Physical modelling of anchored steel sheet pile walls under seismic actions

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Current **design practice** of anchored SSP walls relies on simplified **pseudo-static methods** which may lead to **over-conservative** and **uneconomical design**.

More cost-effective design can be achieved employing **numerical analyses**. However, these have to be **carefully calibrated** and are often **computationally demanding**.

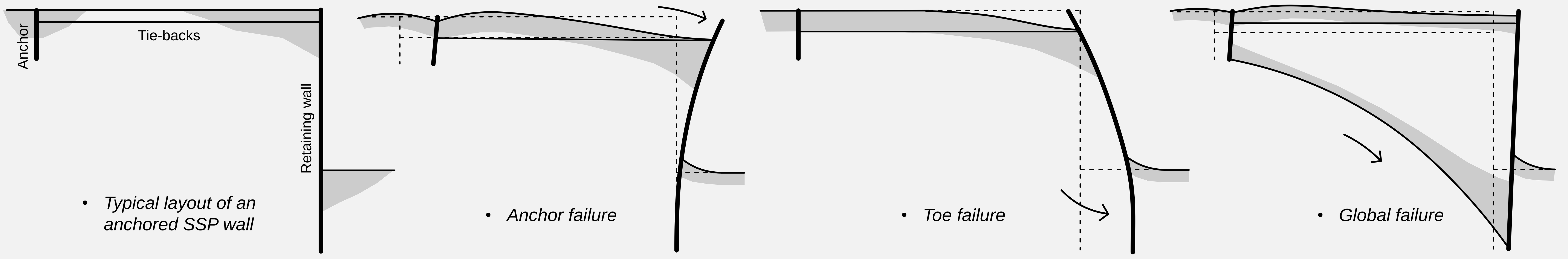
The availability of a **simplified displacement method** would give the opportunity to achieve a **more rational design** without the drawbacks of complex and time consuming analyses.

(1) Displacement: a simplified approach

A **Newmark's sliding block method** is typically employed to estimate permanent displacement of gravity and cantilevered retaining walls during an earthquake.

(2) How to extend it to anchored SSP walls?

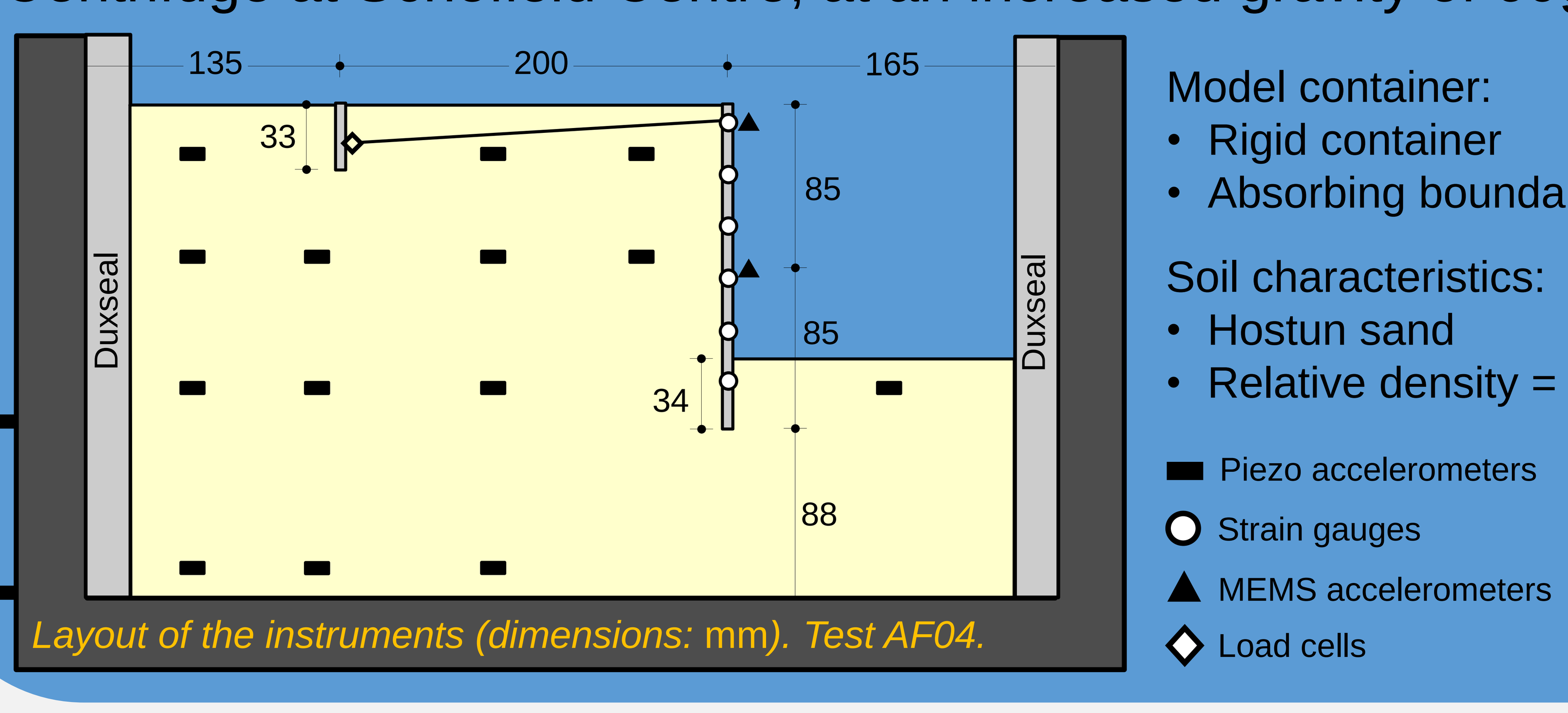
- Identify the **failure mechanism** occurring
- Evaluate the acceleration that fully mobilizes the resistance of the system, defined as **critical acceleration**



- *Typical layout of an anchored SSP wall*
- *Anchor failure*
- *Toe failure*
- *Global failure*

(3) Methodology: centrifuge testing

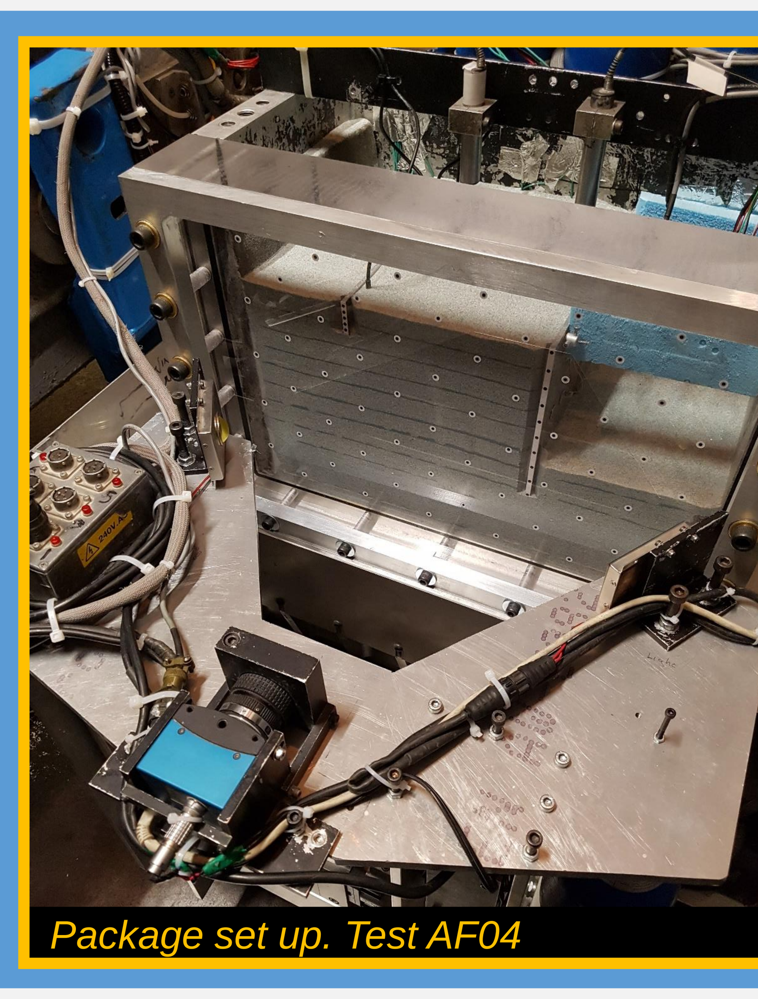
Four dynamic centrifuge tests were carried out on the Turner beam Centrifuge at Schofield Centre, at an increased gravity of 60g.



Layout of the instruments (dimensions: mm). Test AF04.

Model container:
- Rigid container
- Absorbing boundaries

Soil characteristics:
- Hostun sand
- Relative density = 50%



Package set up. Test AF04

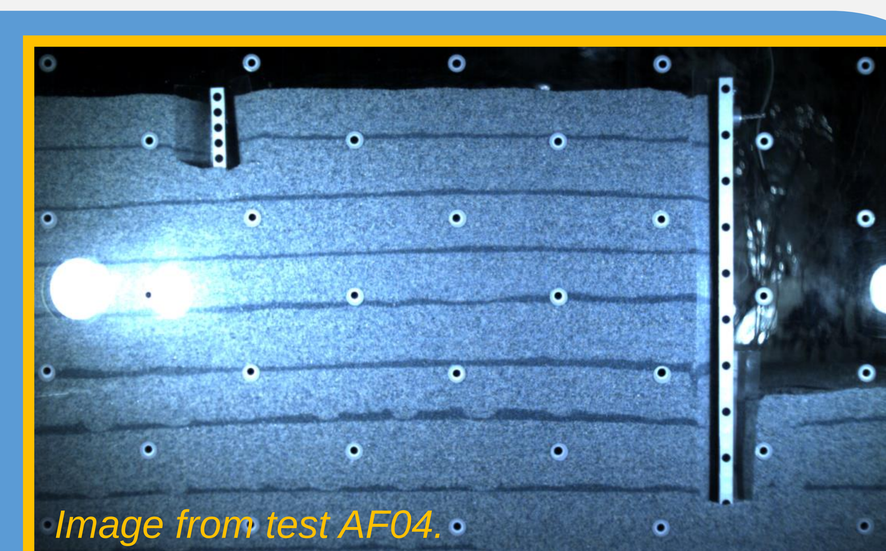
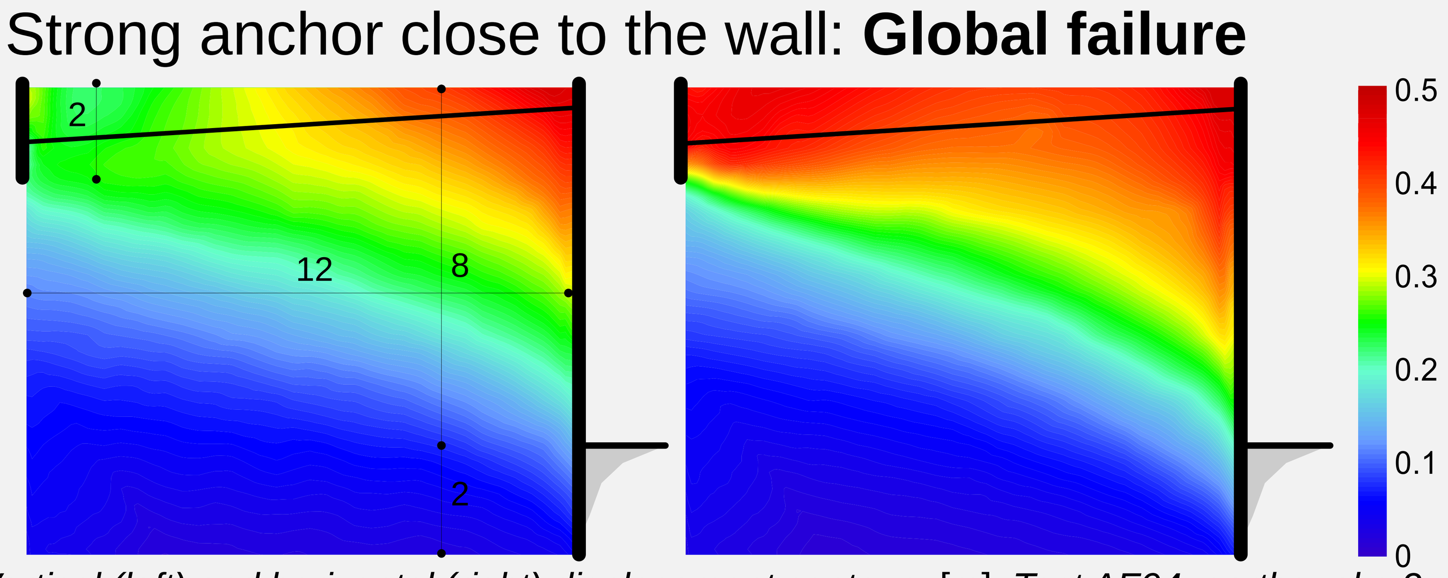


Image from test AF04.

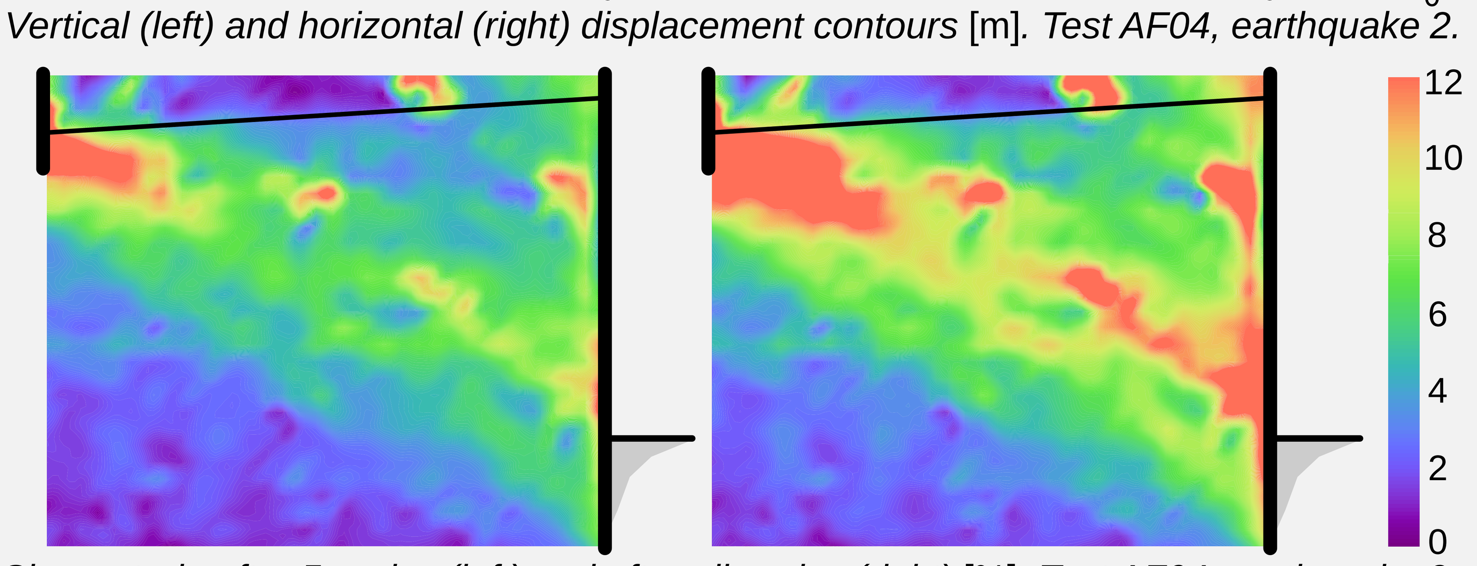
Particle Image Velocimetry:
Since identifying the correct failure mechanism is critical, PIV analyses are being employed to track the displacement field of the soil.

(4) Results

❑ Strong anchor close to the wall: **Global failure**

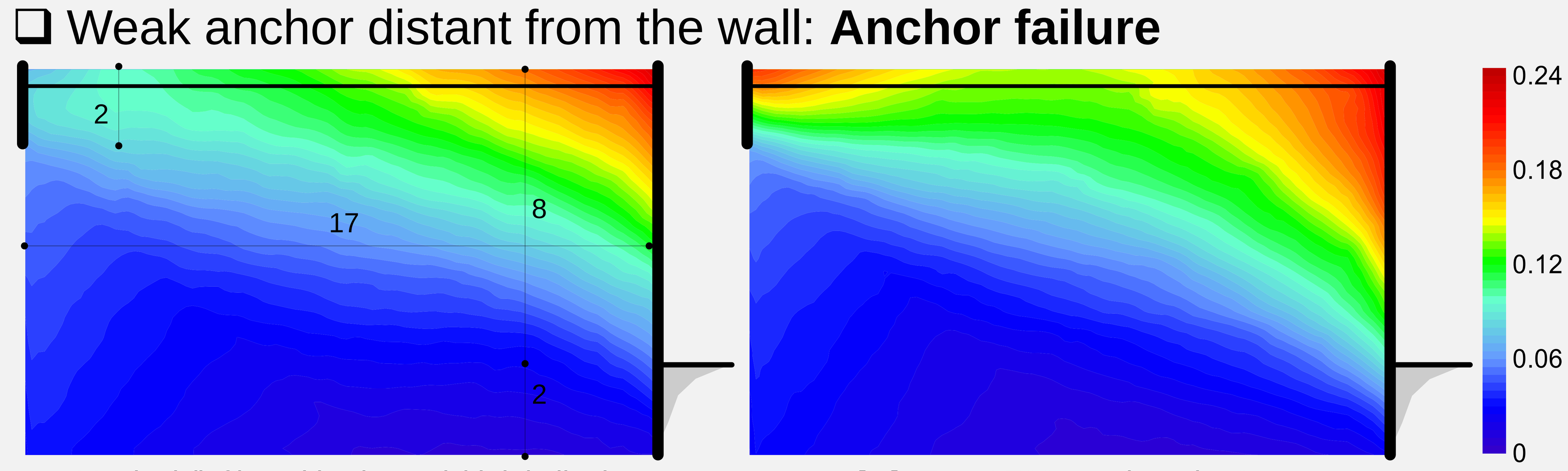


- *Vertical (left) and horizontal (right) displacement contours [m]. Test AF04, earthquake 2.*

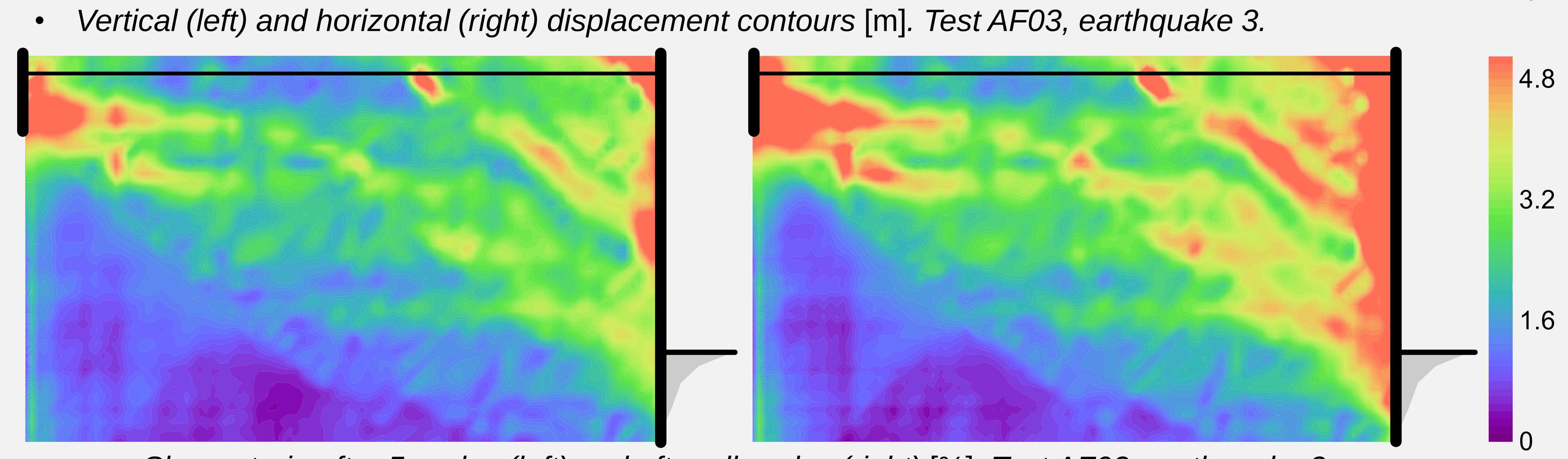


- *Shear strain after 5 cycles (left) and after all cycles (right) [%]. Test AF04, earthquake 2.*

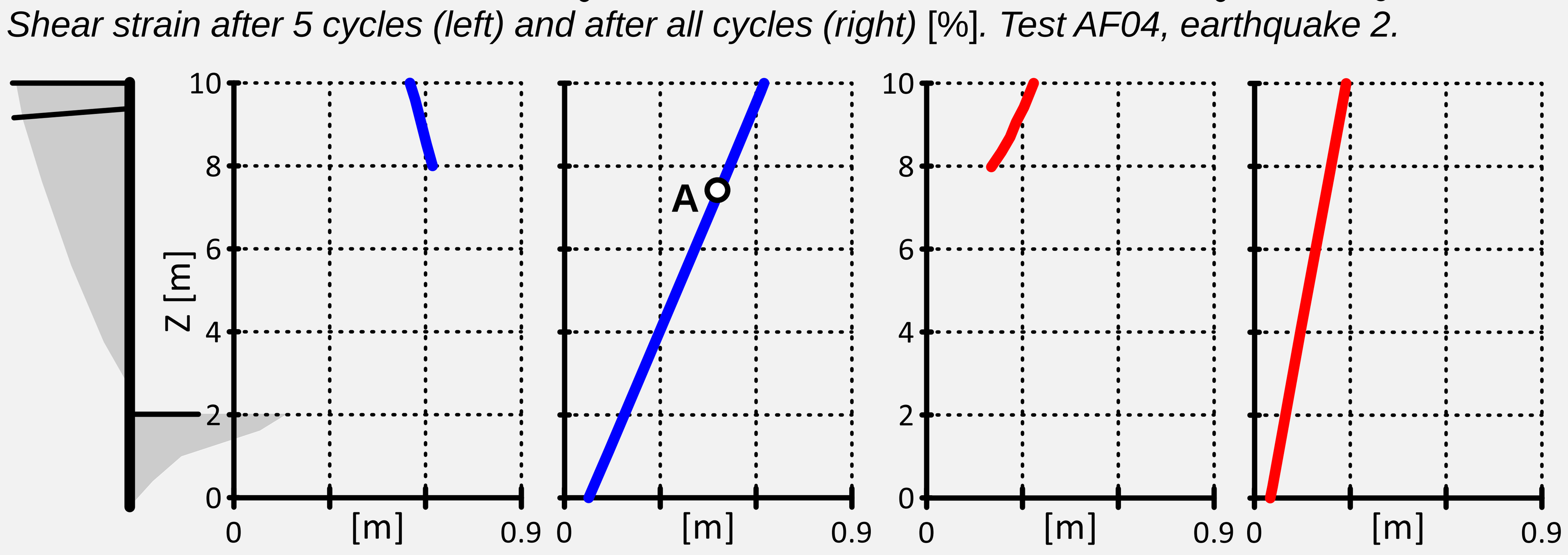
❑ Weak anchor distant from the wall: **Anchor failure**



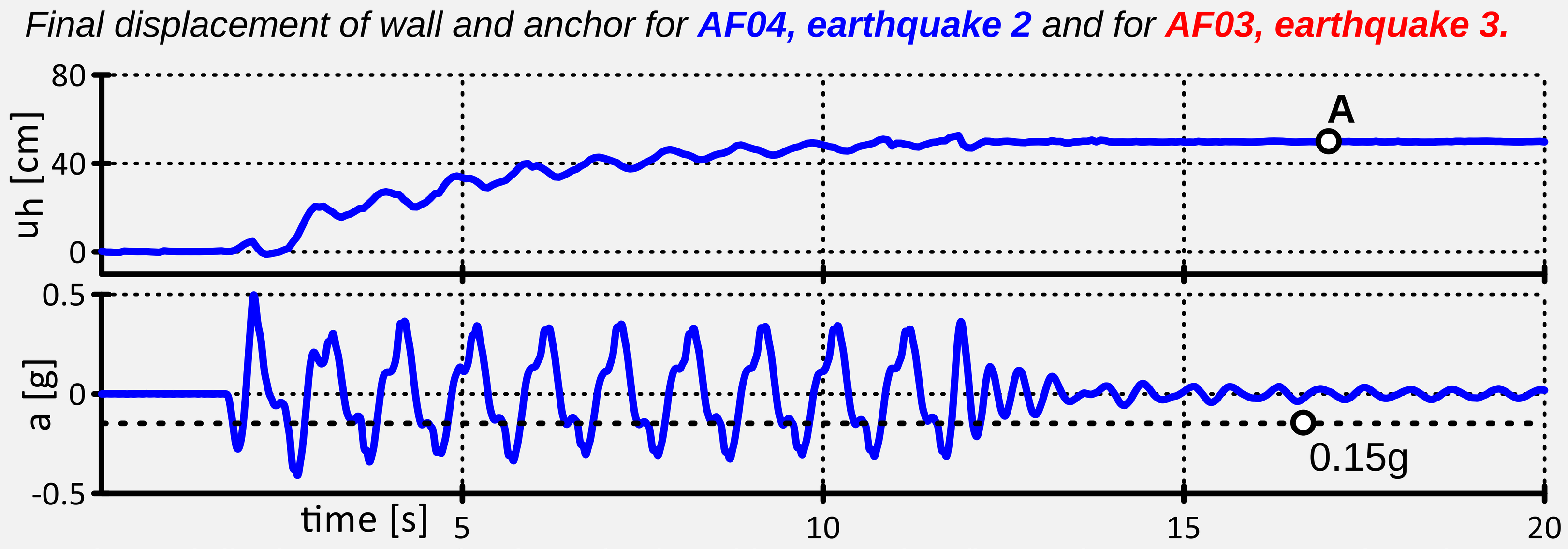
- *Vertical (left) and horizontal (right) displacement contours [m]. Test AF03, earthquake 3.*



- *Shear strain after 5 cycles (left) and after all cycles (right) [%]. Test AF03, earthquake 3.*



- *Final displacement of wall and anchor for **AF04, earthquake 2** and for **AF03, earthquake 3.***



- *Horizontal displacement of point A (top) and input motion (bottom). Test AF04, earthquake 2.*

(5) Conclusions

- **Critical acceleration increases** during shaking
- System tends to fail following a **rotational mechanism**. This must be taken into account in a Newmark's approach
- Limit equilibrium theory proposed by Caputo *et al.* (2019) identifies the **correct failure mechanism**

(6) Future work

- Understand how **critical acceleration varies** during shaking
- Extend to **saturated** conditions

References

- Caputo, G., Conti, R., Viggiani, G.M.B., Prüm, C. Theoretical framework for the seismic design of anchored steel sheet pile walls. In *Proceedings of the 7th International Conference on Earthquake Geotechnical Engineering*, ICEGE, 2019.
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- Conti, R., Madabhushi, G. S. P., & Viggiani, G. M. B. (2012). On the behaviour of flexible retaining walls under seismic actions. *Géotechnique*, 62(12), 1081.

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