Republic of Indonesia
Coordination Ministry for Economic Affairs
Ministry of National Development Plan/ National Development Planning Agency
Ministry of Transportation

Feasibility Study for Jakarta-Bandung High-Speed Railway Project (As a part of Jakarta – Surabaya) Phase I

Final Report (Appendix)

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Japan International Cooperation Agency
(JICA)
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Appendix 1

Towards to be updated in “Blue Book”

Appendix-1 Towards to be updated in "Blue Book"

<Implementation Plan>

1. Project Title	: Jakarta - Bandung High-Speed Railway Project (HSR Project) (As a part of Jakarta-Surabaya High Speed Railway)
2. Duration	: 36 months
3. Location	: Jakarta Metropolitan Area and West Java Province
4. Executing Agency	: Ministry of Transportation
5. Implementing Agency	: Directorate General of Railways, Ministry of Transportation

6. Background and Justification

Railways are currently only operated on the islands of Java and Sumatra in the Republic of Indonesia (hereinafter called Indonesia). The total length of railways operated on Java is 3,425 km, and the number of passengers transported by long-distance trains per year steadily grew from 2006 to 2010 at an average annual rate of 9%, but the percentage of passengers transported by railways is still low at approximately 6%. On the other hand, approximately 85% of all passengers are transported on the highways and roads, resulting in traffic jams of increasing severity on the roads in cities and highways between cities. Accordingly, the government of Indonesia is proceeding with plans for electrification and expansion of tracks to double or quadruple tracks in order to boost the transport capacity of the railway network in Java. In order to enable railways to serve a suitable role in the transport of passengers in competition with air and road transport routes, in addition to improvement of the existing railway lines, further strengthening of the transportation network based on the development of a high speed railway to link cities has been positioned as an issue for urgent review.

The Java High Speed Railway Development has been positioned as outlined below in the main upper-level plans concerning railways.

- Masterplan Percepatan dan Perluasan Pembangunan Ekonomi Indonesia (MP3EI) (Master Plan of Acceleration and Expansion of Indonesia Economic Development)

  The country is divided into six economic corridors. The development of infrastructure to strengthen coordination within each corridor and between corridors is prioritized in MP3EI. This plan positions the Java economic corridor as the area with the foremost importance, under which the development of a high speed railway route in the economic corridors between Jakarta - Bandung and Jakarta - Surabaya should be conducted as an integral part of the railway plan for this corridor.

- National Railway Master Plan (NRMP)

  This plan advocates coordination to realize multi-modal policies for railways with national land utilization plans/other transportation plans. This plan mentions the introduction of a high speed railway connecting Jakarta and Surabaya.

Development of a high speed railway between Jakarta - Surabaya (approximately 733 km) was considered based on the above plans, but from the standpoint of the scale of investment and economic viability, the decision was made to first implement a high speed railway development project on the Jakarta - Bandung - Gedebage route (approximately 140 km), which is expected to have many passengers, as the first development section.

7. Scope of Work

The Jakarta - Bandung High-Speed Railway (hereinafter called HSR) project will be implemented with the following two (2) phases:

Phase 1: Engineering services for review of the feasibility study, basic and detail design (total length 140km, including a depot and five (5) station facilities), preparation of tender documents and assistance of tendering process for the portion of civil, station and depot works

Phase 2: Engineering services for assistance of tendering process for the remaining portions, supervision of construction works and procurement, and assistance for pre-operation

The Phase 1 Engineering Services will be carried out at this time. The works to be conducted are as follows:

Jakarta – Bekasi – Cikarang – Bandung – Gedebage:		Total Length Approx. 140km	
Viaduct & Bridge section	= 39km	NATM (Tunnel) section	= 28km
Embankment & Cutting section	= 58km	TBM (Shield Tunnel) section	= 15km

1) Reviewing the feasibility study
2) Conducting basic design for HSR System including auto train protection system, telecommunication, disaster prevention, operation control center, automatic fare system, platform door, power transmission, substation, power distribution, OHC, rolling stock and so on
3) Conducting detail design for soil investigation, topographic survey, civil engineering, track works, depot, station building and so on
4) Preparing an implementation plan for construction, procurement, operation and maintenance
5) Reviewing the cost estimate
6) Supporting the EIA (AMDAL) and LARAP process including preparation of the environmental management and monitoring plans (RKL & RPL)
7) Reviewing the project scheme and financing plan
8) Preparing the prequalification and tender documents for all portions
9) Supporting the prequalification and tendering process for the civil works and PPP portion

8. Priority

Infrastructure

9. Output and Outcome

a. Output

Development of HSR System

b. Outcome

1) Contributing to upgrading public transport system

2) Contributing to regional economic development

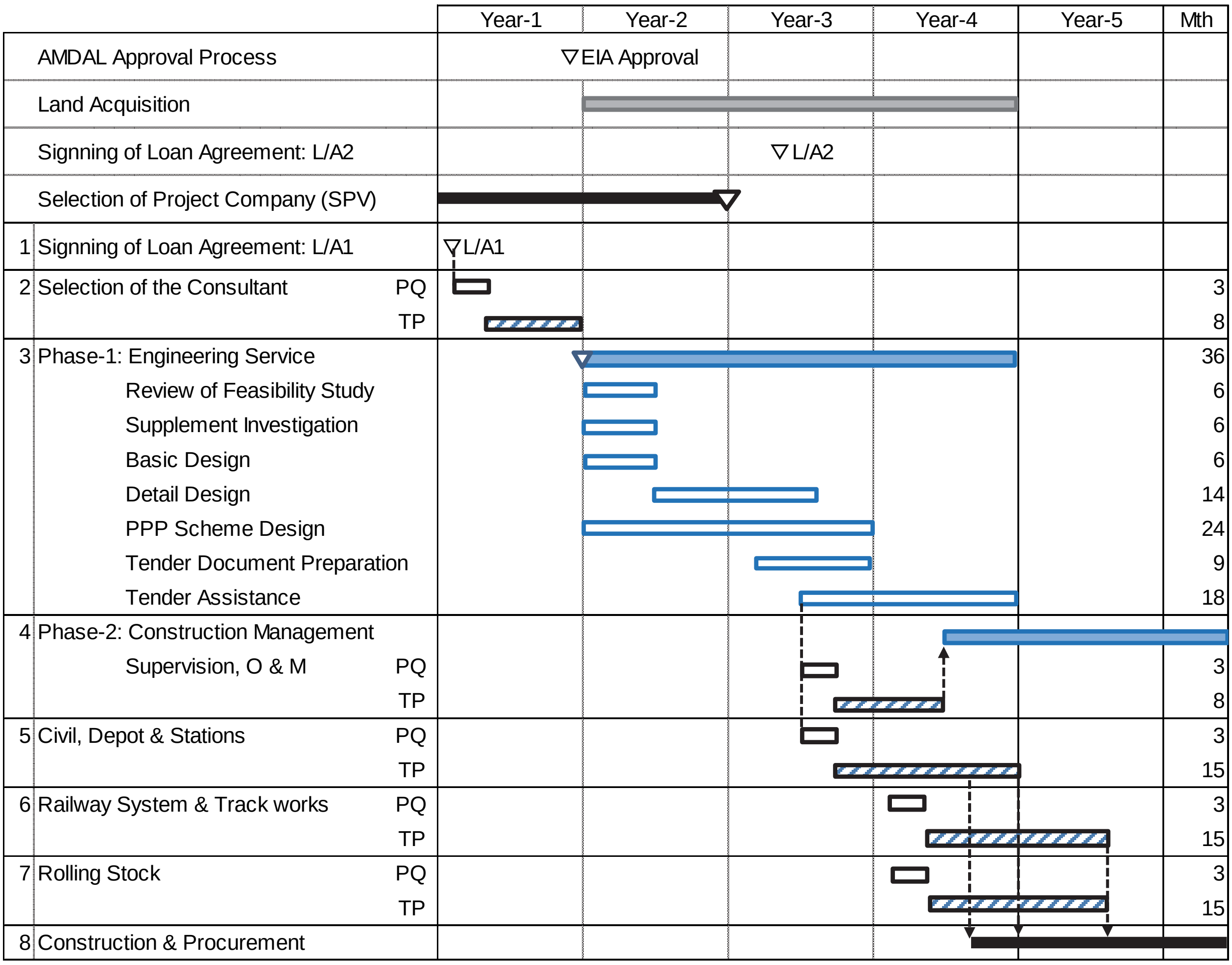
3) Contributing to the environmental protection and energy efficiency (CO_2 Reduction, Saving of Energy and so on)

4) Inducing multiplier effect on the Indonesian economy such as development of business around stations, increase in job opportunities, enhancement of railway-related industries and so on

10. Project Cost

Foreign Funding			• Counterpart Funding		
- Loan	:US$	$70,000,000	- Central Government	:US$	0
- Grant	:US$	0	- Regional Government	:US$	0
Sub Total	:US$	$70,000,000	- State Owned Enterprise	:US$	0
			- Others	:US$	0
			Sub Total	:US$	0
TOTAL	**:US$**	**$70,000,000**			

<Implementation Schedule>



[Note 1] PQ=Pre-qualification, TP=Tender Process

[Note 2] O & M=Operation & Maintenance

Appendix 2

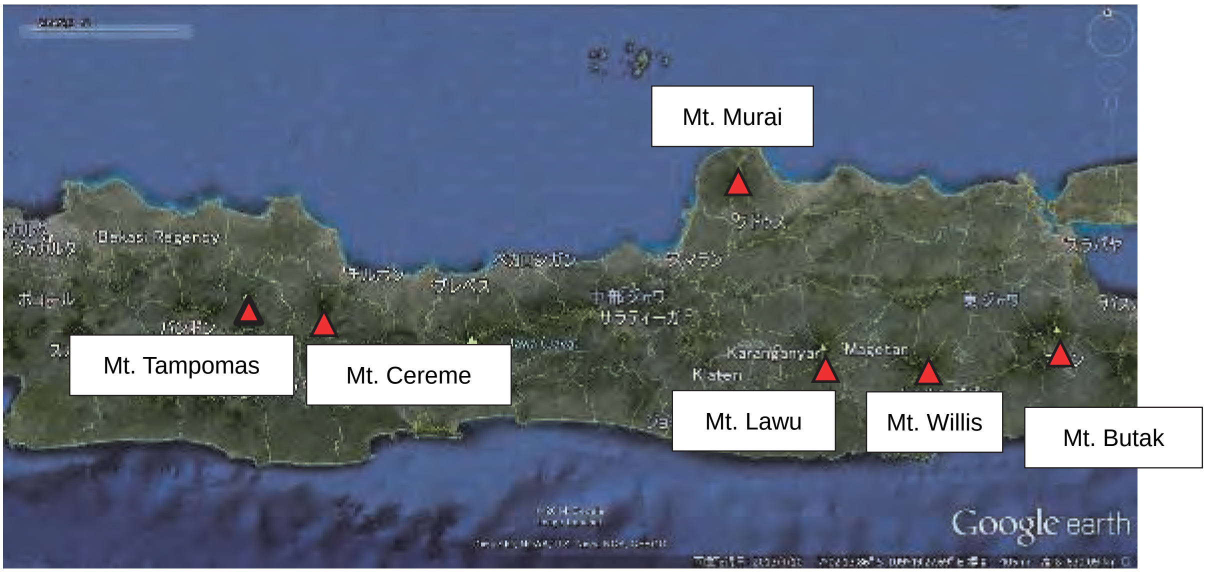
(1) Natural Condition of Study Area

1. Outline of Natural Condition in the Study Area

1.1 Outline of Topography

(a) Jakarta - Surabaya

Figure 1.1-1 shows the topographical outline of West Java, Central Java and East Java between Jakarta and Surabaya.



Source: Google Earth

Figure 1.1-1 Outline of Topography (Jakarta - Surabaya)

An outline of the topographical conditions by section is described below.

<u>Jakarta - Cirebon</u>

An alluvial plain with a ground elevation of 20 masl is widely distributed in the inland area from 15 km to 20 km from the coastline. The ground elevation increases to the south and it forms a hilly and mountainous landform. There are volcanoes such as Mt. Tampomas (elevation 1,684 masl) and Mt. Cereme (elevation around 3,000 masl)

<u>Cirebon - Semarang</u>

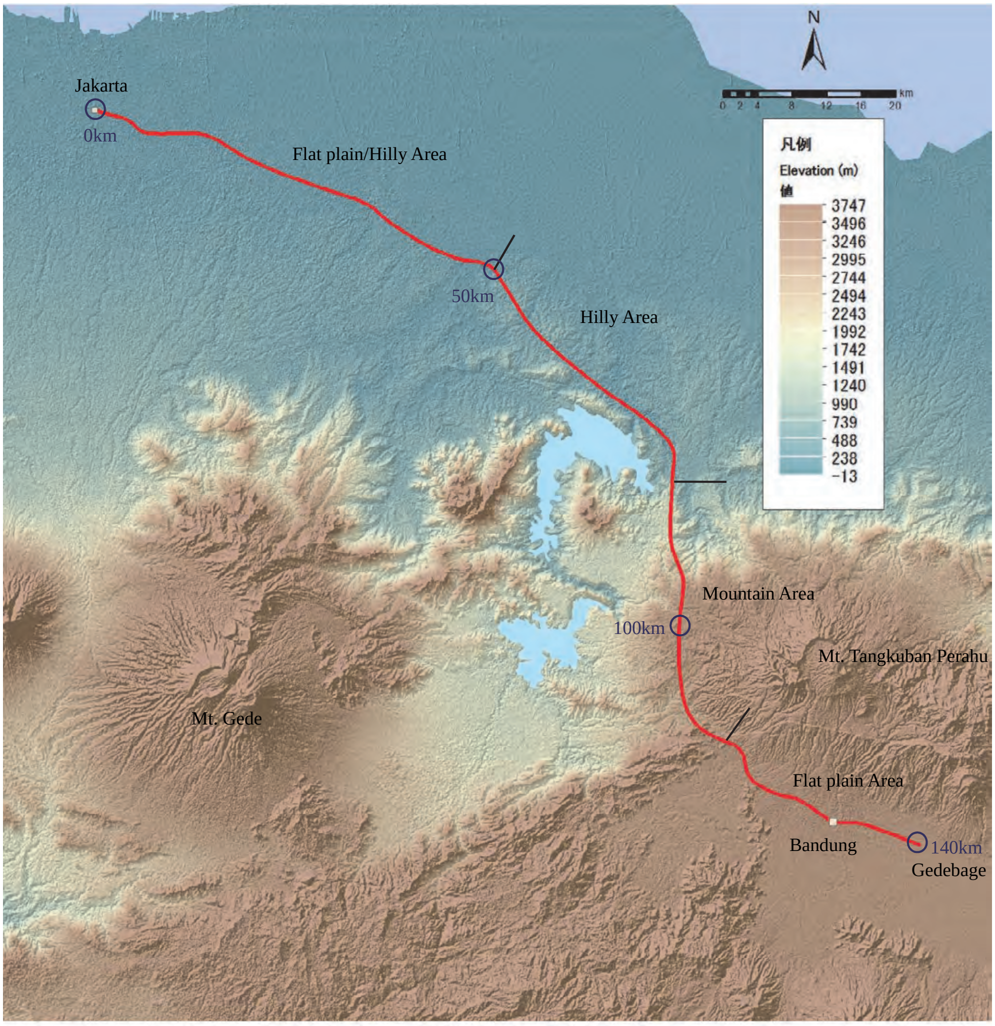
An alluvial plain with a ground elevation of 20 masl is widely distributed in the inland area from 10 km to 15 km from the coastline. The ground elevation increases to the south and it forms a hilly and mountainous landform. Around 30 km to 35 km from the coastline, the mountain ridge of Java is located. The ground elevation of this mountain ridge ranges from 700 to 1,300 masl. However, in a section from 70 km west of Semarang to Semarang, there is a section where the hilly area is close to the coastline and the elevation of the hilly area is around 100 masl. Generally, since the distribution area of the alluvial plain is limited in this area, the hilly area and mountain area are near the coastline.

<u>Semarang - Surabaya</u>

In this section, distribution of the alluvial plain is limited. Hilly lands and mountain areas lie in the west-east and northeast-southwest direction with elevations ranging from 150 to 200 m. And alluvial plains are distributed in the hilly lands and mountain areas. In addition, in the southern part of these hilly lands and mountain areas, several volcanoes, for example Mt. Butak (elevation 2,896 masl), Mt. Kelud (elevation 1,731 masl), Mt. Willis (elevation 2,563 masl) and Mt Lawu (elevation 3,265 masl), are distributed in an east-west direction. These volcanoes were formed in the Quaternary period, and some of them are still active. The Brantas River and Porong River run among the volcanoes. The city area of Surabaya is located on an alluvial plain which has formed at the mouth of the Brantas River and Porong River.

(b) Jakarta - Bandung

Figure1.1-2 shows a topographical outline of the study area. The area with an elevation of less than 100 m (flat plain and hilly area) is shown in green. The area with an elevation ranging from 200 m to 300 m is shown in orange. The area with an elevation higher than 300 m is shown in brown. Bandung area is composed of an area with an elevation ranging from 600 m to 700 m. Mt. Tangkuban Perahu (elevation 2,084 m) is located in the eastern part of the planned route. Volcanic sediments produced by the activity of Mt. Tangkuban Perahu cover the top of ridges in the mountain area. Mt. Gede (elevation 2,958 m) is located in the western part of the planned route. The flat plain area, in which Bandung is located, is mainly composed of lake deposits.



Source: JICA Study Team

Figure1.1-2 Topographical Outline of the Study Area

The topographical characteristics of each area are summarized as follows.

<u>Flat Plain and Hilly Area (Jakarta Area)</u>

- A flat plain area is located between Jakarta and Bekasi east of Jakarta. An area is being developed as a housing site and a commercial area is expanding in this area.
- Small or medium-sized rivers run through the flat plain area to the north.
- A part of the area east of Bekasi has been developed as an industrial area. The geology of this area mainly consists of volcanic sediments and forms hilly land. Like the flat plain area mentioned above, small or medium-sized rivers run through the hilly area to the north. Some portions of the flat area along these rivers are used as paddy fields and some portions of the hilly area are used as farmland within the above-mentioned developed area.
- Some areas along the small or medium-sized rivers have artificial or natural ponds.

<u>Hilly Area</u>

- This hilly area is the only area where large-scale river terraces are formed.
- A large-scale river terrace is found along the Citarum River, which runs from Jatiluhur Dam, and along the Cikao River which runs from the base of Mt. Tangkuban Perahu and joins the Citarum River.

- Three river terraces which have a difference in elevation are found on the left bank of the Cikao River along part of the planned route, where many paddy fields are distributed on the lowest and second lowest terraces and settlements are located on the highest terrace.

Mountain Area

- Mountain area is distributed around and at the base of Mt. Tangkuban Perahu. The elevation of the ground surface decreases to the west.
- The topography of the valley area where small or medium-sized rivers run has steep and deep slopes, but the width of the valley is relatively narrow.
- The bottom of the valley and the top of the ridges are used for paddy fields or tea fields.
- Many tunnels are designed in this mountain area along the planned route.

Flat Plain (Bandung Area)

- A flat plain extends south of Mt. Tangkuban Perahu.
- The topography of the central Bandung area forms an alluvial fan with gentle slopes and flat plain. The geology of the alluvial fan consists of volcanic sediments which are composed of pumiceous materials. This area has been developed as a housing site and a commercial area is expanding in this area.
- Small or medium-size rivers run through this area.
- There is a wide flat plain used as paddy fields near the Gedebage area along the planned route.

1.2 Outline of Geology

(a) Jakarta - Surabaya

Figure 1.2-1 shows the geological distribution between Jakarta and Cirebon and between Jakarta and Surabaya. An outline of the geological conditions of each section is described below.

Jakarta - Cirebon

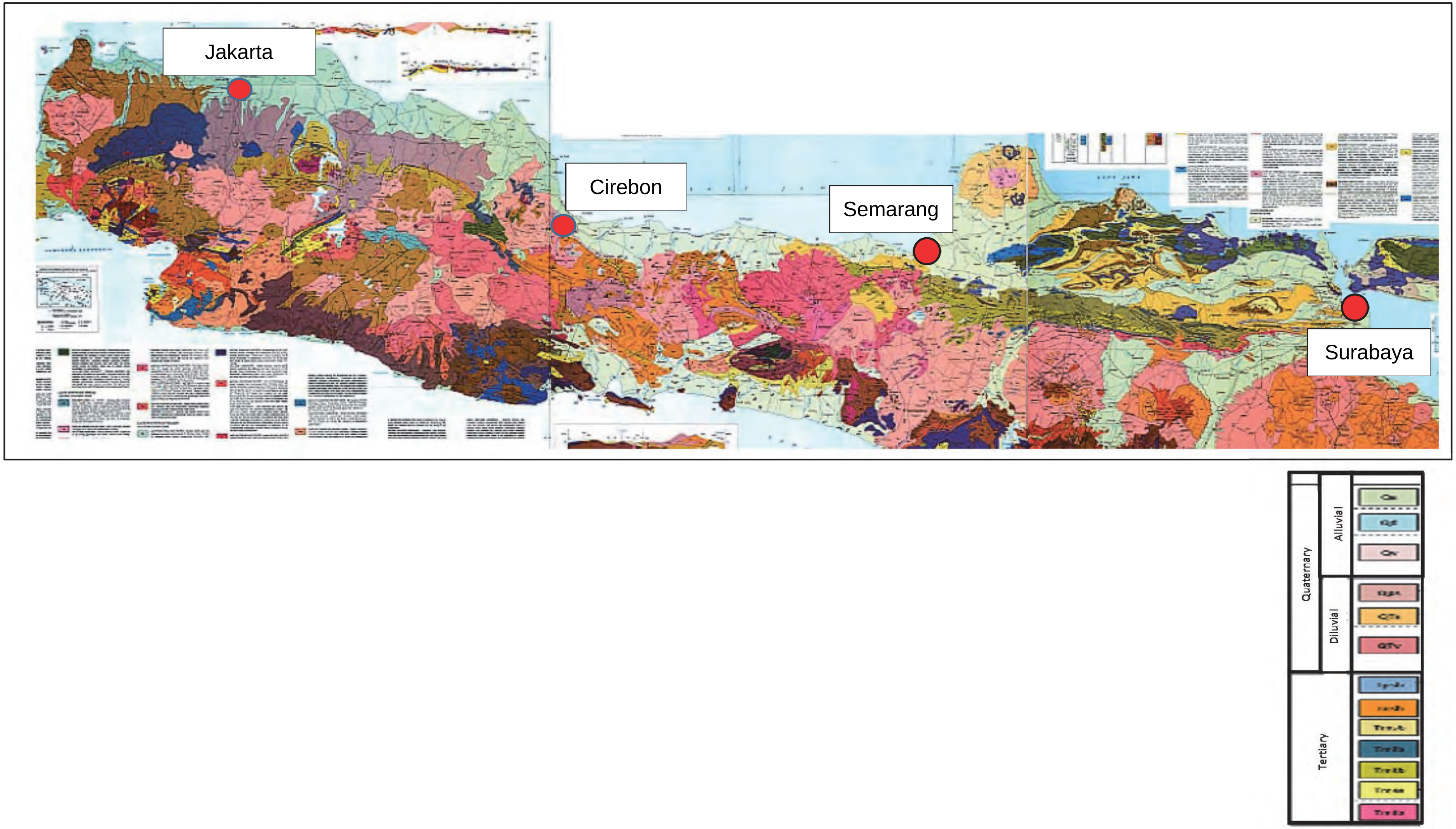
The geology of the alluvial plain that is distributed in the seaside area is composed of alluvium. The geology of the hilly land and mountain area that lie south of the alluvial plain is widely composed of volcanic sediments in the Quaternary period and formations that formed in the Miocene to Pliocene periods in the Neogene are partially distributed. Mt. Tampomas (elevation 1,684 masl) and Mt. Cereme (elevation around 3,000 masl) are volcanoes that were active in the Quaternary period or are still active.

Cirebon - Semarang

The alluvial plain is composed of alluvium. The geology of the hilly land and mountain area was formed in the Quaternary period and in the Neogene. The distribution area of Neogene Formation is relatively large. In the section from 70 km west of Semarang to Semarang, Neogene Formation and volcanic sediments formed in the Quaternary period are distributed in and close to the seaside area.

Semarang - Surabaya

In this section, since the distribution of alluvial plain is limited, the distribution of alluvium is also limited. The geology of the hilly land and mountain area which lie in the west-east and northeast-southwest direction is mainly composed of Neogene Formation. Limestone is also distributed. In addition, south of the hilly land and mountain area formed in the Quaternary period are several volcanoes, for example Mt. Butak (elevation 2,896 masl) , Mt. Kelud (elevation 1,731 masl), Mt. Willis (elevation 2,563 masl) and Mt Lawu (elevation 3,265 masl) , and some of the volcanoes are active. Along the Brantas River and Porong River, there are alluvial plains which are composed of alluvium.



Source: prepared by the JICA Study Team, based on the geological map of the Ministry of Energy and Mineral Resources.

Figure 1.2-1 Geological Map along the Planned Route

(b) Jakarta – Bandung

Geological condition between Jakarta and Bandung, which is based on the result of geological survey and field reconnaissance carried out in this study, is described in section 7.3.3.

In this section, active fault, volcano and land subsidence along the planned HSR route and Jakarta area are described.

Active Faults

Although there are a few active faults or suspicious active faults along the planned HSR route, there is no active fault of suspicious active fault that cross the Planned HSR route. Therefore, it is no need to worry about direct displacement of structure of HSR caused by an activity of active fault. However, seismic motion caused by the activity of active fault should be examined for the design of structure.

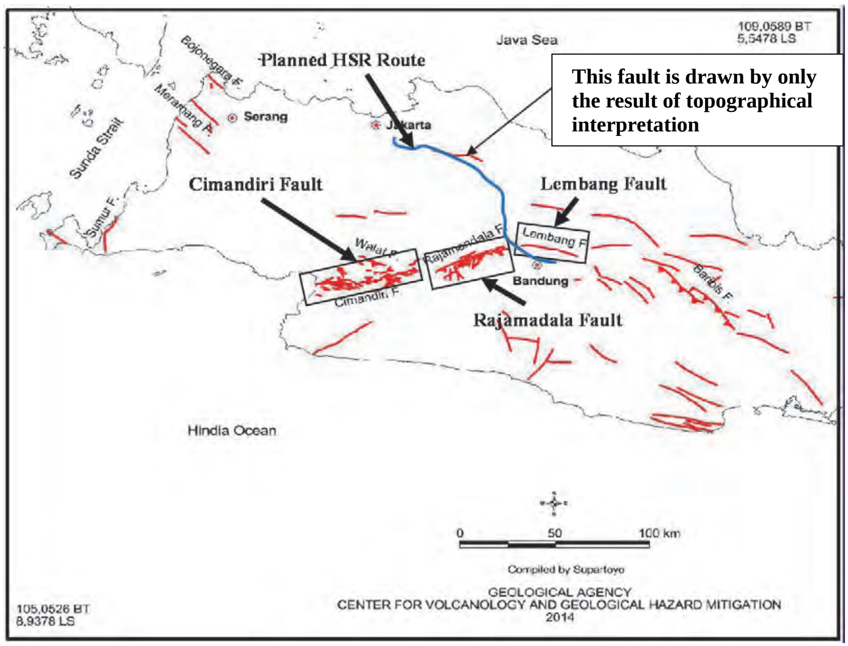


Figure 1.2-2 Distribution of Active Fault/ Suspicious Active Fault along the Planned HSR Route

Volcano

Mt. Tangkuban Perahu(elevation 2,084m) is located in the north of center of Bandung flat plain area. The minimum distance between Mt. Tangkuban Perahu and the planned HSR route is about 15km.

Existing crater that has a small scale volcanic activity is located at east side slope of Mt. Tangkuban Perahu.

If a pyroclastic flow erupts near the crater, the possibility that the planned HSR route has bad influence by the impact of eruption is thought to be very low. Because the planned HSR route is located in the western and southern part of Mt. Tangkuban Perahu. However it is necessary to consider the influence of volcanic ash because of wind direction.

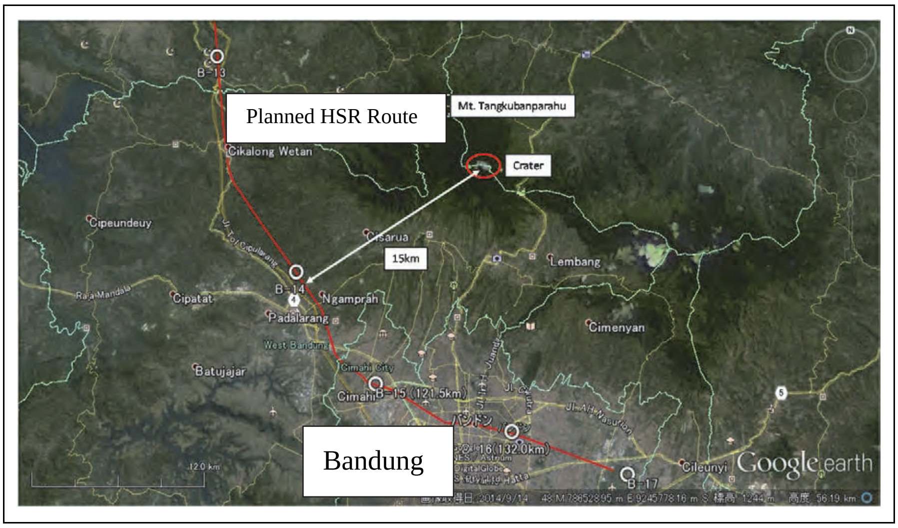
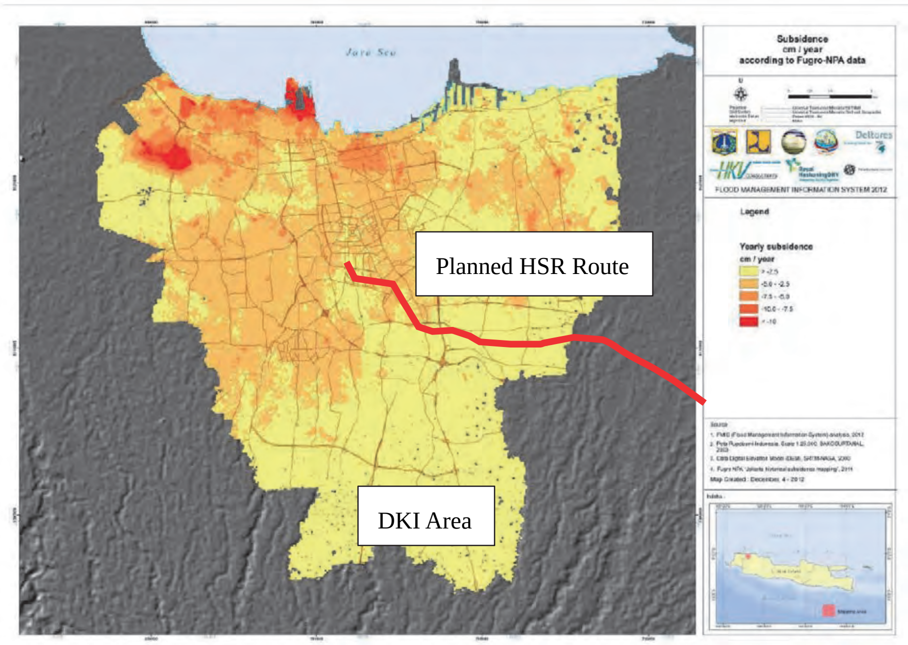


Figure 1.2-3 Relationship between the Planned HSR Route and Mt. Tangkuban Perahu

<u>Land Subsidence</u>

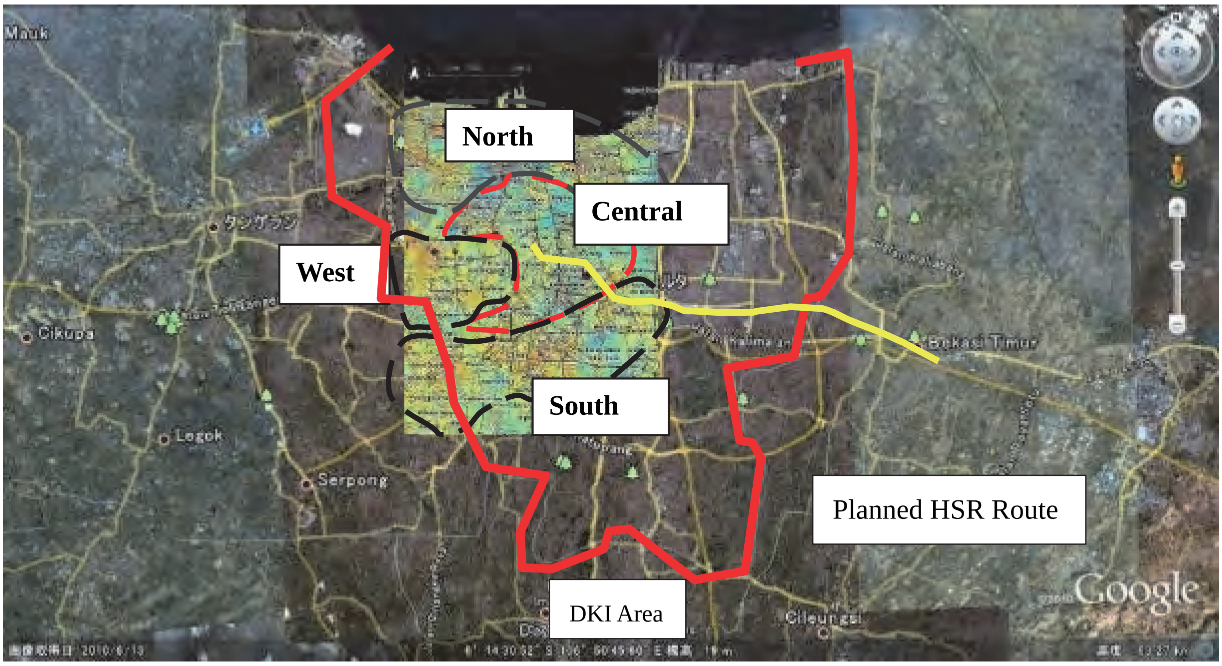
Figure 1.2-4 and 1.2-5 show the rate of land subsidence in Jakarta DKI area by existing study and research result.

Due to urbanization, land subsidence has been a serious issue over a period of many years in Jakarta urban area. According to these result, comprehensively, the planned HSR route passes through an area which has low land subsidence rate. However, it is necessary to consider appropriate measures for the land subsidence on the design of structure such as shield tunnel and viaduct since it passes the land subsidence area.



Source; FMIS Main Report

Figure 1.2-4 Condition of Land Subsidence in the Jakarta DKI Area (1)



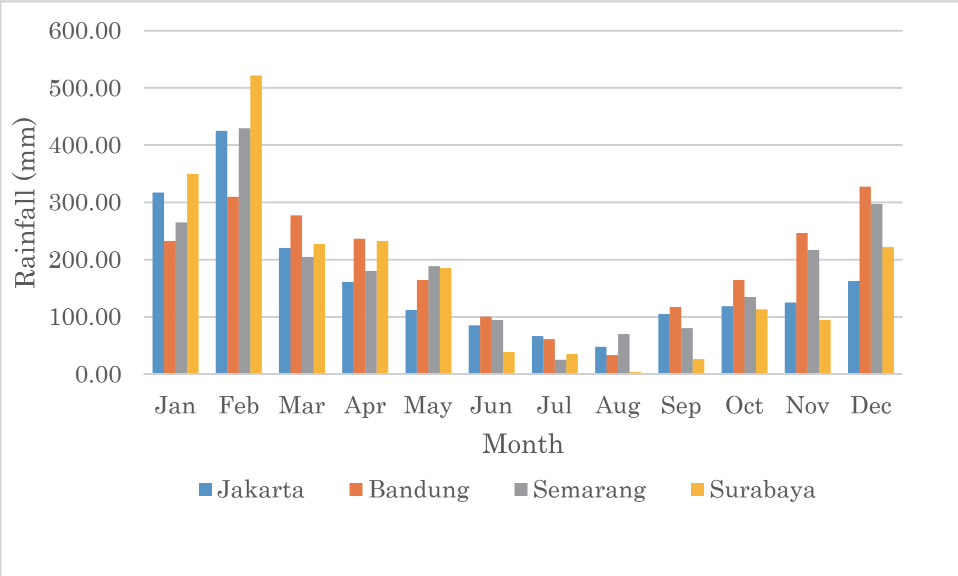
Area	2007～2008	2008～2009	2009～2010	2010～2011	2007～2011	2008～2011
North	6～24	6～12	4～6	～6	～36	～24
West	～8	4～6	～4	～4	～9	～9
South	～6	～8	～4	～4	～12	～12
Central	Limited part	Very small	Very small	Very small	Limited part Several cm	Limited part Several cm

Source: JICA Report

Figure 1.2-5 Condition of Land Subsidence in the Jakarta DKI Area (2)

1.3 Climate

West Java belongs to the tropical rainforest climate zone, while Central Java and East Java belong to the monsoon climate zone. The climate of the Sunda area in the western part of Java Island is different from other parts of the island and it belongs to the same climate zone as Sumatra. The seasons are clearly separated into two, the rainy season and the dry season. The rainy season due to the monsoon from the east lasts roughly from May to October, while the dry season is between November and April because of monsoon rain in the west. The amount of rainfall in Bandung is relatively high, and the monthly variation in Surabaya is high when comparing the four cities of Jakarta, Bandung, Semarang, and Surabaya.



Source: Meteorology, Climate and Geophysics Agency

Figure 1.2-6 Changes in Monthly Rainfall (Average from 2006 to 2010)

2. Topographical Survey

2.1 Topographical Survey by Outsourcing

This topographical survey was carried out for the purpose to grasp the topographical condition along the HSR Route (Bandung-Gedebage) for the route planning. Digital topographical data (scale 1:1,000 level) which displays shape of main ground structure. Specification of the digital topographical map is shown in Table 2.1-1.

Table 2.1-1 Specification of the Digital Topographical Map

Specifications	Note
A detailed topographical map along the planned HSR route based on the ortho-mosaic which obtained by high-resolution satellite image, Topographical map: scale 1:10,000 Total length 160km, width of map 1km	Detailed drawing of both side of 125m width from centerline of planned HSR route

2.2 Topographical Investigation for Grasping Ground Condition and Route Selection

This topographical investigation was carried out to grasp the ground condition from the view of topography in order to select planned route. This investigation was carried out by a Japanese expert.

Main items of this investigation is as follows;

- ✓ To check the existence of unstable slope at a tunnel entrance along the planned HSR route (
- ✓ To check the topographical condition along and around planned tunnel route
- ✓ To clarify the point to be checked by a field investigation

Result of this topographical investigation and response to the result is described in section 7.5.2.2 3).

3. Geological Survey

3.1 Purpose of Geological Survey

For this geological survey total 17 drilling survey (Total length: 645m) were carried out to grasp the geological and geotechnical condition along the planned HSR route of which total length is 140km.

The purpose of this geological survey is described as follows.

- To clarify the geological and geotechnical outline of the Planned HSR Route
- To examine problem on construction of structure such as viaduct, tunnel, cut and embankment
- To suggest an appropriate measures for the problem mentioned above.

Therefore the purpose of this geological survey is not for a detailed design of structure.

For this geological survey total 17 drilling survey (Total length: 645m) were carried out to grasp the geological and geotechnical condition along the planned HSR route of which total length is 140km.

Parallel to drilling survey, field investigation around the boring site and important geological site was carried out.

3.2 Contents of Survey

Table 3.2-1 shows the contents carried out by this survey.

Table 3.2-1 Contents of this Survey

Contents	Specification	Numbers of Survey
Boring Survey	Rotary Drilling	17 boreholes Total length: 645m
In-Site Test 1) Standard Penetration Test (SPT) 2) Undisturbed Sampling	 1) ASTM D-1586 2) ASTM D-1587	 645 times 133 samples
Laboratory Test: Soil Property Test 1) Soil Classification 2) Moisture Contents 3) Liquid Limit, Plastic Limit, Plasticity Index of Soil 4) Specific Gravity 5) Particle Size Analysis 6) Hydrometer Analysis 7) Slake durability	 1) ASTM D-2487・2488 2) ASTM D-2216 3) ASTM D-4318 4) ASTM D-854 5) ASTM D-422 6) ASTM D-1140 7) ASTM D-4644	133 samples

Purpose of the test is summarized in Table 3.2-2.

Table 3.2-2 Purpose and Use of Result of each Test

Name of Test	Purpose	Use of Test Result
Standard Penetration Test	To measure the N value by using drilled borehole	To grasp the depth of Earthquake proof foundation To grasp the concreteness of ground/geological layer
Soil Property Test	To grasp the soil property by using samples sampled from borehole	To evaluate the liquefaction of ground To evaluate the fluidization of layer, etc.
Slake Durability Test	To grasp the slake durability by using samples core	To evaluate the slake-resistance of mud stone of Subang formation and Jatiluhur formation

3.3 Result of Geological Survey

3.3.1 Boring Survey

(1) Location and Specification of Boring Survey

Figure 3.3-1 shows the location of each boring survey and Table 3.3-1 shows the specification of each boring.

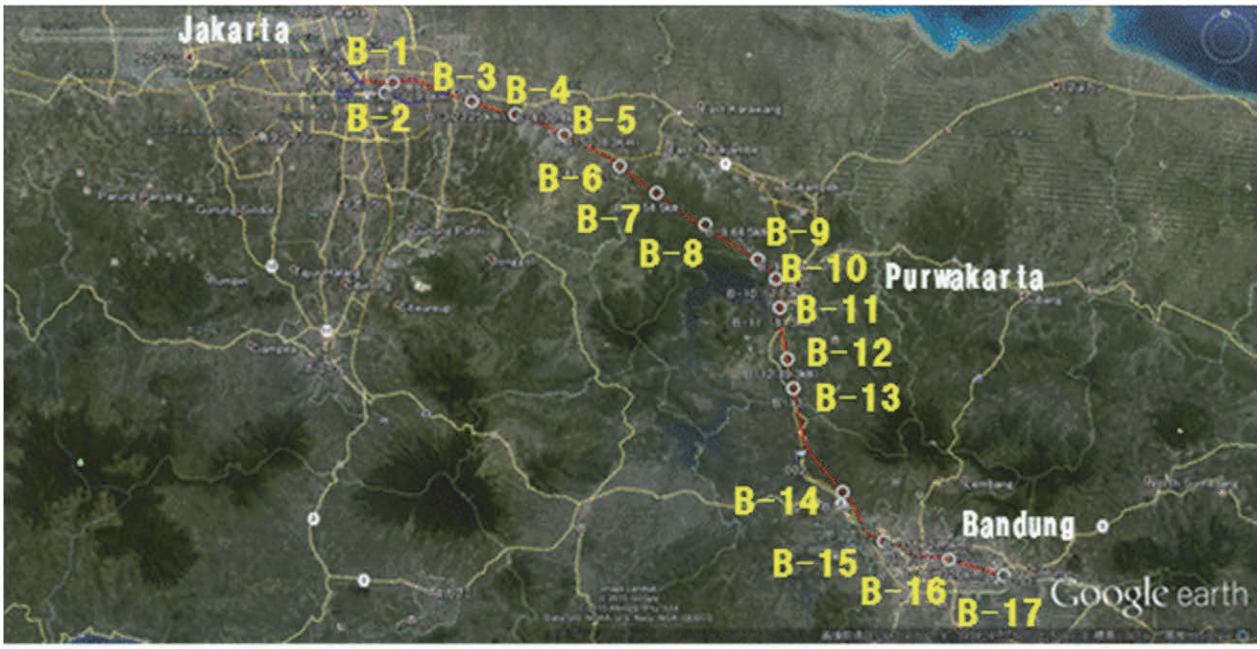


Figure 3.3-1 Location of each Boring Survey

Table 3.3-1 Specification of each Boring

No	Point No	Coordinate		Elevation	Date drilled/Tested		Boring depth (m)	Water Depth (m)	Remarks
		E	N	Z	Started	Completed			
1	B - 1	710072.00	9309435.00	+25.00	October 31, 2014	November 05, 2014	21.45	-1.90	
2	B - 2	711347.00	9310908.00	+26.00	November 12, 2014	November 14, 2014	20.25	-7.00	
3	B - 3	723199.00	9307254.00	+36.00	November 02, 2014	November 07, 2014	50.45	-7.00	
4	B - 4	729719.00	9304856.00	+36.00	October 30, 2014	November 06, 2014	60.45	-1.53	
5	B - 5	710072.00	9309435.00	+25.00	November 13, 2014	November 18, 2014	50.45	-1.20	
6	B - 6	745015.00	9296103.00	+38.00	November 11, 2014	November 13, 2014	30.45	-1.20	
7	B - 7	747029.00	9294481.00	+49.00	December 09, 2014	December 11, 2014	30.45	-5.20	
8	B - 8	761821.00	9282974.00	+40.00	December 05, 2014	December 06, 2014	40.00	-4.20	
9	B - 9	765073.00	9280796.00	+46.00	November 15, 2014	November 17, 2014	46.00	-2.35	
10	B - 10	76731.00	9277691.00	+100.00	November 16, 2014	November 19, 2014	30.25	-6.50	
11	B - 11	767899.00	9273355.00	+141.00	October 26, 2014	November 02, 2014	50.45	-6.05	
12	B - 12	768512.00	9265613.00	+362.00	October 27, 2014	October 30, 2014	30.28	-6.50	
13	B - 13	769063.00	9261204.00	+492.00	October 27, 2014	November 04, 2014	60.29	-10.40	
14	B - 14	775364.00	9245371.00	+723.00	November 10, 2014	November 13, 2014	40.05	-4.71	
15	B - 15	781894.00	9237433.00	+739.00	November 07, 2014	November 10, 2014	33.45	-2.23	
16	B - 16	790830.00	9234286.00	+692.00	November 01, 2014	November 04, 2014	30.45	-4.15	
17	B - 17	798842.00	9231364.00	+675.00	November 07, 2014	November 15, 2014	60.26	-0.70	

Note: Water depth to be measured from ground surface for on land boring

(2) Result of Survey

In this section, planned HSR route is divided into three sections such as 1) Jakarta flat plane- Cikarang hilly land, 2) Karawang- Padalarang hilly land- mountainous area and 3) Bandung flat plane and the result of boring survey is described for each section, respectively.

Details of geological condition of each boring and photo of boring core are shown in Appendix 2-2.

1) Jakarta-Cikarang Flat plain-hilly land area（Sta.0 to 25 ㎞ B-1to B-6）

In this section, Jakarta flat plane- Cikarang hilly land, boring survey was carried out for the following purpose;

- ✓ To grasp the depth of earthquake proof foundation of each boring point for the design of viaduct
- ✓ To grasp the engineering property of soil along the HSR section

Boring B-1 was carried out on the alignment of the Plan-B and boring B-2 to B-6 was carried out on the alignment of Plan –A.

Topographical feature of the section between Jakarta and Cikarang is flat plane and hilly land. Mainly diluvium and alluvium distribute along this section.

Geology of diluvium and alluvium is mainly composed of mud (volcanic ash), sand and gravel with volcanic ash. Alluvium distributes in the lowlands near the coast and bottom land along the river in this section.

Hardness of the sediment of alluvium is very soft. Although the hardness of the sediment of diluvium is soft at the part of ground surface, it has a tendency to become firm toward to a lower part. As a trend, sediments near the ground surface in the Bekasi area is softer than the sediments in the Jakarta area.

As a soil property, gravely layer can rarely be identified in the sediment of diluvium and alluvium in this section.

2) Karawang- Padaralang（Sta.50～115 ㎞, B-7 、B-8、B-9、B-10、B-11、B-12、B-13、B-14）

In this section, structure of HSR is mainly planned as tunnel and partially cutting and embankment.

For this condition, boring survey was carried out for the following purpose;

- ✓ To grasp the geological and geotechnical condition around the entrance of tunnel and section from ground surface to tunnel invert
- ✓ To grasp the outline of geological and geotechnical condition along the HSR route

Geological setting of this section, basement rock comprises geological formation that was formed in the Miocene period in the Neogene. Old volcanic sediments and detritus which were formed in the quaternary period distribute as a covering layer of basement rock. Old volcanic sediment covers basement rock unconformity.

Basement rock comprises sedimentary rocks of the Jatiluhur formation, Citarum formation and Subang formation.

Jatiluhur formation is consisted on mud stone and pyroclastic rocks and well consolidated.

Citarum formation is consisted on pyroclastic rocks such as lapilli tuff and tuff brecciated lava.

Subang formation is consisted on sedimentary rocks such as mud stone and sandstone.

Hardness of basement rock of Citarum and Subang formation is soft near the ground surface due to weathering, however, well consolidated in the deep part.

N value of old volcanic sediments is varied because of content, thickness of a layer and influence of weathering. Hardness of detritus is very soft.
Based on the change of groundwater level during boring work and the result of field survey, an isolated aquifer is formed in the layer of old volcanic sediment.

3) Bandung flat plain area(Sta.115～140 ㎞ B-15、B-16、B-17）

In the Bandung flat plane area, three boring survey were carried out for the following purpose;

- ✓ To grasp the depth of earthquake proof foundation of each boring point for the design of viaduct
- ✓ To grasp the engineering property of soil along the HSR section

Geology of the Bandung flat-plain area comprises alluvial fan deposit which was generated from the Mt. Tangkuban Perahu and lake deposits. Alluvial fan deposit comprises sand and gravel.
Alluvial fan deposits accumulates in the western part of the plain. This sediment comprises sand and gravel and has high permeability.
Lake deposits accumulates in the middle to eastern part of the plain. This sediment is mainly composed of soft clay and partially sandy soil. Component of the lake deposit is assumed to be depends on the sedimentation environment therefore it is assumed that the rate of sandy component is high in the periphery of plain compared to central of the plain.
Although the result of boring survey does not show a remarkable high groundwater level, it is assumed that generally groundwater level is high in the whole area of plain and it is anxious about liquefaction at the area which is consisted on soft and sandy soil

Table 3.3-2 shows a geological stratigraphy of study area ad Figure 3.3-2 shows a geological map of study area.

Table 3.3-2 Geological Stratigraphy

Geological Age		Symbol	Name	Description
Quaternary	Holocene	b	Refilling Soil	Artificial refilling soil along the canal
		dt	Detritus	Secondary deposit on the toe of slope. Properties and condition depended on parent ground. Unconsolidated and loose.
		al	Alluvium	It distributes in the lowlands near the coast and bottom land along the river in the areas between Jakarta and Karawang. It comprises soft volcanic sand and mud.
		ql	Lake deposit	It distributes in the central and eastern part of the Bandung plain. Mainly composed of soft clay and partially sandy.
	Holocene / Pleistocene	tr	Terrace deposit	It distributes the hilly area in the downstream of Jatilfulh lake. Mainly composed of clay to sandy soil. Low degree of consolidation.
	Pleistocene	qf	Fan deposit on the foot of mountain	A fan deposit generated by Mt.Tangkuban Perahu. Mainly composed of pyroclastic sediment such as a gravel of scoria with high permeability.
		vd	Old Volcanic Sediment	It comprises volcanic breccia, tuff breccia, lapilli tuff, lahar sediment and secondary deposit of them. This forms outer layer in the mountain area. Surface soil colors reddish brown color because of lateralization.
		dl	Diluvium	It forms a small highland and hilly land in the section between Jakarta and Karawang. It is mainly composed of clayey soil and sandy soil, and no gravel is contained. Although well consolidated in the lower part, weak in the surface part.
Neocene	Miocene	Tsb	Subang Formation	Sedimentary rock which distributes in the section between Karawang and Purwakarta. It is mainly composed of mud stone in the area near Karawang and tuffacious sand near Purwakarta. Obvious structure of stratification can be seen at outcrop. The dip of structure is flat. Degree of consolidation is relatively high in the fresh part and N value ranges from 50 to 80 in those fresh part.
		Tjh	Jatiluhur Formation	Sedimentary rock which distributes in the section near Purwakarta and Jatilihur. It is mainly composed of mud stone with high degree of consolidation. Fold structure can be seen remarkably and axis of fold is mainly east-west direction.
		Tctr	Citarum Formation	It distributes in the section from Sta.105 to 120km. It comprises of sedimentary rock such as tuff breccia, lapilli tuff,tuff and tuffacious sand. Obvious structure of stratification can be seen. Although it was formed at almost same time as Jatilihur formation, the degree of consolidation of this is lower than the degree of composition of Jatilihur formation.
Intrusive Rock		And	Andesitic Dyke	It distributes in the section from Sta. 118.0 to 118.8km. Basically hard rock except in weathered part.

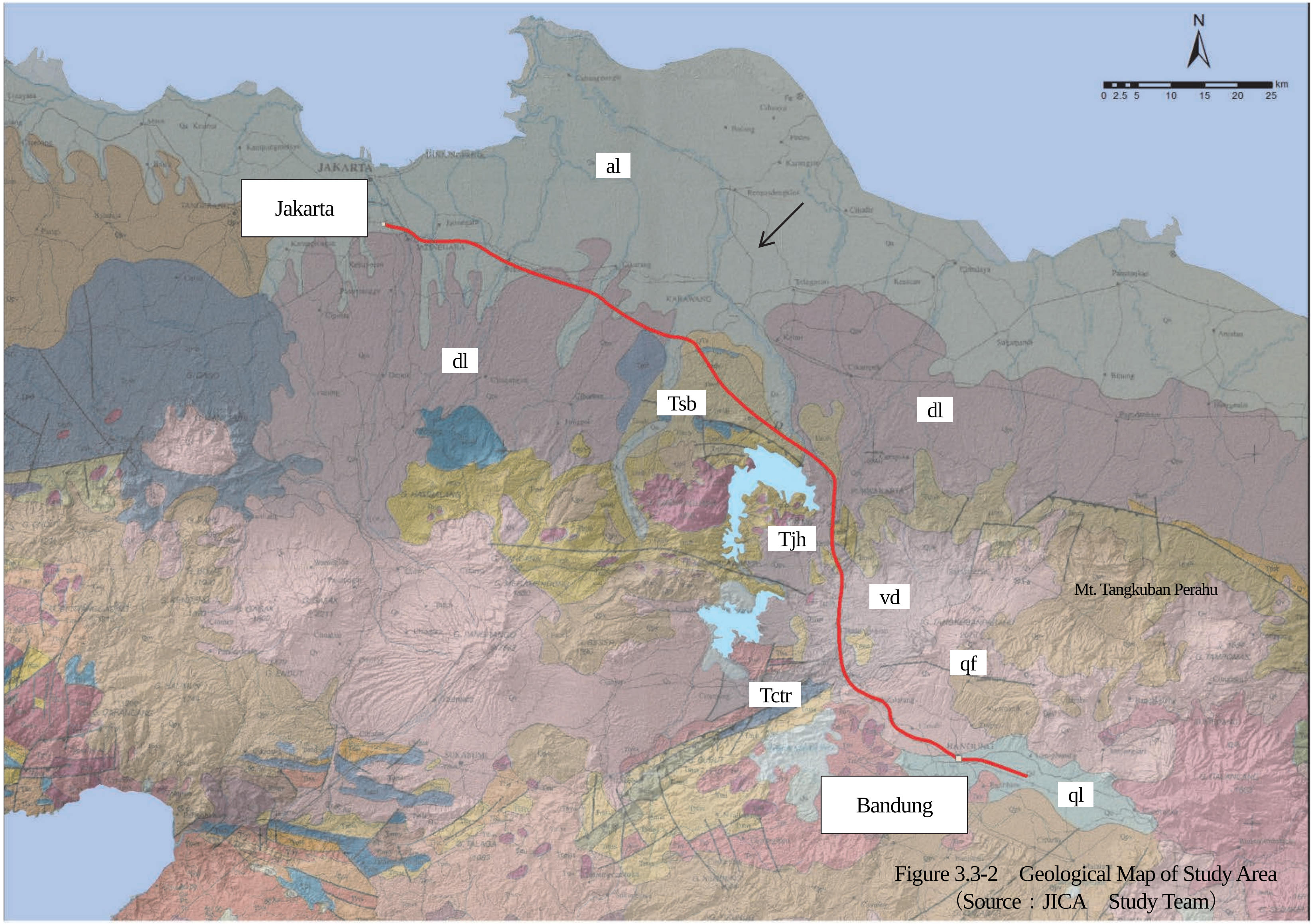


Figure 3.3-2 Geological Map of Study Area
(Source : JICA Study Team)

3.3.2 Standard Penetration Test (SPT)

(1) Method and Number of Test

1) Method

Test method conform to ASTM D-1586.

SPT was carried out for the purpose of grasping following items based on the N value.

- ✓ Depth of earthquake proof foundation
- ✓ Concreteness of ground and geological layer

2) Number of Test

SPT was carried out at interval of 1.0m and total number of test is 645 times.

(2) Result of SPT

Detailed result of SPT is shown on the drilling log of each boring in supplement.

Followings describes relation between ground/geology and N value briefly.

1) Flat Plain

① Jakarta Flat Plain

a) N value of each geological layer and soil

Figure 3.3-3.a) and b) shows the graph of distribution of N value by geology and soil. SPT is carried out at interval of 1m, however, laboratory sample were taken from at interval of 2m from the section N value is less than 50. Therefore, number of dot in figure a) is different from numbers of dot in figure

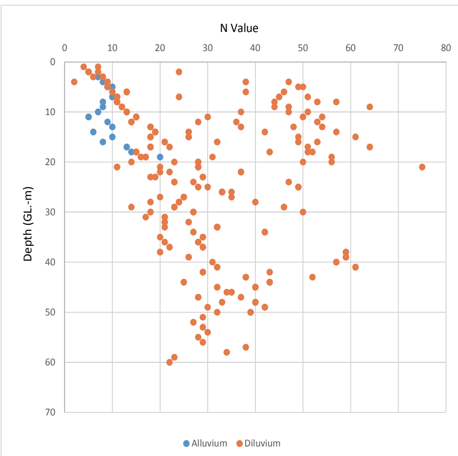
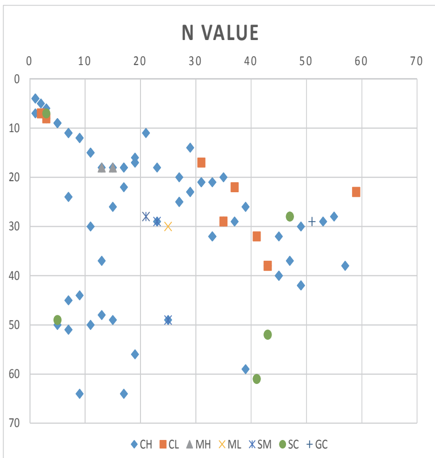
N value by Geology	**N value by Soil Type**
	

Figure 3.3-3.a) N value by Geology **Figure 3.3-3.b) N value by Soil Type**

According to the N value by geology, variation of N value is large. However, a tendency which N value is increased with increasing depth.

b) Depth of the earthquake proof foundation at each boring point

The depth of earthquake proof foundation is defined as the upper surface depth of the point where the N value of more than 50 section is verified continuously. Table 3.3-3 shows the depth of earthquake proof foundation based on the above mentioned definition.

Table 3.3-3 Depth of Earthquake Proof Foundation at each Boring Point (Jakarta Flat Plain Area)

No. of Boring	Depth of Earthquake Proof Foundation（GL-m）	Geology
B-1	15	Fan deposit on the foot of mountain Diluvium
B-2	10	Ditto
B-3	45	Ditto
B-4	Un confirmed until 60m depth	Alluvium/ Diluvium
B-5	38	Diluvium

② Bandung Flat Plain

a) N value of each geological layer and soil

Figure 3.3-4.a) and b) shows the graph of distribution of N value by geology and soil.

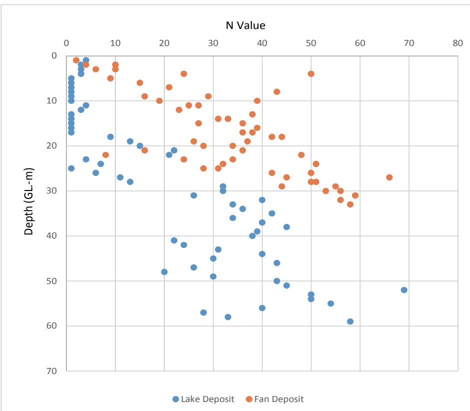
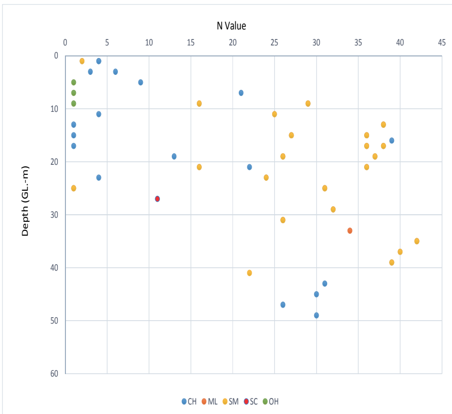
N value by Geology	N value by Soil Type
	

Figure 3.3-4.a) N value by Geology　Figure 3.3-4.b) N value by Soil Type

According to the N value by geology, variation of N value is large. However, a tendency which N value is increased with increasing depth. In addition, regarding fan deposit on the foot of mountain, increase of N value with increasing depth is observed significantly as compared to lake deposit.

b) Depth of the earthquake proof foundation at each boring point

Table 3.3-4 shows the depth of earthquake proof foundation.

Table 3.3-4 Depth of Earthquake Proof Foundation at each Boring Point (Bandung Flat Plain Area)

No. of Boring	Depth of Earthquake Proof Foundation（GL-m）	Geology
B-15	28	Fan deposit on the foot of mountain
B-16	26	Ditto
B-17	52	Lake deposit

2) Hilly land- Mountainous Area

Figure 3.3-5.a) to d) show N value by geology which distributes in this area.

Main geology distributes in this area is (a) old volcanic sediments, (b) Subang formation in Neogene, (c) Jatiluhur formation in Neogene, and (d) Citrum formation in Neogene.

Followings describes characteristics of each geology briefly.

(a) Old Volcanic Sediments (Cover layer: Figure 3.3-5.a））

Old volcanic sediments covers strata of Subang formation, Jatiluhur formation and Citrum formation unconformity. Origin of this sediment is Mt.Tangkuban Perahu. Thickness of this sediment at boring points is around 20m from ground surface. It contains many clay layers the origin of volcanic ash. Concreteness of this sediments has variation. Mainly N value is less than 25.

(b) Subang Formation（Base rock: Figure 3.3-5.b））

Geology of Subang formation is mainly comprise of mudstone, sandstone and pyroclastic rocks which has clayey matrix such as lapilli tuff and tuff brecciated lava. Sand stone is partially distributed. Pyroclastic rocks distributes 20m depth from ground surface and N value is increased with increasing depth.

Mudstone also has a tendency of N value is increased with increasing depth, generally N value is more than 50 at the depth of deeper than 35m from ground surface and concreteness is high. However, average N value of fresh portion of mudstone ranges from 50 to 80, N value is relatively low compared to strata including mudstone of Jatiluhur formation and Citarum formation.

Boring B-7 and B-8, mudstone of Subang formation is distributes from ground surface. At both boring points, N value is more than 50 at the depth deeper than 6m below ground surface.

(c) Jatiluhur Formation（Base rock: Figure 3.3-5.c））

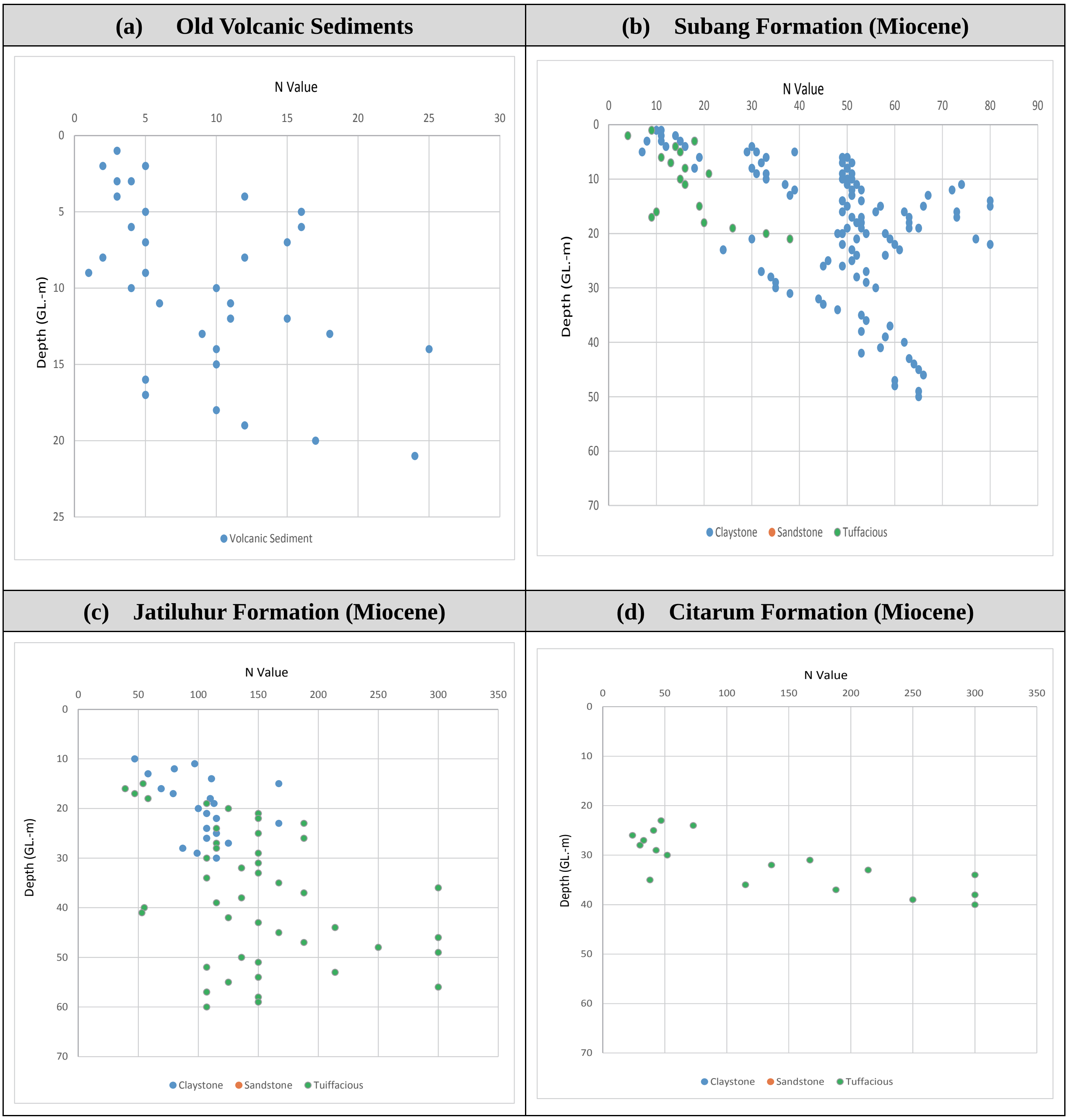
Geology of Jatiluhur formation is mainly comprise of mudstone, sandstone and pyroclastic rocks which has volcanic clayey matrix such as lapilli tuff and tuff brecciated lava. Generally this stratum is covered with the Old volcanic sediments until 10m depth from ground surface. Therefore, there is no N value data of the strata of Jatiluhur formation until 10m depth below ground surface.

Mudstone and pyroclastic rocks distribute at boring point. Immediate after contact with rock at beneath the old volcanic sediment, N value remarkably increases then within 10m after contract rock N value reaches more than 50. Since the conversion N value ranges from 100 to 300 in a deep part of ground, concreteness of strata is extremely high.

(d) Citarum Formation（Base rock: Figure 3.3-5.d））

Geology of Citarum formation is mainly comprise of pyroclastic rocks which has volcanic clayey matrix such as lapilli tuff and tuff brecciated lava, and tuffacious sand. Only pyroclastic rocks are identified at boring point. Generally this stratum is covered with the Old volcanic sediments until 20m depth from ground surface. Therefore, there is no N value data of the strata of Citarum formation until 20m depth below ground surface.

N value of pyroclastic rocks reaches more than 50 at 10m below contact with rock at beneath the old volcanic sediment, the conversion N value ranges from 100 to 300 in a deep part of ground and concreteness of strata is extremely high as well as Jatiluhur formation.



Note) regarding N value more than 100 means conversion N value

Source ; JICA Study Team

Figure 3.3-5 N value of each Geological Formation

Table 3.3-5 shows the range of N value of fresh part of each formation

Table 3.3-5 Range of N Value of Fresh Part of each Geological Layer

Name of Geological Layer	Old Volcanic Sediments	Subang Formation	Jatiluhur Formation	Citarum Formation
	Cover Layer	Base Rock	Base Rock	Base Rock
Range of N Value	<25	50～80	100～300	100～300

(3) N value and Mechanical Properties

Table 3.3-6 shows mechanical property of sandy soil and clayey soil.

Weathered portion which has low N value of strata of Subang formation, Jatiluhur formation and Citarum formation can apply Table 3.3-6. However, it is thought to be inappropriate to apply Table 3.3-6 for a fresh portion of these strata. It is necessary to carry out mechanical test, such as the unconfined compressive strength in order to grasp the mechanical property of each geological layer.

Table 3.3-6 Mechanical Properties of Sandy Soil and Clayey Soil

a. Sandy Soil

Condition of Sand	N value	Relative Density	Internal Friction (°)	Static cone Bearing Capacity (MN/m^2)	Modulos of Deformation (N/mm^2)
Very loose	0～4	0～0.2	28.5 以下	～2.0	1.0～4.0
Loose	4～10	0.2～0.4	28.5～30	2.0～4.0	4.0～8.0
Firm Medium	10～30	0.4～0.6	30～36	4.0～12.0	8.0～16.0
Dense	30～50	0.6～0.8	36～41	12.0～20.0	15.0～40.0
Very dense	50 以上	0.8～1.0	41	～20.0	40.0～

b. Clayey Soil

Classification	Nvalue	Unconfined Compressive Strength (ｋN/m^2)	Modulos of Deformation (N/mm^2)
Very soft	2	～35	4.0
Soft	2～4	35～70	2.0～8.0
Medium	4～8	70～140	4.0～10.0
Stiff	8～15	140～280	10.0～20.0
Very stiff	15～30	280～	20.0～50.0
Remarkable stiff	～30		50.0～

Source : Design of Ground and Foundation, Sankai-do

3.3.3 Laboratory Test

(1) Test Items and Number of Test

1) Test Items and Number of Test

Items and number of each test are described in the Table 3.2-1 mentioned before.

2) Soil Property Test

Table 3.3-7 shows No. of boring which undisturbed sample was taken and number of sample of each boring.

Table 3.3-7 No. of Boring and Number of Samples of each Boring

No. of Boring	Number of Samples
B-1	7
B-2	5
B-3	23
B-4	30
B-5	23
B-15	12
B-16	8
B-17	25
Total	133

Undisturbed samples were sampled from boreholes in Jakarta and Bandung flat plain area. Samples were collected from geological layer of which N value is less than 50 of each borehole.

3) Slake Durability Test

Slaking is a phenomenon of falling to pieces of consolidated soil and soft rock due to repetition of moisture absorption and dryness. Slake durability test was carried out by samples which were sampled from mud stone of Subang formation and Jatiluhur formation.

Based on the result of field reconnaissance of this project, a phenomenon of slaking can be identified in the area which geology is comprise of mud stone of Subang formation at the industrial development area around Karawang- Purwakarta. On the other hand, according to existing geological data, it is mentioned that slaking phenomenon is also can be seen in the mud stone of Jatiluhur formation. For these reason, slake durability test was carried out for the mud stone of Subang and Jatiluhur formation to grasp the characteristics of slaking of those mud stone.

(2) Result of Laboratory Test

1) Soil Properties

Details of test result is shown in attached file. Outline of the test result is described below.

① Properties and condition of Alluvium and Diluvium

a) Classification of Soil Type

Laboratory test are carried out in conformity to ASTM.

Table 3.3-8 shows Japan Unified Soil classification system and Table 3.3-9 shows Unified Soil classification system of ASTM D 2487-06. Japan system corresponds to ASTM.

Table 3.3-8 Japan Unified Soil Classification System

Name of Group	Name of Soil	Definition	Enginnering Group Symbol
Gravel	Gravel	Fc＜5%	G
	Boulder		
	Cobble		
	Pebble		
	Sand and Gravel		
	Silt	5≦Fc＜50%	(G-M)
	Clay		(G-C)
	Organic		(G-O)
	Volcanic Ash		(G-V)
Gravelly Soil	Silty	5≦Fc＜50%	(GM)
	Clayey		(GC)
	Organic		(GO)
	Volcanic Ash		(GV)
Sand	Sand with Gravel	Fc＜5%	S
	Sand		
	Coarse Sand		
	Fine Sand		
	Silt	5≦Fc＜50%	(S-M)
	Clay		(S-C)
	Organic		(S-O)
	Volcanic Ash		(S-V)
Sandy Soil	Silty	5≦Fc＜50%	(SM)
	Clayey		(SC)
	Organic		(SO)
	Volcanic Ash		(SV)
Silt	Sandy Sillt	FC≧50%	(ML) (MH)
	Silt		
	Clayey Silt		
Clay	Sandy Clay		(CL) (CH)
	Silty Clay		
	Clay		
Organic Soil	Organic Silt		(OL)
	Organnic Silt Clay		
	Organic Sandy Clay		
	Organic Clay		
	Kuroboku Soil,Loam		(OH)
Volcanic Clay			(OV)
	Loam		(VH)

Source: Japan Institute of Country-ology and Engineering

Table 3.3-9 Unified Soil Classification System (ASTM D 2487-06)

TABLE 1 *Continued*

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification: Group Symbol	Soil Classification: Group Name[B]
		More than 12 % fines[E]	Fines classify as CL or CH	,urule;1>GC	Clayey gravel[D,F,G]
	Sands	Clean Sands	Cu ≥ 6 and 1 ≤ Cc ≤ 3[E]	SW	Well-graded sand[H]
	50 % or more of coarse	Less than 5 % fines[I]	Cu < 6 and/or 1 > Cc > 3[E]	SP	Poorly graded sand[H]
	fraction passes No. 4 sieve	Sands with Fines	Fines classify as ML or MH	SM	Silty sand[F,G,H]
		More than 12 % fines[I]	Fines classify as CL or CH	SC	Clayey sand[F,G,H]
FINE-GRAINED SOILS	Silts and Clays	inorganic	PI > 7 and plots on or above "A" line[J]	CL	Lean clay[K,L,M]
50 % or more passes the No.	Liquid limit less than 50		PI < 4 or plots below "A" line[J]	ML	Silt[K,L,M]
200 seive		organic	Liquid limit – oven dried / < 0.75	OL	Organic clay[K,L,M,N]
			Liquid limit – not dried	OL	Organic silt[K,L,M,O]
	Silts and Clays	inorganic	PI plots on or above "A" line	CH	Fat clay[K,L,M]
	Liquid limit 50 or more		PI plots below "A" line	MH	Elastic silt[K,L,M]
		organic	Liquid limit – oven dried / < 0.75	OH	Organic clay[K,L,M,P]
			Liquid limit – not dried		Organic silt[K,L,M,Q]
HIGHLY ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor			PT	Peat

Note) an explanatory note of this table by ASTM is omitted.

b) Characteristics by Soil Type

Table 3.3-10 (a) and (b) shows result of soil property by soil type.

Table 3.3-10.(a) Characteristics of Soil（Jakarta flat plain area）

Section	Soil Classification		G_s Specific Gravity	γ_m t/m³ Wet	γ_d t/m³ Dry	W_n % Natural water content	wL % Liquid Limit	wP % Plastic Limit	IP % Plastic Index	IL Liquidity Index	e Void Ration	n % Porosity	Sr % Degree of Saturation	Finer by weight passing no 200 sieve	No. of Sample
Jakarta Flat Plain	CH	Avarage	2.67	1.76	1.29	39.67	72.72	26.56	46.17	0.27	1.17	51	92	93	68
		Maximum	2.84	2.11	1.78	91.30	141.80	52.00	89.80	1.10	2.88	74	100	100	
		Minimum	2.46	1.18	0.67	13.30	44.80	15.70	21.80	-0.38	0.46	32	68	51	
	CL	Avarage	2.69	1.81	1.43	27.38	45.08	19.65	25.43	0.32	0.89	47	84	80	8
		Maximum	2.84	2.00	1.63	32.90	49.10	25.30	32.10	0.51	1.10	52	97	100	
		Minimum	2.63	1.62	1.32	20.10	36.20	15.30	17.60	0.13	0.63	38	52	52	
	GC	Avarage	2.62	1.85	1.37	34.8	81.9	28.9	53.0	0.11	0.91	48	100	41	1
		Maximum	2.62	1.85	1.37	34.8	81.9	28.9	53.0	0.11	0.91	48	100	41	
		Minimum	2.62	1.85	1.37	34.8	81.9	28.9	53.0	0.11	0.91	48	100	41	
	MH	Avarage	2.68	1.49	0.92	62.65	53.95	37.25	16.70	1.53	1.93	66	87	64	2
		Maximum	2.72	1.56	0.97	64.60	56.80	38.50	18.30	1.64	2.06	67	92	67	
		Minimum	2.63	1.42	0.86	60.70	51.10	36.00	15.10	1.43	1.80	64	83	61	
	ML	Avarage	2.62	1.71	1.25	38.95	42.70	30.60	12.10	0.92	1.13	52	89	75	2
		Maximum	2.62	1.80	1.40	49.20	44.90	31.20	14.90	1.94	1.40	58	92	99	
		Minimum	2.61	1.63	1.09	28.70	40.50	30.00	9.30	-0.09	0.86	46	87	50	
	SC	Avarage	2.66	1.83	1.41	30.58	38.76	21.30	17.46	0.50	0.92	47	90	36	5
		Maximum	2.80	1.95	1.61	46.20	47.20	23.60	23.60	0.96	1.25	56	100	43	
		Minimum	2.56	1.69	1.20	20.90	28.10	16.60	11.50	0.29	0.61	38	72	27	
	SM	Avarage	2.68	1.79	1.38	30.97	47.80	33.90	13.90	0.26	0.99	49	84	36	3
		Maximum	2.81	2.07	1.75	37.50	47.80	33.90	13.90	0.26	1.21	55	85	46	
		Minimum	2.60	1.63	1.19	18.40	47.80	33.90	13.90	0.26	0.61	38	80	23	

Table 3.3-10.(b) Characteristics of Soil（Bandung flat plain area）

Section	Soil Classification		G_s Specific Gravity	γ_m t/m³ Wet	γ_d t/m³ Dry	W_n % Natural water content	wL % Liquid Limit	wP % Plastic Limit	IP % Plastic Index	IL Liquidity Index	e Void Ration	n % Porosity	Sr % Degree of Saturation	Finer by weight passing no 200 sieve	No. of Sample
Bandung Flat Plain	CH	Avarage	2.62	1.55	0.94	71.95	101.29	32.56	68.73	0.62	2.01	64	94	77	19
		Maximum	2.90	1.76	1.30	183.5	231.50	41.80	189.7	1.24	4.23	81	100	100	
		Minimum	2.25	1.22	0.43	30.9	60.90	24.70	32.9	0.25	1.37	56	89	58	
	ML	Avarage	2.57	1.73	1.21	42.8	Non Plastic			-	1.12	53	98	52	1
		Maximum	2.57	1.73	1.21	42.8	Non Plastic			-	1.12	53	98	52	
		Minimum	2.57	1.73	1.21	42.8	Non Plastic			-	1.12	53	98	52	
	OH	Avarage	2.26	1.19	0.39	207.92	217.60	53.27	164.33	0.95	4.86	83	97	83	3
		Maximum	2.30	1.25	0.45	222.9	259.0	79.2	179.8	1.07	5.39	84	100	99	
		Minimum	2.21	1.16	0.36	178.4	83.0	39.9	143.1	0.80	4.07	80	95	51	
	SC	Avarage	2.73	1.59	0.93	70.9	93.4	38.7	54.7	0.59	1.94	66	100	43	1
		Maximum	2.73	1.59	0.93	70.9	93.4	38.7	54.7	0.59	1.94	66	100	43	
		Minimum	2.73	1.59	0.93	70.9	93.4	38.7	54.7	0.59	1.94	66	100	43	
	SM	Avarage	2.66	1.72	1.32	30.72	61.80	35.25	26.55	1.68	1.07	50	78	27	23
		Maximum	2.83	1.99	1.66	76.50	74.60	37.90	36.70	2.68	2.30	70	100	42	
		Minimum	2.54	1.45	0.82	15.00	49.00	32.60	16.40	0.68	0.55	36	55	17	

Soil type of CH (High plasticity, clay with viscosity) distributes both of Jakarta and Bandung flat plain area.

This type of soil accounts for overwhelmingly high percentage in Jakarta area. On the other hand, soil type of SM (silty sand) account for high percentage compared to CH in Bandung area, and soil type OH (organic silt to clay) can be identified. Soil type OH cannot be identified in Jakarta area. Soil type SM distributes in fan deposit on the foot of mountain and lake deposit which distribute in Bandung area while soil type OH distributes only in lake deposit.

- Percentage of fine material/ Coefficient of Uniformity

Table 3.3-11 shows the range of percentage of fine material and coefficient of uniformity of each boring.

Table 3.3-11 Range of Percentage of Fine Material and Coefficient of Uniformity of each Boring

No. of Boring	Percentage of fine material（FC）(%)	Coefficient of Uniformity	Geology
B-1	91 - 100	Cannot be calculated	Diluvium
B-2	43 - 68	9.2 – 32.4	Ditto

B-3	23 - 99	5.1 – 89.7	Ditto
B-4	55 - 100	7.2 – 99.9	Alluvium/ Diluvium
B-5	33 - 100	13.0 – 30.9	Diluvium
B-15	19 - 99	16.0 - 115	Fan deposit on the foot of mountain
B-16	22 - 89	18.9 – 50.0	Ditto
B-17	25 - 100	12.1 - 101	Lake deposit

When unconsolidated ground has groundwater, it is concerned about a liquefaction of flow. When evaluates the capability of ground liquefaction of flow, percentage of fine material (FC) and coefficient of uniformity are important factor for it.

Among the geological strata distributing along and around the planned HSR route, sediment of fan deposit on the foot of mountain is unconsolidated and has high water content. However, according to Table 3.3-11 and 3.3-12, since percentage of fine material and coefficient of uniformity of fan deposit is not fall under the criteria of ground liquefaction of flow, this fan deposit has no concern about ground liquefaction of flow.

Table 3.3-12 Indicator of Ground Liquefaction of Flow

	Yabe, et al (1969)	Morito (1973)	Japanese National Railroads Structural Design Office (1977)	JSCE (1977)	Okuzono ,et al (1982)	Kiya, et al (1993)
Indices	Unit weight ≦ 2.65g/cm³ Specific gravity of soil particles ≦ 1.70 Uniformity coefficient ≦ 4 50% particle size ≦ 1.5mm 10% particle size ≦ 0.15mm	Fine fraction content ≦ 10%	(1) Sand of uniform particle size ・Fine fraction content ≦ 10% ・Uniformity coefficient ≦ 5 ・Saturated sand (1) Sand of gravel layers which have a high ground water level (2) Sand aquifer between impermeable layers	Fine fraction content ≦ 10% Uniformity coefficient ≦ 4	Fine fraction content ≦ 8% Uniformity coefficient ≦ 6 Coefficient of permeability ≧ 10⁻³cm/s	(1) Difficult to stand alone - Relative density < 80% - Hydraulic gradient near face is large (2) Condition in which flow may occur Fine fraction content ≦ 10%
Remarks	Kagi Tunnel	Ikuta Tunnel				Shinano River Waterway Tunnel and others Specimen test are necessary for detailed study.

Source: Japan National Railways Design Office (1977)

② Liquefaction

Based on the result of laboratory test, necessity of judgment of liquefaction for geological strata in Jakarta and Bandung flat plain was examined.

- <u>Soil Layer which needs Judgment of Liquefaction</u>

Table 3.3-13 shows criteria of the condition of soil layer which needs to judge liquefaction in accordance with the Japanese guideline and standard.

Table 3.3-13 Target Soil Layer to be Evaluation of Liquefaction

Criteria of Judgment	Name of Guideline/Standard
Criteria (1) Soil layer which comes under all of following three condition need to judge liquefaction. ①Saturated soil which groundwater level is less than 10m below ground surface and located less than 20m below ground surface. ②Soil with the percentage of constituent of fine materials (FC)	Specifications of road bridge/ explanation V Seismic Design Method, Japan Road Association 2012 Objective Structure: Bridge with effective span less than200m

less than 35%, or if FC is more than 35%, Plastic index (Ip) is less than 15. ③Grain size of D50 is less than 10mm and grain size of D10 is less than 1mm.	
Criteria (2) Saturated soil layer which comes under all of following condition ①Soil which groundwater level is less than 10m below ground surface ②Soil which located less than 20m below ground surface ③Grain size of D50 is less than 10mm and grain size of D10 is less than 1mm ④Soil with the percentage of constituent of fine materials (FC) less than 35%, or if FC is more than 35%, percentage of constituent of clay is less than 15 %.	1)Design standard of railway structure/ explanation －Seismic design Method－ Railway Technical Research Institute 1999 2)Manual for design and construction liquefaction of river levee (Draft) Public Works Research Institute Ministry of Construction 1997 3）Ministry of Construction : Technical Criteria for River Work: Practical Guide for Design River Bureau 1997

Note) As a common understanding, liquefaction dose not occurred in diluvium

- Necessity of Judgment of Liquefaction

Based on the criteria mentioned in Table 3.3-13, necessity of judgment of liquefaction against geological layer which distributes in Jakarta and Bandung flat plain area was examined. Result of the examination is shown in Table 3.3-14.a) and b).

Based on the result of laboratory test, liquefaction in Jakarta and Bandung flat plain area is not an important matter.

Table 3.3-14.a) Condition of Jakarta Flat Plain Area

Nome of Boring	Geology until 20m below from ground surface	Groundwater Level at the time of Boring (GL.-m)	Plastic Index (IP) of Soil Layer distribution shallower than 20m below ground surface	Percentage of constituent of fine materials (FC) of soil layer distribution shallower than 20m below ground surface	Percentage of constituent of clay of soil layer distribution shallower than 20m below ground surface （PC）	Necessity of Judgment of Liquefaction
B-1	**Diluvium**	10	34.9-88.1	95-100	27-38	Does not apply
B-2	**Diluvium**	3	21.7-88.1	43-68	4-27	Ditto
B-3	**Diluvium**	7	Non Plastic -89.8	61-94	0-67	Ditto
B-4	**Alluvium (Sand-Silt)**	7	25.3-56.4	55-99	7-55	Ditto
B-5	**Diluvium/ Base Rock**	11	27.2-59.0	82-100	3-68	Ditto

Table 3.3-14.b) Condition of Bandung Flat Plain Area

Nome of Boring	Geology until 20m below from ground surface	Groundwater Level at the time of Boring (GL.-m)	Plastic Index (IP) of Soil Layer distribution shallower than 20m below ground surface	Percentage of constituent of fine materials (FC) of soil layer distribution shallower than 20m below ground surface	Percentage of constituent of clay of soil layer distribution shallower than 20m below ground surface （PC）	Necessity of Judgment of Liquefaction
B-15	**Fan deposit on the foot of mountain**	5	Non Plastic -50.6	17-99	2-35	Sedimentation system of fan deposit is different to that of alluvium. Does not apply
B-16	**Ditto**	9	Non Plastic -67.8	22-89	3-49	Ditto
B-17	**Lake Deposit (Alluvium: mainly composed of Clayey layers）**	10～14	16.4～64.6	25-99 FC<35 : 11.7～12.0（SM）	4-39 PC<15 : 5.7～6.0(OH） 11.7 ～ 12.0 (SM） 17.7～18.0 (CH)	Ditto A part of sandy soil (SM) with lower content of FC can be identified. However, this layer is very thin and located between clayey layers.

2) Slaking

Slaking is a category of squeezing ground.

Table 3.3-15 shows the result of slake durability test.

Table 3.3-15 Result of Slake Durability Test

Sampling Location	地 質	Slake Durability Index (1st cycle)	Slake durability Index (2nd cycle)
B-7 15.45-16.0m	Mudstone, Subang Formation	**64.91**	**51.01**
B-8 18.45-19.0m	Ditto	**64.46**	**33.07**
B-11 40.45-41.0m	Ditto	**25.76**	**13.77**
B-12 20.3-21.0m	Mudstone, Jatiluhur Formation	**38.77**	**32.98**

Table 3.3-16 shows the Slake Durability Classification by Goodman (1980)

Table 3.3-16 Slake Durability Index (Goodman 1980)

Group	Slake Durability Index (First Cycle) (%)	Slake Durability Index (second cycle) (%)
Very High Durability	>99	>98
High Durability	98-99	95-98
Moderate-High durability	95-98	85-95
Moderate Durability	85-95	60-85
Low Durability	60-85	30-60
Very Low Durability	<60	<30

According to Table 3.3-15 and 3.3-16, Mudstone of Subang formation and Jatiluhur formation is a rock type which has low to very low slake durability. This result supports the existing information obtained from Indonesia side and the condition of slaking phenomenon that was checked at outcrop in the developing area of Karawang industrial park.

Occurrence of slaking may affect the construction of slope cutting and tunnel. Table 3.3-17 shows the impact on the construction of HSR by a slaking.

Table 3.3-17 Impact on the Construction of HSR by Slaking

Item	Impact on the construction by Slaking
Slope Cutting	Slope Stability of Cutting Slope, slope collapse due to slaking
Tunnel	Stability of cutting face (collapse, expansion, softening etc.)

4. Engineering Geological Examination along the Planned HSR Route

4.1 Outline of Geology

Table 4.1-1 shows outline of geology and characteristics of engineering geology along the planned HSR route.

From section 4.2, detailed geology and characteristics of engineering geology are described.

Based on the topographical feature, HSR route is divided into following three sections.

① Jakarta Flat Plain Area

② Hilly Land- Mountainous Area

③ Bandung Flat Plain Area

Table 4.1-1 Outline of Geology and Characteristics of Engineering Geology

Section Name	**Geology**	**Sta. No. of Section (Sta.km)**	**Description of Geology**	**Description of Engineering Geology**
① **Jakarta Flat Plain Area**	Alluvium	0-49	This sediment is accumulated along the river channel in Jakarta flat plain area and represents eroded sediment of Diluvium. Generally, it is composed of clay, sand and gravel with volcanic ash, and is weak.	Generally, it is inferred that thickness of alluvium is 20m and maximum thickness is around 30m. Earthquake proof foundation cannot be expected in this sediment. There is no concern about liquefaction based on the result of soil test carried out in this survey.
	Diluvium		This sediment is distributed over as wide area in Jakarta flat plain. This sediment forms hilly land in the flat plain. This sediment is mainly composed of silt with volcanic ash, and partially, composed of layers of pebble and fine sand. Part of ground surface is weak due to weathering.	This sediment forms slight high ground and hilly land between the section Jakarta and Karawang. Depth of earthquake proof foundation from ground surface is shallow until Sta.20km in Jakarta flat plain and 40 to 50m depth in the eastern part, maximum depth in the eastern area is more than 60m. Diluvium is not a subject of examination of liquefaction.
② **Hilly Land-Mountainous Area**	Old Volcanic Sediment	77.8-113.5	This sediment is distributed on the mountain ridges in the mountainous area along the planned HSR route. This sediment is composed of volcanic sediment, mainly comprised of silt and clay with volcanic ash and partially gravel and sand. Based on the result of boring survey in this study, generally, thickness of this sediment is around 20m and it covers base rocks. Sediment near ground surface suffers the influence of weathering and becomes laterite. Comprehensively, property of this sediment is depending on the distance from the source of eruption, however, totally, it is termed “old volcanic sediment” at the present phase.	Low consolidated to unconsolidated. Origin is from pyroclastic rocks and volcanic ejection. Isolated aquifer (unconfined aquifer) is formed in this sediment. In the case that a tunnel passes through the boundary of this sediment and base rock, the spring water leakage into tunnel and impact on water use around tunnel area is of concern. Small scale collapse on the slope surface can be seen in this layer. Basically, a tunnel should be constructed through a section which has enough thickness of base rock below the boundary of this sediment.
	Subang Formation	49～82.5	This formation is comprise of sandstone, pyroclastic rocks and mudstone with clear low-angle stratification can be seen, Hardness of rock is weak near the ground surface due to weathering and well consolidated at deeper part.	Along the planned HSR route, geology of Subang formation is composed of mudstone and is partially composed of pyroclastic rock and sandstone. Rocks of Subang formation is classified into soft rock. In the existing development area in Karawang, there are many cutting slopes and outcrops comprised of mudstone of Subang formation. Those mudstone turns into mud and small pieces due to slaking. Appropriate treatment for the slaking

				phenomena is required when embankment, cutting slope and tunnel are constructed in Subang formation. Since it is assumed that permeability of strata of Subang formation is low, there is low possibility of concentrated inflow into tunnel during tunnel construction.
	Jatiluhur Formation	76.3-77.2 82.4-99.8	Geology of this formation is composed of sedimentary rocks which formed in Miocene. Folding structures are clearly seen in these sedimentary rocks. Direction of axis of those folding structure is northeast to southwest and southeast to northwest. Generally, well consolidated.	There is a tendency in distribution of geology. In the northern part, it mainly comprised of mudstone, and tuff brecciated lava and lapilli tuff are main component in the southern part. Rocks of Jatiluhur formation is classified into soft rock and well consolidated. However, slaking of mudstone is also a problem as with the mudstone of Subang formation. Since generally, it is assumed that permeability of strata of this formation is low, there is low possibility of concentrated inflow into tunnel during tunnel construction. However, permeability is slightly high in a part of this formation.
	Citarum Formation	99.8-112.9	Geology of this formation is composed of sedimentary rocks which formed in Miocene. These sedimentary rocks are mainly comprised of sandy tuff. Although softer than the rocks of Jatiluhur formation in general, they are well consolidated. Folding structure can be seen partially. Maximum thickness of strata is about 1,200m.	Formation time of this strata is almost same as Jatiluhur formation. Rocks of Citarum formation is classified into soft rock and well consolidated. Permeability is thought to be low as well as Jatiluhur formation.
③ **Bandung Flat Plain Area** Note: In the section 7.2.4, section of Bandung flat plain area start from Sta. 116.0km because the end of tunnel is at 116.0km.	Old Volcanic Sediment	112.9-113.5	Description is same as “Hilly land and mountainous area”	Description is same as “Hilly land and mountainous area”
	Fan deposit on the Foot of Mountain	113.4-134.5	This sediment is composed of sand and silt with scoria. Small amount of fine materials and void ratio is high. It is assumed that this sediment accumulated from diluvial to alluvial epoch. Volcanic sand and gravel accumulated on the foot of mountain by running water. This strata has different sedimentation system compared with normal alluvium.	Fan deposit that is composed of sand and gravel. Generally, condition is firm. It is assumed that this strata has high permeability and abundant groundwater. It is concerned about a concentrated in flow into tunnel at the time of construction tunnel. This sediment is also not a subject of examination of liquefaction as well as diluvium.
	Lake Depoait	134.5- 140.0	This sedimentary layer is mainly composed of clay and silt and partially sandy material. It is very weak and soft until 20m depth from ground surface.	For sections composed of this layer, depth of earthquake proof foundation is deep. Based on the result of soil test in this study, there is no concern about liquefaction, however, there is concern about land subsidence.
Accumulate in a small area	Refill Soil	-	This artificial sediment distribute along the canal.	Depth of this sediment is about 5m. This layer is unconsolidated and loose.
	Talus Deposit	-	Secondary sediment. It accumulates on the middle to lower part of slope. Basically is comprised of rock fragment and clay.	Many of existing slope failures are occurred by this sediment. This layer is unconsolidated and loose. Where thickness of this layer is thick at the entrance of tunnel, appropriate design and construction of slope stability measures are needed.

4.2 Condition of each Section

4.2.1 Flat Plain Area

(1) Jakarta Flat Plain Area to Cikarang Hilly Land

1) Outline of Geological Setting in the Section

A schematic geological cross section is shown in Figure 4.2-1.

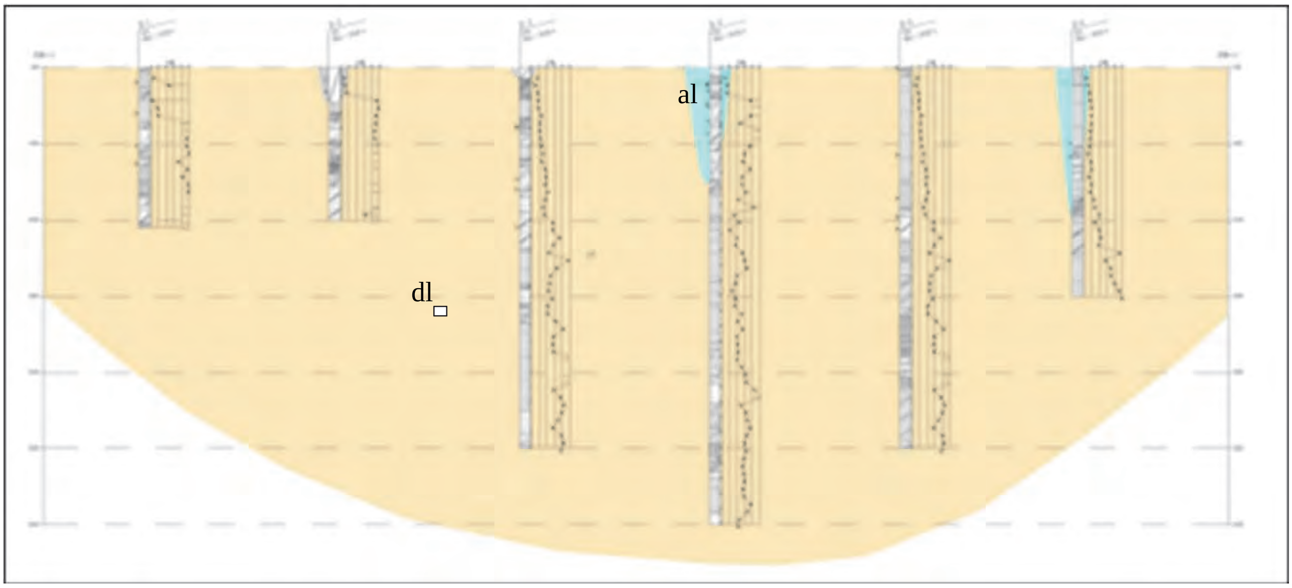
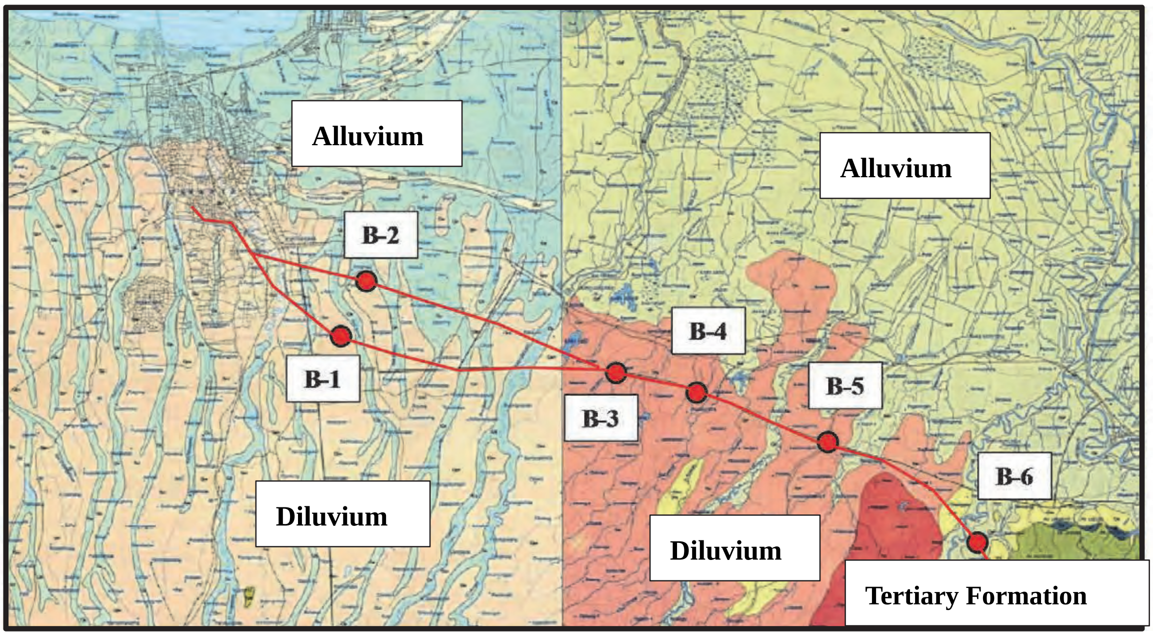


Figure 4.2-1 Schematic Cross Section around Jakarta Flat Plain

Figure 4.2-2shows the location of boring in this survey.



Note) this map is compiled map of two different geological map, therefore, each map has different coloring

Figure 4.2-2 Location Map of Boring in this Survey

Table 4.2-1shows the summary of geological condition along the planned HSR route.

Table 4.2-1 Summary of Geological Condition along the Planned HSR Route (Jakarta Flat Plain Area)

Section(㎞)	Geology	Structure	Description
0.0～20.0	Mainly comprised of Diluvium Alluvium distributes along small rivers with 200 to 400m width and around 20m thickness. Refilling soil with around 5m thickness distributes along the canal.	Shield Tunnel Viaduct	Depth of earthquake proof foundation from ground surface is shallow because of diluvium. Depth of earthquake proof foundation from ground surface at boring point. B-1: GL.-15m B-2: GL.-10m
20.0～39.0	Mainly comprised of Diluvium Alluvium distributes along rivers with 500 to 1,000m width and around 20m depth.	Embankment Viaduct	Depth of earthquake proof foundation from ground surface at boring point. B-3: GL.-38m B-4: Deeper than GL.-60m B-5: GL.-38m
39.0～49.0	Mainly comprised of Diluvium Alluvium distributes along rivers with 3 to 5km width and around 20 to 30m depth.	Viaduct Embankment	Depth of earthquake proof foundation from ground surface at boring point. B-6: Deeper than GL.-30m

2) Geotechnical Characteristics

a) Depth of the Earthquake Proof Foundation and the Distribution of Soft Ground based on the N -Value

① Estimate Depth of the Earthquake Proof Foundation

Table 4.2-2shows estimate depth of the earthquake proof foundation of each section that is estimated by the result of boring survey.

Table 4.2-2 Estimated Depth of Earthquake Proof Foundation in Jakarta Flat Plain (Jakarta- Karawang: Sta.0 to 49.7km

Section Sta.km	Estimated Depth of Earthquake Proof Foundation （GL.-m）
0.0 – 19.0	10
19.0 – 20.0	24
20.0 – 25.0	38
25.0 – 30.0	49
30.0 – 36.0	50
36.0 – 38.0	38
38.0 – 48.0	39
48.0 – 49.0	40
49.0 – 49.7	23

② Soft Ground

Soft ground does not distribute except ground surface. Because ground surface suffers the influence of weathering.

b) Liquefaction of Ground

As described in the section, the result of laboratory test, ground liquefaction is not a problem on the construction of structure in the Jakarta flat plain area.

c) Land Subsidence

- Construction Work in the Land Subsidence Area

Jakarta is known as an area of notable land subsidence area. Outline of situation of land subsidence in Jakarta area is described in section 1.2.

Based on the existing study result, HSR route is planned in the area which land subsidence rate is 5.0cm to 2.5cm/ year or less than 2.5cm. If subsidence at the current rate has continued until 2015, the difference of more than 1m comes into subsidence amount depending on the location. Because amount of land subsidence will be 1.8m in case current rate is 5.0cm/year and 0.9m in case current rate is 2.5cm/year.

Structure along the planned HSR in the section of Jakarta flat plain area is planned as shield tunnel and viaduct. In case viaduct, since a pile foundation constructs on load bearing layer, it is not be affected by land subsidence. On the other hand, in case of shield tunnel, it is affected by land subsidence continuously.

At the junction of viaduct and shield tunnel, consideration in the design is necessary. In addition, depending on economic efficiency, a soil improvement work is thought to be a measurement of land subsidence in the section of the shield tunnel.

- Impact on Surroundings by a Shield Tunnel

All most of the section of shield tunnel is designed passing through firm clayey soil and sandy soil with N value is more than 50. Based on this geotechnical condition, it is assumed that subsidence of the ground surface due to tunnel excavation does not occur. Subsidence of the ground surface should be taken consideration into design and implementation plan when a shield tunnel construct near the ground surface (thin earth covering area).

d) Comparison of Plan A Route and Plan B Route

The depth of the earthquake proof foundation at the boring B-1 point is 15m along the Plan A route, whereas B-2 point along the Plan B route is 10m,shallower than B-1. On the other hand, soft layer is identified at B-1 point at the depth is 4 to5 m from the ground surface and is not identified at B-2 point except in refill soil.

Plan A route is advantageous in terms of economic efficiency compared to Plan B route, because the depth of earthquake proof foundation from the ground surface is shallow and length of shield tunnel is short.

(2) Bandung Flat Plain Area

1) Outline of Geological Setting in the Section

A schematic geological cross section is shown in Figure 4.2-3.

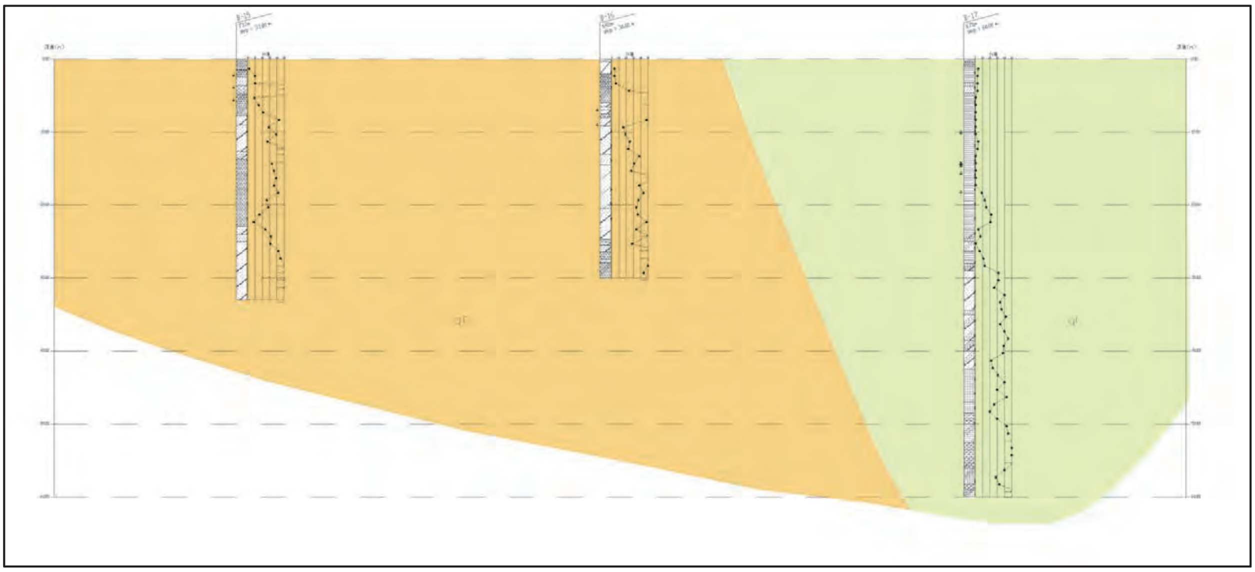


Figure 4.2-3 Schematic Cross Section around Bandung Flat Plain Area

Figure 4.2-4 shows the location of boring in this survey.

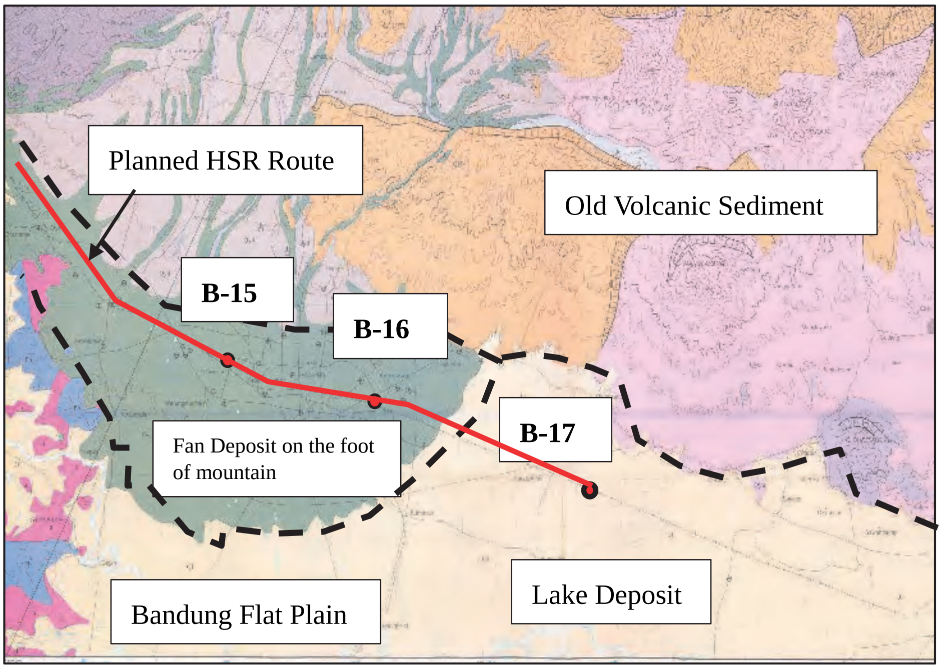


Figure 4.2-4 Location Map of Boring in this Study

Table 4.2-3 shows the summary of geological condition along the planned HSR route.

Table 4.2-3 Summary of Geological Condition along the Planned HSR Route (Bandung Flat Plain Area)

Section(㎞)	Geology	Structure	Description
116.0～135.0	Fan Deposit on the foot of mountain	Tunnel(NATM) Viaduct	Depth of earthquake proof foundation from ground surface at boring point. B-15: GL-.28m B-16: GL-.26m Within 1 to 2m depth from ground surface, soil condition is weak because f weathering. Liquefaction is not a problem on this stratum.
135.0～140.0	Lake Deposit	Viaduct Embankment	Depth of earthquake proof foundation from ground surface at boring point. B-17: GL.-52m At B-17, soft soil distributes until 17m from ground surface

2) Geotechnical Characteristics

a) Depth of the Earthquake Proof Foundation and the Distribution of Soft Ground based on the N-Value

① Estimate Depth of the Earthquake Proof Foundation

Table 4.2-4 shows estimate depth of the earthquake proof foundation of each section that is estimated by the result of boring survey.

Table 4.2-4 Estimate Depth of Earthquake Proof Foundation in the Bandung Flat Plain （Sta. 113.8 to 140.0km）

Section Sta.km	Estimated Depth of Earthquake Proof Foundation (GL.-m)
116.0 – 118.0	27
118.0 – 118.8	10
118.8 – 136.0	27
136.0 – 136.3	30
136.3 – 136.5	35
136.5 – 136.7	40
136.7 – 136.8	45
136.8 – 136.9	50
136.9 – 140.0	52

② Soft Ground

Soil of the fan deposit on the foot of mountain, soft ground, of which N-value is less than 4, only distributes within 1 to 2m from ground surface. On the other hand, soil of the lake deposit, all of the ground until 17m depth from ground surface is composed of soft strata at boring B-17.

b) Liquefaction of Ground

As described in the section 3.3.3 (2), from the result of laboratory test, ground liquefaction is not a problem on the construction of structure in the Bandung flat plain area.

c) Land Subsidence

Areas which is composed of fan deposit in the foot of mountain is not concerned about land subsidence because of sandy deposit. On the other hand, areas which is composed of lake deposit is concerned about land subsidence. Because, lake deposit is consisted of clayey and silty sediments. However, all of section in the Bandung flat area, structure is planned as viaduct. In case of viaduct, a pile foundation constructs on the load bearing layer, therefore, no impact on structure is considered.

4.2.2 Hilly Land – Mountainous Area

(1) Outline of Geological Setting in the Section

A schematic geological section is shown in Figure 4.2-5.

Figure 4.2-6 shows the location of boring in this survey.

Table 4.2-5 shows the summary of geological condition along the planned HSR route.

Table 4.2-5 Summary of Geological Condition along the Planned HSR Route (Hilly land – Mountainous Area)

Section(㎞)	Geology	Structure	Description
49.0～76.0	Bed rock; Mudstone of Subang Formation Cover Layer; 71.3 ㎞ to 75 ㎞, Terrace Deposit Thickness around 2m, slity sediment)	Cutting Embankment Partially, Tunnel (NATM)	Slaking of bed rock: Instability of cutting slope
76.0～77.2	Bed rock; Mudstone of Jatiluhur Formation Cover layer; No accumulation of thick cover layer	Tunnel (NATM)	Ditto
77.2～82.4	Bed rock; Mainly mudstone of Subang Formation, pyroclastic rocks such as tuff brecciated lava, lapilli tuff, in the high altitude zone Cover layer; Talus Deposit on the slope	Embankment Tunnel (NATM) Cutting	Slaking of bed rock Collapse of slope surface (talus deposit)
82.4～99.8	Bed rock; Strata of Jatiluhur formation; Until Sta. 92km: mainly mudstone Sta. 92 to 99.8km: pyroclastic rocks (tuff brecciated lava, lapilli tuff) Cover layer; Old volcanic sediment in the high altitude zone Talus deposit on the slope. It is assumed that thickness of talus deposit is thick when slope gradient is gentle.	Mainly Tunnel (NATM) Bridge Cutting	N value of Jatiluhur formation is high. Slaking of bed rock Talus deposit accumulates in the valley from Sta. 82.4 to 89.5 km and has existing slope failure/collapse. Especially talus deposit is thick in the section from Sta.88.6 to 89.5km, a part of tunnel and entrance f tunnel are planned in the talus deposit, and earth covering of this section is thin. Near the entrance of tunnel section from Sta.88.1 to 88.5km, an occurrence of slope collapse is concerned at the time of tunnel construction. Therefore, it is necessary to examine appropriate construction method and tunnel support.
99.8～112.9	Bed rock; Citarum Formation; Mainly composed of pyroclastic rocks such as tuff brecciated lava, lapilli tuff and tuffacious sand Cover layer; Old volcanic sediment in the high altitude zone	Mainly tunnel (NATM) Bridge Cutting	N value of tunnel section is more than 50(converted n value: 100 to 200). Well consolidated.
112.9～113.5	Old Volcanic Sediment	Tunnel	It is mainly composed of Clayey soil with N value is around 10.
113.5～116.0	Fan Deposit on the foot of Mountain	Tunnel	It is mainly composed of unconsolidated sandy soil which N value ranges from 30 to 50. Relatively compacted. This layer has abundant groundwater, therefore, a concentrated inflow at the time of construction of tunnel and collapse of cutting face due to concentrated inflow is concerned.

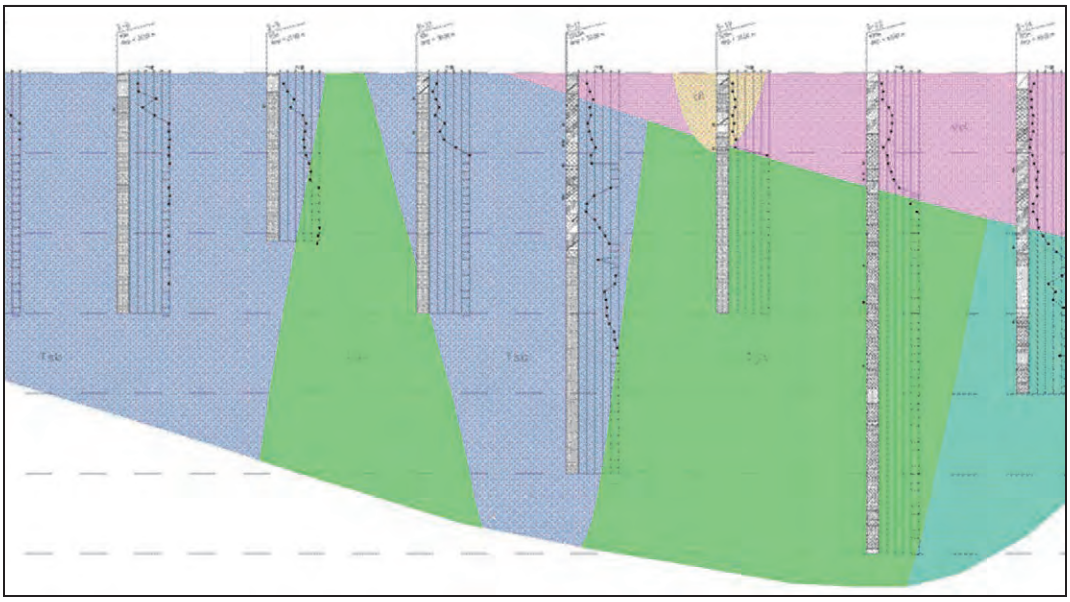


Figure 4.2-5 Schematic Cross Section(Hilly land – Mountainous Area)

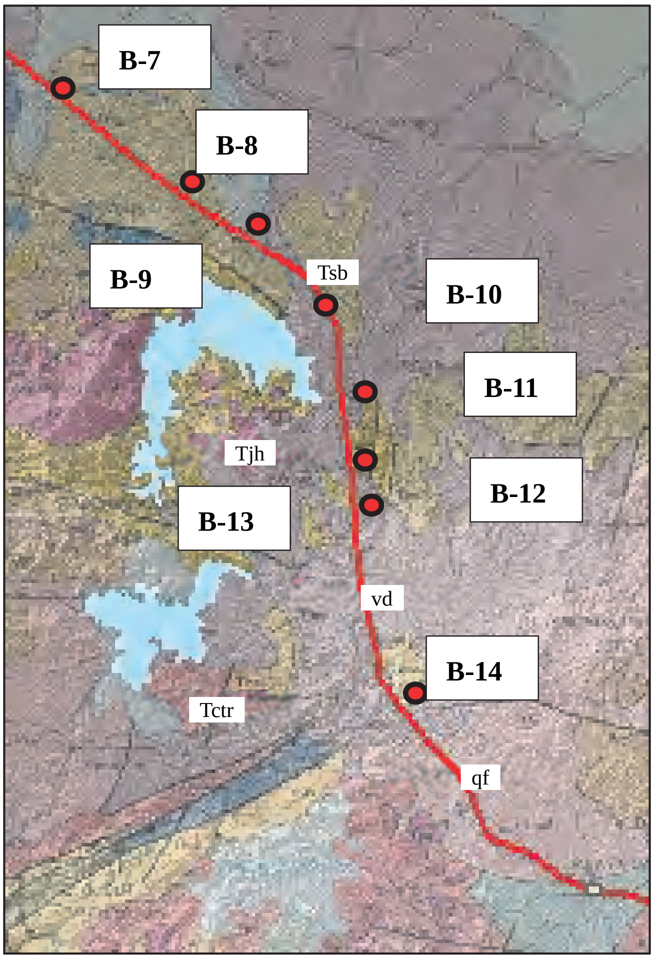


Figure 4.2-6 Location Map of Boring in this Survey

(2) Geotechnical Characteristics

1) Estimation of the Condition of Rock Mass based on the N-Value

a) Old Volcanic Sediment

This sediment is mainly consisted of clayey sediment and partially consisted of sandy sediment and gravel.

Origin of these sediments are pyroclastic rocks and volcanic ash which were produced by the volcanic activity of Mt. Tangkuban Perahu and old volcanic sediment is mainly composed of the secondary deposit of pyroclastic rocks and volcanic ash.

Basically sediment of this layer is low consolidated and unconsolidated. Although sediment in the deeper part is generally compacted, concreteness of this layer is varied and generally, N-value is less than 25.

Isolated unconfined aquifer is thought to be formed in this sediment based on the change of groundwater level of borehole at the time of boring survey.

b) Base Rock

The bed rock to be called here means geological formations which were formed in Miocene epoch in the Neocene and main geological component in the hill land and mountainous area, such as Citarum formation Jatiluhur formation and Subang formation.

Strata composing these geological formation is basically well consolidated in the fresh zone, however, these rocks are classified into “soft rock”.

Table 4.2-6 shows the range of N value of fresh zone of each geological formation.

Table 4.2-6 Rang of N-value of the Fresh Zone of each Geological Formation

Name of Geology/ Formation	Old Volcanic Sediment	Subang Formation	Jatiluhur Formation	Citarum Formation
Range of N -value	<25	50～80	100～300	100～300

In this survey, mechanical test for base rocks is not carried out. However, mechanical test should be carried out for the design of structure.

2) Examination of Special Ground

In this section, examination result of special ground along the planned HSR route from the view of disaster prevention is described.

a) Landslide/ Slope Failure

- **Outline of Landslide in the Study Area**

Figure 4.2.7 shows the distribution map of landslide/ landslide prone area published by Geological Agency Ministry of Energy Mineral Resources (Purwakarta- Bandung, Hilly land- Mountainous area). Generally except area displayed in this figure, location of landslide or landslide prone area is limited.

According to Figure 4.2-7, there is a few areas that has high susceptibility to landslide (red colored area).

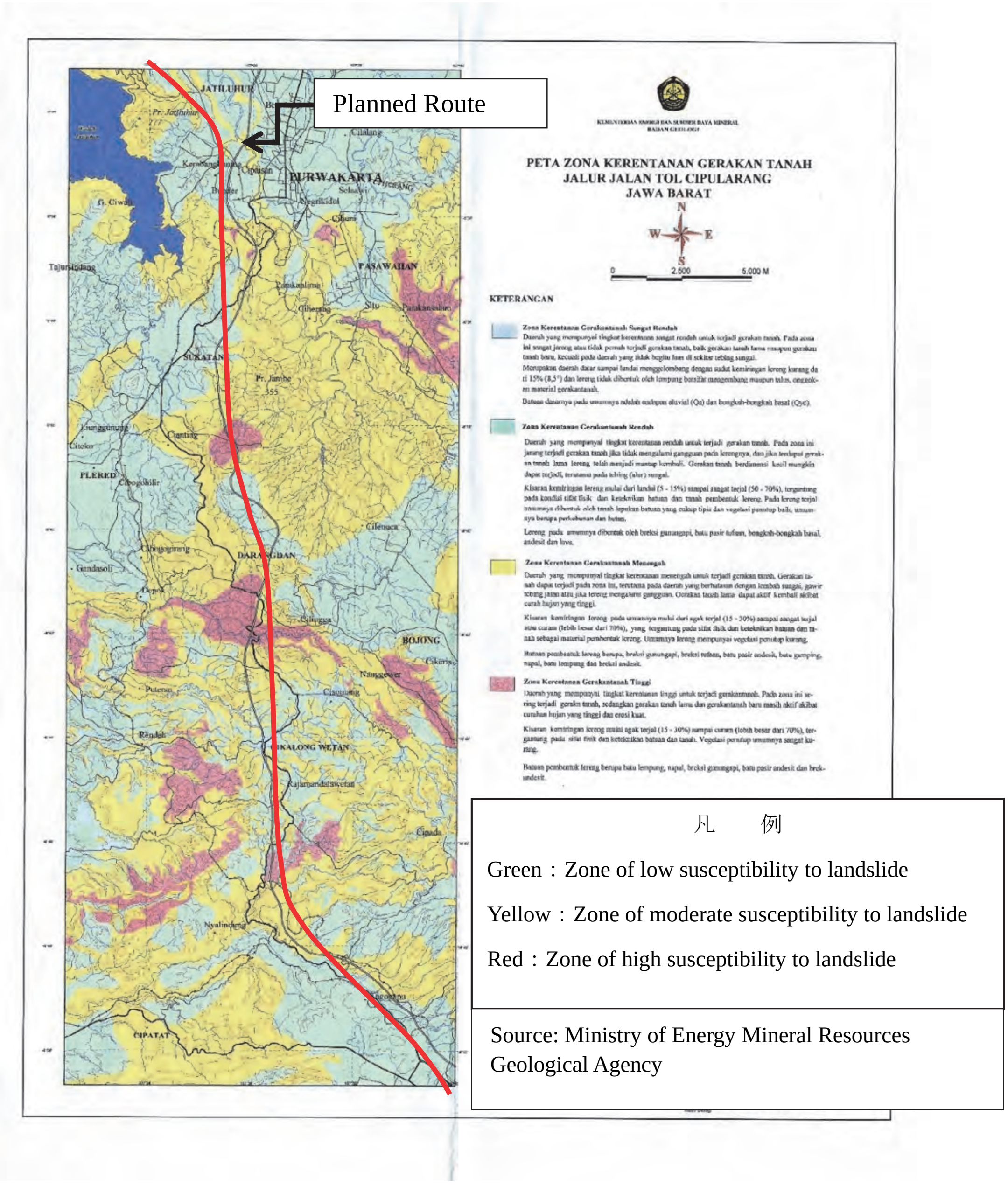


Figure 4.2-7　Landslide Prone Area along the Planned HSR Route

- **Outline of Existing Landslide and Slope Failure**

Based on the result of field survey, type of landslide and slope failure along the planned HSR route is divided into five types as mentioned below.

① Middle to large size landslide which has a sliding surface in the base rock

② Landslide which has a sliding surface along the geological boundary between Old volcanic sediment and base rock

③ Slope failure/collapse caused by lateral erosion by river

④ Slope failure/ collapse prone area which talus deposit accumulates relatively thick

⑤ Slope Failure/ Collapse on the slope, which is composed of old volcanic sediment, caused by artificial change of slope configuration and erosion by rainfall or river water

Followings describe details above mentioned type.

① Middle to large size landslide which has a sliding surface in the base rock

Figure 4.2-8 shows an example of landslide of this type along the planned HSR route near the interchange of Jatiluhur.

Primary cause and cause of the occurrence of this landslide is thought to be as follows;

<Primary cause in terms of geological and geotechnical side>

Geology around this landslide area is comprised of mudstone of Subang formation. The geological structure of this slope has a gentle dip-strike structure. Mudstone that is noticeably distributed near the ground surface becomes soft due to weathering. That weathered zone repeats landslide activity intermittently or continuously. As a result of repeatedly landslide activity, this weathered zone becomes even softer and has properties and conditions the same as talus deposit. This landslide is active at present.

<Cause of Occurrence of Landslide>

The main cause of the occurrence of landslides is thought to be high groundwater level as follows;

- ✓ Topographical features that easily collect surface water
- ✓ Collected surface water easily infiltrates into ground

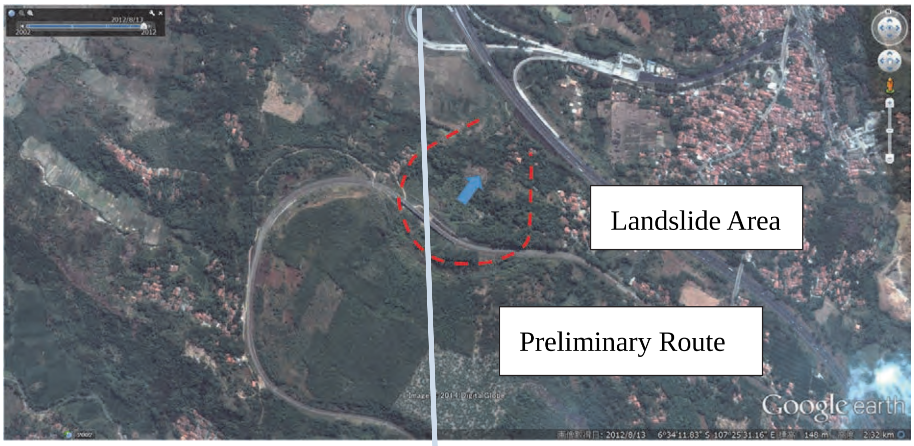


Figure 4.2-8
Examination of Planned route due to an Existence of Landslide Area Sta. 81km

The existing railway passes through this landslide area by using a bridge. At the time of construction of the bridge, a piling work as a landslide countermeasure was constructed, however, this piling work is completely useless at present. Therefore continuous repair work at the joint of bridge due to displacement of bridge by landslide activity has been carried out by P.T .KAI.

Present Condition of Piling Work near the Existing Railroad Bridge	**Repair Work at the Joint of Bridge**
	

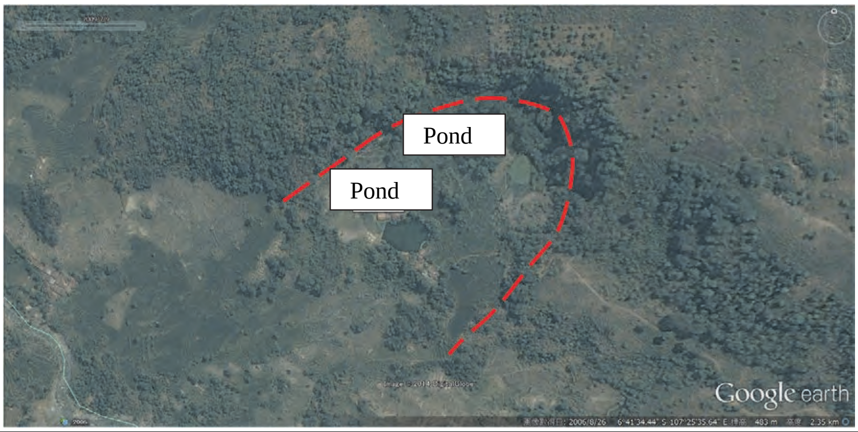
Figure 4.2-9　Condition of Existing Landslide (Sta. 81km)

② <u>Landslide which has a sliding surface along the geological boundary between old volcanic sediment and base rock</u>

Figure 4.2-10 shows an example of landslide of this type. This landslide is located at about 1.5km on the west side from planned HSR route Sta.96km.

This landslide has a sliding surface along the geological boundary between old volcanic sediment and base rock (Jatiluhur formation). An aquifer is formed in the lower part of old volcanic sediment, and spring water from this aquifer was thought to be a cause of the deterioration in slope stability.

Landslide of this type has not been identified along the planned HSR route.



Landslide (1.5km west from planned HSR route of Sta.96km)
Boundary between Old volcanic sediment and Jatiluhur formation

Figure 4.2-10　Satellite Image of Landslide

Type ① and ② of landslide has continuous /intermittent activity and has typical ground configuration of landslide. Therefore it is possible to extract the landslide area by satellite imagery interpretation and topographical interpretation.

③ <u>Slope failure/collapse caused by lateral erosion by river</u>

Figure 4.2-11 shows an example of slope failure/ collapse of this type. This slope failure is located along the existing railway near the planned HSR route Sta.82.5km.

Slope failure of this type has occurred continuously/ intermittently. The area of slope failure extends gradually to existing railway. As a result, the line of existing railway collapsed due to slope failure.

Mechanism of Slope Failure

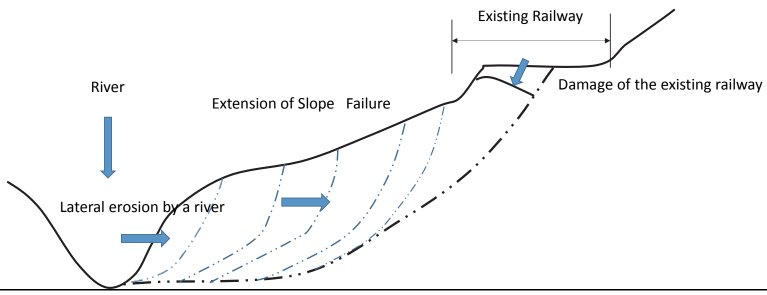


Figure 4.2-11 Example of Existing Slope Failure along the Existing Railway

④ <u>Slope failure/ collapse prone area with relatively thickly accumulated talus deposit</u>

Figure 4.2-12 shows a prone area of slope failure/ collapse. This slope failure is located along the planned HSR route Sta.89.3km.

Talus deposit of this slope is composed of the sediment of which origin is old volcanic sediment and base rock (Jatiluhur formation). When construction work of the entrance of tunnel conducted, slope failure of this slope is concerned.

Planned HSR Route 89.3km

(Boring B-12)

Photo of slope, entrance of tunnel

Area which is surrounded by a white dashed line has thickly accumulated talus deposit.

From Sta. 89.1km to 89.5km tunnel is planned to be constructed in a section with thin earth covering, therefore slope failure/ collapse is of concern at the time of construction of tunnel entrance.

Figure 4.2-12 Slope Failure Prone Area along the Planned HSR Route (Sta. 89.3km)

In addition, as a type of slope failure/ collapse, the following type can be seen. Generally, size of slope failure is thought to be small for this type.

⑤ Slope Failure/ Collapse on the slope, which is composed of old volcanic sediment, caused by artificial change of slope configuration and erosion by rainfall or river water

The size of this slope failure is relatively small. Therefore, it is not thought to be a problem on the design and construction of the HSR compared to other types of landslide and slope failure.

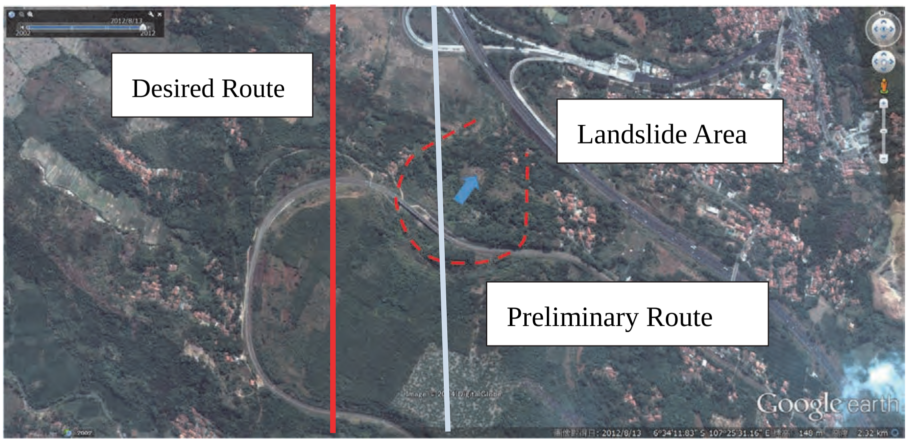
- **Correspondence and Existing Countermeasures for Landslide/ Slope Failure**

① Correspondence for the Existing Landslide（by this study）

In this study, as for a design of alignment of HSR, topographical interpretation of landslide was carried out. Topographical interpretation was carried out by using satellite imagery (Google Earth). Based on the topographical interpretation, landslide area and landslide prone area were checked and selected. Then field reconnaissance of selected landslide area and landslide prone area was carried out.

From the result of these, a suggestion to the design of alignment of HSR was conducted. A concrete suggestion to the design is as follows;

As described before, there is an existing landslide area around Sta. 81km along the preliminary HSR route, and preliminary HSR route was planned to pass this landslide area. Therefore, based on the result of this survey, a suggestion was made for the alignment of the HSR route to avoid passing the landslide area. And it was suggested that HSR alignment should pass through a ridge in the west side of preliminary HSR route (see Figure 4.2-13).



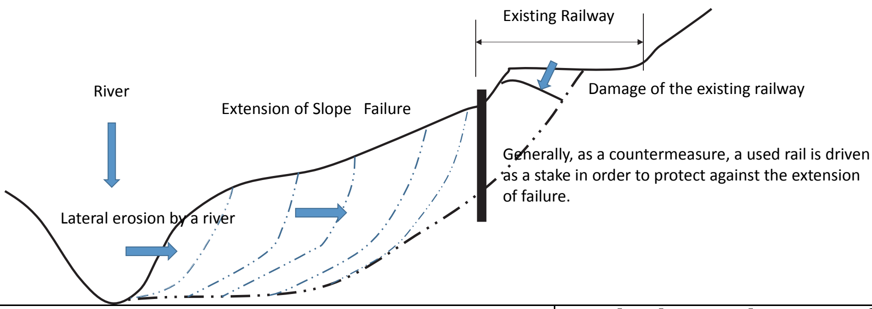
Suggetion to the Alignment of HSR Route (Sta. 81 ㎞)

Figure 4.2-13 Suggestion to the Alignment of HSR Route

② <u>Existing Countermeasure for the Slope Failure (Type③ above) by PT.KAI</u>

Figure 4.2-14 shows an example of existing countermeasure for the slope failure by PT.KAI. Basically, some of used rail were driven into slope as a piling work without any slope stability analysis. Therefore it seem to be an emergency measure.

General Countermeasure for Slope Failure



Used rails were driven into failed slope in order to prevent further slope failure.
Althoug extention of slope failure has not been occurred in this slope after the completion of this slope prevention work, this prevention work is not accepted as a permanent measures for prevention of slope failure.

Figure 4.2-14 Existing Countermeasure for the Slope Failure (Type③) by PT.KAI

b) Unconsolidated Ground

Except talus deposit on the slope, following two types of geology corresponds to unconsolidated ground.

① Old Volcanic Sediment

② Fan deposit on the Foot of Mountain

When unconsolidated ground comes in contact with water, washout of the face, large amount of groundwater or collapse, ground settlement or cave-in may occur when the depth is small.

① Old Volcanic Sediment:

This layer distributes in the mountainous area of section between Purwakarta to Bandung. This layer covers base rocks unconformity. In this layer, an aquifer exists, when a tunnel is constructed in this aquifer, collapse of tunnel face at the time of construction work can be concerned. On the other hand, depending on groundwater usage around tunnel area, an impact on groundwater usage can be considered.

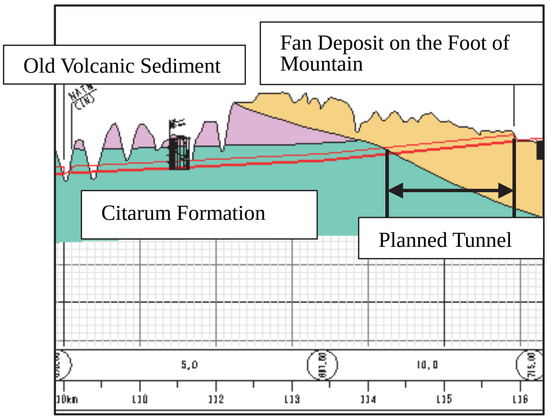
② Fan Deposit on the foot of Mountain:

This layer distributes near the entrance and western part of Bandung flat plain area. This layer is mainly comprised of sand, has high groundwater level. Although condition is relatively firm this layer is classified into unconsolidated ground. When a tunnel is constructed in this layer, concentrated inflow into tunnel and collapse of tunnel face at the time of construction work can be concerned as well as the old volcanic sediment. On the other hand, this layer does not have any anxiety about ground liquefaction of flow based on the result of laboratory test which was carried out in this study.

In principle, it should avoid construction of tunnel in these layers, however, if it cannot be avoided, a section to pass these layers should be short as much as possible.

Table-7.4.7 shows a suggestion given by the result of geological survey to the design of tunnel route.

Table-7.4.7 Suggestion to the Design of Tunnel due to Unconsolidated Ground

	According to the preliminary route of HSR, a tunnel is planned to pass through the fan deposit on the foot of mountain about 700m section. However, it is assumed that a concentrated inflow into tunnel and collapse of tunnel face at the time of construction will occur and length of tunnel section in this layer should be short, therefore, a suggestion on design tunnel is made.

c) Squeezing Ground

Based on the result of field reconnaissance and laboratory test of this project, a phenomenon of slaking can be identified in the area which geology is comprise of mud stone of Subang formation at the industrial development area around Karawang- Purwakarta. Due to the slaking phenomenon, rock mass of mudstone will turn into mud and small pieces. This phenomenon will be a cause of instability of cutting face of tunnel and cutting slope.

When a tunnel and cutting slope are constructed in the mudstone distribution area, repetition of dryness and moisture condition after construction will trigger a slaking phenomenon. Therefore, appropriate design and construction method against the slaking is needed.

Figure 4.2-15 shows the condition of slaking phenomenon at the Karawang industrial development area and river bed near Sta.96.5km.

Mudstone of Subang Formation at Karawang Industrial Development Area	**Mudstone of Jatiluhur Formation at near Sta. 96.5km**
	

Figure 4.2-15 Condition of Slaking Phenomenon of Mudstone

Table 4.2-8 shows the section which distributes mudstone of Subang formation and Jatiluhur formation.

Table 4.2-8 Section which Distributes Mudstone of Subang and Jatiluhur Formation along the Planned HSR Route

Geological Formation	Section（Sta.㎞）	Note
Subang Formation	49.7～76.km 77.1～82.4km	
Jatiluhur Formation	76.3～77.1km 82.4～99.8km	In the southern part from Sta.92km along the planned route, pyroclastic rock and mudstone are distributed alternately, however, details of the distribution of mudstone and pyroclastic rock does not understand yet.

For these section, an execution of shotcrete immediate after cutting slope and planning of appropriate tunnel support is necessary. Furthermore, monitoring and observation at the time of construction work is important.

3) Ground Classification of Tunnel Section

Table 4.2-9 shows a proposed ground classification of tunnel based on the result of geological survey until now.

Table 4.2-10 shows the ground classification of railroad tunnels and Table 4.2-11 shows classification of the type of rock/soil respectively.

Table 4.2-9 Proposed Ground Classification of Tunnel Section

Name of Geology/ Formation	Old Volcanic Sediment	Fan Deposit on the Foot of Mountain	Subang Formation		Jatiluhur Formation		Citarum Formaton	Andesite Dyke
			Mudstone	others	Mudstone	others		
Type of Ground[1)]	F (Clayey)	G (Sandy)	E	E	E	E	E	C
Class of Ground[2)]	Is	I_L	Isp	I_N	Isp	I_N	I_N	I_N

Source 1) 2): Japan Railway Construction Public Corporation (1996) Guide for Design and Construction of NATM

Table 4.2-10 Ground Classification of Railroad Tunnels

Type of Rock/Soil / Class of Ground	Hard Rock			Medium Rock	Soft Rock	Soil	
	A	B	C	D	E	F Clayey	G Sandy
V_N	V_P≧5.2		V_P≧5.0	V_P≧4.2			
IV_N	5.2>V_P≧4.6		5.0>V_P≧4.4	4.2>V_P≧3.4			
III_N	4.6>V_P≧3.8	V_P≧4.4	4.4>V_P≧3.6	3.4>V_P≧2.6 and Gn≧5	2.6>V_P≧1.5 and Gn≧6		
II_N	3.8>V_P≧3.2	4.4>V_P≧3.8	3.6>V_P≧3.0	2.6>V_P≧2.0 and 5>Gn≧4	2.6>V_P≧1.5 and 6>Gn≧4		
I_N	3.2>V_P≧2.5	3.8>V_P≧2.9	3.0>V_P≧2.5	2.6>VP≧2.0 and 4>Gn≧2 or 2.0>V_P≧1.5 and Gn≧2	2.6>VP≧1.5 and 4>Gn≧2	Gn≧2	80≦Dr
I_S	2.5>V_P	2.9>VP	2.5>VP	1.5>VP or 2>Gn≧1.5	1.5>VP or 2>Gn≧1.5	2>Gn≧1.5	-
I_L						-	80≦Dr and 10 Fc
S_S				1.5>Gn	1.5>Gn	1.5>Gn	-
S_L							80>Dr

Vp: Velocity of Primary Wave, Gn: Competence Factor, Dr: Relative Density, Fc: Fine Fraction Content
Source : Standard Specifications for Tunneling-2006 (Mountain Tunnels) Japan Society of Civil Engineers

Table 4.2-11 Classification of the Type of the Rock/Soil

Type of Soil/Rock	Name of Layer/ Geology
A	1) Paleozoic Strata/Mesozoic Formation(Slate, Sandstone, Conglomerate,Chart, Limestone, etc.) 2) Plutonic Rocks (Granite, Granodiolite, etc.) 3) Hypabyssal Rock (Porphry, Porphyrite, Diabase) 4) Volcanic Rock (Andesite, Basalt, etc) 5) Metamorphic Rock (Schist, Gneiss, etc.)
B	1) Metamorphic Rock with remarkable Delimination (Gneiss, Schist, etc) 2) Paleozoic Strata/ Mesozoic Formation with remarkable Delimination or fine laminaPhylite, Slate, Shale)
C	1) Mesozoic Formation (Shale) 2) Volcanic Rock (Andesite, Quartz Rhyolite, Ryolite) 3) A part of Paleogene Formation (Silicic Shale, Silicic Sandstone)
D	Paleogene to Neogen (Shale, Sandstone, Conglomerate, Tuff, Tuff Brecciated Lava,etc.)
E	Neogene (Mudstone, Siltstone, Sandstone, Tuff, etc.)
F	Diluvium, a part of Neogene (low-consolidated strata, unconsolidated strata, Clayey layer, Sandy layer, etc.)

Source : Standard Specifications for Tunneling-2006 (Mountain Tunnels) Japan Society of Civil Engineers

4) Embankment

In this section, not only hilly land - mountainous area but also Jakarta and Bandung flat plain area is described.

<u>Load Bearing Layer of Embankment:</u>
According to the result of geological survey in this study, there is no problem on the construction of embankment as described below;

- Geology of Subang formation, Jatiluhur formation and Citarum formation which distribute in the hilly land – mountainous area is basically classified into soft rock. Therefore, it is no problem to use these geology as a load bearing layer of embankment.
- Alluvium and Diluvium that distribute in Jakarta flat plain area are not concerned about liquefaction. Both of them are composed of clayey sediment, except the sediment distributing in a part near ground surface, almost all layers of Alluvium and Diluvium satisfies the required condition as load bearing layer of embankment.
- Lake deposit that distributes in Bandung flat plain area is generally composed of very soft sediment. Although this layer satisfies the performance rank II and III, it does not satisfy the rank I. However, there is no section of embankment in Bandung flat plain area and almost all section is planned as viaduct.

<u>Embankment Materials;</u>
Soil sample of diluvium that was collected from boring B-2,3,4 and 5 is classified into soil group of CH. According to the Design Standard of Railway Structure/ Explanation, soil that classified into CH has properties of high compressibility and poor workability and when this soil uses for embankment materials, an adequate measures are necessary.

5) Impact on Water Usage by the Construction Tunnel

① Areas to be concerned about Impact

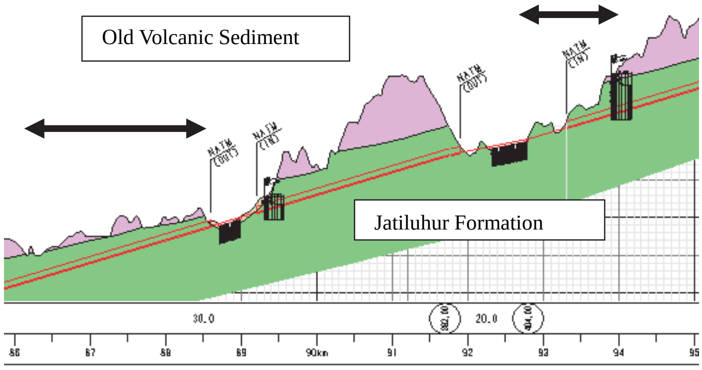
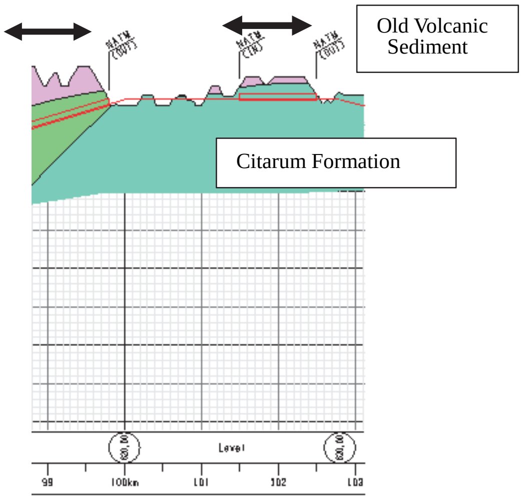
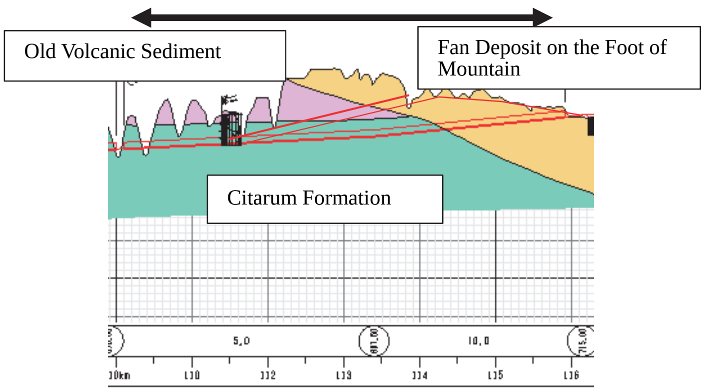
When a tunnel is planned to construct areas below, an impact on water environment, such as water usage, due to lowering of groundwater level is considered.

- Immediately underneath of the valley topography and shallow underground of a ledge which are used as paddy field
- Near a water well

② Section to be concerned about impact along the planned HSR route

Table 4.2-12 shows the section to be concerned about impact along the planned HSR route by the construction tunnel.

Table 4.2-12 Section of Concern Regarding the Impact along the Planned HSR Route

	**a)** **86-88.5km:** Tunnel route is planned as relatively low ground covering section. Land use at present is a forest and paddy field is abandoned. **93-94km:** Tunnel route is planned as relatively low ground covering section. Low land near at 93.5km is used as paddy field.
	**b)** **99.5-103.5km:** Tunnel route is planned as relatively low ground covering section. Land of ground surface is used as forest and tea plantation, and no paddy field therefore this section does not have a concern about impact on paddy field.
	**c)** **110.0-114km:** Tunnel route is planned as relatively low ground covering section. Section between 110 and 112km, land on the bottom of valley and top of the ledge is used as paddy field. Note) HSR route shown on upper part of figure is modified route after the suggestion against unconsolidated ground.

③ Geological condition and groundwater along the tunnel section

The sections mentioned in the Table 4.2-12, geology is comprised of old volcanic sediment and base rock. Base rock is covered with old volcanic sediment. The old volcanic sediment and base rock have aquifers in its body individually. Almost all tunnel section in the Table 4.2-12 planned below groundwater level. On the other hand, geology of Subang formation and Jatiluhur formation is comprised of mud stone and pyroclastic rocks. As far as it can tell from the result of field investigation, permeability of those geology (mud stone and pyroclastic rock) is thought to be low.

④ Method of water intake for the paddy field and water usage around tunnel section

<Paddy Field>

The source of water supplying to the irrigated paddy field is mainly river water. Those rivers roses from the north-west side slope of Mt. Tangkuban Perahu. In the process of river flow to downstream, it is assumed that spring water from the aquifer of the old volcanic sediment and base rock is collected into the river flow. In such case, if groundwater level is lowered around tunnel section due to the impact on construction tunnel, it is assumed that amount of water that supplies to the irrigated paddy field does not decrease remarkably.

On the other hand, section between 93 and 94km, the source of water to the paddy field is manly rainwater and it is called un-irrigated paddy field/ rainwater paddy field (Table 4.2-12.a)). Geology of tunnel section is comprised of Jatiluhur formation and old volcanic sediment does not distribute on the upper part of Jatiluhur formation. It is concerned about the impact on water supply to the paddy field caused by construction tunnel in this section.

<water well, etc.>

Although old volcanic sediment and abase rock have aquifers in its body individually, permeability of old volcanic sediment and base rock is thought to be low. Therefore basically groundwater use at present is thought to be very limited.

⑤ Impact on water usage and monitoring

The information and data of water usage around study area is very limited at the present. In order to grasp the impact on water usage by the construction of tunnel, a systematic monitoring is needed from now on. Example of monitoring item is flow rate of rivers and groundwater level. Furthermore, monitoring work should be continued after the commencement of construction work, therefore, items and location of monitoring work should take into this point consideration.

4.3 Disaster Prevention Measures

(1) Protection Work of Cutting Slope

As the method of protection work of cutting slope, appropriate inclination of slope should be examined applied.

Then basically as for a protection work, planting work should be selected.

Although old volcanic sediment and abase rock have aquifers in its body individually, permeability of old volcanic sediment and base rock is thought to be low. Therefore basically groundwater use at present is thought to be very limited. When it is difficult to keep slope stability only by the planting work, combination work with other method should be examined. Table 4.3-1 shows the type of combination protection work.

Table 4.3-1 Main Measures for Slope Protection Work

Major Solution	Measures
Slope Protection	Shotcrete (mortar, concrete), Masonry, Block Lining, etc。
Retaining wall	Enlarged retaining wall (in case that a tunnel intersects or oblique to slope)
Cut for Slope Stabilization or Counterweight fill	Soil cement
Vertical Reinforcement Bolt	Vertical Reinforcement Bolt
Anchoring	Prevention Pile, Ground Anchor
Drainage	Well Point Drainage, Drainage Boring, Deep Well

Source: Standard Specifications for tunneling-2006: Mountain Tunnels, Japan Society of Civil Engineer

Consideration for the appropriate design of cutting slope for main geology type along the planned HSR route is listed below.

- It is very important to prevent weathering of slope, when cutting slope is constructed in the mudstone of Subang formation and Jatiluhur formation.
- In Jakarta flat plain area, cutting slope will be constructed on the slope which mainly is comprised of silt and volcanic silty soil, and partially fine gravel and fine sand. Therefore, appropriate height and gradient of slope should be examined and designed with suitable slope protection method.
- In Bandung flat plain area, cutting slope will be constructed on the slope which mainly is comprised of sandy soil which relatively well graded. Therefore, appropriate height and gradient of slope should be examined and designed with suitable slope protection method.
- Prevention measures for erosion by rainwater
- For a suitable measures for above mentioned cutting slope protection, shotcrete, masonry and Block Lining are recommendable.

Table 4.3-2 shows examples of cutting slope protection work.

Table 4.3-2 Example of Cutting Slope Protection Work

	
Block Lining	Shotcrete (Mortar)

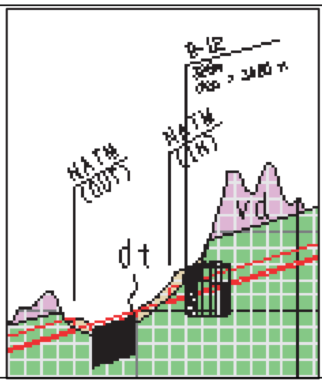
(2) Prevention Measures for a Slope Failure of Portal Zone

Generally, construction in the portal zone, sometimes induces a slope failure or landslide. This is attributed to loosening because of tunnel excavation or slope cut for the construction of the portal. Therefore, during the construction of a portal, the portal is constructed by cutting while using shotcrete, rock bolts or other measures to stabilize natural slope, to ensure safe and simple tunnel excavation.

For the design of portal zones and portals, it is important that the design engineer must decide on an appropriate portal structure construction method, portal form, portal shape and the portal structure by giving sufficient consideration to natural condition, such as the topographic features, geology, groundwater and weather, and social environment in the vicinity of the portals.

Generally it is said that deep cutting of a slope to shorten the tunnel length is likely to cause slope failure or landslide, and it should be avoided. When the portal slope is unstable, positioning the portal slightly forward in combination with counter-weight fill often produces a favorable condition.

Figure 4.3-1 shows a cross section of a slope failure prone area around B-12. Talus deposit (dt) of a cover layer is composed of clayey soil and groundwater level is at the geological boundary of talus deposit (dt) and Jatiluhur formation (Tjh). Depend on the result of further detailed survey and examination, to position the portal slightly forward in combination with counter-weight fill, or the design of highly durable tunnel support for resisting the acting load are required for a prevention of slope failure.



Legend of Geology
dt; Talus Deposit

vd: Old Volcanic Sediment

Tjh: Jatiluhur Formation

Tj

Figure 4.3-1 Cross Section near B-12 point

Appendix 2

(2) Geological Condition and the Change of Groundwater Level by the Boring Survey

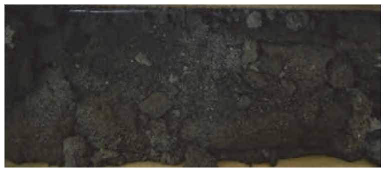
1 B-1：Shield Tunnel Section (Length:21m Sta. 9.8km, Along the Plan B Alignment)

Geology of B-1 is composed of Diluvium. Sediment of Diluvium is comprised of clay with volcanic ash, sandy soil and sand with gravel, etc. Diluvium is covered with thin surface soil. Upper part of Diluvium suffers remarkable influence of weathering and turns into laterite. Lower part of Diluvium is compacted compared to upper part.

Groundwater level change at the time of boring is shown in Figure-1 and below;

When it was drilled at GL.-13m, groundwater appeared at GL.-6m. After that parallel to the drilling work groundwater level was lowering.

Table-1 Geological Condition and N-value (B-1)

Depth (GL-m)	Geology	N-value	Description	Photo of Core
0～0.3	Surface soil	-	A piece of broken glass and vinyl can be seen.	-
0.3～7.0	Diluvium	2～10	Clay to silt with volcanic ash with reddish brown color. Consistency is soft and not compacted. Gravels are included. High value of N-vale in this section is thought to be a due to the gravel	 GL-0.5m Clay with volcanic ash
7.0～21.0		36～50	It is comprised of clay with volcanic ash, sandy soil and sand with gravel. Above groundwater level (GL.-10.3m), sediment colors reddish brown because of oxidation. Below groundwater level (GL.-10.3m), it colors dark gray to black color. Sandy soil can break by digital compression.	 GL-7.5m Clayey sand with gravel  GL-19.6m Sand with gravel

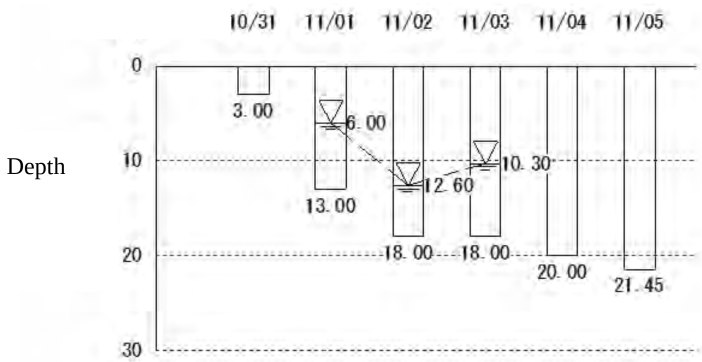


Figure-1 The Chang of Groundwater Level at the Time of Boring (B-1)

2 B-2 : Viaduct Section (Length:20m Sta. 10.6km, Along the Plan A Alignment)

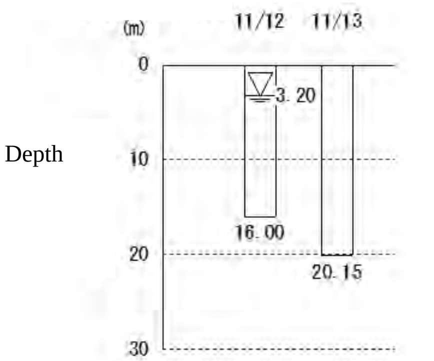
Geology of B-2 is composed of Diluvium as well as B-1 and Diluvium is covered with refilling soil. Sediment of Diluvium is comprised of clay with volcanic ash, clayey soil, sandy soil and sand with gravel. Although the upper part of Diluvium colors reddish brown because of oxidation, concreteness of sediment is well compacted.

N-value of refilling soil is low. This refilling soil was buried artificially at the time of construction of canal.

Groundwater level is GL.-3.2m.

Table-2 Geological Condition and N-value (B-2)

Depth (GL-m)	Geology	N-value	Description	Photo of Core
0～4.5	Refilling Soil	4～7	Clay with gravel. Grass root N-value is remarkable low. Not compacted.	 GL-2.8m Refilling soil
4.5～20.0	Diluvium	31～150	Clay with volcanic ash, sandy soil and sand with gravel. Above GL.-8m, it colors reddish brown obviously. Color of soil is transitioning from reddish brown to dark gray parallel with depth N-value is less than 50 above GL.-10m, however, generally N-value is high and well compacted.	 GL-4.7m Clay with volcanic ash  GL-12.7m Tuffacious sand with gravel



Figue-2 The Chang of Groundwater Level at the Time of Boring (B-2)

3 B-3 : Viaduct Section (Length:50m Sta. 23.3km)

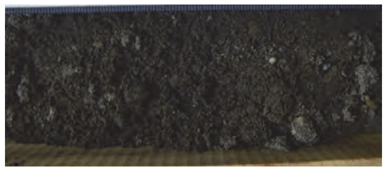
Geology of B-3 is composed of Diluvium and refilling soil as well as B-2.

Sediment of Diluvium is comprised of clay with volcanic ash, silt, sandy soil and sand with gravel. Generally N-value of B-3 is lower than the N-value of Diluvium of B-1 and B-2.

Groundwater level change at the time of boring is shown in Figure-3 and below;

When it was drilled at GL.-22m, groundwater appeared at GL.-7.8m. After that parallel to the drilling work groundwater level was lowering.

Table-3 Geological Condition and N-value (B-3)

Depth (GL-m)	Geology	N-value	Description	Photo of Core
0～1.4	Refilling Soil	7	Mainly comprised of reddish brown colored fine sand to silt with volcanic ash. A piece of plant and gravel of limestone can be seen. N-value is remarkable low. Not compacted.	 GL-0.7m Refilling soil (Gravel of limestone)
1.4～50.0	Diluvium	5～61	Clay with volcanic ash, silt, sandy soil and sand with gravel. Final groundwater level is GL.-21m. Above GL.-17m, it colors reddish brown obviously. Oxidation progress from the rim of core. Concreteness of sediment is low in general, however, turns better at the lower part. This tendency harmonizes with the change of N-value.	 GL-4.8m Silt with volcanic ash  GL-18.5m Fine sand  GL-36.5m Silt

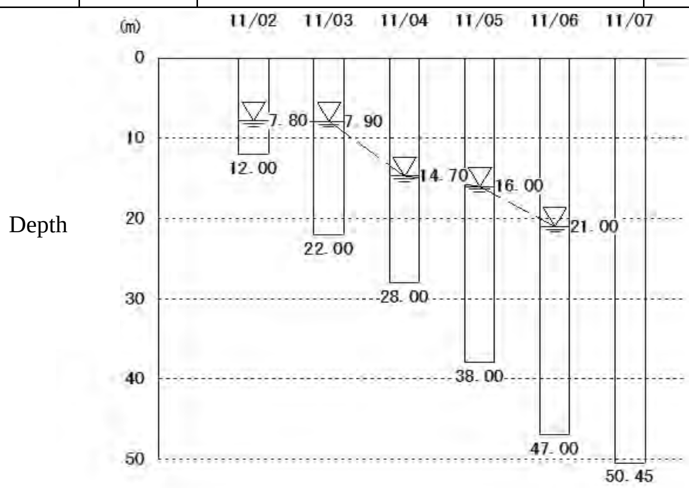


Figure-3 The Chang of Groundwater Level at the Time of Boring (B-3)

4 B-4 : Viaduct Section (Length:60m Sta. 30.2km)

Geology of B-3 is composed of Diluvium and Alluvium.

Sediment of Diluvium is comprised of silt and sandy with volcanic ash. N-value of upper part of this sediment ranges from 20 to 30 and is slightly low.

Alluvium that covers Diluvium is comprised of silt and sand with gravel. Partially N-value is high however this is due to gravel.

Groundwater level change at the time of boring is shown in Figure-4 and below;

When it was drilled at GL.-7m, groundwater appeared at GL.-2.4m. After that parallel to the drilling work groundwater level was slightly lowering. When section from GL-35m and 41m was drilled, groundwater level slightly rose. Geology of this section is comprised of silt or silty-sand that means it does not have high permeability. Therefore, the reason of the rise of groundwater level is not due to confined groundwater and is due to standing water of rainwater or surface water.

Table-4 Geological Condition and N-value (B-4)

Depth (GL-m)	Geology	N-value	Description	Photo of Core
0～1	Surface Soil	-	-	-
1～20.2	Alluvium	5～38	Silt to sand with gravel, Above GL.-8.7m, it colors brown. Section from ground surface to GL.-3m, concreteness of sediment is soft. Lower than GL.-3m, N-value ranges from 16 to 38. Partially N-value is high however this is due to gravel.	 GL-10.6m Fie sand with gravel
20.2～60	Diluvium	11～52	Silt and sandy soil with volcanic ash It colors brown and blueish gray. N-value is low in general and ranges from 15 to 30.	 GL-22.5m Silt  GL-52.5m Silt with volcanic ash

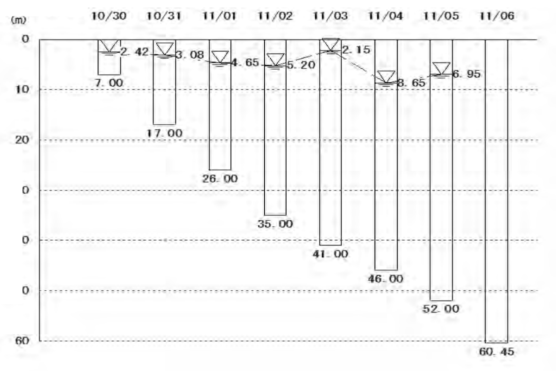


Figure-4 The Chang of Groundwater Level at the Time of Boring (B-4)

5　B-5：Viaduct Section (Length:50m　Sta. 38.2km)

Geology of B-5 is composed of Diluvium and sediment of Diluvium is comprised of sand with clay and gravel.

Soil of shallow part near the ground surface is not compacted by weathering. Deeper than GL.-19m concreteness of soil is well and consolidated.

Groundwater level change at the time of boring is shown in Figure-5 and below;

When section from GL-31m and 41m was drilled, groundwater level slightly rose. Final groundwater level is around GL.-20m.

Table-5　Geological Condition and N-value (B-5)

Depth (GL-m)	Geology	N-value	Description	Photo of Core
0～0.2	Surface Soil	-	-	-
1～50	Diluvium	5～61	Clayey soil and sand with gravel It colors dark gray or brown. Until GL.-19m, N value is low and soft. Deeper than GL.-19m, N value ranges from 21 to 61, concreteness is better than upper part.	 GL-10.6m Fine sand with gravel  GL-22.5m　Silt  GL-39.5m　Sandy silt with pumice

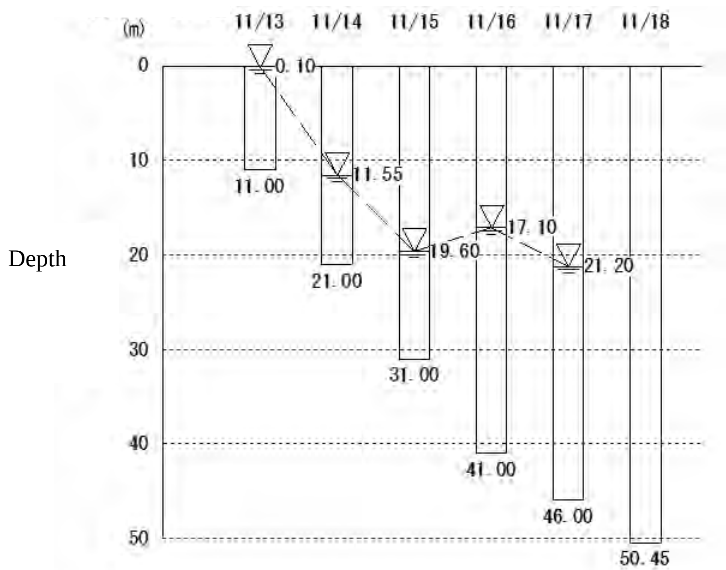


Figure-5　The Chang of Groundwater Level at the Time of Boring (B-5)

6　B-6：(Length: 30m　Sta. 48.0km)

Geology of B-6 is composed of Diluvium and Alluvium. Sediment of Diluvium is mainly comprised of silt. Concreteness of the fresh part is well. Sediment of Alluvium is mainly comprised of silt as well as sediment of diluvium. Concreteness is lower than sediment of Diluvium. In the sediment of Alluvium, blackish carbide and a chip of wood can be seen.

Groundwater level change at the time of boring is shown in Figure-6 and below;

Groundwater level is around GL.-11m and it fluctuated.

Sediment of Diluvium and Alluvium is mainly comprised of silt, therefore, permeability of these layer is thought to be low.

Table-6　Geological Condition and N-value (B-6)

Depth (GL-m)	Geology	N-value	Description	Photo of Core
0～19.45	Alluvium	3～14	Mainly comprised of silt and partially sand lamina Concreteness is not well and soft in the upper part. In the sediment of Alluvium, blackish carbide and a chip of wood can be seen.	 GL-7.5mSilt  GL-12.9m　SIlt
19.45 ～30	Diluvium	14～50	Silt with dark gray color Concreteness is better than alluvium. Partially gravel of scoria	 GL-29.5m　Silt

Depth

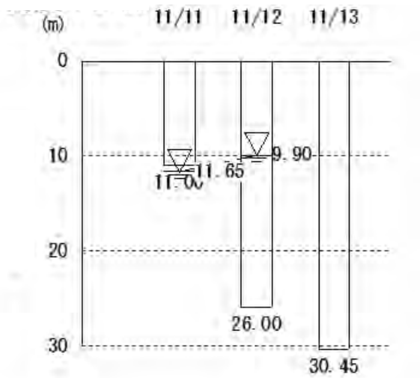


Figure-6　The Chang of Groundwater Level at the Time of Boring (B-6)

7　B-7：(Length: 30m　Sta. 51.0km)

Geology of B-7 is composed of Mudstone and Sandstone of Subang formation.

Concreteness of mudstone and sandstone of Subang formation is well compacted. In the surface part, it is slightly soft and colors reddish brown due to weathering.

Groundwater level change at the time of boring is shown in Figure-7 and below;

Groundwater level is around GL.-6m and stable. This aquifer is thought to be formed in the zone which has slightly high permeability because of weathering. By this reason, a possibility of concentrated inflow to a tunnel at the time of construction tunnel is very low.

Table-7　Geological Condition and N-value (B-7)

Depth (GL-m)	Geology	N-value	Description	Photo of Core
0～0.3	Surface Soil	-	Clayey soil with reddish brown color	-
0.3～15	Mudstone Subang formation	11～53	Mainly comprised of mudstone and partially lamina of sand and sand lens Although sediment is soft in the surface part due to weathering, concreteness becomes better toward to deeper part. Bedding structure can be seen clearly.	 GL-0.5m Mudstone(weathered)  GL-6.6m　Mudstone
15～28.8	Sandstone Subang formation	58～63	Sandstone with dark brown color. Mudstone gradually changes to sandstone. Concreteness of this layer is slightly compacted compared to above mudstone.	 GL-29.5m　Sandstone
28.8～30	Mudstone Subang formation	62～64	Mainly comprised of mudstone and partially lamina of sand and sand lens Dark gray color Well compacted and consolidated.	 GL-29.8m　Mudstone

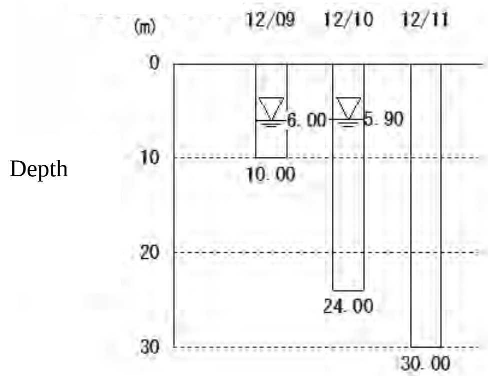


Figure-7　The Chang of Groundwater Level at the Time of Boring (B-7)

8　B-8：(Length: 30m　Sta. 69.3km)

Geology of B-8 is comprised of Mudstone of Subang formation. Cover layer distributes on the mudstone. Concreteness of mudstone is high. N-value is around 50 in fresh zone of depth deeper than GL.-6m. Cover layer is composed of clay and N-value is around 10.

Groundwater level change at the time of boring is shown in Figure-8 and below;

Groundwater level is GL.-4.6m. This aquifer is thought to be formed in the zone which has slightly high permeability because of weathering. This aquifer is thought to be an unconfined groundwater.

Table-8　Geological Condition and N-value (B-8)

Depth (GL-m)	Geology	N-value	Description	Photo of Core
0～3	Surface Soil Cover layer	10～11	Clay with reddish brown color. Basically base rock is mudstone however, due to hard weathered it becomes soil.	 GL-2.9m Cover layer
3～30	Mudstone Subang formation	11～53	It colors dark brown and dark gray. Mudstone near ground surface colors dark brown due to oxidation. N-value is around 50 in the zone which depth is deeper than GL.-6m. A shell is confirmed at depth of GL-28.6m.	 GL-12.9m Mudstone  GL-6.6m　Mudstone

Depth

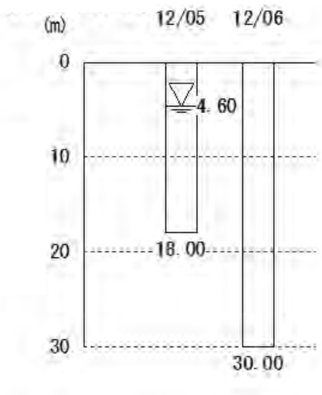


Figure-8　The Chang of Groundwater Level at the Time of Boring (B-8)

9　B-9：(Length: 21m　Sta. 73.2km)

Geology of B-9 is comprised of Mudstone of Subang formation, terrace deposit and surface soil.

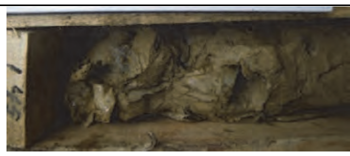
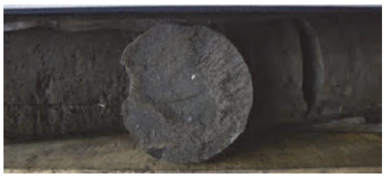
Mudstone of Subang formation, N-value is low near ground surface due to weathering and more than 50 in the deeper zone.

Terrace deposit is composed of silt without gravel. N-value is low.

Groundwater level change at the time of boring is shown in Figure-9 and below;

Groundwater level is GL.-4.2m. This aquifer is thought to be formed in the terrace deposit and weathered zone which has slightly high permeability. This aquifer is thought to be an unconfined groundwater.

Table-9　Geological Condition and N-value (B-9)

Depth (GL-m)	Geology	N-value	Description	Photo of Core
0～0.3	Surface Soil	-	Clayey soil with gravel and grass roots	-
0.3～2.4	Terrace Deposit	5～10	Silt with brown color Soft	 GL-0.5m Weathered mudstone
2.4～21	Mudstone Subang formation	14～57	Mudstone with dark brown color Although N-value is low near ground surface due to weathering, fresh zone in deeper part, concreteness is high. This mudstone includes sand lamina.	 GL-10.5m　Mudstone  GL-13.7m　Sand lamina in mudstone

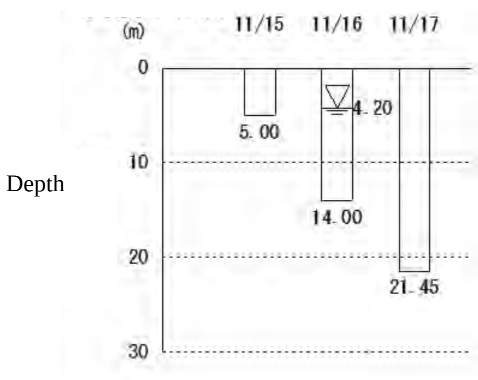


Figure-9　The Chang of Groundwater Level at the Time of Boring (B-9)

10　B-10：(Length: 30m　Sta. 77.2km)

Geology of B-10 is comprised of Mudstone of Subang formation and Jatiluhur formation, and surface soil.

Mudstone of Subang formation covers mudstone of Jatiluhur formation unconformity.

N-value of Mudstone of Jatiluhur formation is higher than Mudstone of Subang formation.

Mudstone of Jatiluhur formation is well consolidated and N-value is more than 50 (converted N-value ranges from 100 to 300).

Mudstone of Subang formation, N-value is low near ground surface due to weathering and more than 50 in the deeper zone.

Groundwater level change at the time of boring is shown in Figure-10 and below;

Groundwater level is GL.-3.15m. Groundwater level is lowering with the progress of drilling work.

Geology of Jatiluhur formation and Subang formation is mainly comprised of mudstone and permeability is thought to be low.

Table-10　Geological Condition and N-value (B-10)

Depth (GL-m)	Geology	N-value	Description	Photo of Core
0～0.4	Surface Soil	-	Clayey soil with sand and grass roots	-
0.4～22.8	Mudstone Subang formation	7～88	Mudstone with brown and grayish brown color Near ground surface, concreteness is low due to weathering, concreteness is high in the deeper zone.	 GL-22.7m Mudstone Subang formation
22.8～30	Mudstone Jatiluhur formation	60～188	Mudstone with dark gray color Mudstone of Jatiluhur formation is well consolidated, section between GL.-25 to28m is very well consolidated.	 GL-27.5m　Sandy part of mudstone Jatiluhur formation

Depth

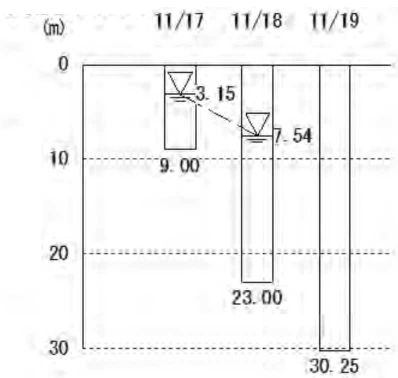


Figure-10　The Chang of Groundwater Level at the Time of Boring (B-10)

11　B-11：(Length: 50m　Sta. 81.6km)

Geology of B-11 is comprised of Mudstone, sandstone and lapilli tuff of Subang formation, and surface soil. Concreteness of mudstone becomes high deeper than GL.-35m. Sandstone and lapilli tuff have low concreteness and N-value is lower than mudstone. In the sandstone zone, partially N-value is high due to gravel.

Groundwater level change at the time of boring is shown in Figure-11 and below;

Groundwater level is GL.-15.7m. Groundwater level rose with the progress of drilling work from GL.-35 to 44m. And finally it lowered at GL.-15.5m. Geology of section from GL.-35 to 44m is comprised of mudstone, it is assumed that an aquifer is formed in the sandstone layer or cracks in this section. This aquifer is thought to be a confined groundwater.

Table-11　Geological Condition and N-value (B-11)

Depth（GL-m）	Geology	N-value	Description	Photo of Core
0～0.1	Surface Soil	-	Silt with gravel Brown color	-
0.1～23	Sandstone /Lapilli tuff Subang formation	9～40	Lapilli tuff and sandstone with low concreteness It colors dark reddish brown or brown because of oxidation. In the sandstone zone, partially N-value is high due to gravel. Generally, N-value ranges from 10 to 40.	 GL-6.8m ス Subang formation Clay with volcanic ash and pumice  GL-17.7m Subang formation Silty sand
23～50	Mudstone Subang formation	24～66	Mudstone with dark brown color Concreteness is high deeper than GL.-35m and N-value is more than 50.	 GL-23.7m Subang formation Mudstone

Depth

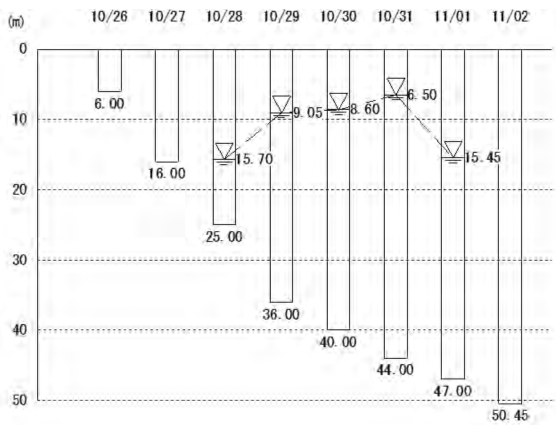


Figure-11　The Chang of Groundwater Level at the Time of Boring (B-11)

12 B-12 : (Length: 30m Sta. 8.3km)

Geology of B-12 is comprised of mudstone of Jatiluhur formation, talus deposit and surface soil.

Concreteness of mudstone of Jatiluhur formation is remarkably high, N-value is more than 50.

Talus deposit is composed of loose silt or sandy soil with brown color.

Groundwater level change at the time of boring is shown in Figure-12and below;

Groundwater level is confirmed at GL.-6.5m. Groundwater level is lowering to GL-9.5m. Depth of the boundary between talus deposit and Jatiluhur formation is GL.-9.6m. Therefore, an unconfined aquifer forms the bottom of talus deposit.

Table-12 Geological Condition and N-value (B-12)

Depth (GL-m)	Geology	N-value	Description	Photo of Core
0～0.1		-	Concrete	-
0.1～9.6	Talus Deposit	4～8	Loose silt or sandy soil with dark brown or brown color This deposit is composed of soil which accumulates debris produced by a slope collapse.	 GL-1.6m Talus deposit
9.6～30	Mudstone Jatiluhur formation	47～167	Mudstone with dark gray or black color Pumice fragment is included. Concreteness is very high and well consolidated. Maximum N-value (converted N-value) is more than 100. Groundwater level is around the boundary between talus deposit and mudstone. However, slickenside cannot be seen surface of mudstone of the boundary.	 GL-18.8m Mudstone Jatiluhur formation  GL-26.8m ditto

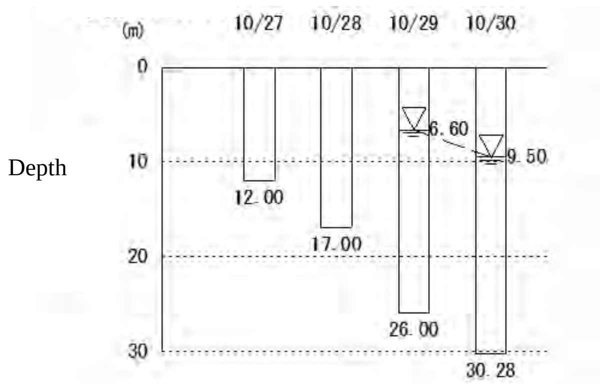


Figure-12 The Chang of Groundwater Level at the Time of Boring (B-12)

13　B-13 : (Length: 60m　Sta. 93.9km)

Geology of B-13 is comprised of lapilli tuff of Jatiluhur formation and old volcanic sediment which covers Jatiluhur formation. Generally, geology of Jatiluhur formation is composed of pyroclastic rocks such as lapilli tuff, tuff brecciated lava and tuff. Concreteness of them is relatively high and N-value is also high.

Old volcanic sediment accumulates on the top of mountain ridge. Generally N-value tends to low and this layer suffers the influence of weathering.

Groundwater level change at the time of boring is shown in Figure-13and below;

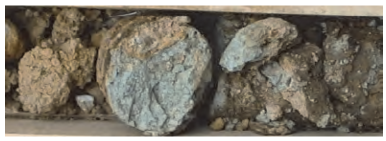
Groundwater level is confirmed at around GL.-12.5m, GL.-28m and GL-36.5m.

Groundwater level at GL.-12.5m is a water head of an aquifer that is formed in old volcanic sediment.

Groundwater level at GL.-28m and 36.5m are water head of aquifer that are formed in Jatiluhur formation.

Based on the Figure-13, there is a possibility to be formed a confined aquifer in the section between GL.-40 and 47m (lapilli tuff and tuff brecciated lava)

Table-13　Geological Condition and N-value (B-13)

Depth (GL-m)	Geology	N-value	Description	Photo of Core
0～1.0	Surface Soil	-	Agricultural soil with brown color Grass roots	-
1～15	Old volcanic sediment	3～25	Silt and clay with volcanic ash and brown to reddish brown color Partially gravel N-value is low and the influence of oxidation can be seen.	 GL-3.6m Clay with volcanic ash
15～60	Lapilli tuff Tuff Jatiluhur formation	39～300	Pyroclastic rocks with high concreteness Mainly comprised of lapilli tuff and tuff brecciated lava and partially tuff. Concreteness of this layer is very high.	 GL-29.8m　Lapilli tuff Jatiluhur formation  GL-59.8m　Tuff Jatiluhur formation

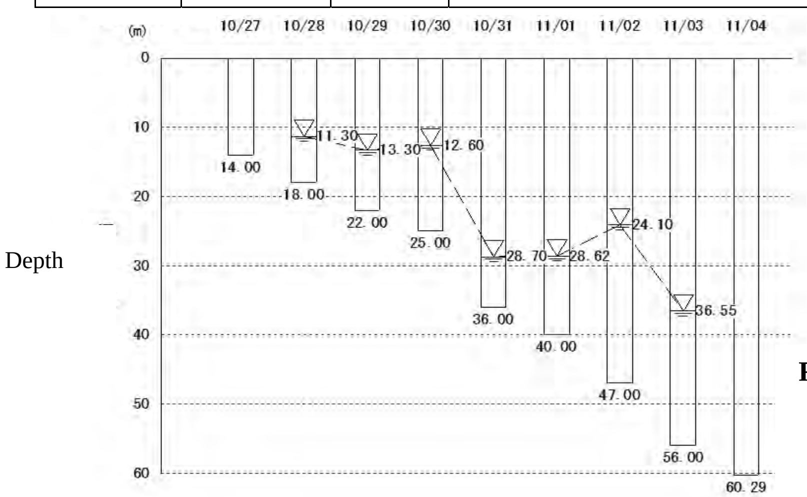


Figure-13　The Chang of Groundwater Level at the Time of Boring (B-13)

14 B-14：(Length: 40m Sta. 111.4km)

Geology of B-14 is comprised of lapilli tuff of Jatiluhur formation and old volcanic sediment which covers Jatiluhur formation. Generally, geology of Jatiluhur formation is composed of pyroclastic rocks such as lapilli tuff, tuff brecciated lava and tuff. Concreteness of them is relatively high and N-value is also high.

Old volcanic sediment accumulates on the top of mountain ridge. Generally N-value tends to low and this layer suffers the influence of weathering.

Groundwater level change at the time of boring is shown in Figure-14 and below;

Groundwater level is confirmed at around GL.-12.5m and GL-31.0m.

Groundwater level at GL.-12.5m is a water head of an aquifer that is formed in old volcanic sediment.

Groundwater level at 31.0m is water head of aquifer that are formed in Jatiluhur formation.

Based on the condition of drilled core, sections between GL.-31.2 and GL.-31.6m, and GL.-36.4 and 37.1m, which matrix was washed away at the time of drilling and is comprised of tuff brecciated lava, are thought to have high permeability

Table-14 Geological Condition and N-value (B-14)

Depth (GL-m)	Geology	N-value	Description	Photo of Core
0～2.0	Surface Soil	-	Agricultural soil with dark reddish brown	-
1～22.5	Old Volcanic Sediment	2～34	Silt or clay with volcanic ash with dark reddish brown to reddish brown Partially gravel of pumice N-value is low and remarkable influence of oxidation. Deeper than GL.-17m, concreteness is slightly high.	 GL-14.8m Silt with volcanic ash and pumice
22.5～40	Lapilli Tuff Jatiluhur formation	24～300	Pyroclastic rocks with high concreteness Mainly comprised of lapilli tuff and tuff brecciated lava and partially tuff. Concreteness of this layer is very high.	 GL-32.8m Lapilli tuff Jatiluhur formation  GL-38.8m ditto

Depth

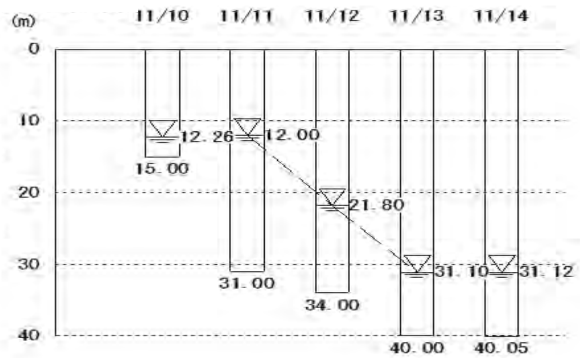


Figure-14 The Chang of Groundwater Level at the Time of Boring (B-14)

15　B-15：(Length: 33m　Sta. 121.5km)

Geology of B-15 is composed of fan deposit on the foot of mountain and refilling soil.

Fan deposit on the foot of mountain is comprised of sand with gravel and volcanic ash with dark gray or black color. Though partially high N-value due to gravel, generally its N-value is varied. However, it has a tendency to increase in N-value deeper part. The fine materials content of this layer is small and void ratio is high, therefor the permeability of this layer is thought to be high.

Groundwater level change at the time of boring is shown in Figure-15 and below;

Groundwater level is confirmed between GL.-2.3 and GL-5.6m and fluctuation is limited.

As described above, generally fan deposit has high permeability, it is assumed that this layer has abundant groundwater in its body.

Table-15　Geological Condition and N-value (B-15)

Depth (GL-m)	Geology	N-value	Description	Photo of Core
0～1.45	Refilling Soil	2	Silt with fine gravel and grass roots	 GL-0.6m　Refilling Soil
1.45～33	Fan Deposit on the Foot of Mountain	8～59	Mainly sand with gravel, partially sand, tuffecious silt etc. N-value is varied. N-value is more than 50 deeper than GL.-28m. Fine materials content is small and high void ration	 GL-6.5m　Fan deposit on the foot of mountain  GL-24.8m　Ditto Sand with scoria

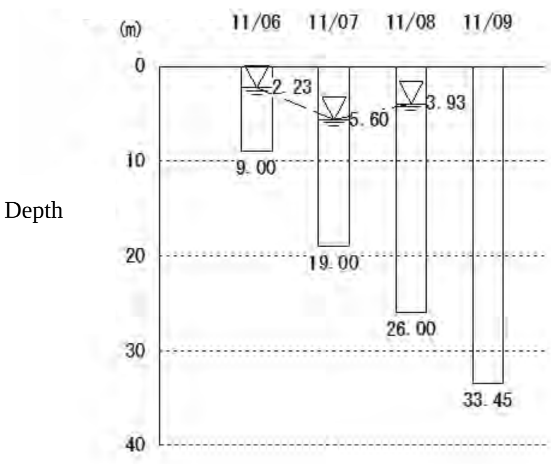


Figure-15　The Chang of Groundwater Level at the Time of Boring (B-15)

16 B-16 : (Length: 30m Sta. 132.0km)

Geology of B-16 is composed of fan deposit on the foot of mountain and refilling soil.

Fan deposit on the foot of mountain is comprised of sand with gravel and volcanic ash with dark gray or black color as well as B-15. Though partially high N-value due to gravel, generally its N-value is varied. However, it has a tendency to increase in N-value deeper part. The fine materials content of this layer is small and void ratio is high, therefor the permeability of this layer is thought to be high.

Groundwater level change at the time of boring is shown in Figure-16 and below;

Groundwater level is confirmed between GL.-7.0 and GL-9.0m and fluctuation is limited.

As described above, generally fan deposit has high permeability, it is assumed that this layer has abundant groundwater in its body.

Table-16 Geological Condition and N-value (B-16)

Depth (GL-m)	Geology	N-value	Description	Photo of Core
0～2	Refilling Soil	4	Piece of brick, grass roots, gravel are contained	 GL-0.6m Refilling soil
2～30	Fan Deposit on the Foot of Mountain	4～66	Mainly fine sand with scoria, partially sand, tuffecious silt etc. N-value is varied. N-value increase toward to deeper part. Content of fine material is small and high void ration	 GL-14.8m Fan deposit on the foot of mountain Sand with scoriaceous gravel  GL-21.7m Ditto

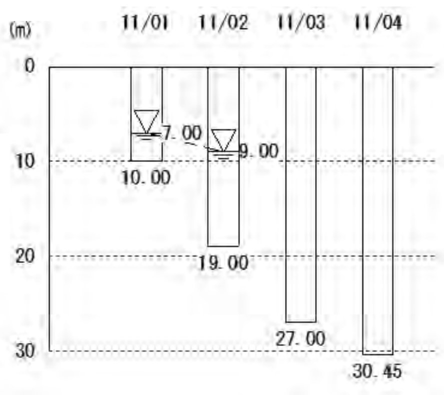


Figure-16 The Chang of Groundwater Level at the Time of Boring (B-16)

17　B-17：(Length: 30m　Sta. 140.6km)

Geology of B-17 is composed of lake deposit and refilling soil.

Lake deposit is mainly comprised of clay or sandy silt and partially sand with gravel.

Upper portion of this layer is very weak and N-value ranges from 1 to 4 until GL.-18m. N-value increases toward to deeper part from GL.-28m.

Groundwater level change at the time of boring is shown in Figure-17 and below;

Groundwater level is confirmed between GL.-10.0 and GL-18.3 and stable at around GL.-14.5m.

Since the layer of sand with gravel which includes lamina of clay is scoriaceous sand, it is inferred that this layer has high permeability and high void ratio, and it functions as an aquifer.

Table-17　Geological Condition and N-value (B-17)

Depth (GL-m)	Geology	N-value	Description	Photo of Core
0～2.0	Refilling Soil	-	Silty sand with piece of vinyl, grass roots	 GL-0.7m　Refilling soil
2.0～60	Lake Deposit	1～4 (～GL.-18m) 1～22 (GL.-19-28m) 20-136 (GL.-28-60)	Mainly clayey soil or sandy silt, partially sand with scoriaceous gravel Very soft until GL.-18m and N-value ranges from 1 to 4. Very high content of water and humic soil N-value increases toward to deeper part from GL.-28m.	 GL-8.6m　Lake deposit Clayey soil  GL-56.9m　Lake deposit Sandy silt

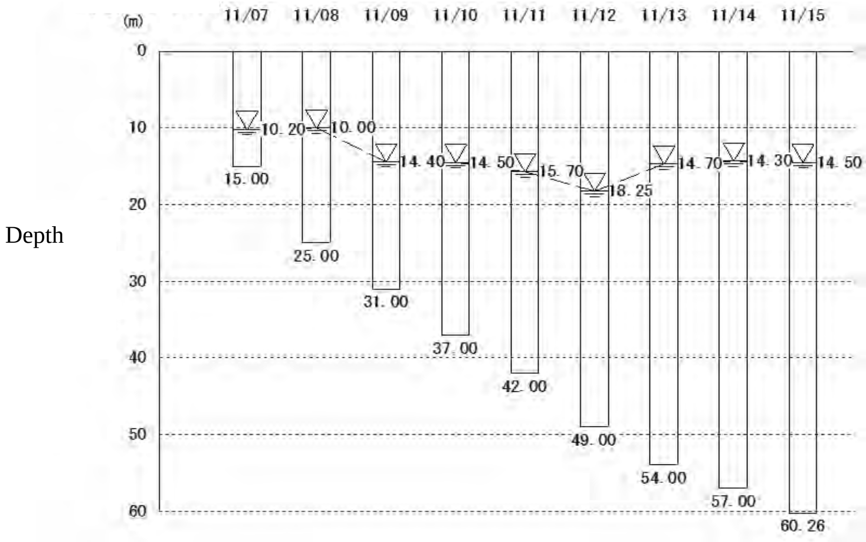


Figure-17　 The Chang of Groundwater Level at the Time of Boring (B-17)

Appendix 2

(3) Geological Condition based on the Field Reconnaissance

1． Geological Setting along the Planned HSR Route

Table-1.1 shows the geological stratigraphy and Figure-1.1 shows the geological outline along the planned HSR route.

Table-1.1 Geological Stratigraphy

Geological Age		Symbol	Name	Description
Quaternary	Holocene	b	Refilling Soil	Artificial refilling soil along the canal
Quaternary	Holocene	dt	Detritus	Secondary deposit on the tow of slope. Properties and condition are depended on parent ground. Unconsolidated and loose.
Quaternary	Holocene	al	Alluvium	It distributes in the lowlands near the coast and bottom land along the river in the areas between Jakarta and Karawang. It comprises soft volcanic sand and mud.
Quaternary	Holocene	ql	Lake deposit	It distributes in the central and eastern part of the Bandung plain. Mainly composed of soft clay and partially sandy.
Quaternary	Holocene / Pleistocene	tr	Terrace deposit	It distributes the hilly area in the downstream of Jatilfulh lake. Mainly composed of clay to sandy soil. Low degree of consolidation.
Quaternary	Pleistocene	qf	Fan deposit on the foot of mountain	A fan deposit generate by Mt.Tangkuban Perahu. Mainly composed of pyroclastic sediment such as a gravel of scoria with high permeability.
Quaternary	Pleistocene	vd	Old Volcanic Sediment	It comprises volcanic breccia, tuff breccia, lapilli tuff, lahar sediment and secondary deposit of them. This forms outer layer in the mountain area. Surface soil colors reddish brown color because of lateralization.
Quaternary	Pleistocene	dl	Dilvium	It forms a small highland and hilly land in the section between Jakarta and Karawang. It is mainly composed of clayey soil and sandy soil, and no gravel is contained. Although well consolidated in the lower part, weak in the surface part.
Neocene	Miocene	Tsb	Subang Formation	Sedimentary rock which distributes in the section between Karawang and Purwakarta. It is mainly composed of mud stone in the area near Karawang and tuffacious sand near Purwakarta. Obvious structure of stratification can be seen at outcrop. The dip of structure is flat. Degree of consolidation is relatively high in the fresh part and N value ranges from 50 to 80 in those fresh part.
Neocene	Miocene	Tjh	Jatiluhur Formation	Sedimentary rock which distributes in the section near Perwakartaand Jatiluhur. It is mainly composed of mud stone with high degree of consolidation. Fold structure can be seen remarkably and axis of fold is mainly east-west direction.
Neocene	Miocene	Tctr	Citarum Formation	It distributes in the section from Sta.105 to 120km. It comprises sedimentary rock such as tuff breccia, lapilli tuff,tuff and tuffacious sand. Obvious structure of stratification can be seen. Although it was formed almost same time of Jatiluhur formation, the degree of consolidation of this is lower than the degree of composition of Jatiluhur formation.
Intrusive Rock		And	Andesitic Dyke	It distributes in the section from Sta. 118.0 to 118.8km. Basically hardness is hard except weathered part.

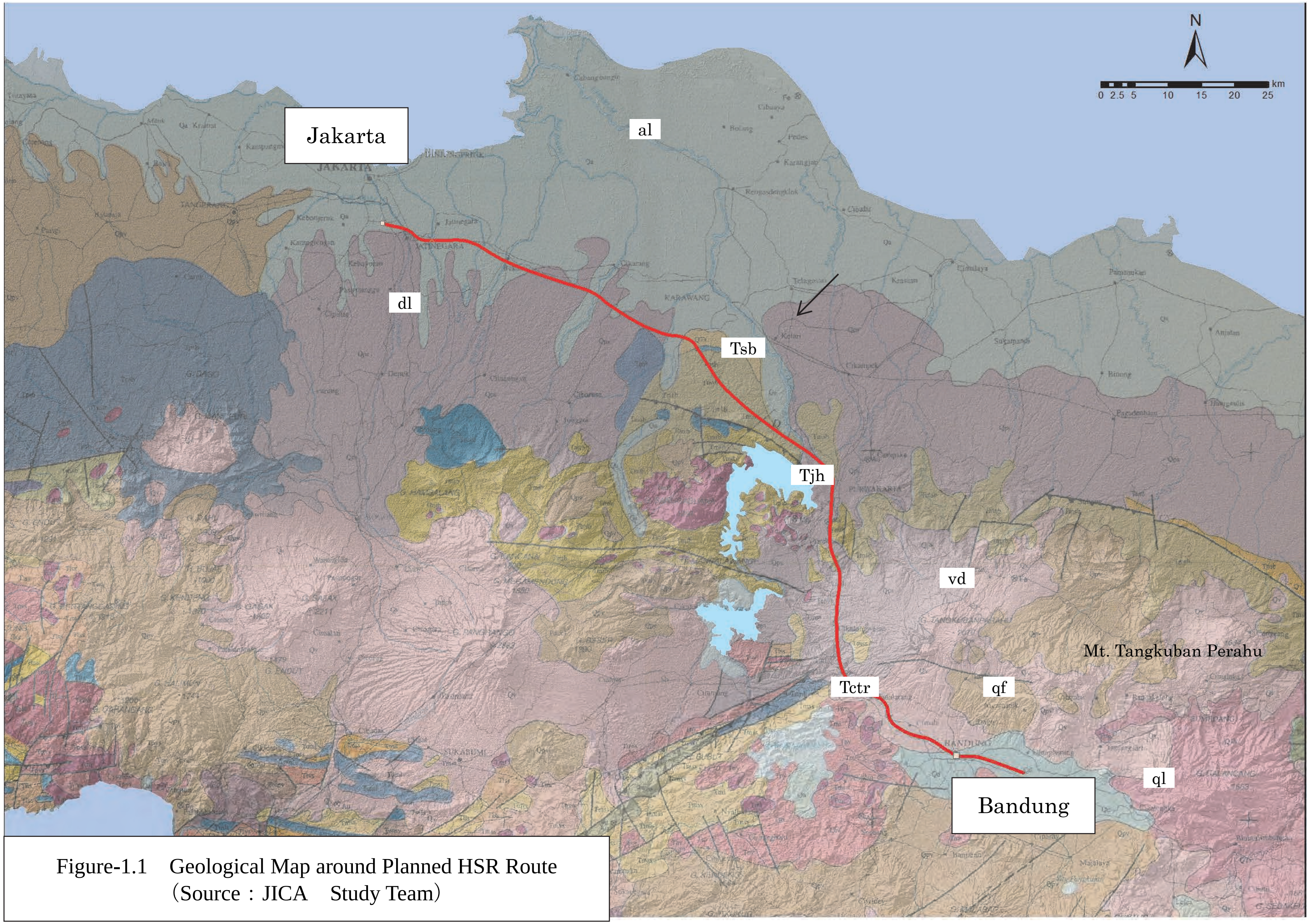


Figure-1.1 Geological Map around Planned HSR Route
(Source : JICA Study Team)

2. Description

A) Citarum Formation (Tctr: Middle Miocene Tertiary)

Geology of this formation distributes in the section between Sta.99.8 to 112.9km. This formation was formed in the Miocene epoch in the Neogene period.

There are some borrow area along the national road No.4 near the Padalarang, it can be observed the bedding structure of sand stone of this formation.

Although basically concreteness of this stratum is relatively high, this stratum is classified into Soft Rock and the tip of geological hammer can be stabbed into the rock surface.

Generally, geology of this formation is widely covered with the Old volcanic sediments (vd) that was formed in the Quaternary period, however, thickness of Old volcanic sediment in this borrow pit area is relatively thin.

Photo-2.1 Citarum Formation of a Borrow Pit

Photo-2.2 Citarum Formation(Tuffacious sand)

B) Jatiluhur Formation (Tjh: Lower to Middle Miocene Tertiary)

Geology of this formation distributes in and around the Purwakarta and Jatiluhur area and comprises sedimentary rocks. Mainly consists on mud stone with high concreteness and sand stone, tuff and tuff breccia etc. Folding structure can be seen many locations. Direction of fold axis is mainly N-SE, NW-SE. Dip and strike of a bedding plane at an outcrop along a river that is located at near 96.5km is N75W71S. Although concreteness of fresh part of rock is relatively high, mud stone near ground surface are prone to slaking due to repetition of dry and wet. Because of slaking, mud stone becomes soft and fragment of rock.

Photo-2.3 Jatilhur Formation (Mud stone)

Photo-2.4 Jatilhur Formation closed photo

Photo-2.5 Outcrop of Mud stone along a river (Softening)

Photo-2.6 Jatilhur Formation (Tuff)

C) Subang Formation (around Purwakarta) (Tsb: Upper Miocene Tertiary)

Geology of the Subang Formation is mainly composed of sedimentary rocks and mainly consists on mud stone and sandstone. Bedding structure which shows low angle is clearly seen. Subang Formation covers the Jatiluhur formation by unconformity. Normal graded bedding can be seen at a part of sandstone.

Although the concreteness of fresh part of rock is lower than that of Jatilhur formation, concreteness is relatively high.

As same as the mud stone of Jatilhur formation, mud stone near the ground surface are prone to slaking due to repetition of dry and wet. Because of slaking, mud stone becomes soft and fragment of rock.

Photo-2.7 Subang Formation (Sandstone)

Photo-2.8 Bedding plane of sandstone

Photo-2.9 Subang Formation (sandstone)

Photo-2.10 Graded bedding of sandstone

D) Quaternary

Sediments of Quaternary are divided into 4 groups such as Old Volcanic Sediment (vd), Fan Deposit on the Foot of Mountain (qf), Diluvium (dl), Alluvium (al) and Lake deposit (ql).

a) Old Volcanic Sediment (vd):

Old volcanic sediment mainly distributes in the mountain area of planned HSR route and covers the top of ridge section between Purwakarta and Bandung. These sediments are composed of volcanic breccia, tuff breccia, lapilli tuff, lahar sediment and secondary deposit of them which are generated by Mt. Tangkuban Perahu.

Characteristics of those sediments are depended on location and environment of sedimentation. Matrix consisted of volcanic ash. Surface soil colors reddish brown color because of lateralization. Small scale slope failure of this sediment can be seen at a steep slope along the existing railway and expressway

Photo-2.11 Surface of the Old Volcanic Sediment

b) Fan Deposit on the Foot of Mountain (qf)

This deposit distributes in the area between southern part of Mt. Tangkuban Perahu and western part of Bandung flat plane. This deposit comprises volcanic sand and scoria which colors dark gray to black. Although concreteness is low, N value is relatively high because of gravelly component. Permeability of this sediment seems to be high because of little content of fine materials and high void ratio. Since this sediment continuously distributes from high elevation area of Mt. Tangkuban Perahu to lower elevation area of Bandung plane, this sediment has a function as an aquifer.

Photo-2.12 Boring core of **Fan Deposit**

c) Diluvium (dl) and Alluvium (al):

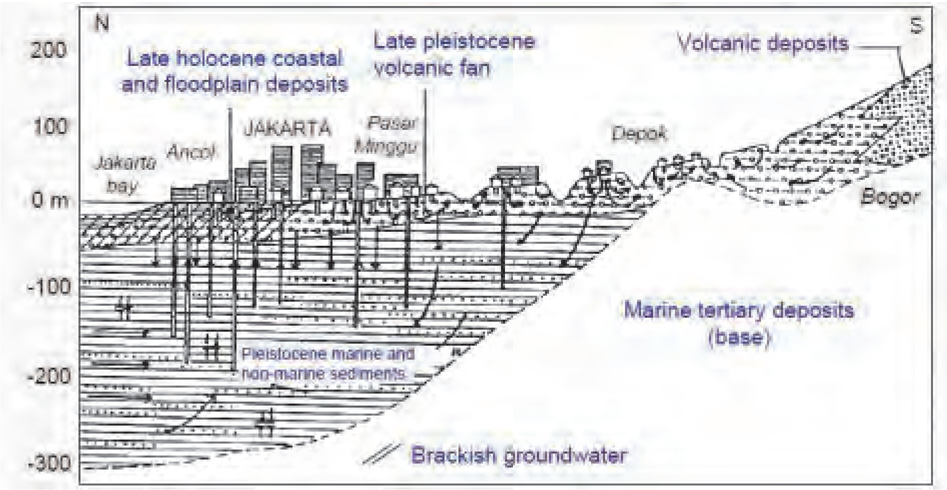
This layer is distributed widely in the flat plain and hilly land area of the section between Jakarta - Karawang.

Figure-2.1 shows a schematic cross section of the Jakarta area.

The maximum thickness of diluvium and alluvium in the Jakarta area is thought to be around 250m below ground surface.

Sediment of diluvium comprises pyroclastic sediment, such as volcanic ash, and it forms hilly land that has slightly high elevation than flat-plain.

Sediment of alluvium comprises sand, mud with volcanic ash and it accumulates flat-plain and low-land along the river channel.



(Source: Hasanuddin Z.Abidin (2001))

Figure-2.1 Schematic Cross Section of Jakarta Area

d) Lake deposit (ql):

In the Bandung flat plain area, the maximum thickness of the lake deposit is thought to be 125 m below ground surface.

This sediment comprises tuffacious clay, sand and gravel. Hardness of soil is quite soft near the ground surface.

e) Others: Terrace deposit

River terraces are widely distributed along the Citarum River and the Cikao River.

The planned route passes through the river terrace along the Cikao River. There are three levels of river terrace along the Cikao River. The terrace with the highest relative height is used as a residential area and the other two terraces with a lower relative height are used as paddy fields.

Appendix 2

(4) Boring Survey Report

(Local outsourcing; Photo of boring, Photo of Boring Core, Drilling Log, Laboratory Test Data)

JOB NO. 3113

JICA STUDY TEAM

TOKYO

GEOLOGICAL (BORING) SURVEY
FOR
JAKARTA – BANDUNG HIGH SPEED RAILWAY PROJECT
(FEASIBILITY STUDY PHASE-I)
INDONESIA

<u>FACTUAL REPORT</u>

DECEMBER, 2014

01	24/12/2014	ALL	ISSUED FACTUAL FINAL REPORT	IR. PADMONO, PE	IR. KABUL S, PE	ANANG RUKADJAT
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0821-8971-7330

Attn.: Mr. Toru Fukushima / Leader of the Team

Subject : Factual Report of Geological (Borings) Survey for Jakarta – Bandung High Speed Railway Project (Feasibility Study Phase 1) Indonesia.

Dear Sirs,

We are pleased to submit 3 (three) hard copy the Factual Report of Geological (Borings) Survey for Jakarta – Bandung High Speed Railway Project (Feasibility Study Phase 1) Indonesia.

This work has been carried out in accordance the Contract Agreement dated on October 20, 2014 between JAPAN INTERNATIONAL CONSULTAN FOR TRANSPORTATION Co., Ltd and PT. SOILENS.

We sincerely appreciate the cooperation and trust that we have received in accomplishing this project. Please do not hesitate to contact us for any further clarification regarding the content of this report.

Yours faithfully,
PT. S O I L E N S

p.t. SOILENS

Ir. Rismantojo
President Director

Anang Rukadjat
Project Manager

Ir. Padmono
Principal Geotechnical Engineer

TABLE OF CONTENTS

1. *INTRODUCTION*

This factual final geotechnical engineering report is carried out by PT. Soilens for JICA Study Team. Its contains the discussion on the field and engineering properties of the subsoil, for the development of High Speed Railway Project, Jakarta - Bandung, Indonesia.

This work is carried out under the contract between.:JICA and PT.Soilens , dated October 10, 2014

2 SCOPE AND PURPOSE

The purpose of the investigation is to explore the subsurface soils at the proposed plant site. The scope of the investigations included:

(1) Soil drilling 17 points with a total depth of 645 m, performing standard penetration test, collecting undisturbed samples, and continuous coring
(2) A laboratory testing program on undisturbed, undisturbed and rock samples to evaluate the engineering characteristics of the sub surface strata encountered.

The vicinity map of the project site and lay-out of the investigated points are shown in **Appendix A.1**.

3 FIELD INVESTIGATIONS

3.1 Drillings

The field investigations were carried out by a team consisting of Project Manager Anang Rukadjat, Site Coordinator Topocidy, Drilling Master A Fido, Aceng D, Dede Djudju, Jojo S, Tatang and Acep Wahyu. The drillings was carried out using 6 (six) "Long Year" drilling machine with 'Sunchine S-45 and Sanchine S-120' pumping unit. The bore holes were advanced by continuous coring using NX-size, single tube core barrels apparatus with outer diameter of 73 mm (2.87 inches). All drillings were supervised by the Assistant Geologists Yan Yusuf, Asep Lukman, Larasati, and Supriadi, who also maintained a continuous logging on the core samples. These core samples were placed in wooden boxes, each containing 5 meter long of samples, and stored at the site. The undisturbed soil samples were carried out on cohesive soil at approximately 5 meter interval or at every change in soil layer forB-1; B-2; B-3; B-4; B-5; B-15, B-16 and B-17).

The detailed classification of the soil samples after refinements in relation to the soil laboratory test results are presented in boring logs included in **Appendix A.2**.The information on the logs also includes the field test results and locations of samples. The samples were brought to PT.SOILENS Soil Laboratory in Bandung where the tests were performed.

3.2 *Standard Penetration Tests (SPT)*

The standard penetration tests were performed in accordance to the ASTM Standard method D1586. The test consists of driving a standard split spoon sampler into the soil/rock at required depth in a bore hole.

A hammer of 63.5 kg weight falling freely from a height of 75 cm (30 inches) on the drill rod is used to drive the sampler. The number of hammer blows to drive the second and the third 15 cm (6 inches) of penetration are called the SPT N-value which represents the number of blows per 30 cm (1 ft) of penetration. The standard penetration test was performed at 1.0 meter interval. In addition, pocket penetrometer tests were also performed on cohesive soil samples that indicated plastic behavior. The SPT results are presented in the boring log enclosed in this report.

3.3 *Undisturbed Samplings*

The undisturbed samples mostly were collected from the top layer for cohesive soil layer. This is done by taking samples from bore hole by means of seamless thin walled steel tube commonly known as Shelby tube, every 2.0m interval for layer with N-SPT <50, each at borehole BH-1, B-2. B-3, B-4, B-5, B-15, B-16 and B-17.

The tube is 76.2 mm (3 inches) in diameter and has beveled butting edge at the lower end. It is connected to the drill rod and hydraulically pushed as static force into the bottom of the hole. When the tube is almost full, it is withdrawn from the hole, removed from the drill rod, sealed at both ends with paraffin, and shipped to PT. Soilens soil laboratory in Bandung for testing. In preparation for test, the samples were ejected from the tubes cut into required length and subjected to various laboratory tests

3.4 *Water Level Observations*

The elevation of ground water level in the bore holes on land varies from -0.7 m to -10.40m below the existing ground surface. The ground water level in each bore hole was recorded every morning and evening, 24 hours after completion of the drilling through the end of the whole field work.

The ground water conditions observed during drilling may not represent the groundwater conditions during construction. The ground water conditions will fluctuate following the wet

& dry season and tide condition. We recommend that the water levels be verified just before/during construction, by installing a Piezometer.

3.5 Summary of Field Works

The summary of the fieldwork carried out are listed in Tables 1. The coordinate and elevation of the investigated points were to be measured by using existing Bench Marks as reference.

Table 1 : *Summary of Investigated Program of Drilling*

No	Point No	Coordinate		Elevation	Date drilled/Tested		Boring depth (m)	Water Depth (m)	Remarks
		E	N	Z	Started	Completed			
1	B - 1	710072.00	9309435.00	+25.00	October 31, 2014	November 05, 2014	21.45	-1.90	
2	B - 2	711347.00	9310908.00	+26.00	November 12, 2014	November 14, 2014	20.25	-7.00	
3	B - 3	723199.00	9307254.00	+36.00	November 02, 2014	November 07, 2014	50.45	-7.00	
4	B - 4	729719.00	9304856.00	+36.00	October 30, 2014	November 06, 2014	60.45	-1.53	
5	B - 5	710072.00	9309435.00	+25.00	November 13, 2014	November 18, 2014	50.45	-1.20	
6	B - 6	745015.00	9296103.00	+38.00	November 11, 2014	November 13, 2014	30.45	-1.20	
7	B - 7	747029.00	9294481.00	+49.00	December 09, 2014	December 11, 2014	30.45	-5.20	
8	B - 8	761821.00	9282974.00	+40.00	December 05, 2014	December 06, 2014	40.00	-4.20	
9	B - 9	765073.00	9280796.00	+46.00	November 15, 2014	November 17, 2014	46.00	-2.35	
10	B - 10	76731.00	9277691.00	+100.00	November 16, 2014	November 19, 2014	30.25	-6.50	
11	B - 11	767899.00	9273355.00	+141.00	October 26, 2014	November 02, 2014	50.45	-6.05	
12	B - 12	768512.00	9265613.00	+362.00	October 27, 2014	October 30, 2014	30.28	-6.50	
13	B - 13	769063.00	9261204.00	+492.00	October 27, 2014	November 04, 2014	60.29	-10.40	
14	B - 14	775364.00	9245371.00	+723.00	November 10, 2014	November 13, 2014	40.05	-4.71	
15	B - 15	781894.00	9237433.00	+739.00	November 07, 2014	November 10, 2014	33.45	-2.23	
16	B - 16	790830.00	9234286.00	+692.00	November 01, 2014	November 04, 2014	30.45	-4.15	
17	B - 17	798842.00	9231364.00	+675.00	November 07, 2014	November 15, 2014	60.26	-0.70	

Note: Water depth to be measured from ground surface for on land boring

4. LABORATORY TESTING

The laboratory soil testing was performed at PT.Soilens soil mechanics laboratory in Bandung, West Java. The laboratory-testing program included classification test (grain size, water content, and specific gravity), and chemical tests. No undisturbed could not be taken those no strength and consolidation parameter can be tested.

The test procedures generally conformed to the applicable ASTM standards and British Standards. The following sections provide descriptions of the laboratory tests performed.

4.1 Classification Test

The method used for Index properties were ASTM Standard Test Method D2487, which is based on the Unified Soil Classification System (USCS). The classification tests performed include tests for moisture content, grain size distribution, and specific gravity. Those data are tabulated in the Laboratory Test Summary provided in Appendix B.

Moisture content test was performed in accordance with standard test method ASTM D2216. Moisture content measurements for the above tests were from samples dried in an oven maintained at approximately 110 degrees Celsius. Specific gravity tests were performed in accordance with ASTM D854.

The particle size distributions of selected samples were determined with the sieve and hydrometer analysis procedures of ASTM D422. In general, sieve analyses were performed on coarse-grained particles and hydrometer analysis were performed on silt- and clay-size particles. Liquid Limits, Liquid Limit and Plasticity Index of soils were tested under ASTM D4318.

133 (one hundred thirty three) undisturbed and disturbed samples were tested in the laboratory. This testing resulted in the identification of 8 (eight) soil types, as CH, SC-MH, SM, ML, CL, CH, SC, GC, and OH. The majority of the soils tested were identified as cohesive soils.

4.2 Slake Durability Test

These test to be performed under ASTM D.4644, covered determination of the slake durability index of shale or other similar rock after drying and wetting cycles with abration. 4 (four) core samples were tested, as follows:

1. B-7 : depth 15.45 – 16.00m
2. B-8 : depth 18.45 – 19.00m
3. B-11 : depth 40.45 – 41.00 m
4. B-12 : depth 20.30 – 21.00m

4.3 Laboratory Test Results

The laboratory test results for each borehole summarized in Appendix B.1 to B.3 enclosed in this report.

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LIMITATIONS OF REPORT

We have prepared this report for the use of JICA Study Team accordance with generally accepted consulting practice. No other warranty, expressed or implied, is made as to the professional advice included in this report. This report has not been prepared for the use by parties other than the Client, the Owner and their respective consulting advisors. It may not contain sufficient information for purposes of other parties or for other uses.

It is recommended that any plans and specifications prepared by others and relating to the content of this report or amendments to the original plans and specifications be reviewed by PT. Soilens to verify that intent of our recommendations is properly reflected in the design.

Whilst to the best of our knowledge information contained in this report is accurate at the date of issues. Subsurface conditions, including groundwater levels and contaminant concentrations can change in a limited time. This should be borne in mind if the report is used after a protracted delay.

There are always some variations in subsurface conditions across a site which cannot be fully defined by investigation. Hence it is unlikely that the measurement and values obtained from sampling and testing during the investigation will represent the extremes of conditions which exist within the site.