

Söderströmstunneln

*A challenging underwater bridge
founded on steel core piles
Påldagen 2013, Fredrik Persson*

ZÜBLIN

Agenda

Introduction // Intro Trafikverket Söderström movie

Södermälärstrand.... Secant piles in soft and unstable fill on steep rock...

In the Middle... Steel core piles with high precision on 25 m depth...

Riddarholmen ...King piles in tough moran...



AGENDA

INTRO

SÖDER-
MÄLARSTRAND

IN THE MIDDLE

RIDDARHOLMEN

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Citybanan

Underground commuter railway system through the center of Stockholm

Construction period

2008 - 2017



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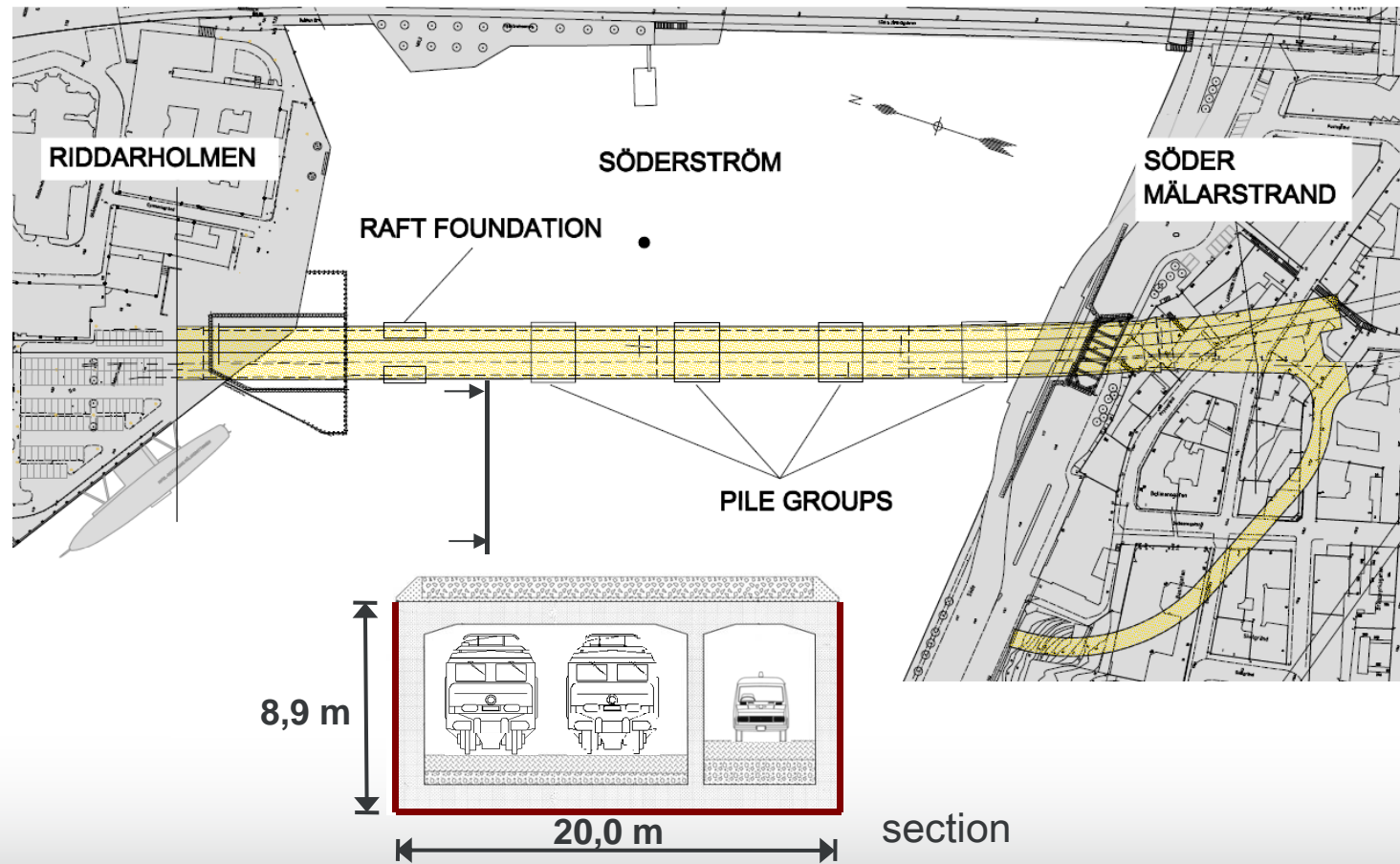
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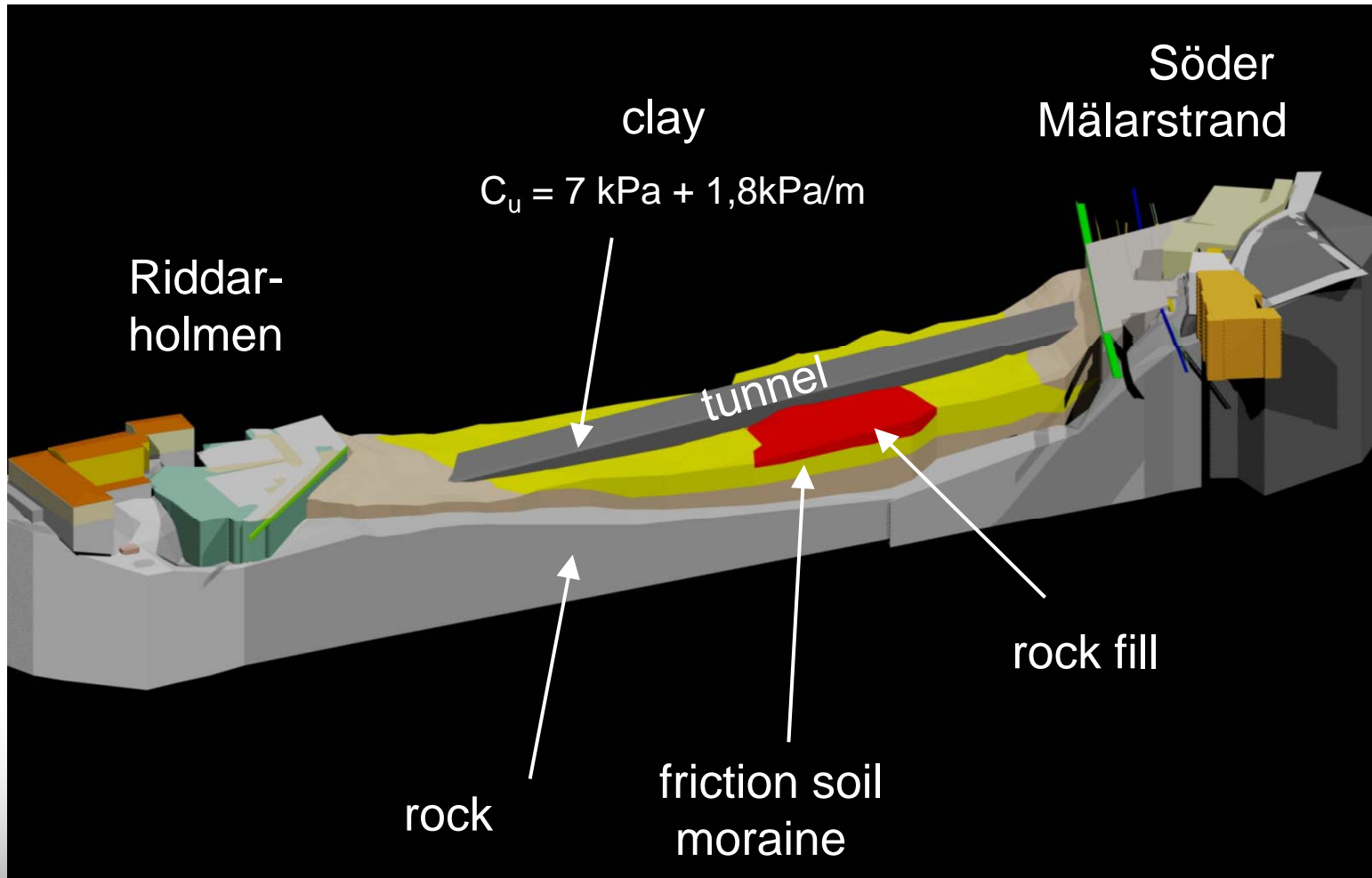
Project overview



- AGENDA
- INTRO
- SÖDER-MÄLARSTRAND
- IN THE MIDDLE
- RIDDARHOLMEN



Geology



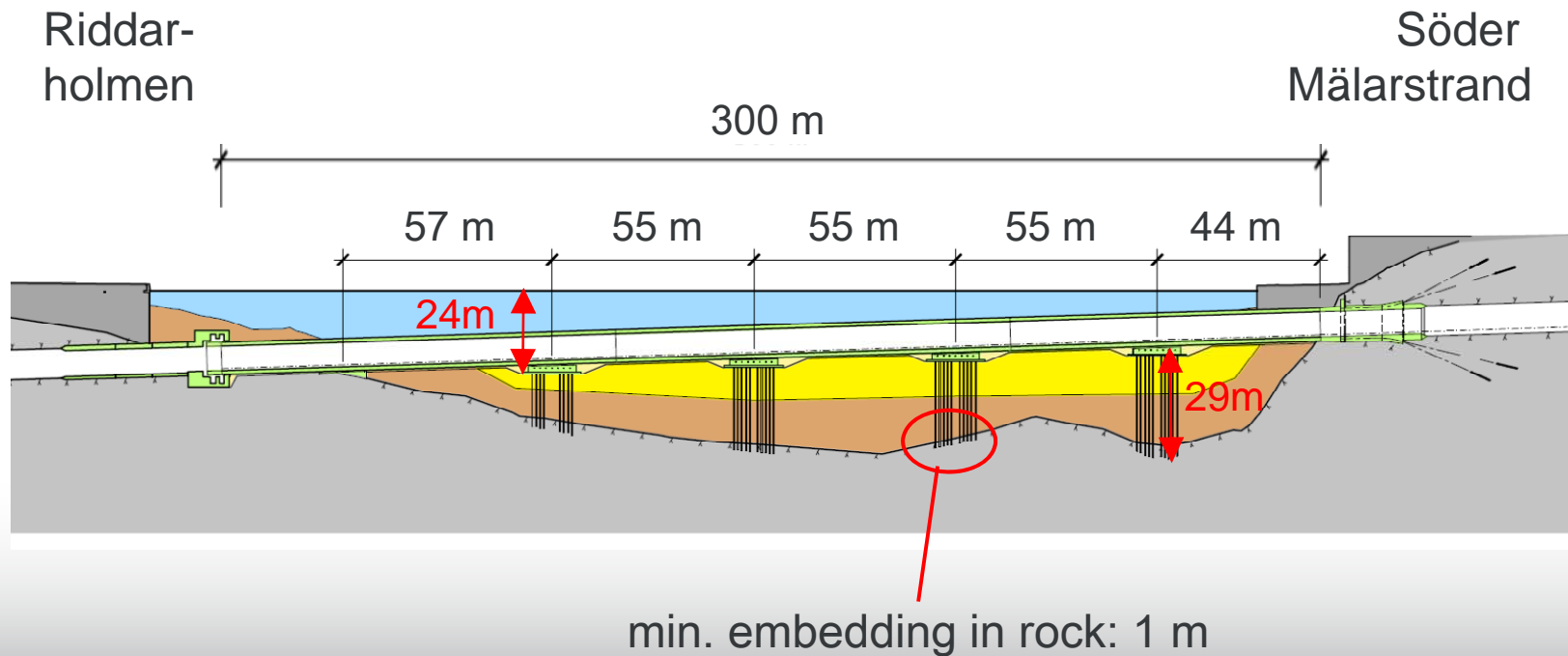
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Foundation layout

156 steel core piles

Ø 180 mm



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pihl

 TRAFIKVERKET



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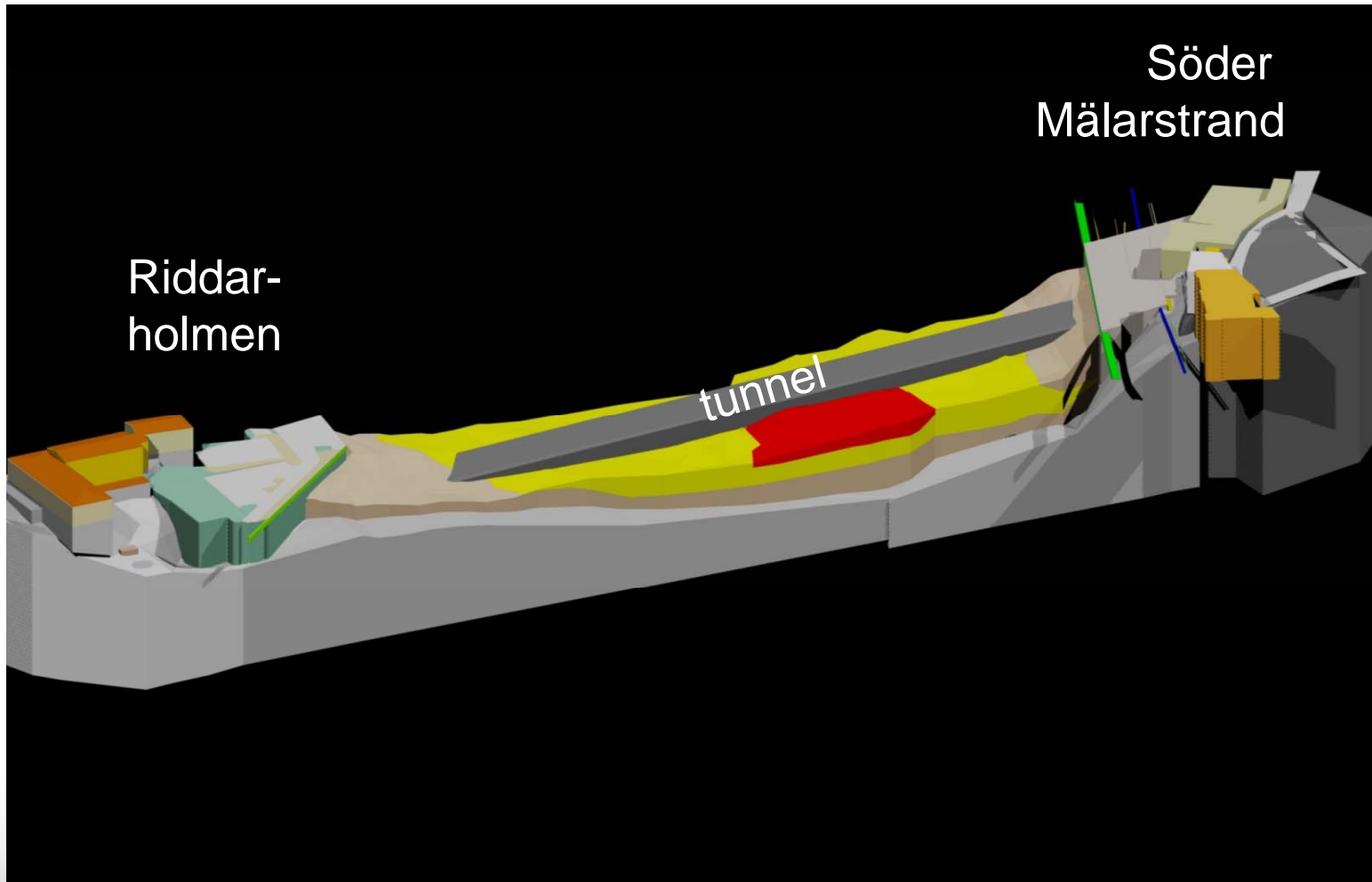
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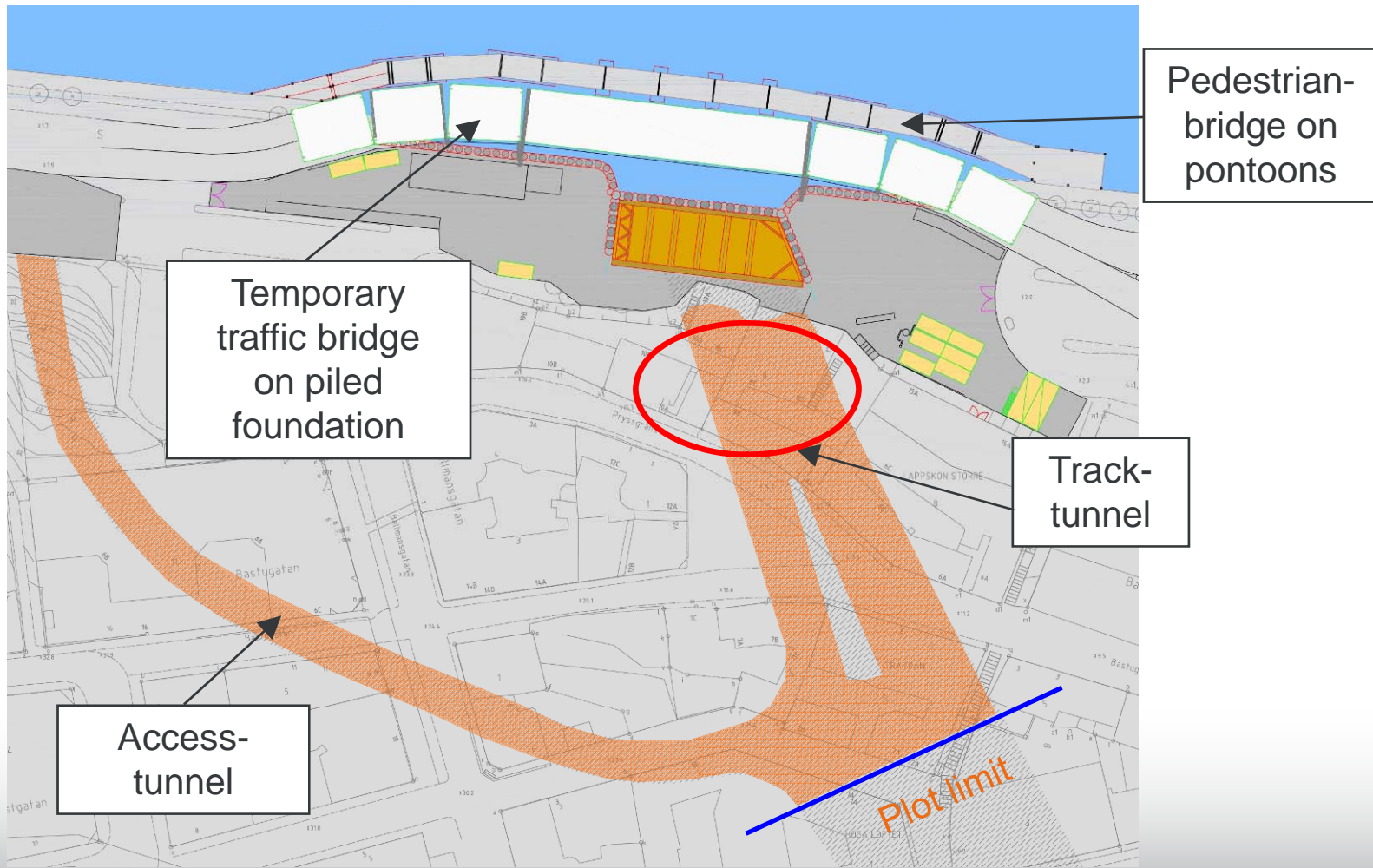
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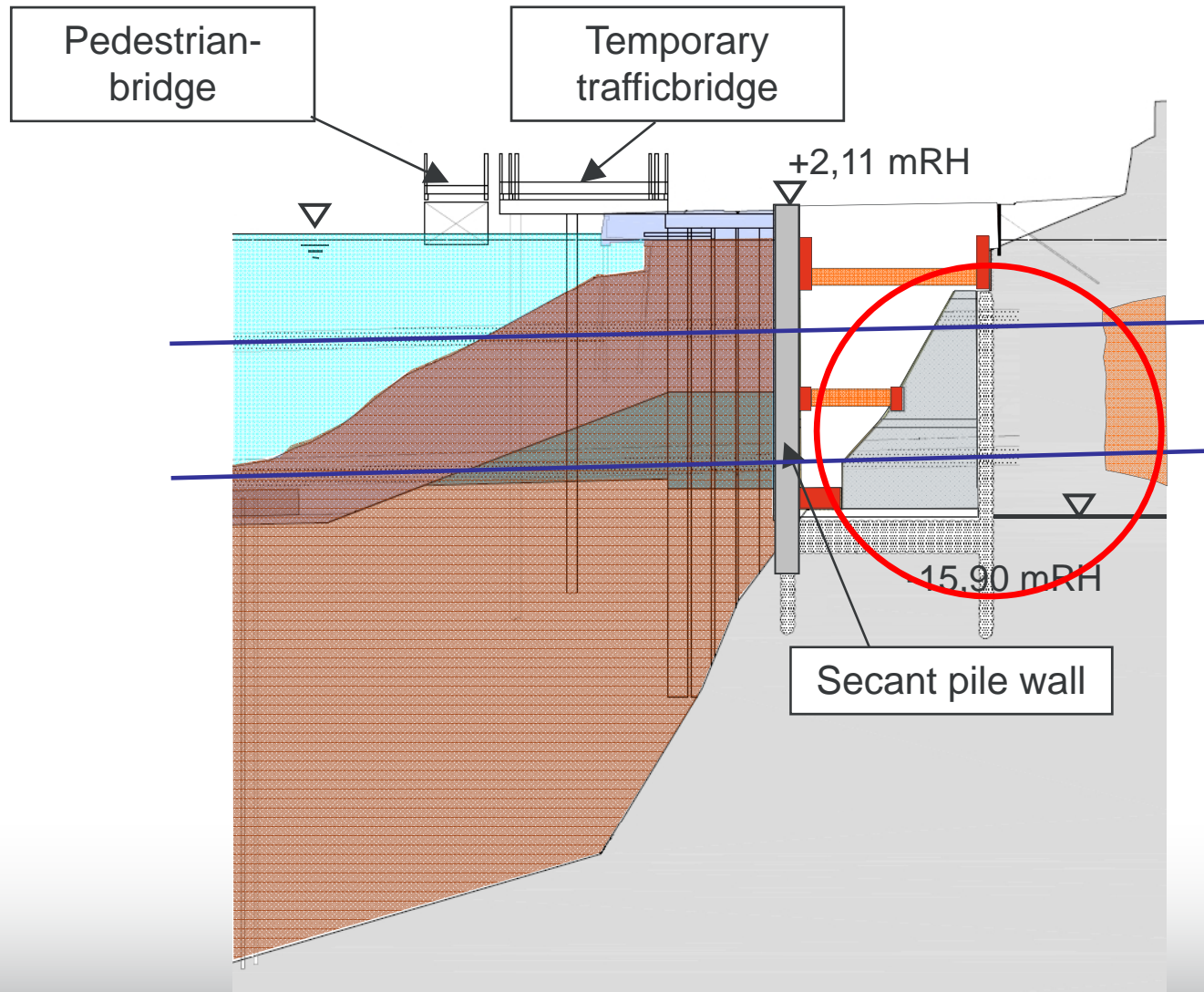
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RIDDARHOLMEN

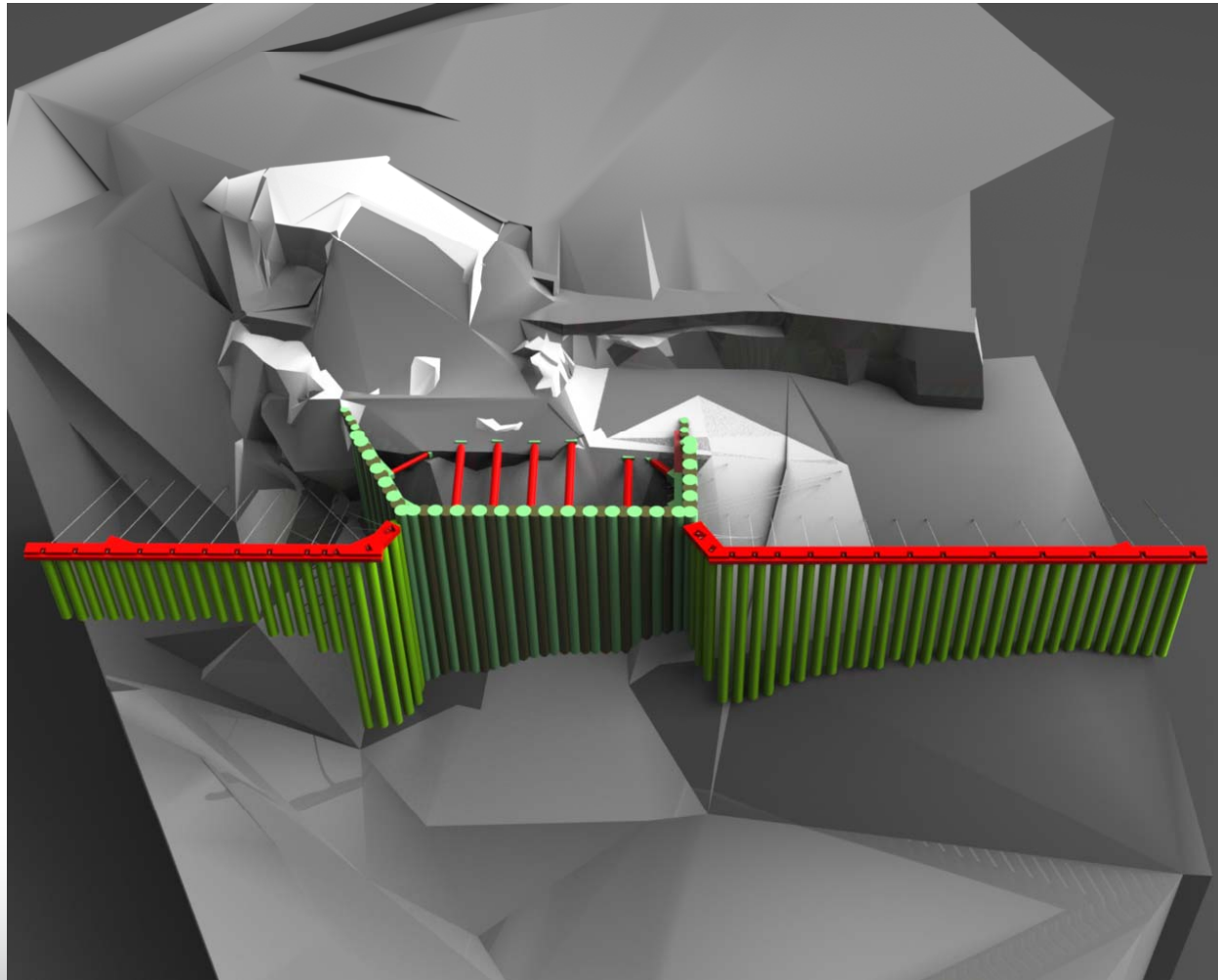


Söder Mälarstrand





Söder Mälärstrand – Construction pit



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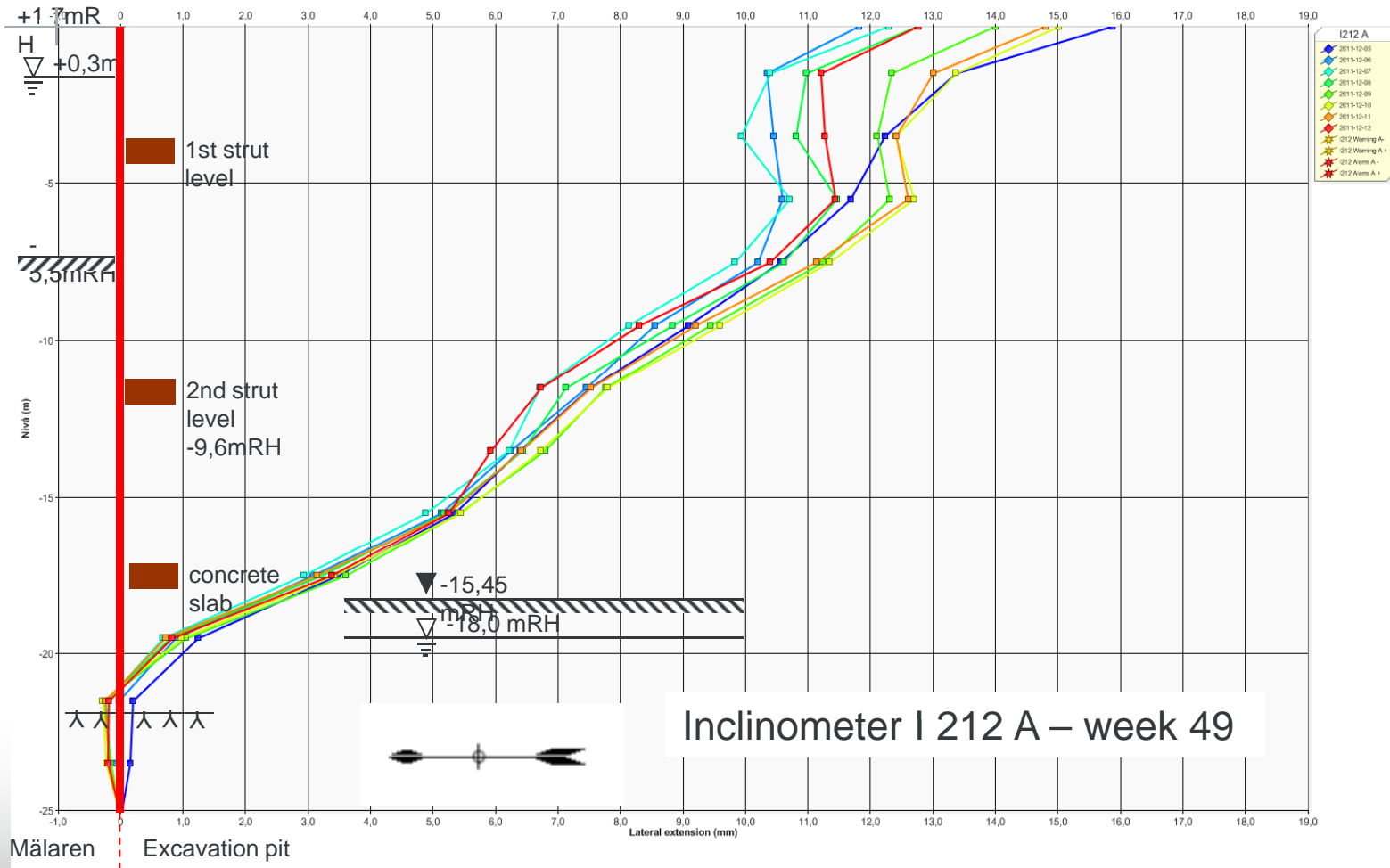
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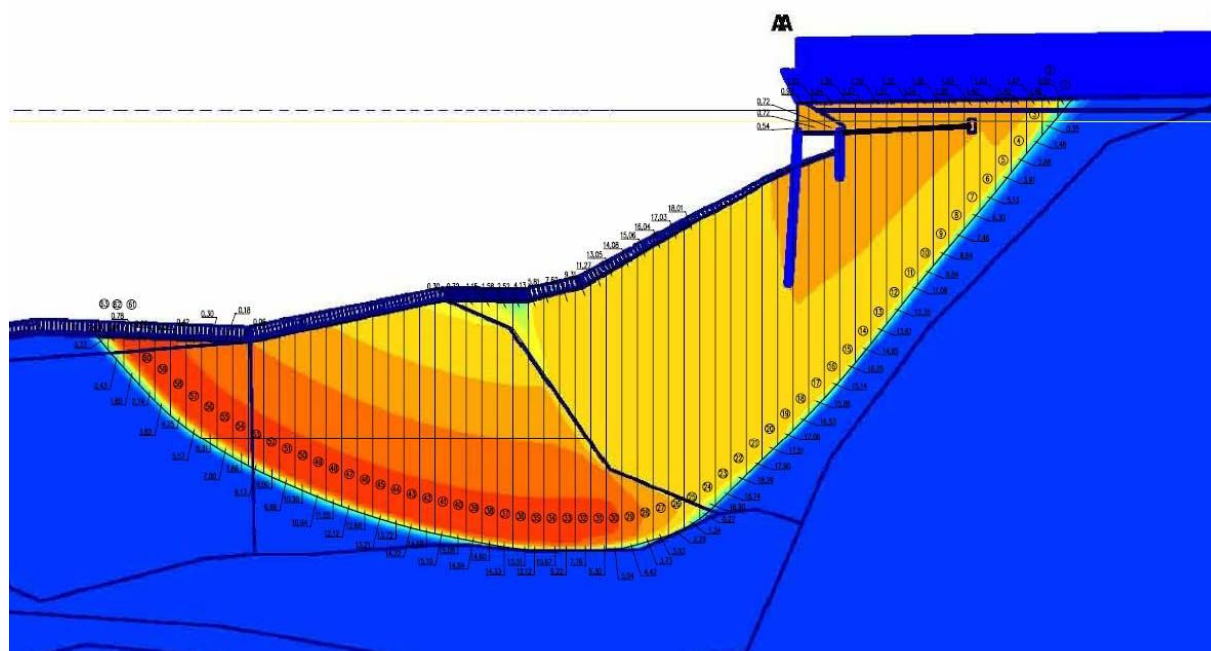
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Söder Mälarstrand – Monitoring



Slope stability

Design Calculation



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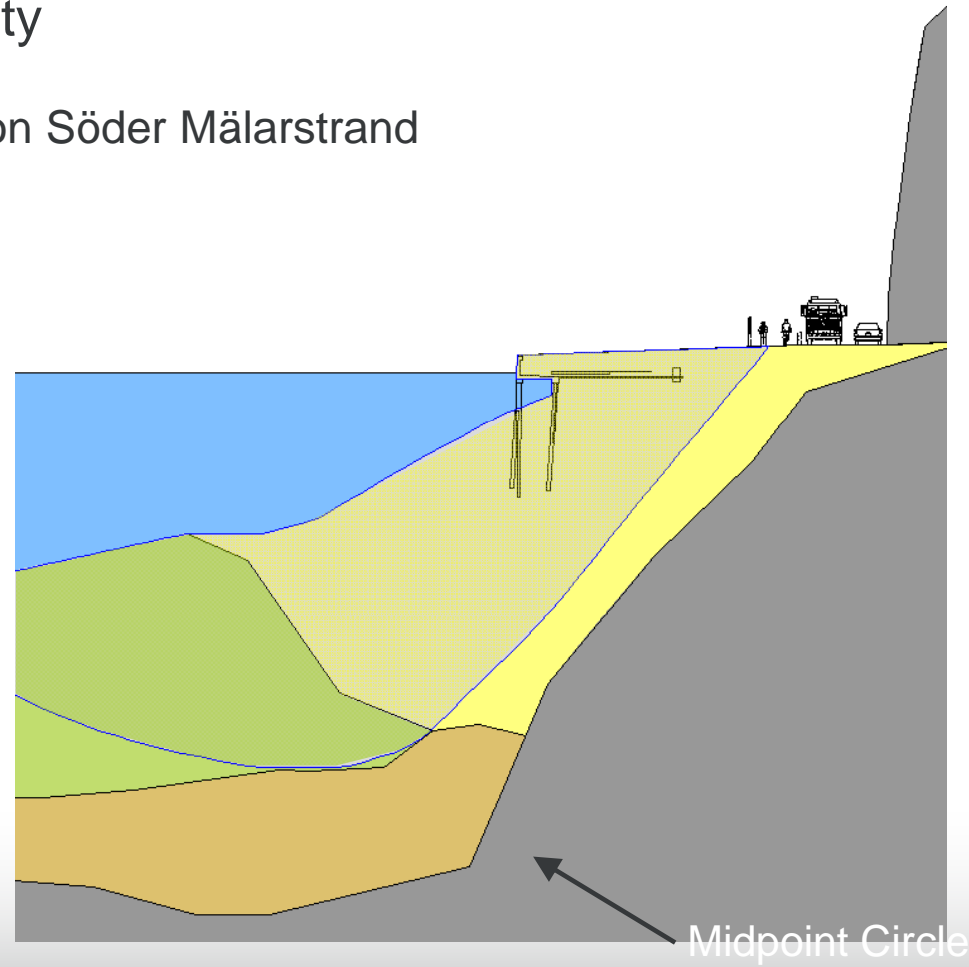
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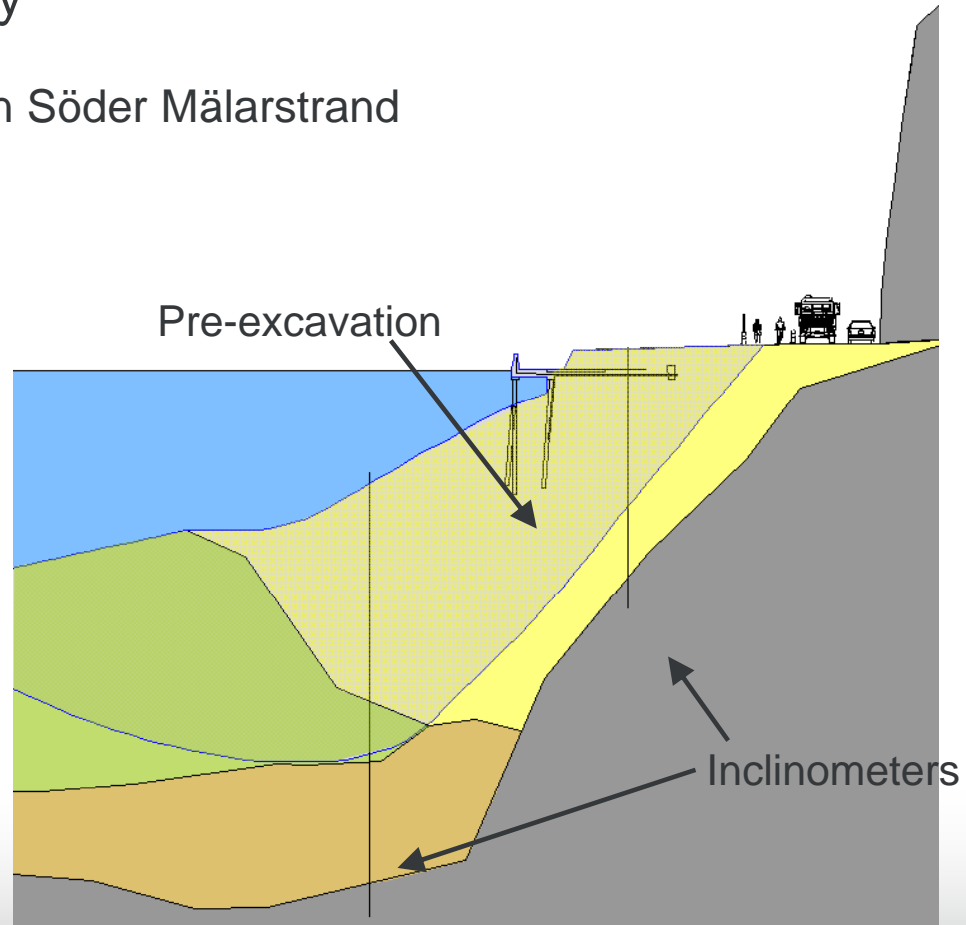
Slope stability

Cross Section Söder Mälärstrand



Slope stability

Cross Section Söder Mälarstrand



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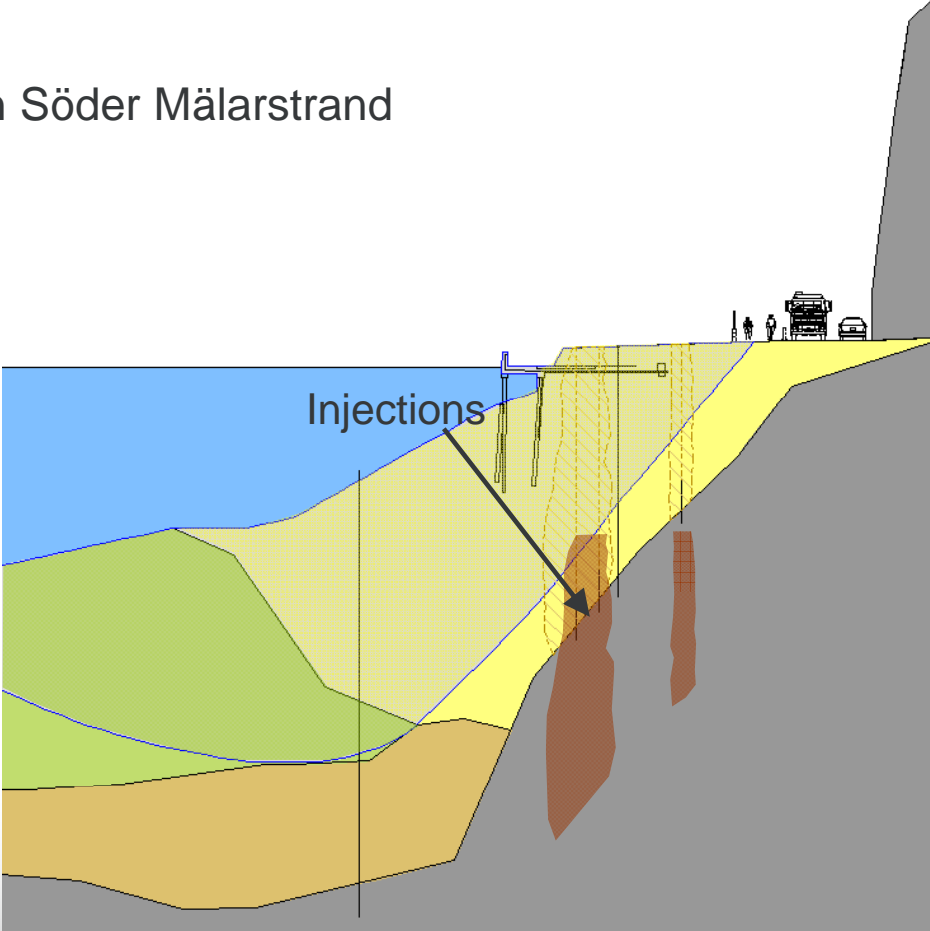
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Cross Section Söder Mälärstrand



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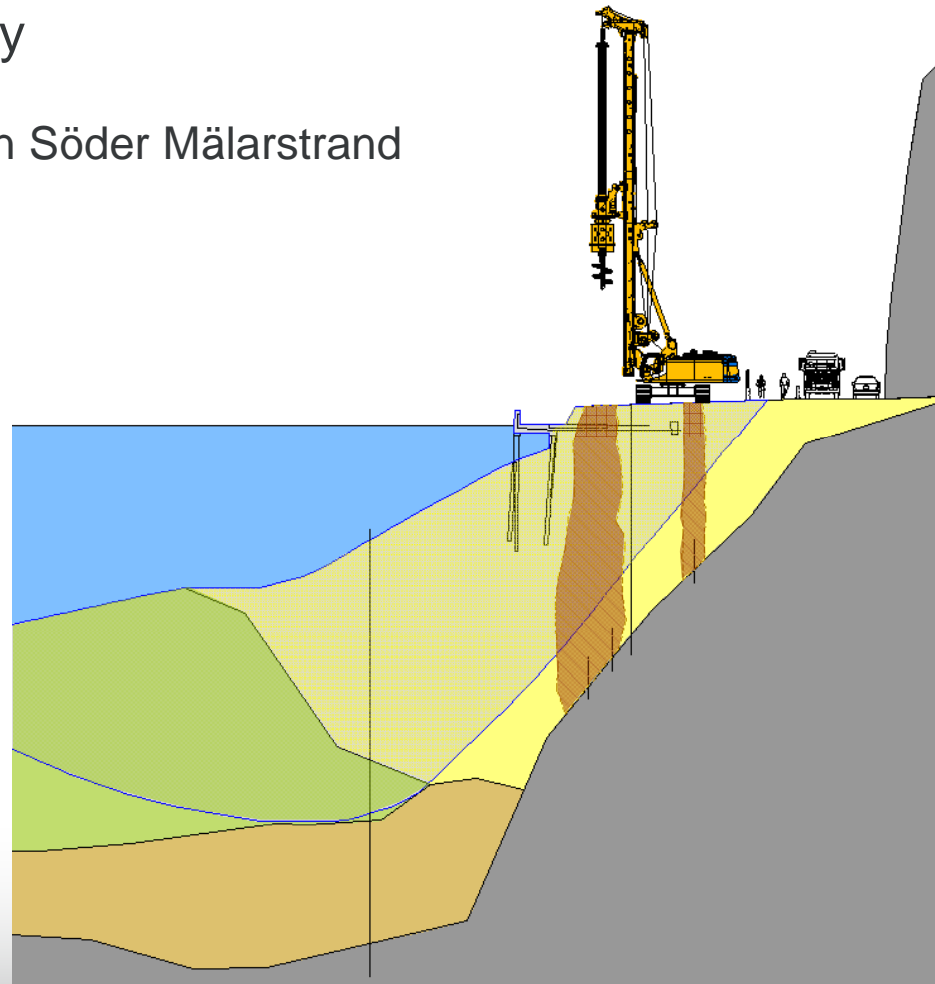
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Slope stability

Cross Section Söder Mälmarstrand



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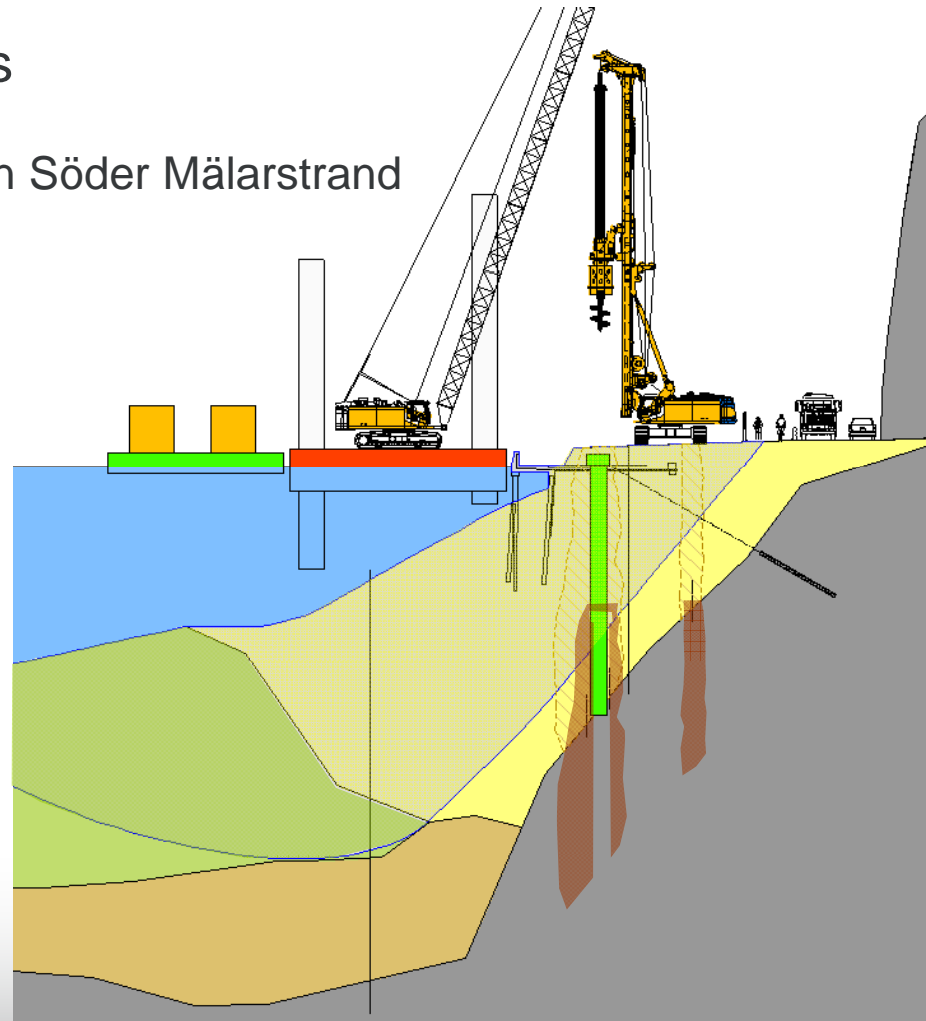
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Söder Mälars

Cross Section Söder Mälärstrand



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Söder Mälarstrand – Temporary Bridges



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Söder Mälarstrand – Casing rotator



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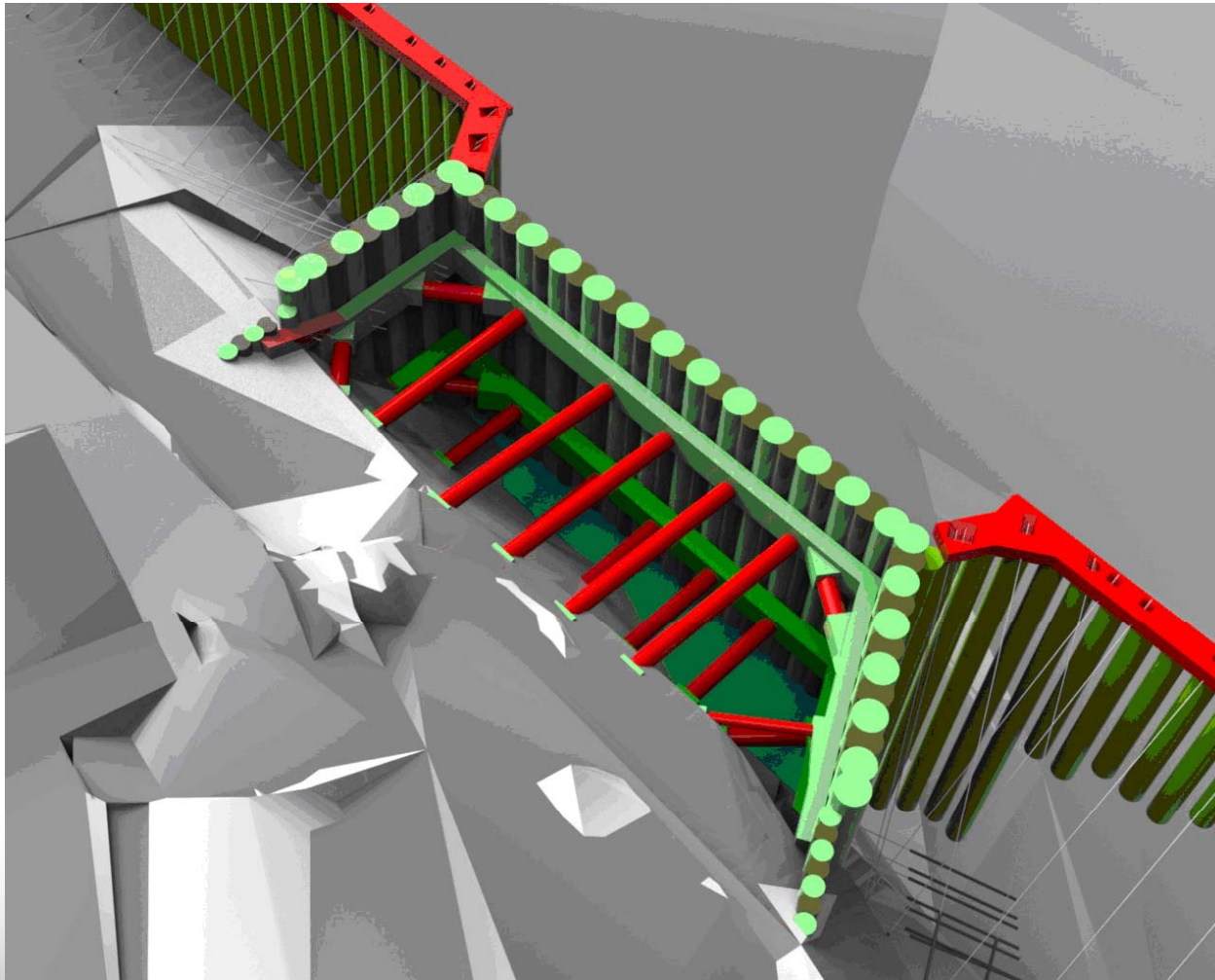
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Söder Mälmarstrand – Construction pit



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Söder Mälarstrand – Construction Pit



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Söder Mälarstrand – Construction Pit



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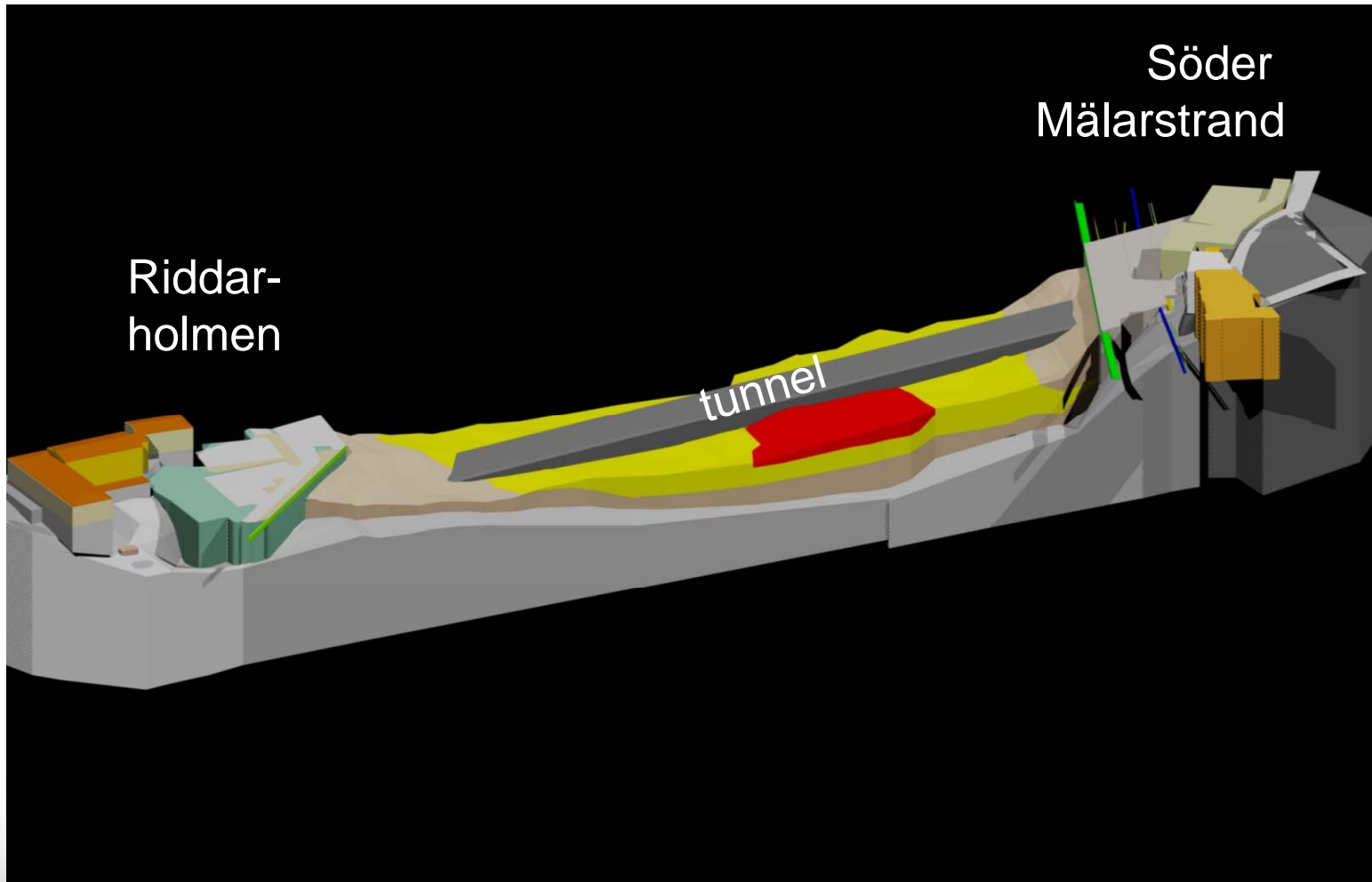
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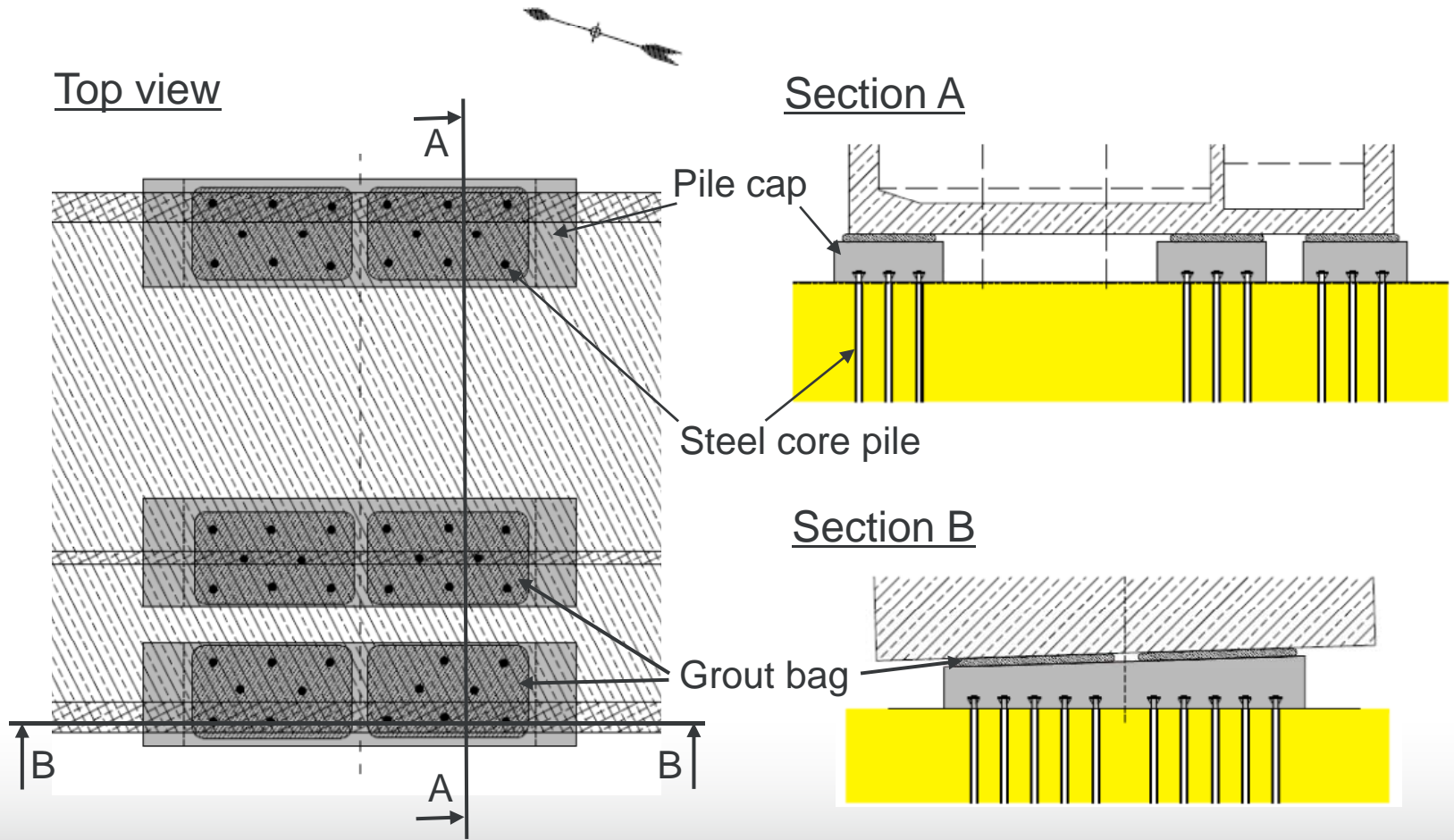
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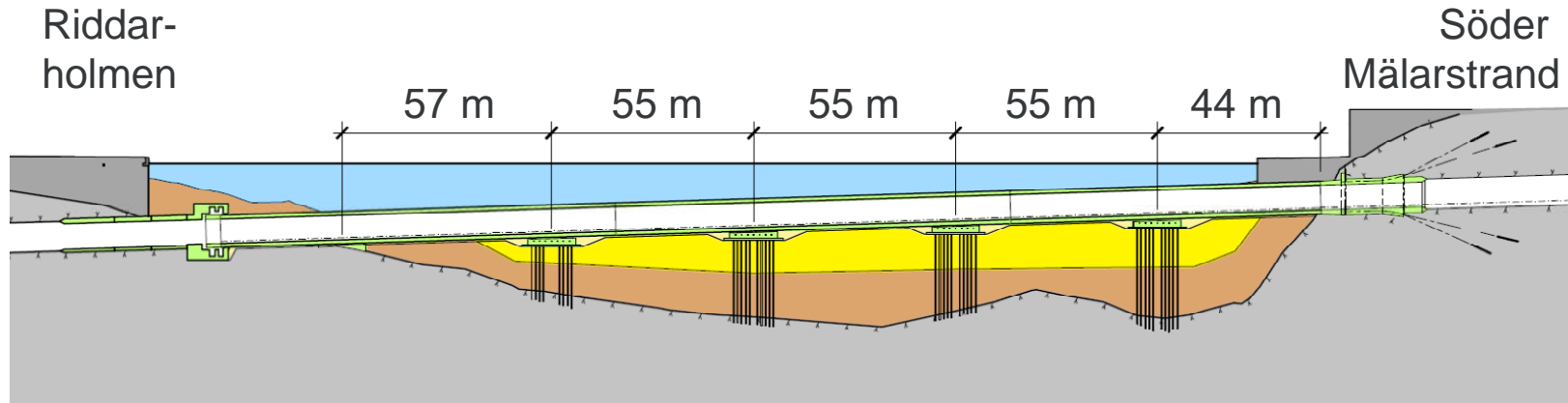
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Foundation layout

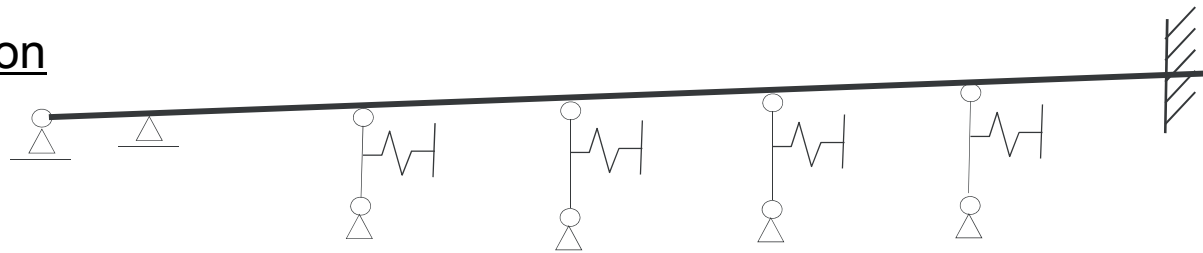


Design

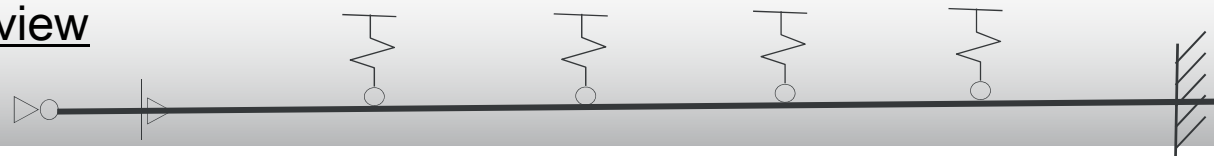


Simplified structural system

Section



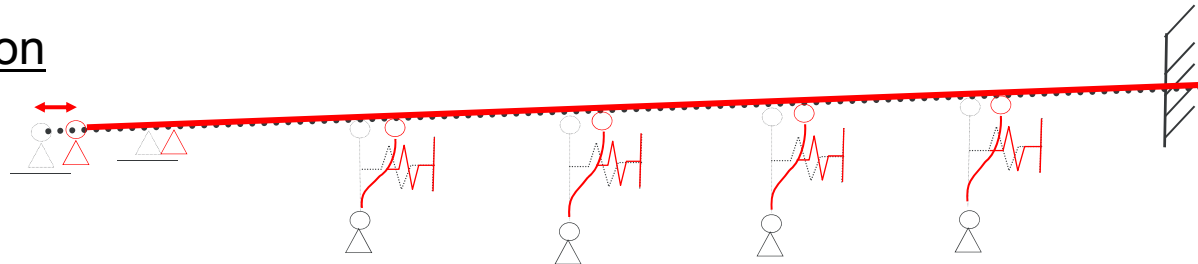
Top view



Design

Simplified structural system

Section



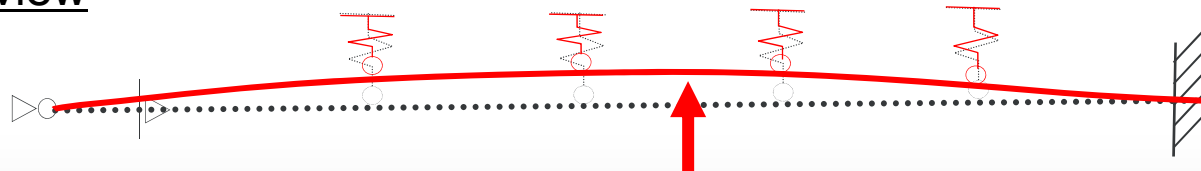
LC ULS creep/shrinkage/temperature:

large longitudinal deformation

low stiffness



Top view



LC ALS ship impact.

large transverse deformation/bending

low stiffness



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Design

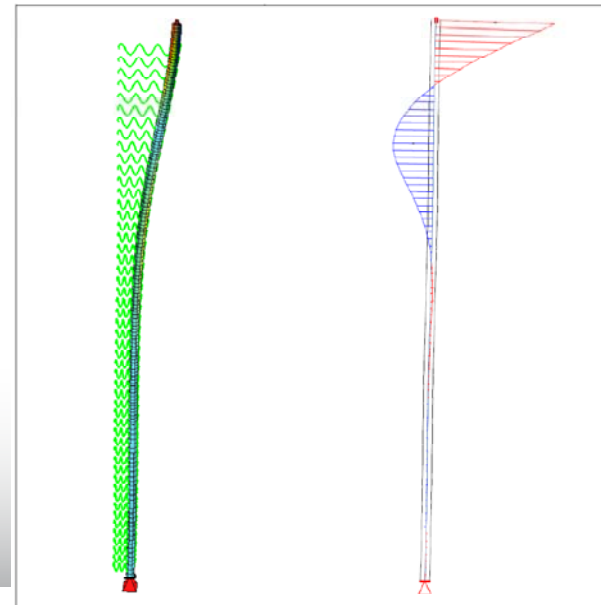
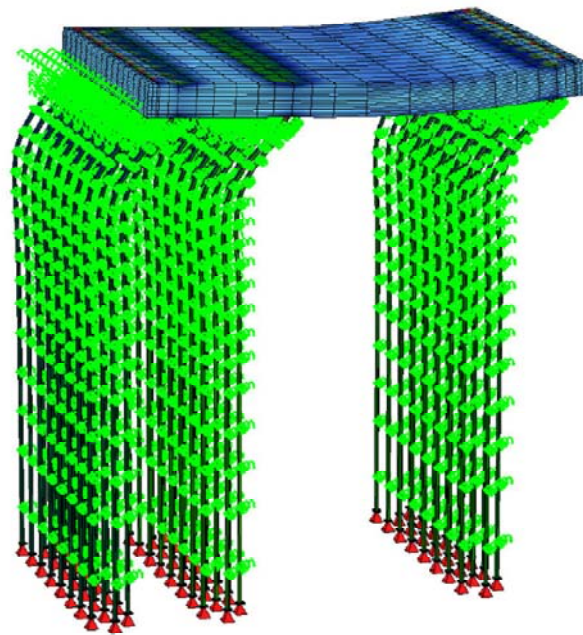
FEM-Method: program Sofistik

3d-model of pile group:

- horizontal stiffness
- stresses/deformation pile cap
- axial force/deformation at pile head

2d-model of single pile:

- internal forces
- buckling



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Execution

Challenges

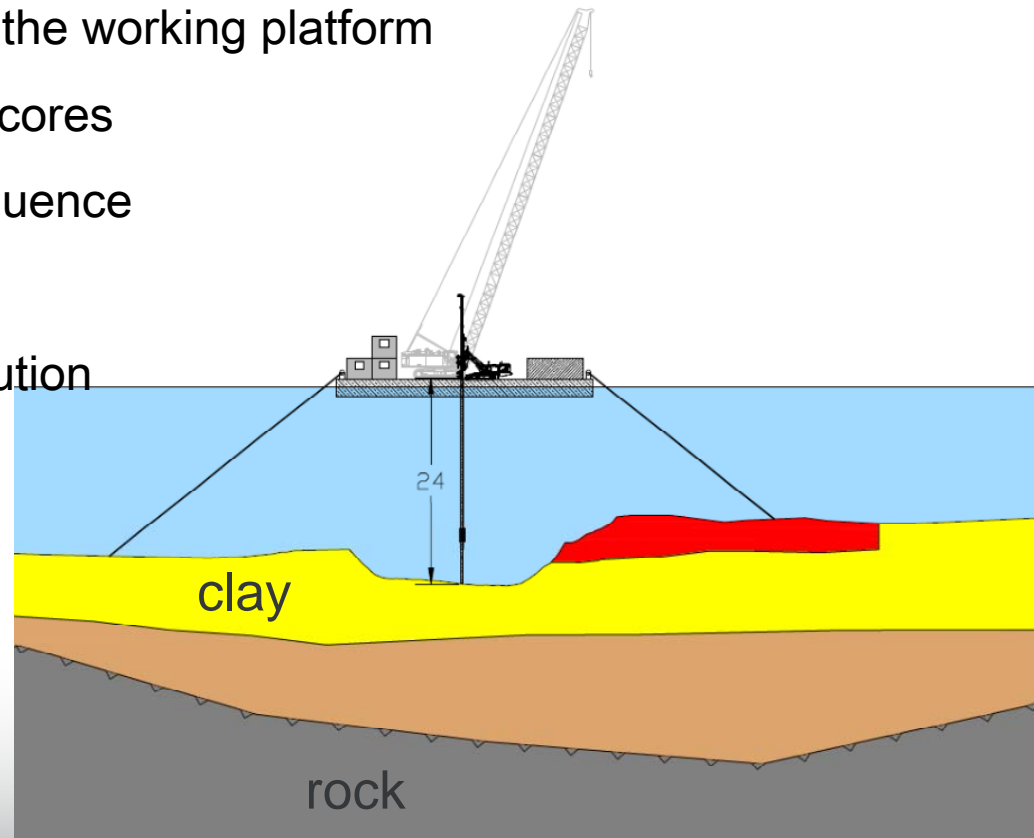
- stability and mobility of the working platform
- positioning of the steel cores
- suitable installation sequence
- surveying under water
- tolerances during execution

Tolerances

+/- 10 cm in height

10 cm in position

2° inclination



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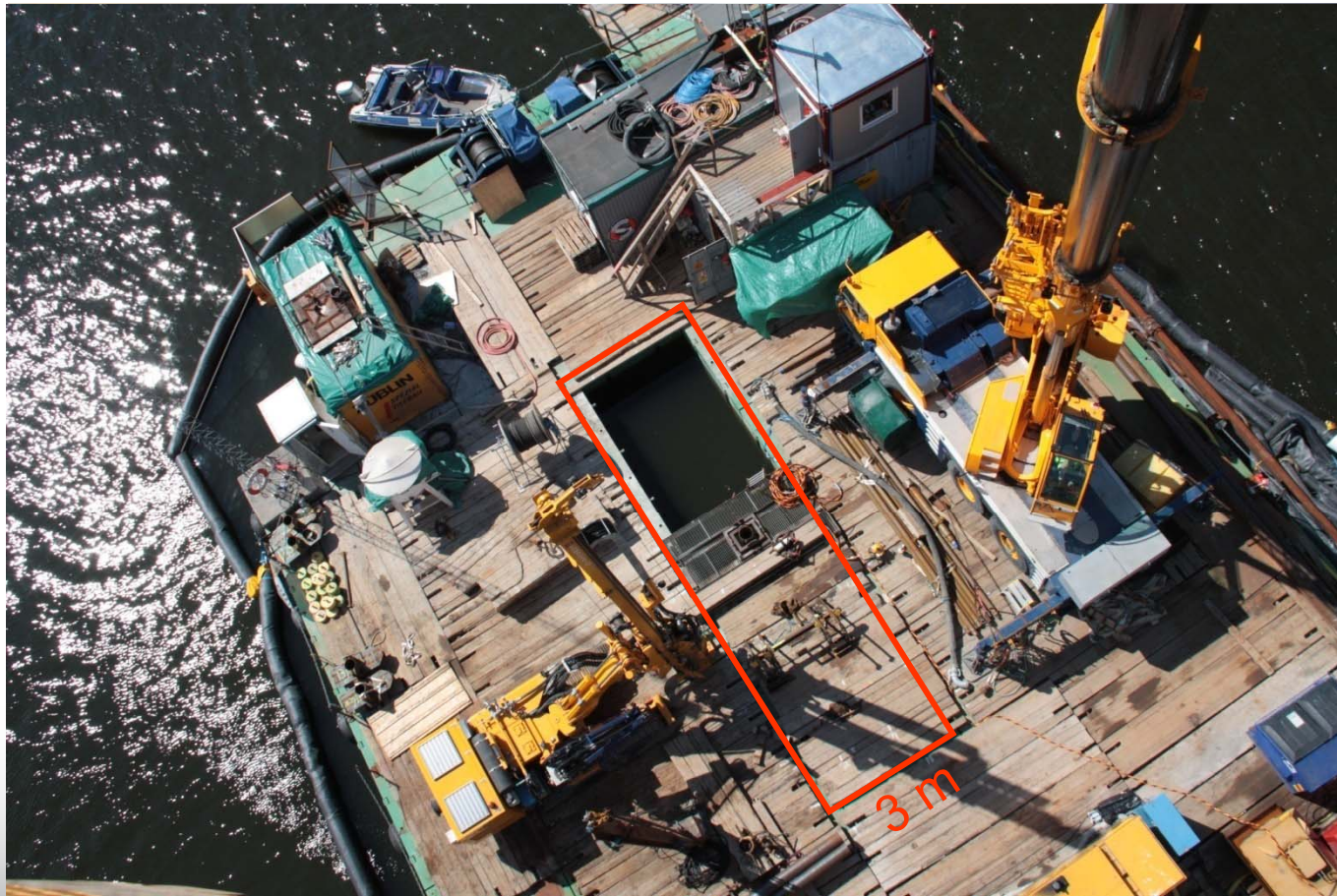
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Execution

Working platform



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Execution

Positioning of working platform

- steering with hydraulic winches
 - continuously GPS controlled
 - position simultaneously shown on screen
- } 10 min for relocation



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Execution

Guiding system

- position accuracy 1 -2 cm
- independent from divers

Stabilizing dead weight



Pitch and roll connection



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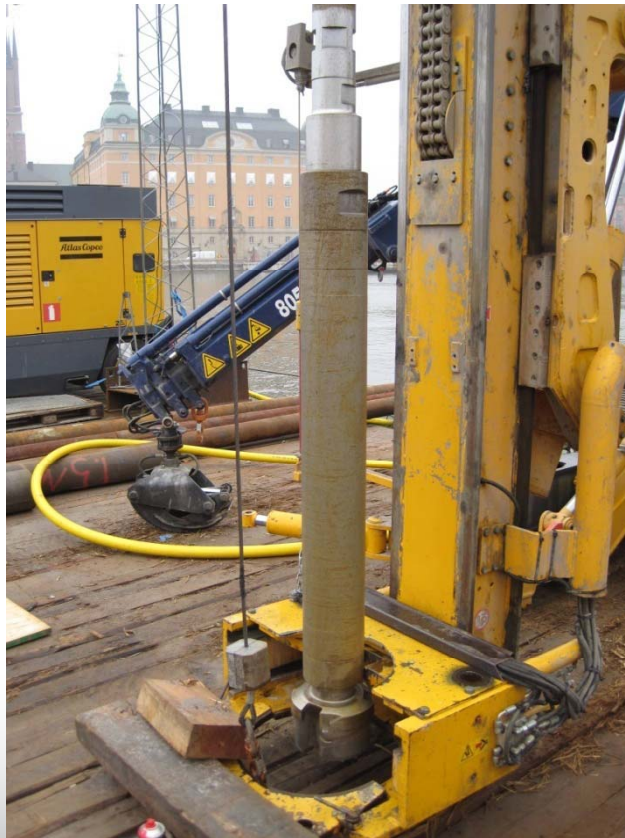
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Execution

Drilling



Equipment	
Drilling rig	Comacchio MC-4,01
DTH-hammer	IR 380 (8")
Ring set	Robit DTH-RoX 273/8
Pilot bit	DTH-RoX with modified airflow
Drill Logger	Jean Lutz LT 3
Casing	Ø273 mm, t=6,3mm 24 m prefabricated starter piece



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Execution

Installation of steel core

Lifting of steel core



Mounting of pipe clamps



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Execution

Smart stick

- 30 m high steel framework
- inclination measurement
- 3 GPS antenna (direction, position)
- software for real time positioning
- 15 mm accuracy



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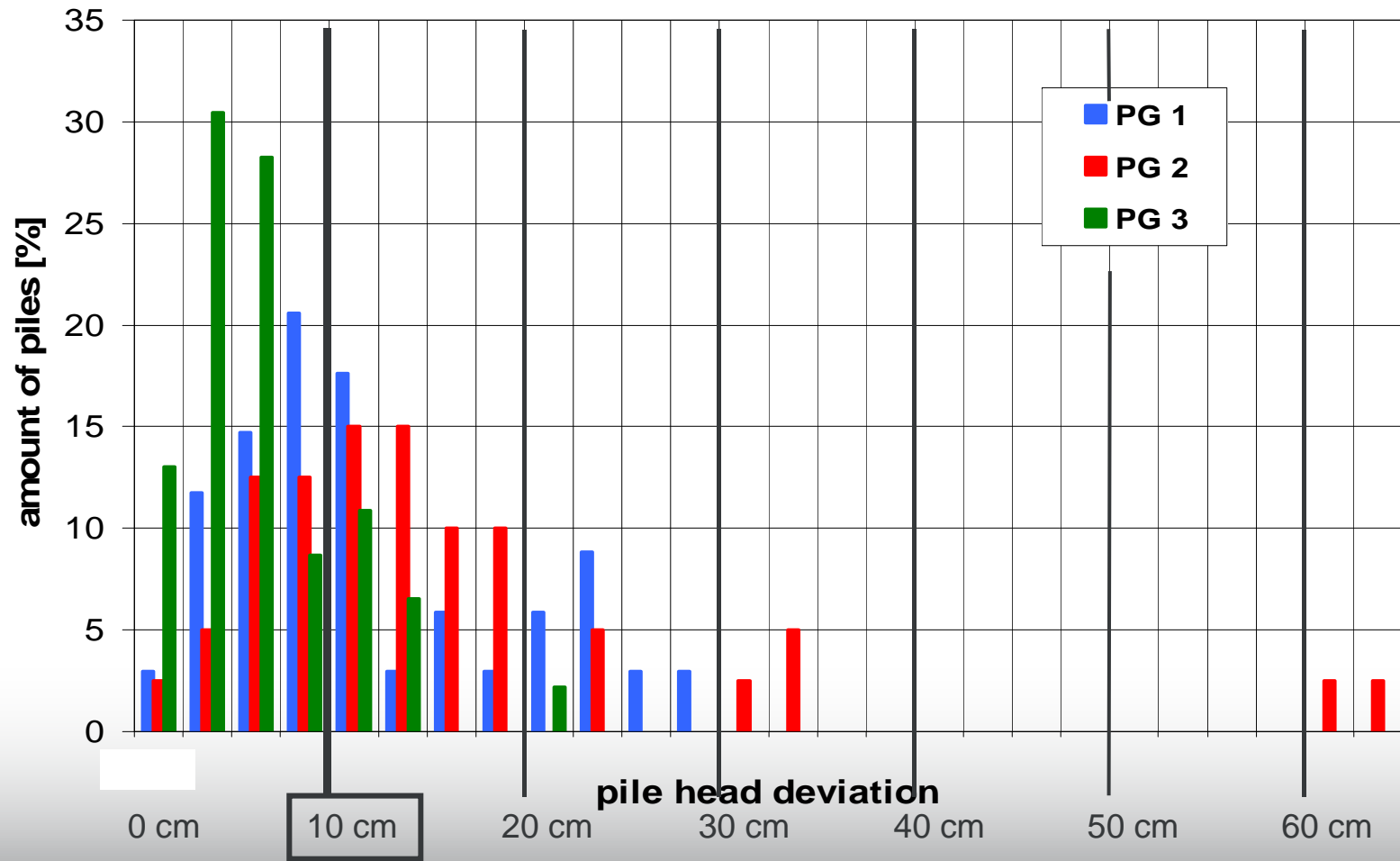
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Conclusion

Distribution of pile head deviation



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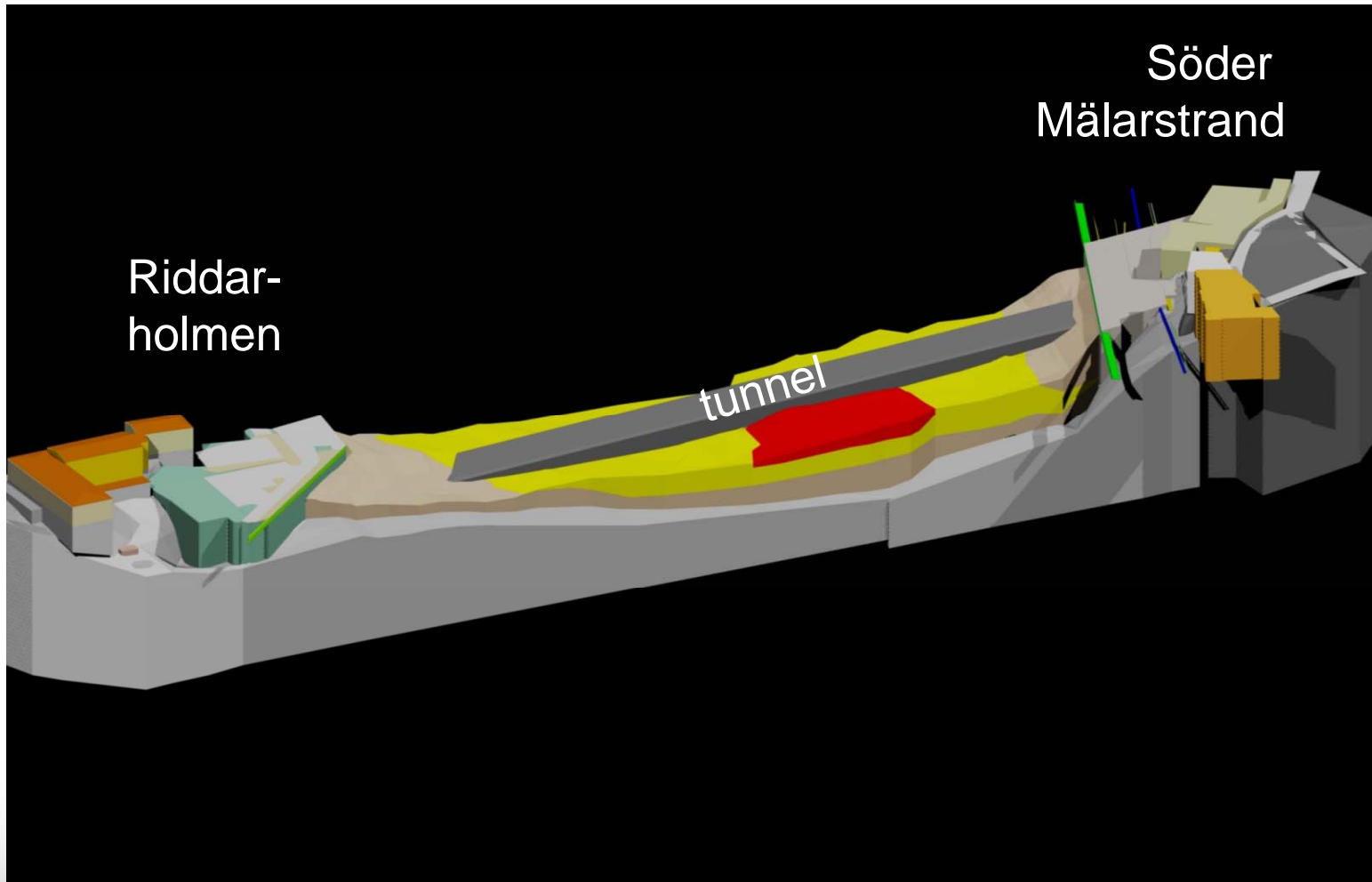
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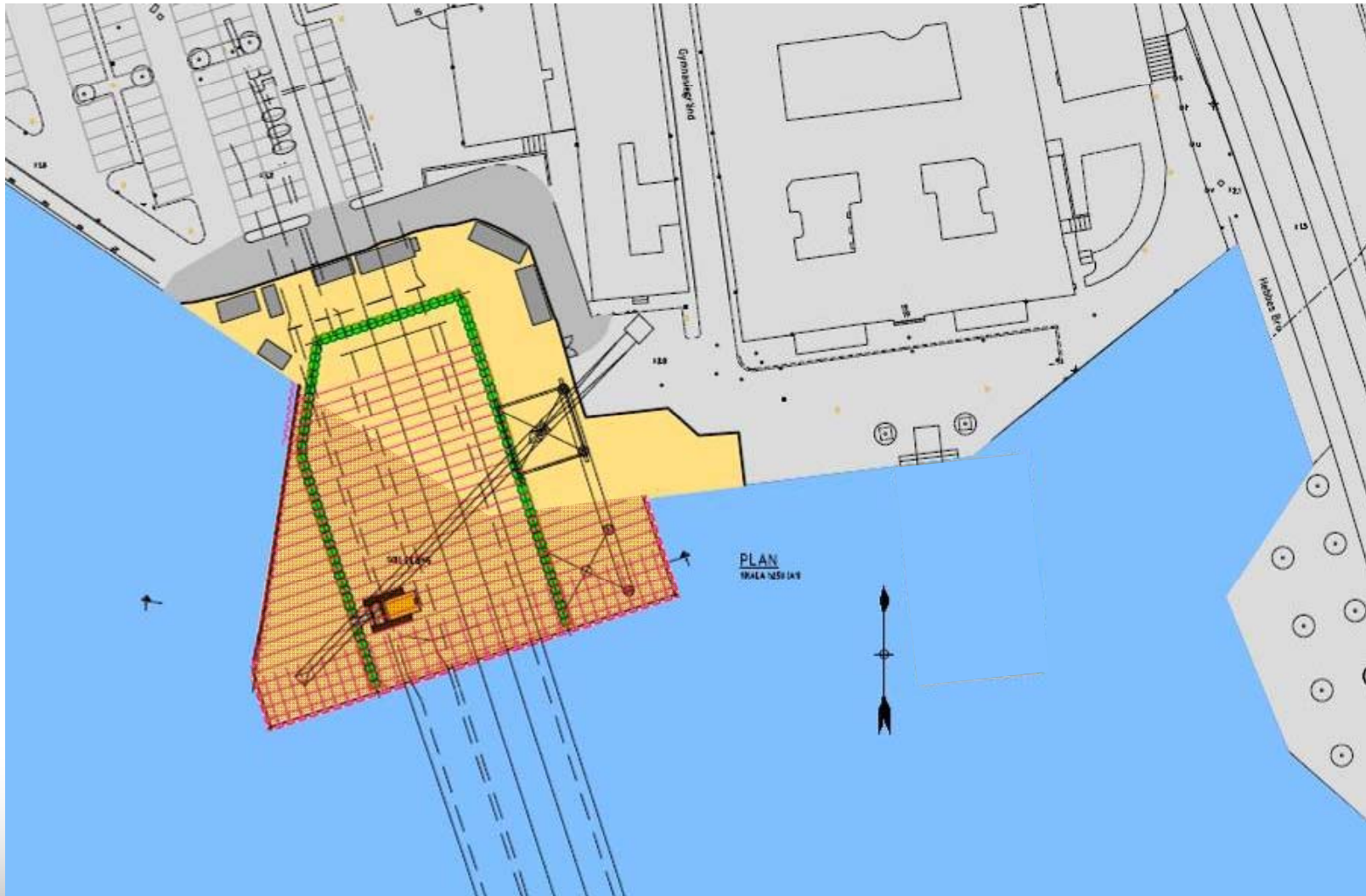
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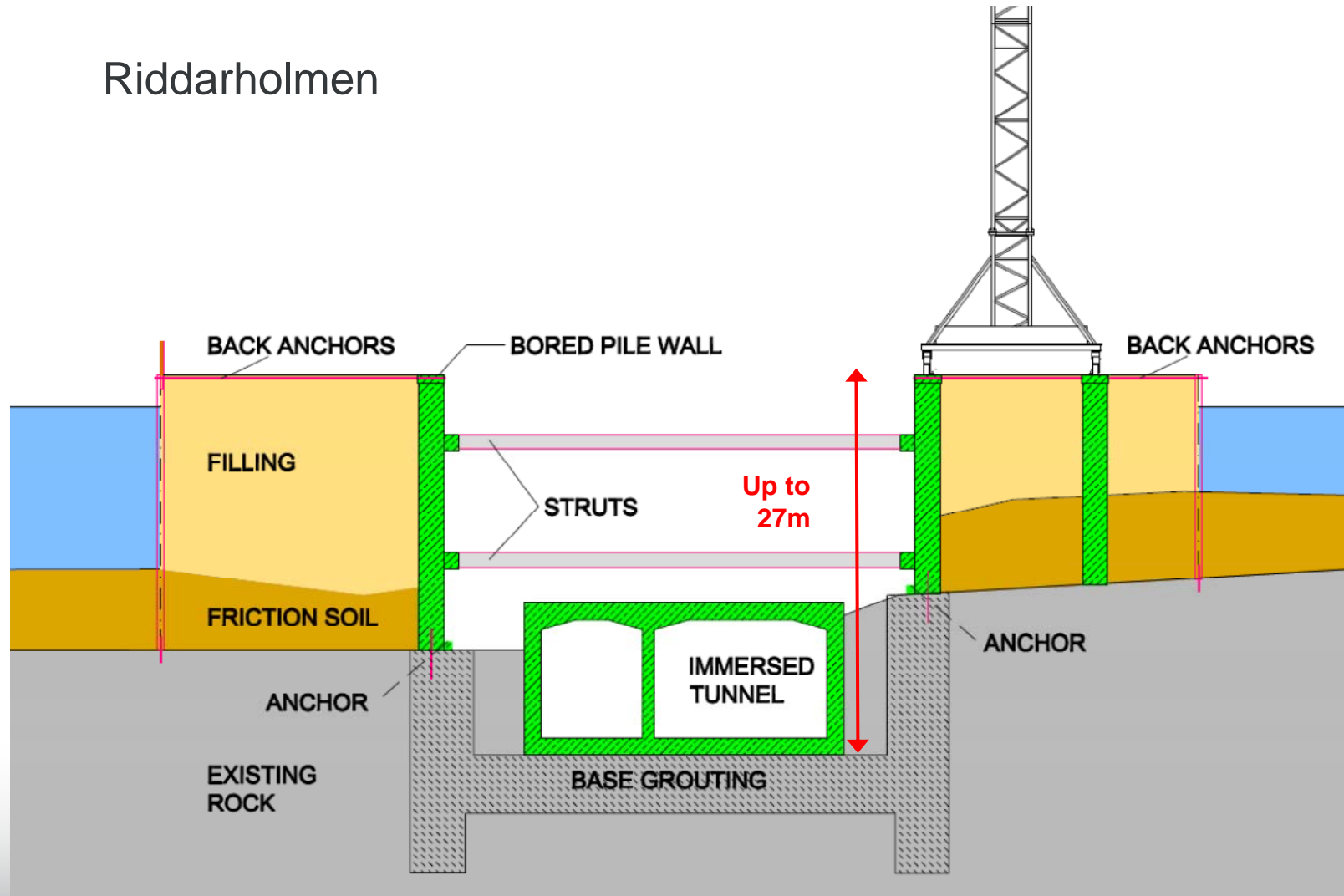
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Riddarholmen



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Riddarholmen



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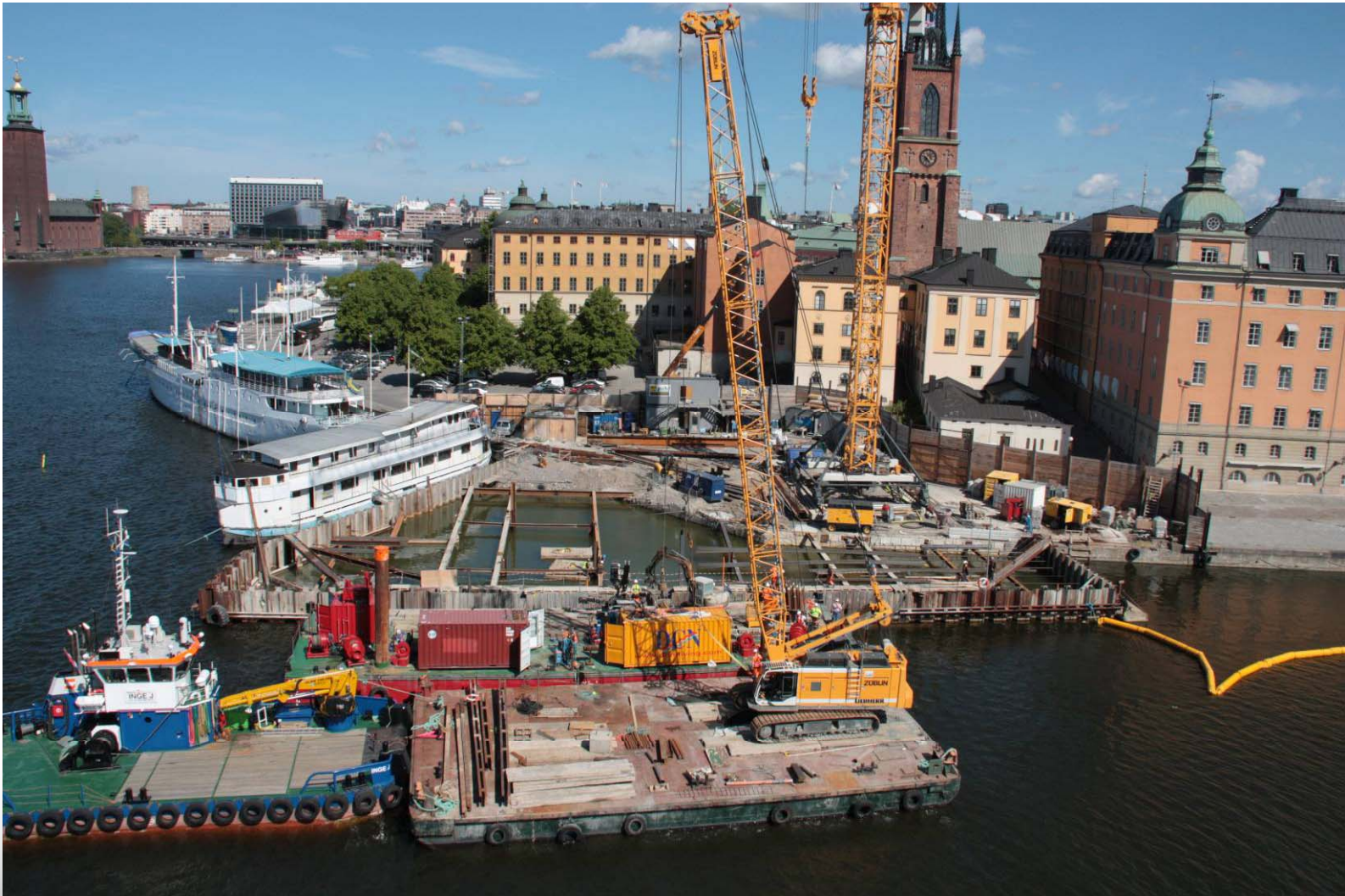
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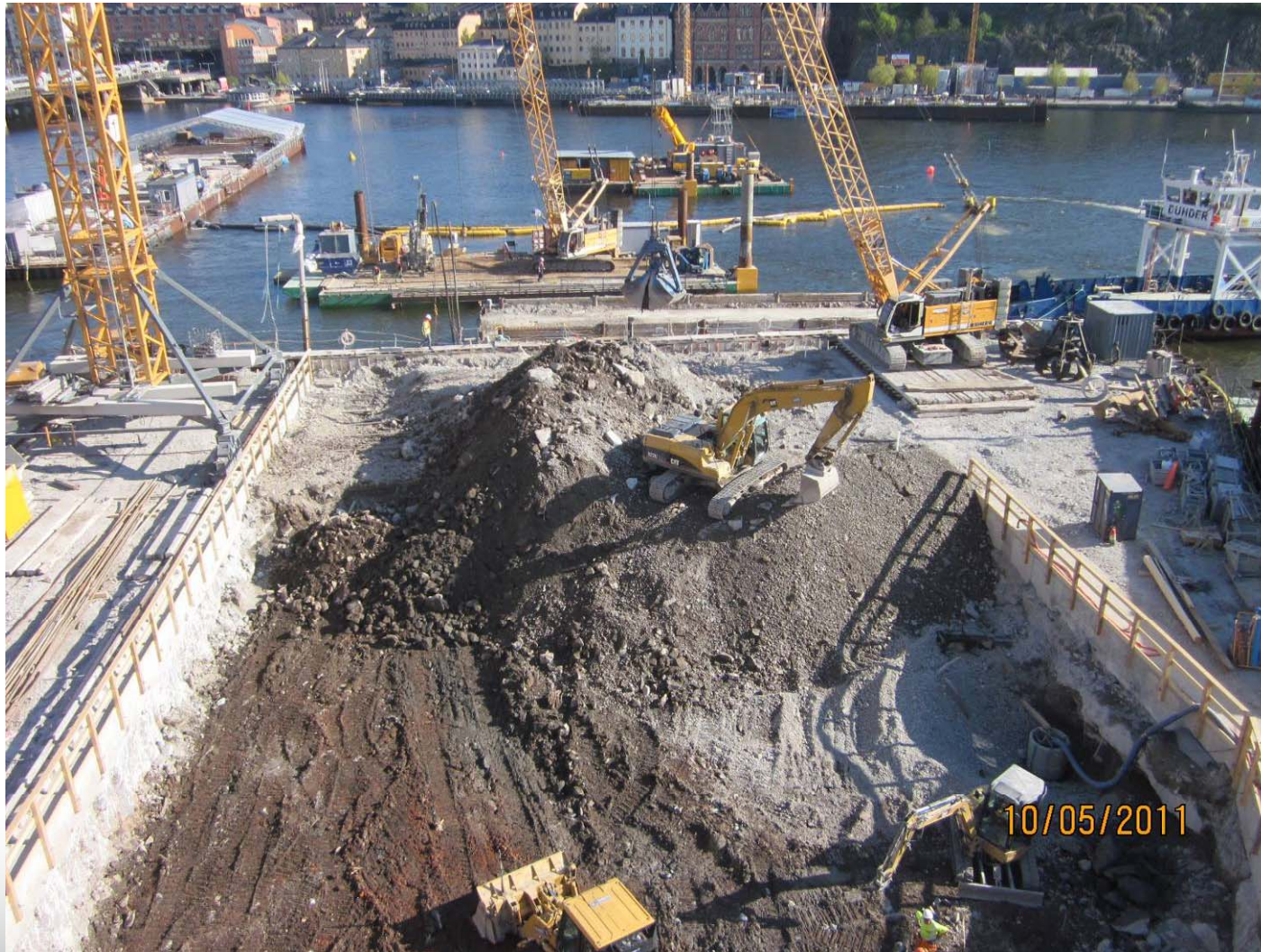
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