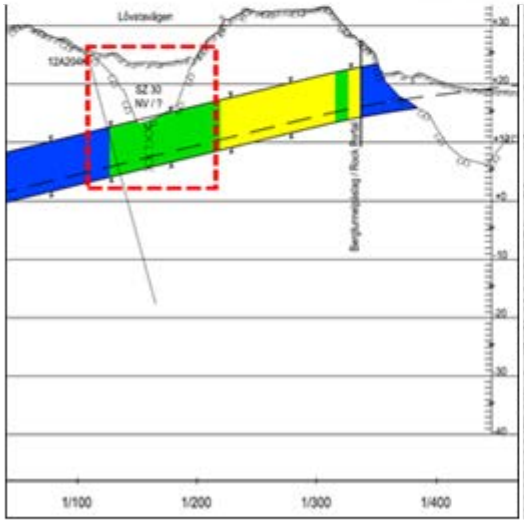
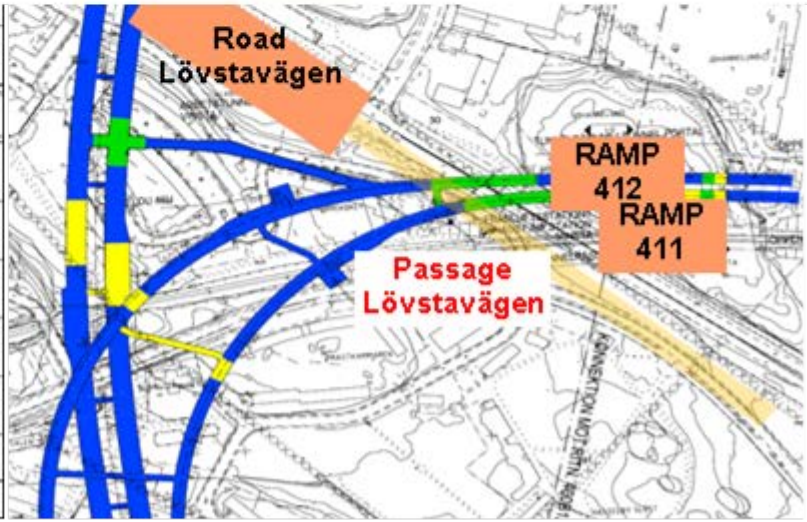
# FÖRBIFART – STOCKHOLM BYPASS


## Förbifart
## Stockholm Bypass, Sweden

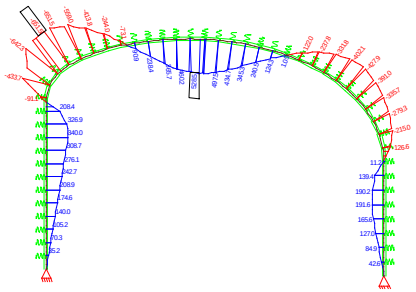
**21 km long highway as western bypass of Stockholm**

### Scope
- 17.3 km of tunnels
- 2 tunnel tubes with 3 lanes each
- 3 complete subsurface junctions
- Cross passages every 150 m
- Ventilation shafts
- Subsurface ventilation centre

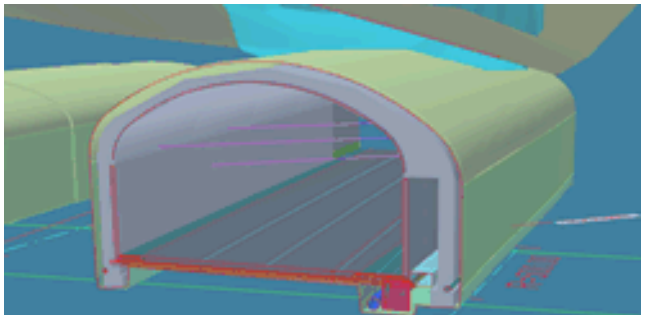
### Challenges
- Hard Scandinavian base rock with covering moraines and soft clay deposits, sensitive to settling
- Large cross-sections, complex geometry in the area of the junctions
- Stringent requirements for the suspended ceiling, in particular in case for the fire loads
- Low coverage in urban area including the under passing of main roads and utilities
- BIM (Building Information Modelling) Project

### Amberg Services
- Consulting for special problems
- Review of the construction project
- Establishment of tender documents
- Establishment of main project
- Client representation at site

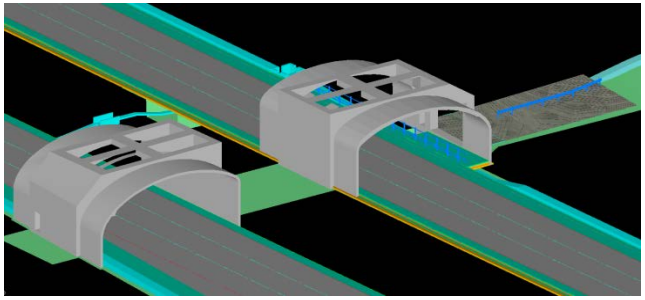
AMBERG ENGINEERING



- Deformations expected at Lövstavägen main road



- Modelling of difficult geometry



- Modelling of crossing structure

## AMBERG FACTS

### Contracted value Amberg

- Total 3.0 Mio. € (Amberg as subcontractor of AF infrastructure)

### Project Phases & Duration

| | |
|---|---|
| Preparation works started | 2011 |
| Project realization started | 2015 |
| Project completion expected | 2021 |

### Project Details

- Planning of heading, reinforcement and lining of under passing of Lövstavägen by means of jet grouting and pipe umbrella. Lower half of profile in Granite/Gneiss, upper half in soft soil
- Development of the project for all areas with low coverage of base rock
- Design and tendering of the suspended ceiling, which defines the driving space and serves as protection against penetrating water in case of fire
- Planning of the ventilation centre in an subsurface cavern, including all concrete works
- Design of the ventilation shafts including lining with cast concrete
- Planning and tendering of the access galleries including verification of required areas for installation of infrastructure
- Client representation at site and review of the design basis in relation to the construction progress

## CLIENT FACTS

### Overall costs

- Total 3.2 billion €

### Overview Project

- 21 km long bypass motorway
- 2 tunnel tubes, 3 lanes each, total 17 km
- Access and ramp tunnels
- All tunnels in urban area

### Geology

- Bedrock, competent granite
- Above rock surface, covering ground consisting of made ground, soft clay layer and water bearing moraines

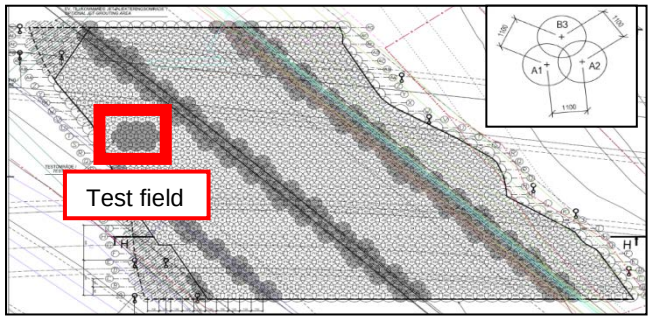
### Contact person

AF Consult, Stockholm
Mrs Malin Hubertsson
Project Manager
Phone: +46 73 412 62 70
E-Mail: malin.hubertsson@afconsult.com

Trafikverket, Solna
Mrs Beatrice Lindström
Project Manager
Phone: +46 70 245 22 37
E-Mail: beatrice.lindstrom@trafikverket.se

AMBERG ENGINEERING

## CHALLENGES




High pressure injections – under passing Lövstavägen

### Jet Grouting in the Area at Lövstavägen Passage

- A Grouting test field has been established for verification of the HDI concept
- Special measures for drilling in areas with utilities (cable ducts, tubes etc.)

**Lövstavägen passage grouting**

- Total grouted area 1100 $m^2$
- 1070 grouting columns, diam. 1.5 m
- Dense equilateral- triangular grid
- Total grouted length 3600 m
- Total grouted volume 3300 $m^3$

## ENGINEERING APPROACH

Pipe umbrella at low rock coverage

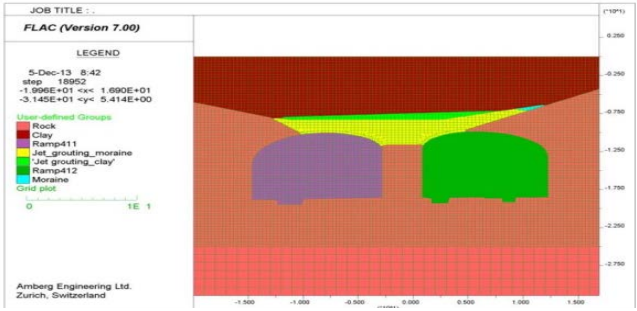
### Pipe Roof Umbrella Ahead of Tunnel Face below Lövstavägen Passage

- Dense pipe roof umbrella to increase stability before excavation

**Lövstavägen pipe roof umbrella**

- Diameter 114 mm
- Spacing 33 cm
- Length 15 m, overlap 3 m
- Inclination 4° offset from tunnel axis
- Installation from 10 – 2 o'clock

## TECHNICAL SOLUTIONS




Numerical analysis for design verification

### Verification of Design Concept by Means of Numerical Analysis (FLAC 2D)

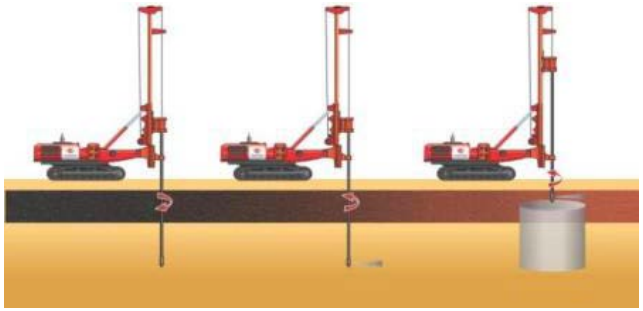
- Model calculations (finite difference) incorporating rock parameters and improvements of stability (grouting, pipe umbrella, cast in place lining)
- Examine ground response due to excavation
- Assess deformations around tunnel/on surface
- Obtain lining loads, verification of lining
- Verification of overall tunnel stability

**Modelling Stages**

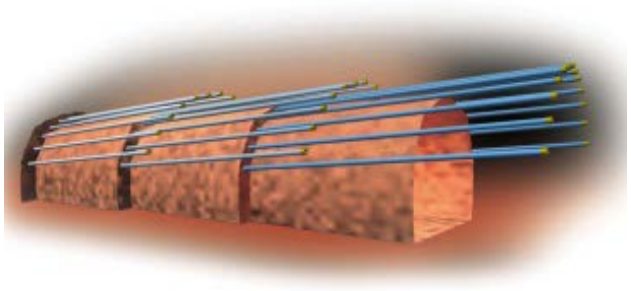
- Application of primary stress state
- Tunnel relaxation (load reduction method)
- Simulation of pipe roof umbrella by means of increase of ground cohesion
- Installation of temporary lining ( shotcrete, rock bolts)
- Final tunnel excavation with full ground relaxation)

AMBERG ENGINEERING

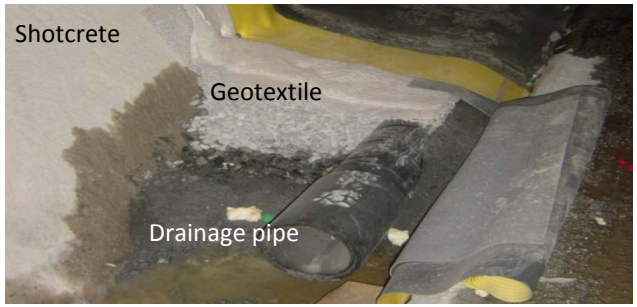
## CHALLENGES



- Jet grouting at surface

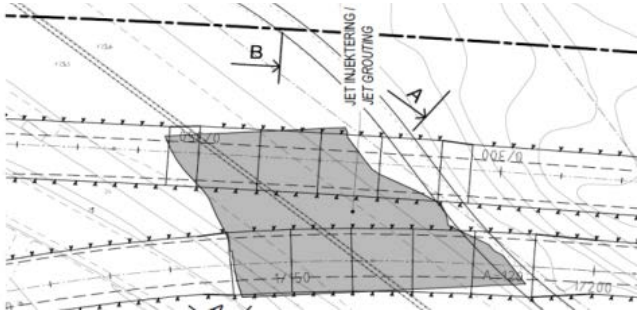


- Pipe roof umbrella ahead of face

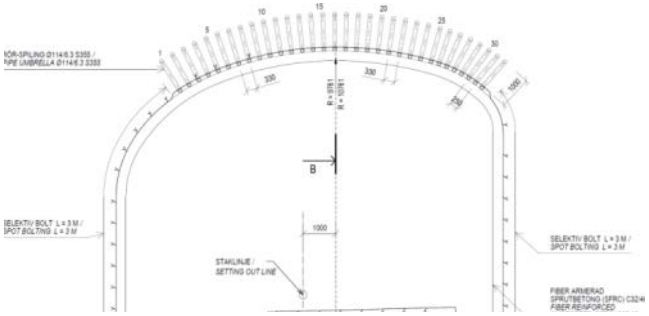



- Reinforcement, lining, sealing & drainage

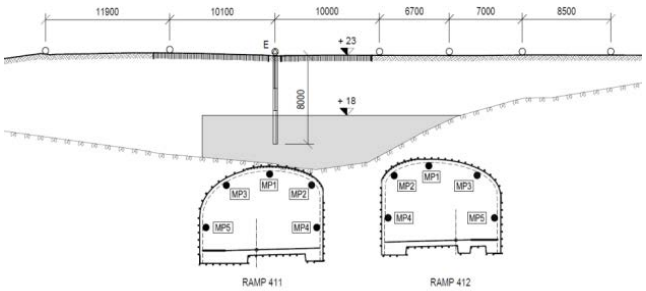
## ENGINEERING APPROACH




- Location of jet grouting at surface

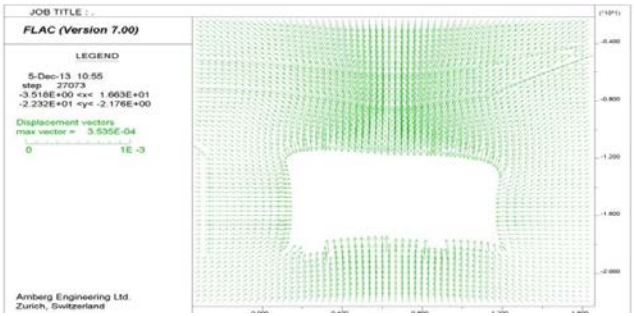



- During excavation application of pipe roof umbrella

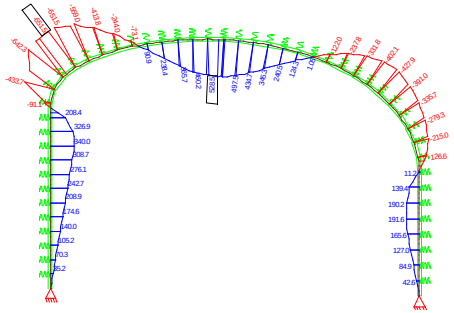



- After excavation, casting vault concrete & sealing

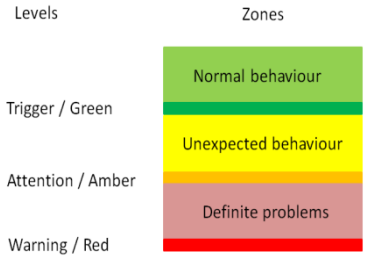
## TECHNICAL SOLUTIONS




- Confirmation of acceptable deformation (< 25 mm)



- Verification of structural capacity, SS EN-1992-1-1




- Ground control and work supervision

AMBERG ENGINEERING