Challenge to the tunnel construction that supports national resilience

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June 14th, 2016

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Profile of TEPPÉI TOMITA

- Professional Engineer (Japan) in Mountain Tunnel
- Planning, design, inspection, maintenance of mountain tunnel
- Civil Engineering Degree, Fukuoka University of Science, Japan, in 1997
- Experience of Consultant for 17 years
- Main Projects: 60
  - Installation support at tunnel construction of very large cross section
  - Modified design tunnel in fragile ground including landslides
  - Plan of glasses tunnel in Yokohama
  - Plan of the tunnel of 5.0km of extension
  - Research and diagnosis of the tunnel
Our tunnel results recently

400 cases during 1995-2015

- Facility design: 98
- PD, Outline design: 39
- Detailed Design: 137
- Supervise: 24
- Renual: 19
- Inspection, maintenance: 83

- extra-large cross-section tunnel
- parallel tunnels
- New PLS
- Environmental impact assessment by the water balance analysis
1. The tunnel technology in Japan

2. The principle of the mountain tunnel

3. Major Projects

4. Advantages and disadvantages of tunneling technology
1. Tunnel technology in Japan

- Mountains: 70% of the country is mountaineous → a lot of tunnel was built
- Volcano land: Complex geology features → The development of construction technology
- Lowland: High level of awareness of Safety and disaster prevention, maintenance
1. Tunnel technology in Japan

Overwhelming tunnel excavation amount compared with other country

The used tunnel (as of 2004)

Railway about 4,300km road about 2,800km

Excavation amount (Million m$^3$)

JAPAN(NATM)

JAPAN(ALL)

Germany

Norway

Switzerland

All method

NATM

AGE

2. The principle of the mountain tunnel

Four of the tunnel construction method
(① Shield tunnel ② Mountain tunnel ③ Open cut tunnel ④ Immersed tunnel )

Subway in Bangkok is due to shield tunneling.
2. The principle of the mountain tunnel

**Differences in the four tunnels**

- **Mountain tunnel**: It breaks rock with dynamite to support by sprayed concrete and lock bolt.

- **Shield tunnel**: The soft ground was excavated by a shield machine, to support by the segment.

- **Open cut tunnel**: Excavated from the ground, backfilling to create a structure.

- **Immersed tunnel**: Created tunnel on the ground, connect and immersed in the sea.
2. The principle of the mountain tunnel

Mountain tunnel evolve from timbering support method to the NATM method.

By sprayed concrete and lock bolt immediately after drilling are suppress the loosening of the ground = (the ground regarded as a structure)
2. The principle of the mountain tunnel

◆ NATM construction image
Excavation → Sprayed concrete → Lock bolt → Steel support → Lining

CONCRETE SPRAYING
2. The principle of the mountain tunnel

Recentry by the development of auxiliary construction method, The adoption of NATM method increased even in soft and weak ground.

Hard ground

Soft ground

Piping and the pouring-injection toward the front, move forward from harden the ground
2. The principle of the mountain tunnel

◆ **TBM method** *(tunnel boring machine)*

- Scraping the rock by rotating the face plate, driving force is to secure from the rock through the gripper
- Support is carried out in a sprayed concrete configuration and lock bolt.
- It is adopted when long extension is less vulnerable ground.

![Gripper (Pressed against the rock)](image-url)
3. Major Projects

① Shin-Takeoka Tunnel and (The largest diameter in Japan, because branched in the ground)

Complete photo

Main line
Ramp line

21.7m (245m²)
3. Major Projects

STEP1  Side drift upper half drilling

STEP2  Side drift under half drilling

STEP3  Basic concrete construction
3. Major Projects

STEP 4  Upper half drilling

STEP 5  Under half drilling

STEP 7  Invert pouring

Reaction force secured
3. Major Projects

STEP4  Upper half drilling by Breaker
3. Major Projects

② Yoshinomoto tunnel (placed in large scale land sliding site)

- Position of tunnel and land sliding
- Crack on the ground
- Deformed tunnel
- Excavate direction
- Land slide site
- Crack on spray concrete coating

Origin

約70m
3. Major Projects

② Yoshinomoto tunnel continued…

Origin of the geological layer around the tunnel is around 32 million years ago. It was formed by uplift of the land-slided sea bottom layer.

Characteristics
① soft lithology
② weather quickly
③ frequent slope failure/land slide

Folding on the face
3. Major Projects

② Yoshinomoto tunnel continued…

- excavated section: ground water drainage, earth removal works
- un-excavated section: Correction of the alignment, loading embankment works

**Excavated section**: Ground water drainage, earth removal works

**Un-excavated section**: Correction of the alignment, loading embankment works
4. Advantages and disadvantages of tunnelling technology

Tunnels are highly resistant to the effects of earthquakes and typhoons. On the other hand, they have some disadvantages. Countermeasures taken in Japan against the disadvantages.

<table>
<thead>
<tr>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typhoon</td>
<td>Fire</td>
</tr>
<tr>
<td>Earthquake</td>
<td>Maintenance cost</td>
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</tbody>
</table>
4. Advantages and disadvantages of tunnelling technology

① construction of strong tunnels resistant to heavy rain disasters

Kumamoto pref Takimurozaka
Heavy rain disaster in 2012

Aso somma caldera region of
Shallow landslides of volcanic ash deposits

It has less disaster history.
4. Advantages and disadvantages of tunnelling technology

Setting the portal zone where the disaster history in the vicinity

Oita side

Takimurozaka Northern route

South route of basin

Portal zone of basin

Takimurozaka South route

Sakanoue tunnel

2012年 disaster

Portal zone of basin

vertical alignment

Sakanoue tunnel of basin

vertical alignment

Portal zone of basin

South route of basin

滝室坂トンネル周辺の流域図

熊本側入口
4. Advantages and disadvantages of tunnelling technology

The final Tunnel linear

- Tunnel extension: L-4.8km
- Difference in height: 約200m
- Vertical alignment: 4%
4. Advantages and disadvantages of tunnelling technology

Introduction of BIM in the construction business
(CIM: Construction Information Modeling)
4. Advantages and disadvantages of tunnelling technology

② Road disrupted situation in Kumamoto Earthquake
4. Advantages and disadvantages of tunnelling technology

Support at the time of fire: To reduce the secondary disaster

Jet Fan Inverter controlled aeration system

Prior art: take time

New technology: Shorten the time

Control was carried out in the number.

Possible air volume control by the inverter introduction
4. Advantages and disadvantages of tunnelling technology

Reduction of the cost of the maintenance

- The change into the LED illumination
  The visibility becomes good and the electric bill can reduce.
- The photovoltaic generation which used a road slope face
In recent years, Attention is collected to the route among Thai, Myanmar, Laos, Vietnam at the East-West economic corridor.

Also, a southern corridor and northern-southern corridor, too, are planned.

In the future I think that there is a turn of the mountain tunnel.

In that case we would like to help is.
Thank you for your kind attention

Please contact me if there are any questions!

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Key Point in mountain tunnel design

1. Selection of the tunnel route
   Read the information from geographical features (landslides, etc.)

2. Investigation of the surrounding environment
   Water use (farmland, water pumping, etc.), precious species.

3. Acquisition of geological information
   In particular of the portal information

4. Selection of the tunnel excavation method
   Blasting or Machine or TBM
Appendix

To interpretation from aerial photographs

Land Slide