ALBA Critical Floor Area Vibrational Response

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CELLS

OUTLINE

- Introduction
- Construction method
- Vibrational characterization

Introduction

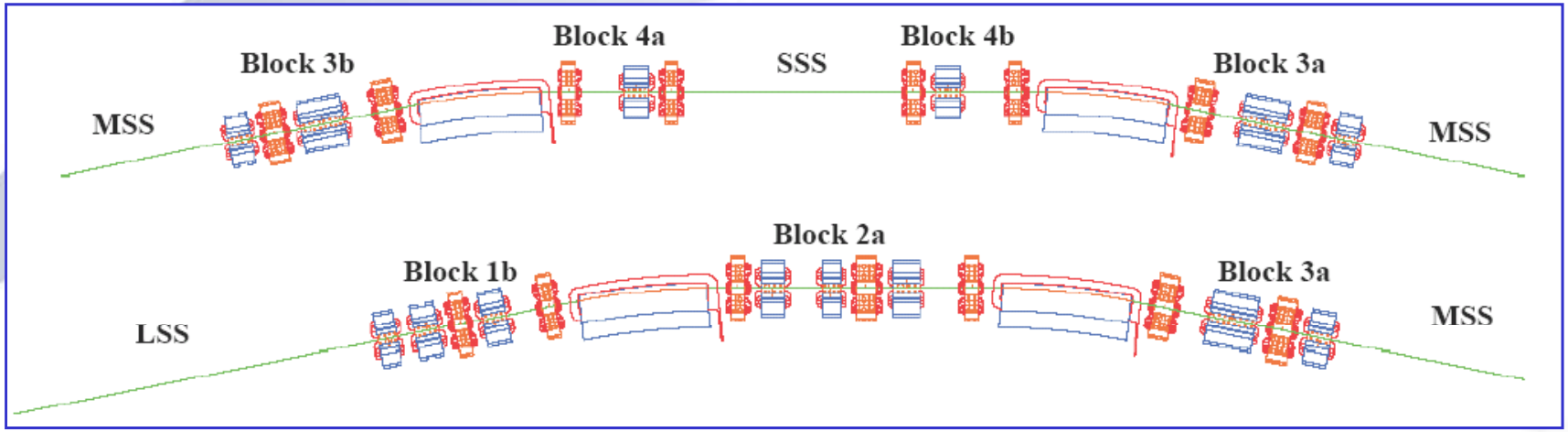
- Case
- Site
- Solution adopted

Lattice

Energy	GeV	3.0
Nominal current	mA	250
Design current	mA	400
Horizontal Emittance	nm.rad	4.3
Lattice		Expanded DBA
Storage ring Circumference	m	268.8
No. of dipoles		32
Bending angle	mrad	196.34
Radius of curvature	m	7.047042
Dipole magnetic field	T	1.42
Critical energy from dipole	keV	8.5
Total photon flux at the design current	Ph/sec	$9.7 \cdot 10^{20}$
Total power at the design current	kW	407
Harmonic number		448
Frequency	MHz	500
Momentum Compaction Factor		$8.8 \cdot 10^{-4}$
Chromaticity (Horizontal/Vertical)		-39.8/-25.6

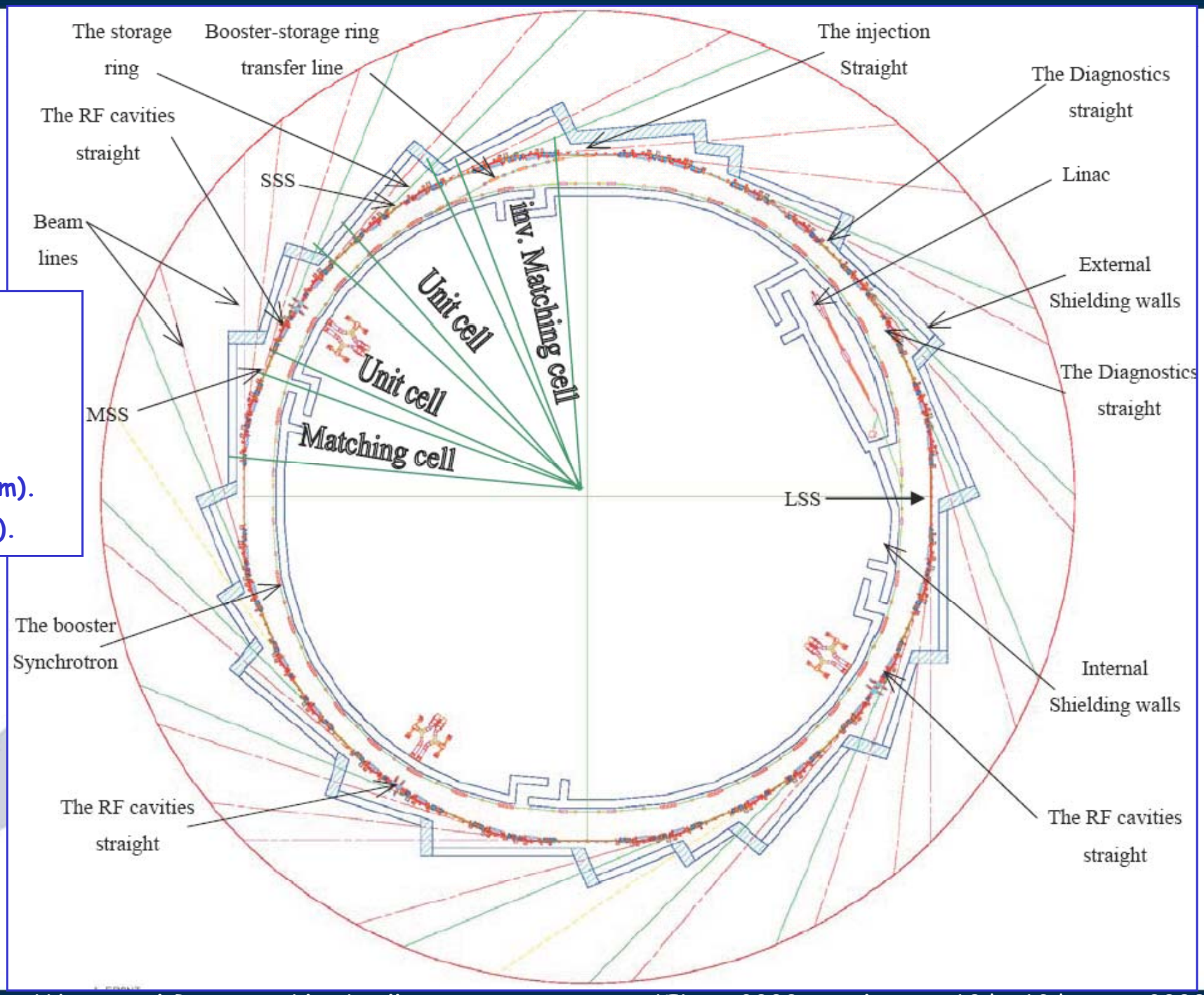
Unit Cell

Matching Cell



ALBA Lattice

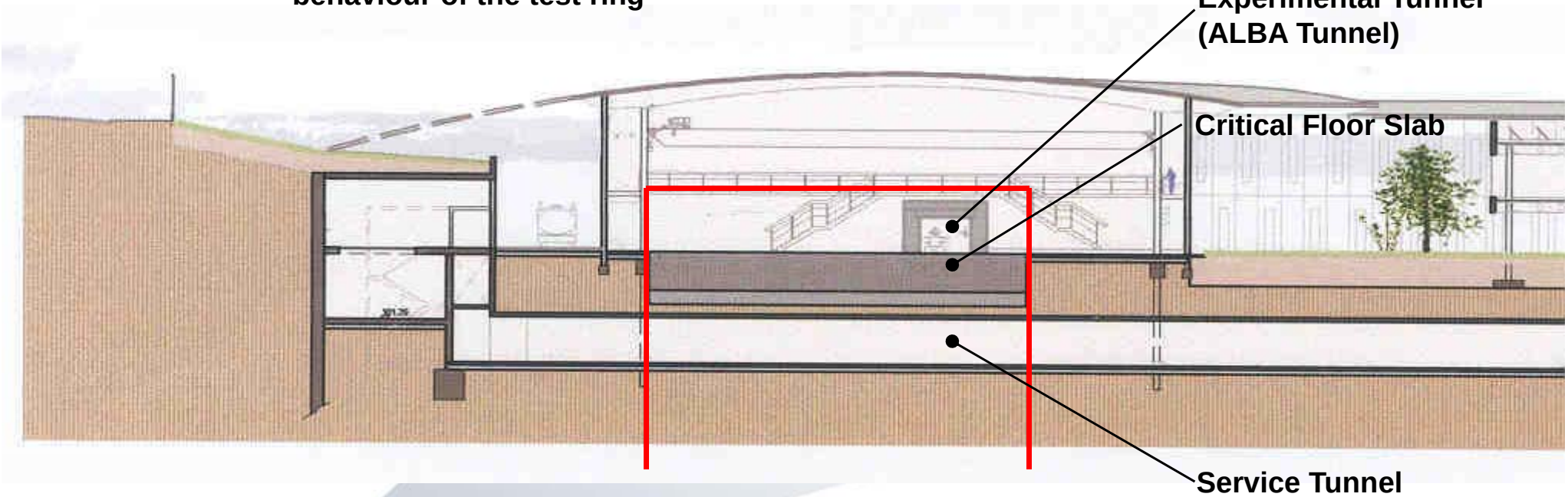
* 8 unit cells
* 8 Matching cells
* Straights:
  - 4 LSS (8m).
  - 12 MSS (4.2m).
  - 8 SSS (2.6m).



Vibrations

Vibrations, affecting the behaviour of the test ring

Design



Critical Area Requirements

Loads on the slab	
Distributed load	1,5 Tm/m²
Max. concentrated load	5 Tm/m²
Dynamic Load	2 Tm

Vibrations		
Vertical amplitude	< 4 μm	De 0,05 – 1 Hz
	< 0,4 μm	1 – 100 Hz
Horizontal amplitude	2 μm	

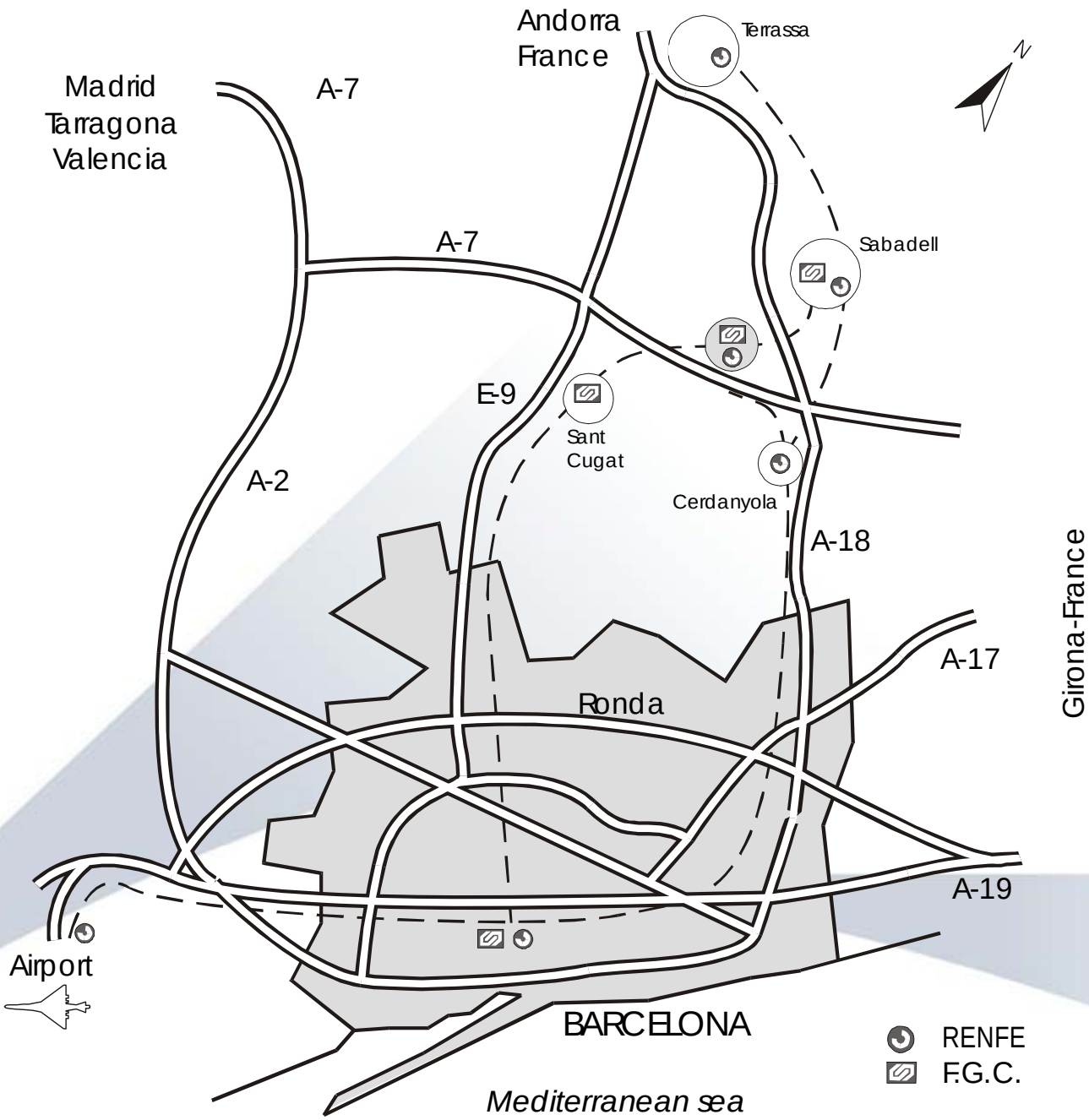
Floor slab differential displacements	
Slow relative displacements	< 0,25 mm/10 m/year
	< 0,05 mm/10 m/month
	< 10 μm/10 m/day
	< 1 μm/10 m/hour
Maximum differential displacements over the whole perimeter	< 2,5 mm/year

Floor slab deformability due to loads	On the application point	At 2 m
Static load of 500 Kg	6 μm	1 μm
Dynamic load of 100 Kg		1 μm

Site

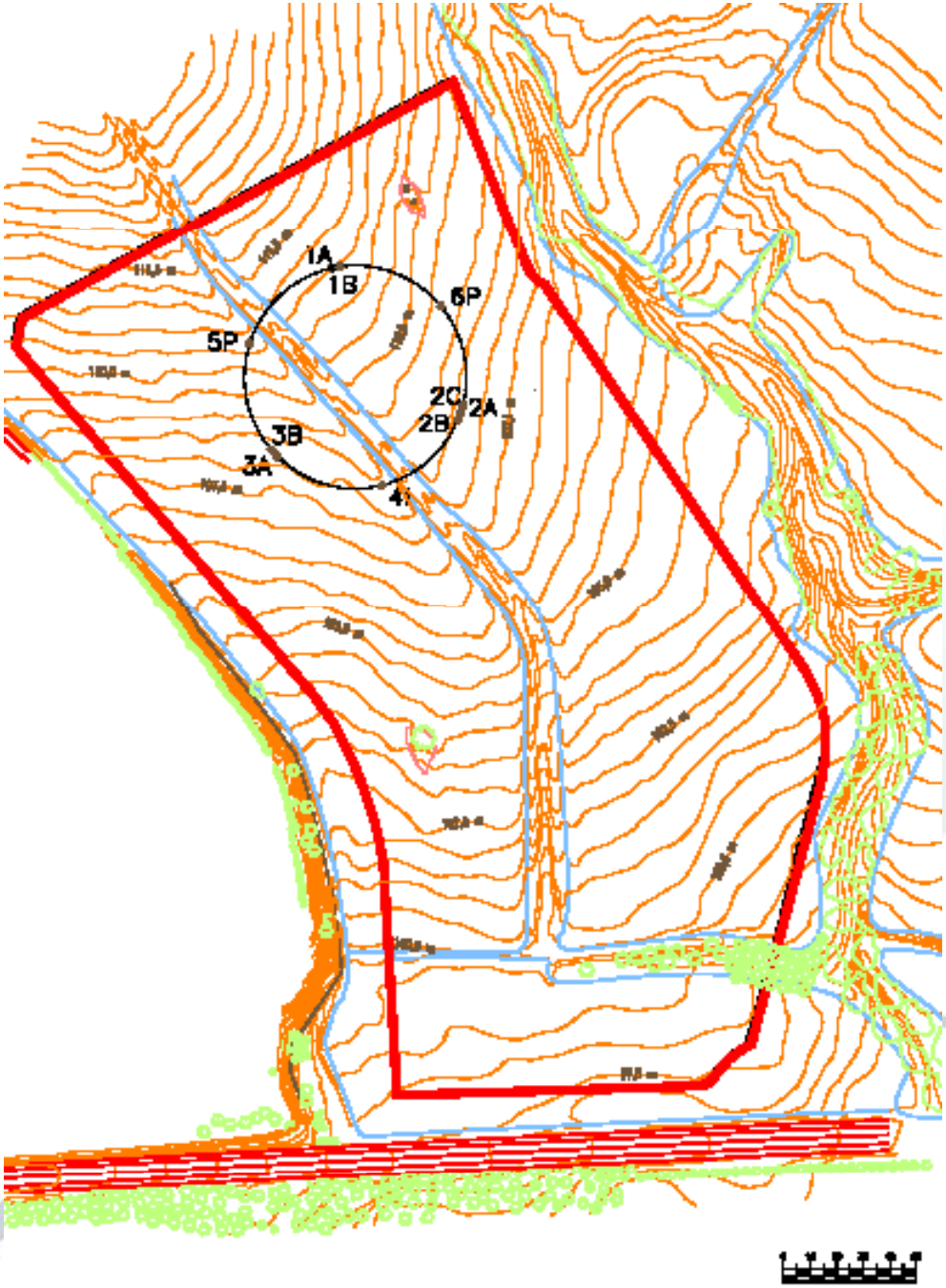
ALBA: A Spanish Synchrotron Light Source

Site


Andorra
France
Terrassa
N
Madrid
Tarragona
Valencia
A-7
A-7
Sabadell
E-9
Sant
Cugat
Cerdanyola
A-2
A-18
Girona-France
A-17
Ronda
A-19
Airport
BARCELONA
RENFE
F.G.C.
Mediterranean sea

Site

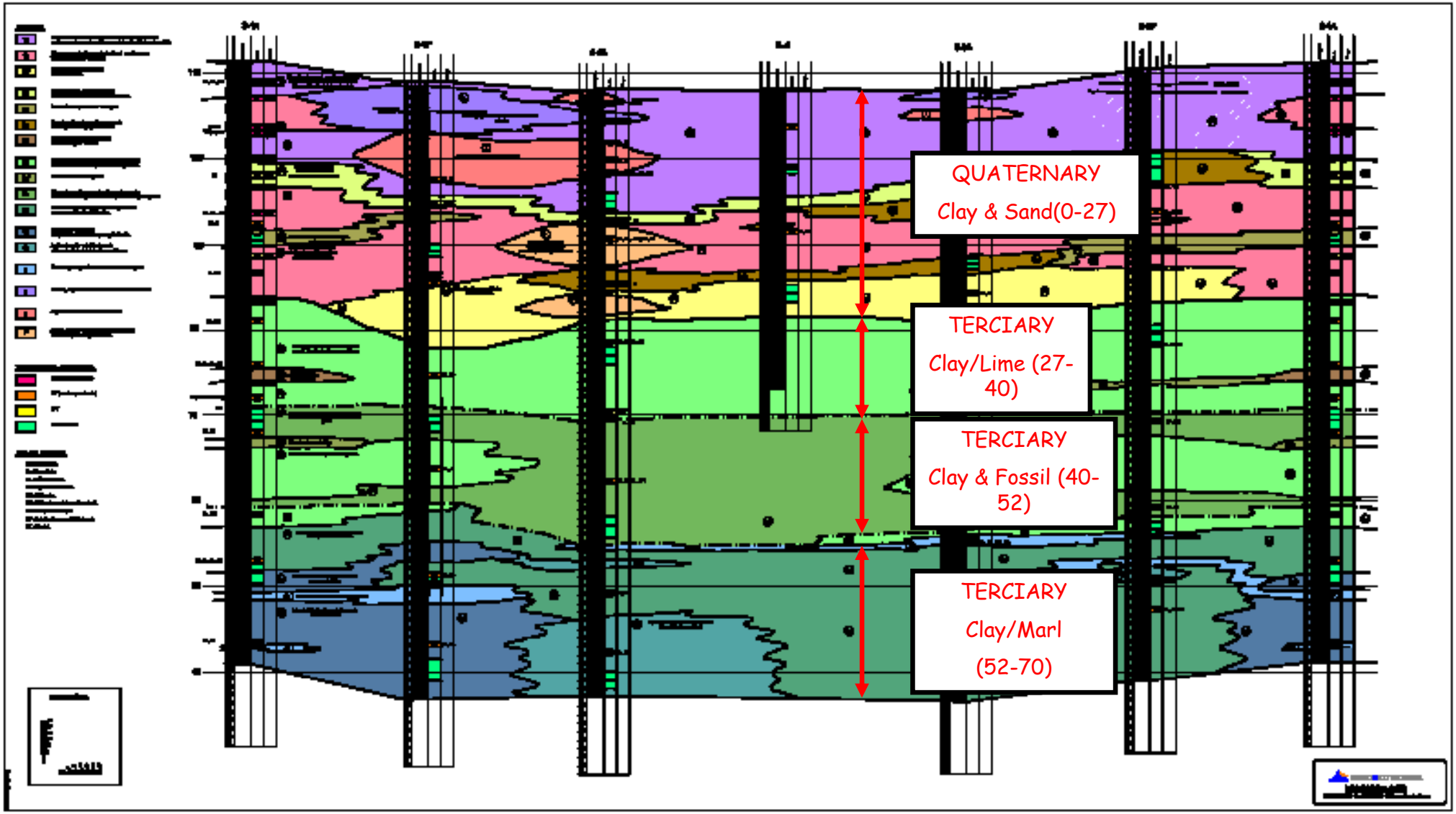
Measurements and instrumentation



Boring	Depth (m)	Instrumentation
1A	70	Micrometer
2A	70	Micrometer
3A	70	Micrometer
4I	35	Slope indicator
5P	70	Extensiometer
6P	70	Extensiometer
1B	14,21,47,60	Piezometer
2B	15,23,45,65	Piezometer
3B	14,21,45,58	Piezometer

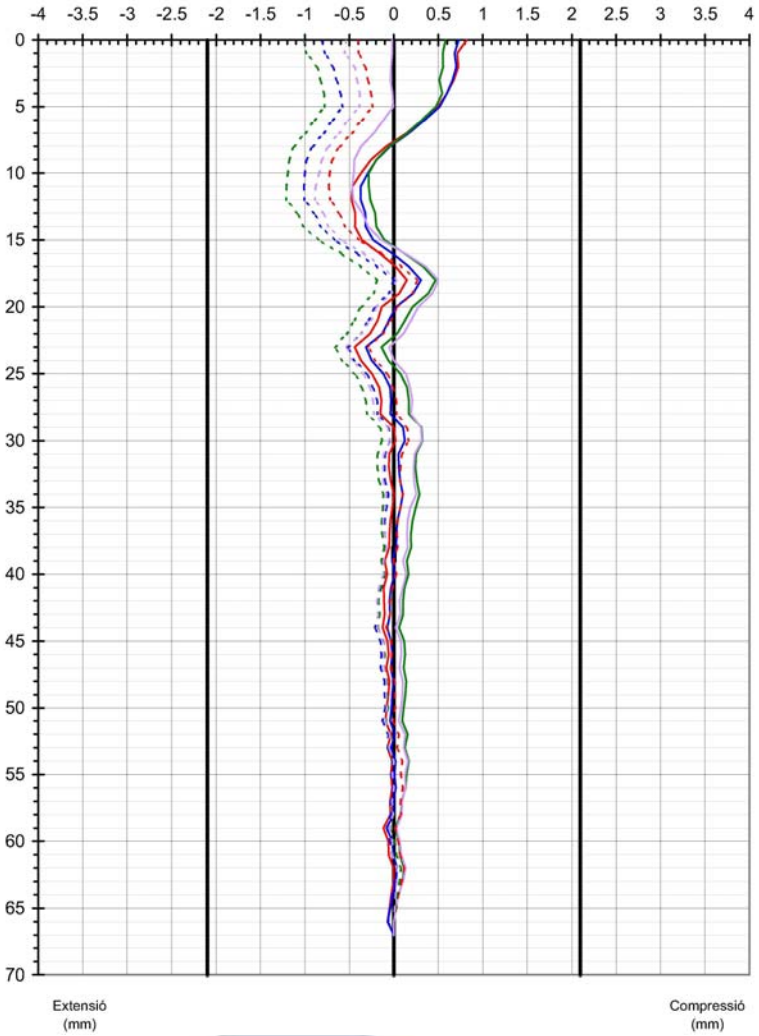
- Remote data acquisition
- Periodically crosscheck manual/ remote
- Monthly reports

Measurements and instrumentation

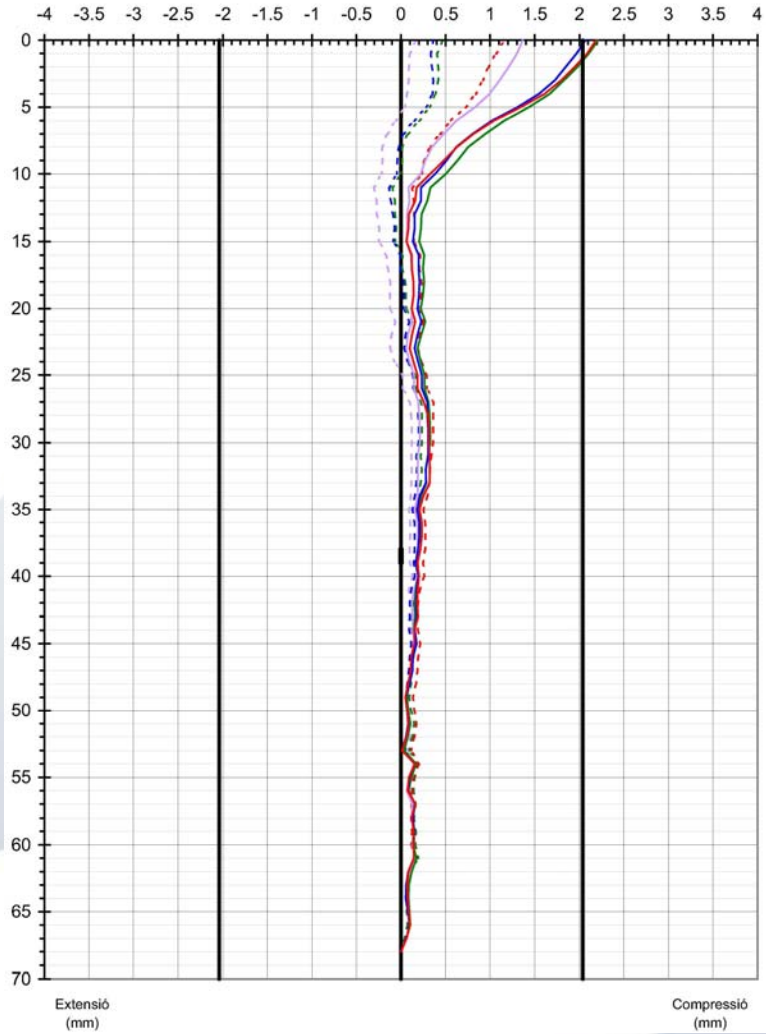


Measurements and instrumentation

Deformations, TUB M1A



Deformations, TUB M3A



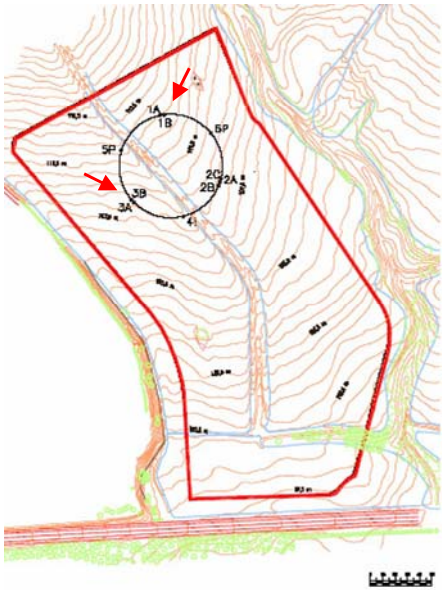
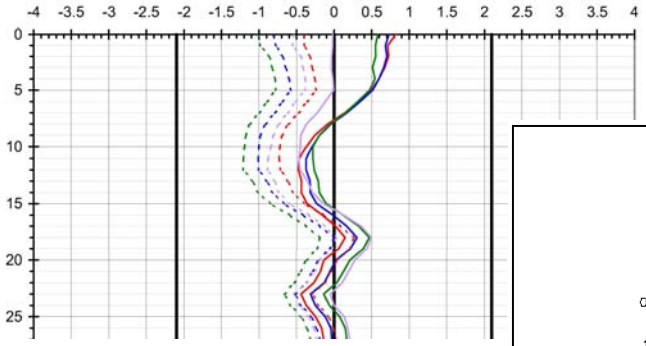


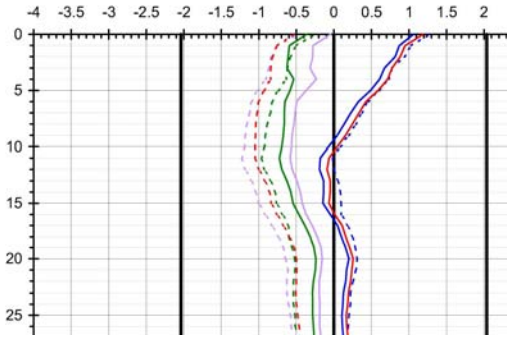
Figure 1: Location of the Installed Field Sensors

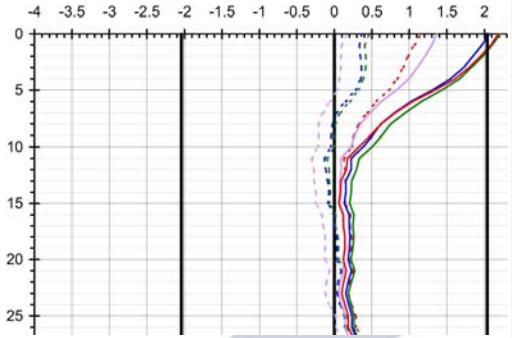
Mesura de referència:
0 — 03/06/04

Mesura:	Data:
12	26/11/04
13	22/12/04
14	31/01/05
15	28/02/05
16	29/03/05
17	28/04/05
18	30/05/05
19	29/06/05

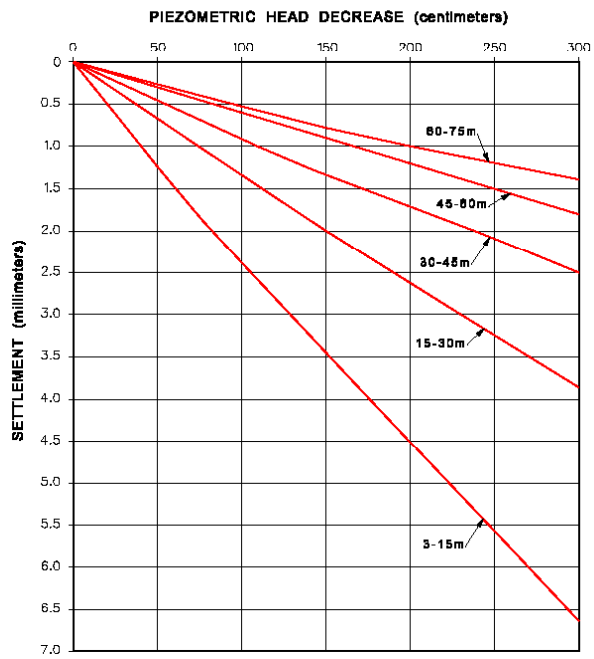
Measurements and instrumentation







- **Assumptions**



LEGEND

60-75m Ground depth interval

ESTIMATED SETTLEMENTS DUE TO PIEZOMETRIC HEAD DECREASES

(For different depth intervals of the ground)

FIGURE 3

e subsoil within the top 15 m of
resulting **vertical differential**
the top surface of about **4 mm**
a.

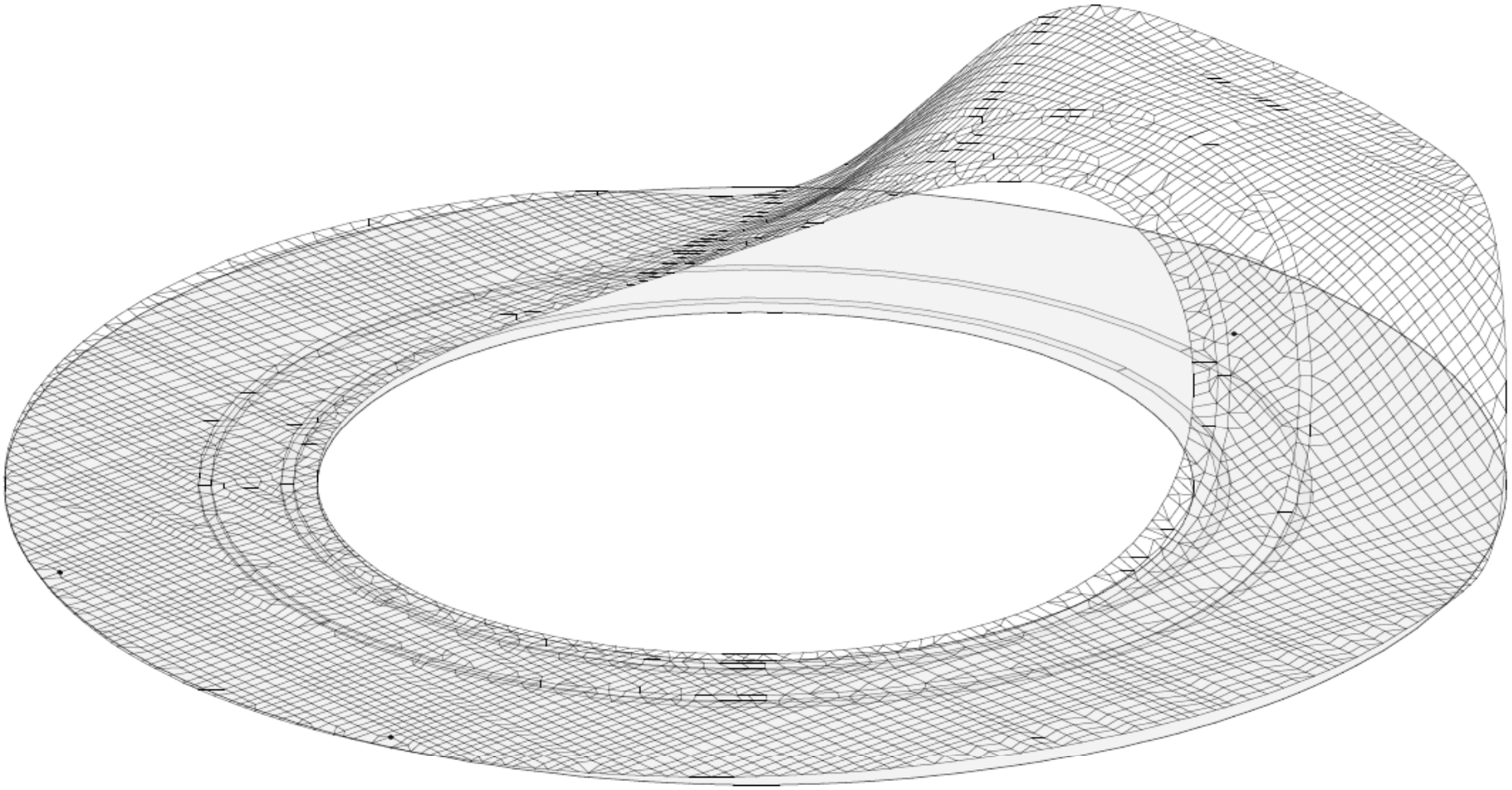
fected area within the critical floor

nded on the ground.

ab surface deformations.

ulting slab deformations with
puter models.

Simulation

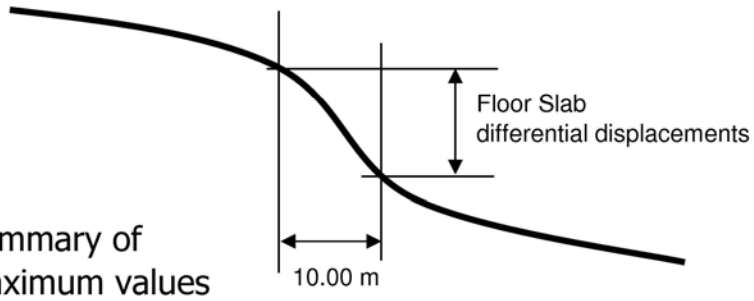


Simulation

Floor Slab differential displacements (mm/10m)

	Slab thickness	alpha = 45°		alpha = 75°		alpha = 135°	
		Trajektory R = 42.80 m	Tangential to the trajektory	Trajektory R = 42.80 m	Tangential to the trajektory	Trajektory R = 42.80 m	Tangential to the trajektory
Model H&S	**t = 1.00 m**	1.25	1.50	1.25	1.30	1.30	1.50
	t = 1.80 m	1.10	1.30	1.20	1.15	1.10	1.30
	t = 8.00 m	0.60	0.40	0.60	0.50	0.55	0.50

		t = 1.80 m	***t = 1.00 m***
PLAXIS	equal upheave	1.70	1.95
	triangular uph	1.35	1.50
	upheave 2 m	2.00	
	upheave 5 m	1.85	
	upheave 10 m	1.40	1.70
	upheave 15 m	1.20	



Summary of
Maximum values

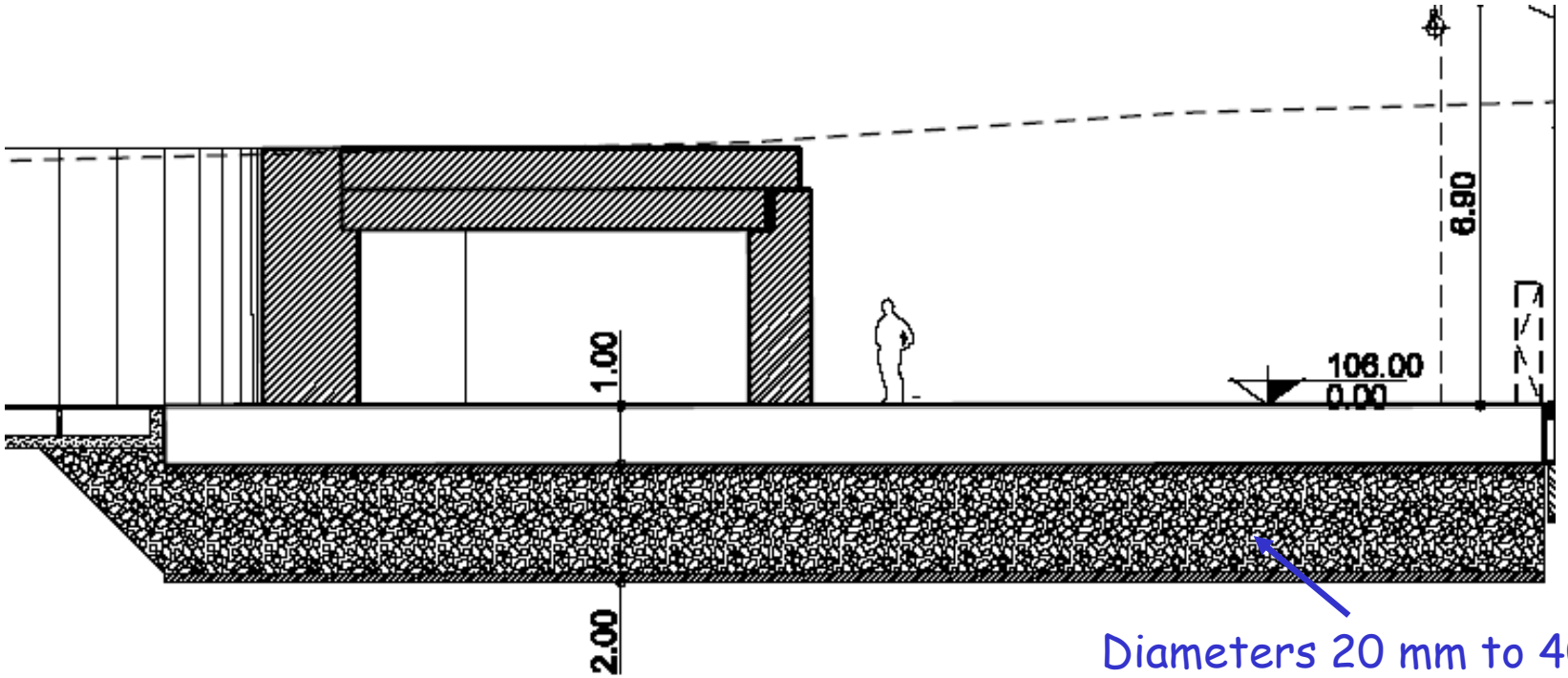
Conclusion

Mechanical Stability/deformations main conclusion

The critical area stability specification, 0.25 mm over 10 m per year can not be guaranteed due to the autogenous movements of the soil

Continue monitoring soil as much as possible

Solution

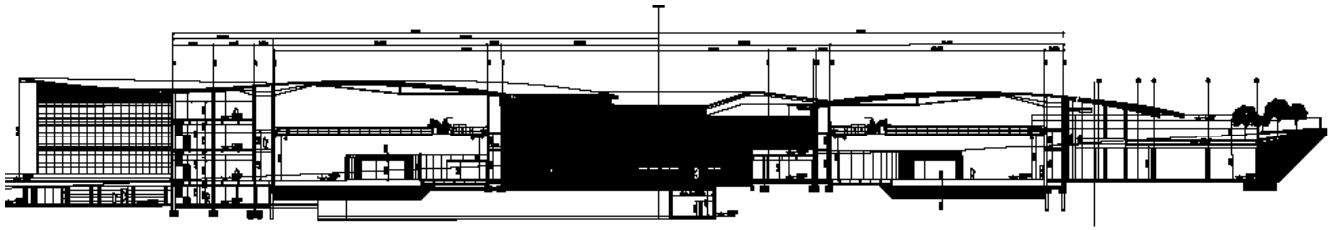


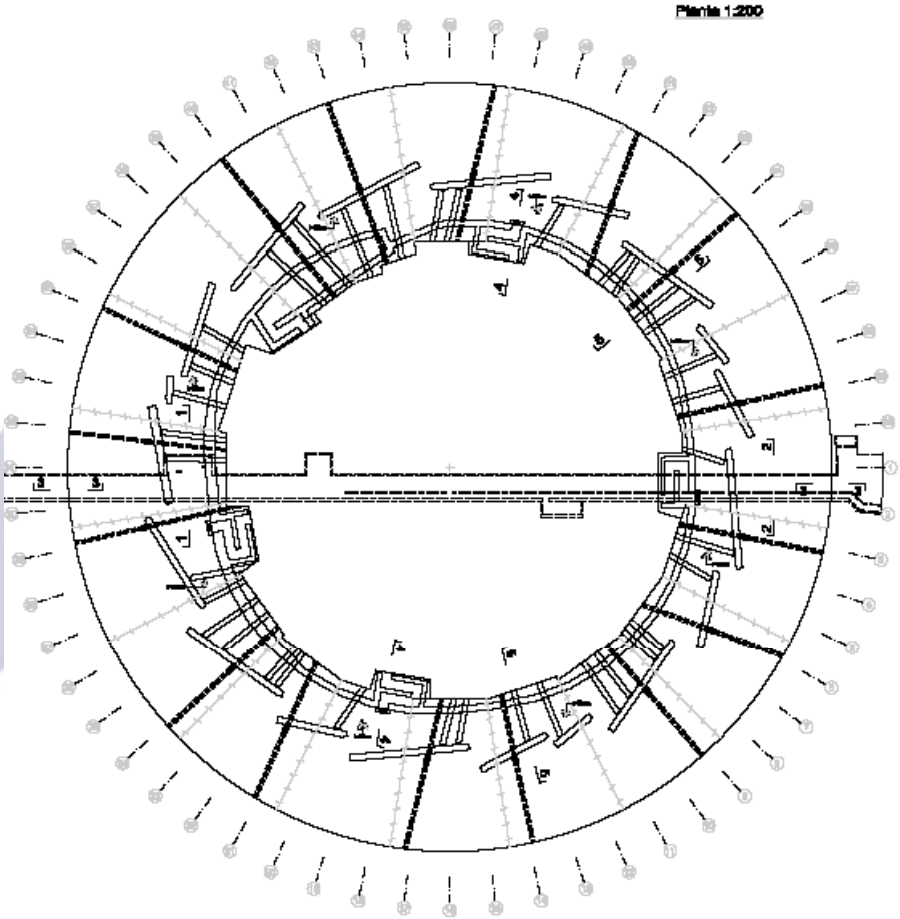
Diameters 20 mm to 40 mm

Cross section of the solution for the critical floor area

Solution

Cross section of the ALBA buildings





Top view of the critical floor area

Construction method

Initial Status

June 06'

Image © 2008 Institut Cartogràfic de Catalunya
©2007 Google™
Puntero 41°29'14.88" N 2°06'35.81" E
Secuencia 100%
Alt. ojo 1.86 km

June 06'

- Works started on the 26th May.
- Site conditioning. Vegetal layer removal.
- Start excavation up to level 105,5 m.

Initial Status

Vegetal layer removal

After Vegetal layer removal

Start excavation

July 06'

- Excavation to level 105,5 m.
- Geothecnical instrumentation movement.
- Start preparation for the execution of the deep conventional foundations (piles).
- Start sewage construction. Provisional and definitive.

Sewage works

Soil movements

August 06'

- Soil movement to level 105,5 m finalized. Sewage provisional connection executed.
- Services tunnel excavation started.
- Preparation of conventional deep foundations finalized.
- 85 piles executed.

Soil movements

Piles execution

Start services tunnel excavation

Sewage connection

September 06'

- Services tunnel excavation. Collapse of slopes due to strong rains.
- 145 piles executed.
- Final sewage network works.

Sewage works

Piles execution

Services tunnel excavation

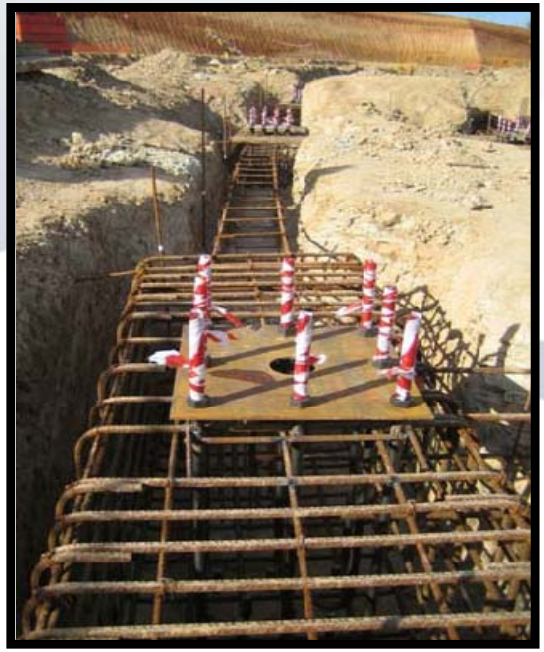
October 06'

- Services tunnel excavation.
- Piles execution completed.
- Surface foundations start.
- Ground network start.

Services tunnel excavation

Piles execution

Surface foundations



November 06'

- Services tunnel slab execution.
- Critical floor area excavation.
- Surface foundations completion.
- Services tunnel walls construction start.

Services tunnel slab execution

Services tunnel walls construction

Critical floor area excavation

Surface foundations execution

December 06'

- Services tunnel slab execution.
- Critical floor area excavation.
- Services tunnel walls construction.

Critical floor area excavation

Services tunnel

January 07'

- Services tunnel slab execution.
- Critical floor area excavation completion.
- Technical building slab start
- Technical building excavation completion.
- Services tunnel walls construction.

February 07'

- Critical floor area gravel.
- Technical building basement execution.
- Services tunnel walls construction.

March 07'

- Critical floor area gravel.
- Technical building basement execution.
- Services tunnel walls construction.

1

2

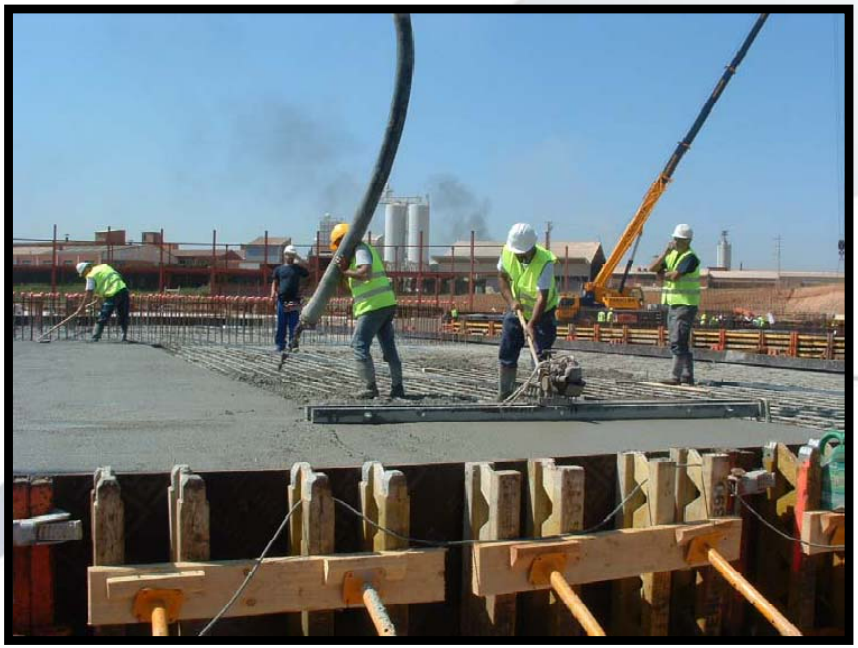
40 cm layers

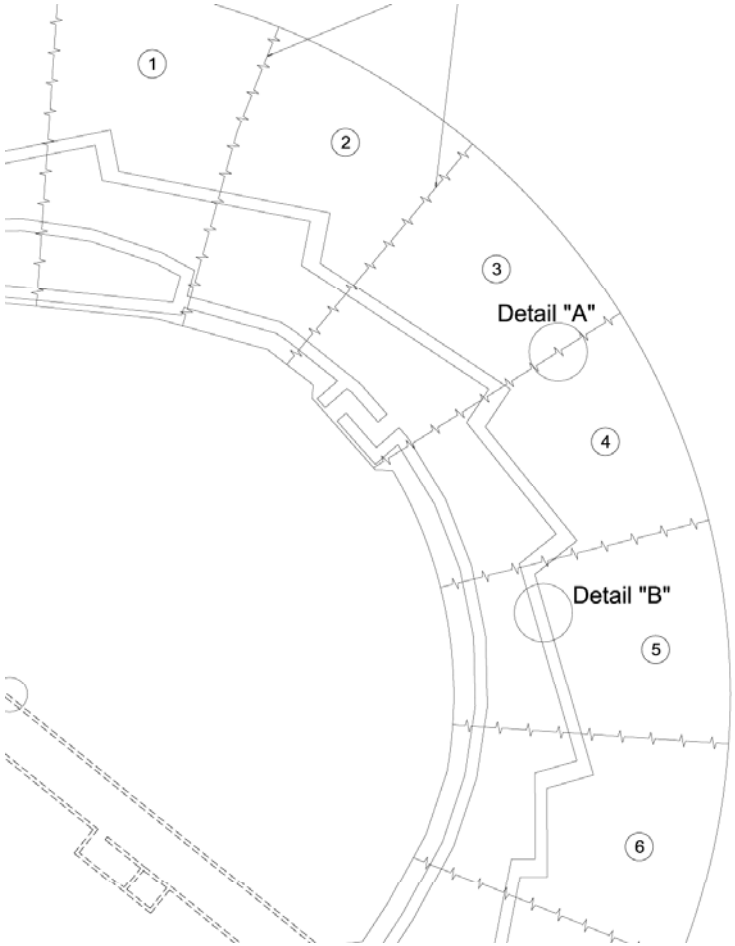
3

4

April 07'

- Critical floor area gravel.
- Critical floor area slab start.
- Services tunnel walls construction.





Main data for one segment

Length along outer radius 18.85 m

Length along inner radius 11.30 m

Width of test ring approx. 24.0 m

- Area of single segment 365 m^2
- Concrete quantity 365 m^3
- Ordinary reinforcement 32 tons

Total 20 segments for critical floor slab

April 07'

- Critical floor area slab.
- Services tunnel roof construction.

May 07'

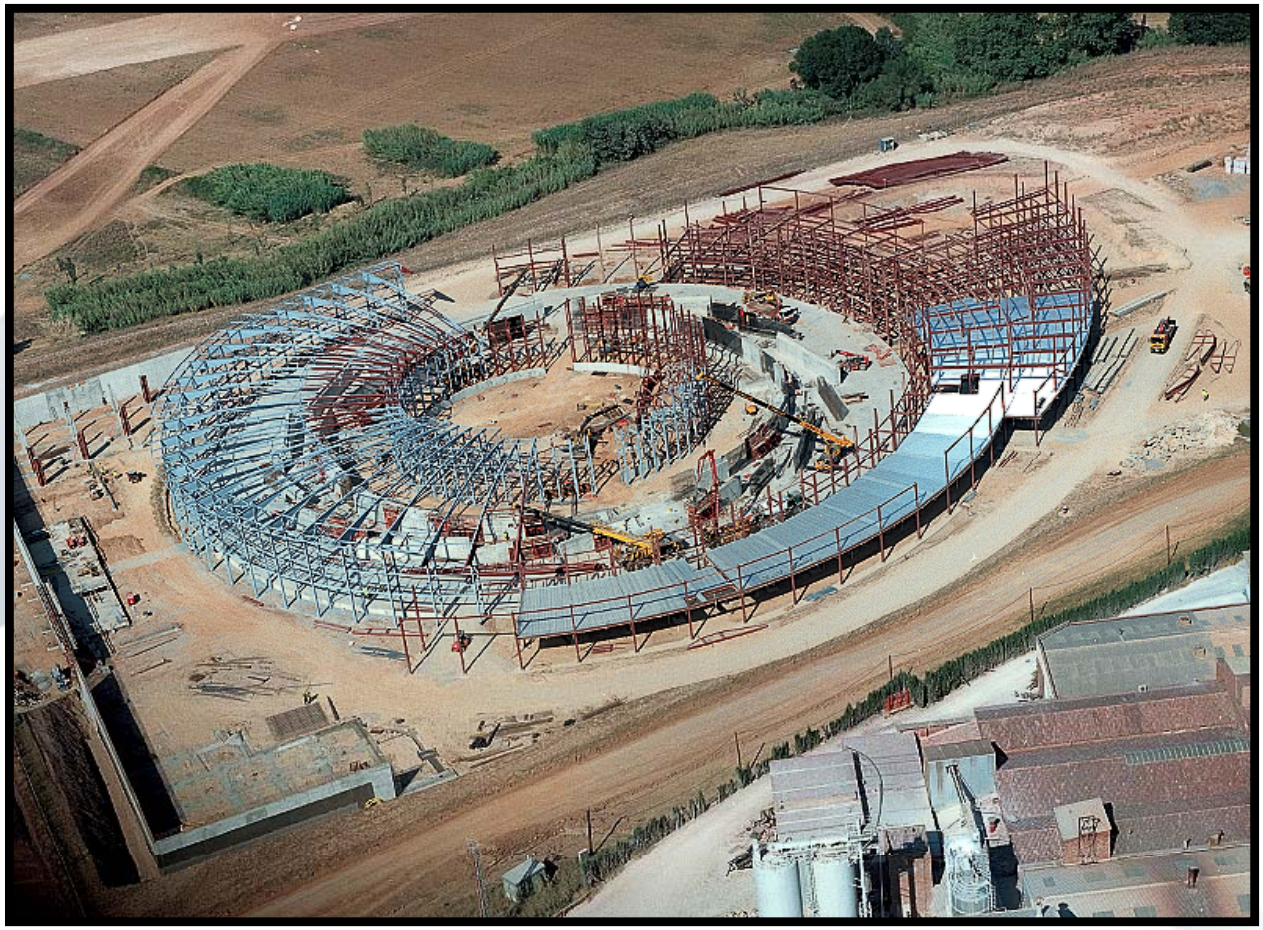
- Critical floor area slab.
- Shielding tunnel start.

June 07'

- Critical floor area slab.
- Shielding tunnel execution.

July 07'

- Critical floor area completion.
- Shielding tunnel execution.



August 07'

- Shielding tunnel execution.

September 07'

- Shielding tunnel execution.
- Shielding tunnel roof installation.
- Front walls installation.

Vibrational Response

- Measurements
- Conclusion

Instrumentation. 2 units Güralp CMG-6TD three component digital seismometers

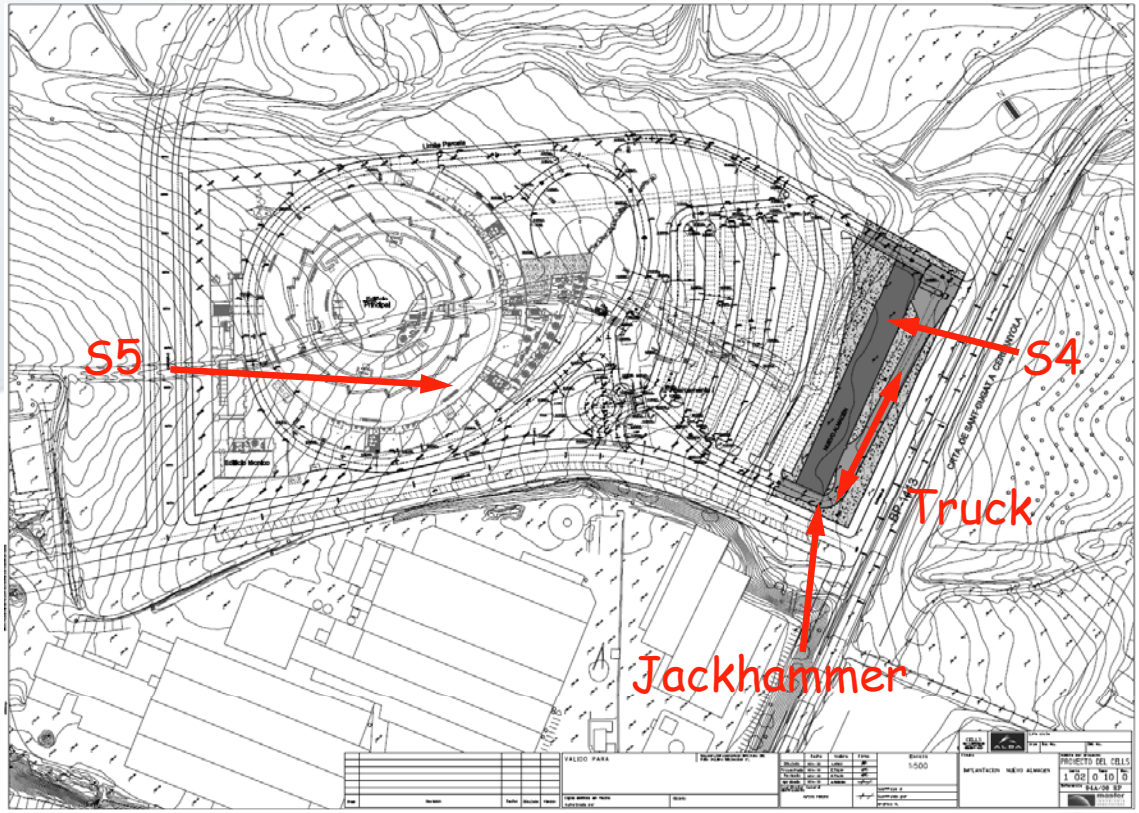
CMG-6TD

Digital broadband seismometer

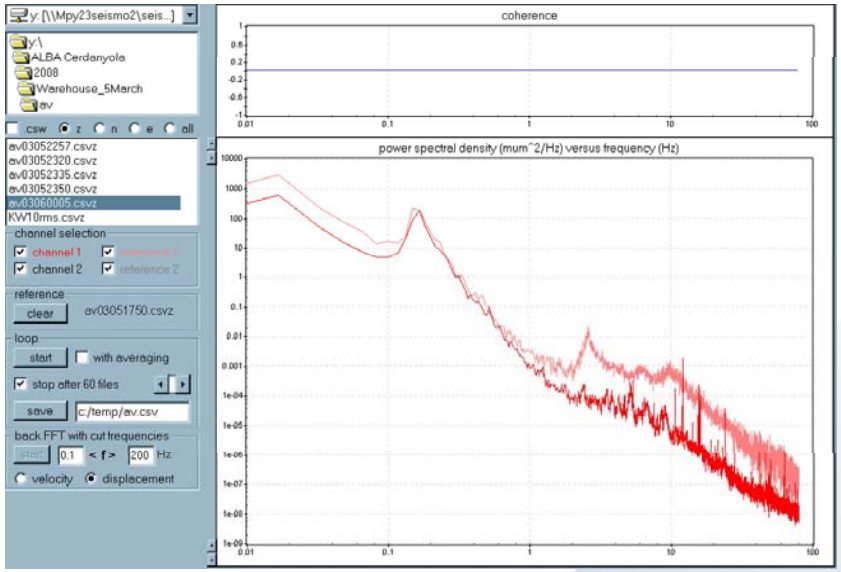
Velocity output high corner	100 Hz
Velocity output low corner	30 s (**optional** 60 s)
Velocity output sensitivity	2 × 1200 V/m/s,
Lowest spurious resonance	450 Hz
Linearity	> 95 dB
Cross-axis rejection	> 60 dB
Electronics noise level	–147 dB (rel. $1 m^2 s^{-4} Hz^{-1}$)
Data output format	GCF over RS232, Firewire, Ethernet or Wi-Fi
Sample rates	1000 – 1 samples/s
Digitizer resolution at 1 sample/s	21 bits

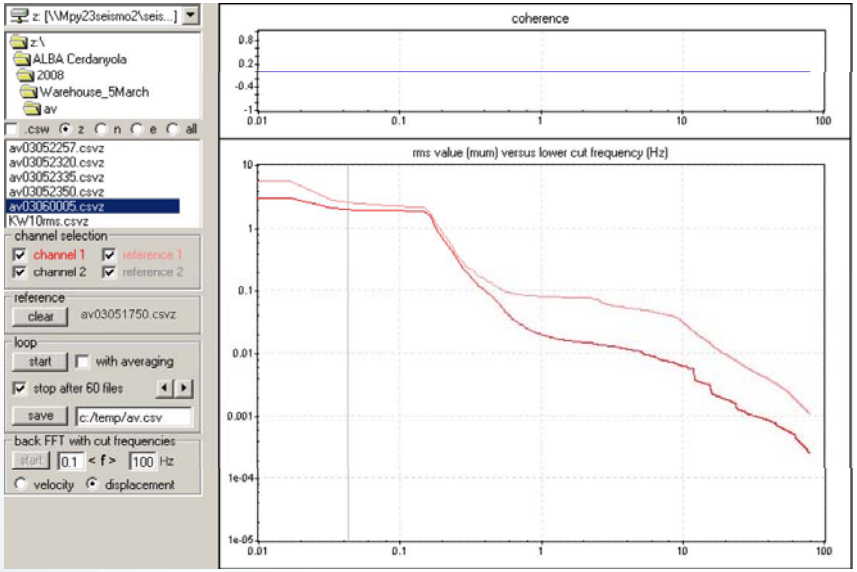
Case 1

- Measurements on 5th March 2008
- Measurements after site working time
- Sensors nearby the warehouse (S4), and on the critical floors area slab (S5)
- Measurements conditions
  - Road traffic
  - Truck on warehouse road
  - Jackhammer.
  - Factory activity



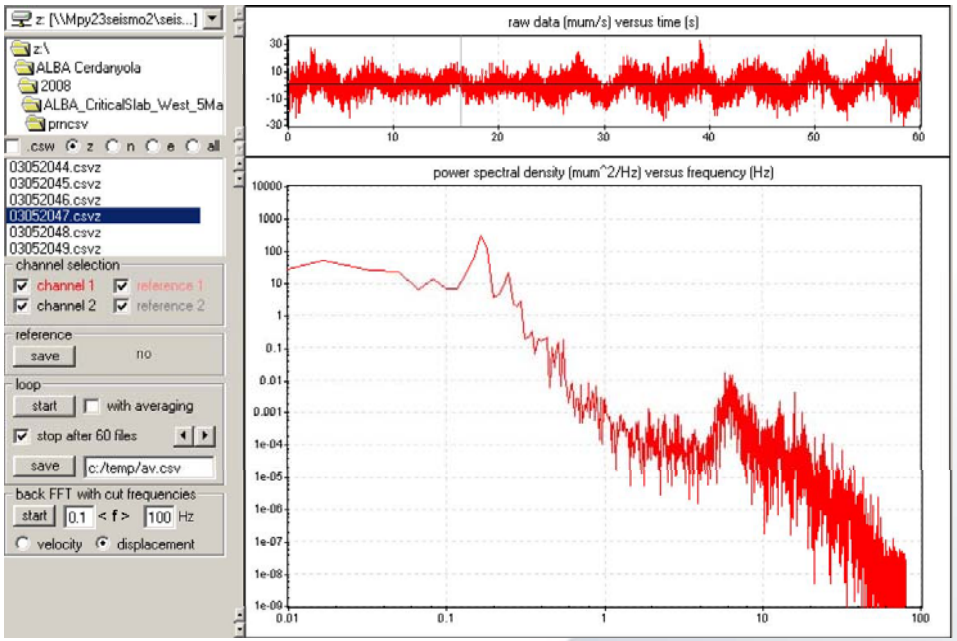
Road traffic evaluation at S4

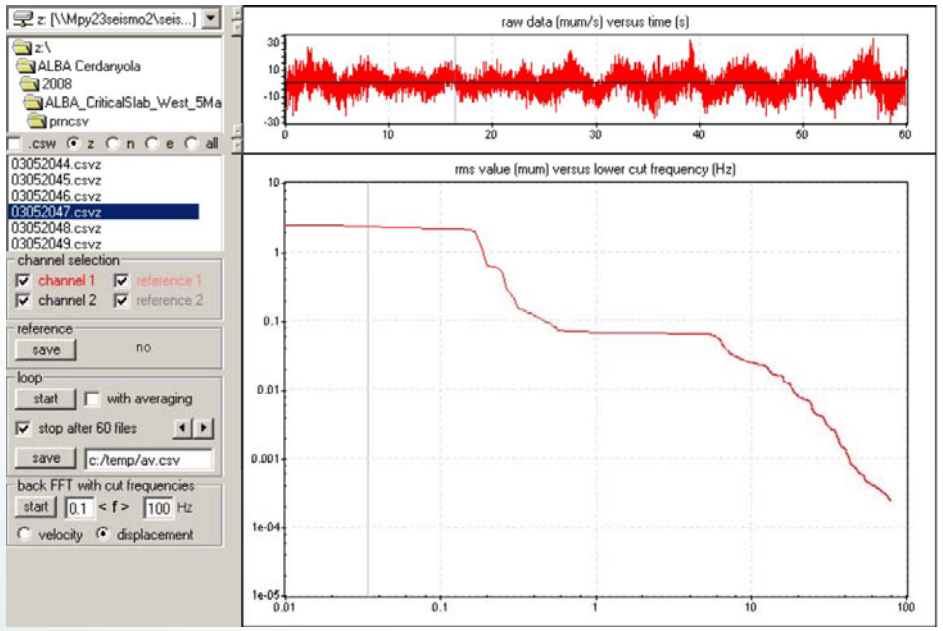




- Difference between traffic at 17:50 and at midnight, 00:05 (15 minute averages),@ 1 Hz, 79 nm vs. 20 nm respectively. 12 Hz, 16 Hz, 24 Hz lines are seen in the midnight spectra, most probably due to motors running in the ceramic factory.
- Instantaneous substantial variations up to 123 nm)@ 1 Hz.

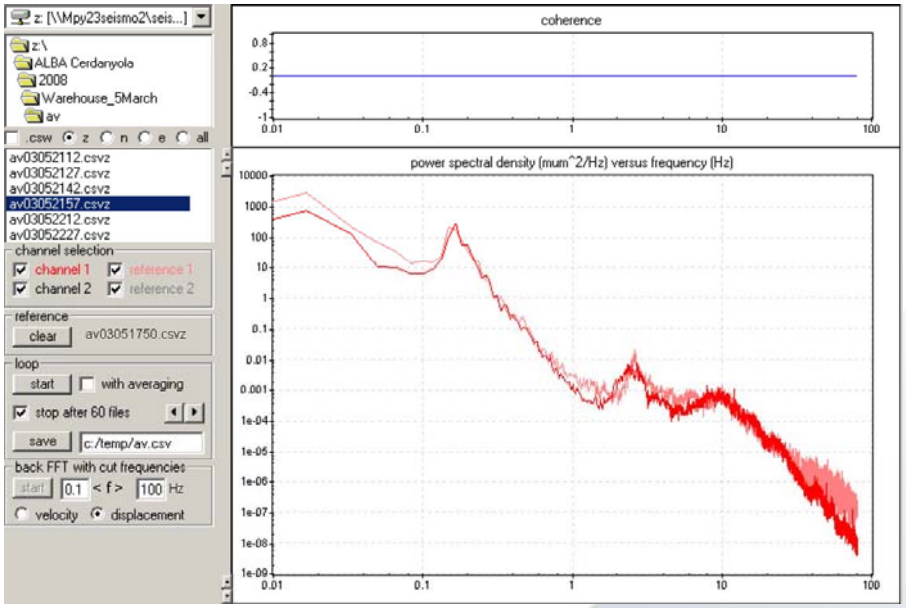
Road traffic evaluation at S5

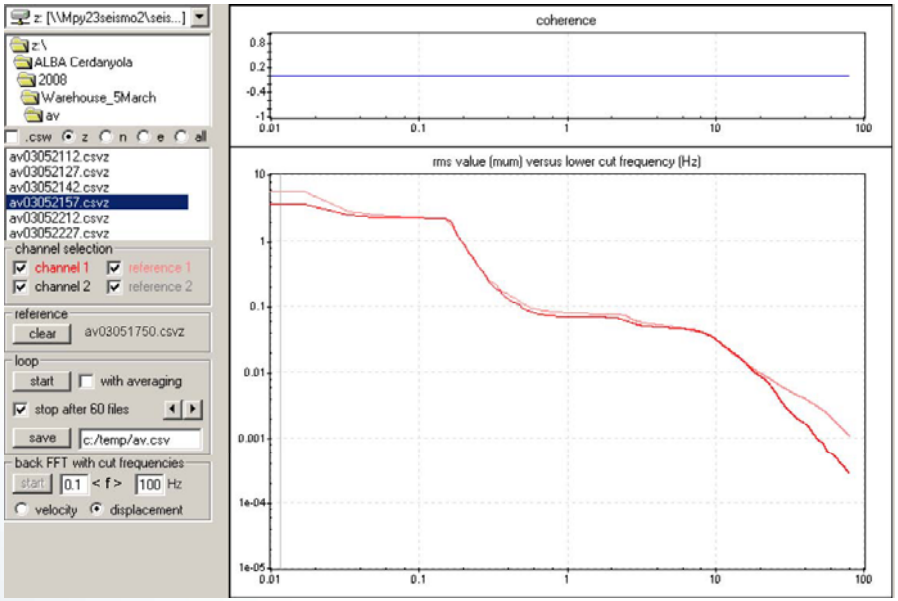




The slab registers the traffic as it is low frequency noise, but the amplitudes are lower. There are instantaneous fluctuations, for example, 67 nm at 1 Hz is registered and a very clear bump at 6 Hz, due to traffic in the road is detected.

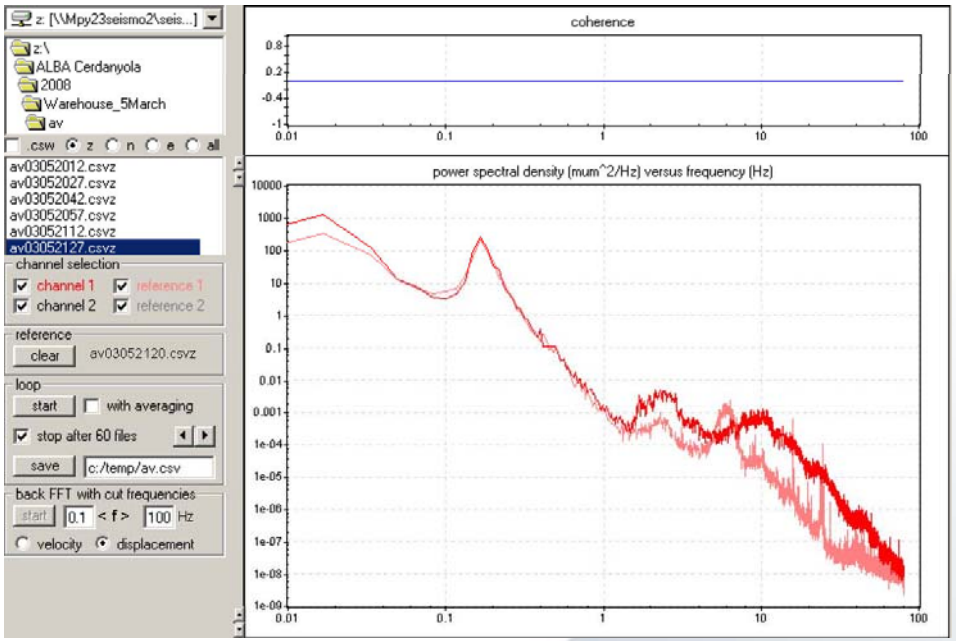
Road traffic simulated by truck at S4

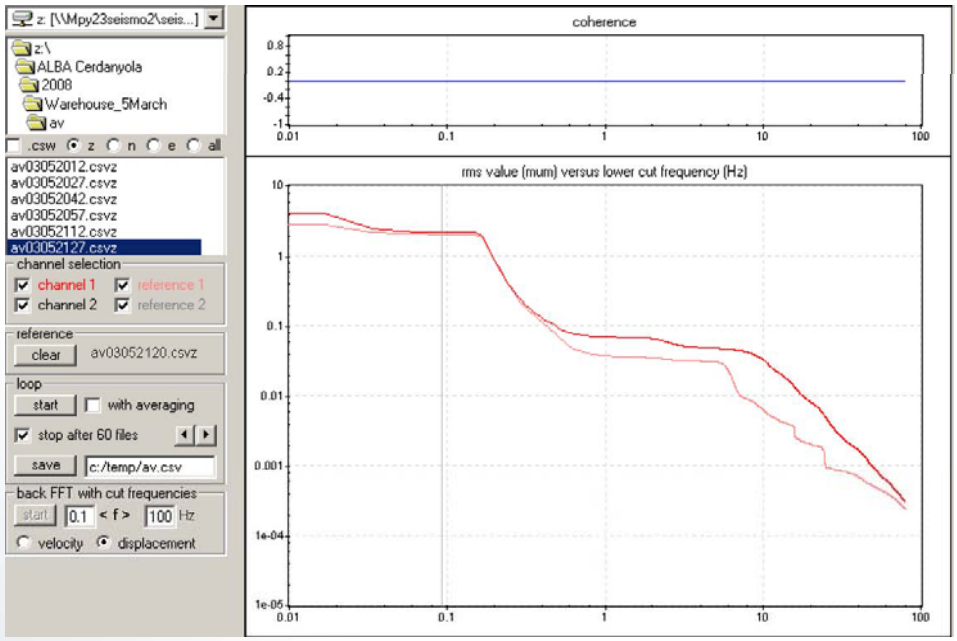




- Truck driving on the road nearby the warehouse could simulate the traffic in the late afternoon. Traffic at 17:50 @ 1 Hz is 79 nm compared with truck at 21:57 which is 69 nm at this frequency region.
- Minute by minute fluctuations can get up to 85 nm.

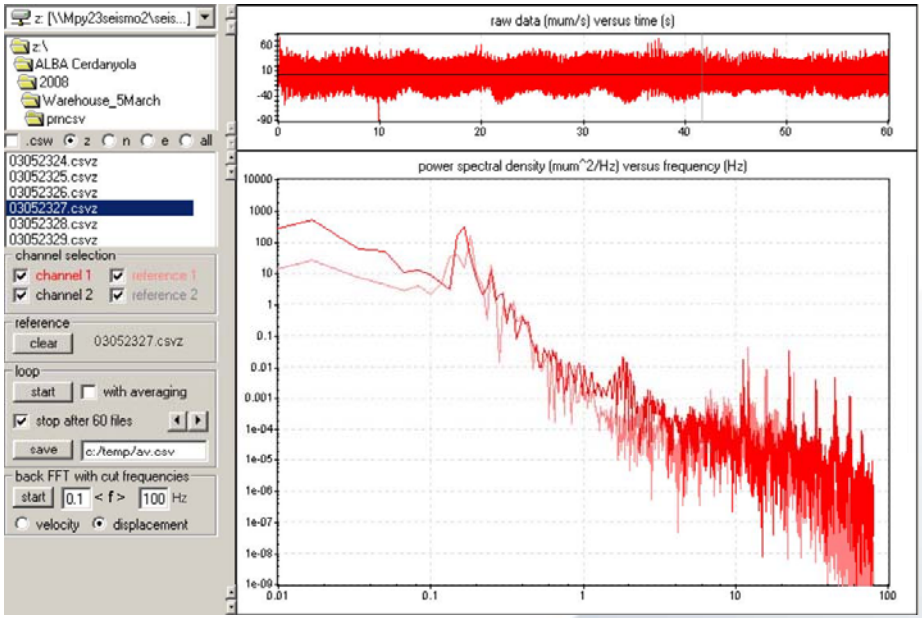
Road traffic simulated by truck at S5

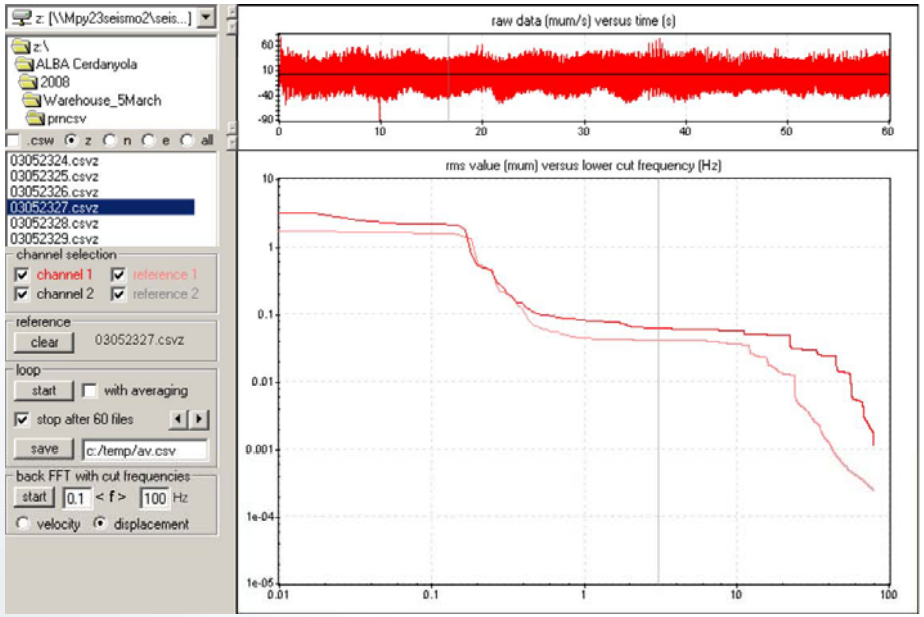




Smaller amplitude of vertical vibration is registered at S5 wrt to S4. Two lines @ 16 and 24 Hz are however detected on the slab which are due to the motors of the factory. @ 1 Hz, S5 registers a movement of 37 nm, S4 registers 68 nm (15 minutes average files).

Comparison S5 vs S4 due to jackhammer

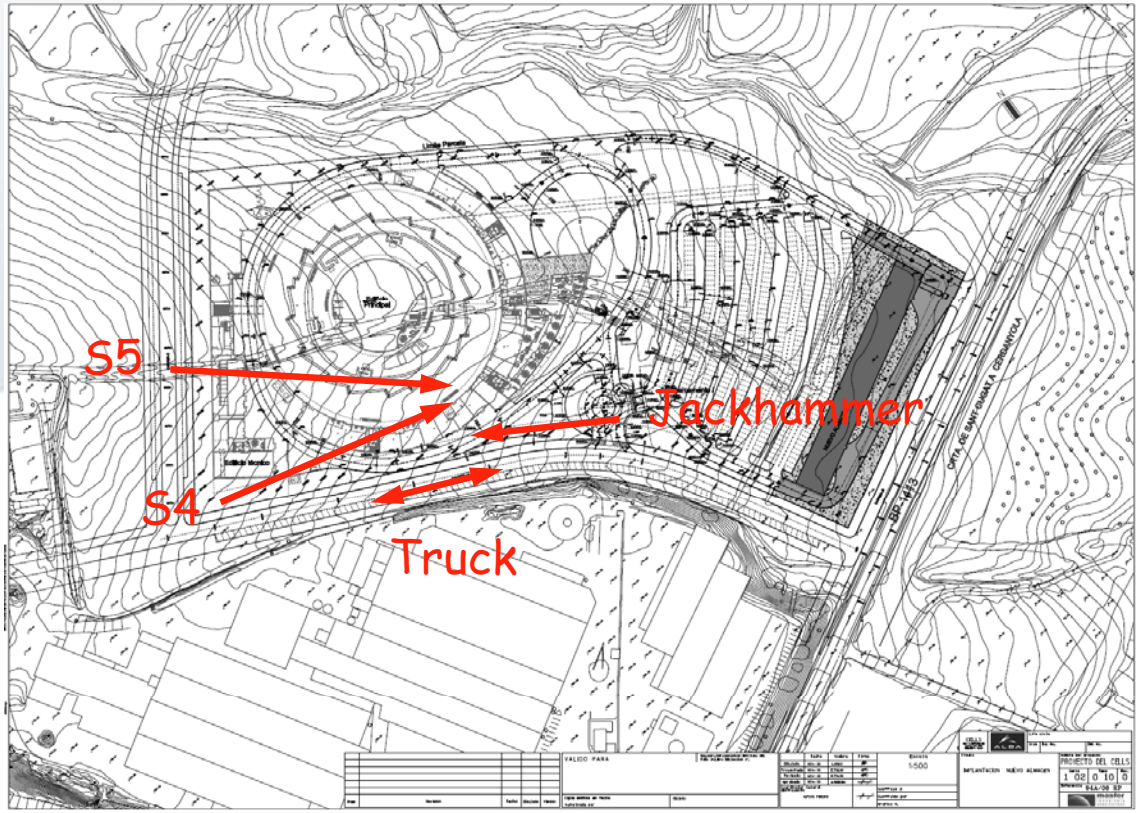




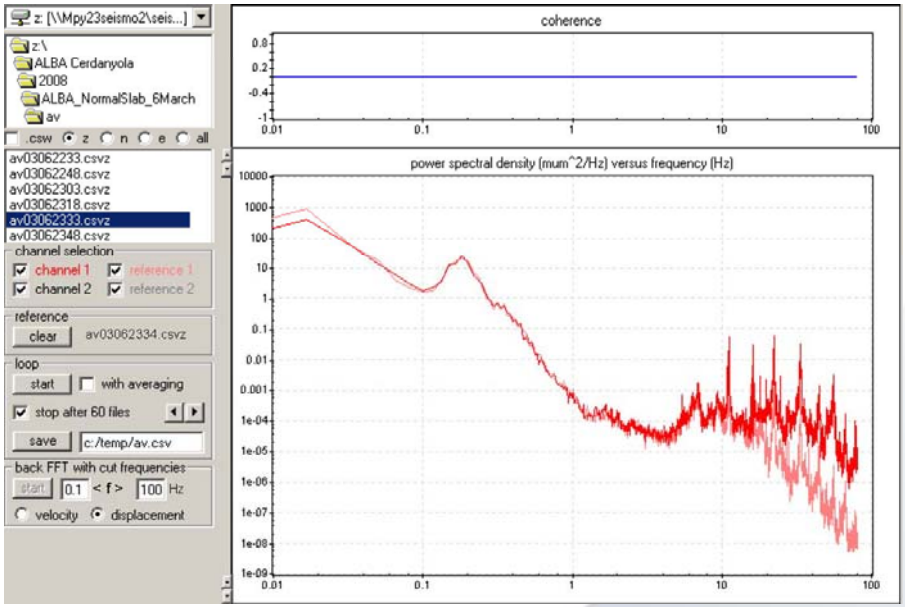
The slab dampens all high frequency components generated by the jack hammer.
The vertical vibration amplitude @ 1 Hz is 81 nm measured at S4 and 44 nm at S5.

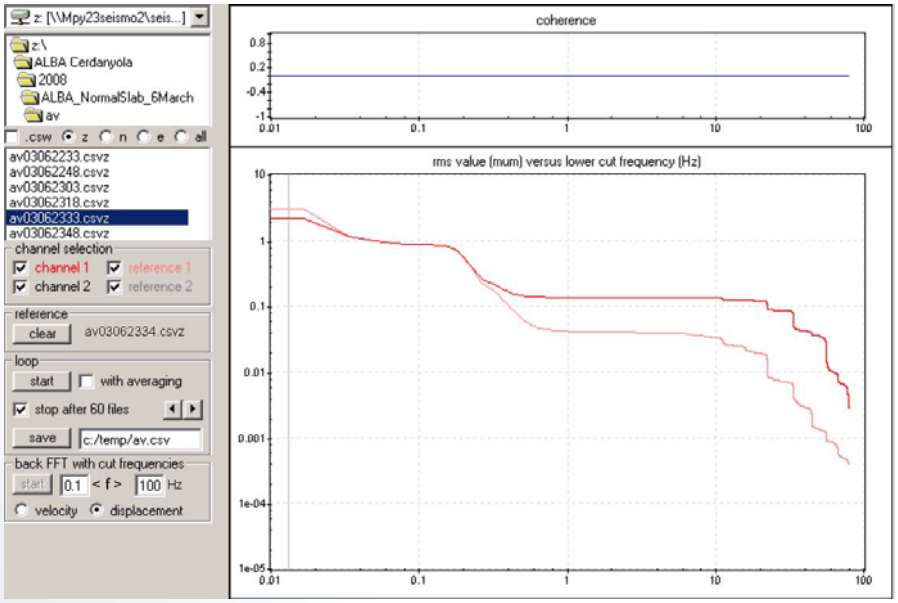
Case 2

- Measurements on 6th March 2008
- Measurements after site working time
- Sensors on corridor (S5), and on the critical floors area slab (S4)
- Measurements conditions
  - Road traffic
  - Truck on site path
  - Jackhammer
  - Factory activity



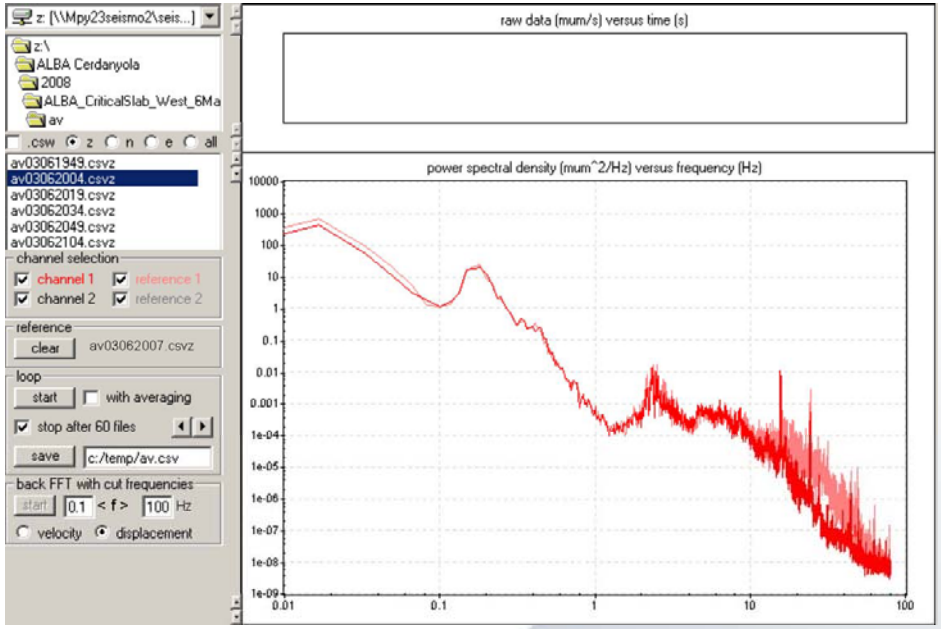
Comparison S5 vs S4 due to jackhammer

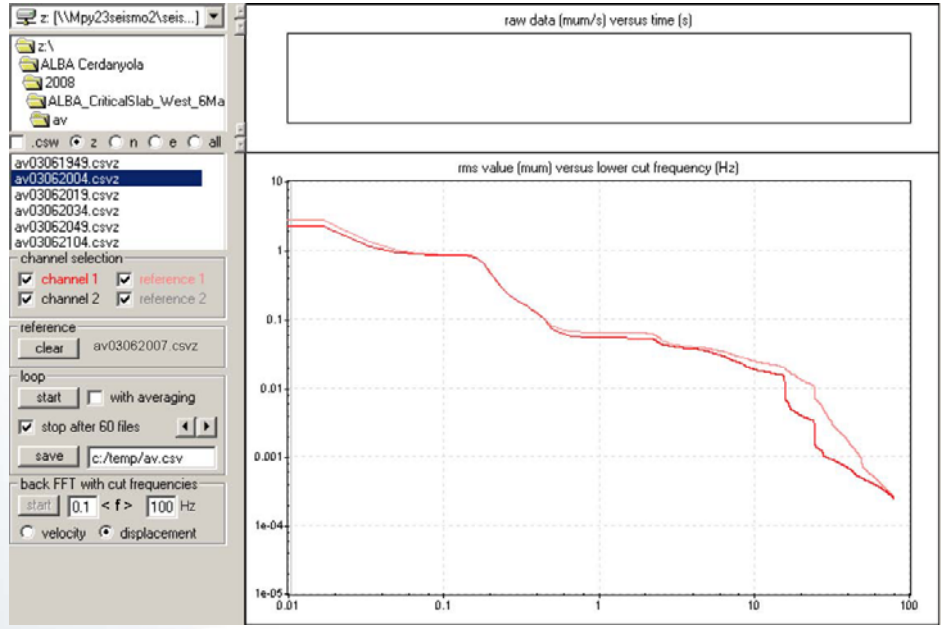




A jackhammer was used to generate high frequency noise (> 10 Hz). Many peaks are seen at 11, 18, 22, 33, 44, 55, 68 Hz which are due to jackhammer, plus the lines at 15, 16, 18, 20 Hz due to mills and motors of the ceramic factory. @ 1Hz, 41 nm of vibration is registered on S5 compared with 135 nm on S4. The critical slab seems to dampen high frequency technical noise.

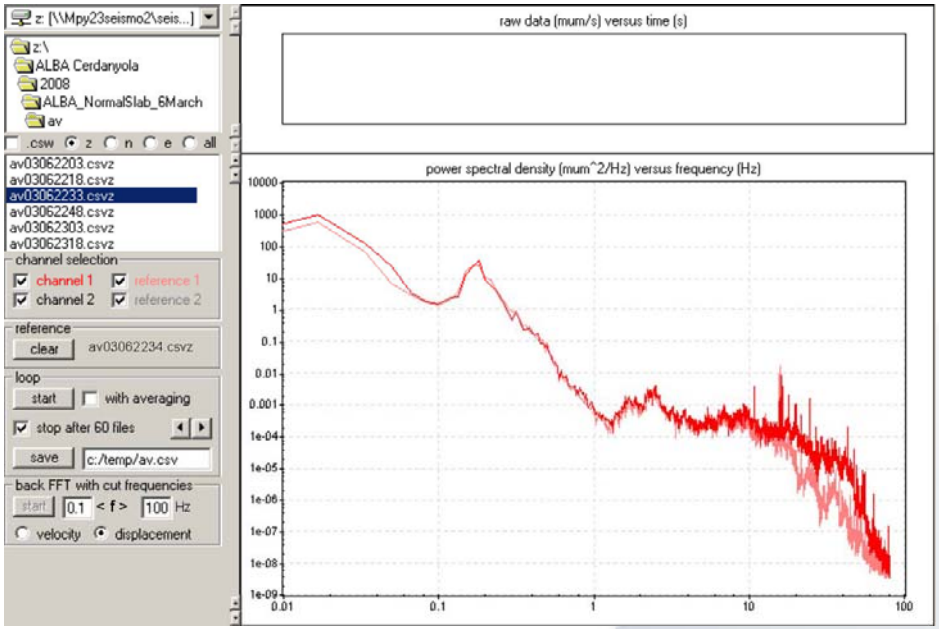
Comparison S5 vs S4 due to road traffic

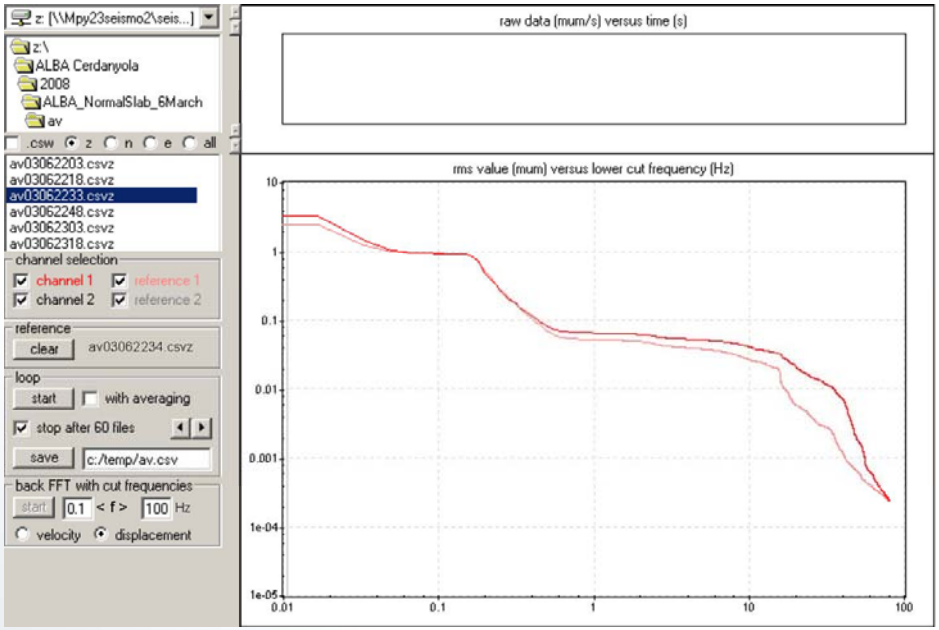




A comparison of 15 minute average files shows that the ALBA slab dampens high frequency noise, but the low frequency noise, due to traffic is not affected. @ 1 Hz, the amplitude measured at S5 is 54 nm at S4 is 64 nm

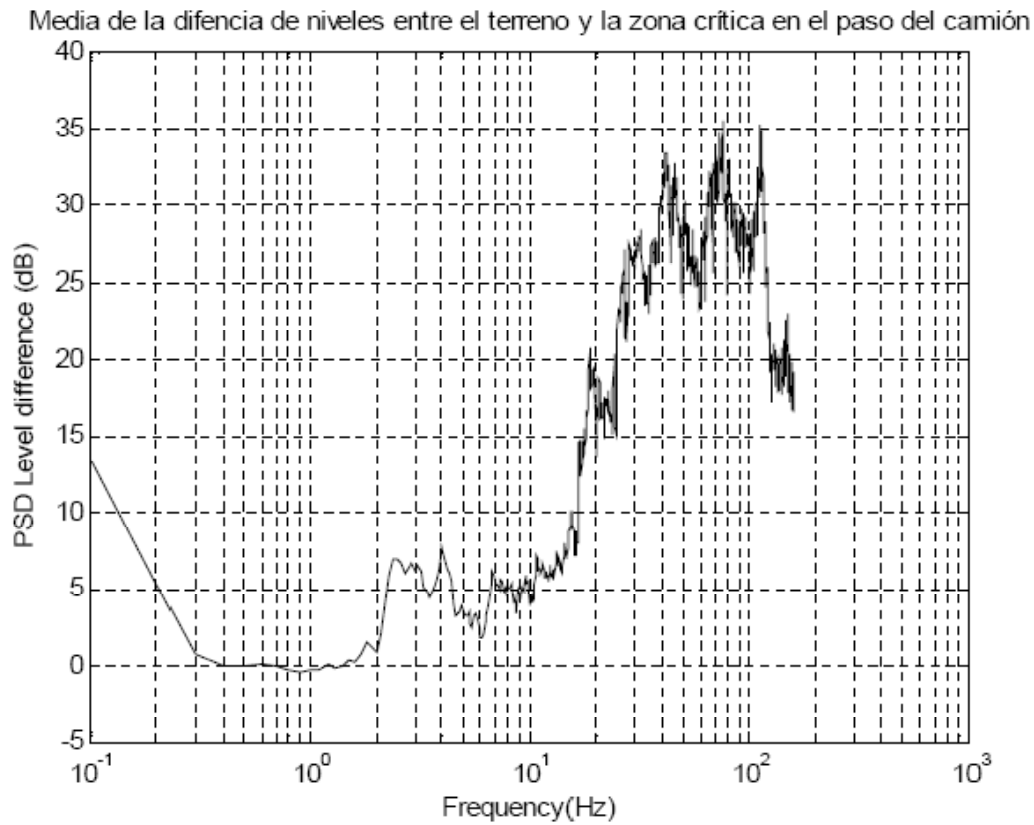
Comparison S5 vs S4 due to truck





15 minute average taken for S4 and S5. @ 1 Hz, the amplitude of the vibration is 65 nm and 52 nm respectively.

Measurements with accelerometers



- No attenuation up to 2 Hz.
- 5 dB up to 10 Hz.
- Up to 30 dB at 100 Hz.

CONCLUSIONS

- Critical Floor area foundation solution has dumping effects with increasing vibration frequency.
- No dumping effects below 2 Hz.
- 5 dB dumping effect up to 10 Hz.
- Up to 30 dB dumping up to 100 Hz.
- Factor 3 amplitude dumping for above 1 Hz frequencies.
- Coherent results accelerometers vs seismometers.

THANKS FOR YOUR ATTENTION