TBM Selection and Specification

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Date: 13 June 2009

- TBM Selection - Challenges to be met
- TBM Technology
- Auxiliary Measures and Backup
- New Developments
- Summary of Selection Process
- Procurements
- Specification
- Conclusions
TBM Selection – Challenges to be Met

- Ground Movements
- Ground Water Control
- Excavation Stability
- Speed of Construction
- Dealing with the unforeseen
- Site Consideration
- Risk and Cost

TBM Selection – Challenges to be Met

- Geology
- Tunnel Alignment
  - Design and build to negotiate both Vert. & Horiz. Alignment
- Tunnel Diameter
- Site Restrictions
  - Mechanisms to deliver, assemble and launch the TBM will impact TBM type employed
- Local Experience and Availability
- Project Time-frame
  - TBM can be customised exactly in accordance with projects specification
TBM Selection - Challenges to be Met

- KDB200 – Kowloon Southern Link
- WIL 703 – West Island Line
- DSD Tsuen Wan Drainage Tunnel
- SMART Tunnel (Singapore)
- CLP Castle Peak cable Tunnel

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TBM Technology

- Pressure Bulkhead
- Cutting Wheel
- Excavation Chamber
- Screw Conveyor
- Cutting Wheel Drive
- Erector
- Compressed Airlock
- Shield Tail Seal
- Segments
- Push Cylinder

TBM Technology - Types of TBM

- Multi Head EPM TBM
- Slurry Shield TBM
- Multi Head EPM TBM
- Mixed Shield TBM
- Open Mode TBM
- EPB TBM
TBM Technology – Types of TBM

1. Open Hard Rock TBMs
   - Circular-Head Equipped with disc-cutters spaced in spiral fashion from centre to periphery
   - Selected for tunnels in solid rock (UCS 50-300MPa)
   - Provides no means of preventing groundwater entering the excavation

TBM Technology – Open mode TBMs

- Open Face Shields
- Gripper Shield
- Segmental Shield
- Double Shield
TBM Technology – Principal Types of TBM

2. Shielded TBMs
   - Suitable for low face stability
   - Pre-cast concrete segmental lining constructed directly behind the shield
   - Different types of TBM shields to suit different ground conditions (i.e. Slurry Machines, Mixed Shields, Earth Pressure Balance Machines)
   - Depending on ground conditions, Cutters discs or soft-ground picks and scrapers may be equipped accordingly

TBM Technology – Shield TBM (Closed) Family
TBM Technology – Slurry or Earth Pressure Balance??

Advantages of Earth Pressure Balance Machines
- In the event of face collapse, ground loss is limited
- Able to operate in open mode in firm ground
- Better production rates are possible
- Lower capital cost
- Smaller work Site and launch shaft

Advantages of Slurry TBMs
- Working pressure control is systematic
- Muck is only evident at the surface
- Less power requirement at cutterhead
- Less torque required
- Easier to understand and operate
- Reduced cutter wear, less frequent interventions

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Auxiliary Measures and Back-up - Precast segmental lining

Auxiliary Measures and Back-up - Cutter Disc
Auxiliary Measures - Site Constraints

- Segment Storage
- TBM Back-up
  - Slurry treatment plant
  - Compressed Air
  - Medical locks
  - Electrical sub-station
- Excavated material storage
- Cutter workshop
- Bentonite / conditioner storage

Auxiliary Measures and Back-up - Slurry Plant
Auxiliary Measures - Facilities

- Automatic guidance system
- Real time information
- Automated segment erection

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New Developments

Non-Circular Section by Tunnel Boring Machine Technology

Example of tunnel cross section

New Developments – Post Reaming

Tunnel Boring by Reaming - TBE
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Summary of Selection - Process

Is a TBM Required?

- Drive length / programme
- Ground conditions
- Ground water
- Environmental considerations
- Control of settlements
- Shape of the tunnel
Summary of Selection - Process

What type of TBM

- Stability of the face
- Ground conditions
- Site constraints
- Special features

Summary of Selection - Process

Are there remaining risks

- Unforeseen conditions
- Border line ground conditions

Is it clear what TBM should be selected?
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TBM Procurement

Level playing field

- State clearly the Employer’s Requirements
- Consider base lining the principal assumptions
- To specify or not to specify
- Cash flow

Who should procure?
TBM Procurement

Employer Procurement

Advantages
- Potential programme advantage
- Certainty of machine type
- Base lines a major risk
- Base lines functionality
- Greater certainty in costs/cash flow

Disadvantage
- Claims from Contractor on suitability
- Reduces contractor’s innovation
- Suitability to final design
- Dictates method of working
- The client is sold a pup

TBM Procurement

Contractor Procurement

Advantages
- Allows innovation in TBM design
- Best placed to manage risks
- Utilisation of existing plant
- Use of preferred supplier
- High level of experience
- Total sign-up to delivery

Disadvantage
- Long lead in times
- May seek to cut costs
- Cash flow
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TBM Specification

- Only use detailed specification if you are sure that it will meet the requirements
- Specification should not rule out and competition
- Clearly state Employer’s Requirements
- Check that the Specification is not in conflict with base lined information
- Maintain options if compatible with approach
- Be mindful of Contractor’s preference
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TBM Selection and Specification - Conclusions

- Knowledge of ground conditions is essential
- Knowledge of the possible impact of tunnelling is essential
- Be clear on what you are expecting the TBM to achieve
- Is your selection of TBM compatible with base line items
- Is your selection of TBM compatible with site constraints
- Determine who is best placed to procure the TBM
- Don’t over specify
TBM Selection and Specification

The End
Thank You