地鐵公司
MTR Corporation

Association of Geotechnical & Geoenvironmental Specialists (HK)
Seminar: 'Tunnelling – Selected Topics'

Planning a Tunnel and it's Excavation

(Case Study: Express Rail Link)

Alan Morris Construction Manager – XRL Tunnels

13 Jun 2009

Agenda

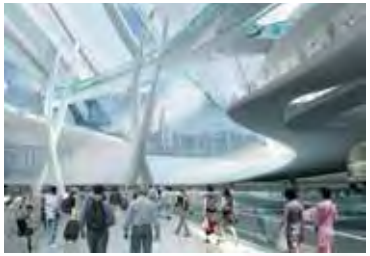
- XRL Background
- Tunnel Route Selection
- Geology
- Liaison / approval
- Tunnelling Methods
- Contract Strategy / Programme

XRL Background

XRL Background – RDO 2000

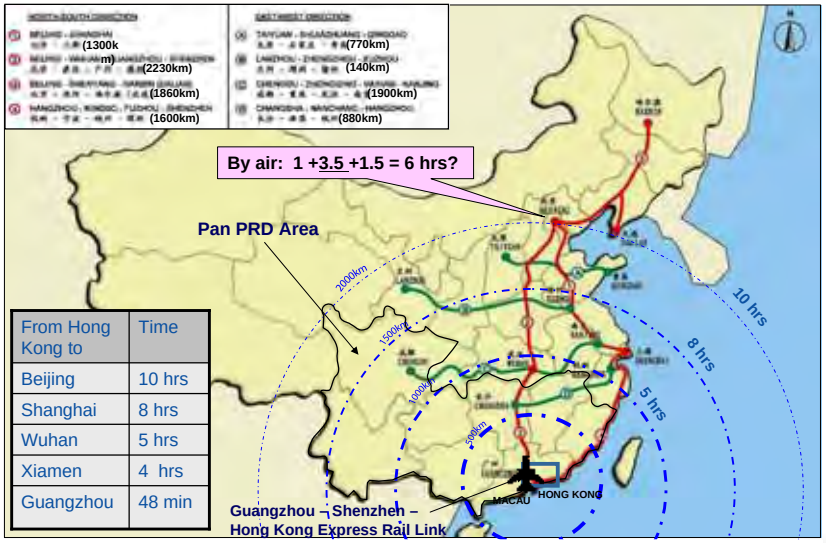
XRL Background - Introduction

- Express Rail Link (XRL) provides a cross boundary high-speed rail link between Hong Kong and Mainland
- Part of the national high-speed network
- Mainland Section ~ 124 km, 6 stations
- Hong Kong Section
  - 24.6 km, 1 station (terminus)
  - 8 vent shafts / adits / Emergency Access Points (EAP)
  - Shek Kong Stabling Sidings (SSS) & Emergency Rescue Siding (ERS)



XRL Background – Mainland Network

XRL Background – High Speed Travel



From Hong Kong to	Time
Beijing	10 hrs
Shanghai	8 hrs
Wuhan	5 hrs
Xiamen	4 hrs
Guangzhou	48 min

XRL Background – Rolling Stock

CRH1 (Bombardier - Regina)

CRH2 (Kawasaki - Shinkansen E2)

Shuttles: 8-car , 200m long, 600 px | Long Haul: 16-car, 400m long, 1,200 px

CRH5 (Siemens - Velaro CN)

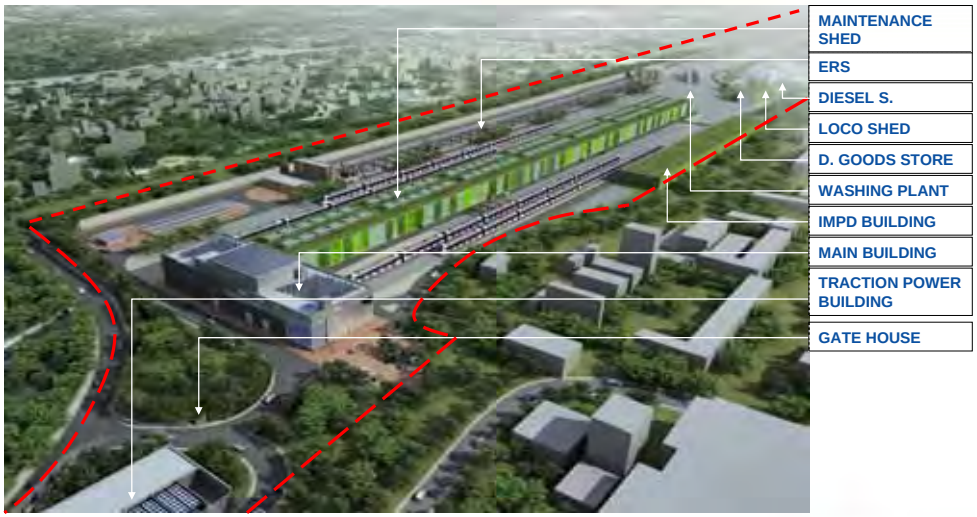
CRH5 (Alstom - Pendolino SM3)

XRL Background - Guangzhou-Shenzhen-Hong Kong HK Line

	Route Length	Journey Time
WKT to the Boundary	26 km	-
WKT to Futian	30 km	14 mins
WKT to Shibi	142 km	45 mins

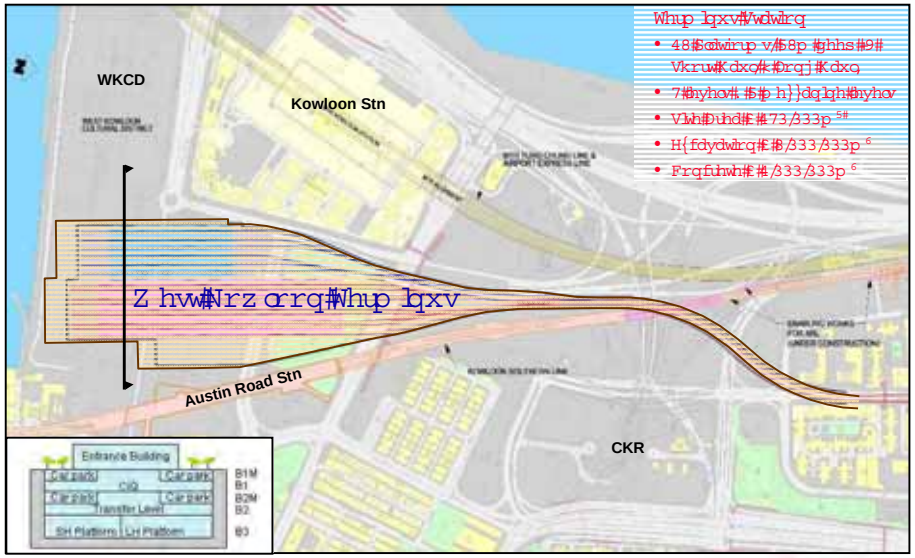
XRL Background – Alignment

XRL Background - SSS and ERS

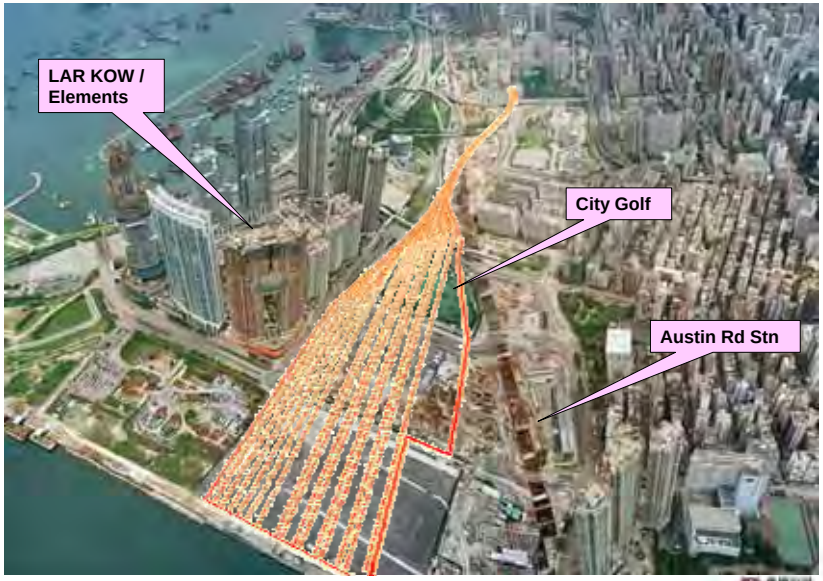


XRL Background – Ventilation / EAP Bldg

XRL Background – Terminus Scope



XRL Background – Terminus Location



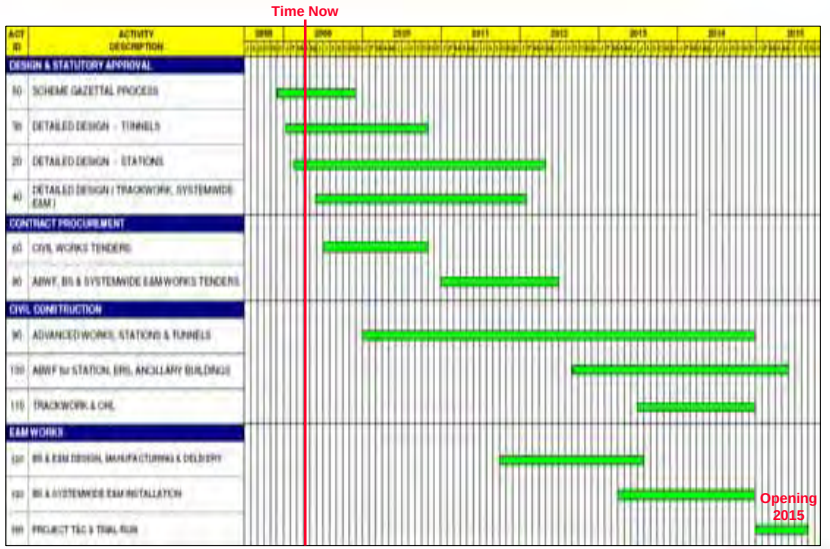
XRL Background – CE's Policy Address 2007~2008

Cross-boundary Infrastructure Projects

(4) **The Guangzhou-Shenzhen-Hong Kong Express Rail Link:** Our country is now building a high-speed national rail network of some 12 000 kilometres to link up major cities, with maximum train speeds of 200 to 300 kilometres per hour. The network will substantially enhance the Mainland's transport capacity. To seize the opportunities, we are pressing ahead with the building of the Guangzhou-Shenzhen-Hong Kong Express Rail Link running from West Kowloon to Shibi, Guangzhou. When running in Hong Kong, this Express Rail Link will use a dedicated line to ensure its smooth operation. We will actively study the provision of a common immigration and customs clearance system for Hong Kong and the Mainland at the Kowloon Terminal. Our target is to complete the planning and design processes within next year, so that construction will commence in 2008.

Donald Tsang Oct 07

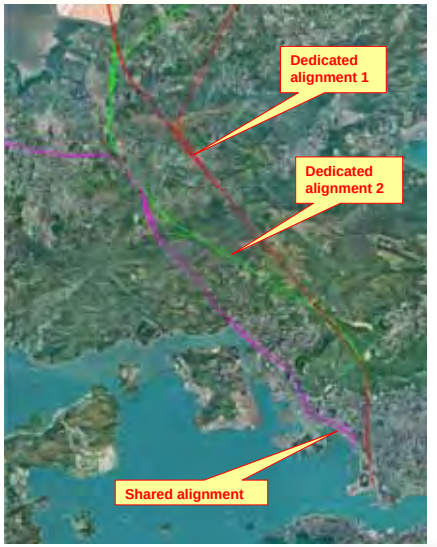
XRL Background – Programme



Tunnel Route Selection

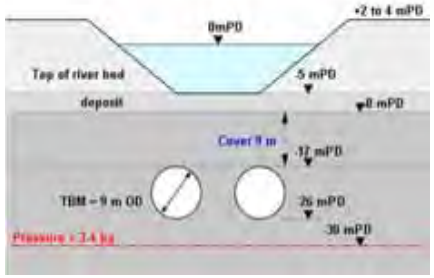
Route Selection - Feasibility Design

- PPFS carried out in 2006/2007
- Principal objective was to assess dedicated versus shared alignment (West Rail) corridors
- Concluded with two alignments, Base and Alternative
  - Base alignment trough Sham Shui Po area
  - Alternative alignment via West Rail Depot



Route Selection - Prelim Design (Constraints)

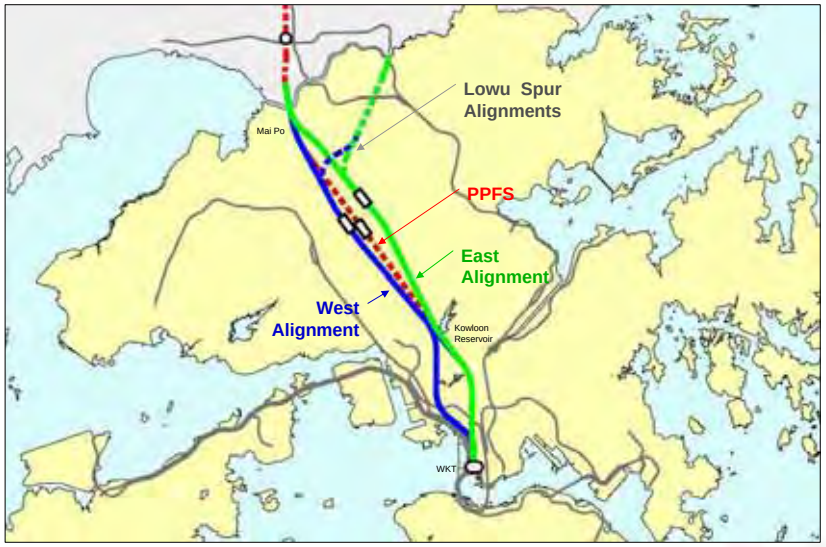
- Depth of TBM drives limited to be less than allowable compressed air intervention pressure of 50psi (3.45 bar) in mixed / soft ground. Approx 30m to 35m depth max.
- High speed railway (200 kph): minimum horizontal radius 2,000m & maximum 2% gradient.
- Avoid existing foundations and buildings



Route Selection - Prelim Design (Selection)

- PD commenced April 2008
- First task to determine preferred dedicated alignment corridor
- Two VE Workshops held in June 2008
- Six principal alignment corridors assessed. Narrowed down to two in north, two in south
- Qualitative and Quantitative evaluations used to select overall Preferred Alignment

Route Selection - Prelim Design (Short List)

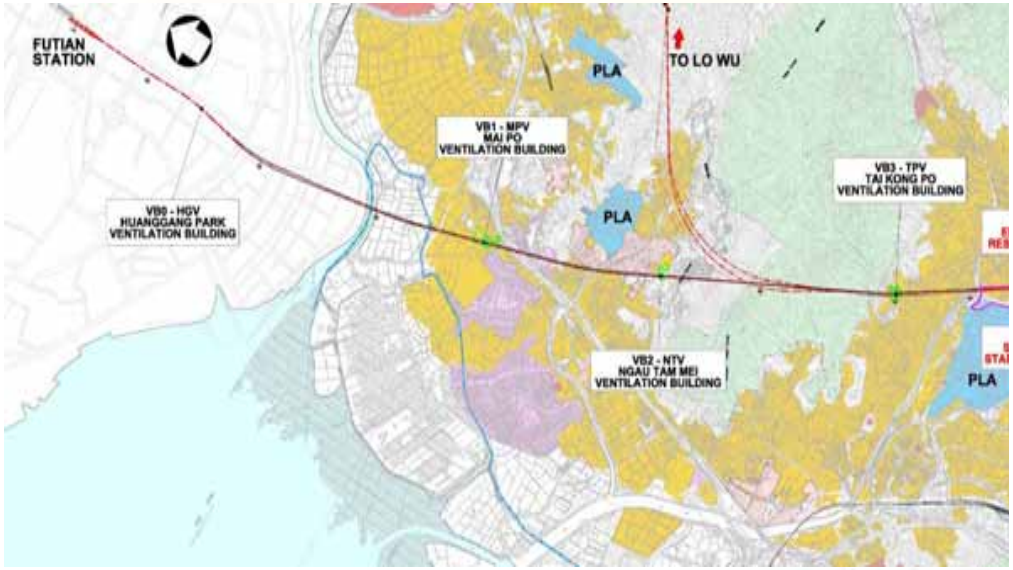


Route Selection - Prelim Design Alignment

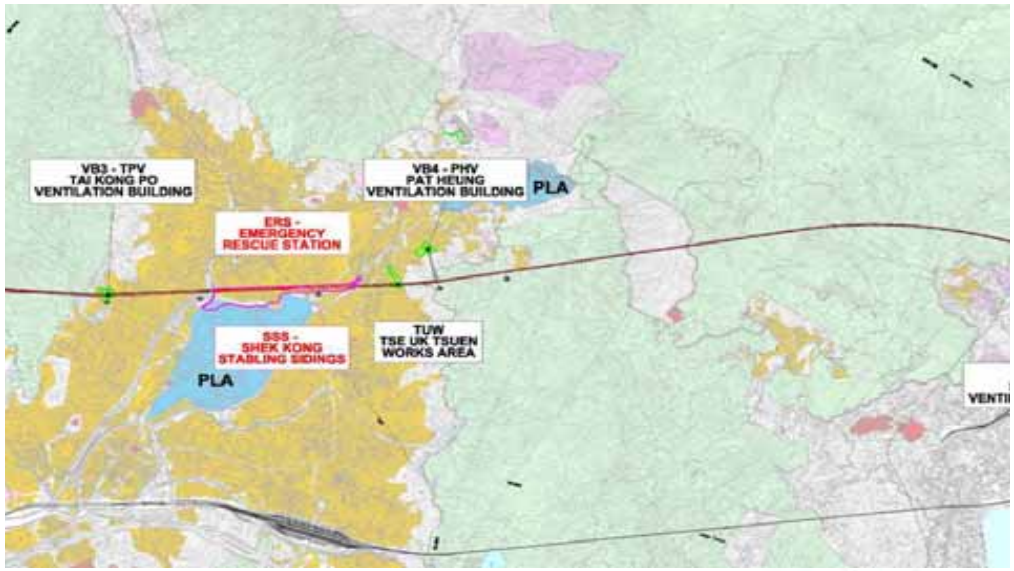
Route Selection – Main Drivers

- Primary Drivers
  - Geology - SI identified deep rock head (mixed ground to -70m PD) in Sham Shui Po
  - Land availability for SSS/ERS in Kam Tin valley
  - Track geometry
- Secondary Drivers
  - Reduced impact to EBS
  - Improved works sites
  - Programme benefits

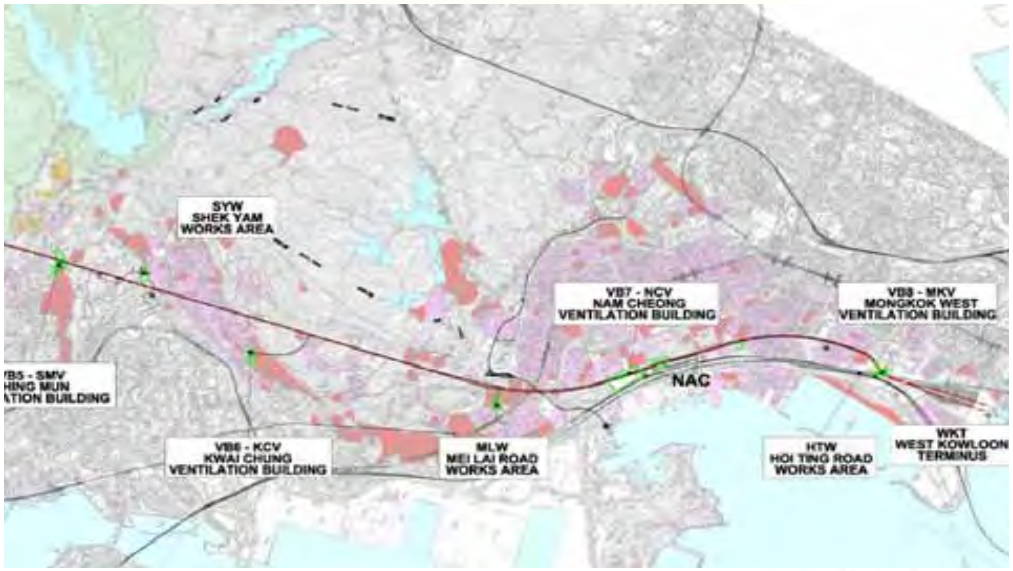
Route Selection – Northern Section



Route Selection – Central Section

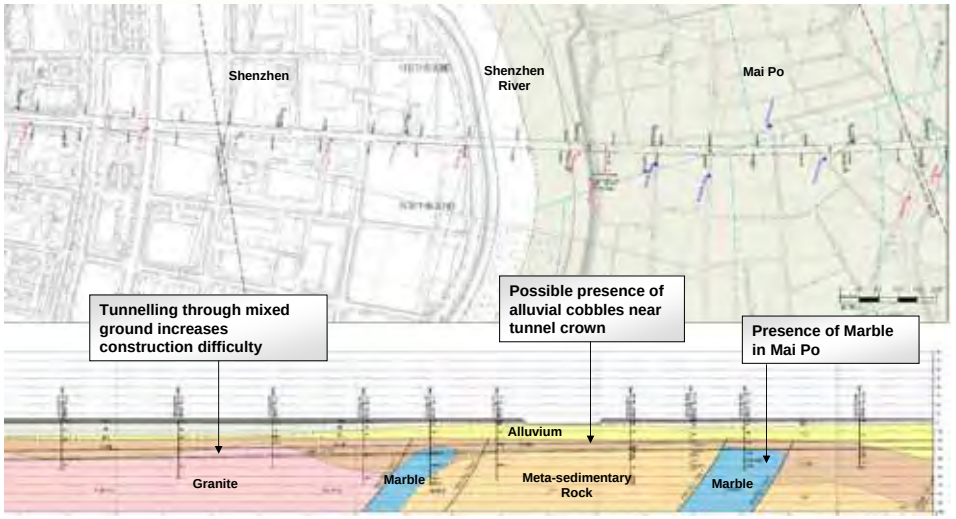


Route Selection – Southern Section

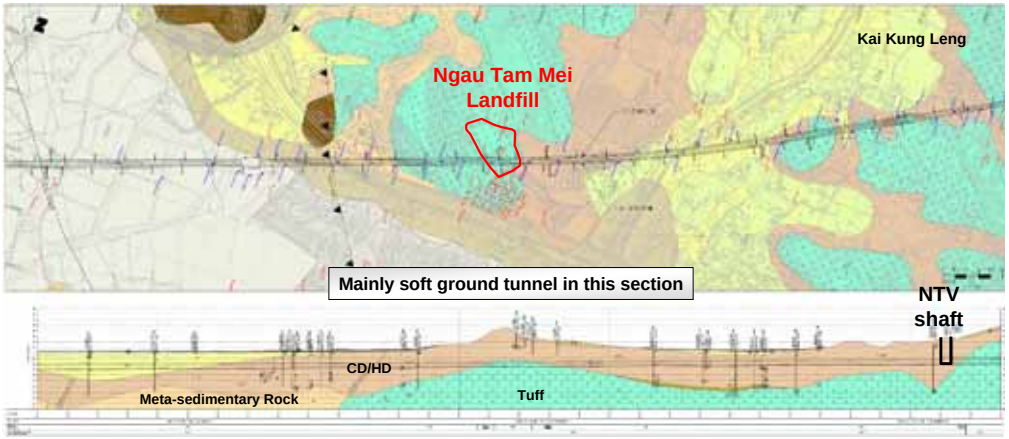


Geology

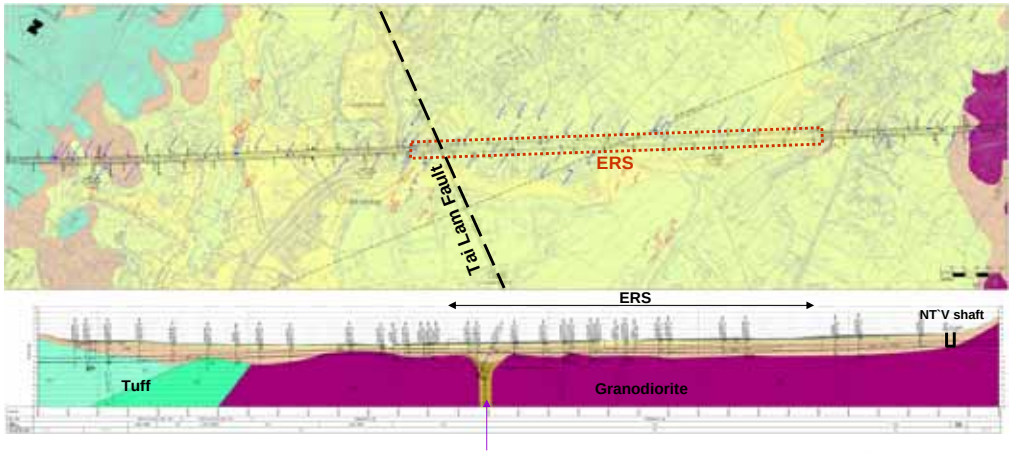
Indicative Geology (Mai Po)



Indicative Geology (Ngau Tam Mei)

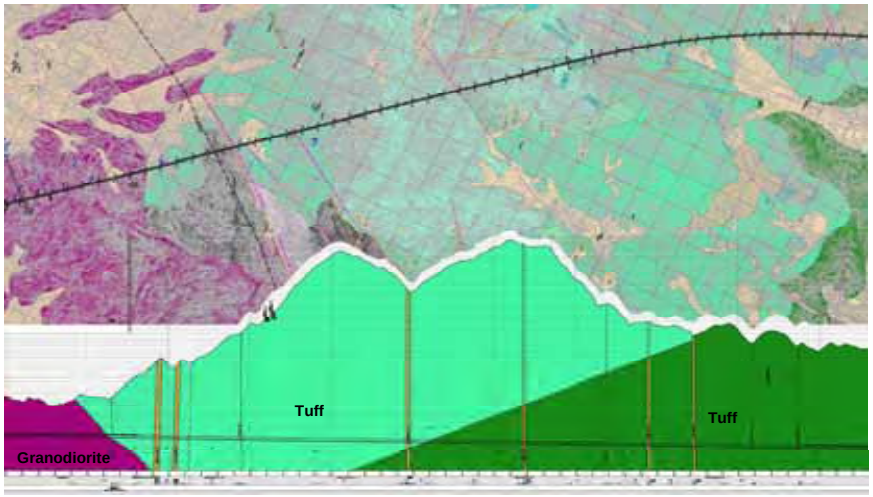


Indicative Geology (Kam Tin Valley)

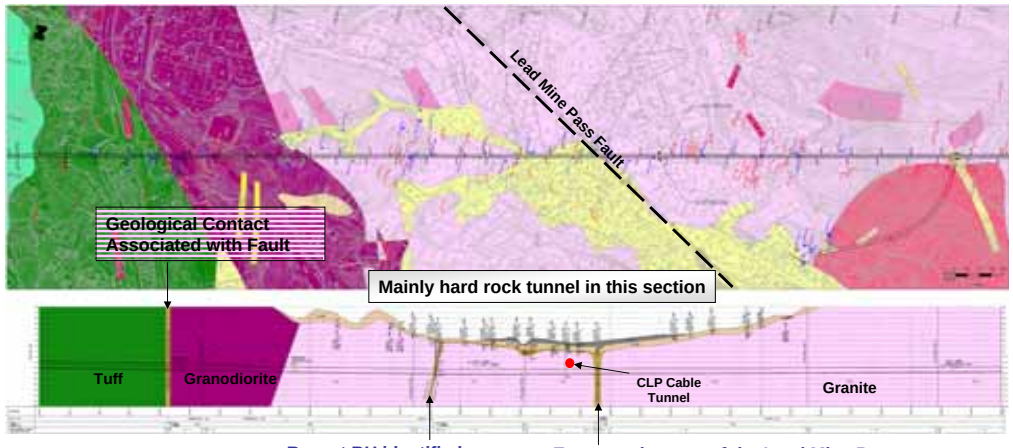


Tai Lam Fault Across ERS

Indicative Geology (Tai Mo Shan)



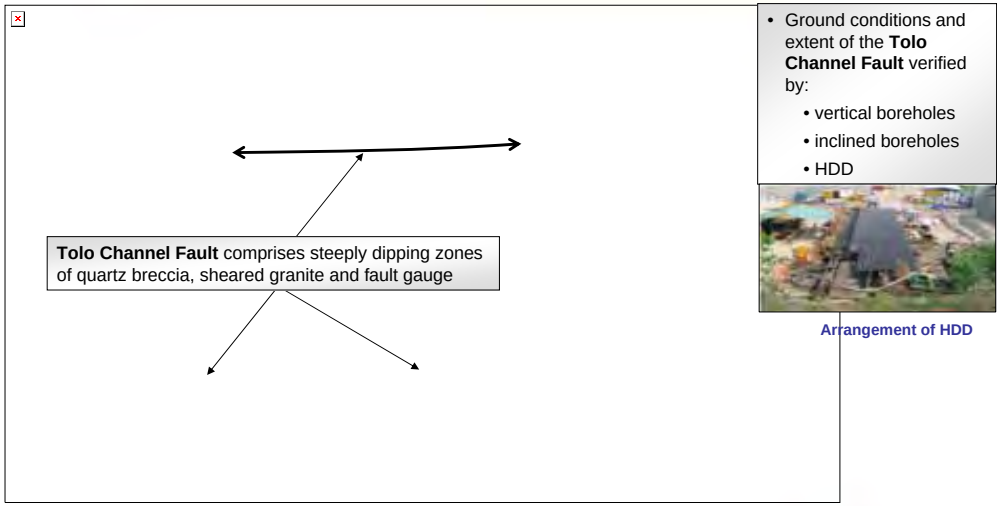
Indicative Geology (Kwai Chung)



Recent BH identified unrecorded fault

Extent and nature of the Lead Mine Pass Fault to be verified by ongoing GI

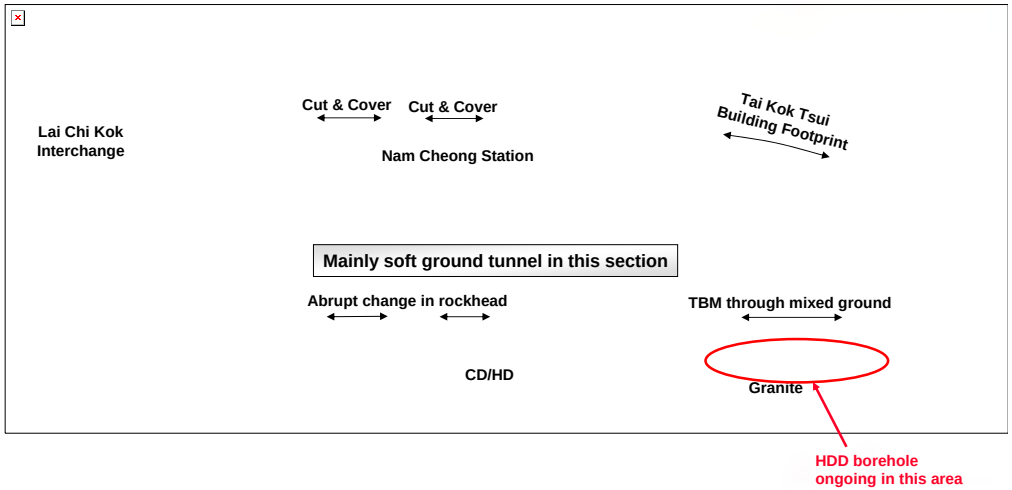
Indicative Geology (Lai Chi Kok)



- Ground conditions and extent of the **Tolo Channel Fault** verified by:
  - vertical boreholes
  - inclined boreholes
  - HDD

Arrangement of HDD

Indicative Geology (West Kowloon)



Liaison / approvals

Liaison / approval - Government Depts

- CEDD - *BAR, magazine*
- TD - *TIA, TTMs*
- WSD - *WIA, diversions, hydro geological impact*
- DSD - *culvert diversions and reinstatement*
- HyD - *footbridges and highway impact assessments*
- EIA - *EIA Report, hydrogeology, landscaping*
- LandsD - *Tree removals*
- MarDep - *MTIA*

Civil Engineering and Development Department
Transport Department
Water Supplies Department
Drainage Services Department
Highways Department
The Government of the Hong Kong Special Administrative Region
Environmental Protection Department
Planning Department
Lands Department

Liaison / approval – Utility Companies

Diversion Required
- 400kV cables and junction box at TBM Launching Shaft
- 132kV cables at VB5, TWL Protection Work and NC1

Diversion Required
- 200 & 400mm gas main at TWL Protection Work
- 315 & 400mm gas main along Sham Mong Road (TBM Launching Shaft , Nam Cheong Property Foundations & NC1)

Diversion may be required if cables cannot be slew
- PCCW telecom cables at TWL Protection Work

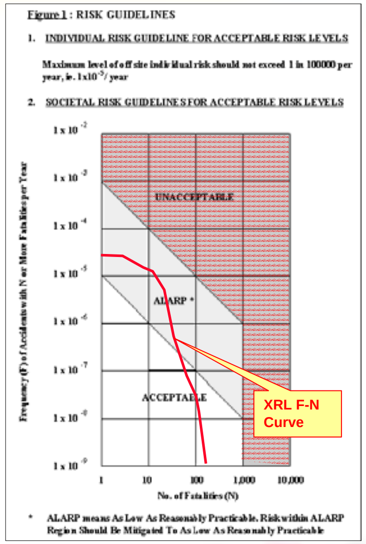
Liaison / approval – Environmental Impact Assessment (EIA)

- EIA
  - Project Profile → Study Brief from EPD
  - Proponent to Study:
    - ecology
    - fisheries impact
    - airborne noise
    - ground-borne noise
    - landscape and visual impact
    - cultural heritage
    - potential land contamination
    - waste generation
    - water quality / air quality impacts
    - HtL: explosives / potential landfill gas hazards (QRA)

Liaison / approval – Site Explosives Magazines

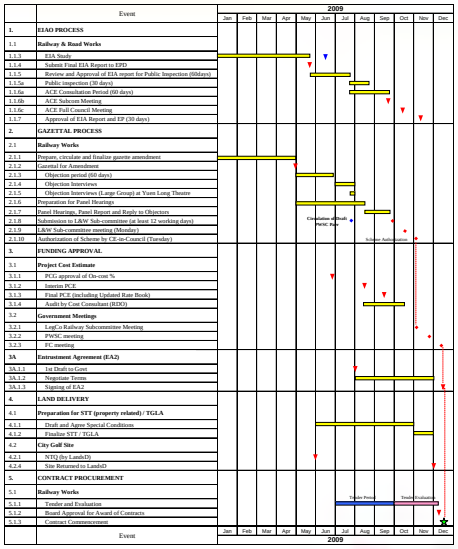
Liaison / approval – Quantitative Risk Assessment (QRA)

- Qhhg#wr#wxg|#Kd}dug#wr# Olih#KwO,#li#wrulqj# h{sorvlyhv#ryhuqljkw#Vlwh# P djd}lqh,
- Vwxg|#Vwrudjh#Wudqvsruw# dqg#Kvh#qrw#do#surmhfw# uhtxluh#fvh#wr#eh#wxglhv,
- HDR#WP#=#Fulwhuld#iru#KwO#wr# p hhw#Jlvn#Jxlghdqhv=
  - Dffhswdeoh>
  - Dv#Orz#Dv#Uhdvrqded|# Sudfwlfdeoh#+DODUS,#dqg
  - Xqdffhswdeoh



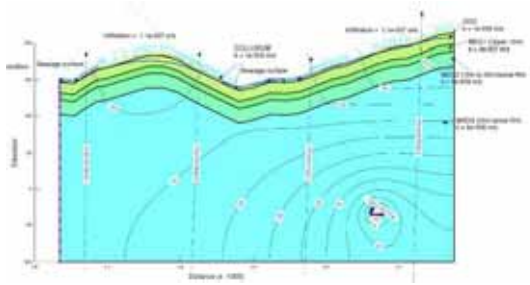
Liaison / approval – Land and Gazettal Process

- Gazette under Railways Ordinance Cap 519
- Briefings to District Councils before gazette to obtain “buy-in” from the community
- Acquisition / timing of private land in NT a particular issue



Liaison / approval – Others

- WSD: Impact on existing structures / facilities
- DSD: Impact on existing structures / facilities
- Trees: tree transplanting / felling applications

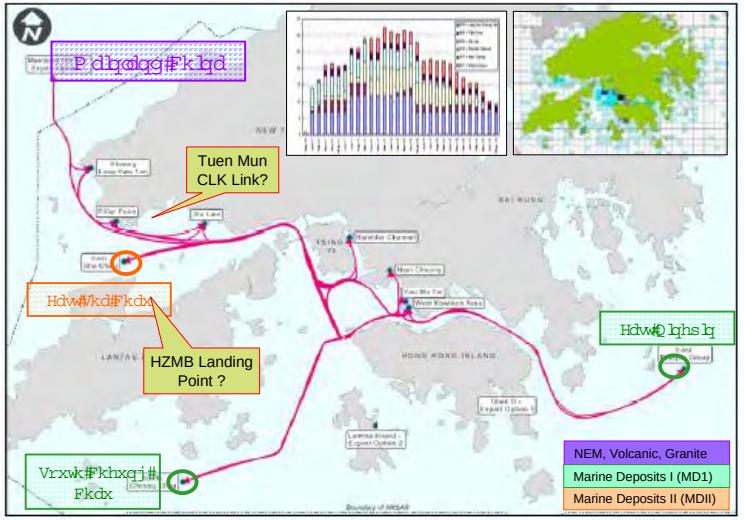


Liaison / approval – Traffic Impact Assessment (TIA)

Liaison / approval – Traffic Impact Assessment (TIA)

Liaison / approval – TIA / Spoil Disposal

Liaison / approval – Marine Traffic Impact Assessment (MTIA)

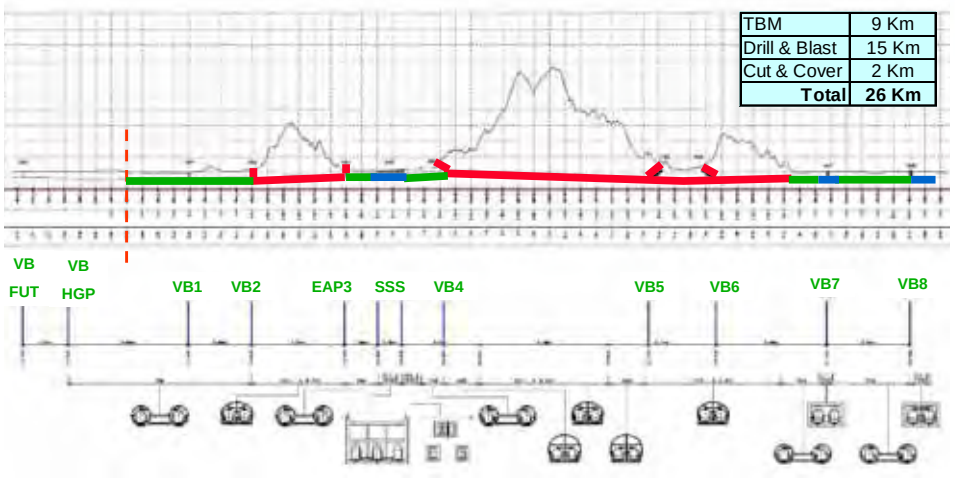


Tunnelling Methods

Tunnelling Methods – TBM versus Blasting

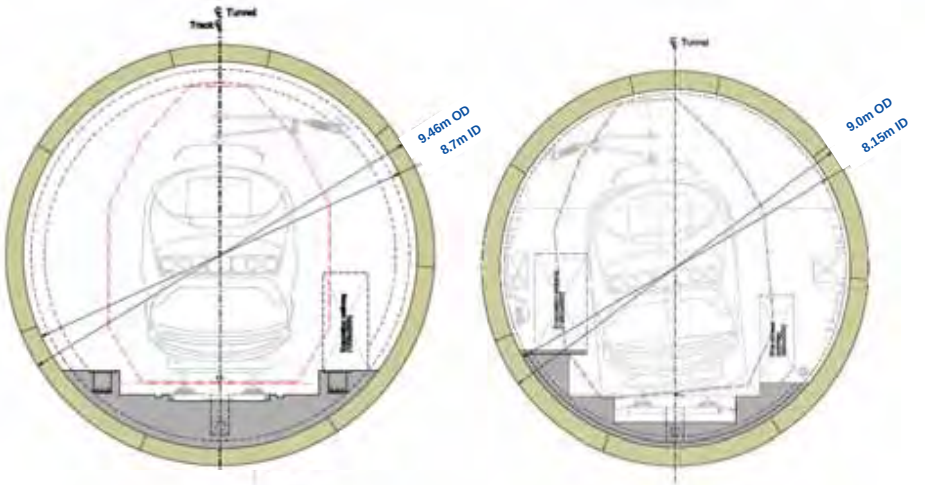
Factors	TBM	Blasting
Geometry	Circular	Horse shoe, D-shaped
Lining	Precast segments	In-situ concrete using lining formwork
Cross Passage	250m centres (XRL)	Twin Track with Partition wall CP doors for single track
Construction Risks	Ground subsidence Segment opening for CP construction	Flyrock (at shaft / portal / open cut) Ground subsidence
Vibration	Minimal	Ground vibration Air over-pressure
Noise	Ground-borne noise (continuous)	Explosion noise (5 to 10 seconds)
Explosive Magazine	Not required	Required if working 24 hours
Geology	Hard rock Soft / Mixed ground	Rock
Programme	18 months for TBM procurement 1 tunnelling face / TBM	3~6 months for blasting permit application >1 blasting face is feasible
Cost	High capital cost for TBM Cost effective for tunnelling >3km	Low capital cost Intensive labour cost

Tunnelling Methods – XRL Tunnelling Methods



Drill & Blast
TBMs (mixed ground)
Cut & Cover

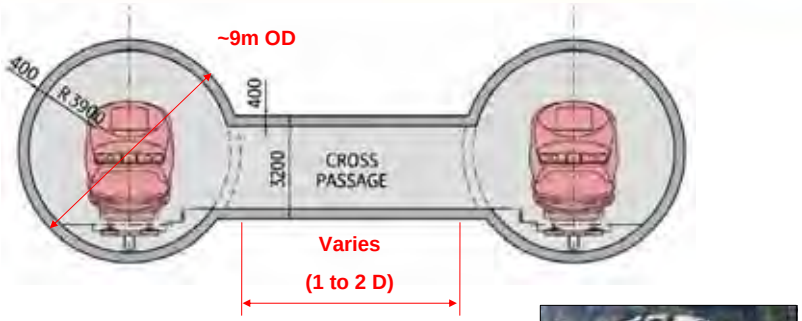
Tunnelling Methods – Mainland / HK TBM Bores



Mainland Section (1.6km)

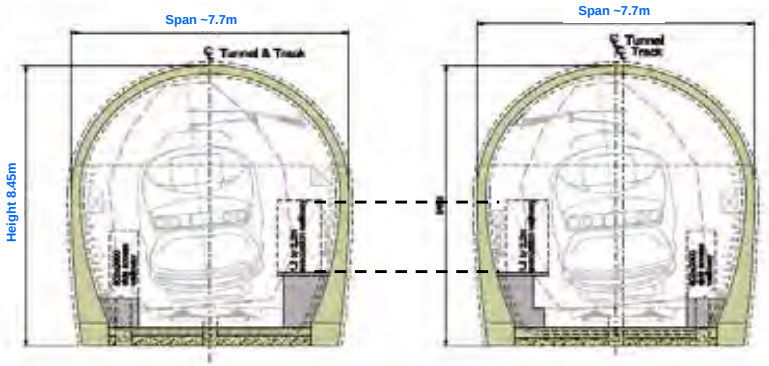
HK Section (7.0km)

Tunnelling Methods – Typical HK Cross-Sections



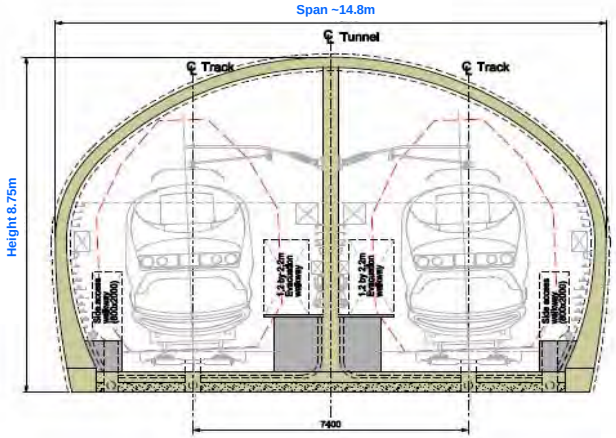
face area ~ 68 m²
cross-passages @ 250m intervals

Tunnelling Methods – Typical HK Cross-Sections



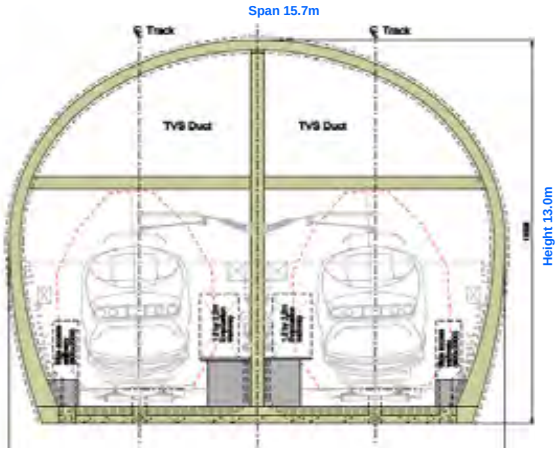
Single Track D&B Section
~ 2 km

Tunnelling Methods – Typical HK Cross-Sections



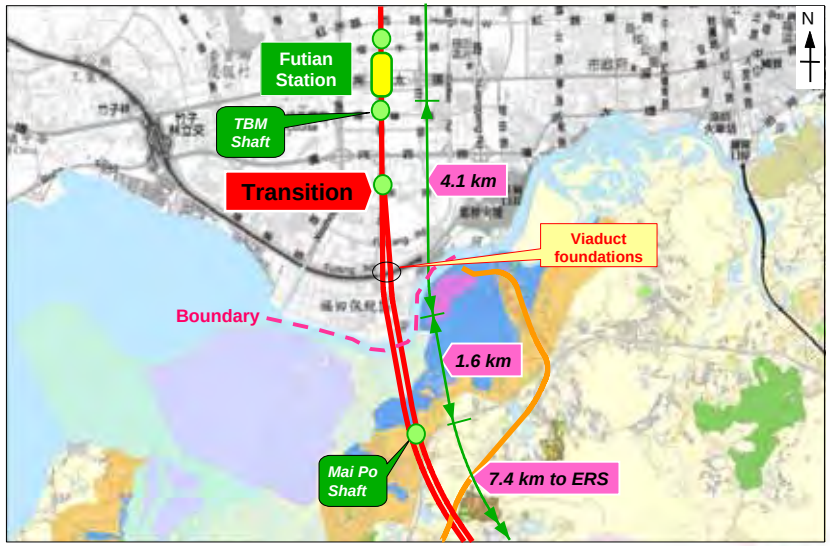
Twin Track D&B Section
~ 8.5 km

Tunnelling Methods – Typical HK Cross-Sections

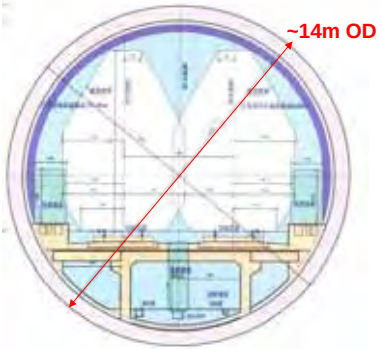


D&B Oversized Tunnel Section
~ 3.8 km

Tunnelling Methods – Boundary Area

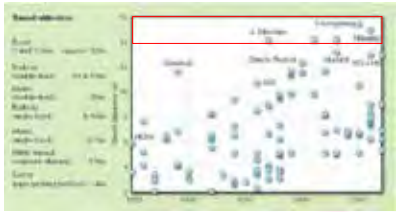


Tunnelling Methods – Shenzhen Area Tunnels

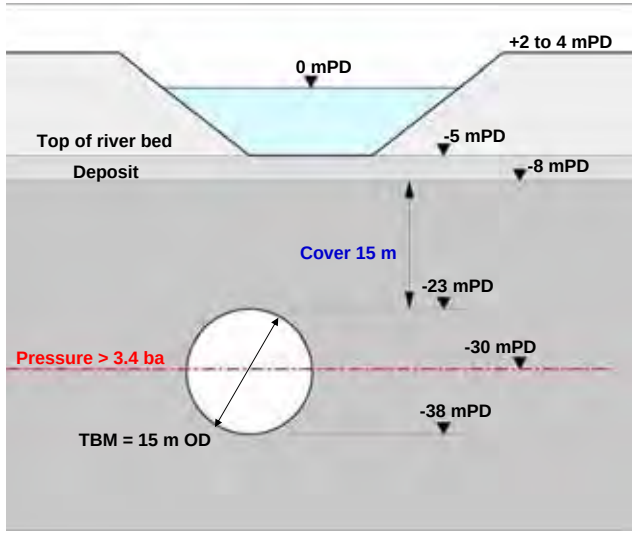


Herrenknecht 15.2m OD TBM Madrid: gypsum, soft rock

Mainland adopting a single large diameter mixed face TBM (~14m OD) for some of the Shenzhen drives.



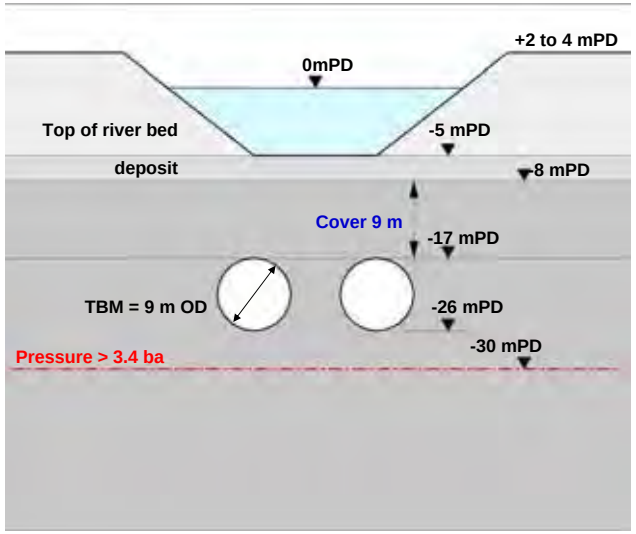
Tunnelling Methods – Boundary Configuration



Key Factors:

- Cover to underside of Shenzhen River.
- Clash with flyover foundations forces deeper alignment.
- Difficulties maintaining face pressure over TBM diameter (1.5 bar diff).
- Invert exceeds max pressure in HK compressed air working regulations (3.4 bar).

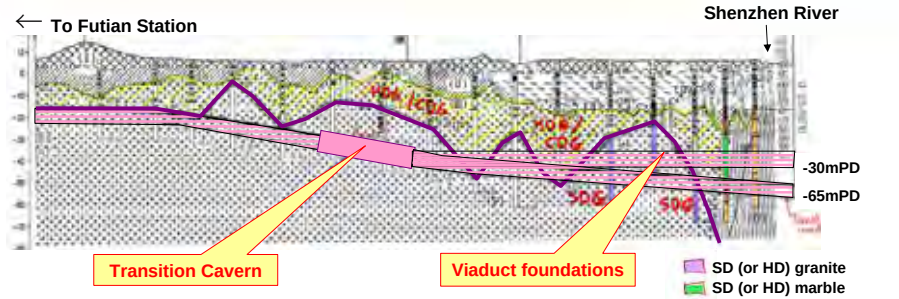
Tunnelling Methods – Boundary Configuration



Key Factors:

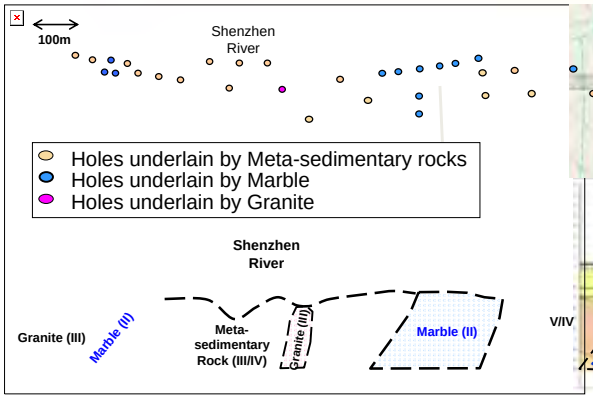
- Cover to underside of Shenzhen River may be increased if required.
- Tunnels can be located either side of flyover foundations (less deep)
- Compressed air interventions do not exceed max pressure in HK compressed air working regulations (3.4 bar)

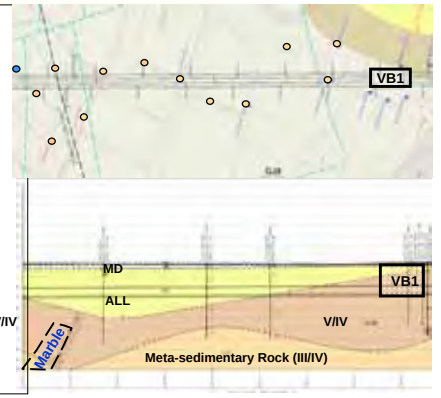
Tunnelling Methods – Shenzhen Area Geology



- Transition cavern within rock section near Huanggang Park
- Flyover across Guan-Shen a constraint on vertical alignment
- Alignment initially at -65m PD at Shenzhen River. Subsequently raised to -30mPD re compressed air interventions

Tunnelling Methods – HK Area Geology





Tunnelling Methods – Cutter Changes

Damaged disc cutters

Regular inspections in cutter head

Mixed Ground TBMs

- Cutter head made up of picks and cutter discs capable of excavating very hard granite (incl corestones)
- Discs large & heavy (19" inch discs approx 200 kgs)
- Regular daily inspections required and frequent disc changes
- Cutter head inspections / changes within mixed face conditions often require compressed air to retain water and ground

Tunnelling Methods – Compressed Air Interventions

- HK Regulations limit work in compressed air to 50 psi (3.4 bar)
- Nitrogen narcosis onset occurs between 3 to 4 bar within compressed air
- Short working times & extended decompression periods required > 4 bar in compressed air
- Mixed gas (eg. Trimix, Heliox) used > 3.5 bar to increase work time & decrease decompression – costly hence via face masks
- Conventional compressed air diving limited to 5 bar – saturation diving required > 5 bar

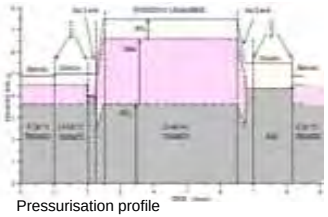
Tunnelling Methods – Saturation Diving

Shuttle docking in surface living quarters

Shuttle docked

Shuttle transfer from surface to TBM

Shuttle docking in TBM cutter arm



Pressurisation profile

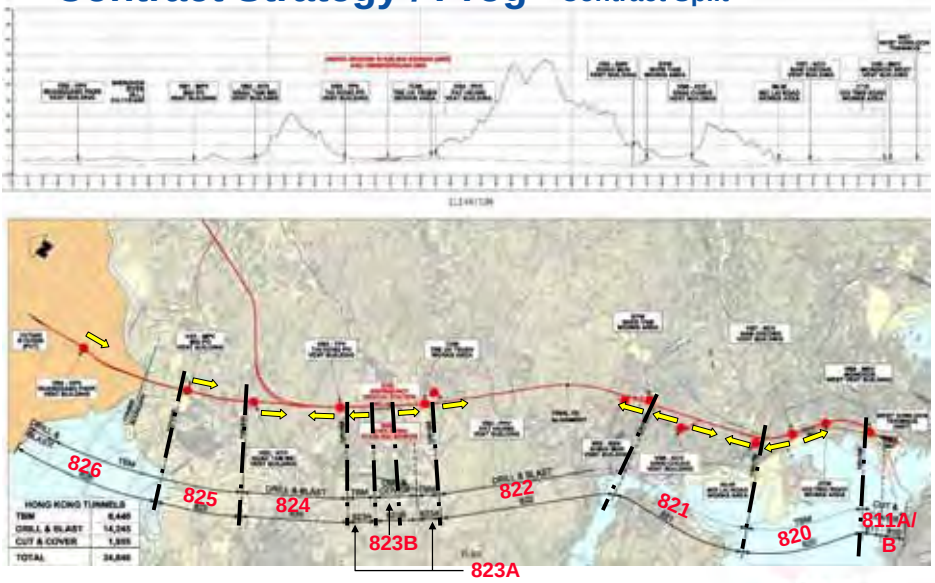
Zero-vis Diving in Bentonite

Westerschelde TBM Germany circa 2000

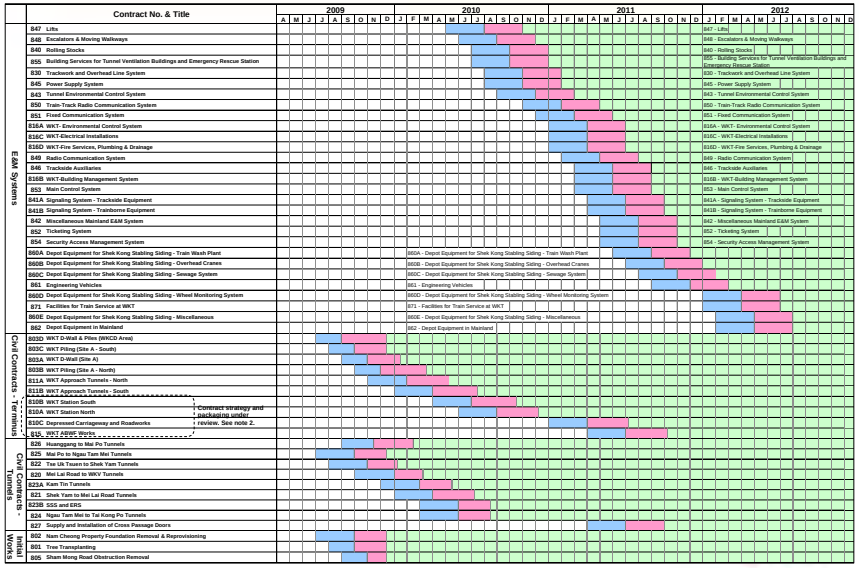
- **6.5 bar intervention within bentonite suspension – zero visibility**
- **Shuttle size requires min 11m OD TBM**
- **Professional divers trained as mechanics (*not vice-versa*)**
- **Divers live / work in compressed air for over 4 weeks (*no decompression*)**
- **Changed damaged soft ground picks**
- **Highly specialised, technical & costly.**

Contract Strategy / Programme

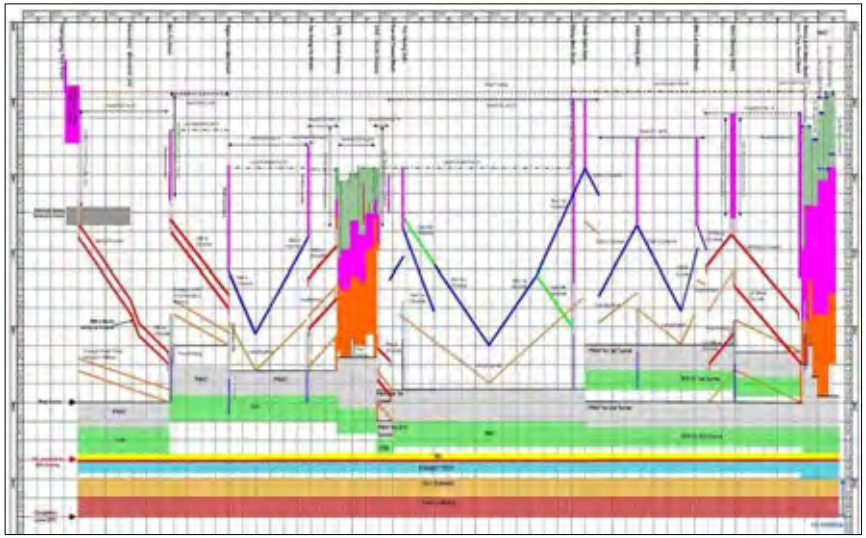
Contract Strategy / Prog – Contract Split



Contract Strategy / Prog – Tender Cascade



Contract Strategy / Prog – Time-Chainage



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