Complex AGF measure near to the Spree Canal in Berlin –
directional drilling, freezing and holistic thermal assessment
Complex Artificial Ground Freezing measure near to the Spree Canal in Berlin –
directional drilling, freezing and holistic thermal assessment

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The U5.
For more togetherness.

Project overview
Location in the midst of valuable building fabric

Project overview
Infill
Sands of the Berlin glacial valley
Glacial marley till
Glacially preloaded meltwater sands
Freeze-Pipe Installation

Especially developed rig for accurate horizontal directional drilling over the whole cross-section
Freeze-Pipe Installation

New inertial steering probe for MWD-drilling with outstanding long-term-accuracy
Freeze-tunneling in Berlin sands

Freeze plant

- 3 coupled chillers
- 1,3 Megawatts freezing capacity
- 81 m³ brine in circulation
- Frozen body dimensions: L105m x W26m x H12m
- Duration of freezing: 80 Days
Freeze-tunneling in Berlin sands

Freezing system - Distribution and manifold

Western bridge

Eastern bridge

Freezing cellar
Freeze-tunneling in Berlin sands

Main-tunnel drive

- Excavation using a tunnel excavator with an attached milling machine

- Leading-dome-drive with approx. 6 m trailing sole

Unfrozen core
Freezing Control - Requirements for the frozen soil

Requirements depending on the phase of the tunnel drive and the location in the cross section (ISP ZT GmbH & CDM Smith GmbH)

**CROSS SECTION**
Requirements for the frozen soil

**LONGITUDINAL SECTION**

<table>
<thead>
<tr>
<th>Section</th>
<th>Requirements</th>
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<tbody>
<tr>
<td>A</td>
<td>D ≥ 1,5 m, T_m ≤ -5°C</td>
</tr>
<tr>
<td>A'</td>
<td>D ≥ 2,2 m, T_m ≤ -7,5°C</td>
</tr>
<tr>
<td>C</td>
<td>D ≥ 2,5 m, T_m ≤ -10°C</td>
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**Central tunnel**

- Shotcrete
- Frozen soil
- Unfrozen soil
Freezing Control – Evaluation Methods

Daily quantitative evaluation of the frozen soil (mean temperature and thickness)

- Cooling-Down Phase: Measurements + numerical simulations
- Maintenance Phase: Direct evaluation based on measurements
Freezing Control – Cooling Phase

Numerical simulation of the ground freezing in four measurement cross sections

- Comparison and validation with measurements
- Verification of the state of the frozen soil before tunnel drive
Freezing Control – Maintenance Phase

Evaluation of the temperature profile for relevant cross sections

- Automated and fast data evaluation
- Objective basis for the freeze mode

Exemplary temperature profile (schematic)
- Outer \(-2 ^\circ C\) isotherme
- Thickness \(D\)
- Evaluation of \(T_m\) over 2.5 m
- Freeze pipe
- Temperature sensor
Exemplary evaluation of thickness and temperature of the frozen mass (main-tunnel drive)
Monitoring of the frozen body

3D- Visualization with fully mobile Web-UI

• High sampling rate, display in near realtime
• Meshed bus system
• 1911 pieces of fully digital temperature sensors
• 81 fully digital pressure sensors
Freezing Control – Thawing Phase (Active)

Heating system with district heating

Goals
• Early impact of water pressure on the inner shell → leak test
• Faster thawing of the frozen body within the cohesive soil → Faster lifting resets

Execution
• Duration: 87 days, of which 33 days with heated brine, then with hot water at 35 - 40°C
• Feeding of 17 freezing pipes below the tunnels
• Energy input approx. 290 MWh
Conclusions

- Complex freezing measures require expert support.
- The trusting cooperation of all parties involved is crucial for success.
- This requires experienced people on both sides of the meeting table.
- Careful planning of all components is vital. Redundancy is not a luxury.
- Dome drive in the frozen body is possible. The criteria are to be chosen accordingly.
- One model is no model. Ongoing analytical cross-checks are necessary.
- The permissible range of important parameters should be known in advance.
- Artificial Ground Freezing is based on the observation method. The measurement system is its backbone.
Thank you for your kind attention
Thank You

Any further questions?

D’autres questions?

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