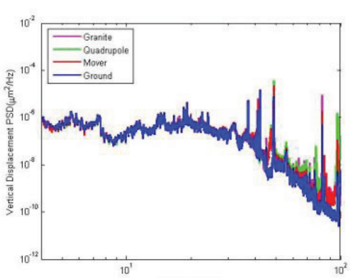

Figure 9: Displacement PSD spectra (vertical direction).

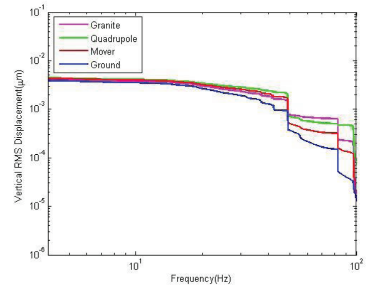

Figure10: RMS Displacement spectra (vertical direction).

CONCLUSIONS

In this paper the dynamic performance of the support for BBA has been studied by FE analysis and modal measurement. Both FE calculations and modal measurement have been performed on two prototypes. The comparison of vibration measurement of support for BBA in DCLS has been also performed. Based on the analysis by FE and modal measurement，the prototype2 is chosen as the final support in DCLS and SXFEL because of its higher first eigenfrequency. In additional, the vibration ratio of Quadrupole/Ground measured in tunnel of DCLS is small，which can meet the requirement of SXFEL and DCLS projects.

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