Myanmar Tunneling and Underground

Space Committee (MTUSC)

Underground Space Usage in *Urban and Technical Aspects of Design & Construction for Sustainable City Development*

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DATE: 9 am to 12:00 noon, 28-01-2023, Saturday

❖ ***Objectives of Presentation:***

1. ***Knowledge shearing for sustainable development of construction Industry in urban area.***

Overview of Presentation:

1. Introduction
2. Underground Space Usage for "Better City and Better Life"
3. Review on Technical Aspects of UG Space Design and Construction
4. Examples of UG Space Usage in Various Purposes
5. Conclusion

1. Introduction

Better City, Better Life

UN Habitat is running the World Urban Campaign which has the theme ***'Better City, Better Life'.*** The campaign includes a vision of what sustainable urban development. All infrastructures should ***be integrated construction***.

Integrated Approach

KEY FOCUS AREAS (EES)

- ***Economic,***
- ***Environment and***
- ***Social***

Better City, Better Life

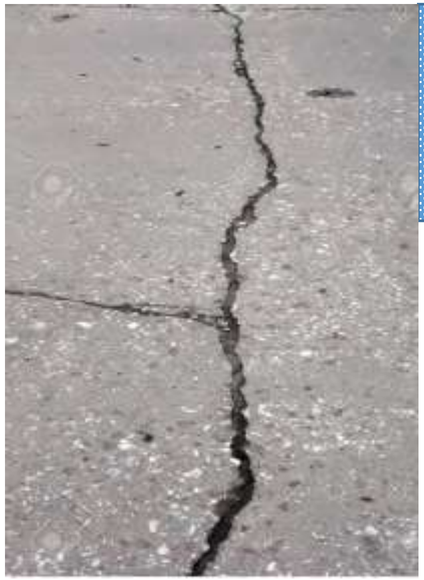
Duties and Responsibilities

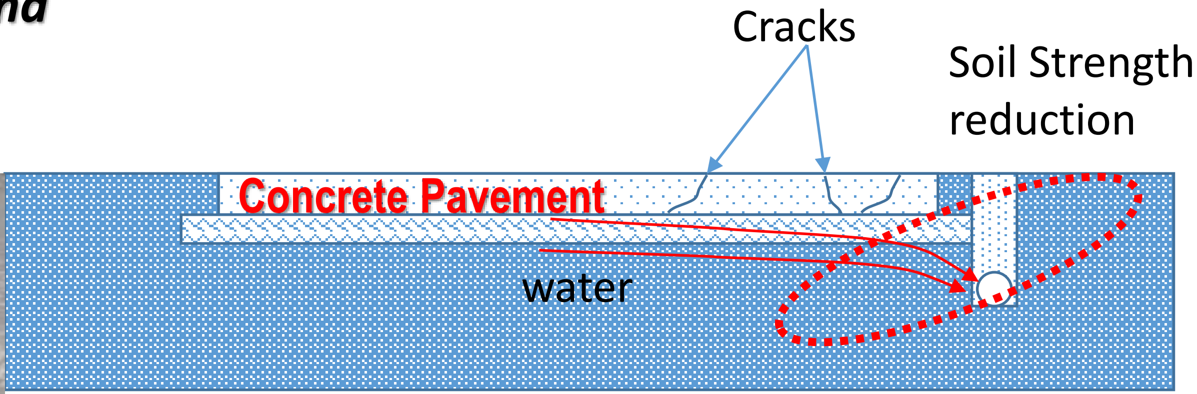
One of the Examples for Less of Sustainability of Construction Industry

Pipe line installation using open excavation
for water distribution

KEY FOCUS AREAS *(EES)*

- ***Economic***
- ***Environment and***
- ***Social***





Road damages

Trenchless Techniques

The Use of *Trenchless Techniques* for the Construction of Underground Infrastructures

Trenchless or no-dig techniques

- ✓ Ducts, pipes or direct buried cables
- ✓ Trenchless techniques can reduce environmental damage and social costs and at the same time, provide an economic alternative to open-trench methods of installation.

Pipeline design considerations

1. Pipe Jacking and Guided Boring
2. Horizontal Directional Drilling

1 Pipe jacking and guided boring

Pipe Jacking uses hydraulic equipment to push lengths of pipe through the ground. Guided Boring uses hydraulics to power a drilling head with spoil taken away by an auger. Alignment is maintained by laser.

A minimum pit plan size of 5m x 5m, mini 150 m from a pit.

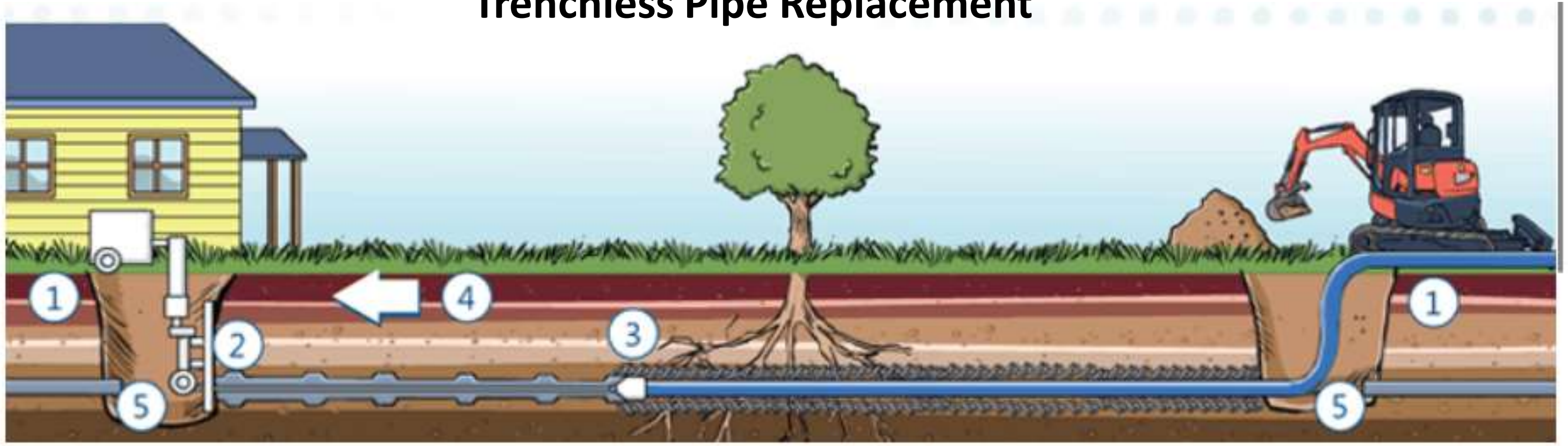
2 Horizontal directional drilling (HDD)

HDD is a trenchless method of installing underground conduits, pipes and cables from the surface. In this group of techniques the drill process begins at ground level from a prepared launch site. The drill is directed into the ground at a relatively steep angle in order to get the drilling head underground and away from the surface as quickly as possible.

Trenchless Pipe Placement

Trenchless Pipe Placement

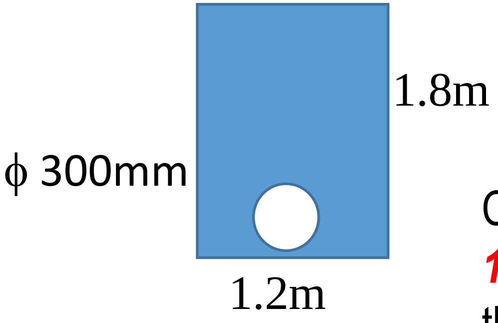
Trenchless Pipe Replacement



Cost Comparison between ***Horizontal Directional Drilling and Open-Cut Con***

HDD is preferred in many urban areas of the world due to three basic reasons:

1. the costs of restoring the surface in the case of open-cut are high,
2. the municipal authorities find it ***very inconvenient to perform open-cut in the congested areas and business districts***,
3. the right-of-way is not accessible due to other structures that have been developed over the years.



Cost using HDD method was ***12.71% more expensive*** than the open cut method.

Cost category	Open Cut		HDD	
	Amount (KSh)	Percentage of total cost	Amount (KSh)	Percentage of Total Cost
Labor Cost	775,492	4.81%	915,714	5.04%
Burden	1,380	0.01%	7,367	0.04%
Permanent Material	5,306,867	32.93%	8,394,449	46.20%
Construction Material	700,927	4.35%	1,108,504	6.10%
Equipment Cost	7,353,853	45.64%	4,780,545	26.31%
Site Expenses	494,848	3.07%	760,328	4.18%
Project Markup	706,925	4.39%	1,064,460	5.86%
General Expenses	706,925	4.39%	1,064,460	5.86%
Bond	67,283	0.42%	75,510	0.42%
Total Cost	16,114,500	100 %	18,171,337	100%

Ref: Cost of HDD and open cut for the *installation of 1000m long of 30cm in diameter* waterlines underneath the busy streets of Nairobi, Kenya

Percentage Urbanization by Development Group, 1950-2050

Source: United Nation (2012)

Development Group	Percentage Urban (%)				
	1950	1970	2011	2030	2050
World	29.4	36.6	52.1	59.9	67.2
More Developed regions	54.5	66.6	77.7	82.1	85.9
Less developed regions	17.6	25.3	46.5	55.8	64.1

The metro area population of Yangon

Source: UNOCHA, Early September 2022

Years	Population	Growth Rate	Remark
1950	1,329,000	Avg. about 2%	-
2017	5,053,000	2.06%	from 2016
2018	5,157,000	2.06%	from 2017
2019	5,244,000	1.69%	from 2018
2020	5,332,000	1.68%	from 2019
2021	5,422,000	1.69%	from 2020
2022	5,514,000	1.70%	from 2021
2023	5,610,000	1.74%	from 2022

Remark: 974,000 people had been internally displaced since Feb, 2021

Population Density

Bangkok **1,569 km²**

The metro area population 14,626,225 **(2022)**

Population per km² = 9,322

Kuala Lumpur **243 km²**

The metro area population **7,564,000 (2022)**

Population per km² = 31,128

Singapore **728.6 km²**

The metro area population **6,040,000** (**2022**)

Population per km² = 8,290

Yangon **598.8 km²**

The metro area population **5,514,000 (2022)**

Population per km² = 9,208

Traffic Jam in cities

Ref: Internet from respective departments of individual country

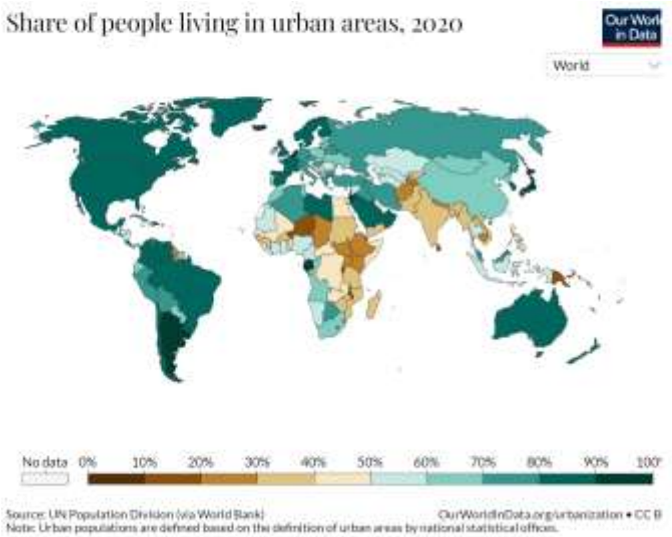
❖ Effective Use of Underground Space

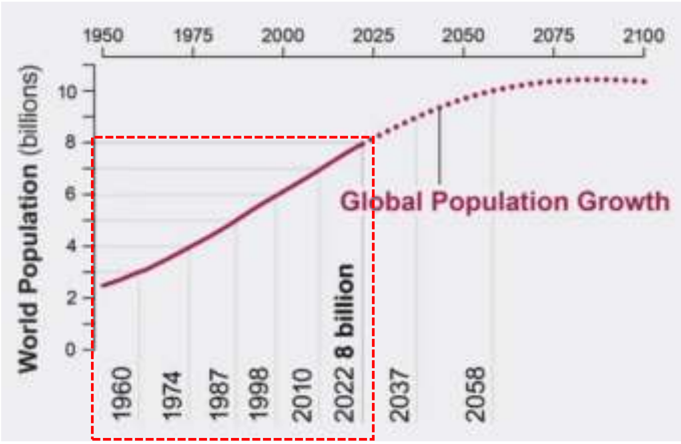
'Better City, Better Life'

The world today is facing major challenges, one of which is rapid urbanization.

The reasons for benefits from going underground for development;

1. Land use and location - For a lack of surface space (*Storage*)
2. Urban environmental quality - Environmental preservation for a variety of advantages in terms of protection of environment.
3. Topographic reason – For the use of tunnels improves or makes feasible various transportation such *as roads, railways, canals, etc. in the hilly or mountainous areas.*
4. Aesthetic (Visual) – For removing unattractive structures such as *car parks, roads, and tunnels*. In line with that, we can save more surface space for other developments.
5. Safety, security, and protection against natural disasters - Disaster preventing benefit for sustainable development in urban areas (*Electric transmission line*)





Results for the use of underground space for city development:- Underpass, Transport way, Drainage line, Storage room, Sewage line, Underground cable line etc.:

1. ***Urban Perspective*** - Spending urban areas more appropriate, compactly locating large objects in the building structure, increasing the efficiency of utilization of engineering and transport infrastructure facilities.
2. ***Environmental Effects*** - Less of environmental impact (physically, visually: increasing the area of landscaping, improving the sanitary and hygienic condition of the city, reducing energy costs for the operation of facilities.).
3. ***The economic effect*** - More safe and less transportation cost in mountainous regions.
4. ***More safe for potential hazards*** - Earthquake, fire, land slide, road accidents etc.

Note:

- *Design constraints are significant effect on the cost of underground construction. Therefore, tunnel and underground space construction should be planned properly to achieve the cost-effective construction.*
- However, apart from real-estate impacts associated with surface structure solutions, when long term operation costs are considered in addition to direct construction costs, underground solutions would be an option to avoid disappointment in supporting sustainable urban growth.

Policy for Underground Space Usage:

Legal considerations for Urban Plan

- ✓ The importance of reviewing legal considerations to identify problems and solutions regarding the integrated planning of underground space, environmental protection, and construction liabilities.
- ✓ This ensures that the development of underground space does not create problems in the future alongside the influence of other aspects.
- ✓ The restrictions imposed by legal considerations are one obstacle in developing and using underground space.
- ✓ Obstacles to development include ambiguity in the regulations, the unclear implementation of legislation, and uncertainty in matters relating to the ownership of and rights to land including mineral and natural resources.

Legal considerations for underground space development

- ✓ Any development of land on the surface or underground must comply with the relevant rules, regulations, and legislations.
- ✓ For land development, the main legislation in Malaysia is the National Land Code 1965 (NLC, 1965).
- ✓ Since the development of underground space comes later in urban planning, legal considerations must be integrated with that of the surface space.
- ✓ A suitable legal framework is needed to ensure that the underground space is systematically developed, because once excavated it cannot be restored.
- ✓ In addition, legal considerations affecting the underground space must first be established.

Four key elements of legal considerations that are identified for the development of underground space ;

1. underground space ownership,
2. landowner's of rights,
3. depth, and
4. underground space utilization.

1. Underground space ownership

- ✓ In Malaysia, the State List in the Federal Constitution positions land under the authority of State Authority. According to Section 'Enhancing the policy for underground space development' of the NLC, **the State Authority** is the Ruler or Governor of the State; thus, all land in the State belongs to the State Authority.
- ✓ The power for land disposal in Malaysia is completely controlled by the State Authority. State Authority has the power to dispose of the land through alienation to eligible applicants
- ✓ Nowadays, the trend in urban areas is considering underground space as an option for development.

2. Landowner's rights

- ✓ The United Nations Economic Commission for Europe (2005) defines the rights to land as including the "rights of ownership and rights of use." The bundle of rights included in a certain right, who the holder of the right is, and the extent of the right for a piece of land.
- ✓ Previous underground space developments in Malaysia were limited to infrastructure and utilities such as the SMART Tunnel, underground parking spaces, rail transportation, and cables and pipelines. Most of these developments are on State land.
- ✓ Nevertheless, for development for the public under private land, the developer must deal with the surface landowners. Section 92 B (1) (a) of the NLC 1965 states that for alienated land without a specified depth, only the landowners have the right to apply for the title and to develop it.

3. Depth of development

- ✓ Developments on the surface and underground are dependent on each other, because the foundation of the surface structures is constructed below the ground, and access to underground buildings must be from the surface. Therefore, it is important to define the extension of ownership by focusing on the depth boundaries of the surface and underground space ownership.
- ✓ The depth of land ownership and possession as well as the right of use of underground space is a worldwide issue that must be resolved.
- ✓ The depth of ownership should not be less than *6 m in the case of agricultural land*, and not less than *10 and 15 m* respectively for the building and industrial categories ***(Regulations 2006 in the NLC 1965 (Act 56), Malaysia***).

4. Underground space utilization

(ဃ) အထပ်မြင့်အဆောက်အအုံများတွင် ကားပါကင်ထည့်သွင်းခြင်း

(၁) မြေကွက်အကျယ် (၅၀ ပေ x ၅၀ပေ) အရွယ်မြေကွက်များတွင် (၄)ထပ်နှင့်အထက် အဆောက်အဦ ဆောက်လုပ်ပါက မြေညီထပ်တွင် မဖြစ်မနေ ကားပါကင်ထည့်သွင်းရမည်။

(၃၅) **အဆောက်အအုံနယ်သတ်မျဉ်း** ဆိုသည်မှာ ကော်မတီ၏ တရားဝင်ဆောက်လုပ်ခွင့်ရရှိသည့် အဆောက်အအုံတစ်ခု၏ မျက်နှာစာနံရံနှင့် လမ်းနယ်နိမိတ်၏ အကွာအဝေးကို သတ်မှတ်ထားသော မျဉ်းကြောင်း ရှိရမည့်နေရာကိုဆိုသည်။

၃၀။ အစိုးရဌာနများ၊ အဖွဲ့အစည်းများနှင့် ပုဂ္ဂလိကအဖွဲ့အစည်းများသည် မြို့တော်နယ်နိမိတ်အတွင်း အောက်ပါလုပ်ငန်းကိစ္စများ လုပ်ကိုင်ဆောင်ရွက်လိုလျှင် ကော်မတီနှင့် ညှိနှိုင်းဆောင်ရွက်ရမည် -

(က) မြို့တော်နယ်နိမိတ်အတွင်း မြေအသုံးချခြင်း၊ အဆောက်အအုံတည်ဆောက်ခြင်း၊ မြေပြုပြင်ခြင်း၊

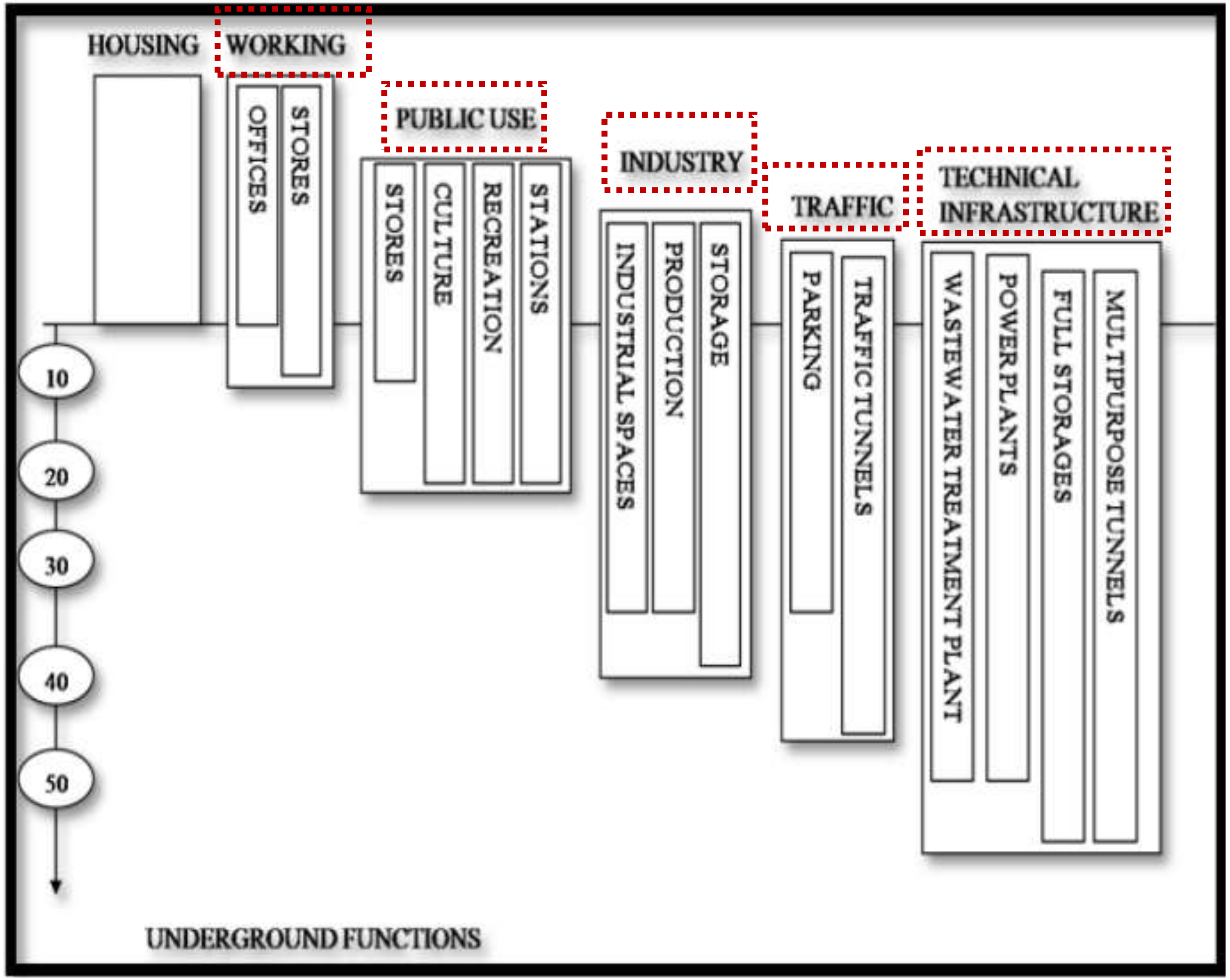
(ခ) အထူးစီးပွားရေးဇုန်များနှင့် စက်မှုဇုန်များတည်ထောင်ခြင်း၊ လုပ်ကိုင်ခြင်း၊

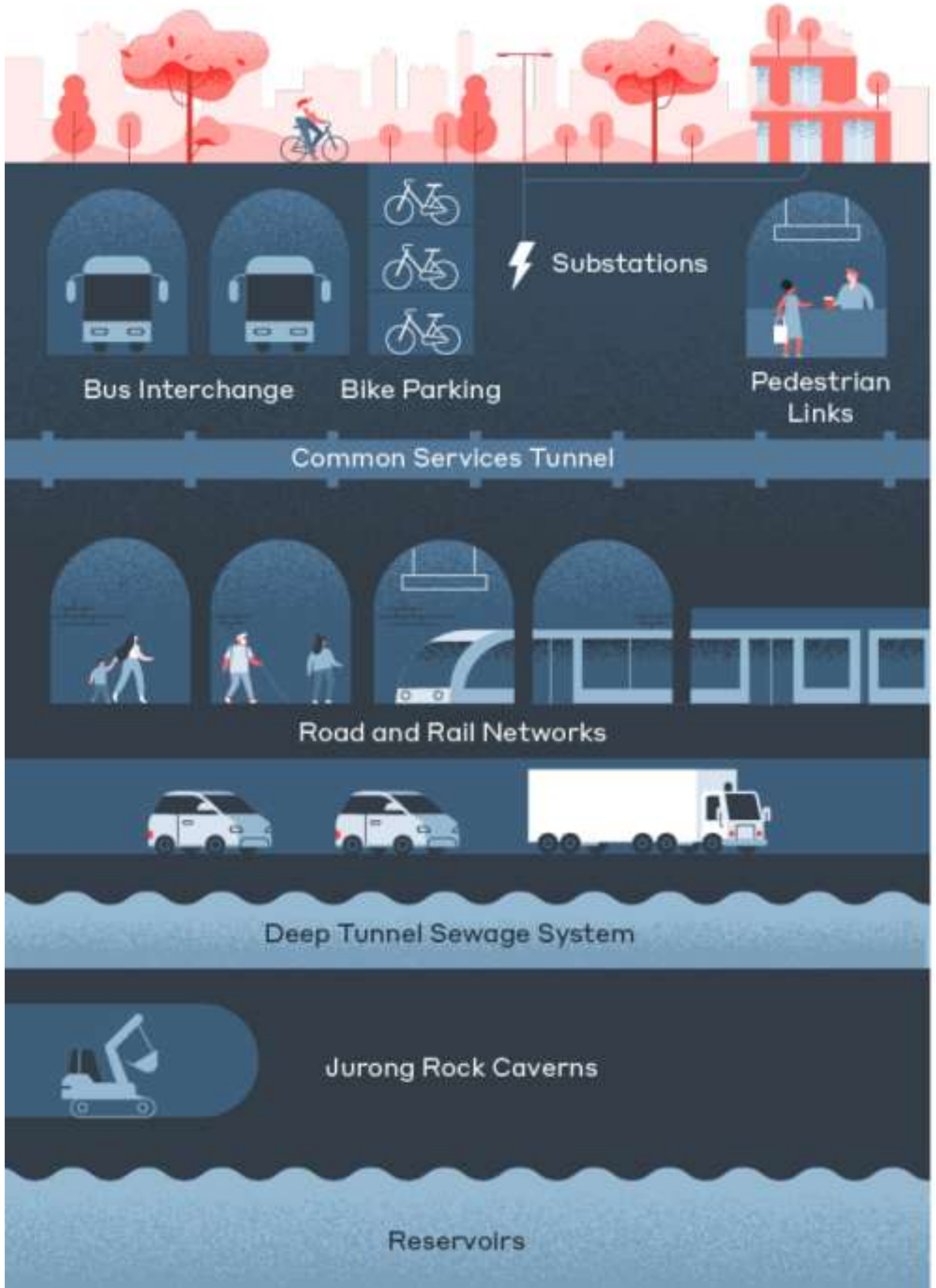
(ဂ) လမ်းနှင့်တံတားဆောက်လုပ်ခြင်း၊ ဆက်သွယ်ရေးတာဝါတိုင်များ၊ လျှပ်စစ်မီးတိုင်များ၊ မြေပေါ်မြေအောက်ဆက်သွယ်ရေးကွန်ရက်များ၊ နန်းကြိုးများ၊ ပြွန်များနှင့် ပိုက်လိုင်းများ ဆက်သွယ်ခြင်း၊ မြေအောက်ဥမင်လိုဏ်ခေါင်းများ ဆောက်လုပ်ခြင်း။

- ## Underground Space Usage in Urban

Feasible Depth of Underground Development

Source: Ronka*et al.* (1996)






Review on Technical Aspects of
Design and Construction

Geotechnical Impact Assessment (GIA)
for Construction of Foundation/Basement

Geotechnical Impact Assessment (GIA):

1. ***Hazard Assessment on surrounding structures***
2. ***Risk Assessment***

A Geotechnical Assessment is an essential factor in *the integrity of any construction or engineering project*.

Concepts of Urban Basement Construction

I. Basic principle of open excavation is mainly for flexible support.

<u>Objectives are</u>: (1) stability is critical

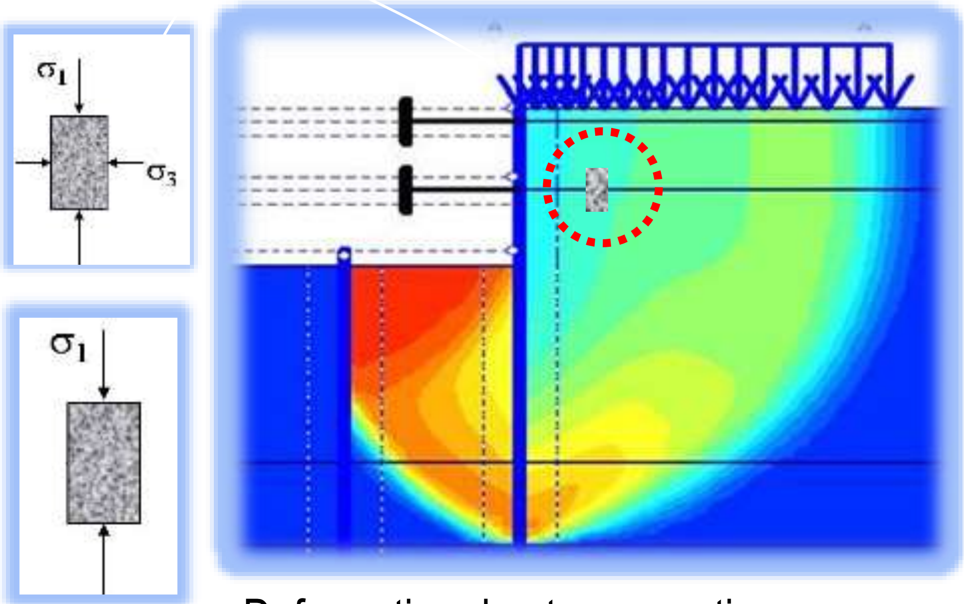
(2) deformation is not critical (usually desirable)

II. Basic principle of excavation in Urban is mainly for Rigid Support

(Control of Ground displacement).

<u>Objectives are</u>: (1) displacement (deformation) is critical (to be minimized)

(2) stability is ensured by controlling deformation



Deformation due to excavation

Geomechanics (Soil/Rock) Aspects

Design Soil Parameters:

- c, ϕ, m, s (Mathematical model criteria)
- E,
- ψ, etc.
- Soil Behavior (Hardening, Perfectly plastic, Softening, Brittle)
- Hydrological conditions

Construction Materials

Design Parameters:

- Yield strength, c, ϕ
- E,
- ψ, etc.
- Material Behavior (Ductility, Brittle)
- etc.

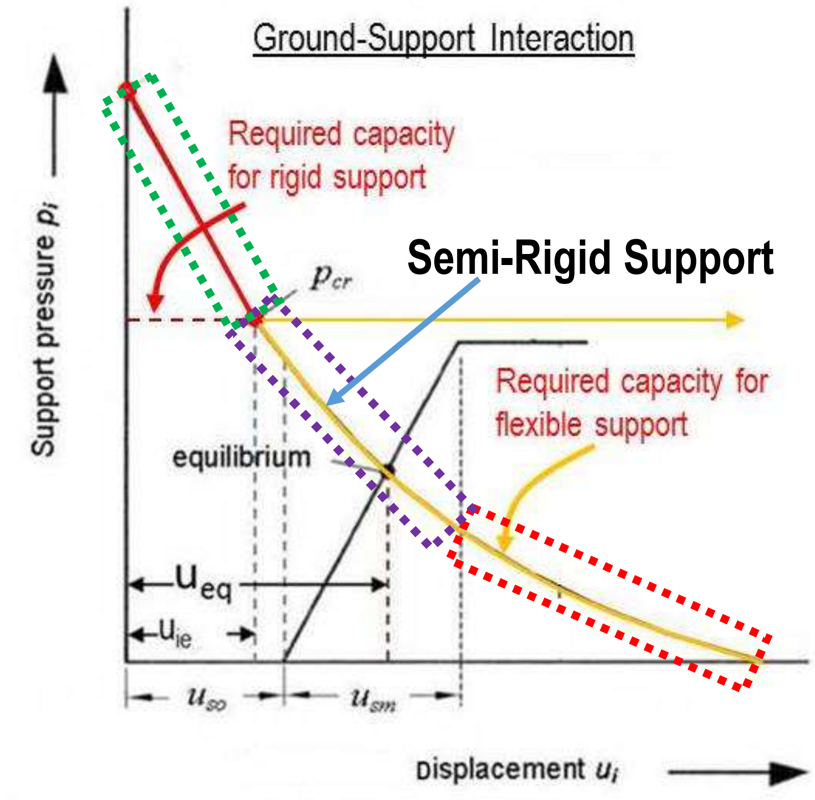
• Technical Aspects of Design & Construction of UG Space

Consideration in Design and Construction

Support Methods
1. Flexible Support Method
2. Semi-Rigid Support Method
3. Rigid Support Method

Design Consideration

- Depth of Excavation
- Nature of Soil (types of soil and its permeability)
- Ground water table (permanent and temporary)
- Adjacent structures and facilities
- Excavation methodology
- Substructure detail



Where,

u_{so} = total initial displacement of support

u_{sm} = maximum elastic displacement of support

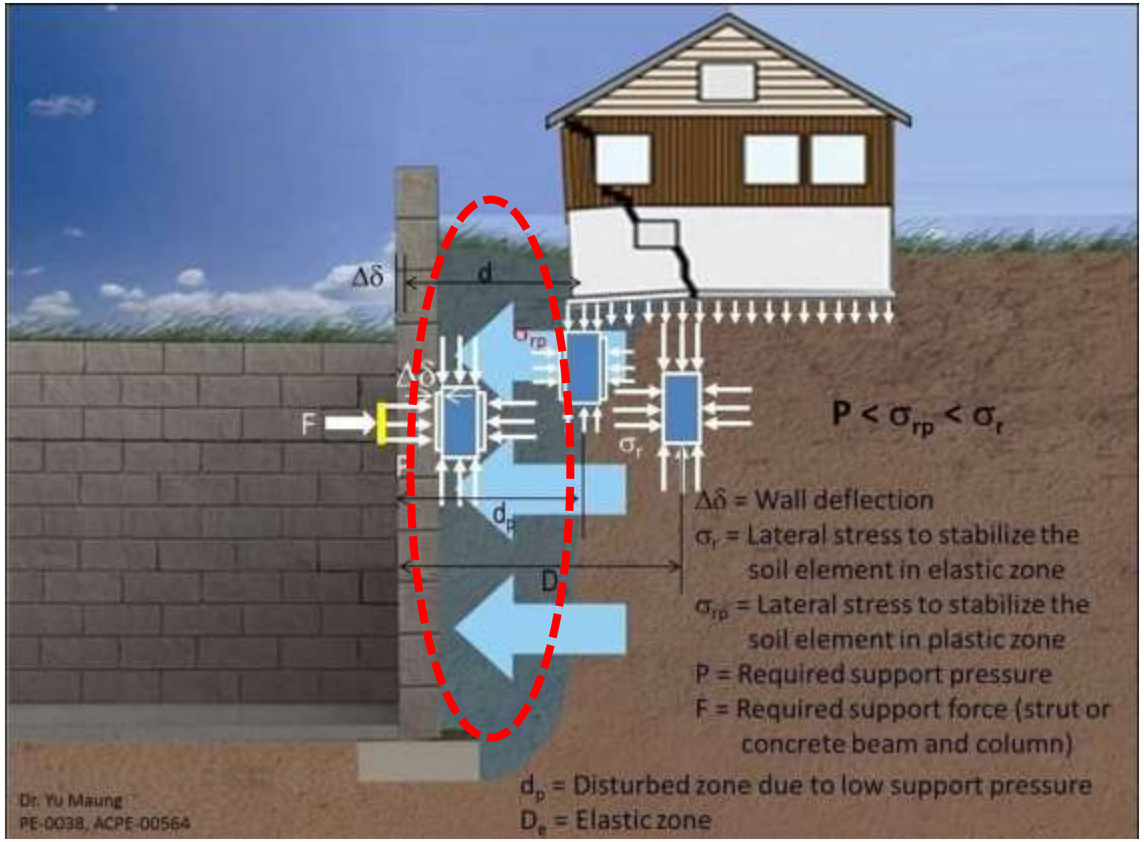
u_{ie} = maximum elastic displacement of support

u_{eq} = total displacement in equilibrium condition

Technical Aspects of Urban Basement Construction

1. Ground Movement Control

Engineering Perspectives in Myanmar

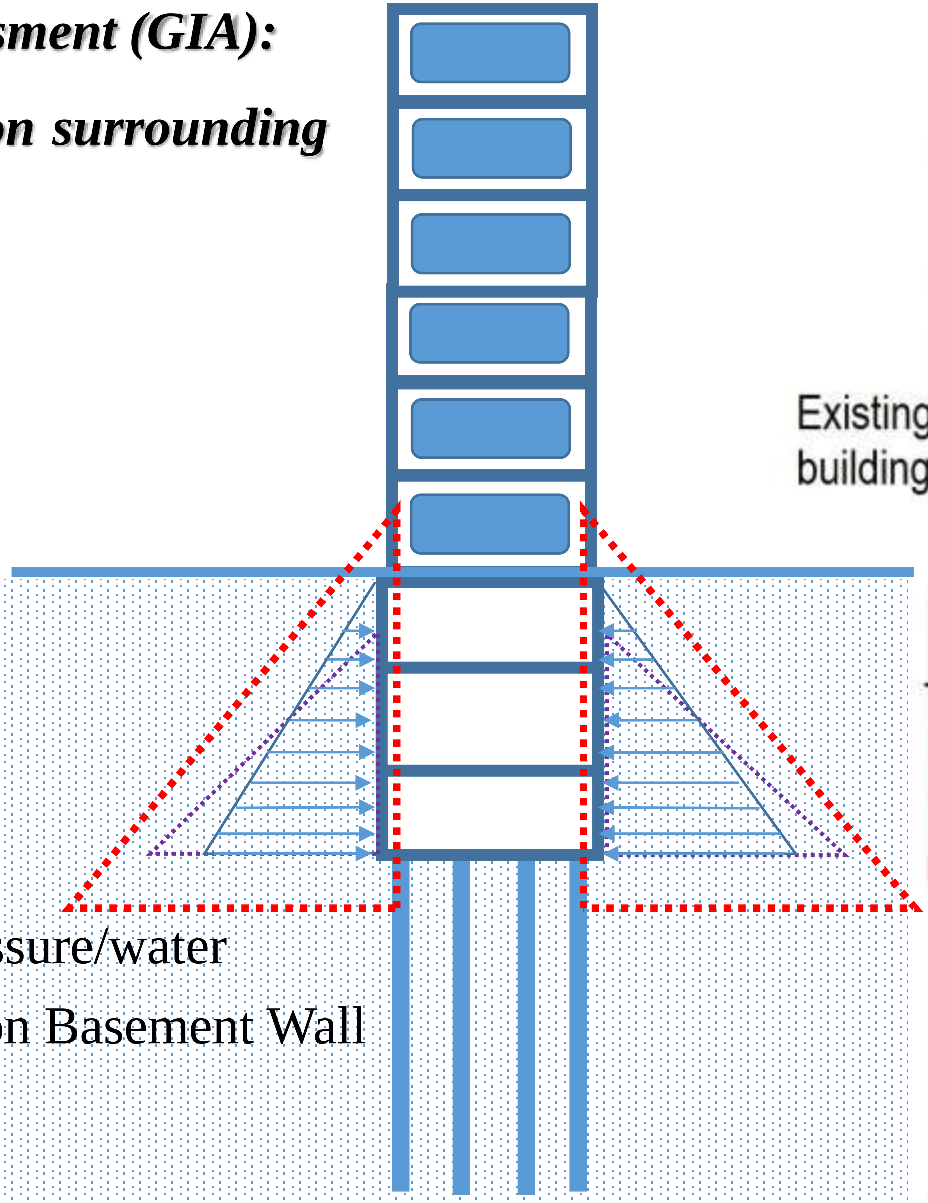


$$P < \sigma_{rp} < \sigma_r$$

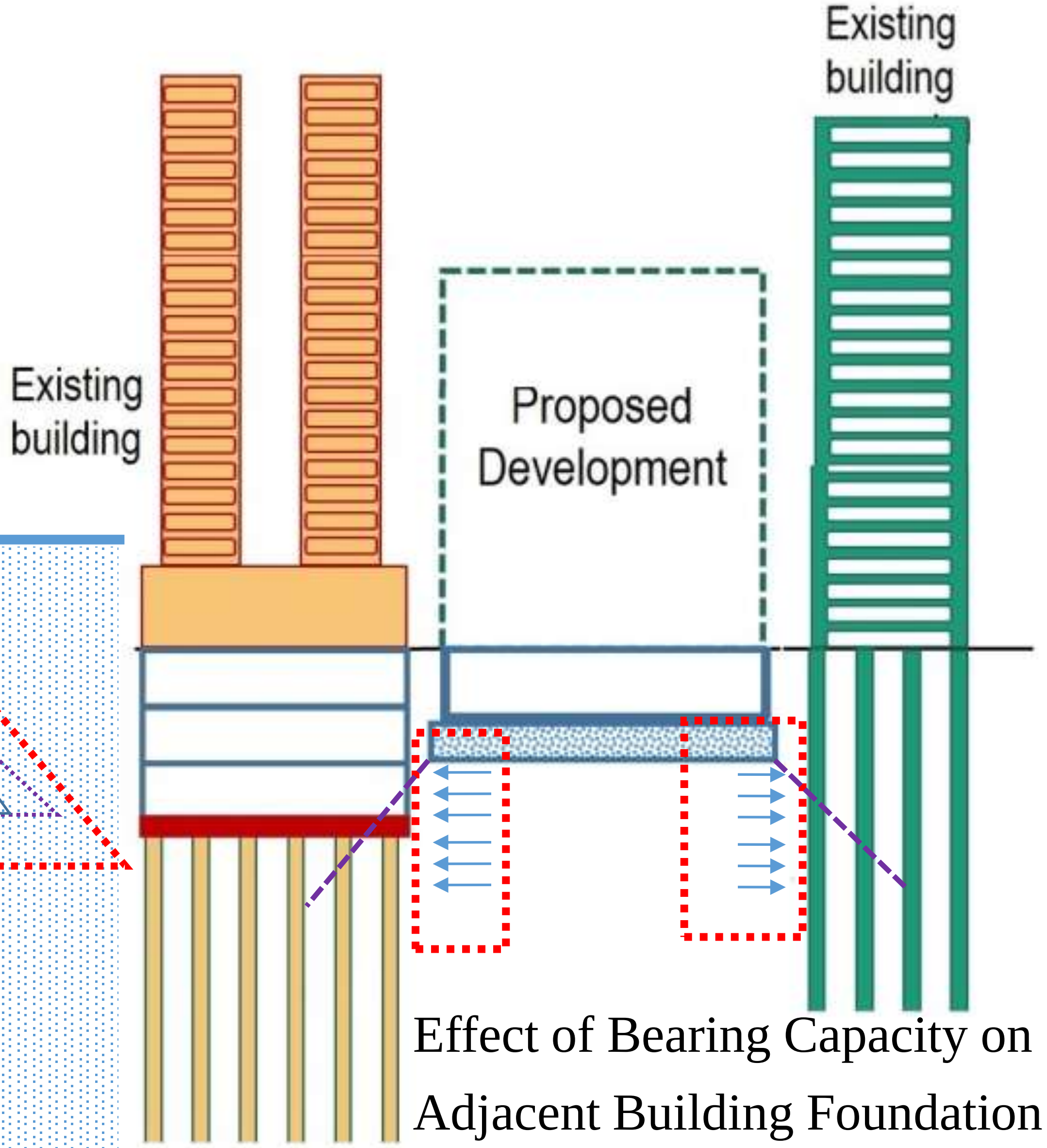
1. Planning Stage

Geotechnical Impact Assessment (GIA):

1. ***Hazard Assessment on surrounding structures***
2. ***Risk Assessment***



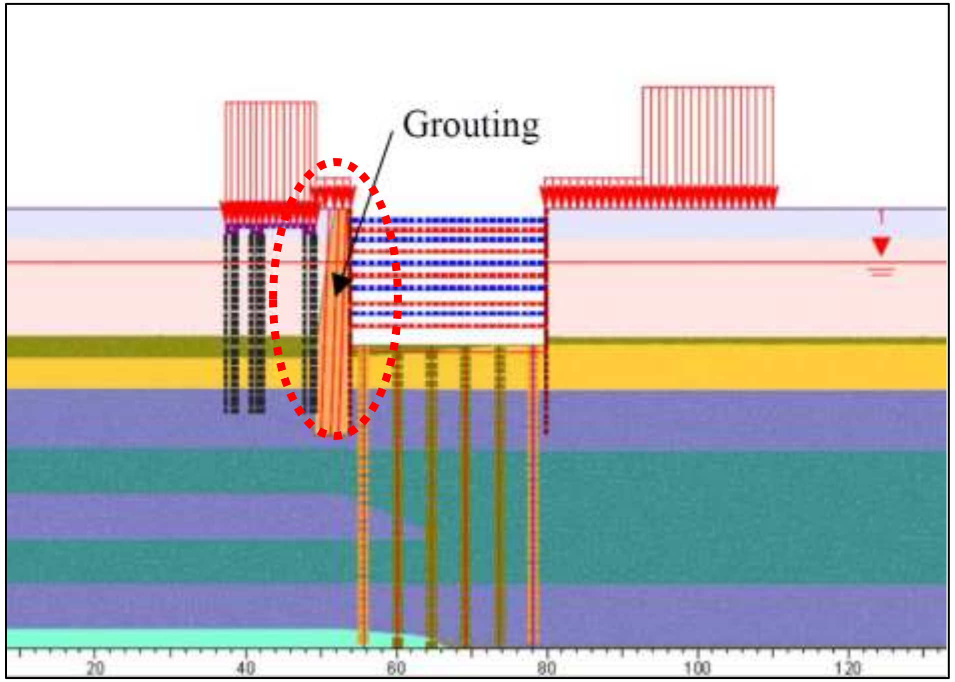
Earth pressure/water pressure on Basement Wall

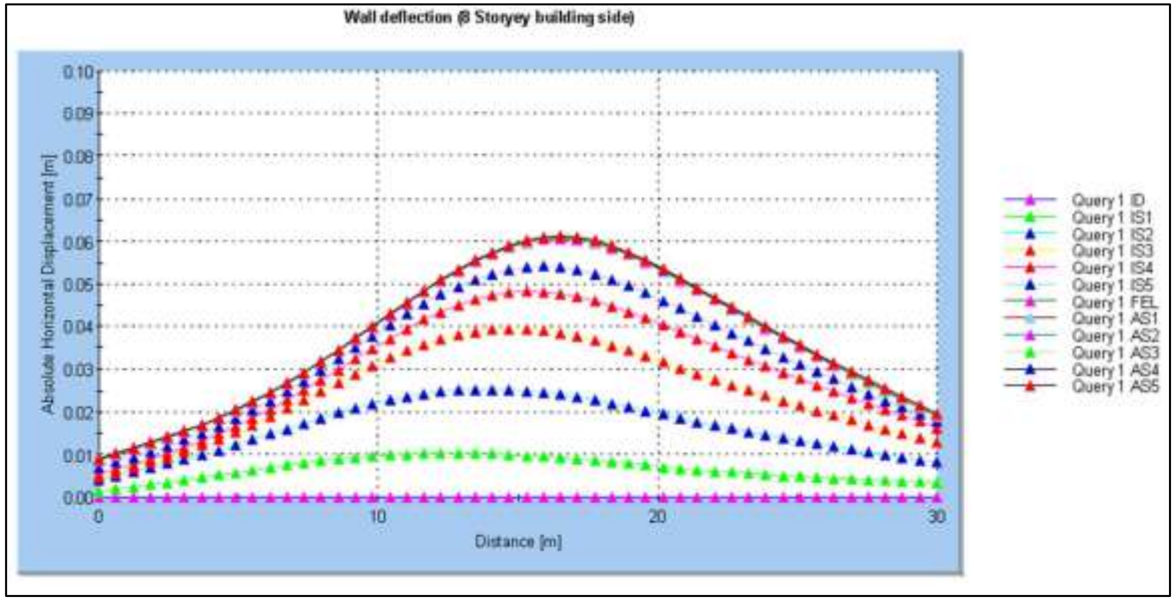


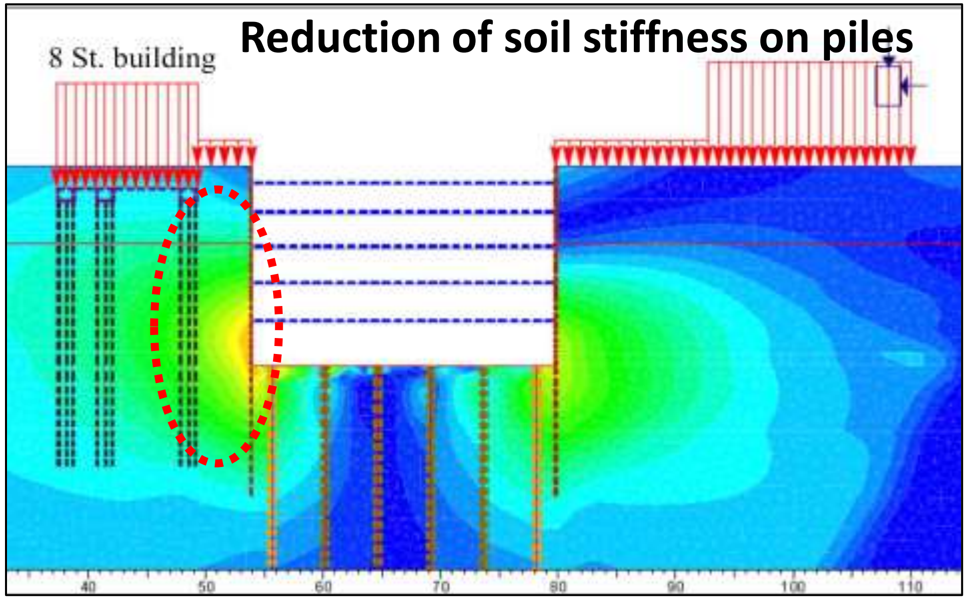
Effect of Bearing Capacity on Adjacent Building Foundation

2. Design Stage

1. ***To identify the effect of basement construction or foundation***
2. ***To predict the ground movement/pressure, which will be within allowable limits on adjacent structures***
3. ***To provide preventive methods where the construction effects on adjacent structures***



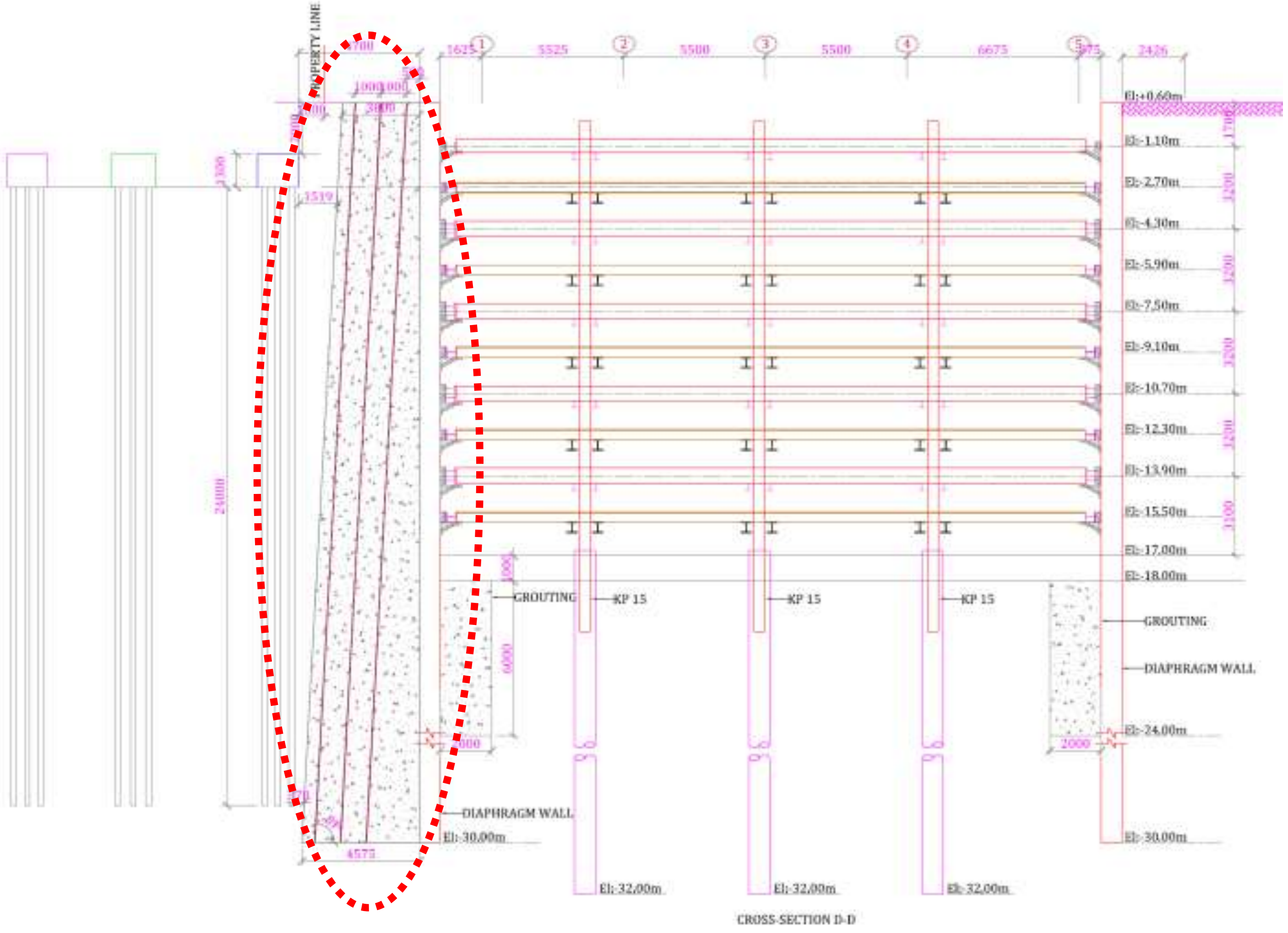


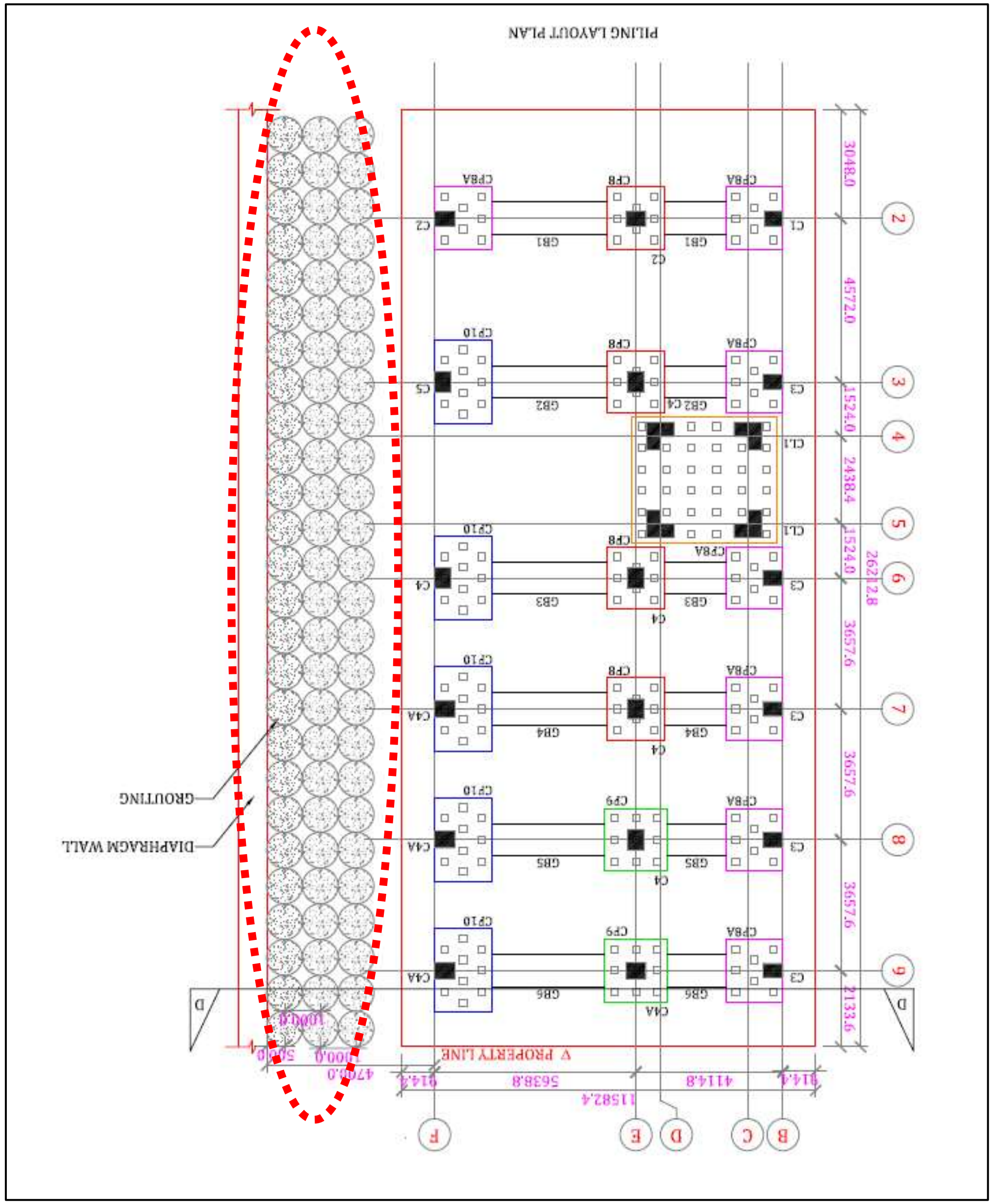


Jet Grouting Method to increase the stiffness of soil

Grout Material properties:

1. *As per design requirement*
2. *In-situ Testing and laboratory test*





3. Construction Stage

1. *To carried out the predetermined excavation sequence*
2. *To monitor according to design requirement*
3. *To analyze the monitoring results and remedial measures will be carried out where the monitoring results are exceeded the allowable limit.*
4. *In-situ Testing and laboratory test*

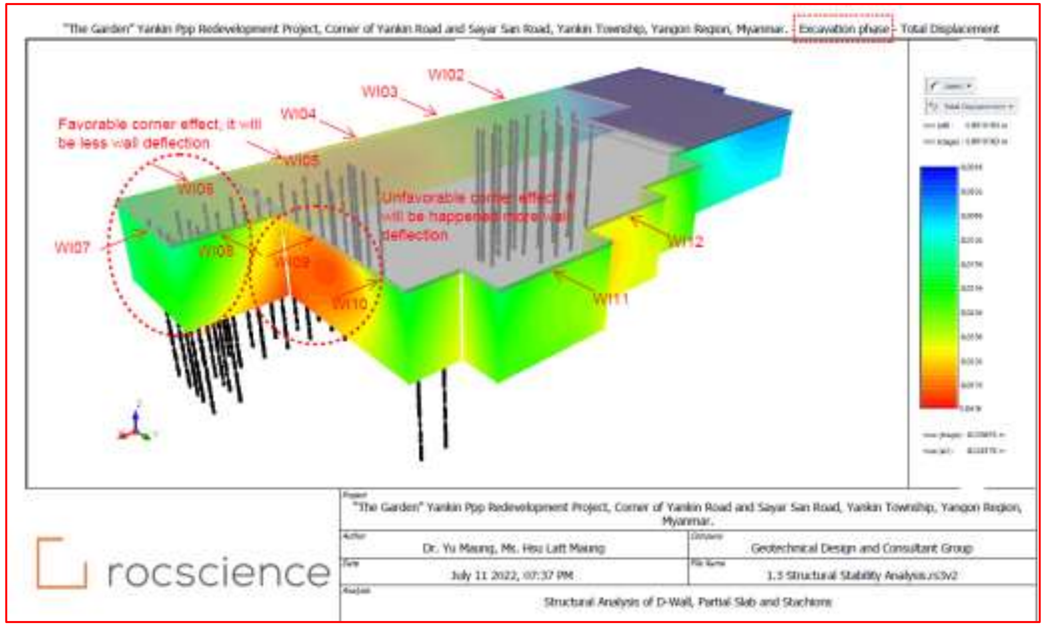
Construction Period:

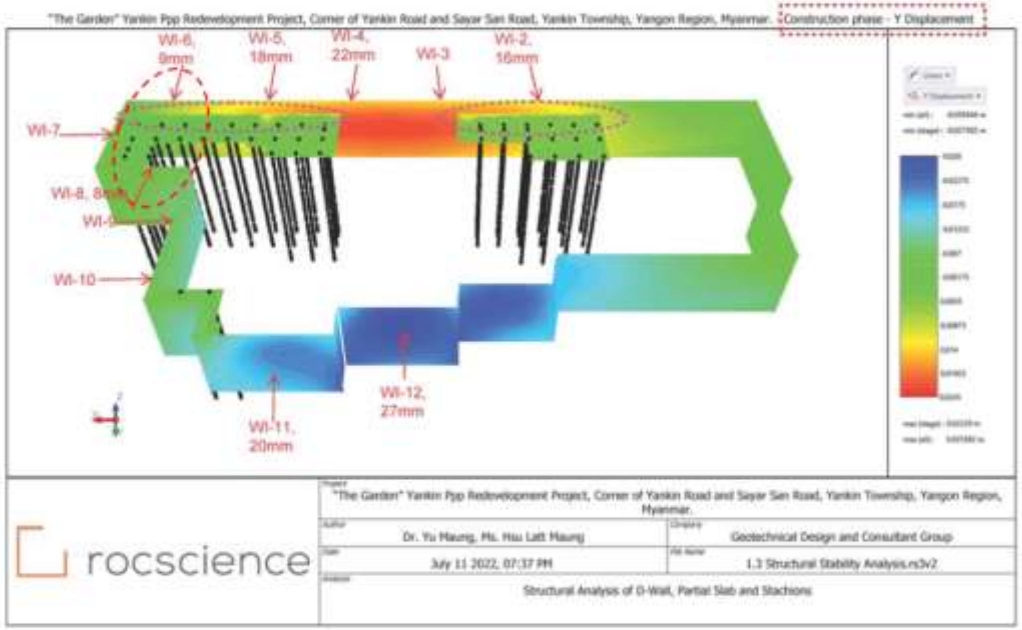
1. Technical Management

✓ Construction management is very different in U/G space construction compared to superstructure construction due to ground response ***because of induced initial stress***.

✓ Technical requirement would be changed depending on the actual site condition.

Design of Diaphragm Wall Support System





1. Ground Movement Control

a. Wall deflection (basement) and Inward displacement (Tunnel or cavern)

b. Pore pressure reduction

c. Ground loess (effect of hydraulic velocity)

Table 11.1 Limiting values of angular distortion (Bjerrum, 1963)

Angular distortion	Type of damage
1/750	Dangerous to machinery sensitive to settlement
1/600	Dangerous to frames with diagonals
1/500	Safe limit to assure no cracking of buildings (factor of safety included)
1/300	First cracking of panel walls (factor of safety not included)
1/300	Difficulties with overhead cranes
1/250	Tilting with high rigid buildings become visible
1/150	Considerable cracking of panel and brick walls
1/150	Danger of structural damage to general buildings
1/150	Safe limit for flexible brick walls (factor of safety not included)

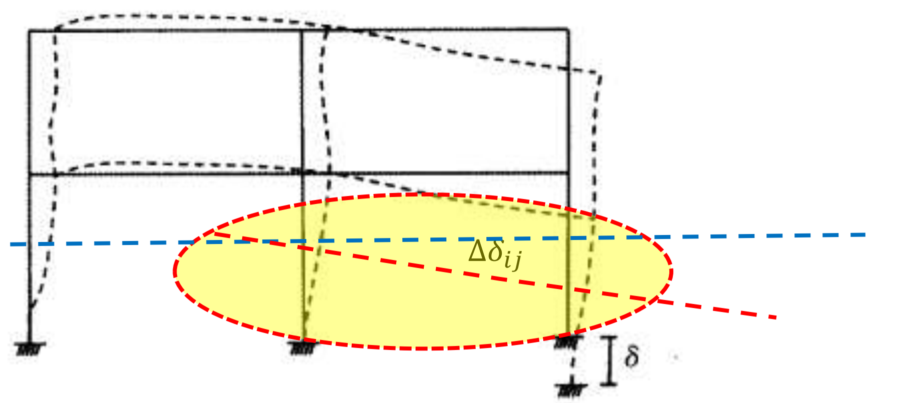


Figure 11.3 Differential settlement of a structure with individual footings.

Net column spacing of Building, L = 12 ft and 20 ft

Allowable settlement of Building, $\delta_{ij} = \delta_{max} - \delta_{min}$

$$\Delta\delta_{ij} \leq \left(\frac{1}{300}\right) \times 12\ ft = 0.48\ in \approx 12\ mm$$

$$\Delta\delta_{ij} \leq \left(\frac{1}{300}\right) \times 20\ ft = 0.8\ in \approx 20\ mm$$

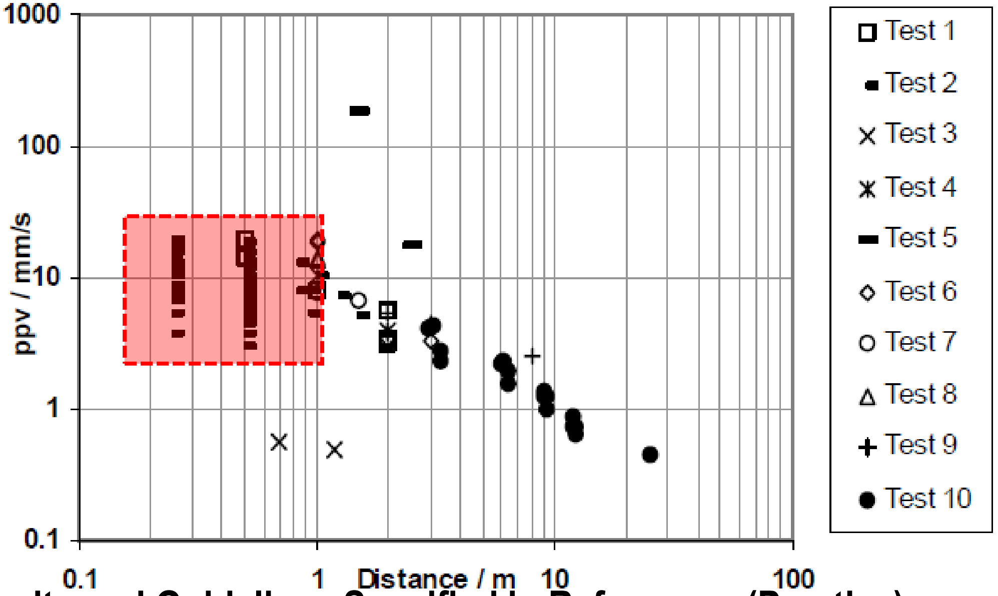
$$\Delta\delta_{ij} \leq \left(\frac{1}{500}\right) \times 12ft = 0.29\ in \quad 7\ mm$$

$$\Delta\delta_{ij} \leq \left(\frac{1}{500}\right) \times 20\ ft = 0.48\ in \quad 12\ mm$$

2. *Ground Vibration Control*

a. Vibration due to piling, heavy machinery, blasting

PPV Vs Distance data acquired from press-in sites



Limits and Guidelines Specified in References (Practice):

Reference codes	Allowable limits, PPV, mm/s	Remarks
Netherlands	3.00	Residential buildings
USA	2.5 - 4.3	Residential buildings

General guide line for allowable PPV depended on Frequency (ref: BS 7385 Part 1:1990)

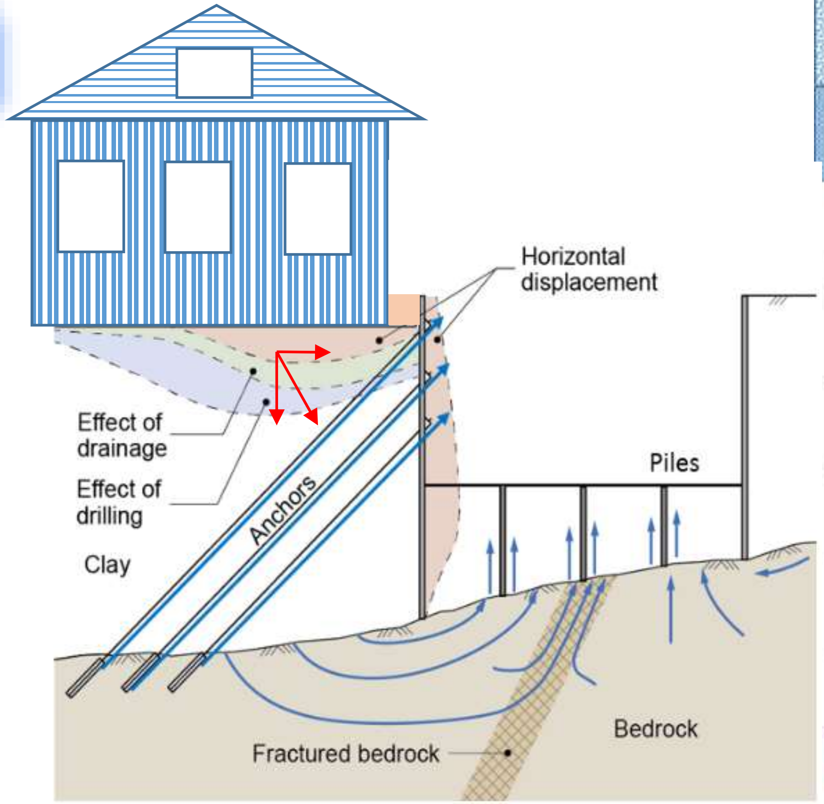
Type of Building	Guide value of Maximum PPV, mm/s	
	Transient Vibration (eg. Drop hammer)	Continuous Vibration (eg. Vibratory hammer)
Stable building in general	15	7.5
Vibration sensitive building	7.5	3.0

Maximum construction time / days (limits from Eurocode 3)		Piling method		
		Press-in	25 kJ drop hammer	170 kW 27Hz vibrohammer
With warning	<6 (3 mm/s)	3.5 m	39.5 m	18.5 m
	6-26 (2.3 mm/s)	4.5 m	51.5 m	24.1 m
	>26 (1.5 mm/s)	7.0 m	79 m	37 m
Without warning	<6 (1.5 mm/s)	7.0 m	79 m	37 m
	6-26 (1.3 mm/s)	8.0 m	91.2 m	42.7 m
	>26 (1.0 mm/s)	10 m	>100 m	55.5 m

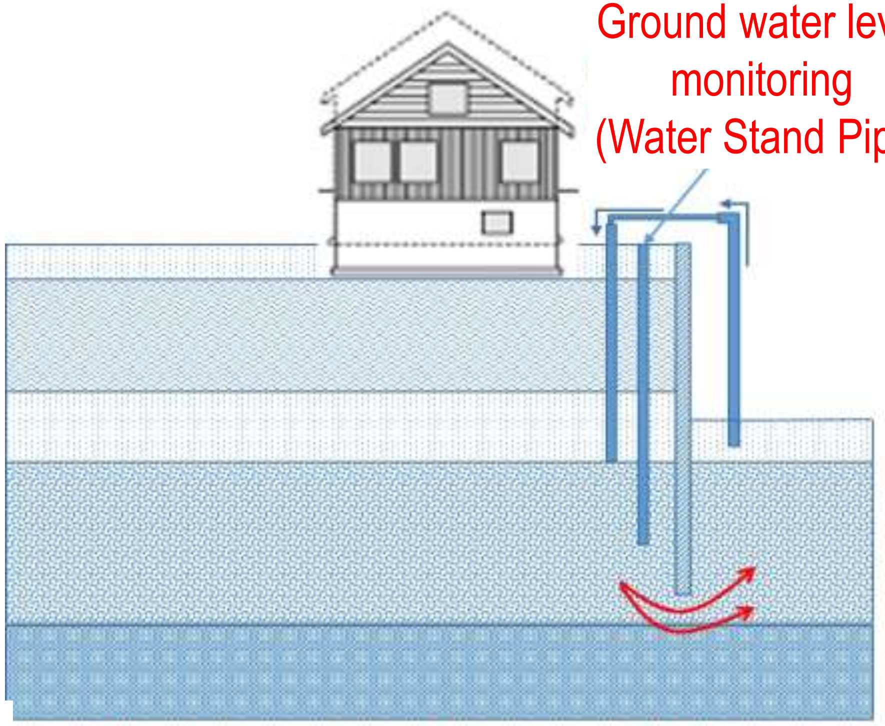
3. Excessive Seepage Control

Settlements caused by:

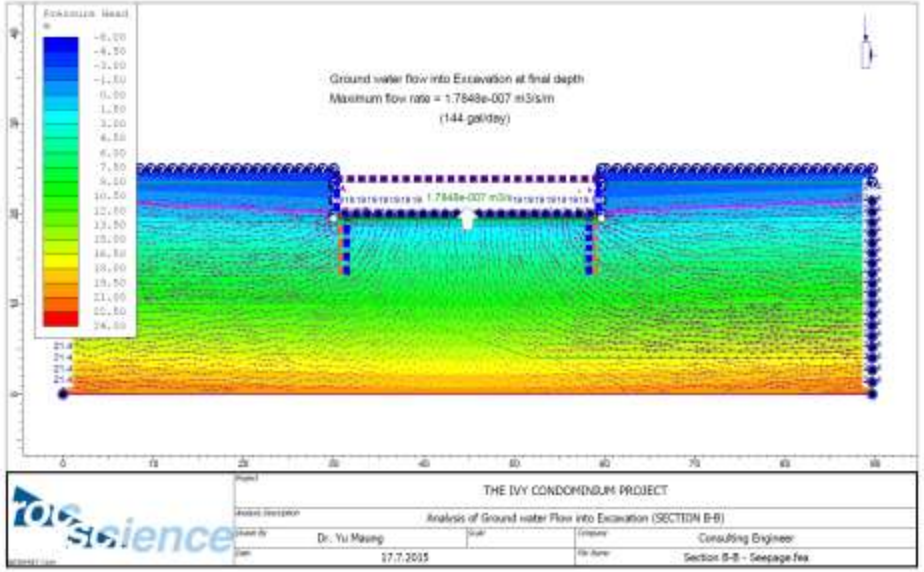
1. **drainage including soil erosion and**
2. ***pore pressure reduction***



Ground water level monitoring (Water Stand Pipe)



Maintain groundwater level in permeable Soil



4. Instrumentation and Monitoring in Construction Stage

Purpose and Choice of Instrumentation

Monitoring

1. Ground Movement monitoring
2. GWL monitoring
3. Vibration monitoring
4. Gas monitoring (Air quality)

Why we need to monitor ground displacements?

Monitoring is a part of risk responding.

- Design Verification
- Construction Control
- Quality Control
- Safety
- Legal Protection

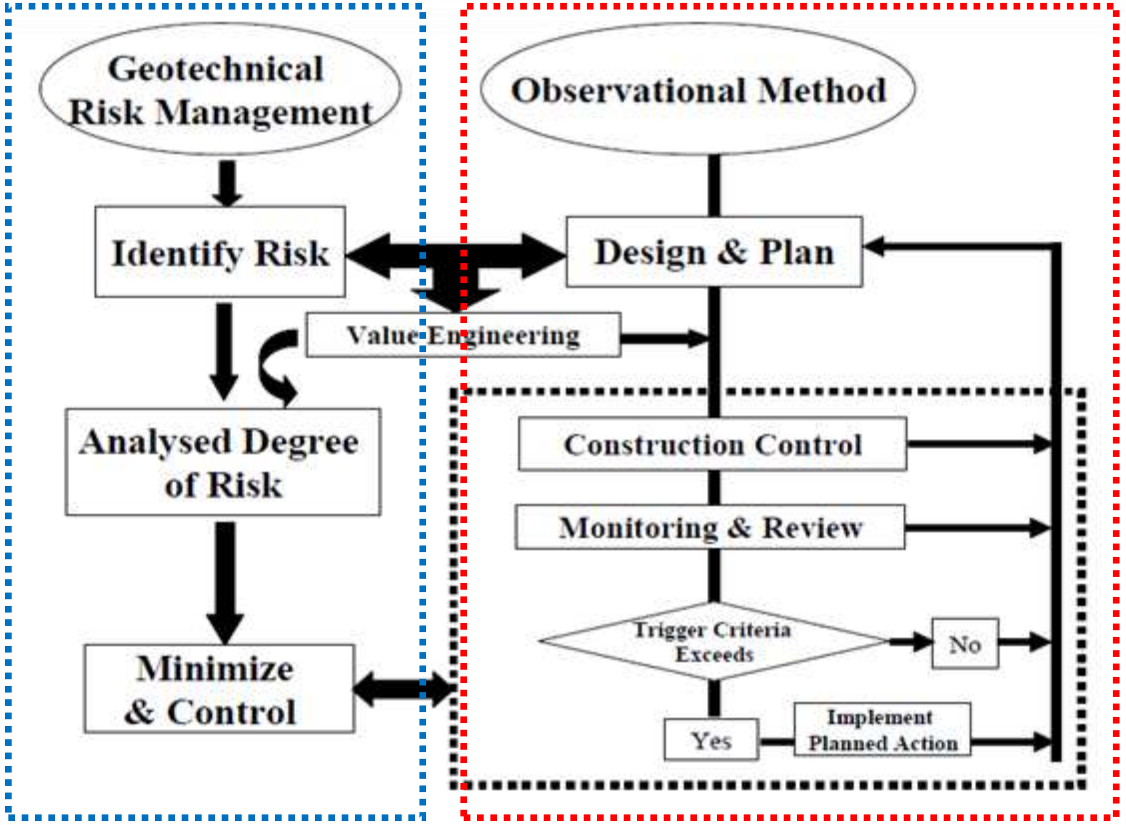


Figure 12 - The elements of observational method and risk management with integration of value engineering in deep excavations,(Aye et. al., 2006)

QP (Design)

QP (Construction)

Coffee Break
10 minutes

Projects

The Use of U/G Space for the Construction of Underground Infrastructures

Project-1

Transmission Line & Underground Cable, Example: Experienced in Malaysia

Malaysia has successfully changed from an agricultural-based economy to an industrial one, within just two decades (Khairul, 2003). For example, from January to August 2008, investments amounting to RM 49.8 billion were approved in Malaysia's manufacturing sector. Investments for the first eight months of 2008 have also surpassed the record for the whole of 2007, which was RM 33.4 billion (MIDA, 2008).

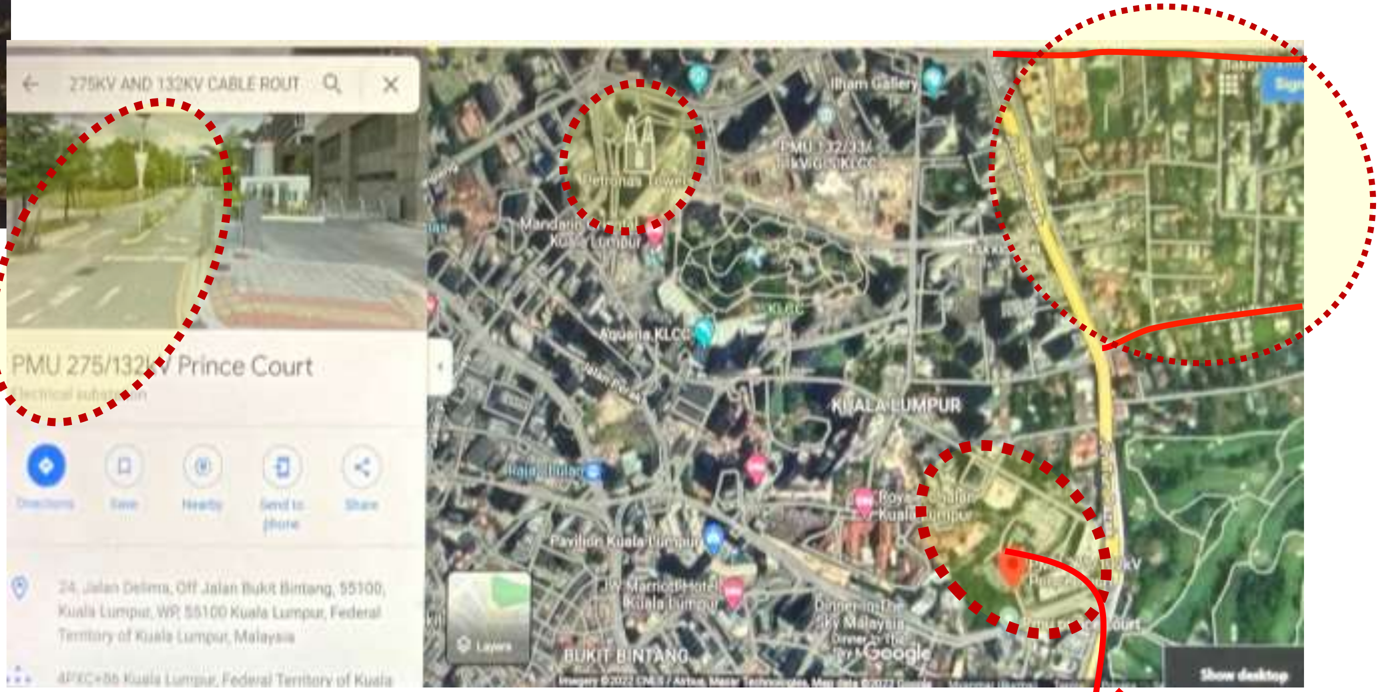
Gross Domestic Product (GDP): 5.9% in 2006 < 6.0% in 2007 < 7.1% in 2008.

And electricity demand of Malaysia will be expected to increase by 4.7% per year.

The National Grid consists of:

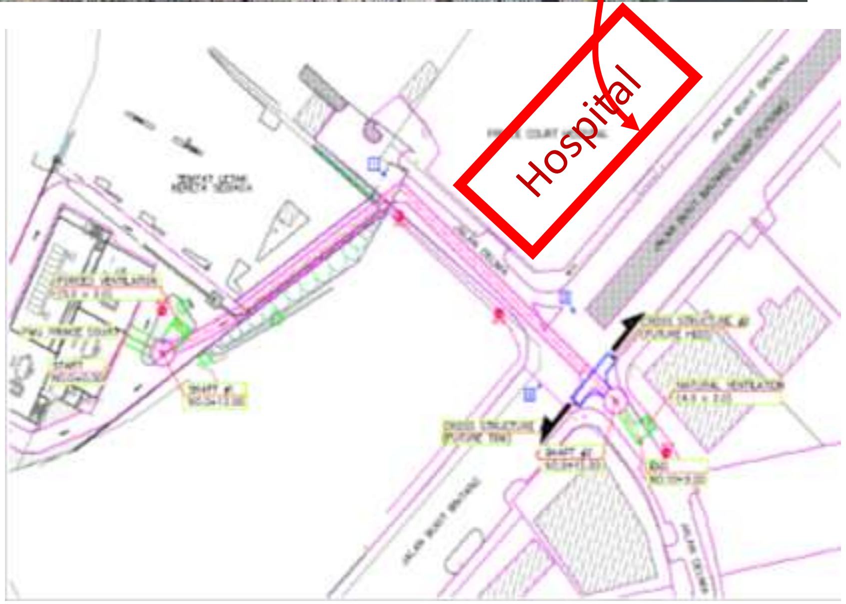
1. approximately 17,836 kilometers of *overhead transmission lines*,
2. ***741 kilometers of underground transmission cables*** and
3. 385 substations with transformation capacity of 75,828 MVA (TNB, 2008).

Transmission Line & Underground Cable, Malaysia



PMU 275/132kV Prince Court, Electrical Substation

Central Kuala Lumpur from the Prince Court area to Jalan ***Taman U-Thant*** and connecting to Jalan Ampang towards Jelatek area

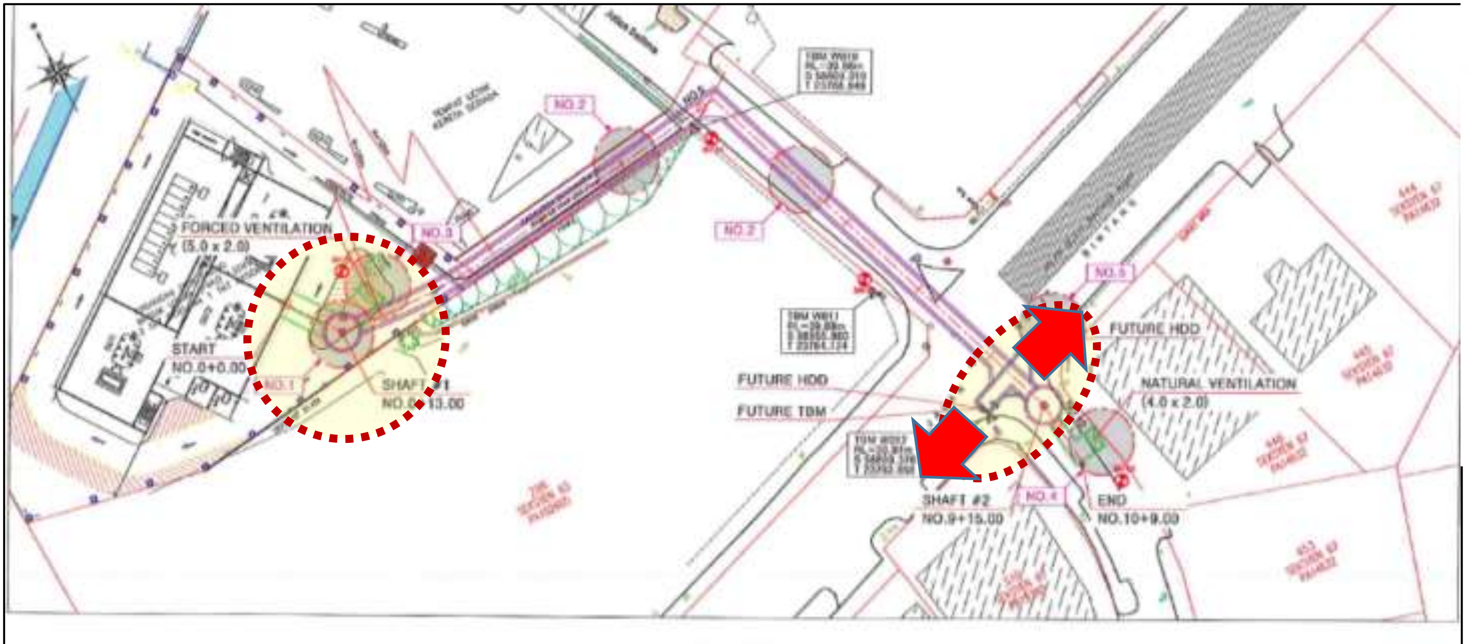


Underground Cable Projects

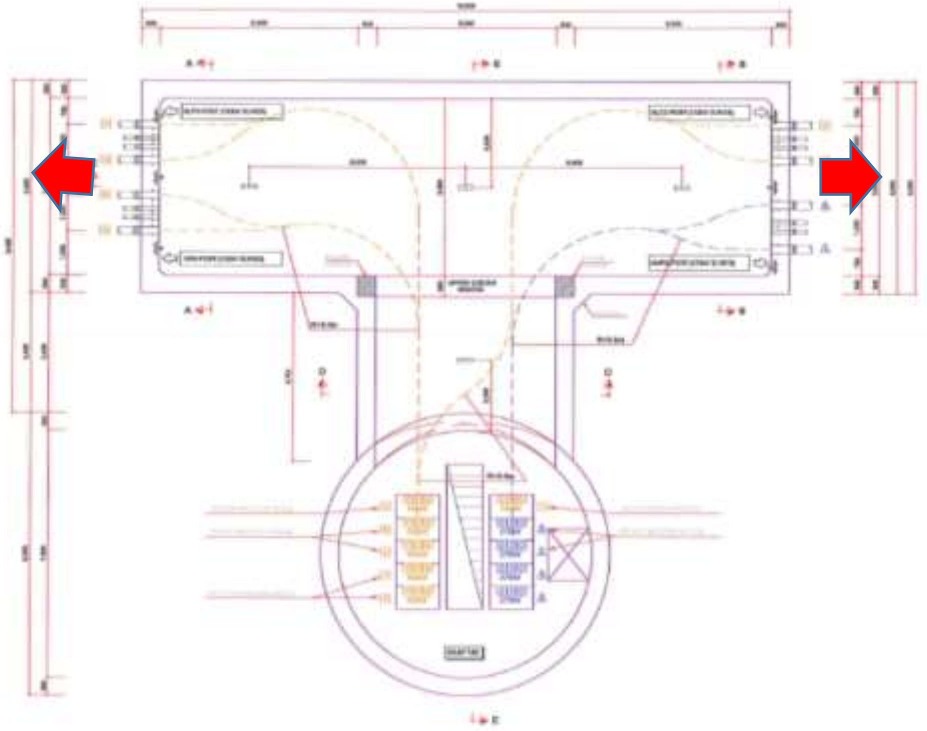
Year	Client	Description	Country	Substation Name
2021	Tenaga Nasional Berhad	Turnkey Project Inclusive of Design, Engineering, Supply, Erect and Commissioning of 275kV XLPE Power Cable (Transformer Trail) for Super Grid Transformers and 33kV XLPE Power Cables System for PMU 500/275kV Junjung, Kedah, Malaysia.	Malaysia	PMU 500/275kV AIS Junjung
2021	Tenaga Nasional Berhad	Turnkey Project Inclusive of Design, Manufacture, Supply, Erect and Commission Approximately 5050 route meter of 275kV Double Circuit Cable from PMU Ampang to Proposed PMU Prince Court, Selangor, Malaysia.	Malaysia	275kV PMU Ampang to Proposed PMU Prince Court
2020	Tenaga Nasional Berhad	Turnkey Contract with Inclusive of Design, Supply, Construct, Testing and Commissioning of Approximately 2300 route	Malaysia	132kV PMU Tg. Agas to the Proposed STME

Transmission Line & Underground Cable

The cable system is to deliver a minimum of 500 MVA power for each 275kV cable circuit under this project.



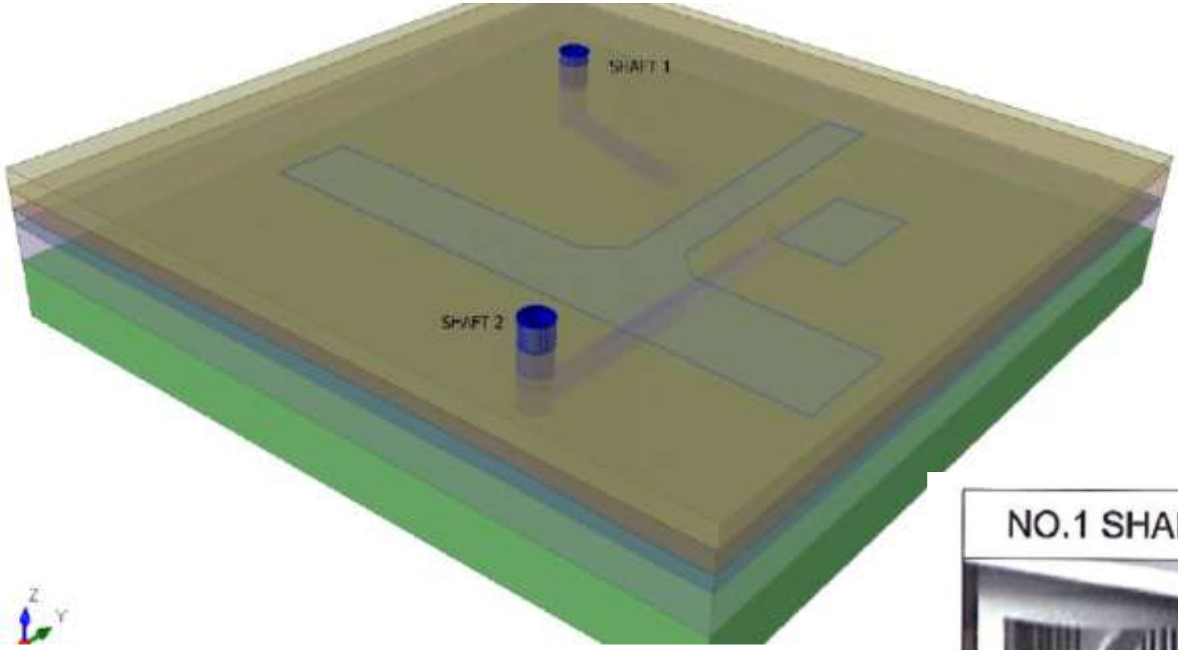
PLAN VIEW

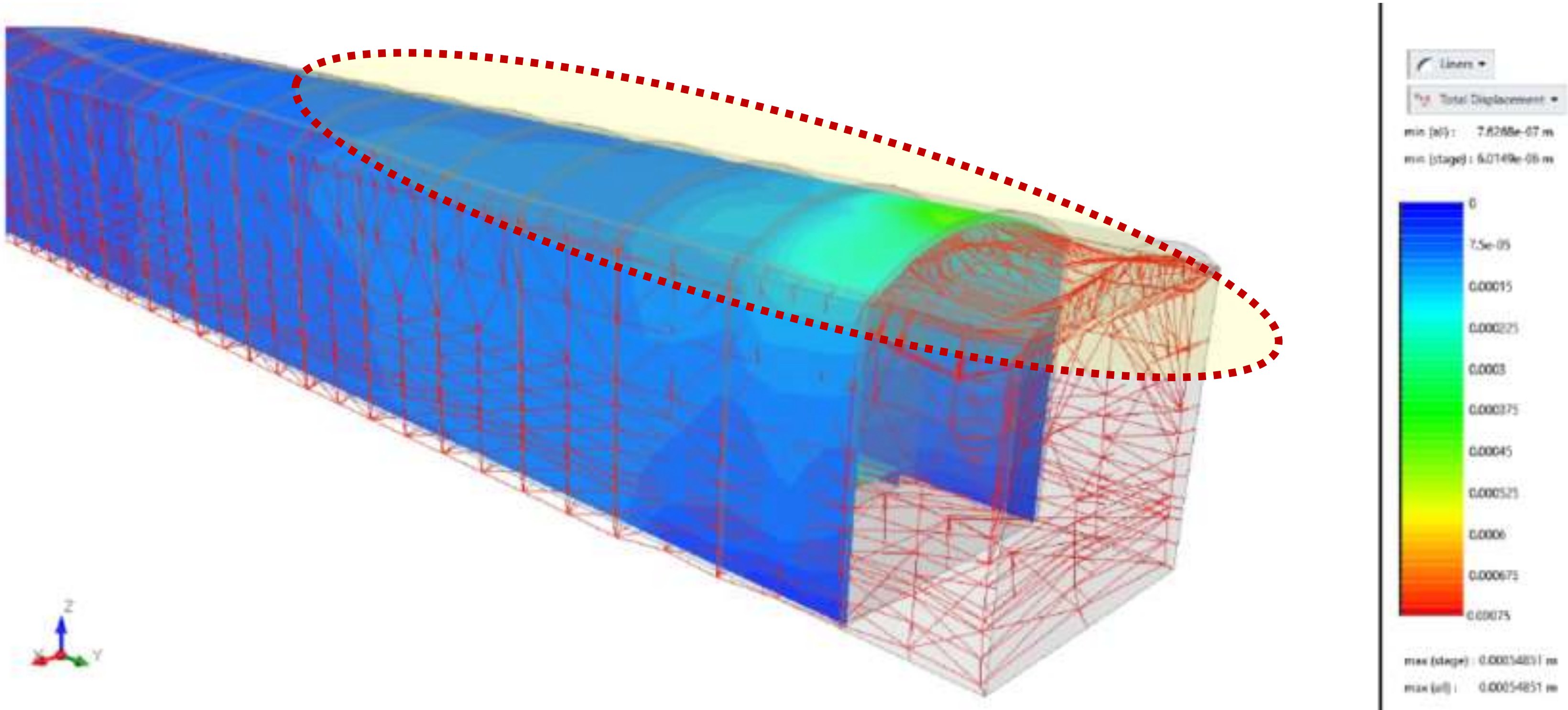


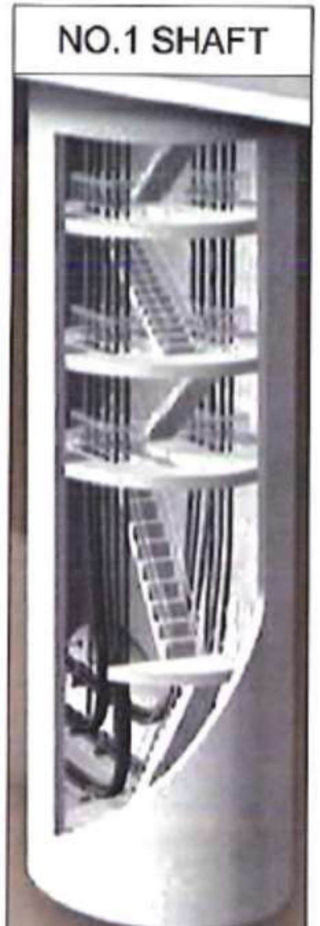
HDPE conduit pipe power conduit installed inside the ground trench

Major Technical Requirements in Design Phase

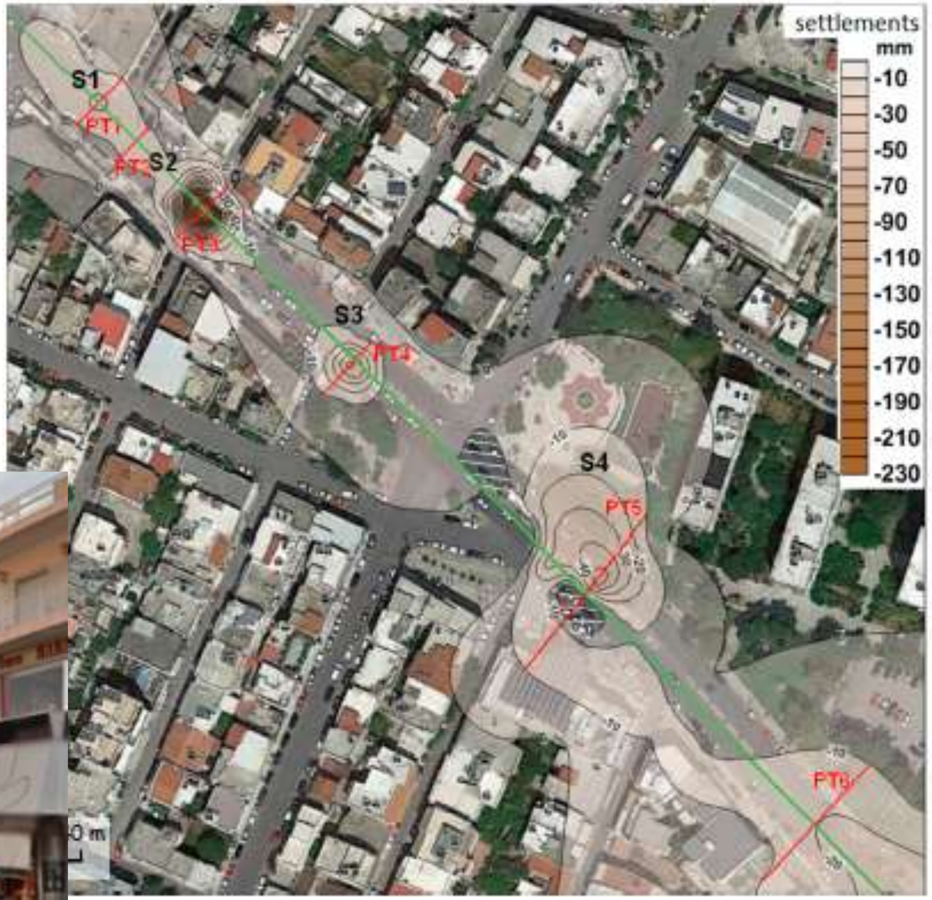
- ✓ Tunnel stability
- ✓ Road settlement control to prevent the ground losses
- ✓ Temporary rigid support method with steel support for settlement control
- ✓ Seepage prevention
- ✓ Vibration control induced by blasting method

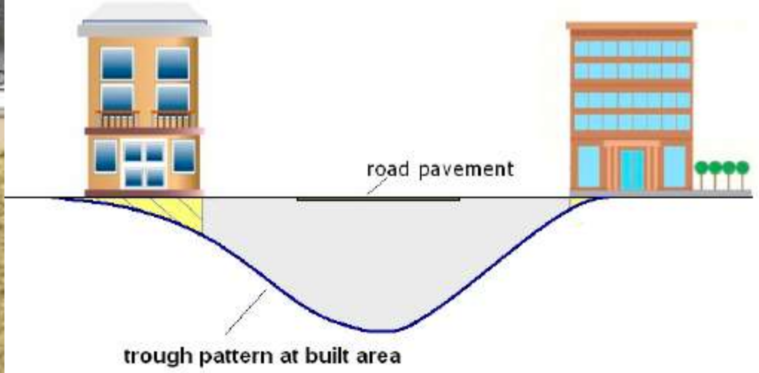






✓ Road Failure and Ground Losses





Started the Secant piling for cable tunnel shaft no-1 (3-1-2023)

Project-2

Project name: Underpass's, Damansara city development project, Kuala Lumpur

Length: 26.17 m, Both sides of retaining wall = 1000 mm diameter bored pile

Width x Height = 9.925 m x 7.35 m (including underground cable line)

Construction designed by : : Dr. Yu Maung

Date: 31-5-2014

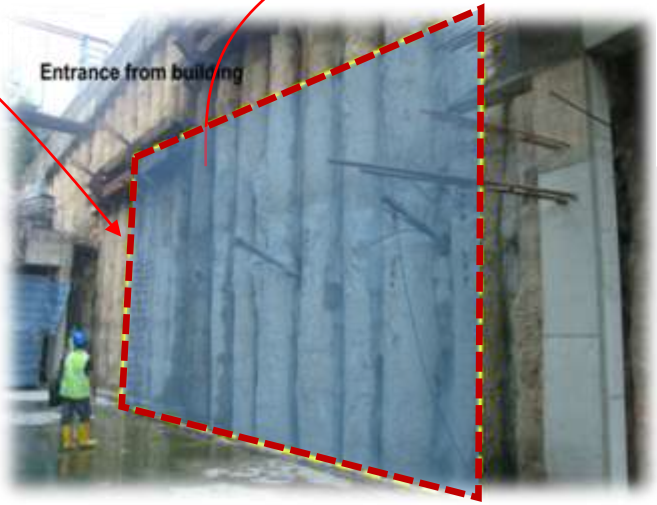
Proposed underpass (2013)

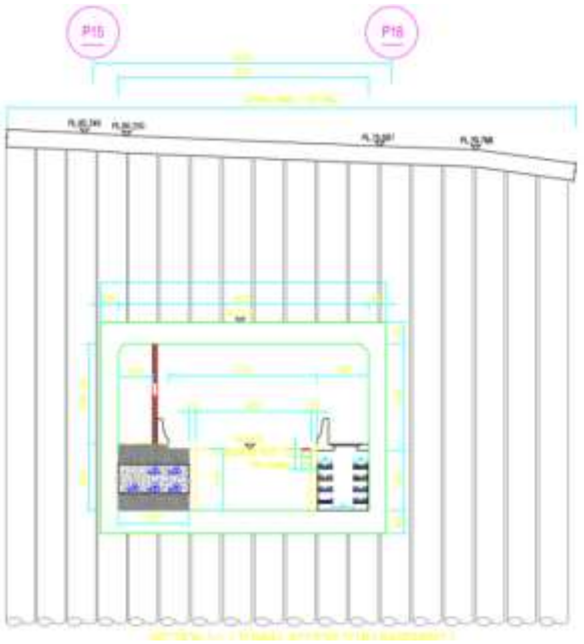
Design and Construction:

Underpass construction methods-

- **Cut and Cover Method or**
- **Tunneling method (*No digging policy*)**

Before





- Major technical requirements

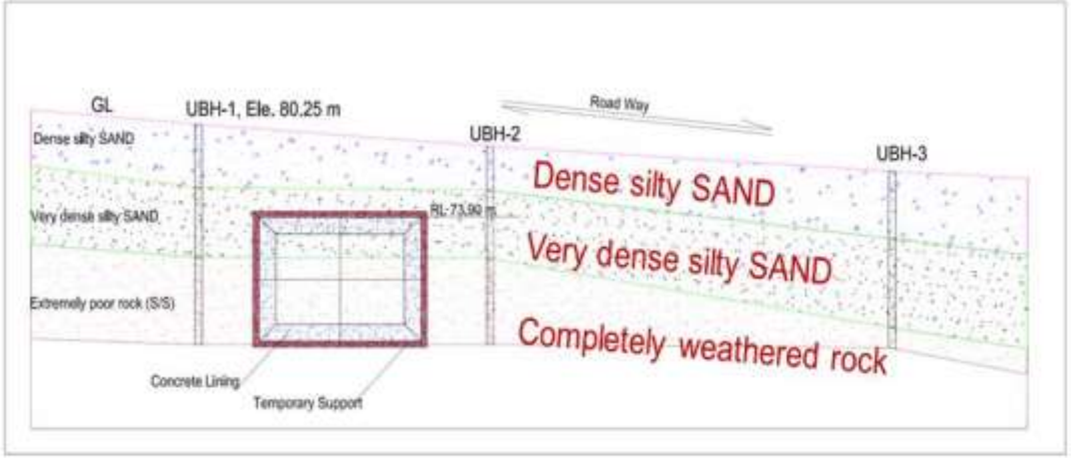
✓ Over burden, 6 m

✓ Stability of underpass

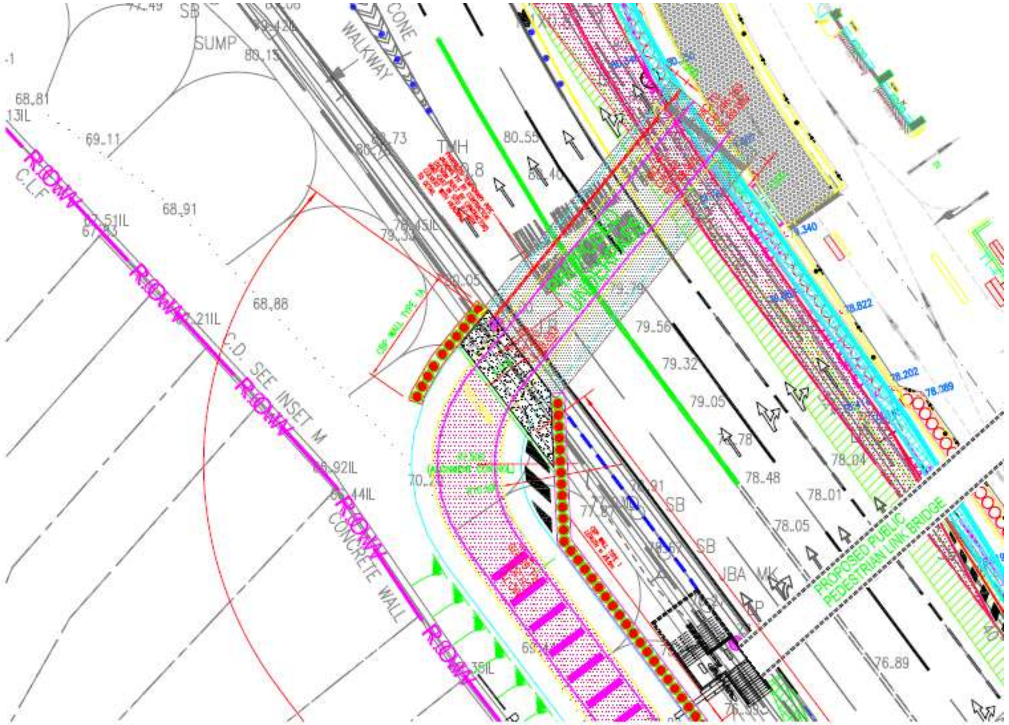
✓ Road settlement control (15 mm)

✓ Ground losses (grouting)

Settlement due to ground losses after tunnel construction



Soil Profile of Tunnel



- **Major Technical Requirements in Design Phase**
  - ✓ Road side walls: Using CBP wall
  - ✓ Analysis for allowable ground settlement
  - ✓ Grouting to prevent ground loss
  - ✓ Rigid support method with pipe roofing
  - ✓ Partial excavation and provision of temporary support
  - ✓ Partial removal of temporary support and partial concreting

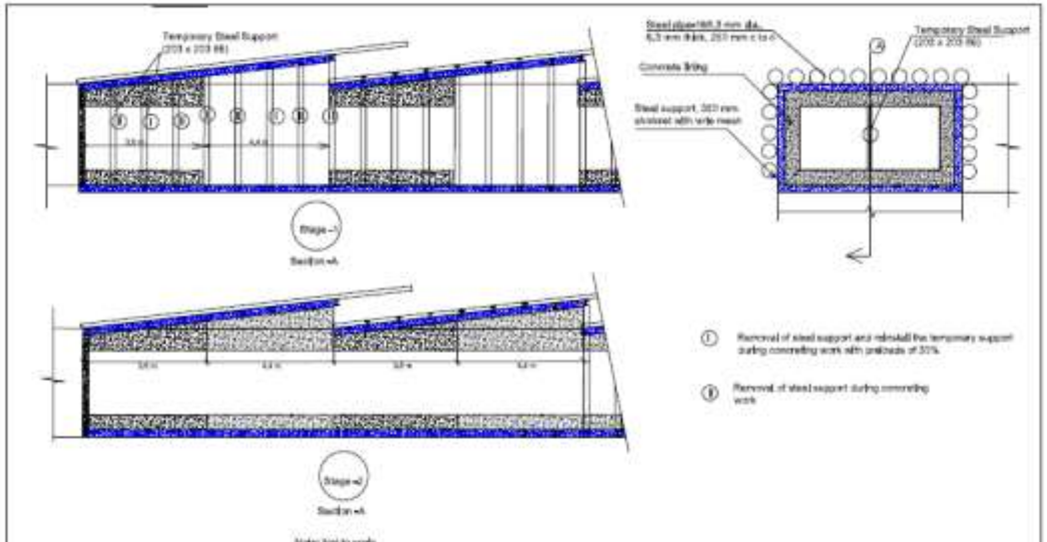
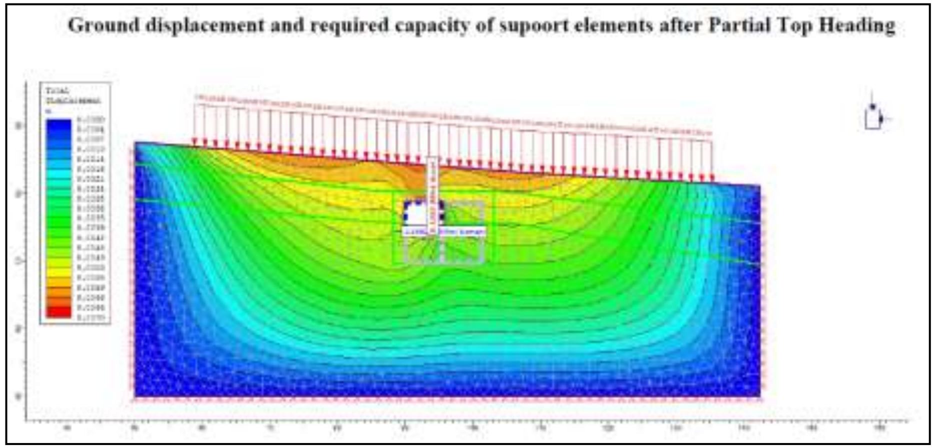
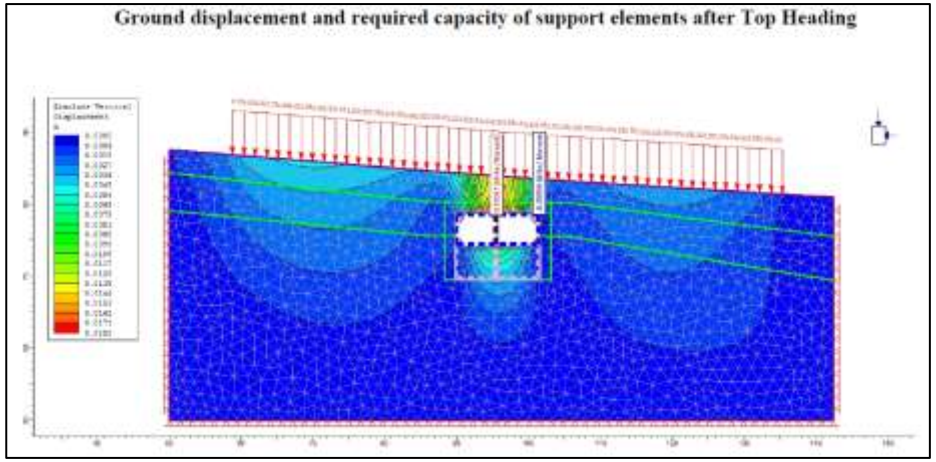


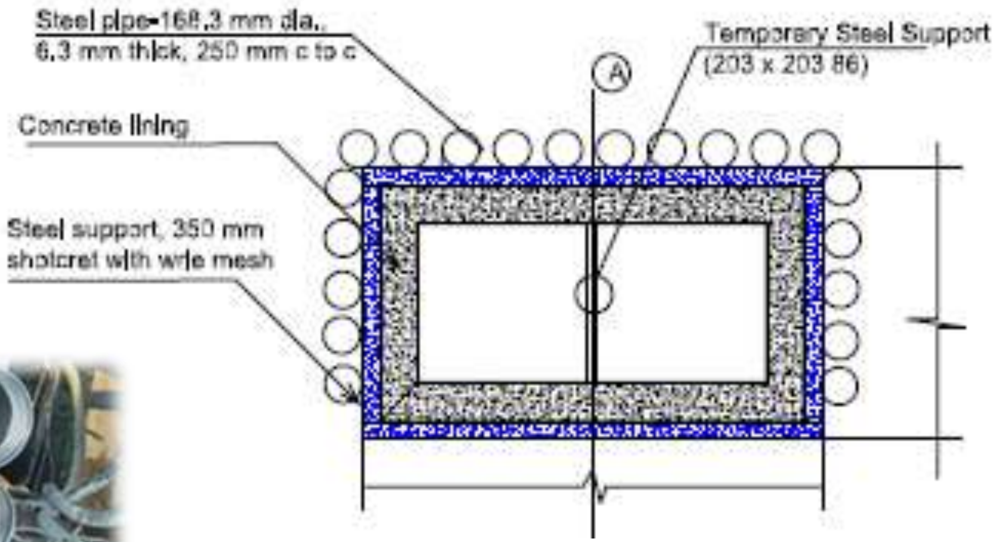
Figure (6) Lining Construction Sequence

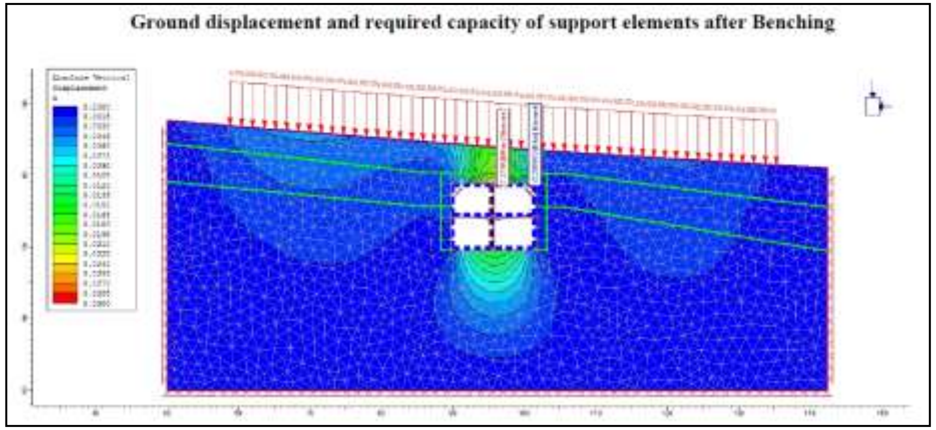
Construction sequence
for control of road settlement

- **Construction Phase**
  - ✓ Partial excavation method to control the settlement
  - ✓ Grouting to avoid the ground losses
  - ✓ Monitoring and revised design









Underpass Construction Project, Malaysia

Planning for Traffic flow

(Basement ⇔ Public Road)

After completion of project

(Present condition)

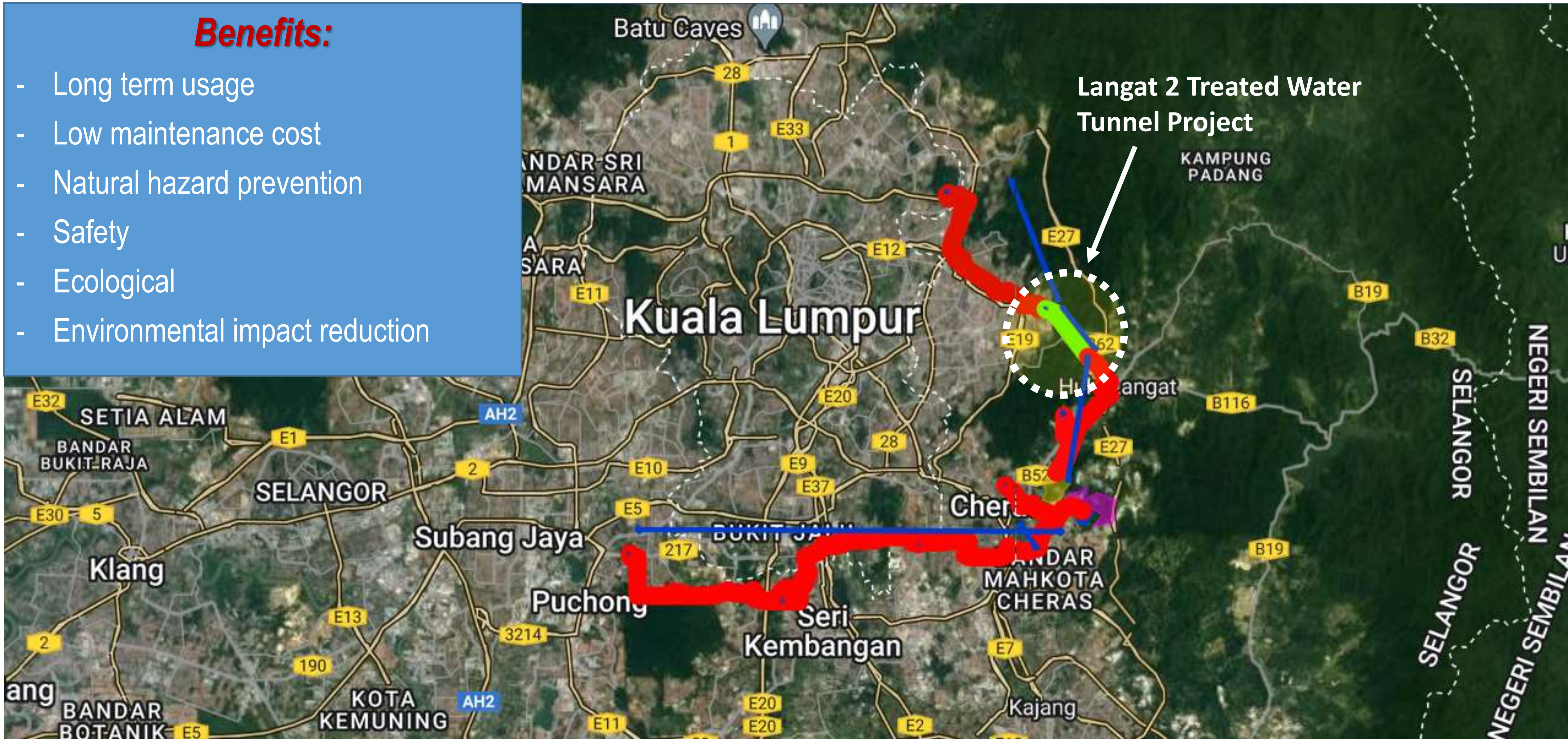
Project-3

Langat 2 Treated Water Tunnel Project

LRAL2 will be the largest Water Supply Scheme in Malaysia supplying 1890 MLD of treated water.

Benefits:

- Long term usage
- Low maintenance cost
- Natural hazard prevention
- Safety
- Ecological
- Environmental impact reduction

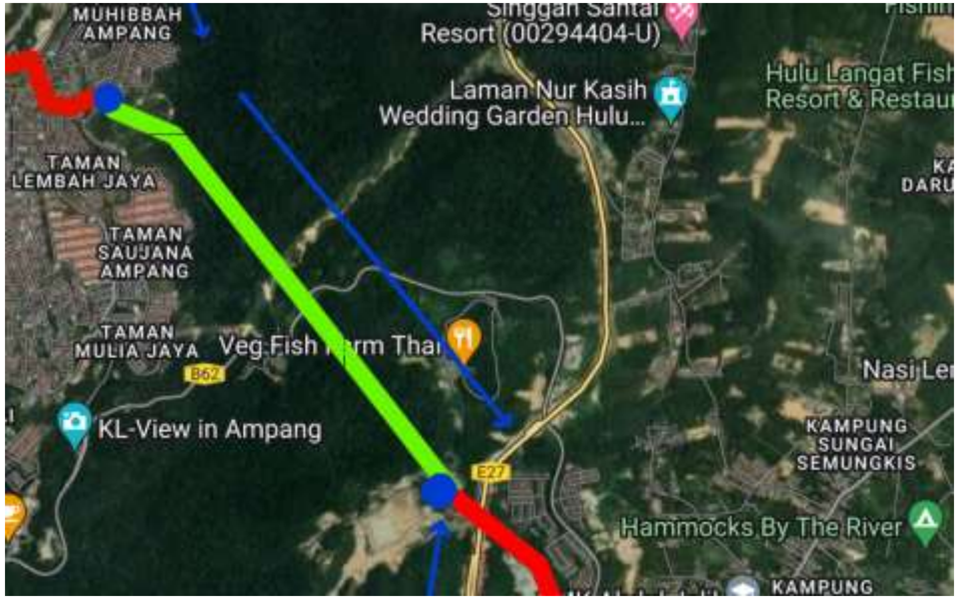


The construction and completion of the 1,130 million liter/day Langat 2 Water-treatment Plant

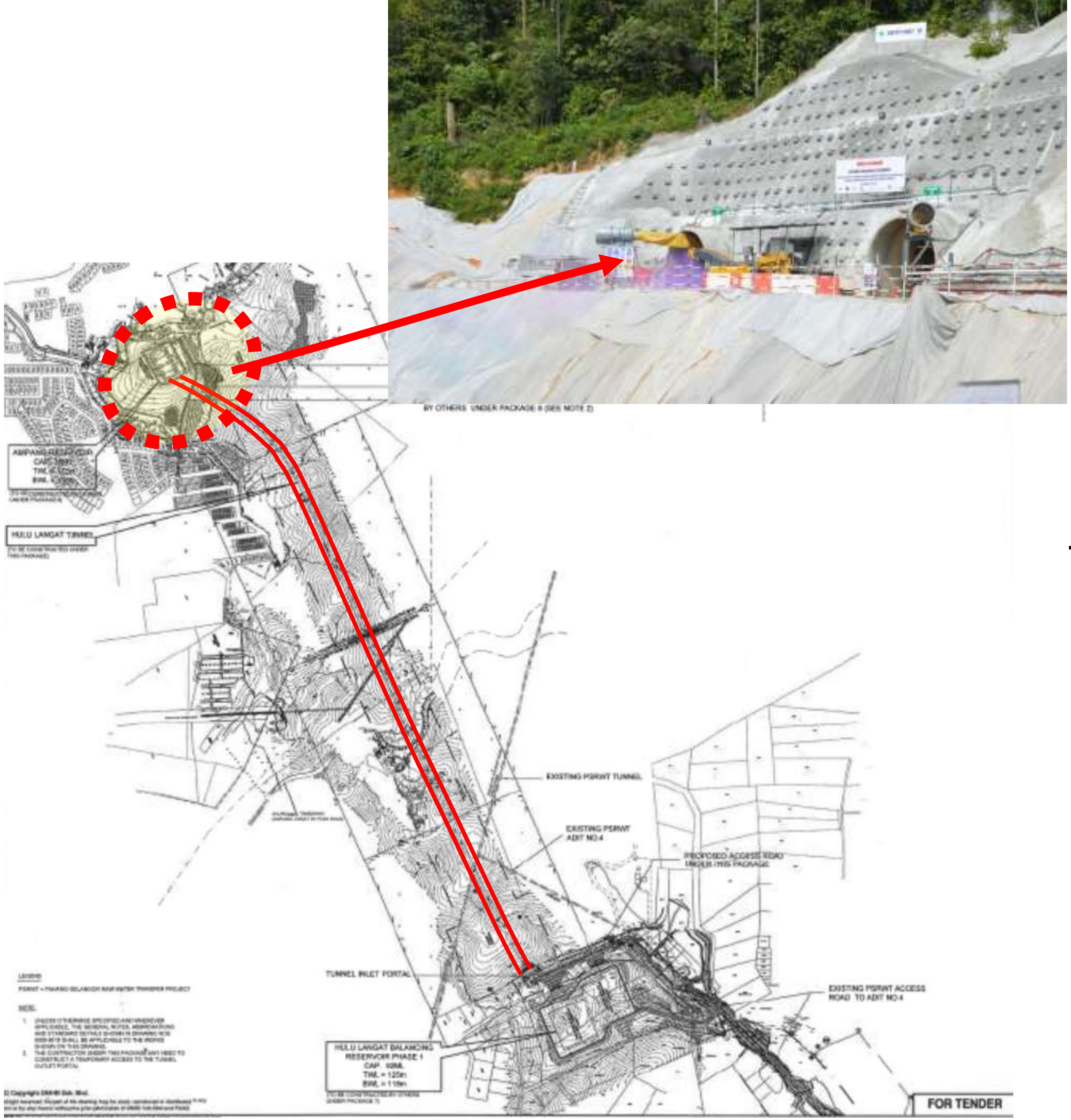
Project Cost - RM 1 billion contract by the Government

Joint Venture of:

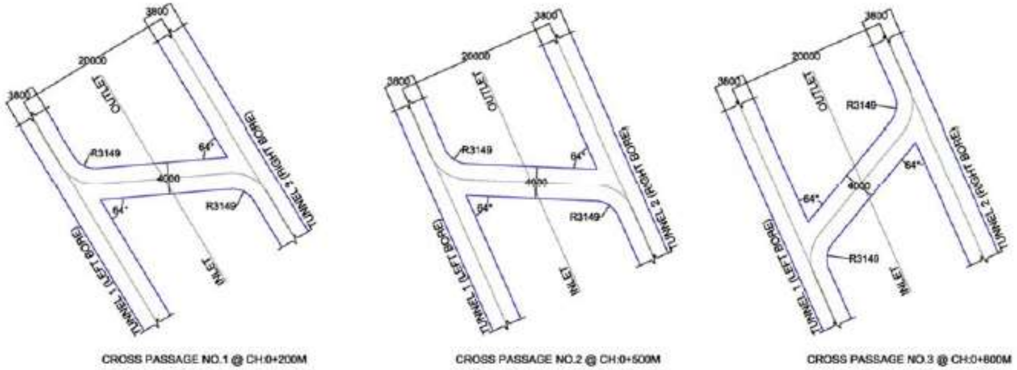
1. ***Salcon Bhd (Salcon) - 36%,***
2. ***MMC Corp Sdn (MMC) - 34%***
3. **Ahmad Zaki Resources Bhd (*AZRB*) - *30%***



Average gradient for shortest distance = +28 %, -26%



Cross Passage Construction



Proposed Cross Passage

Technical feasibility assessment for construction of CP:

1. Deformation analysis consideration of in-situ geotechnical information
2. Cross passage dimensions
3. Excavation method that will be effective on surrounding rock
4. Initial support schemes
5. Back filling material
6. Plugging section with grouting
7. Ground treatment around the tunnel

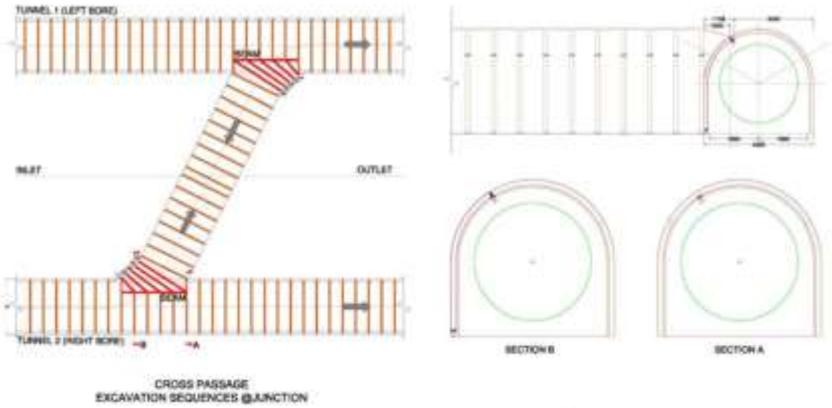
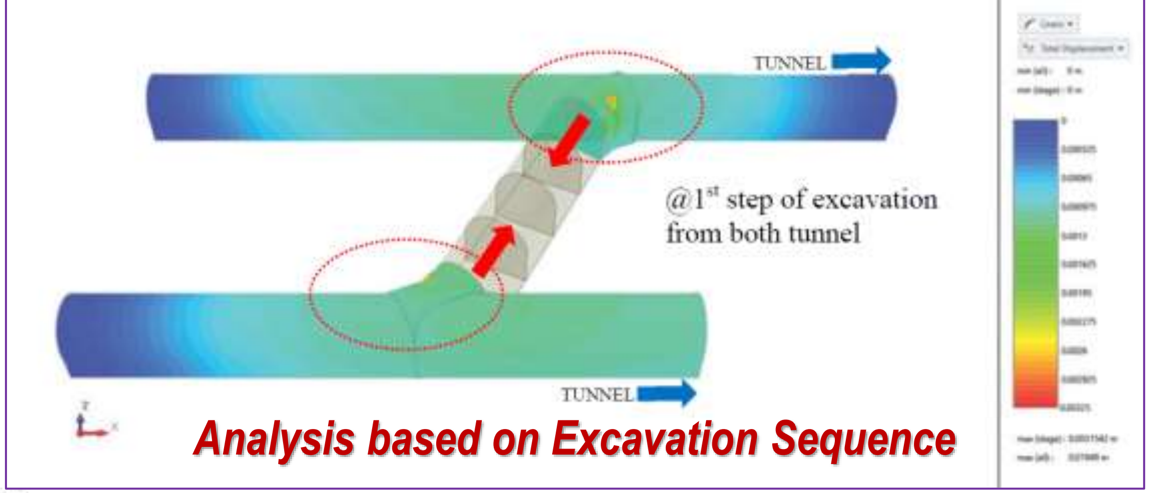
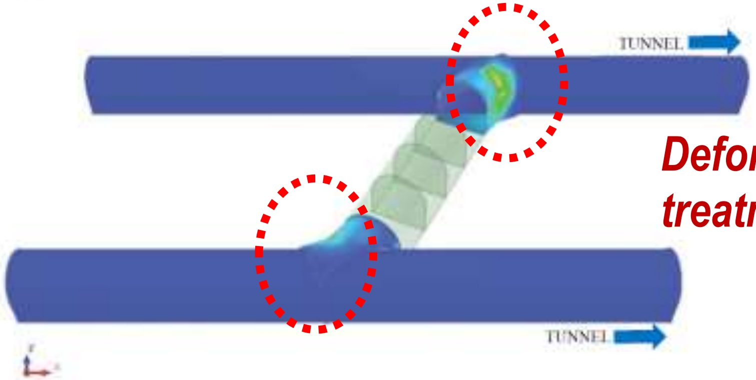


Figure (3.3) Construction Sequence of CP

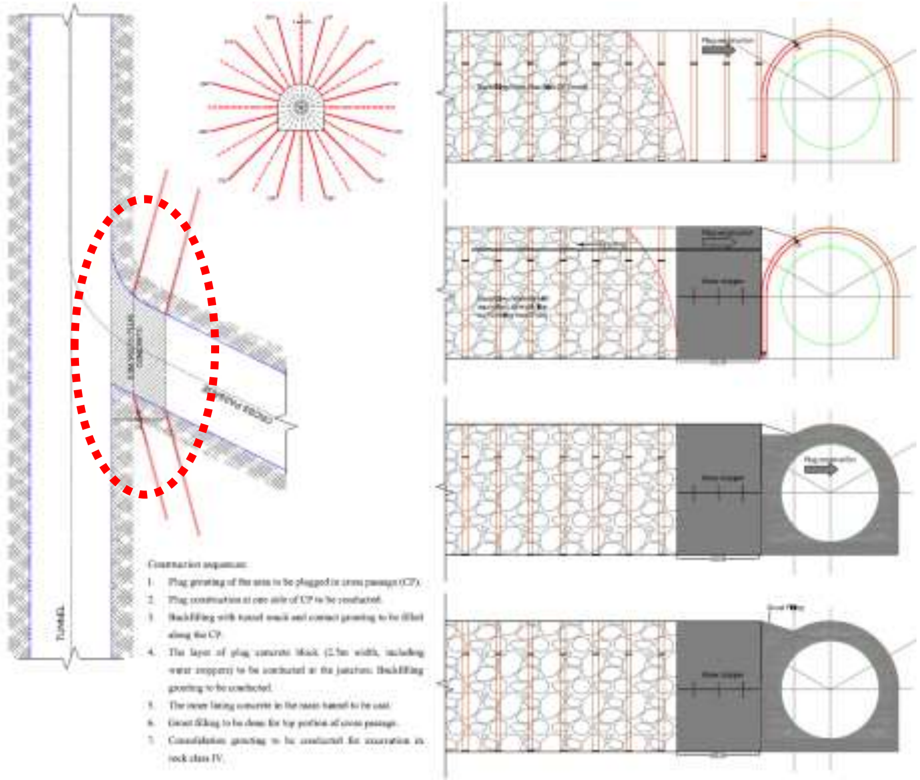
Support method selection and construction sequence



CH:0+500m



Deformation results for ground treatment



Plugging methods and plugging sequence

Project-4

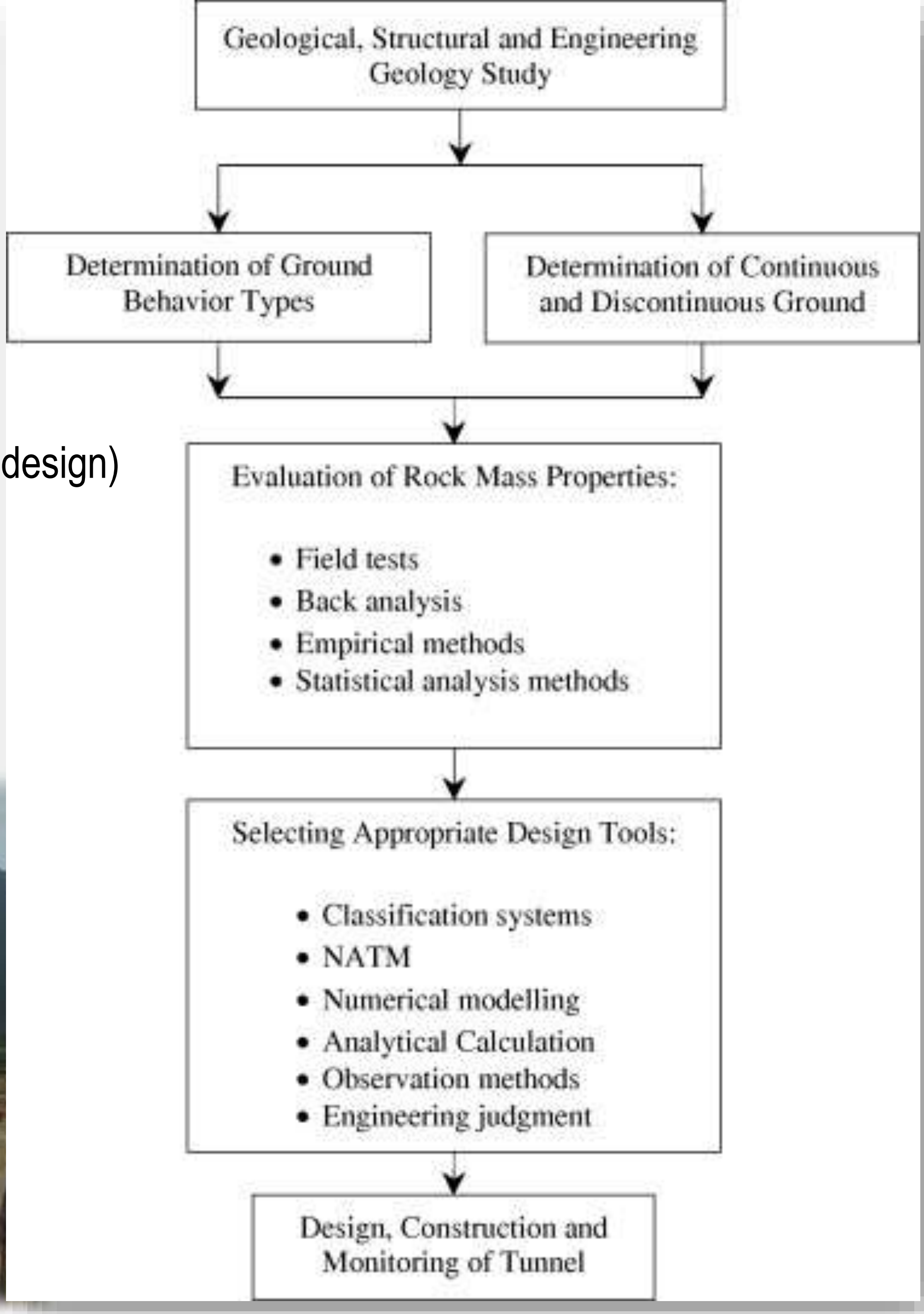
- ❖ **Design and Construction of Double Track Railway Tunnel**

Design Development Stages:

1. Conceptual design stage
2. Preliminary design stage
3. Tender design stages
4. Construction design stage

- ❖ **Berapit Twin Tunnel**

1. Stability design (Temporary and Lining design)
2. Excavation design
3. Drilling and Blasting design
4. Ventilation design
5. Inside drainage design



Project Information:

Project name: **Electrified Double Track Construction Project , Ipoh to Padang Besar, Malaysia**

Outline: The Construction, Completion of Slab Track for Bukit Berapit Twin Tunnel

Location: Taiping - Padang Rengas, Perak, Malaysia

Value: US $ 37 Million

Length: 5.762 km

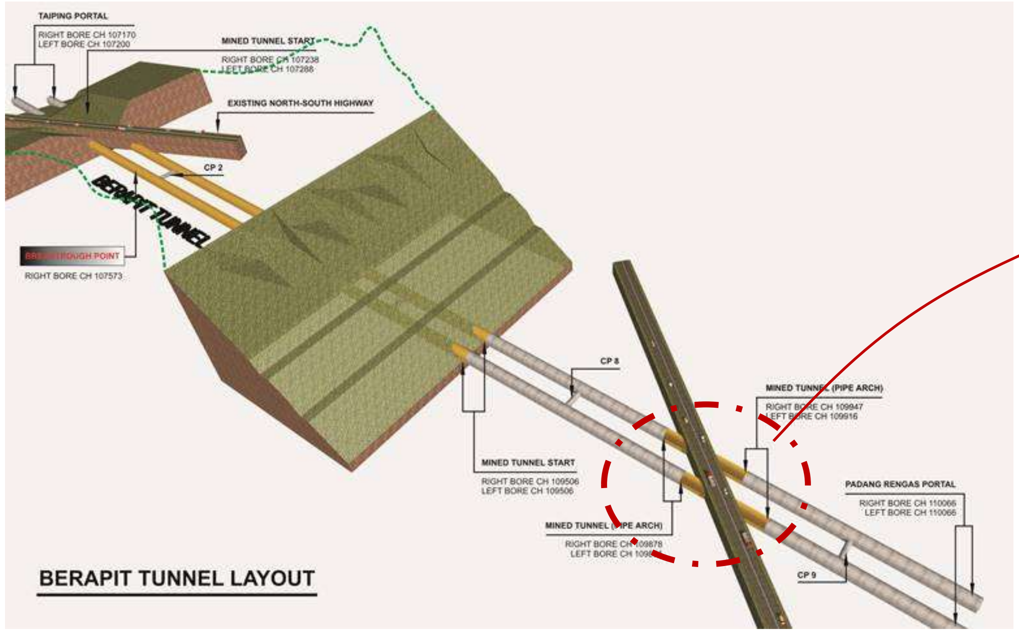
Construction designed by: Dr. Yu Maung

Tunnel	Drill & Blast tunnel, m	Underpass tunnel, m	Cut and cover tunnel, m	Total, m
Left tunnel	2218.0	59.0	589.0	2866.0
Right tunnel	2268.0	62.5	565.5	2896.0
				5762.0

Project Cost = 9,763,000 MMKs/m

Challenging problems of Technical Management

1. Construction planning (Sequence of excavation and Lining construction)
2. Due to the construction period limitation, Judgment of construction sequence, material handling and required technical specifications during drilling and blasting operation due to limiting period.
3. Stability design, planning of construction and support which largely effect on the project quality, safety and economy.
4. Under pass construction.



Underpass Tunnel below the PLUS High Way Road

Road settlement Control for road settlement

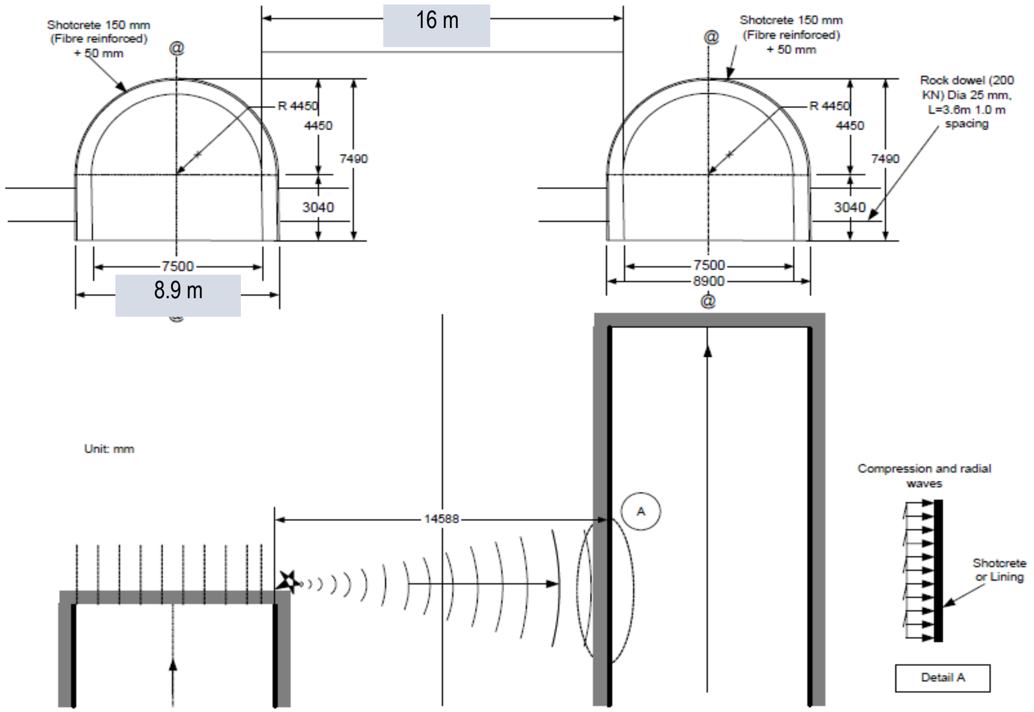
Rigid Support System

Semi-rigid support:
Settlement Control for tunnel settlement

Major technical Aspects in Design Phase

- ✓ Stability of underpass and tunnel
- ✓ Support methods
- ✓ Highway Plus Road settlement control
- ✓ Ground losses (improved by grouting)
- ✓ Blasting Control for over break
- ✓ Vibration Control
- ✓ Construction sequence

→ **Cost-effective Design**

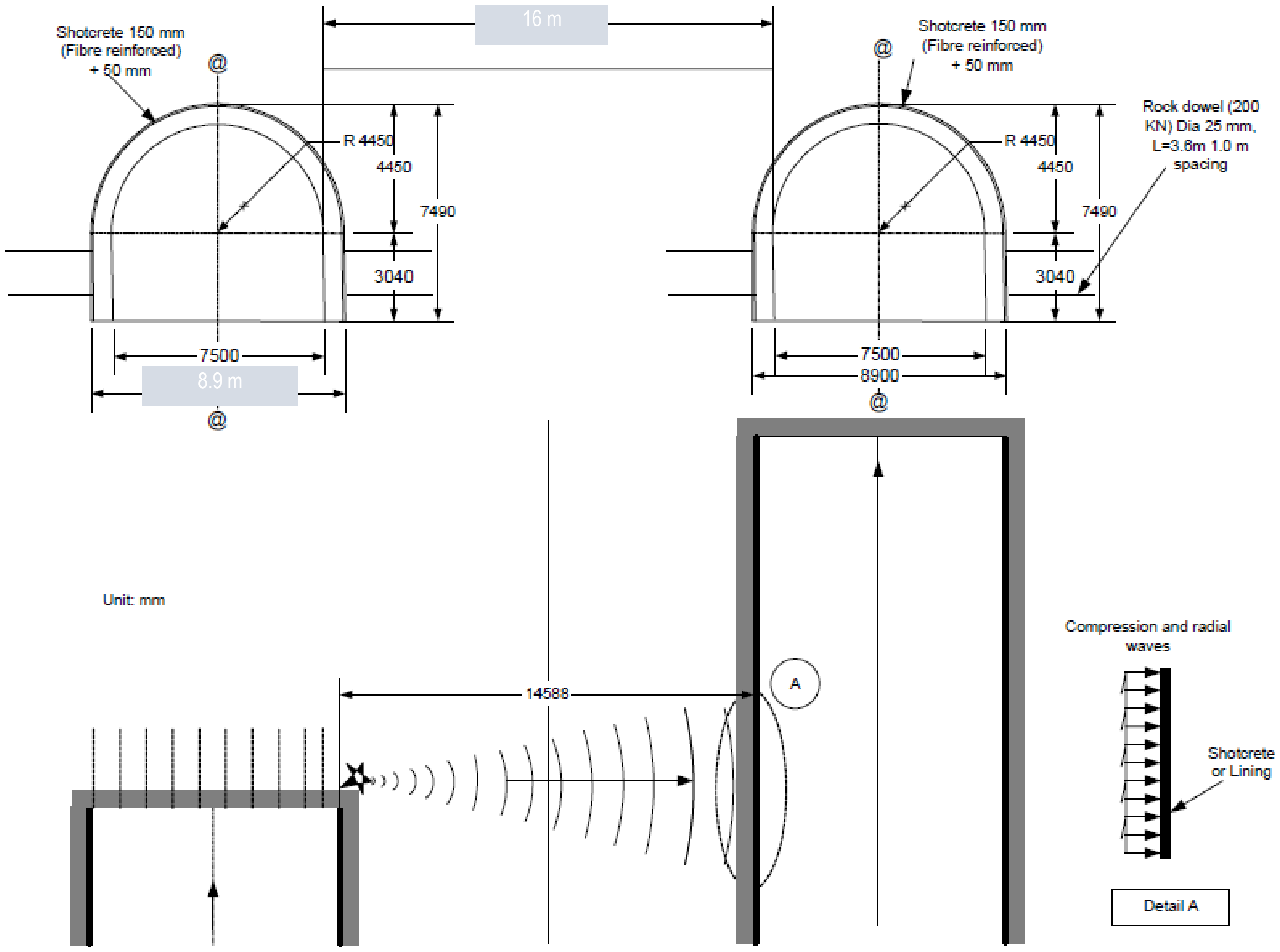


Blasting Control monitoring

1. Over break control for reduction of rock mass strength
2. Vibration control

Design consideration on construction sequence due to the side effect of Blasting:

1. Ground vibration control for temporary (Shotcrete)
2. Ground vibration control for permanent Lining



Ground Water Seepage Prevention

Allowable Infiltration

Tunnels ≤ 0.002 gal/sq. ft/day

Underground public space ≤ 0.001 gal/sq. ft/day

Tunnel Waterproofing

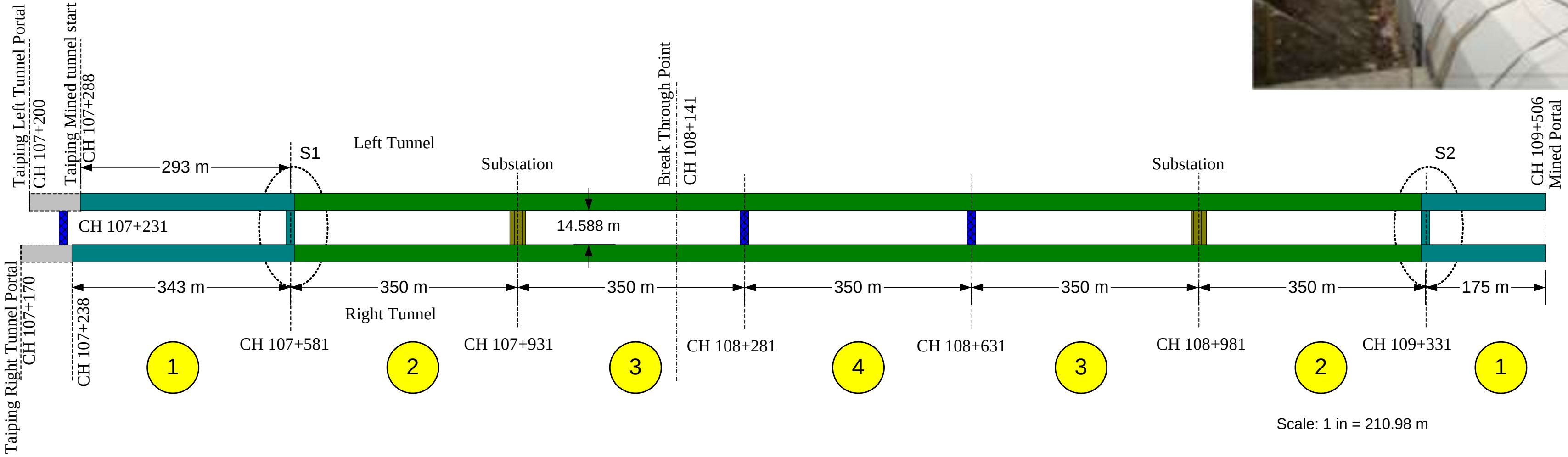
HDPE membrane; 2 mm welded HDPE with geotextile protective will be attached along the both sides of the lower side walls started from horizontal drainage pipe line.

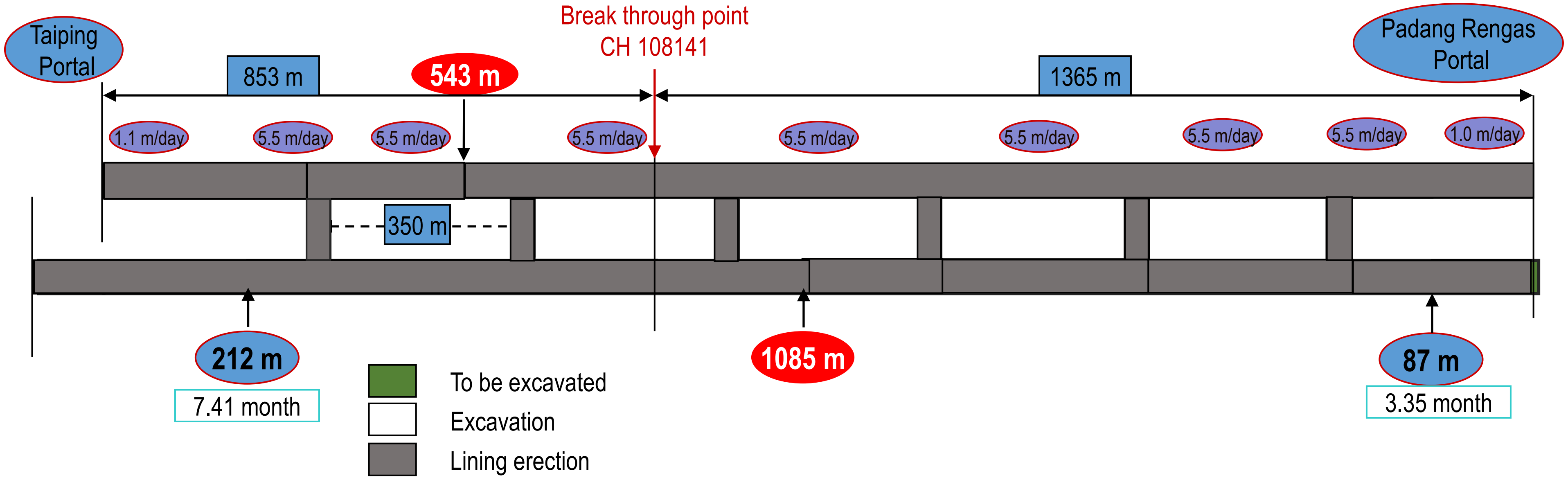
Ref: Based on criteria obtained from the International Tunneling Association (ITA), Singapore's Land Transport Authority (LTA), Singapore's Public Utilities Board (PUB), Hong Kong's Mass Transit Rail Corporation (MTRC) and the German Cities Committee

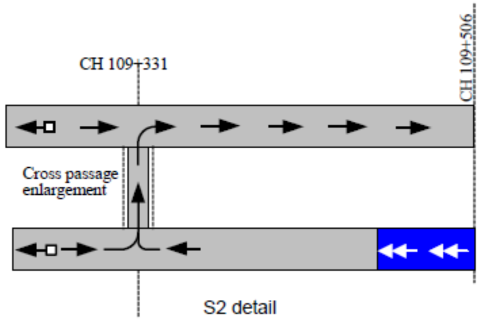
Construction Methodology of Twin Tunnel, Malaysia

Construction Sequence:

Design Constraint due to Construction Period Limitation

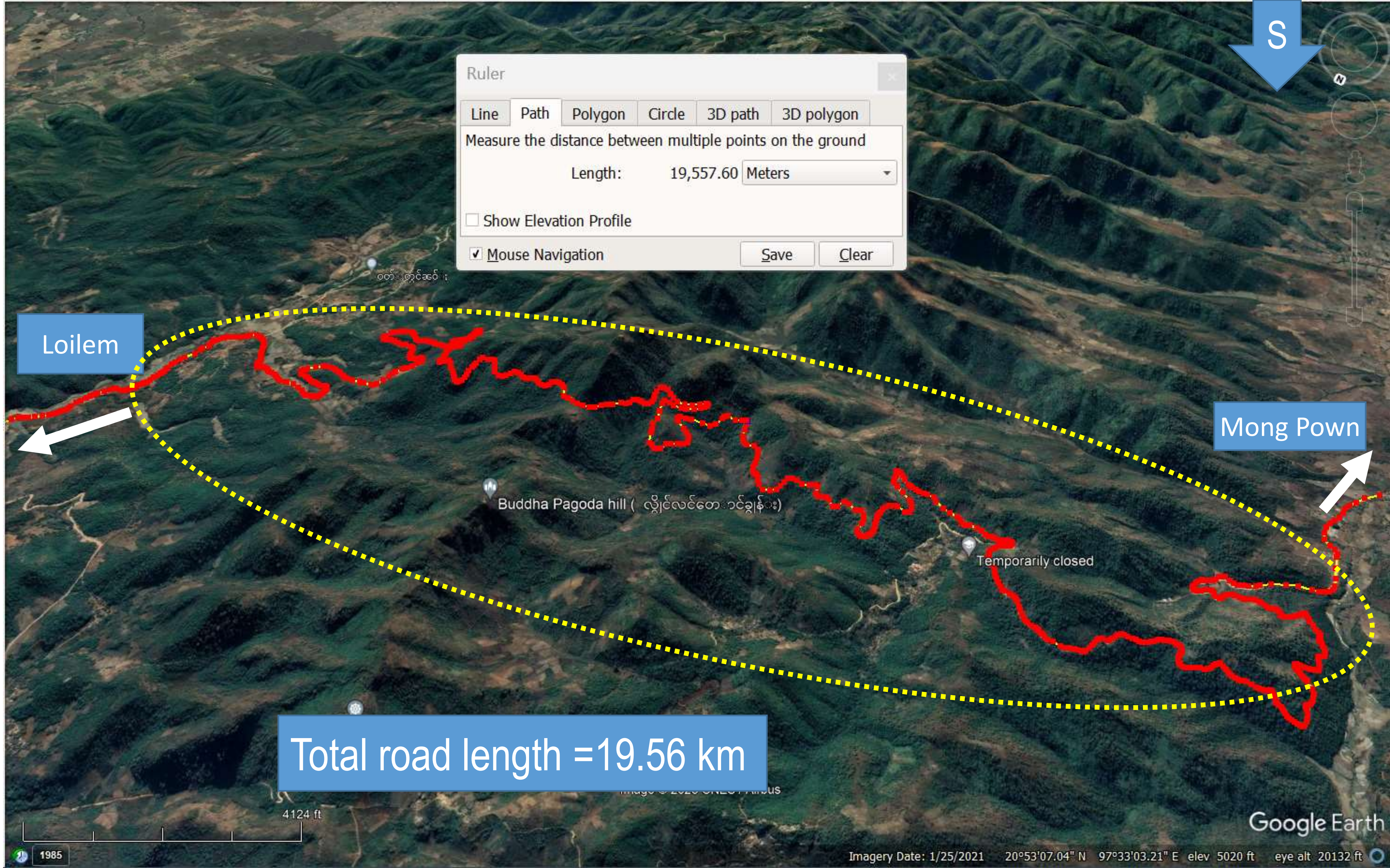





“The Author’s Dream”

Myanmar

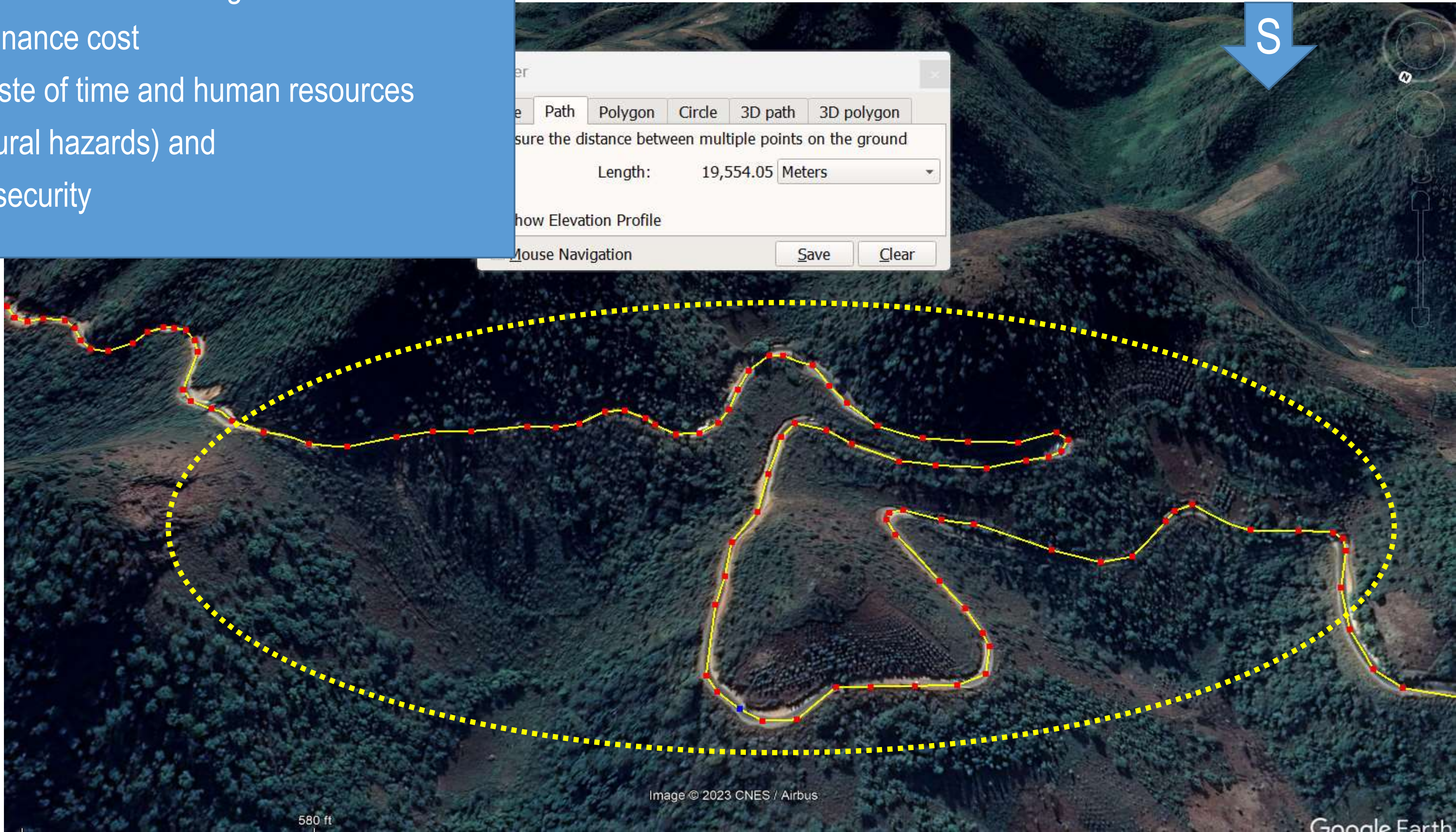

N
Housing Project
Lashio
Puer 普洱市
Monywa
Mandalay
Myanmar
Old Bagan
Xishuangbanna Dai Autonomou
Loilem
Taunggyi
Road Tunnel
Keng Tung
Mong Pawn
Kalaw
Nam Ha National Bio-Diversity...
Tachileik
Huay Xai
Max Myanmar
CHIANG RAI
MAE HONG SON
Taungoo
PHAYAO
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
Chiang Mai
Phyu
NAN
LAMPHUN
Google Earth
22°22'13.12" N 93°36'13.52" E elev 4999 ft eye alt 476.58 mi
Myanmar
Loilem
Road Tunnel
Taunggyi
Kalaw
Mong Pawn

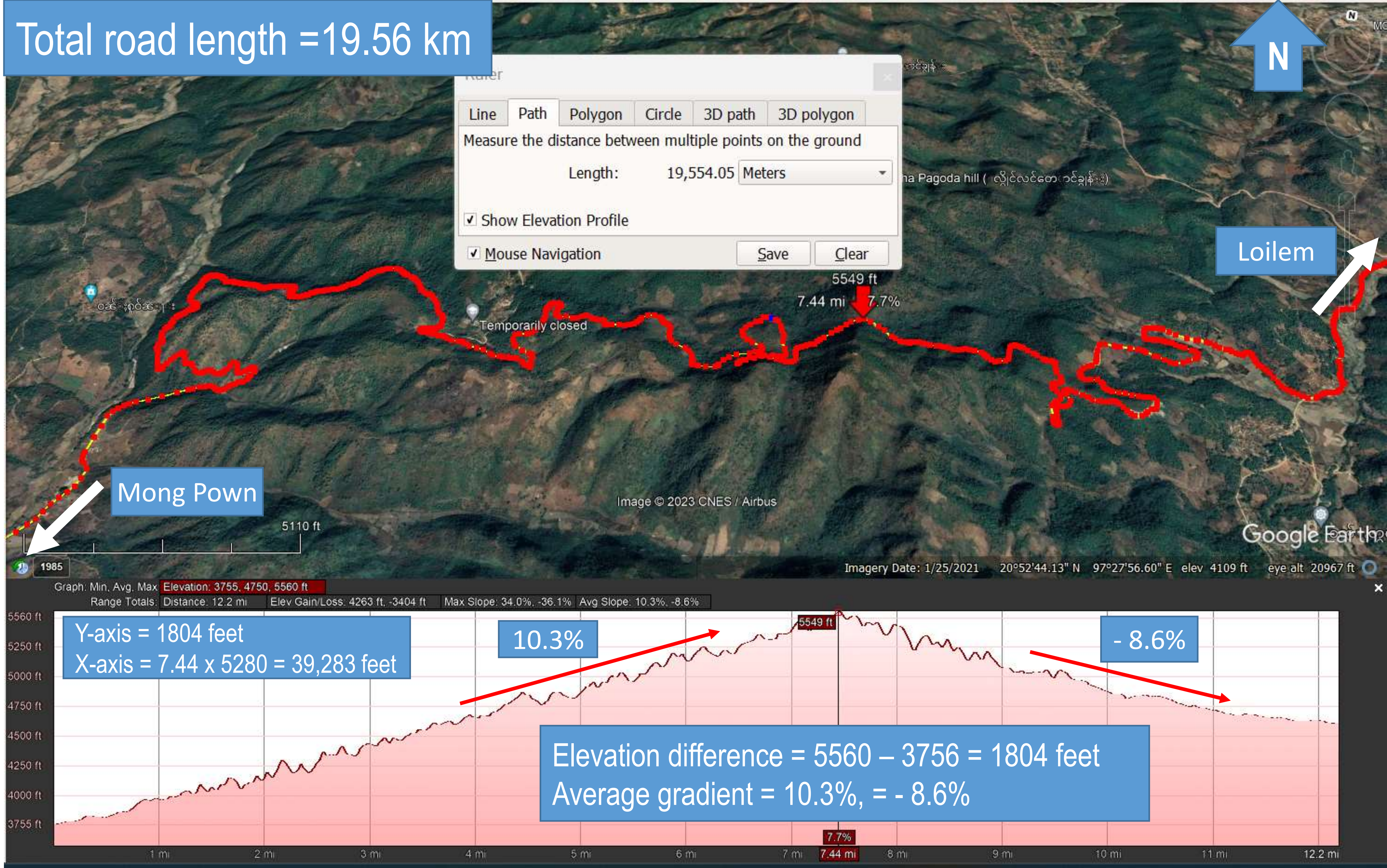


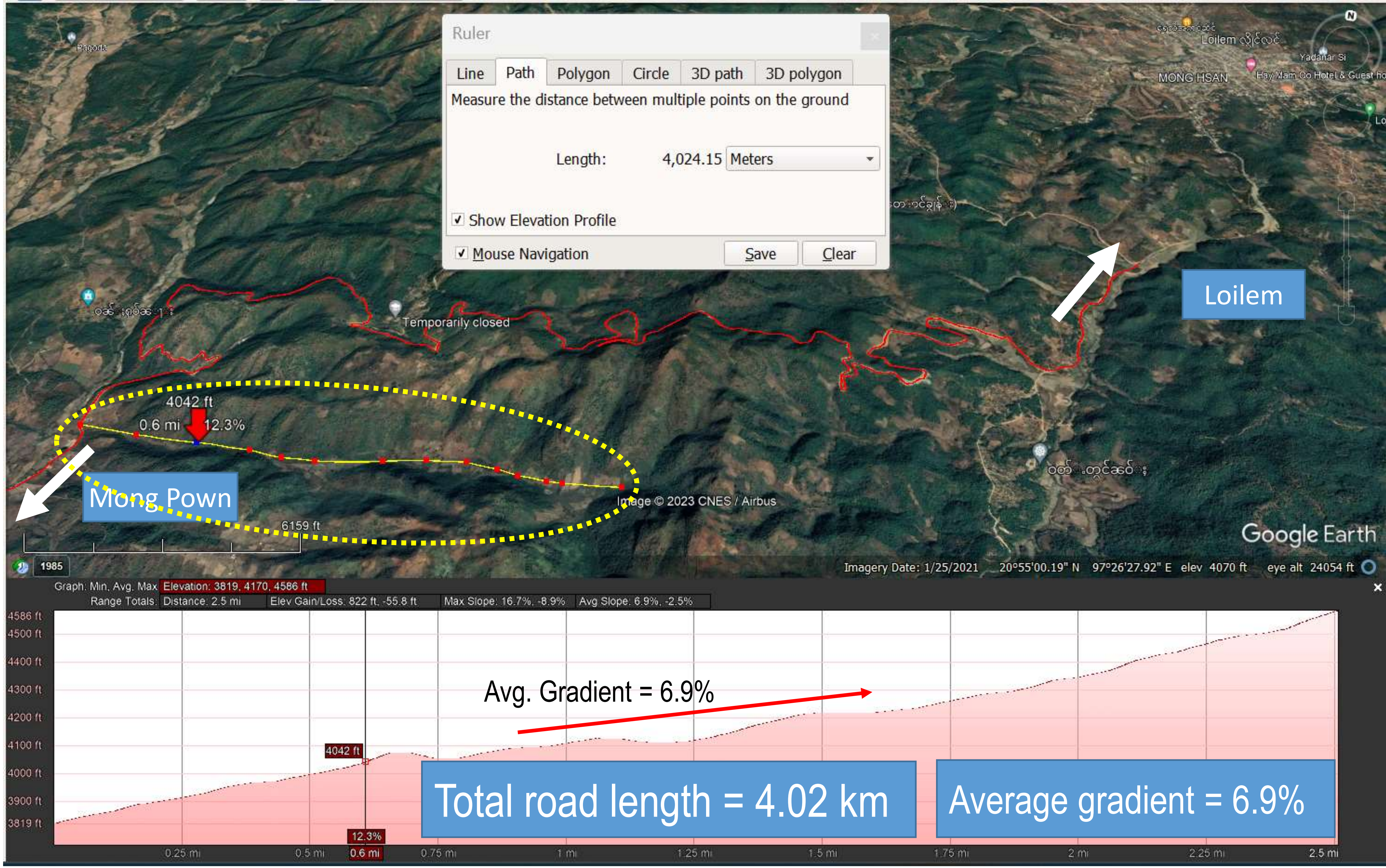
S
Ruler
Line
Path
Polygon
Circle
3D path
3D polygon
Measure the distance between multiple points on the ground
Length: 19,557.60 Meters
Show Elevation Profile
Mouse Navigation
Save
Clear
Loilem
Mong Pown
Buddha Pagoda hill
Temporarily closed
Total road length =19.56 km
4124 ft
1985
Google Earth
Imagery Date: 1/25/2021 20°53'07.04" N 97°33'03.21" E elev 5020 ft eye alt 20132 ft

What are the benefits?

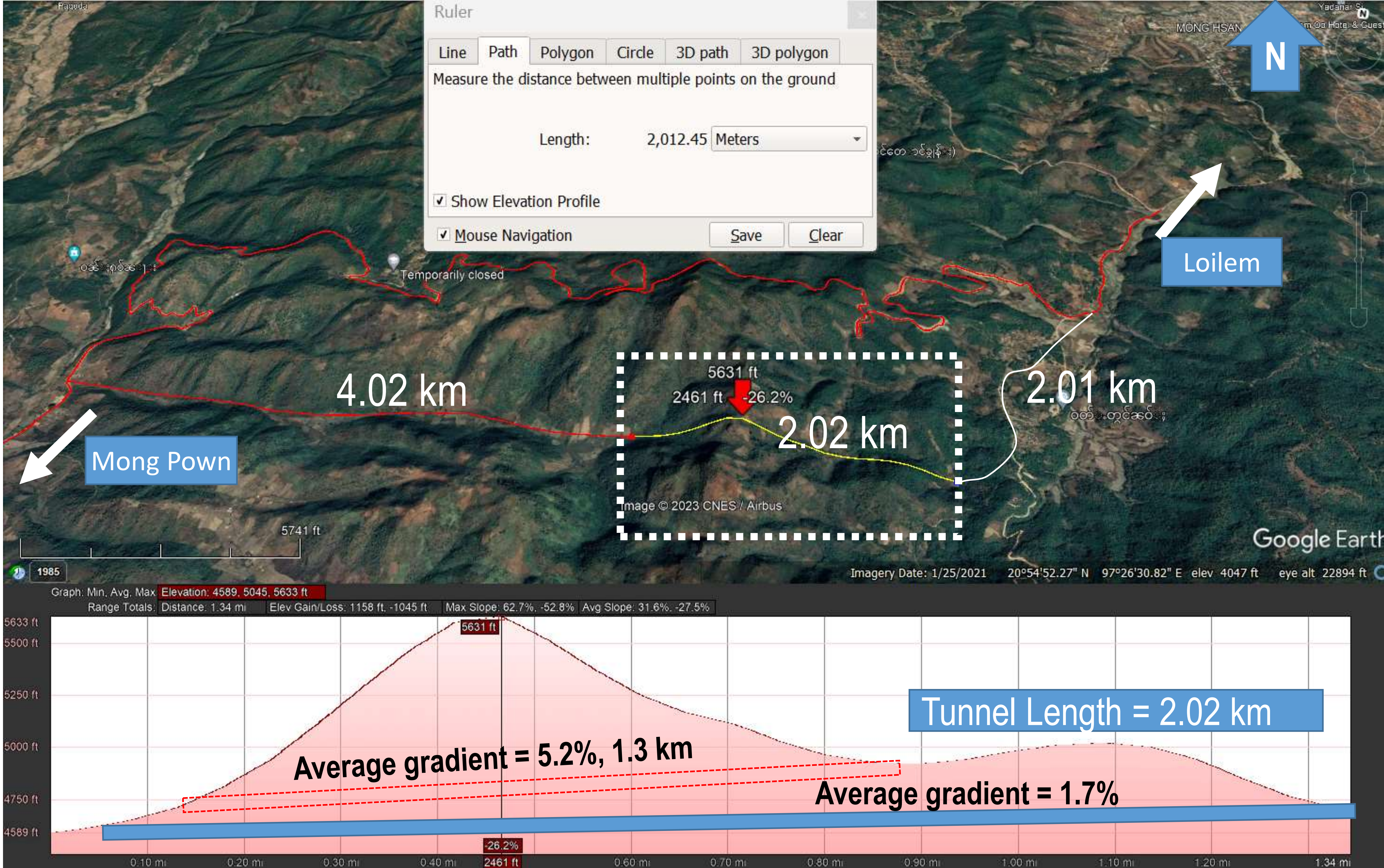
1. Low transportation cost in long term
2. Low maintenance cost
3. Reduce waste of time and human resources
4. Safety (natural hazards) and
5. Ecological security




Total road length =19.56 km
N
Line
Path
Polygon
Circle
3D path
3D polygon
Measure the distance between multiple points on the ground
Length: 19,554.05 Meters
Show Elevation Profile
Mouse Navigation
Save
Clear
Loilem
Temporarily closed
5549 ft
7.44 mi
7.7%
Mong Pown
5110 ft
Image © 2023 CNES / Airbus
Google Earth
1985
Imagery Date: 1/25/2021
20°52'44.13" N 97°27'56.60" E elev 4109 ft
eye alt 20967 ft
Graph: Min, Avg, Max Elevation: 3755, 4750, 5560 ft
Range Totals: Distance: 12.2 mi
Elev Gain/Loss: 4263 ft, -3404 ft
Max Slope: 34.0%, -36.1%
Avg Slope: 10.3%, -8.6%
5560 ft
5250 ft
5000 ft
4750 ft
4500 ft
4250 ft
4000 ft
3755 ft
Y-axis = 1804 feet
X-axis = 7.44 x 5280 = 39,283 feet
10.3%
5549 ft
- 8.6%
Elevation difference = 5560 – 3756 = 1804 feet
Average gradient = 10.3%, = - 8.6%
7.7%
1 mi
2 mi
3 mi
4 mi
5 mi
6 mi
7 mi
7.44 mi
8 mi
9 mi
10 mi
11 mi
12.2 mi



Ruler
Line
Path
Polygon
Circle
3D path
3D polygon
Measure the distance between multiple points on the ground
Length: 4,024.15 Meters
Show Elevation Profile
Mouse Navigation
Save
Clear
Loilem
Mong Pown
4042 ft
0.6 mi
12.3%
Temporarily closed
Image © 2023 CNES / Airbus
6159 ft
Google Earth
1985
Imagery Date: 1/25/2021 20°55'00.19" N 97°26'27.92" E elev 4070 ft eye alt 24054 ft
Graph: Min, Avg, Max Elevation: 3819, 4170, 4586 ft
Range Totals: Distance: 2.5 mi Elev Gain/Loss: 822 ft, -55.8 ft Max Slope: 16.7%, -8.9% Avg Slope: 6.9%, -2.5%
Avg. Gradient = 6.9%
Total road length = 4.02 km
Average gradient = 6.9%
4586 ft
4500 ft
4400 ft
4300 ft
4200 ft
4100 ft
4000 ft
3900 ft
3819 ft
0.25 mi
0.5 mi
0.75 mi
1 mi
1.25 mi
1.5 mi
1.75 mi
2 mi
2.25 mi
2.5 mi

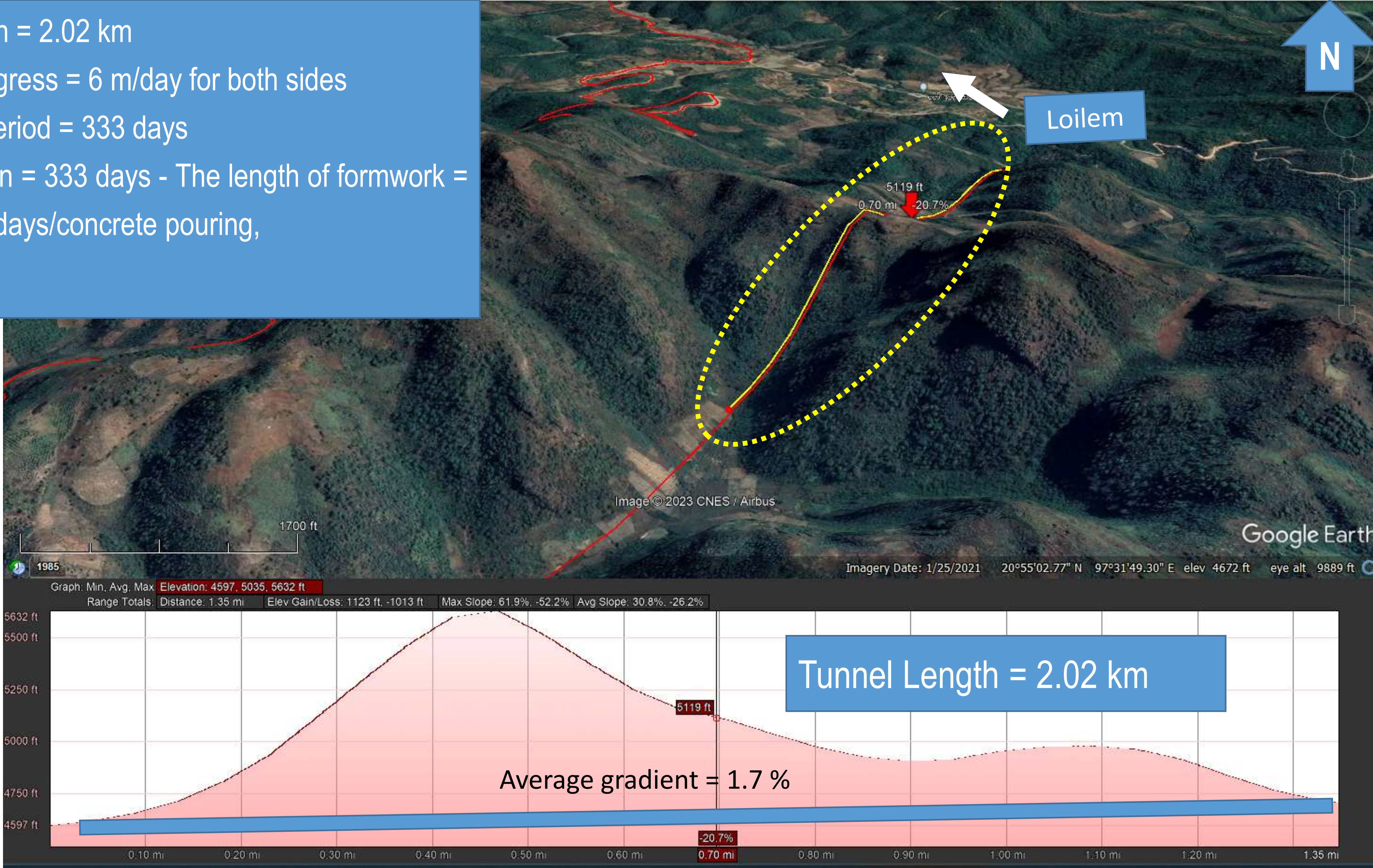

Ruler
Line
Path
Polygon
Circle
3D path
3D polygon
Measure the distance between multiple points on the ground
Length: 2,012.45 Meters
Show Elevation Profile
Mouse Navigation
Save
Clear
N
Loilem
Mong Pown
4.02 km
2.01 km
2.02 km
5631 ft
2461 ft -26.2%
Temporarily closed
Image © 2023 CNES / Airbus
Google Earth
Imagery Date: 1/25/2021 20°54'52.27" N 97°26'30.82" E elev 4047 ft eye alt 22894 ft
Graph: Min, Avg, Max Elevation: 4589, 5045, 5633 ft
Range Totals: Distance: 1.34 mi Elev Gain/Loss: 1158 ft, -1045 ft Max Slope: 62.7%, -52.8% Avg Slope: 31.6%, -27.5%
Tunnel Length = 2.02 km
Average gradient = 5.2%, 1.3 km
Average gradient = 1.7%

Tunnel Length = 2.02 km

Minimum progress = 6 m/day for both sides

Excavation period = 333 days

Lining erection = 333 days - The length of formwork = 12 m long, 4 days/concrete pouring,



Conclusion

1. Underground Space usage is the vital role in development of particular region or area as well as the development of whole country.
2. Urban underground space can play a vital role in creating cities that are able to develop within the hyper-dynamic context of modern times.
3. Planning for underground space poses new challenges to planning professionals but also provides them with new opportunities in urban area.
4. A multi-disciplinary approach is required at all levels to further enhance our understanding of underground space and to make it possible to use.
5. Due to the multi-disciplinary approach, **the authorized persons or decision makers**, who will be responsible to coordinate and manage, are vital important in sustainable development of particular region or country.

END

Thank you for your attention