Latest achievements in Microtunnelling: progress by experience and innovation.

Uwe Breig, Herrenknecht AG
Dubai, 19th February 2019

Latest achievements in Microtunnelling:
- Advanced Microtunnelling
  - Long-distance pipe jacking
  - Sea Outfalls, Intakes and Landfalls
  - Retractable machine concepts
  - Curved and inclined alignments
  - Cross passages technology
- Shaft Sinking: Mechanized shaft construction with VSM

Trends in Pipe Jacking:
- Higher hydrostatic pressures (river crossings / outfalls)
- Larger tunnel profiles
- More heterogeneous ground conditions
- Lower overburdens (inner-city)

Long-distance Pipe Jacking
Long-distance Pipe Jacking.
Increasing number of long-distance projects on and offshore.

- Saving shafts by long drives
- More than 70 long-distance projects > 1,000m since early 1990s.
- Europipe, Germany 1994: 2.5km world record, ID 3000.
- Mexico 2018: 2,246m Sea Outfall for Pipeline, ID 2600.

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Introduction

Long-distance PJ

Sea Outfalls
Retractables
Curved drives
Shaft Sinking
Cross Passages

River Crossing for Pipeline Casing Tunnel.

- M-1439M, AVND2400, OD3025
- Location: Hamburg, Germany
- Tunnel length: 1,580m
- Installed within 112 days

3rd Project – Bacharach, Germany: 6 x 700m

Development of AVNS microtunnelling machine (for ID 400 – 1200)

Drive lengths: 1,000m – 1,500m

Special requirement for underground cable installation
  - Depth: 1,5m to 4m, constant
  - High precision: constant distance between lines 1m – 2m

3rd Project – Bacharach, Germany: 6 x 700m

Sea Outfalls, Intakes and Landfalls

Outfalls
  - Sewage | Stormwater | Brine

Water Intakes
  - Desalination | Cooling

Pipeline Landfalls
  - Oil & Gas | Cables
Sea Outfalls, Intakes and Landfalls.

Trenchless installation methods.

- Pipe Jacking
- Microtunnelling
- Direct Pipe®
- Segment Lining
- Sea Outfalls, Intakes and Landfalls.
- Shaft Sinking
- Cross Passages

Introduction

Long-distance PJ

Sea Outfalls

Retractables

Curved drives

- M-1130M + M-1131M, 2x AVN2800AH, OD3440
- Outfall length: 2 x 2,000m
- Min. curve radius: 400m
- Geology: rock, approx. 100Mpa
- Contractor: GCD Alliance

- M-1275M, AVN1000DP
- Drilling length: 1,930m World Record
- 2 x HK500PT Pipe Thruster
- Use of Pipeline: Army Bay Wastewater Treatment Plant Outfall Replacement
- Location: Auckland, New Zealand
- Geology: sandstone, mudstone

Performance:
- Best daily performance: 42.5m
- Best monthly performance: 210.7m
Sea Outfalls, Intakes and Landfalls.
HDD: 3.048m Berri causeway crossing - meeting in the middle.
- 2 HDD Rigs: HK400M, HK250T | HK500PT Pipe Thruster
- Drilling length: 2 x 3.048m
- World’s longest undersea HDD recovery operation
- Use of pipeline: 24" oil trunk, 30" water injection
- Geology: sand, corals
- Contractor: Tatco Boring

Retractable machine concepts.
Applications and cutterhead design.
- No reception shaft possible
- Blindhole required with minimum loss of equipment:
  - E.g. HDD casing through gravel layer
  - Pipe Arch construction

Retractable machine concepts.
Pipe Arch secures the subway station to be excavated.
- Location: Subway Station Brandenburger Tor, Berlin, Germany
- Machine: 2 x AVN1200 | OD 1610
- Project: 30 blind hole drives completed, of 90m length each
- Geology: Sand (with inclusions of gravel, stones and blocks), groundwater
Retractable machine concepts.
AVN800 with foldable cutterhead.

Curved and inclined alignments

Curved Pipe Jacking.
Tight curves and long drives.
- M-2133M, AVN2000, OD2725
- Location: Zug, Switzerland
- Project: Lake Zug Flood Protection and Rainwater Tunnel
- Tunnel length: 1,832m
- Max. drive length: 882m
- Tight curve radius: $r = 250m$
  - Horizontal and vertical
- Geology: sand, silt, gravel
- Contractor: Sonntag Baugesellschaft mbH & Co. KG

Inclined Pipe Jacking.
Water Pressure Tunnel Maerzenbach.
- M-974M, AVN 1600 TB, OD 1970
- Location: Zillertal, Austria
- Tunnel length: 863m
- Slope: 11.6 % | 7°
- Geology: rock, schist, quartzite (170MPa)
Cross passage technology

Tuen Mun - Chek Lap Kok Link.
Herrenknecht technology involved.

- 2 road tunnels (Traffic Tunnelling)
- 3 x Mixshields supplied by Herrenknecht
  - S-880 Ø 17.6m, world’s largest TBM
  - S-881 Ø 14m
  - S-882 Ø 14m
- 46 cross passages built by Mini-TBM
- 2 x AVN 3000 with special equipment

- Length of cross passages: up to 13m
- Max. confinement pressure: 5.5 bar
- Geology: sand, silt, clay, gravel, granite

Shaft Sinking
VSM – Vertical Shaft Sinking Machine.

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VSM – Vertical Shaft Sinking Machine.
Overview of VSM machine range.

Shaft ID
in m

VSM 9.000
VSM 10.000
VSM 12.000
VSM 14.000
VSM 18.000

References
73 shafts built so far
with up to 85m depth

Application fields

Storage
Microtunnelling
Sewage
U-Park
Metro
Emergency and Ventilation

Project challenges:
- narrow conditions
- Settlements risk highly considered due to close buildings
- No noise accepted

VSM – Vertical Shaft Sinking Machine.
Reference Projects – Railway Girona, Spain.

- 4 Railway shafts
- ~ 20m depth, Ø ID 5250, OD 5950
- Only 12 meter between houses
## VSM – Vertical Shaft Sinking Machine for U-Park®

Number of parking spaces per level according to shaft diameter.

<table>
<thead>
<tr>
<th>Shaft depth</th>
<th>Variant 1</th>
<th>Variant 2</th>
<th>Variant 3</th>
<th>Variant 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 m</td>
<td>50</td>
<td>75</td>
<td>150</td>
<td>200</td>
</tr>
<tr>
<td>60 m</td>
<td>60</td>
<td>90</td>
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<tr>
<td>70 m</td>
<td>70</td>
<td>105</td>
<td>210</td>
<td>280</td>
</tr>
</tbody>
</table>

**Introduction**

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- Retractables
- Curved drives
- Shaft Sinking
- Cross Passages

**Variant 1**

**Variant 2**

**Variant 3**

**Variant 4**

**Pioneering Underground Together**