Tunnel monitoring and Tunnel construction -
In the case of Hualien New Zigiang tunnel

隧道監測與施工對策之探討-
以花蓮新自強隧道為例

Presenter: Feng-Jen Wang
Adviser: Prof. Jia-Jyun Dong
Date: 2018.11.22
Outline

- Introduction
- Methodology
  - Tunnel Excavation Mapping
  - Tunnel Monitoring
- Results
  - Monitoring results
  - Rolling correction Site improvement
- Conclusions
Introduction

New Zigiang tunnel
For railway,
Double track,
Started service in Sep 26, 2017
Length: 2,667m,
Height: 6.75m,
Width: 11.3m.
Tunnel Excavation Mapping

浅覆蓋隧道段

台9線

自強隧道 L = 2750m

新自強隧道（長2667公尺）

築 mantener とは

Location Photo
Geology Profile of Tunnel

5

浅覆蓋段

69K+765-530

V:H=6:1

67K+982

69K+982

Wuhe Conglomerate

Lunshan Slate

Yuli Schist

Clay

Geology Profile of Tunnel
Methodology

Tunnel Excavation Mapping
## Methodology

### Tunnel Excavation Mapping

<table>
<thead>
<tr>
<th>C II (o)</th>
<th>C II (b)</th>
<th>D III (o)</th>
<th>D III (b)</th>
<th>覆蓋級別</th>
</tr>
</thead>
<tbody>
<tr>
<td>69K+220</td>
<td>69K+220</td>
<td>69K+220</td>
<td>69K+220</td>
<td>69K+220</td>
</tr>
<tr>
<td>69K+200</td>
<td>69K+200</td>
<td>69K+200</td>
<td>69K+200</td>
<td>69K+200</td>
</tr>
</tbody>
</table>

### Geologic Survey

- **69K+168.5**
  - Tunnel excavation pre-orientation 0.88°
  - Method: CL212-GTS032-A
  - Geologist: Jane
  - Scale: 1:200

- **Geological Features**
  - Yellow brown Tectonic grey cobble with silt
  - Dark grey silt interfaces with small cobble
  - Clay interfaces with silt
  - Old Tectonic grey cobble with silt
  - Old Tectonic grey cobble with silt

- **Environment**
  - Groundwater

---

*(Note: The diagram and table provide a visual representation of the tunnel excavation and geologic survey data.)*
Tunnel collapse Photo

(Huang etc, 2017)
Tunnel collapse Photo

(Fortune company., 2011)
Reason and Deformation

Huang etc, 2017

(Sinotech, 2012)
Tunnel material

Clay, layered, composed of extremely fine-grained clay, unconsolidated, with few carbonaceous sediments of different thicknesses.

Ductile, and poor water permeability, poor bonding between particles, but large deformation after tunnel excavation, it is easy to produce tiny cracks under the influence of external force decompression, which may cause partial groundwater to infiltrate and cause partial sedimentation to produce mud flow.

Groundwater is estimated to be located about 6~9 meters above the top of the tunnel.
Main mineral: After XRD: Quartz, Chlorite, Biotite

Size: $D_{50}: 19.09\,\mu m$
➢ Methodology

Tunnel Monitoring

Monitoring

1. Tunnel Roof (Top arch) Sinking

2. Tunnel space convergence
Monitoring results

5/13 累計3.5cm

5/13 累計3.1cm
Rolling correction Site improvement

Countermeasures

1. Ring Excavation (開挖鏡面留土心)
2. Stiffen Ribs Bottom (支堡腳加勁) (micro pipe grouting)
3. Roof Ring Grouting (頂拱環狀灌漿)
4. Mirror Face Grouting (開挖鏡面灌漿)
5. Inverted arch closed (臨時仰拱閉合)
6. Central Pilot Tunnel (中導坑)
Site Improvement

Central Pilot Tunnel
(中導坑)

Grouting(pipe)

Mirror Face Grouting
(開挖鏡面灌漿)
Stage 1: Step Excavation, grouting material: cement
Stage 2: Step Excavation, grouting material: Polyurethane resin
Stage Central pilot tunnel, grouting material: cement, resin, LW
Monitoring results

S-052Z (里程: 69K + 250) 隧道沉陷观测 (Vertical)

07/19后全面改用PU灌浆
Conclusions

1. Tunnel monitoring can quickly show the deformation status of the tunnel. The tunnel construction Strategy, especially during the tunnel collapse and deformation, can be quickly reviewed by Compared with Tunnel monitoring data.

2. The Strategy to do with tunnel collapse and deformation should be multi-way and multi-stage, can be rolling correction with monitoring data and find the most effective construction way.

3. In the Future, tunnel monitoring should be based on the ability to quickly obtain numerical values, such as automated reading tools.
Thanks for Listening