Design and Vibration Measurements of High Stiffness Massive Supports for the ESRF Nano-precision Engineering Platform Integration Laboratory

P. Van Vaerenbergh, M. Lesourd, L. Zhang, R. Barrett, L. Eybert, Ph. Marion, T. Mairs, J-C. Laidet, L. Ducotté

European Synchrotron Radiation Facility, B.P. 220, 38043 Grenoble, France

OUTLOOK

1. The Nano-Precision Engineering Platform and the Integration Laboratory
1. The concrete base support structure
2. The synthetic granite base support structure
3. Conclusions

1. The Nano-Precision Engineering Platform and the Integration Laboratory

- In 2006, creation of the Nano-Precision Engineering Platform (see the talk of Ph.Marion tomorrow)

  -> setting up of 6 working groups

  (e.g. the Vibration Control Working Group)

  -> building of the Integration Laboratory

- Missions of the Vibration Control Working Group:

  Investigate and advise on the best strategies to minimise the effect of ground vibrations inherent at ESRF site (with respect to the challenges connected with nanometre sized beams).

Slide 3

PV1 “The ESRF Nano-precision Engineering Platform : Overview and First Results”, presented by Ph. Marion

Pierre Van vaerenbergh, 6/3/2008

- The Integration Lab. is a place where many of the sensitive ESRF instruments will be assembled and tested.

- Specificity of the lab:
  - its environment is close to those of an ESRF beamline
  - the vibration level is kept to its minimum
  - closely controlled temperature (i.e. 0.15° C peak to peak over more than a week)
  - cleanliness (i.e. class 10000 clean room).

Slide 4

PV2 “The ESRF Nano-precision Engineering Platform : Overview and First Results”, presented by Ph. Marion

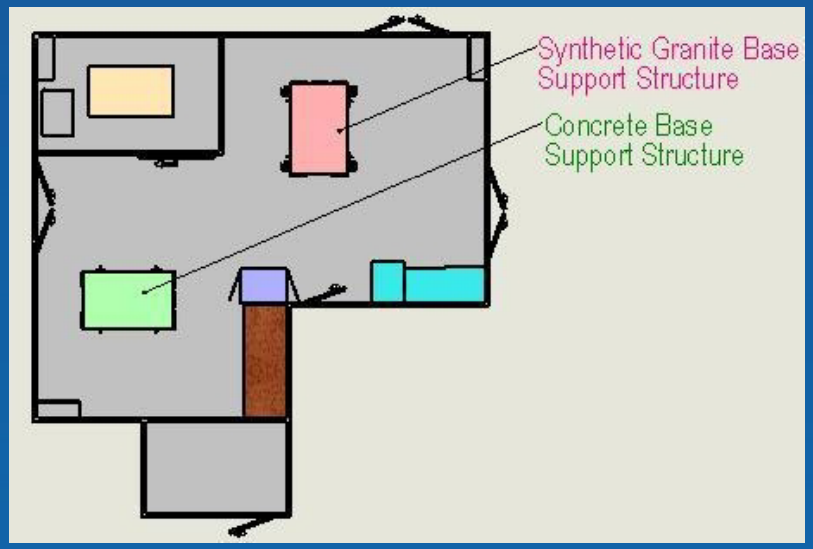
Pierre Van vaerenbergh, 6/3/2008

The laboratory identified the need to have, among its equipment, 2 stiff support structures (work benches).

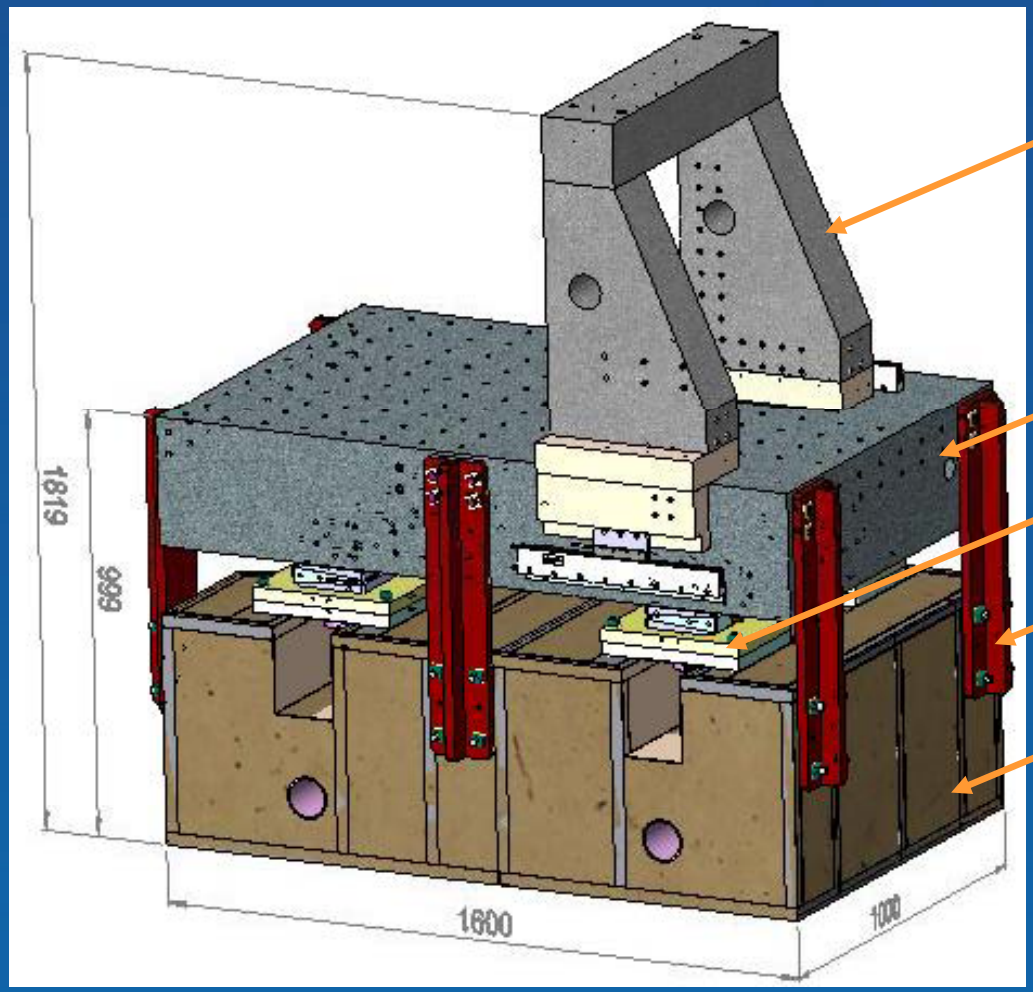
The Vibration Control Working Group made the design, construction and commissioning of the 2 benches.

Use this opportunity to test different techniques and materials (+ assessed by vibration measurements):

- concrete vs synthetic granite
- Airloc levellers vs Nivell
- pre-loading the levellers
- support on 3 - 4 - 5 points
- test extra stiffeners



2. The concrete base support structure (1st bench)



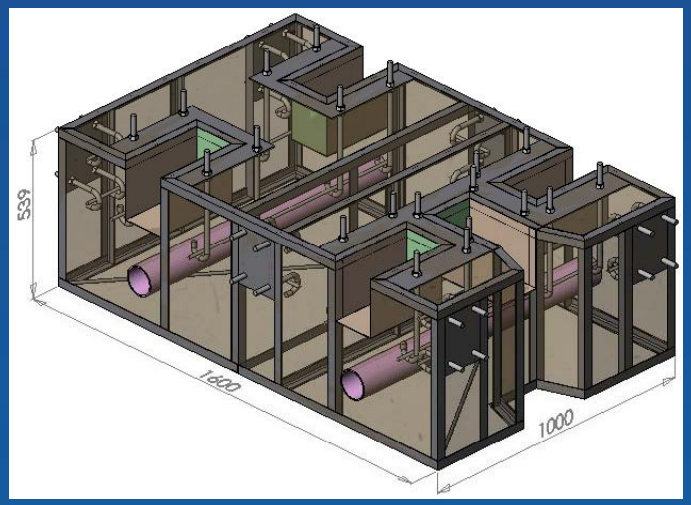
Gantry

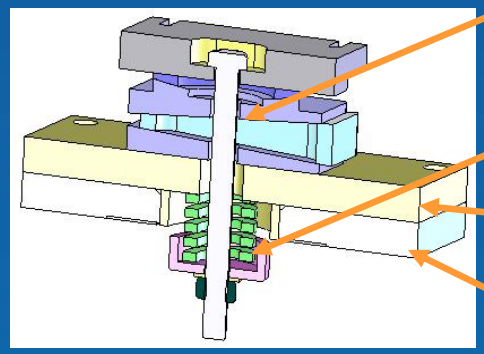
Granite

Levelling system

Rib stiffener (optional)

Concrete





Airloc 2140-KSKC

Loading spring

Al Plate

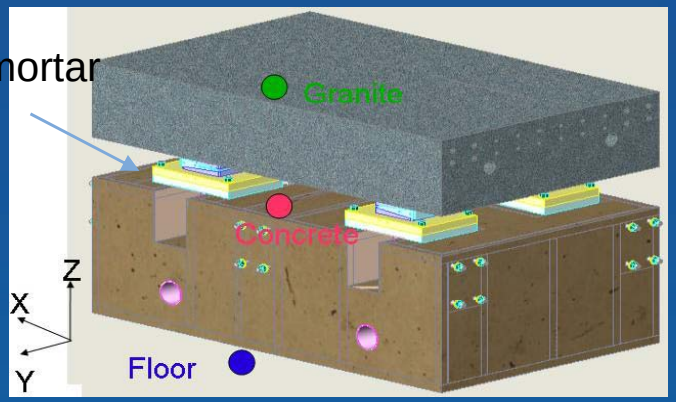
No shrink mortar

2.1 Construction of the concrete block

- Corner iron plate frame–> fixed to floor
- Iron framework was made and installed on site
- Cast concrete on site (in the clean room)
- Strict concrete composition (see paper for full description)
- Full tests on concrete samples (to be able to reproduce it for future projects) :
  - Settling measurement of fresh concrete
  - Shrinkage (made @ 1,7,14,28 days)
  - Compression strength (made @ 2,7,14,28 days)
  - Density measurements (made @ 7,14,28 days)

2.2 Vibration measurement results of the bench

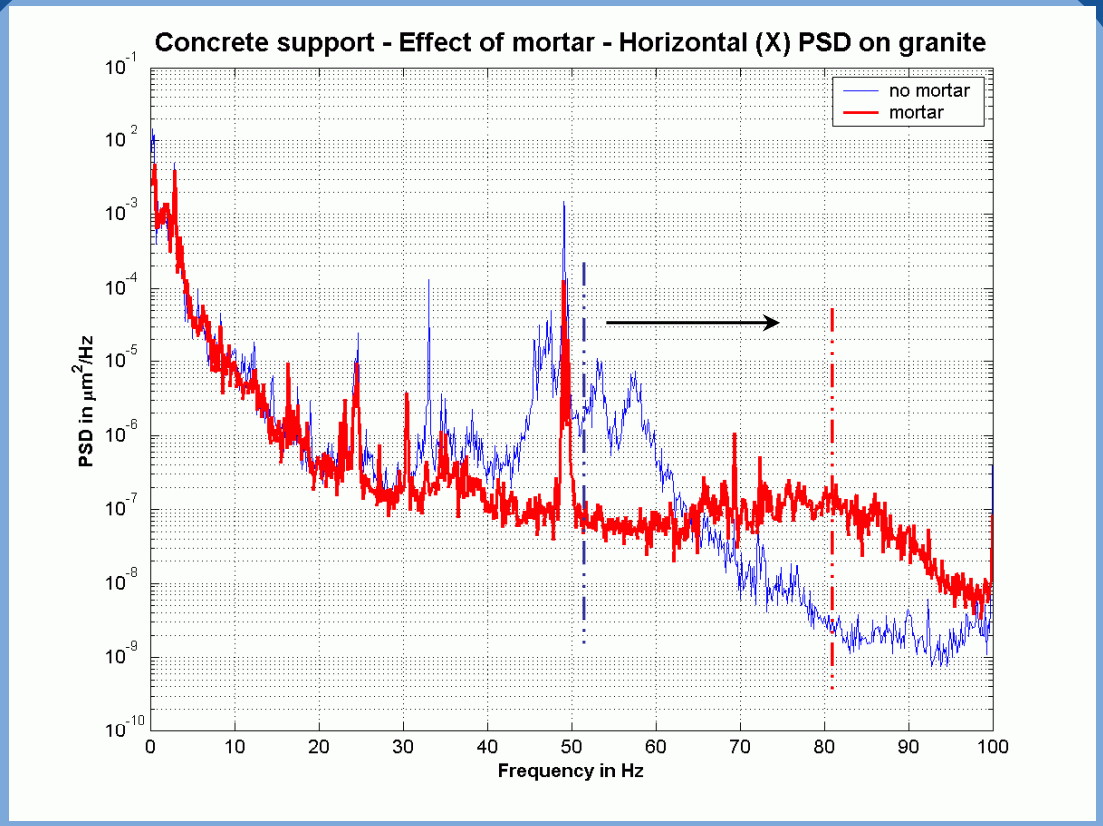
A. Effects of the mortar(*) between the Airloc and the concrete (measured with only 3 levellers) :



Significant shift of the natural frequency by 30 Hz (X), 19 Hz (Y) and 16 Hz (Z) towards the higher frequency

Note: there is a strong floor excitation peak at 49 Hz! (<- electrical pumps located in the surroundings)

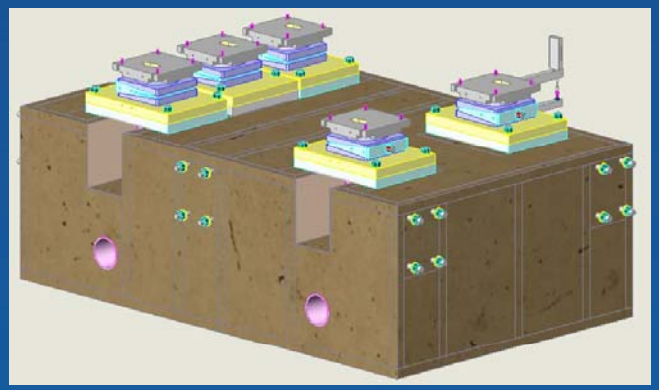
=> to be damped…



=> this mortar has improved drastically the rigidity of the support structure.

2.2 Vibration measurement results of the bench (cont.)

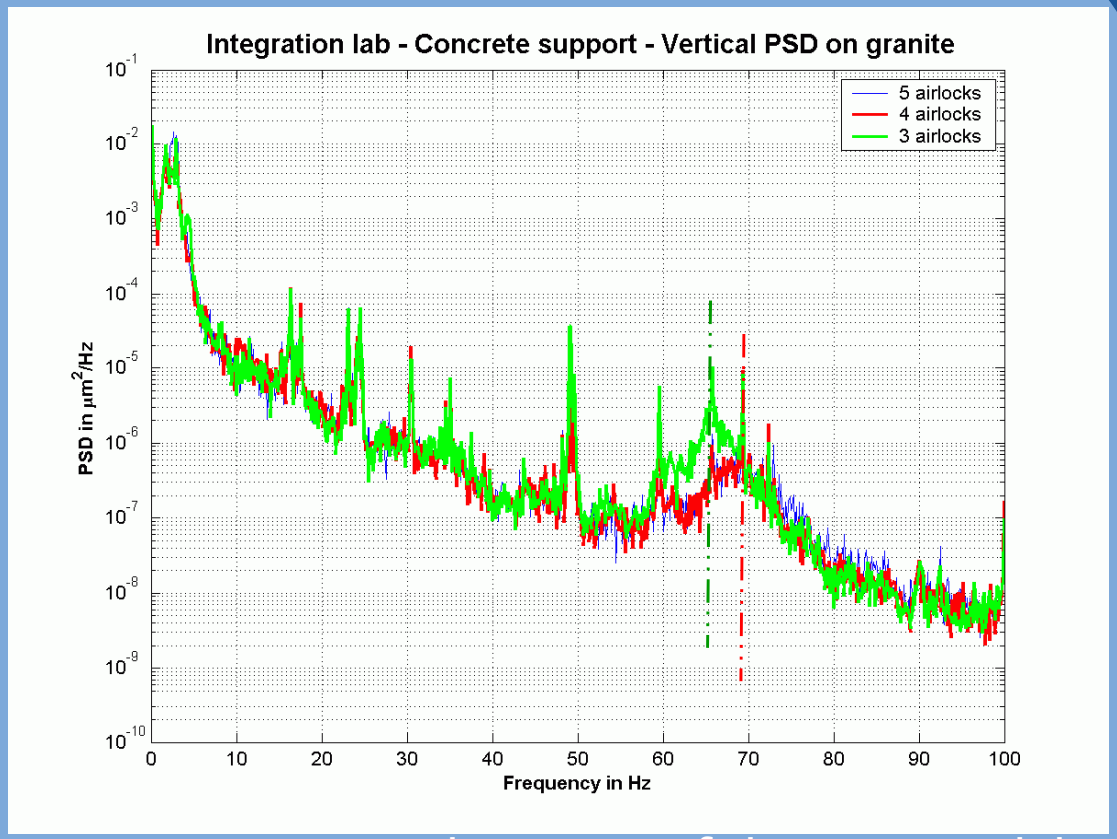
B. Effects of the number of support points:



Test on 3 – 4 – 5 support points:

=> Nearly no gain of stiffness (4 to 5 Hz along Y, Z axis) !

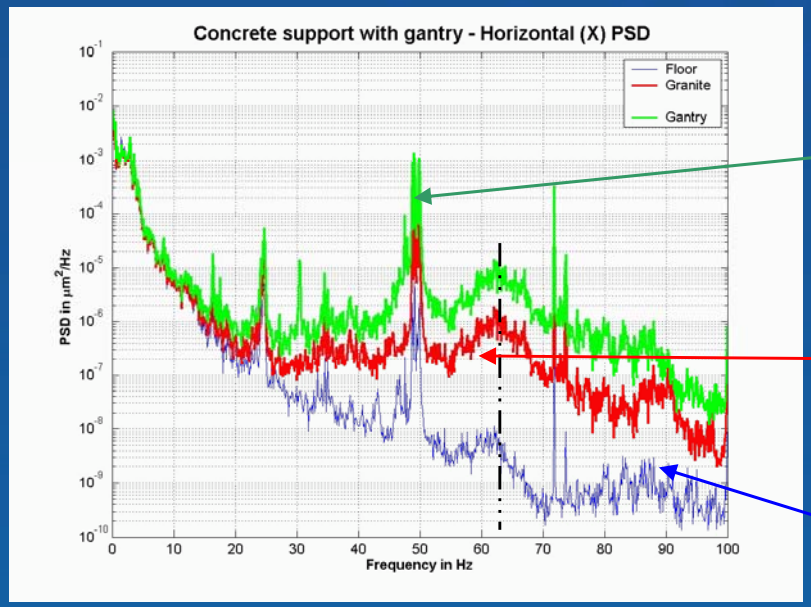
=> As far as dynamic stiffness is concerned, a 3-points support structure seems sufficient!

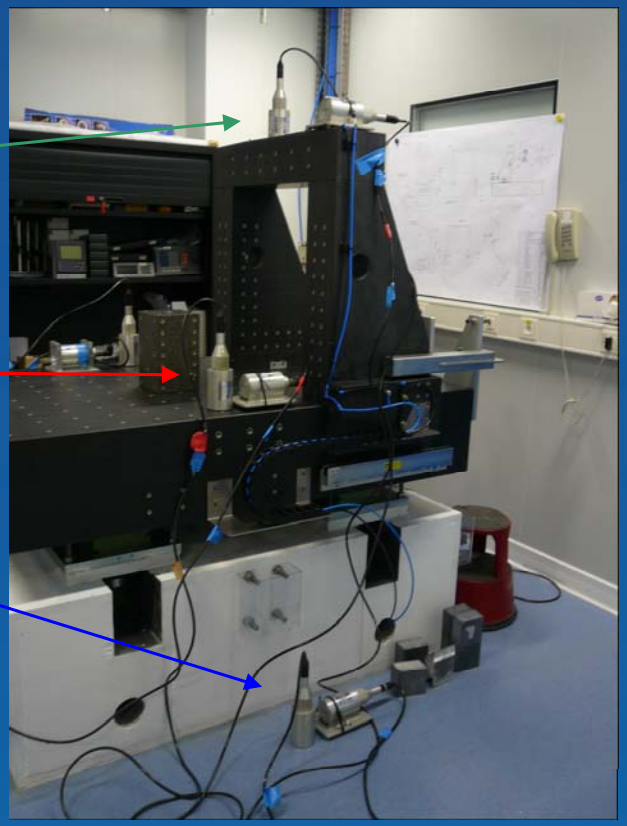


Measurements made on top of the granite slab

2.2 Vibration measurement results of the bench (cont.)

C. Effects of adding a gantry on the granite slab (measured with only 3 levellers) :





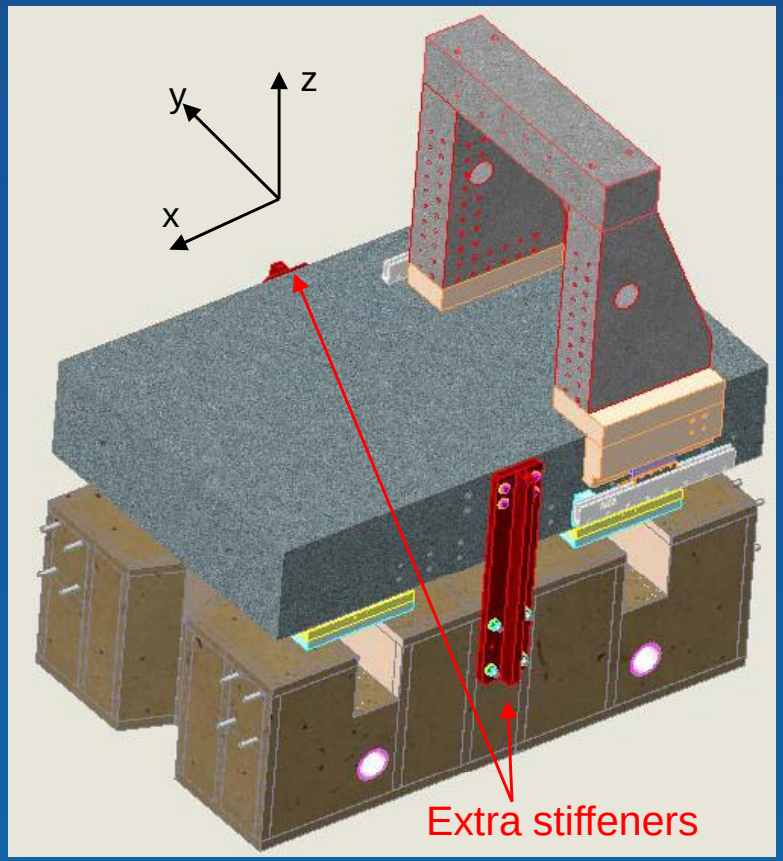
Axis	Natural frequency [Hz] without the gantry	Natural frequency [Hz] with the gantry
X	83	63
Y	66	47
Z	64	48

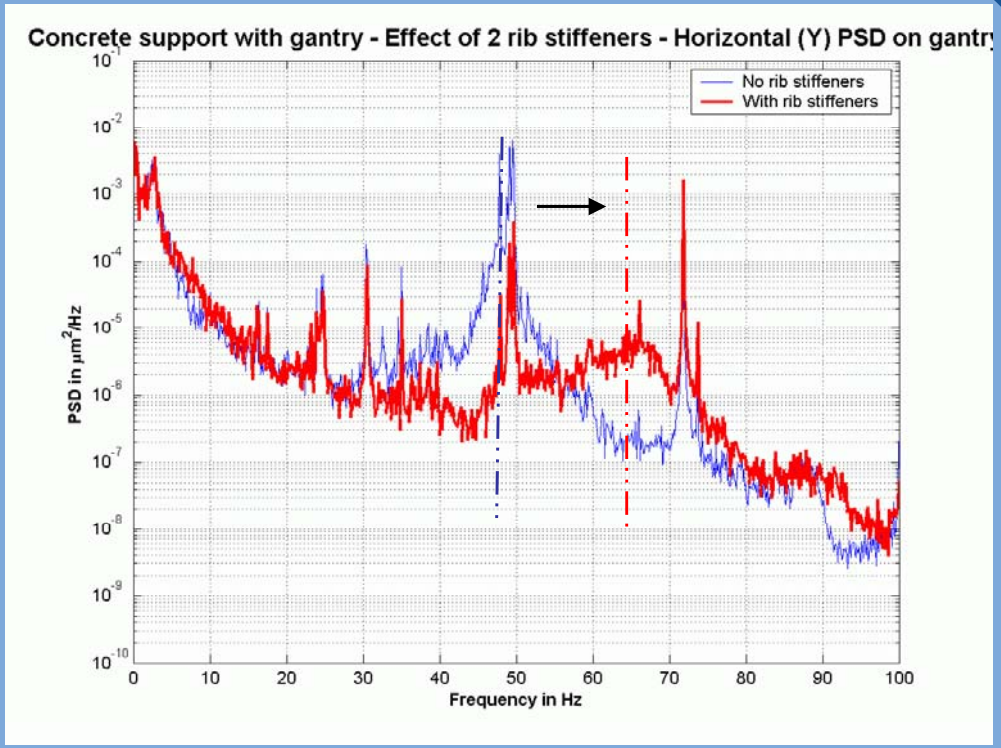
Additional load (with high center of gravity) => reduce considerably the F_{nat}!

Due to the gantry, we need to increase the stiffness of the structure

2.2 Vibration measurement results of the bench (cont.)

D. Effects of adding rib stiffeners on 2 sides (long sides) :





The 2 stiffeners have considerable effects (along Y only) => they shift the F_{nat} from 48 Hz to 65 Hz

2.3 Future prospects regarding the concrete base support structure

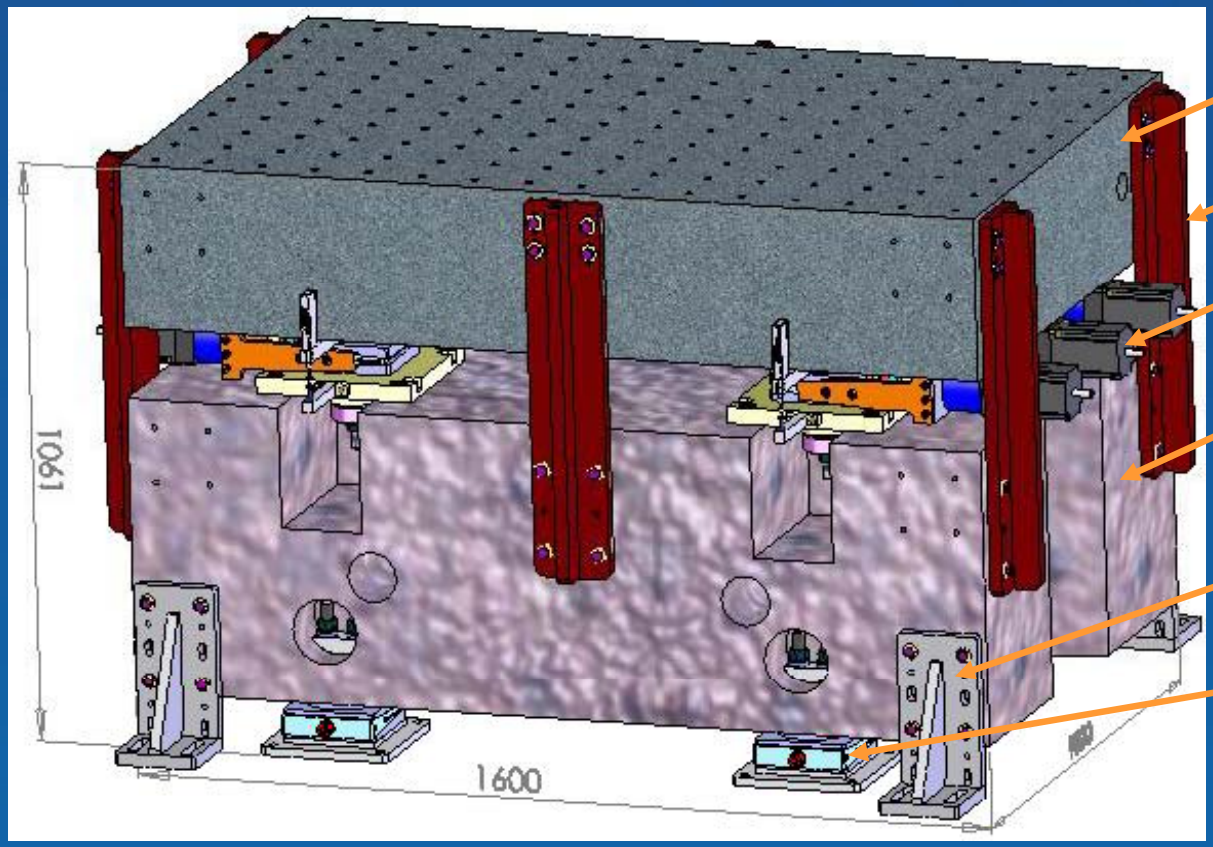
This bench is now validated to measure instruments installed on the top granite slab. It is rigid enough and only 3 support points are necessary.

However when the gantry is put in place, it is necessary to increase the stiffness of the bench!

Therefore it is planned to:

- repeat the vibration measurements by adding 4 more rib stiffeners (2 on each shorter sides of the granite).
- characterise the pre-loading of the springs on this bench.

3. The synthetic granite base support structure (2nd bench)



Granite slab

Rib stiffener (optional)

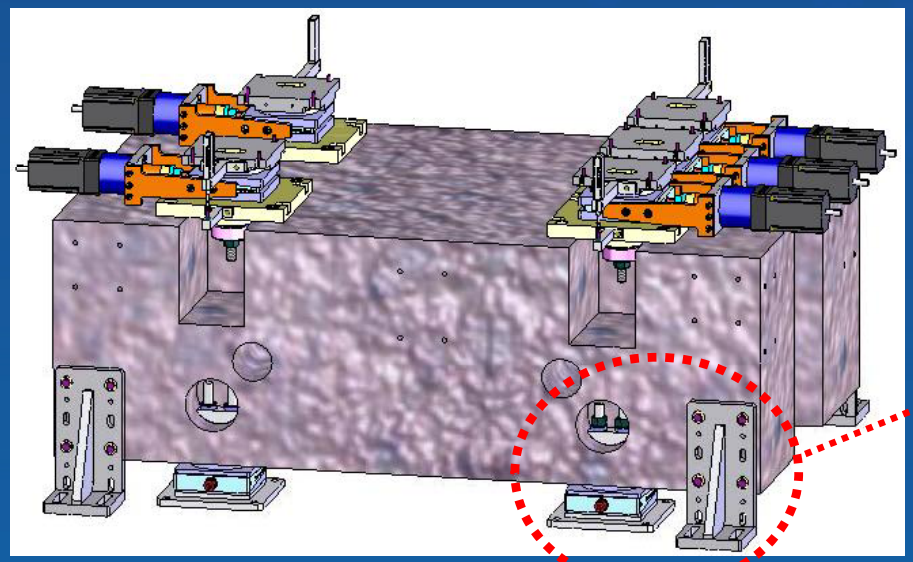
Motorised levelling system

Synthetic granite block

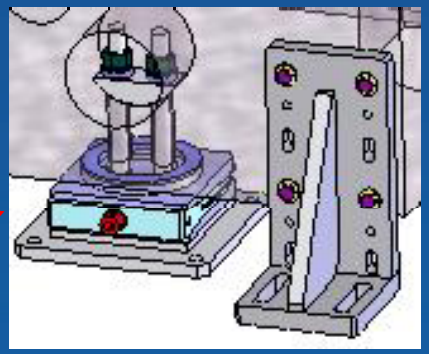
Corner stiffener (optional)

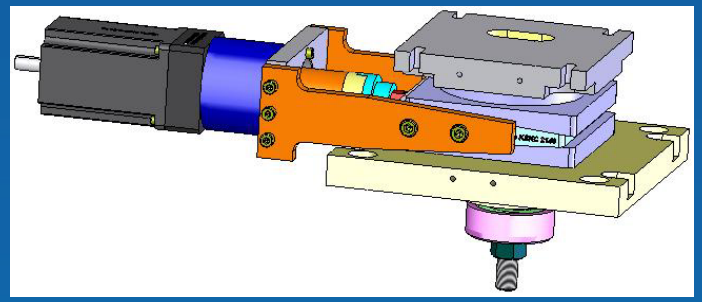
1st Airloc level

3. The synthetic granite base support structure

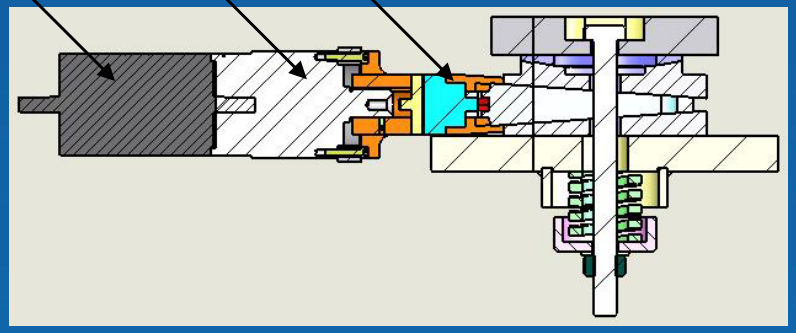


1st Airloc level





Motor Reductor Oldham



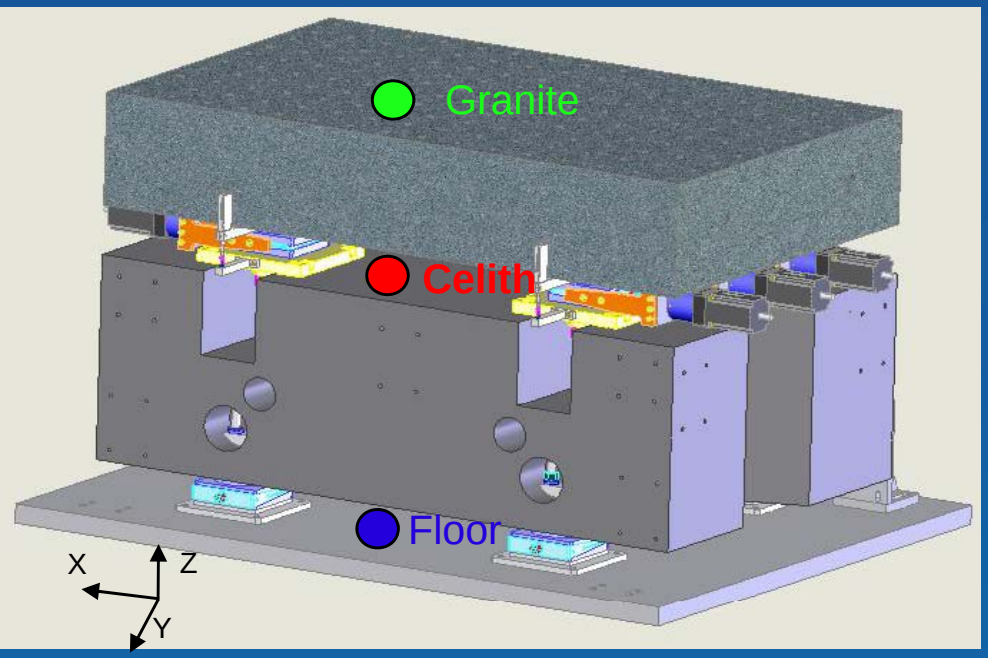
3.1 Construction of the synthetic granite block

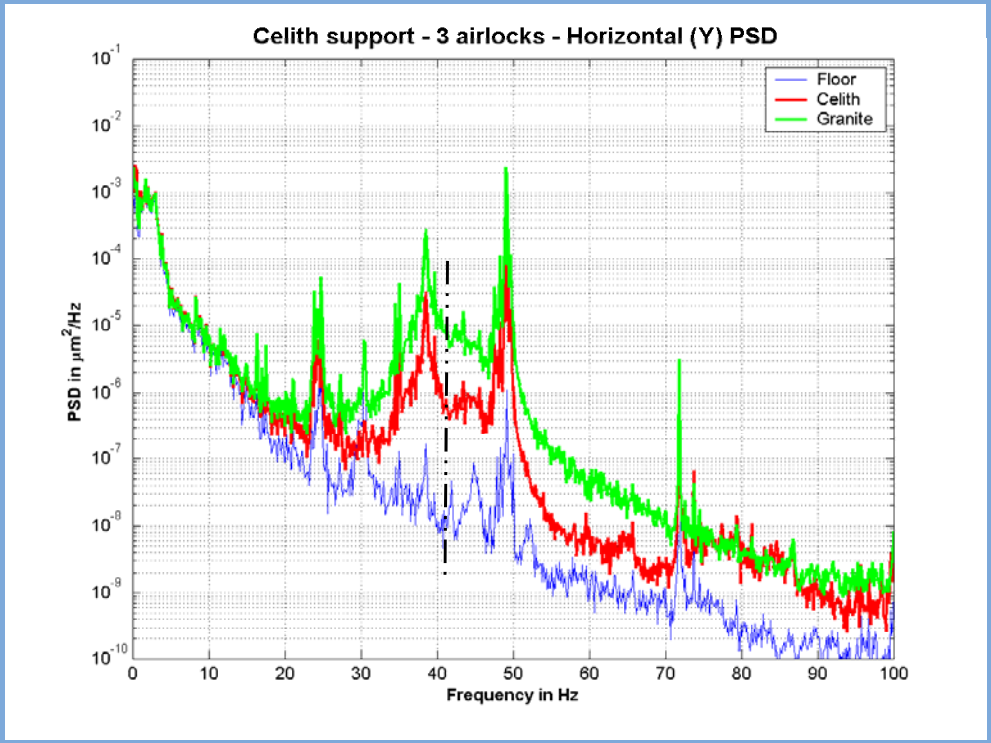
- Base block made of CELITH materials (from *Microplan*)
- Obtained by casting (mix of different size of granite pebbles + epoxy)

	Natural granite	CELITH granite
Density [kg/dm3]	2.7–3	2.3–2.5
Elasticity modulus [kN/mm²]	35–45	30–40
Linear thermal expansion coef. [10^{-6}/°C]	5–7	9–13
Thermal conductibility [W/m.°C]	2	1–3
Compressive strength [N/mm²]	350	120–150
Tensile strength [N/mm²]	10–15	10–15

3.2 Vibration measurement results of the bench

A. Measurement without any corner and rib stiffeners (on 3 support points) :



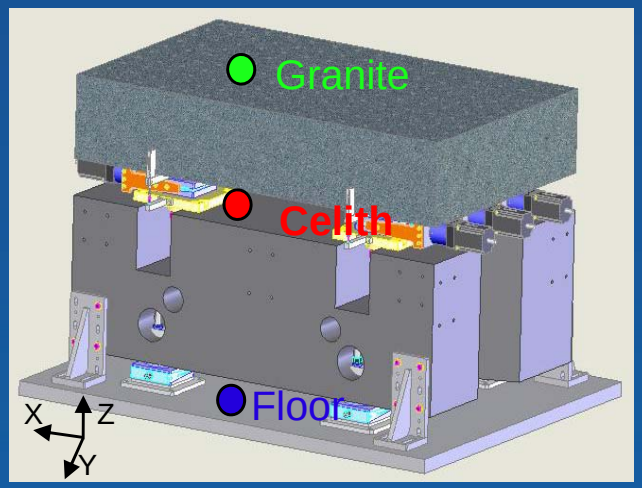


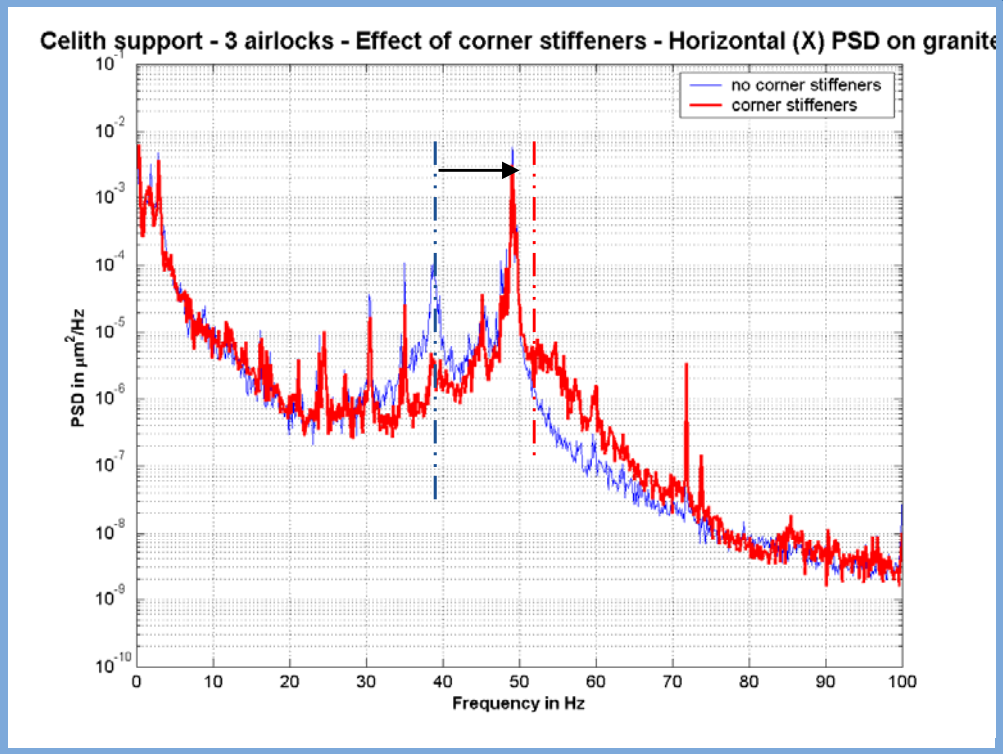
F_n~40 Hz instead of 66 Hz previously

=> NOT stiff enough!

3.2 Vibration measurement results of the bench

B. Effects of adding 4 corner stiffeners :



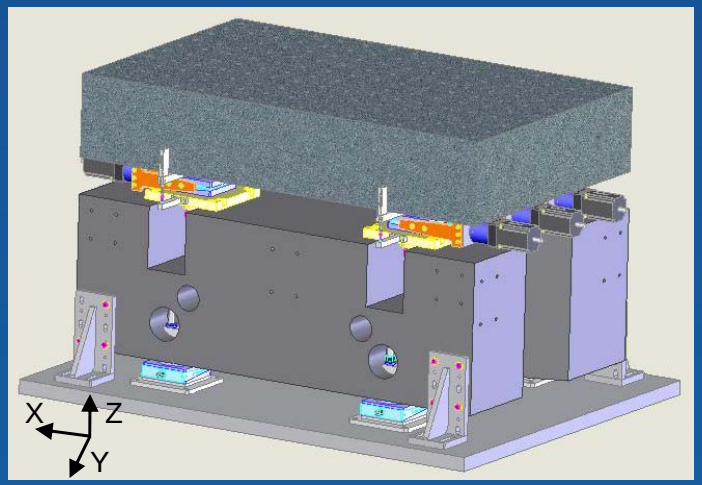


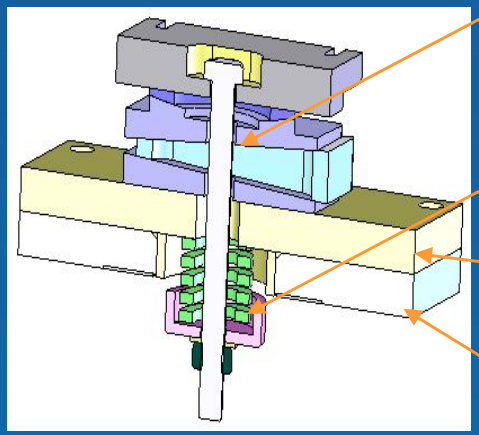
F_n has shifted by respectively of 13 and 10 Hz along X and Y

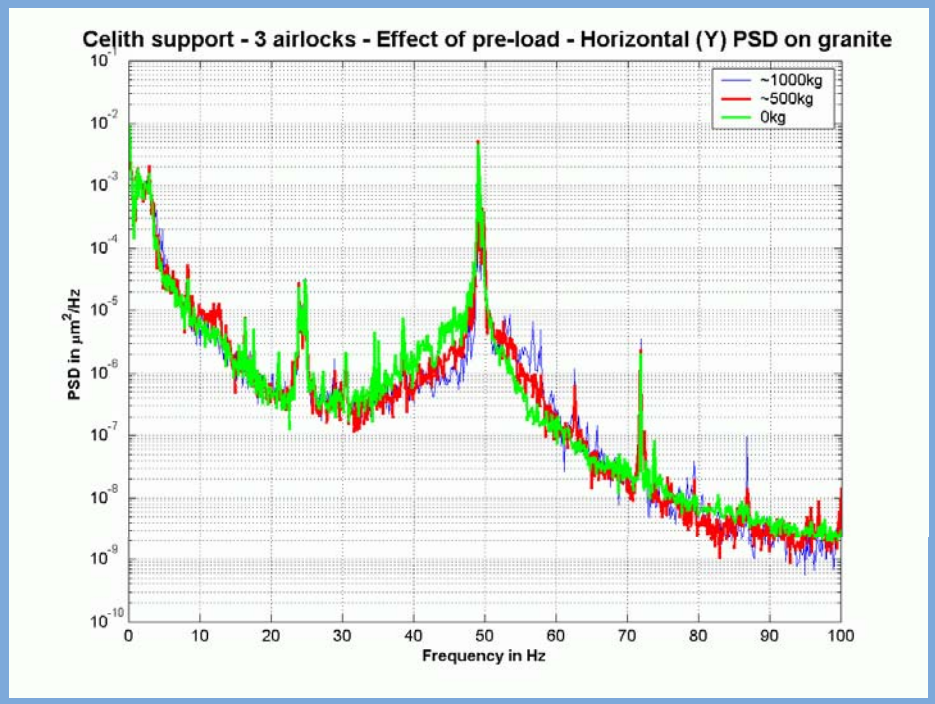
=> strong effects BUT not sufficient

3.2 Vibration measurement results of the bench

C. Effects of spring pre-loading :





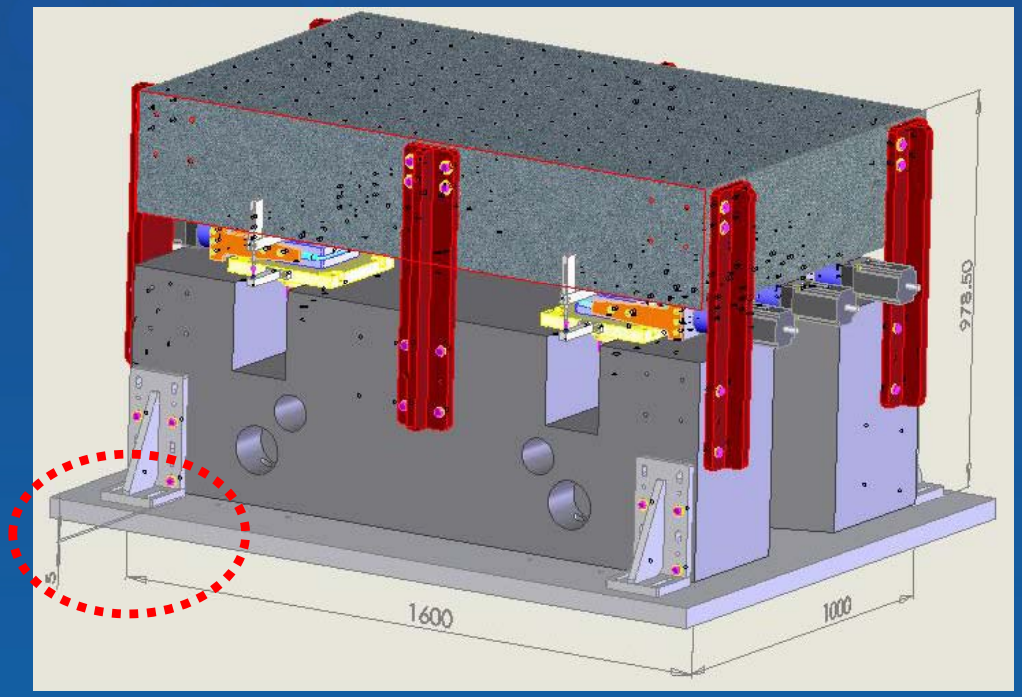


Surprisingly, no major change was measured when the spring was loaded up to 1000 kg!

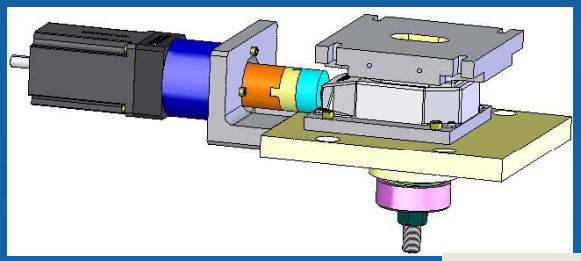
<= weak rigidity at the floor interface

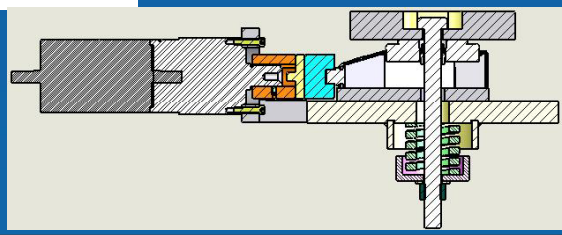
3.3 Future prospects regarding the synthetic base support structure

- Due to the lack of rigidity of the link between the floor and the block, the lower Airloc adjustment levellers will be removed and the Celith block will be glued to the floor with an epoxy resin.
- Pre-loading and rib stiffeners characterisation will be repeated after this modification.



- The Airloc of the second layer will be replaced by the Nivell ones (known to be stiffer but with a more limited stroke)





4. Conclusions

- Poured concrete support is more rigid than Celith support in the current configuration (strong bonding of the concrete to the floor). Celith block glued to the floor should improve significantly the stability.

- Additional masses (with high center of gravity) affect strongly the response of the support.

- 3 Airloc levellers under the granite slab seems sufficient except if a gantry is installed.

- The rib stiffeners (for the concrete block) improve drastically the rigidity.

- The corner stiffeners (for the Celith block) have a significant effect on the rigidity, but this is not enough to compensate the loss of rigidity induced by the first layer of Airloc.

5. Acknowledgements

The authors gratefully acknowledge the ESRF staff who have contributed to the design and the building of the two support structures; principally:

- the Draughtsmen (Jean-Francois Ribois and Eric Gagliardini),
- the Mechanical and Mounting Group (Claude Richard, Pascal Dideron and his team),
- the Handling Group (Ceferino Alonso and his team),
- and the Survey and Alignment Group (Noel Levet and his team).

… thank you for your attention …