Technology Transfer & Knowledge Sharing Program

Tunneling Technology

Federation of Myanmar Engineering Societies (Fed.MES)

Win Myint Thein

AGTI MINING (1978), BE. MINING (1983)

PE 0202, ACPE 01187/MM, AE 9222

DIRECTOR

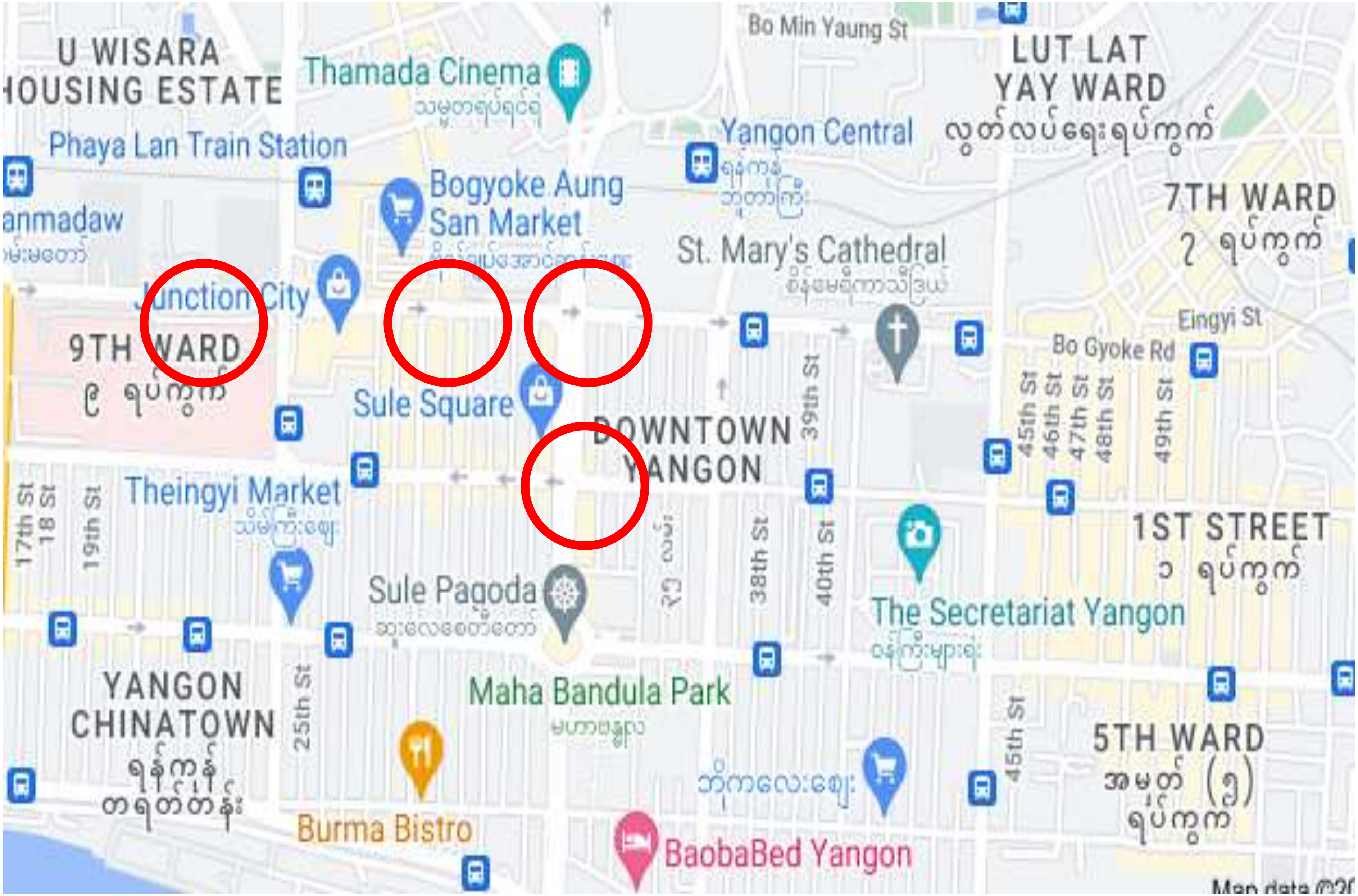
KAJIMA YANKIN PPP CO., LTD

11 May 2024

PART – 1
Tunneling Technology

PART-2
Diversion Tunnel Construction Method

Down Town Yangon Map



B.E. Final Year Thesis Location

Part -1 Contents

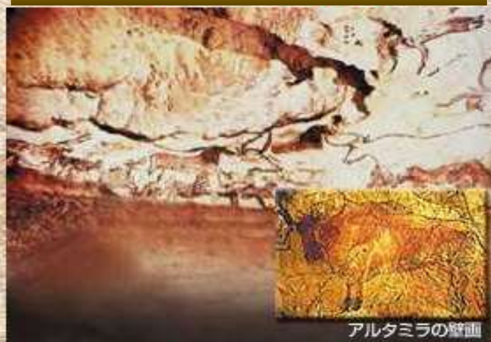
1. Tunnel History
2. Tunnel Classification by Function
3. Tunnel Classification by Construction Method
4. Introduction of Construction Method

   - NATM for typically mountain tunnel

   - TBM for typically mountain tunnel
5. Safety and Environmental Protections
6. Tunnel in Myanmar
7. Feasibility Studies in Myanmar for Road Tunnel

Tunnel History

Altamira cave (Spain)

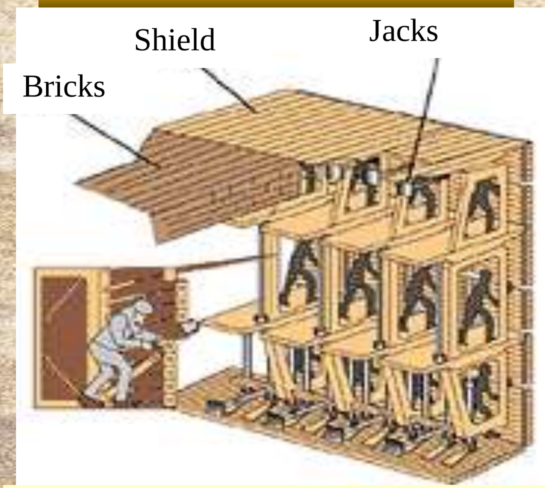


Ice age (50,000 years ago)
Ancients to keep off cold and hunger

First traffic tunnel under river

The oldest record of tunnel 4,000 years ago in Babylonia under Euphrates river

The first shield tunnel



Thames Tunnel under river was complete in 1843 using shield method

World Tunnel Record upto 2018

Rank	Country	Total length (km)	Number of tunnels	Year
1	China	15285.1	16229	2017[1]
2	Japan	4026	9760	2012[2]
3	Norway	1338	1400	2017[3]
4	Italy	900	9718	2000[4]
5	Korea	649	932	2011[5]
6	Switzerland	403	468	2011[6]
7	Spain	233	250	2015[7][*circular reference*]
8	United States	185.4	504	2018[8]
9	Germany	183	243	2006[9]
10	Faroe Islands	43.7	20	2018[10]
11	Netherlands	34	38	2013[11]
12	Hong Kong	31	17	2015[12]
13	Sweden	20	21	2006[13]

Number of up date Recent Tunnel

Tunnel in China (30 Jan 2024) : 24850 Nos

Tunnel in Japan (31 Mar 2020) : 10920 Nos

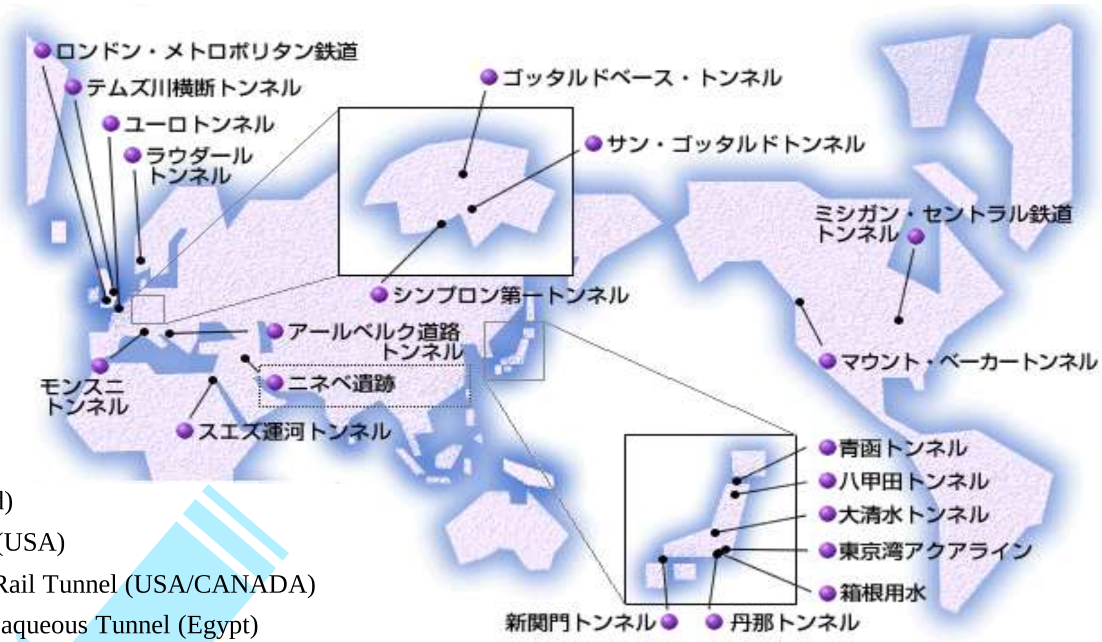
Tunnel in Italy : 9718 Nos

Tunnel in South Korea : 1400 Nos

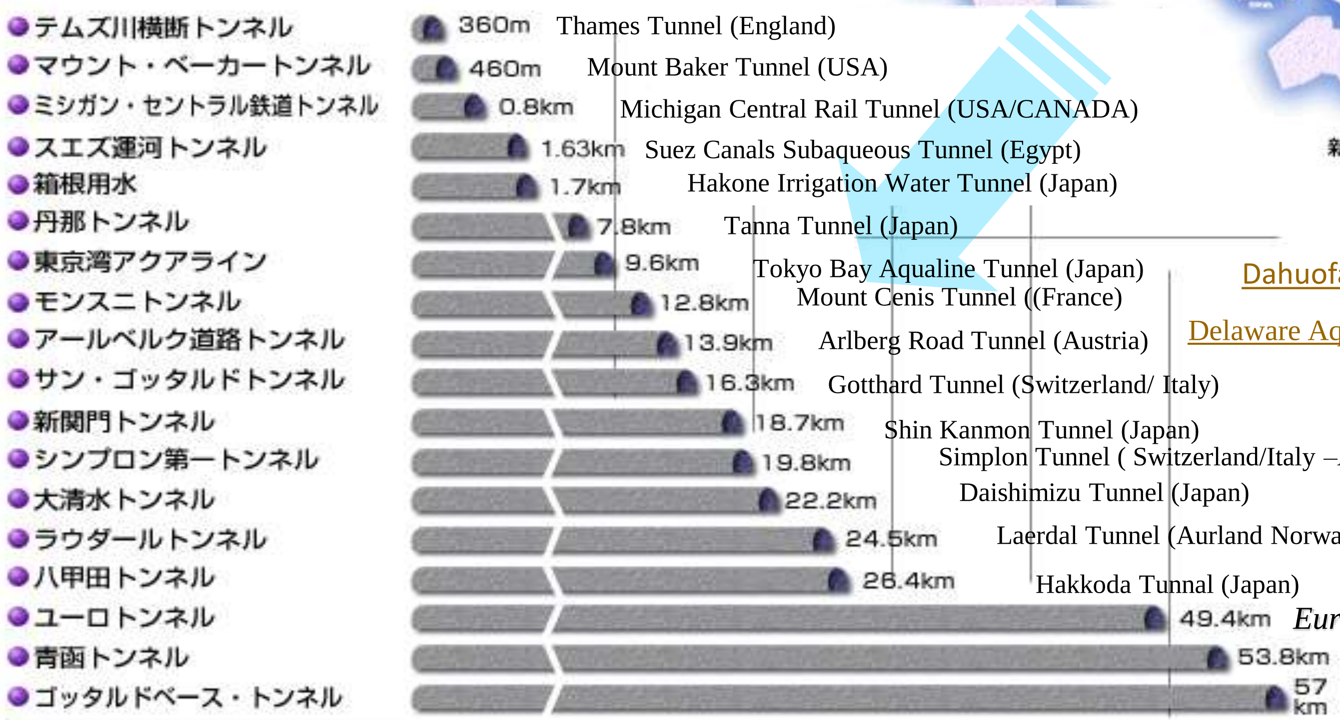
Road Tunnel in Japan

1) Yumesaki Tunnel 2.14 km 2009
2) Shin-Kobe Tunnel (Expressway) 8.50 km 2012
3) Hida Tunnel (Expressway) 10.70 km 2008
4) Kan-Etsu Tunnel (Expressway) 11.00 km 1991

Recent Tunnel Information up to 2018



Tunnel Length



Dahuofang Water Tunnel (China), 85.3km

Delaware Aqueduct water supply tunnel (New York, US) 137km

WORLD FAMOUS TUNNEL

Shin-Tanna Tunnel is a tunnel on Tōkaidō Shinkansen that runs from Kannami town and Atami town in Shizuoka city, Shizuoka Prefecture with total length of 7.959 km. It was built and completed in 1964 located parallel to old Tanna Tunnel.

JAPAN

7.96 km Tunnel, Dec 1964

Tokyo Bay Aqua-Line

The **Tokyo Bay Aqua-Line** (東京湾アクアライン *Tōkyō-wan Akua-rain*[1]?), also known as the **Trans-Tokyo Bay Highway**, is a bridge–tunnel combination across Tokyo Bay in Japan. It connects the city of Kawasaki in Kanagawa Prefecture with the city of Kisarazu in Chiba Prefecture, and forms part of National Route 409. With an overall length of 14 km, it includes a 4.4 km bridge and 9.6 km tunnel underneath the bay—the fourth-longest underwater tunnel in the world.[2]

JAPAN

9.6 km Tunnel, Dec 1997

Mont Cenis Tunnel

The **Fréjus Rail Tunnel** (also called **Mont Cenis Tunnel**) is a rail tunnel of 13.7 km (8.5 mi) length in the European Alps, carrying the Turin–Modane railway through Mount Cenis to an end on connection with the Culoz–Modane railway and linking Bardonecchia in Italy to Modane in France. It passes beneath the *Pointe du Fréjus* (2,932 m) and the *Col de Fréjus* (2,542 m).

The initial gallery was 12.8 kilometres long, twice as much as the previously longest tunnel. . The tunnel opened for traffic on 17 September 1871, thus making it the oldest of the large tunnels through the Alps. The gallery was extended to its present length in 1881 with a new reinforced entrance on the French side.

FRANCE

12.8 km Tunnel, 1881

The **Arlberg Road Tunnel** with a length of 13,976 metres is Austria's longest road tunnel. It carries the S16 Arlbergschnellstraße (German for "Arlberg Highway") under the Arlberg massif from Tyrol to Vorarlberg. The tunnel is 1228 m (4,030 feet) above sea level with the road above the tunnel being 1640 m (5,400 feet) elevation.[1] It was built between July 1974 and December 1978 and its costs amounted to 4 billion Austrian schillings (~300 million €). The tunnel is designed for 1800 vehicles per hour.

AUSTRIA

Arlberg Road Tunnel, 13.976 km, 1978

The Shin-Kanmon Tunnel is a 18.713-kilometre long undersea railway tunnel under the Kanmon Straits connecting Shin-Shimonoseki Station and Kokura Station. At the time of opening in March of 1975, it was the longest railway tunnel in Japan before being overtaken by in 1988 the opening of the Seikan

JAPAN

Shin Kanmon Railway Tunnel, 18.7 km, 1975

The **Gotthard Tunnel** (German: *Gotthardtunnel*, Italian: *Galleria del San Gottardo*) is a 15-kilometre (9 mi) long railway tunnel and forms the summit of the Gotthard Railway in Switzerland. It connects Göschenen with Airolo and was the first tunnel through the Gotthard massif. It is built as one double-track, standard gauge tunnel.

The tunnel rises from the northern portal at Göschenen (1106 metres / 3650 ft) and the highest point (1151 metres, or 3800 ft) is reached after approximately 8 kilometres (5 mi). After two more kilometers, the border between the cantons of Uri and Ticino is passed; after another 5 kilometres (3 mi), the tunnel ends at the southern portal near to Airolo (1142 metres or 3770 ft). The trip takes about seven to eight minutes by train. Services are operated by the n

SWITZERLAND

Gotthard Tunnel, 15.002 km, 1882

The Simplon Tunnel is a railway tunnel on the Simplon railway that connects Brig, Switzerland and Domodossola, Italy, through the Alps, providing a shortcut under the Simplon Pass route. It is straight except for short curves at either end. It consists of two single-track tunnels built nearly 15 years apart.

SWITZERLAND

Simplon Tunnel, 20 km, 1906

The **Daishimizu Tunnel** (大清水トンネル?) is a railway tunnel on the Jōetsu Shinkansen on the border of Gunma Prefecture and Niigata Prefecture, Japan.

In 1978, the Dai-Shimizu tunnel was completed. This tunnel was dug for the Jōetsu Shinkansen that was to be completed in 1982.

JAPAN

Daishimizu Railway Tunnel, 22.2 km, 1982

Lærdal Tunnel (Norwegian: *Lærdalstunnelen*) is a 24.51-kilometre (15.23 mi) long road tunnel connecting Lærdal and Aurland in Sogn og Fjordane, Norway and located approximately 175–200 kilometres (109–124 mi) north-east of Bergen. It is the longest road tunnel in the world succeeding the Swiss Gotthard Road Tunnel. The tunnel carries two lanes of European Route E16 and represents the final link on the new main highway connecting Oslo and Bergen without ferry connections and difficult mountain crossings during winter.

Norway

Laerdal Tunnel, 24.51 km, 2000

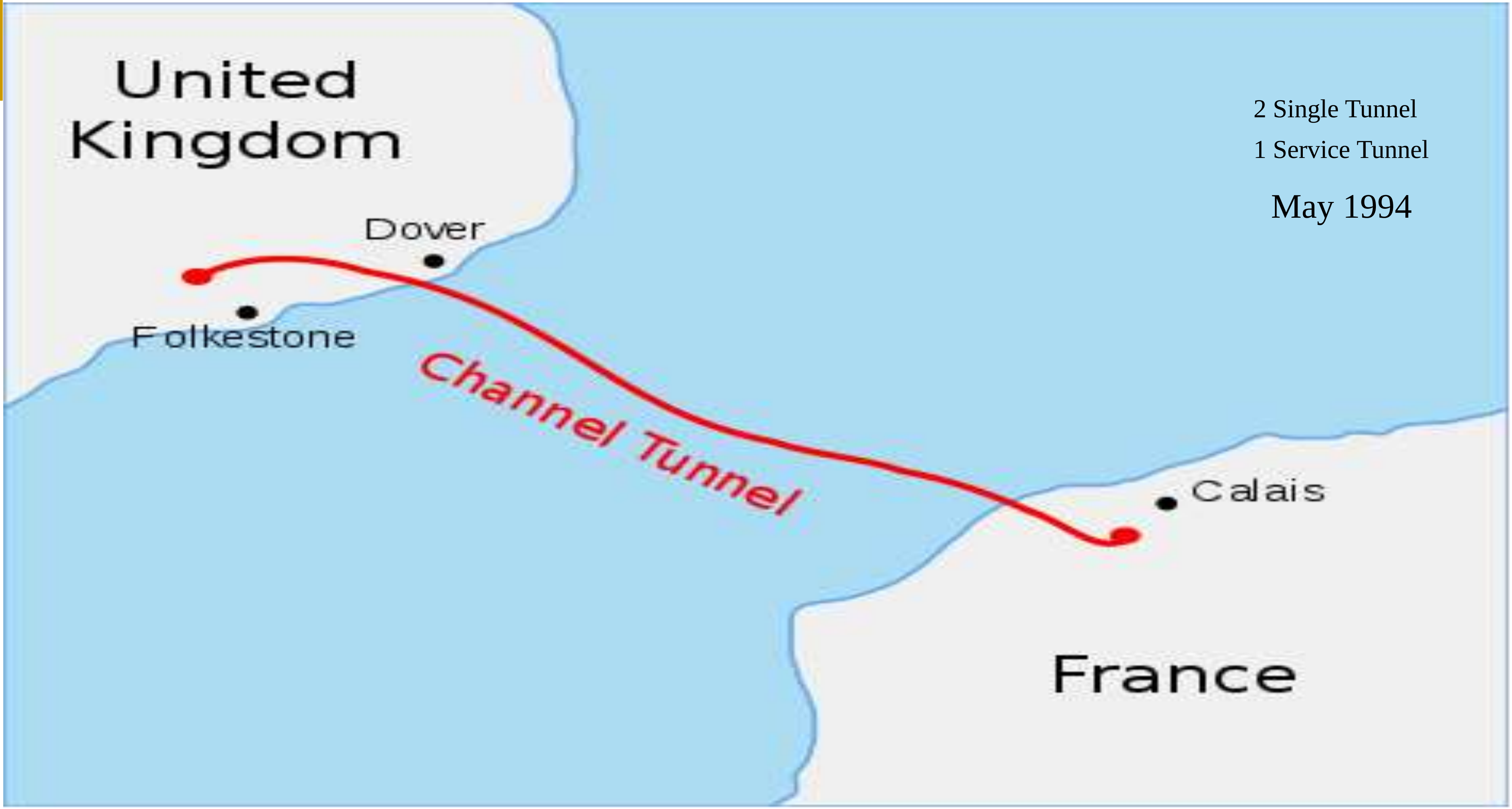
The **Hakkōda Tunnel** (八甲田トンネル *Hakkōda tonneru*[?]) is a 26.445-kilometre (16.432 mi) railway tunnel in located in central Aomori Prefecture, in northern Japan. It passes through the Hakkōda mountain range and links the village of Tenmabayashi with the city of Aomori.

The Hakkōda Tunnel is part of the northern extension of the Tōhoku Shinkansen, and is located between the stations of Shichinohe-Towada and Shin Aomori.

T… Tu… railway tunnel in the v…

JAPAN

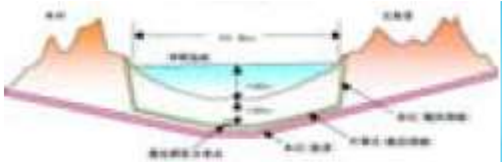
Hakkoda Tunnel, 26.445 km, 2010

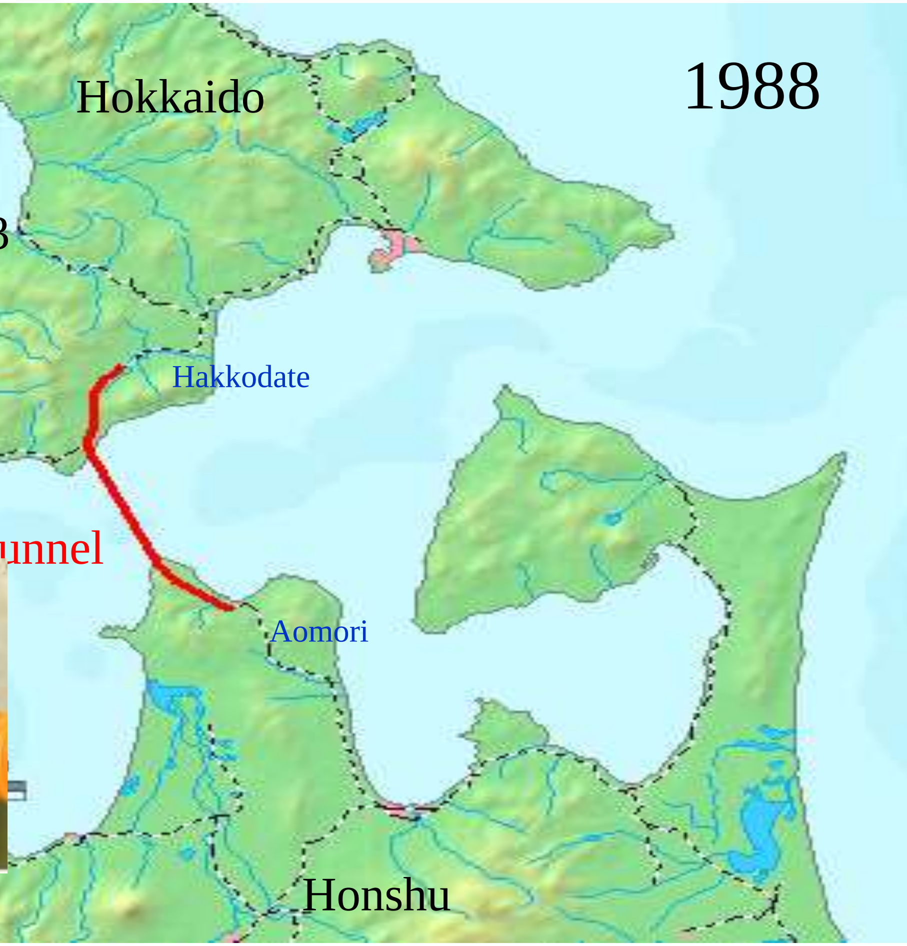


The **Channel Tunnel** (French: *Le tunnel sous la Manche*; also referred to as the **Chunnel**)[2][3] is a 50.5-kilometre (31.4 mi) rail tunnel linking Folkestone, Kent, in the United Kingdom, with Coquelles, Pas-de-Calais, near Calais in northern France, beneath the English Channel at the Strait of Dover. At its lowest point, it is 75 m (250 ft) deep.[4][5][6] At 37.9 kilometres (23.5 mi), the tunnel has the longest undersea portion of any tunnel in the world, although the Seikan Tunnel in Japan is both longer overall at 53.85 kilometres (33.46 mi) and deeper at 240 metres (790 ft) below sea level.

UK

Channel Tunnel, 50.5 km, 1994





Steel: 160,000 ton
Concrete: 1.74 mil m3

Explosive: 2860 ton

The **Seikan Tunnel** (青函トンネル *Seikan Tonneru* or 青函隧道 *Seikan Zuidō*) is a 53.85-kilometre (33.46 mi) railway tunnel in Japan, with a 23.3-kilometre (14.5 mi) long portion under the seabed. The track level is about 100 metres (330 ft) below the seabed and 240 m (790 ft) below sea level.[1] It travels beneath the Tsugaru Strait — connecting Aomori Prefecture on the Japanese island Honshu and the island Hokkaido — as part of the Kaikyo Line of Hokkaido Railway Company. The name *Seikan* comes from combining the *on'yomi* readings of the first characters of Aomori (青森?) and Hakodate (函館?), the nearest major city on the Hokkaido side.

JAPAN the lo Seikan Tunnel, 53.85 km, 1988 he world.

The **Gotthard Base Tunnel** (GBT) is a railway tunnel in the heart of the Swiss Alps expected to open in 2016.[3] With a route length of 57 km (35.4 mi) and a total of 151.84 km (94.3 mi) of tunnels, shafts and passages,[2] it is the world's longest rail tunnel, surpassing the Seikan Tunnel in Japan.

SWITZERLAND

Gotthard Base Tunnel, 57 km, 2016

List of World Longest Tunnel

1. Gotthard Base Tunnel (Railway)
2. Seikan Tunnel (Railway)
3. Channel Tunnel (Railway)
4. Yulhyeon Tunnel (Railway)
5. Sengshan Lake Tunnel (Railway)
6. Lotschberg Base Tunnel (Railway)
7. New Guanjiao Tunnel (Railway)
8. Guadarrama Tunnel (Railway)
9. West Qinling Tunnel (Railway)
10. Taihary Tunnel (Railway)

1. Gotthard Base Tunnel (Railway)

Switzerland

Length=57.1km
March 2016

Total Length
=151.84km

March 2024

2. Seikan Tunnel (Railway)

Japan

Length=53.58km

1988

(23.3 km undersea)

3. Channel Tunnel (Railway)

France/UK

Length=50.5km

1914

(38km undersea)

4. Yulhyeon Tunnel

South Korea

Length=50.3km

Dec 2016

5. Songshan Lake Tunnel (Railway)

China

Length=38.8km

Dec 2017

6. Lotschberg Base Tunnel (Railway)

Switzerland

Length=34.6km

2007

New Guanjino Tunnel (Railway)

China

Length=32.7km

2014

8. Guadarrama Tunnel (Railway)

Spain

Length=28.4km

2007

9. West Qinling Tunnel (Railway)

China

Length=28.23km

2007

10. Taihary Tunnel (Railway)

China

Length=27.84km

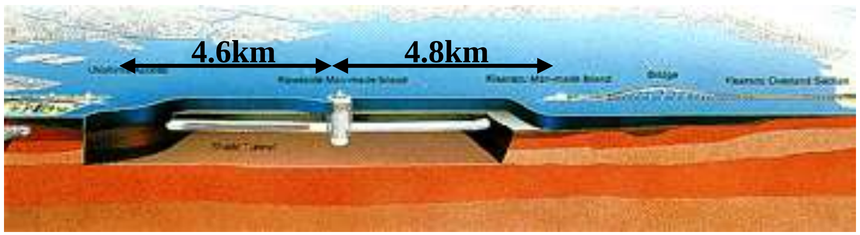
2007

Tunnel Classification by Function

- Road Tunnels
- Railway Tunnels
- Waterway Tunnels
- City Utility Tunnels
- Storage Tunnels

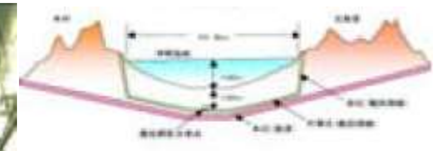
Road Tunnels

Yamate Tunnel L=10.9km (Tokyo, Japan)



Aqua-line Tunnel L=9.6km (Tokyo bay, Japan)

Railway Tunnels



Seikan Tunnel (Aomori - Hokkaido, Japan)
L=53.8km

Fukutoshin Subway Line (Tokyo, Japan)

Waterway Tunnels

Dai Ninh Hydropower Project (Vietnam)

City Utility Tunnels

Kasugai Multi Purpose Tunnel (Aichi, Japan) L=6.82km

Storage/Flood Control Tunnels

Located 50m in deep along
National Road No.16

Storage Capacity: 670,000m3

D10m , L=6.3km

Metropolitan Area Water Storage Tunnel (Saitama, Japan)

Kuji Oil Storage (Iwate, Japan)

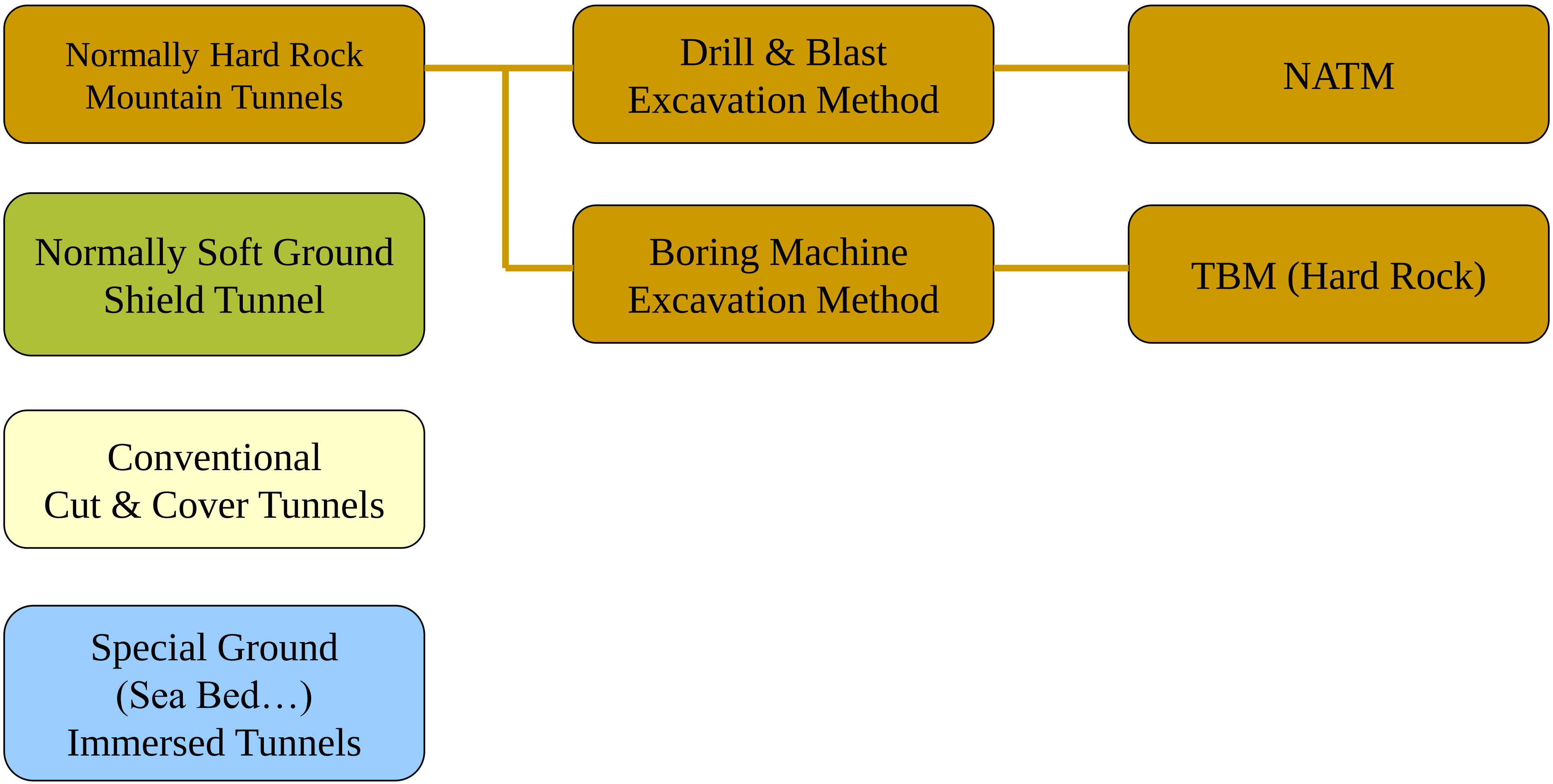
Storage Capacity: 1,750,000m3

Width: 18m

Height: 22m

Length: 540m x 6 =3,240m

Tunnel Classification by Construction Method



Mountain Tunnels

- Typically by NATM or Hard Rock TBM

NATM

For Mountain Tunnel

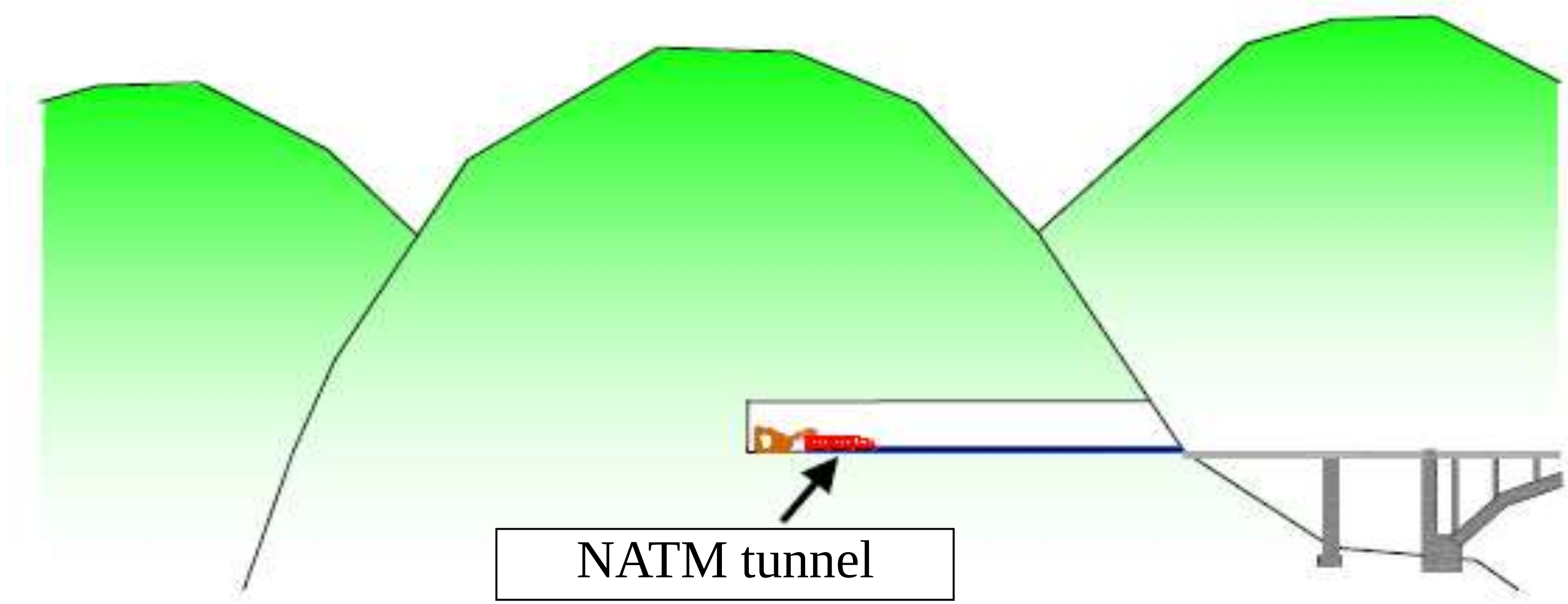
New **A**ustrian **T**unneling **M**ethod

- *Mountain Tunnel*
  - *NATM*
  - *TBM*
- *Shield Tunnel*
- *Cut and Cover Tunnel*
- *Immersed Tunnel*

NATM

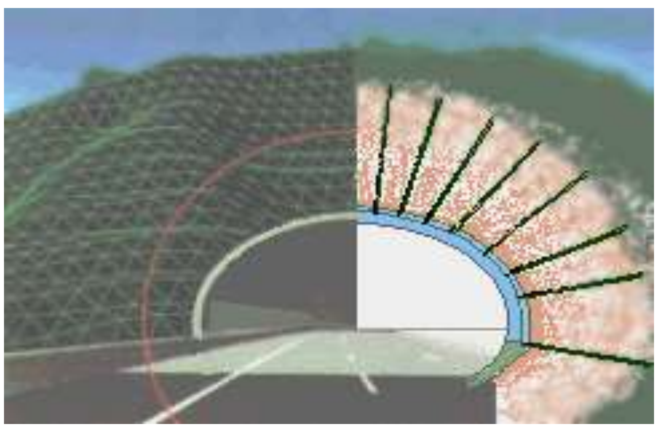
(New Austrian Tunneling Method)

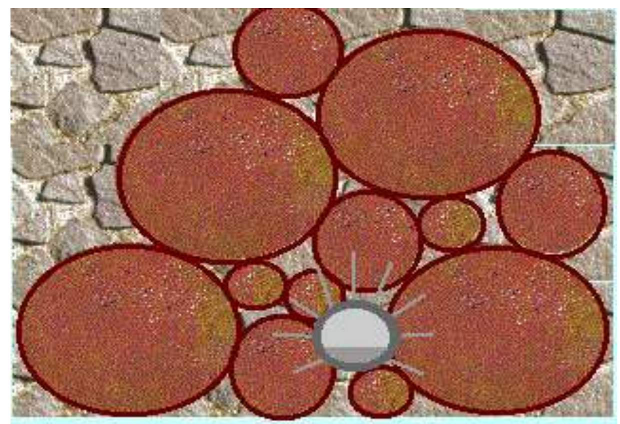
- Established by Dr. Rabcewicz in 1964
- Tunnel with immediate shotcrete, rock bolts and lining concrete



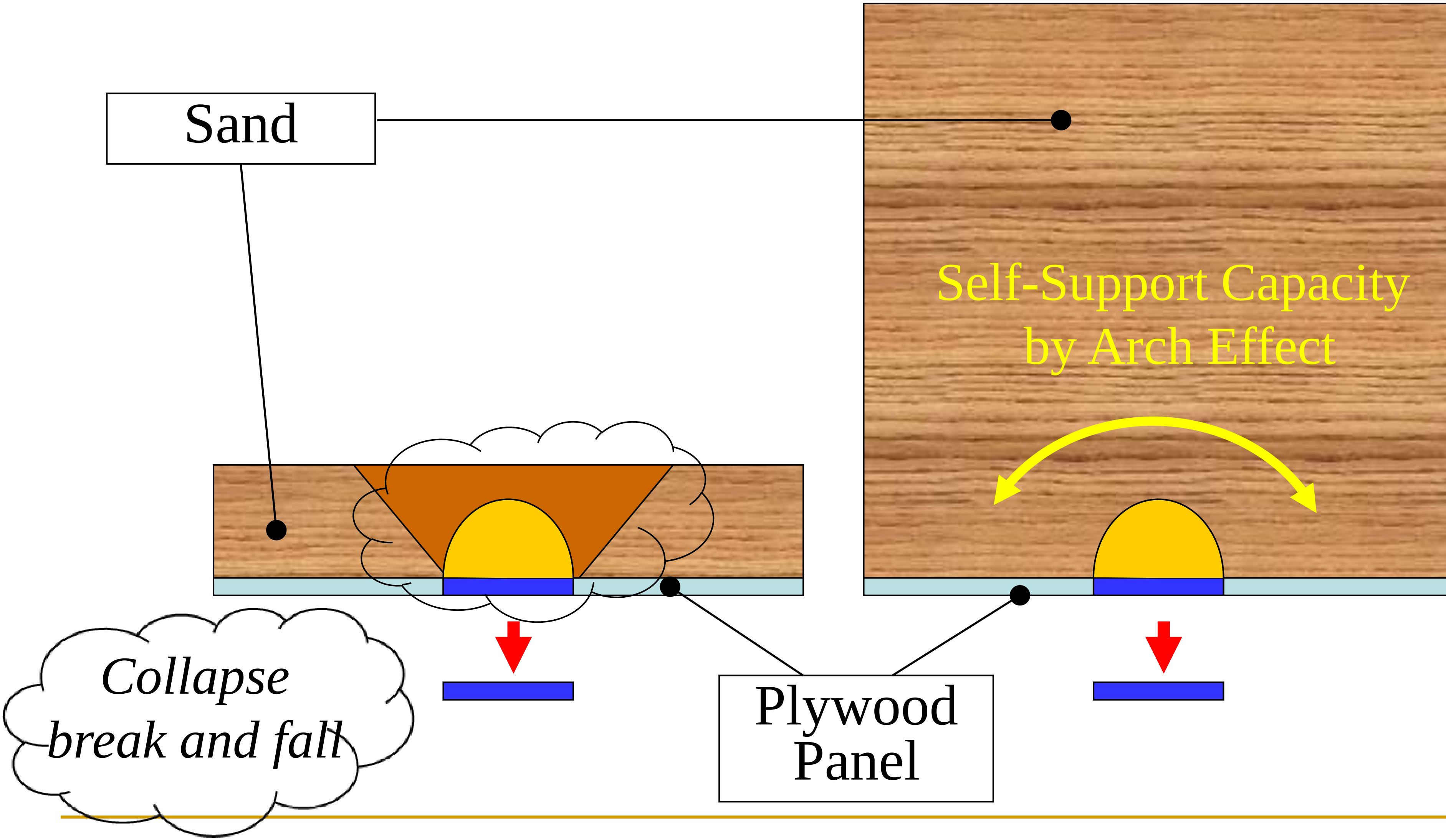
Basic Concept

- To integrate shotcrete / rock bolts with the mountain = To make the tunnel support system as a part of the ground
- To expect self-support capacity of the excavated tunnel



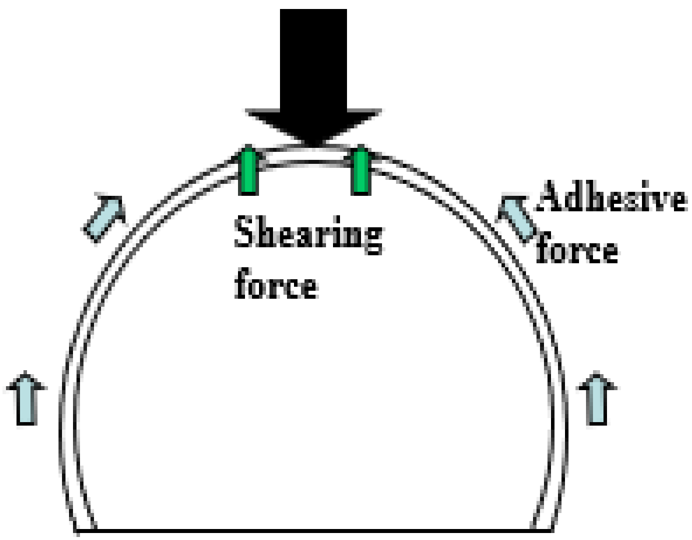


Test for Self-Support Capacity

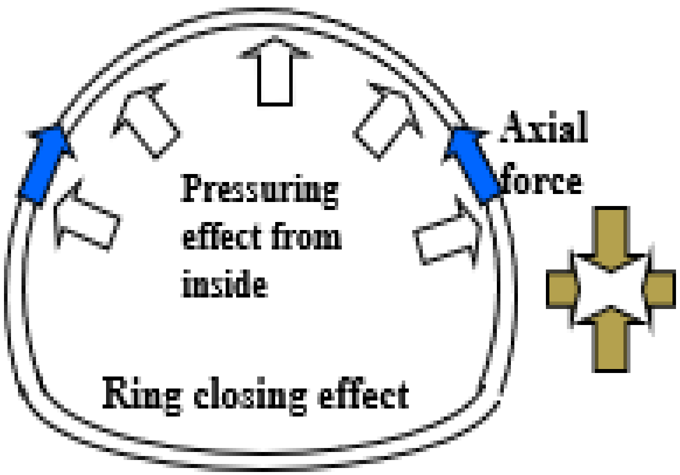


Design Standard: **Effects of sprayed concrete**

Main effects of the sprayed concrete



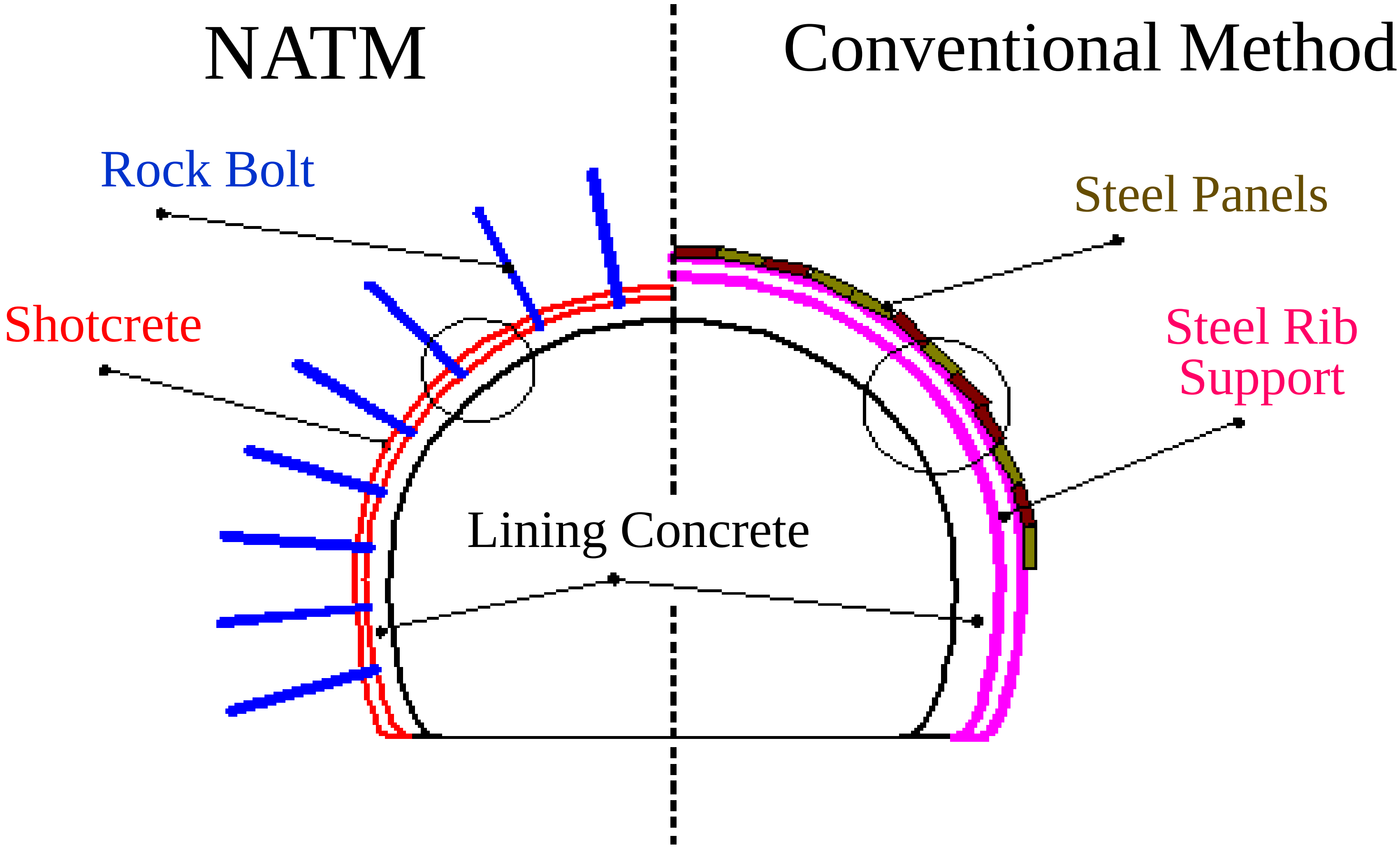
The sprayed concrete, in the rock of middle hardness with many cracks, has an effect of dispersing the load by adhesion force, and of giving shearing resistance to cracks.



The sprayed concrete is effective in creating a three axial state of the ground to increase the deformation of ground and external loads from ground.

The sprayed concrete, on being placed thickly in the soft rock or in the ground soil, has the effect of working as an axial force element and of producing inner pressure.

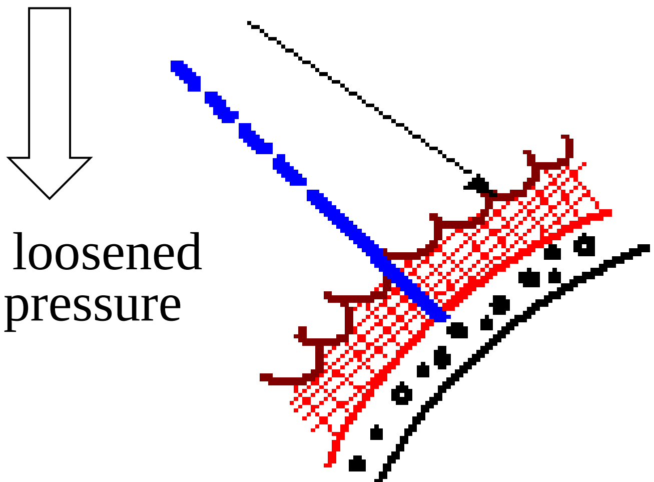
Comparison


NATM
Conventional Method
Rock Bolt
Shotcrete
Steel Panels
Steel Rib
Support
Lining Concrete

Comparison

NATM

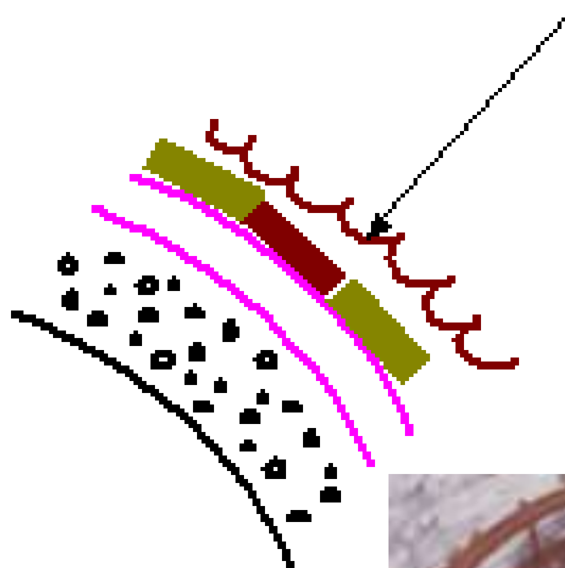
No gaps between excavated surface and shotcrete



Small loosened rock pressure

Conventional Method

Gaps between excavated surface and steel supports



Large loosened rock pressure

Construction Cycle of NATM

<u>Excavation</u>

1) Drilling & Blasting
2) Hauling
3) Scaling
4) Shotcreting
5)Rockbolting

↓

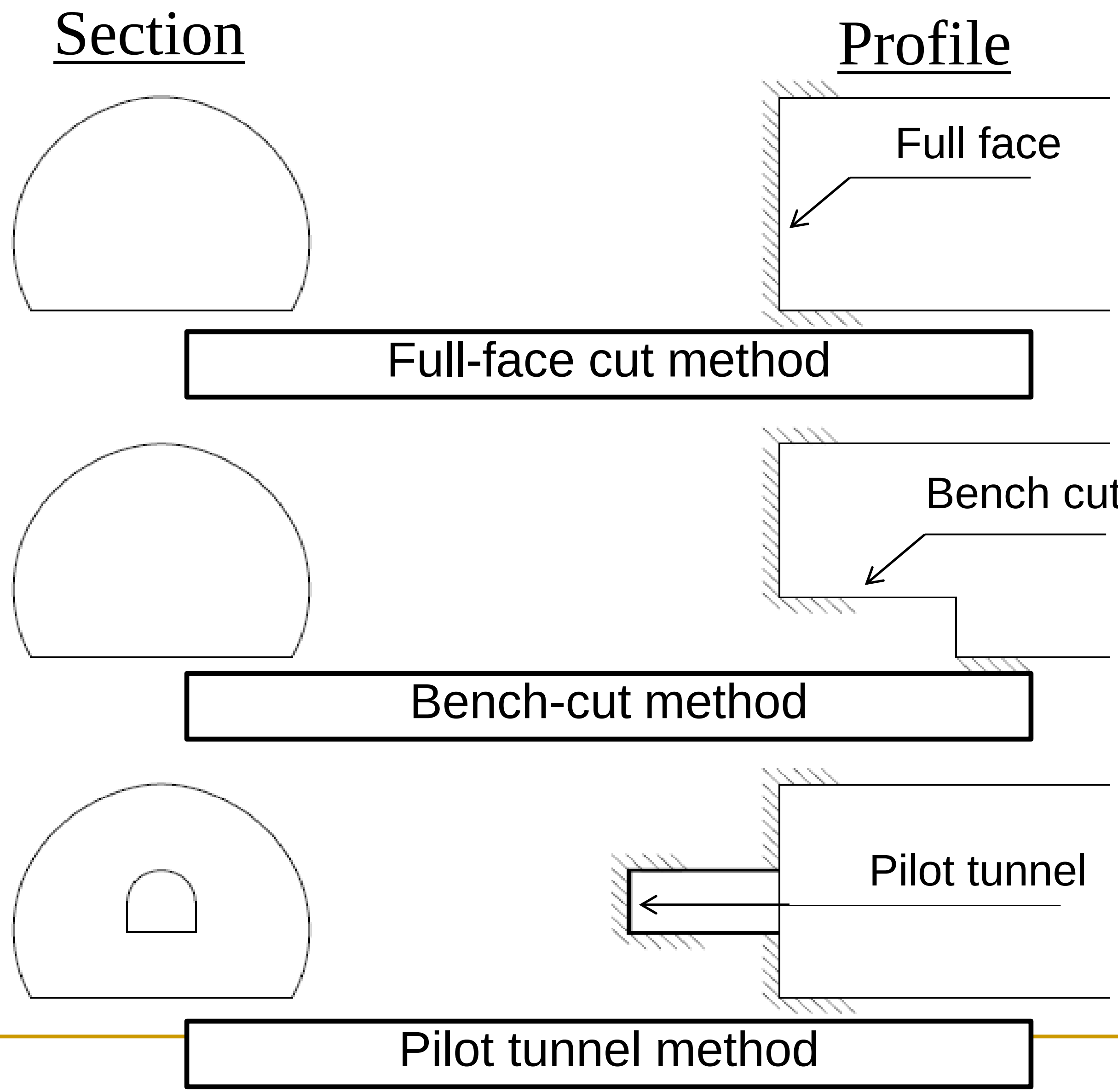
<u>Invert Concrete</u>

↓

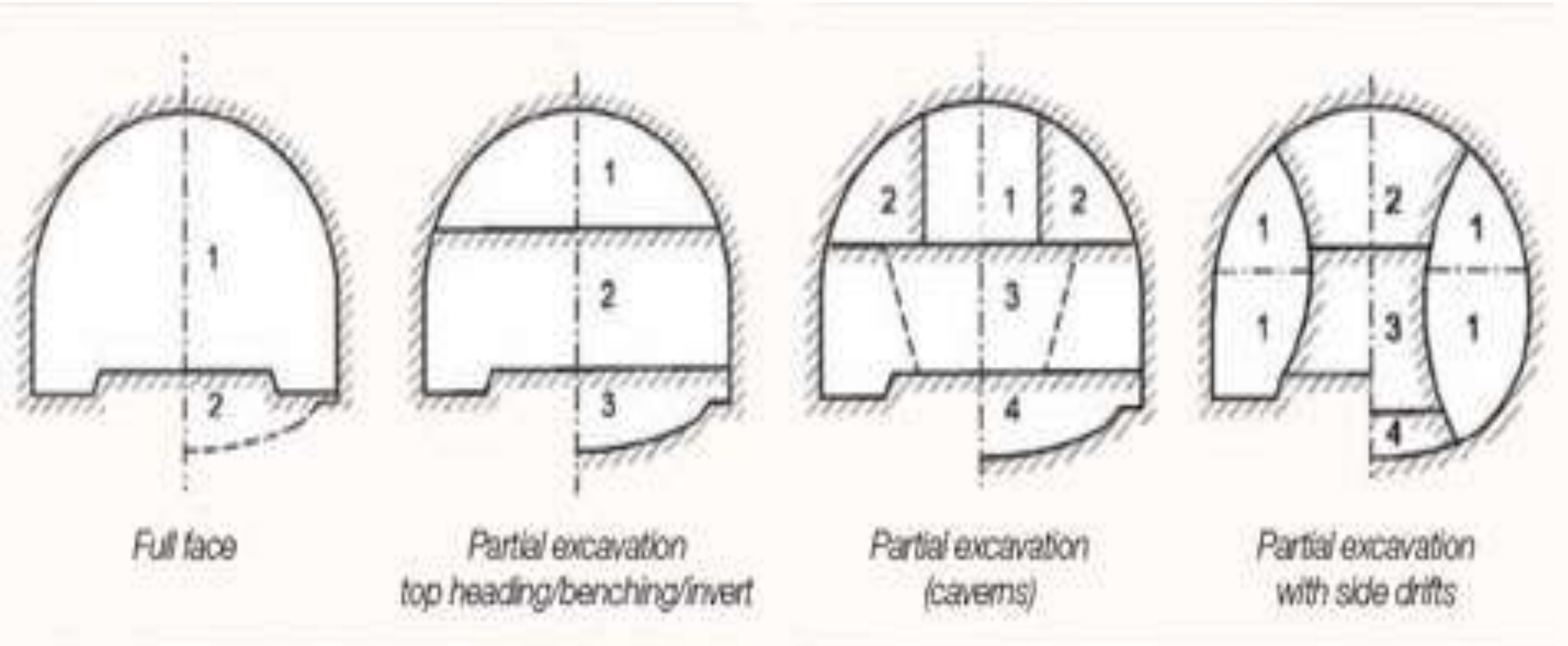
<u>Concrete Lining</u>

1) *Installing WTR proof sheet*
2) *Installing steel reinforcement*
3) *Concreting with steel formworks*

Excavation method of face of tunnel

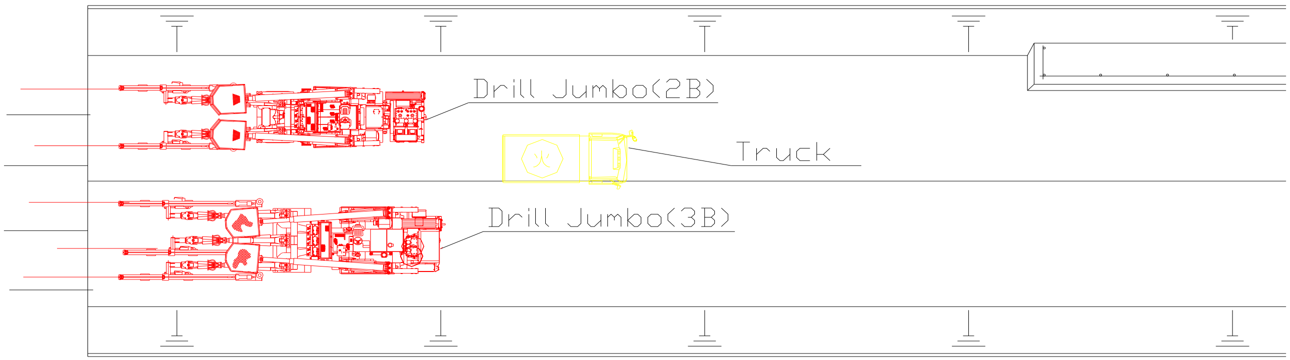


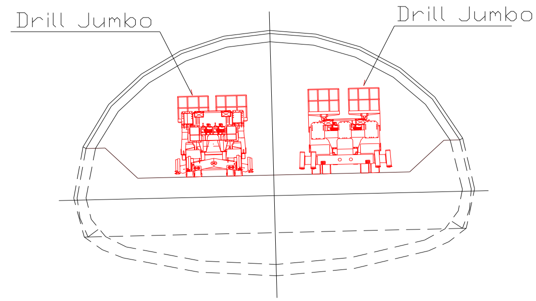
Typical excavation sequences in conventional tunneling



Excavation (Step-1)

A. Drilling, Charging, Blasting





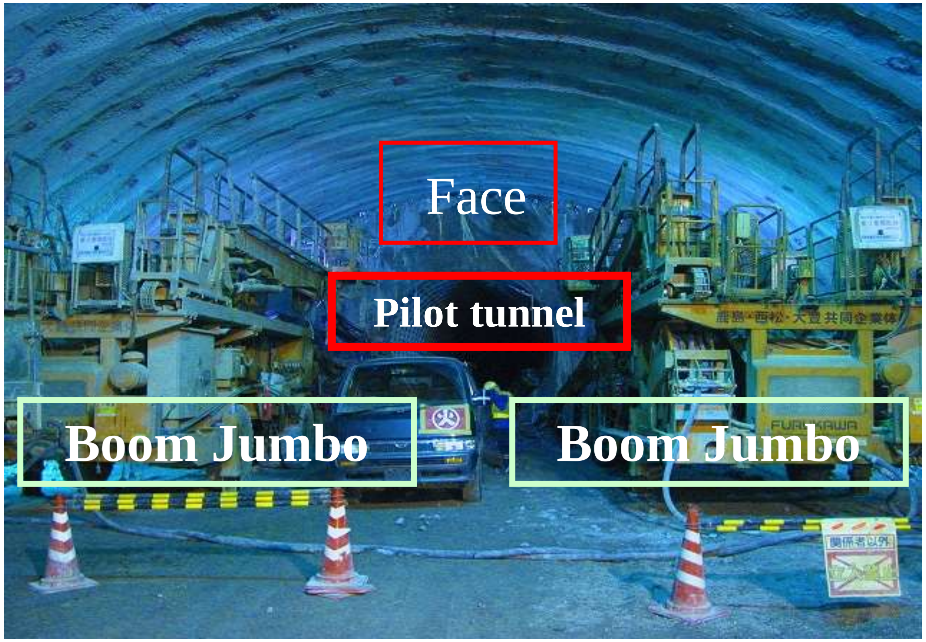
1.Drilling of charging hole

by 2- or 3-booms Jumbo

2.Charging of explosives

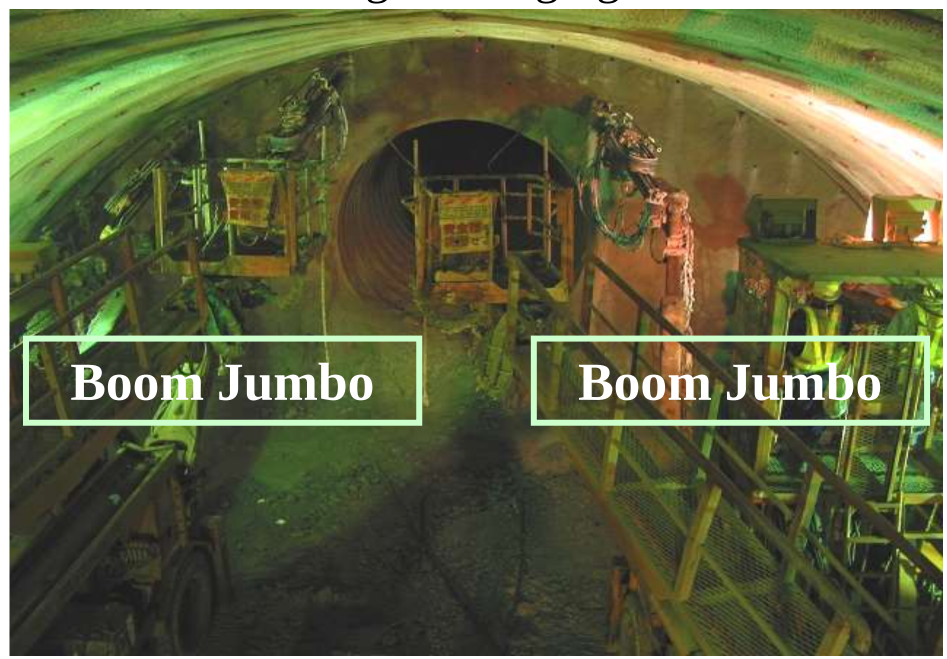
3.Blasting

Drilling, Charging, Blasting



General view

Drilling of charging hole



Drilling, Charging, Blasting

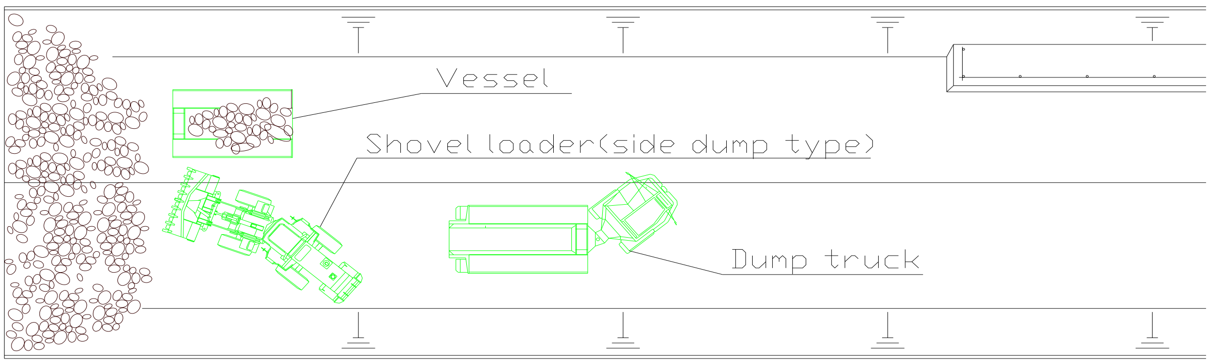
Charging of explosive

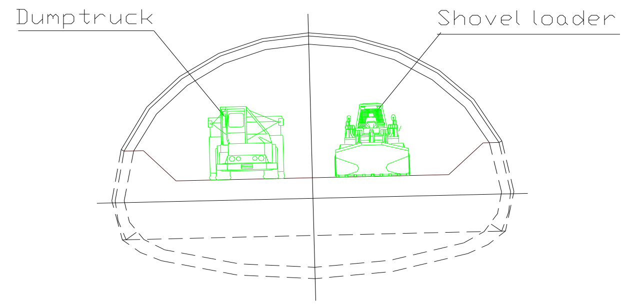
Blasting

This flash light is a moment of dynamite explosion

Excavation (Step-2)

B. Hauling





4. Loading blasted material by Shovel loader.

5. Hauling blasted material by Dump truck.

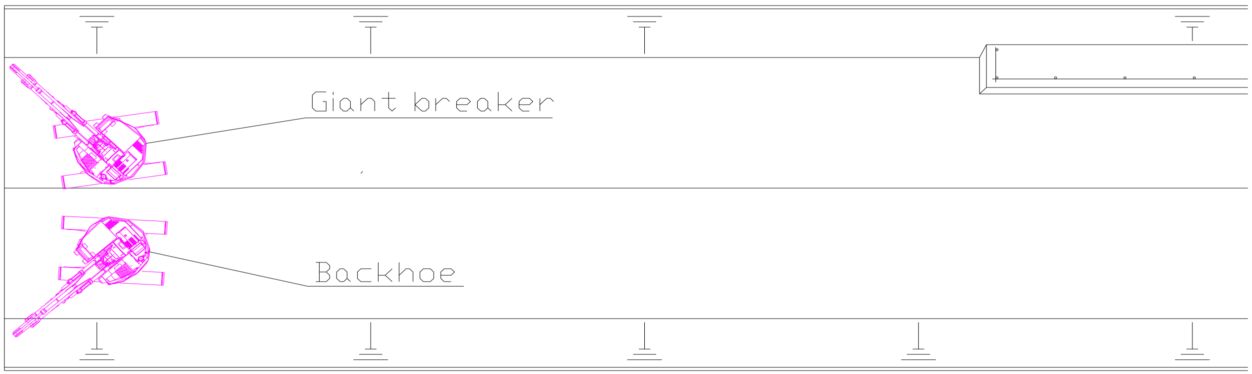
Hauling

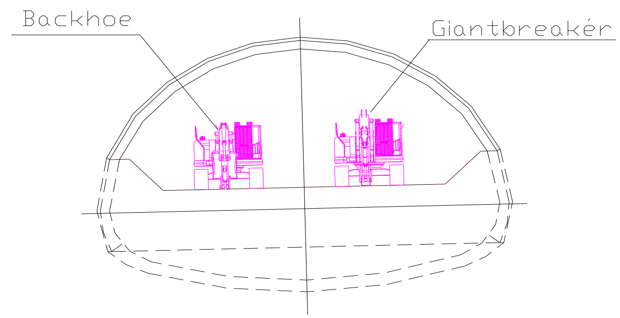
Loading blasted material (rock)

Hauling blasted material (Rock)

Excavation (Step-3)

C. Scaling



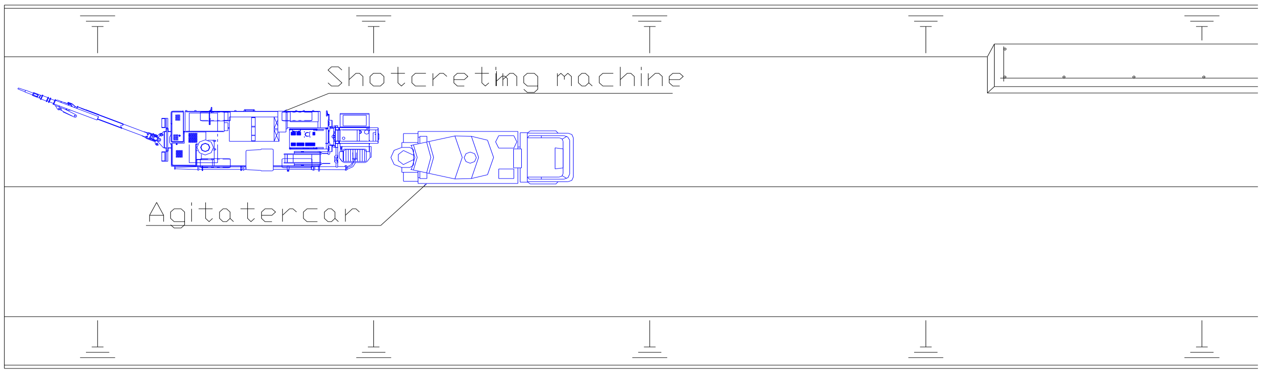


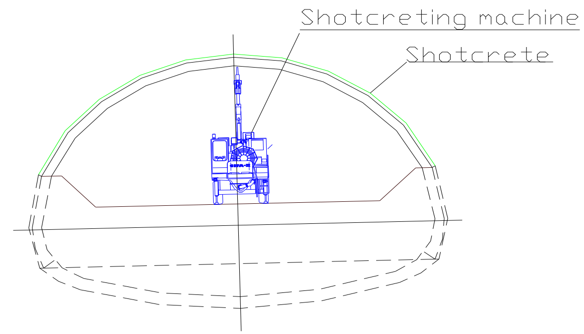
6.Scaling by Giant-breaker and Backhoe

Scaling

Excavation (Step-4)

D. Shotcreting

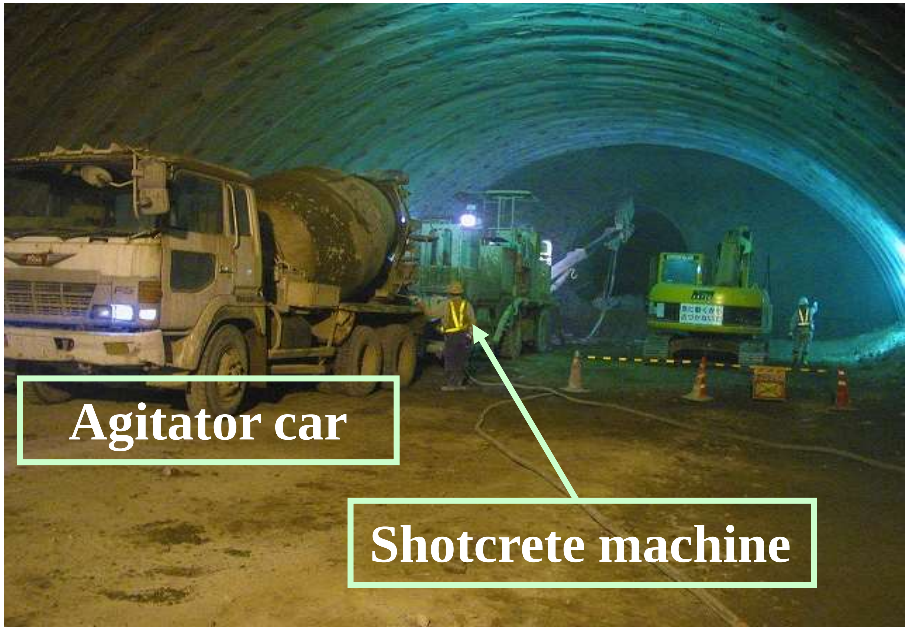


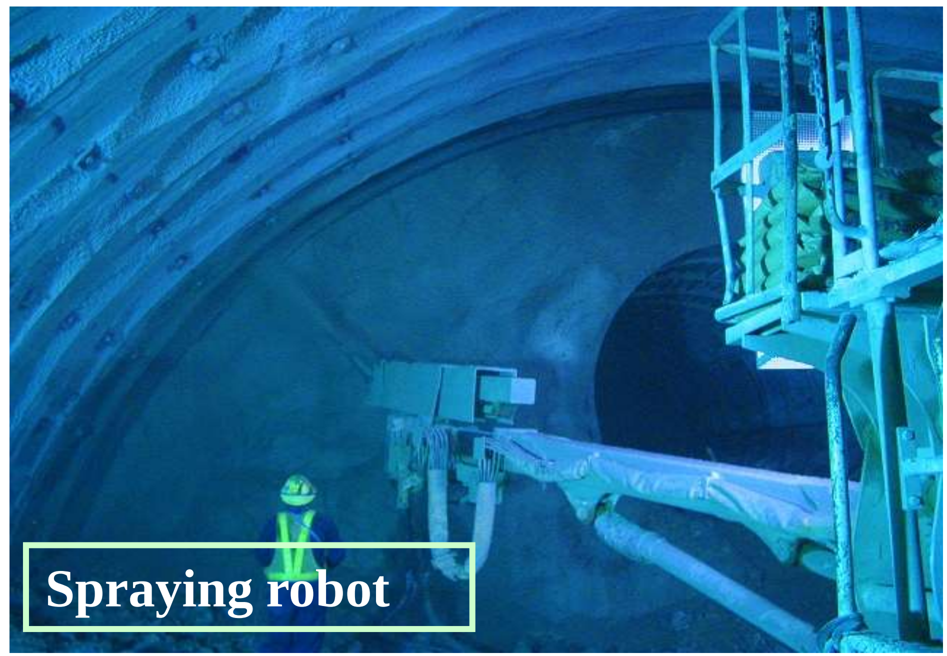


7.Shotcreting with Wiremesh (if necessary) by Shotcrete machine and Spraying Robot

8.Shotcrete material transported by Agitator car from Concrete plant

Shotcreting

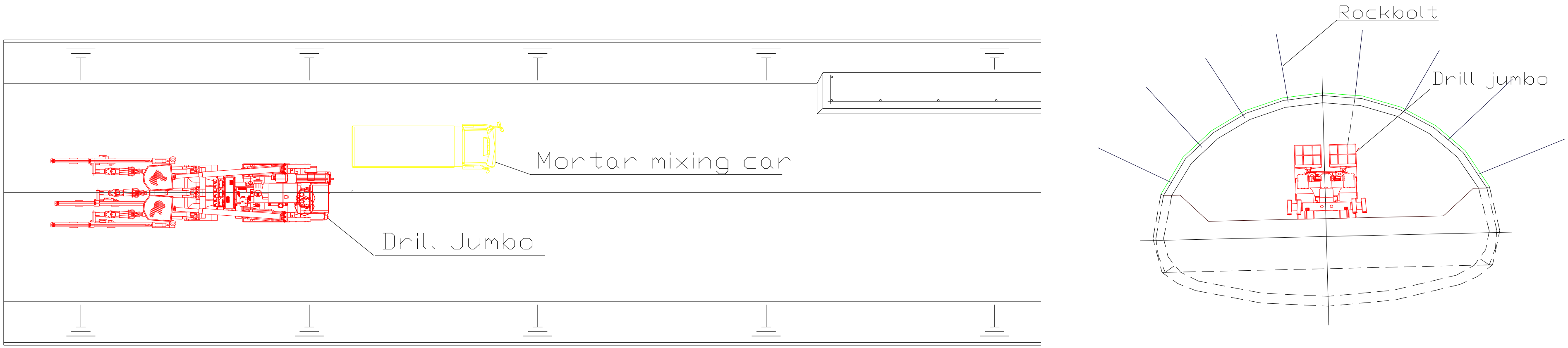




Shotcrete

Sequence of Tunnel Excavation (Step-5)

F. Rockbolting

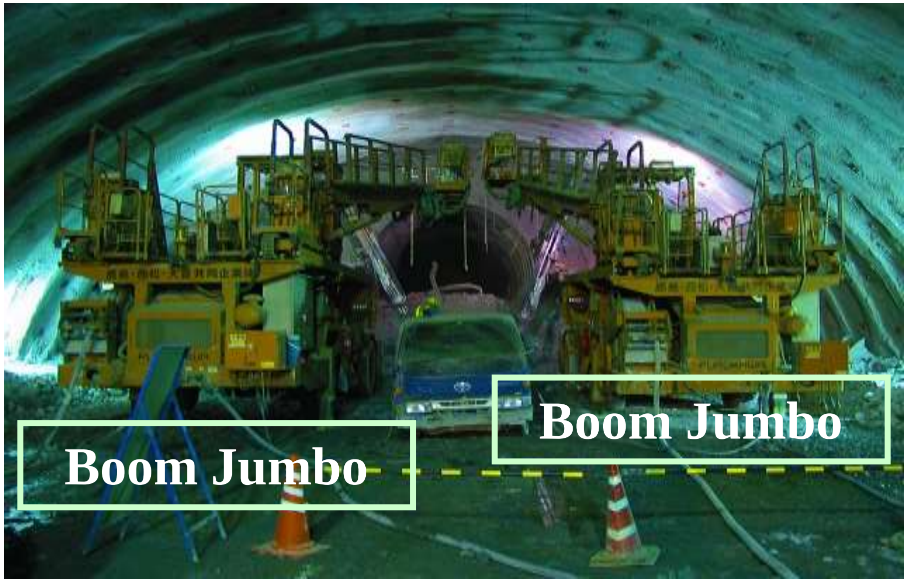


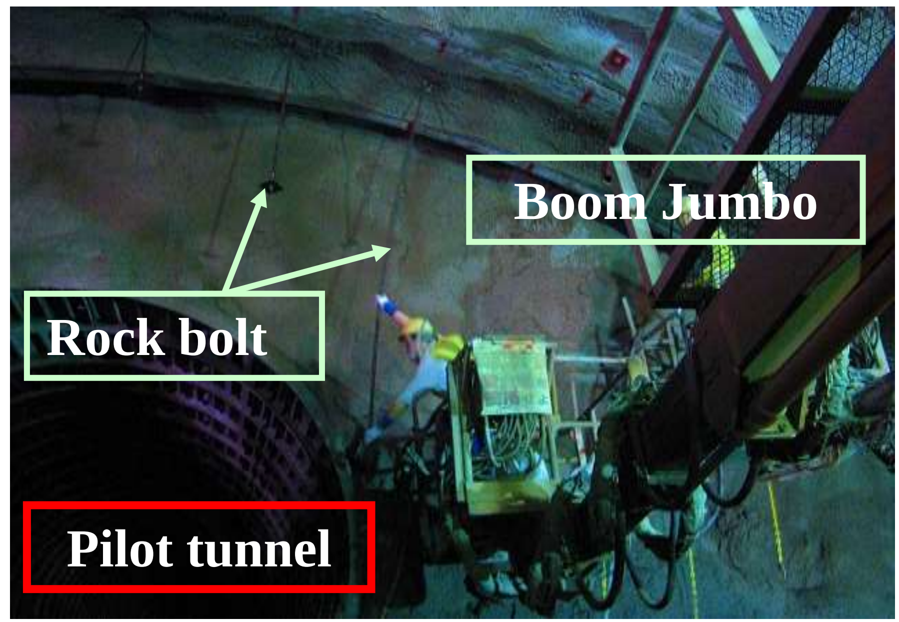
10. Drilling of Rockbolt hole by Jumbo (3B)

11. Charging of mortar in the hole and installing of Rock bolt

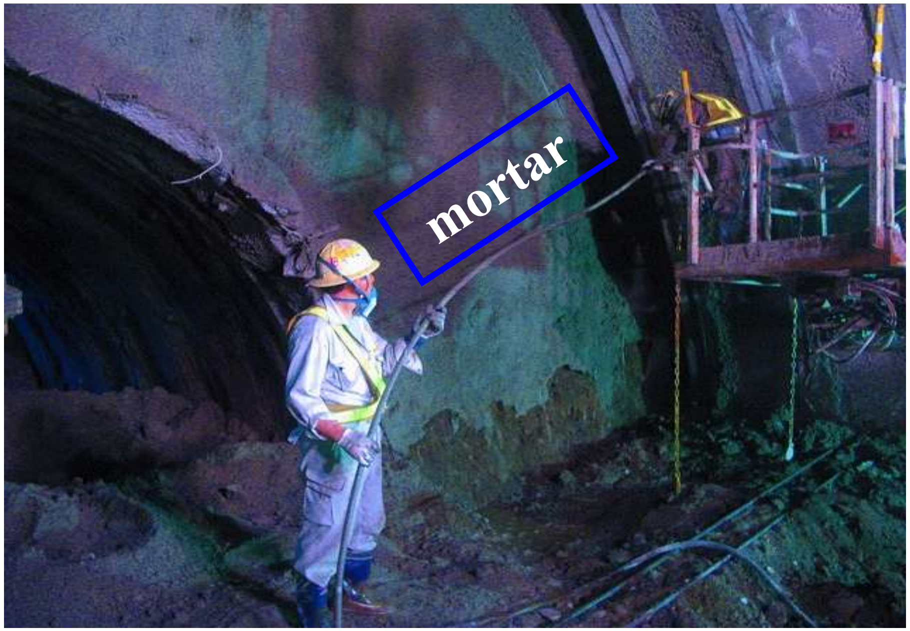
Drilling of Rockbolt hole

Installation of Rock bolt

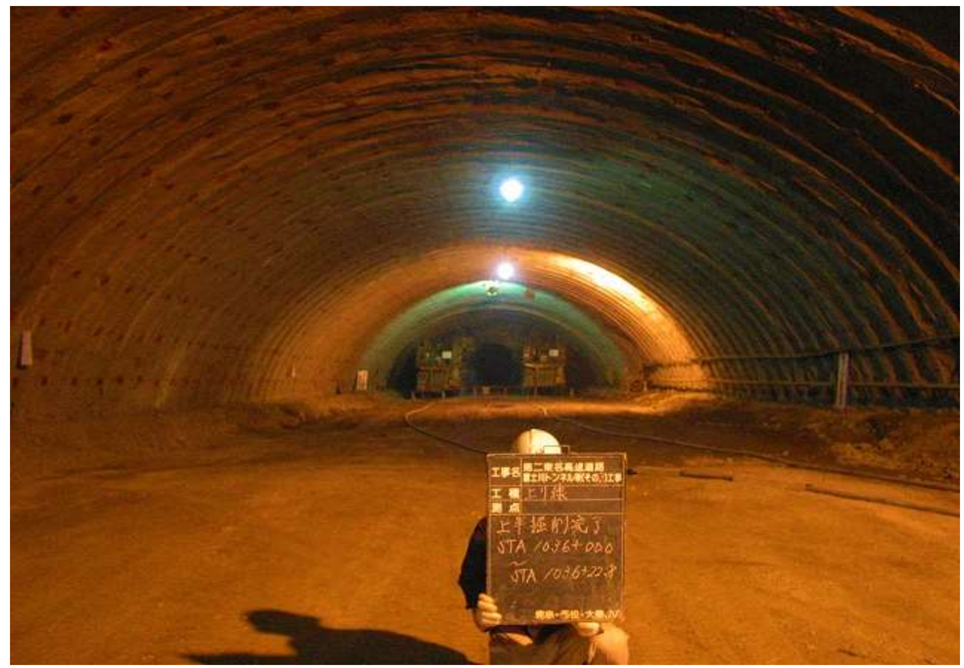




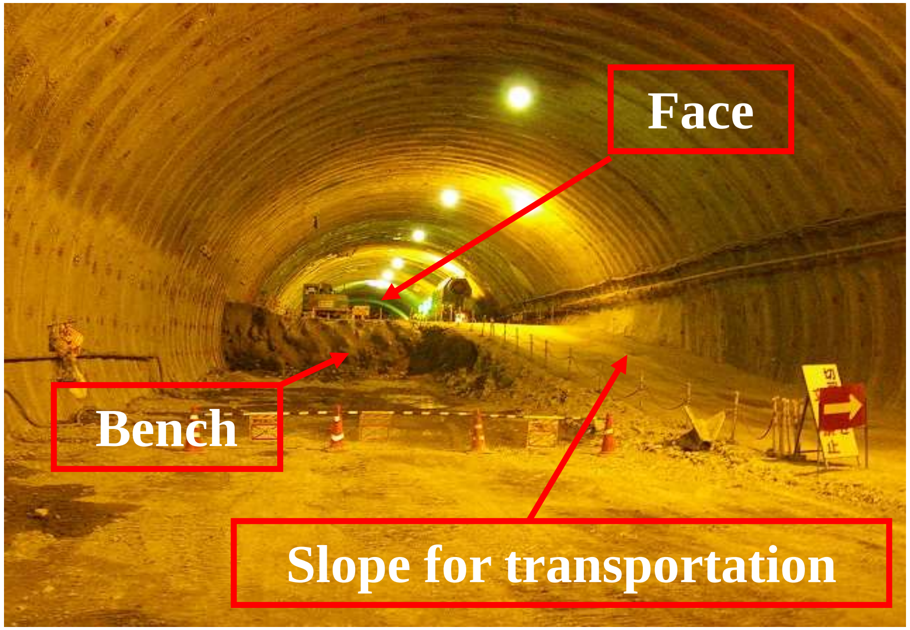
Injection of Mortar, Completion of upper half section



Completion of Upper half section



Lower half Section



Invert: Excavation

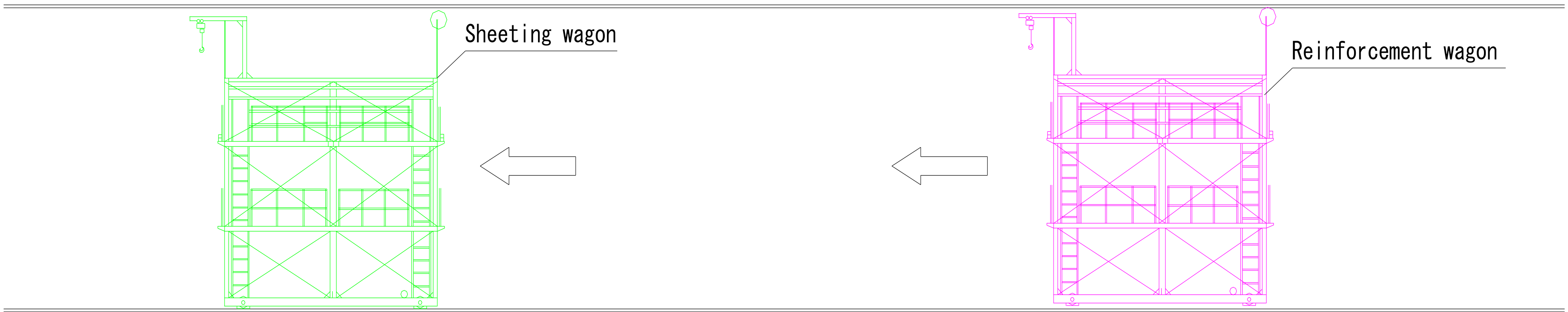
Invert

Reinforcement bar

Concrete placing

Sequence of Tunnel Lining (Step-1)

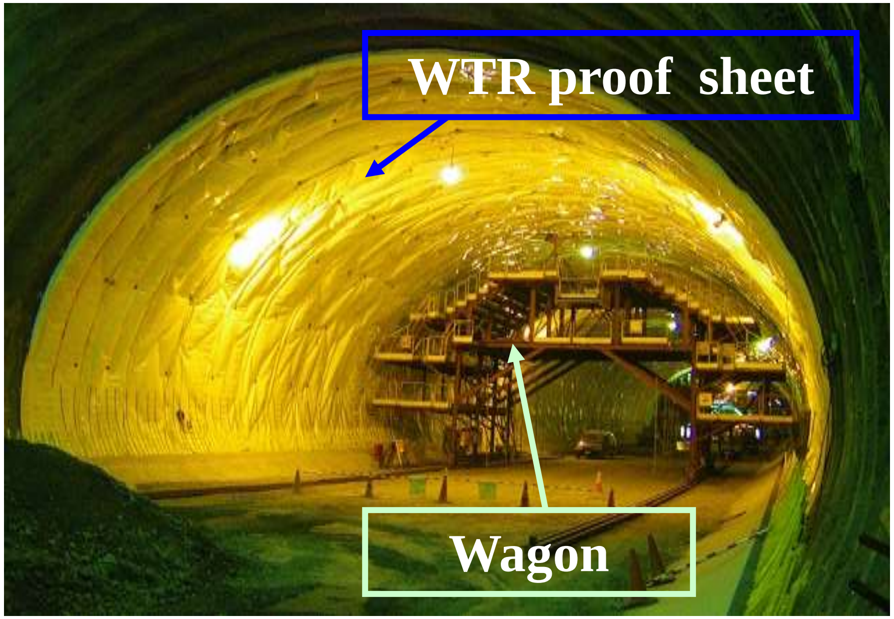
A. Sheeting and Reinforcement



1.Installation of Waterproof sheet on wagon

2.Installation of Reinforcement bar on wagon

Sheeting and Reinforcement



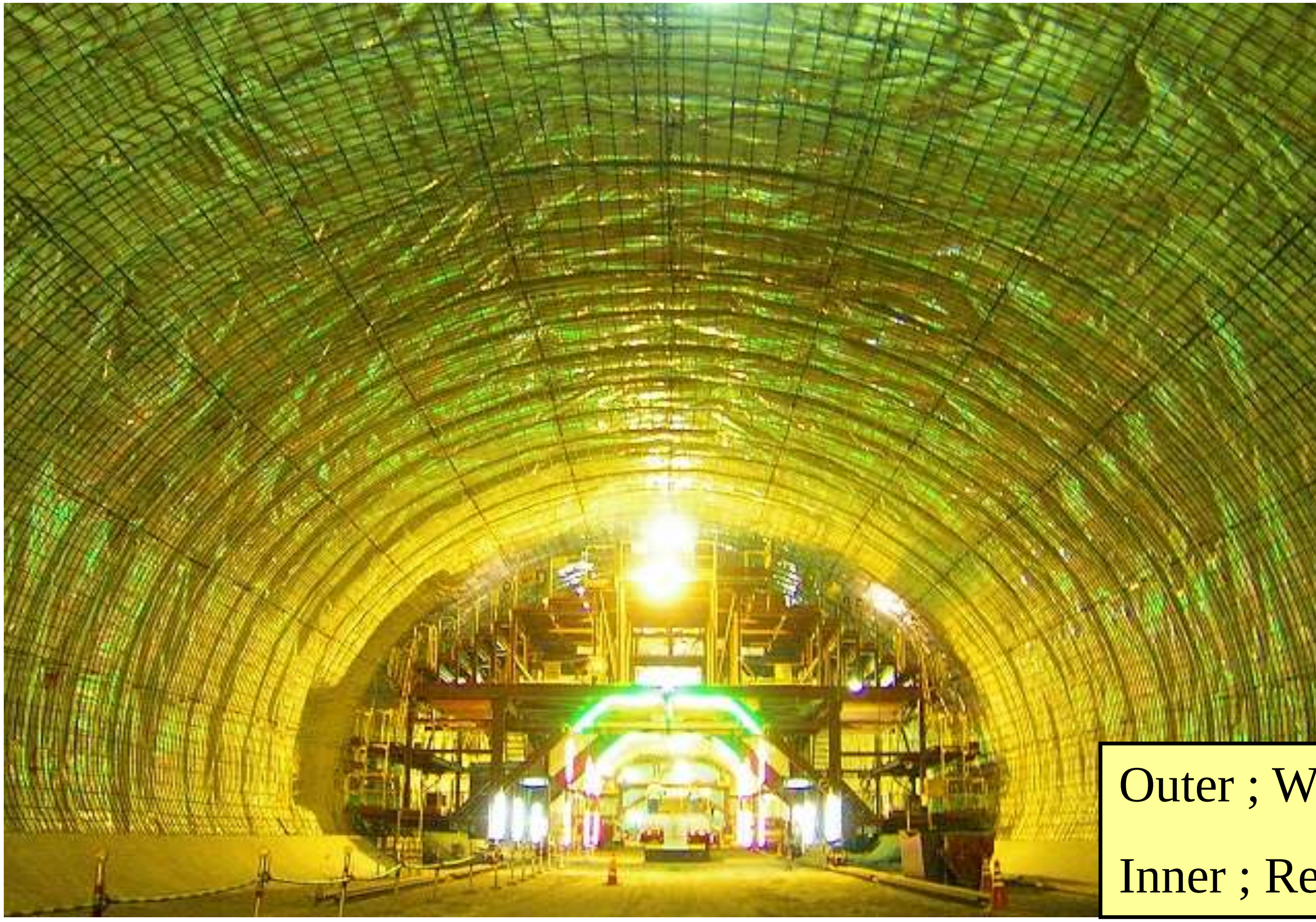
Installation of dewatering sheet

Installation of reinforcement bar

Outer ; WTR proof sheet

Inner ; Reinforcement bar

Installation of reinforcement bar

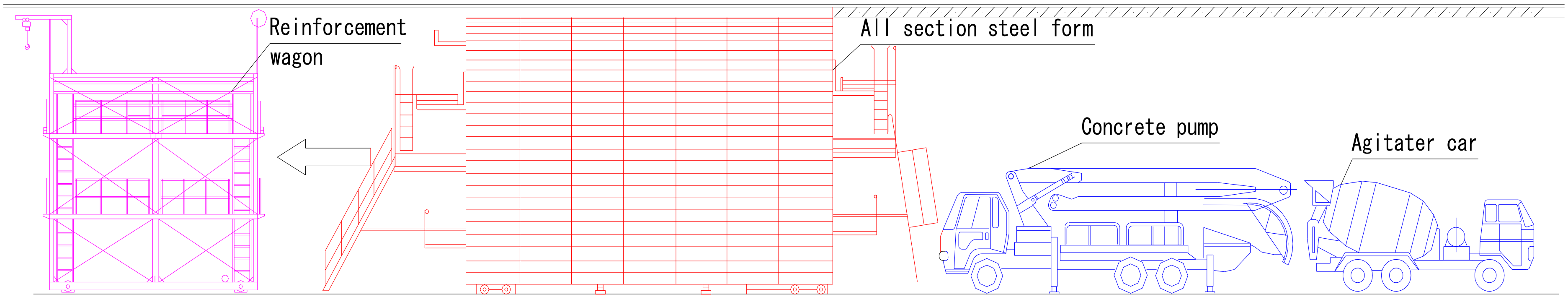


Outer ; WTR proof sheet

Inner ; Reinforcement bar

Sequence of Tunnel Lining (Step-2)

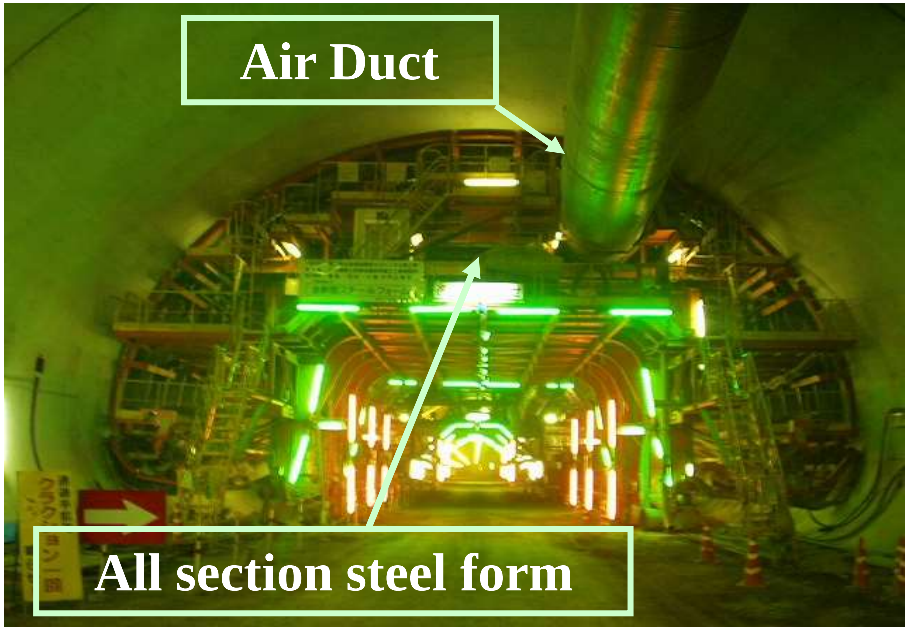
B. Concrete lining



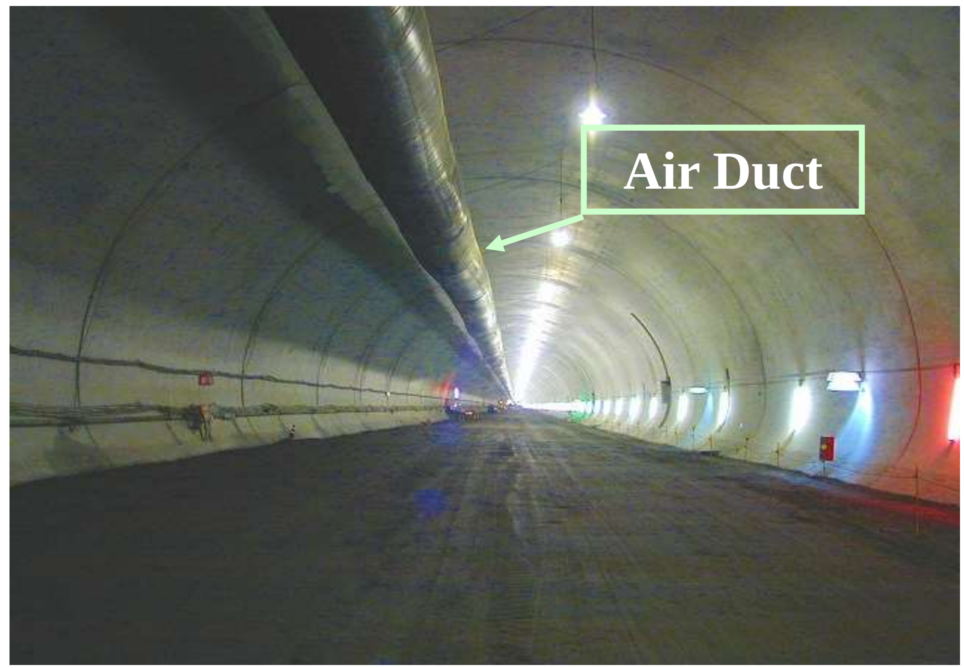
3.After the installation of sheet and reinforcement bars, “All section steel form” is moved and set for placing concrete.

4.Concrete is transported by Agitator car and placed by a concrete pump.

Concrete Lining, Completion of Concrete lining



Completion of Concrete lining



Advantages and Disadvantages of NATM

Advantages

Eliminates the need for using some expensive TBM equipment during excavation.

Suitable for a wide range of geometry (shafts, junctions, non-circular tunnels and tunnels with variable shapes)

Disadvantages

Its suitability diminishes in softer ground, which can subside when excavated.

Not suitable below water table in highly permeable soils.

Main characteristics

Tunnel Lining – Sprayed Concrete.

Typical Performance – 1m to 3m per day. Actual performance and costs will depend on ground conditions and tunnel diameter.

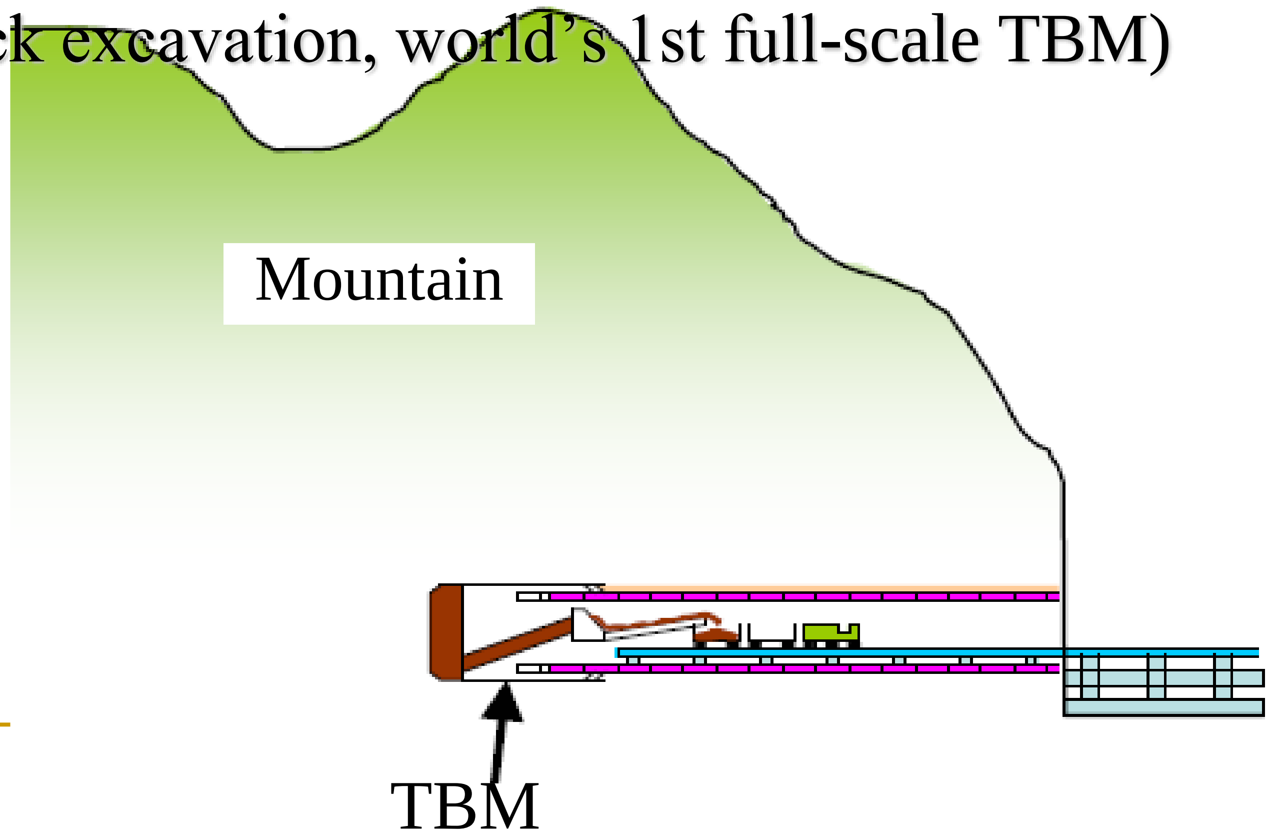
TBM Method

For Mountain Tunnel

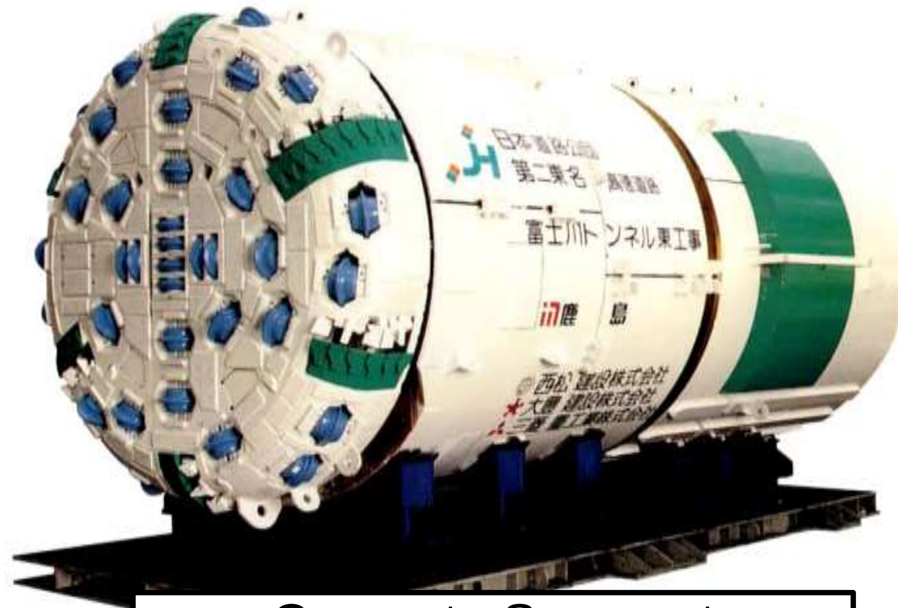
Tunnel **B**oring **M**achine Methods

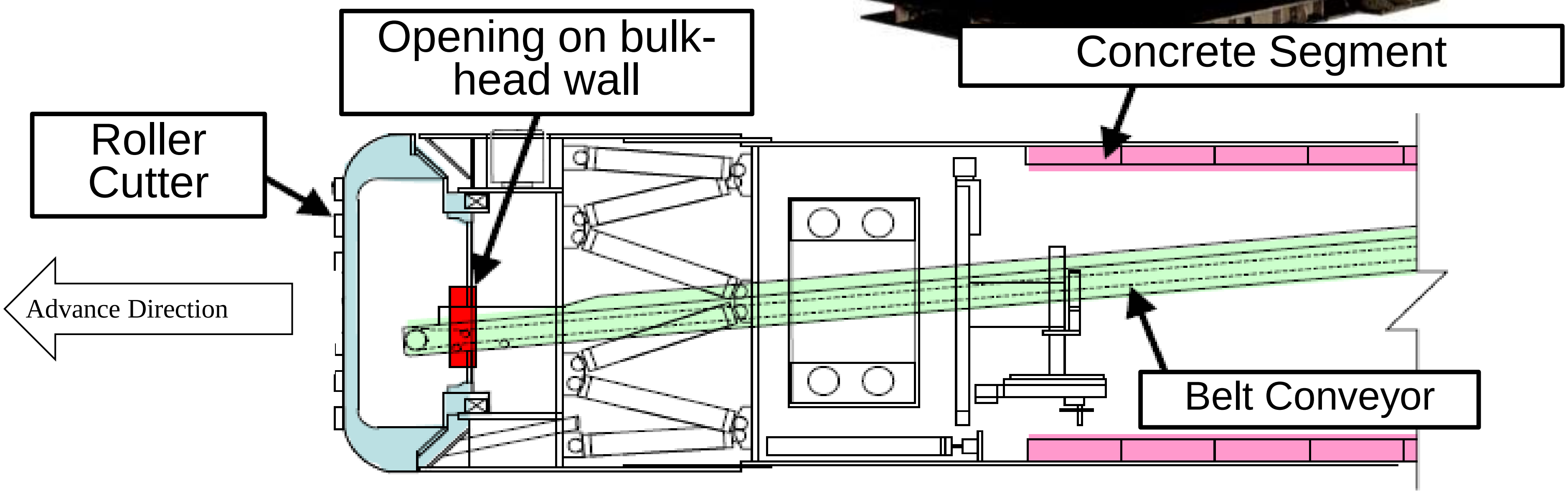
TBM

- 1851 Charles Wilson (US) developed a tunnel drilling machine for rock excavation
- 1850's through 1940's Succession of trials and errors
- 1956 Robbins Company built a roller cutter TBM (success in hard rock excavation, world's 1st full-scale TBM)



TBM





Profile of TBM

Way to Advance

To extend main reaction gripers
and anchor them into mountain rock

↓

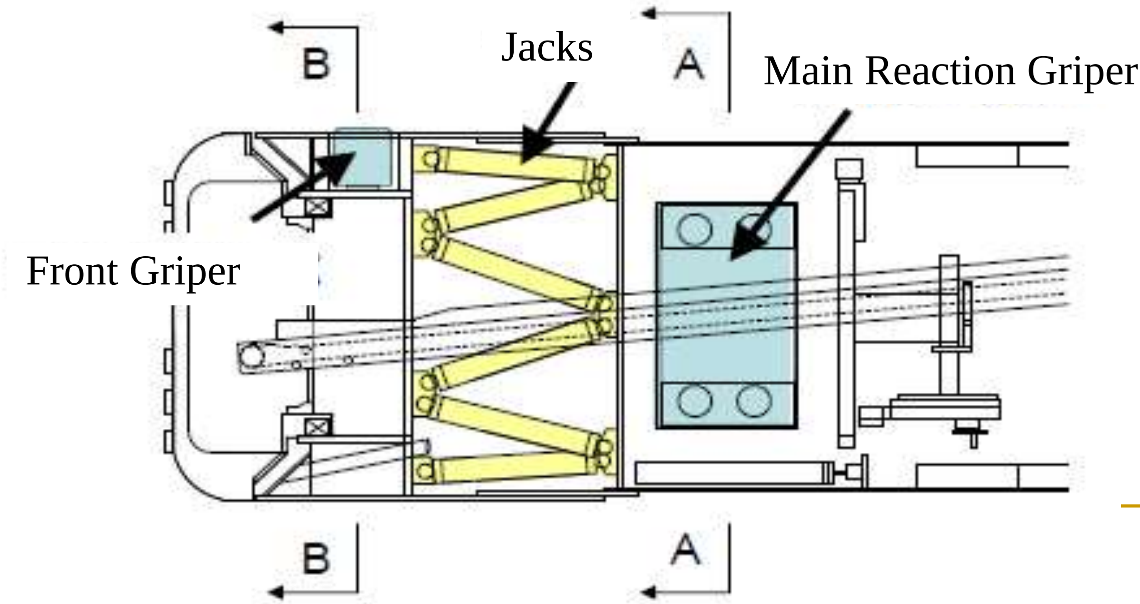
To extend jacks / advance TBM

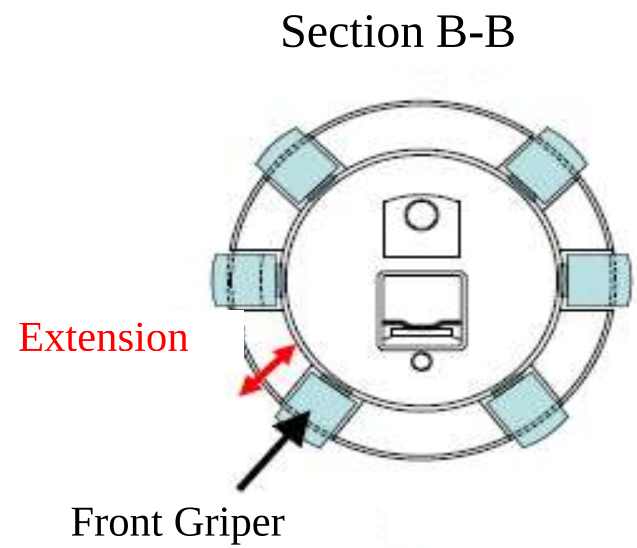
↓

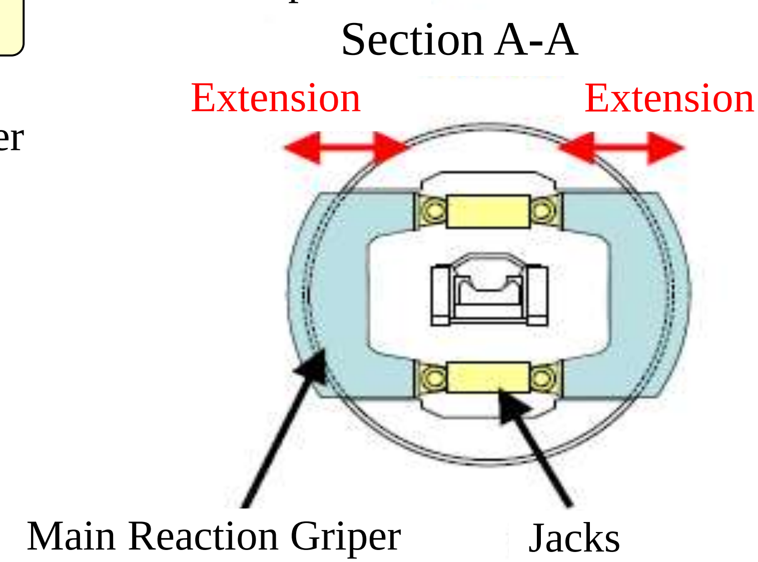
To extend front gripers
and anchor them into mountain rock

↓

To retract jacks







Advantages and Disadvantage of TBM

- *Advantages*

  1. Rapid construction (average 500m/month)

  2. Smooth excavation wall surface

     (less overbreak $\rightarrow$ less damage to the ground)

- *Disadvantages*

  1. Limited to circular section with constraints in diameter

  2. High priced machinery costs

  3. Only applicable to the limited geological conditions

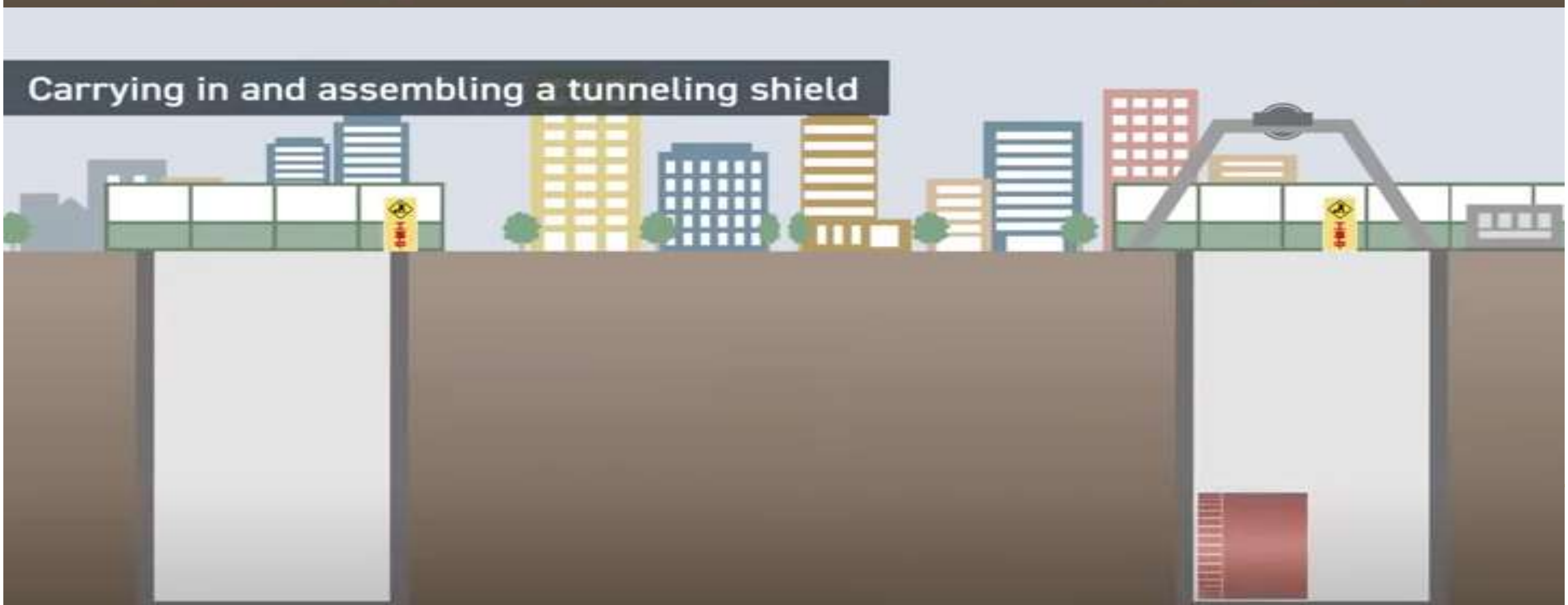
the selection of TBM to match rock conditions

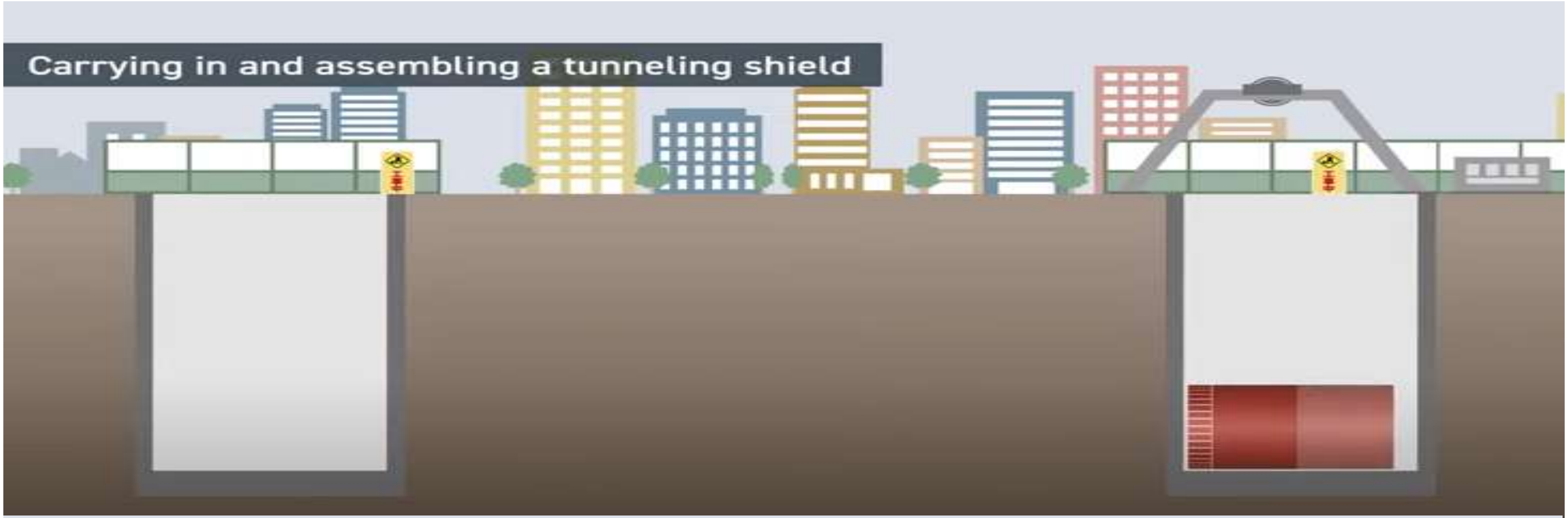
Shield Tunnels

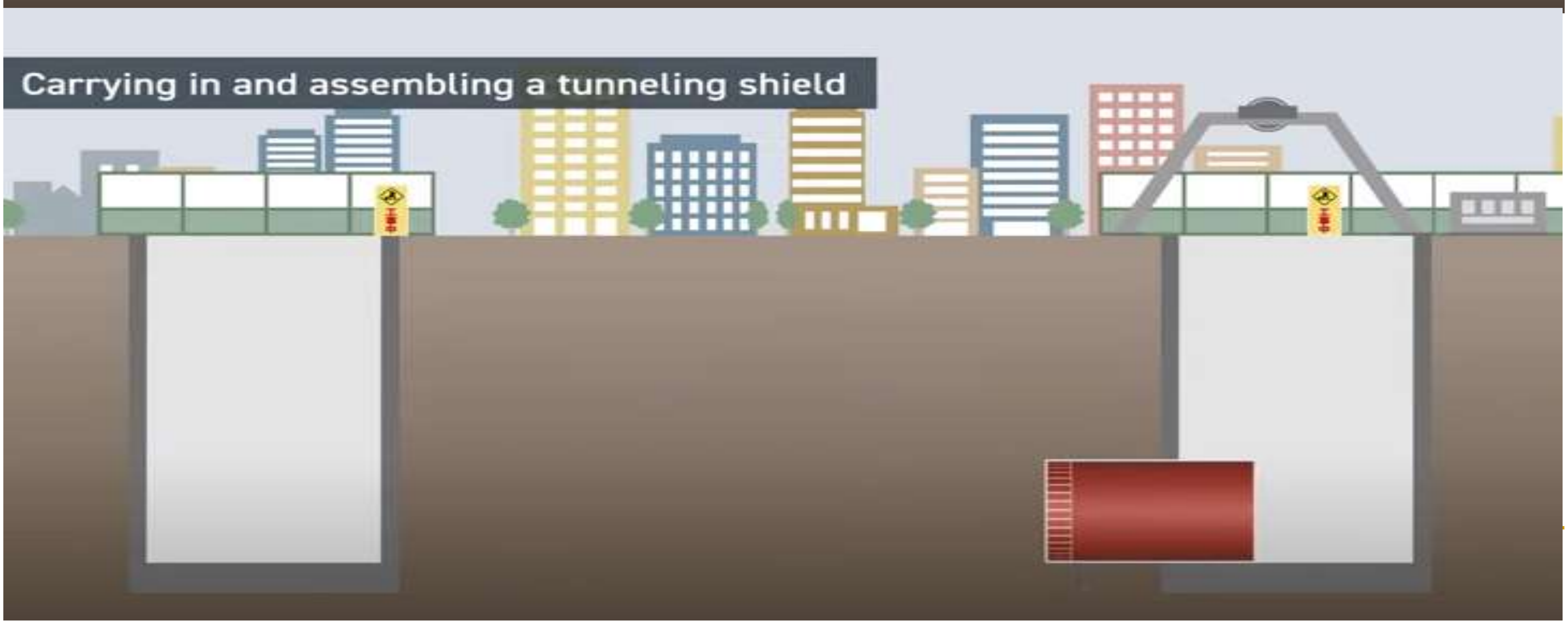
- Normally for Soft Ground Excavation by Shield Machine

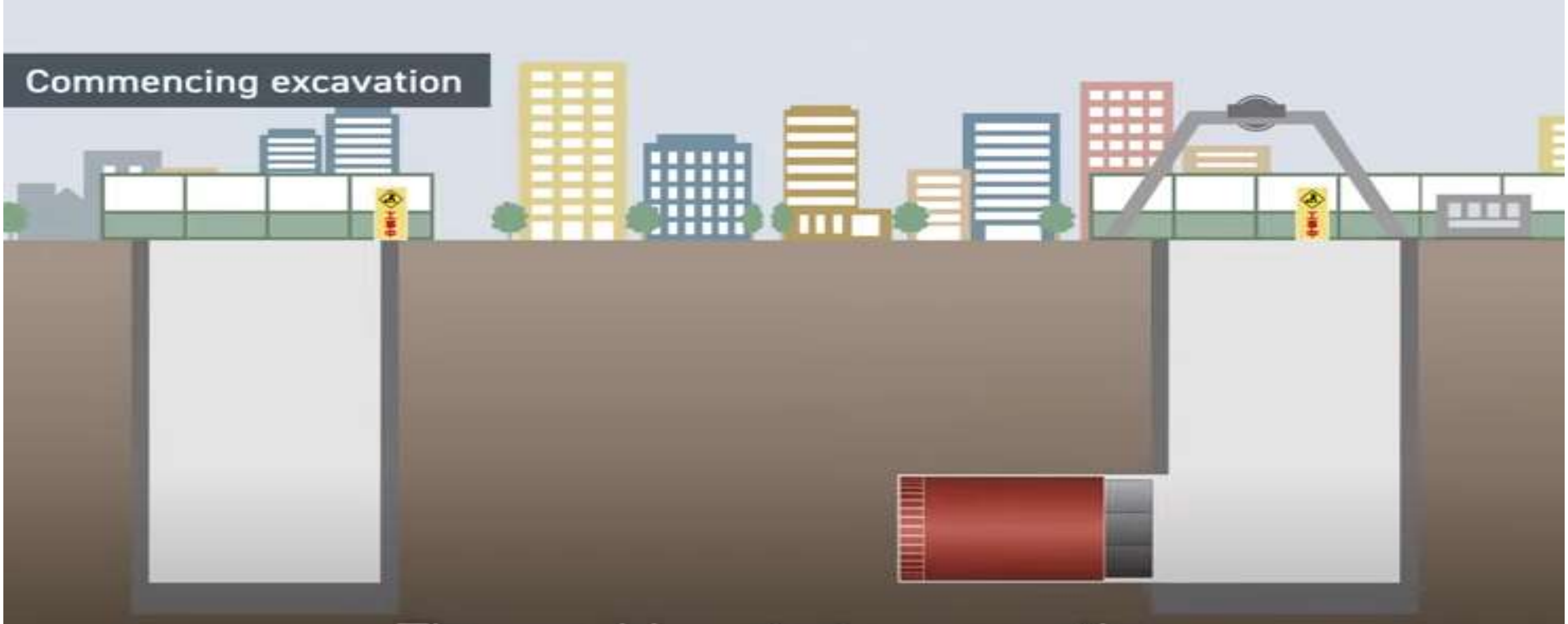
Excavator shield tunneling is a trenchless method used for larger diameter utility and crossing tunnels. This specialized form of tunneling includes a steerable forward shield with a hood that extends beyond the excavating face for ground stabilization.

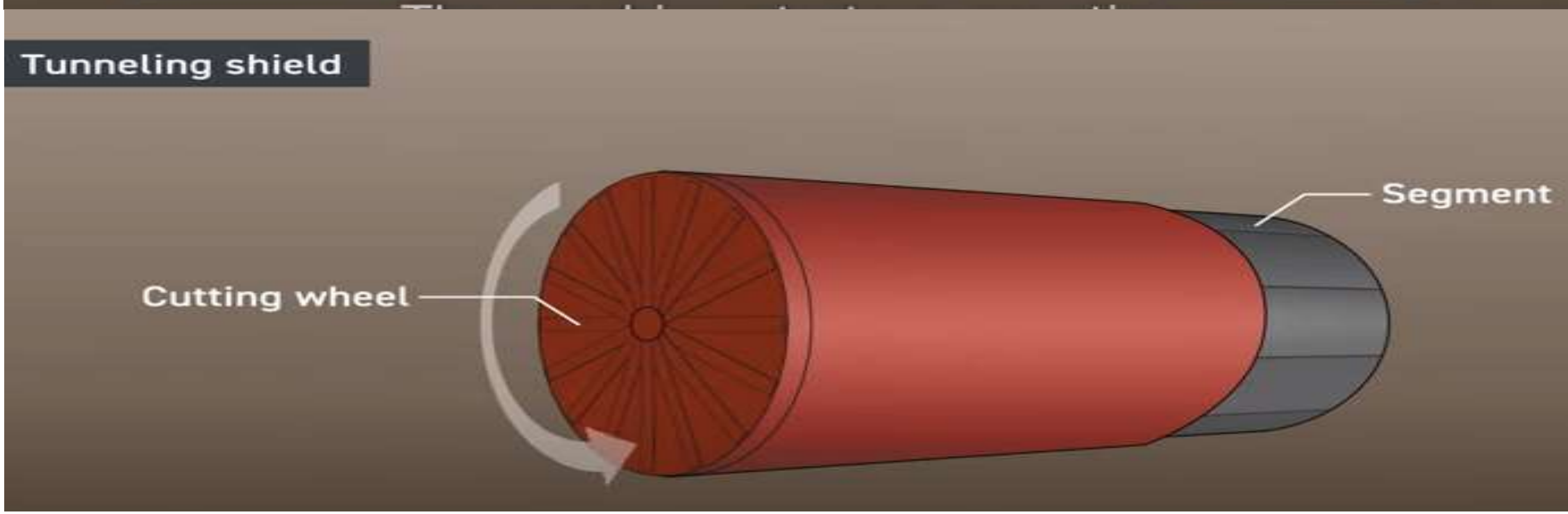

Drilling a vertical pit

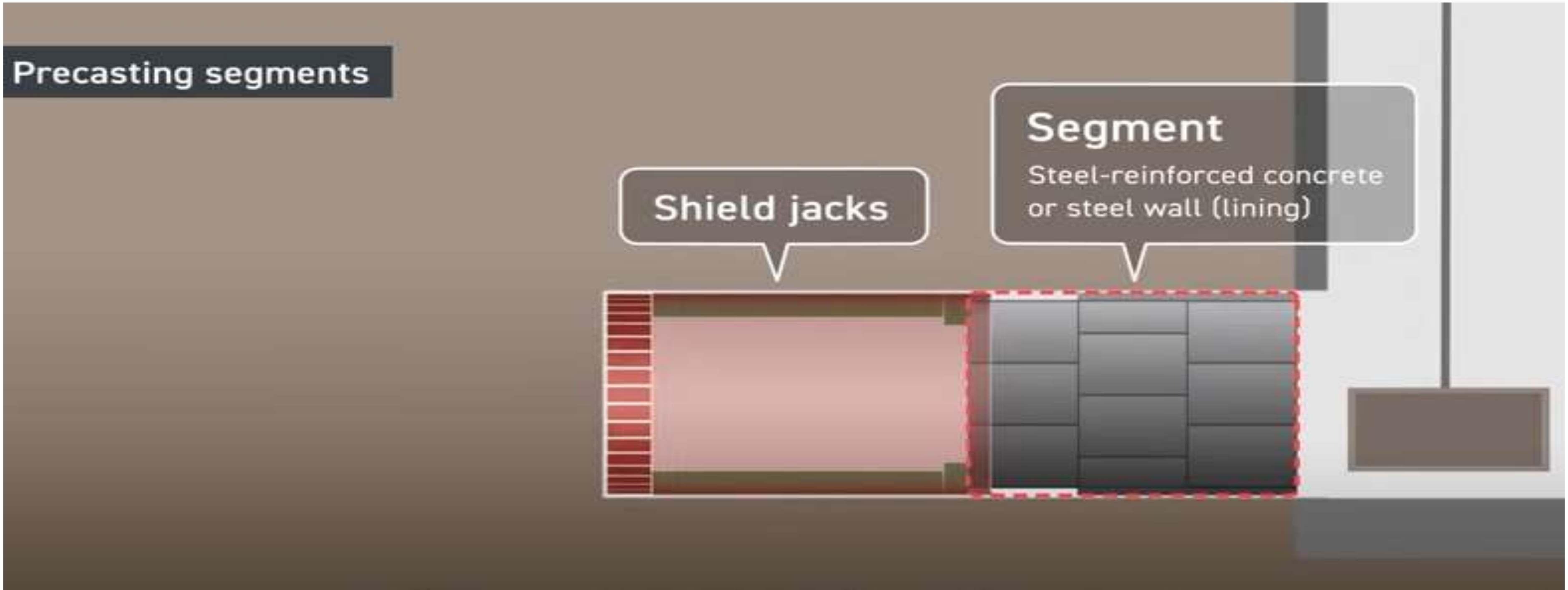

Carrying in and assembling a tunneling shield

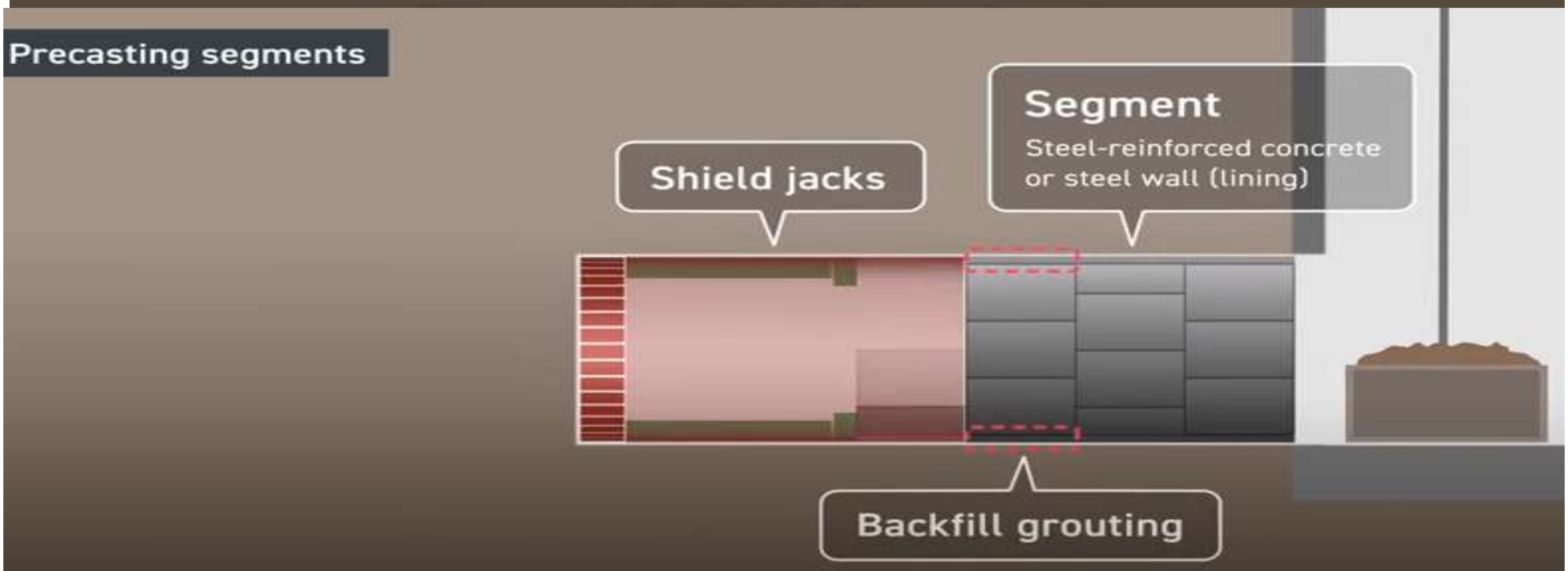

Carrying in and assembling a tunneling shield

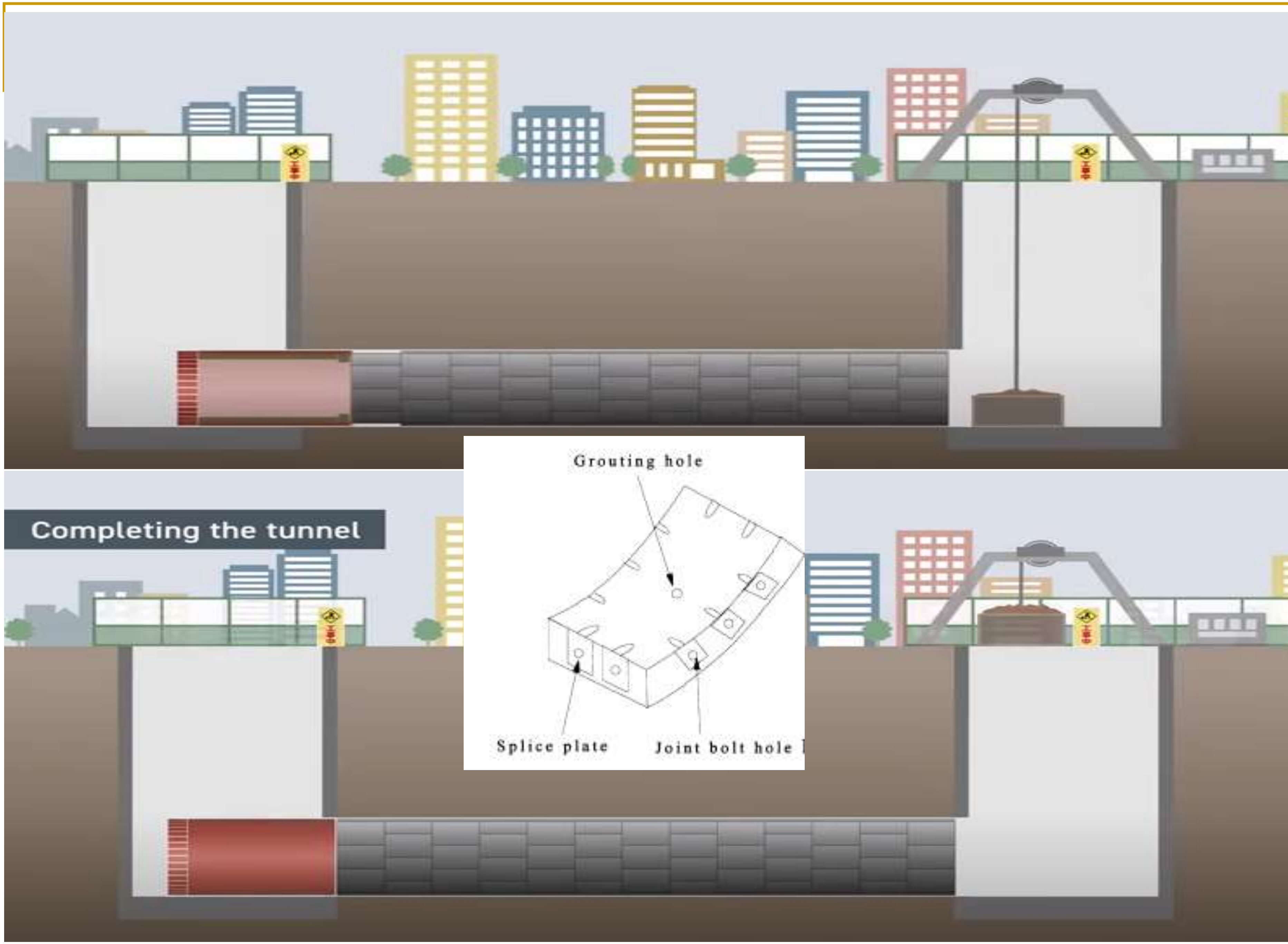

Carrying in and assembling a tunneling shield

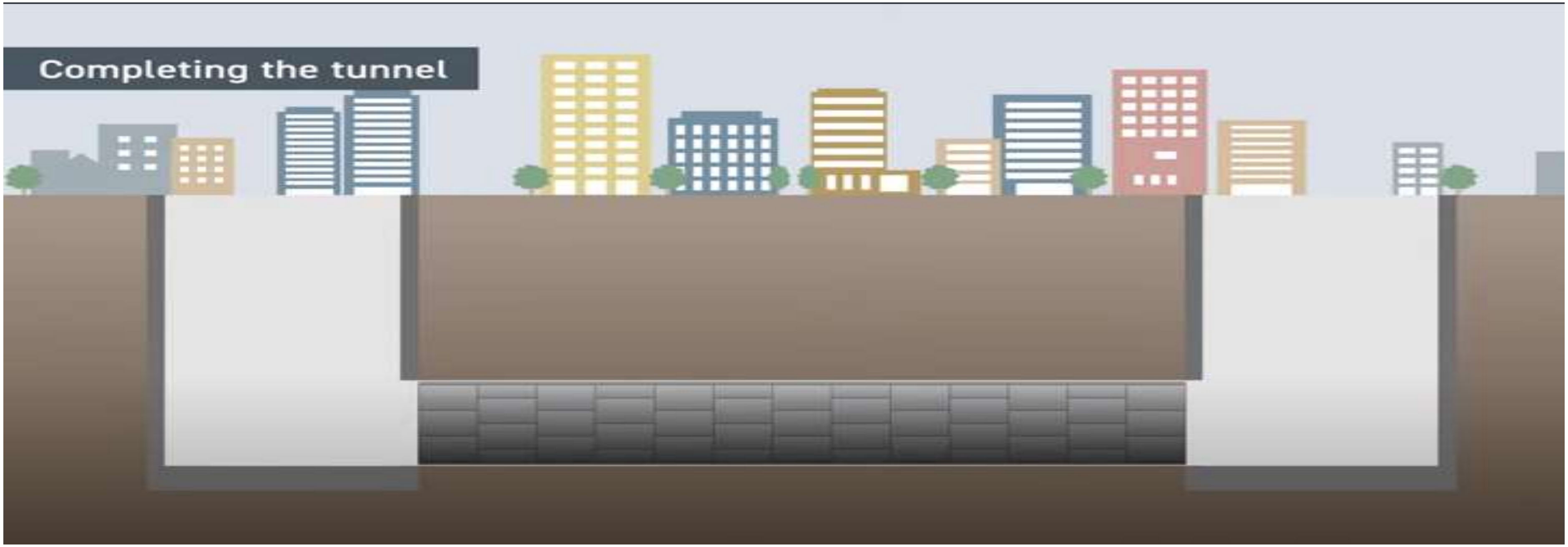

Commencing excavation

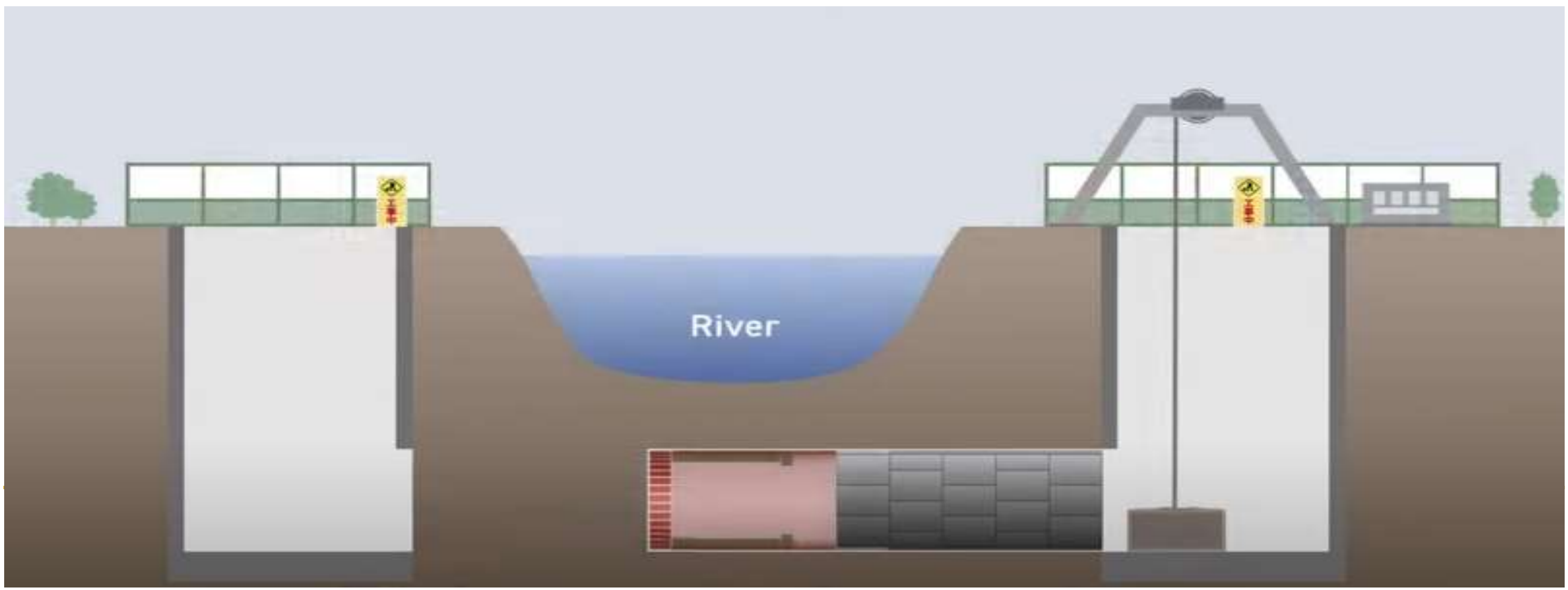

Tunneling shield
Segment
Cutting wheel


Precasting segments
Shield jacks
Segment
Steel-reinforced concrete
or steel wall (lining)


Precasting segments
Shield jacks
Segment
Steel-reinforced concrete
or steel wall (lining)
Backfill grouting


Grouting hole
Splice plate
Joint bolt hole
Completing the tunnel


Completing the tunnel


River

SUBWAY TBM

Advantages and disadvantages of Shield Tunneling Method

Advantages

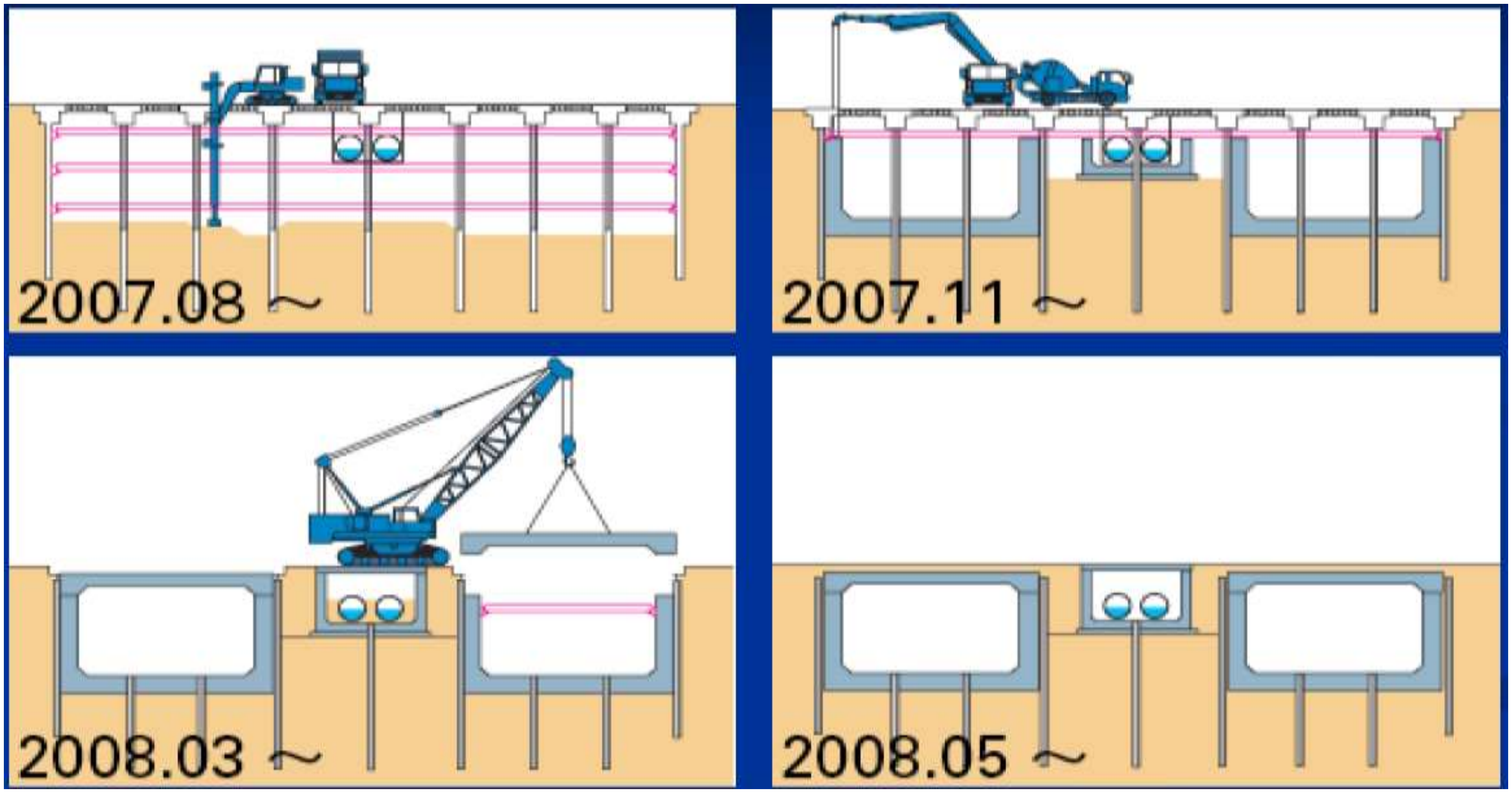
1) Economical and better quality control
2) Time of completion is less
3) Saving in manpower & Machinery
4) No involvement of crane and heavy equipment
5) Less involvement of other department

Disadvantages

1) Needs trained staff and skilled supervision
2) Imposition of caution order exists for long period
3) Once the vertical & the lateral alignment of m/c disturbed, it become almost impossible to rectify it.

Cut and Cover Tunnel

- Underpass in Sapporo City Center



Advantages and disadvantages of Cut & Cover Tunneling Method

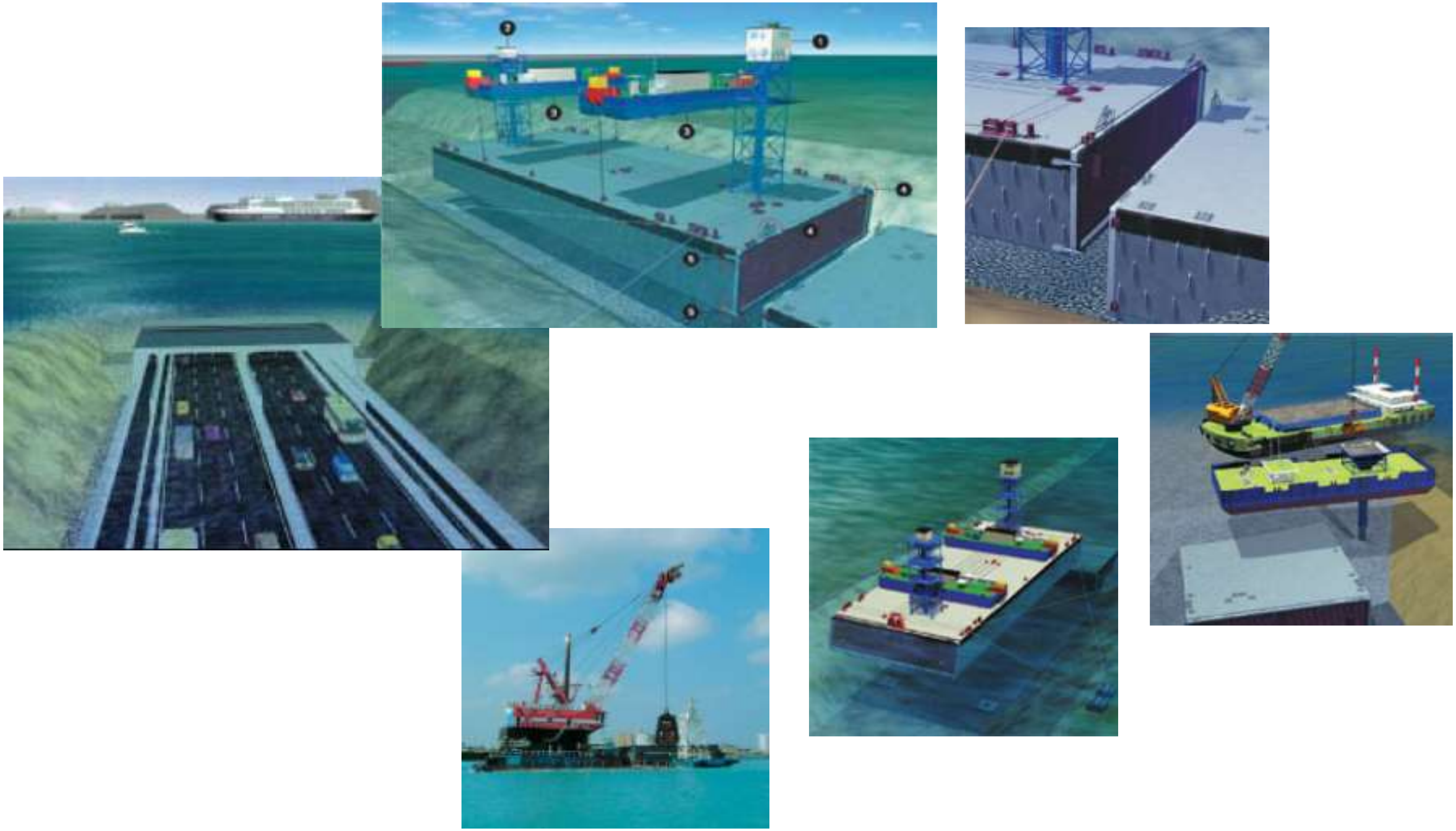
Advantages

1) The Construction duration is shorter because of shift work
2) The depth is less than one and a half of tunnel height
3) The shallow overburden
4) Good for Subway Station Construction

Disadvantages

1) Urban Area Surface interruptions,
2) Restrictions with the alignment
3) Direct and Indirect Construction Cost is higher
4) Construction risk for utility relocation and reinstatement of the surface
5) Higher demand of Reinforcement, Excavation and Backfill material
6) Suitable for shallow overburden only

Immersed Tunnel



Okinawa Port Tunnel (Okinawa, Japan)

Advantages and disadvantages of Immersed Tunneling Method

Advantages

The main advantage of an immersed tube is that they can be considerably more cost effective than alternative options – i.e., a bored tunnel beneath the water being crossed (if indeed this is possible at all due to other factors such as the geology and seismic activity) or a bridge. Other advantages relative to these alternatives include:

Their speed of construction

Minimal disruption to the river/channel, if crossing a shipping route

Resistance to seismic activity

Safety of construction (for example, work in a dry dock as opposed to boring beneath a river)

Flexibility of profile (although this is often partly dictated by what is possible for the connecting tunnel types)

Disadvantages include:

Immersed tunnels are often partly exposed (usually with some rock armour and natural siltation) on the river/sea bed, risking a sunken ship/anchor strike

Direct contact with water necessitates careful waterproofing design around the joints

The segmental approach requires careful design of the connections, where longitudinal effects and forces must be transferred across

Environmental impact of tube and underwater embankment on existing channel/sea bed.

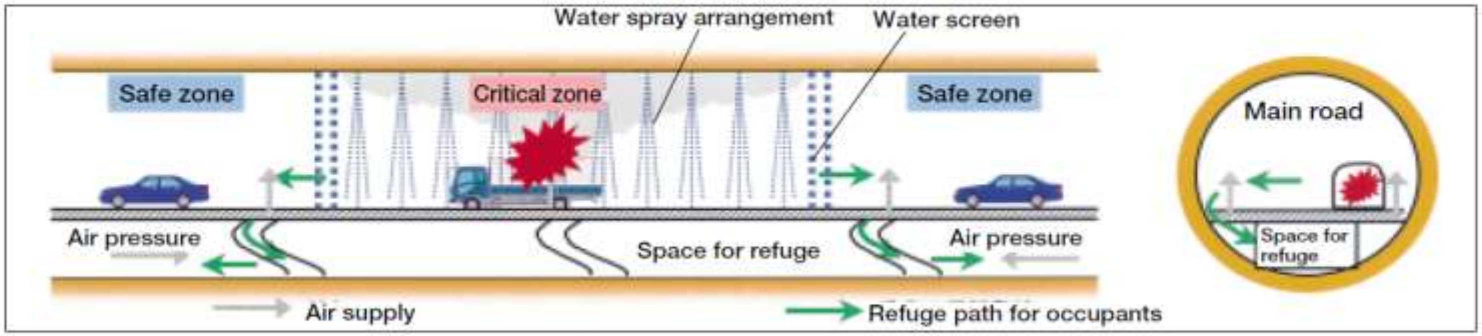
Tubes can be round, oval and rectangular. Larger strait crossings have selected wider rectangular shapes as more cost effective for wider tunnels.

Safety and Environmental Protections

- Countermeasures for tunnel fires
- Evacuation Passenger Path
- Environmental issues

Countermeasures for tunnel fires

- Water Screen System (Kajima)



Fire prevention system in a road tunnel

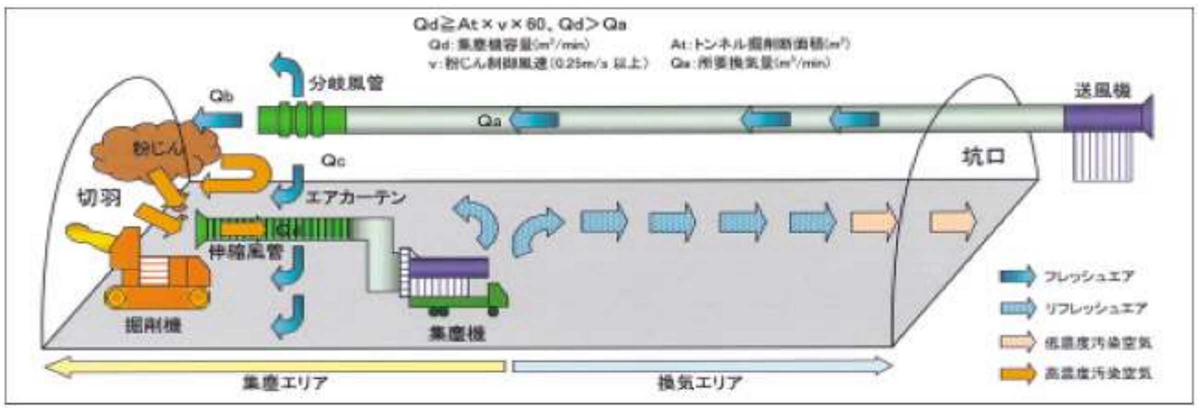
View of the system when applied to a road tunnel

Evacuation Path

- Independent Evacuation Path

Better work environment during construction

- Cooling measures, ventilation, lihghts



Environment outside tunnels

- Ventilation for exhaustion from vehicles

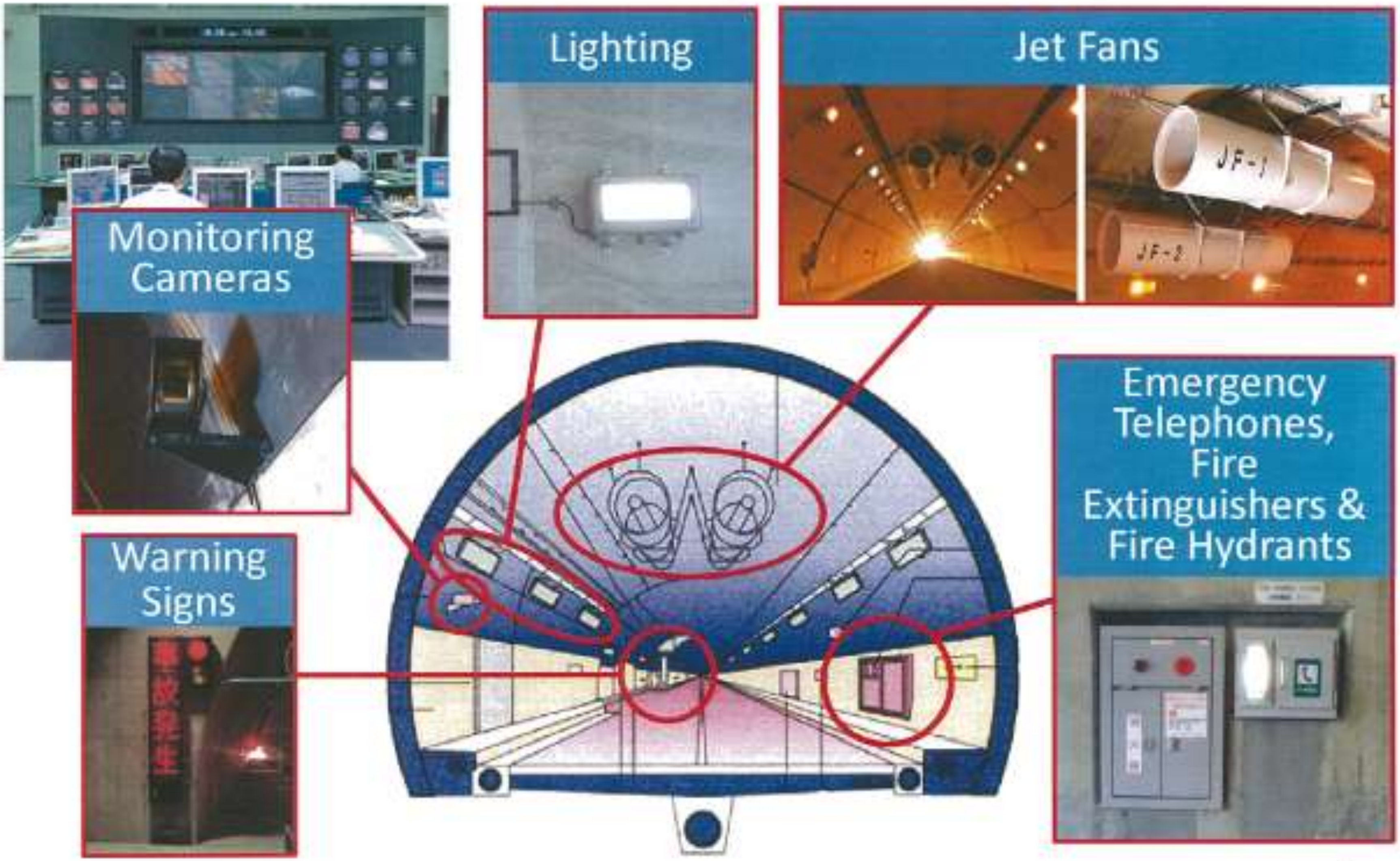
"Kaze-no-tou" (Tower of wind)
(Aqua-line Tunnel, Tokyo)

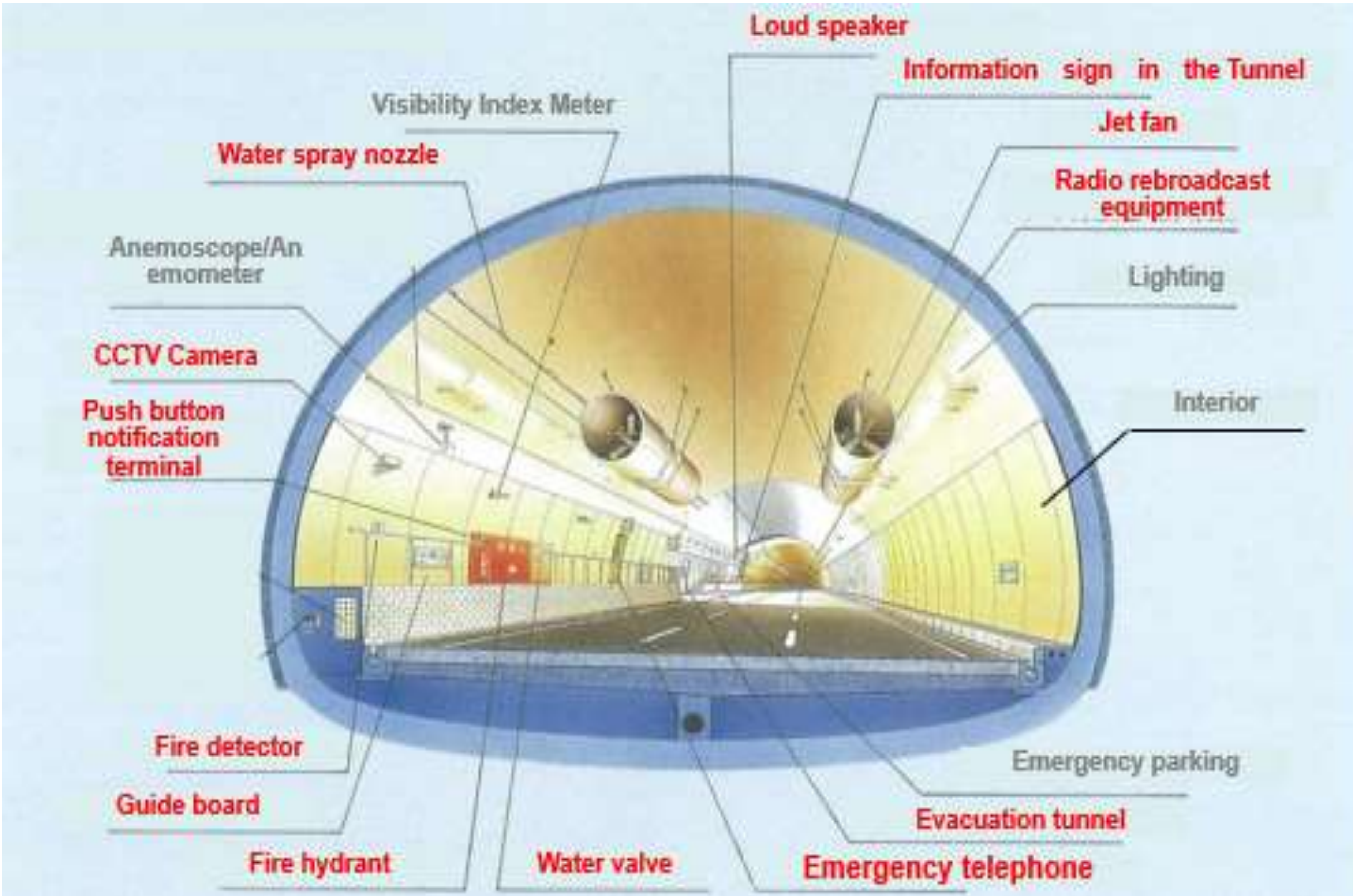
Ventilation Towers
(Metropolitan Highway, Tokyo)

Environment outside tunnels

- Vibration reduction during construction
- Noise reduction during construction
- Waste water treatment during construction

Tunnel Facilities





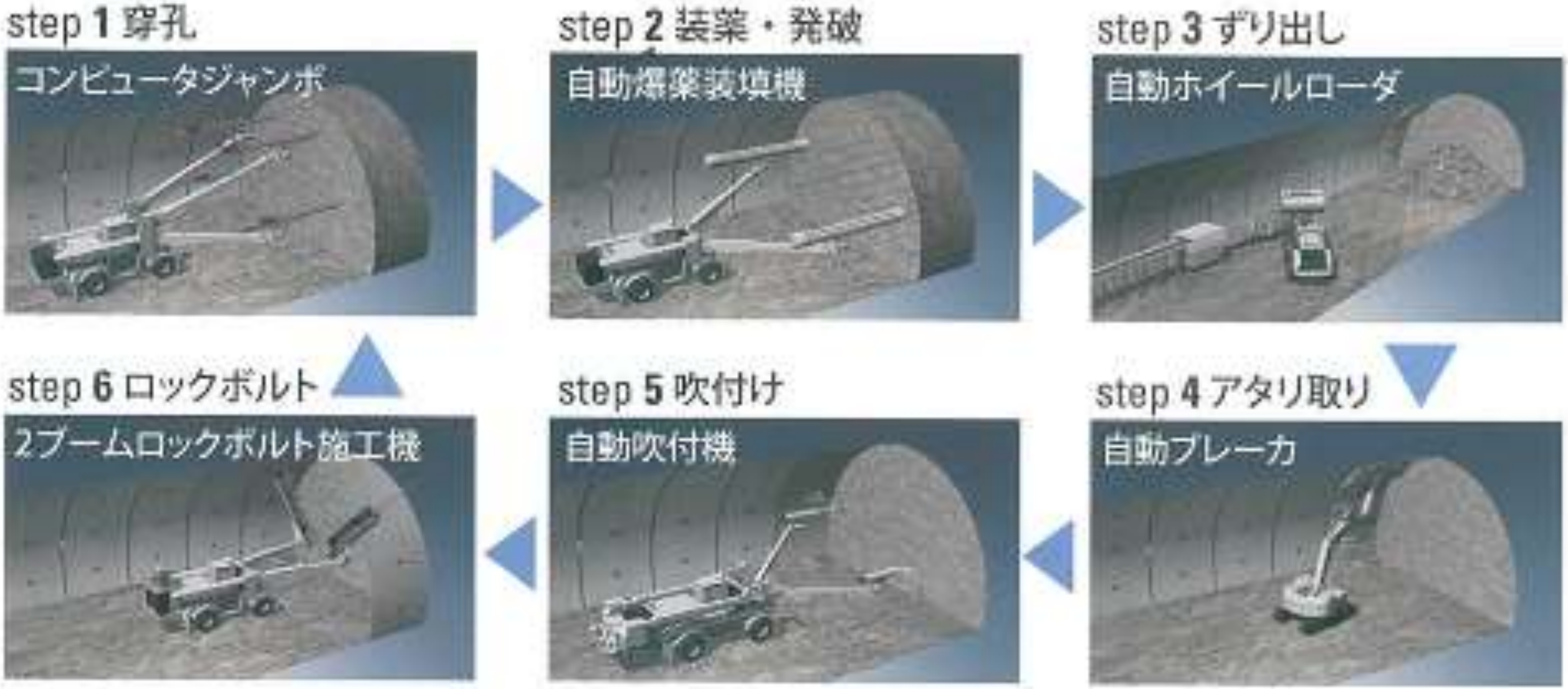
Tunnel Facility

Latest Technology (Ref: KAJIMA CORPORATION, Mar 2024)

Drilling by
by Computer Jumbo

Charging and Blasting
by Auto Explosive Loading M/C

Mucking by Automatic
Wheel Loader

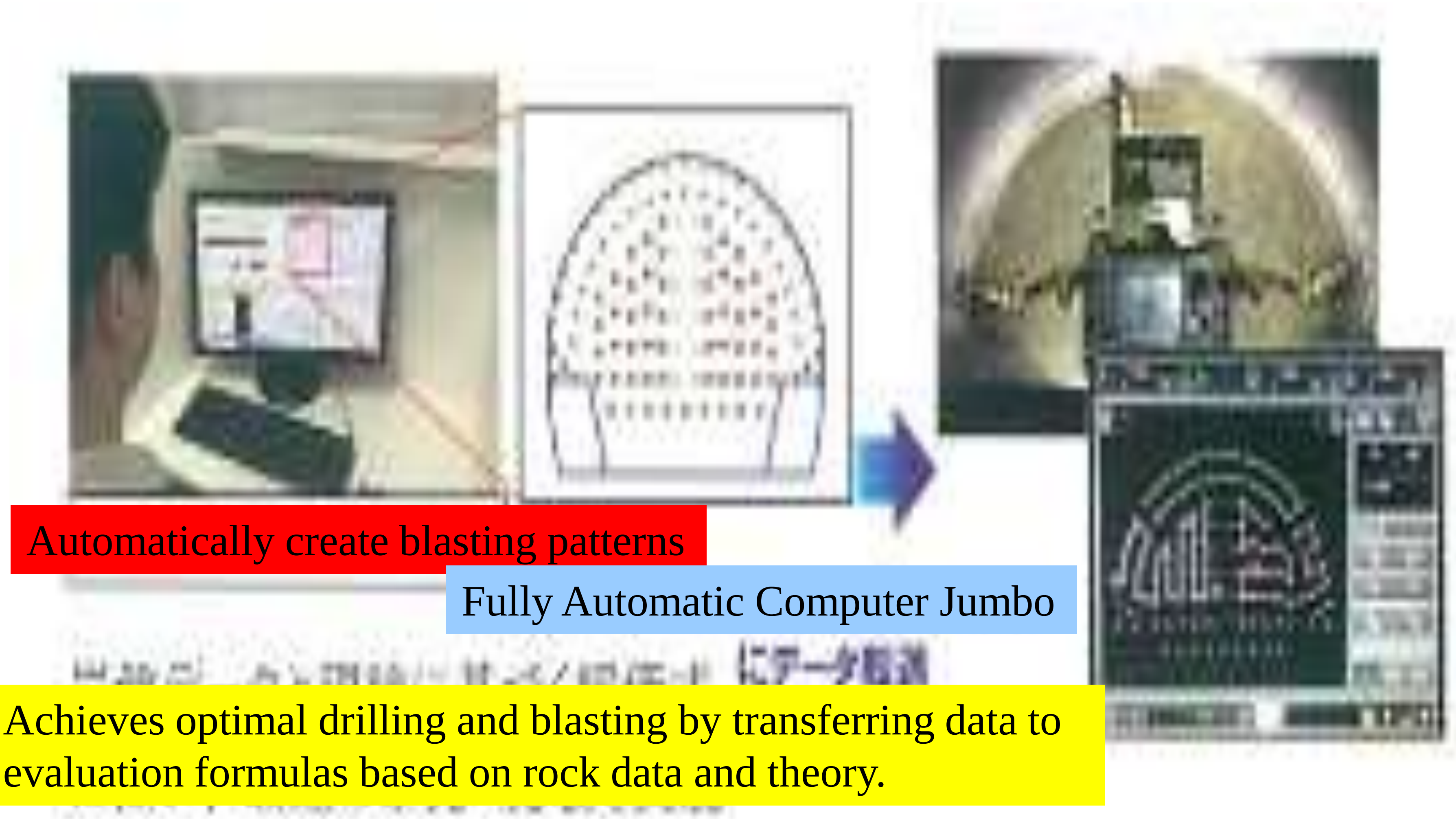


Rock Bolt installation by
Automatic 2 boom M/C

Shotcrete by Automatic
Spraying M/C

Breaking by Automatic
Breaker

Latest Technology (Ref: KAJIMA CORPORATION, Mar 2024)



Automatically create blasting patterns

Fully Automatic Computer Jumbo

Achieves optimal drilling and blasting by transferring data to evaluation formulas based on rock data and theory.

Data Input : Strength of Rock, Design Cross-section

Latest Technology (Ref: KAJIMA CORPORATION, Mar 2024)

Automatic a series of Shotctere operation

Automatic a series of rock bolting operation

TUNNEL IN MYANMAR

Myanmar – China Friendship Tunnel in Kachin State (2015)

Myanmar – China Friendship Tunnel (Road Tunnel)

Myanmar – China Friendship Tunnel

Myanmar - China Friendship Tunnel in Kachin State

A railway tunnel on the Kalaw-Yinmarpin (1917)

A railway tunnel on Goteik (2 Tunnels, 1[illegible])

Maungdaw Buthidaung Tunnel (Tunnel 24) 1918

1941-1945

Maungdaw Buthidaung Tunnel (Tunnel 24) 1918

Maungdaw Buthidaung Tunnel (Tunnel 24) 1918

Bawdwin Tigher Tunnel (Bawdwin Mine-1914)

Bawdwin Tigher Tunnel (Bawdwin Mine-1914)

Bawdwin Tigher Tunnel (Bawdwin Mine-1914)

Bawdwin Tigher Tunnel (Bawdwin Mine-1914)

Bawdwin Tigher Tunnel (Bawdwin Mine-1914)

Ponnya Taung Railway Tunnel (2006)

Ponnya Taung Railway Tunnel (2006)

Ponnya Taung Railway Tunnel (2006)

Ponnya Taung Railway Tunnel (2006)

Pontaung-Ponnya Railway Tunnel (12 June 2010)

A tunnel of Pontaung-Ponnyataung seen on Kyaw-Yemyetni railroad.

Pyay Road Pedestrian Tunnel (road underpass) 2023

Tunnel Length = 427 ft

Tunnel Heigh = 10 ft

Tunnel Width 40 ft

Pedestrian width = 19 ft

Construction = Feb 2020

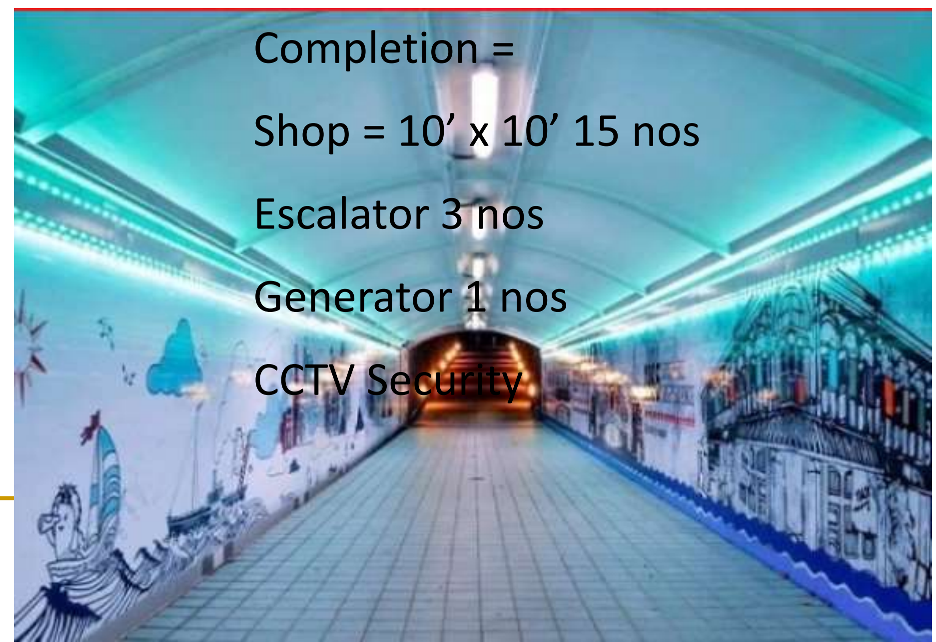
Completion =

Shop = 10’ x 10’ 15 nos

Escalator 3 nos

Generator 1 nos

CCTV Security



U Wisara Pedestrian Tunnel (road underpass)

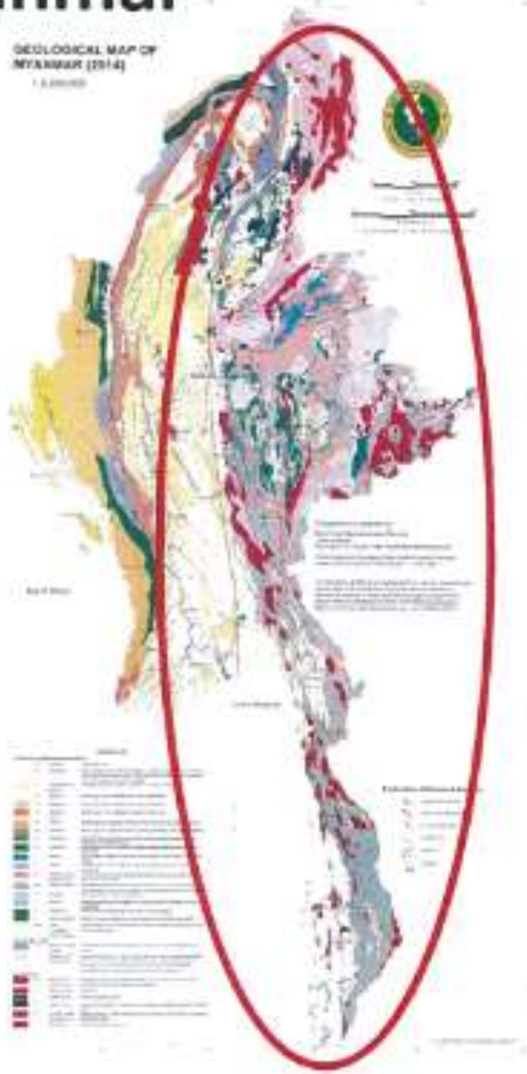
Under construction (74 m)

Feasibility Studies in Myanmar For Road Tunnel (NATM)

1. Watalone Tunnel
2. Pontaung Tunnel
3. Ye Tunnel (Malwe Taung)
4. Lane Li Tunnel
5. Dawei Tunnel (Elephant Cry Hill)
6. Kalaw Bypass Tunnel
7. Dawei Tunnel – (Htee Kye) Tunnels
8. Rakhine Tunnels

Geological Similarity

Myanmar

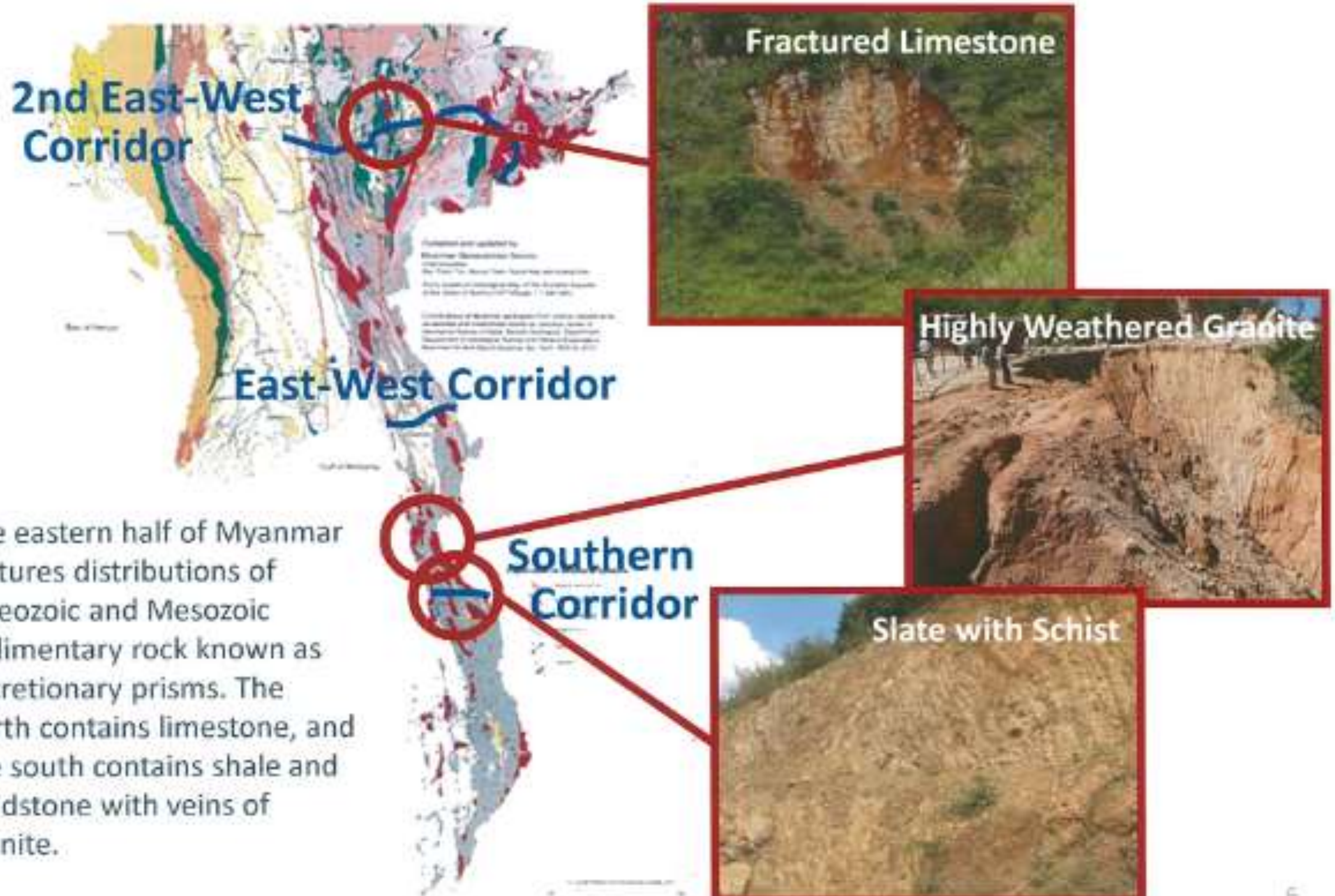


Myanmar and Japan are very similar geologically – they both feature a formation of accretionary prisms as well as faults and other tectonic lines.

Japan

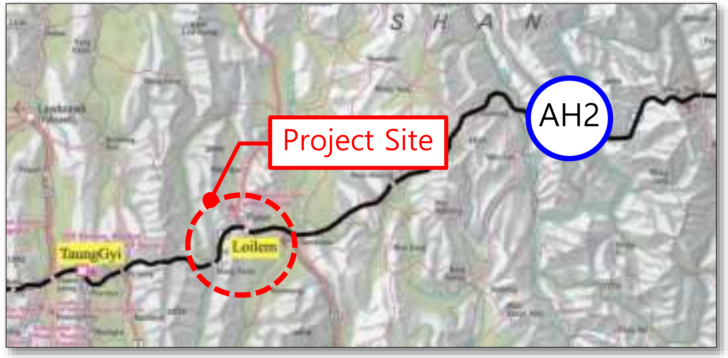
5

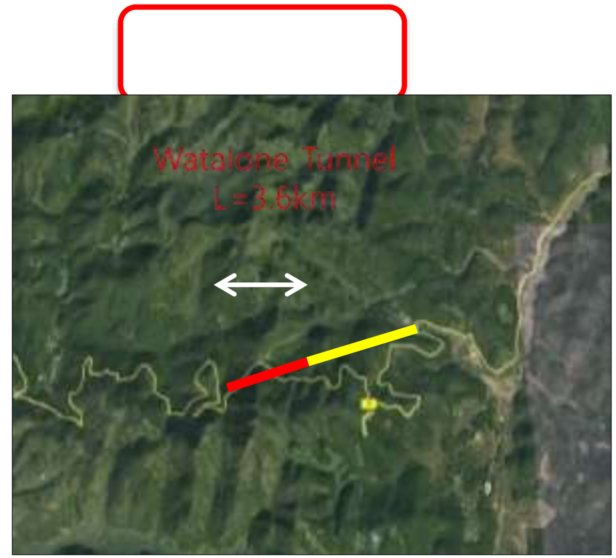
Geology of Required Tunnel Locations



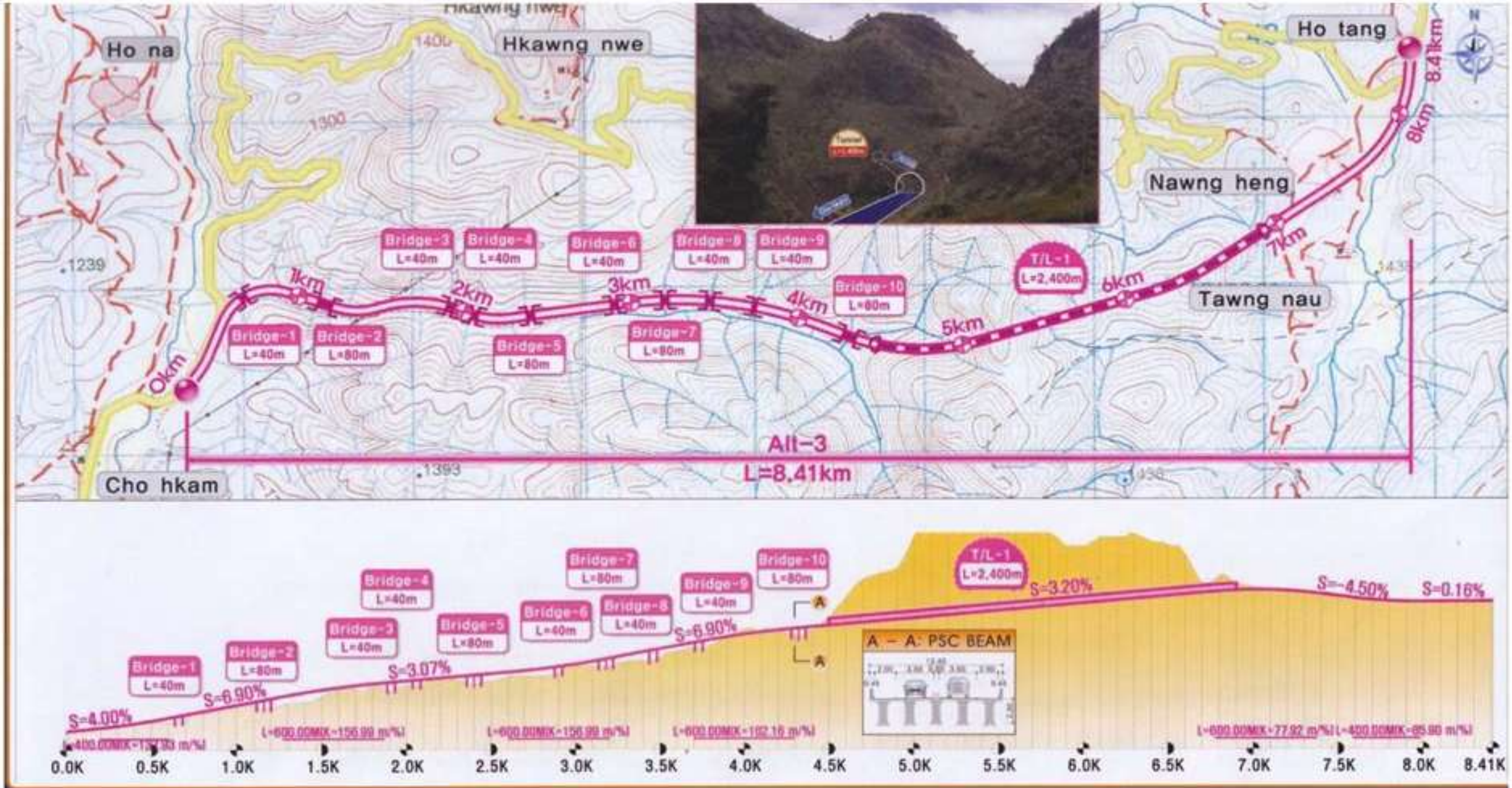
The eastern half of Myanmar features distributions of Paleozoic and Mesozoic sedimentary rock known as accretionary prisms. The north contains limestone, and the south contains shale and mudstone with veins of granite.

Watalone Tunnel in Shan State (Bi- directional Tunnel)





Watalone Tunnel in Shan State (Bi- directional Tunnel)



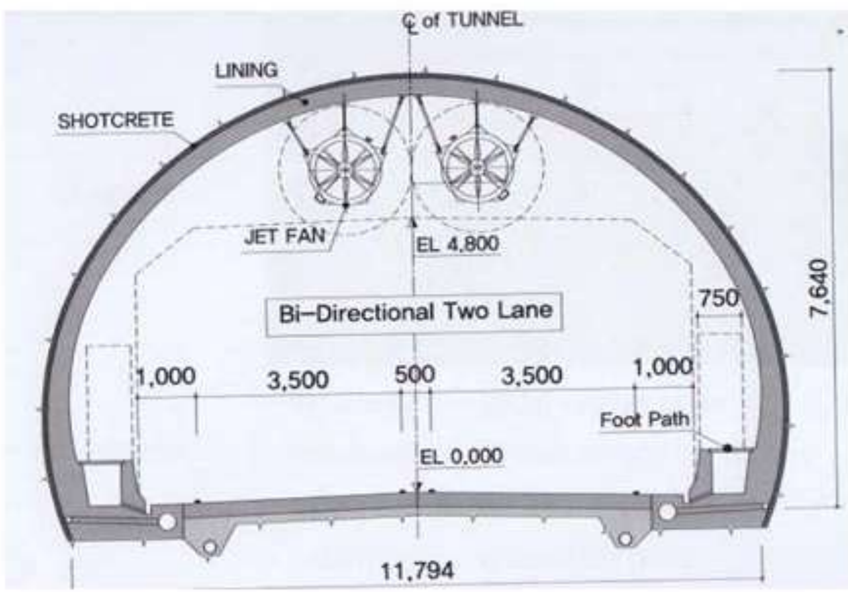
Contents • Satisfying geometric requirements → good road function, small number of structures(2,960m)

Total Length : 8.41 km Normal Section : 5,447 m	Bridges :10 nos (L=560m) Tunnels : 1 nos (L=2,400m)	Driving Time : 8.4 min Construction Cost : 96.8 million US ($)

Watalone Tunnel in Shan State (Bi- directional Tunnel)

Tunnel Length	2,400 m
Horizontal Alignment	R=1,200-15,000m Straight
Vertical Alignment	+3.2%
Traffic Method	Bi-Directional Two Lane
Ventilation Type	Jet-fan
Excavation method	Drill & Blast, NATM
Portal Type	Arch face shape
Emergency Parking	3 EA
Emergency Shelter	6 EA

Elevation



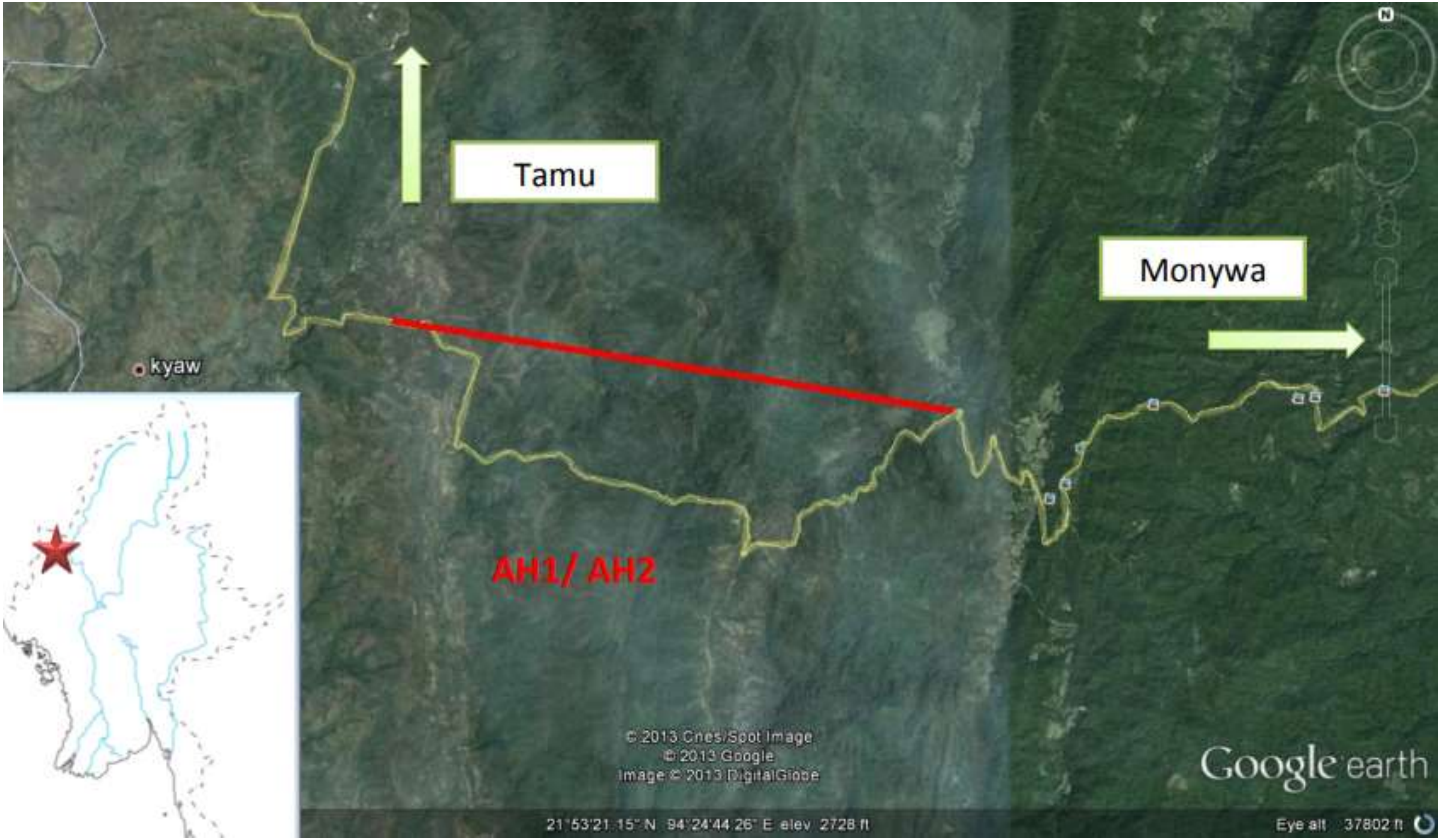
B/C	0.77
IRR	9.95%

Carriageway Width	9.5m (2@3.5+0.5+2@1)
Width of Median	500 mm
Vertical Clearance	4.8 m
Tunnel Width/ Height	W=11.794m/H=7.64m
Footpaths Width	750 mm
Drain Waterway Width	750 mm
Lining Thickness	300 mm
Excavation Area	82.828 m^3

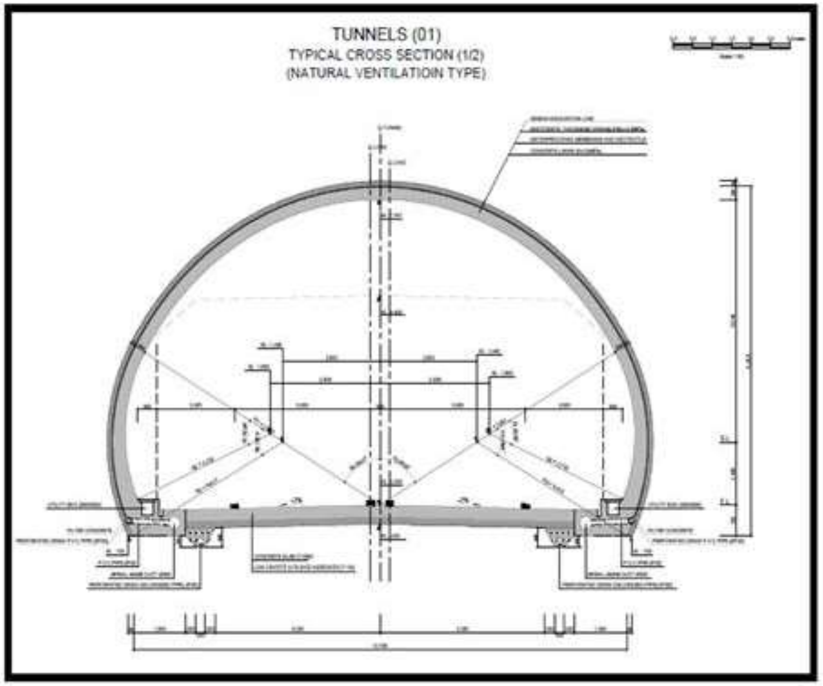
Cross Section

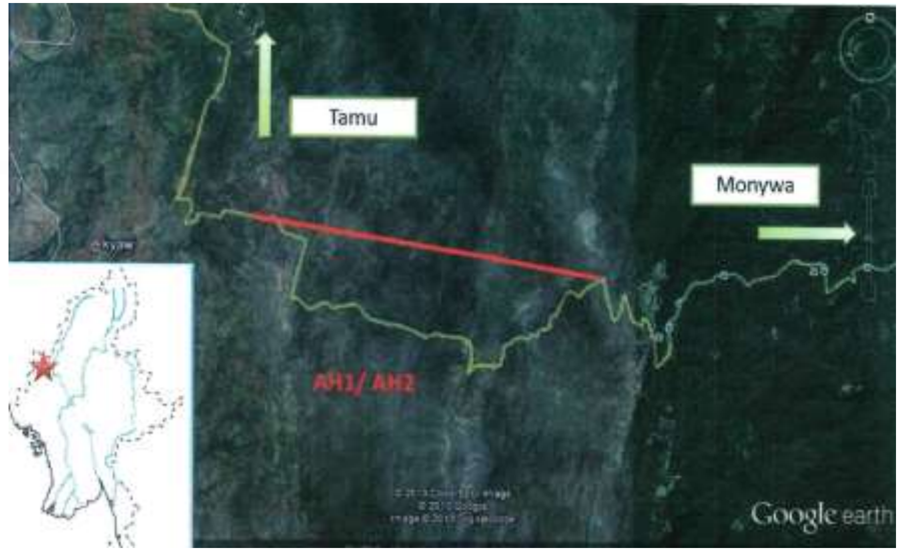
Watalone Area Road Condition

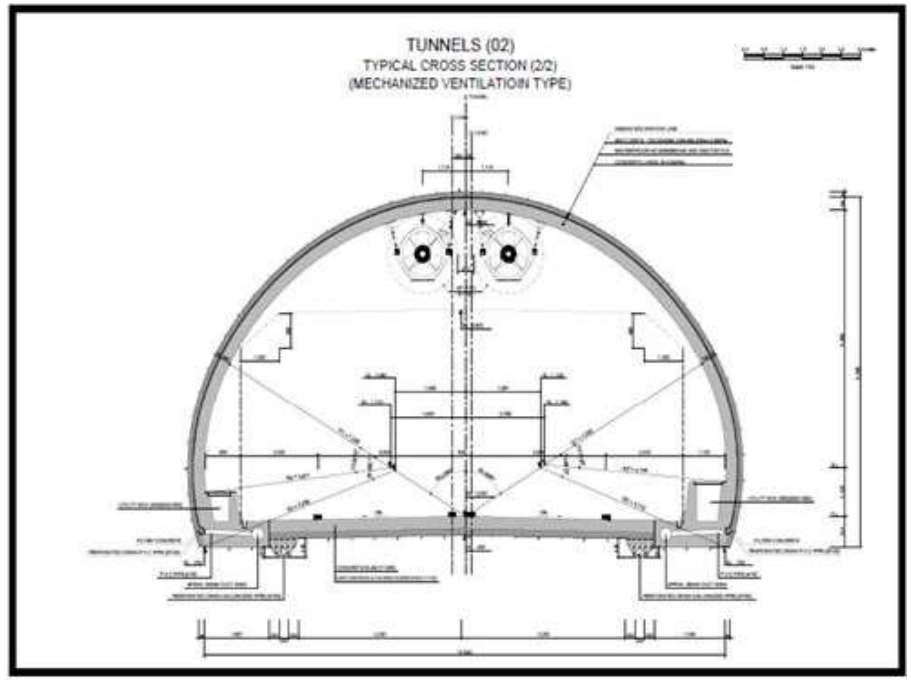
Pontaung-Ponnya Tunnel



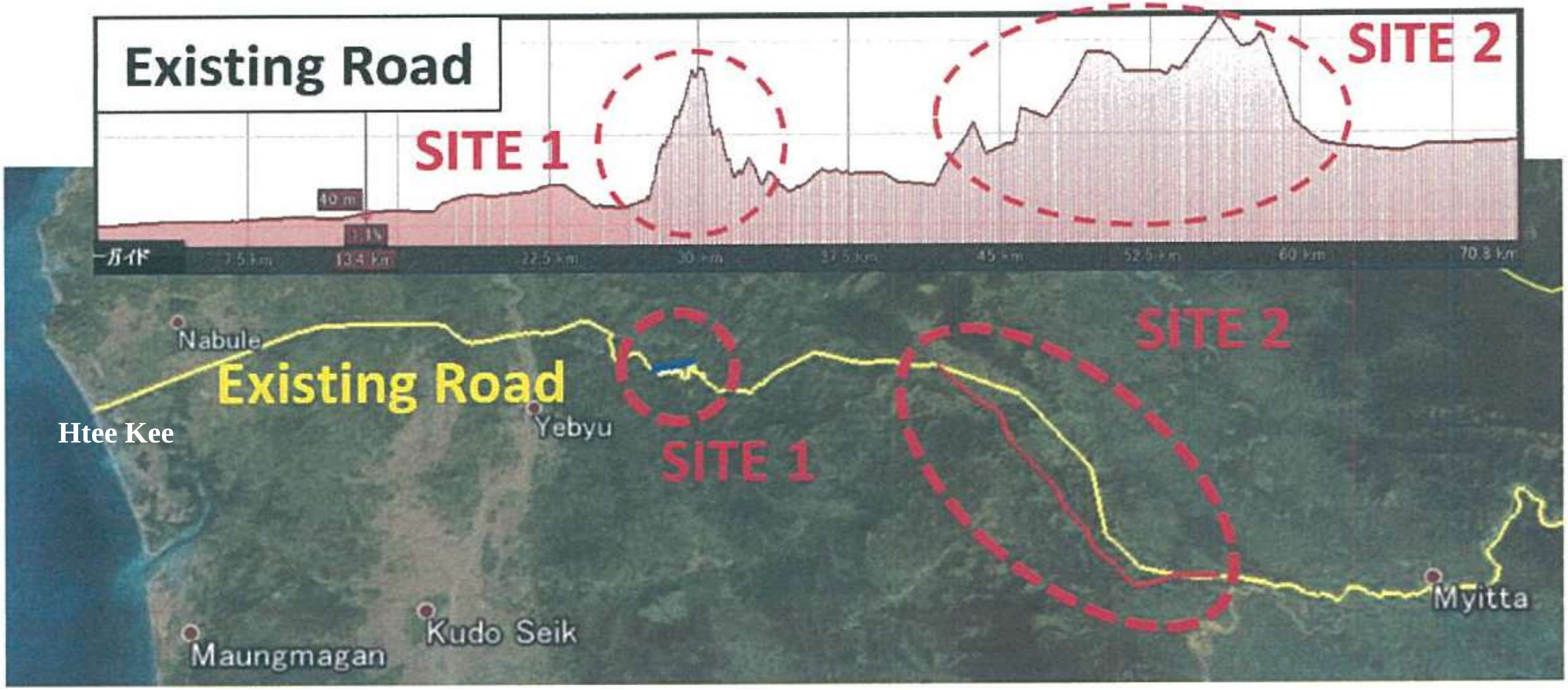
Pontaung-Ponnya Tunnel



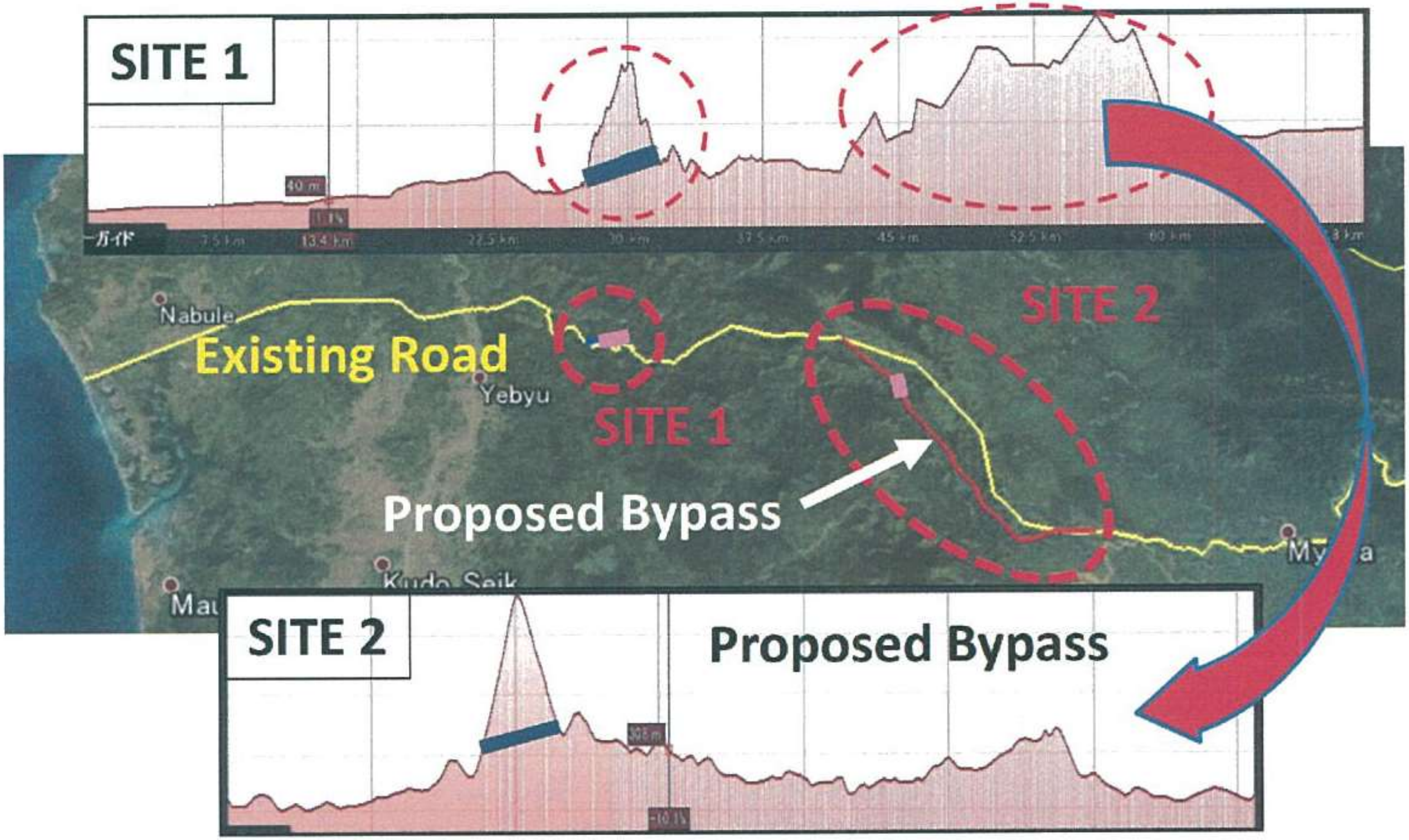




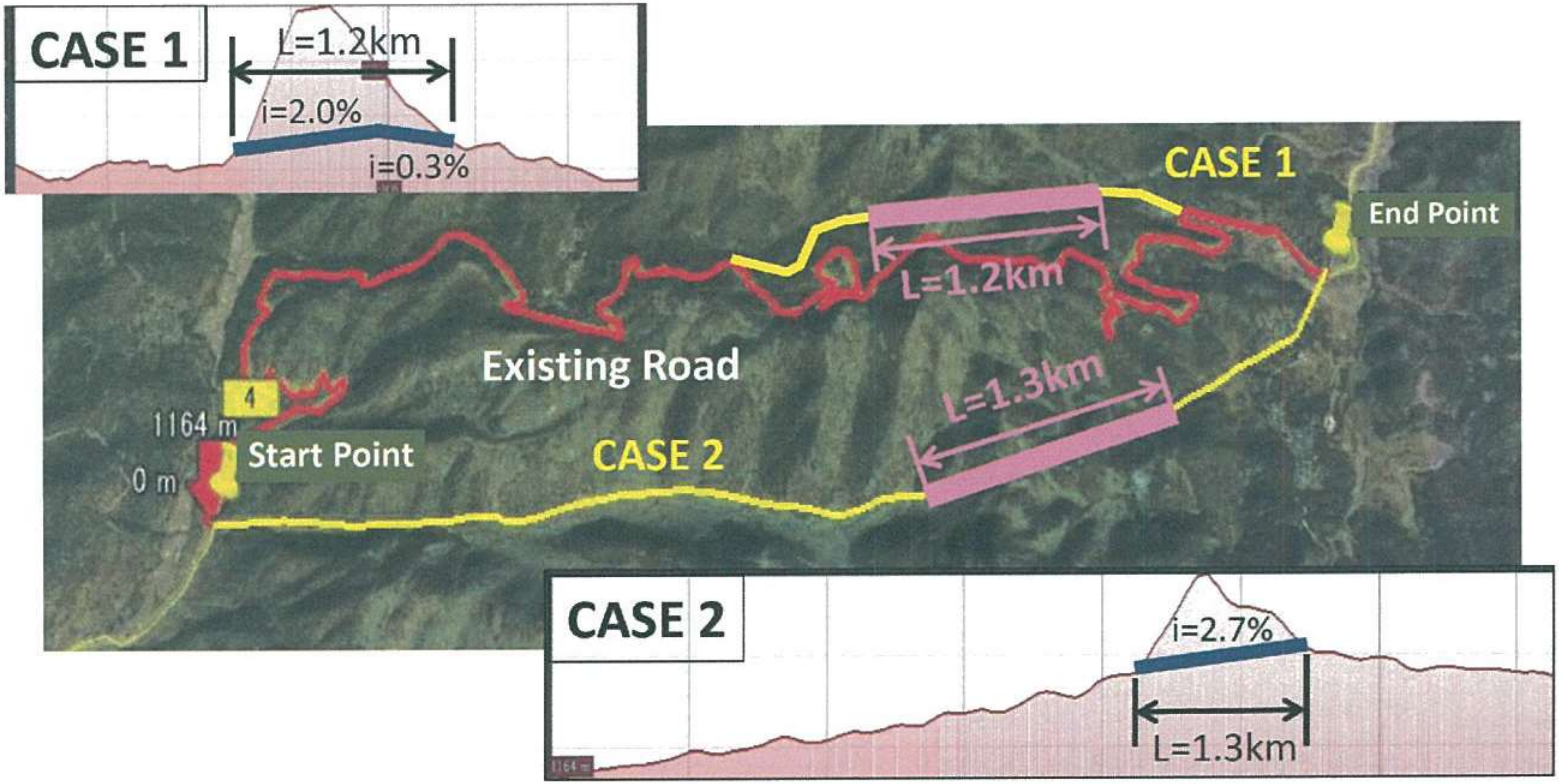
Dawei Tunnel



Dawei Tunnel



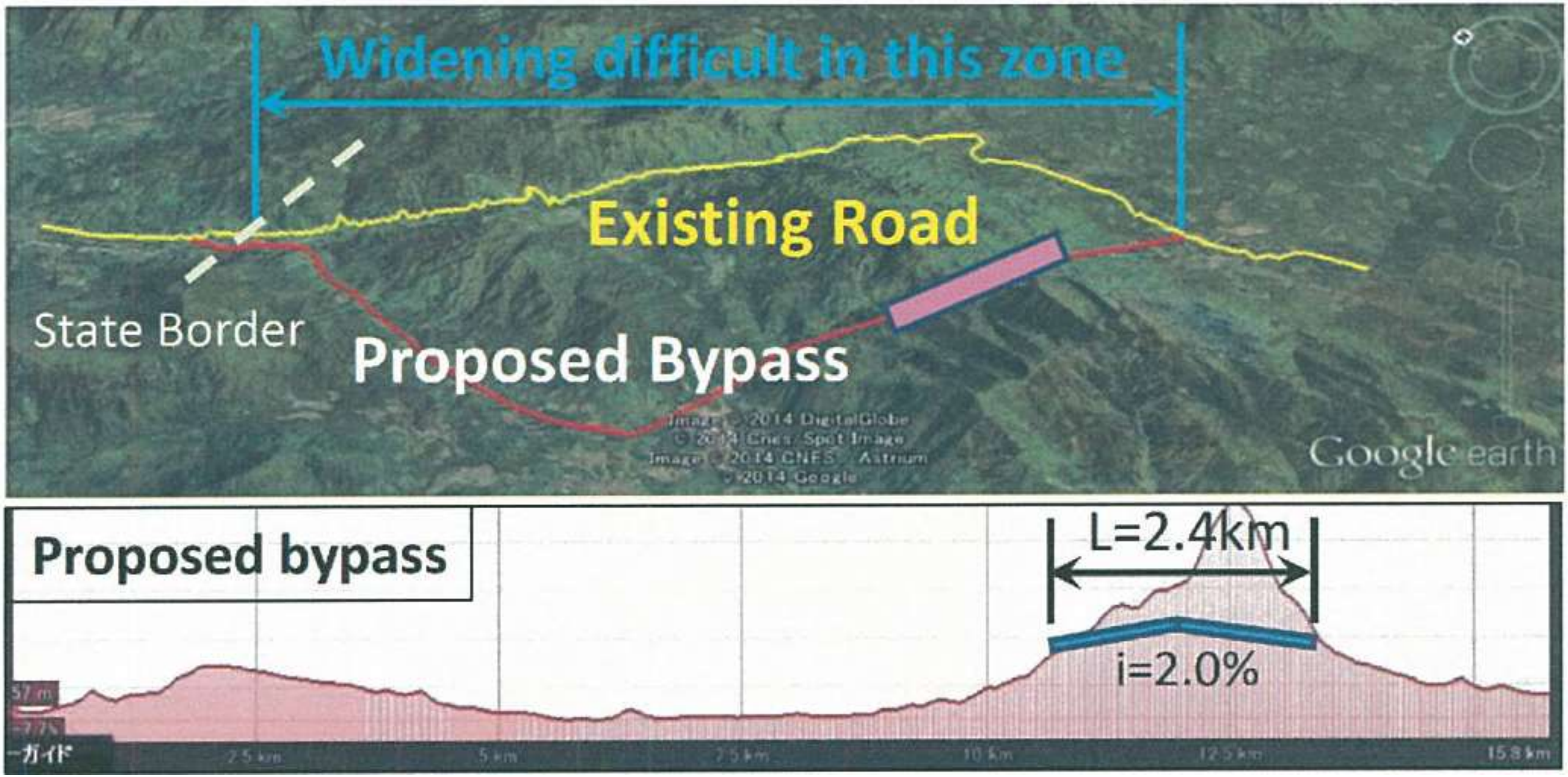
Kalaw Tunnel



Land Slide and Slope Failure at Escarpment

Road between Kalaw and Yinmarpin

Ye Tunnel


Widening difficult in this zone
Existing Road
State Border
Proposed Bypass
Image © 2014 DigitalGlobe
© 2014 Cnes/Spot Image
Image © 2014 CNES / Astrium
© 2014 Google
Google earth
Proposed bypass
L=2.4km
i=2.0%
2.5 km
5 km
7.5 km
10 km
12.5 km
15.8 km

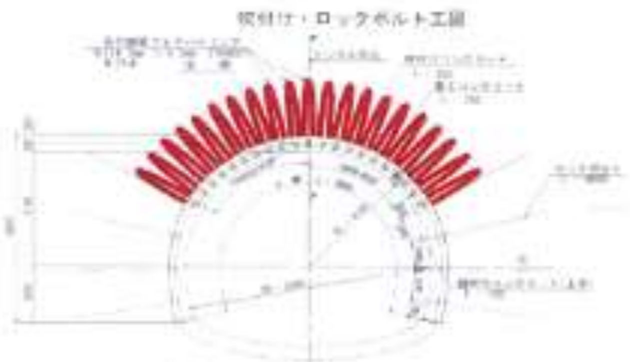
High Standard Highway Network

Road beyond the high mountains, by steep, narrow and winding, are forced to speed down, traffic jam, exhaust gas increases, danger driving by surface collapse, etc. Tunnel construction which designed on low-gradient, wide roads and gradual curves, leads to the high-standard highway, to achieve the reduction of traffic jam, exhaust gas and traveling time.

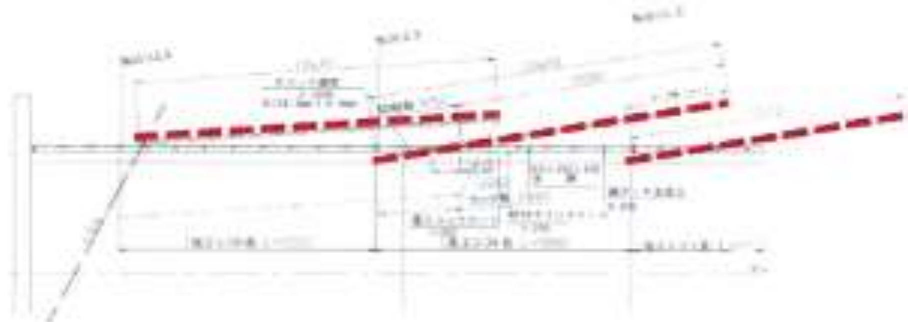
Route Selection
(Thanphyuzayet–Ye–Dawei–Myeik–Kawthung Road)
(Weathered Granite)

Granite Excavation - Crown Reinforcement

Long Steel Pipe Forepiling



Cross-section



Vertical-section

Construction Work Image

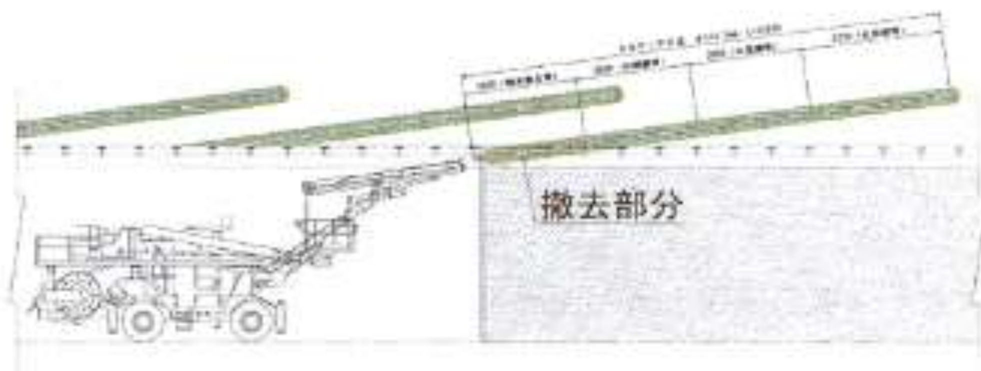
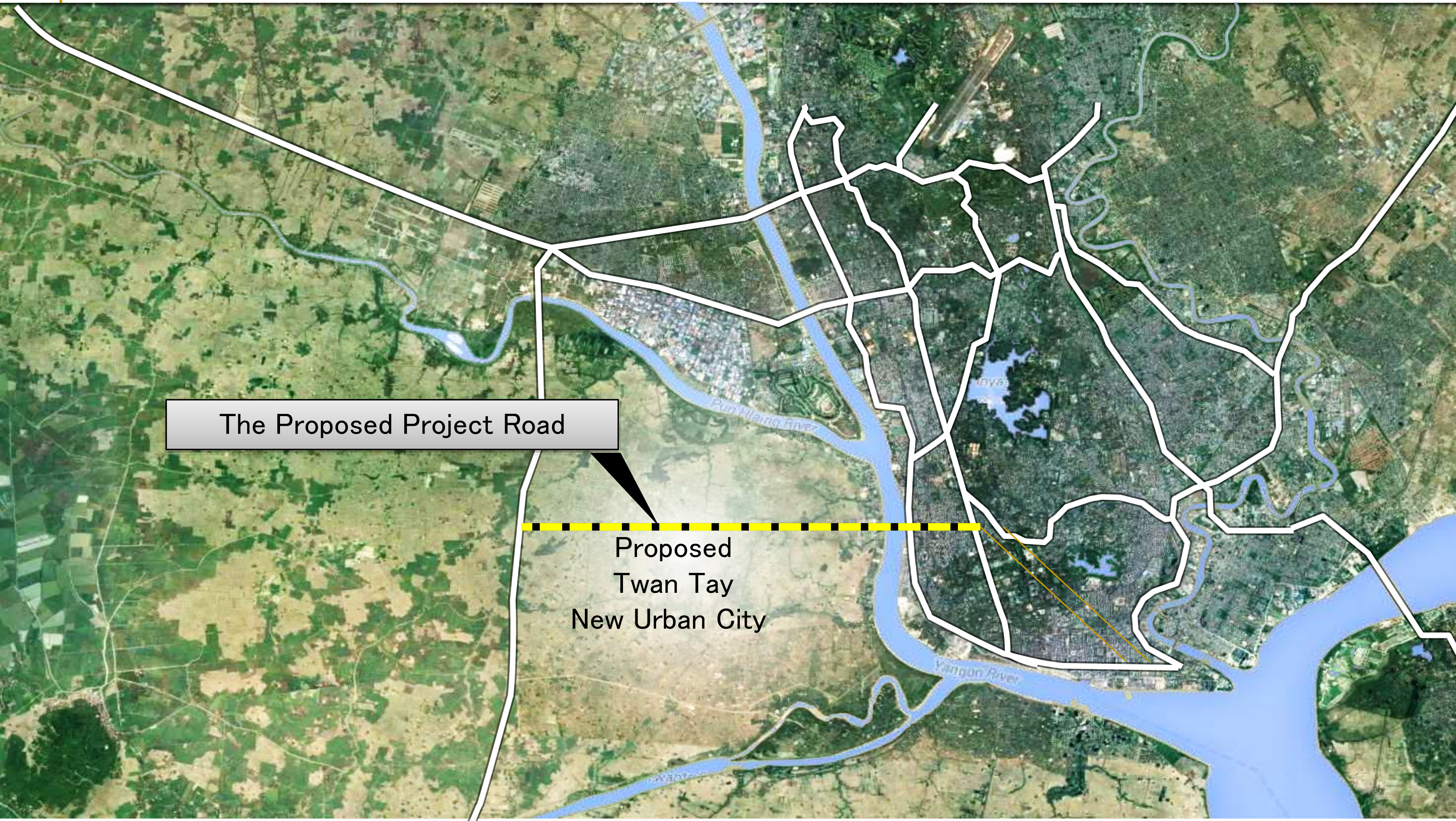


Diagram of Work

Lain-Li Tunnel (Naypyitaw ~ Pinglaung Road)

Kyee Myin Dyne Tunnel



Location Map

Kyee Myin Dyne Tunnel

Option 1 : Bridge

- Main span will be more than 400m
- Steel Cable-stayed Bridge
- Navigation Clearance H =400m, V = 53m

Option 2 : Immersed Tunnel

- Hybrid Type (Open Sandwich
- Structure)

Option 3 : Shield Tunnel

Structure	Option 1: Bridge (Cable-stayed Bridge)	Option 2: Immersed Tunnel (OS structure)	Option 3: Shield Tunnel
Total Length (m)	2,657m	1,329m	2,141m
Constructability	**Moderate** Navigation route control will be required during construction of pylons.	**Moderate** Dry dog in Myanma Shipyard can be used during fabrication of steel plate. Concrete can be placed near the construction site on the river.	**Superior** No placing structure on river and land except for shield staring shafts.
Cost Ratio	1.24	1.00	1.55
Construction Period	Approx. 4 years	Approx. 4.5 years	Approx. 5 years
Environment	**Inferior**	**Superior**	**Moderate**
Evaluation	Construction period is shortest but construction cost and environmental aspect are inferior to Option 2.	**Recommended** Construction cost and environmental aspect are superior to others.	Constructability is superior but other aspects are inferior to others.

WORK EXPERIENCE

1. KINDA HYDRO ELECTRIC POWER PLANT PROJECT

2. BALUCHAUNG HYDRO ELECTRIC POWER PLANT PROJECT
   Project Management Training in Kajima Head Office, Tokyo, Japan

3. MERAK CHEMICAL PTA PLANT SITE PREPARATION PROJECT

4. MERAK CHEMICAL PLANT PROJECT

5. SURALAYA COAL FIRED POWER PLANT UNIT #5, 6, 7 PROJECT

6. TUBAN CHEMICAL PLANT PROJECT

7. MERAK-BAKAUHENI SEA FERRY TERMINALS PROJECT

8. SURABAYA INTERNATIONAL AIRPORT CONSTRUCTION PROJECT

9. SOUTH SULAWESI DIVERSION TUNNEL AND RIVER DIVERSION PROJECT

10. KAREBBE DAM AND POWER PLANT CONSTRUCTION PROJECT

11. YANKIN PPP REDEVELOPMENT PROJECT

PART-1 (end)

- *Thank you for your kind attention*

Win Myint Thein