A Study into the Long-term Stability of Front End X-ray Beam Position Monitor Support Columns at Diamond Light Source

C. Houghton, C. Bloomer, L. Bobb, D. Crivelli, H. Patel and J. Melton, Diamond Light Source, Oxfordshire, UK

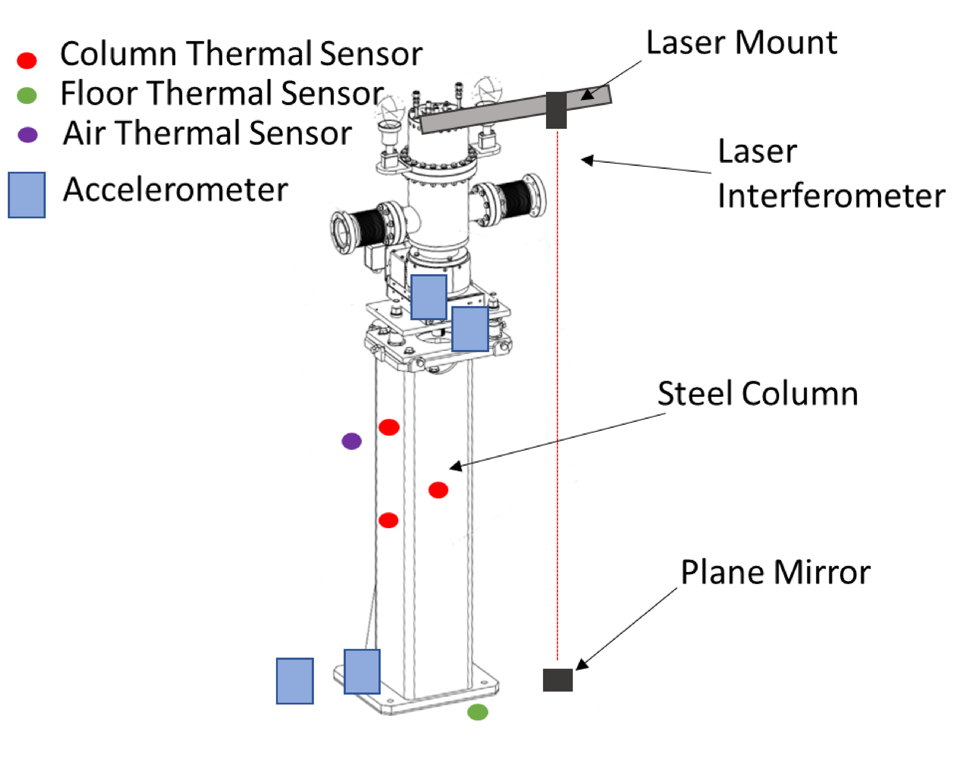
ABSTRACT

Sand-filled steel columns are used at Diamond Light Source to support front-end X-ray beam position monitors. This approach is chosen due to the relatively large thermal mass of the sand being considered useful to reduce the rate at which expansion and contraction of the column occurred as the storage ring tunnel temperature varied, particularly during machine start-up. With the higher requirements for mechanical stability for the upcoming Diamond-II upgrade, there is now a need to assess and quantify the current system's impact on X-ray beam movement. A study of thermal and mechanical stability has been carried out to quantify the stability performance of the front end X-ray beam position monitor's columns and the impact that column motion may have on the X-ray beam position measurement. Measurements have been made over a range of different timescales, from 250Hz up to 2 weeks. The measured stability of the support column is presented, showing that it meets our Diamond-II stability requirements. A comparison of the stability of the column with and without a sand filling is presented.

Measurement systems/devices used:

- Laser interferometry system (in grey), laser source mounted to the top of the X-ray Beam Position Monitor (XBPM) vessel.
- Four piezoelectric accelerometers (blue squares) placed on the floor, column base, column top and XBPM mounting plate.
- Seven thermal sensors (circles); red for column thermal sensors, purple for air thermal sensors and green for a sensor bolted to the floor.

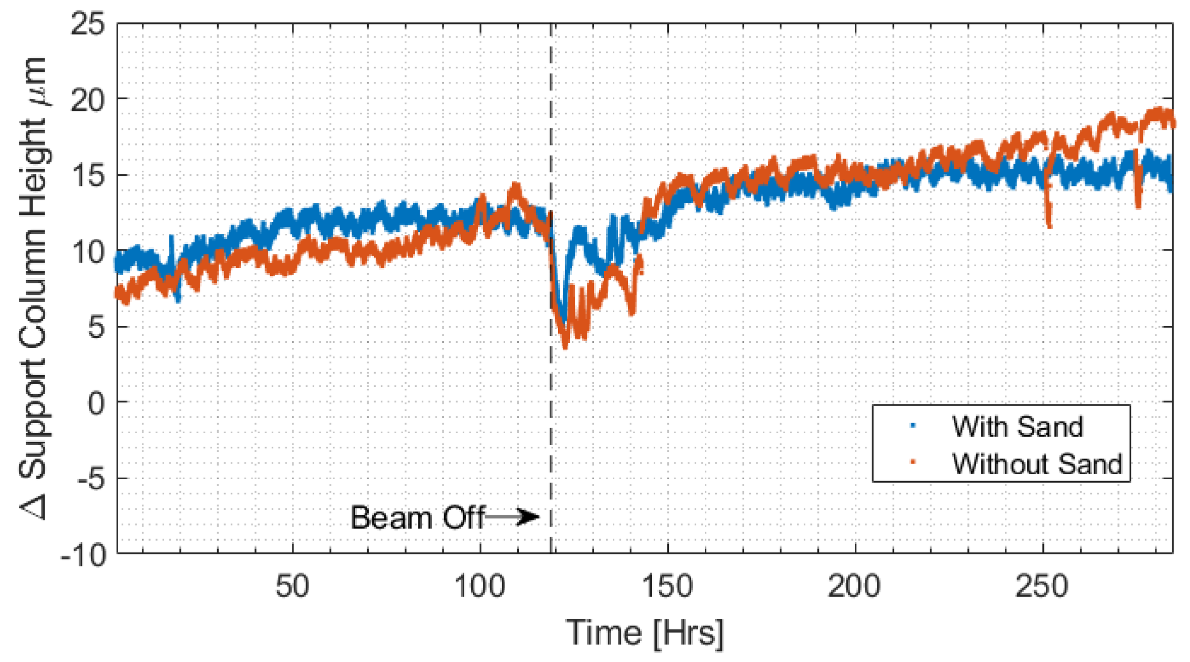
The steel column's height was tracked for weeks with and without sand, accounting for environmental factors like air temperature, pressure, and humidity.



A drawing of the XBPM and its support column, with the locations of the different devices.

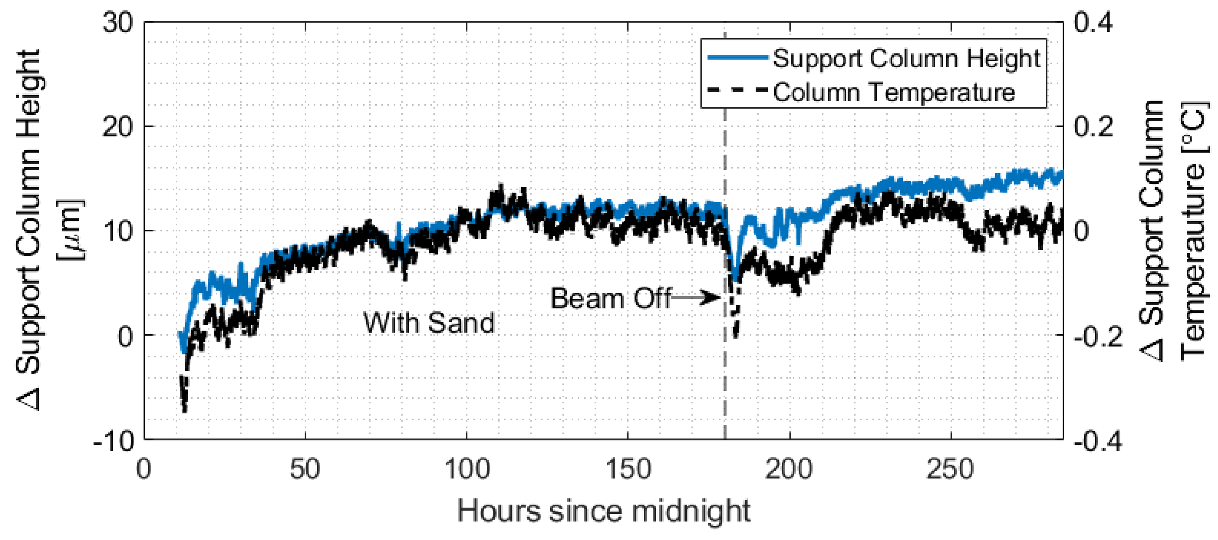
Long-Term Stability

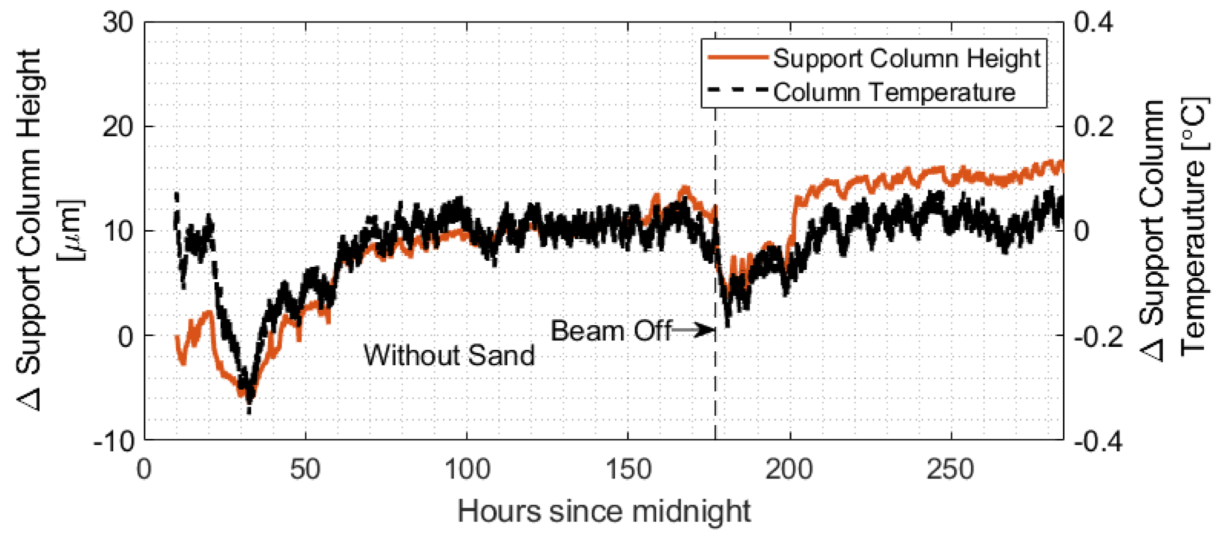
During a typical week, the electron beam is turned off to allow for machine development, during this time the machine cools, this can be seen clearly on the height change of the steel column.



The change in the support column height measured with and without sand filling the column

- Minimal difference between the steel column with and without sand
- Variation in column height with sand ~6.5μm
- Variation in column height without sand ~8.4μm
- Over 11 days empty column sees a variation of column height of 10μm

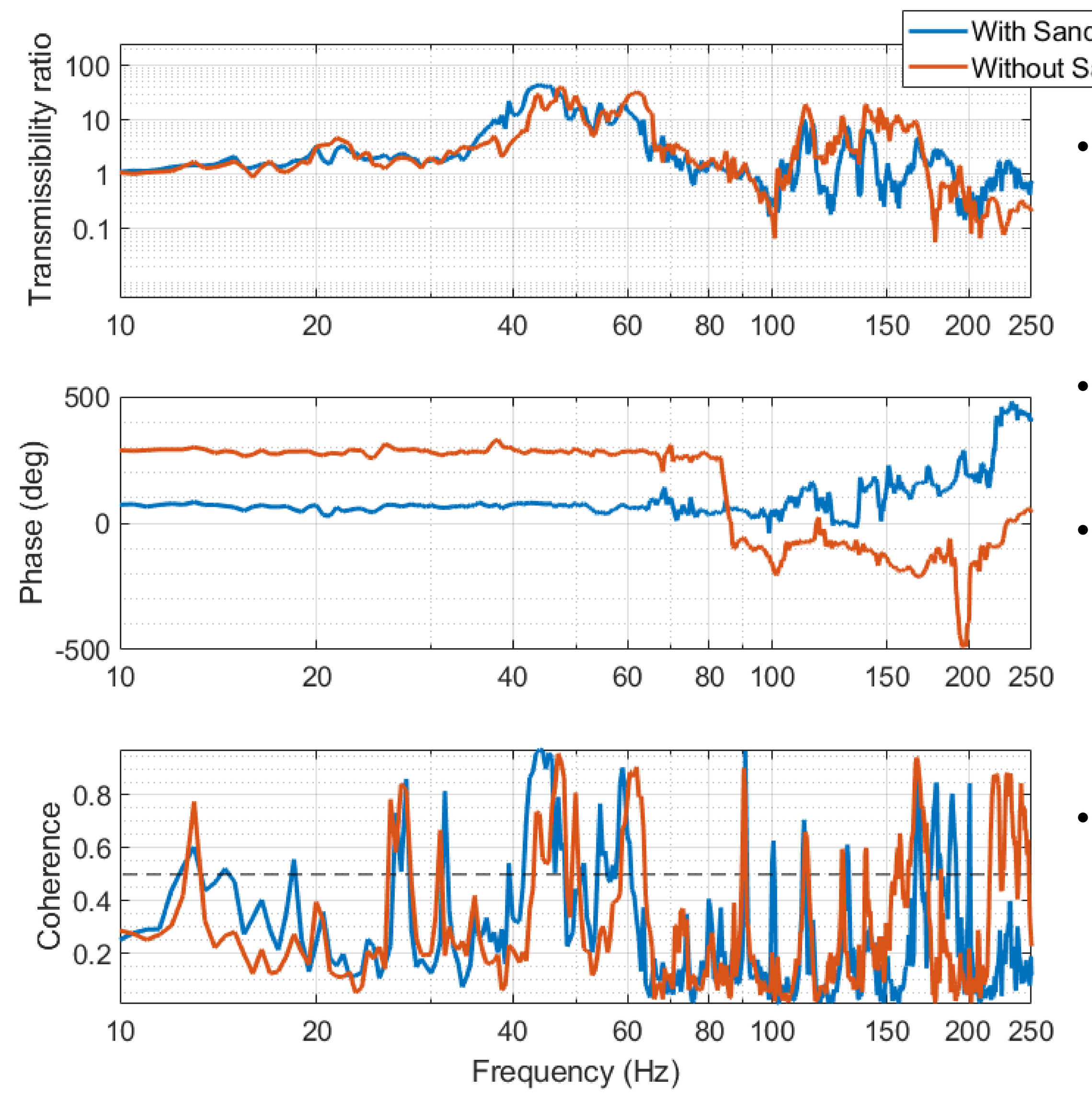




The change in the support column height and the average column temperature measured with (top) and without (bottom) sand filling the column

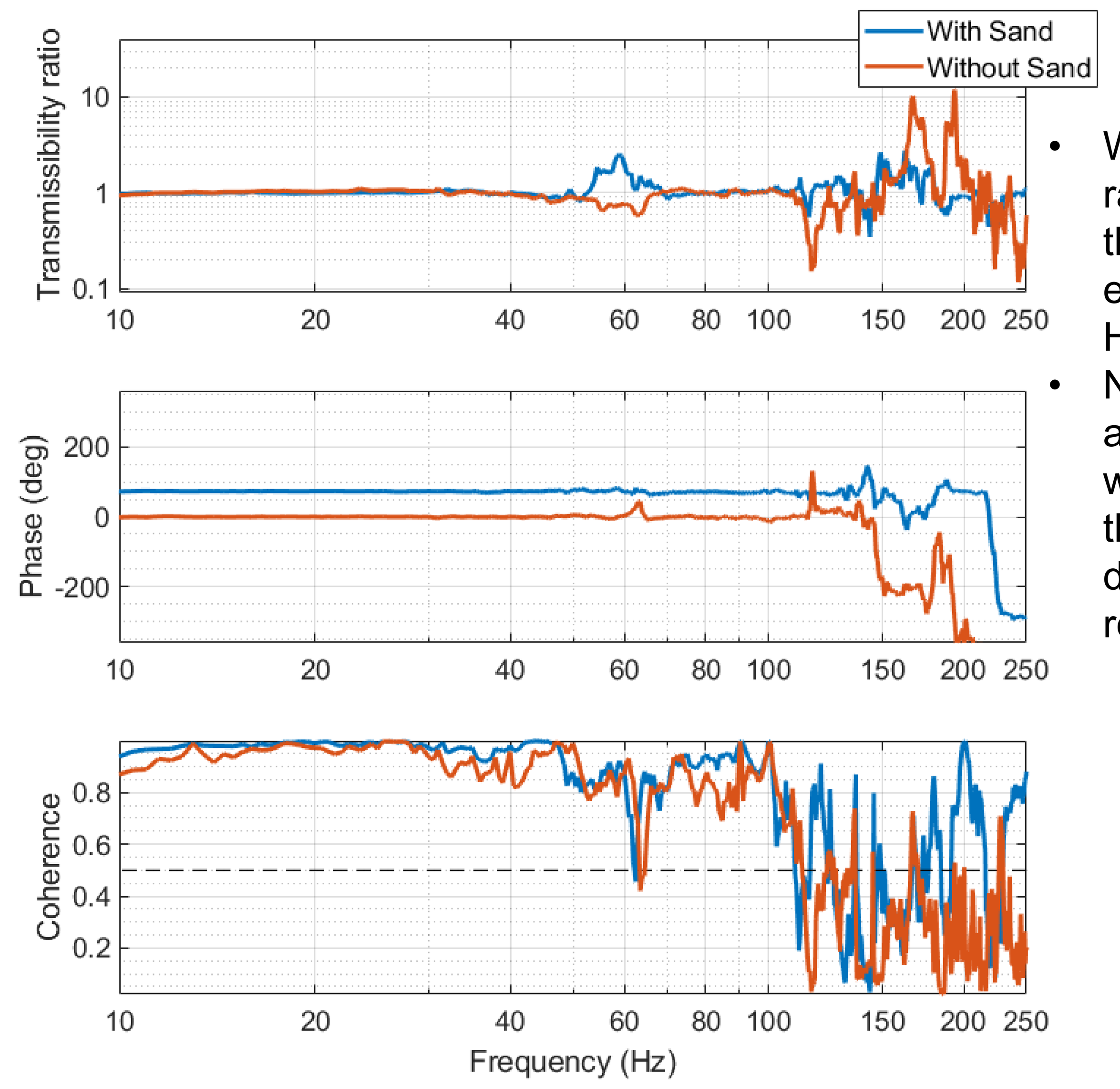
- Clear correlation between support column height and average column temperature.
- User beam returned to the machine at ≈ 200 Hrs.
- The column temperature takes 5 hours to return to the level before the beam dump when it is filled with sand.

Short-Term Stability



- Horizontal transmissibility ratio similar both with and without sand up to ~120 Hz.
- Amplification of motion above 30 Hz in both datasets.
- Fewer damping troughs without sand 140 Hz and 166 Hz suggesting larger amplification. at these frequencies
- Vibration of the bottom of the column and top of the XBPM mounting plate go out of phase at 84 Hz, indicating a resonance of the system.

The horizontal transmissibility ratio of the XBPM support column bottom plate to the XBPM mounting plate



- With sand transmissibility ratio is close to one across the frequency range, except for a peak at 50 Hz-70 Hz
- New relatively large peaks at 167 Hz and 193 Hz without sand, suggesting that the sand works to dampen these resonances.

The vertical transmissibility ratio of the XBPM support column bottom plate to the XBPM mounting plate

CONCLUSION

The mechanical stability of an XBPM support column has been assessed and results show that sand-filled steel columns effectively maintain the required thermal and mechanical stability for supporting front-end X-ray beam position monitors at Diamond Light Source. Through laser interferometer and accelerometer measurements, both short-term and long-term stability were examined, highlighting the negligible impact of sand on high-frequency mechanical stability and its beneficial role in reducing vertical column variations over extended periods. These findings verify the columns' suitability for the upcoming Diamond-II upgrade, ensuring accurate and reliable X-ray beam position measurements. The current sand-filled steel columns are sufficiently stable to meet the Diamond-II requirements and will remain during the upgrade.

diamond

For more information, please contact Claire Houghton at claire.houghton@diamond.ac.uk