交通部鐵路改建工程局南部工程處
Southern Region Engineering Office, Railway Reconstruction Bureau, MOTC

Safety Challenge for Railway Underground Reconstruction at Metro Area of Kaoshiung in Taiwan



Presented by:
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Outline

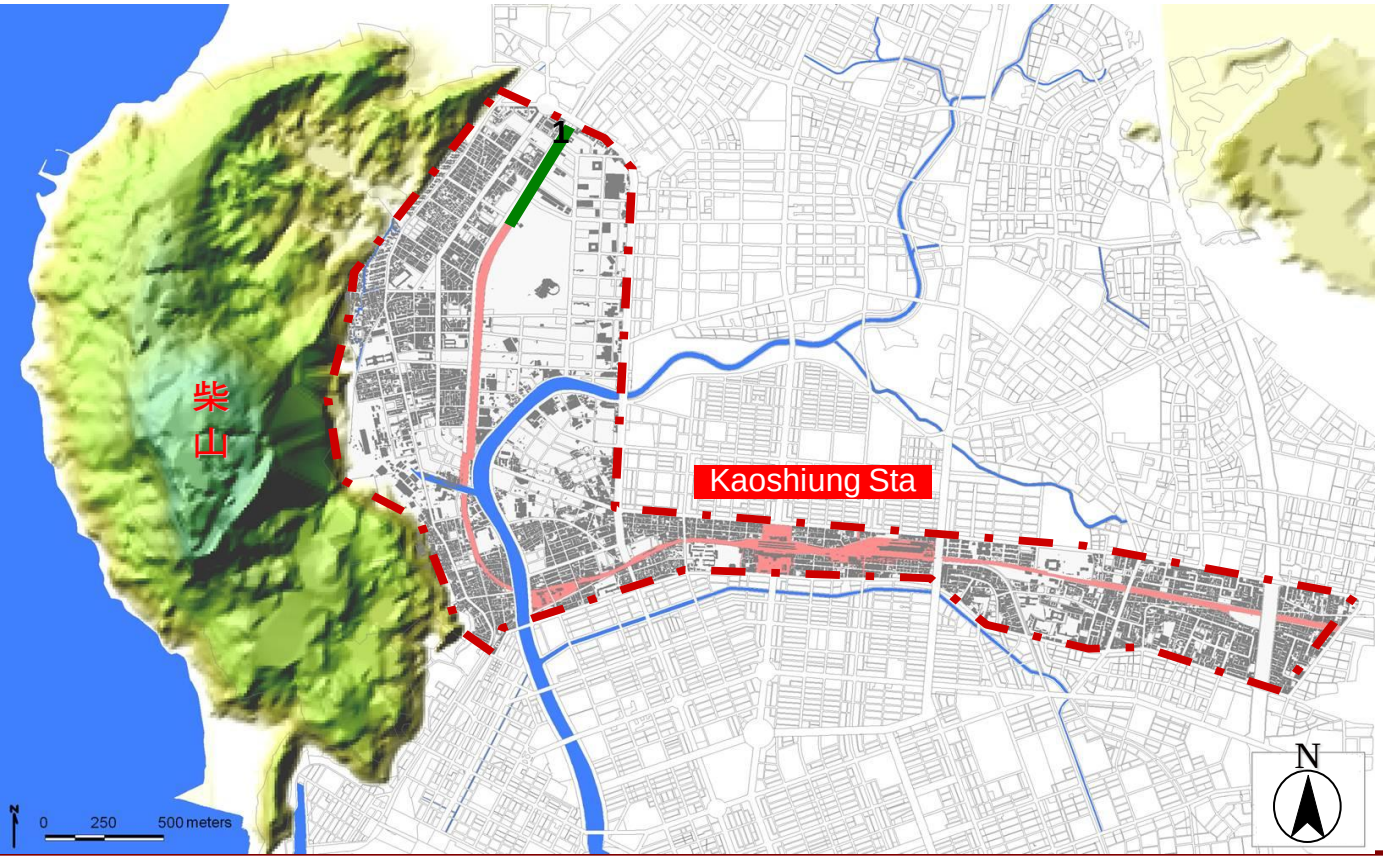
A	Railway Underground Reconstruction in Kaoshiung
B	Safety of Temp railway
C	Safety Construction through the love river
D	Safety Construction through bridges
E	Safety Construction through the car underpass
F	Safety Operation





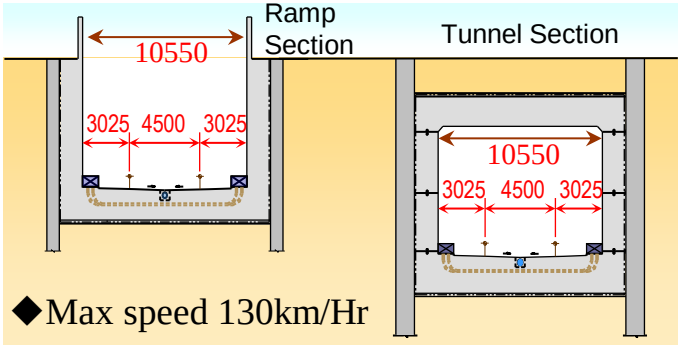

A.Railway Underground Reconstruction in Kaoshiung

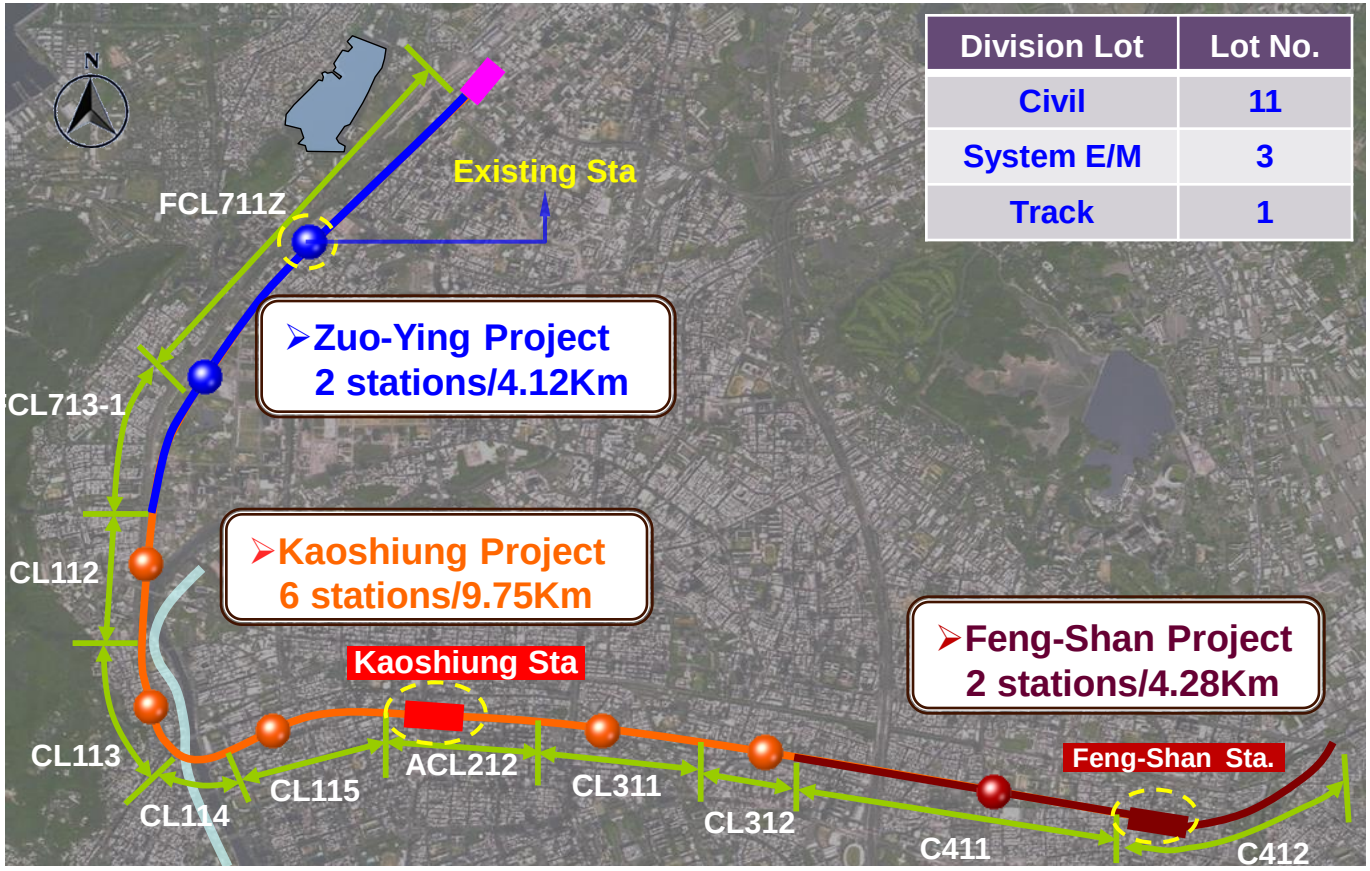
- Renew city、raise land value、improve local development & increase safety (7 crossways、16 traffic intersections)
- Project was approved at 2006.Jan
- Construction Period：2008.6~2017.12



A.Railway Underground Reconstruction in Kaoshiung

- Length：15.37Km
- Station：10 stations (CECI-7+2 temp.)
- Lots of Project ：15 lots
- Budget：NT 100 Billion (US 3.2Billion)





Division Lot	Lot No.
Civil	11
System E/M	3
Track	1


Kaoshiung Sta


San-Kuai-cuo Sta.

A.Railway Underground Reconstruction in Kaoshiung

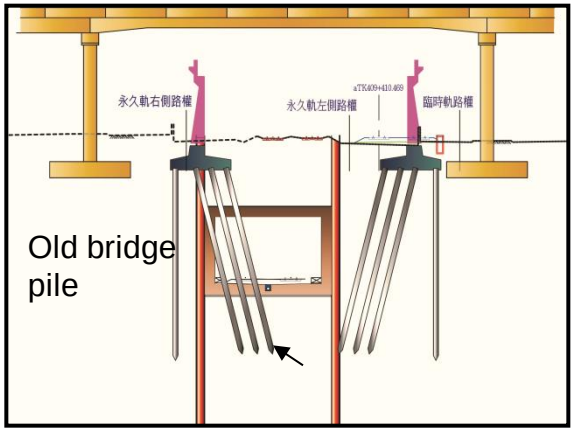
Soft stratum / High Ground Water / Flood

Intensive Houses/Limited Space/Adjacent Railway

River/Bridge/Underpass/Crossway/Obstacle

River/Bridge/Underpass

Limited space construction



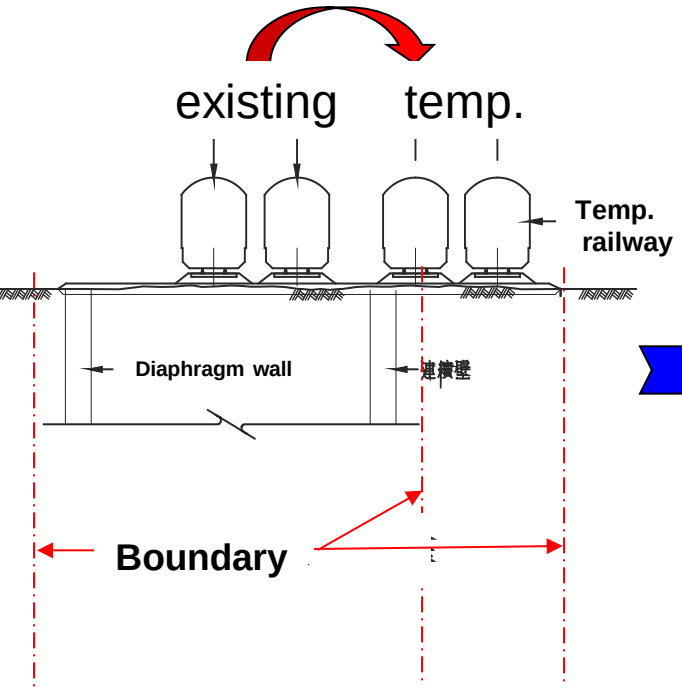
Underground obstacles

B.Safety of Temp railway

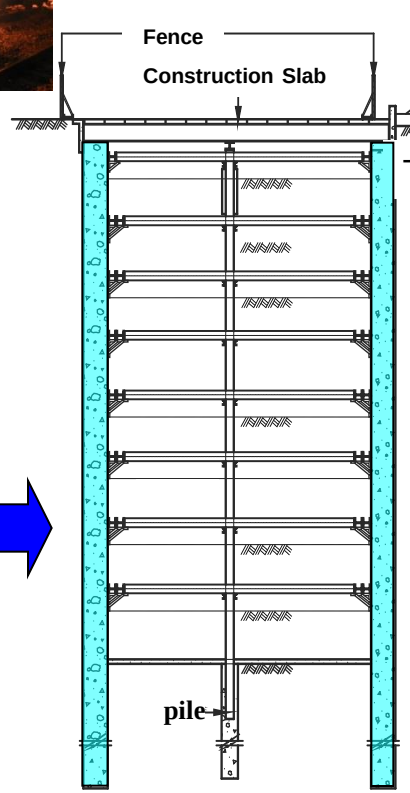
✓ **Distance <1.5m**

Track & signal shift during 6 Hrs

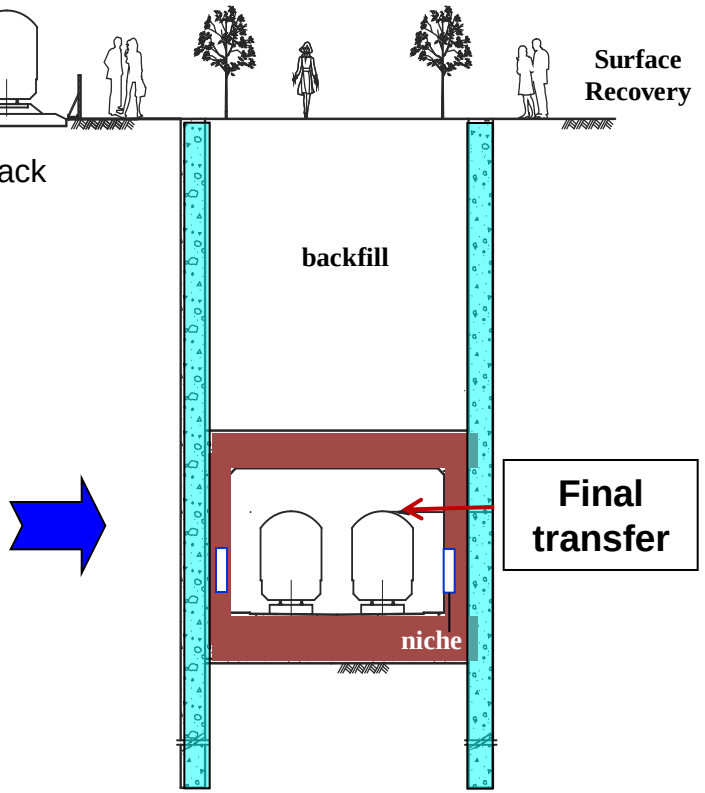
◆ Cut & cover method



Temp. railway change



Excavation



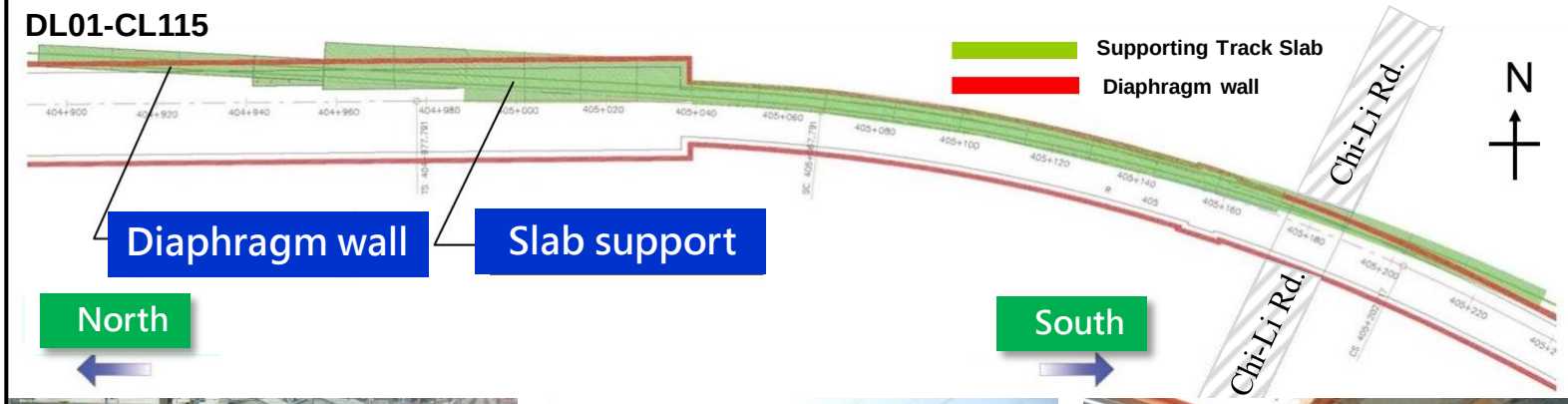
Formal operation & surface recovery

B.Safety of Temp railway

Deep Excavation
& Complicated Lifelines
& High Water Table
& Soft/loose Ground

B.Safety of Temp railway

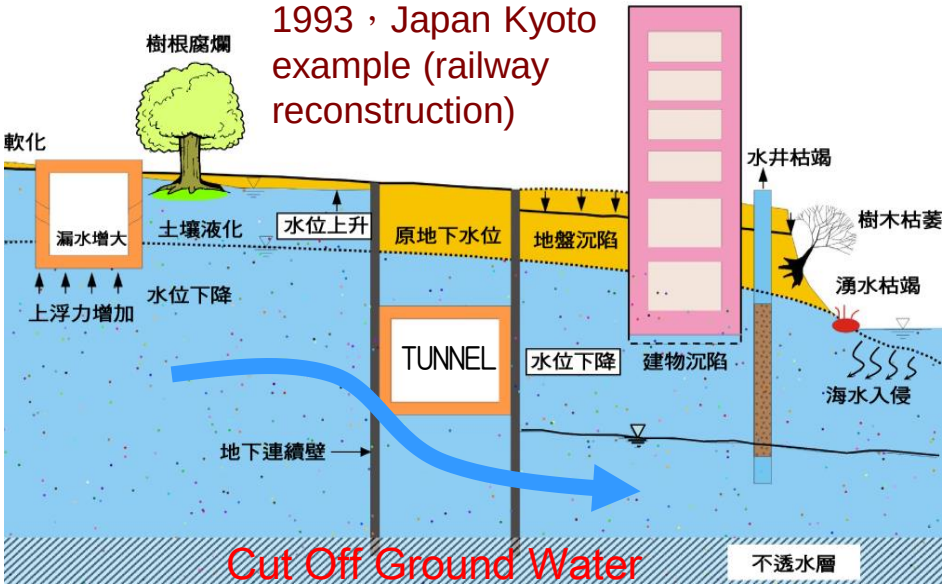
Limited railway space

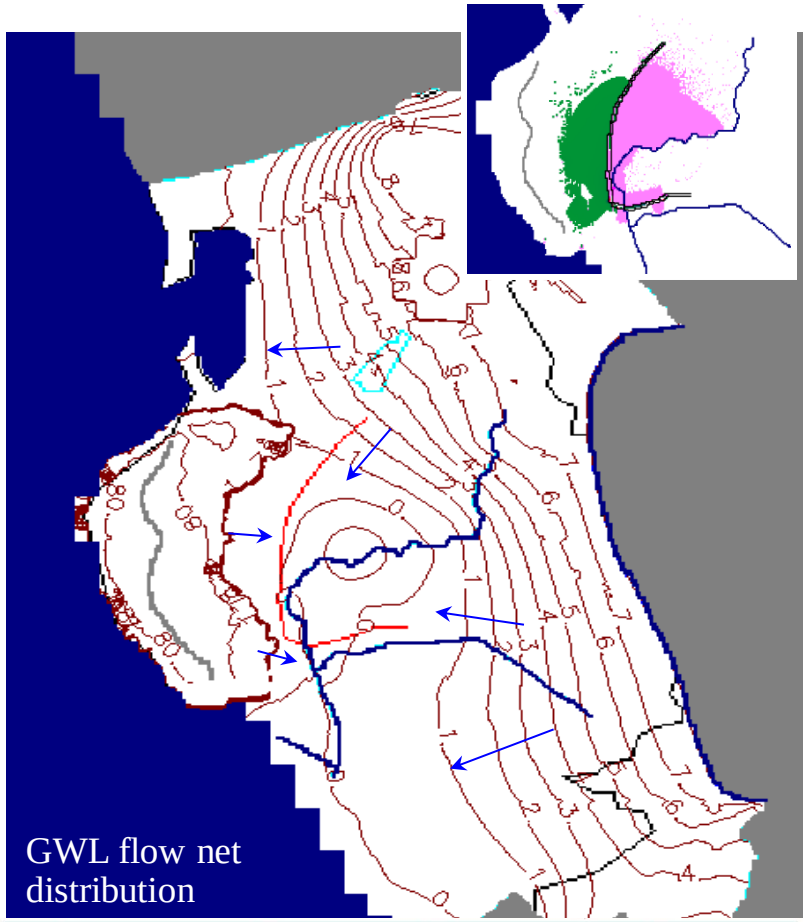


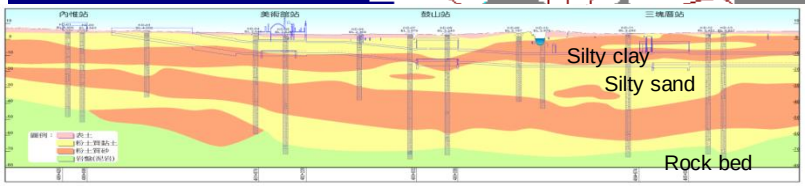
Limited height under bridge

B.Safety of Temp railway

Diaphragm wall Effect to Environment





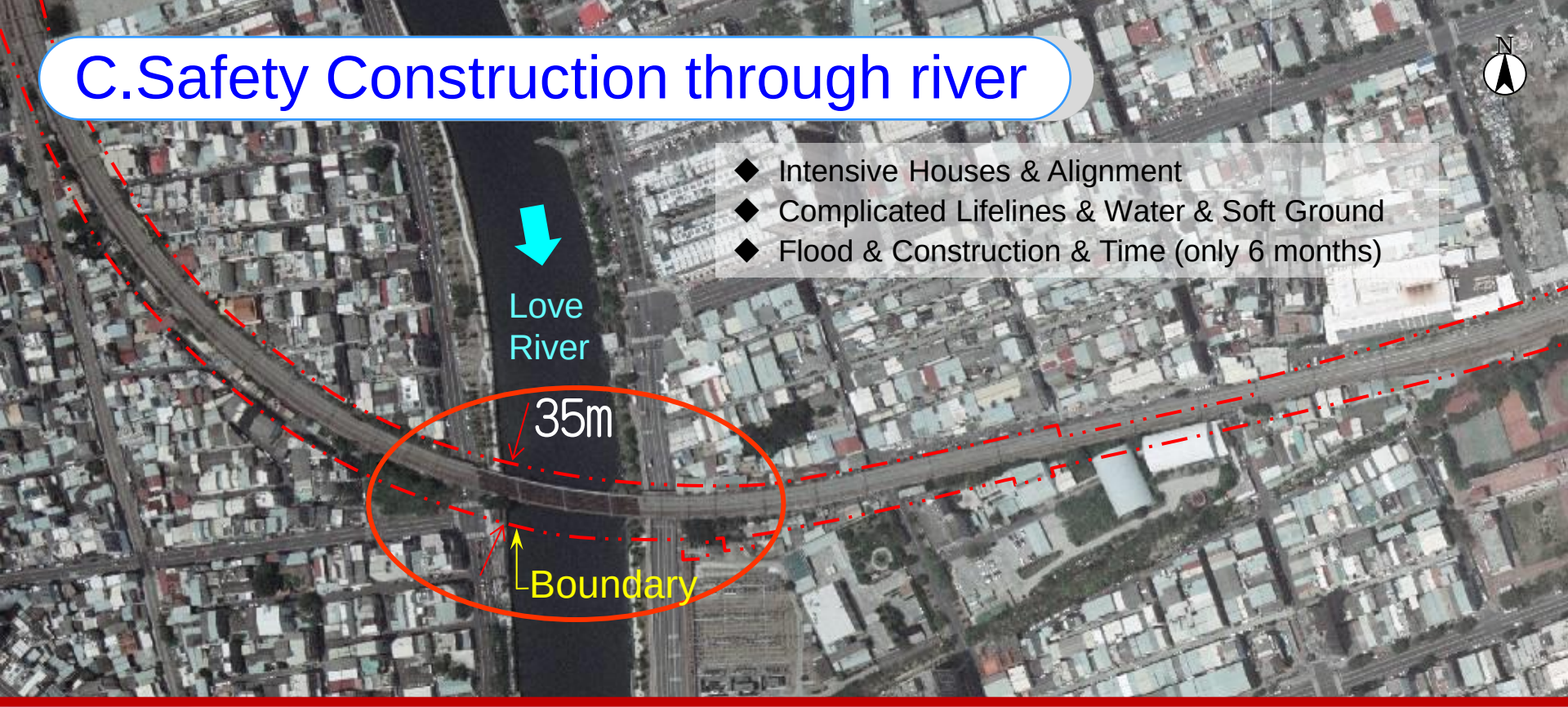


- GWL uprise
  1. Liquefaction
  2. Structure buoyancy

- GWL reduce
  1. Ground Settlement
  2. Structure damage
  3. Well dry
  4. Trees die

- After 6 months monitoring，G.W.L. reduce +1.25 cm & -0.89 cm 。
- The diaphragm wall didn't cut off the lover river inflow totally, G.W.L. & water flow will recover automatically

C.Safety Construction through river



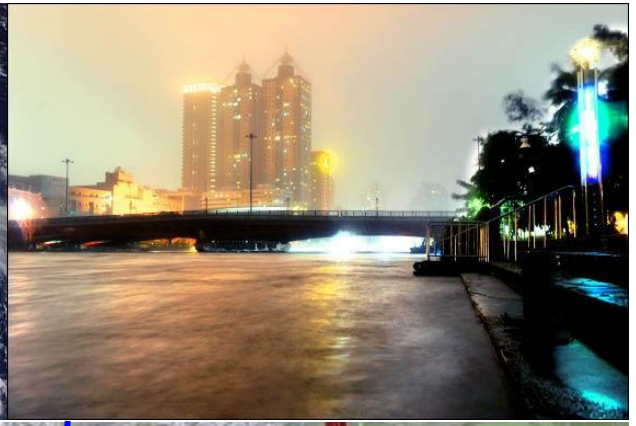
- Intensive Houses & Alignment
- Complicated Lifelines & Water & Soft Ground
- Flood & Construction & Time (only 6 months)

C.Safety Construction through river

Flood History

Construction & Time

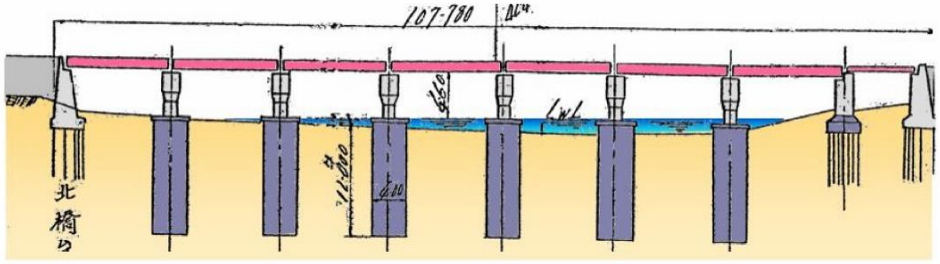
- The authority is not allowed to have any structure or construction in the river during the flood season (Nov.~May.)

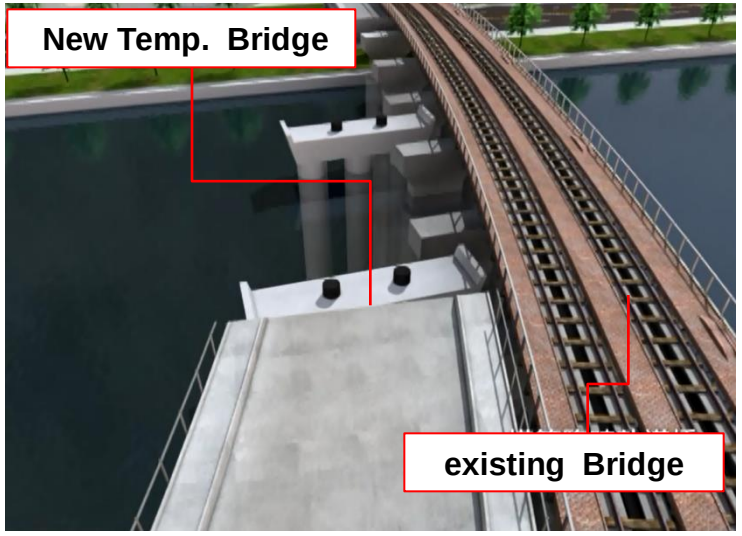


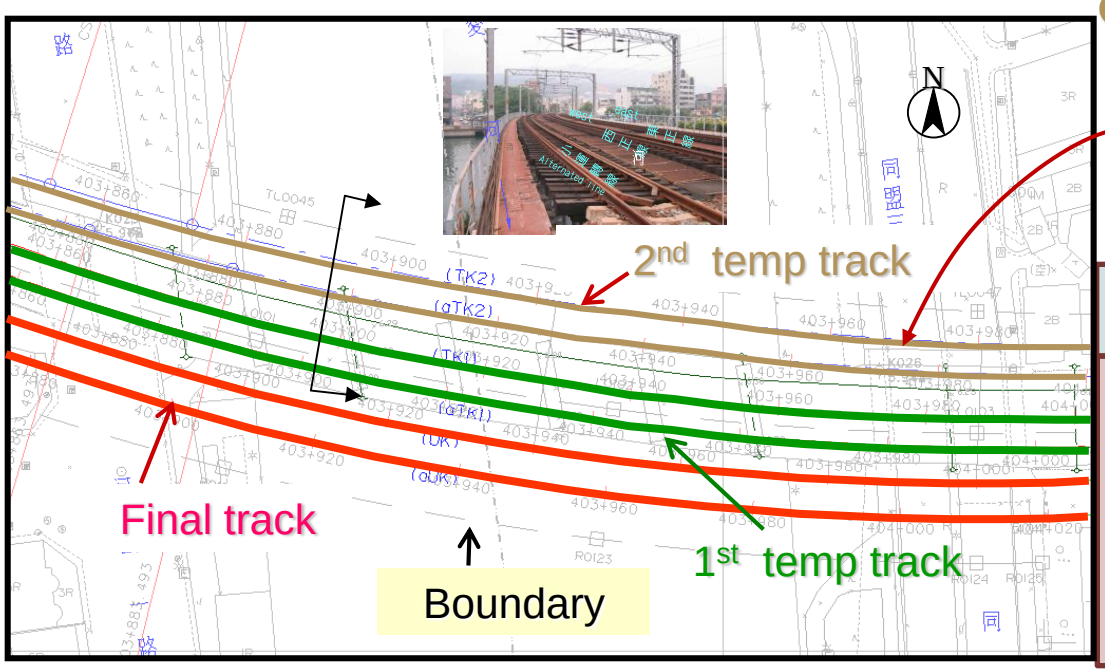
C.Safety Construction through river

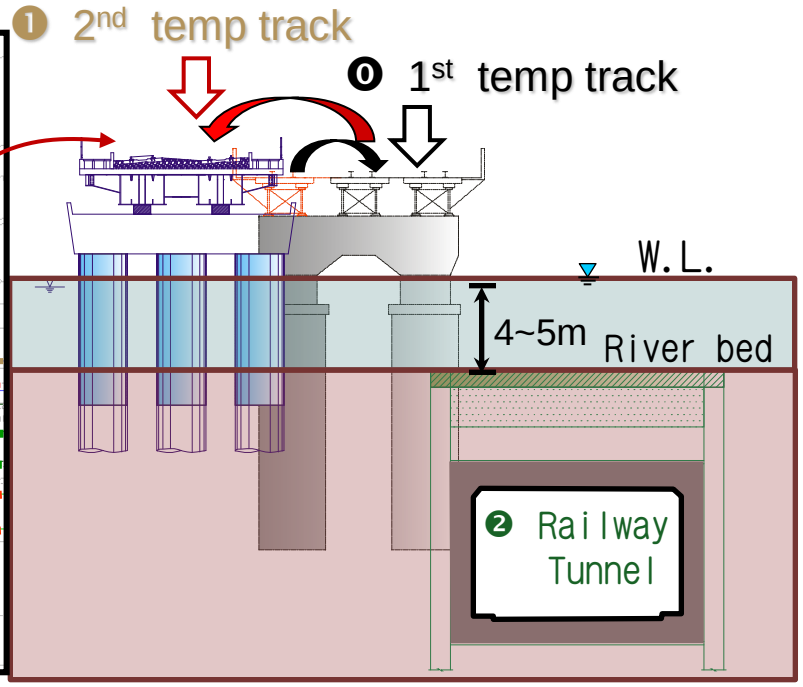
Temp. Bridge

- Built in 1934 / 6 Span=13.6m
- Cassion(ϕ =4m) / L=12m
- Several Track shifts in limited space



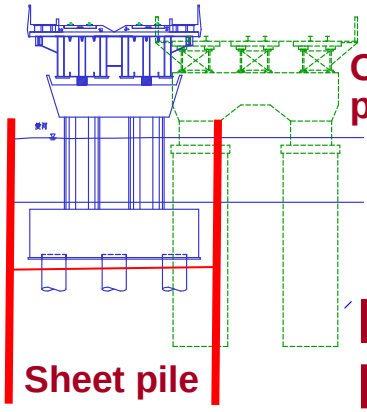


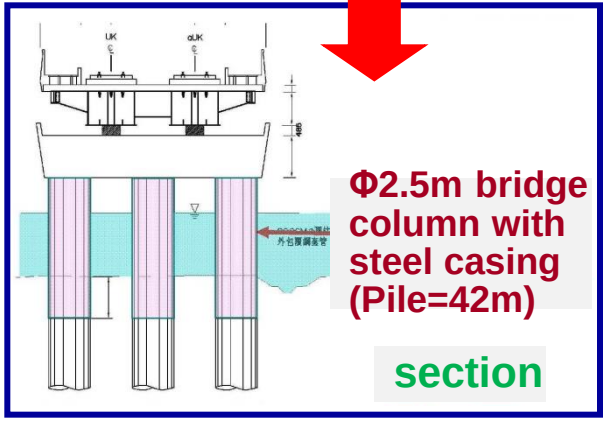


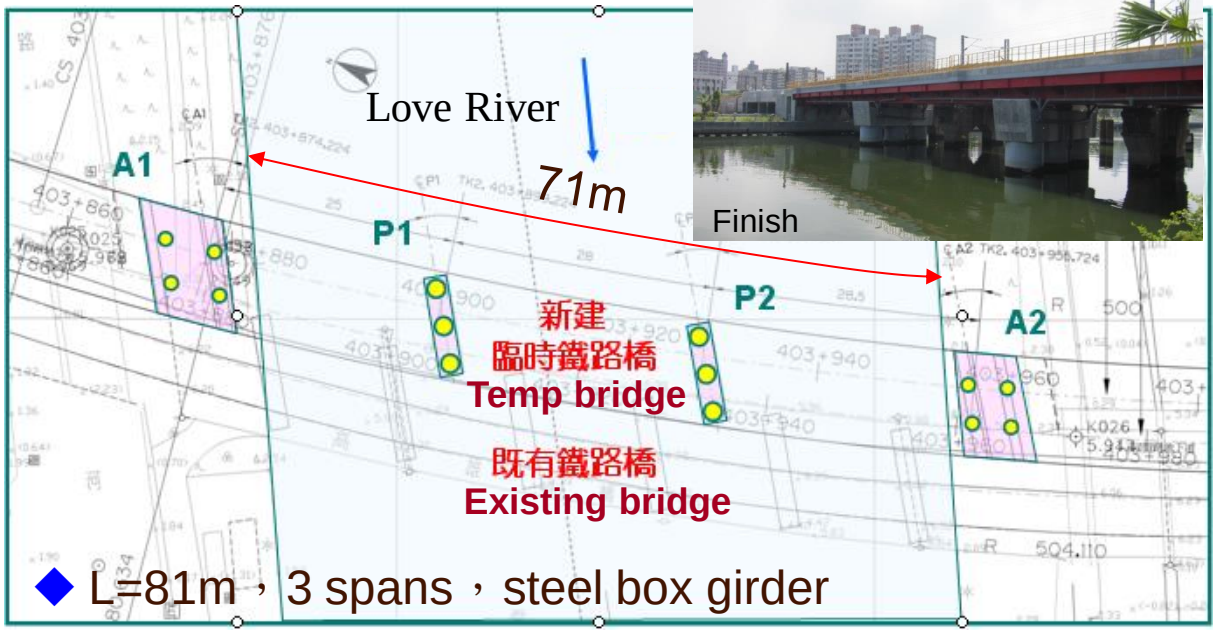


C.Safety Construction through river

New Railway Temp. Bridge

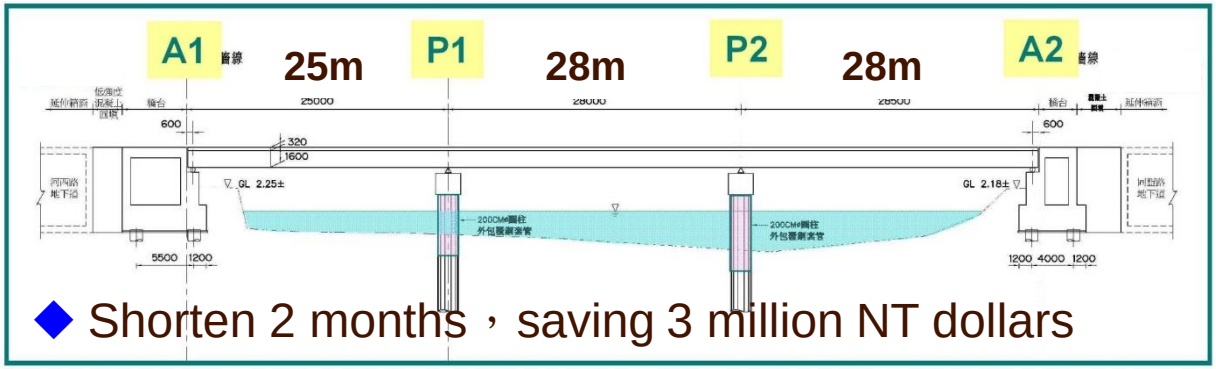






◆ L=81m，3 spans，steel box girder

Temp. Bridge



◆ Shorten 2 months，saving 3 million NT dollars

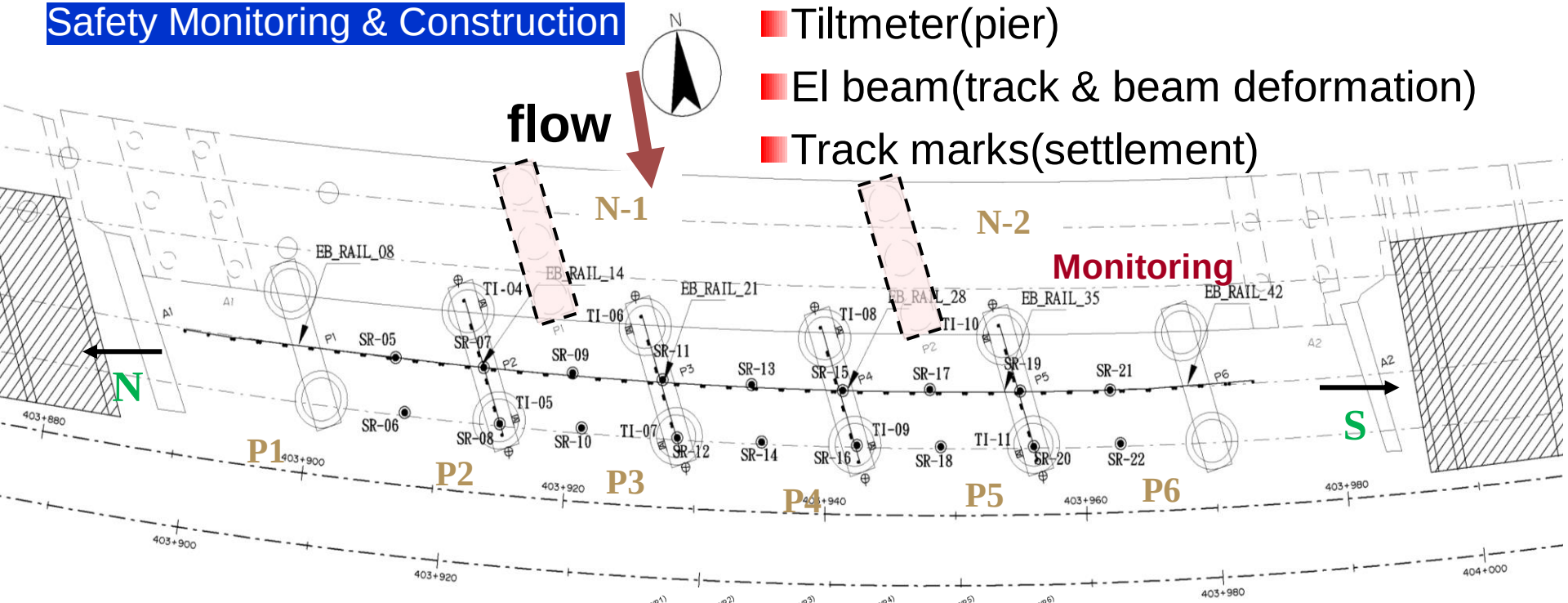
◆ It is designed to use the Φ2.5m pile(L=42m) as deep foundation and also bridge piers for the temp. railway bridge directly, it doesn't need to construct the bridge slab by using high risk cofferdam method.

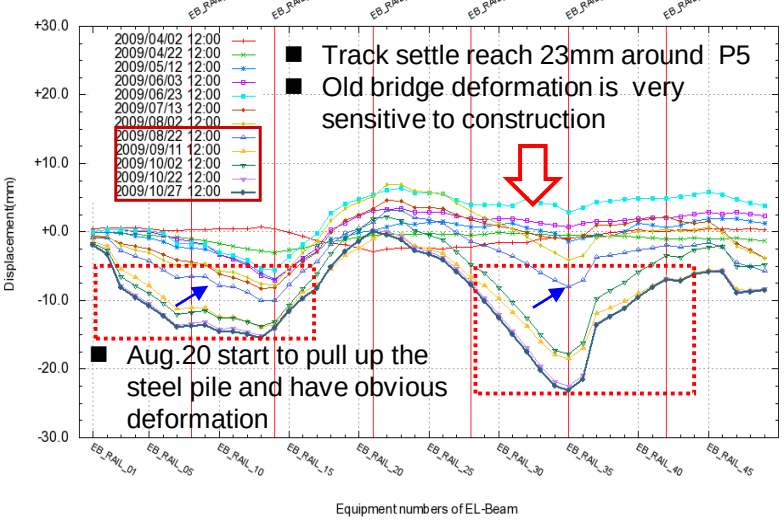
C.Safety Construction through river

Temp. Bridge

Safety Monitoring & Construction

- Tiltmeter(pier)
- El beam(track & beam deformation)
- Track marks(settlement)

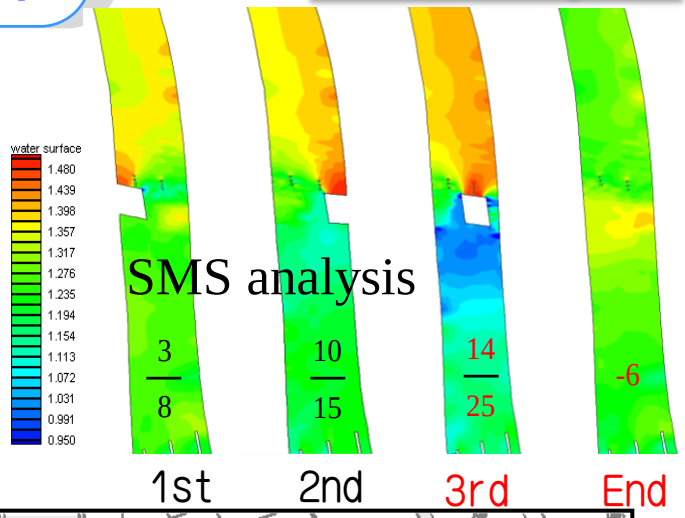


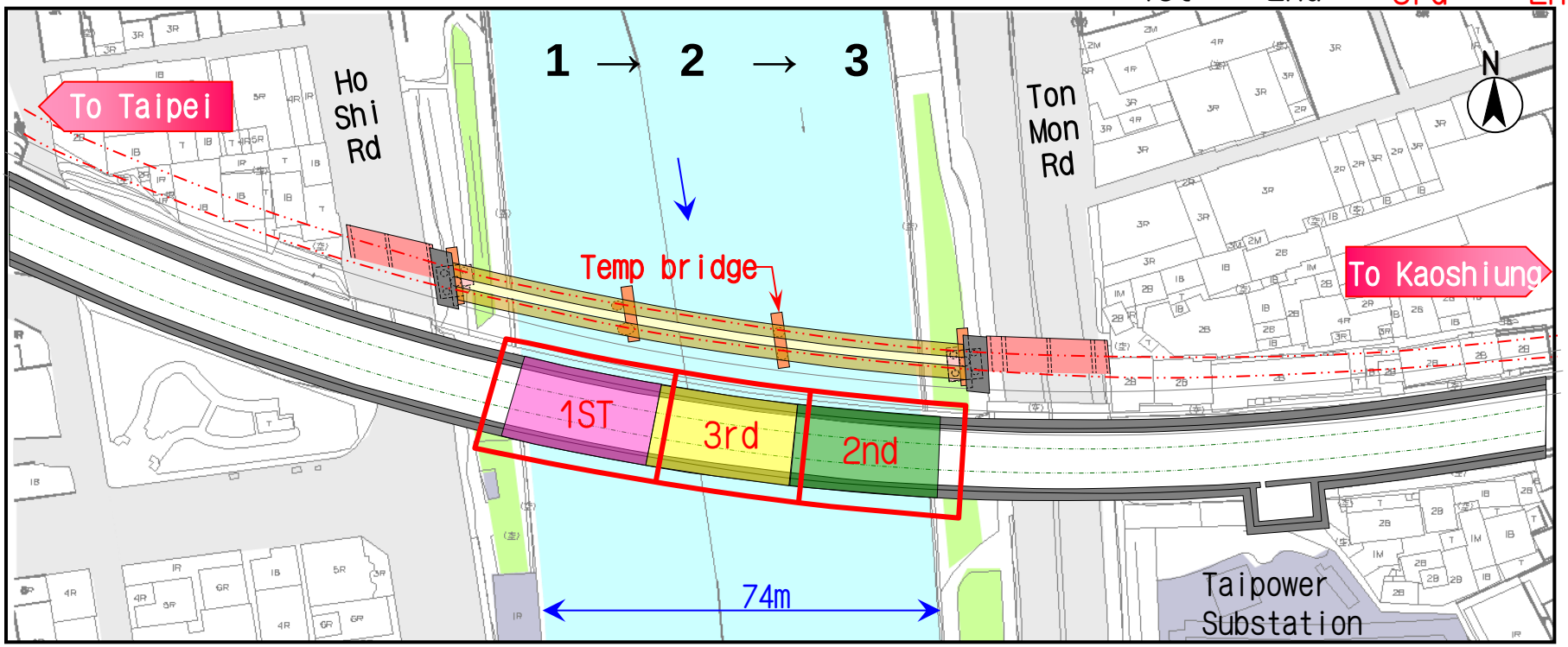


C.Safety Construction through river

- 3 stages construction during non-flood period
- Hydraulic analysis use 10 years flow occurrence and SMS 2D FEM software
- Water level raise up 14cm in average (25cm at local) at the 3rd stage
- Water level lower down 6cm after completion

Flow Analysis

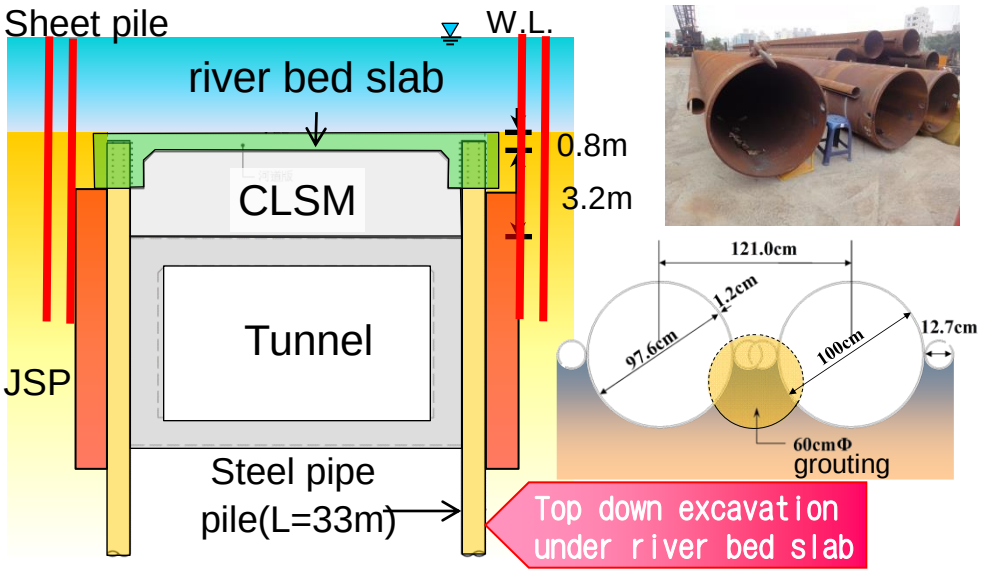




C.Safety Construction through river

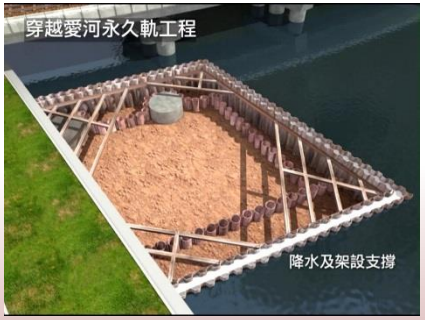
Construction

- Non-flood：6 months to construct cofferdam & river bed slab, and removing sheet pile before flood season(May~Oct.)

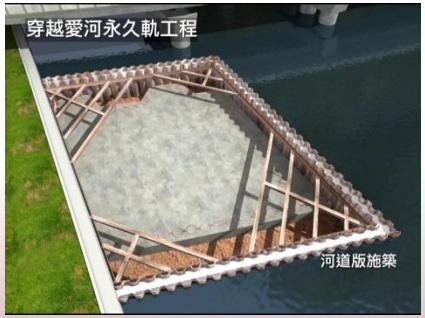


Non-flood season(Nov.~April)

(1) Sheet/Pipe pile



(2) Cofferdam/Bracing



(3) River bed slab

Flood season

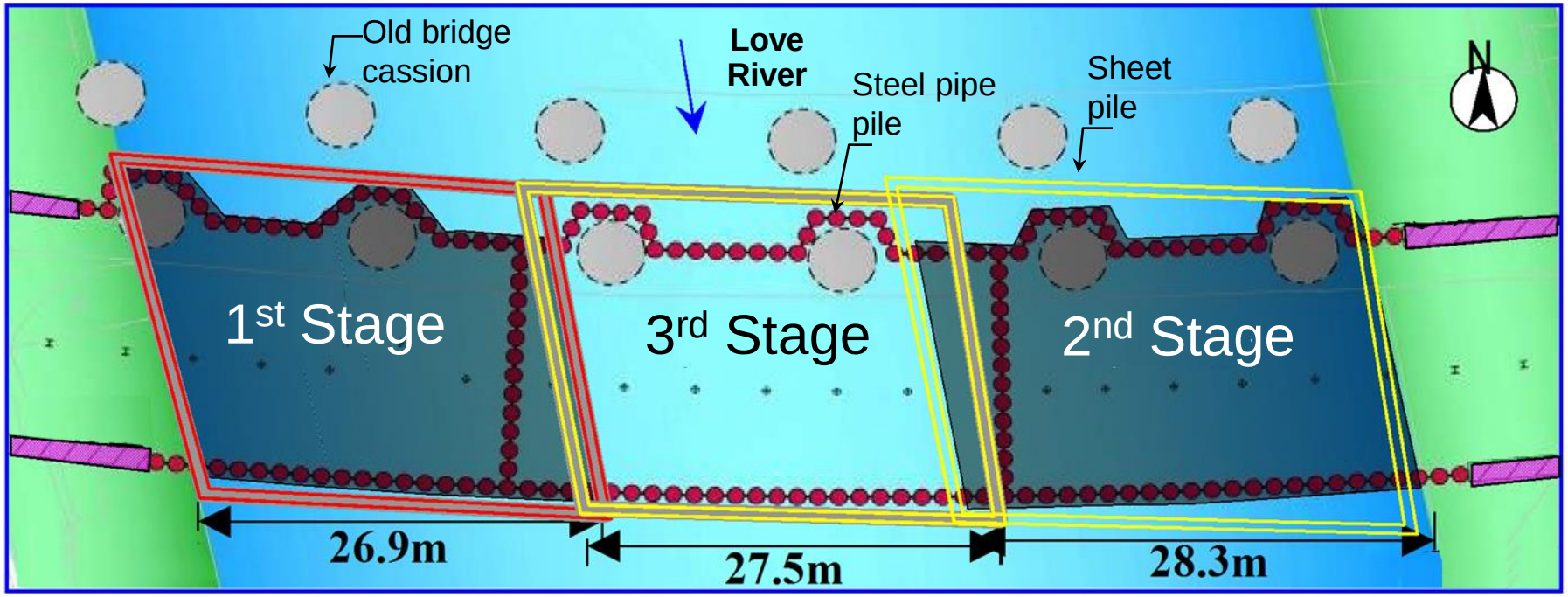
(4)Tunnel Structure

C.Safety Construction through river

Schedule

Cofferdam construction time

- 1st Stage 2011.12~2012.5 6 months
- 2nd Stage 2012.12~2013.4 5 months
- 3rd Stage 2013.12~2014.4 5 months

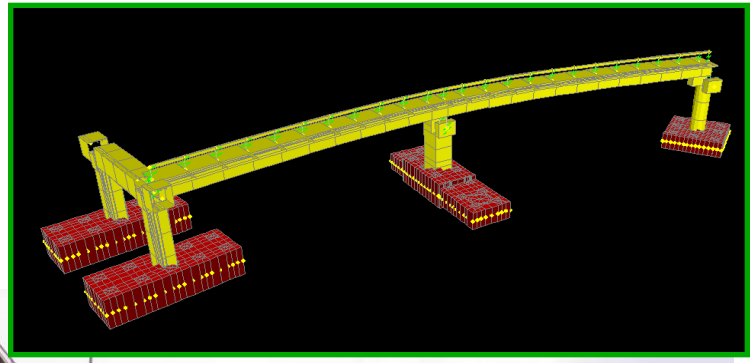


C.Safety Construction through river

D.Safety Construction through Bridge

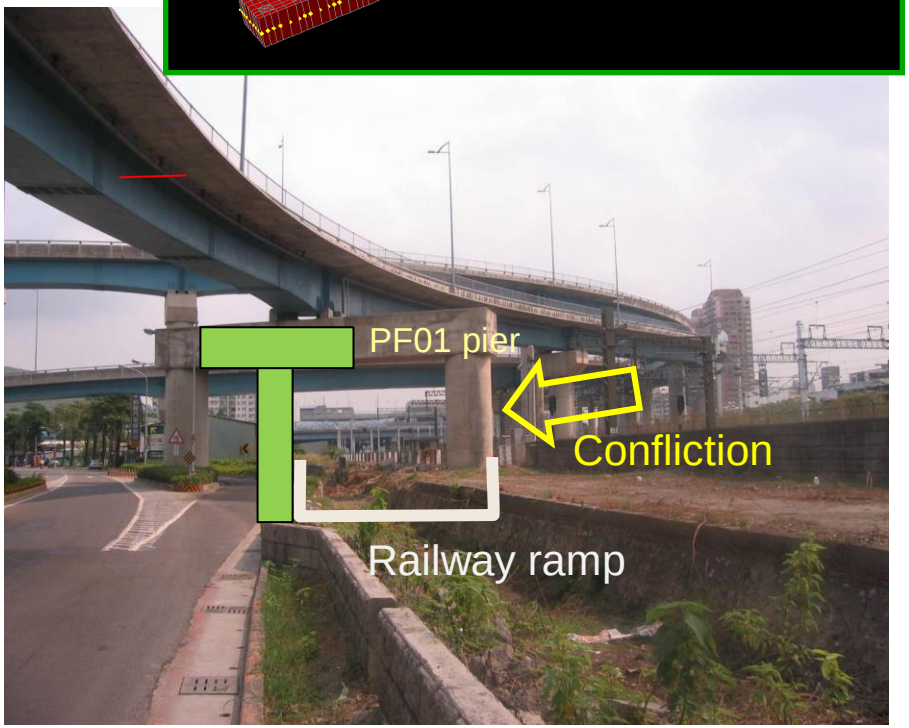
Da-Chung Bridge

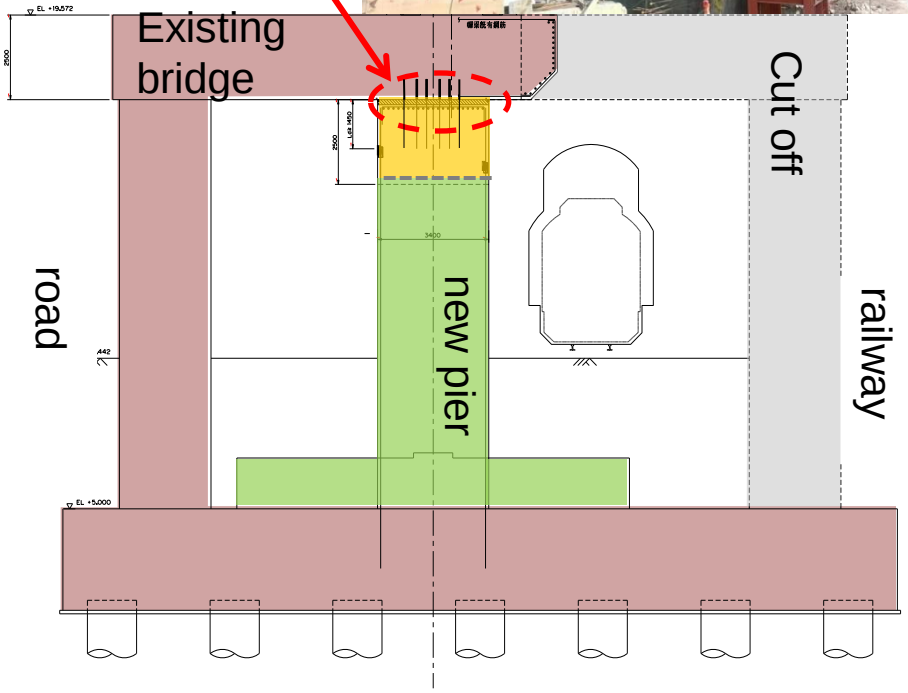
- Confliction between PF01 bridge pier and approach section of tunnel
- Using existing foundation and build new underpinning pier



Hilti-anchorage
(42 bolts)

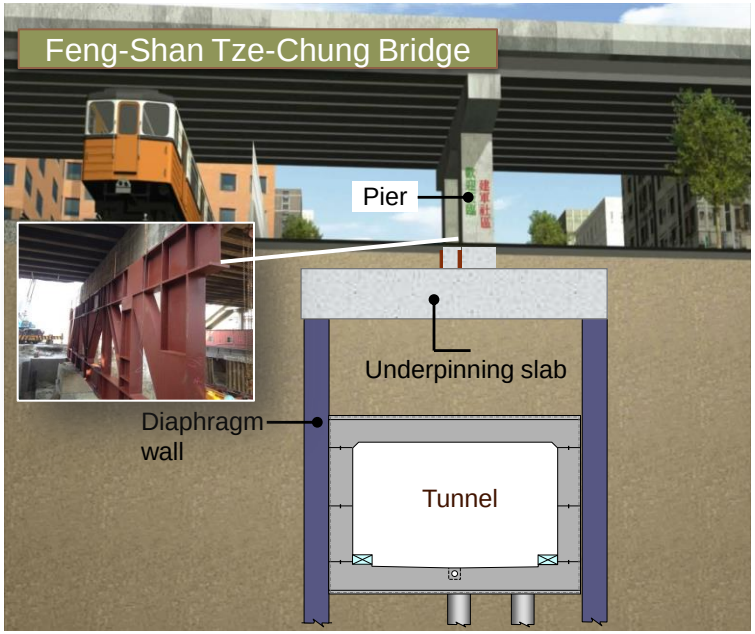
Hinge
(Rebar coupler)



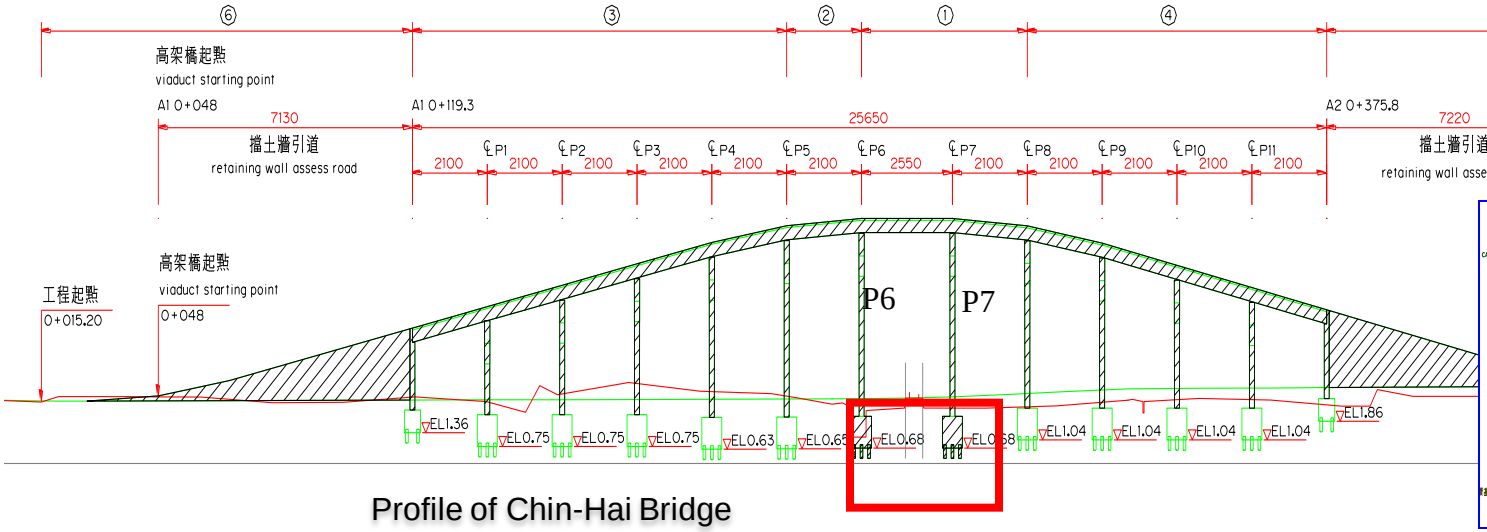


D.Safety Construction through Bridge

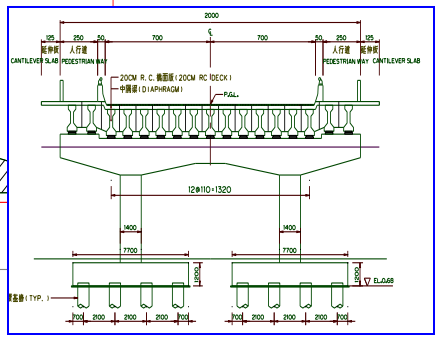
Chin-Hai Bridge



- Dedicated passing route for dump trucks
- Add a new railway-crossing is not allowed
- Adopt underpinning method to support the bridge and to keep construction

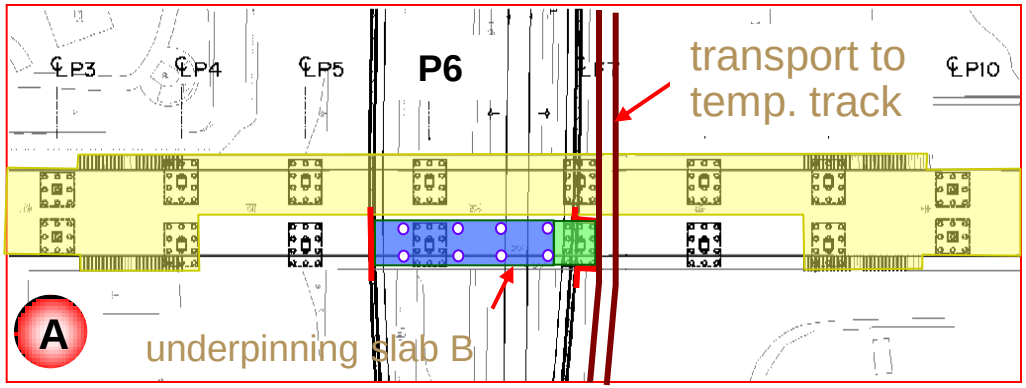


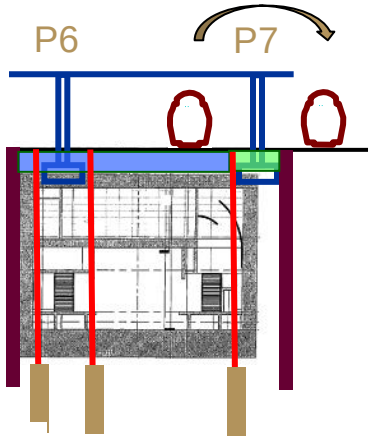
Profile of Chin-Hai Bridge



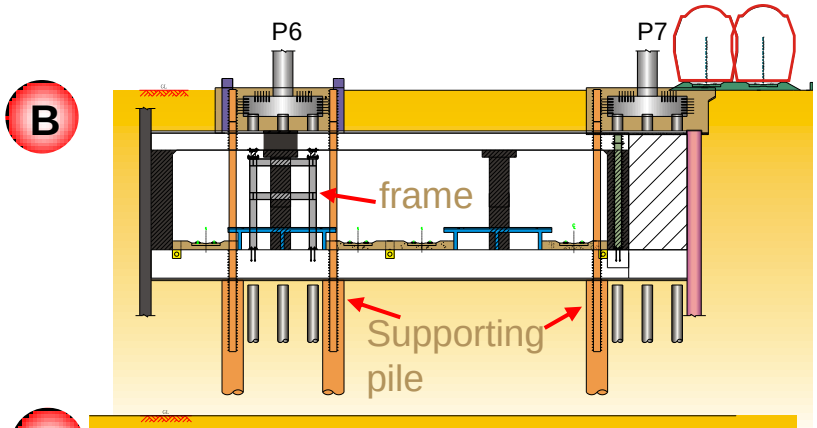
D.Safety Construction through Bridge

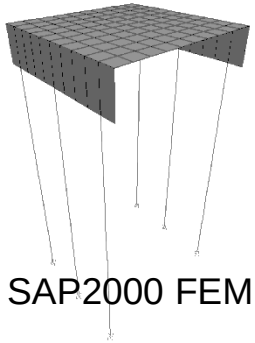
Chin-Hai Bridge



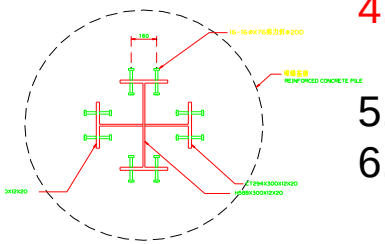


1. Transfer to temp. track operation
2. Slurry wall & piles as support
3. Underpinning slab build

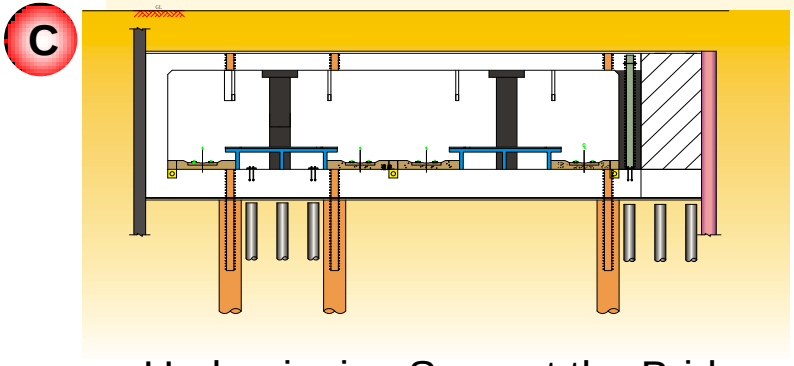




SAP2000 FEM



4. Excavation & cut off existing piles
5. Supporting frame
6. Build station structure & column



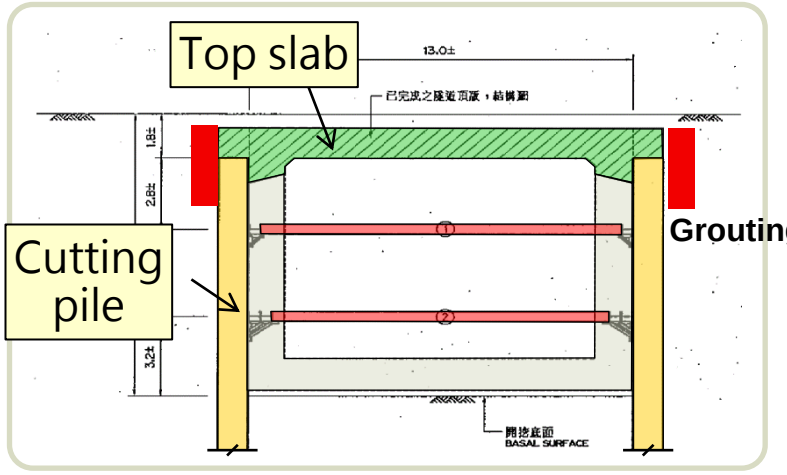
Underpinning Support the Bridge

7. Cut off & remove support pile & column
8. Sta. decoration
9. Tear down the Chin-Hei bridge

E.Safety Construction through underpass

Chung Wha-3 road

- Maintain the traffic lanes → Rebuild the sidewalk tunnel into motor tunnel
- Cavity → Grouting around the interface of slab & Semi top-down construction method to shorten the time and quickly recover the traffic



E.Safety Construction through underpass

Chung Wha-3 road

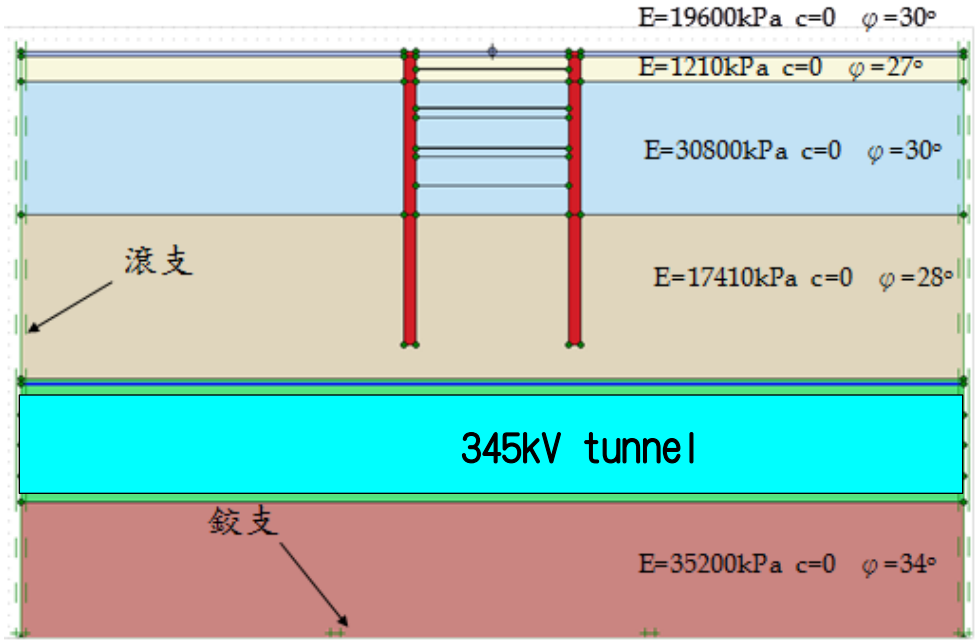
Secure the existing Taipower 345kV transmission tunnel

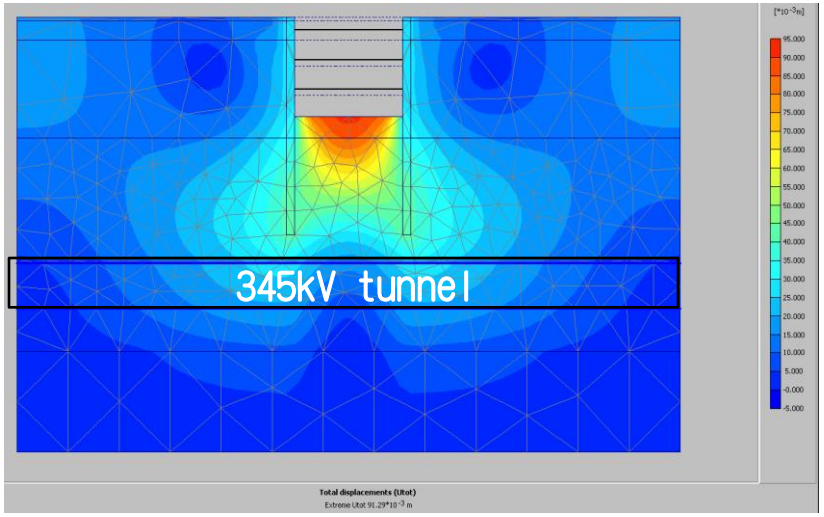
1.Cutting pile as retaining wall

2.PLAXIS analysis

3.Safety monitoring

Measured Disp. (mm)	Alarm disp. (mm)	Allowable disp. (mm)	Check
3	10	17	OK





F. Safety Operation

1. Flood & Water

2. Fire-proof Station

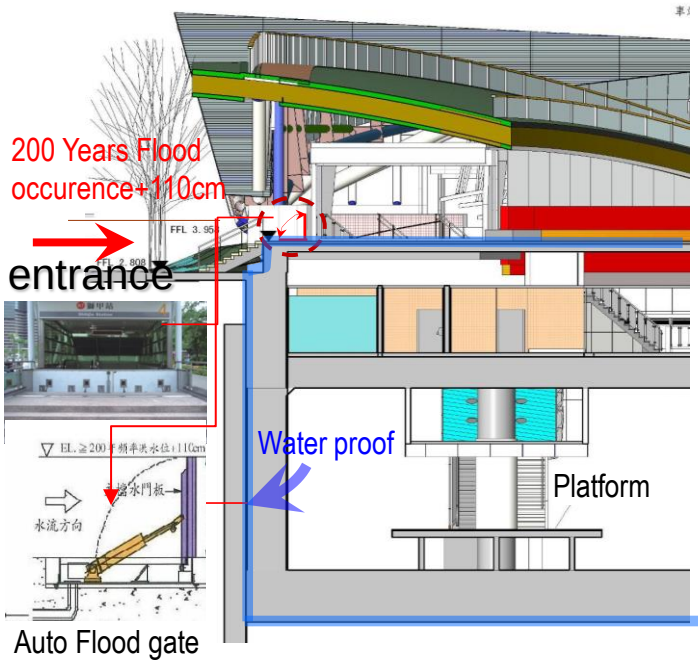
3.Alarm / Broadcast / Passenger Guide

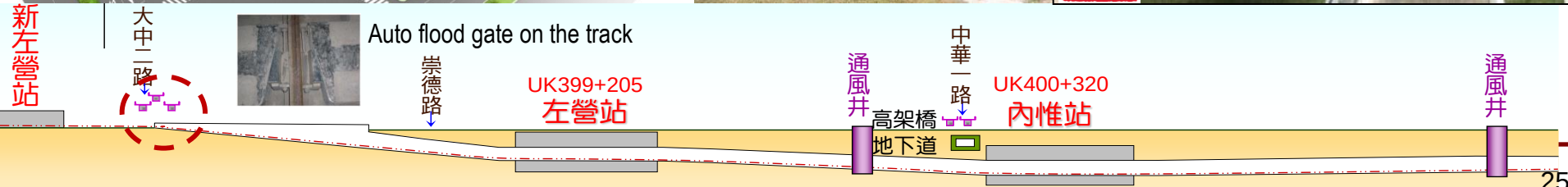
4. Fire fighting & Ventilation

5. Evacuation and Rescue

F. Safety Operation

Flood





F. Safety Operation

Station Fire-proof

Museum of Fine Arts

美術館站

Gu-Shan Sta.

鼓山站

San-Kuai-cuo Sta.

- One of main stations during 1900’
- Main entrance is wood structure (using 2Hrs less-combustible wood)

Build at 日明治41年 (1908)

Build a new “old station”

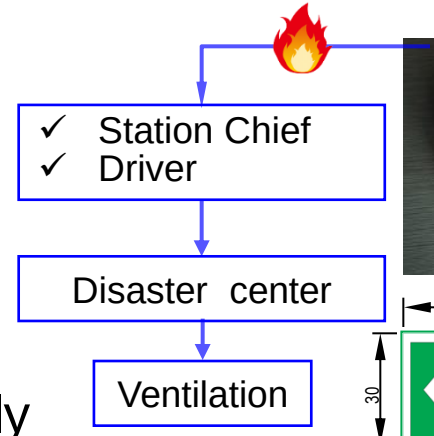
記歷憶史

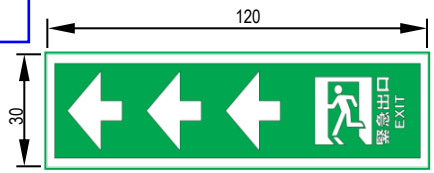
三塊厝站

F. Safety Operation

Alarm/Broadcast/Passenger Guide

- Fire Detector
- Broadcast
- Evacuation Indicator
- Emergent Lighting
- Emergent Power Supply





Emergent Power Supply Items

Taipower Failure	Fire
1、Lighting	1、Fire Alarm
2、A.C.	2、Emergency Lighting、Evacuation Indicator
3、24Hr A.C.	3、Firefighting Pump
4、Water/Sewer Pump	4、Emergent Smoke Extraction
5、Elevator	5、Tunnel Ventilation
6、Fire Alarm	6、Tunnel Lighting
7、Emergency Lighting、Evacuation Indicator	7、Monitoring、Telecommunication
8、Tunnel Ventilation	
9、Tunnel Lighting	
10、Monitoring、Telecommunication	

F. Safety Operation

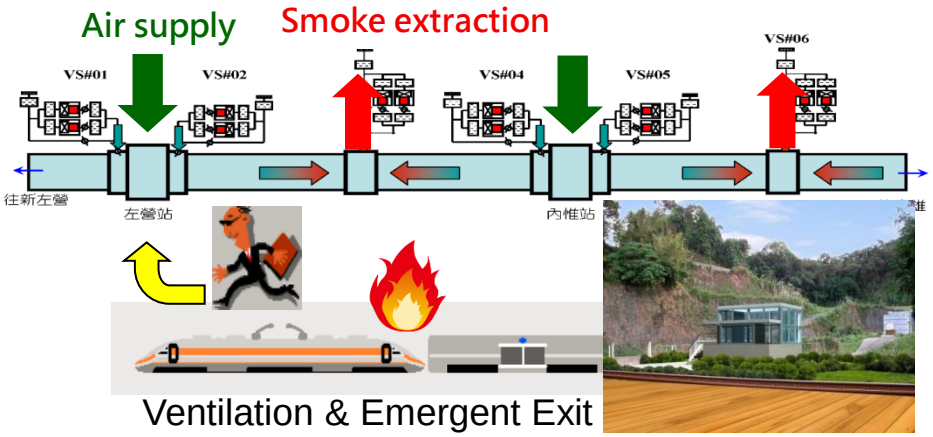
Fire fighting & Ventilation

Early Fire Fighting

Extinguishing

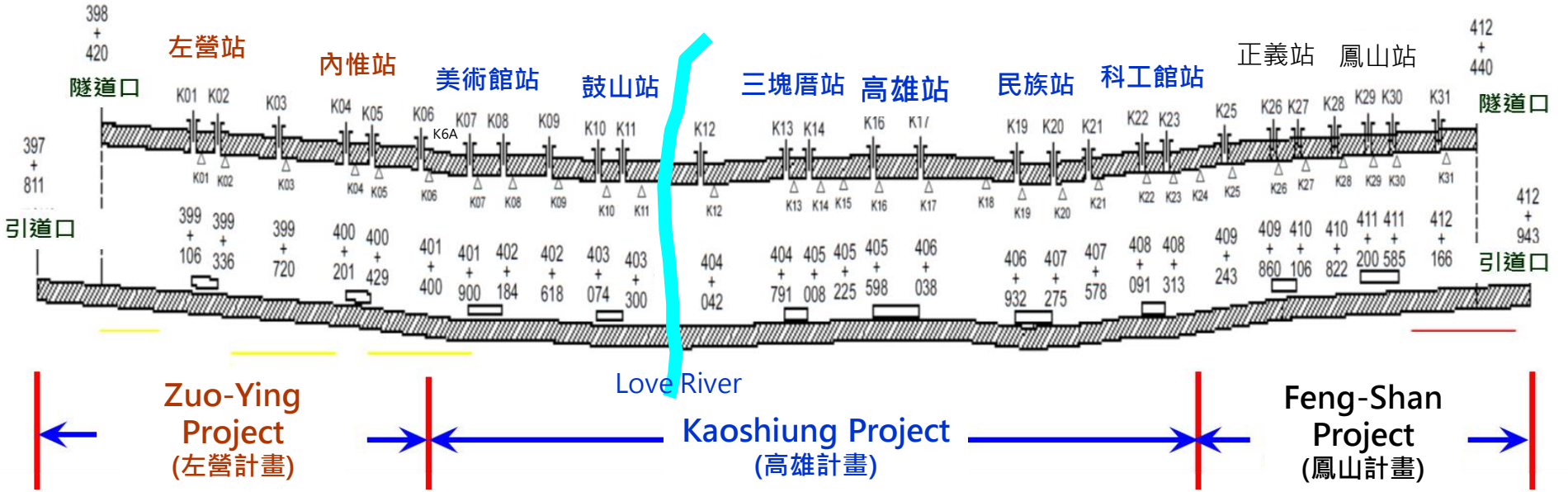



NFPA130 → Interval < 762m



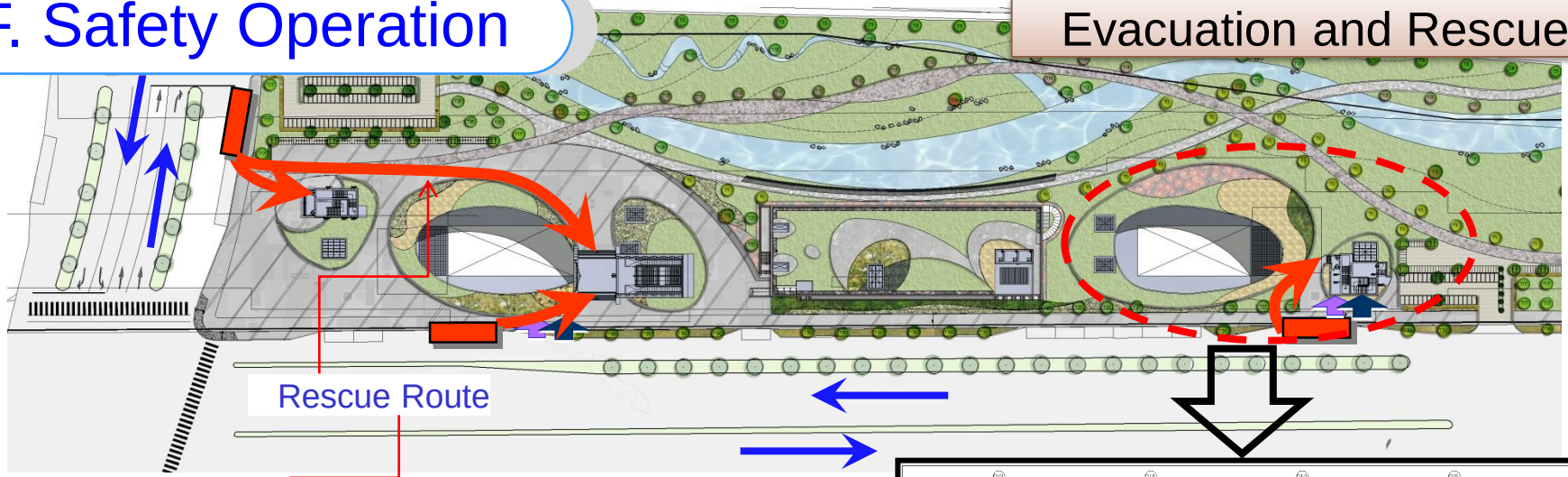
Ventilation & Emergent Exit

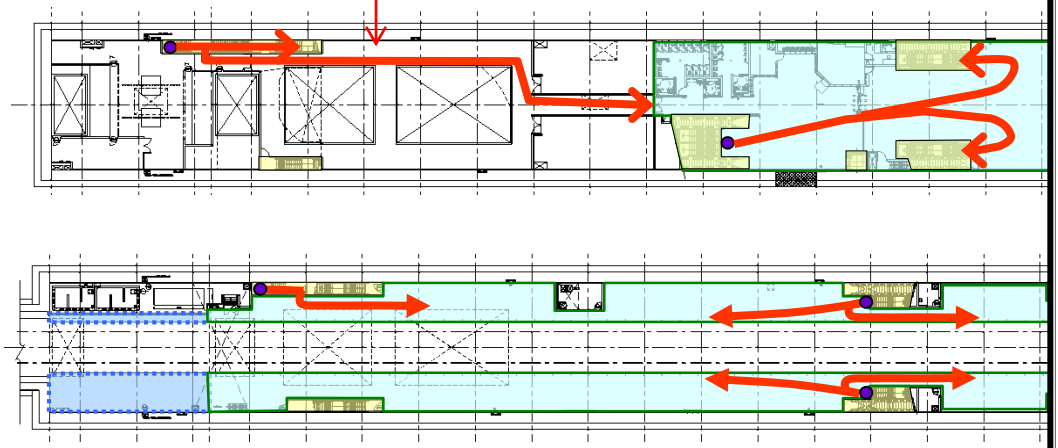
北 ← 32 Ventilation Shafts(14.02km) → 南

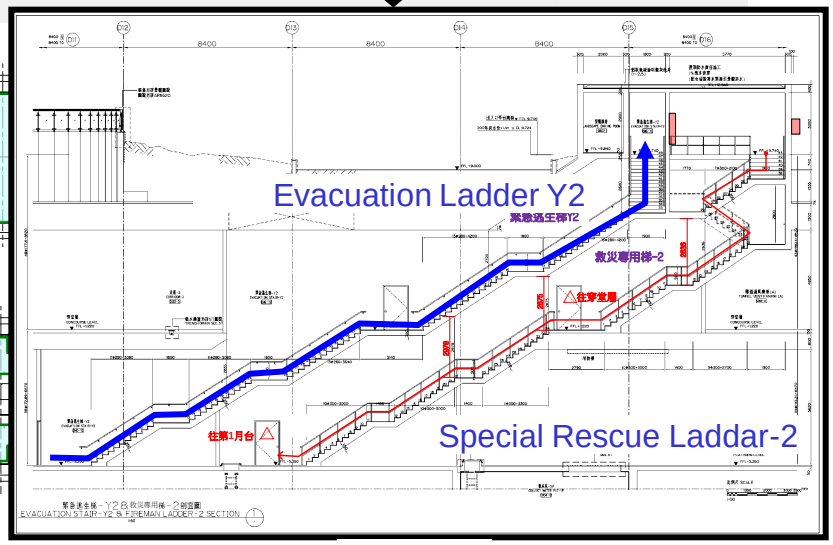


F. Safety Operation

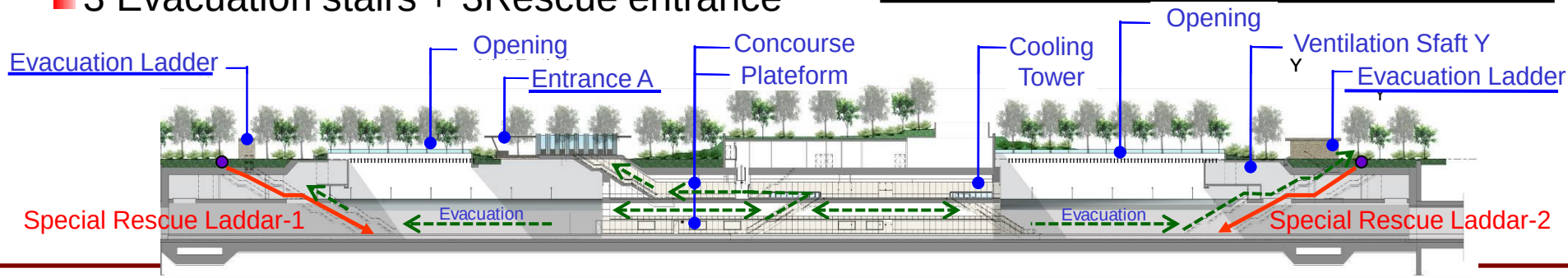
Evacuation and Rescue





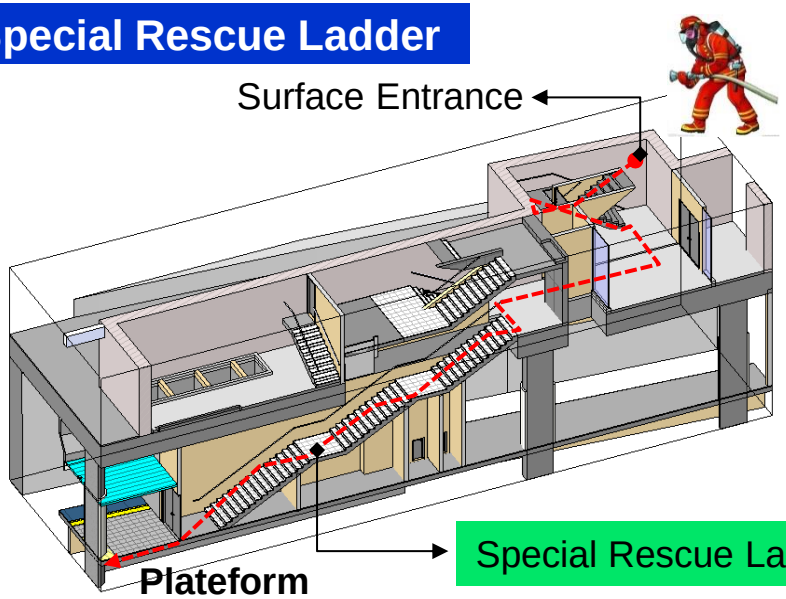


- 3 Evacuation stairs + 3Rescue entrance



F. Safety Operation

Special Rescue Ladder

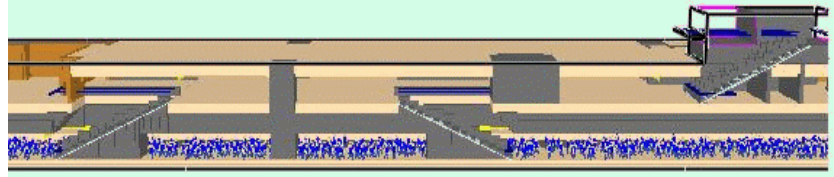


Evacuation and Rescue

EVAC Evacuation Senerio Result

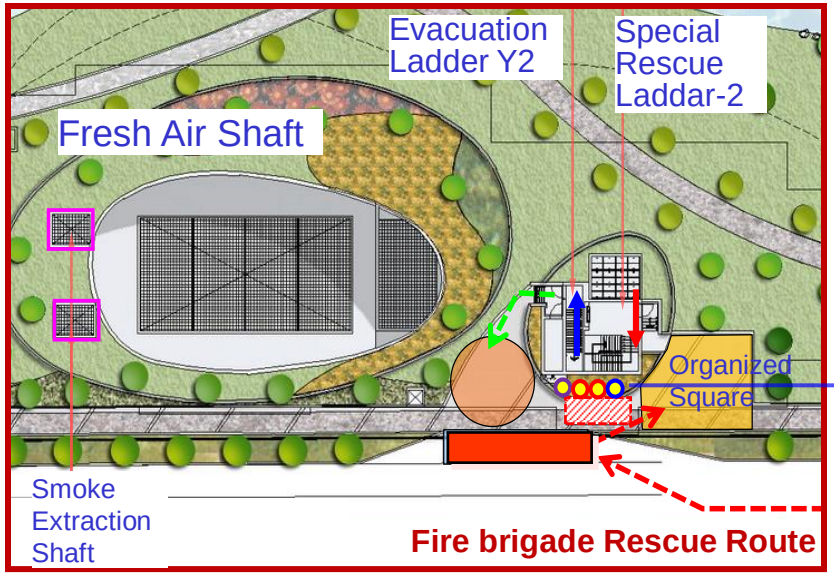
Standard to evacuate

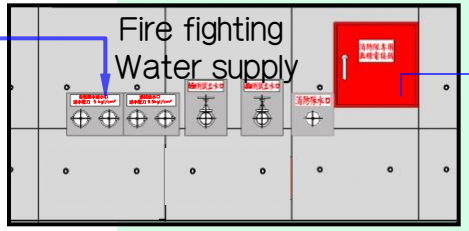
- Platform to concourse ： 240sec
- Platform to ground ： 360sec



Result

- Check1(Dis./Velocity)：281<360sec
- Check2(EVAC)： 357<360sec





Layout of Fire-Fighting Wall

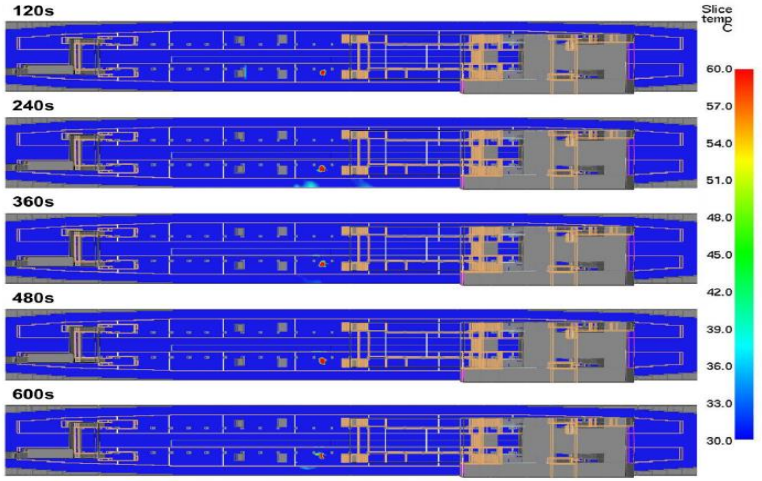
Time: -0.5

F. Safety Operation

Evacuation Analysis

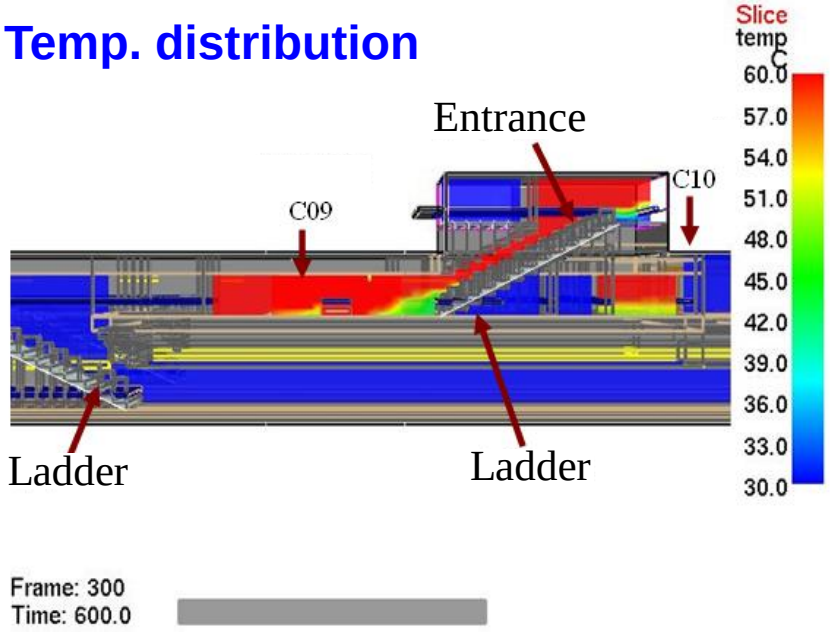
CFD Fire Senerioco

Temp. distribution > 1.8m

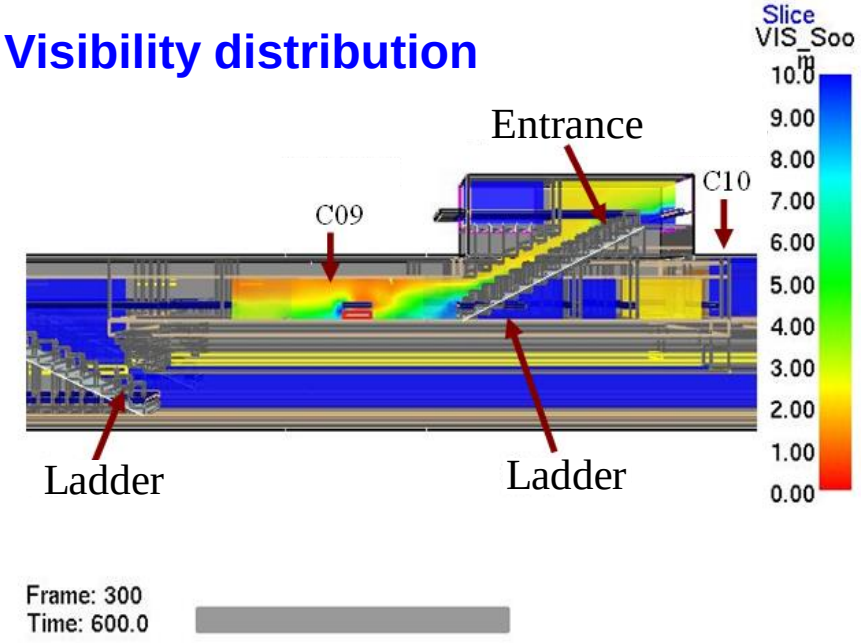


- Passenger Safe clearance > 1.8m(from F.L.)

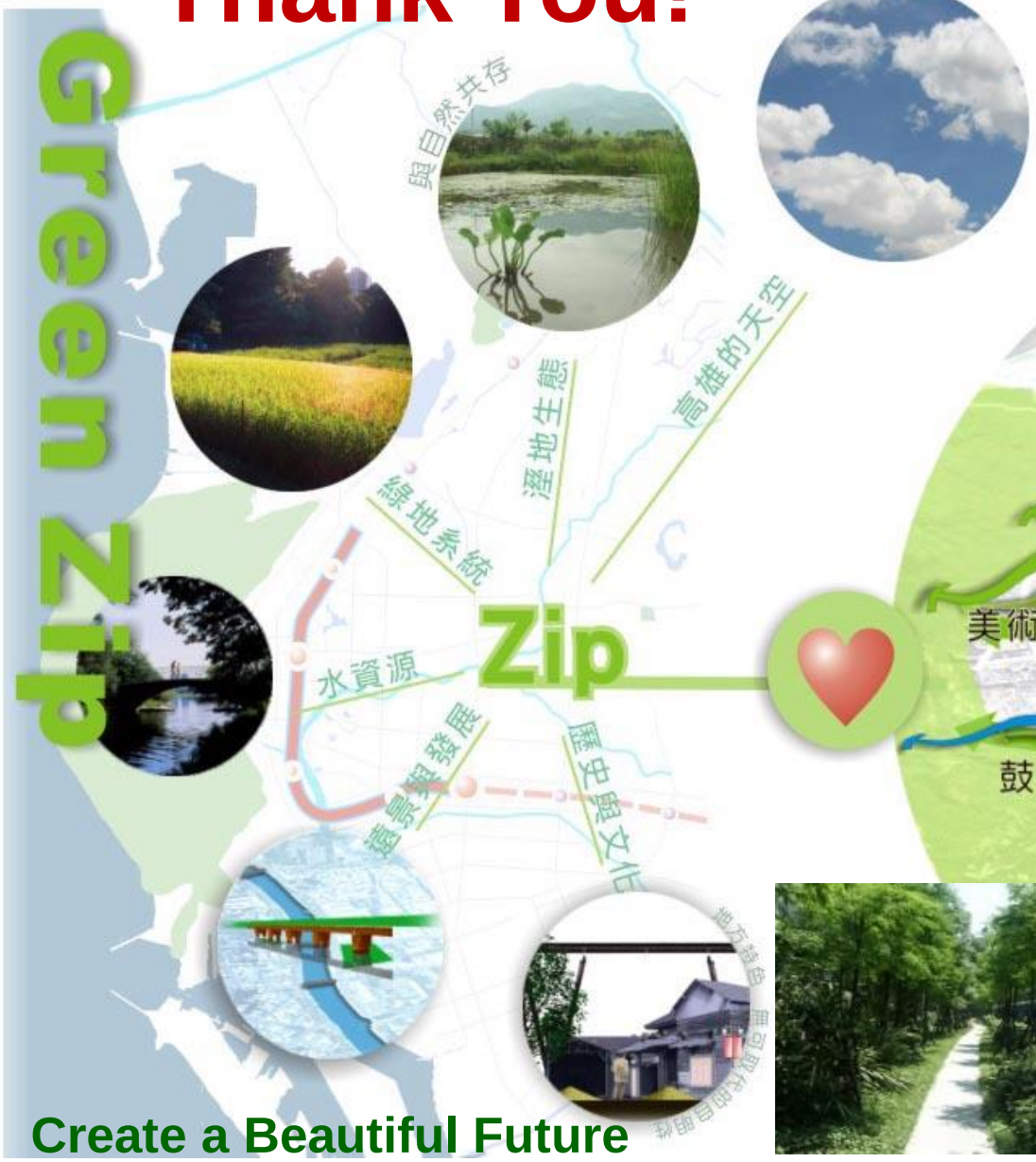
Temp. distribution



Visibility distribution



Thank You!



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