

# Photo Illustration to support the teaching of the topic on Tunnel Construction

Prepared by Raymond Wong

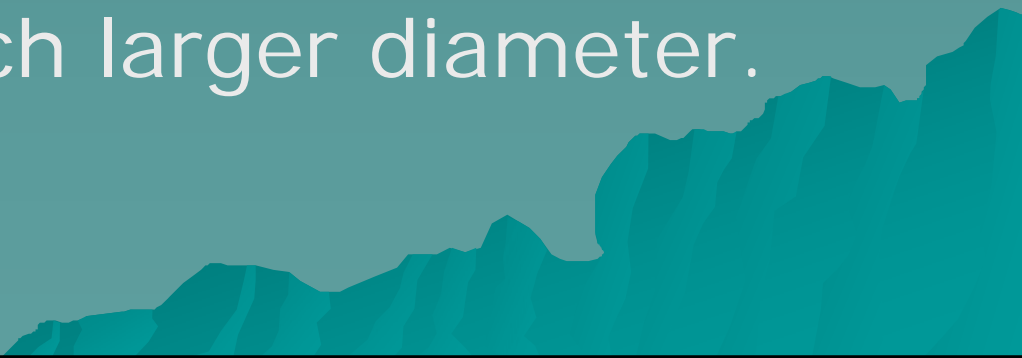


# Remember how to find a bore pile?

Three basic consideration:

- how to cut the soil/rock
- how to remove the spoil
- how to protect the bore hole from collapsing

Forming tunnel is similar to form a bore pile, but in a horizontal manner and in most cases in a much larger diameter.

A stylized, dark teal silhouette of a mountain range is positioned at the bottom right of the slide, extending from the right edge towards the center.

# Tunnel Construction using Drill-and-Blast Method

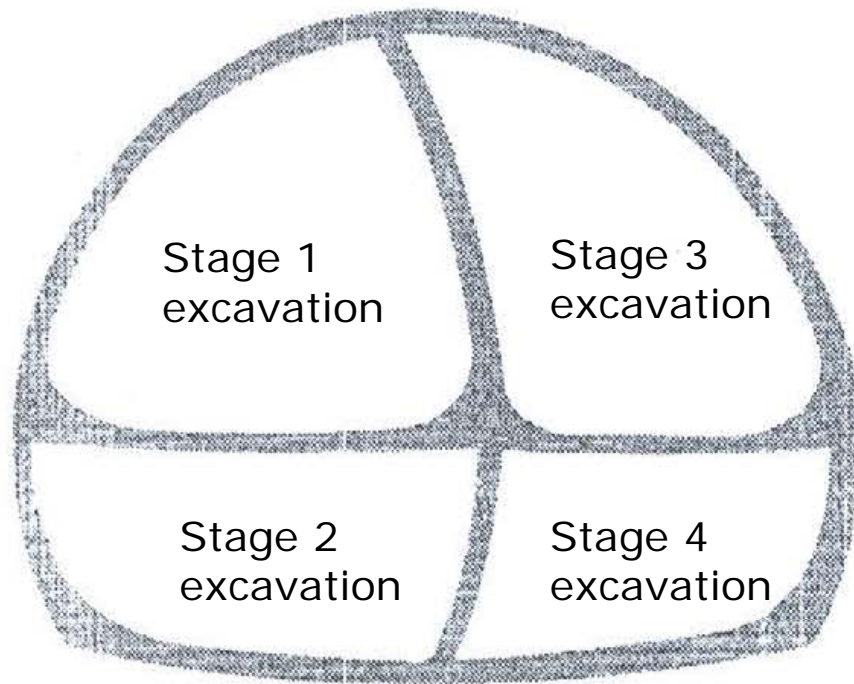




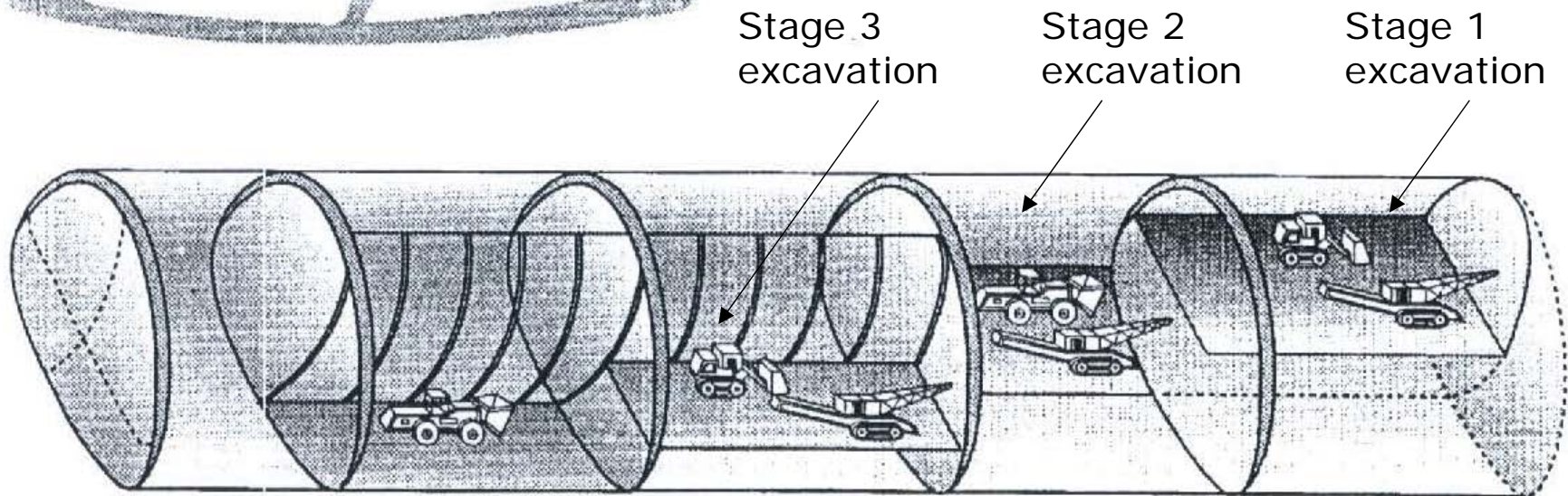
**A trial tunnel section being formed**



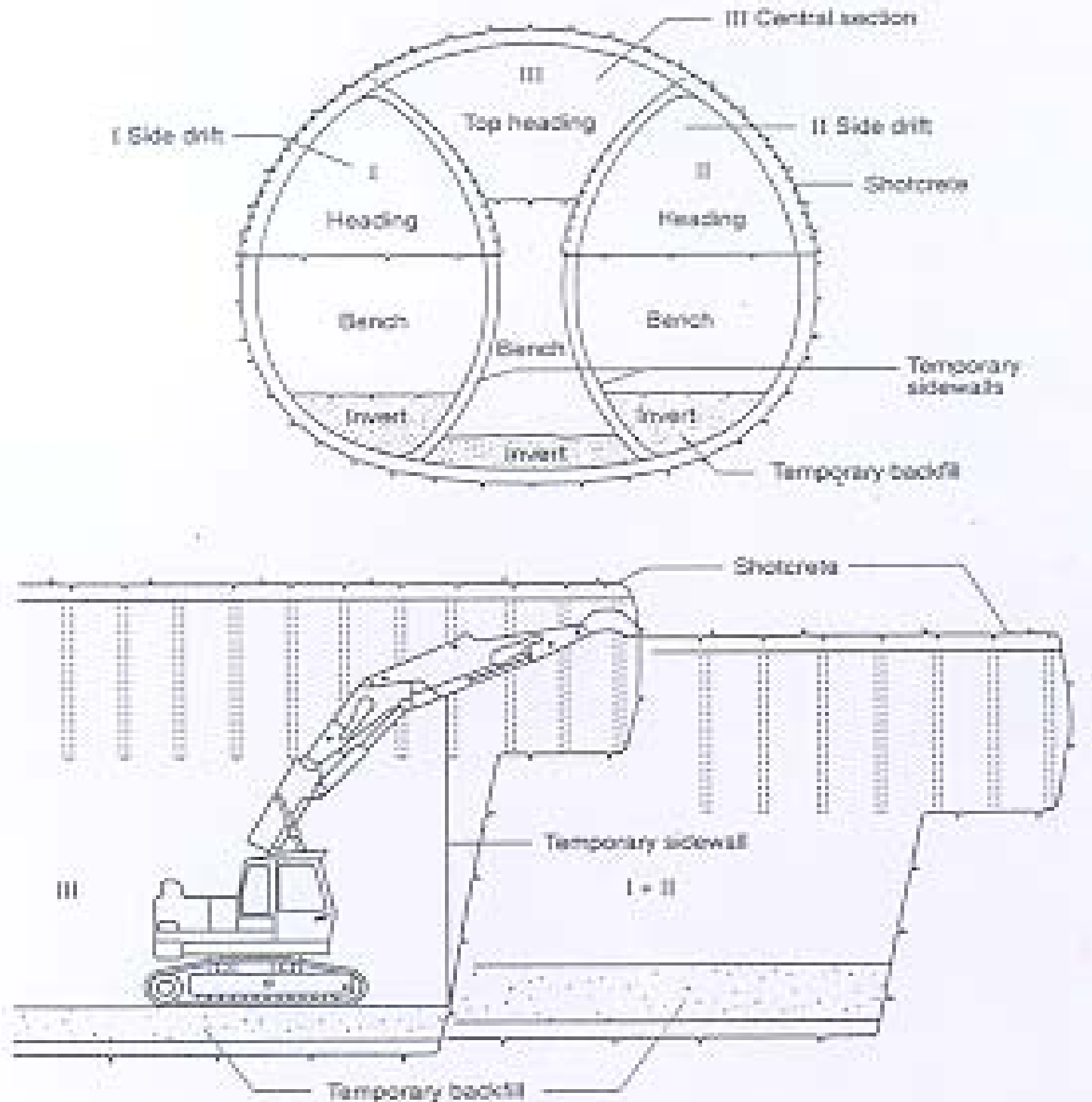
Entrance arrangement to the tunnel portal for the 3.7km long Tai Lam Tunnel of Route 3 at Kam Tin as seen in early 1996. Tai Lam Tunnel consists two main tunnels, each measures 15.5m wide and 10.5m high, and a 950m long servicing duct for ventilation and other supply purposes in between the main tunnels.



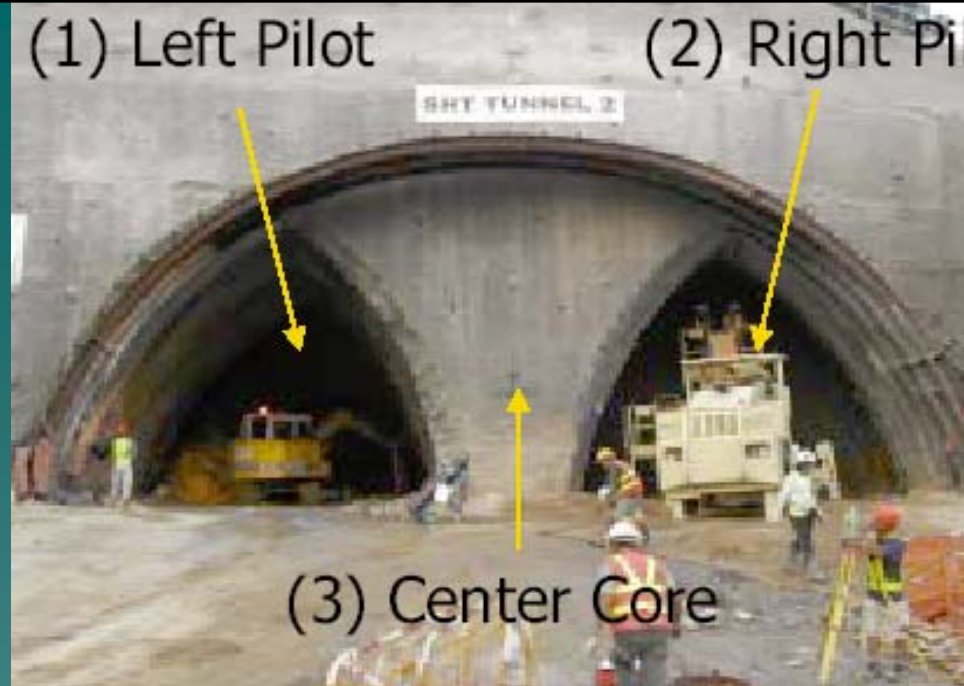
**Construction of tunnel  
using the New Austrian  
Tunnel Method (NATM)  
for soft ground**



**Drawing showing the excavation sequences using the New Austrian Tunnel Method. The principle of constructing large sectioned tunnel using this method is to subdivide the tunnel section into several arched smaller sections for the sake of easier control and safer supporting during excavation. The newly formed surfaces are often required to temporary supported by girder sections, shotcrete, nails or anchors.**



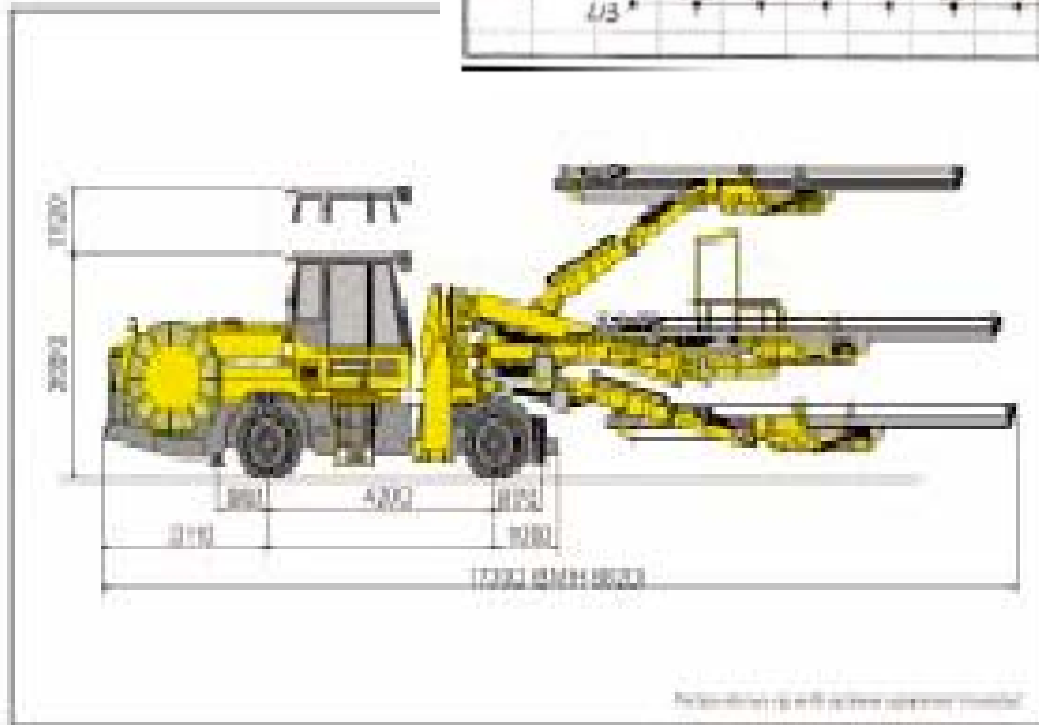
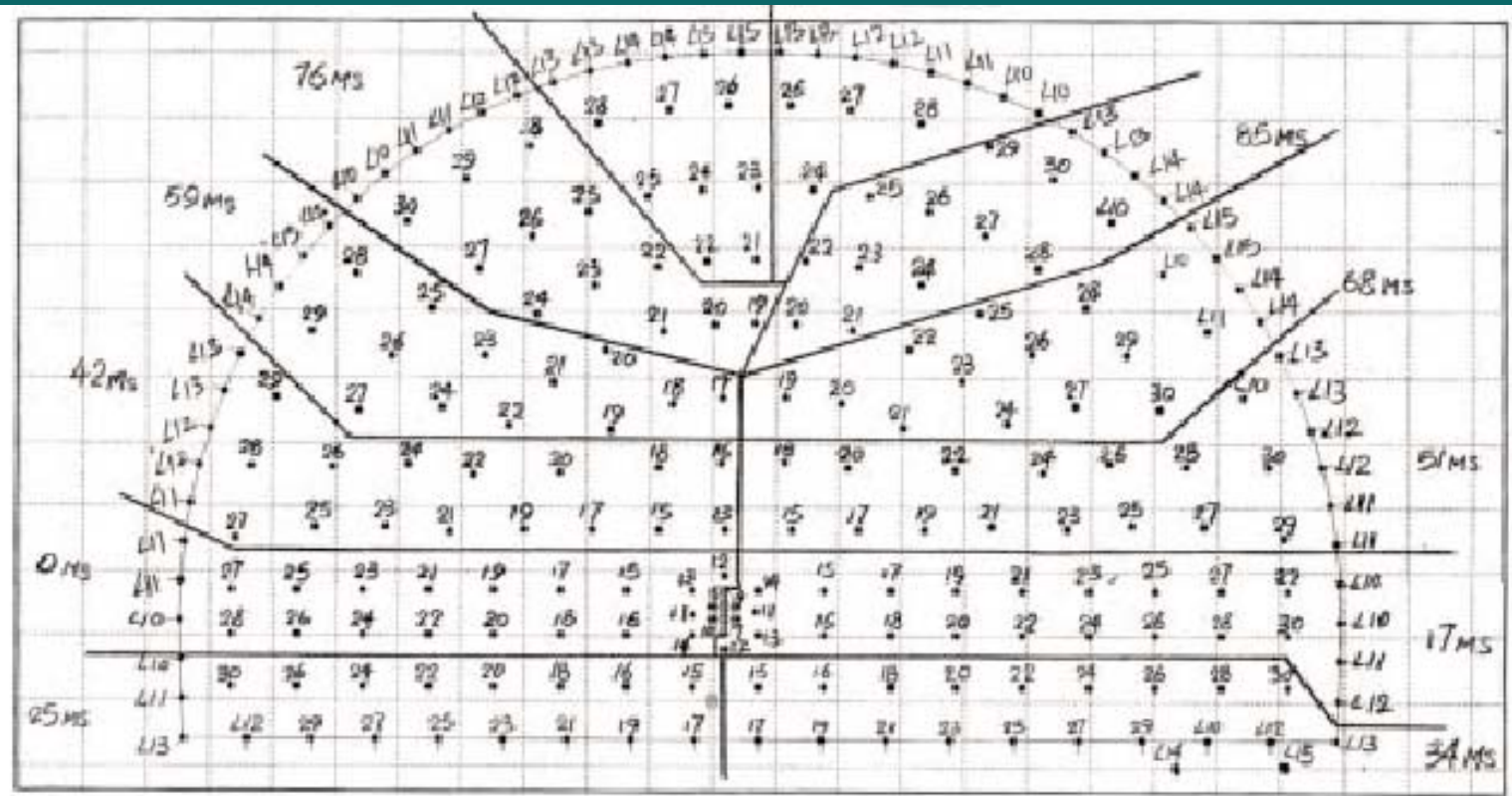




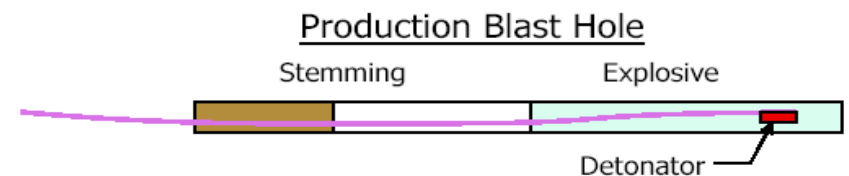
A trial section of tunnel excavation making use of the concept of New Austrian Tunnel Method.



## Blast hole layout pattern



Machine use for the drilling of the blast hole





The machine, known as Jumbo tunneling machine, is used to drill and form holes inside the tunnel for the placing of explosive to activate the blasting. This machine is computer controlled and can drill 3 holes at the same time with direction or angle precisely set.



Placing explosive  
into the blast hole





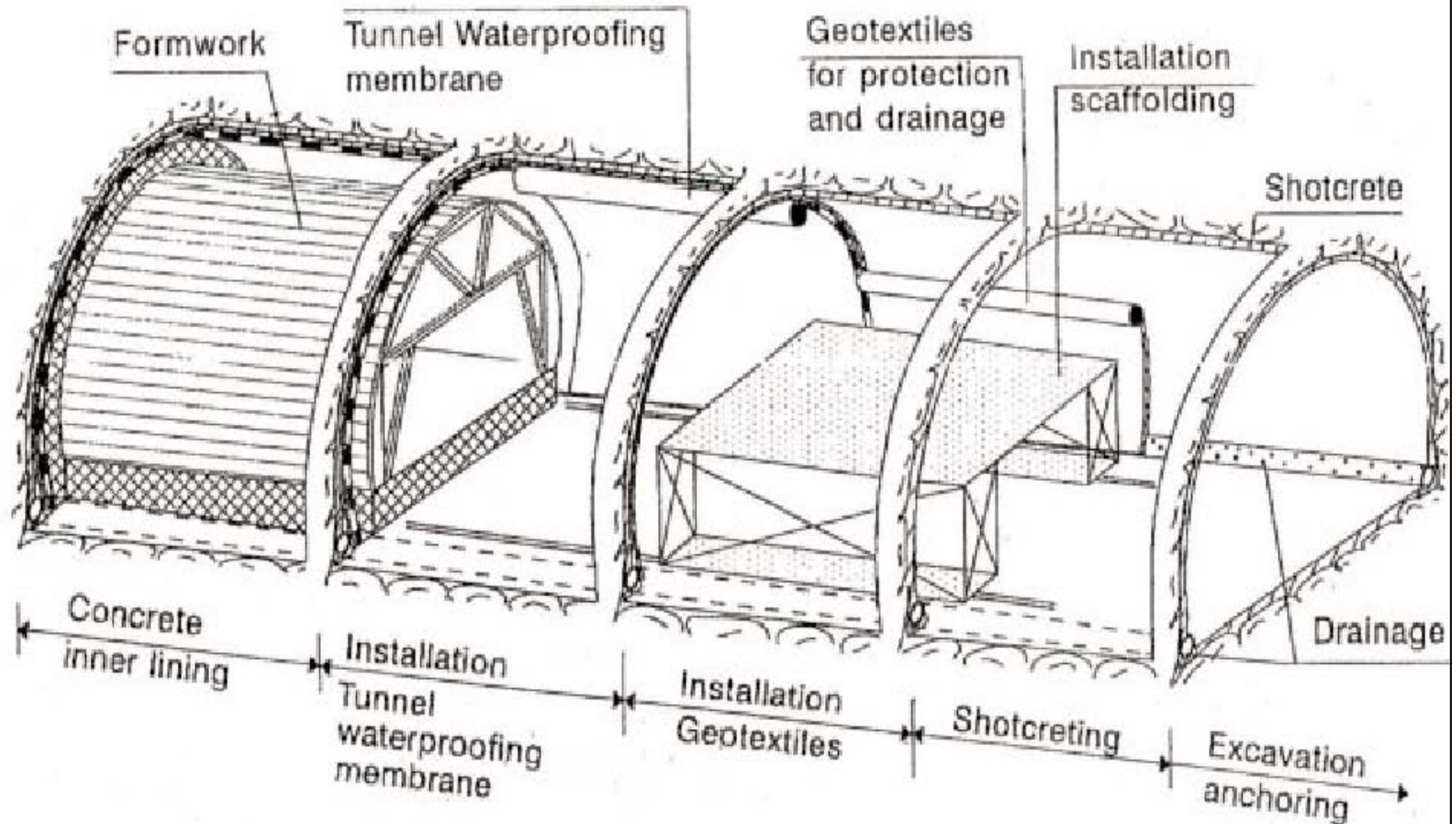
The erection of the gantry-type formwork for the forming of tunnel lining at entrance of the tunnel portal on Ting Kau side.





**Detail look of the gantry-type formwork for the forming of tunnel lining**

# Construction sequence for tunnel waterproofing and permanent lining





Forming the tunnel lining –  
laying of waterproofing  
membrane and fixing of  
reinforcement bar before  
concreting





After the tunnel formed by drill and blast process, the newly formed tunnel surface is to be lined with an in-situ concrete lining to stabilize the exposed soil or rock faces. The photo shows the gantry-type formwork used to form the in-situ concrete lining.



**Interior of the Tai Lam Tunnel before paving. The installation of the service void by the use of a traveling-type formwork gantry**



Traveling-type  
formwork gantry to  
form the ceiling  
service void



# Tunnel Construction using Tunnel Boring Machine (TBM)





The tunnel boring machine for the forming of the 3.8m diameter tunnel tube on Butterfly Valley side.





Close up of the cutter head. The cutting disc can cut into hard rock and the granulated spoils will be collected and removed by a conveyor system that is positioned immediate at the back of the cutting head.



Soil disposal wagons at the disposal area on Butterfly Valley side portal. The spoil will be kept at this location waiting for the removal by dumping vehicles.



Arrangement of the portal as viewed from the tunnel exit. The spoil disposal area is located on the right side of the exit with rail track heading to that direction. Rail track on the left is the depot and servicing centre for the soil disposal wagons, as well as for general loading and unloading purposes.



A view of the tunnel interior with the partly formed lining, tunnel supporting girders, rail track for soil disposing wagon, ventilation hose and other supply pipe lines etc.



A similar tunnel boring machine employed for the forming of a cable tunnel for the Hong Kong Electric on the Hong Kong Island side. Observe the hydraulic jack systems behind the cutter head that enable the machine to stabilize itself, pushing forward, or even slight adjustment of its heading direction.



Formation of the tunnel portal and  
other logistic set-up to  
facilitate the tunnel construction works  
- The KCR West Rail Tsing Kwai Tunnel case





**The formation of the tunnel portal for the Kwai Tsing Tunnel at Mei Foo side.**



The tunnel portal gradually in shape.



Tunnel portal during the process of tunnel excavation can serve several purposes: to provide an entrance into the tunnel tube to facilitate the movement of tunneling equipments and materials; as an exit for the disposal of spoils; to form a ramp into the tunnel tube which is usually at sub-grade level; or to provide supporting space for the temporary storing or assembling of equipments. This photo shows a traveling-type working gantry is being assembled inside the portal area of Kwai Tsing Tunnel at Mei Foo side.



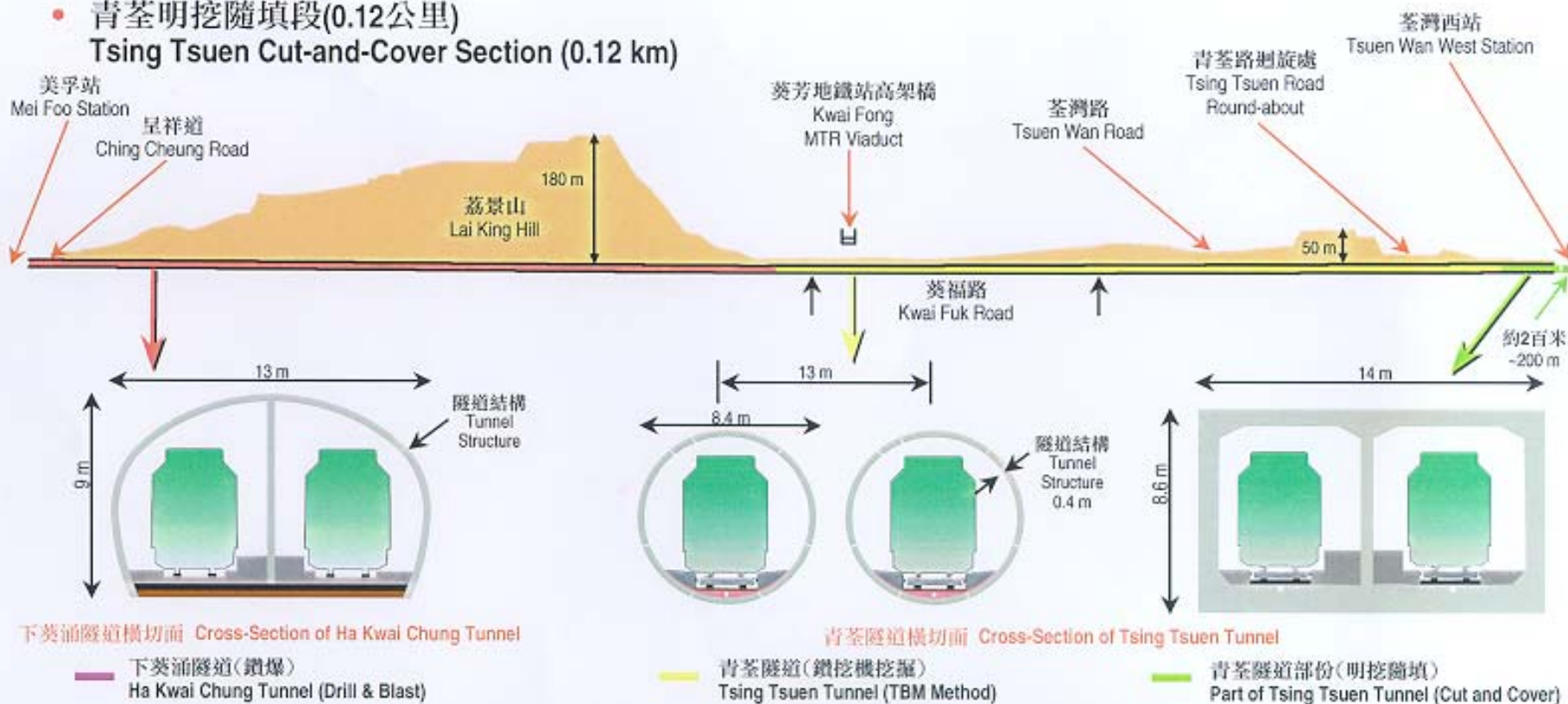
The finally completed 25-m wide tunnel entrance, cutting across about 10m above which, is the Lai King Hill Road. The formation of such a large void below a roadway can seriously endanger the stability of the road sub-structure. Note the waling and rock anchors above the entrance and the rib-form structure, a type of lattice girder beam, which helps to support the Lai King Hill Road above.



The jumbo tunneling machine at work to form the tunnel entrance.

# 葵青隧道—3.6公里 Kwai Tsing Tunnels – 3.6 km

- 下葵涌隧道(1.7公里)  
Ha Kwai Chung Tunnel (1.7 km)
- 青荃隧道(1.78公里)  
Tsing Tsuen Tunnel (1.78 km)
- 青荃明挖隨填段(0.12公里)  
Tsing Tsuen Cut-and-Cover Section (0.12 km)



Typical tunnel sections showing the routing and formation of Kwai Tsing Tunnels from Mei Foo to Tsuen Wan.





An access and servicing shaft located at Lai King at the mid-way of the Kwai Tsing Tunnels. The construction of the tunnels from Mei Foo to the shaft here at Lai King is by traditional drill and blast method. While for the section further on heading towards Tsuen Wan, a mixed-ground earth pressure balanced tunneling machine is employed for the forming of the tunnel.



The general layout arrangement of the work depot and tunnel shaft located at Tsuen Wan near Water Side Plaza. Besides serving as the tunnel portal, this shaft is also used for the assembly of the EPBM for the forming of the Kwai Tsing Tunnels from Tsuen Wan to Lai King.



Sections of the shield of the EPBM before assembly and the precast segments for the forming of the tunnel lining stored at the work depot in Tsuen Wan.



A gantry crane  
serving in the  
depot at Tsuen  
Wan for the  
Kwan Tsing  
Tunnel project

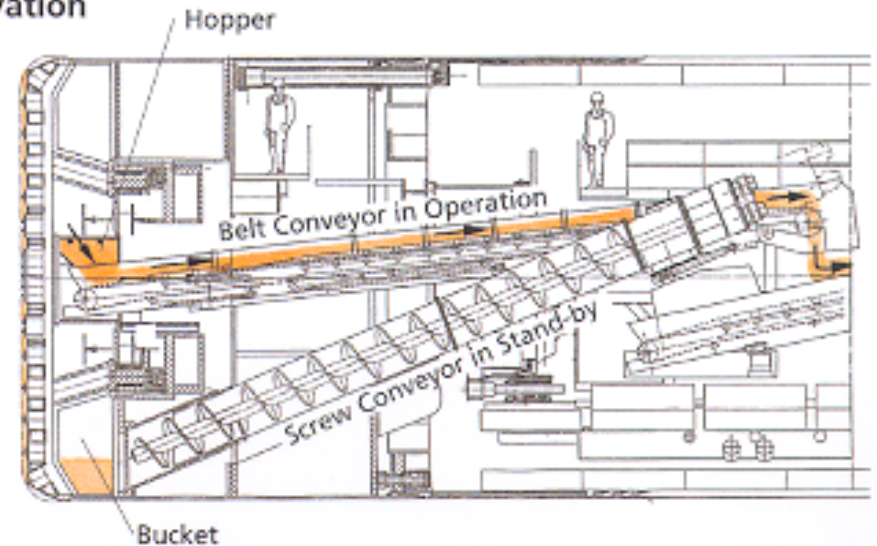
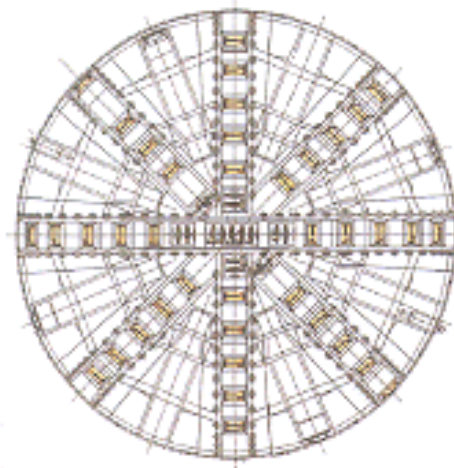


The shield of the EPBM being lowered into the shaft for onward assembly. The 8.7m diameter cutter head will later be connected to the front (on the left side) of the shield.

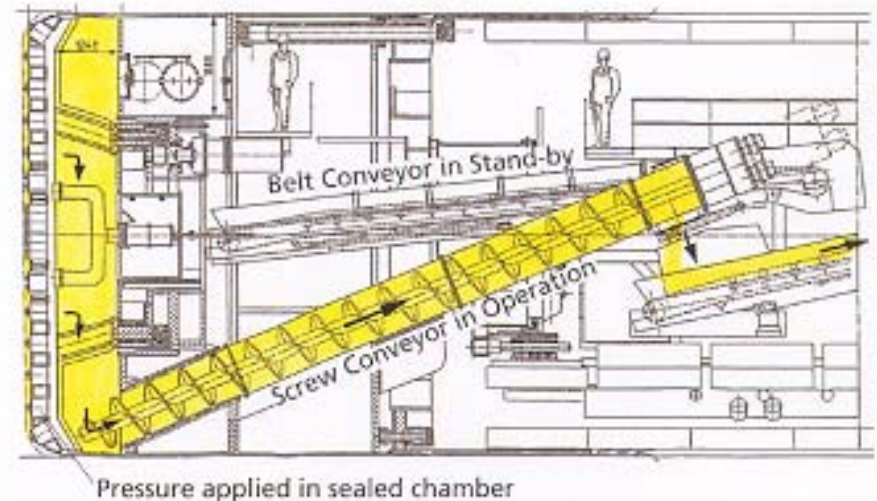
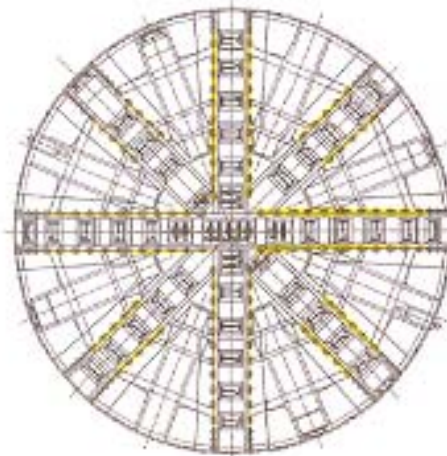


The working principle of the mixed-ground earth pressure balanced tunneling machine under the open mode and earth pressure balanced mode.

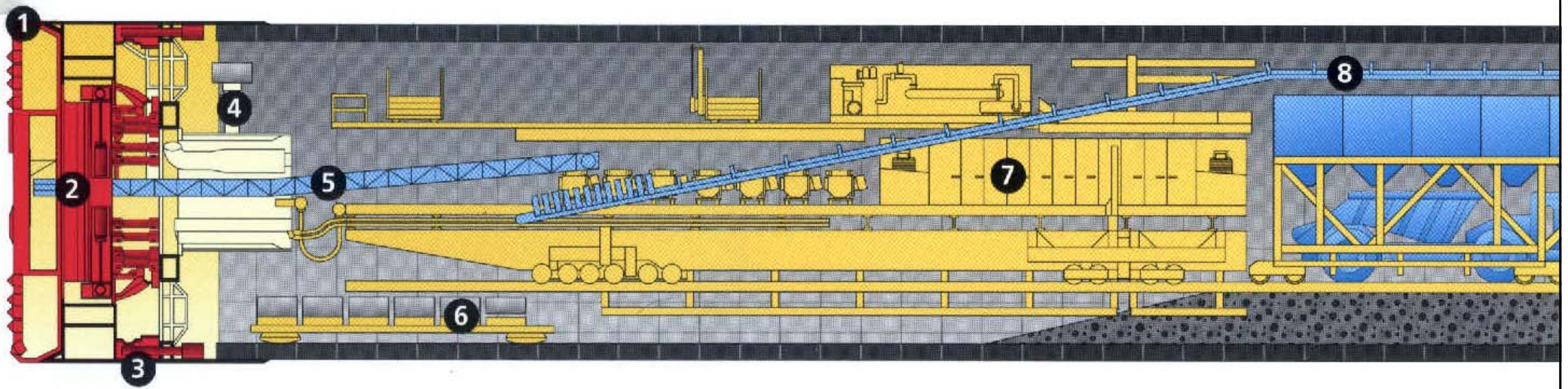
Open Mode for hard-rock excavation



EPB Mode for Soft-ground excavation

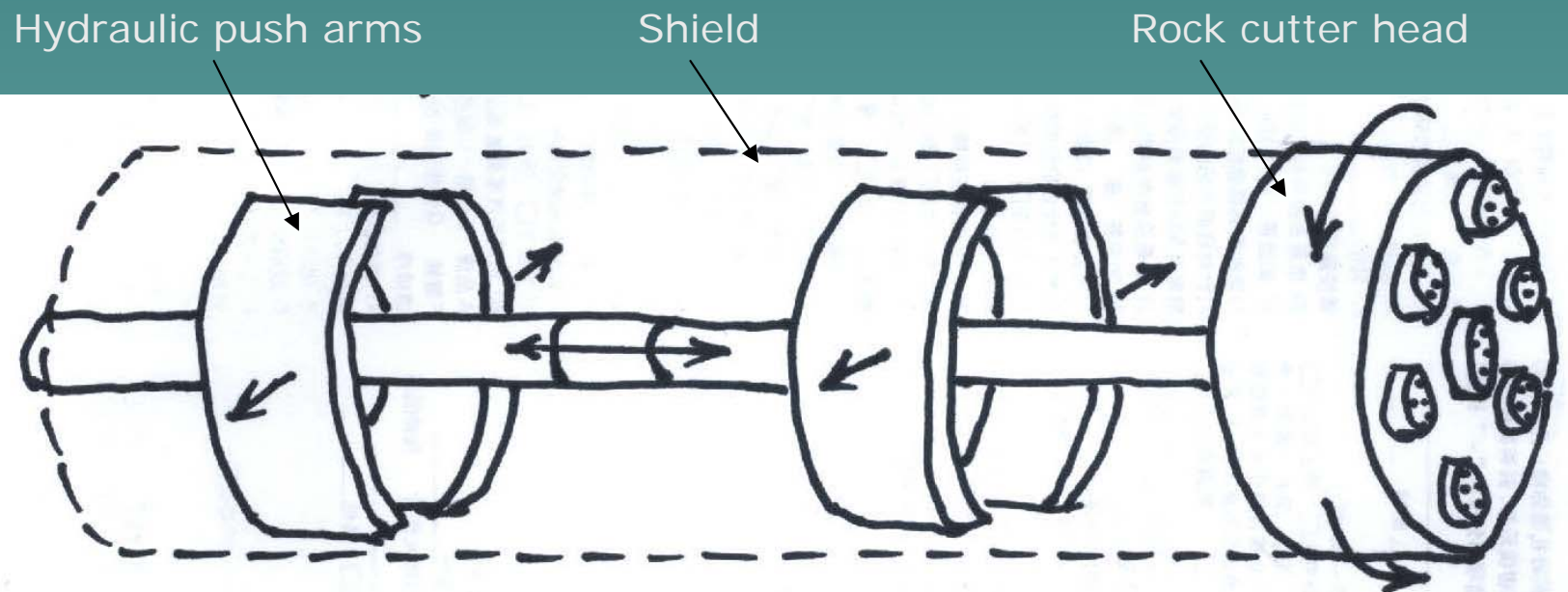






- |                    |                   |                          |
|--------------------|-------------------|--------------------------|
| 1 Rock cutter head | 4 Erector         | 7 Electrical switch gear |
| 2 Drive unit       | 5 Conveyor I      | 8 Conveyor II            |
| 3 Push cylinder    | 6 Segment handler |                          |

## Construction of BTM







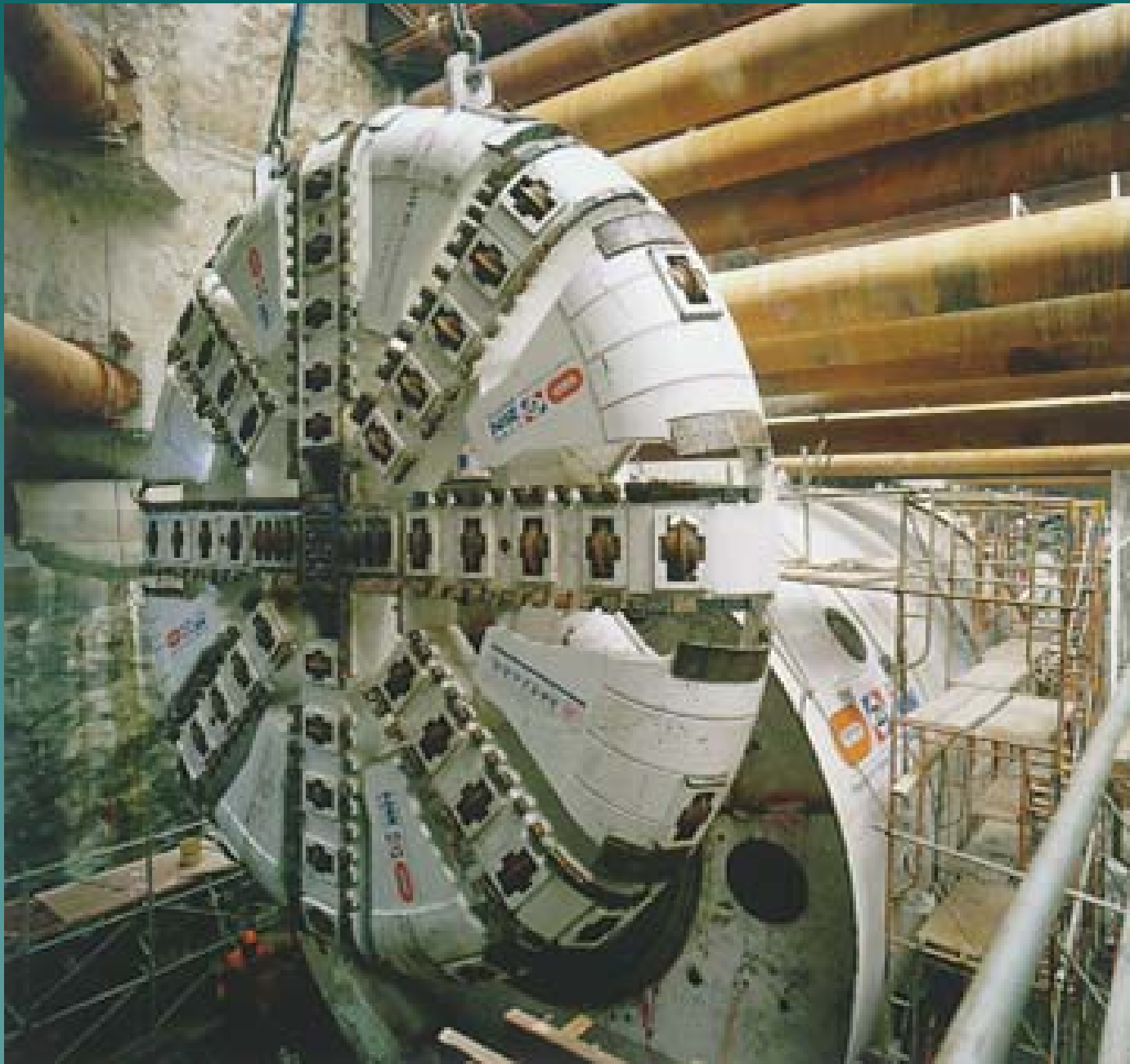
Another set of tunnel boring machine at the fabricating factory at Guangzhou in 2005 preparing for the tunnel work for the KCR Kowloon Southern Link project.

The trial assembly of the tunnel boring machine in 1998 at the fabricating factory at Shanghai before shipping to Hong Kong for final operation.





The trial assembly of the EPBM at the fabricating factory at Shanghai being shipping to Hong Kong.



The cutter head is being connected to the shield of the EPBM by the help of a track-mounted gantry crane positioned on the ground level. The rows of steel tubes on the background are lateral support used to stabilize the 25m deep tunnel shaft.

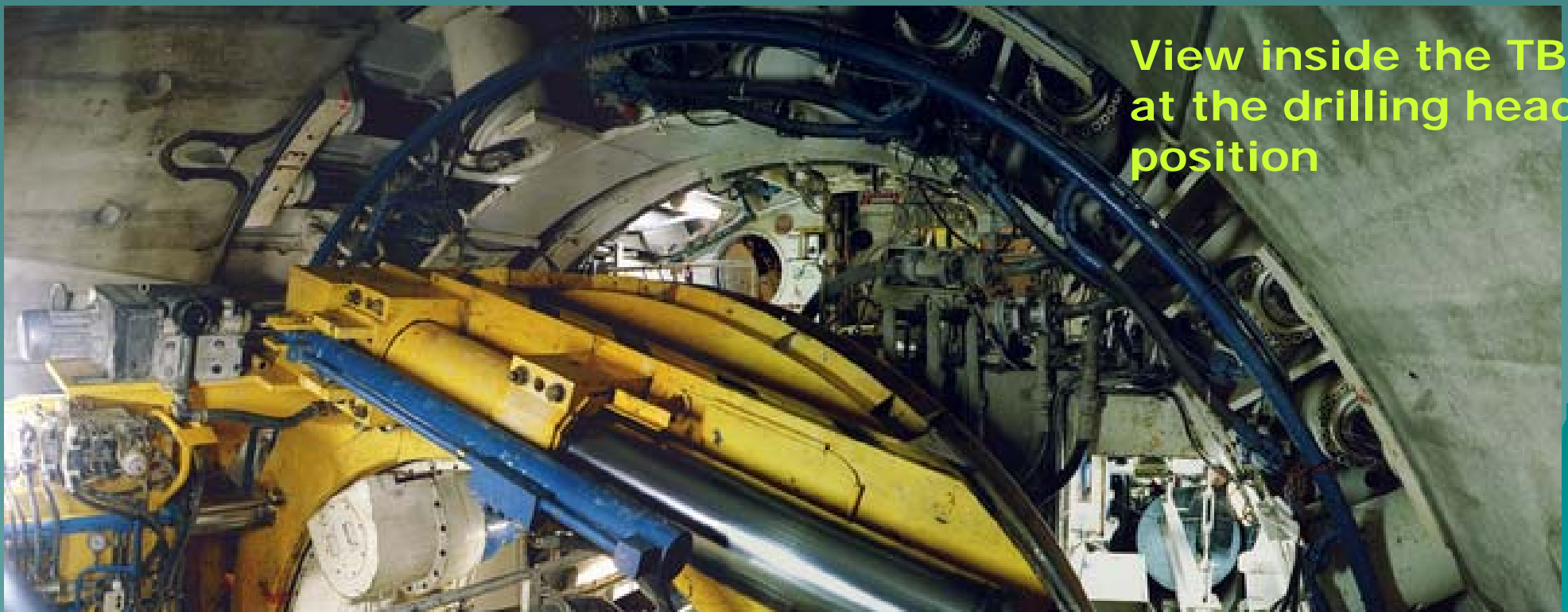




The overall view of the EPBM pictured at the Commissioning Ceremony of the machine on 31<sup>st</sup> March 2000.



Tunnel portal leading into the tunnel tube formed by the TBM



View inside the TBM at the drilling head position

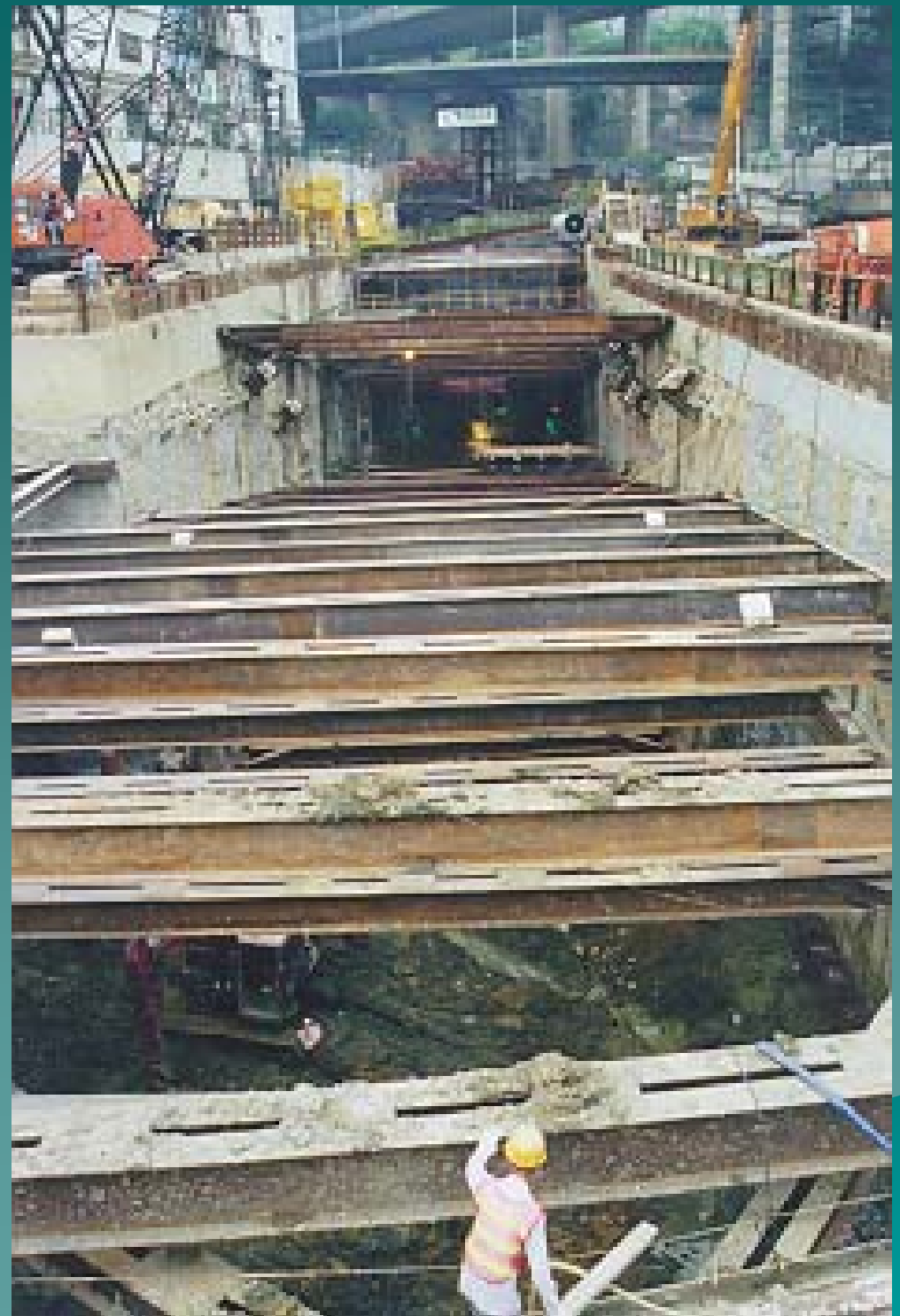
Formation of the tunnel portal and  
other logistic set-up to  
facilitate the tunnel construction works  
- The KCR West Rail Tai Lam Tunnel case

**Tai Lam Tunnel of KCR  
West Rail is a 5.5km long  
tunnel linking Tsuen  
Wan to Kam Tin and is  
constructed using drill  
and blast method. The  
photo shows the early  
stage of forming the  
tunnel portal along Hoi  
Hing Road at Chai Wan  
Kok, Tsuen Wan.**





Portal of Tai Lam Tunnel at Chai Wan Kok viewed towards the Tuen Mun Highway direction. The elevated bridges in the far background are the main connecting bridges at the entrance to Tuen Mun Highway. The tunnel will cut through the foundation of one of the elevated bridges. Underpinning work to the foundation is thus required before the proceeding of actual tunnel excavation.





A servicing gantry unit under assembly. This unit is mounted with ventilation fans and its function is to provide fresh air and air circulation inside the tunnel.



**Tunnel entrance under Tuen Mun Highway**



# Tunnel end preparing for the drilling and insertion of explosive







The ventilation gantry unit at work inside the tunnel. Note the I-section girders which act as temporary support to the exposed face of the tunnel before the forming of permanent lining using in-situ concrete.



The portal arrangement of Tai Lam Tunnel at Kam Tin side.



An axial fan installed to provide ventilation for the 5.7km long Tai Lam Tunnel



Interior view of the Tai Lam Tunnel. The plastic lining on the tunnel faces is water- proofing membrane which helps to prevent the leaking of water into the tunnel interior through the concrete lining. The nylon hose on the right side of tunnel is the ventilation hose, on the left is the conveyor system for the removal of spoils.



The gantry type scaffold that used to install the waterproofing membrane. Majority of servicing equipments working inside tunnels are track mounted and constructed in gantry form to fit the section of the tunnel interior.





An overall view of the tunnel lining formwork gantry used to form the in-situ concrete lining of the tunnel.



The tunnel interior with the in-situ concrete lining already been placed.

Tunnel Construction  
using Cut-and-Cover Method  
(Airport Railway at Central Reclamation)





**An aerial view showing the overall layout of the Hong Kong Station and the approach tunnels for the Airport Railway (Airport Express Line and Tung Chung Line) at the Central Reclamation in late-1996.**



A 400m section of approach tunnels connecting the Hong Kong Station and the immersed tube harbour crossing tunnel is formed using cut-and-cover method. This method is more effective and economical to construct shallowly positioned tunnel in softer ground (reclaimed land in this case with limited marine boulders). Diaphragm wall strutted with steel tube and soldier piles wall supported using ground anchors are both used to form the cut-off systems during the excavation of the tunnels.





The approach tunnels basically in shape. The portion on the left hand side of the temporary pedestrian bridge is the ground structure of the Hong Kong Station. The structure on the right end of the tunnel near the seawall housed the flood gate and other control and electrical gears for the tunnel system. From that onward, the tunnel crosses the Victoria Harbour through the immerse-tube tunnel.

Section of the tunnel pit formed by diaphragm wall and strutted by the use of steel tubes. The construction of the tunnel sections using in-situ method can be seen inside the pit.





Section of the tunnel pit formed by soldier pile wall and laterally supported by anchors. The structure of the approach tunnel have basically been completed pending for backfilling at a later stage.



# Tunnel Construction using Cut-and-Cover Method (MTR Tseung Kwan O Line)





Large amount of cut-and-cover tunnels were constructed in the MTR Tseung Kwan O Line in the reclaimed land of TKO New Town



Cut-and-cover  
tunnel constructed  
in difficult  
environment





Cut-and-cover tunnel  
constructed in hard rock zone

Box-section tunnel tube was constructed inside the tunnel trench using a set of traveling-type tunnel formwork





Tunnel Construction  
using Cut-and-Cover Method  
(KCR Kowloon Southern Link)





Section making use of cut-and-cover method to construct

Alignment of the Kowloon Southern Link from Tsim Sha Tsui to Nam Chong





Tunnel section near Jordon with the cut-off walling support already installed before the commencement of excavation in full scale





Note: the tunnel needs special traffic diversion arrangement when cutting across existing roadway

Tunnel section near Jordan/Tsim Sha Tsui with the cut-and-cover tunnel trench being formed down to the formation level (part of the future West Kowloon Station)







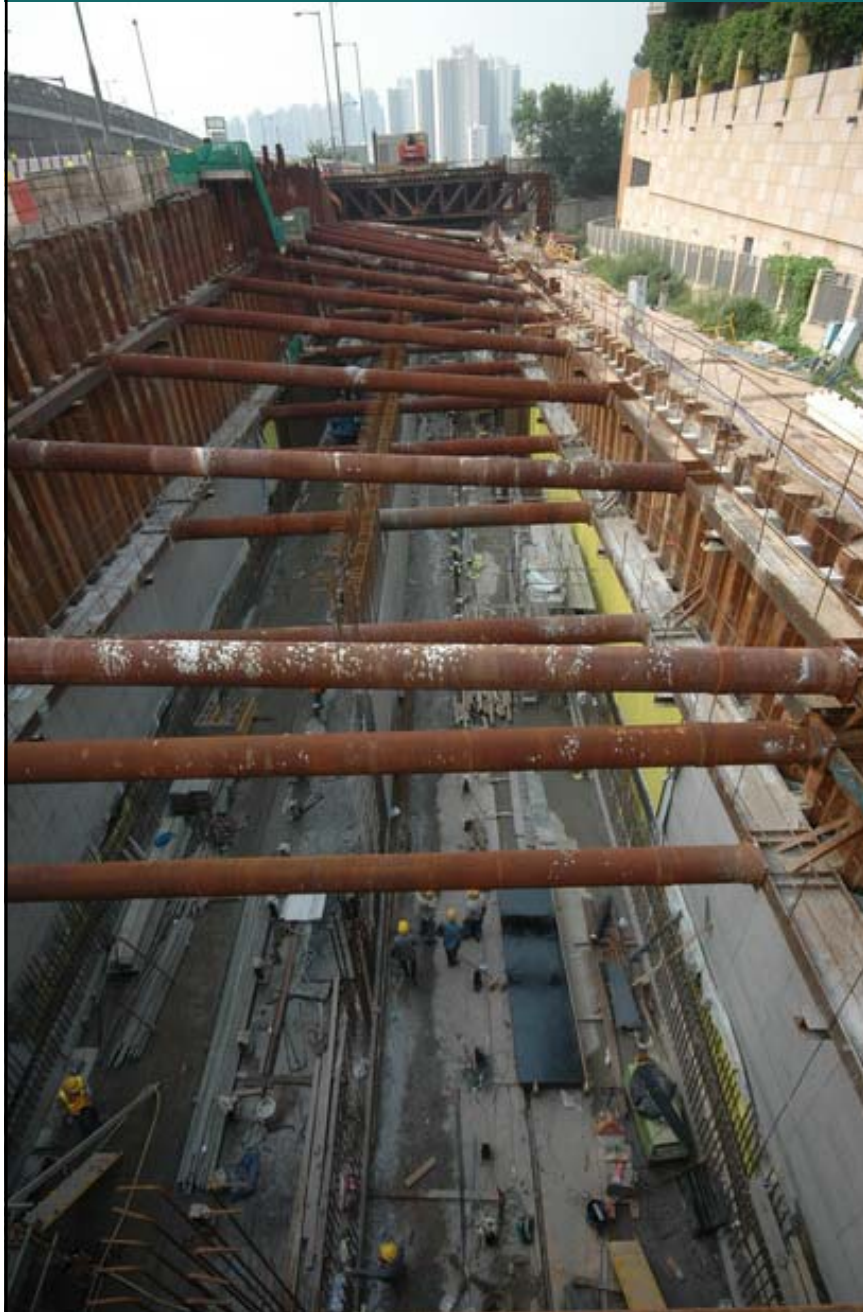
→ Alignment  
of tunnel

Tunnel section along  
Jordon/Tai Kok Tsui  
(excavation up to about half of  
formation level)



Tunnel trench crossing main  
water pipes and flyovers





Tunnel section between  
Olympus Station and  
Nam Chong Station





Falsework for work platform  
and access opening for work  
and handling of  
materials/equipments



Excavation halfway to the formation level



Excavation at various stages

Excavation completed down to the formation level and construction started for the tunnel structure using in-situ method







Tunnel excavation and construction - crossing under an existing highway bridge with limited headroom and congested working environment

crossing under an existing storm water discharge culvert

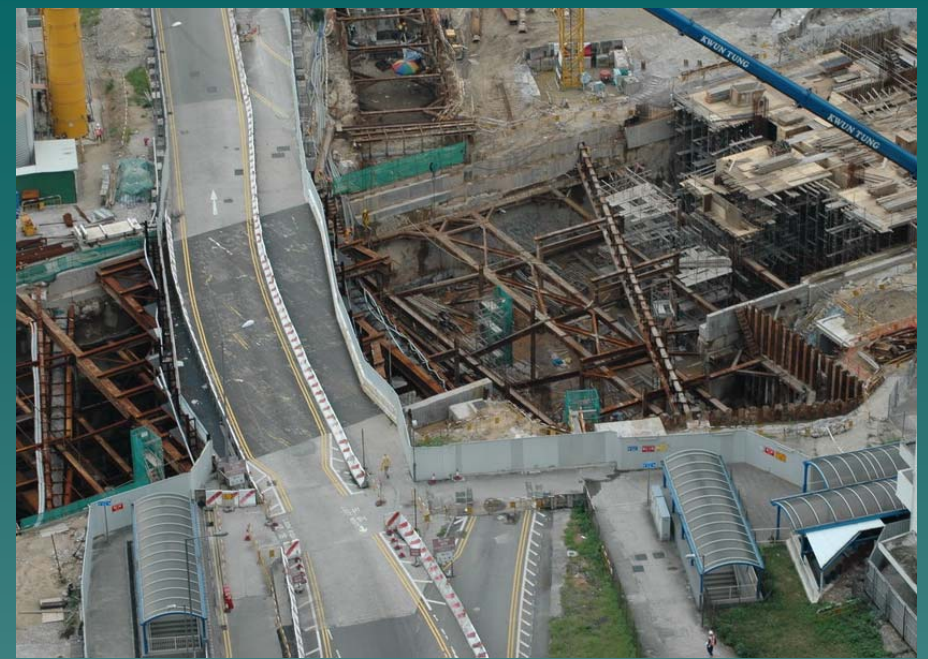


Large-size storm water discharge culvert

Tunnel tube under construction

Tunnel working under very difficult condition





Temporary  
road deck  
supported  
by shoring

Tunnel working under very difficult condition - crossing under busy surface roadway



Existing large dia.  
water main



Foundation for  
existing pedestrian  
footbridge



Tunnel working under very  
difficult condition - crossing  
congested underground service





Construction of the tunnel using in-situ method

# Tunnel Construction using Immersed Tubes







Western Harbour Crossing is constructed using precast concrete immersed tube sections. A total of 12 sections have been used, each measures 113m x 33.5m x 8.5m high and weighs about 35,000 tons. The photo shows one of the 3 batches of immersed tubes being formed in the casting yard at Shek O, HK

**The arrangement of the approach tunnels on West Kowloon Reclamation side. As can be seen here, the ventilation building also serves as the coupling structure to receive the first approaching immersed tube. After the tube being connected, the water embraced by the elbowing land would be filled to secure the coupling connection and make the tube land-bound.**



The second immersed tube being towed to the launching position for sinking and connecting onto the first tube. The first tube at this stage has already been firmly positioned at the seabed and cannot be seen on the surface.







**Touching up of the land surface after the completion of the immersed tube connection. Note also the construction of the tunnels for the Airport Railway on the right hand side of the reclaimed land.**



Construction of the tunnel approach on both side of the Western Harbour Crossing





Associate works of  
the finished tunnel –  
the approach tunnel  
and the connecting  
roadwork





# Tunnel Construction

## Final Finishes and Fitting-out





**Tunnel Section –  
forming of the  
accessible service  
void**

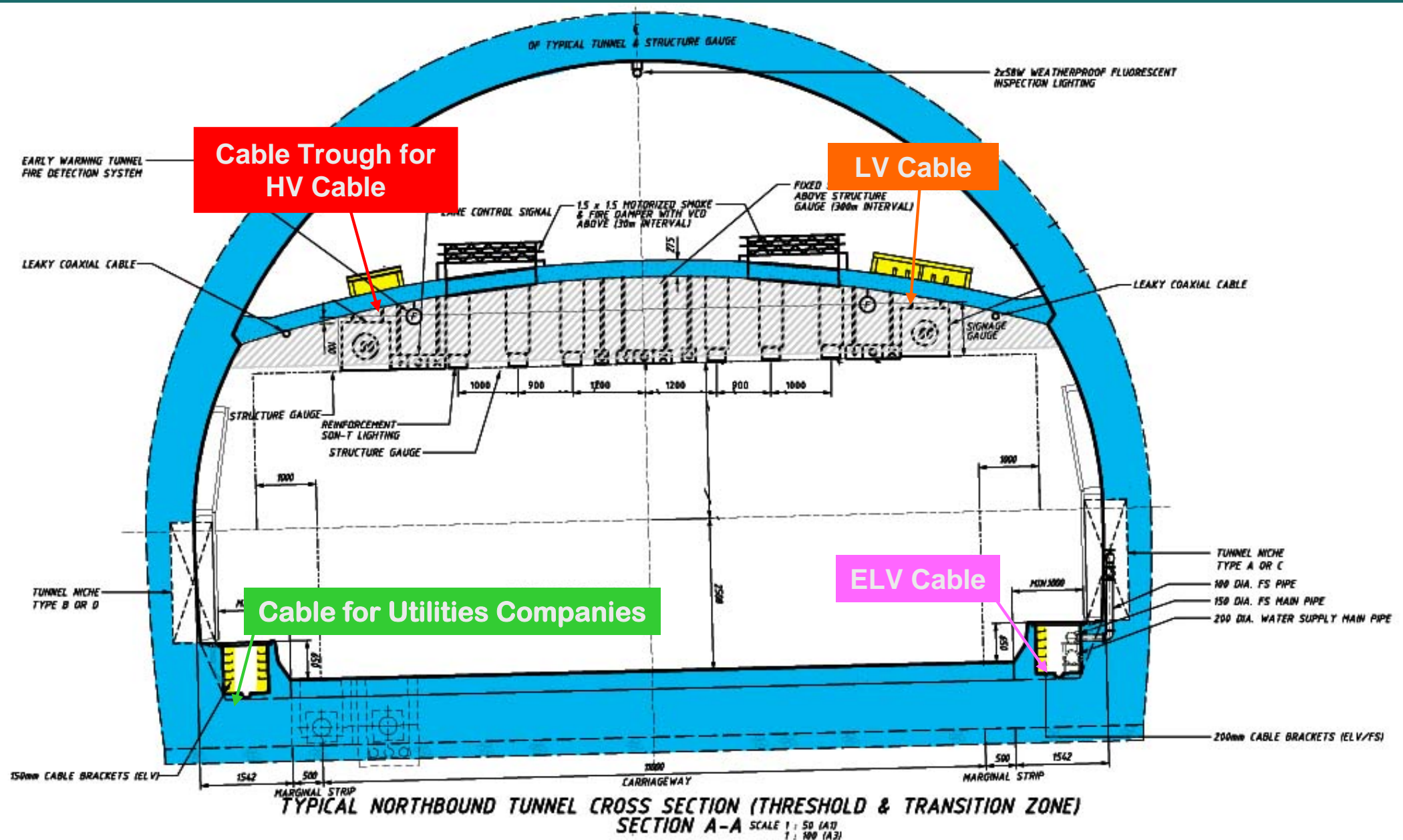




Covering of the  
tunnel wall and  
paving work



# E&M facilities in a Tunnel





**Fitting out of the  
tunnel interior and  
services installation**





Installation of the  
tunnel wall panel



## Laying of rail track in railway tunnel



End of presentation