Philippines

NIPPON KOEI

Metropolitan Cagayan de Oro and Northern Mindanao Region Online Business Seminar on Transportation Infrastructure and Energy

Tunnel Auxiliary Method for Safety Construction and Environmental Protection

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Japan's No.1 International Engineering Consultants
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Outline

1. Introduction
2. Example of Occurrence of Water leaking and Subsidence in Japan
3. Auxiliary Method in Japan

1. Introduction

1.1 Self-Introduction

Speaker : Wako NOTO (Date of Birth: 20th November 1968)

Education : B.En., Civil Engineering, Faculty, Kansai University, Japan, 1991

Licentiate : Professional Engineer (Civil Engineering Tunnel)-Japan

Specialty : Underground Space Development Specialist, Civil Engineer

Employment record : **2013 to Date Nippon Civic Consulting Engineers Co., Ltd.**

2009 to 2013 Nippon KOEI Co., Ltd

1991 to 2009 Nippon Civic Consulting Engineers Co., Ltd.

Project Involved in Philippines

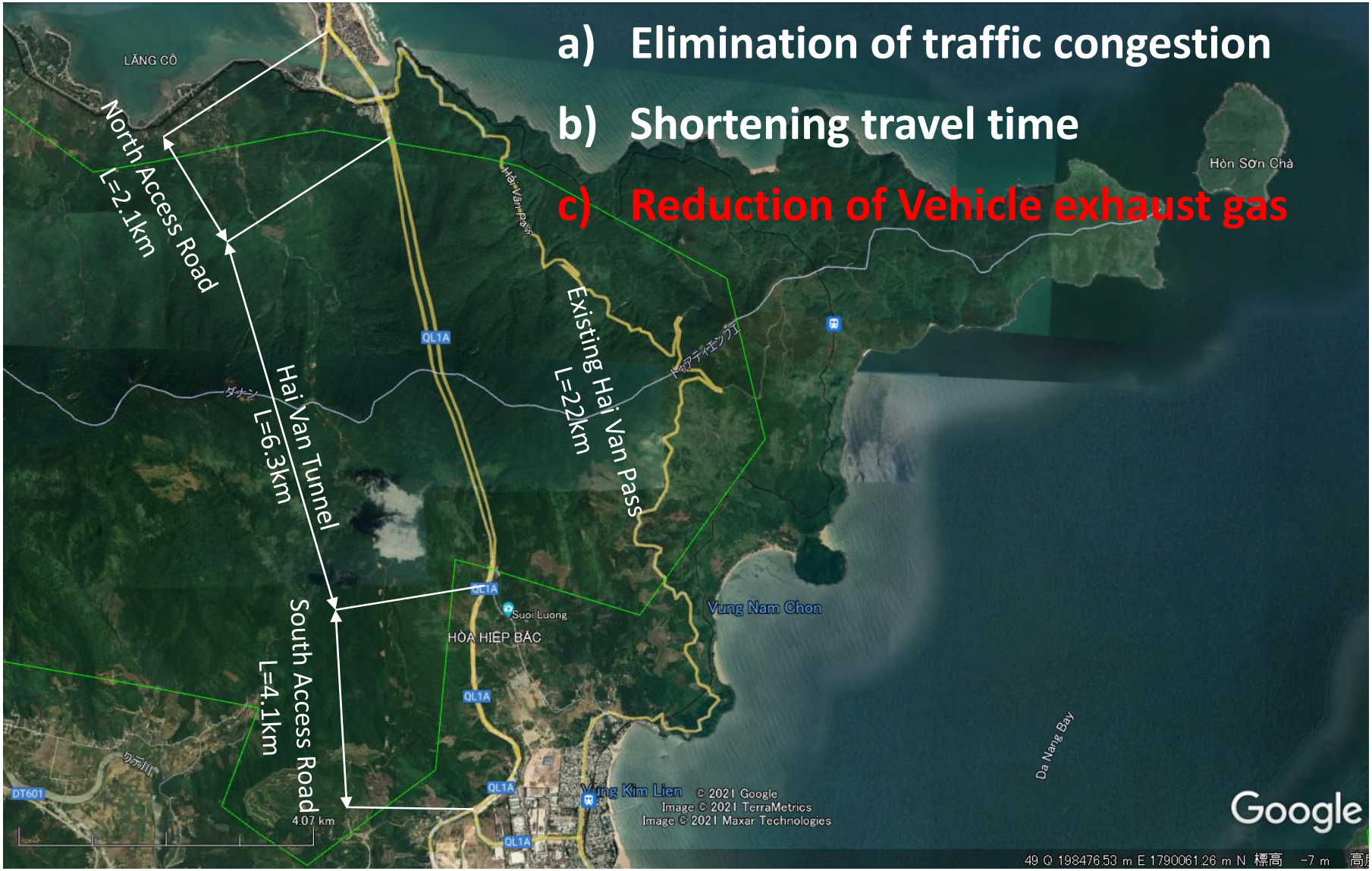
Acting Project Manager: Detailed Design and Construction Supervision

Davao City Bypass Construction Project

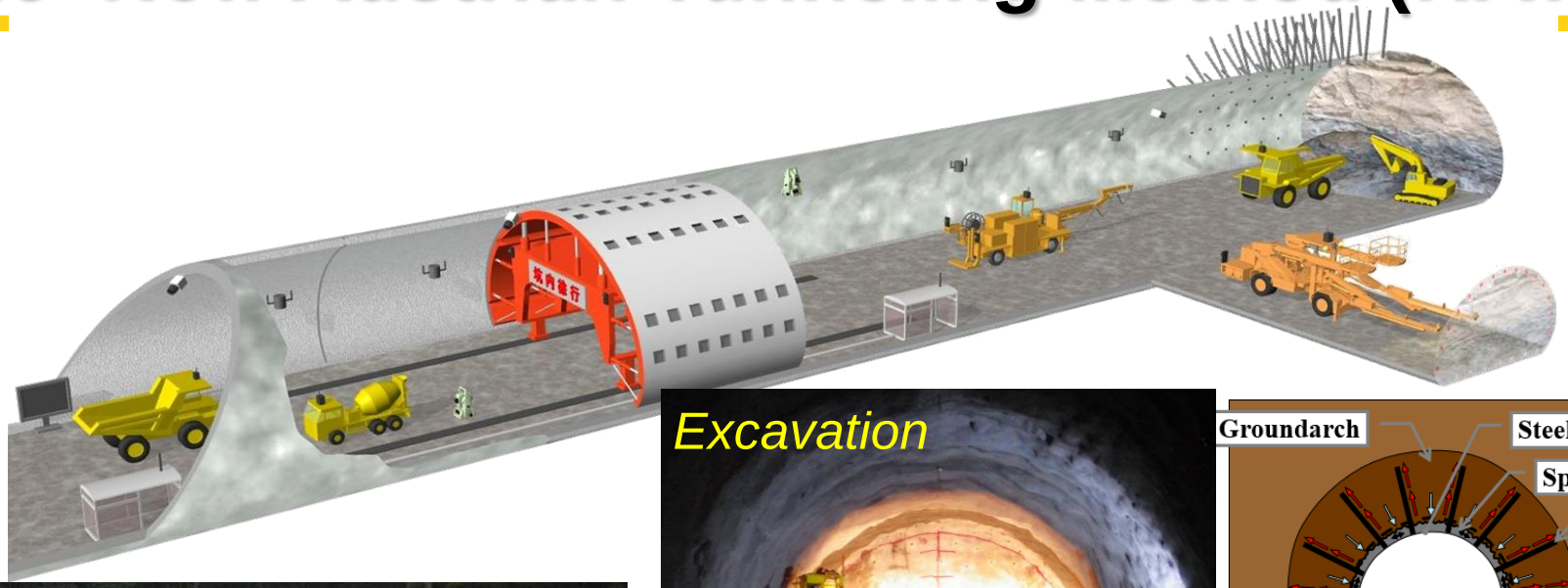
Tunnel Planner: Preparatory Survey for Dalton Pass East Alternative Road

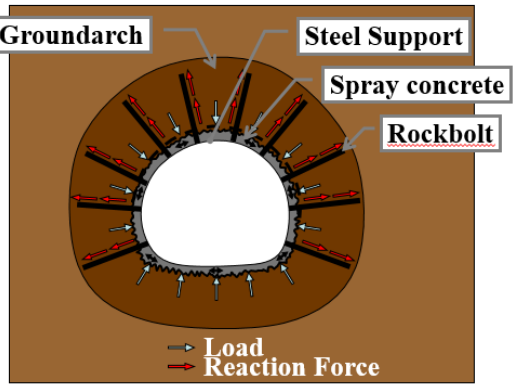
Tunnel Adviser: Subic Freeport Expressway (SFEX) Capacity Expansion Project

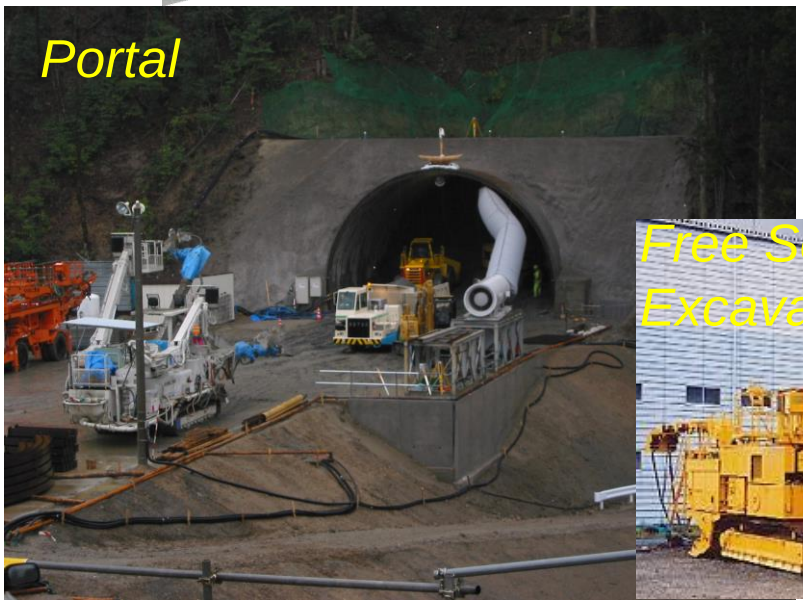
1.2 Environmental Effects by Tunnel



1.3 New Austrian Tunneling Method (NATM)







1.4 General

Tunnel auxiliary methods are the construction methods of a secondary or special nature adopted to ensure tunnel face stability and tunnel safety and to preserve the environmental in cases where either conventional support patterns or division of heading section don't provide effective solution or where they are not advantageous.

1.5 Objectives

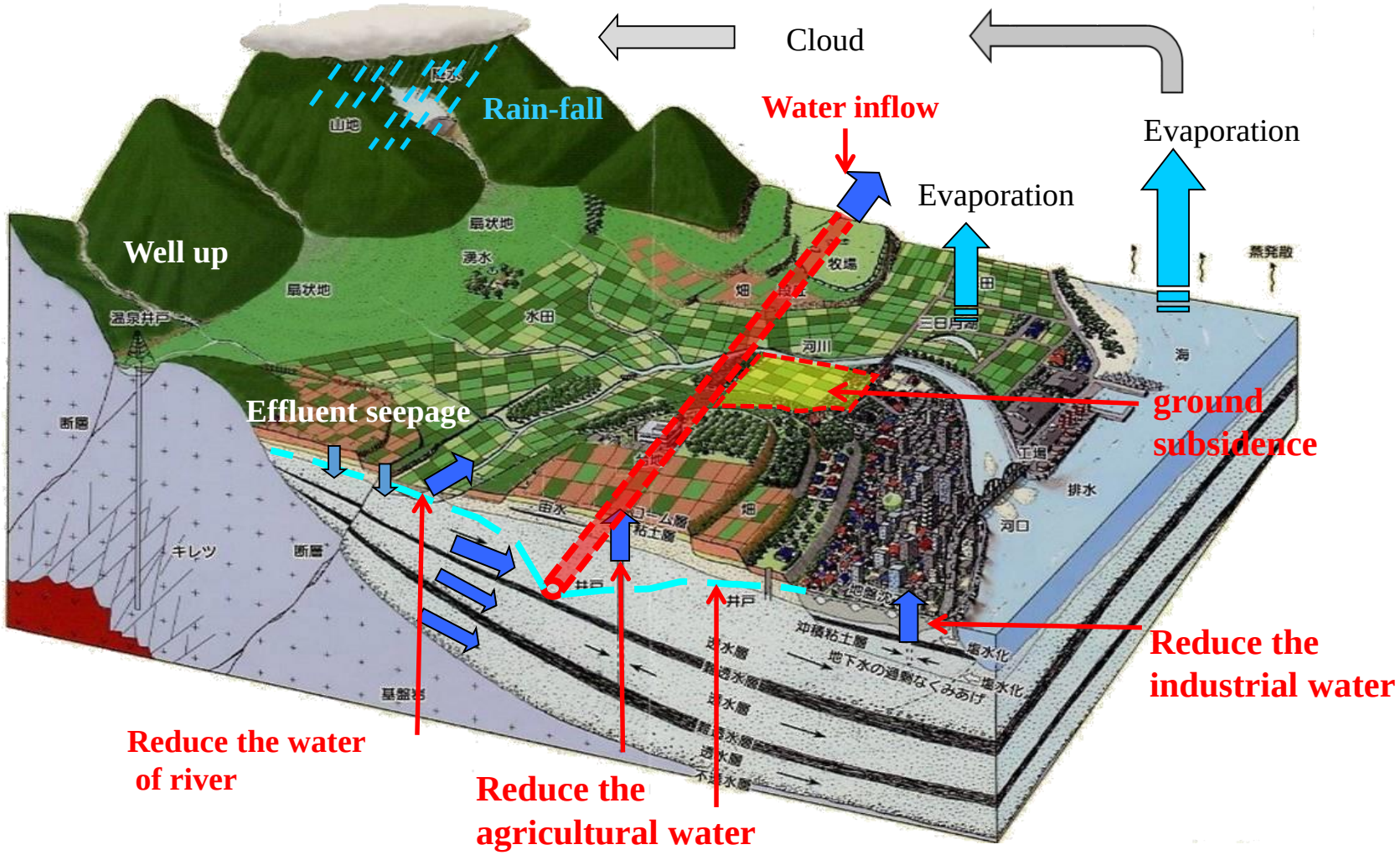
The major objectives of auxiliary methods;

(1) Ensuring safety of tunneling (face stabilization and measures against water inflow)

(2) Preservation of the environment (groundwater measures, countermeasures against surface settlement and measures to prevent adverse impact on neighboring structures).

1.3 Environmental Impact

If lowering of groundwater level,



2. Example of Occurrence of Water leaking and Subsidence in Japan

2.1 Conditions where the occurrence of water leaking is concerned

Water leaking occurs under the following three conditions.

a) Fault fracture zone

b) Unconsolidated ground

c) Ground where high water pressure or much ground water is anticipated

2.2 Example of water leaking in tunnel construction

Water leaking from fault fracture zone of Mizuho tunnel

2.3 Cause and mechanism of Subsidence occurrence

Cause and mechanism of Subsidence occurrence is shown the following three conditions.

a) Stress release of ground by excavation

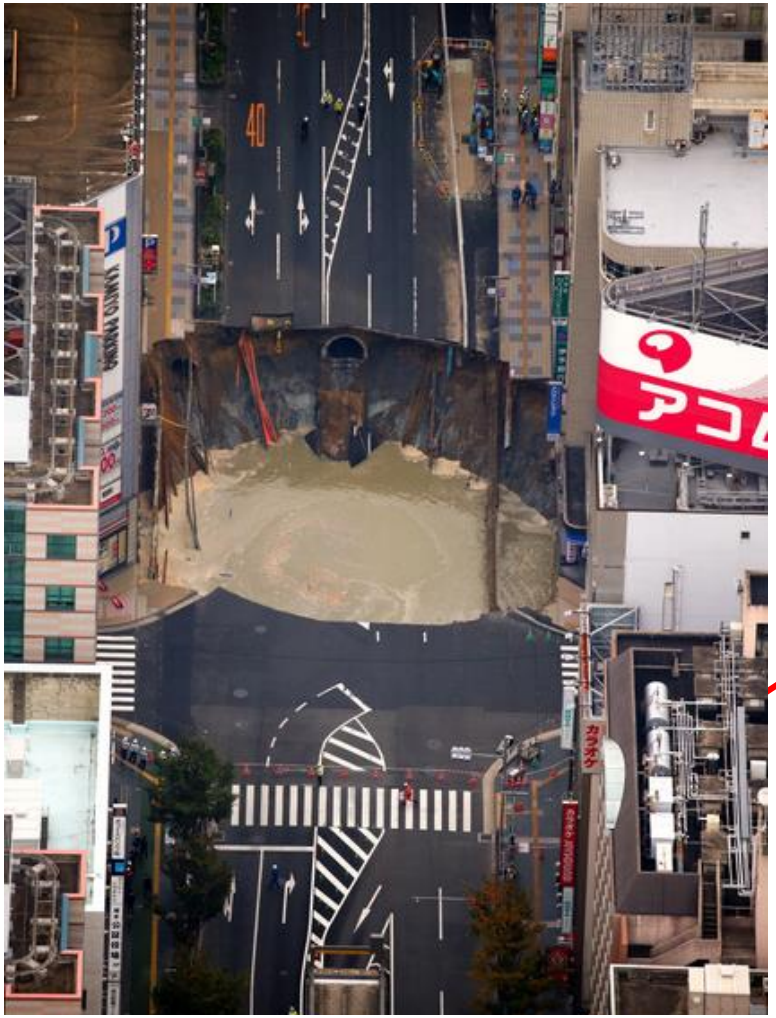
b) Variation of groundwater

- Immediate settlement in the sandy grounds
- Consolidation settlement in the cohesive soil grounds.

c) Tunnel construction

by such as looseness of ground due to the deformation of support or excavation.

2.4 Example of Subsidence by Tunnel Construction



Source: Asahi.com

W27m x L30m x D15m

Source: MLIT Report

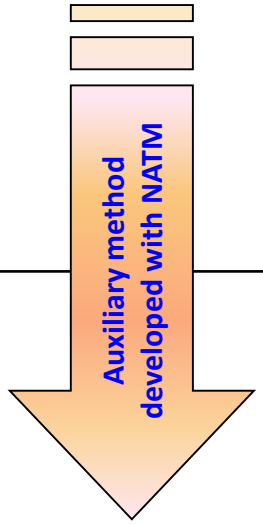
Road subsidence collapse accident in Hakata

3. Auxiliary Method in Japan

3.1 General of Auxiliary Method

a) History of auxiliary method

Year	Support	Groundwater measures	Subsidence measures
Before 1960	Wooden Support	・Drainage drift Human power excavation	・Only by the tunnel construction method
1960	Steel arch Support	・Drainage boring	・Only by the tunnel construction method
1975	NATM Shotcrete and Rock-bolt	・Well point, Deep well, Grouting, Cut-off wall	・Forepoling(filling, grouting), Face shotcrete, Face bolt, Long face bolt, Temporary invert, Footing reinforcement bolt, Footing reinforcement pile, Steel pipe forepiling(grouting),
after 2000	NATM New Support TBM	・Watertight tunnel	・Horizontal jet grouting (injection and mixing), Slit concrete method, Vertical pre-reinforcement, Pipe roof, Neo AGF



3.1 General of Auxiliary Method (continued)

b) Process for application of auxiliary method

- In case where it is deemed realistic to apply an auxiliary method in the original design, appropriate methods shall be selected by evaluating the ground conditions, environmental conditions and construction method.

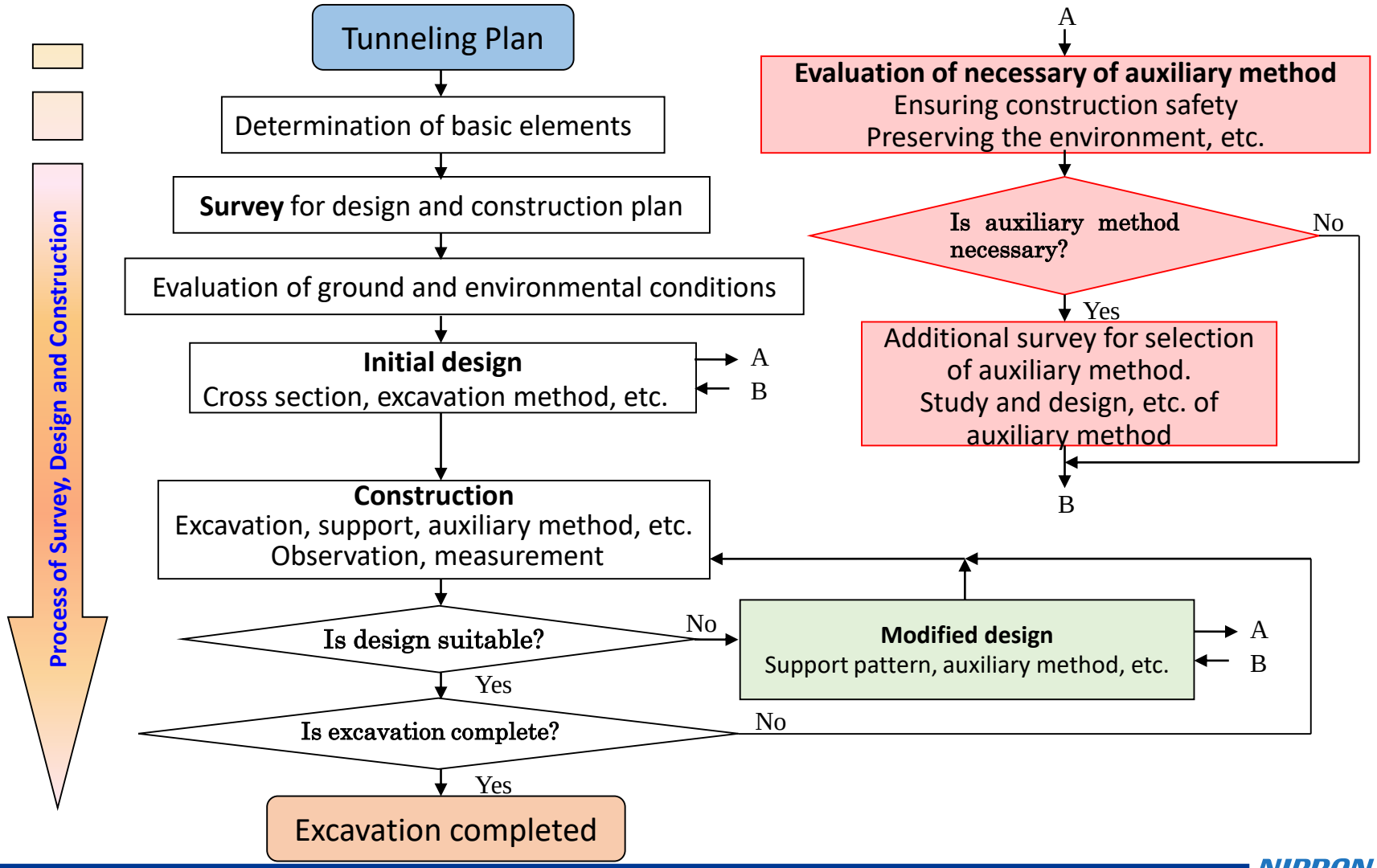
Input survey result during design

- In case where auxiliary method is judged necessary during the tunnel excavation, an appropriate auxiliary method shall be selected after evaluating the tunnel safety, environmental impact, effectiveness, economic efficiency and compatibility with the tunneling method.

Input survey result during excavation

3.1 General of Auxiliary Method (continued)

c) Flow of tunnel project focusing auxiliary method



3.1 General of Auxiliary Method (continued)

d) Selection of auxiliary method

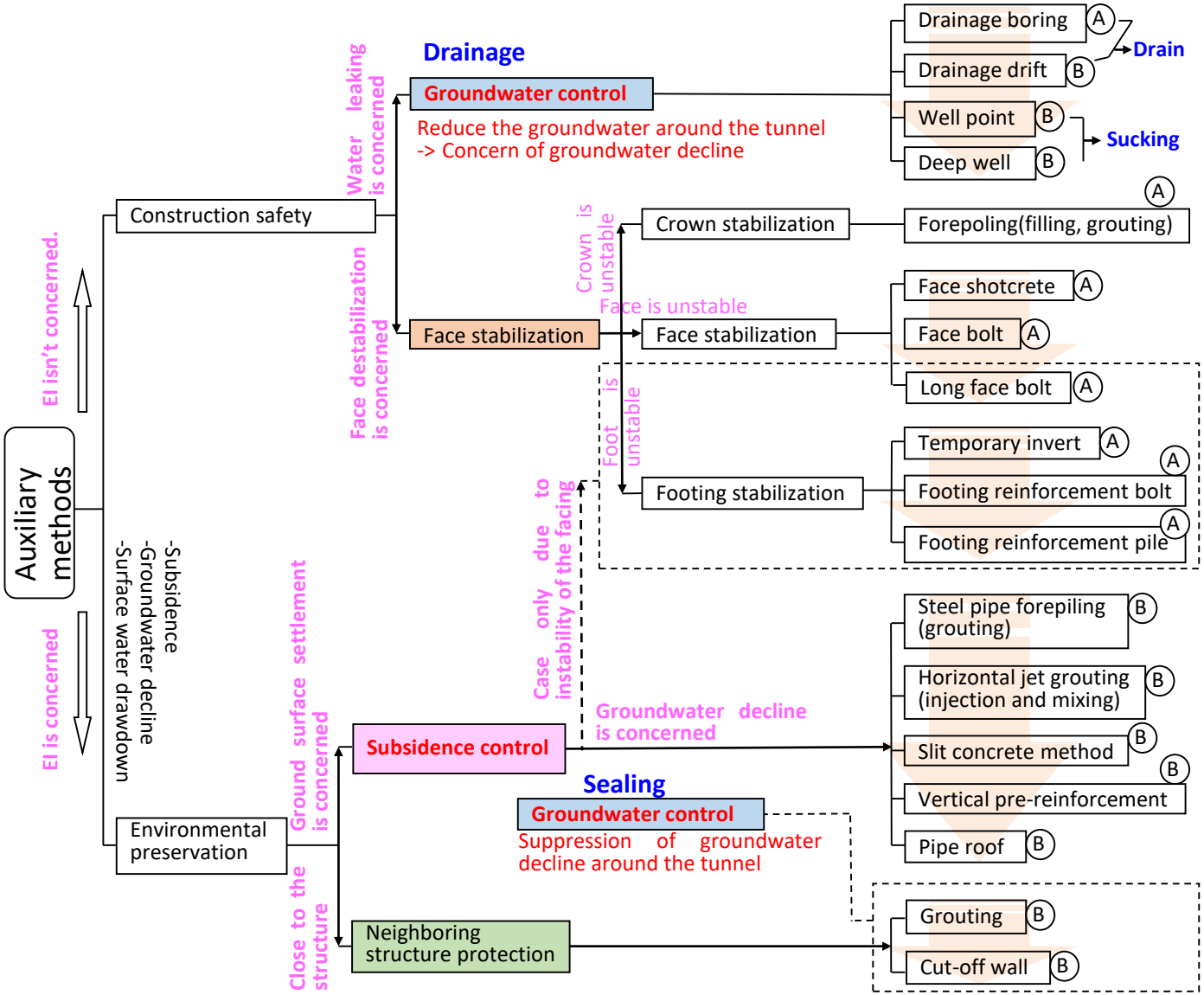
An auxiliary methods are classified into broad categories according to their objectives: face stabilization, groundwater measures, subsidence measures and measures for neighboring structures.

Auxiliary methods should be selected in terms of safety, effects and cost performance, evaluating the conditions ahead to the face, the face itself and behind the face, on the basis of comprehensive study, always involving latest available technological information.

3.1 General of Auxiliary Method (continued)

Method			Purpose							Ground which method can be applied		
			Construction safety					Environmental preservation				
			Face stabilization			Groundwater control		Subsidence control	Neighboring structure protection	Hard rock	Soft rock	Soil
			Crown stabilization	Face stabilization	Footing stabilization							
Subsidence control	Presupport	Forepoling (filling, grouting)	X							X	X	X
		Steel pipe forepiling (grouting)	X					X	X		X	X
		Pipe roof	X					X	X		X	X
		Horizontal jet grouting (injection and mixing)	X	X	X			X	X			X
		Slit concrete method	X					X	X		X	X
Face reinforcement		Face shotcrete		X						X	X	X
		Face bolt		X						X	X	X
Subsidence control		Long face bolt		X				X		X	X	X
	Footing reinforcement	Footing reinforcement bolt			X			X			X	X
		Footing reinforcement pile			X			X			X	X
		Temporary invert			X			X			X	X
Groundwater control	Drainage	Drainage boring	X	X	X	X				X	X	X
		Well point	X	X	X	X						X
		Deep well	X	X	X	X						X
		Drainage drift	X	X	X	X				X	X	X
Subsidence control	Water searing	Grouting	X	X	X	X	X	X	X	X	X	X
		Cut-off wall				X	X	X	X			X
	Ground reinforcement	Grouting	X	X				X	X			X
		Vertical pre-reinforcement	X	X				X				X

3.1 General of Auxiliary Method (continued)



3.2 Necessity of Auxiliary Method

Face stabilization

➢Face stabilization: The mountain tunneling methods is predicated on the stability of the cutting face and the tunnel crown until the supports have been built. In case where the cutting face is unable to stand itself until the completion of the placement of the support because of the ground conditions, it is necessary to take appropriate face stabilization measures to ensure safe and efficient construction.

3.2 Necessity of Auxiliary Method (continued)

Ground water control

➢Water leaking control: When water flows is anticipated to flow into the tunnel through the face excavation, the inflow ground water need to be drained to stabilize the face and improve construction efficiency. However, caution should be exercised if water leaking is to be controlled, because it could results in surface collapse.

When the surrounding environmental might be affected including depletion of the groundwater, surface settlement caused by drainage is not permissible, the drainage measure can't be used.

The common auxiliary method applicable in such case is grouting. Grouting is the most reliable for stabilizing the face, which will reduce water leaking and discontinuous layers with sand intercalations where water drainage or weep holes are not effective.

3.2 Necessity of Auxiliary Method (continued)

Subsidence control

➢Surface settlement control: Surface settlement during the tunnel excavation could be related to several issues i.e. topographical and geological conditions, ground water condition, construction methods. Major causes of surface settlement can be loosening of ground induced by the tunnel excavation and discharge of the groundwater.

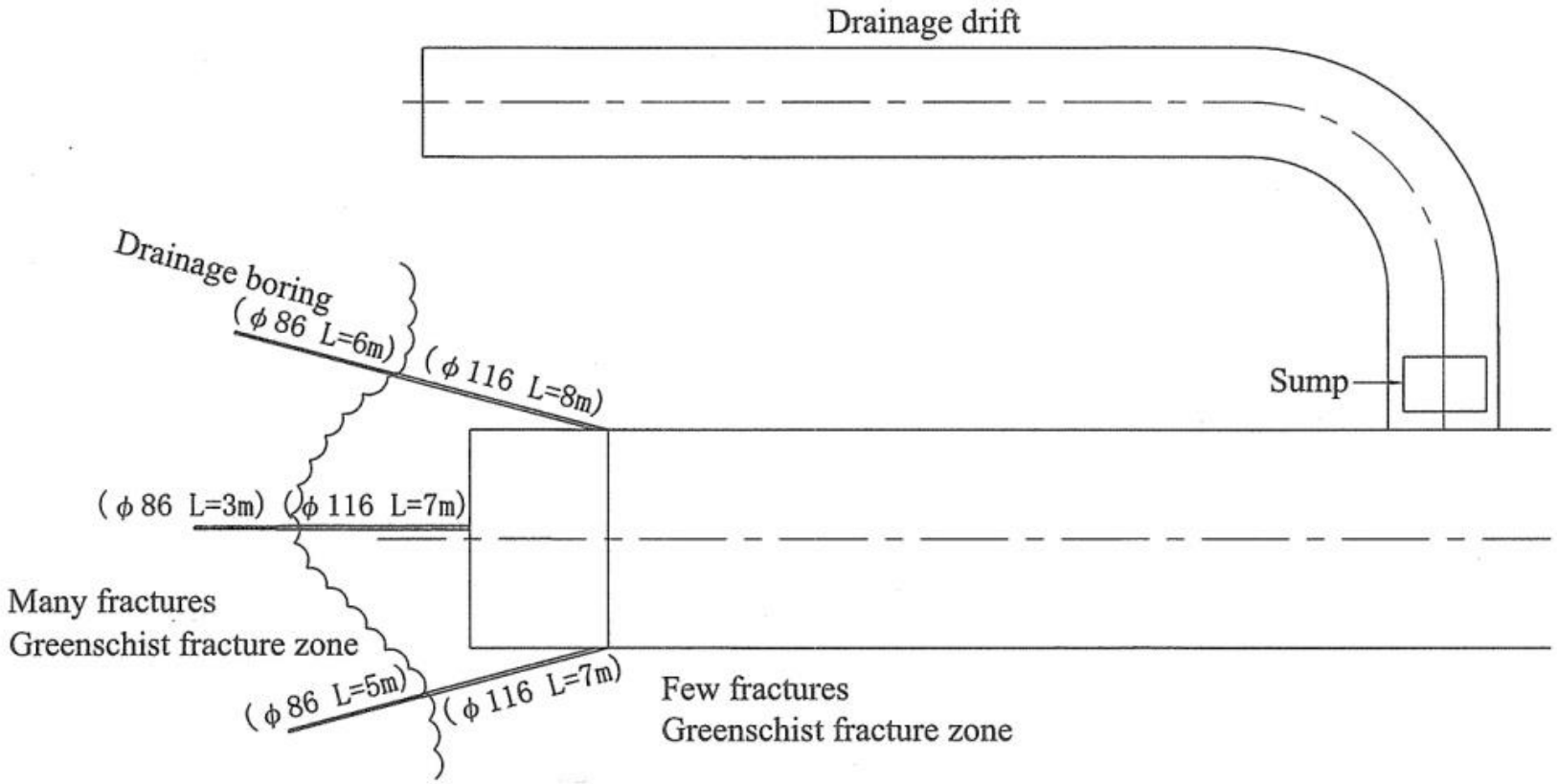
3.2 Necessity of Auxiliary Method (continued)

Protection of neighboring structures

➢Protection of neighboring structures: When tunnels are excavated in urban areas, sometimes there exists some surface structures, such as buildings and bridges, near to the excavation point. In such cases, appropriate auxiliary measures are taken to protect those structures.

3.3 Auxiliary Method for water leaking

a) Drainage boring and drift, Drainage method



Combined use of Drainage Drift and Drainage Boring

3.3 Auxiliary Method for water leaking (continued)

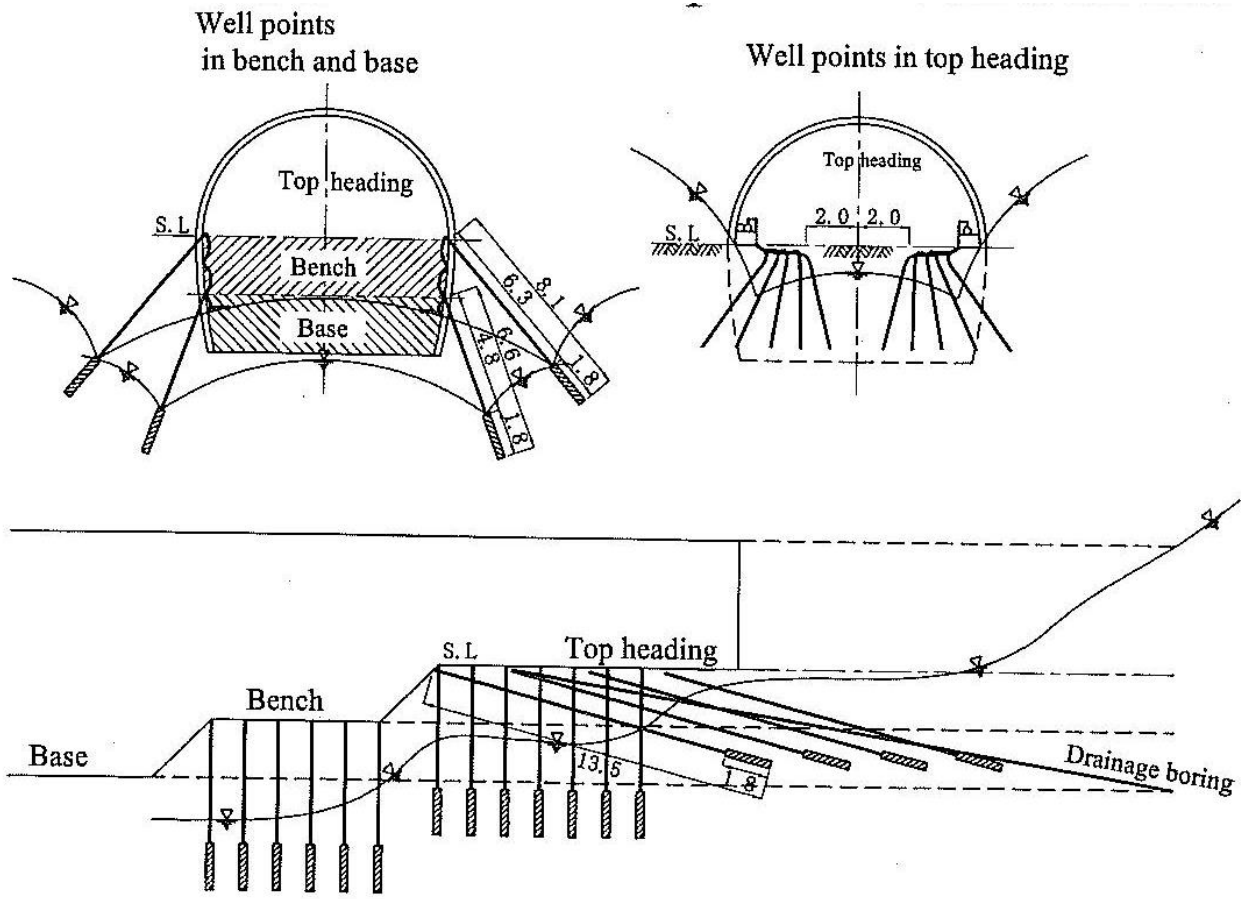
a) Drainage boring and drift, Drainage method

Drainage boring of
Kanayama Gero Tunnel

Drainage Drift of
Kanmuriyama Tunnel

3.3 Auxiliary Method for water leaking (continued)

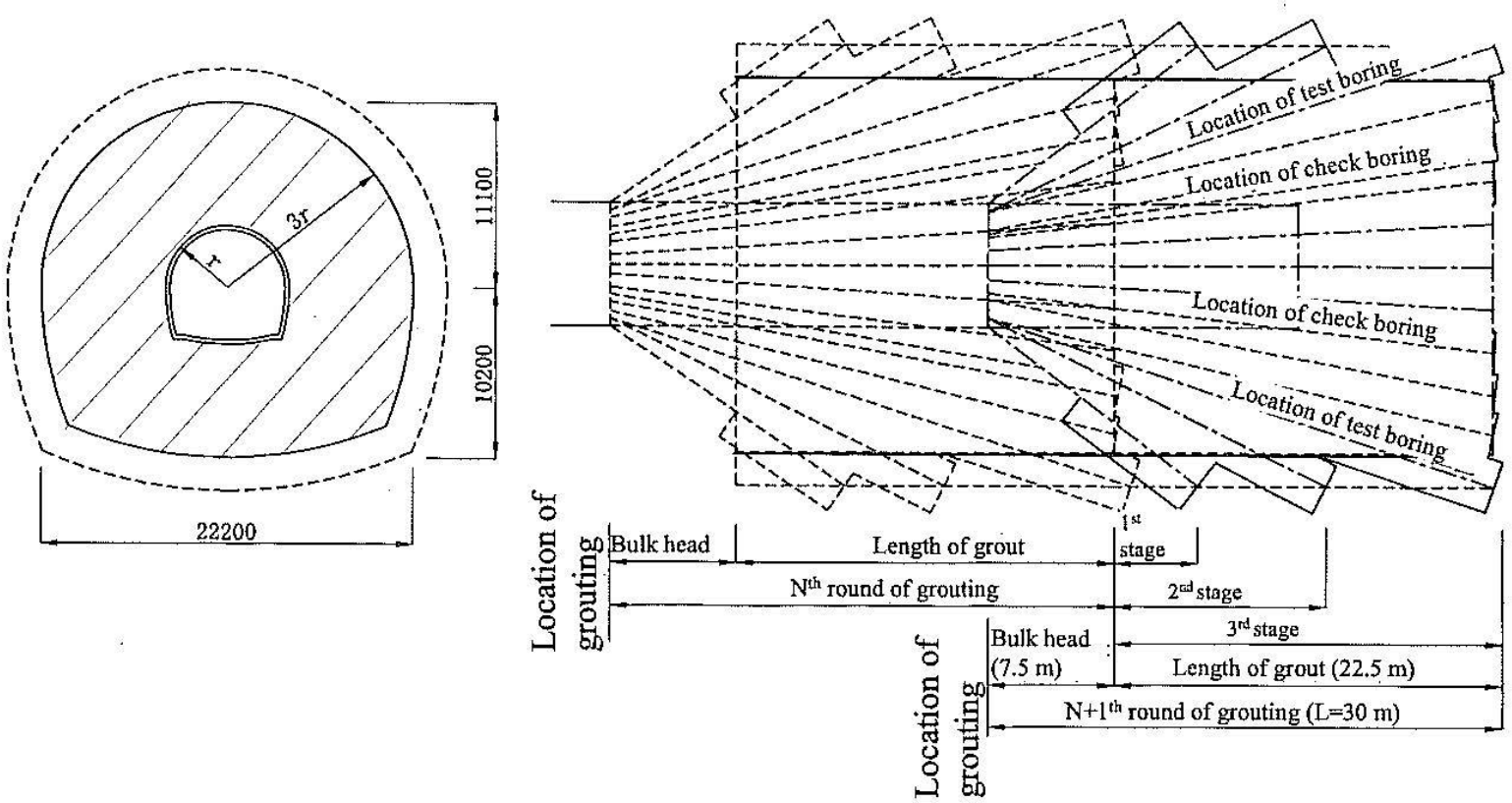
b) Well point drainage, Drainage method



Example of the well point from inside the Mugiuda tunnel

3.3 Auxiliary Method for water leaking (continued)

c) Water sealing methods, Water sealing method

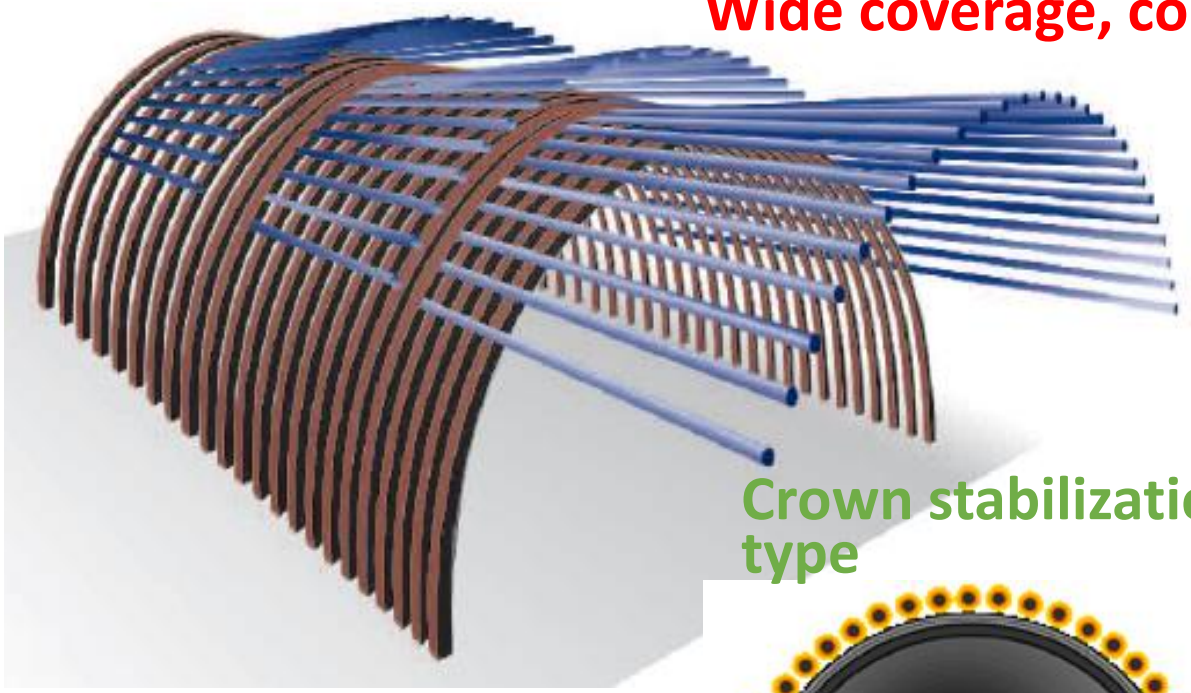


Example of the grouting from inside the Mugiuda tunnel

3.4 Auxiliary Method for subsidence

a) AGF (All Ground Fasten), Against subsidence

Wide coverage, cohesive soil - Hard rock



Long steel pipe L=12.5m

Crown stabilization type

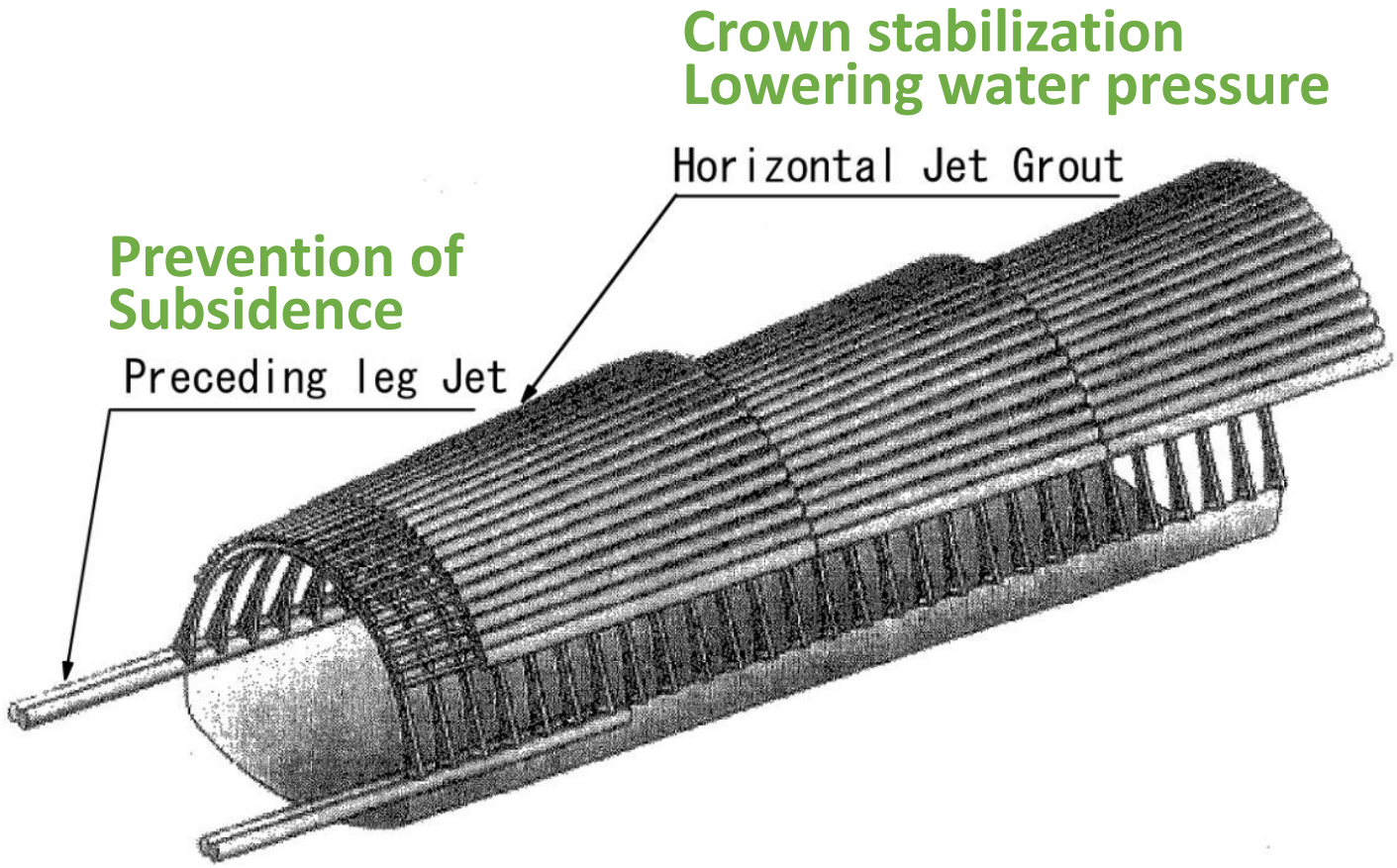
Prevention of deformation by fore-roof

Lowering water pressure type

Prevention of ground breakup with water flow

3.4 Auxiliary Method for subsidence (continued)

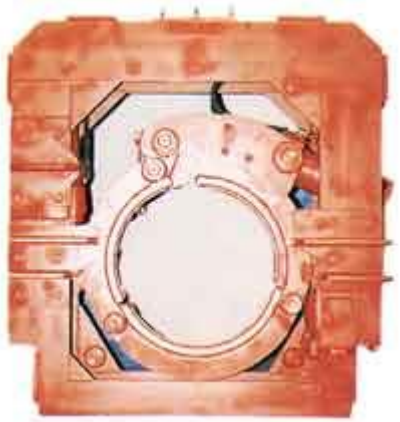
b) Horizontal jet grouting method, Against subsidence



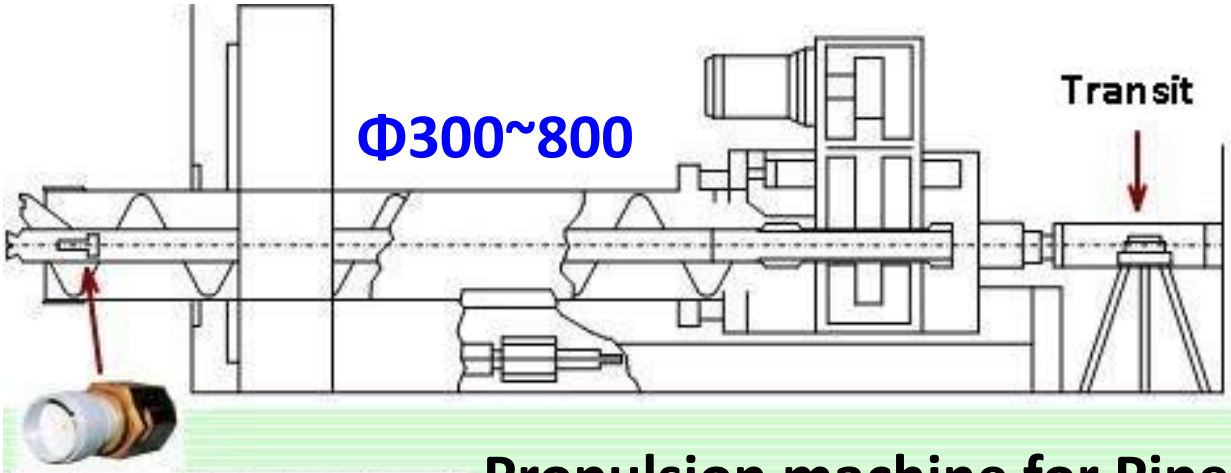
3.4 Auxiliary Method for subsidence (continued)

c) Pipe roof protection, Against subsidence

Target by LED type



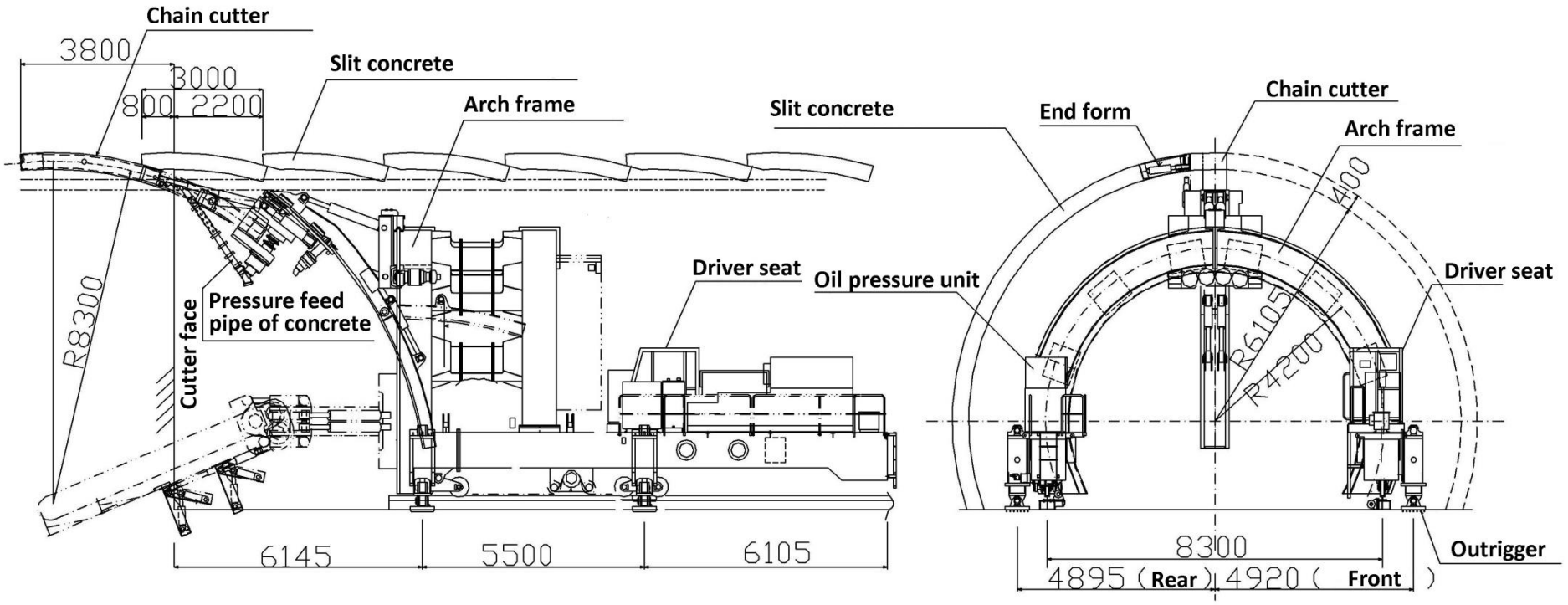
Directional correction equipment



Propulsion machine for Pipe roof

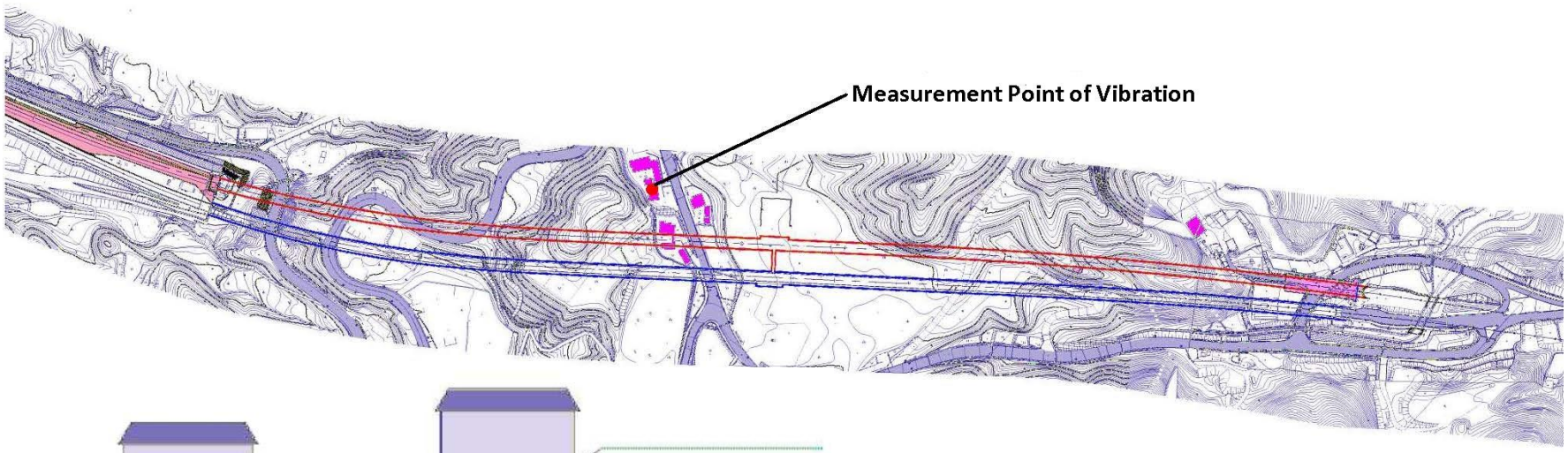
3.4 Auxiliary Method for subsidence (continued)

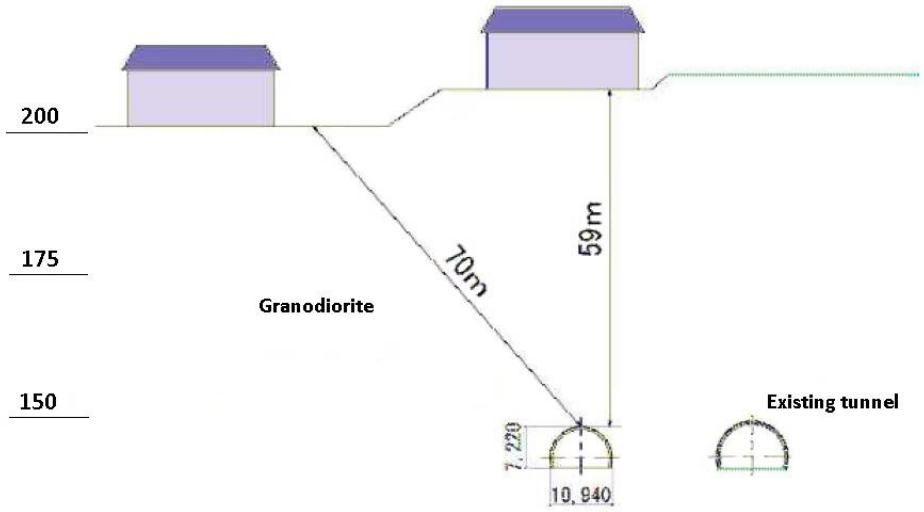
d) Slit concrete method, Against subsidence



3.5 Auxiliary Method for vibration

a) Measurement of Vibration



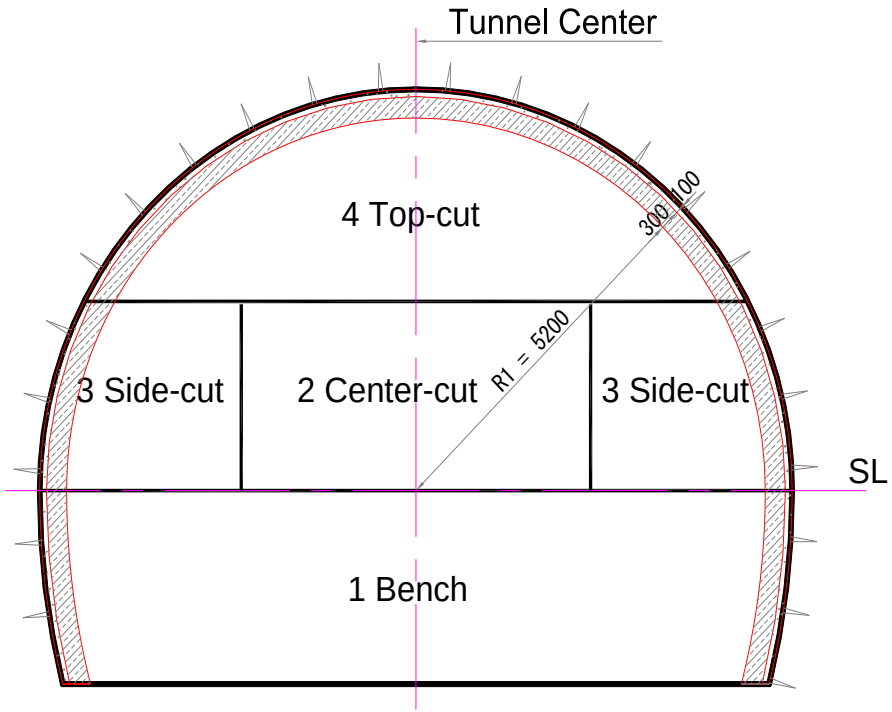


Measure the vibration at the point of houses above the tunnel.

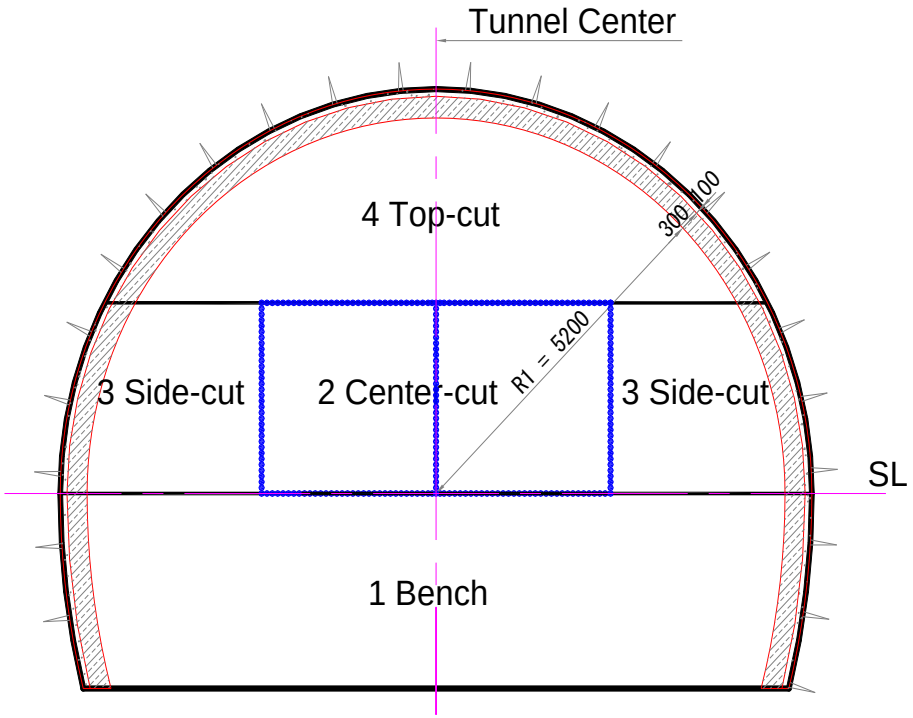
Monitor the vibration value for control value.

3.5 Auxiliary Method for vibration (continued)

b) Partial Blasting



Partial Blasting Section, 4 split



Additional Slit by Rock Drill

Sequence: 1 Bench →2 Center-cut →3 Side-cut 4 Top-cut

DAGHANG SALAMAT!