BRINGING THE GROUND UP

When is two less than one?

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ABSTRACT

The Advanced Photon Source Upgrade (APSU) project has employed the use of high-heat-load dual-mirror systems in the new feature beamlines being built. Due to the shallow operating angles of the mirrors at a particular beamline, XPCS, the two mirrors needed to be approximately 2.5 m apart to create a distinct offset. Two separate mirror tanks are used for this system. However, it is unclear if the vibrational performance of these tanks would be better if they were both mounted on one large plinth or each mounted on a small plinth. Using accelerometers at the installation location, the floor vibrations were measured. The resulting frequency response function was then imported into a finite element analysis software to generate a harmonic response analysis. The two different plinth schemes were modeled, and the floor vibration was introduced as an excitation to the analysis. The relative pitch angle (θ_Y) between the mirrors was evaluated as well as the relative gap between the mirrors (X_{MAG}). Results showed that a single plinth reduces the relative X_{MAG} (RMS) compared to two plinths by approximately 25%. However, the relative θ_Y (RMS), which is arguably more critical, is significantly lower by approximately 99.7% in two plinths when compared to a single plinth. Therefore, it is more effective to use two separate plinths over a longer distance as opposed to a single longer granite plinth.

MOTIVATION

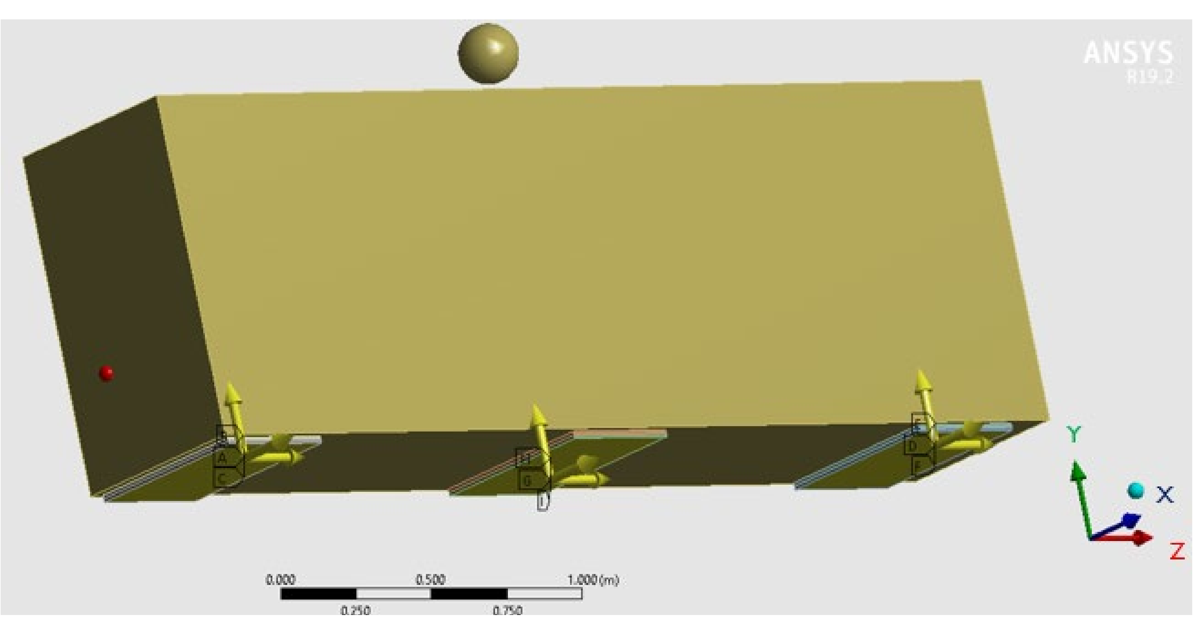
Floor and support vibrations can introduce unwanted motion in a beamline. Optics, such as mirrors, are especially sensitive to these vibrations as they operate at small angles and small variations in the angle can propagate into large errors over several meters. In the case of the XPCS beamline, the high-heat-load dual-mirror system operates at a shallow angle and are separated by 2.5 m along the beam direction. The question arose whether having the mirror tanks on one large granite plinth as a base would be better to minimize vibrations or would it be better to use two smaller granite plinths, one for each mirror tank.

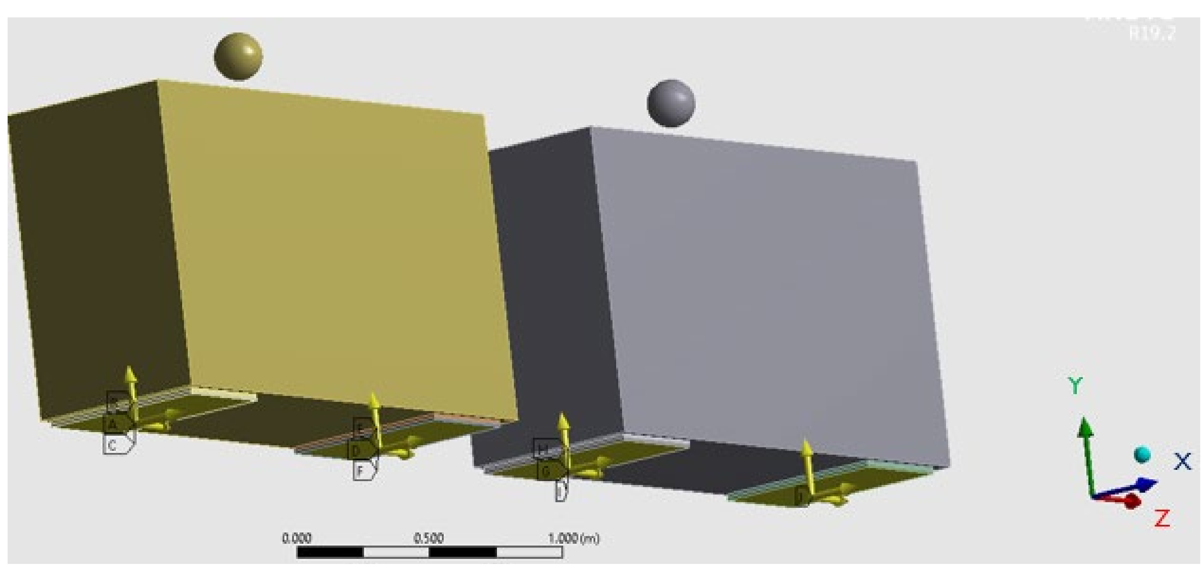
METHODS

- Two sets of tri-axial accelerometers are placed on the floor to measure floor vibrations over 200 Hz bandwidth
- Accelerometers can measure floor vibrations parallel to the beam direction as well as two orthogonal directions.

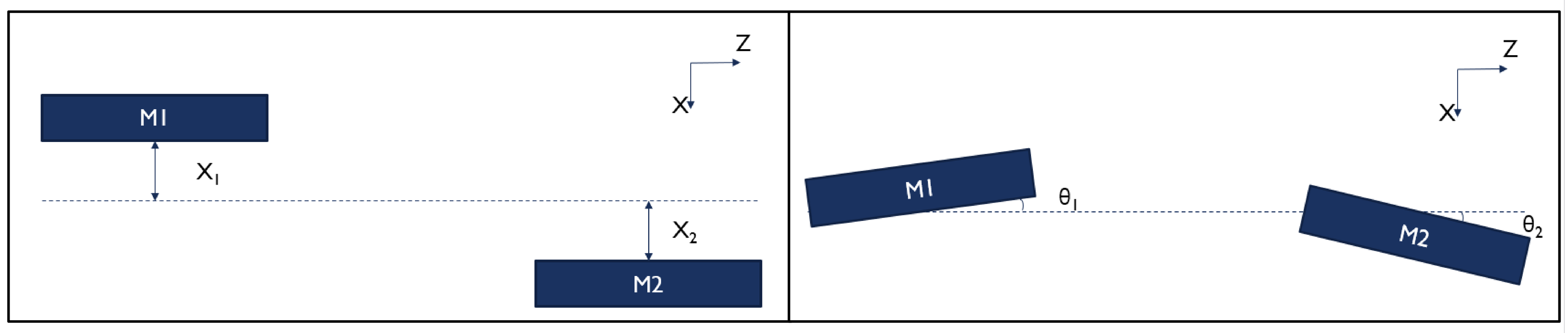
FINITE ELEMENT ANALYSIS

- Once the measurements were taken, two finite element analysis studies were generated using ANSYS to measure the effects of the floor vibrations on the two parameters. The first study used the case of a single large granite plinth while the second used two smaller granite plinths.





- Floor vibrations were applied to the plinths through grouted plates modelled at either end of the granite. The displacements of the mirror centers along the X direction are extracted along with their respective rotations about Y. From these values, relative X_{MAG} and θ_Y can be calculated



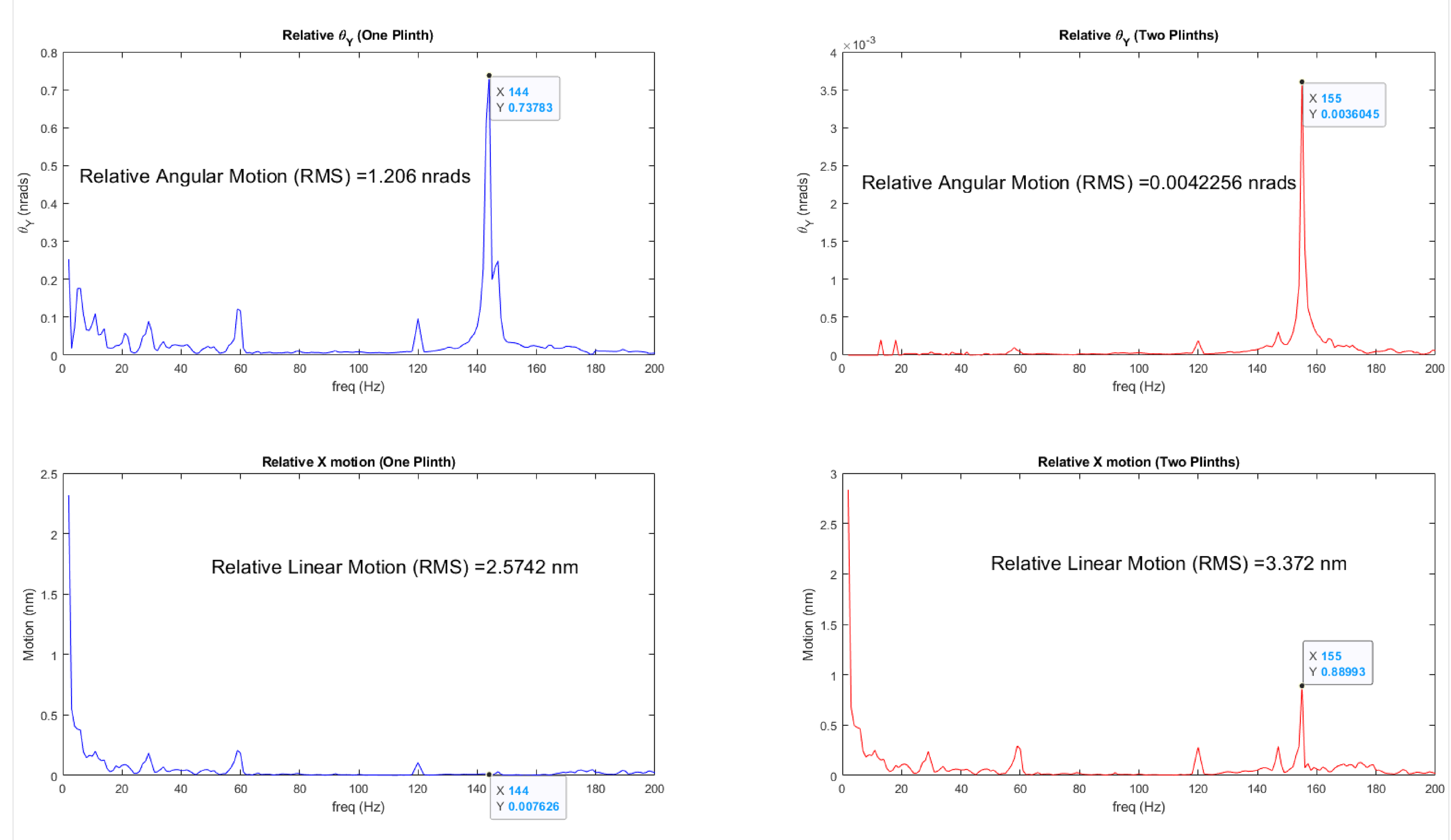
$$X_{MAG} = X_1 - X_2 \qquad \theta_Y = \theta_1 - \theta_2$$

RESULTS

- ANSYS data was processed in a custom MATLAB script to calculate the X_{MAG} and θ_Y RMS values over the bandwidth. The results show a 25% reduction in X_{MAG} for the single plinth case as opposed to two plinths. However, the θ_Y is three orders of magnitude less in the two plinths case compared to the single plinth.

Summary of Relative Stability

Study	θ_Y (RMS)	X_{MAG} (RMS)
One Plinth	1.2 nrad	2.6 nm
Two Plinths	0.0042 nrad	3.4 nm



CONCLUSIONS

- The θ_Y parameter is more critical as it can affect the energy ranges of the beam along with the beam displacement. Therefore, the two plinths solution gives a drastic improvement over the single plinth case.
- Additionally, using two smaller plinths provides more ease in installation especially when maneuvering into tight enclosures.

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