Rock mechanical experiences of excavation Laakso Joint Hospital (LJH) parking halls

Presentation

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Contents of presentation

- Project overview
- Rock mechanical simulations
- Geological mapping
- Rock mechanical monitoring

Project overview

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LJH project as numbers

5 Hospital buildings

4 to Laakso
1 to Ohkola

2 renovated
3 new buildings

over 900 nursing bed's
over 900 toilet rooms

550 underground parking spaces

Construction 2022–2030

1 003 million € budged

500 000 m³ rock excavation

50 000 truck loads of blasted rock

2 000 persons working when hospital is ready

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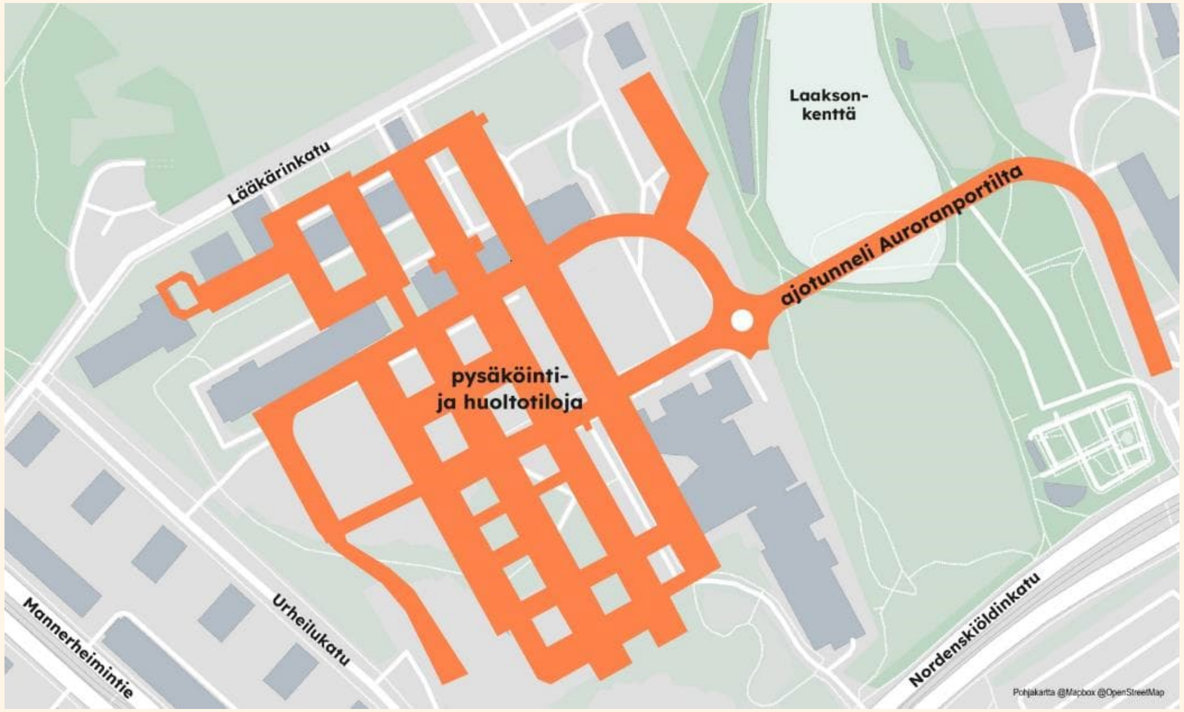
Northern new building
~11 500 brm²
New main building
~ 95 000 brm²
Renovation buildings (2)
~ 18 000 brm²

Designed undergound spaces

Under rock surface has been excavated:

- Customer ja ambulance route, elevator connections to all hospital areas in new buildings
- Logistic trafic and –areas on lower level
- 550 parking slots to customers and workers
- Civil defence center



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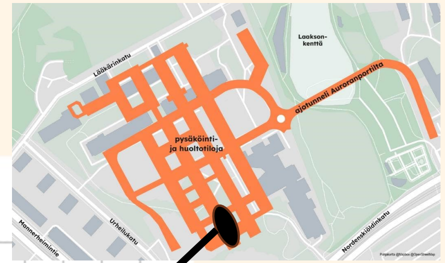
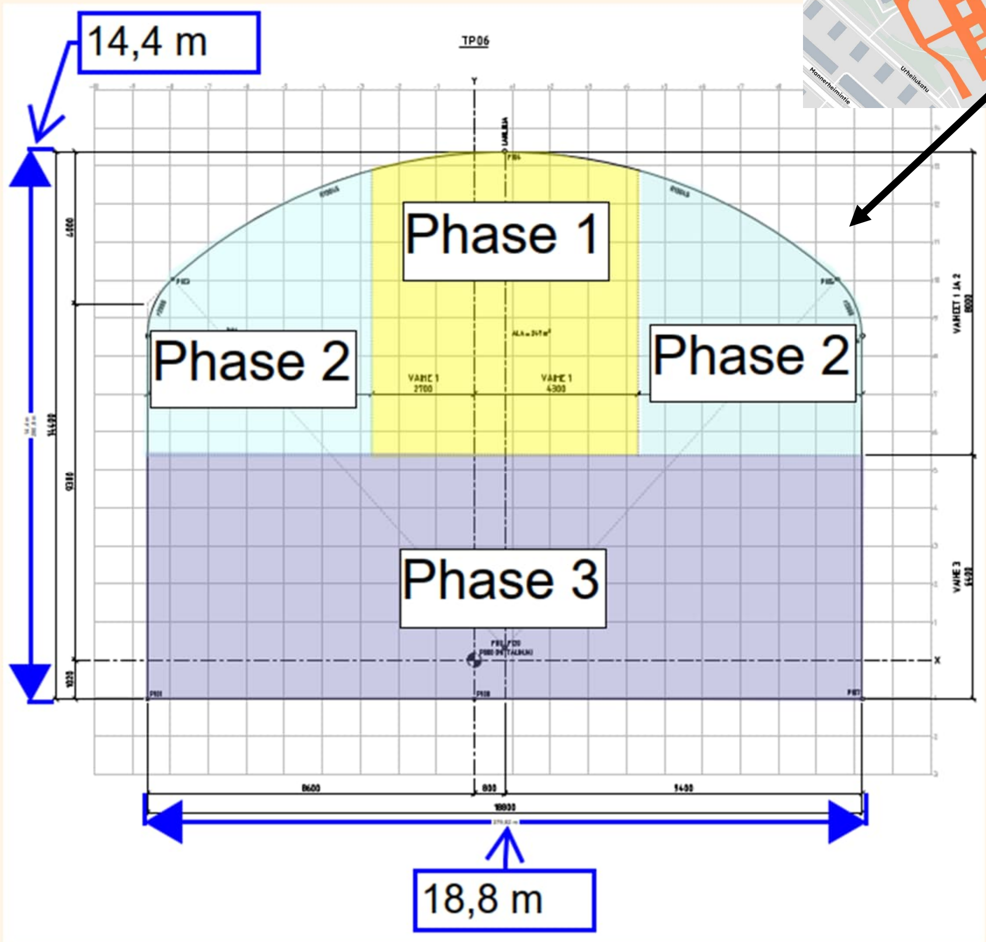
Excavation of undergound spaces



- Excvation with drill and blast-method.
- Excavation divided in large profiles up to four parts that were excavated in three phases.
  - First two phases in consist of three different vault-side parts
  - Finally bottom part



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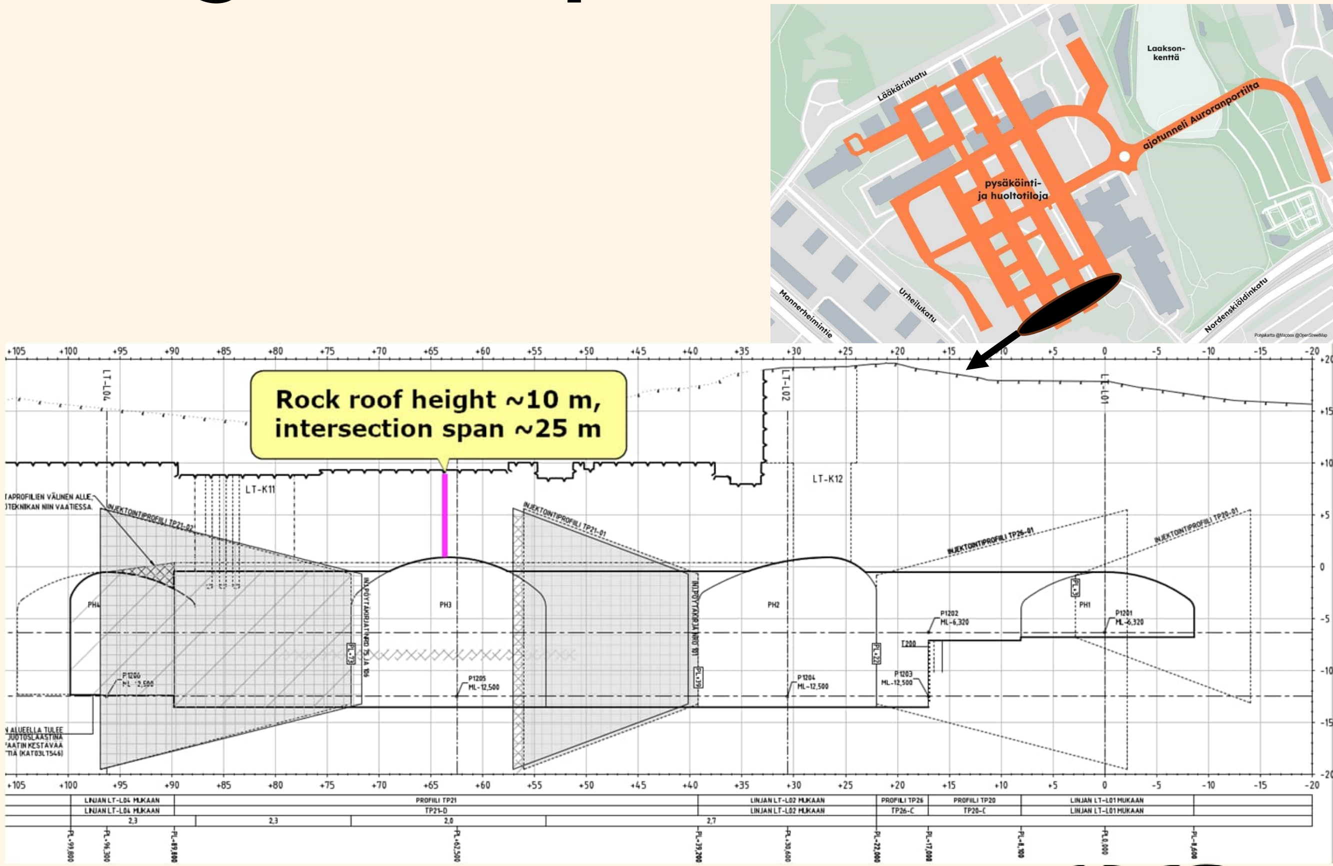
Excavation of undergound spaces

- Good communication between site personels and designers ensured success during suprises.
- Excavation work completed aproximetly 6 months ahead of original schedule.



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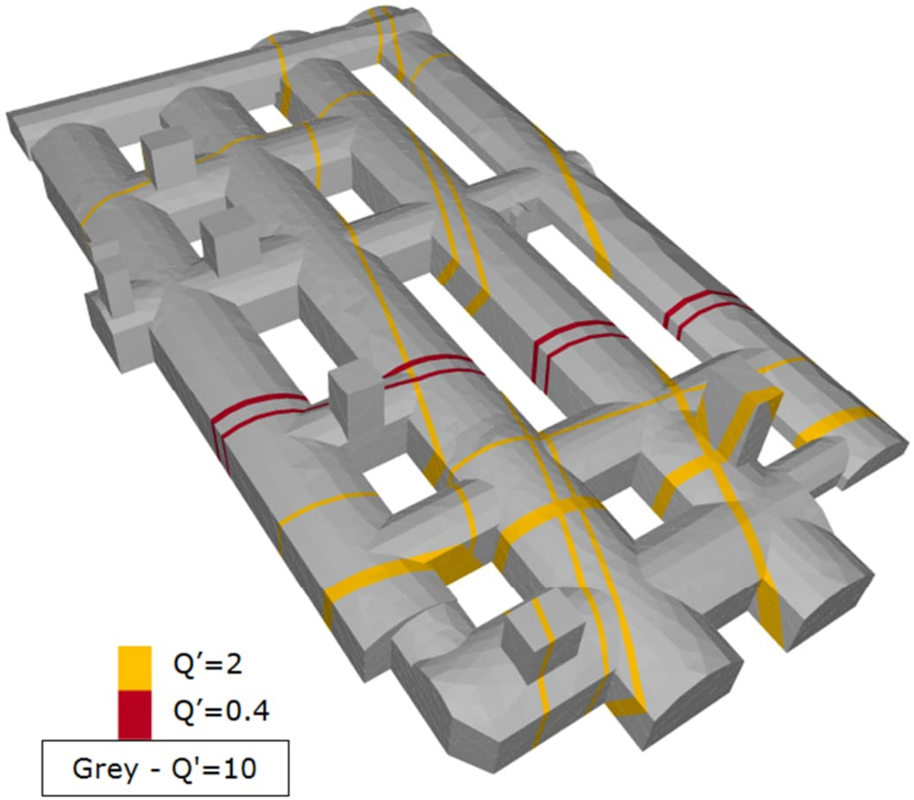
Rock mechanical simulations

Overview of Rock mechanical simulations

- Done thorough different phases of the project.
- Simulations of different areas of interests:
  - <u>Main parking caverns</u>
  - Round-a-bout area
  - Earlier concept simulations

	Normaali kallio	Heikkousvyöhyke	Heikkousvyöhyke	
Q'	10	2	0.4	
GSI	65	50	36	
GSI-mallinnus	75	60	45	
DFN-area				
sigci	120	80	60	(MPa)



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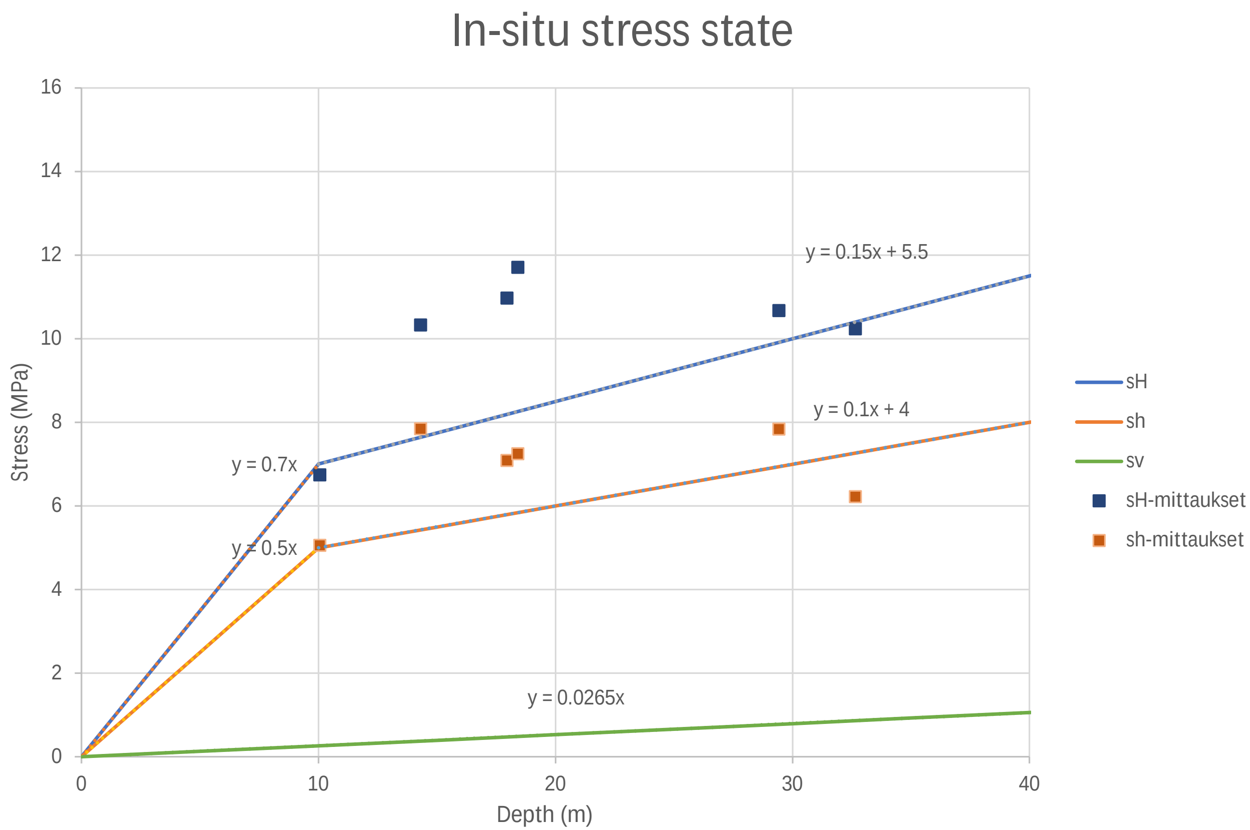
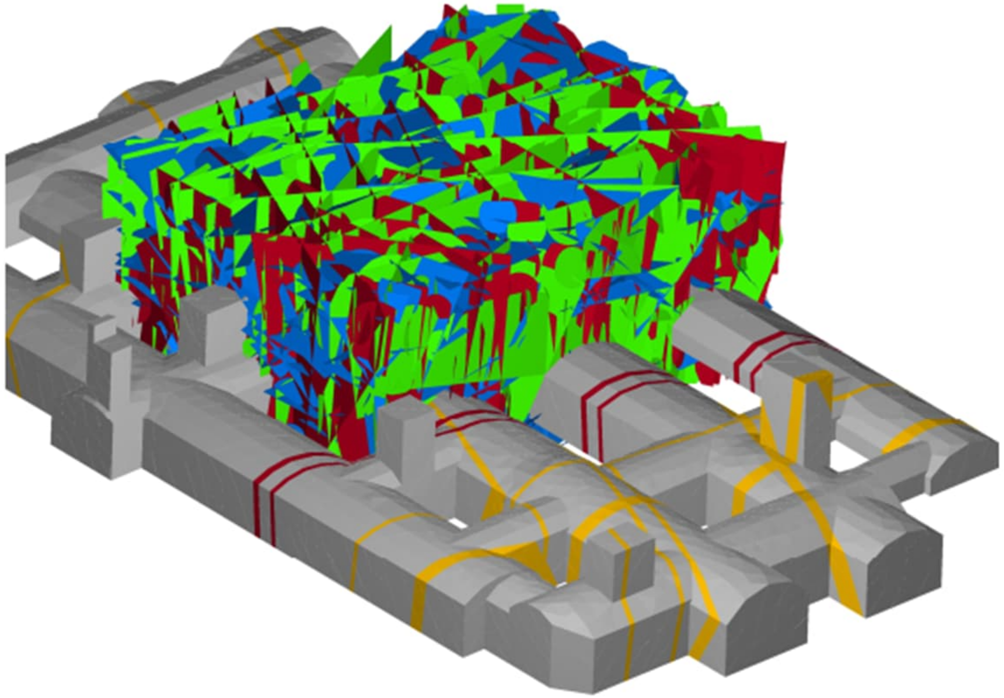
In-situ stress state

- In-situ stress state based on HF-tests.
- Main principal stress 60° from North
- Vertical stress from self-weight of the rockmass.
- Main caverns roughly perpendicular to principal stress.



Rock joints

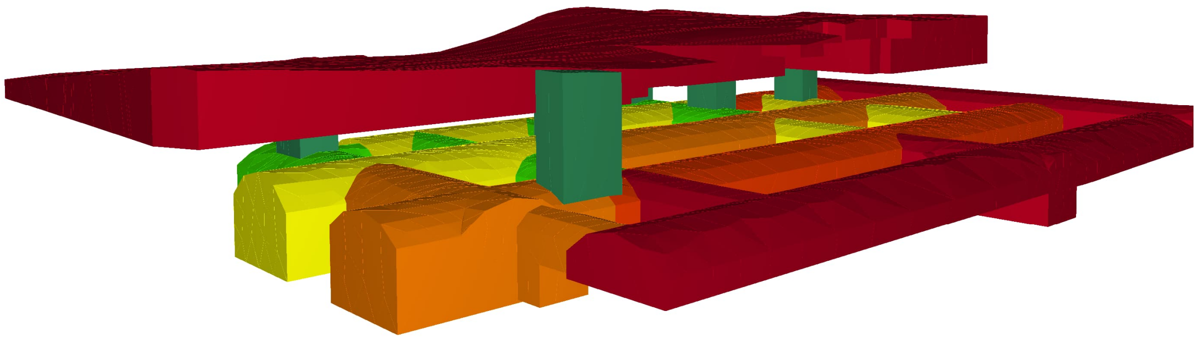
- Three main joint-sets (dip/dip direction):
  - 3°/200° (blue joints)
  - 90°/154° (green joints)
  - 84°/59° (red joints)
- Joints modelled as discrete fracture network.
- Fiction angle 32°, Normal stiffness 50 GPa/m, Shear stiffness 5 GPa/m.

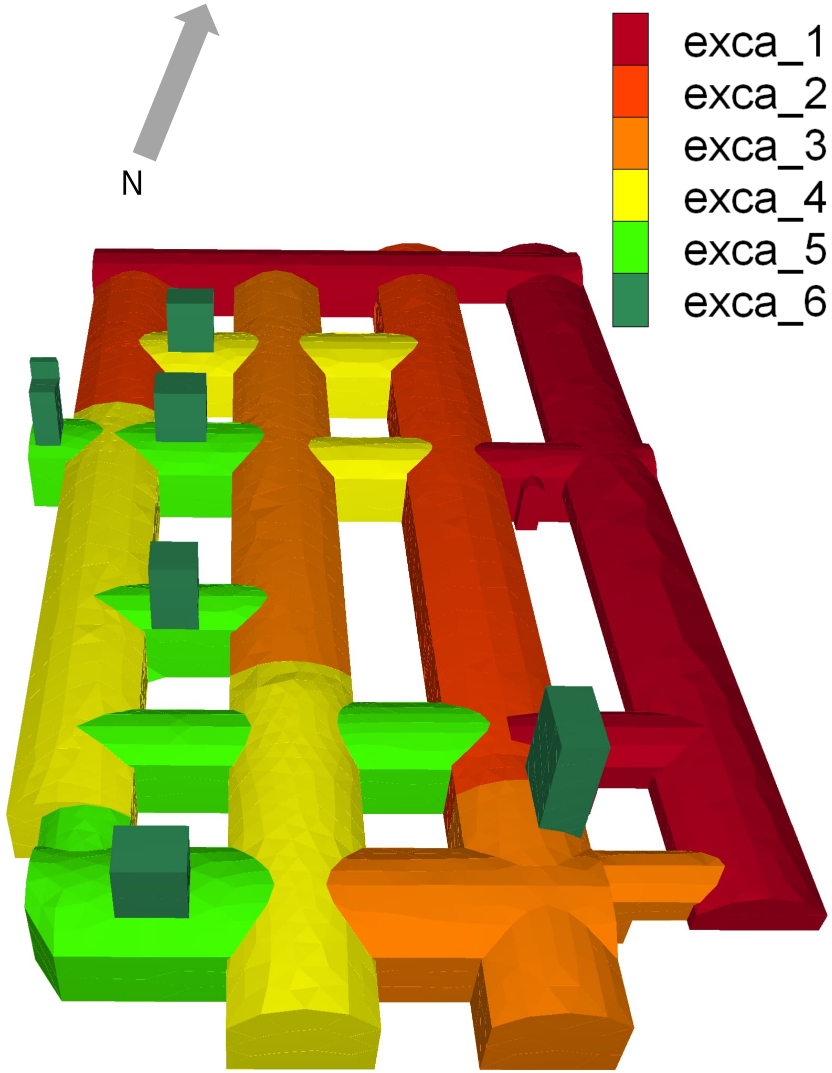


Excavation sequence

Six main excavation phases:

- First rock surface excavations along Eastern cavern.
- Then caverns roughly from East to West.
- Excavation of all shafts as final phase.





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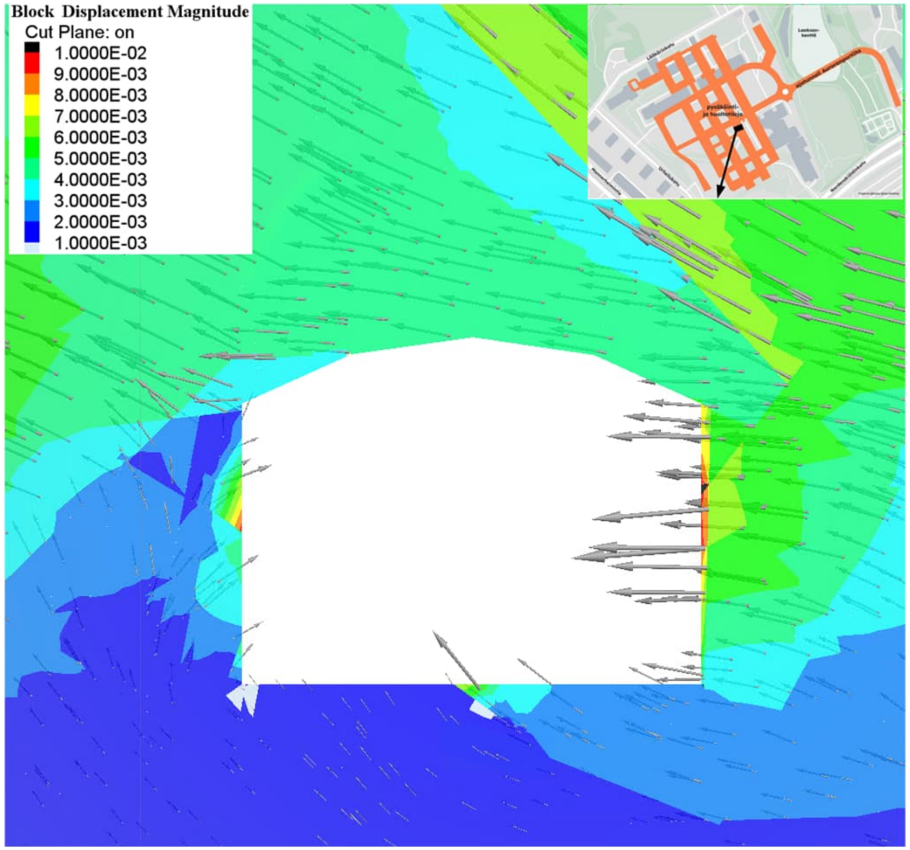
Results of rock mechanical simulations

- Displacements:
  - Walls up to ~10mm
  - Vaults up to 3–5 mm
  - Near weakness zones > 5 mm
  - Near shafts up to 10 mm
- Unstable rock blocks:
  - Main failure type was unstable rock blocks.
  - Overall stresses holds rock blocks in place at vault and walls, preventing major collapses.



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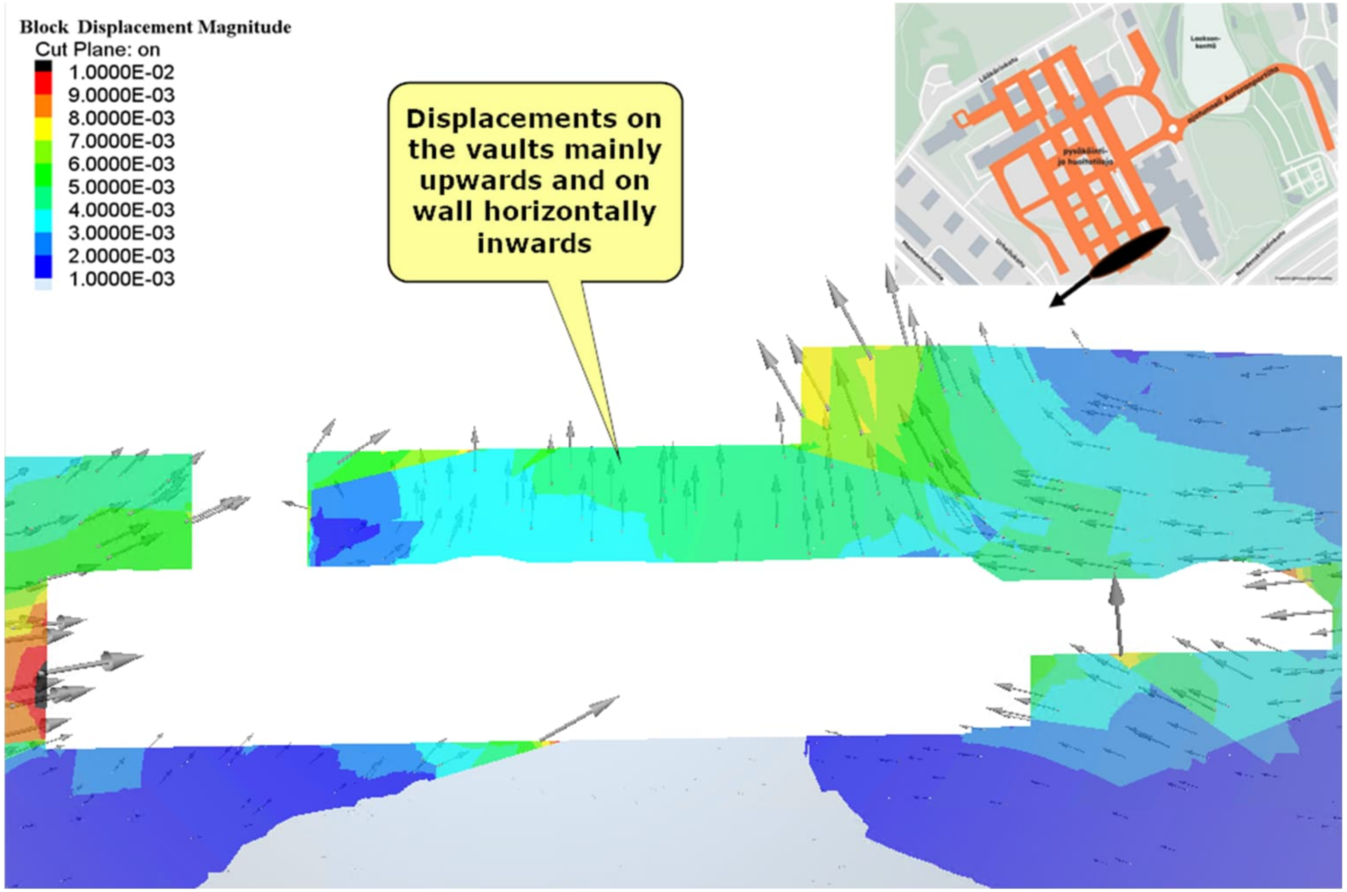
Results of rock mechanical simulations



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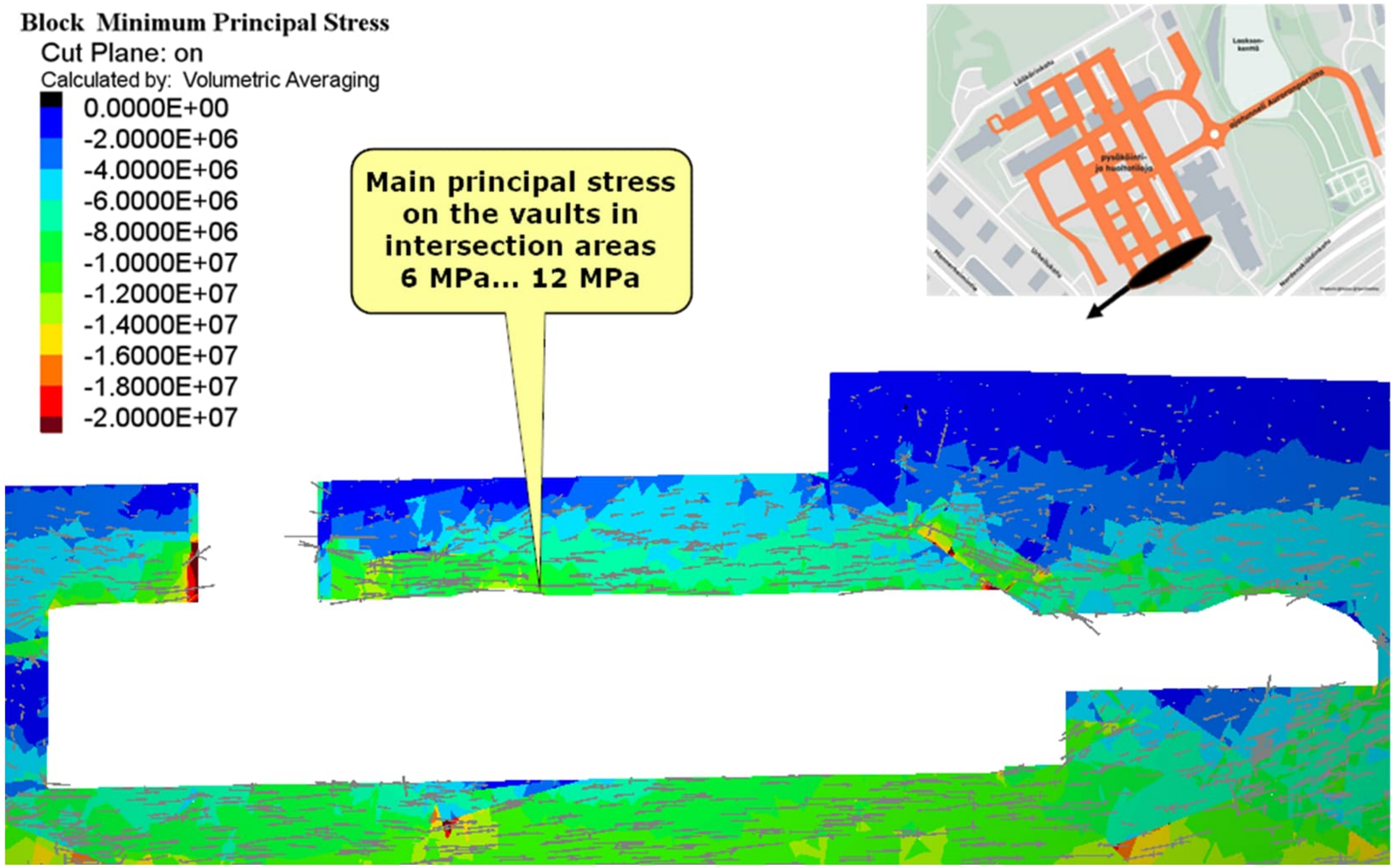
Results of rock mechanical simulations



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Pictures from site

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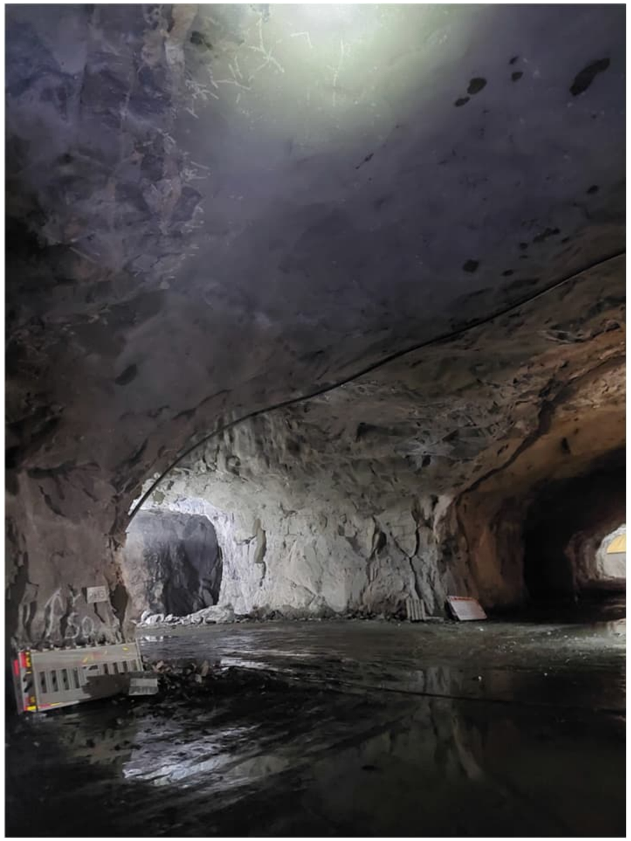
Rock surface
excavation 8/2023

Entrance to tunnels
8/2023

Entrance to tunnels
8/2023

Caverns during excavation 2/2024



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Caverns during excavation 8/2024

Geological mapping

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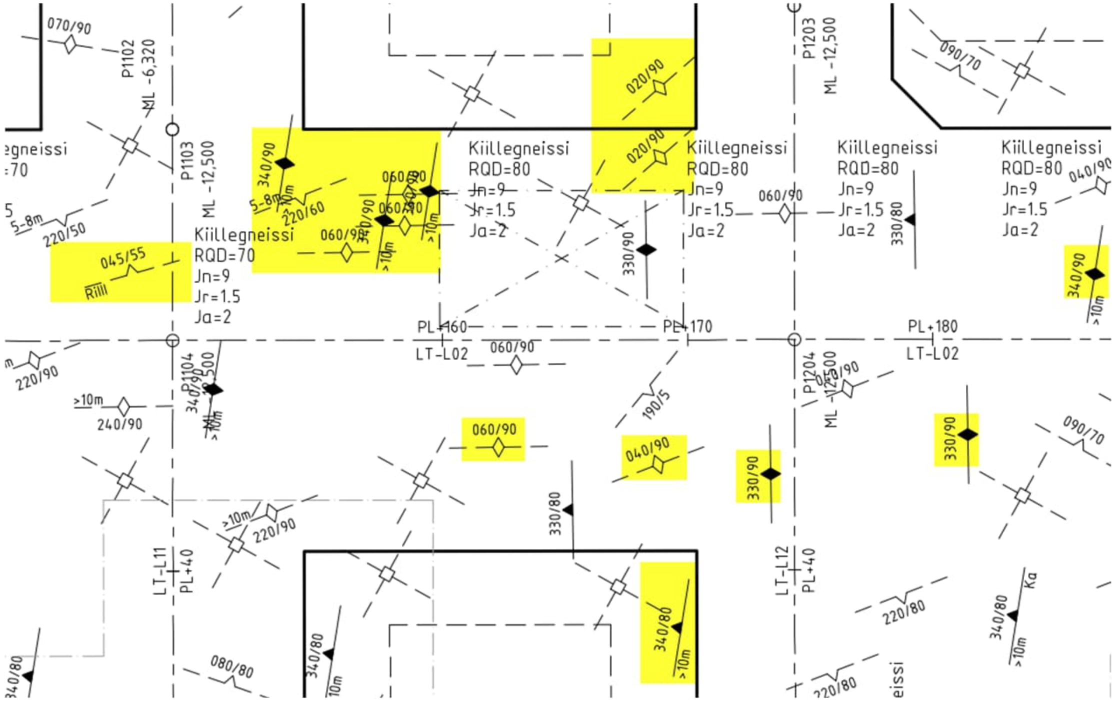
Overview geological mappings

- Rock quality better than anticipated, especially in weakness zones.
- Main joint orientations thorough excavation caverns blocky; horizontal and vertical joint-sets.
- Joints with dip 30°...60° were rare.



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Rock mechanical monitoring

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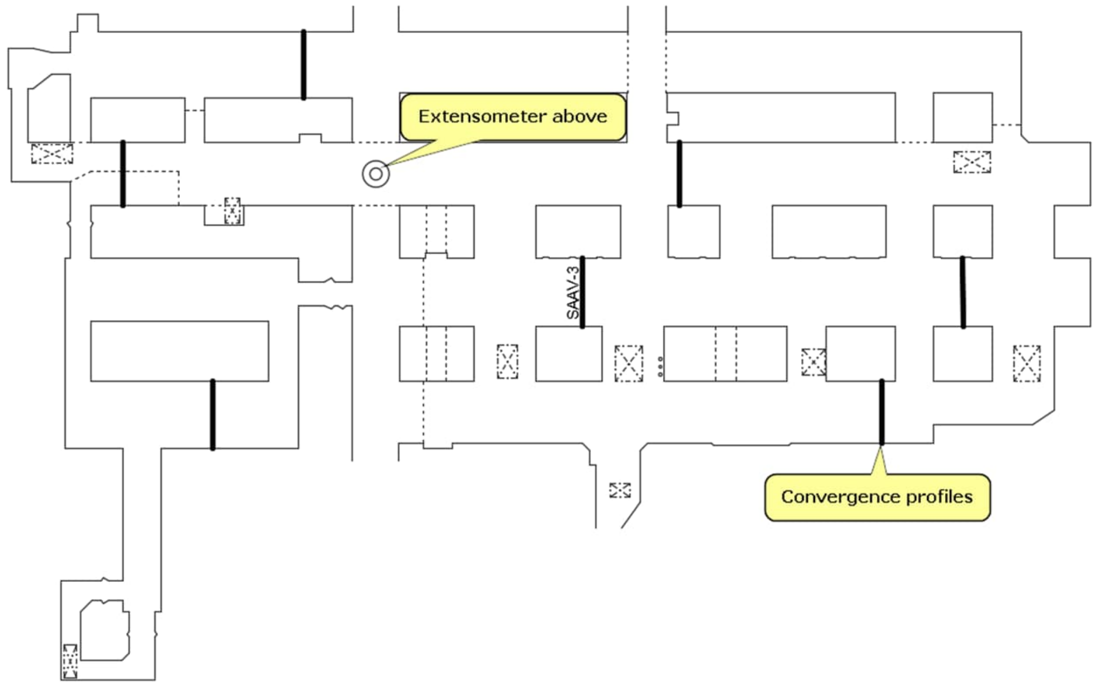
Overview of Rock mechanical monitoring

- Extensometer
- Manual convergence profiles
- The ShapeAccelArray Field (SAAF/SAAV)
- Rock surface elevation monitoring



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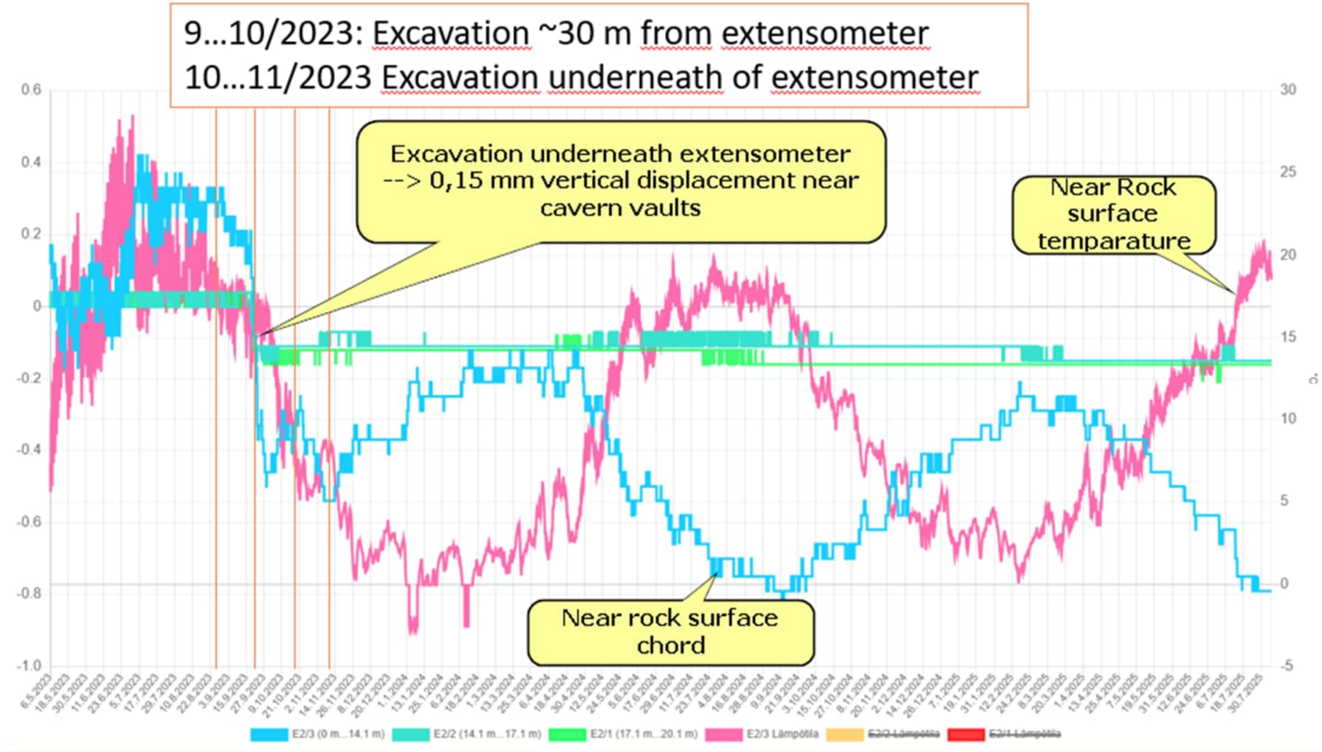
Rock mechanical monitoring

- Extensometers have been reliable and steady source of monitor data.
- Displacements much smaller than simulated.



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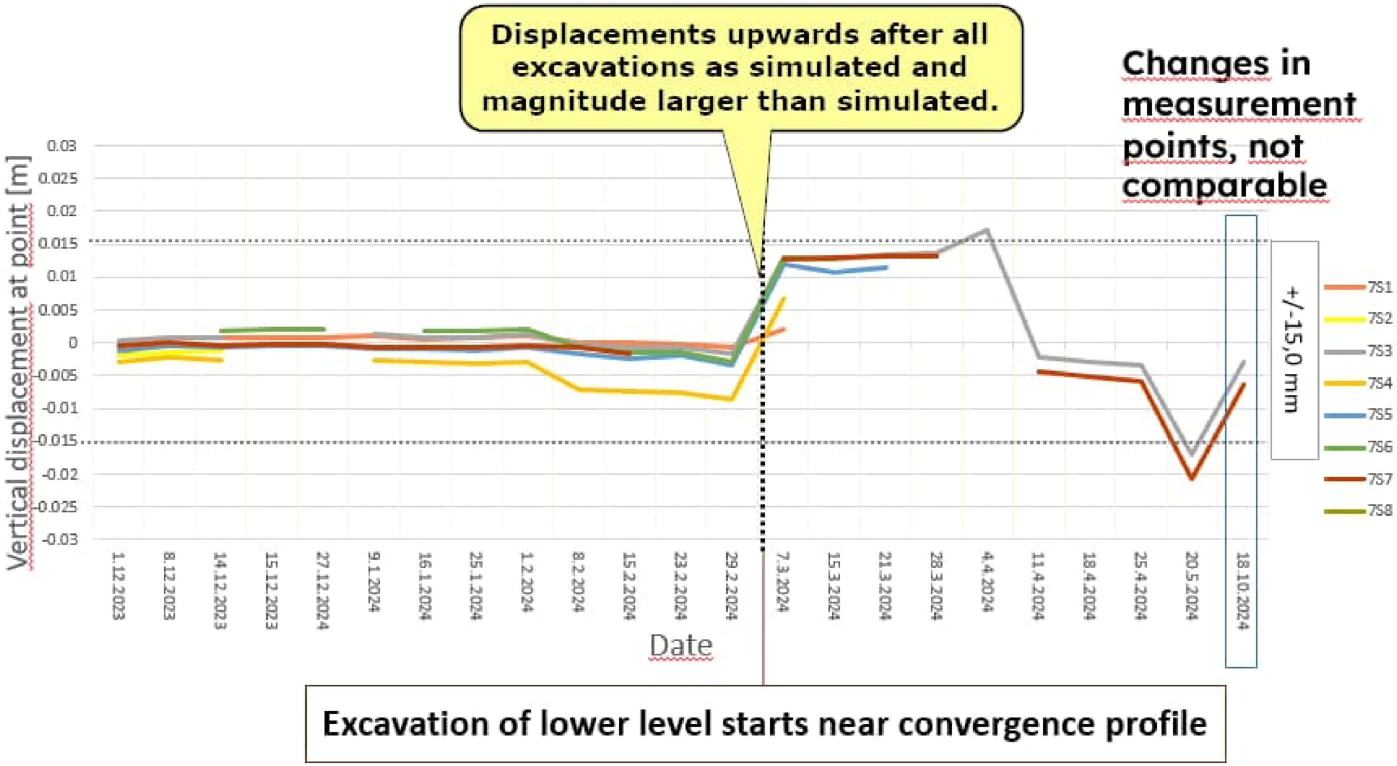
Rock mechanical monitoring

- Tachymeter measurement of convergence profile point coordinates.
- Displacements depending on profile either smaller or larger than simulated.
- Challenges of getting data during excavation works.



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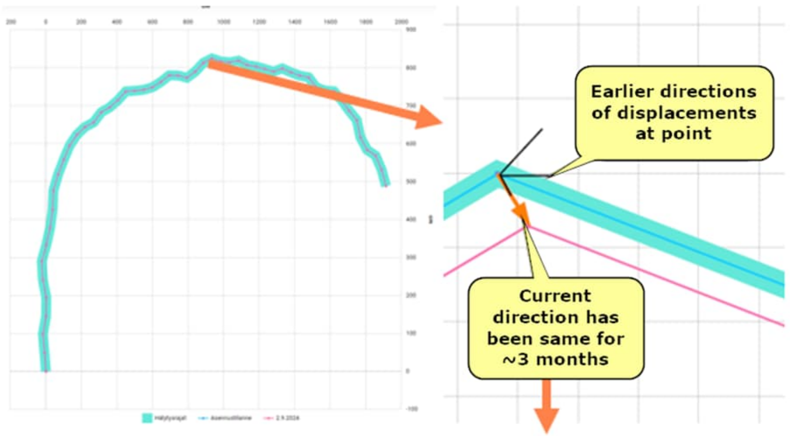
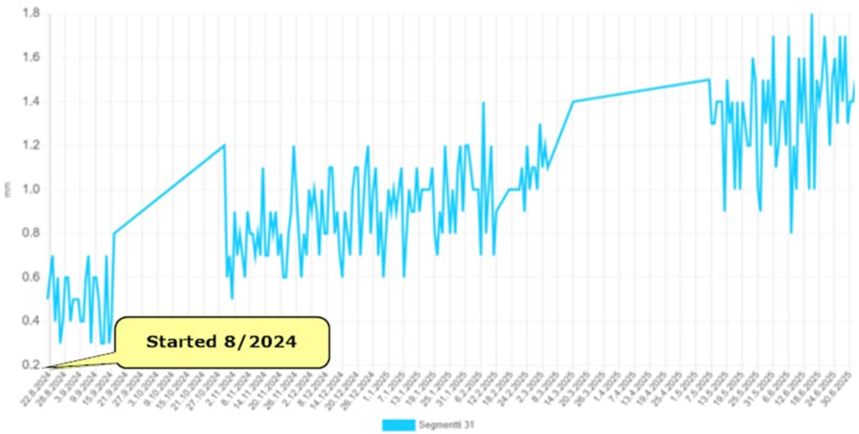
Rock mechanical monitoring

- Automatic profile displacement data from SAAV-lines.
- SAAV-lines measure tilt in flexible joints between ridgid elements.
- Challenges of data connection between site and server.
- Much noise in the data. Displacements mainly inline with simulation.





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Summary of rock mechanical monitoring and -simulations

- No unexpected behavior. Main failure type unstable blocks, that have been reinforced during excavation.
- Rock monitoring results are partly inline with the simulations when considering differences in simulated- and real excavation sequence.
- Extensometers have been the most reliable- and SAAV-automatic profiles the most unreliable source of monitoring data.
- Rock mechanical monitoring with different methods has provided resilience to unexpected situations, when one kind of measurement has been unavailable.

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Questions?