Vibration Studies of the ALBA Prototype Girder

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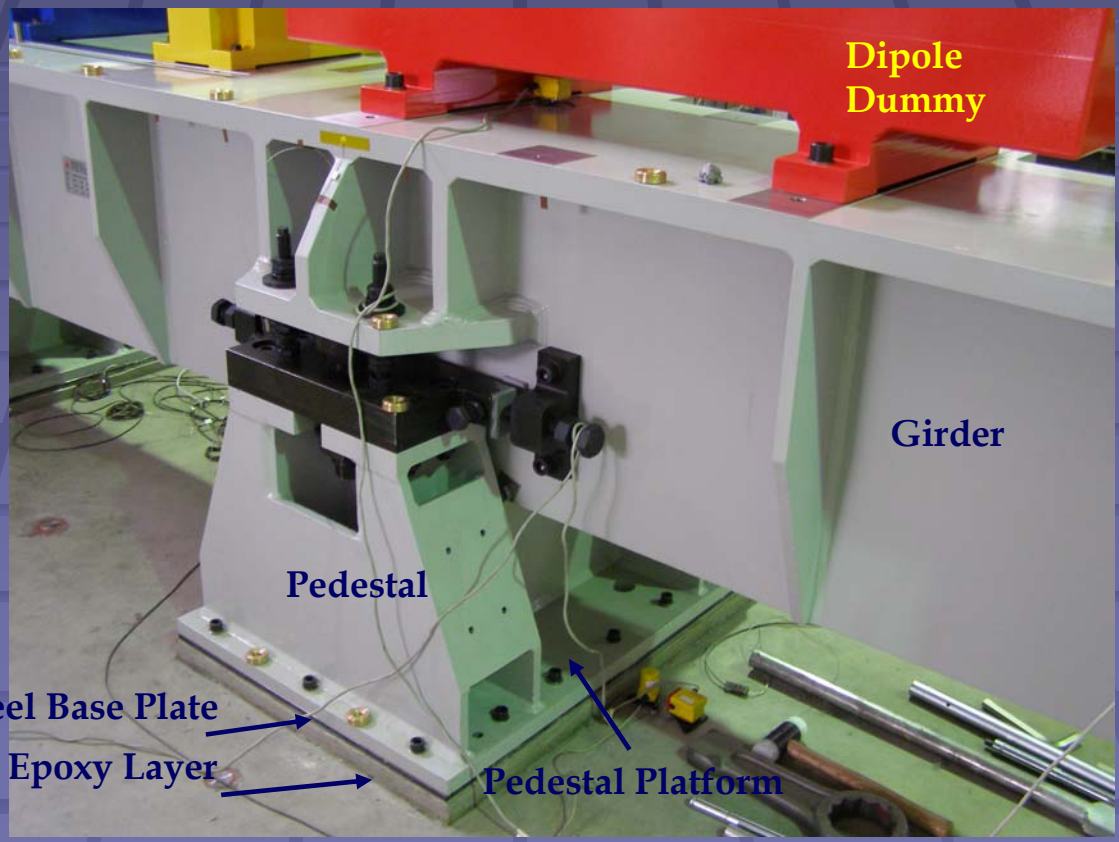


Measurements

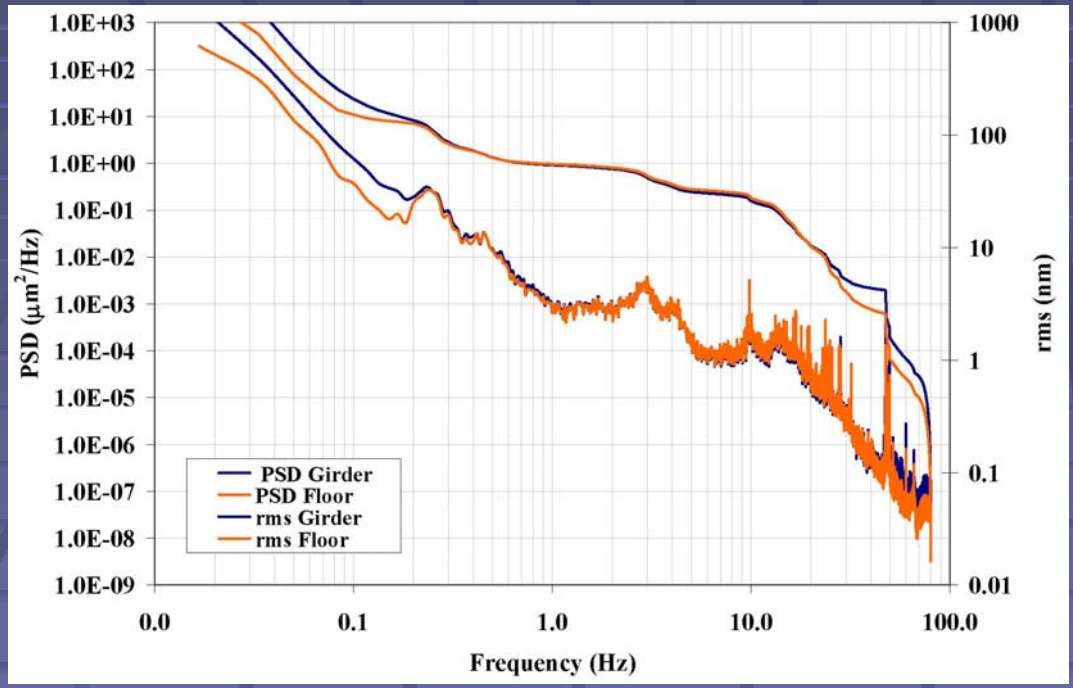
- Two triaxial seismometers (Güralp, CMG-6TD, frequency range: 60s -80 Hz) one placed on the surface of the girder, the other on the floor.
- Four single axis (two vertical and two horizontal) geophones (SENSOR SM-6), placed:

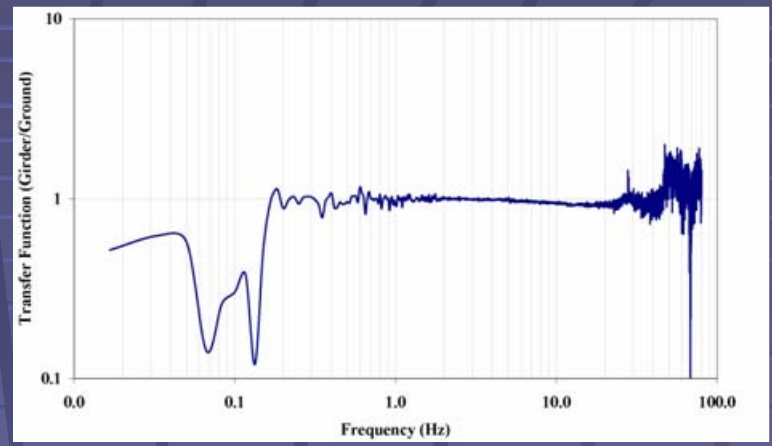
1) On the pedestal platform and the surface of the girder & on the floor and the pedestal platform to evaluate the transfer function of the girder structure.
2) On the surface of the girder and the magnet dummies to evaluate the transfer function between the girder and the magnet dummies.
3) On the left and right most corners of the girder surface to look for any twist modes predicted by FEA (ANSYS).

Data Analysis & Definitions

$x(t), y(t)$	time series of length T, N points each
$X(\nu_i), Y(\nu_i)$	FFT
$\langle XX^* \rangle, \langle YY^* \rangle$	Estimated displacement power spectral density (PSD)
$\frac{\lvert\langle XY^* \rangle\rvert^2}{\langle XX^* \rangle \langle YY^* \rangle}$	Coherence
$\sqrt{\frac{\lvert\langle XY^* \rangle\rvert}{\langle XX^* \rangle}}$	Transfer function amplitude
$\sqrt{\frac{1}{T}\sum_{i=k}^{N/2} \langle XX^* \rangle(\nu_i)}$	Integrated RMS amplitude at frequency ν_k

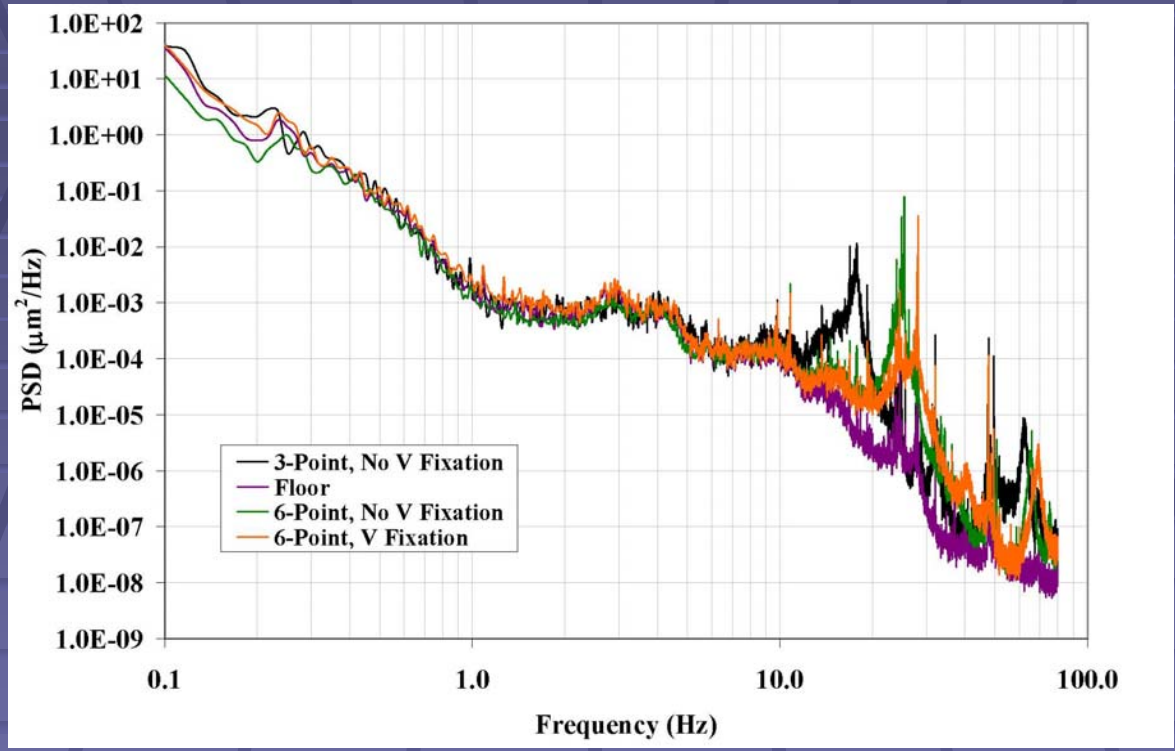
6-Point Support (Vertical)





Average displacement PSD and integrated PSD of the vertical vibration measured on the girder surface versus the ground. Transfer function (shown on the right) is ~1 up to 40 Hz at least. The girder design is rigid in the vertical direction.

Displacement PSD of 6-Point vs. 3-Point Girder Support (Horizontal Transverse)

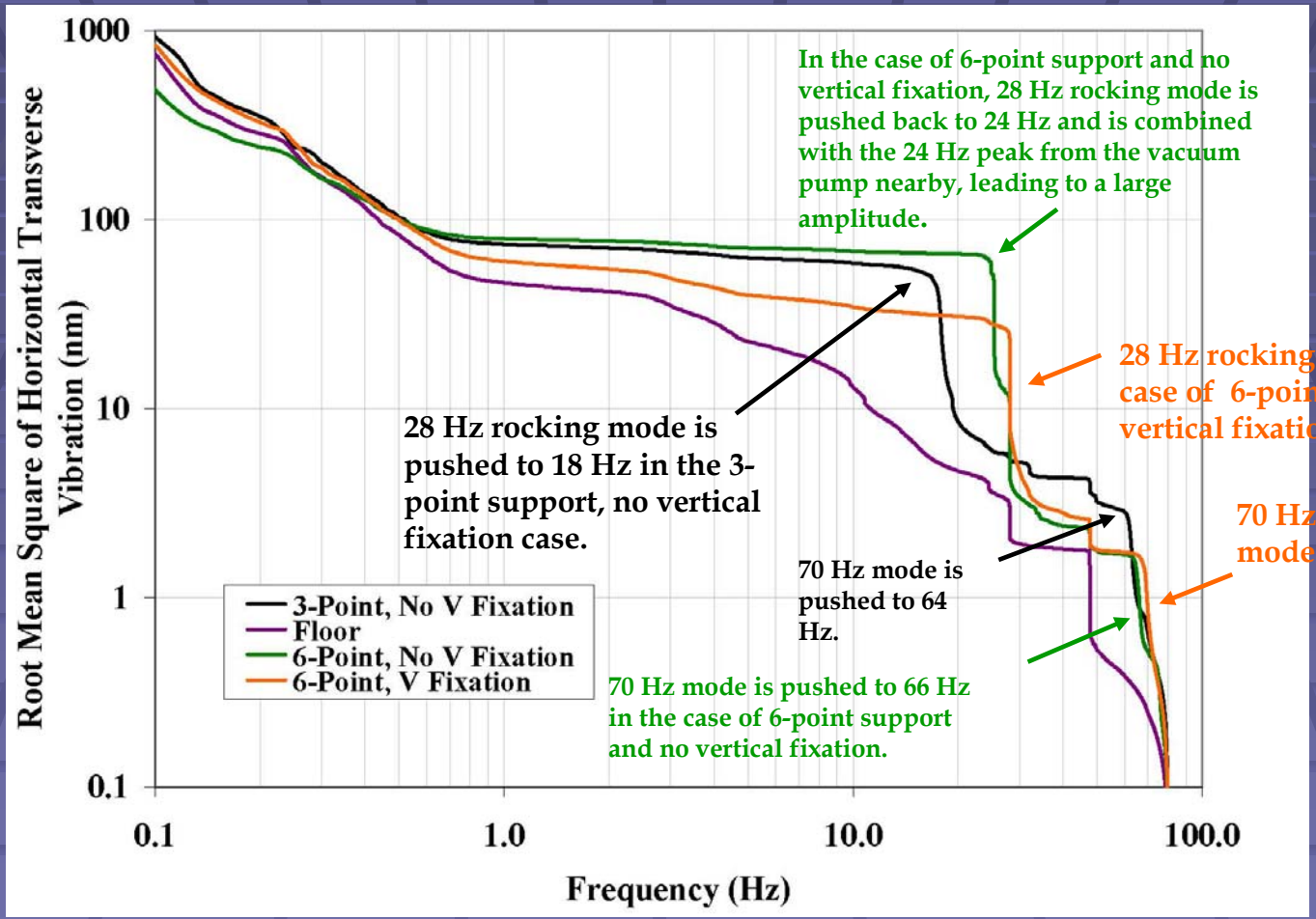


Baseline design, 6-point support & vertical fixation (shown in orange): 28 Hz rocking due to the girder/ground interface; 70 Hz is first eigen mode of the girder; 24 Hz is due to a vacuum pump nearby and is unrelated to the girder structure.

6-point support & no vertical fixation (shown in green): high amplitude @28 Hz as the 28 Hz peak is pushed backwards to 24 Hz and is combined with the 24 Hz peak due to the vacuum pump; 70 Hz is pushed to 66 Hz.

3-point support and no vertical fixation (shown in black): 28 Hz peak is pushed backwards to 18 Hz; 70 Hz is pushed to 64 Hz.

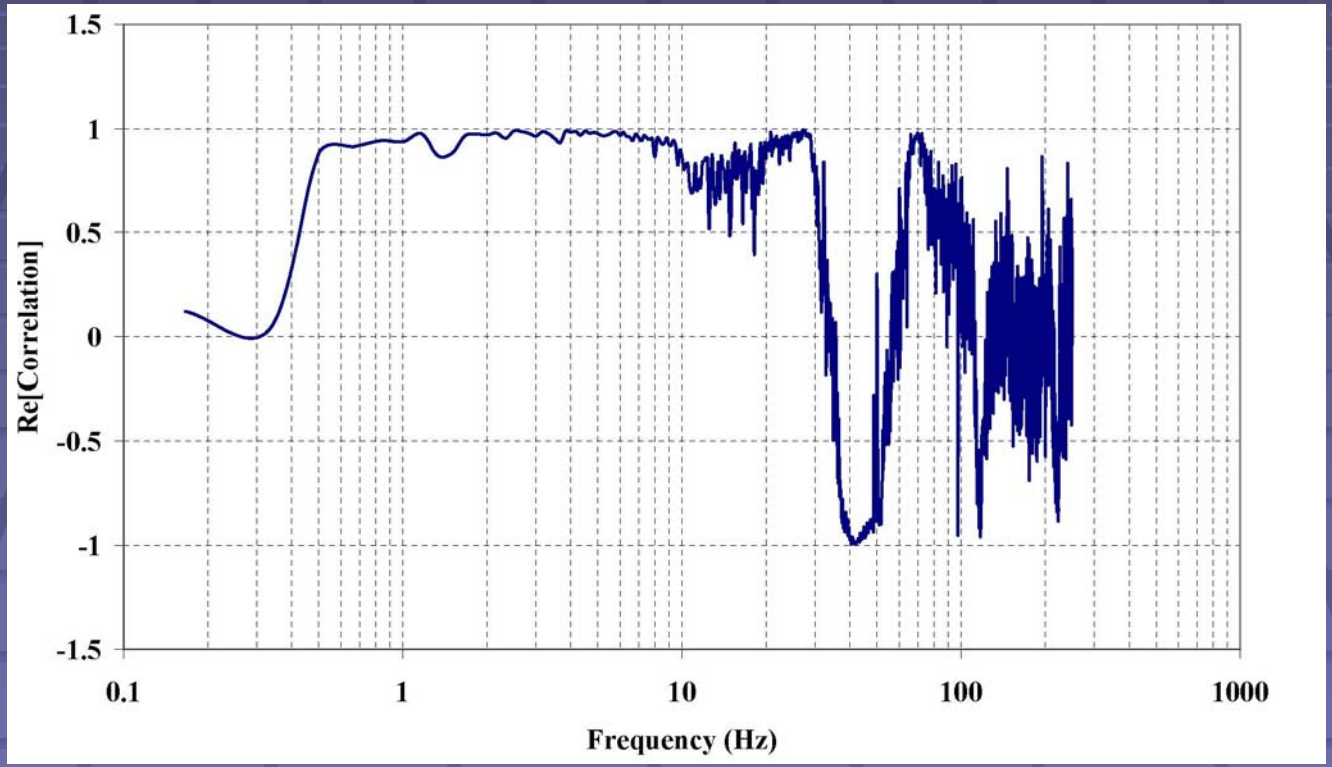
Integrated Displacement PSD of 6-Point vs. 3-Point Girder Support (Horizontal Transverse)



The rms of the integrated displacement PSD @ 1 Hz in all three cases is between 50-60 nm. Vertical fixations do not affect the rigidity of the girder markedly. The 6-point support system is clearly favored over 3-point support system.

Twist Mode

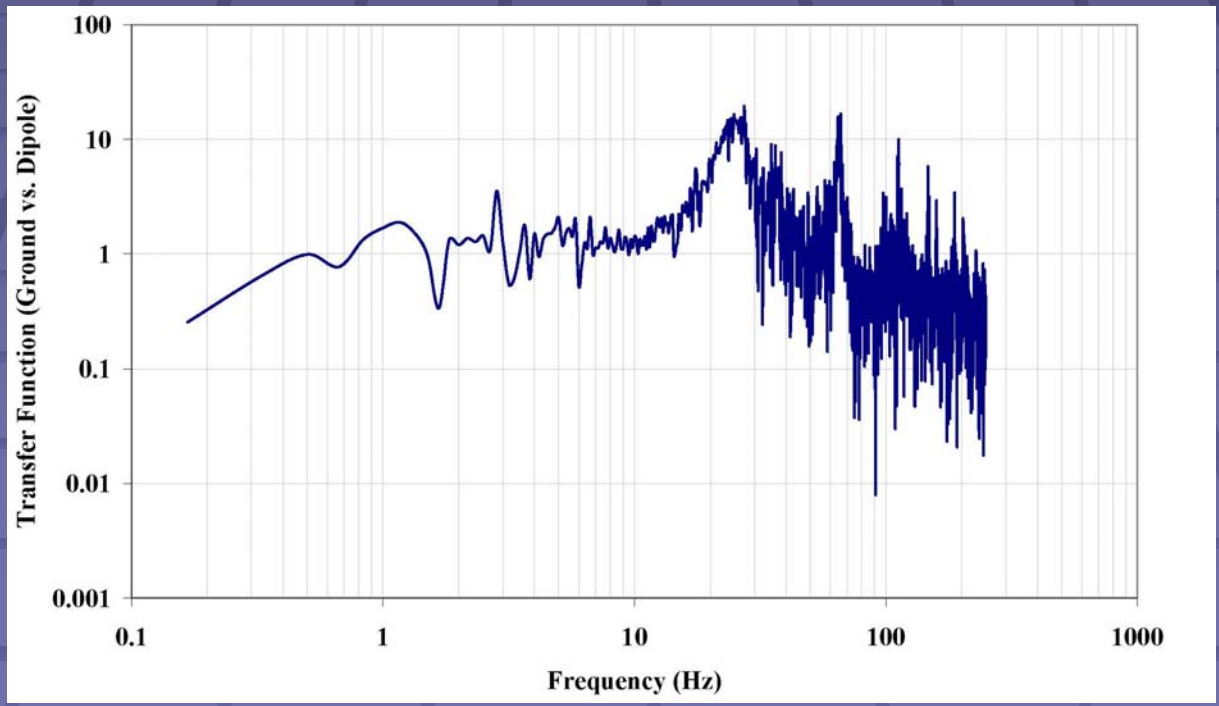
In order to check for a twist mode predicted by ANSYS, horizontal geophones were placed on extreme corners of the girder surface and correlation between the two signals was computed.



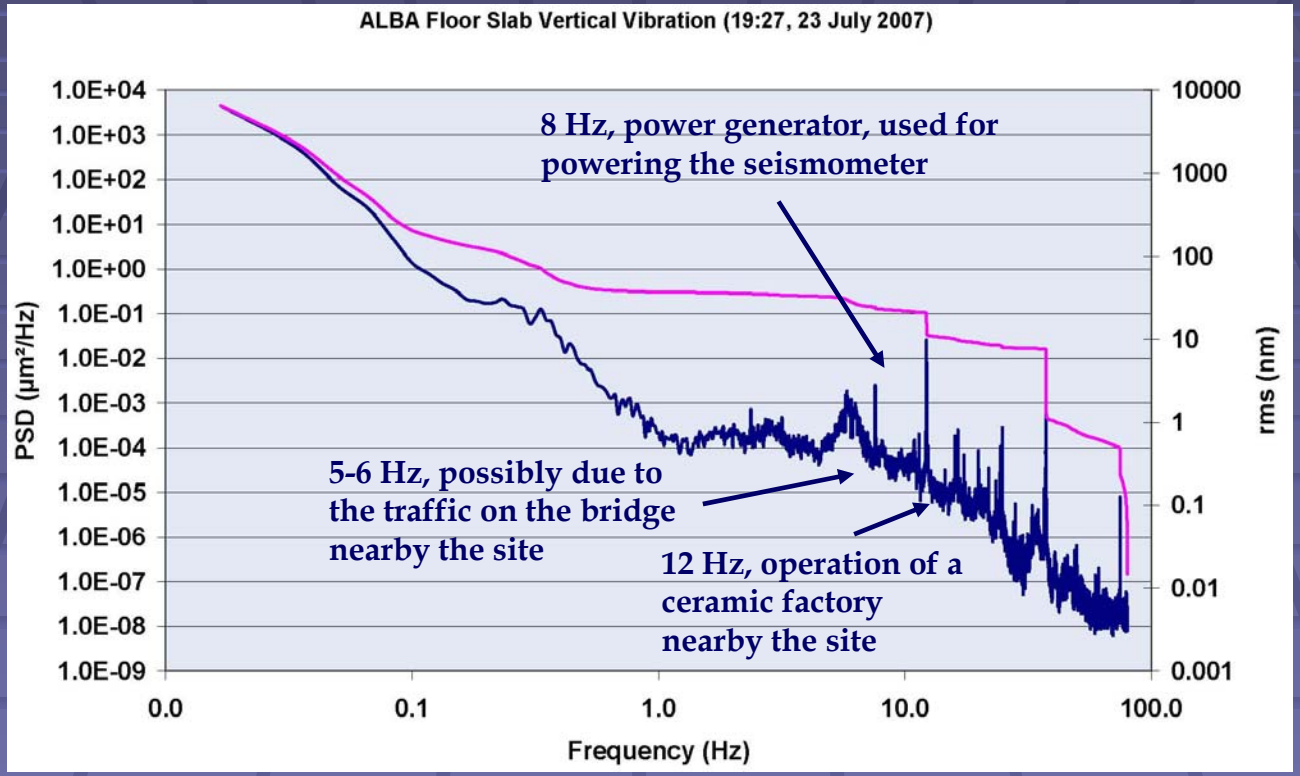
The twist mode is clearly seen @ 40 Hz, lower than the value calculated (64 Hz). This could be due to the effect of the pedestal-floor layout.

Measurement on the Magnet Dummies (Horizontal Transverse)

The transfer function of the magnet dummies, in going from the ground to the top of the magnets in the horizontal transverse direction, was measured. The configuration was the 6-point support set up but with no vertical fixation. Vertical measurements are planned in the near future with the baseline configuration, i.e., 6-point support and vertical fixations. The most dominant frequency is @ 28 Hz due to the rocking mode of the whole girder structure on the floor. This mode may be pushed to higher frequencies by designing a better girder-floor interface.



Ground Vibration Measurements of the ALBA Floor Slab



Average displacement PSD and rms of integrated PSD, @ f > 1 Hz, of vertical vibration of the ALBA slab floor, in one location only, during construction; measured on 23 July 2007 from 19:00-20:00 with a Güralp CMG-6TD. @ 1 Hz, the vibration level is ~34 nm at the time of the measurement.

Conclusions

- The girder is rigid in the vertical direction with a girder/ground transfer function of 1:1 up to a frequency of 40 Hz at least.
- In the horizontal transverse direction, the baseline design of 6-point support configuration is strongly recommended. In this configuration, a 28 Hz peak is seen which is due to the girder rocking around its interface with the floor. The first girder eigen mode is @ 70 Hz. The 24 Hz peak seen in all the spectra is the result of a vacuum pump nearby.
- The girder- floor interface may be improved to push this rocking mode @ 28 Hz to higher frequencies.
- A twist mode (around the longitudinal axis) is seen @ 40 Hz which is predicted to exist @ 64 Hz in ANSYS. However, this discrepancy may be due to the interface between girder-floor. The twist mode may affect the transfer function of the two further most sextupoles on the girder.
- The transfer function of the magnet dummies should be measured for the baseline design and in the vertical direction.
- Please turn off the vacuum pump, in the mechanical workshop, for the future measurements!