HONG KONG, Tsuen Wan Drainage Tunnel

TBM excavation in difficult ground conditions and narrow working space
The Drainage Tunnel System includes:

- 3 Intake Structures
- 1 Outfall Structure
- 1 Tunnel: Length = 5.1 km – Diameter = 6.5 m
Tunnel characteristics:
- Length = 5.1 km
- Internal Diameter = 6.5 m
- Lining Thickness = 250 mm

Tunnel excavation by DOUBLE SHIELD TBM:
- Excavation Diameter = 7.27 m
- Manufactured and operated by SELI

Main Challenges:
**ENVIRONMENT** = narrow working space in a dense urban area
**GEOLOGY** = extremely strong, abrasive and fresh rocks
Environment Constraints:

- Limited available working space
- Interference between tunnelling operations and civil works
- Steep sloping terrain
- Tunnel Portal 14 m above the road level
- Site area between residential buildings
- Working time limitations
- Only one congested access road to the Site
- Traffic restrictions
- Trucking and delivery operations limited
**Geology**

<table>
<thead>
<tr>
<th>Rock Type</th>
<th>UCS mean (MPa)</th>
<th>UCS max (MPa)</th>
<th>E (GPa)</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volcanic coarse ash, tuff</td>
<td>208</td>
<td>374</td>
<td>73</td>
<td>0.25</td>
</tr>
<tr>
<td>Fine ash, vitric tuff, interbed of sandstone / siltstone</td>
<td>280</td>
<td>410</td>
<td>72</td>
<td>0.25</td>
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<tr>
<td>Granodiorite - Dacite</td>
<td>176</td>
<td>290</td>
<td>67</td>
<td>0.25</td>
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</tbody>
</table>

- Fault zones associated with highly permeable zones
- Groundwater inflows
TBM Operations on 2 YARDS:

**UPPER YARD:**

- Plant & Facilities for TBM Operations

**LOWER YARD:**

- Delivery/Transport of Tunnel Materials

**Special Provisions:**
- Noise Enclosure
- Noise Barriers
- Noise Monitoring
Environment - Solutions

UPPER YARD

- Grouting Plant
- Overhead Gantry
- Conveyor Belt
- Ventilation
- Power Supply
- Pea-Gravel
- Segment stock
LOWEYARD

- Muck Hoppers: 1,000 m³ capacity
- Disposal lorries beneath the hoppers
- Tower Crane
- Segment Delivery Point
TBM DESIGN – Assembly & Launching in a limited space

- Assembly of TBM + 3 B-U Decks equipped to pre-excavate
- Pre-Excavation
- Assembly of B-U Decks one by one
### TBM Design

Robust and powerful TBM subject to heavy stresses and vibrations

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Value</th>
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<tbody>
<tr>
<td>Shield length</td>
<td>m</td>
<td>12.250</td>
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<tr>
<td>Total weight</td>
<td>T</td>
<td>550</td>
</tr>
<tr>
<td>Excavation diameter</td>
<td>mm</td>
<td>7270</td>
</tr>
<tr>
<td>Excavation D. Max overcut</td>
<td>mm</td>
<td>7330</td>
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<tr>
<td>Cutting disc</td>
<td>no.</td>
<td>47</td>
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<tr>
<td>Cutting disc type</td>
<td>inches</td>
<td>19</td>
</tr>
<tr>
<td>Installed power</td>
<td>kW</td>
<td>2520</td>
</tr>
<tr>
<td>Cutterhead revolution speed</td>
<td>rpm</td>
<td>0-7</td>
</tr>
<tr>
<td>Cutterhead nominal torque</td>
<td>kNm</td>
<td>2750</td>
</tr>
<tr>
<td>Cutterhead maximum torque</td>
<td>kNm</td>
<td>4140</td>
</tr>
<tr>
<td>TBM Belt width</td>
<td>mm</td>
<td>800</td>
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<tr>
<td>Belt Capacity</td>
<td>t/hr</td>
<td>650</td>
</tr>
</tbody>
</table>

*Robust and powerful TBM subject to heavy stresses and vibrations*
TBM Design

PROBING / GROUTING Ability

- Probe drilling ahead provided by 2 drill machines (behind TBM)
- Probe holes guide pipes installed on the Tail Shield
- Pre-excavation Grouting ahead to control water inflows
- Ground Treatment in fault zones
**TBM Design**

**CUTTERHEAD DESIGN**

- N. 47 discs 19” diameter (thrust capacity 300kN each)
- N. 8 large buckets on CHD
- Grill Bars spaced 250 mm
- Bolted steel bucket lips
- Anti wear chromium carbide plating on all CHD gauge area
- Shock protection plates
- Multi spray nozzle system at very high water pressure
TBM Performance

TBM parameters (last 500 m)

Thrust Force
average = 9000 kN

Penetration Rate
average = 5.5 mm/rev

Advance Speed
average = 36 mm/min
TBM Performance

Thrust Force-Penetration Rate in Granodiorite (CH 4+694-4+532)
Cutter changes resume

- "Other"
- Oil leakage
- Blocked disk
- Disk chipping
- Worn out

Posizione cutter

Sostituzioni
TBM Performance

Thrust Force-Penetration Rate

Ring Chainage

High Silicified/High in Iron contenten Silstone in band
Conclusions

The tunnel is still in progress

20 -25 m/day advance limited by external muck hopper

Mitigation of Risks associated with:

- Management and planning of tunneling operations
- Geological challenges
- Very narrow space with limited accesses
- Dense traffic road
- Close residential neighbourhood

Thanks to a combination of solid engineering and deployment of very competent tunnel resources
THANK YOU