

# City – Tunnel Leipzig



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Consortium Site Management/ Site Supervision City – Tunnel Leipzig

Kopenhagen, 01 September 2009

**ARGE BOL/BÜ**

## Outline



- **Project data**
- **History**
- **Basic conditions/ Location in the city**
- **Tunnel boring machine „Leonie“**
- **Compensation grouting (CG)**
- **Soil freezing**
  - **Underpinning of the main station**
  - **Hotel Marriott**

## Project Data – ARGE BOL / BÜ



### Technical & Commercial Lead Management

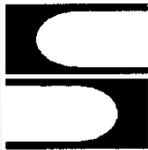


Engineering Office Dipl. Ing. Vössing GmbH

### Project Execution



Engineering Office Dipl. Ing. Vössing GmbH



SPIEKERMANN AG Consulting Engineers



ILF Consulting Engineers GmbH



Emch + Berger Project and Construction  
Management GmbH

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**Project Data - Clients**



**The Free State of Saxony  
DEGES GmbH**



**Tunnel shell including ramps**

**Shell construction and finishing  
of the stations, accesses**

**Restoring of surfaces**

**Deutsche Bahn AG  
DB ProjektBau GmbH**



**Equipment of the tunnel for rail  
operation**

**Integration into the railway  
network**

**Measures for supplementing the  
railway network**

**Total Construction Volume: approx. 720m €**

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## Project Data – Companies involved



### ARGE City – Tunnel Leipzig building lot A

- STRABAG AG
- Wayss & Freytag Ingenieurbau AG



### ARGE City – Tunnel Leipzig building lot B

- DYWIDAG Bau GmbH
- ALPINE BAU DEUTSCHLAND AG
- Oevermann Vermögensverwaltungs GmbH & Co. KG
- GSB Grund und Sonderbau GmbH
- STRABAG AG



### ARGE City – Tunnel Leipzig building lot C

- Wayss & Freytag Ingenieurbau AG
- STRABAG AG



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## History of the City - Tunnel



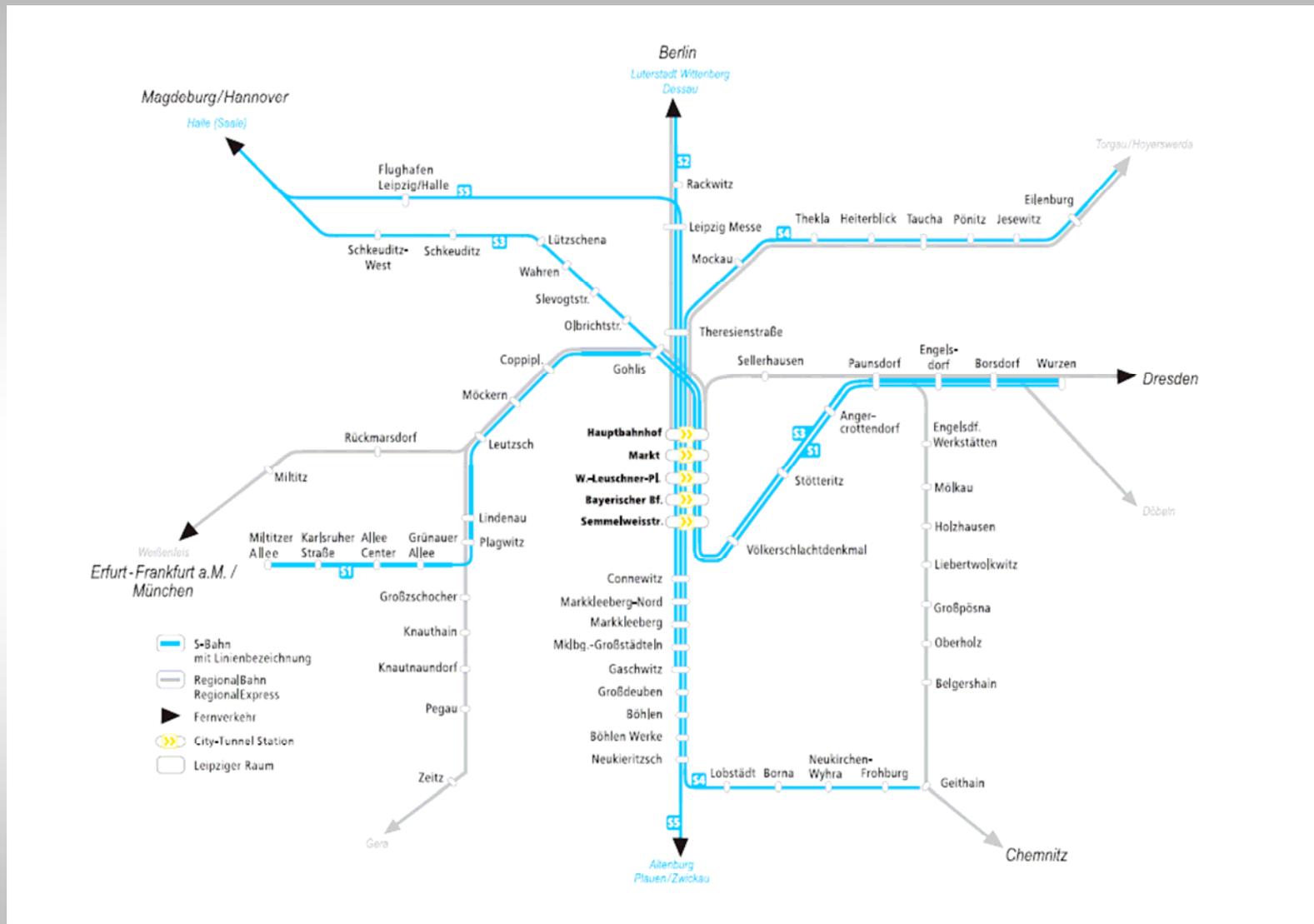
- 1893 First investigations for an elevated railway
- 1911 Design of an underground connection by Siemens
- 1915 Construction of a tunnel section at the eastern part of the main station (200 m)
  
- 1930 New approaches – lack of money
- 1970 Renewed attempts: tunnel or elevated railway?
  
- 1996 Founding of the SBTL
- 2000 Official approval of the plans
- 2001 Confirmation of the designs
- 2002 Signing of the financing agreement
- 2003 Start of construction works: CG shaft at the Bildermuseum

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# Railway network Leipzig



## Technical project data



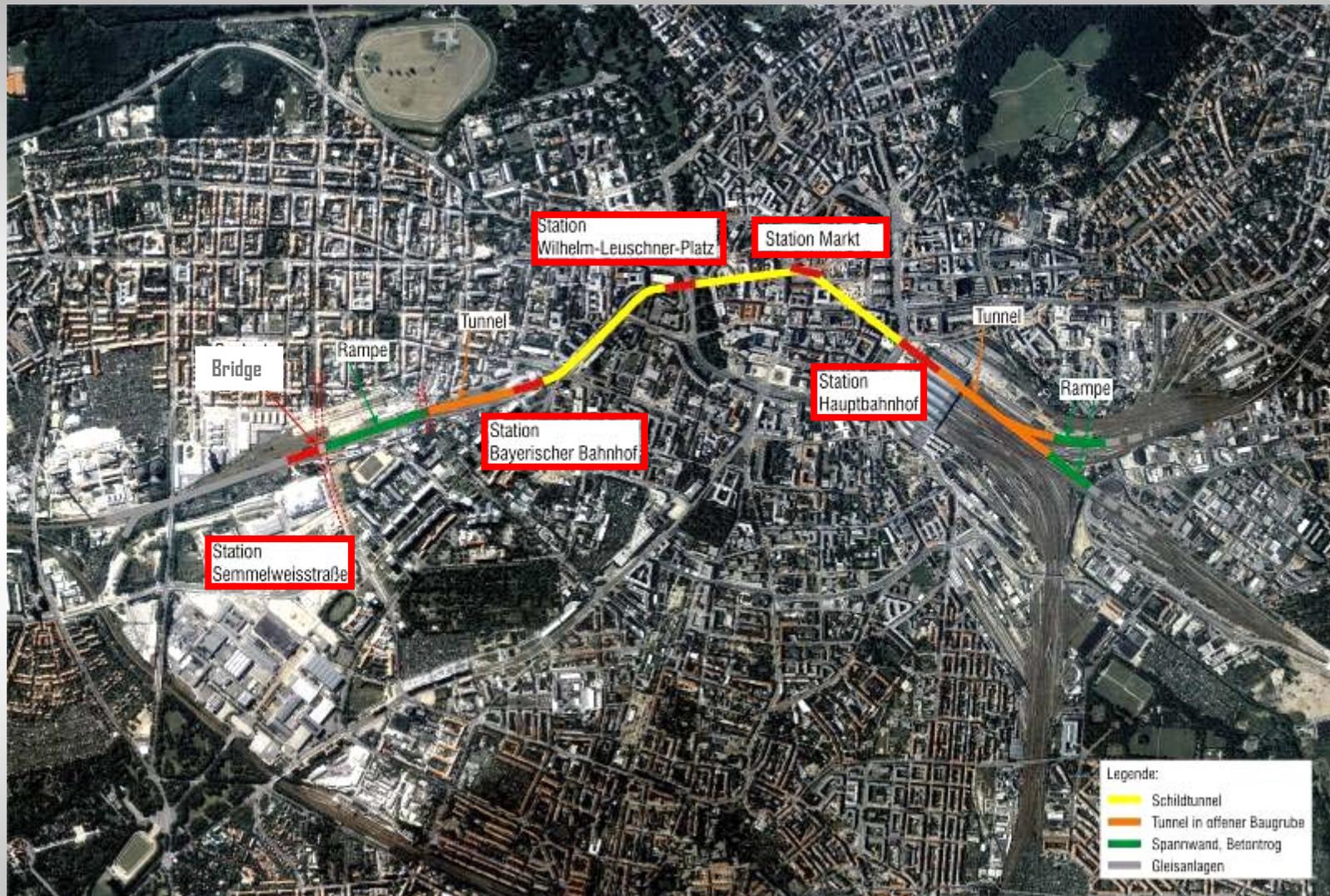
- Total length of the project approx. 5.3 km
- Length of the tunnel including stations and ramps approx. 4.0 km
- Two single-track tunnel tubes were produced by means of shield driving
- Length per tunnel tube 1.4 km
- Excavation cross-section 9.0 m
- Inner diameter of the tunnel tubes 7.9 m
- The top edge of the tunnel runs between 8 m and 16 m below ground level
- The platforms are located between 17 m and 22 m deep

## Project data



- starting 2003: Preliminary measures
- 2005 till 2008: Building security measures (CG)
- as from 2004: Start of construction works at the stations Bayerischer Bahnhof, Wilhelm-Leuschner-Platz and Markt
- as from 2005: Start of construction works at the main station
- 2007 till 2008: Shield tunnelling
- 2009: Completion of shell construction work at the stations
- 2010 till 2012: Space-shaping finishings / railway finishings / trial operation and approvals
- December 2012: Commissioning along with the timetable change

## Routing and location of the stations



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## Stations



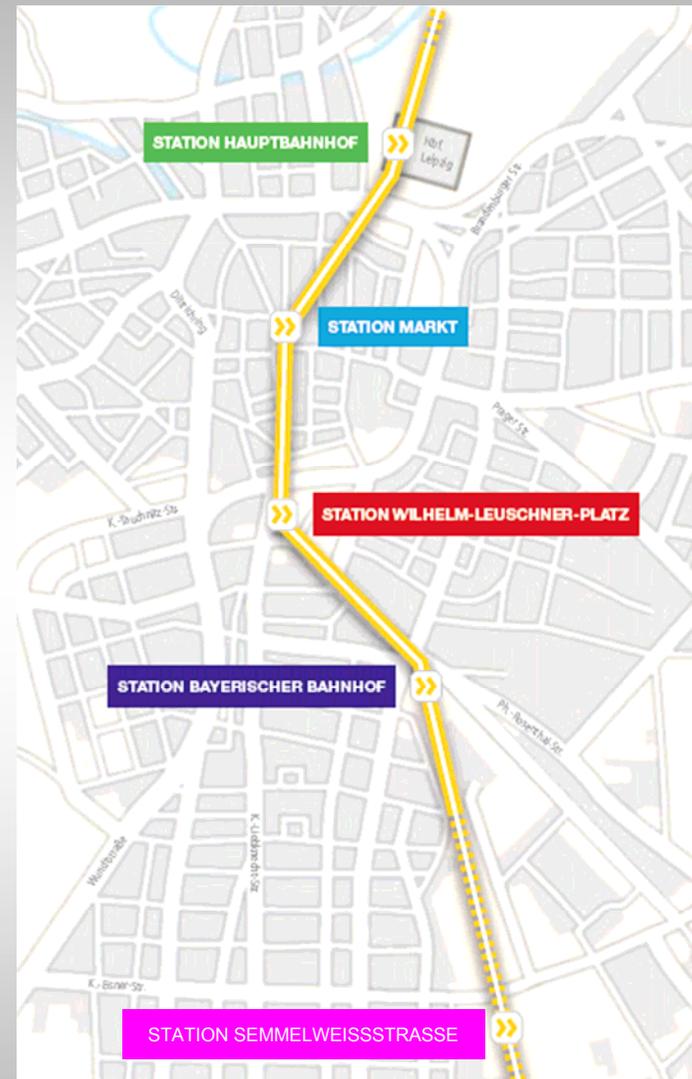
- Construction of 4 cut-and-cover underground stations
- Stop „Sammelweißstraße“ as an above-ground station
- Underground stations: island platforms
- Stop „Sammelweißstraße“: 2 side-boarding platforms
- Platform length: 140 m each
- The main station is an exception, with a platform length of 400 m
- Width of the stations: approx. 20 m

## General map



### Building lot A

- › Southern area of emergence
- › Stop „Simmelweißstraße“
- › Tunnel ramp and square tunnel using the cut-and-cover method
- › Start of construction works: March 2004



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**Building lot A – ramp area**



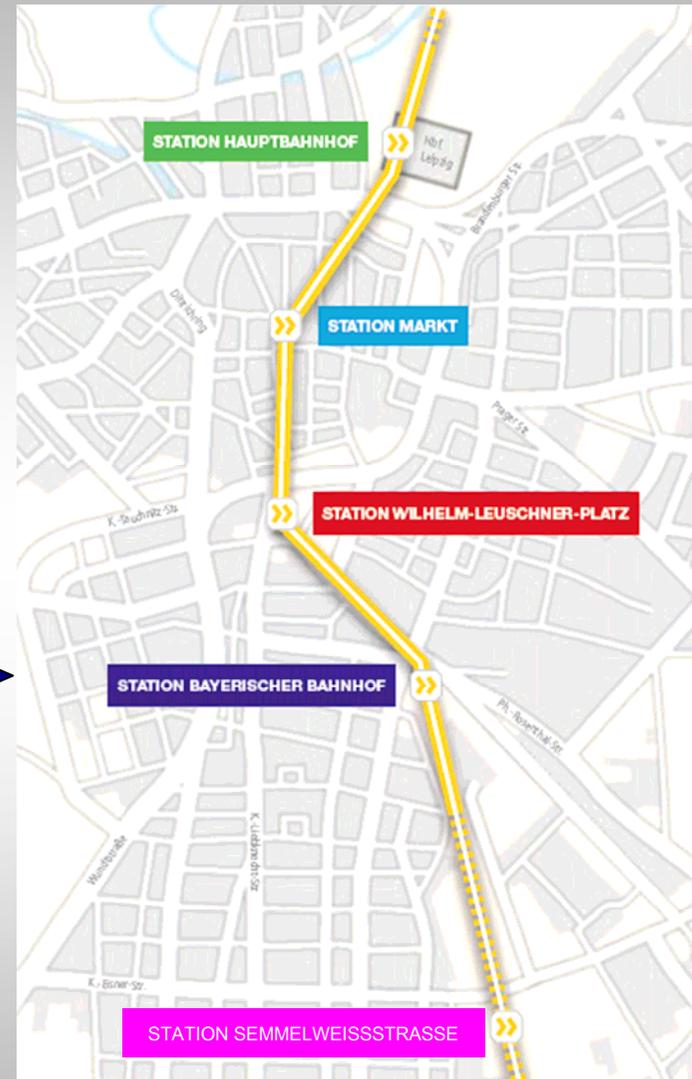
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## General map



## Building lot B

- › **Station Bayerischer Bahnhof**
- › Specialty: preservation of the historical portico
- › Starting point of the TBM
- › Start of construction works: March 2004



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## Relocation of the portico



- Height: 16.0 m
- Width: 6.80 m
- Length: 28.0 m
- Total weight which has to be relocated: 2.800 t
- Relocation distance: 30.5 m



# Relocation of the portico



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# Vision station Bayerischer Bahnhof



Architectural office PETER KULKA

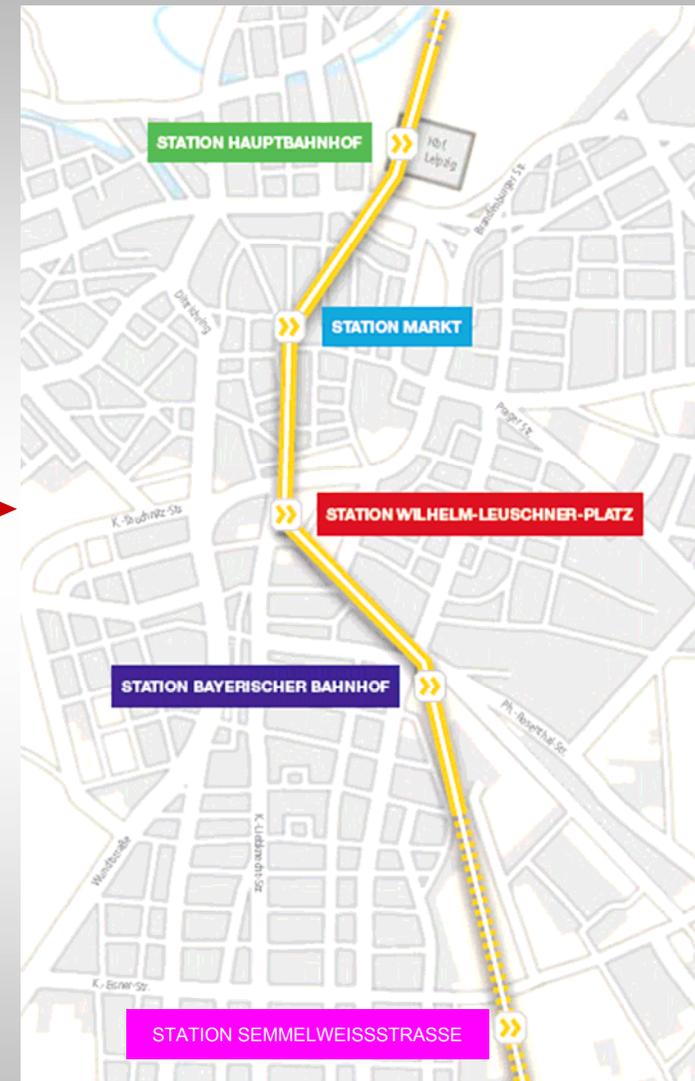
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## General map



## Building lot B

- › **Station Wilhelm-Leuschner-Platz**
- › Dig-and-cast construction method with diaphragm walls
- › Specialty: tunnelling below the ring road



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# Station Wilhelm-Leuschner-Platz



Maintenance of traffic and local public transport

Traffic and local public transport in present situation



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## Vision station Wilhelm-Leuschner-Platz



Architectural office MAX DUDLER

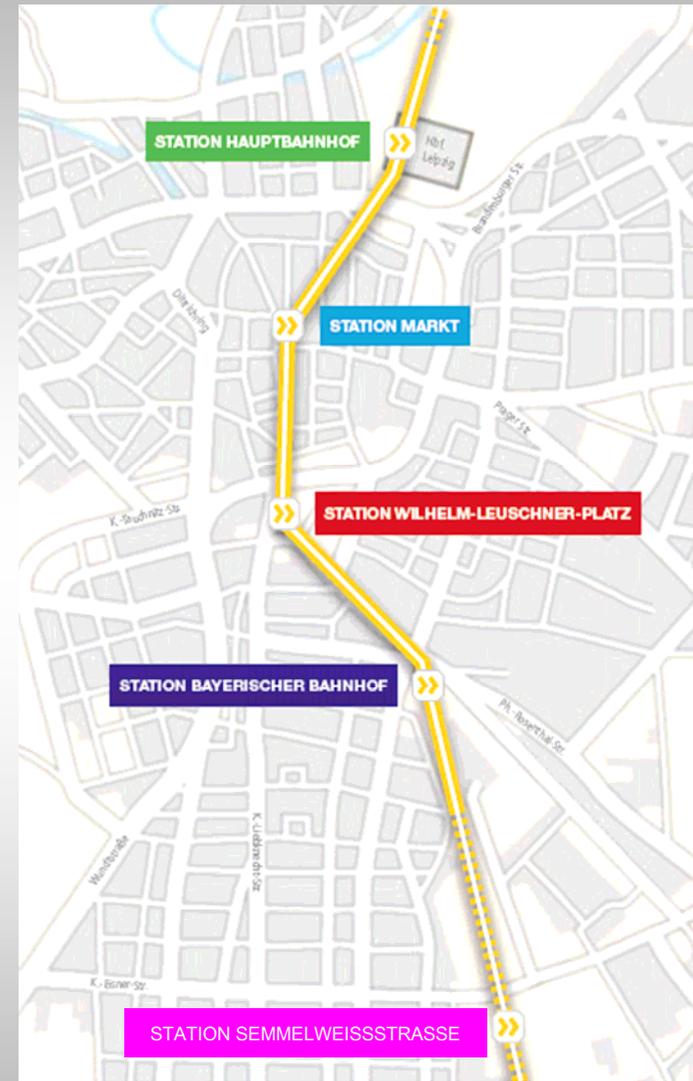
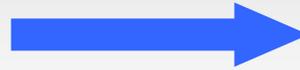
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## General map



### Building lot B

- › **Station Markt**
- › Dig-and-cast construction method with diaphragm walls
- › Specialty: demolition of the underground exhibition hall
- › Entrance area of the underground exhibition hall will be reused as southern entrance of the station



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## Station Markt



Demolition of the underground exhibition hall (October 2005)



Construction of slotted walls (November 2005)

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# Station Markt



Applying of floor joists  
(February 2006)



Aerial view  
(April 2009)

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## Vision station Markt



Architectural office KELLNER, SCHLEICH, WUNDERLING

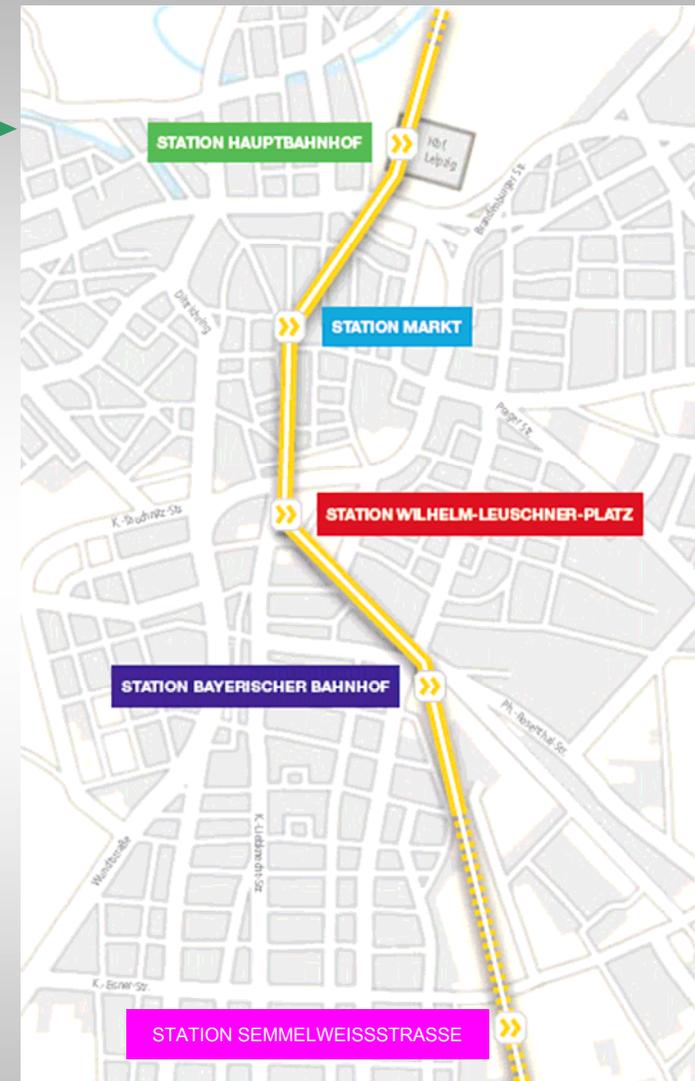
**ARGE BOL/BÜ**

## General map



## Building lot B / C

- › **Station Hauptbahnhof**
- › Dig-and-cast construction method with diaphragm walls
- › Specialty:
  - Tunnelling below the ring road
  - Shell construction of the station divided into 5 phases
  - Tunnelling below the west wing secured by means of soil freezing



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## Station Hauptbahnhof



**View of the construction site within the station building (November 2006)**

**Phase:** Construction of the ceiling of the station in flowing traffic (October 2005)



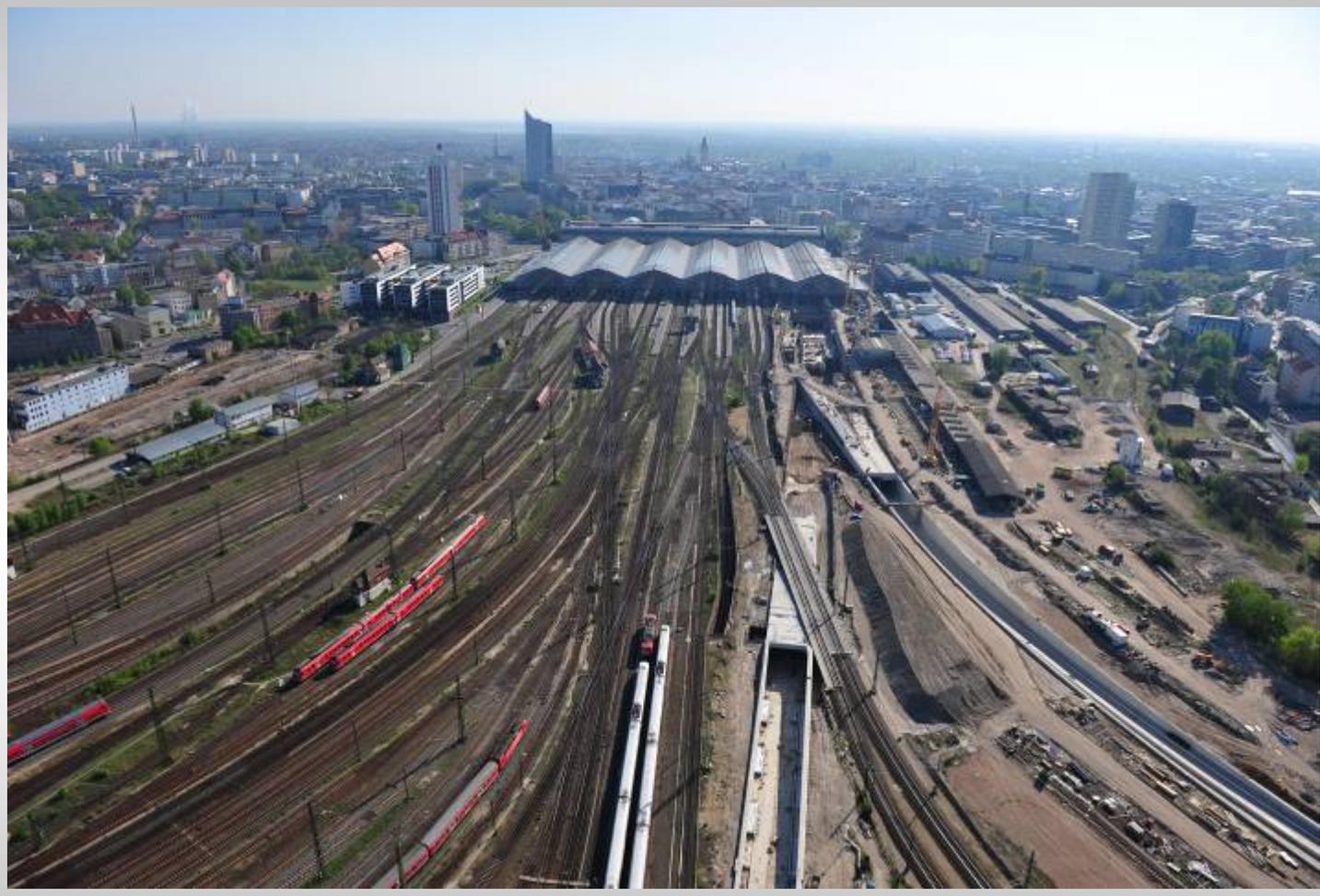
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Building lot C: ramp area (before the start of construction works)



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**Building lot C: ramp area (April 2009)**



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## Station Hauptbahnhof / ramp



**Provisional bridges**  
(for maintaining the rail traffic,  
November 2007)



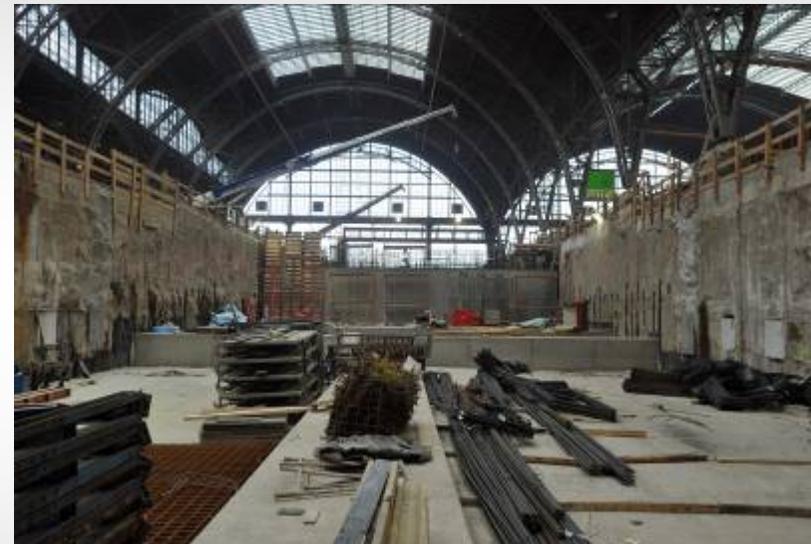
**Line branch-off**  
(March 2009)

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## Station Hauptbahnhof



**View of the construction site within the station building**  
(February 2008)



**Construction dock A**  
(March 2009)

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## Vision station Hauptbahnhof



Architectural office HENTRICH - PETSCHNIGG

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## TBM - Technical data

- Length of the TBM: 65 m
- Total weight: 1,100 t
- The TBM is driven by 14 pairs of presses, the compressive force amounts to 65 MN
- The stone crusher within the cutting wheel can crush stones with an edge length of up to 80 cm
- Seismic system can detect soil layer boundaries and deviations up to 40 m in advance
- The cutting wheel had been constructed as a closed hydro-shield
- Drive: 8 electric motors (880 kW)
- Cutting wheel comprises 176 peeling knives, 42 drill bits and 16 scrapers



## Tunnel boring machine



### Personnel airlock

(for pressure equalization, at the working face there is an overpressure of 4 bar)

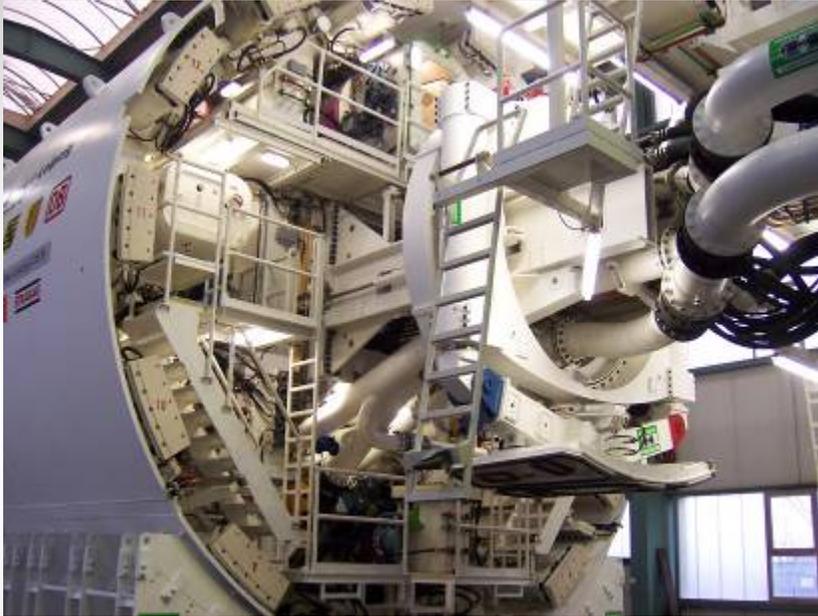


### Control station

(visualization of the states of driving and performance parameters)

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## Tunnel boring machine



### Erecting device

(for inserting the tubbing segments)



### Tubbing segment on the erecting device

(Stones are picked up pneumatically and positioned within the tube)

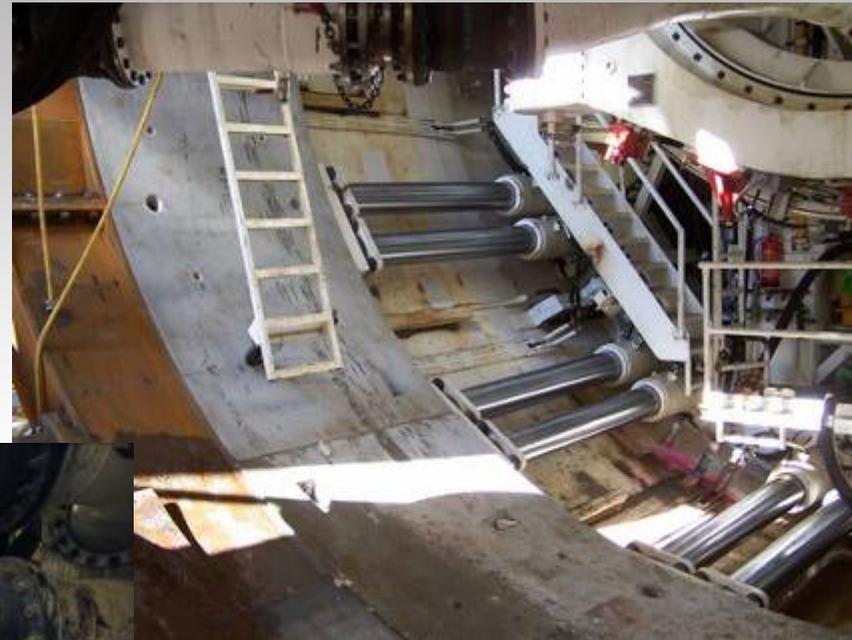
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## Tunnel boring machine



### Blind rings

(as starting position of the TBM blind rings are inserted, against which the TBM pushes via presses)



Longitudinal transport of a tubbing segment to the erecting device

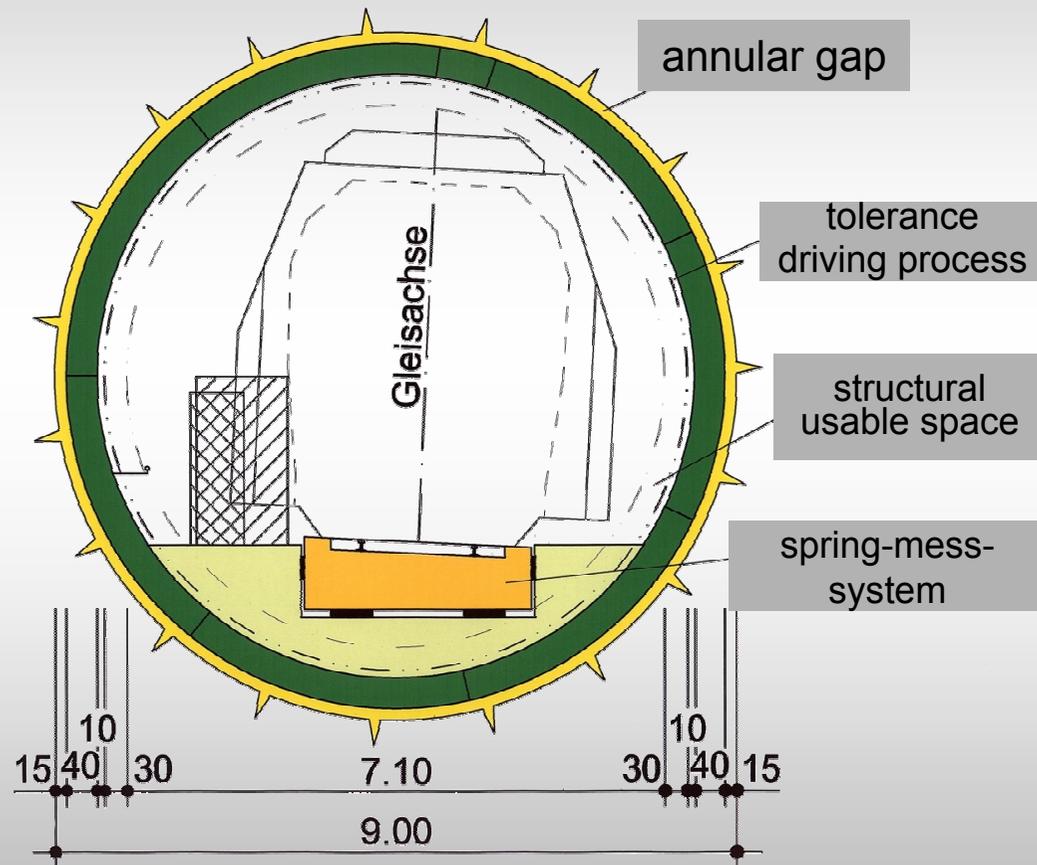
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## Standard cross-section



### Tubbings

- Tubing segment:  
40 cm wall thickness  
1.80 m width
- 1 tubing ring consists of 7 segments and a capstone (weight: approx. 47 t)
- 1,634 rings have been built in
- Total number of tubing segments: approx. 13,072 pieces = 77,000 t



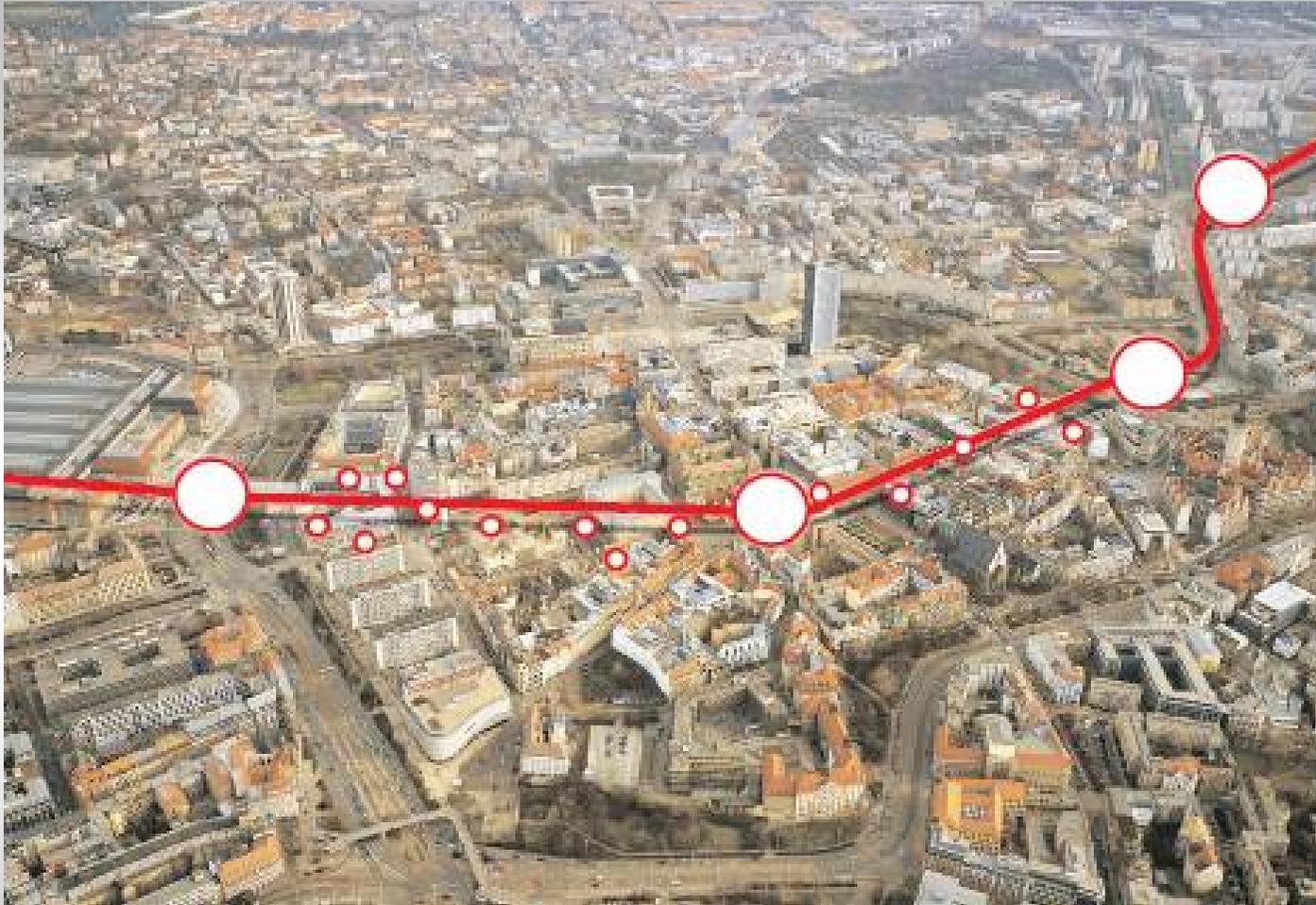
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## Compensation grouting



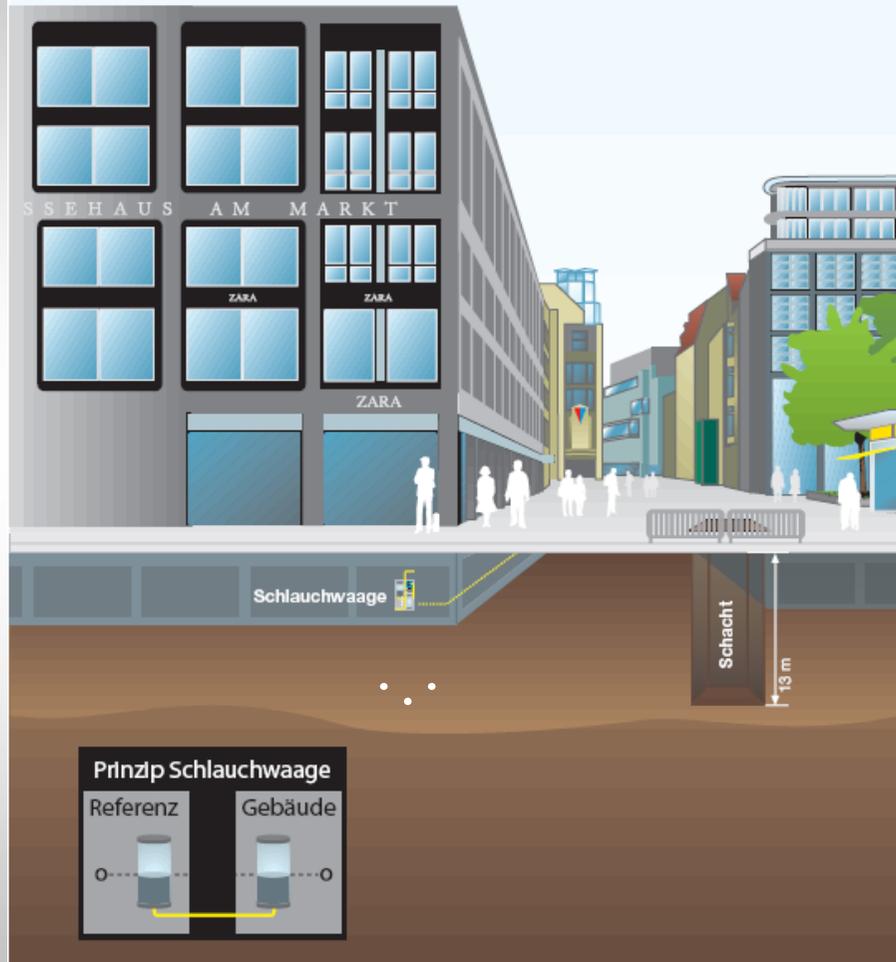
Stations and CG shafts

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## Compensation grouting

Phase 1: Shaft construction and installation of water level gauge



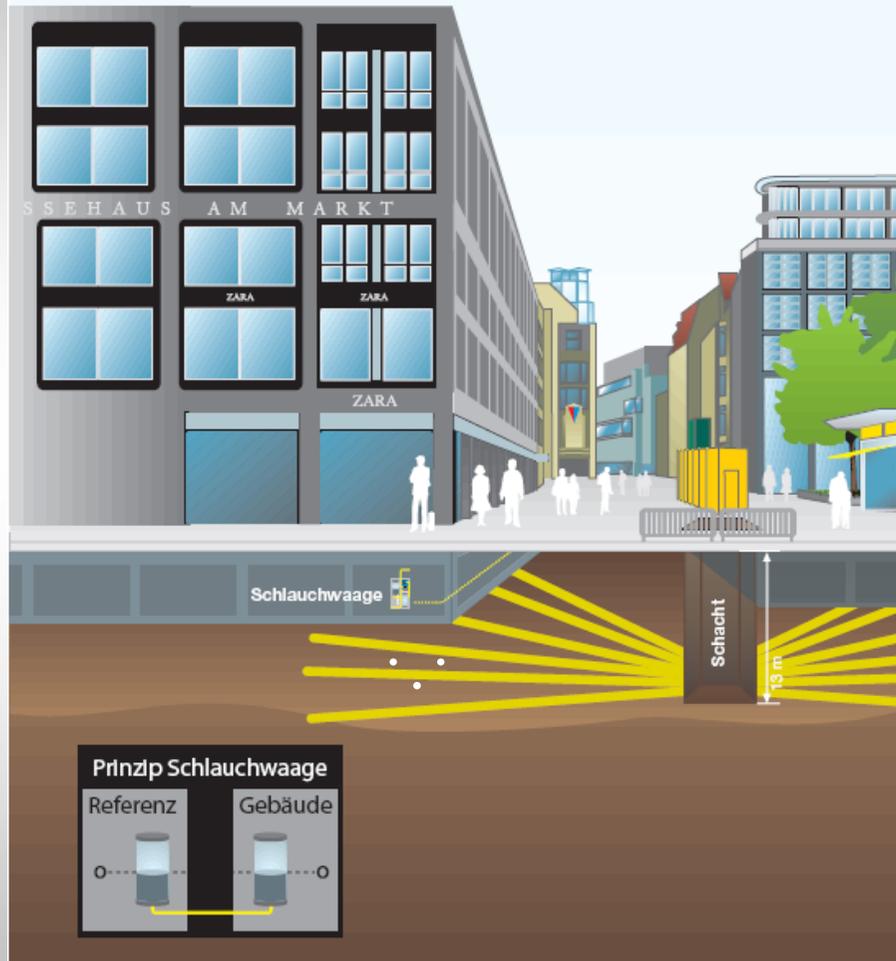
### Activity:

- Installation
- Baseline measurement



## Compensation grouting

### Phase 2: Drilling



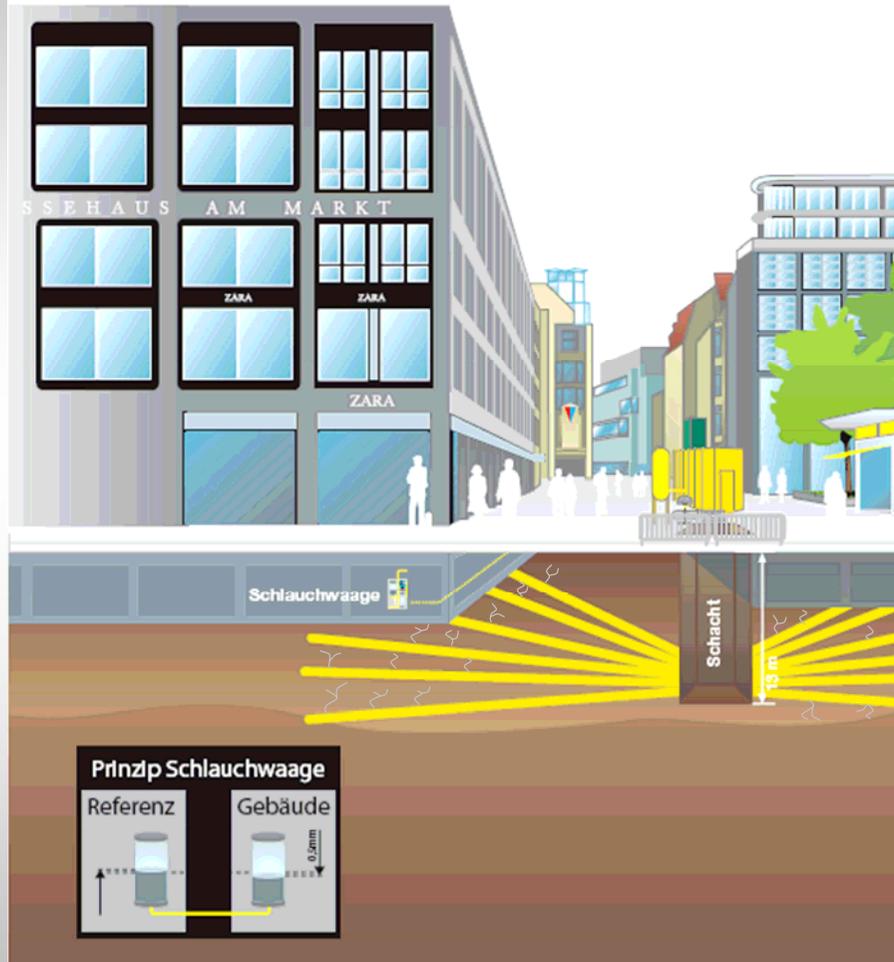
### Activity:

- Building monitoring
- Documentation of measurement results



## Compensation grouting

Phase 3: Grouting of the subsoil



### Activity:

- Grouting with consistent intensity until the water level gauges show a slight tendency towards lifting



## Compensation grouting

Phase 4: Preliminary raising



### Activity:

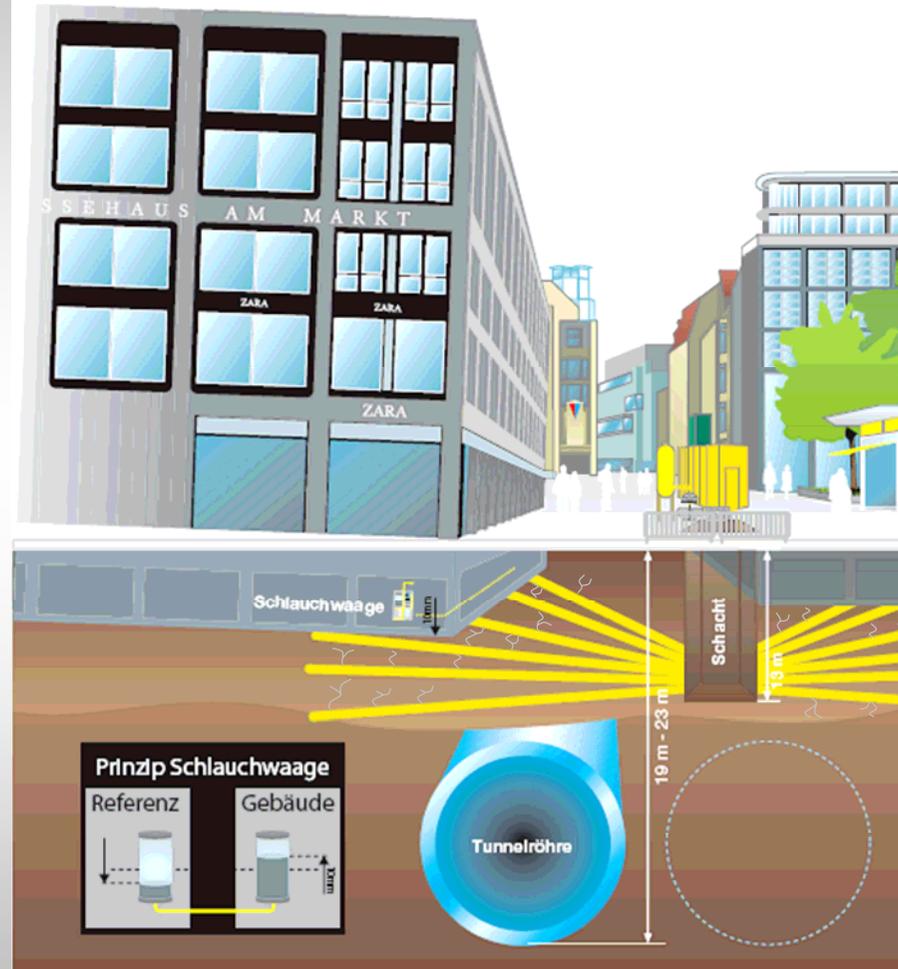
- Measurement results of the water level gauges determine the amount of grouting

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## Compensation grouting

Phase 5: Tunnelling & compensatory grouting



### Activity:

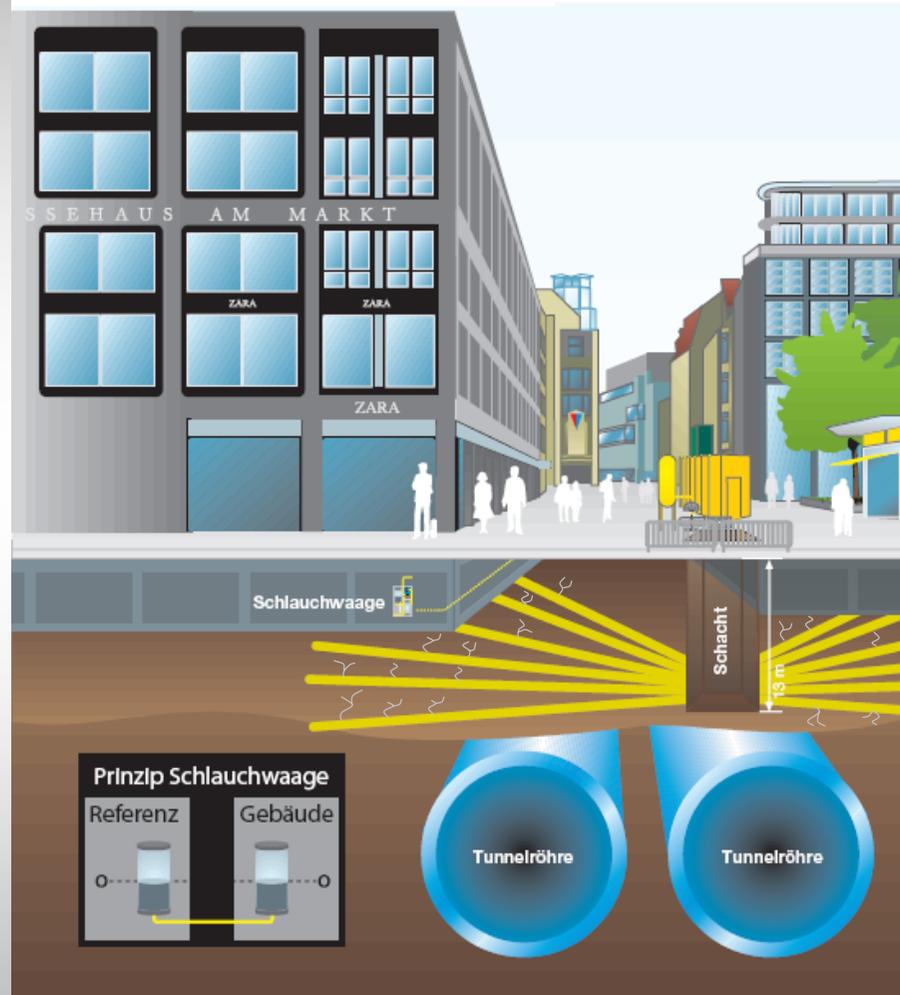
- Compensation of subsidence by means of injection

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## Compensation grouting

### Phase 6: Subsequent grouting



### Activity:

- Subsequent compensatory injection

## Compensation grouting



Water level gauge

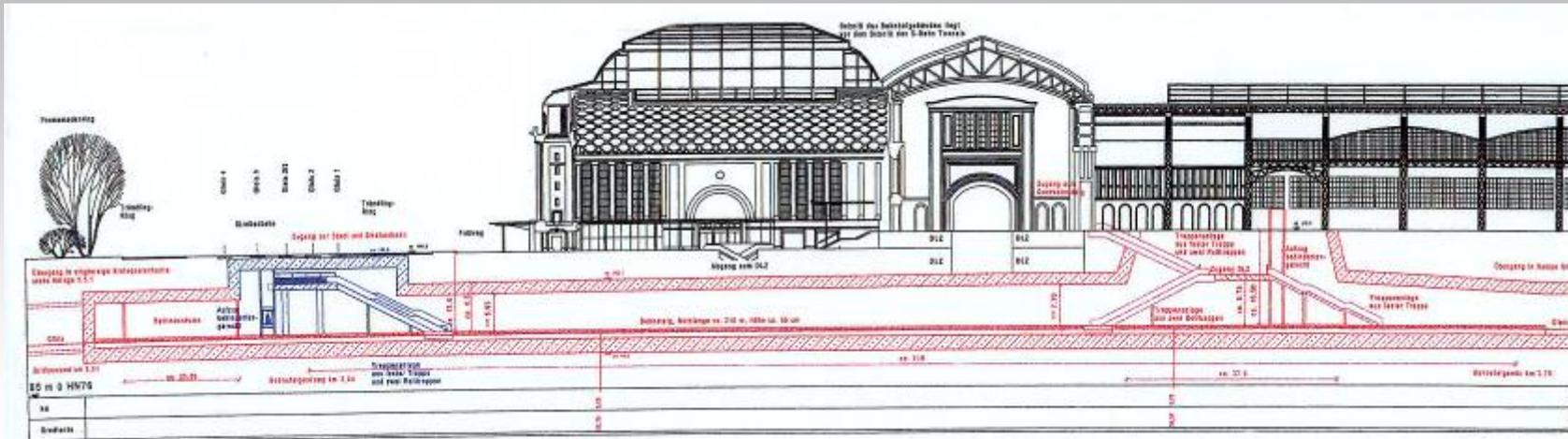
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# Soil freezing main station



Ring road,  
5 tramway tracks

Dig-and-cast  
construction method

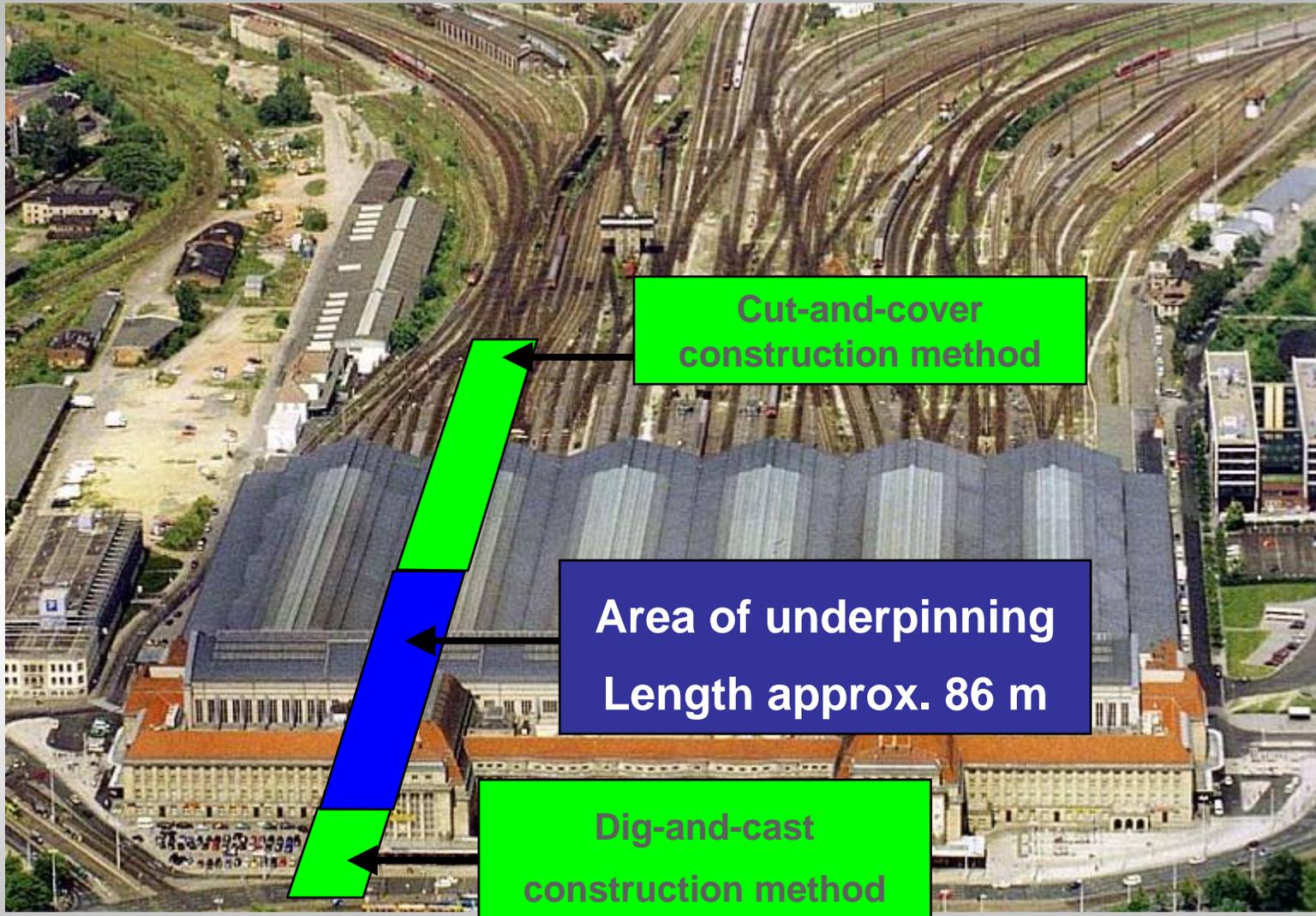
Station building

Area of underpinning

Platform hall

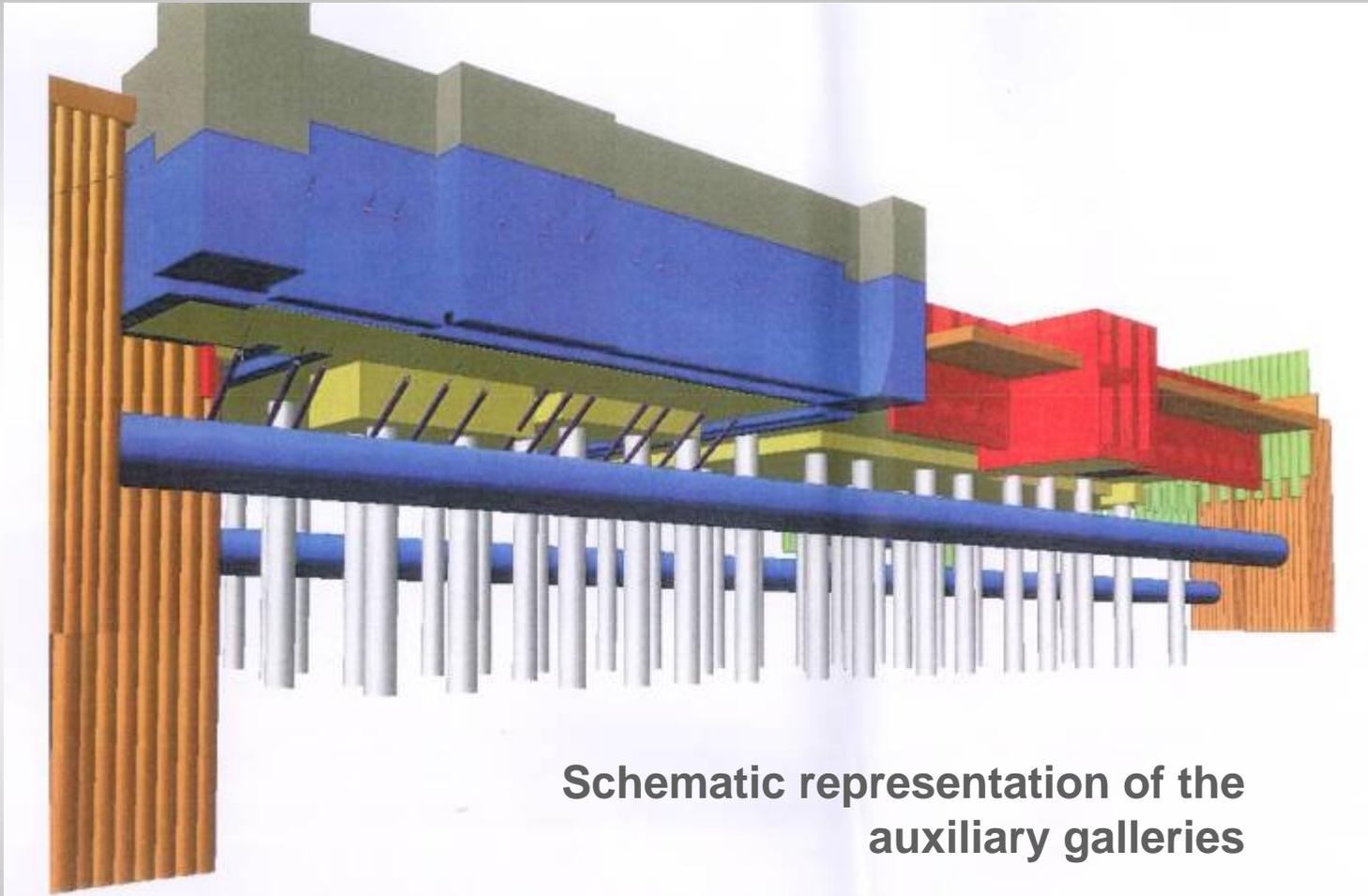
Cut-and-cover  
construction method

# Soil freezing main station



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## Soil freezing main station



**Schematic representation of the  
auxiliary galleries**

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## Soil freezing main station



- Construction of two auxiliary galleries
- Pipe jacking with the TBM (d = 3,0m)

**Soil freezing main station**



**Special drilling boom for freezing boreholes**

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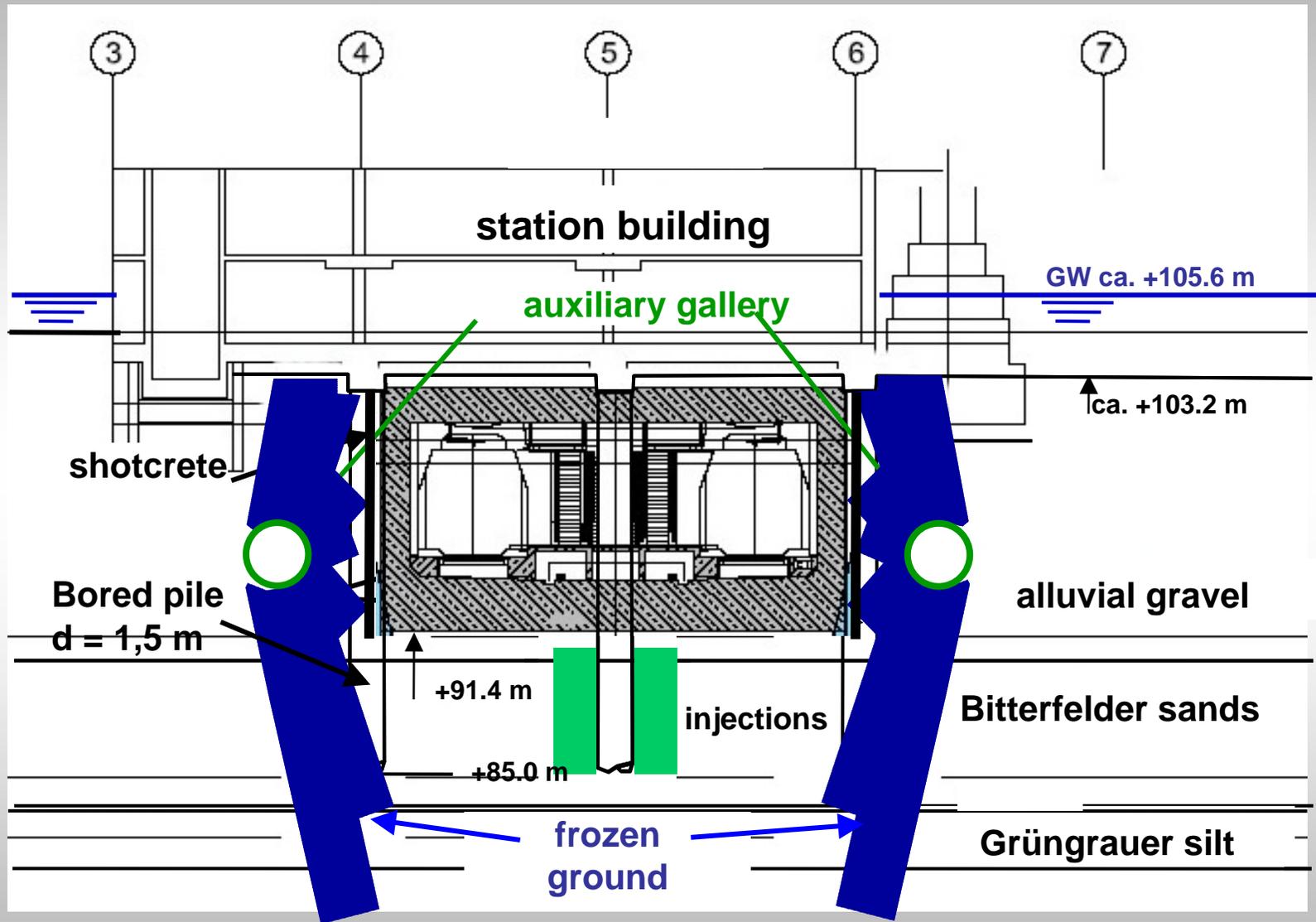
## Soil freezing main station



Soil freezing : freezing installation within the auxiliary gallery

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# Soil freezing main station



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# Soil freezing main station



## Gefrieranlagen- und Frostkörperüberwachungs-System



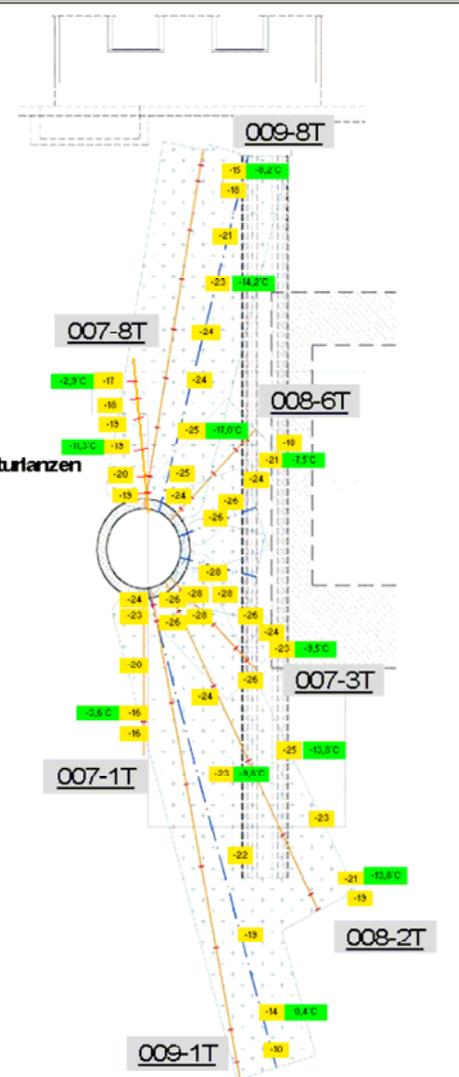
Inst. f. Grundbau und Bodenmechanik  
TU Braunschweig

### Stollen West TQ2

Temperaturverteilung an den Temperaturlanzen  
Aktuelle Messwerte:

Datum: 22.10.2008

Uhrzeit: 06:02:18



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# Soil freezing main station



## Messwerte der Gefrieranlage

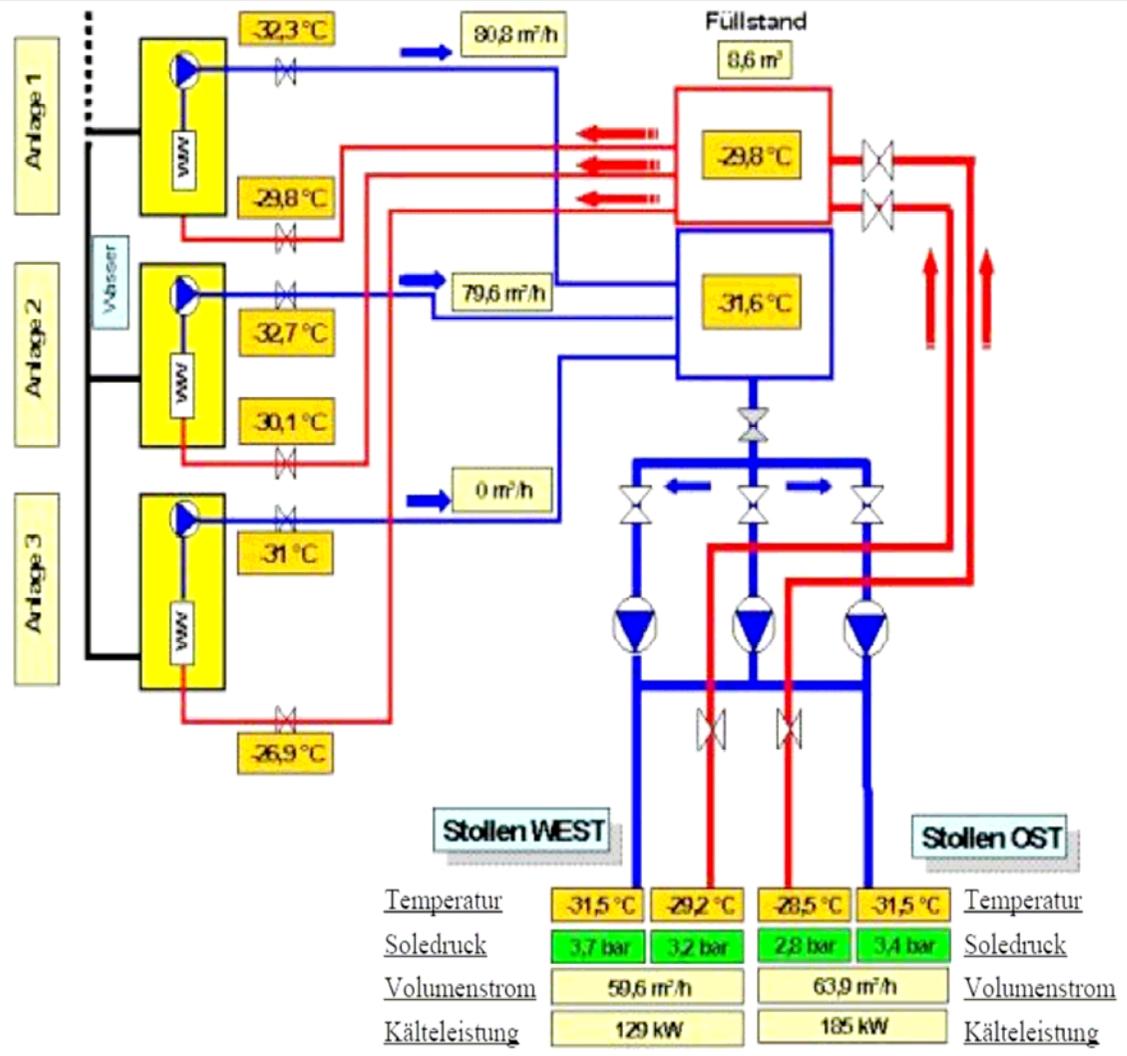
Aktuelle Messwerte

Legende:

Datum 22.10.2008

Uhrzeit 06:26:27

Temperatur [°C]
Druck [bar]
Durchfluss [m³/h]



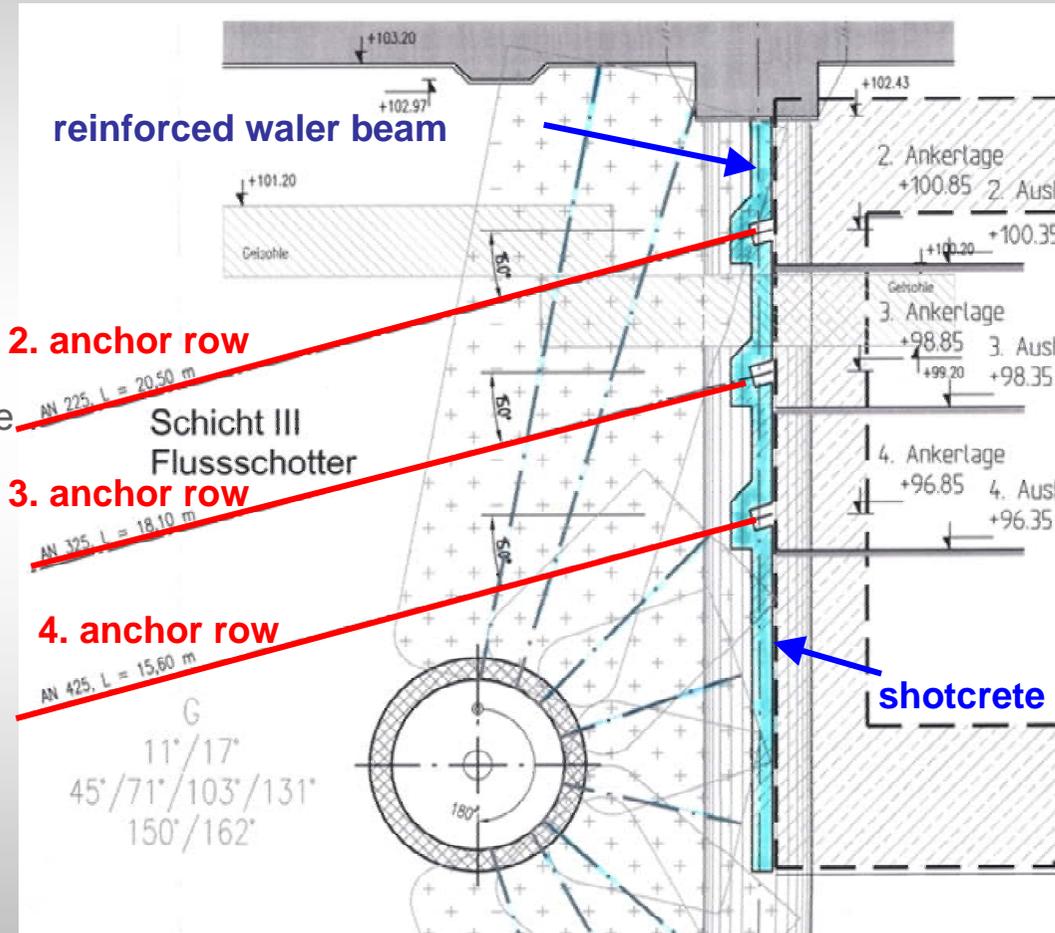
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## Soil freezing main station



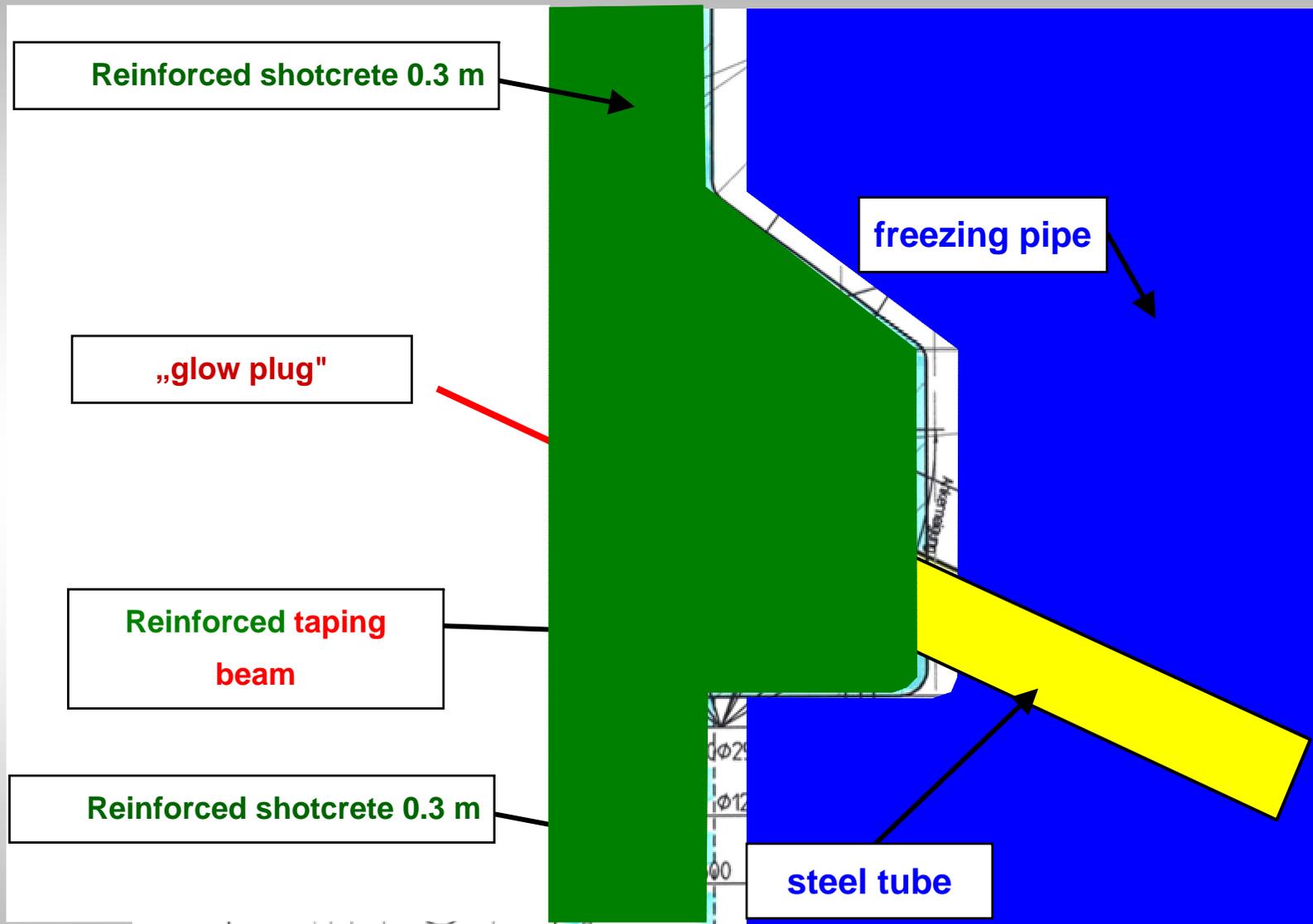
### Specialties of anchoring

- Anchor length approx. 12 – 26 m
- Anchor loads approx. 600 to 800 kN
- 2 to 4 anchor rows
- Anchors can be retensioned due to the creeping effect of frozen soil
- Rows of anchors depending on measurements of the freezing pipe
- waler beam allows for flexible arrangement in longitudinal direction
- Permanent monitoring of brine flow and pressure
- Excavation depth: 11 m to 16 m
- Excavation in sections steps of max. 3.5 m height
- Exposed surface strengthened with shotcrete



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# Soil freezing (at the) main station



steel tube

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## Soil freezing main station



### Informations:

- **Length of the frost body:** approx. 86 m
- **Thickness of the frost body:**  $d = 9.0$  to  $10.0$  m
- **Total volume of the frost body:** approx.  $16,000 \text{ m}^3$
- **Number of temperature transducers:** approx. 700 pieces
- **Freezing temperature (brine):**  $T \leq -35 \text{ }^\circ\text{C}$
- **Power of the freezing plant:** approx. 1,100 kW
- **Freezing pipes:** 1,071 pieces; length = approx. 8,200.0 m
- **Temperature measuring pipes:** 119 pieces; length = 970.0 m

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**Soil freezing main station**



**Area of underpinning main station**

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## Outline

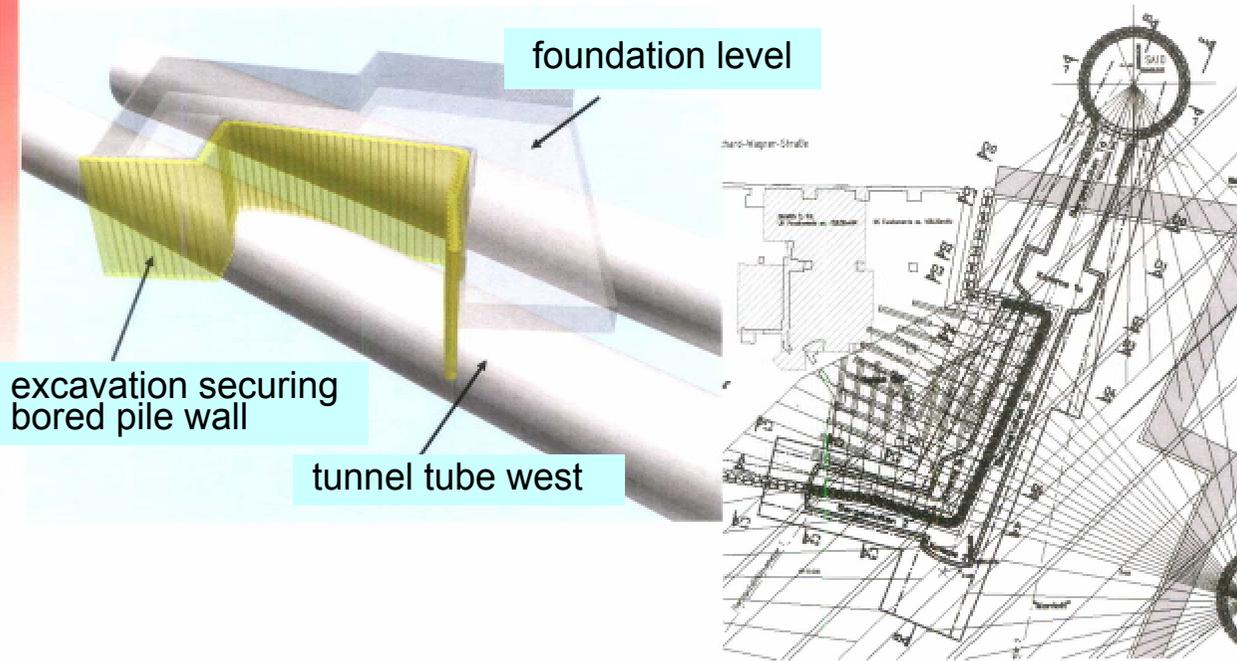


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## City Tunnel Leipzig, Los B

- 4 shield driving
- 4.4 gallery (general view)



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Wir bauen auf Ideen

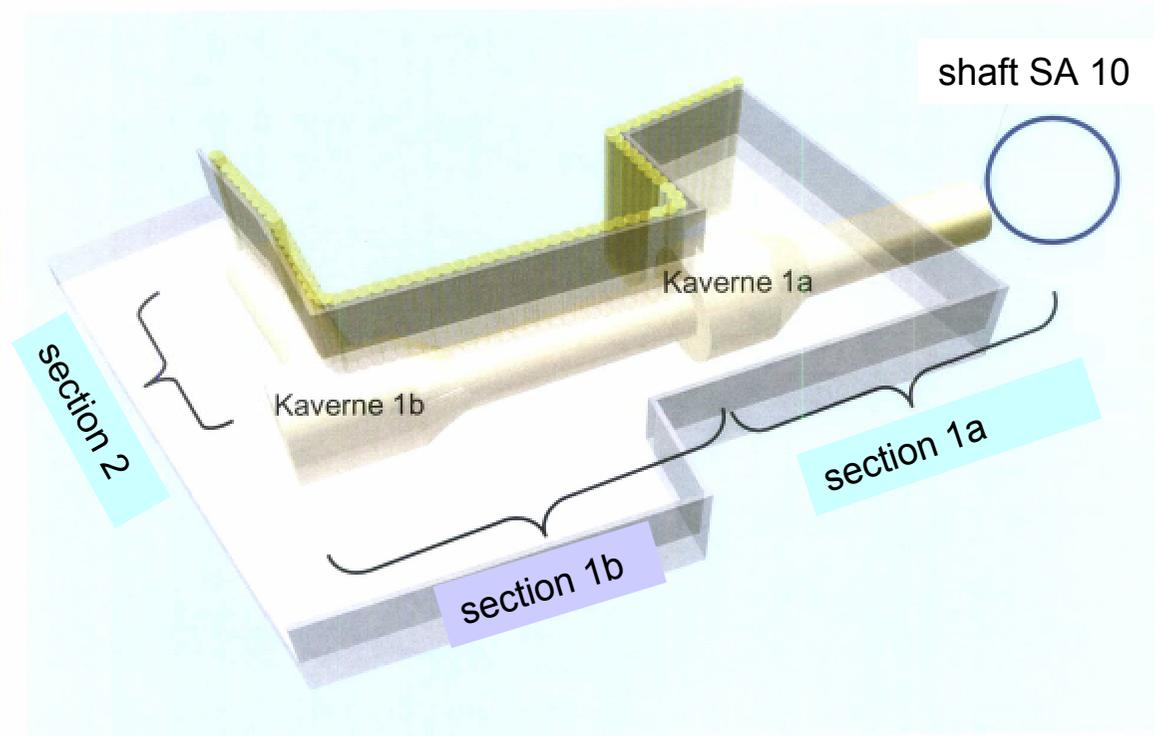
DYWIDAG

Problem: bored pile wall intersecting the tunnel alignment

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City Tunnel Leipzig, Los B



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Wir bauen auf Ideen

DYWIDAG

Solution: gallery secured by means of soil freezing

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# Soil freezing Hotel Marriott



Phase 4

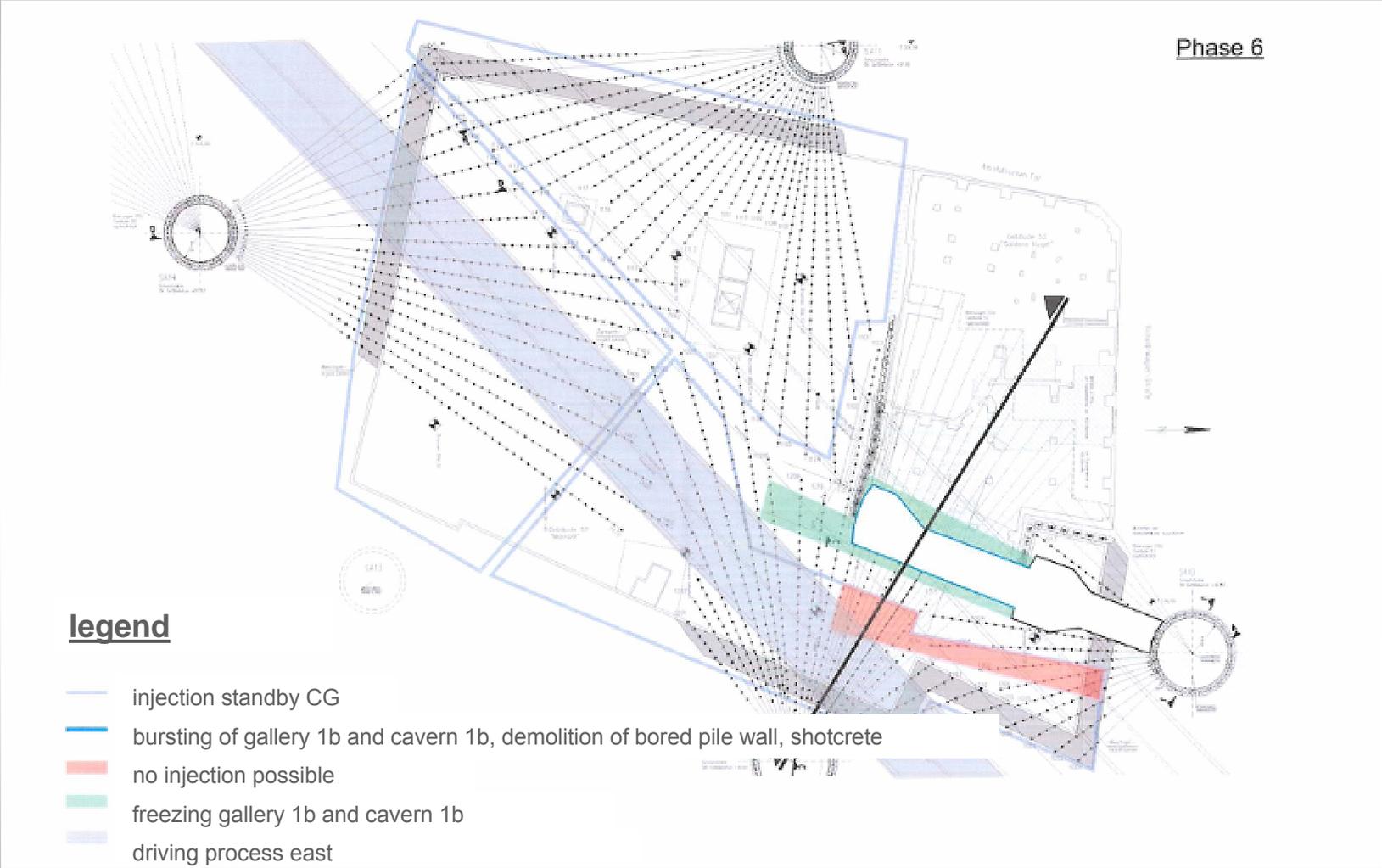
If CG fan SA12/SA14 is too dense, it may be necessary to include SA13

### legend

- drillings CG Marriott from shaft SA11/SA12 in the 2. fan plane
- drillings gallery 1b/ cavern 1b and niche from cavern 1a
- freezing of gallery 1a and cavern 1a

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# Soil freezing Hotel Marriott



# Soil freezing Hotel Marriott



Phase 12

## legend

- injection standby CG
- bursting of niche and gallery 2, demolition bored pile wall, shotcrete
- no injection possible  
driving process east

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City – Tunnel Leipzig



Thank you for your attention, **GOOD LUCK!**



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