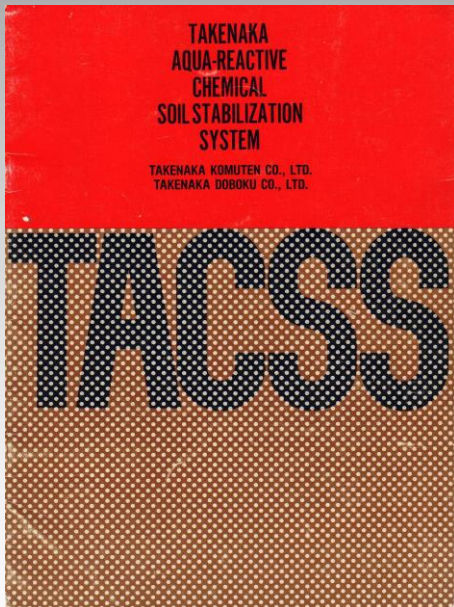
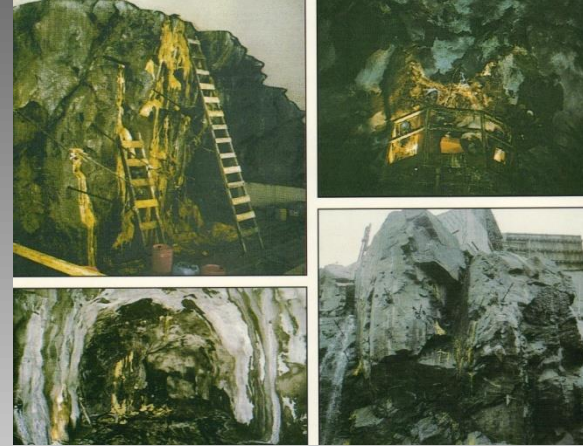



# Sealing the zone between soil and rock to stop water and quick clay

Helen Andersson



# Introduction on polyurethane grout



 Regjeringen.no

Tetningsmidlet TACSS har vist seg å være et svært effektivt hurtigbindende tetningsmiddel. En SFT-godkjent utprøving på 350 kg dokumenterte dette. For å sikre en forsvarlig gjennomføring av arbeidet med bruk av dette kjemiske middelet har det på oppdrag fra Samferdselsdepartementet blitt gjennomført en system- og kvalitetskontroll fra firmaet Grøner AS av selskapets og entreprenørens arbeidsopplegg. Etter ytterligere utprøving av 1000 kg TACSS med kontroll av utslipp av ftalater, har SFT konkludert med at utslippene forbundet med bruk av TACSS ikke har medført noen uakseptabel miljørisiko.



a description of the construction techniques employed by BPA for

## a complicated tunnel

under the Göta river in Gothenburg

client: the Göteborg Energy Authority

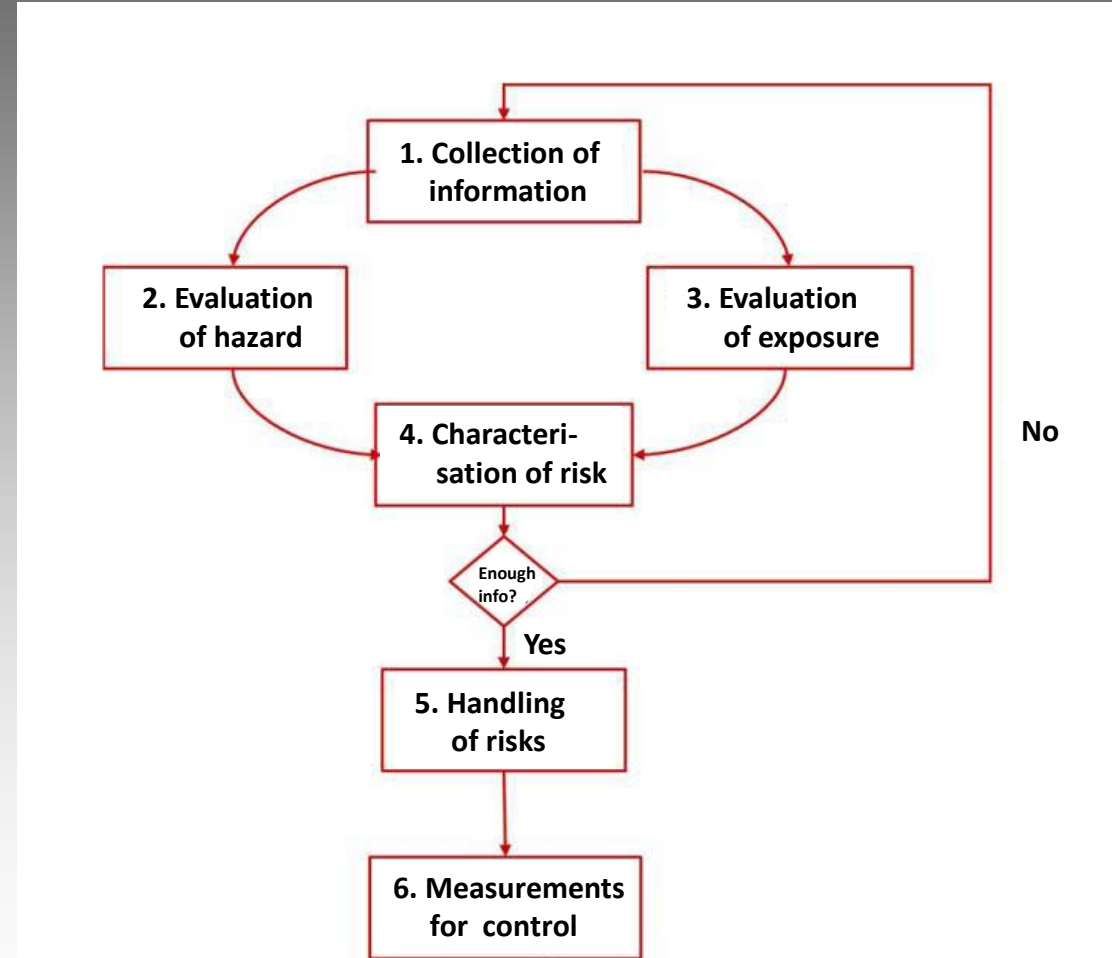
# Environmental aspects for polyurethane

- Environmental risk assessment – Romeriksporten, Oslo
  - use of all chemical grouts was stopped due to the Rhocagil scandal
  - very high requirements were set on health and environmental aspects
  - investigation and information seeking led to trial grouting rounds with PU
  - water measurement program and calculations controlled the pollution



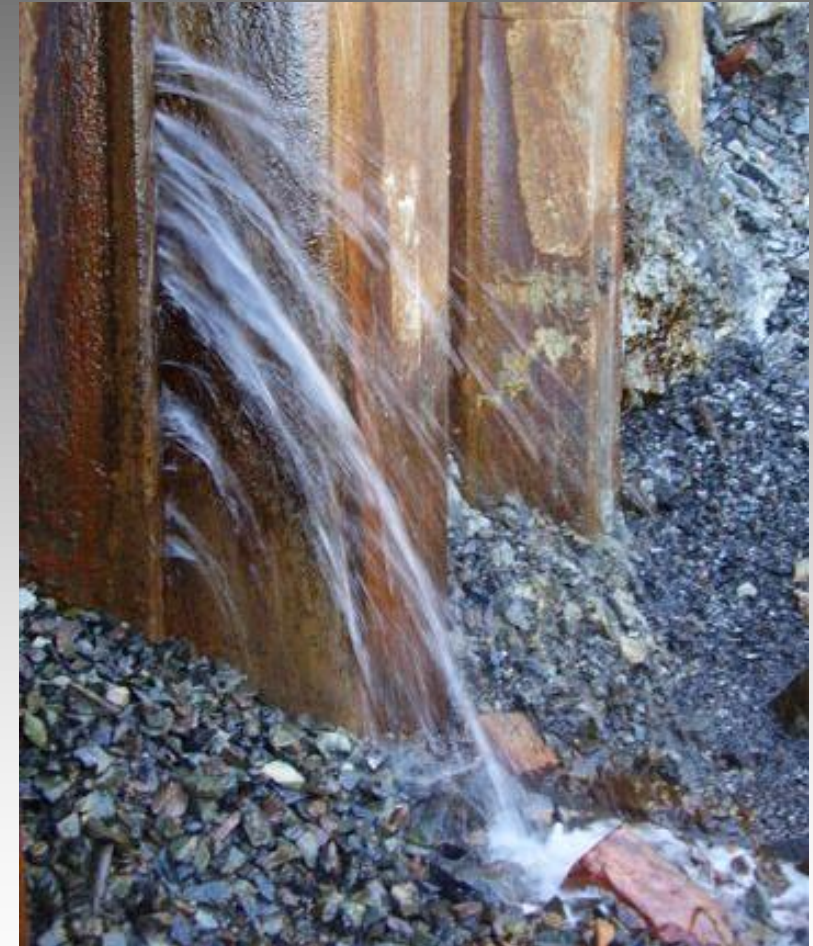
# Environmental aspects for polyurethane

- Environmental risk assessment – typical methodology
  - initially low detailing combined with very high safety factor
  - risk characterisation may require collection of additional data
  - larger information base allows a lower safety factor to be used
  - unwanted risk is handled and pollution is controlled



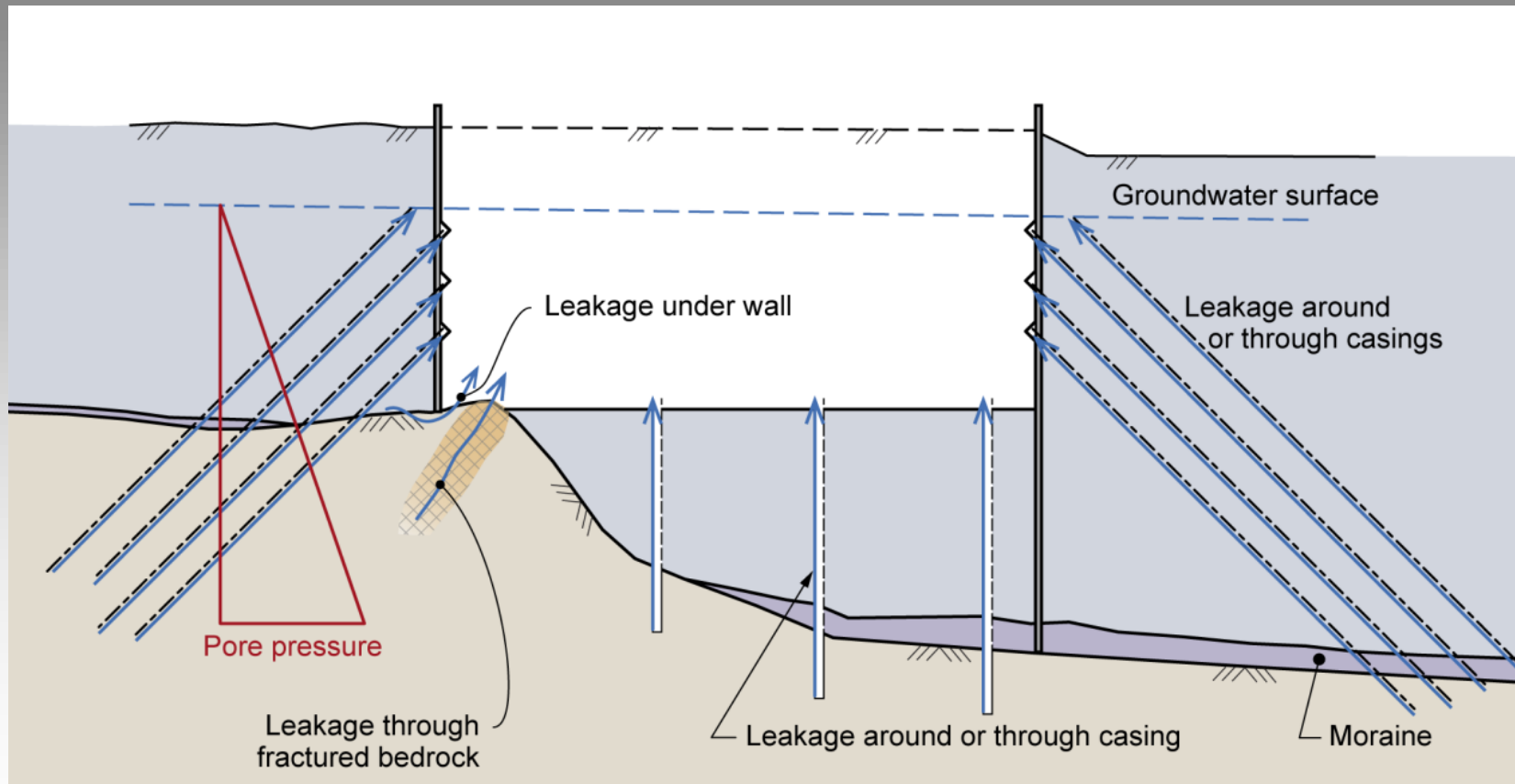
# Limit damages due to deep excavations

- BegrensSkade II (REMEDY)
  - how to conduct deep excavations in a safe manner for the surroundings
  - Byggegruppveiledningen 600++ p., 2019
- Pore pressure reduction
  - drilling for tiebacks and/or piles, through casing or along drill string
  - holes in sheet pile and/or interlocks
  - gaps between bedrock and toe
  - joints and fissures in bedrock



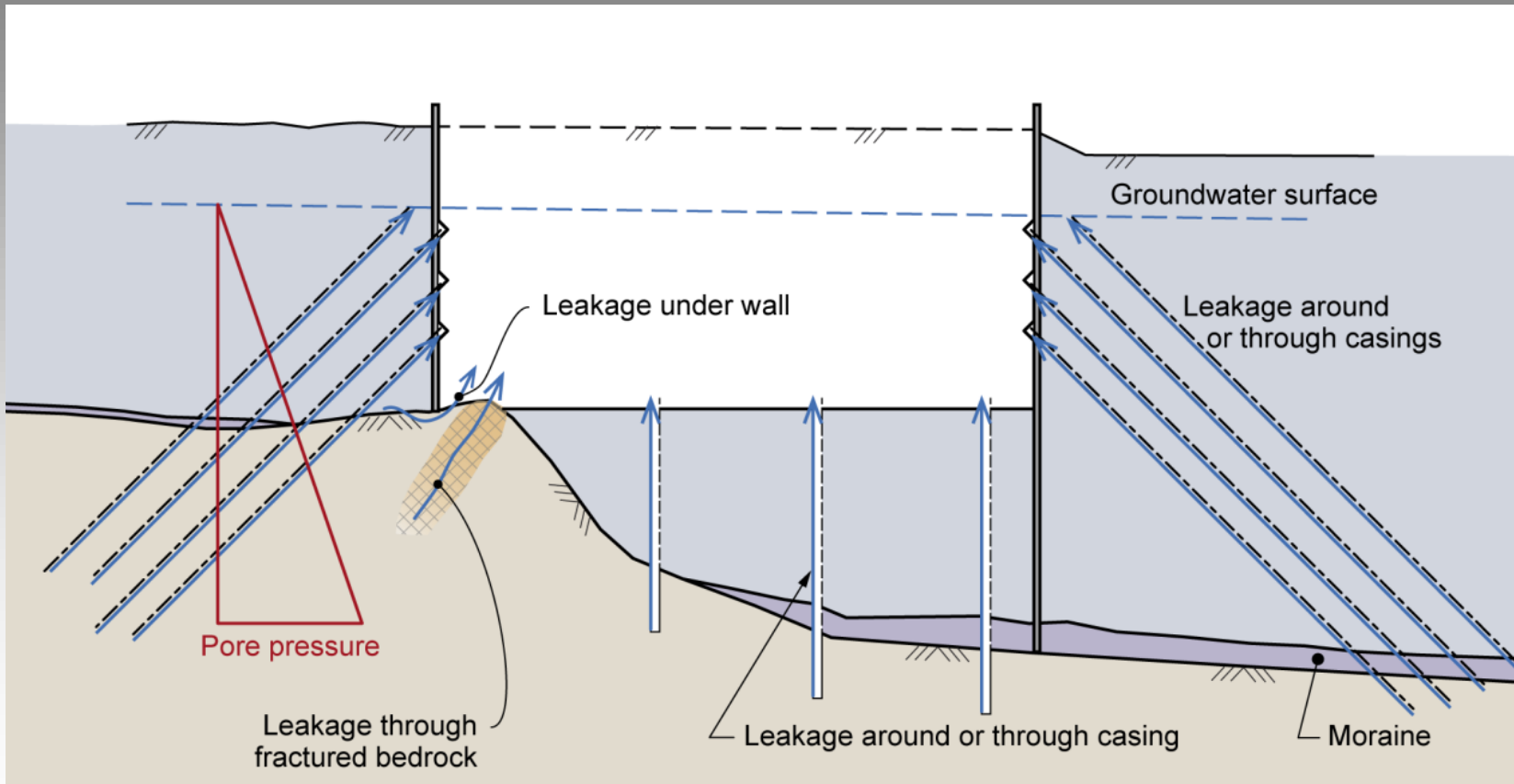
# Limit damages due to deep excavations

- Grouting to seal a sheet pile wall



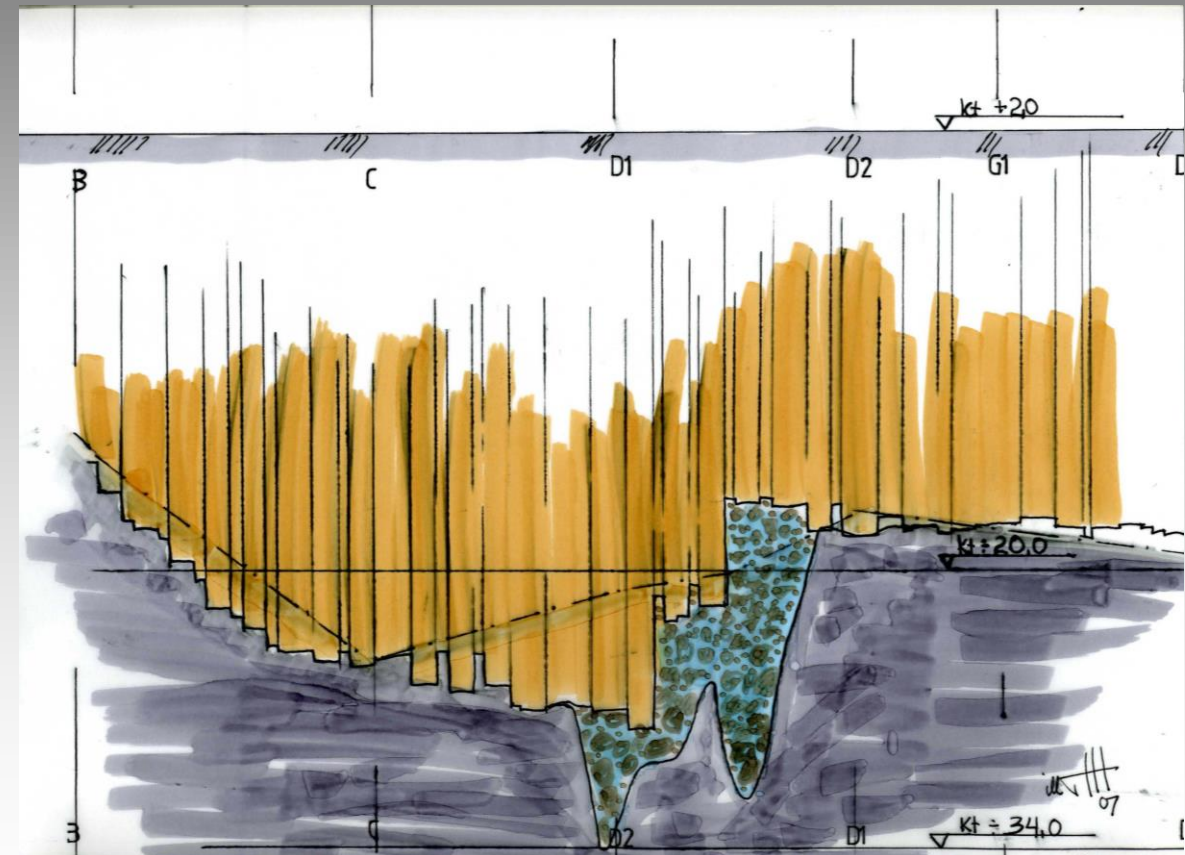
# Limit damages due to deep excavations

- Grouting to seal a sheet pile wall



# Limit damages due to deep excavations

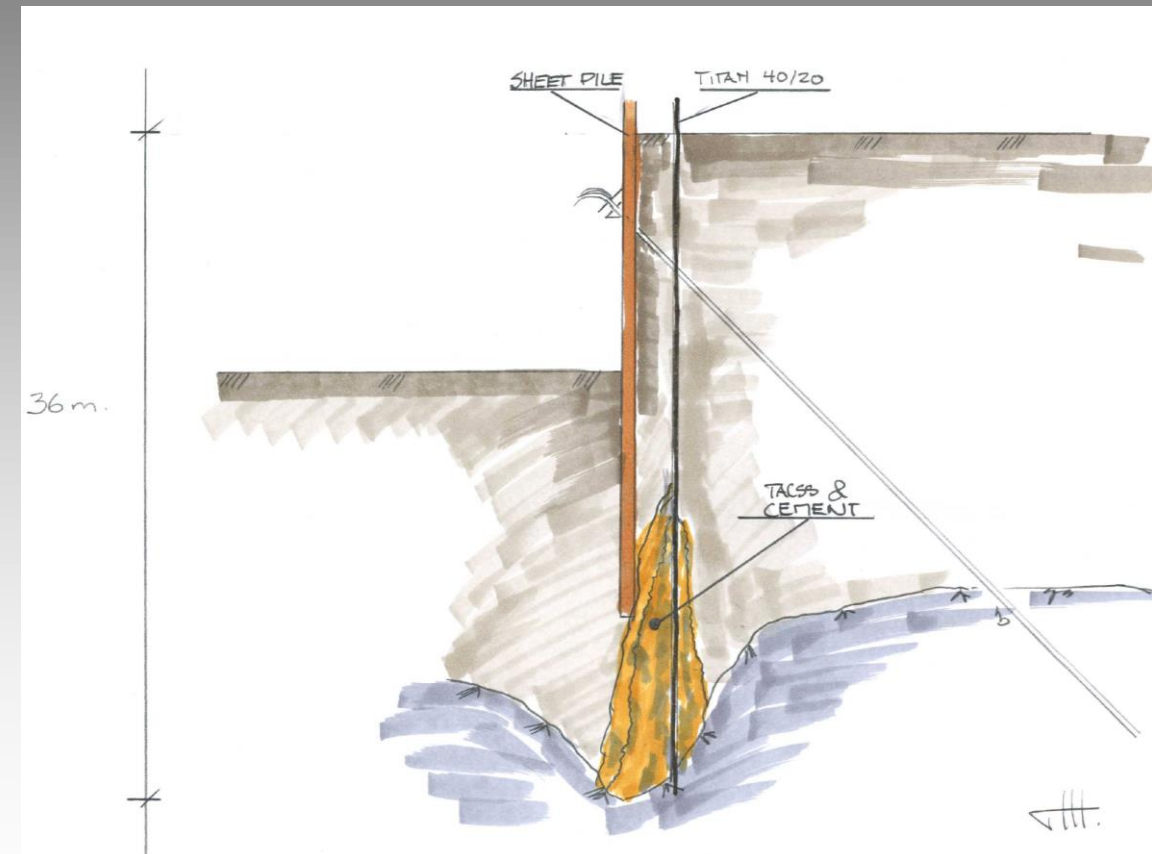
- Grouting to seal gaps below a sheet pile wall
  - illustration Havneleret, Oslo, gaps between toe and bedrock
  - false stops of sheet pile in hard permeable moraine with blocks
  - in some places more than 10 m between sheet pile and bedrock
  - large water leakage into the building pit despite jetgrouting





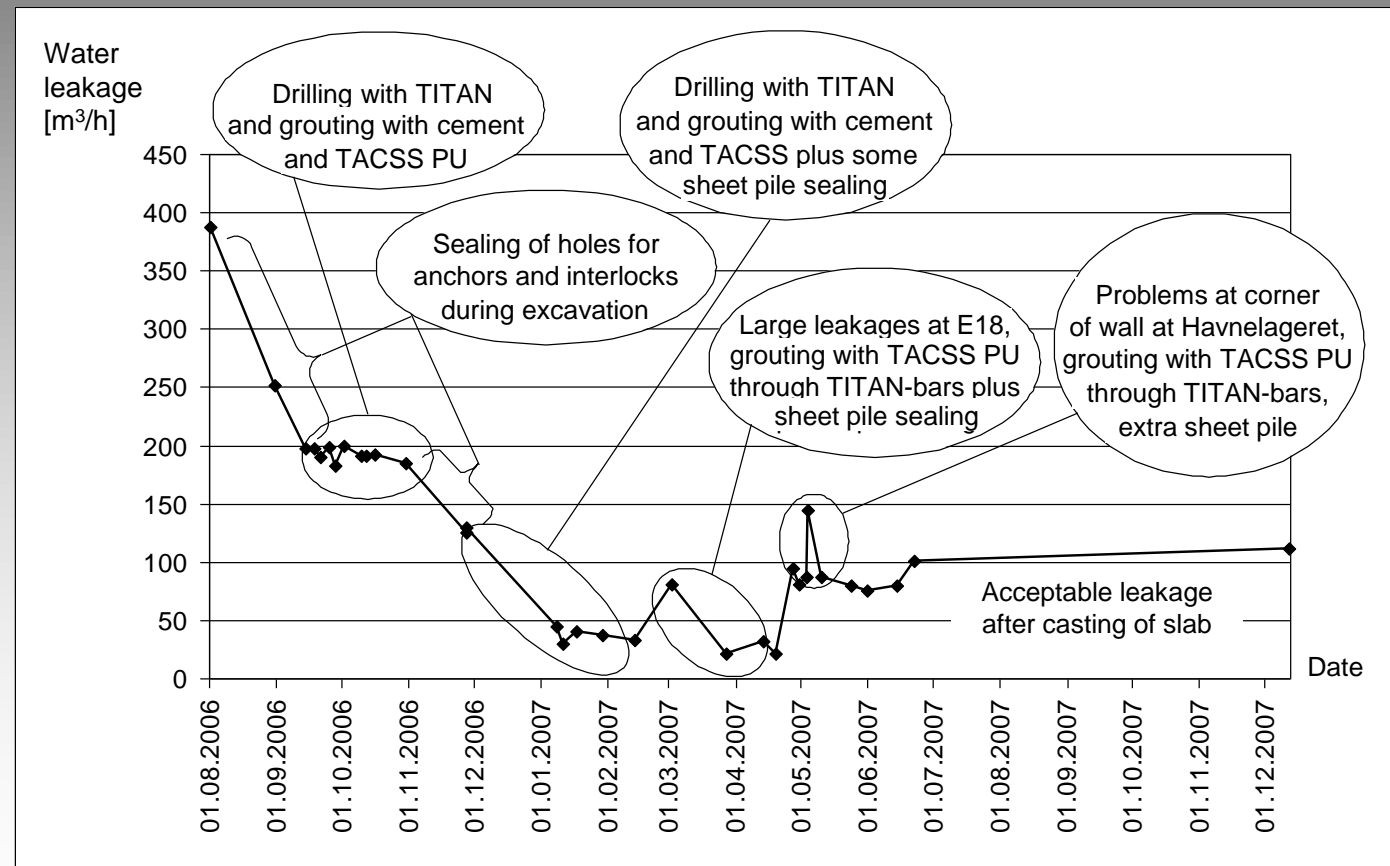
# Sealing against water ingress

- Havneleret, Oslo
  - primitive but effective sealing with PU of holes for tiebacks in and interlocks the sheet pile
  - drilled to more than 30 m depth with TITAN 40/20 hollow bar and performed combination grouting
  - Combi Grouting is a downstage grouting method where PU is added to the cement grouting



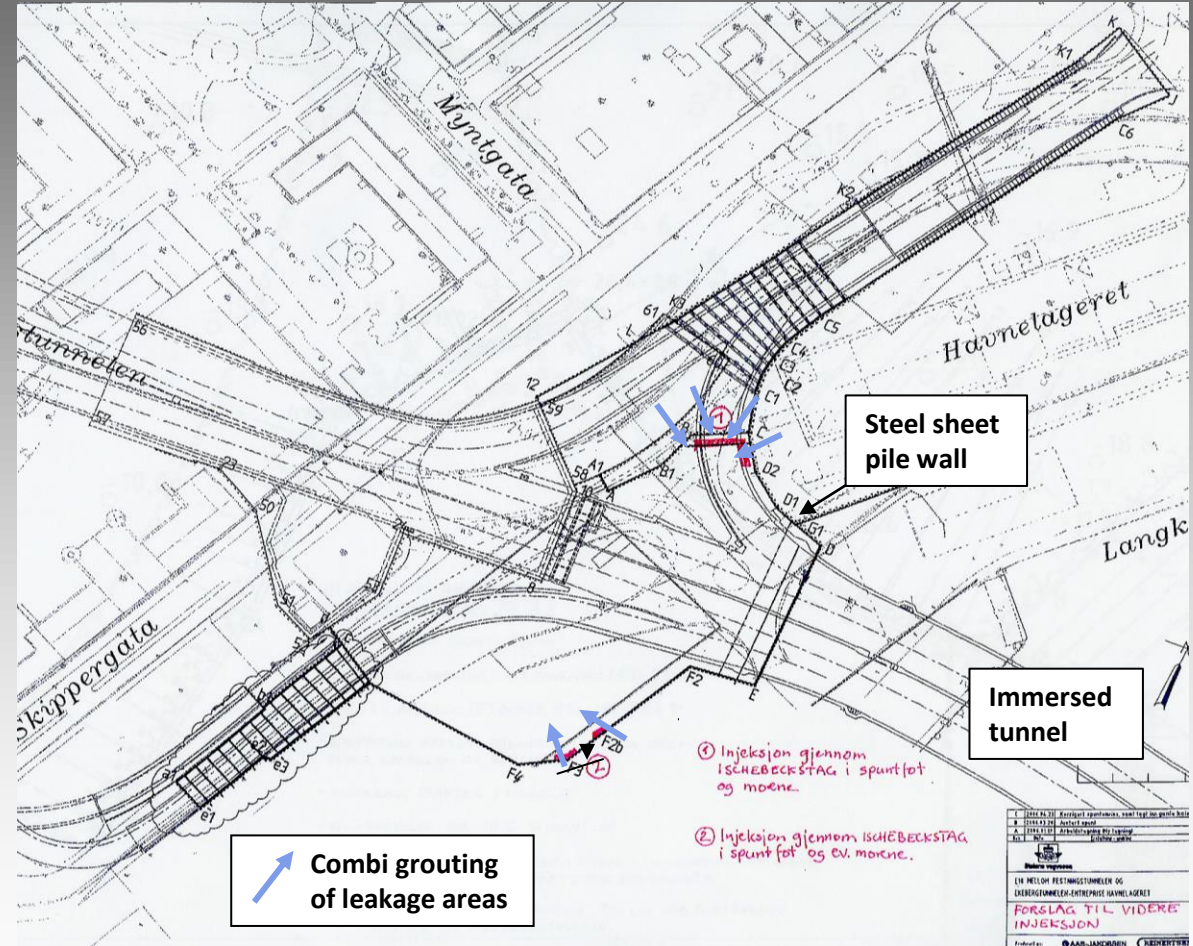
# Sealing against water ingress

- Havneleret, Oslo
  - polyurethane grouting to seal holes for tiebacks and interlocks in the sheet pile
  - combination grouting with polyurethane and cement to seal below sheetpile toe
  - water leakage ~400 m<sup>3</sup>/h to ~50 m<sup>3</sup>/h (excavating), ~100 m<sup>3</sup>/h ok with slab



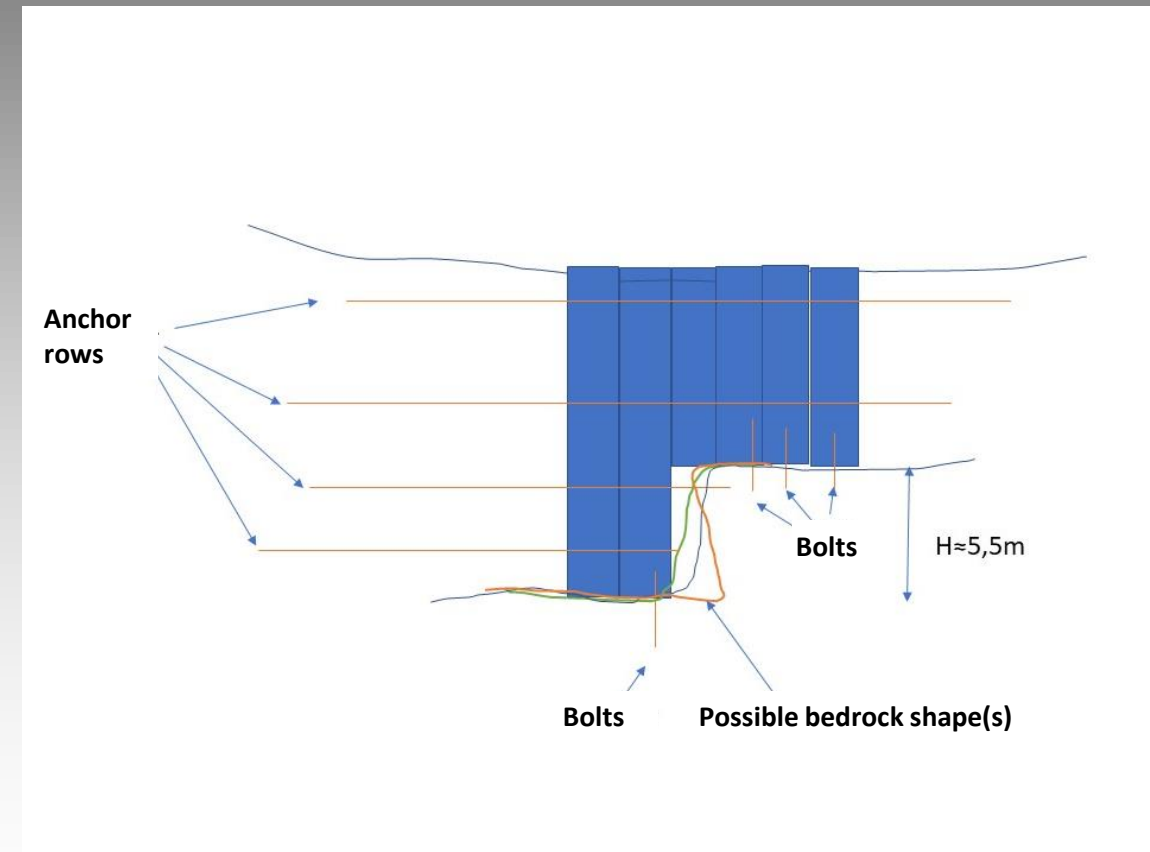
# Sealing against water ingress

- Havnelageret, Oslo



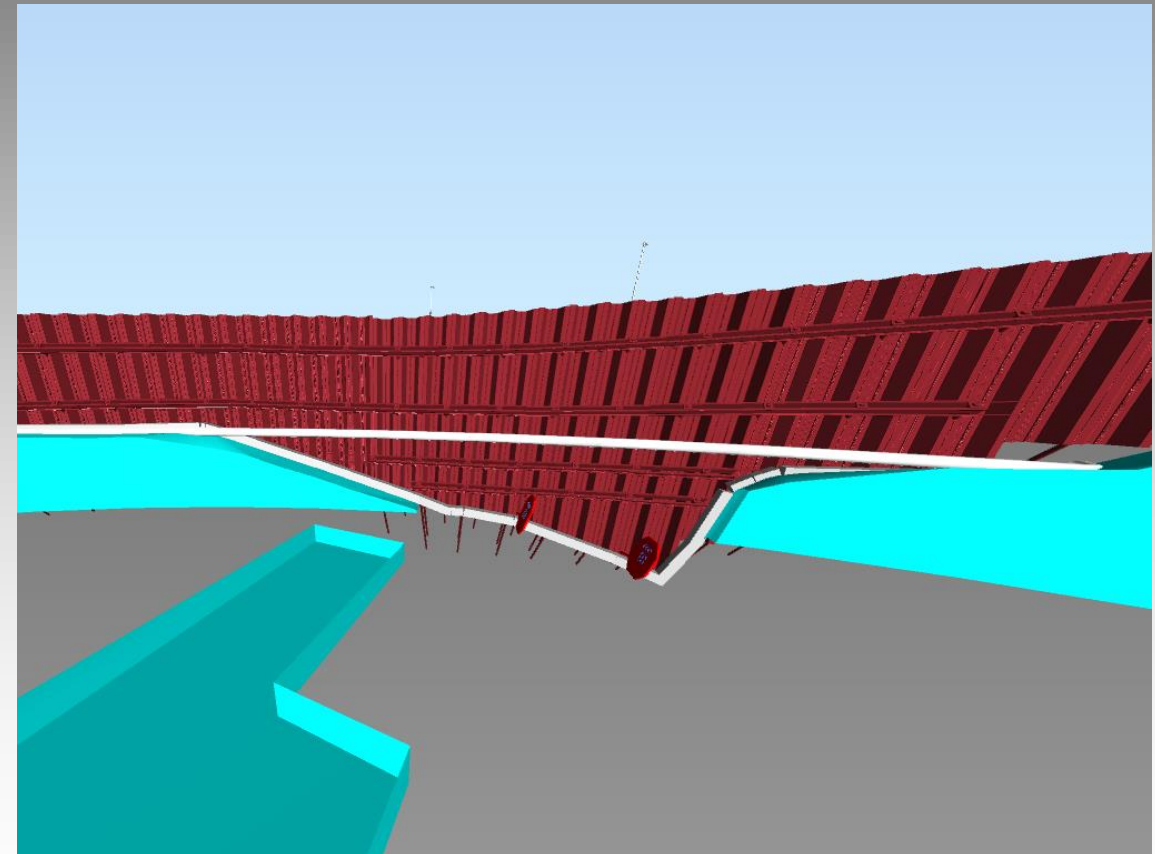
# Sealing to prevent quick clay

- Fornebubanen K4, Oslo
  - polyurethane grouting have been used a couple of times to prevent quick clay
  - a large deviation discovered when installing the sheet pile, bedrock at 7 m and 15 m depth
  - planning of the grout efforts was made unnecessarily difficult by the 3D-model



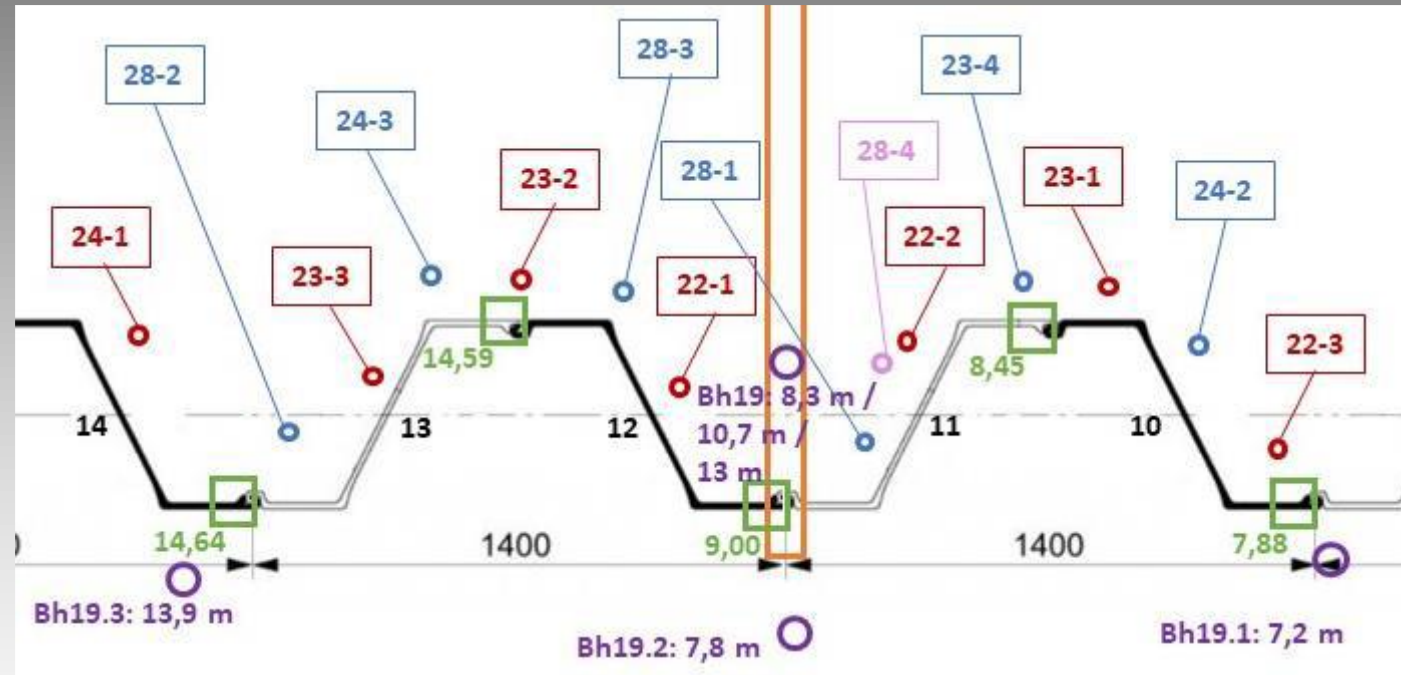
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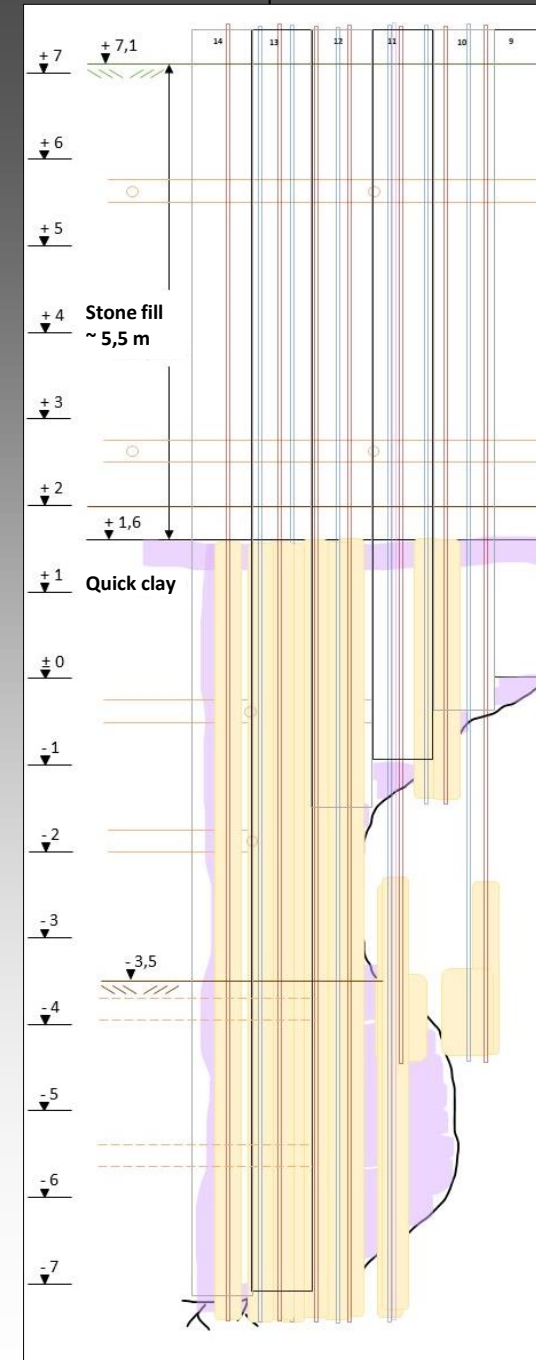
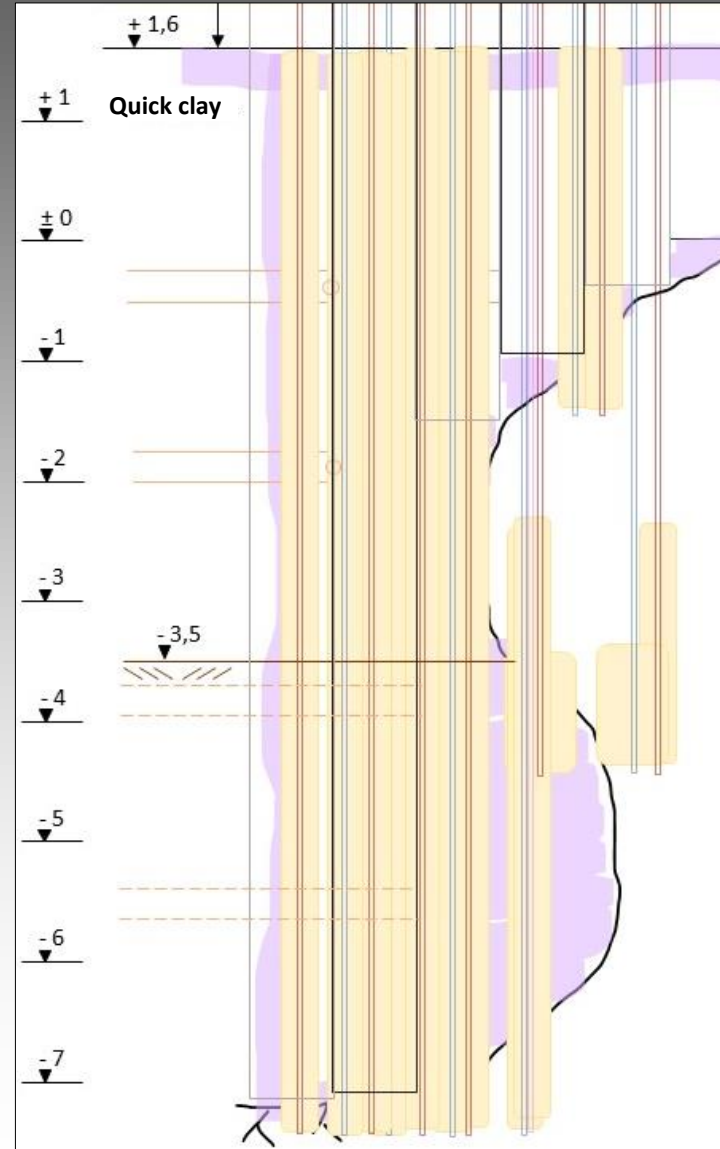
# Sealing to prevent quick clay

- Fornebubanen K4, Oslo
  - grouting with polyurethane to prevent inflow of quick clay during excavation
  - placement of grout holes for two grouting rounds, *i.e.* split spacing
  - decisions also made from observations from drilling of the hollow bars



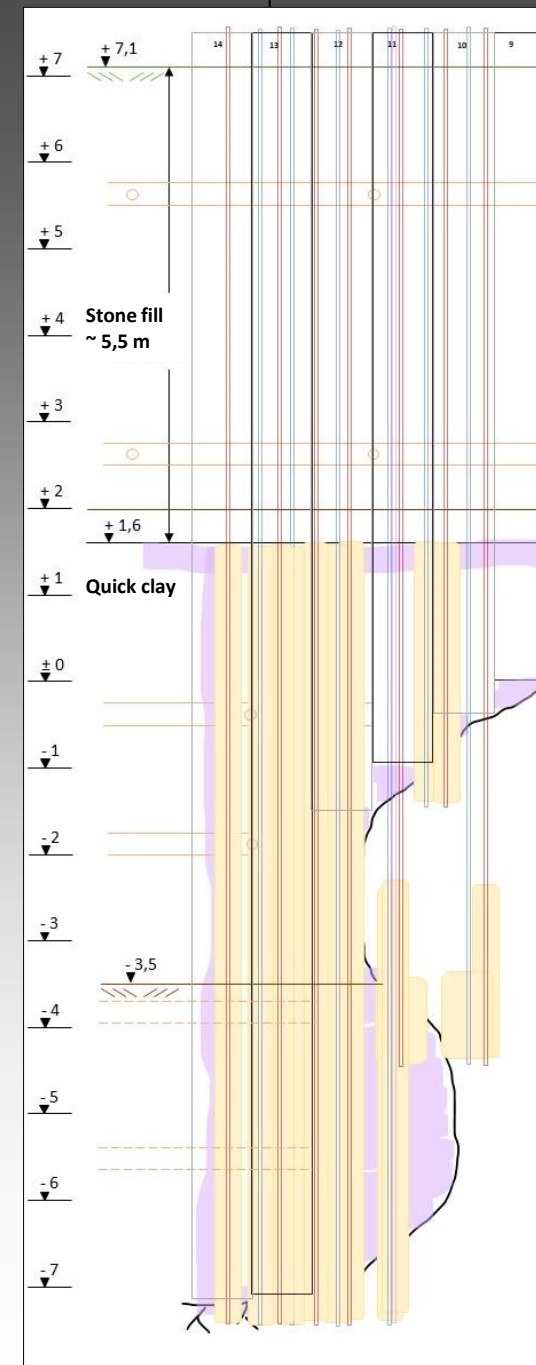
# Sealing to prevent quick clay

- Fornebubanen K4, Oslo
  - drilling with water flushing through the upper 5,5 m stone fill to save PU
  - drilling to, or through, the rock “shelf” to investigate, retracting before grouting
  - important to seal also the possible inflow of quick clay at 9 m full height



# Sealing to prevent quick clay

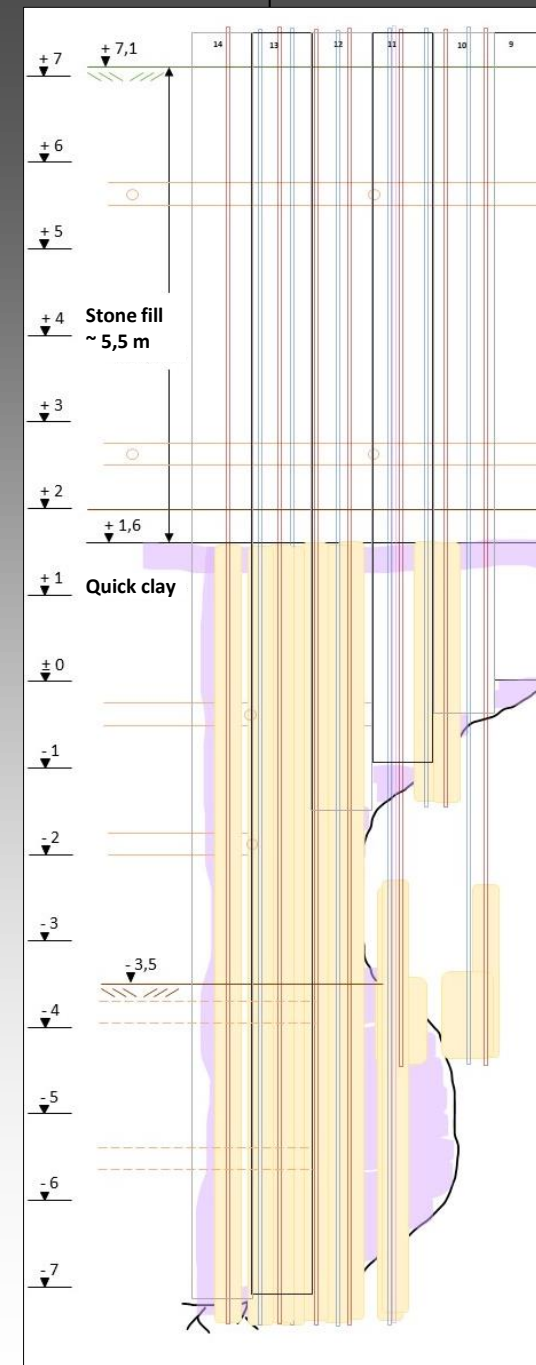
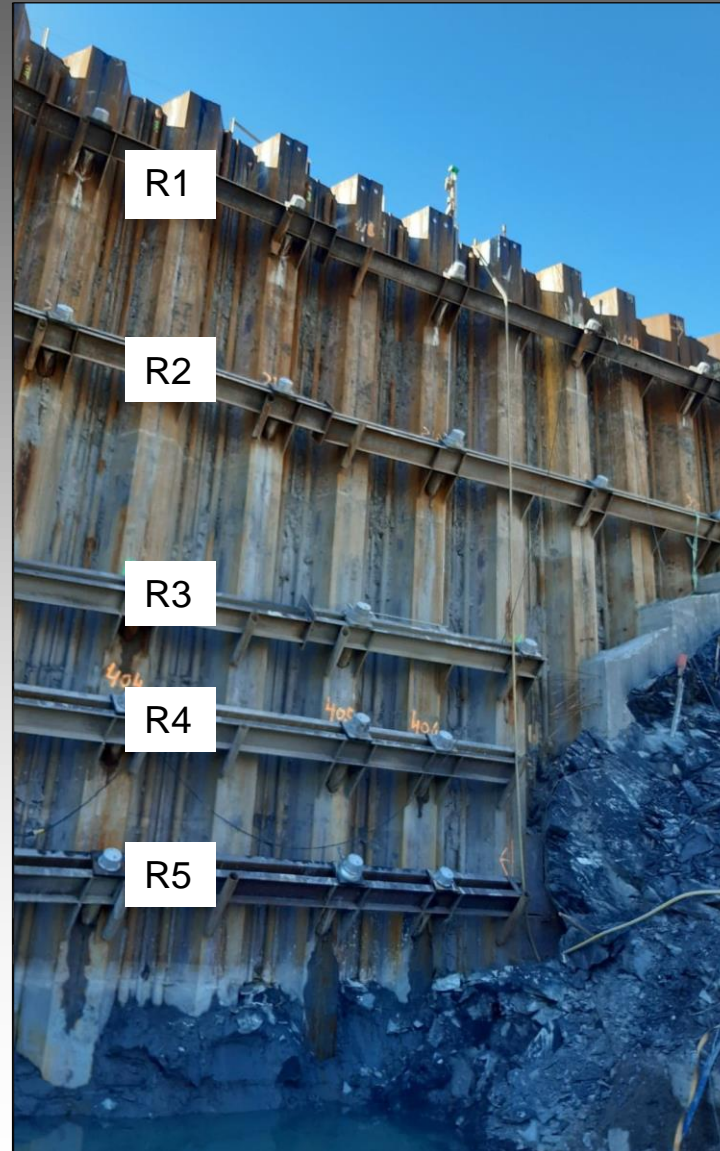
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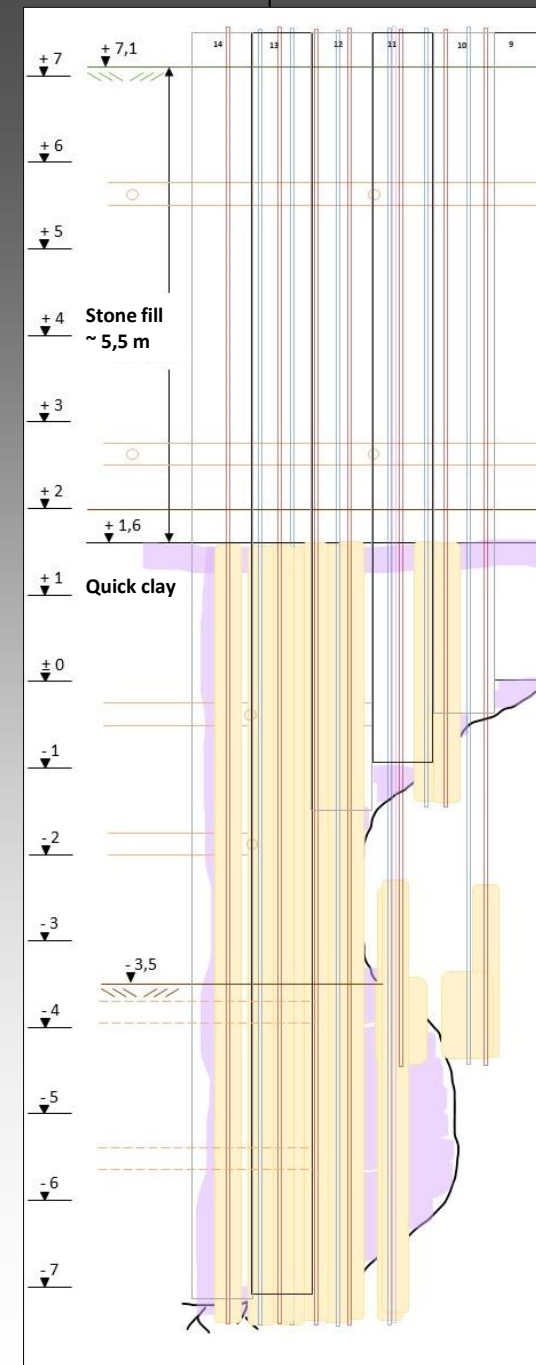
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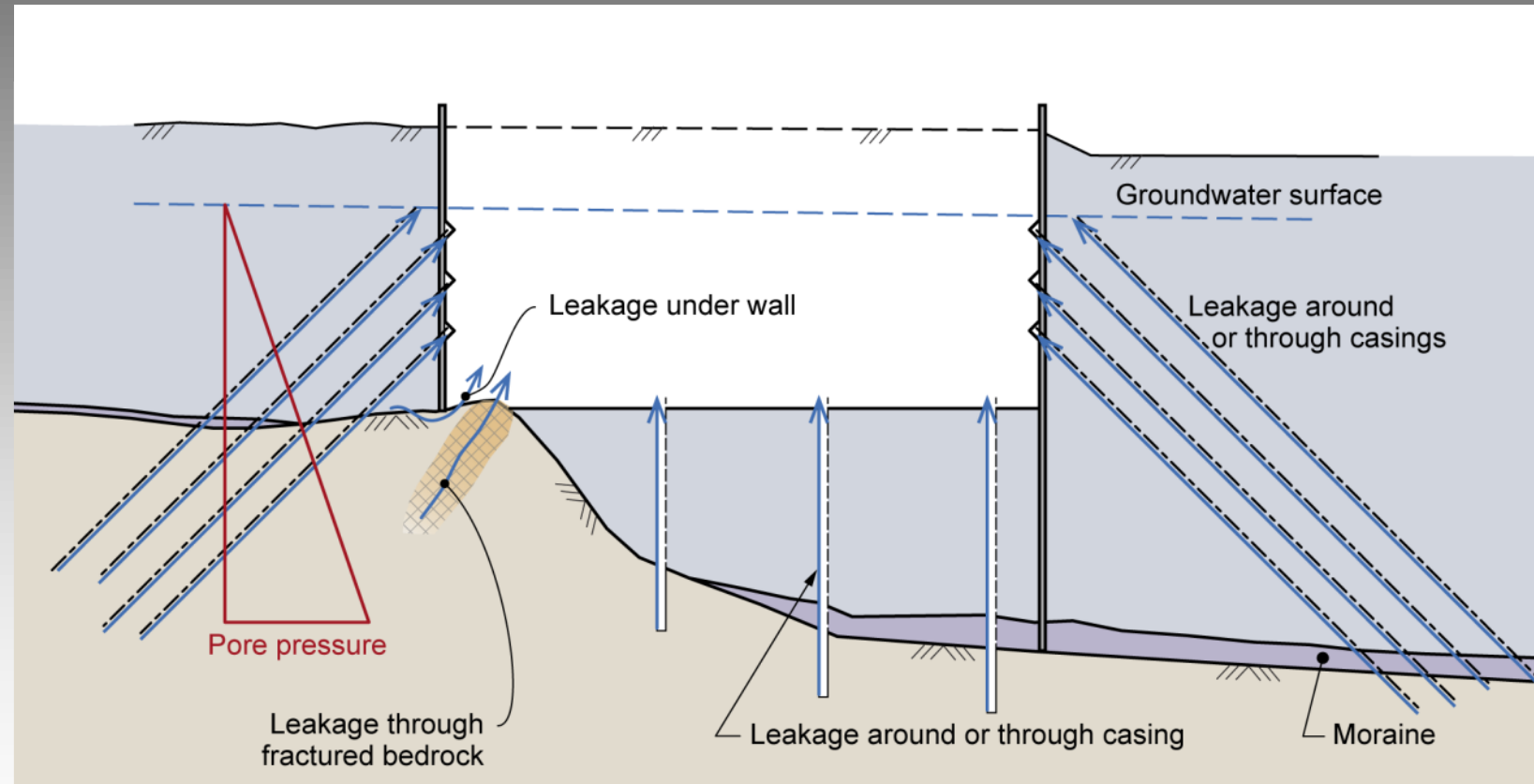
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# Limit damages due to deep excavations

- In summary
  - BegrensSkade identified different causes of damage
  - polyurethane can handle the sources of settlements, but beware of silt
  - environmental risk evaluation may be required, or not



# Thanks for listening!

Helen Andersson

