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# HAMMERHEAD SUPPORT DESIGN AND APPLICATION AT SSRF*

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*Abstract*

Electron beam stability is very important for Shanghai Synchrotron Radiation Facility (SSRF). One of the major players on beam stability is the vibration stability of magnet support systems. This paper describes several kinds of hammerhead magnet support prototypes with different structures, materials and ground fixation. Modal and response analyses of these prototypes are contrasted by finite-element analysis (FEA) and tests. The design can be applied to guide and improve the mechanical structures and the stability of magnet support systems at SSRF and other light source facilities.

## INTRODUCTION

The Shanghai Synchrotron Radiation Facility (SSRF) is a third-generation light source, which requires high electron beam stability [1-2]. The electron beam stability is one of the most import elements that influence the properties of light sources. SSRF locates near the Huangpu River which flows to the east sea from west to east of Shanghai, which makes the soil soft. What makes things worse is the heavy traffic day and night and the nearby magnetic levitation. So the fact is that the ground vibrations at SSRF are larger than at other light sources due to altogether these factors [3].

The important demands of electron beam stability result in the high mechanical stability requirement for the light sources key parts such as quadruple magnets. Since the mechanical support system for the magnets provides supporting, location and position adjustment, the high mechanical stability of the support is indirectly expected. The first eigenfrequency is an important index for the stability and performance of girders, based on the condition of SSRF, which motivates us to take measures to improve the stability of mechanical support system for magnets.

Marble bases produced from Shandong Province of China have been used as the main component of the support for quadruple in Shanghai Soft X-ray FEL (SXFEL) infrastructure [4]. S. Sharma proposed a girder-free support system. The system took account of several main aspects such as mechanical stability and thermal stability [5]. Based on these references, we developed several kinds of girder prototype for magnets at SSRF.

This paper describes an attempt to understand and increase the first eigenfrequency of different kinds of hammerhead support with different structures, materials and ground fixation to improve the stability. Modal hammering experiments and the Finite-element (FE) analysis of prototypes were carried out at SSRF. The results are discussed in this paper.

## STRUCTURE OF PROTOTYPES DESIGN

Figure 1 shows the mechanical structure of hammerhead support design for magnets. Figure 2 shows the size of one support. Two hammerhead supports are connected with two C-channel beams. The beams bolted to hammerhead supports are 2.9m in length and 0.4m in height, welded by steel plates. Magnets are assembled accurately on the top of supports with required good alignment techniques. Eight wheels fixed on both sides of the hammerhead supports can make the heavy support system move easier in the tunnel in the future. One prototype is about 2m long, with two quadrupoles and two sextupoles. Different materials and fixation methods between supports and floor are used for the design of prototypes.

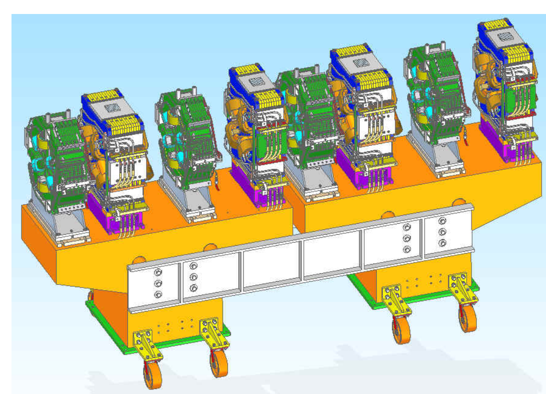

Figure 1: Structure of the hammerhead support system.

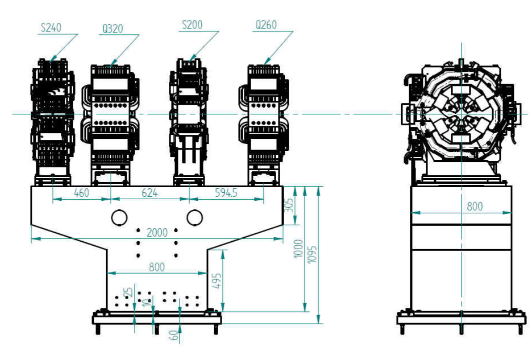


Figure 2: Size of the hammerhead support.

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### *Design of Prototypes*

Figure 3 shows the prototypes was designed to have two main parts, steel blocks instead of magnets are assembled on the top of supports, which are similar with real condition in the tunnel in the future. We proposed two types of hammerhead support.

- Prototype1 support contains two components of a marble block with a low thermal expansion coefficient and three layers of steel plates (see Fig. 4a). The bottom steel plate called grouting plate is fixed on ground with 4 tightening bolts and non-shrinkage cement having high strength. The four shims located on the four corners between grouting plate and marble fixed plate. 3 directions adjusting can be done by adjusting shims located on steel and 4 M16 jack screws.
- Prototype2 is similar to prototype1, Prototype2 support also contains two components of a steel welded box and two layers. Shims are sandwiched between the bottom of box and upper surface of grouting plate (see Fig. 4b). Compared with prototype 1, the prototype2 has no such a layer like marble fixed plate.

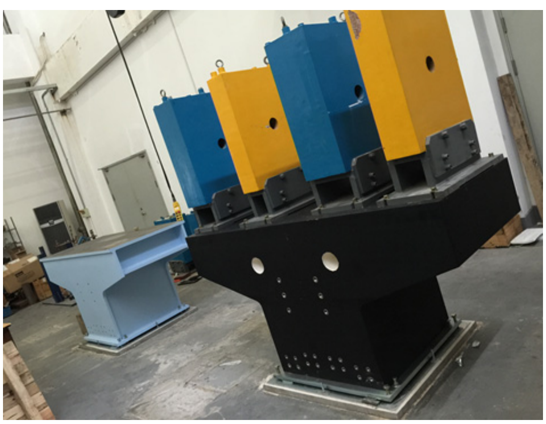

Figure 3: Hammerhead support Prototypes (Left: Steel base support; Right: Marble base support).

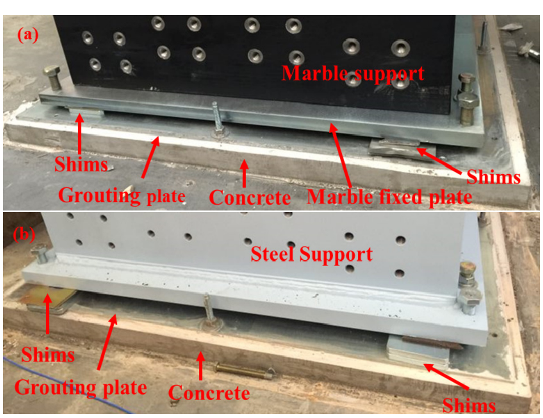


Figure 4: Fixation of Hammerhead support Prototypes on the floor (a: Marble base; b: Steel base).

## FE ANALYSIS & MODAL HAMMERING MEASUREMENT OF PROTOTYPES

Table 1: First Eigenfrequency (Hz) (Transverse) of Two Prototypes

| | Steel FE/Measurement | Marble FE/Measurement |
|---|---|---|
| With shims, and grouting plate and magnets assembled | 63.5 Hz / 20.5 Hz | 75.43 Hz / 18.75 Hz |
| Without shims and magnets | — / 56.15 Hz | — /66.25 Hz |

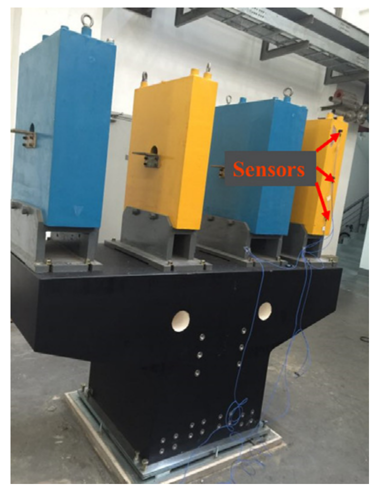


Figure 5: Modal measurement by acceleration sensors.

### *FE Analysis and Modal Analysis & Measurement*

This section aims to investigate the dynamic performance of prototypes with different structure, materials and connections with floor and improve the mechanical design from a mechanical point of view. FE analysis (ANSYS Workbench14.0) and dynamic measurements (Device: DH5902N Data Collector system， Donghua Testing Technology. Co.,LTD and PCB333B30 Acceleration sensors) have been performed on prototypes . In the modal analysis, different connections between the bases and the floor are considered. In the modal measurement (see Fig. 5), 3 accelerometers are adhered evenly to the side of bases of two prototypes. Table 1 shows the results of FE and modal measurement. It is obvious to see the measured values are lower than FE calculations (see Fig. 6) both in marble support and steel support. This big difference can be explained by the different boundary condition in the FE modals. The results suggest that the layers between support and ground make the support system more weakness than the simulated fixed restriction in FE models.

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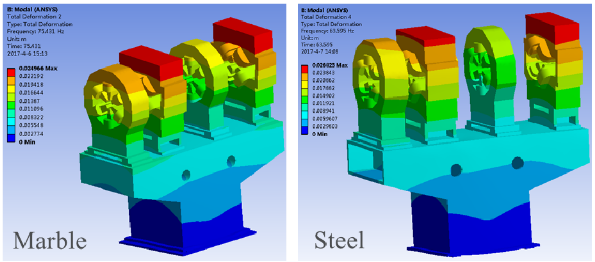


Figure 6: Hammerhead support Prototypes (1st modal in transverse -Mable: 75.35 Hz; Steel: 63.5 Hz).

Table 2: First Eigenfrequency (Hz) (Transverse) of Two Prototypes

| | Steel Measurement | Marble Measurement |
|---|---|---|
| Full grouted without magnets | 69.33Hz | 48.75Hz |
| Full grouted with magnets | 24.1Hz | 23.2Hz |

The results also suggest the first eigenfrequency of marble support is a little higher than steel support. To further understand the influence of the connection layers, the bases with magnet assembled or not were grouted directly by concrete (see Fig. 7) on the floor without any shims and grouting plates. In addition, there was still a marble fixed plate located between the marble base and the floor, because the holes on the marble fixed plate was needed for marble base installation. Then, we did the previous modal measurement again. Table 2 shows the results of the two bases. Figure 8 shows the first modal shape of two prototypes with full grouted in transverse direction. Base on the above FE and modal analysis, the full grouted connection between bases and floor is proposed to improve the first eigenfrequency of the prototypes. The first eigenfrequency of steel base is higher than that of marble base, which can be explained there was still a marble fixed plate between marble base and grouted concrete, the bolted connection makes the lower eigenfrequency.


Figure 7: Prototypes with full grouted bottom surface.

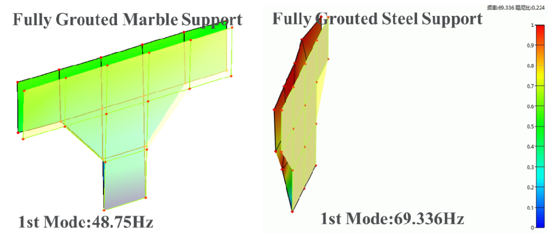


Figure 8: First modal shape of prototypes without magnet assembled.

## CONCLUSION

In this paper the dynamic performance of hammerhead magnet support prototypes has been studied by FE analysis and modal measurement. Both FE calculations and modal measurement have been performed on two prototypes. The comparison of different connections between bases and floor has been also performed. Based on the result of FE analysis and modal measurement, the connection of full grouted is better than the case of bases with shims because of its higher first eigenfrequency, but the bases without shims were more difficult to installation and adjustment. In addition, the marble base of shims and magnets assembled has better performance than steel base in first eigenfrequency aspect. In FE calculations, maybe the fixed boundary applied at the bottom of bases prevents bending of plates and hides the weakness of tightening bolts. The boundary condition in the FE modals should be considered again in order to reflect the real connection between bases and floor. Further research about connection will be carried out to find a better way to design and installation of supports.

## ACKNOWLEDGEMENTS

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## REFERENCES

[1] X. Wang *et al.*, "Mechanical stability of the magnet girder assembly at the SSRF", *J. Synchrotron Rad.*, vol.15-4, Jul. 2008, pp. 385-391, doi:10.1107/S090904950800650X.

[2] X. Wang *et al.*, "Dynamic performance of the beam position monitor support at the SSRF", *J. Synchrotron Rad.*, vol. 16-1, Jan. 2009, pp. 1-7, doi:10.1107/S0909049508028872.

[3] L. Ouyang *et al.*, "The SSRF Ground vibration measurements and the beam COD calculations", presented at MEDSI18, this conference, to be published.

[4] F. Gao *et al.*, "Dynamic performance of a support system for BBA components in SXFEL", in *Proc. MEDSI 2016*, Barcelona, Spain, June 2017, paper MOPE31, DOI: 10.18429/JACoW-MEDSI2016-MOPE31.

[5] S. Sharma, "A girder-free magnet support system design", in *Proc. MEDSI 2016*, Barcelona, Spain, June 2017, paper TUPE32, DOI:10.18429/JACoW-MEDSI2016-TUPE32