January 29, 2008

Construction of tunnels, shafts and cross passages

by Johannes Truschel
The Group
Malmö Citytunnel Group is a joint venture consisting of the German company Bilfinger Berger AG and the two Danish companies Per Aarsleff A/S and E. Phil & Søn A.S. The three contractors belong to the European elite in the field of civil construction.
Malmö Citytunnel

A piece in the puzzle that will:

1. Increase the competitiveness of the railbound public transport in Skåne
2. Contribute to an improvement of the integration in the Öresund region
3. Strengthen the competitiveness of the national railroad traffic
4. Reduce the environmental problems along the Continental Line
5. Strengthen the development of localities with railroad connections in Skåne
6. Strengthen Malmö City Center as being the center of the region
7. Constitute a step towards an environmentally adjusted transportation system and a long-term lasting society
The project as a whole consists of a number of contracts, of which a dozen is procured today.

MCG’s part consists of:
- two 4.6 kilometre bored tunnels
- ramp and excavated tunnel section in Hyllie
- the rock cavity at Triangeln, where Triangeln station is located
- 13 cross tunnels between the main tunnels
- two access shafts
- four pressure equilization shafts
- road bridge over ramp
MCG are boring the two 4,6 km long tunnels that will run below Malmö.

The tunnels are part of the 17 km electrified railway which connects Malmö Central Station and the Öresund bridge.
longitudinal section track No. 74
Tender bid evaluation

- **Price**: 60%
- **Cooperation capacity, management and organisation**: 20%
  - in connection with evaluation cooperation capacity, management and organisation the builder will attach great importance to:
    - systems and routines for establishing and maintaining cooperation forms
    - organisation structure with short decision channels and clear distribution for responsibility and competence for decision makers,
    - relevant experience and education for key staff,
    - structure, contents and connection of project plans to the execution of the works contract
    - system and routines for risk management documented in the project plan
- **Environment and work environment**: 10%
- **Technique**: 10%
Risks are identified and assessed in our database. Here you will also find necessary information about risk reducing activities, persons in charge, dead lines etc.

**General control documents**

**ProjektPlan**

**Genom-FörandePlan**

**LIST DGFP/KP**

**Content List**

**DelGenom-FörandePlan**

**General Procedure**

**Risk management**

**Arbets-Beredning**

**Risk Assessment**

**KP**

- Reports
- Instructions
- Statistics
- Control

**Access Data base**

Responsible: the section manager
RISK MANAGEMENT AT MCG

- Not only contractual requirement but actively used
- Fully integrated from design phase to completion
- Risks discussed and shared with the Client
- Risk sessions (discussions) involving all disciplines as well as Client representatives for each major work activity
These risk areas must be considered...

- Health and Safety
- Environment
- Finance
- Time
- Confidence/Public Opinion
- Property
- Third party injury
- Third party property
## Risk rating

<table>
<thead>
<tr>
<th>L - Likelihood</th>
<th>S - Severity</th>
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<tbody>
<tr>
<td>5</td>
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<td>2 4 6 8 10</td>
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</tbody>
</table>

A-Acceptable for all areas
A-Acceptable for all areas
R-to be Reduced if possible
U-Unacceptable except HS + IP3 + E
## The Risk database, start page

### Risk Management Diagram

- **Identifying**
- **Assessing**
- **Mitigating**
- **Follow up**
- **Closing**

### Not assessed risks

<table>
<thead>
<tr>
<th>Risk ID</th>
<th>Phase</th>
<th>Risk name</th>
<th>Responsible</th>
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<tbody>
<tr>
<td>201 FA 01</td>
<td>Project</td>
<td>Setting</td>
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<tr>
<td>201 FA 02</td>
<td>Project</td>
<td>Landslide</td>
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<tr>
<td>201 FA 03</td>
<td>Project</td>
<td>Noise</td>
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<td>201 FA 04</td>
<td>Project</td>
<td>Fall down of limestone</td>
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<td>201 FA 05</td>
<td>Project</td>
<td>Collision between vehicles</td>
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<tr>
<td>201 FA 06</td>
<td>Project</td>
<td>Increased volume of grout</td>
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<td>201 FA 08</td>
<td>Project</td>
<td>Boring of rock anchors-Personal Injury</td>
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<td>201 FA 10</td>
<td>Project</td>
<td>Collapse of anchor</td>
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<tr>
<td>201 FA 11</td>
<td>Project</td>
<td>Spraying of concrete-Personal Injury</td>
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### Latest

<table>
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<tr>
<th>Risk ID</th>
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<tr>
<td>201 1370-13</td>
<td>Underground test</td>
</tr>
<tr>
<td>201 03-01</td>
<td>Cross Passing - Pumped water</td>
</tr>
<tr>
<td>201 03-04</td>
<td>Formworks</td>
</tr>
<tr>
<td>201 03-03</td>
<td>Piping of reinforcement</td>
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<tr>
<td>201 03-02</td>
<td>Horizontal</td>
</tr>
<tr>
<td>201 03-01</td>
<td>Concrete works</td>
</tr>
<tr>
<td>201 03-06</td>
<td>TBM shield rotation</td>
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<tr>
<td>201 03-05</td>
<td>TBM doors</td>
</tr>
<tr>
<td>201 03-04</td>
<td>Clogging at walls</td>
</tr>
<tr>
<td>201 03-05</td>
<td>Clogging at walls</td>
</tr>
<tr>
<td>201 1370-12</td>
<td>Testing</td>
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</table>
SITE HOLMA

- Site establishment, workshop, warehouse, office
- 440 m ramp / 360 m cut-and-cover tunnel
- TBM start area
- Conveyor belt station with storage for mucking
- Batching plant
- Segment factory with segment storage
• 2 SKAKO plants (2.0 m$^3$ and 1.5 m$^3$ mixers)
• 10 000 m$^3$ monthly
• 240 000 m$^3$ total
• Microsilica and PP-fibres dosing
• Delivery by mixer tracks and conveyor bucket
**Details segment lining**

- Number of segments: 7+1
- Length of segments: 1800 mm (in middle)
- Tapering: 50 mm
- Diameter (outside/inside): 8600 mm / 7900 mm
- Thickness: 350 mm
- Weight per ring: 42 ton
- Number of segments: 40960
- Number of rings: 5120
- Concrete volume per ring / total: 16.33 m³ / ~ 84000 m³
TBM Data

- **Supplier**: Herrenknecht, Germany
- **Type**: EPB – Shield Earth Pressure Balance
- **Length**: 10 m shield + 110 m backup
- **Diameter**: 8.90 m
- **Power**: 4MW
- **Groundwater**: max. 25 m above base
- **Excavation**: 580,000 m³ (solid)
Launching TBM S 341

TUNNELLING TO THE FUTURE
Naming ceremony
December 4, 2006 and 2007
SITE TRIANGELN

Rock cavern builds the new underground station

- Length 285 m
- Width 26 m
- Invert level about 25 m below ground level
- Excavated by mechanical excavation in sequences
- One pillar tunnel
- Two side tunnels, length 197 m
Aktuella bilder från Triangeln

July 2006
Access for the fire fighters…
…to the tunnel in case of a fire
…..in each quarter of the tunnel lining
WORK AREA NORTHERN HARBOUR

September 2005

November 2007
Here we are now
Timetable

- December 2003 - Submission
- November 2004 - Signing of contract E201
- April 2005 - Construction start
- December 2006 - TBM handling
- April 2007 - Completion of rock chamber Triangeln
- Spring 2008 - Completion of TBM-drives
- Summer 2009 - Completion of Contract E201
- 2011 - Inauguration of Citytunnel