Selection Criteria of Tunnel Boring Machines - Examples

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ENGINEERS
General Selection Criteria

1. Geotechnical behaviour of the ground
2. Presence of ground water and pressure
3. Boundary conditions of the project
4. Experience of the contractor
### Criteria for Selection

(by Babendererde 1999)

<table>
<thead>
<tr>
<th>Rock Strength</th>
<th>Rock Structure</th>
<th>Water Ingress</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Jointing</td>
<td>Grain size</td>
</tr>
<tr>
<td><strong>Unilat. compr. MPa</strong></td>
<td>RQD</td>
<td>Distance</td>
</tr>
<tr>
<td>&gt; 250</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>250 - 100</td>
<td>-</td>
<td>behind TBM</td>
</tr>
<tr>
<td>100 - 50</td>
<td>-</td>
<td>behind TBM</td>
</tr>
<tr>
<td>50 - 25</td>
<td>-</td>
<td>recom.</td>
</tr>
<tr>
<td>25 - 5</td>
<td>-</td>
<td>recom.</td>
</tr>
<tr>
<td>5 - 1</td>
<td>recom. required under shield</td>
<td>&lt; 25 %</td>
</tr>
<tr>
<td>&lt; 1</td>
<td>&gt; 30</td>
<td>required under shield</td>
</tr>
<tr>
<td><strong>Soil</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 - 10</td>
<td>recom. required under shield</td>
<td>&gt; 30 %</td>
</tr>
<tr>
<td>10 - 5</td>
<td>recom. required under shield</td>
<td></td>
</tr>
<tr>
<td>5 - 1</td>
<td>required required under shield</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>required required under shield</td>
<td></td>
</tr>
</tbody>
</table>
TBM type - difference by the way of face support

- No face support
- Mechanical support
- Compressed air
- Active, by support medium: EPB or Slurry
No face support – Hard rock TBMs
Active face support helps!
Range of Slurry- and EPB- TBM Application
Considering Grain-size Distribution

Slurry-TBM drives
1. Lyon
2. Hamburg
3. Grauholztunnel
4. Wesertunnel
5. Zürich, Hermetschloo-Werdhölzli
6. Zürich, Thalwil
7. Portland, Gravel Alluvium
8. Wittenberg (polymer suspension)

EPB-TBM drives
9. Essen, U-Bahn Los 32/33
10. Milano, Passante Ferroviario
11. Metro Porto
Selection of TBM with active face support

**Slurry limitation**

High content of fines < 0.06 mm requires expensive separation process

**EPB limitation**

High permeability $k > 10^{-3}$ m/s requires intensive conditioning
Face support

Slurry-TBM
- compressed air cushion
- feed line
- transport line
- stone crusher

EPB-TBM
- fluid injection
- screw conveyor
- guillotine gate
Typical Thrust and Torque of a Ø 9m TBM
Water Strait Crossings in Northern Germany

- River Weser Tunnel
  Ø 11.7m
- River Elbe Tunnel
  Hamburg West
  Ø 14m
- River Elbe Tunnel
  4th Tube Hamburg
  Ø 14m

Herrentunnel
under river Trave
Ø 11.7m
Tunnel under the River Weser

Kleinensiel

Start Shaft

Dyke

Min. Overburden 8.40 m

-10 m
-20 m
-30 m

Ø 11.80 m

Sand with stones

Dyke

Dedesdorf

End Shaft

Dyke

1.635 m
Moscow Metro Escalator Tunnels, Russia