Chapter 5

Station Vicinities and Urban/Regional Development

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5.1 High-Speed Railway and Urban / Regional Development

5.1.1 Urban and Regional Development with Shinkansen in Japan

It was 50 years ago in 1964 that the Tokaido Shinkansen, Japan's first high-speed railway (bullet train) construction was completed for operation. Japan was just waking up to the new era of rapid economic growth. Many heavy industrial parks were developed and major changes in production took place along the Tokai coastal alley (Pacific Industrial Belt) between Tokyo and Osaka, the two largest cities of the nation. The existing ordinary railway at the time in the Tokai region, the so-called Tokaido Line, was just about reaching its capacity and more passenger and freight trains needed to be operated in order to meet the heavy demand for transportation. And the Tokaido Shinkansen contributed to the success of the Tokyo Olympic Game held in that year with its transportation capacity and high-speed operation between Tokyo and Osaka. The mass transit system like the Shinkansen is very important for a big event a lot of people come from extensive area such as the massive sports event. In 1972 the Shinkansen line was extended to Okayama, then to Hakata in 1975. Such extension of the line not only contributed to increasing the national transport capacity but also strengthened the inter-connection and relationship between the cities along the corridor, thus bringing much larger transportation demand in Japan. The Tokaido Shinkansen was originally built in order to strengthen the transport capacity. In June 1982 the Tohoku Shinkansen between Omiya (a suburb of Tokyo) and Morioka (Iwate prefecture) opened, then in November 1982 the Joetsu Shinkansen between Omiya and Niigata in the Hokuriku region opened. Besides the original purpose of the Tokaido Shinkansen to increase capacity, the Tohoku and Joetsu Shinkansen delivered the unique function of connecting cities along the corridor to Tokyo, the capital. As a result of this effect, remote cities such as Sendai and Niigata developed a large number of Tokyo-targeted businesses. Therefore, subsequent Shinkansen lines were planned and developed for inter-connection of remote regions and/or cities to the capital, Tokyo. The Shinkansen in Japan has grown thanks to its high-quality, high-speed, mass-transportation capacity and on-time operation, and it provides passengers with a sense of unity with the capital city, Tokyo.

5.1.2 Urban and Regional Development with High-Speed Railway in Indonesia

The history of the Japanese Shinkansen indicates that high-speed railway development will deliver mainly two possible impacts on Java's economic growth.

(1) Traffic Capacity Increase and Modal Shift in the Region

- There is a potential to increase the transportation capacity between Jakarta and Bandung for passenger travel in the project target region while shifting the transportation trend from automobile-oriented mode to railway-oriented mode to reduce the heavy load of road traffic. It is indeed apparent today that the traffic demand in toll road goes on increasing as continuous traffic jams are observed on the toll road. The demand for travel between Jakarta and Bandung is always high, so the capacity upgrade of transportation in the region should effectively match the solution of the current problem in transportation. Thus, the introduction of HSR development will definitely contribute to such a modal shift in regional transportation.

- The area between Jakarta and Karawang has been highly developed with medium-heavy industrial parks providing high-quality production of automobiles and electrical products, and a high-speed traffic link between these areas is necessary for further economic growth and expansion of industry. Thus, the high-speed railway will contribute to the region's further industrial development and ultimately to economic growth and sustainable development of society.

(2) Connecting the Regional Centers Directly to the Capital

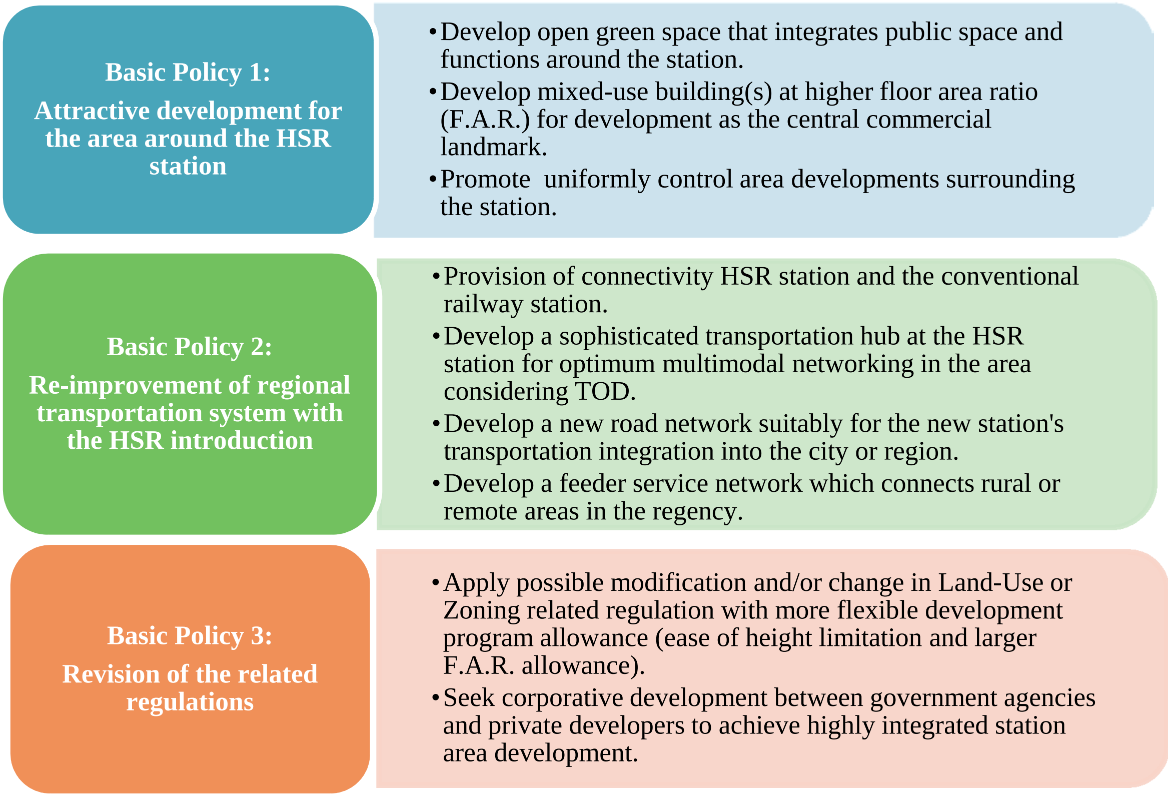
- As West Java Province has identified three metropolitan development areas, these growth nodes should be directly connected to the capital city, Jakarta, for further economic development based on Jakarta-centered businesses or Jakarta-targeted business models. Bandung, in particular, is an educational and research-oriented city, so a link with other industrial cities will soon be desired by high-speed transportation connection.
- On the other hand, from the tourism point of view, the currently-experienced long drives on congested toll roads and fragile weather-based dependency on air travel will be exchanged for more stable and timely rail travel when the high-speed railway system is introduced for pleasure travelers traveling between the cities in the region.
- As it will be connected with the capital city, Jakarta, more demand in the service industry will be sought in the Bandung region in view of high-quality employment promised by its educational environment. Moreover, Jakarta-based and Bandung-based businesses will quickly develop a regional business network for a wide range of services, which is the basis of the manufacturing industry distributed among those cities. Consequently, remote city connection to the capital city will be another benefit to local economic growth.

5.2 Study of Urban and Spatial Development Plans for the Proposed Station Areas

It is apparent that the HSR has a positive impact in the urban and regional development through the examples of the HSR in the world, but it is necessary to take some actions in the areas where the HSR passes. Based on the regional development and spatial plans discussed above, possible development plans and constraints as well as necessary actions for each proposed station site and city area shall be visualized.

5.2.1 Strategy for Urban Development Plans around the Proposed Stations

The strategy to be taken by each city and regency is examined here so that the ripple effect by High-Speed Railway development becomes widespread. Each city or planned station site has many uniquely situated growth pattern, and it is necessary to formulate development plan of each station vicinity based on those strategies.



Source：Study Team

Figure 5.2-1 Strategy for Urban Development Plans around the Proposed Stations

Basic Policy 1: Attractive development for the area around the HSR station and formulation of built-up area centering on the HSR station

- Develop open green space that integrates public space and functions around the station in order to create a pleasant urban environment.
- Develop mixed-use building(s) at higher floor area ratios (F.A.R.) for development with the station as the central commercial landmark where the HSR station is located at a newly developed site.
- Designate the area surrounding the station as for commercial, service, financial and public use and uniformly control private developments in the area.

Basic Policy 2: Re-improvement of regional transportation system with the HSR introduction

- Where any railway station exists in the targeted city or area, the necessary connecting transportation system should be provided between them.
- Develop a sophisticated transportation hub at the HSR station for optimum multimodal networking in the area (including a bus station, taxi lane and other transport service stations) considering TOD.

- Develop a new road network or organize the existing road network suitably for the new station's transportation integration into the city or region.
- Develop a feeder service network which connects rural or remote areas in the regency and provides access to the urban transit network for as many people as possible.

Development around HSR Station

Improvement of Regional Transportation based on the PublicTransport (TOD)

Figure 5.2-2 Development Images

Basic Policy 3: Revision of the related regulations

- Apply possible modification and/or change in Land Use or Zoning related regulations with more flexible development program allowance (ease of height limitation and larger F.A.R. allowance) to the private developers who own the land around the station, where it is necessary to acquire the land from the private owners for the HSR station development.
- Seek cooperative development between government agencies and private developers to achieve highly integrated station area development.

5.2.2 Station Area Development Strategy

Based on the above-mentioned planning strategies and the characteristics of each station, each station and the area around the station are proposed as follows:

(1) Jakarta (Dukuh Atas) Station Area Development Plan

A major action to be taken with regard to the HSR station development is to highly integrate the station into the previously master-planned Dukuh Atas area redevelopment, which includes the new MRT station which is under construction, the existing Kereta Api Sudirman station along the canal, the projected airport link line, projected circular line and BRT, Trans Jakarta and newly proposed LRT line, since the stations for these transit systems may be in the same area of the city. Figure 5.2-3 illustrates possible Dukuh Atas central development prepared by JICA.

Source: JICA Study Report 2013

Figure 5.2-3 JICA Study: Jakarta Transport and Urban Development Model at Dukuh Atas

According to the previous JICA study, the projected stations will be connected by a newly designed pedestrian deck and building complex since they are located at a distance from each other, and the area is densely developed so that the land acquisition for development is very difficult. The deck may span the existing roads and canal in order to create a large open space by the connection. The HSR station will also be located at a certain distance from the other projected stations, so some architectural solutions to physically connect the passenger flow between stations should be made.

As it's commonly known, the proposed Dukuh Atas area is part of the most congested area of the city, and the HSR station development should be well planned to contribute to reducing the traffic congestion. The Dukuh Atas station complex, therefore, should have an effectively connected passenger flow pattern and architectural spatial design. The newly developing and projected railway systems as well as the HSR shall be well programmed to allow the use by a wide range of people in terms of, for instance, income level, and the effective connection between the rail systems as well as a well-integrated transportation network are necessary to reduce automobile approach to the station area. Ideally, only public transportation and volume-controlled taxi services should be allowed within the Dukuh Atas complex premises. Approach by private car might be allowed only in a regulated manner, such as applying an area entry charge.

The following are the fundamental strategies for Dukuh Atas HSR station development, and the following Figure 5.2-4 illustrates the concept of DKI Jakarta Transport Network with High-Speed Rail Development.

1) Attractive development for the area around the HSR station and formulation of built-up area centering on the HSR station
   - Reorganize the possible architectural and building arrangement of the previously made Dukuh Atas station area redevelopment plan to properly incorporate the HSR station functions.
   - Develop a multi-purpose building in the HSR station to provide a highly convenient environment for users as well as service operators in the city center, and enable the complex to play the role of a landmark at the location for economic activities.
   - Provide as large a public open space in the station complex as possible to create a pleasant urban space in the area.

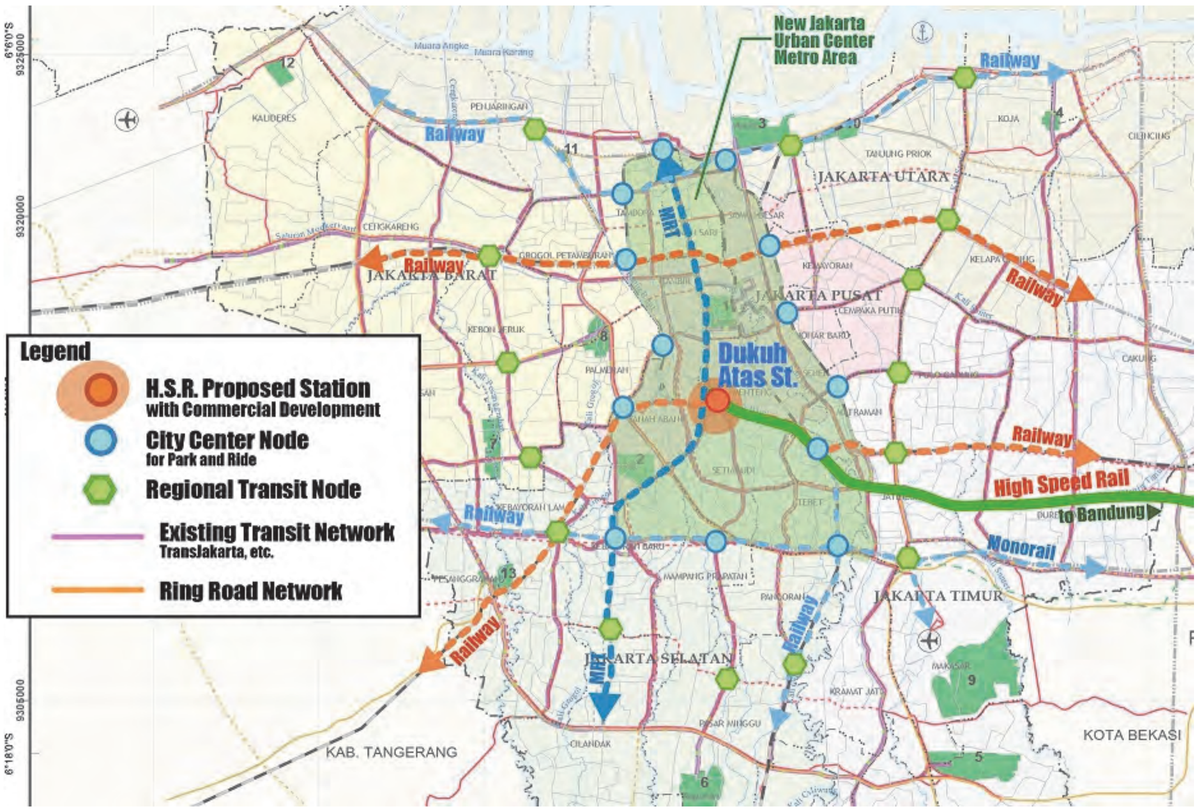
- Provide effective linkage between the HSR station and other stations including projected stations, even if they will be constructed after the HSR station development.

2) Re-improvement of regional transportation system with the HSR introduction

- Provide an effective feeder network from the relevant Dukuh Atas rail systems in order to serve the overall city area and enable people to gain the benefit of HSR transportation.
- Provide more Park-and-Ride facilities for the city railway stations to enable private cars and bikes to park outside the city center.
- Develop a multimodal transit complex at Dukuh Atas Station where major regional & city bus services and public feeder services including regulated taxi services are housed, and only pick-up and drop-off lanes for private cars and bikes are provided under city center entry regulations.

3) Revision of the related regulations

- Follow the land use pattern as suggested in the previous Dukuh Atas development plan with possible adjustments, if necessary, for better integration of the HSR station into the targeted location of the area.
- Current land use and zoning regulations should be changed in the future around Dukuh Atas area for more commercial oriented and dense development rather than residential use.



Source: JICA Study Team

Figure 5.2-4 Concept of DKI Jakarta Transport Network with High-Speed Rail Development

(2) Bekasi Station Area Development Plan

The existing Bekasi city urban area extends to both sides (north and south) of the Jakarta - Cikampek toll road, and Bekasi railway station is about 2 km from the toll road. A large area of the urban center still has a high density of old and small structures. However, the development area along Jenderal Ahmad Yani Road is highly developed with major commercial buildings, such as shopping malls.

The proposed HSR station is located along the toll road, approximately 2.4 km east of Bekasi Timur toll gate where a monorail station is being considered by the provincial government, and the HSR station is about 6.0 km from the existing Bekasi railway station. Although Bekasi station and the HSR station are located in certain distance, the HSR station is at the important development center for future industrial development with certain ridership demand expected, so the transportation link between the HSR station and the industrial development should be well planned and prepared. Figure 5.2-5 illustrates the current development and condition of Bekasi city.

Left: Jenderal Ahmad Yani Road, Right: Street near the existing railway station

Source: JICA Study Team

Figure 5.2-5 Current City View of Bekasi

The following are the fundamental strategies for Bekasi HSR station development, and the following Figure 5.2-6 illustrates the concept of Bekasi Transport Network with High-Speed Rail Development.

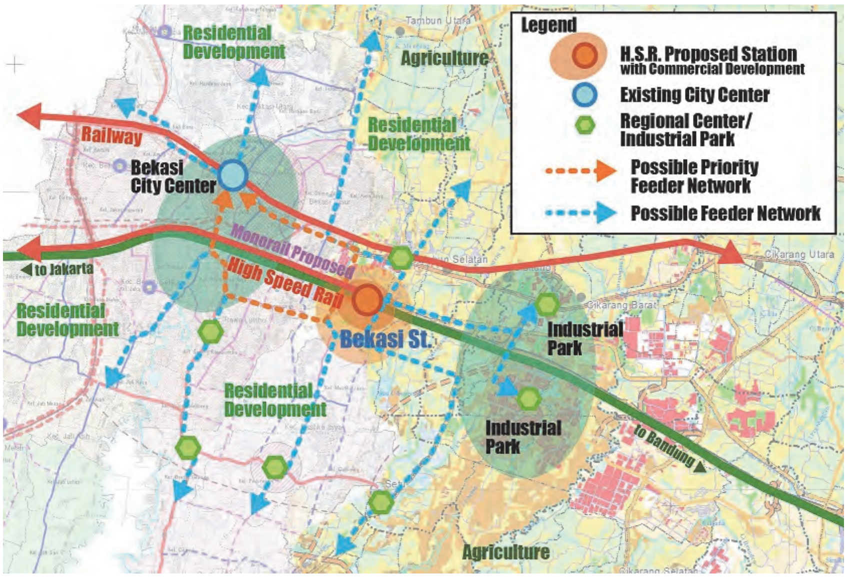
1) Attractive development for the area around the HSR station and formulation of built-up area centering on the HSR station
   - Select the less problematic site for land acquisition for the HSR station development.
   - Designate new urban commercial, service and residential land use zones around the HSR station area with mainly commercial use at the station.

2) Re-improvement of regional transportation system with the HSR introduction
   - Develop appropriate station front facilities including a TOD based multimodal transport network terminal with easy access for users.
   - Formulate a road and transport plan to effectively link the station site to the surrounding industrial development sites as well as residential development areas, and develop the plan for HSR station and its surrounding area to contribute the regional development.

- Develop a new road network including the upgrading of the existing roads and bridges to the existing Bekasi urban center in order to provide a convenient feeder system between areas.
- Possibly extend the projected monorail line to the HSR station site in order to integrate the commuter rail system with the new HSR development.
- Strengthen and upgrade the existing road network between Bekasi city residential area and the developing industrial zone in order to expand the service capacity of the industrial parks so that more jobs will be created and demand will increase.

3) Revision of the related regulations

- Cooperative development work should be made between Bekasi City and Bekasi Regency since the station for Kota area will be set within the jurisdiction of the Bekasi Regency, while the HSR economic benefit should be well shared between both local governments and communities.



Source: JICA Study Team

Figure 5.2-6 Concept of Bekasi Transport Network with High-Speed Rail Development

(3) Cikarang Station Area Development Plan

The HSR station site at Cikarang has major economic development potential not only because there are large industrial park developments close by, but also because the Bekasi Regency government complex has recently been developed nearby. Although the government complex is located near the Bekasi - Karawang jurisdictional border, it will draw more government service-industry settlement to the area along with factory development in the parks as a lot of municipal level administrative procedures with regard to industrial park organization and production services are required. A large number of passengers from the regency government as well as the industrial park administration will possibly use the HSR service.

Industrial park development is the core economic driving force in the region, and it is expected to grow further in the coming decades so the working population is also estimated to increase significantly. Not only will production facilities be developed but also residential development will increase further in the region for both local and international workers. As many foreign workers are expected to work in the industrial parks, the HSR station will contribute to the shuttle service between the airports, Jakarta city and the Cikarang area, and accommodation facilities as well as the commercial and service industry will be developed around the project station.

Except for the possible future Karawang airport development and HSR station, HSR Cikarang Station will be the last commuter pick-up and drop-off point along the corridor and Cikarang Station together with Bekasi Station may play the role of Jakarta - Cikarang commuter section for more frequent transit. According to this possible situation, the feeder service between the HSR station, the industrial parks and the neighboring residential areas should be effectively planned and more frequent operation will be introduced as the APM (Automatic Passenger Mover) system within the Cikarang industrial parks has been studied for feasibility by JICA scheme. Figure 5.2-7 shows the current development of the Bekasi Regency Government complex and a streetscape in an industrial park in the area.

Left: Government Office Complex, Right: Boulevard in the Industrial Park

Source: JICA Study Team

Figure 5.2-7 Current Cikarang Area: Bekasi Regency Government Complex and Industrial Park

The following are the fundamental strategies for Cikarang HSR station development, and the following Figure 5.2-8 illustrates the concept of Cikarang Transport Network with High-Speed Rail Development.

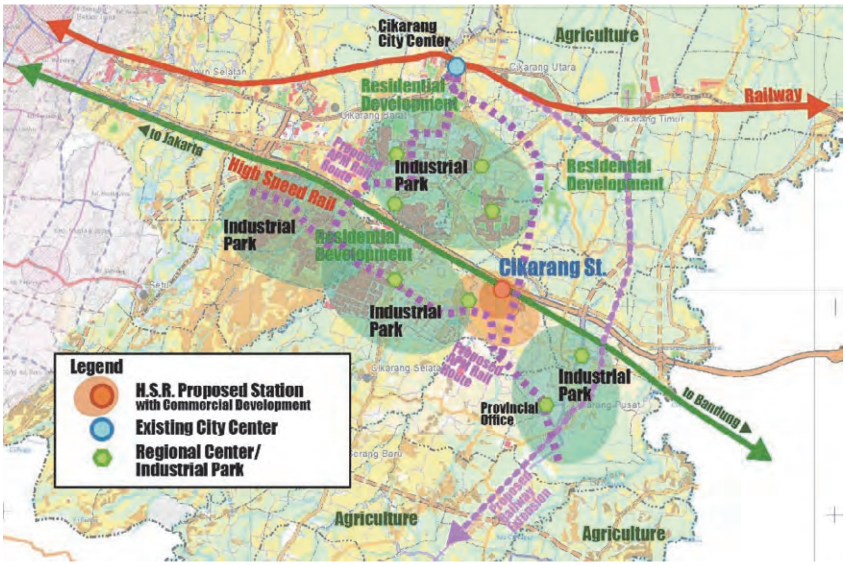
1) Attractive development for the area around the HSR station and formulation of built-up area centering on the HSR station
   - Select less problematic site for land acquisition for HSR station development among the industrial development zones.
   - Develop appropriate station front facilities including a multimodal transport network terminal with easy access for users with good feeder services to the industrial parks and related residential areas.
   - Develop a new road network to effectively link the station site to the surrounding industrial development sites as well as residential development areas in the area.

2) Re-improvement of regional transportation system with the HSR introduction

- Formulate a road and transport plan to effectively link the station site to the surrounding industrial development sites as well as residential development areas, and develop the plan for HSR station and its surrounding area to contribute the regional development.
- Develop a new road network including upgrading of the existing roads and bridges in order to provide a convenient feeder system between areas.
- The Regency proposed APM transit system should be well connected for better transport integration in the area so that the beneficial flow of economic and service activities will be achieved through HSR and APM developments over a larger region.
- Locations of the APM station and HSR station should be well connected for easy distribution of users between the systems, and the HSR service should be tied with all industrial parks, residential areas and government administrative complex where the APM will run through.

3) Revision of the related regulations

- Designate new urban commercial, service and residential land use zones around the HSR station area with mainly commercial use at the station.



Source: JICA Study Team

Figure 5.2-8 Concept of Cikarang Transport Network with High-Speed Rail Development

(4) Bandung and Gedebage Station Area Development Plan

The major development plan visualized by the local government is to create twin urban centers in Bandung city. The current city center is considered as the old and traditional center of Bandung with a more historic identity that will be redeveloped by some transportation network reorganization. New urban development is planned in the Gedebage area where there are much larger open land areas currently used as rice fields, and its history of textile production will be more emphasized by the new development to give a new identity to the area together with TOD concept. Gedebage area indeed has started construction of a large residential development in its south part.

The major TOD plan is under preparation with the commuter railway system planned between Padalarang and Cicalengka for approximately 42 km in distance to serve the working class who commute in the region as well as Bandung city monorail development plan, and a study was carried out by an American consultant on its introduction. The commuter rail alignment follows the existing railway track and the stations may be in similar locations for easy linkage. When the HSR is introduced along the existing railway and the commuter railway service is inaugurated, Bandung and Gedebage stations will be hubs for the region's multi-railway network.

Bandung International Airport (Husein Sastranegara) has a certain volume of passengers today. However, West Java Province in partnership with the central government has already implemented the construction of a new international airport in Kertajati to which the commercial functions of Husein Sastranegara will be transferred, so Husein Sastranegara airport will be a full military-based airport within a few years. Thus, the existing Bandung Airport may not be a major destination to link transportation for better services with HSR.

The new Gedebage urban center will be more commercial and service-oriented place with residential development around. The development area extends south of the railway, and the recently completed stadium will be a part of the urban complex. The existing textile industry may be expanded and the development will aim to bring out the unique concept of the textile city and region as well.

The older part of Bandung city will grow as an educational and tourism-oriented center as well. Educational institutions and industrial development will be well integrated for better production and technology invention. The innovative environment will be strengthened by the upgrading of educational institutions and research facilities, so the growth of the student and researcher population can be expected as well.

A large number of local tourists visit Bandung every weekend, and foreign tourists from Asian countries also visit the city for short vacations. The city area on weekends is packed with tourist vehicles creating congestion not only in the central area but also along the toll road. Thus, reorganizing the roads and traffic patterns in the city area is an important issue to be considered with HSR station development to deliver a convenient multimodal transit network in the city. Figure 5.2-9 shows the current Bandung urban area.

Source: JICA Study Team

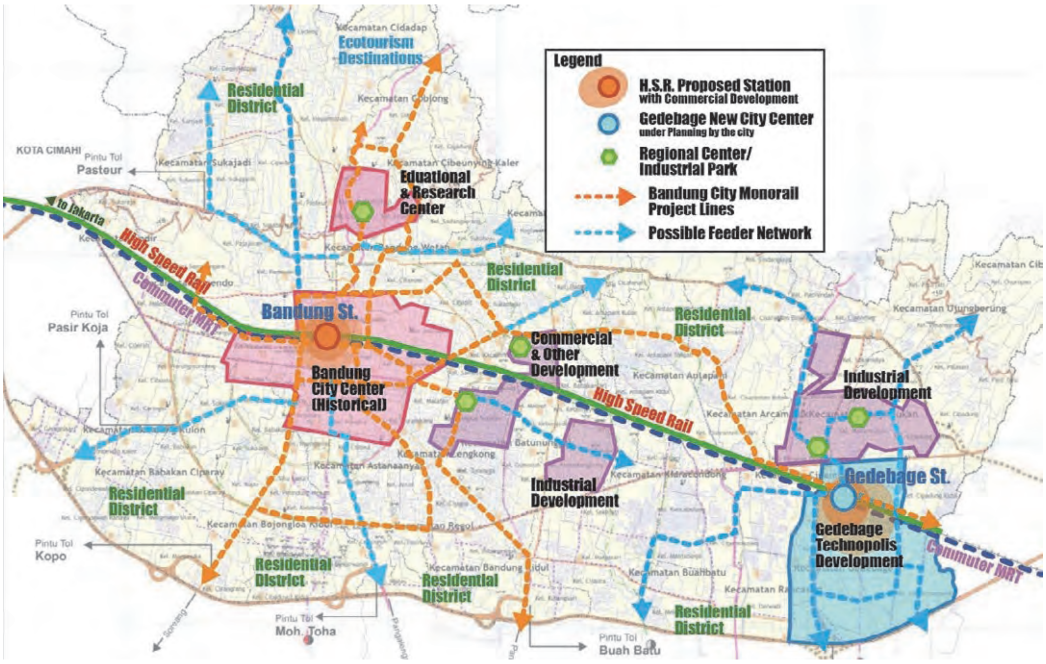
Left: Bandung Street View, Right: Bandung Railway Station

Figure 5.2-9 Bandung City Current Development

The following are the fundamental strategies for Bandung and Gedebage HSR station developments, and the following Figure 5.2-10 illustrates the concept of Bandung Transport Network with High-Speed Rail Development.

1) Attractive development for the area around the HSR station and formulation of built-up area centering on the HSR station
   - Coordinate with the commuter railway and city monorail development plans as the HSR station will be developed at the same location in the city where the existing railway station is located.
   - Integrate the station development with the local government planned land use of the urban area.
   - Synchronize the HSR development with the ongoing Bandung TOD plan and its activities for both Bandung and Gedebage stations.
   - Designate the area surrounding the station as commercial, service and public use oriented zones for development, including tourist accommodation and attractions.
   - Develop a tourist bus terminal and Angkot station for the tourist attractions connected with the railway station complex.

2) Re-improvement of regional transportation system with the HSR introduction
   - Integrate the projected city road network plan to effectively connect the railway station complex to the urban transport network.
   - Provide an effective feeder and public transportation network including a commuter railway and monorail networks in the city for easy access to city functions, which include two urban centers and the development in Bandung and Gedebage.
   - Develop school and institution service bus terminals for the convenience of the institution workers and students at the railway station complex.
   - Provide a feeder service network from the railway station complex to all over the city.



Source: JICA Study Team

Figure 5.2-10 Concept of Bandung Transport Network with High-Speed Rail Development

(6) Other City or Urban Center Linkage with the HSR Development

There are areas and several cities without HSR stations along the proposed alignment. Although these cities and areas are not directly connected with the HSR services, these should also be well integrated as parts of the development benefit. According to the analysis and hearings from each local government agency, some important actions have been identified to take during the actual project implementation.

1) Karawang Station Area Development Plan

The industry driving and growing the economy in Karawang, especially along the toll road, is the manufacturing industry, the same as in the Bekasi and Cikarang urban areas. There are a few growing industrial parks in the area as described in Chapter-3, and more migration is expected due to the increased employment. Because of the extension of the Jakarta - Cikampek toll road to Cirebon, this area including Cikampek and further east to Subang is being considered for more investment in industrial park development. Moreover, Karawang Regency has issued development permits for over fifteen industrial and residential parks in a large area south of the toll road. Being aware of the high potential of increased production in the region, the provincial government has planned a freight transportation network between Karawang urban area and Cilamaya Port where a new international port development is planned by the central and provincial governments. The freight transportation network will be accomplished by a highway and freight railway on a double-deck elevated structure, according to information from BAPPEDA Karawang spatial planning department. Although this development plan does not specifically propose a link with the double-double track upgrade project for the existing railway, strengthening freight transportation in the region will benefit the manufacturing industry in Karawang.

Karawang city center is densely occupied for residential use and many factory workers live in the city. Although the city has a large population, the urban area of Karawang is not well developed and the basic infrastructure, such as roads, needs to be upgraded for a better living environment. There is a bus service in the city with large-capacity vehicles, but the bus network does not fully cover all the residential areas because the road network is very limited, and they are not large enough and well maintained.

Except for the area along the toll road and the urbanized area in Karawang, most of the land in the north and south are used for agricultural production or forest preservation with minor forest and plantation production. Especially in the area on the flat land north of Jatiluhur dam lake, the forest land under provincial land use is designated for preservation or limited use.

As the HSR alignment runs through this area and the future development plan for Karawang airport is located in the same area, high level policy changes in land use should be well coordinated for the development of the area through government consultation.

Although there have been many discussions and a JICA study has been conducted, Karawang airport and its development plan are not yet finalized either in schedule or actual location. The proposed HSR Karawang station should serve to connect the airport facility to Jakarta and Bandung, and the information on the airport development plan must be updated in order to finalize the alignment and the location of the station for optimum functionality. Figure 5.2-11 indicates the current city development in Karawang urban area.

Left: Karawang Railway Station, Right: City center near the existing station

Source: JICA Study Team

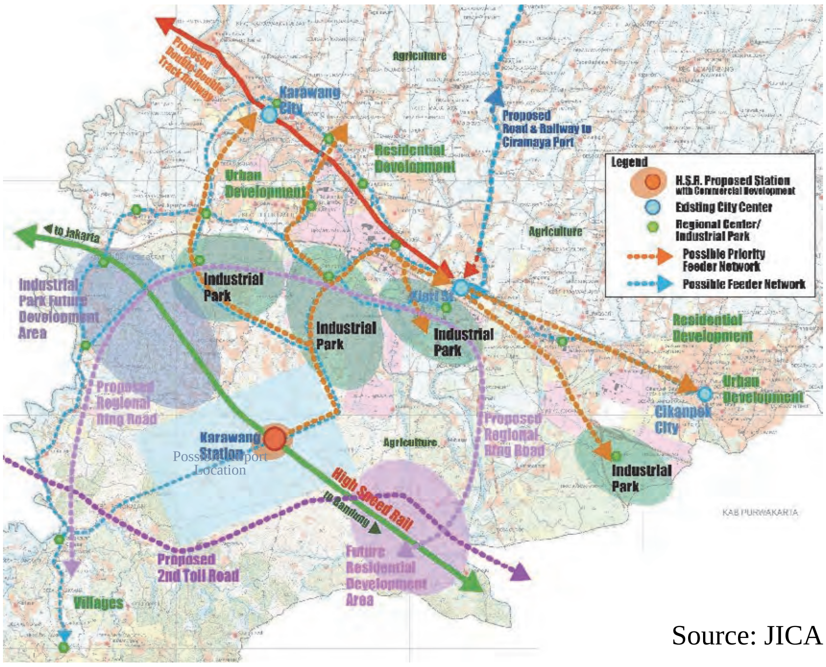
Figure 5.2-11 Current Urban Development of Karawang City Center

According to local government officials in Karawang city, the acquisition of farmland is rather difficult because the Ministry of Agriculture is keen to preserve farmland for more production by primary industry. Thus, the alignment as well as the station location must be carefully selected from this point of view along with taking into account the land use regulations. The following are the fundamental strategies for Karawang Airport HSR station development, and the following Figure 5.2-12 illustrates the concept of Karawang Transport Network with High-Speed Rail Development.

1) Attractive development for the area around the HSR station and formulation of built-up area centering on the HSR station
   - Select the best suitable location for station development with regard to the future airport development and facility layout as far as possible.

2) Re-improvement of regional transportation system with the HSR introduction
   - Develop new roads to connect the station area to Karawang urban center north of the toll road.
   - Connect HSR development together with the projected second toll road as well as the industrial area ring network work by the local government.
   - Extend and develop the existing southbound road along the Bekasi - Karawang border to connect the industrial development zone and the airport station as well as the far south region of the regency.
   - Develop effective integration of the airport station and develop the industrial park zone with an appropriate road and transportation network.
   - Develop an effective feeder service and transit network within the region, connecting the existing railway stations, urban centers, industrial parks, new residential developments and airport station for both passenger and goods transportation.

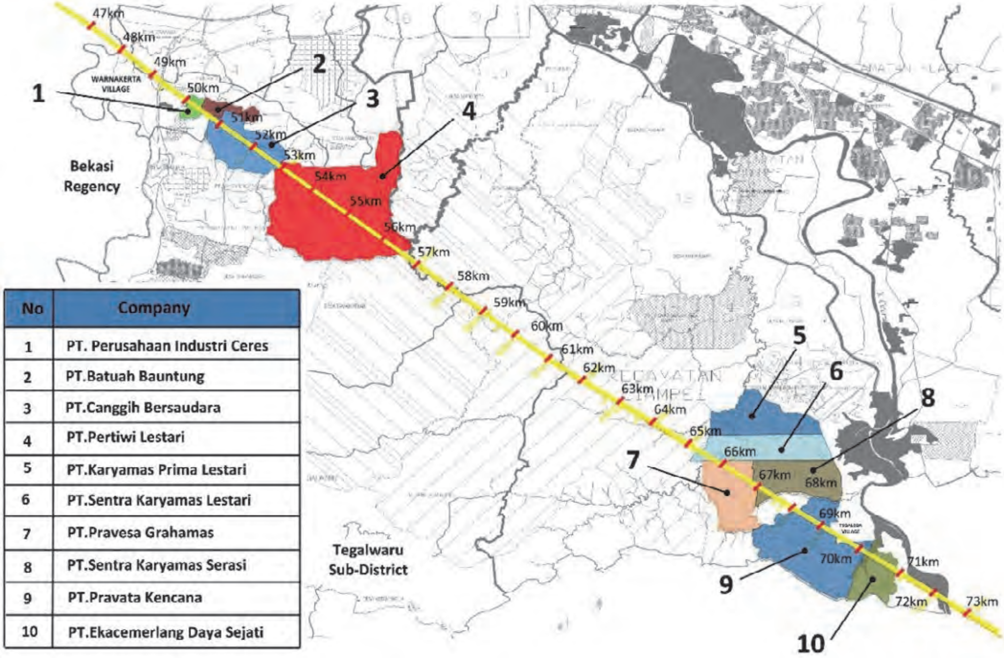
3) Revision of the related regulations
   - Work with the provincial and central governments to set the station and coordinate in land use regulation adjustment (forest, agricultural land, preserved land and others) if necessary.
   - Work cooperatively between the central and the local governments for land use and zoning regulation modifications or adjustments to settle land acquisition from the industrial developers whose land falls into the proposed alignment in order to achieve a win-win situation.



Source: JICA Study Team

Figure 5.2-12 Concept of Karawang Transport Network with High-Speed Rail Development

The following Figure 5.2-13 illustrates current land ownership along the HSR alignment in Karawang area. Multiple landowners exist, and many development plans have been approved for actual development. Before the HSR development moves to the actual implementation, all affected land concerned for the HSR development should be acquired by the implementation agency, therefore the high level negotiation with all landowners shall be completed considering fair property exchange and cooperative development actions along the HSR alignment and facilities.



Source: JICA Study Team

Figure 5.2-13 Current Land Ownership Map along the HSR Alignment

2) Walini Area: Future HSR Station Location for West Java Capital City

During the West Java Province regional meeting held in order to discuss about the station locations, alignment and spatial & regional development under the HSR project, it was confirmed that the future West Java capital city will be developed in the Walini area although the final location has not yet been identified by the provincial government. Therefore, a rough location of the future capital city development was analyzed based on the data provided by the government, and the alignment is adjusted and runs through or nearby the proposed area. Thus, the station will be located in or near the future capital city in Walini. However, only the possible location is reserved for the future development, because further information has not been shared by the local government.

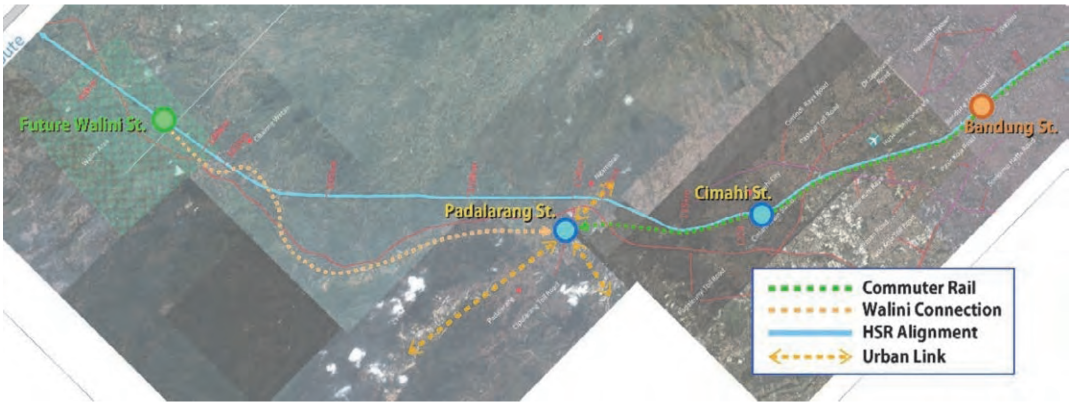
3) West Bandung Area and Cities

West Bandung is another area where some urban developments have been made, although there is no station projected other than the Walini future station area. The area has smaller but stable industrial activities, such as textile production, and a certain amount of population increase will be expected. However as the demand analyzed by the previous study illustrates, this area will not be expected for large ridership. On the other hand, there is an extension of the commuter rail development from the Bandung urban area, therefore it is more realistic to utilize the commuter rail system to connect the

HSR services to the West Bandung area for economic benefit. A few actions should be considered to take with the area including to:

- Develop commuter rail network from Bandung urban area to integrate the West Bandung area with HSR services, especially to Padalarang urban area.
- Develop new transportation network between the future Walini HSR station and Padalarang urban area for better service connection, when the HSR Walini station is realized.
- Develop well organized local transportation network connecting city centers, industrial areas and other developing places in the region.

The following Figure 5.2-14 illustrates the concept of Bandung City, West Bandung and Walini Transport Network.



Source: JICA Study Team

Figure 5.2-14 Concept of Bandung City, West Bandung and Walini Transport Network

4) Cimahi City

Cimahi city is a neighboring city of Bandung and is growing as a part of Bandung metropolitan area. However, it is not nominated as a HSR station site because of its position close to Bandung city, although Cimahi city is growing and its textile industry is the one of the largest producers in Java. It is important to consider the effective connection and transit integration with Bandung city under the HSR development. Since HSR station is not projected in Cimahi city, it is very important to set the commuter rail station at Cimahi city center as well as other surrounding developing centers, so that the HSR transportation service and economic benefit will also come to the region.

- Set commuter rail stations at most effective locations in the urban areas of Cimahi city with better connectivity to the HSR services.
- Revitalize the urban center of Cimahi as well as the existing industrial zones to boost economic activities.
- Develop a well-organized local transportation network connecting city centers, industrial areas and other developing places in the region.

The following Figure 5.2-15 illustrates the concept of Cimahi City Transport Network with Bandung Urban Area.

Source: JICA Study Team

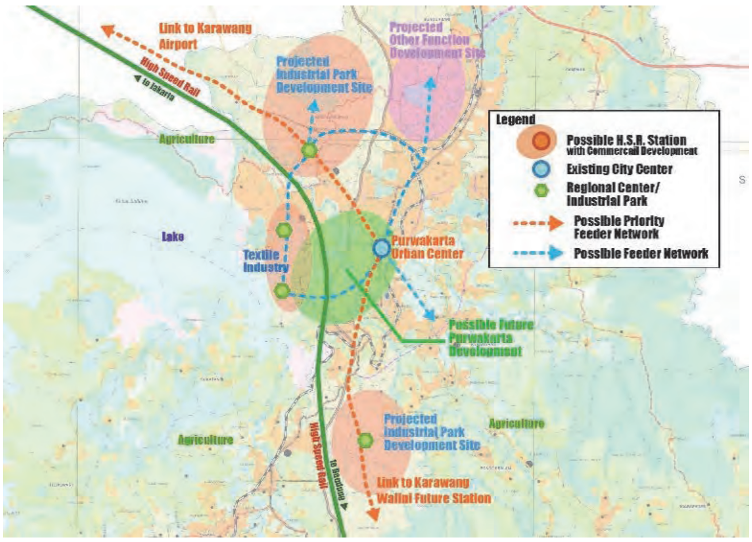
Figure 5.2-15 Concept of Cimahi City Transport Network with Bandung Urban Area

5) Purwakarta Regency

Although the HSR alignment runs through the Purwakarta Regency land, there is no projected station site in the area. However, it is important to consider good economic connections through the transportation network between regions with Purwakarta. There are many projected developments of industrial parks as well as other functions. The textile industry is one of the major production sectors of Purwakarta and this should be well supported by the TOD integration development of the country. Since the region is mountainous, natural disaster management is one of the largest issues to take into account while undertaking any development. There are a few major actions to be made during the actual development implementation.

The following Figure 5.2-16 illustrates the concept of Purwakarta Regional Transport Network with Neighboring Areas.

- Develop transportation network from Walini area to integrate the Purwakarta region with larger economic network.
- Develop new transportation network between the future Karawang Airport and the Purwakarta region for better service connection, when Karawang station is realized.
- Develop well-organized local transportation network connecting city centers, industrial areas and other developing places in the region.



Source: JICA Study Team

Figure 5.2-16 Concept of Purwakarta Regional Transport Network with Neighboring Areas

5.3 Development Concept of Station Plaza from the Regional Development Viewpoint

According to the condition of each station location and its surrounding development activities and transportation integration plan, each station and its station front plaza shall be independently designed with necessary functions, such as bus terminal, taxi stands, pick-up & drop-off section, parking space, etc. The size of the station plaza of each site differs as well, according to the ridership and demand forecast. The size of the plaza for each station is described in the following Table-5.3-1.

Table 5.3-1 Required Development Facilities and Area for Station Plaza

		Unit	Jakarta	Bekasi	Cikarang	Bandung	Gedebage
Bus Facility	Number of Pick-up berths	berth	(11)	3	5	20	9
	Number of Get-off berths	berth	(6)	2	2	10	4
Taxi Facility	Number of Pick-up berths	berth	5	2	3	4	3
	Number of Drop-off berths	berth	13	6	7	12	7
	Taxi Parking Capacity	car	257	116	129	238	133
Private Car Facility	Number of berths	berth	36	12	22	27	30
	Car Parking Capacity	car	(178)	58	107	132	147
Total Area		**m^2**	25,000	13,000	18,000	34,000	24,000

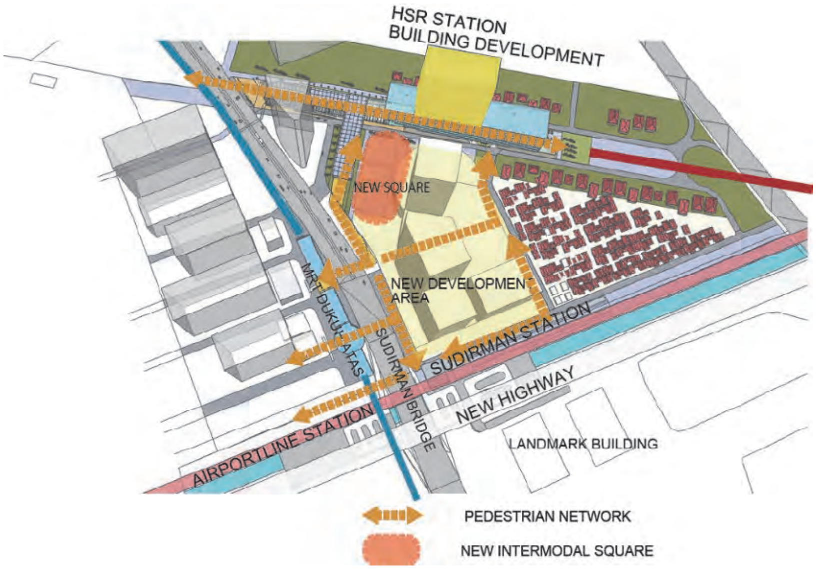
Note: Numbers in brackets are not considered for floor area calculation for plaza development.

Source: JICA Study Team

(1) Dukuh Atas Station Plaza

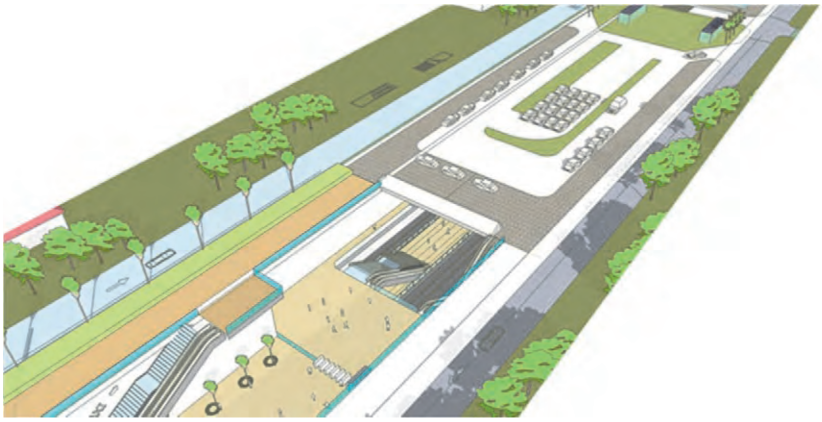
Land acquisition to satisfy the station square function is difficult in the Dukuh Atas area. Therefore the station square is planned on the first floor above the station area. In the Preparatory Survey on Jakarta Transport and Urban Structure Development Project (PPP Infrastructure), a traffic square with an elevated pedestrian deck is planned running east-west along Sudirman Bridge. Even if this is completed, it will be far from the HSR station site, and there is a need to ensure an independent HSR traffic square.

Not only the pedestrian connection but also urban revitalization around the HSR station is necessary to expand business and commercial activities as well as to improve revenue from the area for better TOD effectiveness. Therefore, it is expected that the central government will act on adjusting the land use and zoning regulations at this location for integrated TOD and commercial mixed-use development.



Source: JICA Study Team

Figure 5.3-1 Future Station Front Development Concept Image at Dukuh Atas



Source: JICA Study Team

Figure 5.3-2 Station Plaza Development Concept Image at Dukuh Atas

(2) Bekasi Station Plaza

It is proposed to locate the station square on the south side of the station. The station square will provide kiss and ride facilities, a taxi stand, taxi parking and bus berths. Large development cannot be expected on the north side since there is an existing highway with limited open land, so that the park and ride facilities are also proposed with the station. Road access to the highway interchanges and to the north side across the highway and the river should be secured for Bekasi regional development with HSR service network.

(3) Cikarang Station Plaza

The station square is proposed on the south side of the station. The station square will provide kiss and ride facilities, a taxi stand, taxi parking and bus berths. Large development cannot be expected on the north side since there is an existing highway on the north side, so that the park and ride facilities are also proposed with the station. Road access to highway interchanges and a road network to surrounding industrial parks including LIPPO Cikarang and Kota Deltamas industrial park should be secured as the projected APM transit system being integrated.

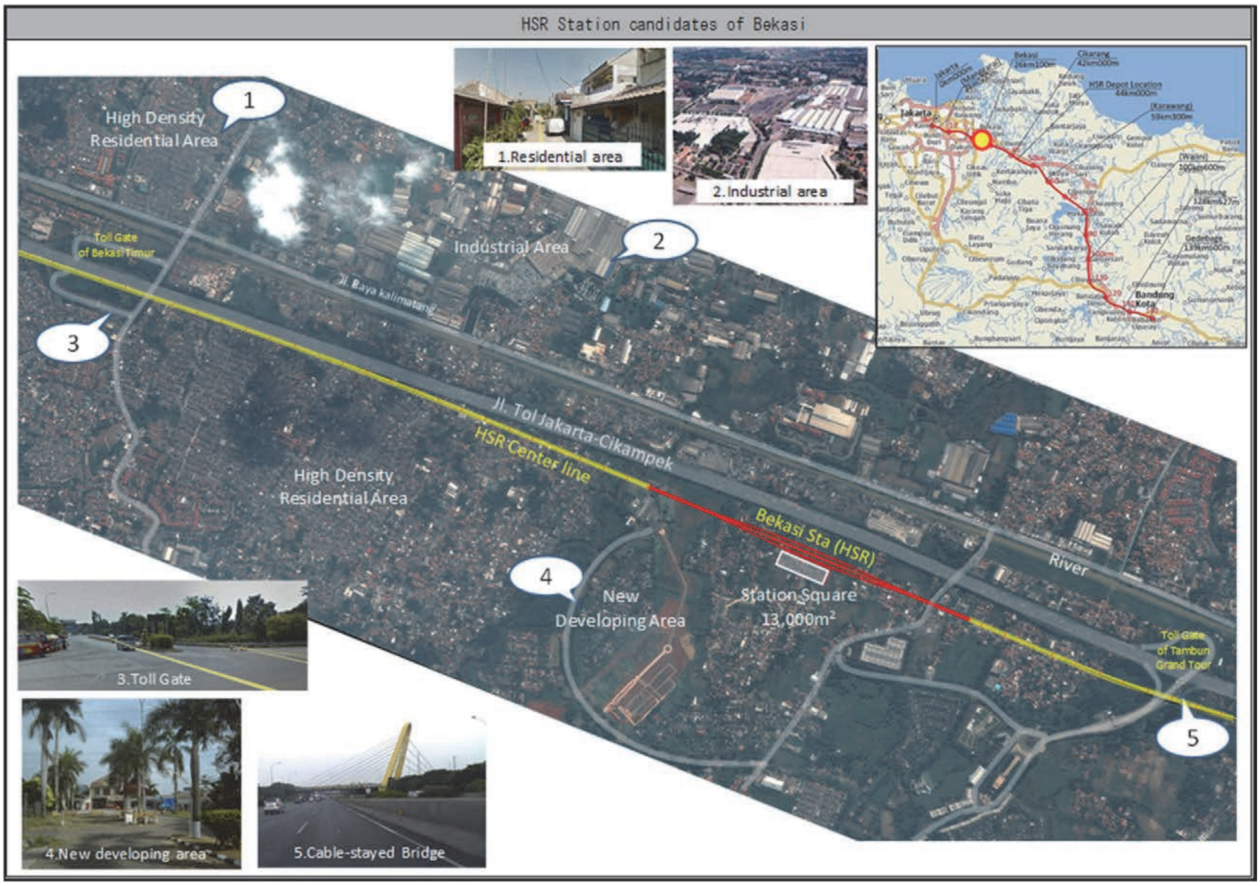


Figure 5.3-3 Station Plaza Development Image for Bekasi

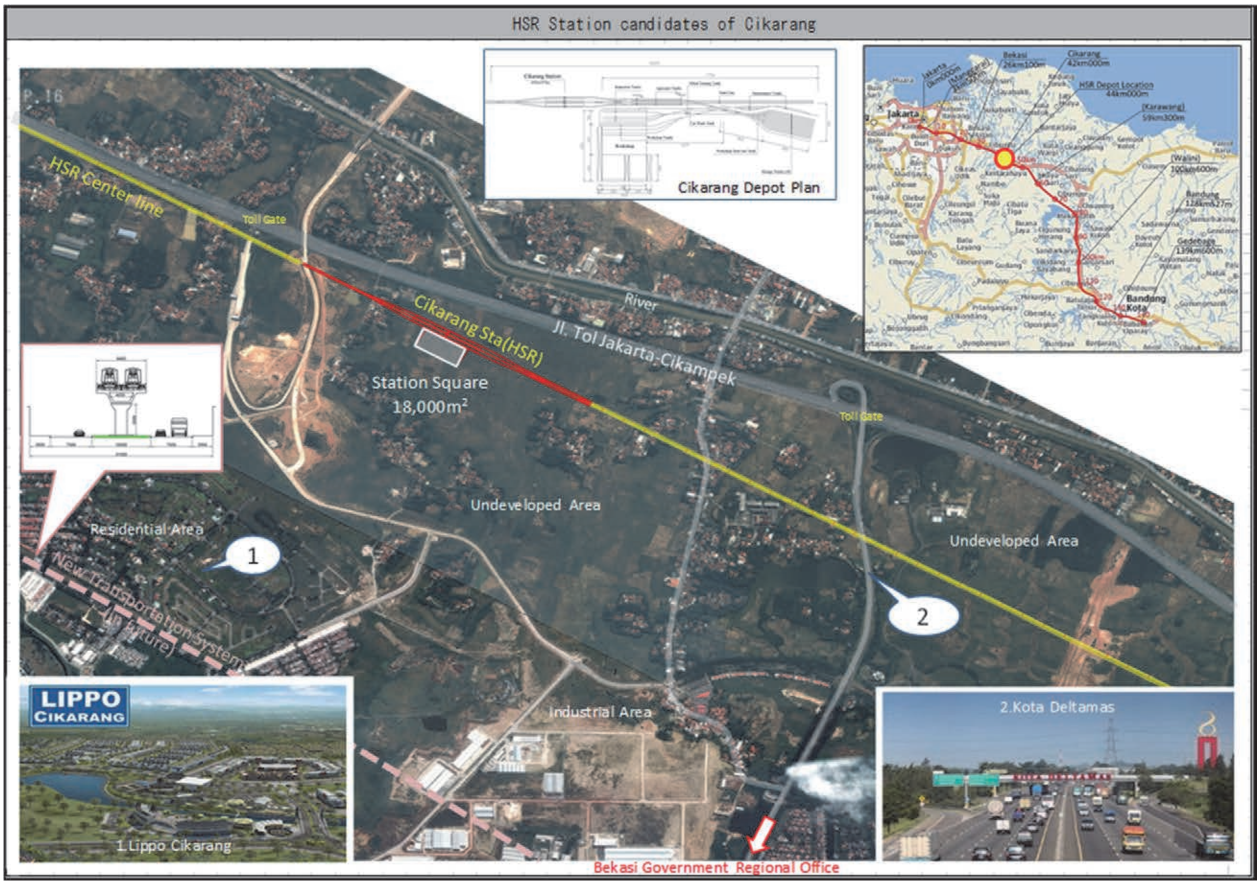


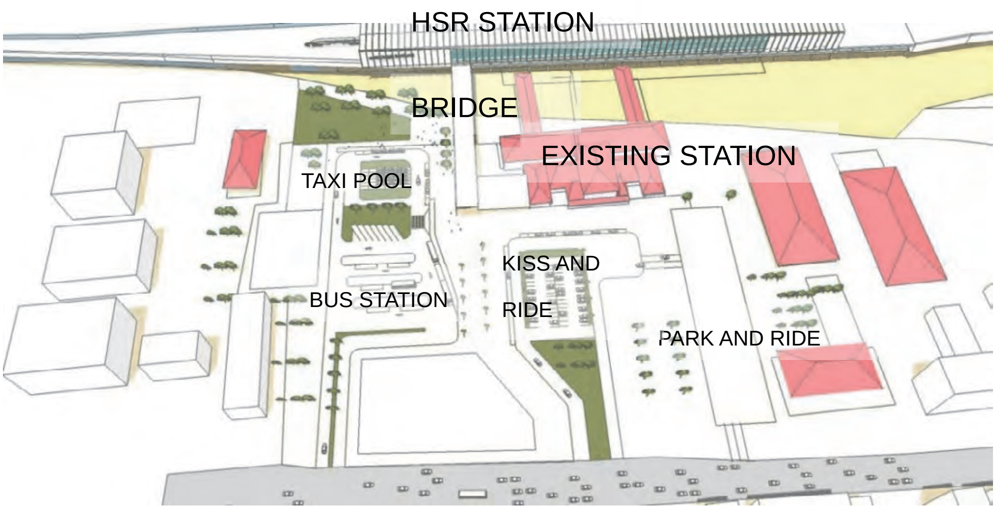
Figure 5.3-4 Station Plaza Development Image for Cikarang

(4) Karawang Station Plaza

Karawang station is a very particular facility to be developed as a part of the national airport development plan, and the HSR station and its station plaza will not be independent from the airport function. Therefore, the plaza development and its plan will be integrated with the future airport terminal design, and the project does not propose a particular concept during this stage of study. Necessary transportation network and integration from the HSR station to the surrounding region of Karawang is described in the previous section of the report.

(5) Bandung Station Plaza

There are station buildings to the north and south of Bandung Station. It is favorable to plan a station square on both sides. However on the south side, there is limited vacant land for development. Therefore, a station square is proposed on the north side by using the existing parking lots, and a station square on the south side shall be developed in the future. In consideration of the present conditions, it is assumed that most passengers will transfer to private cars or taxis from the HSR. Considering the promotion of bus use, a station square including bus and Angkot terminal facility is proposed. The current station square provides only private car parking, therefore it is necessary to increase the convenience of transfer by introducing TOD concept and functions. In addition, it is more effective providing a taxi stand, and taxi parking, and dividing the park and ride functions as well as kiss and ride functions for private cars. Pedestrian space should be also provided for vitalizing the station area.



Source: JICA Study Team

Figure 5.3-5 Future Station Front Development Concept Image at Bandung

(6) Gedebage Station Plaza

According to the information provided by Bappeda Bandung city, the TOD terminal development plan for Gedebage new urban area is under preparation by the city and its consultant, and the new “Techno-Polis” development project seeks its unique transit oriented urbanization in Gedebage area. The Gedebage TOD terminal building will consist of station facilities for the existing railway, newly planned commuter rail, Bandung monorail network, city bus network, Angkot service and taxi service as a whole of TOD, and the HSR service is included as a part of the city transportation network system with others. The TOD complex will be a mixed-use high-rise structure with a lot of functions including shopping center and others. The transportation system and these station facilities will be housed within the complex. However, the design of the TOD complex is still under development so that the station plaza arrangement should wait for the TOD complex plan in order to set HSR service into the complex program. Therefore, HSR plan does not stand alone for the station plaza development for Gedebage station.

Chapter 6

Demand Forecast

Chapter 6 Demand Forecast

6.1 Demand Forecasting Method

To estimate the number of users of HSR in the future, the following procedures were executed.

(1) The future growth rates by traffic mode (passenger car, bus, rail and air) were set by analysis of the time series data of traffic by mode and GRDP.

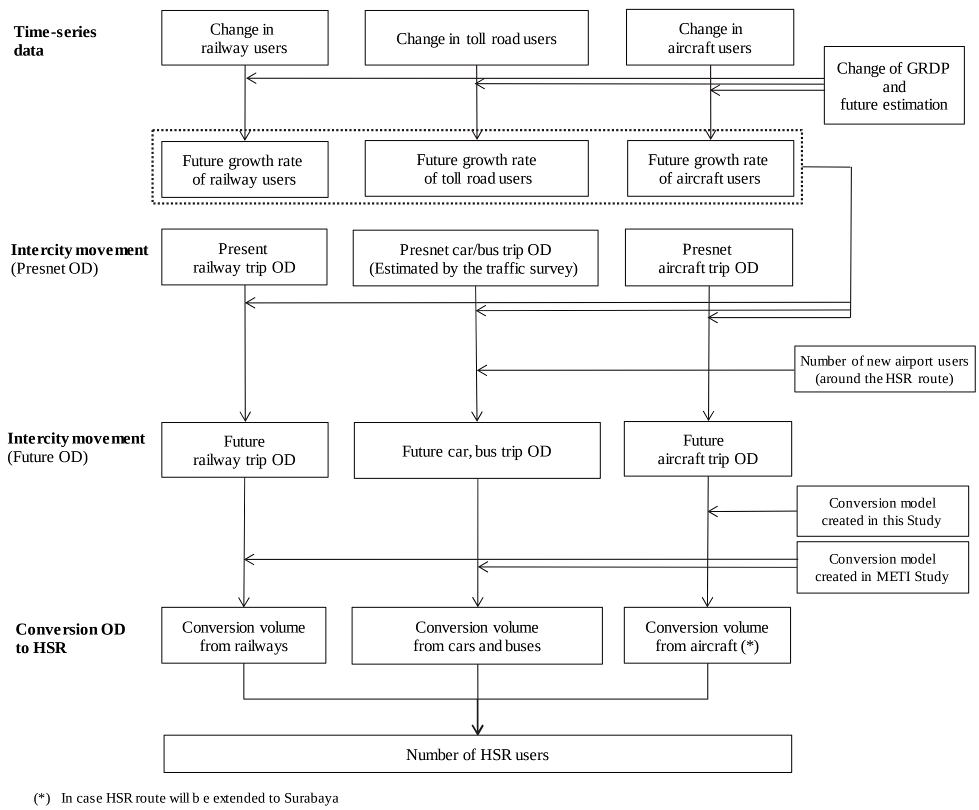
(2) The present OD volume data by traffic mode were obtained. OD data by train and by air were obtained by the statistical data, but OD data by passenger car and bus did not exist and they were obtained by the implementation of traffic surveys and forecasting.

(3) The future OD volumes were calculated by multiplying the growth rates which were calculated in (1) by the present OD volumes which were obtained in (2).

(4) The access traffic to the two new planned airports was calculated and was added to the future OD traffic which was obtained in (3).

(5) The conversion rate models from the existing traffic mode to HSR were prepared. The models for passenger car, bus and rail created in the METI survey were reused, and the model for air was made by implementation of a stated preference (SP) survey.

(6) The number of HSR users was estimated using the conversion rate models which were prepared in (5) and the future OD volumes by the models which were prepared in (3).



Source: JICA Study Team

Figure 6.1-1 Flowchart for Demand Forecasting

6.2 Traffic Situation in the Study Area

6.2.1 Traffic Networks in the Study Area

Figure 6.2-1 shows the major traffic networks in the study area. The toll roads which connect Jakarta and Bandung are the Jakarta - Cikampek toll road and Purbaleunyi toll road, with 6-8 lanes and 4 lanes, and road lengths of 83 km and 123 km respectively. As for the toll system, distance charges are set in 5 classes, and the tariff between Jakarta IC and Cileunyi for Class I (passenger cars and buses) is 52,500 Rp. Motorcycles are not allowed on the toll roads.

Table 6.2-1 Toll Road Charges

Name	Distance (km)	No. of lanes	Tariff (Rp.)						
			From	To	Class I	Class II	Class III	Class IV	Class V
Jakarta - Cikampek	83	6-8	Jakarta IC	Cikampek	12,000	19,500	24,000	30,000	36,500
			Jakarta IC	Dawuan IC	10,500	17,000	20,500	26,000	31,500
Purbaleunyi	123	4	Dawuan IC	Cileunyi	42,000	63,500	82,000	103,000	123,500

Note: Class I: Passenger cars, buses, Class II: 2-axle trucks, Class III: 3-axle trucks, Class IV: 4-axle trailers, Class V: 5-axle trailers

Source: Jasa Marga website, et al.

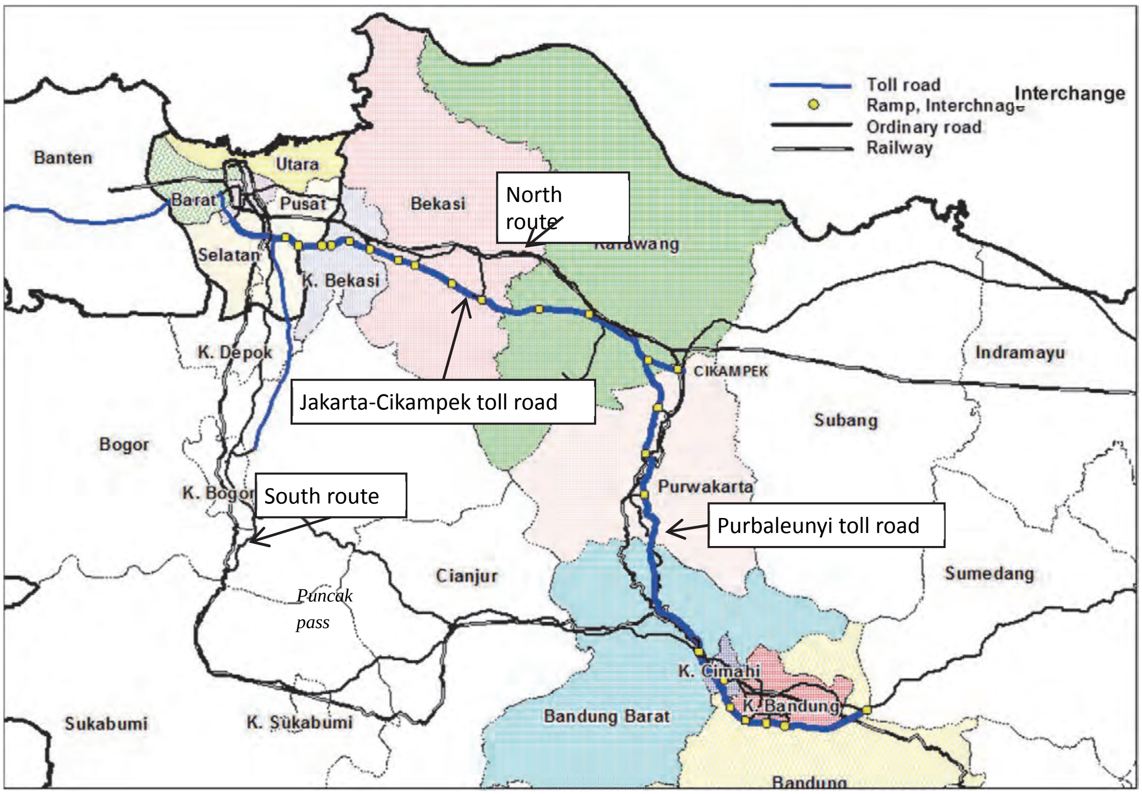
There are two ways to travel between Jakarta and Bandung by ordinary roads. One is the north route which connects Jakarta, Bekasi, Cikampek, Purwakarta and Bandung, and the other is the south route which connects Jakarta, Bogor, Cianjur and Bandung. Both routes are mainly used by local traffic and there is little use by intercity traffic. In particular, the south route is rarely used because it takes a long time to get across the Puncak Pass.

As for the railways, two kinds of trains, express trains and local trains, operate now on the line (166 km) which connects Jakarta, Bekasi, Cikampek, Purwakarta and Bandung.

Another line which connects Jakarta, Bogor, Sukabumi and Bandung also exists, but it is not used by intercity transportation because the travel distance is longer than the former, and the track between Bogor and Sukabumi was blocked from 2005 to 2008 due to sediment disaster.

The travel time by express train between Jakarta and Bandung is around 3 hours because the maximum speed is limited to 50 km/h due to the approximately 700 meter difference in elevation between Cikampek and Bandung and the existence of steep slopes and poor alignment sections.

On the other hand, the toll road opened in 2005 and it became possible to travel between Jakarta and Bandung in two hours during off-peak time. Therefore, railway competitiveness declined rapidly and the number of trains on the same section decreased.



Source: JICA Study Team

Figure 6.2-1 Major Traffic Networks

6.2.2 Traffic Movement in the Study Area

(1) Railways

There are two railway lines between Jakarta and Bandung. One connects Jakarta Gambir Station and Bandung Station by express train (called Argo Parahyangan) and the trains run 6 times (+3 times temporarily) per day. The other connects Jakarta Kota Station and Kroya Station in Central Java via Bandung Kiaracondong Station by local train (called Serayu Pagi and Serayu Malam) and the trains run twice per day. The fares on the same section are 60,000 - 110,000 Rp. for the express train and 45,000 Rp. for the local train. The fare for the local train is subsidized by the government to ensure easy movement for the low-income group.

The origin and destination for express train passengers are mostly Gambir Station and Bandung Station, and the origin and destination for local train users are mainly Kota Station and Kroya Station and a few passengers use Kiaracondong Station in Bandung. Therefore, only express train users are regarded as divertible to HSR. The number of express train users between Jakarta and Bandung in 2013 was 860,600 pax/year.

Table 6.2-2 Train Type, Number of Operations, Seat Capacity, Fare, and Number of Users in 2013

Stations	Round Trips/Day	Class	Seat Capacity	Between Jakarta and Bandung	
				Fare (Rp.)	Number of Users in 2013
Gambir - Bandung	6 (everyday) +3 (extra)	Executive	3-4 cars x 52 seats	100,000 - 110,000	676,647
		Business	2-3 cars x 64 seats	60,000 - 65,000	183,928
Jakarta Kota - Kiaracondong - Kroya	1 (daytime) +1 (overnight)	Economy	6 cars x 106 seats	45,000	n/a

Source: PT KAI Timetable, Volume dan pendapatan tahun 2013

(2) Roads

The major roads in the study area are the Jakarta - Cikampek toll road and the Purbaleunyi toll road. The number of users in 2012 was 194.9 million vehicles/year and 60.3 million vehicles/year respectively. Moreover, the average daily traffic volumes on the main sections in October 2013 are shown in Table 6.2-3.

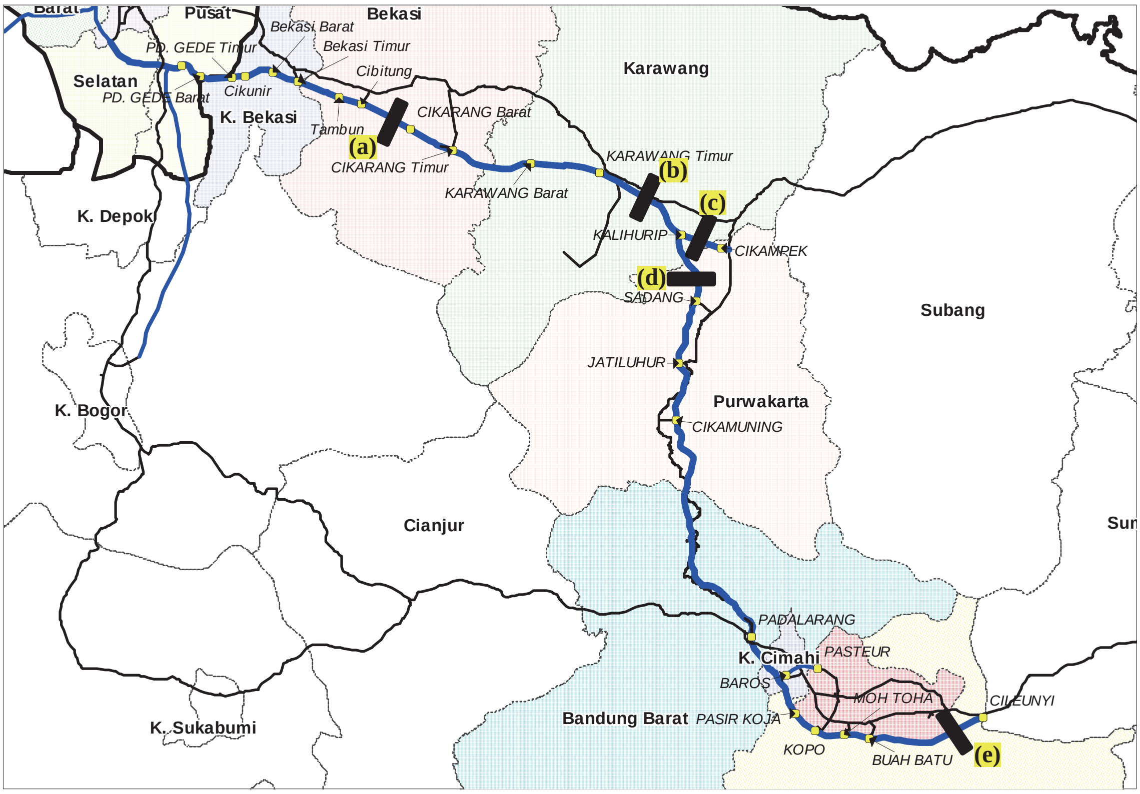
The highest volume with 136,000 vehicles/day in total was counted on (a) section which is the nearest section from Jakarta, and 112,000 vehicles/day were counted on (b) section located near Dawuan IC between Jakarta - Cikampek toll road and Purbaleunyi toll road.

About 70% of the traffic which passes Dawuan IC is related to travel between Jakarta and Bandung, because 69,000 vehicles/day on (d) section and 56,000 vehicles/day on (e) section of the Purbaleunyi toll road were counted, whereas only 33,000 vehicles/day on (c) section were counted on the eastern edge of the Jakarta - Cikampek toll road.

Table 6.2-3 Average Daily Traffic by Class and by Major Section

Class	Jakarta - Cikampek toll road			Purbaleunyi toll road	
	(a) Cibitung - Cikarang Barat	(b) Karawang Timur - Dawuan IC	(c) Kalihurip - Cikampek	(d) Dawuan IC - Sadang	(e) Buah Batu - Cileunyi
I	100,734	84,833	22,405	56,541	47,437
II	21,878	17,478	6,938	7,989	6,646
III	7,986	6,410	2,161	3,247	1,820
IV	3,363	1,755	829	590	153
V	2,262	1,306	622	475	183
Total	136,223	111,782	32,955	68,842	56,239

Source: Data volume lalu intas transaksi, October 2013, Jasa Marga



Source: JICA Study team

Figure 6.2-2 Location Map of Major Sections on the Toll Roads

(3) Air

No airlines operate between Jakarta and Bandung now. The number of air passengers in 2013 between Jakarta and Semarang and Surabaya, and between Bandung and Semarang and Surabaya is shown in Table 6.2-4.

Table 6.2-4 Number of Passengers by Air in 2013

Route		Passengers (pax/year)	Flights (flights/year)
Jakarta-Semarang	CGK-SRG	2,272,235	15,372
Jakarta-Surabaya	CGK-SUB	5,555,702	37,768
Bandung-Semarang	BDO-SRG	28,648	585
Bandung-Surabaya	BDO-SUB	489,727	3,401

Source: Directorate General of Air Transportation, 2014

(4) Intercity Bus

There are two kinds of buses which connect Jakarta and Bandung. One is a large bus and the other is a small bus called a “shuttle”. Large buses are operated from the 4 major intercity bus terminals located on the outskirts of DKI Jakarta, and shuttles are operated from the several shuttle bus terminals located in the center of DKI Jakarta.

Source: JICA Study team

Figure 6.2-3 Location Map of Intercity Bus Terminals (DKI Jakarta)

There were 466 passengers and 74 large bus services per day in 2013 at the 4 major intercity bus terminals in DKI Jakarta. Though the number of bus users from the major terminals was only 6 on average, other passengers might use the large buses at bus stops along the way.

Table 6.2-5 Number of Large Bus Users from Jakarta to Bandung in 2013

Name of bus terminal	No. of bus services/day	No. of passengers/day	Average travel time
Pulo Gadung	7	30	3 hours
Kalideres	1	3	4 hours
KP Rambutan	63	416	3 hours
Tanjung Priok	3	17	3 hours
Total	74	466	-

Source: Road transportation terminal management unit, transportation service, DKI Jakarta Province, 2014

The operation numbers per day for the major shuttle bus companies are shown in Table 6.2-6, and at least 1,240 or more buses are operated. Moreover, the average number of passengers on weekdays is 5 - 6 people, according to the hearing survey results.

Table 6.2-6 Number of Shuttle Services from Jakarta to Bandung in 2013

Company name	No. of services/day
Cipaganti	481
X Trans	200
Day Trams	180
Baraya	351
Transline	28
Total	1,240

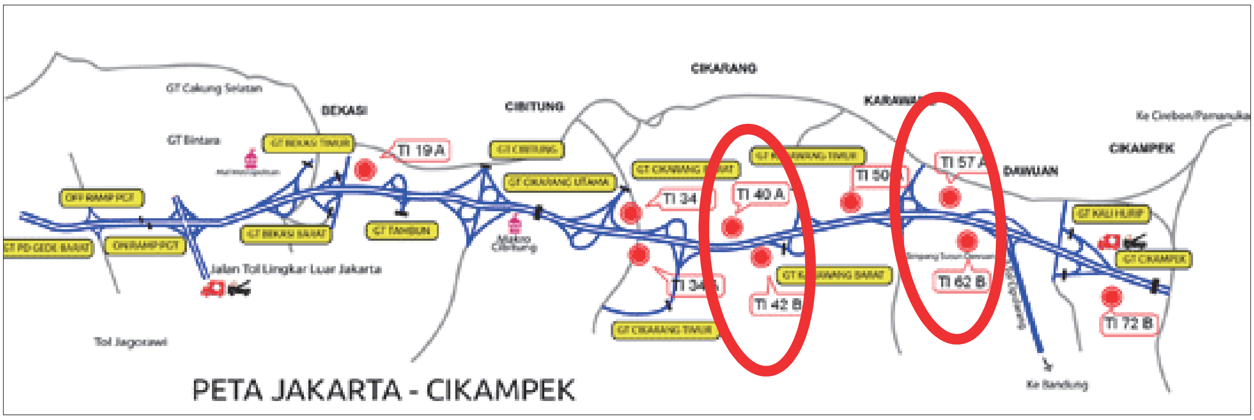
Source: Website timetables

The bus fare is around 35,000 Rp. for economy class, 60,000 Rp. for executive class for the large bus, and 85,000 Rp. for the shuttle. The fares change at peak and off-peak times.

6.3 Traffic Surveys

6.3.1 Creation of Present OD for Passenger Cars and Buses

Much of the traffic between Jakarta and Bandung is passenger cars and buses, but there were no OD tables for these modes. Therefore, an OD interview survey and traffic count survey were conducted at 4 rest areas (42 km and 62 km points on the inbound lanes, and 40 km and 57 km points on the outbound lanes) on the Jakarta - Cikampek toll road.



Source: JICA Study Team

Figure 6.3-1 Traffic Survey Points

Table 6.3-1 shows an overview of the traffic survey results. Many users were observed at the 57 km point on the outbound lanes and 42 km point on the inbound lanes. In particular, many bus users were observed at the 57 km point compared with the other survey points and the number of passengers reached 29,300 trips/day.

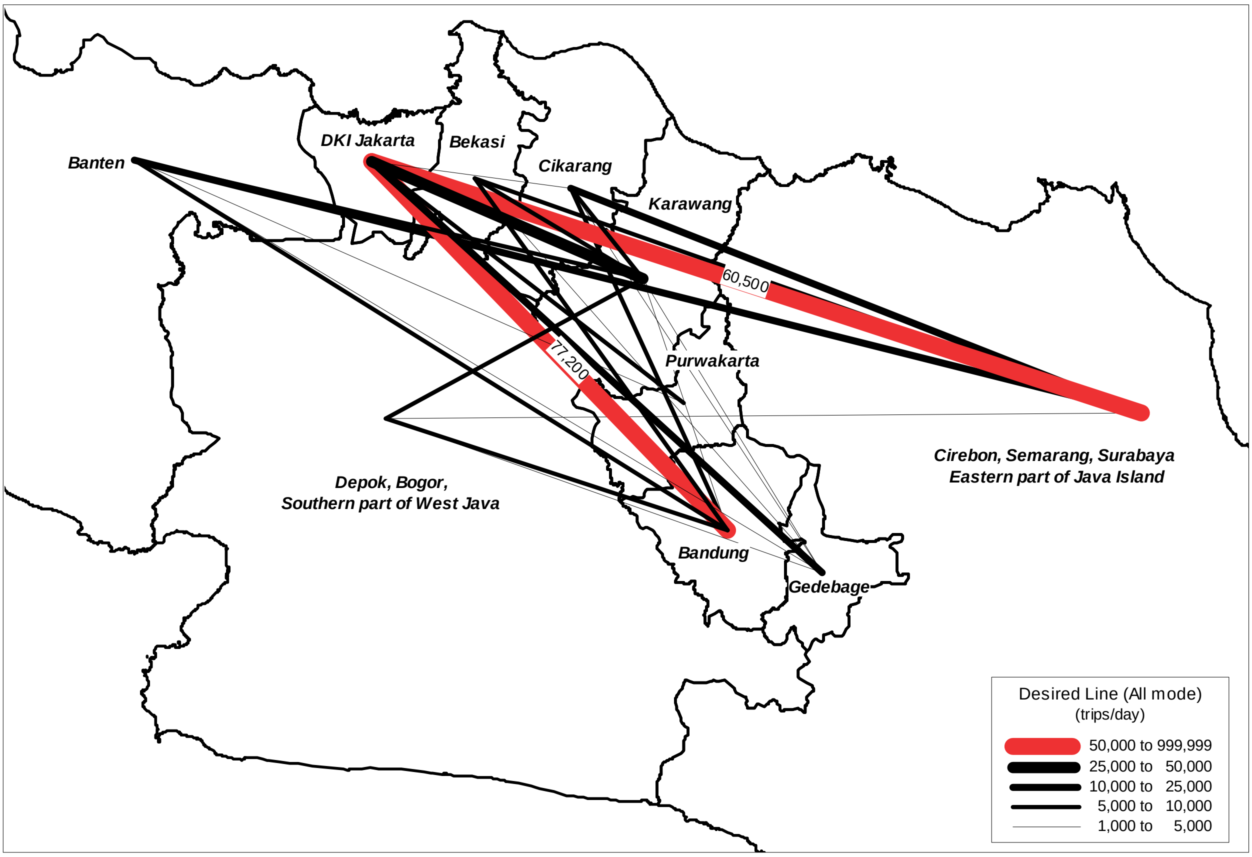
Table 6.3-1 Overview of Traffic Survey at Rest Areas

Bound	Location	Number of Vehicles (veh/day)				% of Buses	Traffic on the Main Road (veh/day)	Rate of Use %	Number of Passengers (pax/day)			
		Car	Small Bus	Large Bus	Total				Car	Small Bus	Large Bus	Total
Down	40A	4,829	461	569	5,859	17.6%	53,448	11.0%	12,443	1,424	8,673	22,540
	57A	4,617	815	931	6,363	27.4%	42,267	15.1%	16,525	2,722	10,073	29,320
Up	62B	2,386	674	781	3,841	37.9%	42,556	9.0%	7,554	1,167	9,831	18,552
	42B	4,015	385	273	4,673	14.1%	53,498	8.7%	12,952	1,935	4,179	19,066

Source: JICA Study Team

Figure 6.3-2 shows the desired lines for the present passenger OD table which created from the traffic survey results. The numbers of passengers by vehicle type by major OD pairs are also shown in Table 6.3-2.

The highest volume of traffic on the Jakarta - Cikampek toll road is 77,200 trips/day between Jakarta and Bandung, and the second highest is 60,500 trips/day between DKI Jakarta and Cirebon, Semarang and the eastern part of Java Island. The breakdown of the traffic between Jakarta and Bandung shows that 84% of trips are by passenger cars, which is the highest, followed by small buses with a share of 14%.



Source: JICA Study Team

Figure 6.3-2 Desired Line for Jakarta - Cikampek Toll Road Users

Table 6.3-2 Traffic by Car Type by Major OD Pair

(Unit: trips/day)

OD pair	Car	Small Bus	Large Bus	Total
Jakarta - Cikarang	1,200	0	0	1,200
Jakarta - Karawangg	31,400	0	4,700	36,100
Jakarta - Purwakarta	7,500	1,200	200	8,900
Jakarta - Bandung	65,100	10,500	1,600	77,200
Jakarta - Gedebage	19,200	3,100	500	22,800
Jakarta - Cirebon, East Java	53,600	0	6,900	60,500

Source: JICA Study Team

6.3.2 Creation of Transport Mode Shift from Air to HSR (In the event that the HSR will be extended to Surabaya)

The stated preference (SP) survey, which is a kind of interview survey that asks some questions about the conditions under which people would change their transport mode from air to HSR, was conducted of passengers going to board flights to Surabaya at Soekarno-Hatta Airport. The conversion model to forecast the number of HSR passengers in the event that HSR is extended to Surabaya was then created. Table 6.3-3 shows the number of services between Jakarta and Surabaya on weekdays, and Table 6.3-4 shows the number of target flights and the number of samples. There are 49 direct flights on weekdays, and the ratio of LCC was 78%. Assuming the number of seats per flight is 180, the maximum transport capacity is about 9,000 pax/day. The number of targeted survey flights was 16, and 89% of the seats were occupied on the flights, and the SP survey was conducted on 400 of the passengers (15%).

Table 6.3-3 Number of Flights from Jakarta to Surabaya on Weekdays

Airline Company	IATA code	Number of Flights	
		Normal	LCC
Garuda	GA	11	-
Lion Air	JT	-	21
Citilink	QG	-	9
Air Asia	AK	-	5
Mandala Tigerair	RI	-	2
Merpati Nusantara	MZ	-	1
Total		11	38
Share %		22%	78%

Source: Airline timetables

Table 6.3-4 Target Flights, Passengers and Number of Interviewees

Flight Number	Departure Time	Aircraft	Number of Seats	Number of Passengers	Number of Interviewees
JT 692	9:10	Boeing 737	215	207	29
JT 576	10:55	Boeing 737	215	186	33
GA 312	11:20	Boeing 737	162	150	18
QG 803	11:30	A320	180	139	18
GA 314	12:30	Boeing 737	162	150	40
GA 316	13:30	Boeing 737	162	157	30
QG 805	13:40	A320	180	145	11
JT 582	14:00	Boeing 737	215	201	34
JT 578	15:40	Boeing 737	215	198	34
QG 813	15:45	A320	180	143	14
JT 696	16:50	Boeing 737	215	204	31
GA 322	17:10	Boeing 737	162	162	40
QG 817	18:10	A320	180	138	14
GA 326	19:30	Boeing 737	162	157	32
GA 324	20:00	Boeing 737	162	159	4
QG 807	20:10	A320	180	133	18
16 flights (Normal=6, LCC=10)		Total	2,947	2,629	400
% of embarkations				89%	-
% of interviews					15%

Source: JICA Study Team

An airplane fare for the economy class the interviewees paid averaged out 1,107 thousand Rupiah for Garuda, while 552 thousand Rupiah for LCC at around half the fare.

Table 6.3-5 Average Airplane Fare to Pay for the SP Interviewees

Company	Airplane Fare (Rp./pax)		
	Business Class	Economy Class	
Garuda	2,296,000	1,107,000	
Lion air	-	541,000	552,000
Citilink	-	578,000	

Source: JICA Study Team

The main purpose of the SP survey was to ask subjects which transport mode they would choose from the given 9 alternatives under different conditions. Based on these results, the transport selection model was formulated adopting the binary logit model shown below.

$$P_{HSR} = 1/\{1 + exp(V_{Air} - V_{HSR})\}$$

Where,

$$V_{Air} = \alpha \times (\text{Access time} + \text{Waiting time (hr)}) + \beta \times (\text{Travel time (hr)}) + \gamma \times (\text{Fare (Rp.)})$$
$$V_{HSR} = \alpha \times (\text{Access time} + \text{Waiting time (hr)}) + \beta \times (\text{Travel time (hr)}) + \gamma \times (\text{Fare (Rp.)})$$

Variables	parameter	t-value
α: Access+waiting time (hr)	-1.06425	-8.06
β: Travel time (hr)	-0.97617	-11.38
γ: Fare (Rp.)	-5.23E-06	-20.64
$\bar{\rho}^2$	0.16	
Hit-Ratio	70.7	
Number of samples	2,718	

Source: JICA Study Team

Table 6.3-6 shows the estimated choice probability with 9 alternatives.

Table 6.3-6 Estimated choice probability with 9 alternatives

Alt.	Access Time (min.)		Waiting Time (min.)		Travel Time (min.)		Fare (Rp.)		Choice Probability	
	Air	HSR	Air	HSR	Air	HSR	Air	HSR	Air	HSR
1	45	15	15	10	80	180	400,000	450,000	0.780	0.220
2	90	30	30	15	80	180	800,000	650,000	0.380	0.620
3	135	60	60	30	80	180	1,400,000	1,000,000	0.089	0.911
4	90	30	60	30	100	220	400,000	450,000	0.650	0.350
5	135	60	15	10	100	220	800,000	650,000	0.438	0.562
6	45	15	30	15	100	220	1,400,000	1,000,000	0.282	0.718
7	135	60	30	15	120	260	400,000	450,000	0.720	0.280
8	45	15	60	30	120	260	800,000	650,000	0.606	0.394
9	90	30	15	10	120	260	1,400,000	1,000,000	0.276	0.724

Source: JICA Study Team

6.4 Demand Forecasting Results

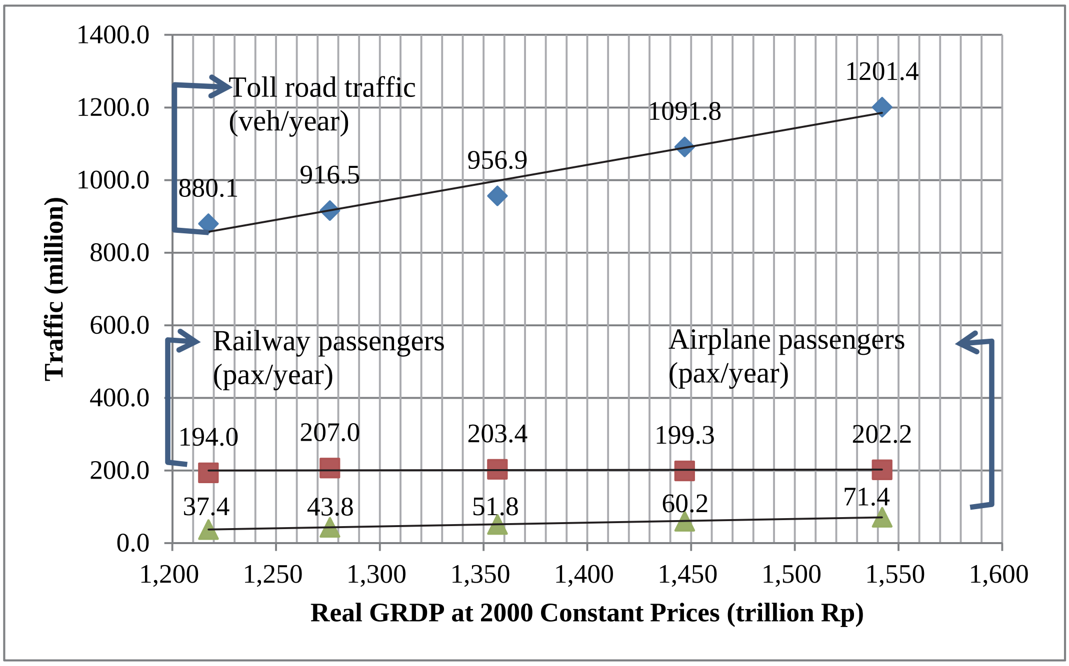
6.4.1 Preconditions

(1) Target Year

The start year of HSR operation is set at 2020 in consideration of the construction period and relevant projects, and the evaluation period is set at 30 years based on the railway project evaluation period in Japan. Therefore, the target year for demand forecasting is from 2020 to 2050 with a 10-year interval.

(2) Comparison with Socioeconomic Indicators

When GDP rises, traffic demand rises. Therefore, linear regression models by mode were made by transition of GRDP and transition of traffic by mode, and then the models reflect the expansion of production activity and commerce by economic growth to the increased traffic demand. However, as the accuracy of the regression for rail demand was low, the future demand was estimated using the annual growth rate (see Figure 6.4-1). GRDP in the future was established using examples from the long-term forecasting under MP3EI (see Table 6.4-1 and Figure 6.4-2). After that, traffic demand by mode in the future was estimated by inputting the future GRDP to the linear regression models.



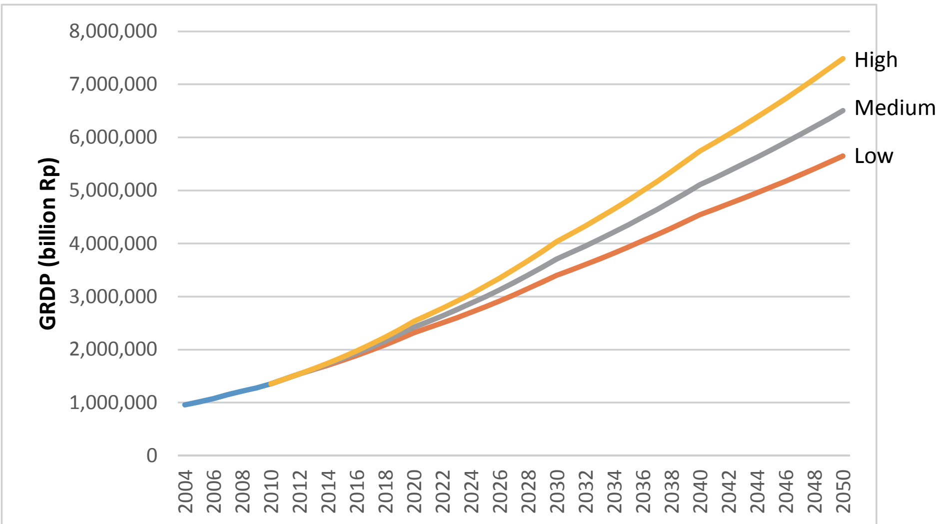
Source: JICA Study Team

Figure 6.4-1 Relation between GRDP and Traffic by Mode

Table 6.4-1 Combination of GRDP Annual Growth Rate by Period

	Low	Medium	High
2012-2020	5.2%	5.8%	6.4%
2020-2030	3.9%	4.4%	4.8%
2030-2040	2.9%	3.3%	3.6%
2040-2050	2.2%	2.4%	2.7%

Source: JICA Study Team



Source: JICA Study Team

Figure 6.4-2 Estimated GRDP in Java Island (at 2000 constant prices)

(3) Conversion Traffic from Road Traffic

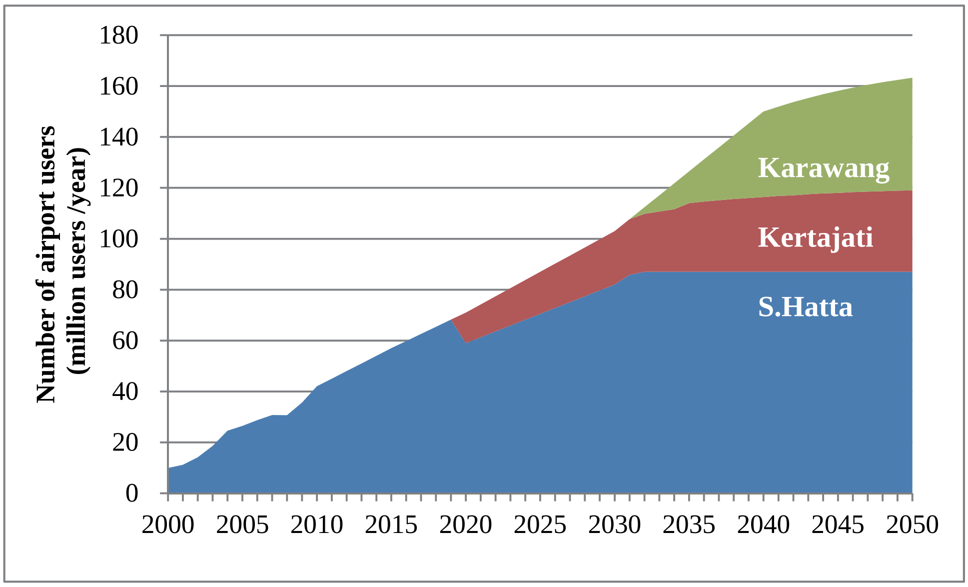
- There are two ways to travel between Jakarta and Bandung by road, one is to use the Jakarta - Cikampek and Purbaleunyi toll roads, and the other is to use ordinary roads. However, the ordinary roads have several problems such as poor road conditions compared to the toll roads, heavy congestion by local traffic and so on. Therefore many road users use the toll roads which provide good traffic performance such as shorter arrival time and comfortable road conditions. Moreover, as it is difficult to identify the origins and destinations of ordinary road users, the conversion traffic from road users to HSR is limited to toll road users.
- In the event that the HSR will be extended to Surabaya, it is not possible to grasp the traffic between Cirebon and eastern Java Island, because such traffic will not use the Jakarta - Cikampek toll road. Therefore, the volume of converted traffic from road users to HSR will be lower than the actual volume.

(4) Conversion Traffic from Rail Traffic

For railway users between Jakarta and Bandung, executive class and business class users, they are assumed to be able to pay to some extent and to travel by business trip, are targeted as the conversion traffic users from rail to HSR.

(5) Influence of Airport Development

Soekarno-Hatta Airport plans to extend the facility capacity to 62 million persons/year by 2015 by the improvement of terminals 1 to 3, and finally to extend to 87 million persons/year by the development of the 4th terminal. Also, the development of the new Kertajati international airport, which the Government of West Java Province plans to open in 2020, and the new Karawangg international airport in 2032 are planned, and the number of airport users in the future is estimated as shown in Figure 6.4-3. In this study, it is assumed that all users of Kertajati and Karawangg new international airports will access the airports by passenger car, and the number of airport users is added to the passenger car OD table.



Source: METI Report, 2012

Figure 6.4-3 Number of Airport Users

(6) Conversion Model from Passenger Car, Bus and Rail to HSR

The SP survey was conducted and conversion models by mode by binary logit type were formulated to forecast the future demand of HSR in the METI study. Therefore, those conversion models are extended to this study.

Table 6.4-2 Model Parameters

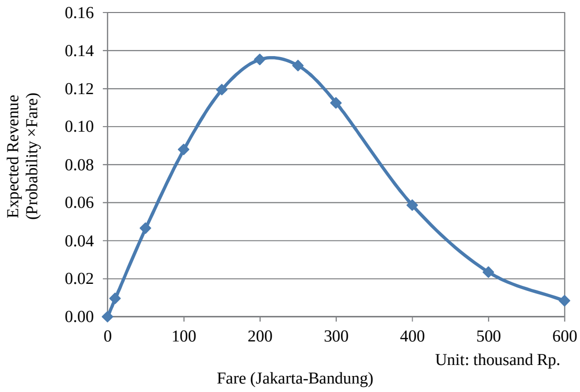
Variables	Car		Bus		Railway	
	Parameter	t-value	Parameter	t-value	Parameter	t-value
α: Access+waiting time (hr)	-0.58100	-1.80	-0.00153	-2.24	-0.11628	-7.16
β: Travel time (hr)	-0.47000	-8.50	-0.64845	-12.07	-0.83326	-7.17
γ: Fare (Rp.)	-3.8E-05	-3.89	-1.6E-05	-7.54	-1.1E-05	-3.26
$\bar{\rho}^2$	0.23		0.18		0.16	
Hit-Ratio (%)	73.3%		69.7%		70.0%	
Number of samples	1044		738		477	

Source: METI Report, 2012

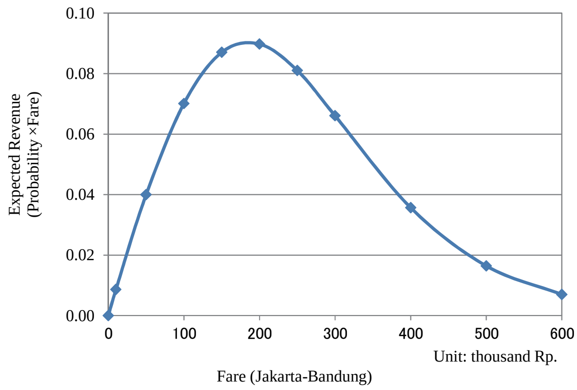
(7) Fare Setting

According to the correlation between the fare and expected revenue which was estimated for the Jakarta - Bandung section where the number of users is the highest, using the formulated models shown in Table 6.4-2, the expected revenue is highest when the HSR fare is set at 200,000 Rp. (see Figure 6.4-4).

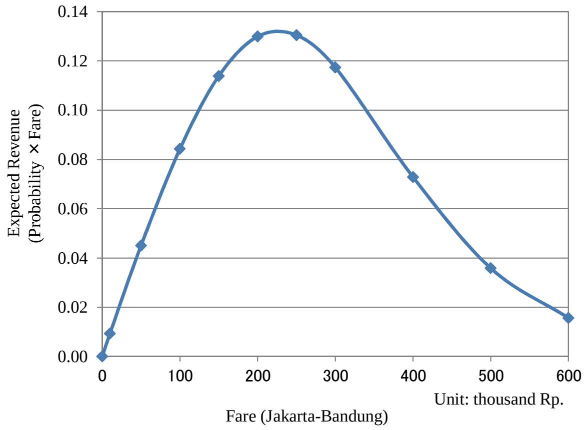
Car



Bus



Rail



Source: METI Report, 2012

Figure 6.4-4 Fare and Expected Revenue

Therefore, the HSR fare for the Jakarta - Bandung section is set at 200,000 Rp., and the results of setting the fares between other stations by distance are shown in Table 6.4-3.

Table 6.4-3 HSR Fare Table

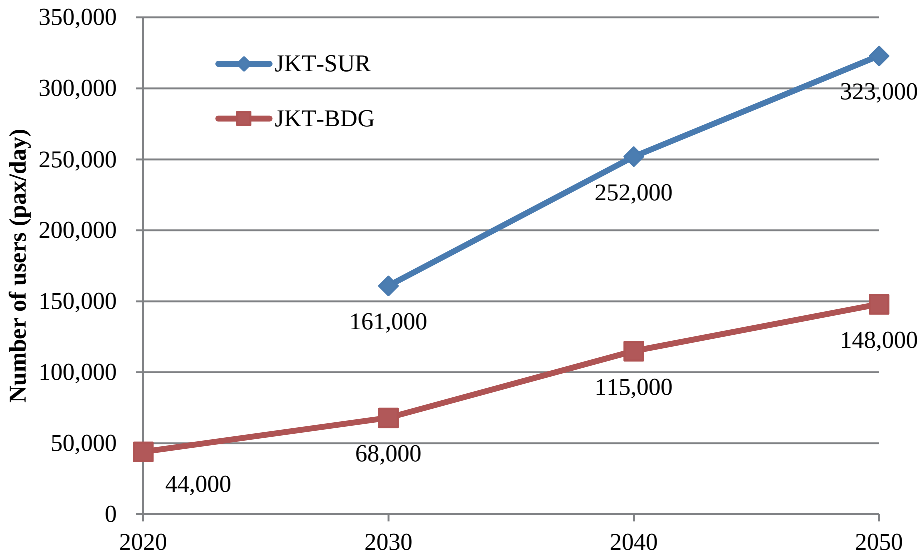
(Unit: Rp.)

Station	Jakarta	Bekasi	Cikarang	Karawang g	Bandung	Gedebage	Cirebon	Semarang	Surabaya
Jakarta	-	40,000	70,000	90,000	200,000	220,000	380,000	550,000	800,000
Bekasi	40,000	-	30,000	50,000	160,000	180,000	340,000	520,000	770,000
Cikarang	70,000	30,000	-	20,000	130,000	150,000	310,000	500,000	740,000
Karawang g	90,000	50,000	20,000	-	110,000	130,000	290,000	490,000	720,000
Bandung	200,000	160,000	130,000	110,000	-	20,000	180,000	480,000	710,000
Gedebage	220,000	180,000	150,000	130,000	20,000	-	160,000	470,000	700,000
Cirebon	380,000	340,000	310,000	290,000	180,000	160,000	-	320,000	720,000
Semarang	550,000	520,000	500,000	490,000	480,000	470,000	320,000	-	400,000
Surabaya	800,000	770,000	740,000	720,000	710,000	700,000	720,000	400,000	-

Source: METI Report, 2012

6.4.2 Number of HSR Users

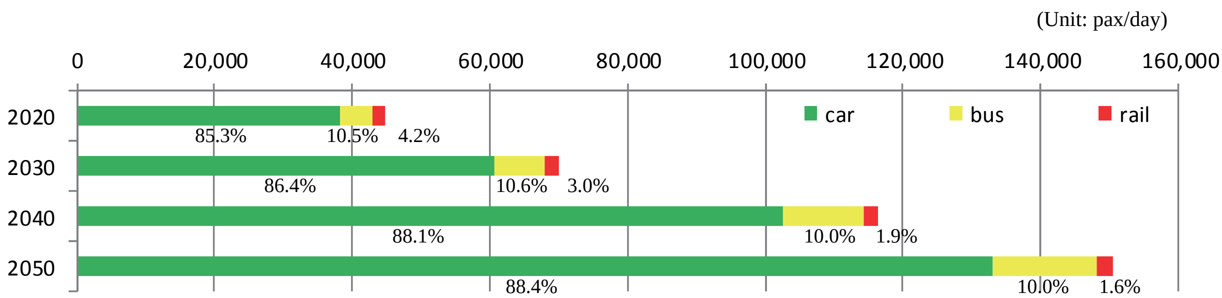
Figure 6.4-5 shows the estimated number of HSR users. The number of HSR users will be 44,000 pax/day by 2020, and it will increase 3.4 times, by 4.1% of the annual growth rate, to 148,000 pax/day by 2050 when the HSR is inaugurated between Jakarta and Bandung. If the HSR is extended to Surabaya, the number of HSR users will be 161,000 pax/day by 2030, and it will increase 2.0 times, by 3.5% of the annual growth rate to 323,000 pax/day. The reason why the growth rate between 2030 and 2040 is higher than the rate between 2020 and 2030 is that Karawangg international airport is due to open in 2032.



Source: JICA Study Team

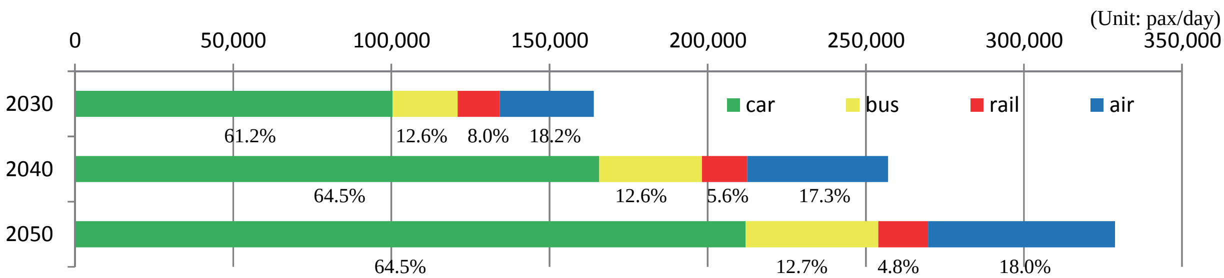
Figure 6.4-5 Number of HSR Users

Figures 6.4-6 and 6.4-7 show the estimated conversion volume from each transport mode to HSR. If the HSR is inaugurated between Jakarta and Bandung, most of the conversion volume will come from passenger cars, and the conversion rate from passenger cars will be 85 to 88%. That means that the HSR introduction will contribute to reduce traffic volume of passenger cars. On the other hand, if the HSR is extended to Surabaya, the conversion rate from passenger cars will be 61 to 65% followed by the conversion rate of air of 17 to 18%.



Source: JICA Study Team

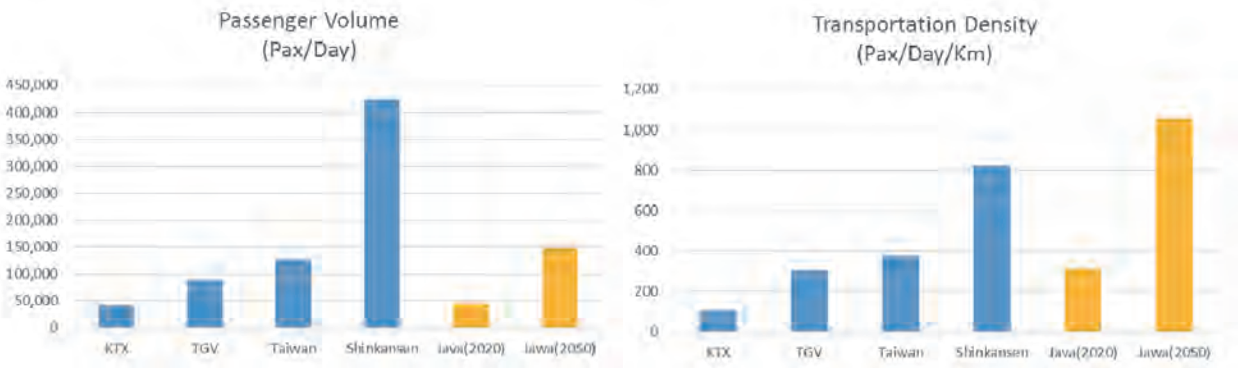
Figure 6.4-6 Conversion Volume from Each Transport Mode to HSR (Jakarta - Bandung)



Source: JICA Study Team

Figure 6.4-7 Conversion Volume from Each Transport Mode to HSR (Jakarta - Surabaya)

Figure 6.4-8 shows comparison of the HSR ridership in the world. It is estimated that the passenger volume of Jakarta – Bandung operation case in 2020 will be almost same as that of Korea, and its transportation density will be almost the same as TGV (France) even in the inaugural year. Moreover, the transportation density in 2050 is predicted to exceed that of Japanese Shinkansen (Tokaido).



Type	Line	Distance	Yearly Passenger Volume	Year of Statistics
KTX	Gyeongbu	412 km	15,220,000	2009
TGV	Atlantique	290 km	32,000,000	2008
Taiwan HSR		339 km	46,310,000	2013
Shinkansen	Tokaido	515 km	154,820,000	2013
Java (Study)	Jakarta – Bandung	140 km	16,060,000	2020 (Estimated)
Java (Study)	Jakarta – Bandung	140 km	54,020,000	2050 (Estimated)

Source: JICA Study Team

Figure 6.4-8 Demand Comparison of High Speed Railways in the World

6.4.3 HSR Transport Volume by Section

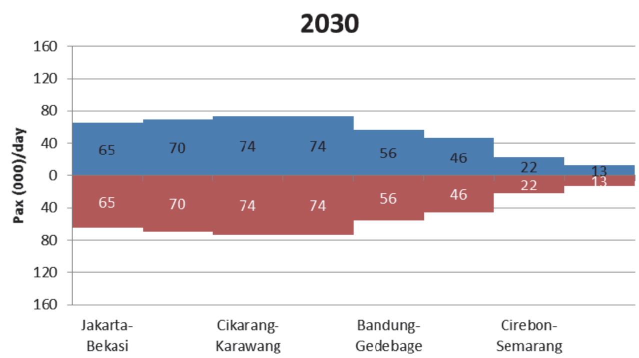
Table 6.4-9 shows the section volume in each case by each estimated year. If the HSR is inaugurated between Jakarta and Bandung, the transport volume by section will be high throughout between Jakarta and Bandung. In particular, the section volume between Bekasi and Cikarang will be the highest until 2030 and the section volume between Cikarang and Karawangg will be the highest after 2040. On the other hand, the section volume between Bandung and Gedebage will stay at 33 - 35% of the volume between Jakarta and Bandung.

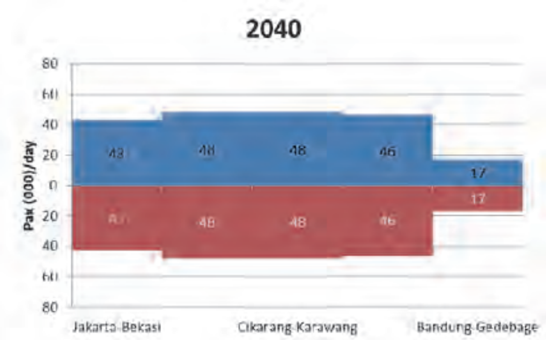
If the HSR is extended to Surabaya, the section volume between Cikarang and Bandung will be the highest in 2030, and the volume between Cikarang and Karawangg will be the highest after 2040. The volume will decline after passing Bandung, and 16 - 17% of the maximum section volume is estimated between Semarang and Surabaya.

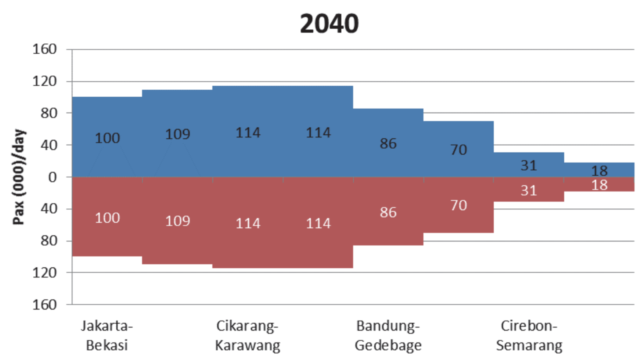
If the HSR is inaugurated between Jakarta and Bandung

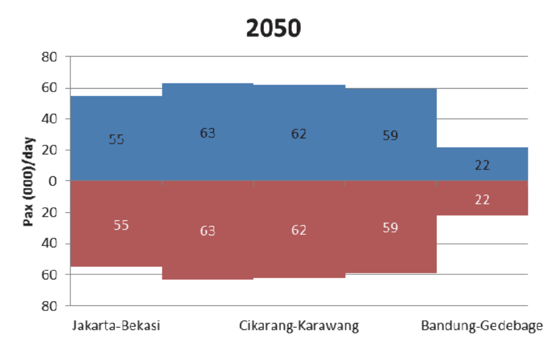
If the HSR is inaugurated between Jakarta and Surabaya

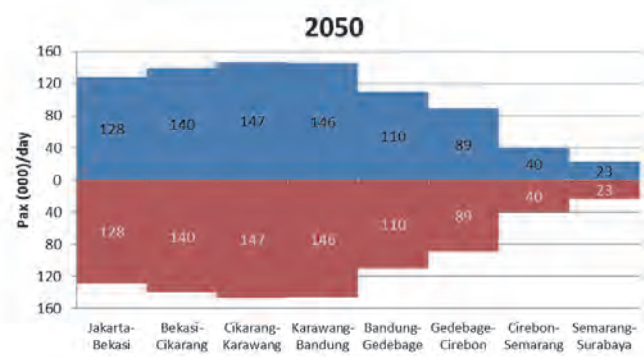
HSR will not inaugurated yet in 2020











Source: JICA Study Team

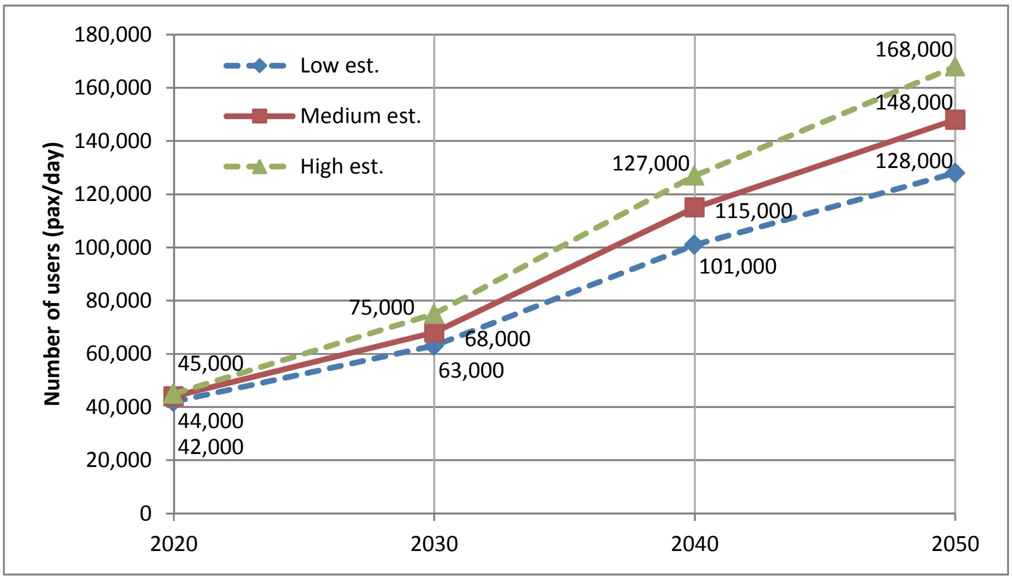
Figure 6.4-9 HSR Transport Volume by Section

6.5 Demand Sensitivity Analysis

The demand forecast is estimated based on several preconditions, and it will necessarily fluctuate when the preconditions change. Fluctuation in the demand forecast result is analyzed by changes of GDP growth rate, HSR fare and the future traffic congestion (travel speed).

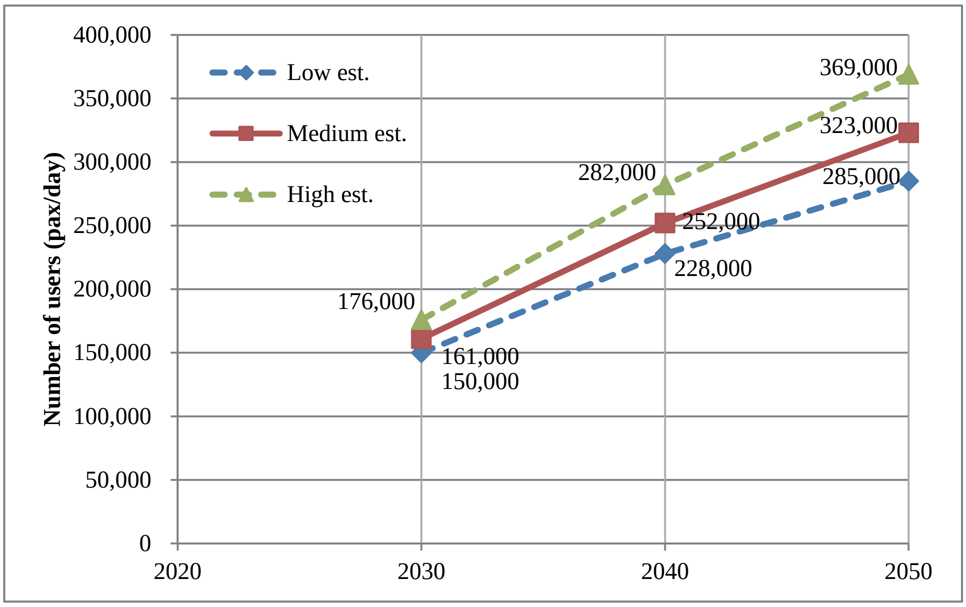
(1) Fluctuation by change of GDP

Figures 6.5-1 and 6.5-2 show the changes in number of HSR users if the GRDP of Java Island goes up or down within the range shown in Table 6.4-1. If the GRDP of Java Island falls lower than expected (-10% of the medium estimate), the HSR users in 2050 will decline from 148,000 pax/day to 128,000 pax/day if the HSR is inaugurated between Jakarta and Bandung, and from 323,000 pax/day to 285,000 pax/day if the HSR is inaugurated between Jakarta and Surabaya. On the other hand, if the GRDP of Java Island rises higher than expected (+10% of the medium estimate), the HSR users will increase, too. The possible range will be -14% to +14% in 2050.



Source: JICA Study Team

Figure 6.5-1 Changes in HSR Users with Increase or Decrease in GRDP (Jakarta - Bandung)



Source: JICA Study Team

Figure 6.5-2 Changes in HSR Users with Increase or Decrease in GRDP (Jakarta - Surabaya)

(2) Fluctuation by changes of HSR fare and traffic congestion

Figures 6.5-3 and 6.5-4 show the changes in number of HSR users in cases that the HSR fare is set at 10% lower than basic case, and the travel speed goes down at 15% lower than the basic case due to deterioration in the road congestion.

If the HSR fare is set at 10% lower, the HSR users will increase within 9% to 12% for Jakarta to Bandung operation, and around 15% for Jakarta to Surabaya operation. In the Jakarta to Surabaya operation case, the total revenue will increase even if the HSR fare is set lower, because the level of numbers of passenger will increase more than the level of HSR fare reduction. Thus it is necessary to consider the appropriate HSR fare level. On the other hand, if the travel speed goes down 15% lower than that of basic case, the HSR users will increase within 21% to 24% from Jakarta to Bandung, and around 26% from Jakarta to Surabaya.

According to the results of the sensitivity analysis, it is apparent that HSR demand is mostly impacted by decline in travel speed, meaning that HSR will have a more positive impact if the road improvement has not progressed.

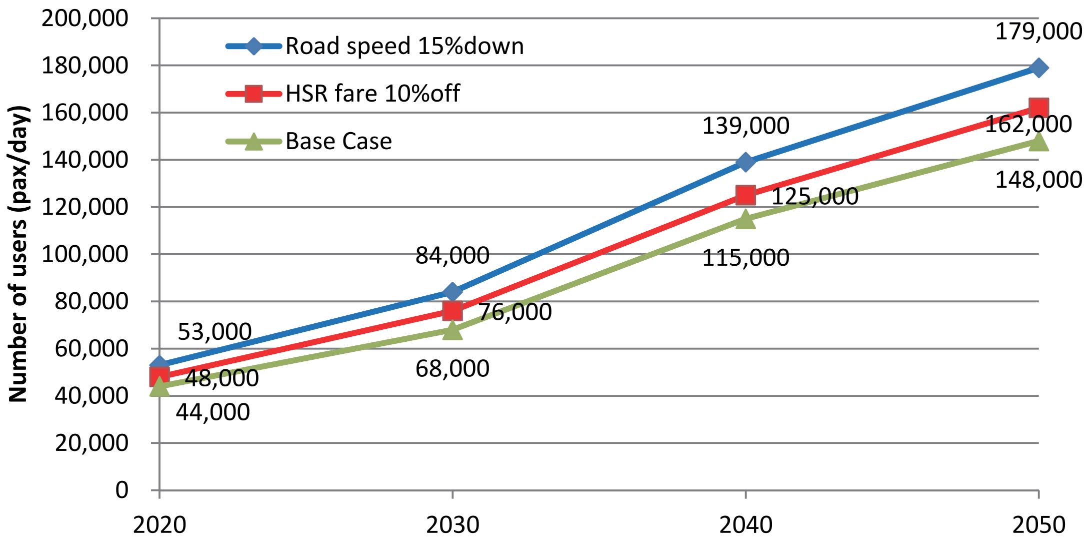


Figure 6.5-3 Changes in HSR Users with Decline in HSR Fare and Road Travel Speed (Jakarta - Bandung)

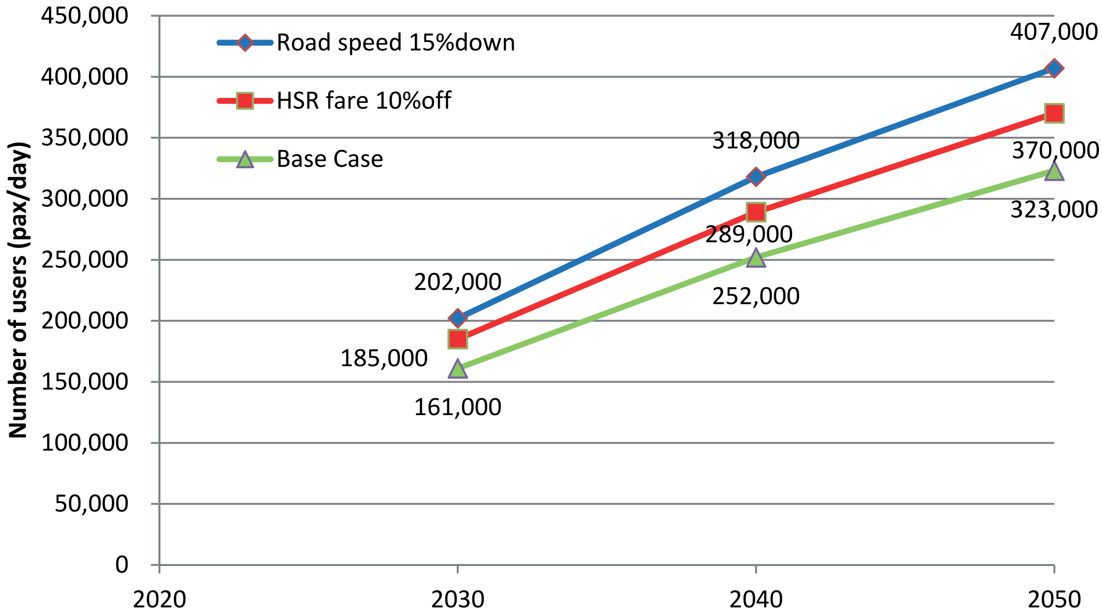


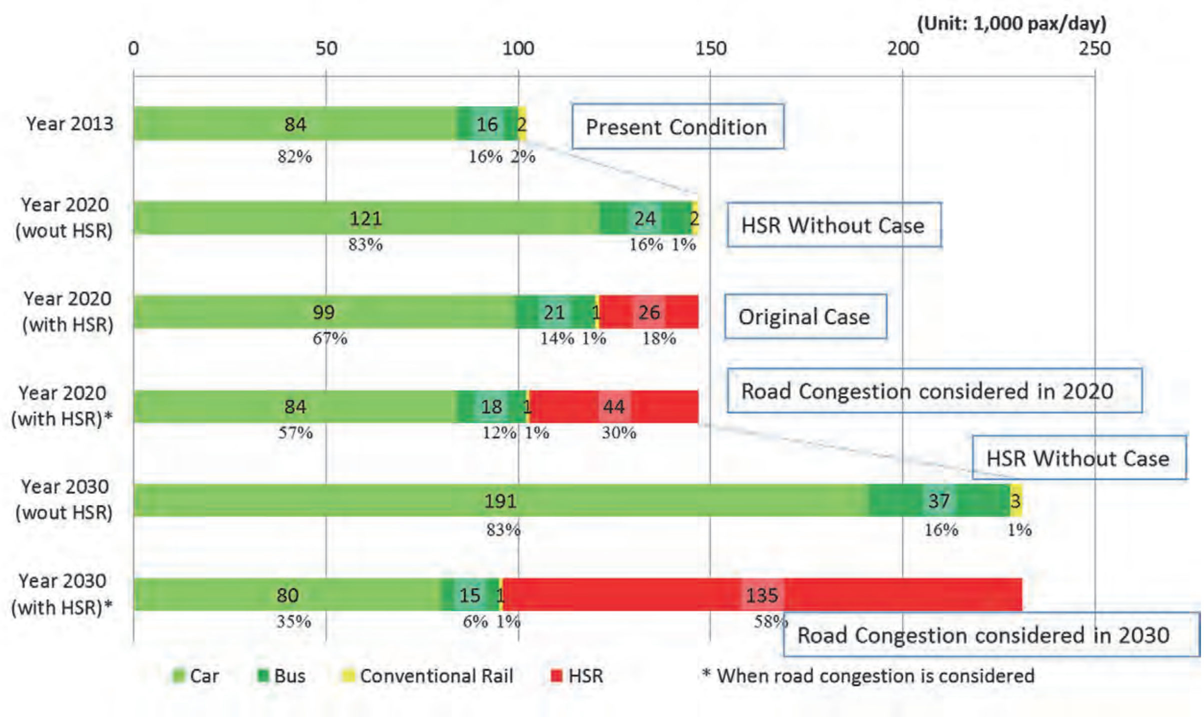
Figure 6.5-4 Changes in HSR Users with Decline in HSR Fare and Road Travel Speed (Jakarta - Surabaya)

6.6 HSR Characteristics from the Demand Forecast

(1) Impact to the other transportation modes by HSR Introduction

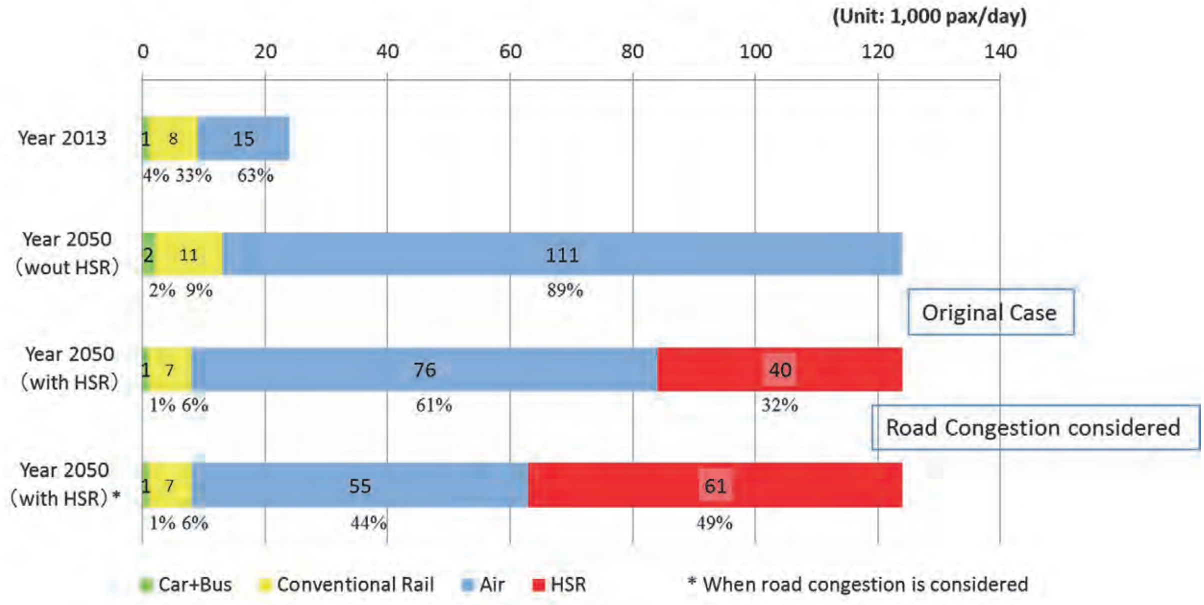
HSR works as a principal transportation in the area when it is completed. Figures 6.6-1 and 6.6-2 show the transportation mode of Jakarta – Bandung, Gedebage and Jakarta – Surabaya OD pairs. The composition ratios of HSR are 18% in Jakarta – Bandung and Gedebage while 32% in Jakarta – Surabaya in the basic case. Moreover, these ratios will increase if the road improvement does not progress and the travel speed goes down. The HSR shares increase from 18% to 30% in 2020, while from 18% to 58% in 2030 in case of Jakarta – Bandung operation, and also increase from 32% to 49% in case of Jakarta – Surabaya operation. Accordingly, the HSR share is around 50% among all transportation methods, and it is apparent that HSR is the most important transportation mode in these sections.

Figure 6.6-3 shows the conversion ratio from vehicle to HSR by travel distance. The share of vehicle and HSR becomes even with a range of around 500km, and HSR is superior to a vehicle over 500km. Figure 6.6-3 indicates that HSR share increases in proportion as the travel distance increases, and almost all passengers use the HSR for journeys over 700km.



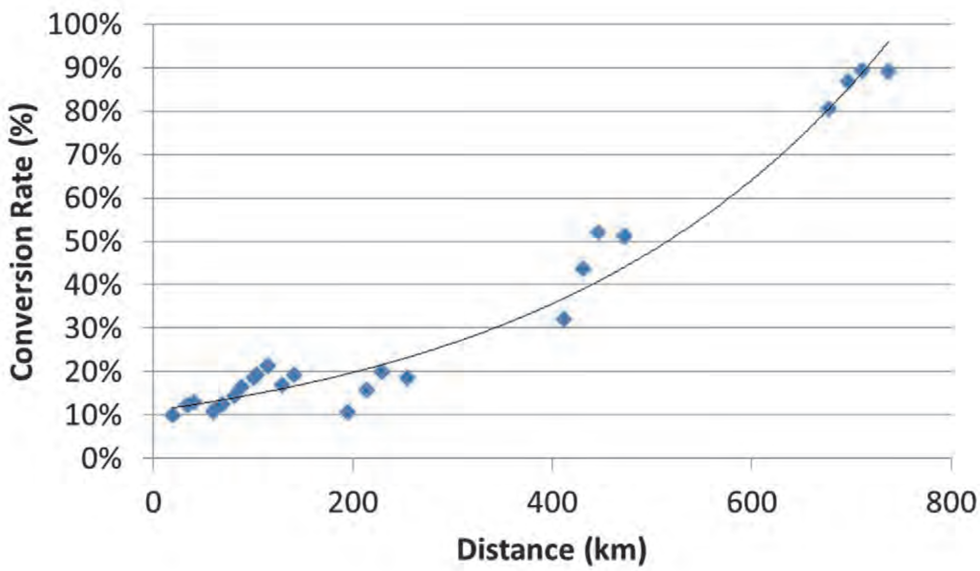
Source: Study Team

Figure 6.6-1 Transportation Mode of Jakarta – Bandung, Gedebage OD Pairs



Source: Study Team

Figure 6.6-2 Transportation Mode of Jakarta – Surabaya OD Pair



Source: Study Team

Figure 6.6-3 Conversion Ratio by Travel Distance

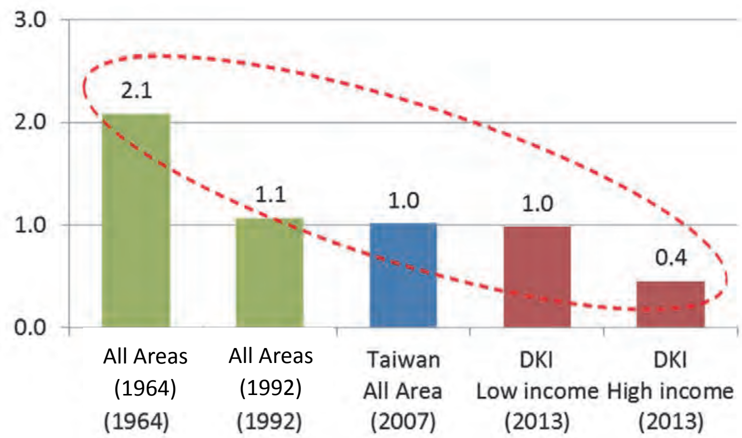
(2) Comparison of Japan and Indonesia in HSR Fare

The HSR fare from Jakarta to Bandung is set at Rp. 200,000 in this study. Table 6.6-1 and Figure 6.6-4 show the comparison of HSR fare between Japan and Indonesia. In 1964, when the Shinkansen was introduced for the first time in Japan, the Shinkansen fare was equivalent to 2.1 days salary. In 1992, after about 30 years had passed, that fare was equivalent to 1.1 days salary. On the other hand, the HSR fare from Jakarta to Bandung is equivalent to 1.0 days salary for the low income persons, and 0.4 days salary for high income persons. In consequence, the HSR in the Indonesia is not a transportation for just the wealthy but for all common citizens.

Table 6.6-1 Comparison of Japan and Indonesia in HSR Fare

		HSR Fare	Wage/day		Remarks
		(A)	(B)	(C)=(A)/(B)	
Japan	All Areas (1964)	¥ 2,480	¥ 1,191	2.1	
	All Areas (1992)	¥ 14,430	¥ 13,620	1.1	
Taiwan	All Areas (2007)	NT$ 1,490	NT$ 1,480	1.0	
Indonesia	DKI Low income (2013)	Rp. 200,000	Rp. 204,501	1.0	Non-agricultural low income level urban household
	DKI High income (2013)	Rp. 200,000	Rp. 445,517	0.4	Non-agricultural high income level urban household

Source: Preparation by Study Team



Source: Preparation by Study Team

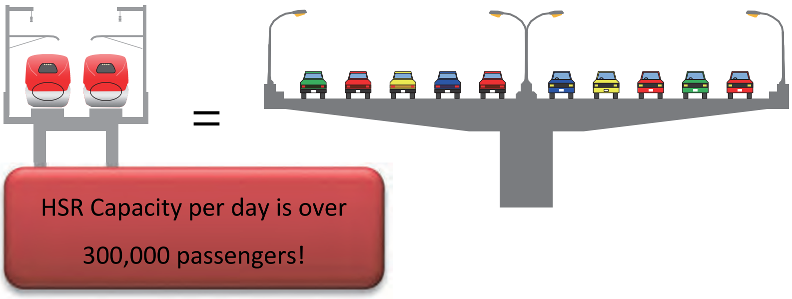
Figure 6.6-4 Comparison of Japan and Indonesia in HSR Fare

(3) Transportation Efficiency of HSR

The maximum passenger capacity of HSR is supposed to be 303,000 per day. To achieve this level of transport, the train operation should be planned at 6 minute intervals at peak hours with 22 trains, and only Japanese Shinkansen technology enables this to be realized because it has the dedicated facilities for HSR and experiences to achieve transporting a huge passengers. This passenger capacity is equivalent to 10 lanes of highway. Table 6.6-2 shows the calculation method, and it indicates excellent efficiency. Moreover, its capacity is equal to 76% of the total traffic demand of 398,000 passengers among Jakarta and Bandung, and it indicates how large the HSR capacity is.

Table 6.6-2 Calculation of HSR Capacity

Highway Capacity: 10,000 veh. /day /lane
303,000 pax. /day ÷ 3.0 pax. /veh. ＝ 101,000 veh. /day
101,000 veh. /day ÷ 10,000 veh. /day /lane ＝ 10 lanes



(4) Measures for HSR Demand

Needless to say, it is necessary to generate enough revenue corresponding to the investment in order to make HSR introduction feasible. This revenue mostly comes from the ticket sales, and it is essential to consider how to secure the ridership in the financial feasibility. Figure 6.6-6 shows some measures to create HSR demand, and those are classified into 3 items; measures for HSR, measures for other transport modes and others. In the measures for HSR, introduction of several preffered rates in HSR fare and increase in train frequency are supposed. On the other hand, in the measures for other transport modes, the improvement of accessibility by transfer transport modes to the HSR station and connection with the new international airport are supposed. Finally, in the other measures, the promotion of station vicinity area development to attract residents and workers is recommended, as well as the station being located in the central business district. Among them, the improvement of accessibility to the HSR station is the most important, and it is necessary to develop the station vicinity area and the transportation network centering on the HSR station as well as handling the promotion of HSR project.

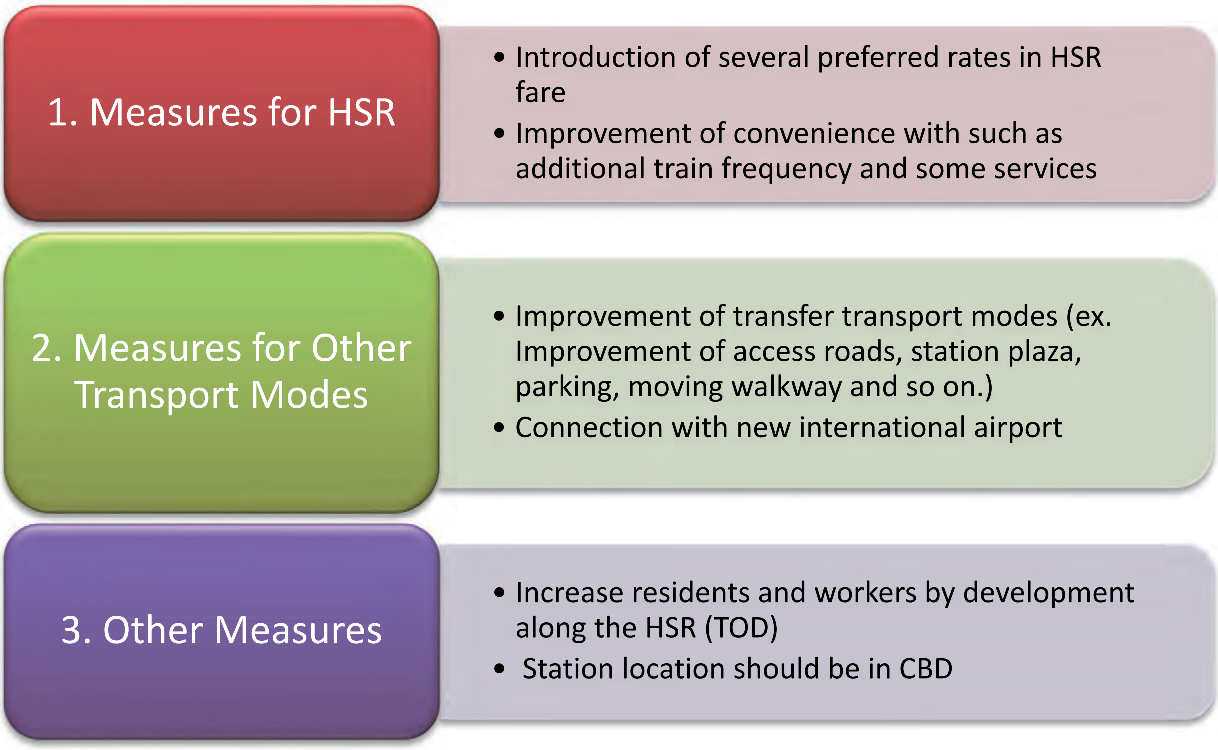


Figure 6.6-5 Measures for HSR Demand Increase

Chapter 7

Natural Condition Survey

Chapter 7 Natural Condition Survey

7.1 Outline of Survey

It is very important to grasp the topographical and geological condition of the whole area of planned HSR route in order to optimize the plan of alignment and structure and also to formulate a feasible project plan. In this survey, collection of existing topographical and geological data, and photographic surveying by using satellite imagery and boring survey were carried out in order to evaluate risk to HSR construction and examine measures for the risk.

7.1.1 Purpose and Contents of Survey

(1) Topographical Survey

Topographical survey was carried out in order to grasp the configuration of ground, location of rivers and streams, arrangement of large-scale structures and land use along the planned HSR route. For that purpose, drawing up of topographical map and photomap with scale of 1:10,000 was carried out by photographic surveying using satellite imagery. These results are described in Chapter 8 “Detailed Examination of Route Planning” and shown in the “Route Book” of a separate volume.

(2) Geological Survey

Survey was carried out in order to grasp the configuration of ground, location of river stream, arrangement of large-scale structure and land use along the planned HSR route. For that purpose, drawing up of topographical map and photomap with scale 1:10,000 were carried out by photographic surveying by using satellite imagery. These results are described in the chapter 8 “Detailed Examination of Route Planning” and shown in “Rout Book” of a separate volume.

For this geological survey, boring survey and standard penetration tests were carried out mainly in order to collect basic information on the estimation of construction cost and for the following purpose:

- To grasp the depth of load bearing layer and the strength of ground for the evaluation of progress of tunnel excavation and necessity of tunnel support

Furthermore, laboratory testing was carried out in order to grasp the property of soil by using soil samples which were collected from boreholes.

Figure 7.1-1 shows the location of boring survey and Table 7.1-2 shows the content of Survey.

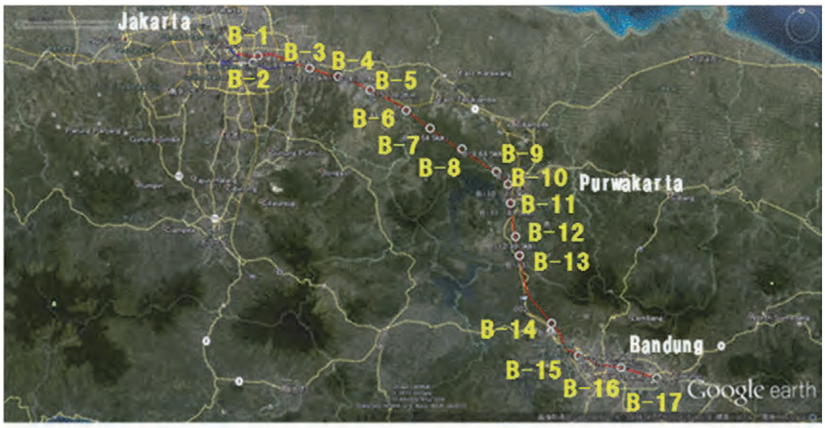


Figure 7.1-1 Location of Boring Survey

Table 7.1-1 List of Boring Survey

Point No	Coordinate		Elevation	Date drilled/Tested		Boring	Water
	E	N	Z	Started	Completed	Depth (m)	Depth (m)
B - 1	710072	9309435	+25.00	31-Oct-14	5-Nov-14	21.45	-1.90
B - 2	711347	9310908	+26.00	12-Nov-14	14-Nov-14	20.25	-7.00
B - 3	723199	9307254	+36.00	2-Nov-14	7-Nov-14	50.45	-7.00
B - 4	729719	9304856	+36.00	30-Oct-14	6-Nov-14	60.45	-1.53
B - 5	710072	9309435	+25.00	13-Nov-14	18-Nov-14	50.45	-1.20
B - 6	745015	9296103	+38.00	11-Nov-14	13-Nov-14	30.45	-1.20
B - 7	747029	9294481	+49.00	9-Dec-14	11-Dec-14	30.45	-5.20
B - 8	761821	9282974	+40.00	5-Dec-14	6-Dec-14	40.00	-4.20
B - 9	765073	9280796	+46.00	15-Nov-14	17-Nov-14	46.00	-2.35
B - 10	767631	9277691	+100.00	16-Nov-14	19-Nov-14	30.25	-6.50
B - 11	767899	9273355	+141.00	26-Oct-14	2-Nov-14	50.45	-6.05
B - 12	768512	9265613	+362.00	27-Oct-14	30-Oct-14	30.28	-6.50
B - 13	769063	9261204	+492.00	27-Oct-14	4-Nov-14	60.29	-10.40
B - 14	775364	9245371	+723.00	10-Nov-14	13-Nov-14	40.05	-4.71
B - 15	781894	9237433	+739.00	7-Nov-14	10-Nov-14	33.45	-2.23
B - 16	790830	9234286	+692.00	1-Nov-14	4-Nov-14	30.45	-4.15
B - 17	798842	9231364	+675.00	7-Nov-14	15-Nov-14	60.26	-7.00

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

Table 7.1-2 Content of Survey

Contents	Specification	Numbers of Survey
Boring Survey	Rotary Drilling	17 boreholes Total length: 645m
On-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 4 samples

7.1.2 Outline of Geology

Based on the result of existing data collection and analysis, and geological survey, Table 7.1-3 and Figure 7.1-2 show the outline of geology along the planned HSR route.

Table 7.1-3 Geological Stratigraphy along the Planned HSR Route

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 depend on parent ground. Unconsolidated and loose.
		al	Alluvium	Distributed in the lowlands near the coast and bottomland along the river in the areas between Jakarta and Karawang. Comprised of soft volcanic sand and mud.
		ql	Lake deposit	Distributed in the central and eastern part of the Bandung plain. Mainly composed of soft clay and partially sandy.
		tr	Terrace deposit	Distributed in the hilly area downstream of Jatiluhur 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	Comprised of volcanic breccia, tuff breccia, lapilli tuff, lahar sediment and secondary deposits of them. This forms the outer layer in the mountain area. Surface soil colors are reddish brown in 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, it is weak in the surface part.
Neocene	Miocene	Tsb	Subang Formation	Sedimentary rock which is distributed in the section between Karawang and Purwakarta. It is mainly composed of mudstone in the area near Karawang and tuffaceous sand near Purwakarta. Obvious structure of stratification can be seen at outcrops. The dip of structure is flat. Degree of consolidation is relatively high in the fresh parts and N value ranges from 50 to 80 in those fresh parts.
		Tjh	Jatiluhur Formation	Sedimentary rock which is distributed in the section near Purwakarta and Jatiluhur. It is mainly composed of mudstone with high degree of consolidation. Fold structure can be seen remarkably and axis of fold is mainly east-west direction.
		Tctr	Citarum Formation	Distributed in the section from Sta.105 to 120 km. Comprised of sedimentary rock such as tuff breccia, lapilli tuff, tuff and tuffaceous sand. Obvious structure of stratification can be seen. Although it was formed at almost same time as Jatiluhur formation, the degree of consolidation of this is lower than the degree of composition of Jatiluhur formation.
Intrusive Rock		And	Andesitic Dyke	Distributed in the section from Sta. 118.0 to 118.8 km. Basically hard rock except in weathered part.

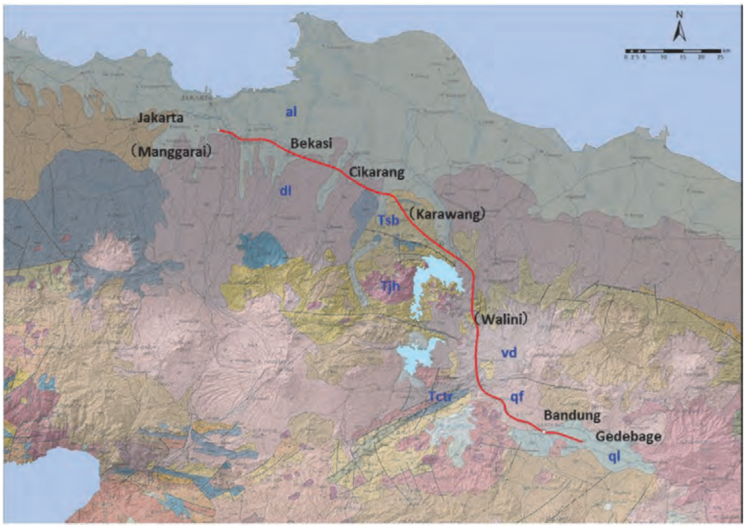


Figure 7.1-2 Outline of Geological Distribution

Table 7.1-4 shows geotechnical description of main geology distributed along planned route.

Table 7.1-4 Geotechnical Description

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 a 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. 20 km 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 comprised 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 are classified into soft rock. In the existing development area in Karawang, there are many cutting slopes and outcrops comprised of mudstone of Subang formation. That 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.

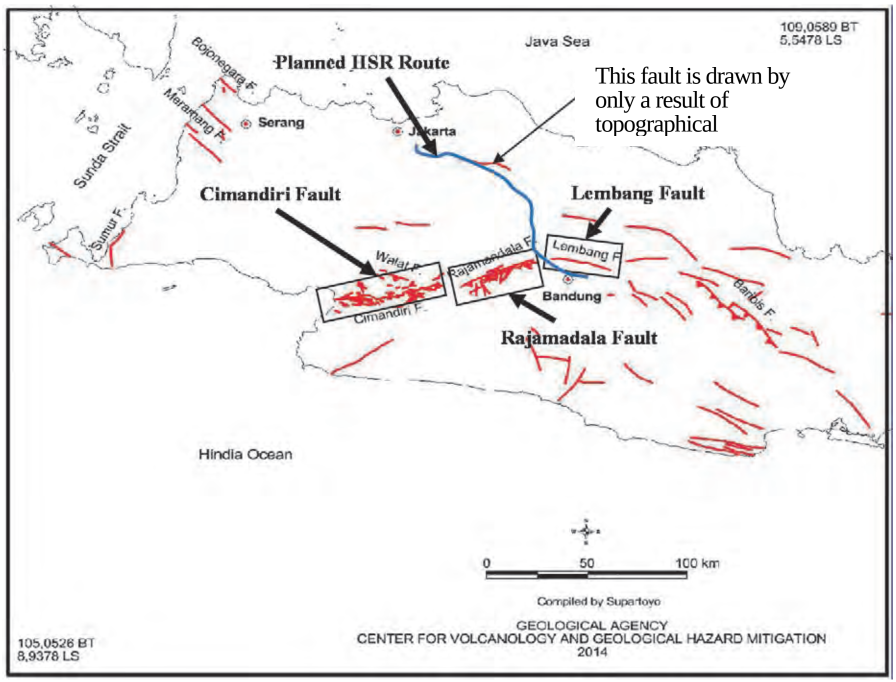
	Jatiluhur Formation	76.3 – 77.2 82.4 – 99.8	Geology of this formation is composed of Miocene sedimentary rocks. Folding structures are clearly seen in these sedimentary rocks. Direction of axis of those folding structures are northeast to southwest and southeast to northwest. Generally well consolidated.	There is a tendency in distribution of geology. In the northern part, it is mainly comprised of mudstone, and tuff brecciated lava and lapilli tuff are main components in the southern part. Rocks of Jatiluhur formation are 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 are classified into soft rock and well consolidated. Permeability is thought to be low as with Jatiluhur formation.
③ **Bandung Flat Plain Area** Note: In section 7.2.4, of Bandung flat plain area this starts from Sta. 116.0 km because the end of tunnel is at 116.0 km.	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. A concentrated inflow into tunnel at the time of construction of tunnel is of concern. This sediment is also not a subject of examination of liquefaction as with as diluvium.
	Lake Deposit	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.
Accumulated in a small area	Refill Soil	–	This artificial sediment is distributed along the canal.	Depth of this sediment is about 5m. This layer is unconsolidated and loose.
	Talus Deposit	–	Secondary sediment. It is accumulated on the middle to lower part of slope. Basically is comprised of rock fragments and clay.	Many of existing slope failures occurred due to this sediment. This layer is unconsolidated and loose. Where thickness of this layer is deep at the entrance of tunnel, appropriate design and construction of slope stability measures are needed.

7.2 Natural Condition to be Considered on the Planning of HSR

7.2.1 Distribution of Active Faults

Figure 7.2-1 shows the distribution of active faults along the planned HSR route.

According to Figure 7.2-1, there are a few active and potentially active faults along the planned route. However, according to the Geological Agency, Ministry of Energy and Mineral Resources, the interval of activity of these faults is as long as several thousands of years, therefore, direct impact to HSR due to those active faults is thought to be unlikely.



Source: Dr. Supartoyo Bandung Geological Agency

Figure 7.2-1 Distribution of Active Faults along the Planned HSR Route

7.2.2 Distribution of Volcanoes

Figure 7.2-2 shows the distribution of volcanoes along the planned route.

Mt. Tangkuban Perahu (elevation 2,084 m) is located in the north of center of Bandung. The minimum distance between the mountain and the planned route is around 15 km. Volcanic activity has been observed. However, since the location of activity of this volcano is limited to the east side of mountain, there is a very low possibility that the planned route will suffer any direct damage due to such activity. However, it is necessary to consider the influence of volcanic ash because of wind direction.

Figure 7.2-2 Relation between Mt. Tangkuban Perahu and Planned HSR Route

7.2.3 Depth of Load Bearing Layer (Earthquake Proof Foundation)

The N-value that is obtained from the result of standard penetration test (SPT) is an indicator of the solidity and condition of compaction of soil. Generally, HSR requires severely limited permissible amounts of displacement of railway track, therefore it is necessary to drive a pile into a load bearing layer which is solid with an N-value greater than 50. For this, to grasp the depth of load bearing layer and geological component is very important in order to check the validity of structural planning and estimate project cost.

Table 7.2-1 shows the estimate depth of the bearing layer (earthquake proof foundation) in the Jakarta and Bandung flat plain by the result of SPT.

Table 7.2-1 Estimate Depth of Bearing Layer (Earthquake Proof Foundation)

Area	Section (Sta. km)	No. of Boring	Depth of Bearing Layer(GL m)
Jakarta	0.0 ~ 19.0	B-1, B-2	10
Bekasi	19.0 ~ 20.0	B-2, B-3	24
	20.0 ~ 25.0	B-3	38
	25.0 ~ 30.0	B-4	49
	30.0 ~ 36.0	B-4	50
Cikarang	36.0 ~ 38.0	B-5	38
	38.0 ~ 48.0	B-5	39
	48.0 ~ 49.0	B-6	40
	49.0 ~ 49.7	B-6, B-7	23
Bandung	116.0 ~ 118.0	B-14, B-15	27
	118.0 ~ 118.8	B-15	10
	118.8 ~ 136.0	B-16	27
Gedebage	136.0 ~ 136.3	B-16	30
	136.3 ~ 136.5	B-16, B-17	35
	136.5 ~ 136.7	B-16, B-17	40
	136.7 ~ 136.8	B-16, B-17	45
	136.8 ~ 136.9	B-17	50
	136.9 ~ 140.0	B-17	52

7.2.4 Liquefaction

Liquefaction is a phenomenon in which solid ground becomes liquid due to the influence of pressurized groundwater and liquefaction leads to structural destruction and damage. Therefore it is important to consider the influence of liquefaction during the design phase when a structure is planned to be constructed on the ground which has a possibility of liquefaction. As shown in Table 7.2-2 and 7.2-3, based on the result of evaluation of liquefaction from the laboratory test results, it was judged that ground of Jakarta and Bandung flat plain area has very low possibility of liquefaction.

Table 7.2-2 Result of Judgment of Liquefaction (Jakarta Flat Plain Area)

Name 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 7.2-3 Result of Judgment of Liquefaction (Bandung Flat Plain Area)

Name 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.

7.2.5 Land Subsidence

Due to urbanization, land subsidence has been a serious issue over a period of many years in the Jakarta urban area.

According to the result of existing study, the central area of Jakarta, which the planned HSR route passes through, has a low land subsidence rate, while land subsidence rate is around 10cm/year in the north part of Jakarta DKI area.

However, even though the land subsidence rate is small, since land subsidence can have a severe impact on the maintenance of high-speed railway, appropriate consideration on design of structure is needed.

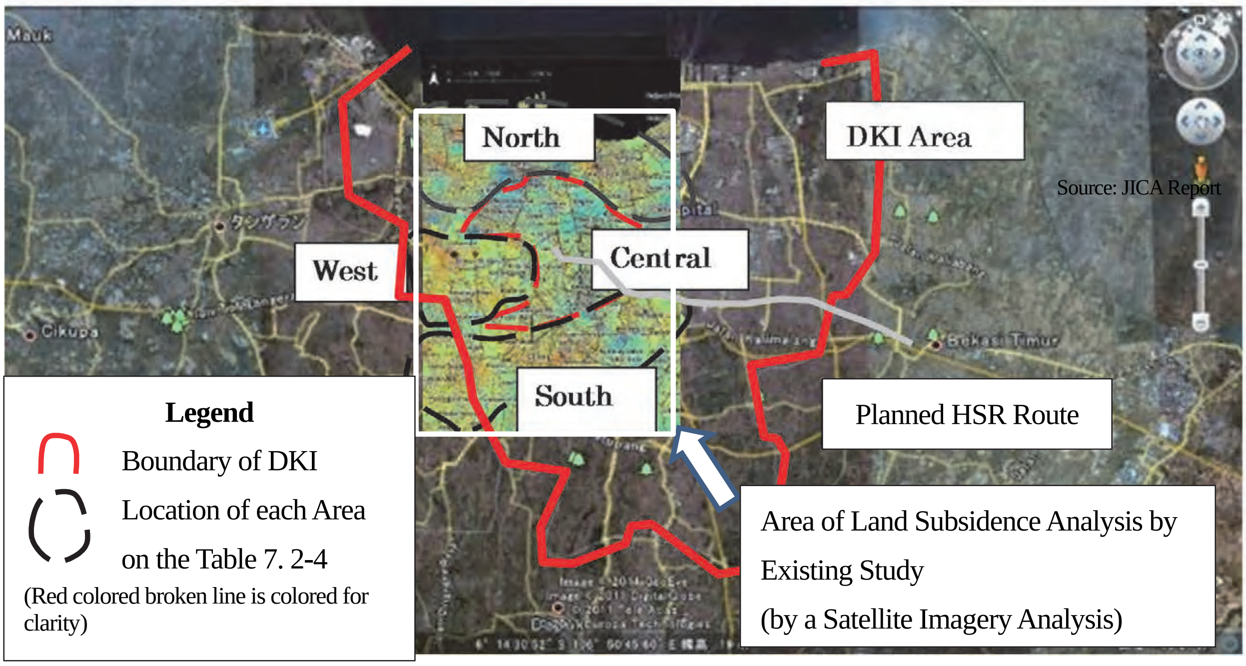
Table 7.2-4. Condition of Land Subsidence in the Jakarta DKI Area

(unit: cm)

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

Note) Subsidence rate of North, West, South and Central on this table shows highest rate during the period.



Source: JICA Report

Figure 7.2-3 Condition of Land Subsidence in the Jakarta DKI Area

7.2.6 Landslide/Slope Failure

(1) Definition of Landslide/Slope Failure

Landslide and slope failure in Japan is defined as follows based on the activity type and scale of slope.

＜Landslide＞

A landslide is a natural phenomenon through which the soil/rock mass resting on top of a slippery layer, such as clay, starts to slowly move due to the impact of groundwater. By the time that the landslide movement has ceased, a specific topography associated with a landslide has been formed.

＜Slope Failure/Collapse＞

Slope failure/slope collapse is a phenomenon of landmass movement on the slope. However, with slope failure/slope collapse, a sliding surface does not exist.

When a landslide occurs at the entrance of a tunnel, countermeasure work costs money and takes time. Therefore an alignment of railroad should avoid landslide areas or landslide prone areas at the time of design. On the other hand, generally the size of slope collapse is smaller than the size of landslide, and where there is concern about slope failure at the time of construction of a tunnel entrance, examination of an appropriate design of tunnel support is necessary.

(2) Outline of Existing Landslide and Slope Failure

Based on the result of field survey, the types of landslide and slope failure along the planned HSR route are divided into the following five categories from the viewpoint of mechanism.

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

Figure 7.2-4 Existing Landslide Area Sta. 81 km

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

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

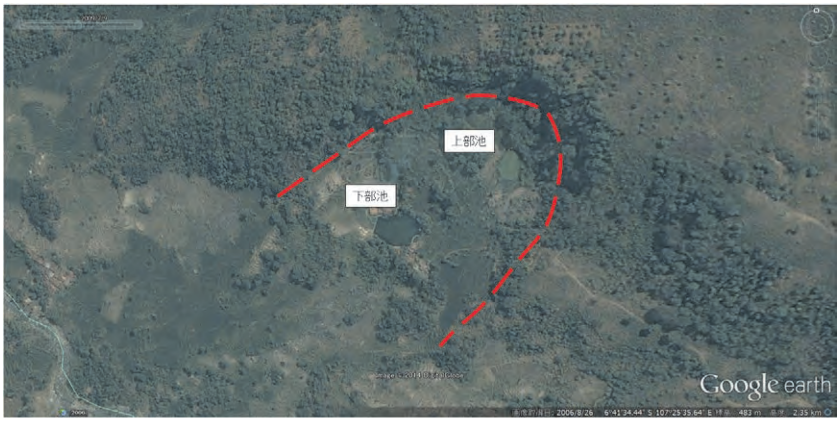
Repair Work at the Joint of Bridge

Figure 7.2-5　Condition of Existing Landslide (Sta. 81 km)

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

Figure 7.2-6 shows an example of landslide of this type. This landslide is located at about 1.5 km on the west side from planned HSR route Sta. 96 km.

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.



Boundary between old volcanic sediment and Jatiluhur formation

Figure 7.2-6 Landslide 1.5 km West from Planned HSR Route of Sta. 96 km

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

3) Slope failure/collapse caused by lateral erosion by river

Figure 7.2-7 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. 82.5 km.

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

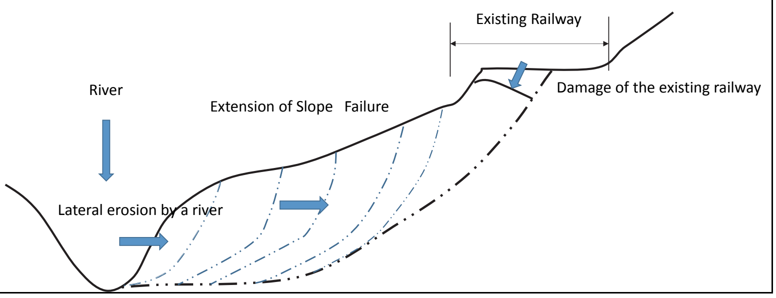


Figure 7.2-7 Example of Existing Slope Failure Caused by Erosion of River

4) Slope failure/collapse prone area with relatively thickly accumulated talus deposit

Planned HSR Route 89.3 km

(Boring B-12)

Photo of slope, entrance of tunnel

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

From Sta. 89.1 km to 89.5 km, 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 7.2-8 Slope Prone Area along the Planned HSR Route (Sta. 89.3 km)

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 and artificially changed, by erosion by rainfall

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.

Figure 7.2-9 shows the landslide prone area along the planned HSR route prepared by the Geological Agency, Ministry of Energy Mineral Resources.

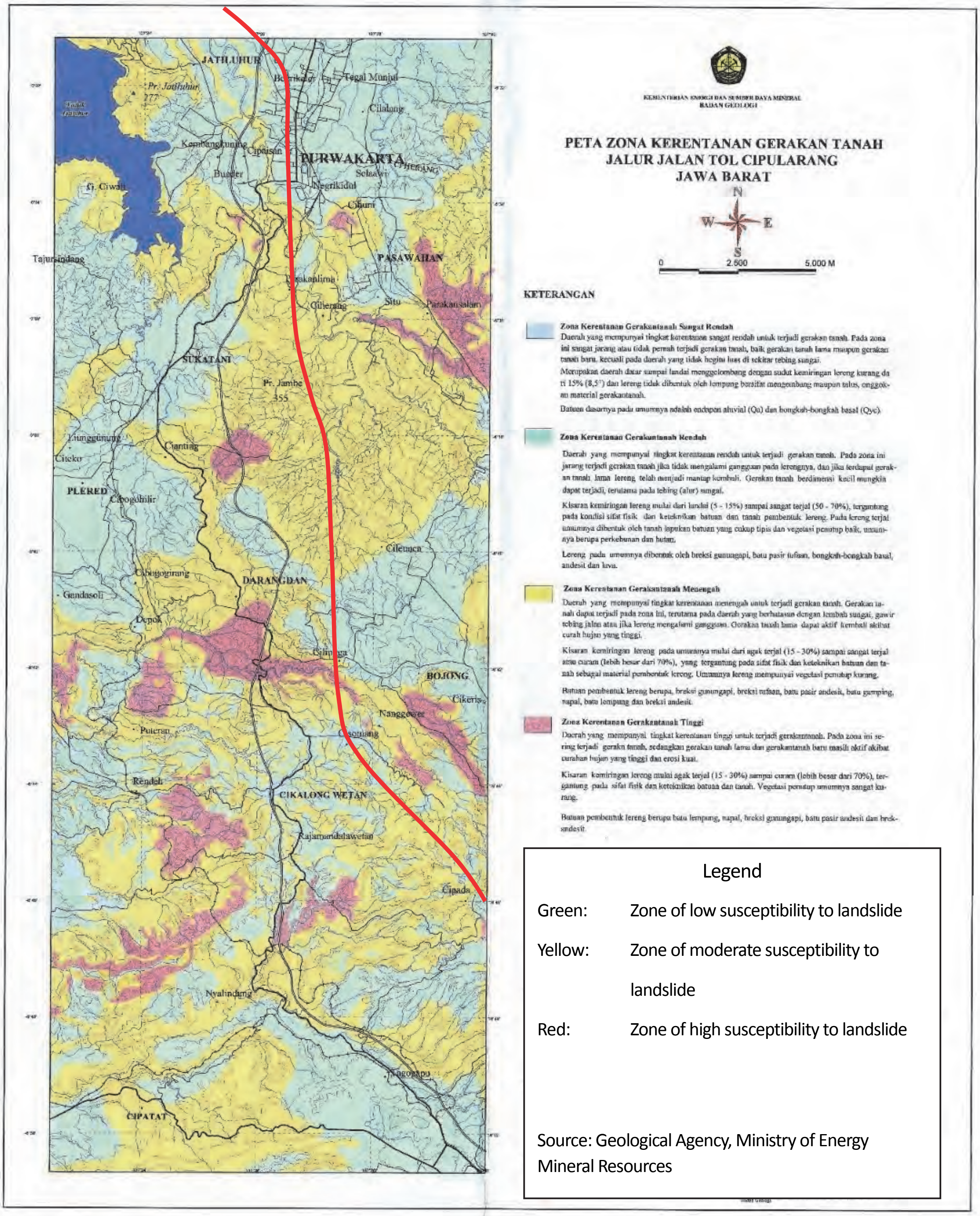


Figure 7.2-9 Landslide Prone Area along the Planned HSR Route

7.2.7 Unconsolidated Ground

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

In evaluating the capability of ground liquefaction of flow, percentage of fine material (FC: contents of silt and clay) and coefficient of uniformity (CU: D60 (grain size of 60%)/ D10 (grain size of 10%)) are important factors.

Based on the result of evaluation about the ground liquefaction of flow of geology along the planned HSR route, since FC and CU do not come under indicators of ground liquefaction of flow, there is no concern about ground liquefaction of flow.

Table 7.2-5 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^{-3}cm/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)

7.2.8 Extensive Ground

Squeezing ground including slaking is a phenomenon that is caused by a repetition of dry and moist conditions of ground. Due to the slaking phenomenon in which the rock mass will turn into small pieces, the ground will expand. This phenomenon has a severe impact on a workability of mountain tunnels.

Mudstone of Subang formation and Jatiluhur formation which is distributed between Karawang and Walini has a tendency of slaking. For this section, an execution of shotcrete immediate after cutting slope and planning of appropriate tunnel support is necessary.

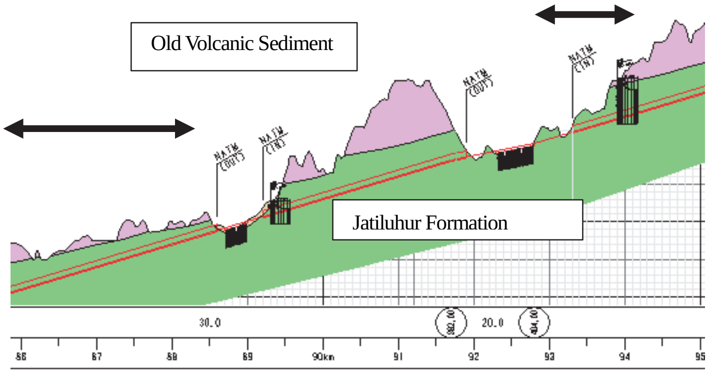
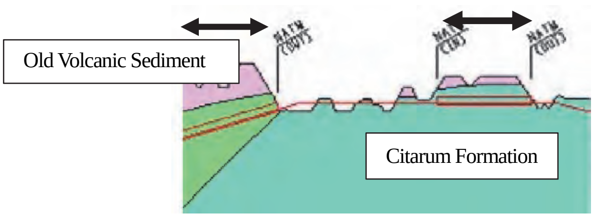
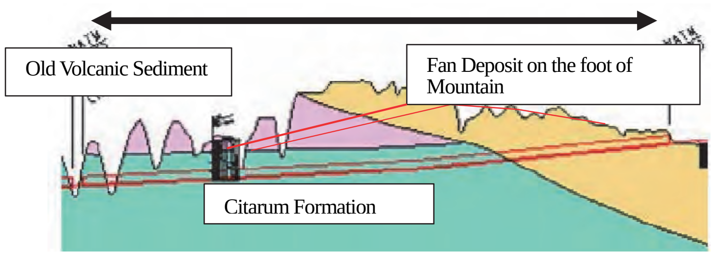
Figure 7.2-10 Condition of Slaking of Mudstone (Jatiluhur formation)

7.2.9 Conservation of Water Resources

When a tunnel is constructed underground of paddy fields and closed areas of water wells, impact on existing water usage must be considered.

Table 7.2-6 shows the section of concern regarding such impact along the planned HSR route.

Table 7.2-6 Section of Concern Regarding the Impact along the Planned HSR Route

	**a)** **86-88.5 km:** Tunnel route is planned as relatively low ground covering section. Land use at present is a forest and paddy field is abandoned. **93-94 km:** Tunnel route is planned as relatively low ground covering section. Low land near at 93.5 km is used as paddy field.
	**b)** **99.5-103.5 km:** 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)** **110.0-114 km:** Tunnel route is planned as relatively low ground covering section. Section between 110 and 112 km, 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.

＜Paddy Fields＞

The source of water supply to irrigated paddy fields is mainly river water. Those rivers rise from the north-west side slope of Mt. Tangkuban Perahu. In the process of river flow 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 of tunnel construction, it is assumed that amount of water that is supplied to the irrigated paddy field does not decrease remarkably.

On the other hand, for the section between 93 and 94 km, the source of water to the paddy field is mainly rainwater and it is termed an un-irrigated paddy field/rainwater paddy field (Table 7.4-18.a). Geology of tunnel section is comprised of Jatiluhur formation and old volcanic sediment is not found on the upper part of Jatiluhur formation. The impact on water supply to the paddy field caused by tunnel construction tunnel in this section is therefore of concern.

＜Water wells, etc.＞

Although old volcanic sediment and base rock have aquifers in their 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.

7.2.10 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 and applied.

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

When it is difficult to keep slope stability only by the planting work, combination work with other methods should be examined. Table 7.2-7 shows the type of combination protection work.

Table 7.2-7 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 is 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 Engineers

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 is 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 suitable measures for above mentioned cutting slope protection, shotcrete, masonry and Block Lining are recommendable.

Table 7.2-8 shows examples of cutting slope protection work.

Table 7.2-8 Examples of Cutting Slope Protection Work

	
Block Lining	Shotcrete (Mortar)

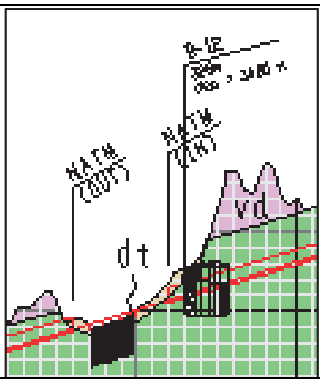
(2) Prevention Measures for a Slope Failure of Portal Zone

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 the 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 7.2-11 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). Depending 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 7.2-11 Cross Section near B-12 point

7.3 Geological Section

Geological section of the planned HSR route that is drawn by the result of geological survey is shown in Figures 7.3-1 to 7.3-9.

Appendix

2-(1) Natural Condition of Study Area

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

2-(3) Geological Condition based on the Field Reconnaissance

2-(4) Boring Survey Report (Local outsourcing; Photo of boring, Photo of Boring Core, Drilling Log, Laboratory Test Data）

Embankment

Structure	Shield Tunnel		Viaduct		Shield Tunnel
Landform	Flat Plain				
Geology	Diluvium (Partially Alluvium; along rivers)				
Comments	Geology of this area is mainly comprised of Diluvium. According to the existing study result, land subsidence rate along the planned HSR route is small. Shield tunnel is planned deeper than the mean earthquake proof foundation, therefore it is assumed that influence by land subsidence on structure is relatively low.		The depth of earthquake proof foundation is inferred as GL.-10m.		Geology of this area is mainly comprised of Diluvium. According to the existing study result, land subsidence rate along the planned HSR route is small.

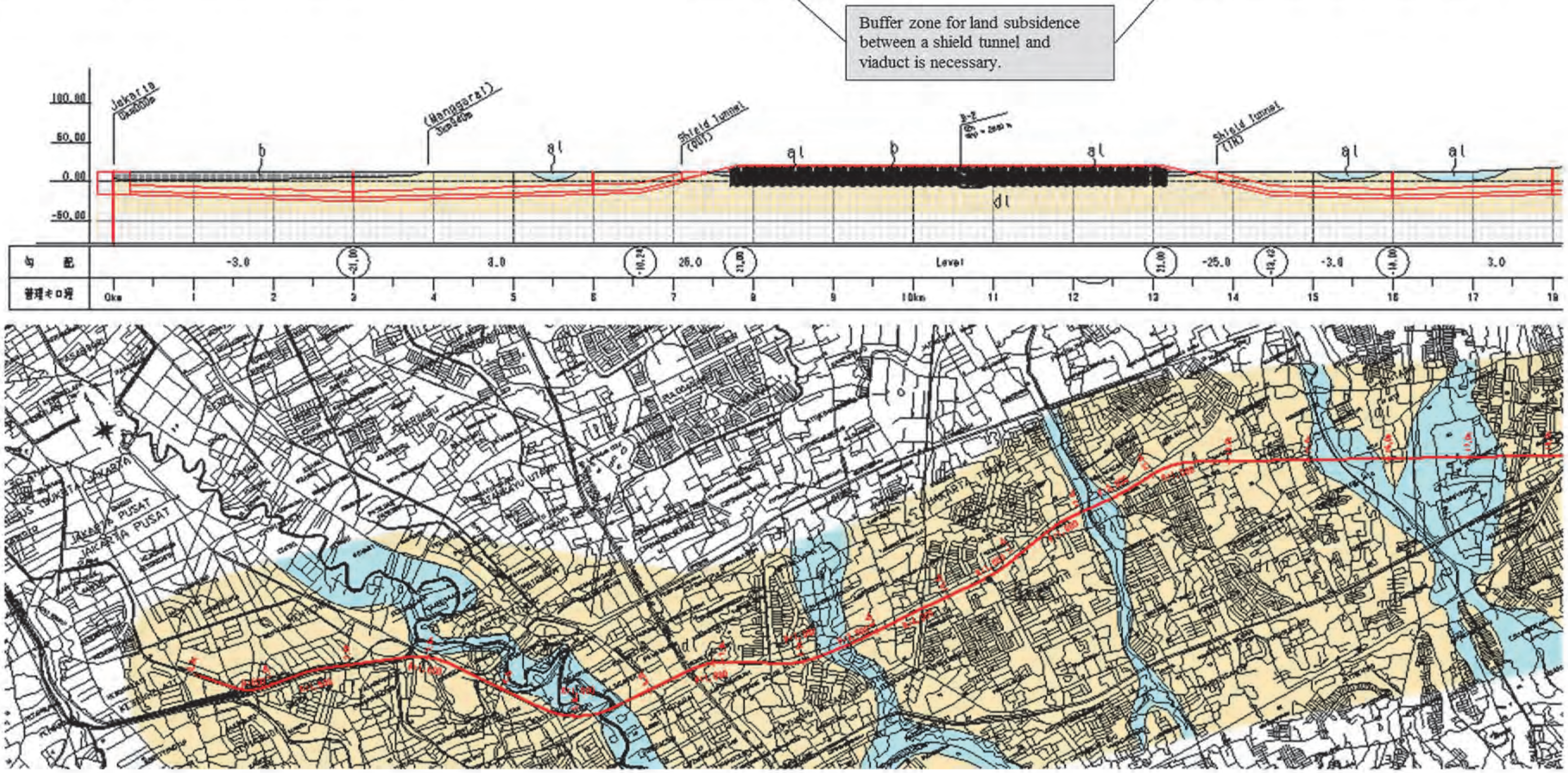


Figure 7.3-1 Geological Section (1/9)

Source: JICA Study Team

Structure	Shield Tunnel		Viaduct	Shield Tunnel and Embankment	
Landform	Flat plain + low land along rivers			Low land along river + Flat plain	
Geology	Diluvium			Alluvium + Diluvium	
Comments	The depth of earthquake proof foundation is inferred as GL.-10m.		The depth of earthquake proof foundation is inferred as GL.-38m.	The depth of earthquake proof foundation is inferred as GL.-49m. N-value of alluvium until GL.-4m from ground surface is less than 10.	The depth of earthquake proof foundation is inferred as GL.-50m. N-value of alluvium until GL.-4m from ground surface is less than 10.

The depth of earthquake proof foundation is inferred as GL.-24m.
*Buffer zone for land subsidence between a shield tunnel and viaduct is necessary.

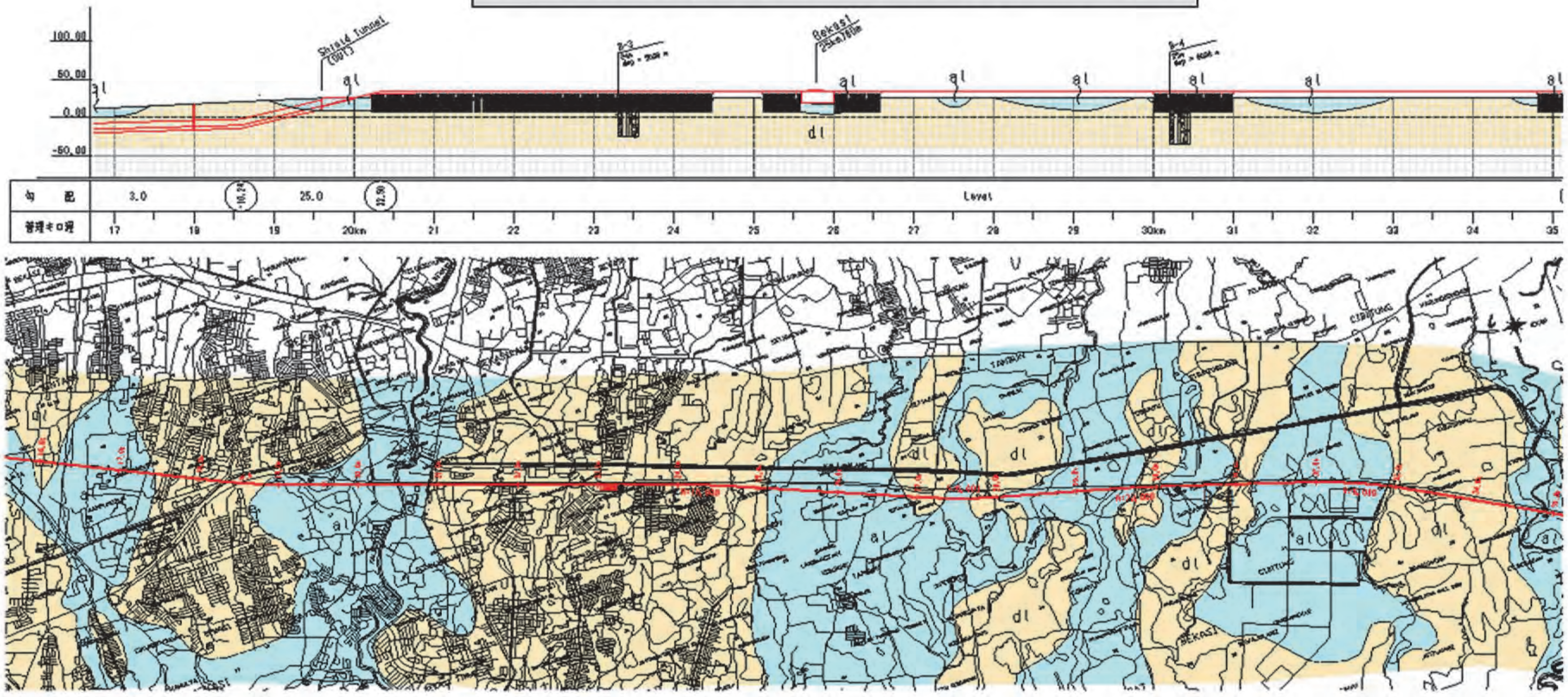
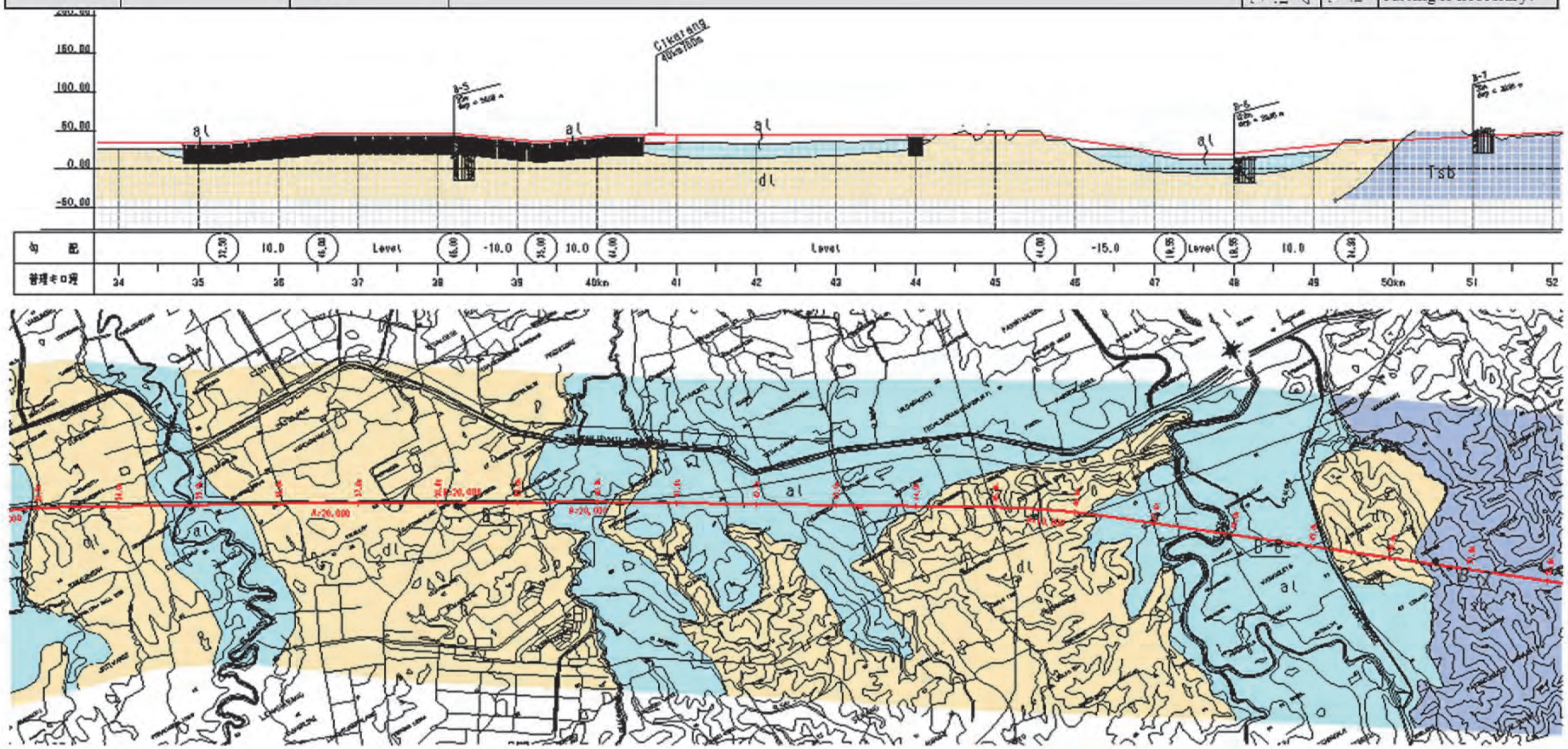


Figure 7.3-2 Geological Section (2/9)

Source: JICA Study Team

Structure	Embankment	Viaduct	Embankment	Cutting	Embankment	Cutting + Embankment
Landform	low relative height hilly land		Low land along river			Hilly land
Geology	Diluvium (Partially Alluvium)	Alluvium	Diluvium	Alluvium	Diluvium	Subang Formation(Mudstone)
Comments	The depth of earthquake proof foundation (EPF) is inferred as GL.-50m.	The depth of earthquake proof foundation is inferred as GL.-38m. N-value until GL.-6m from ground surface is less than 10.	The depth of earthquake proof foundation is inferred as GL.-39m. N-value of alluvium until GL.-10m from ground surface is less than 10 and weak soil until GL.-2m.	The depth of EPF is inferred as GL.-40m.	The depth of EPF is inferred as GL.-49m.	Mudstone has low slake durability, appropriate slope protection work immediate after slope cutting is necessary.



Source: JICA Study Team

Figure 7.3-3 Geological Section (3/9)

Structure	Cutting/Embankment	Tunnel (NATM)	Cutting	Embankment	Cutting	Cutting/Embankment
Landform	Hilly land					
Geology	Subbing Formation (Mainly Mudstone)					
Comments	Geology of this area is mainly comprised of mudstone of Subbing formation. Kerrawang industrial development area is located in this map area. There are many cutting slopes and outcrops comprised of mudstone. That mudstone turns into mud and small pieces due to slaking. According to the result of laboratory test in this survey, it is confirmed that slake durability of that mudstone is low. N-value is less than 15 until GL.-2 to 3m from ground surface, less than 50 until GL.-6m, more than 50 at deeper than GL.-6m and converted N-value ranges from 50 to 80. Mudstone is well consolidated and classified into soft rock. However due to slaking, appropriate treatment is required when embankment, cutting slope and tunnel are constructed in this mudstone.					

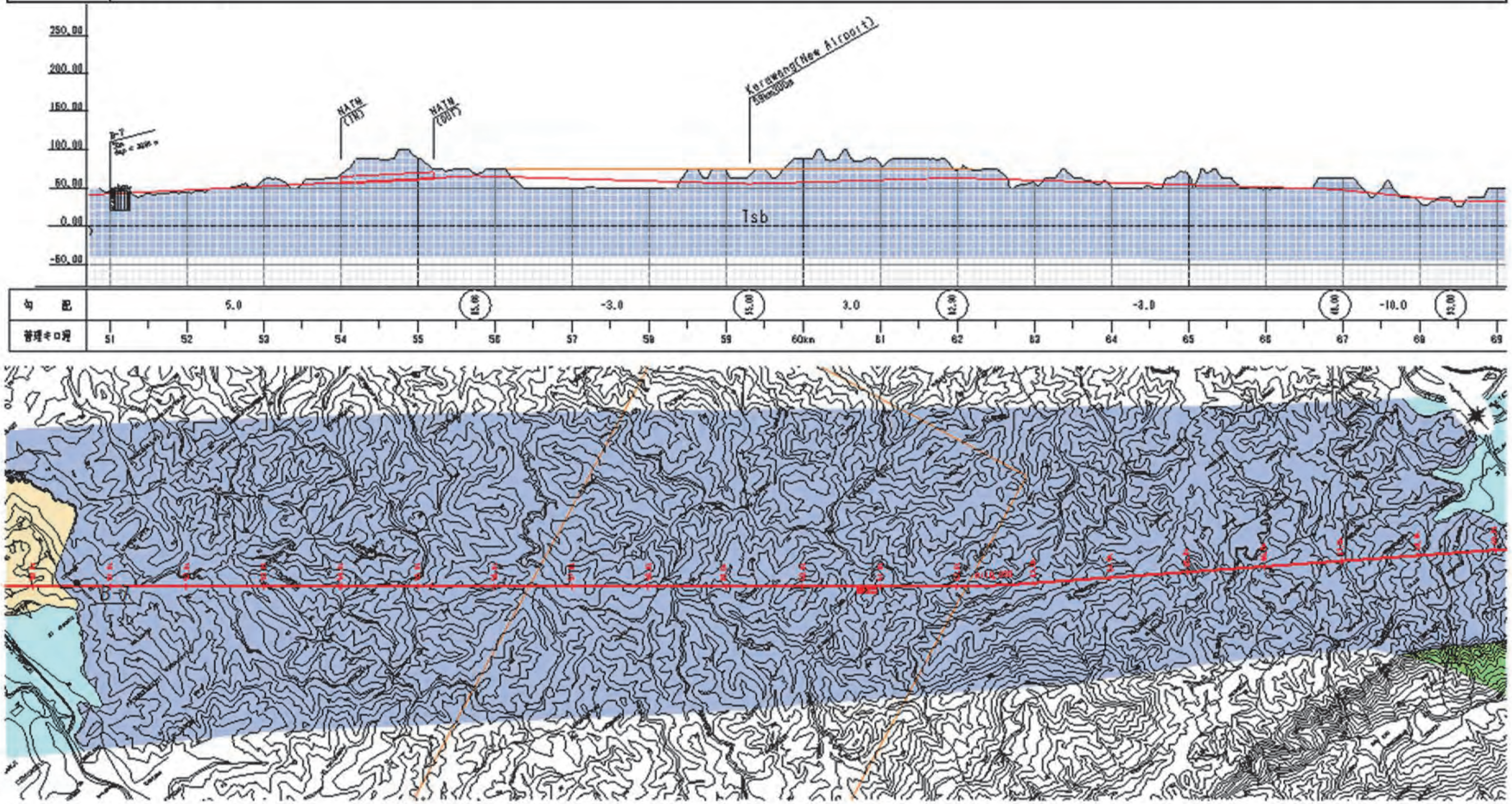


Figure 7.3-4 Geological Section (4/9)

Source: JICA Study Team

Structure	Cutting	Embankment (partially cutting)	Tunnel NATM	Embankment	Tunnel NATM	Bridge	Cutting	Embankment	Tunnel NATM	Bridge	Tunnel NATM
Landform	Hilly land	River terrace	Hilly land						Mountainous area		
Geology	Terrace deposit/Subang formation (mudstone)			Jatiluhur formation Mudstone	Old volcanic sediment distributes high elevation area of the terminus side. Subbing formation is mainly comprised of mudstone, and pyroclastic rock and sandstone distribute high elevation area.				Mainly comprised of mudstone of Jatiluhur formation. Surface of mountain ledge is covered with old volcanic sediment.		
Comments	Near the ground surface, hardness of rock is slightly weak due to weathering. N-value deeper than GL.-6m from ground surface ranges from 50 to 80.	Terrace deposit is composed of silty sediment. In the terrace deposit sedimentation area, terrace deposits covers mudstone of Subang formation. N-value; until GL.-5m: less than 30, less than 50 until GL.-15m, deeper than GL.-15m from ground surface ranges from 50 to 80.	N-value is estimated more than 50.	N-value is estimated more than 50 deeper than GL.-6m to 10m below ground surface.			Influence by slaking phenomenon is concerned for the stability of cutting slope. Section of embankment is located in a paddy field, surface soil of paddy field is assumed to be soft. It is assumed that the layer which N-value is more than 50 distributes deeper than GL.-20m from ground surface.		Depth of weathered zone at the entrance of tunnel (starting point side) is about 20m. Small size slope failure can easily occur at a slope of mountain side.		Geology of tunnel section is mainly composed of mudstone, therefore, influence by slaking on the stability of cutting face of tunnel is concerned.

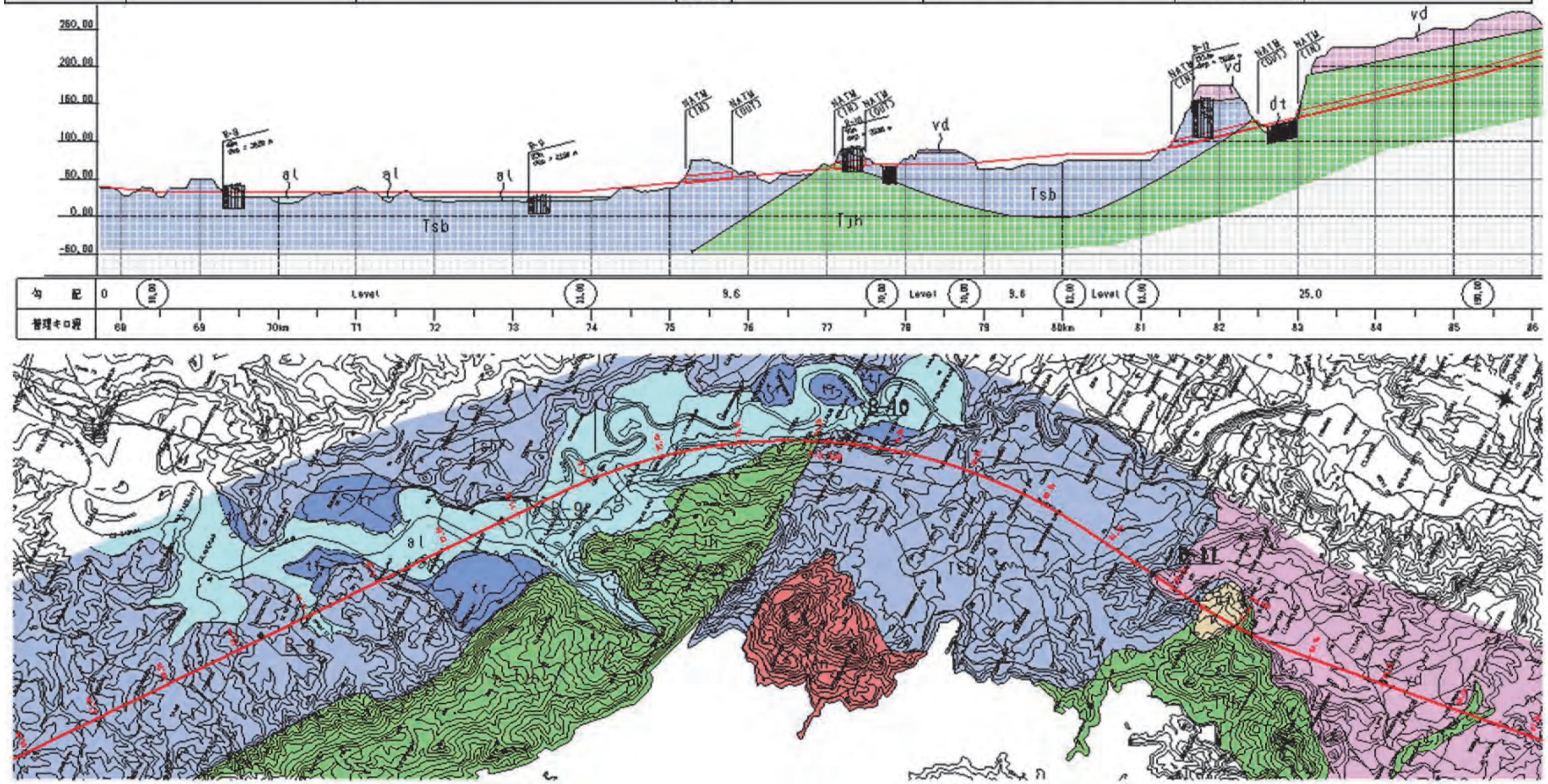


Figure 7.3-5 Geological Section (5/9)

Source: JICA Study Team

Embankment

<table>
<tr><td>Structure</td><td>Tunnel (NATM)</td><td>Bridge</td><td>Tunnel (NATM)</td><td>Bridge/Cutting</td><td>Tunnel (NATM)</td><td></td><td>Tunnel (NATM)</td><td>Cutting/Embankment</td><td>Tunnel</td><td>E/C</td></tr>
<tr><td>Landform</td><td>Mountainous area- hilly land</td><td>Valley</td><td>Mountainous area</td><td>Valley</td><td colspan="6">Mountainous area (partially river valley)</td></tr>
<tr><td>Geology</td><td colspan="3">Old volcanic sediment accumulates on the top of ridge, partially it accumulates thick. Base rock is mudstone of Jatiluhur formation. Talus deposit accumulates on a slope with slightly thick.</td><td colspan="4">Old volcanic sediment accumulates thick on the top of ridge. Geology of Jatiluhur formation is comprised of pyroclastic rock (tuff brecciated lave, lapilli tuff, etc.).</td><td colspan="3">Citarum formation
Mainly pyroclastic rock</td></tr>
<tr><td>Comments</td><td colspan="3">Geology of tunnel section is mainly composed of mudstone, therefore, influence by slaking on the stability of cutting face of tunnel is concerned. N-value is more than 50 (more than 100 of converted N-value) deeper than GL.-10m. Rock type is classified into soft rock. In the section from 88.5 to 89.5km, a thick talus deposit accumulates at the entrance of tunnel. It is concerned about a slope failure of talus deposit. Furthermore, since thickness of the earth covering at the entrance of tunnel is thin, an examination of appropriate method of construction and tunnel support is necessary.</td><td colspan="4">N-value of pyroclastic rock of Jatiluhur formation is more than 50 (more than 100 of converted N-value) immediate beneath rock contact (immediately under the old volcanic sediment). It is well consolidated. Rock type of this pyroclastic rock is classified into soft rock.</td><td colspan="3">N-value of pyroclastic rock of Citarum formation is more than 50 (more than 100 of converted N-value) deeper than 10m from the boundary of old volcanic sediment. It is well consolidated. Rock type of this rock is classified into soft rock.</td></tr>
</table>

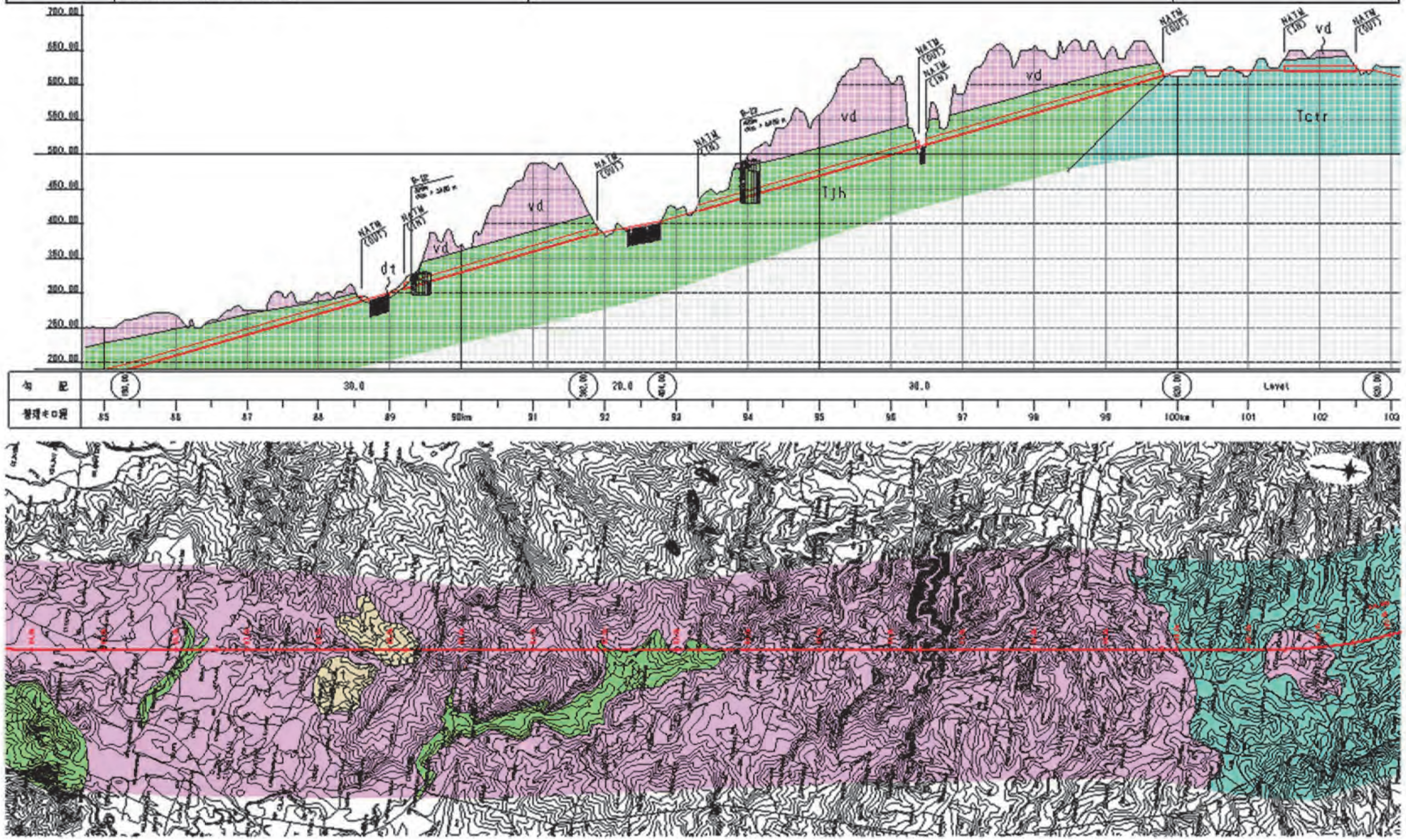


Figure 7.3-6 Geological Section (6/9)

Source: JICA Study Team

Viaduct

Structure	Tunnel	Bridge/Cutting	Tunnel (NATM)	Cutting	Cutting/ Embankment	Viaduct	Cutting/ Embank	Tunnel	Viaduct
Landform	Mountainous area (partially vallay cut by small rivers)			Hilly land	Flat plain			Peak	Flat plain
Geology	Old volcanic sediment accumulates on the top of ridge. Base rock is pyroclastic rocks, such as tuff brecciated lava, lapilli tuff, etc., of Citarum formation. Old volcanic sediment →			Fan deposit on the foot of mountain. Fan deposit on the foot of mountain →				Andesite dyke →	
Comments	Weathering depth of Citarum formation is shallow. N-value of planned tunnel section is more than 50 (converted N-value ranges 100 to 200) except the entrance of tunnel section. Rock type is classified into soft rock and well consolidated.			Cutting slope is constructed in unconsolidated ground of fan deposit on the foot of mountain. It is necessary to examine appropriate design of slope and slope protection method.				Hard rock. Many cracks and joints	

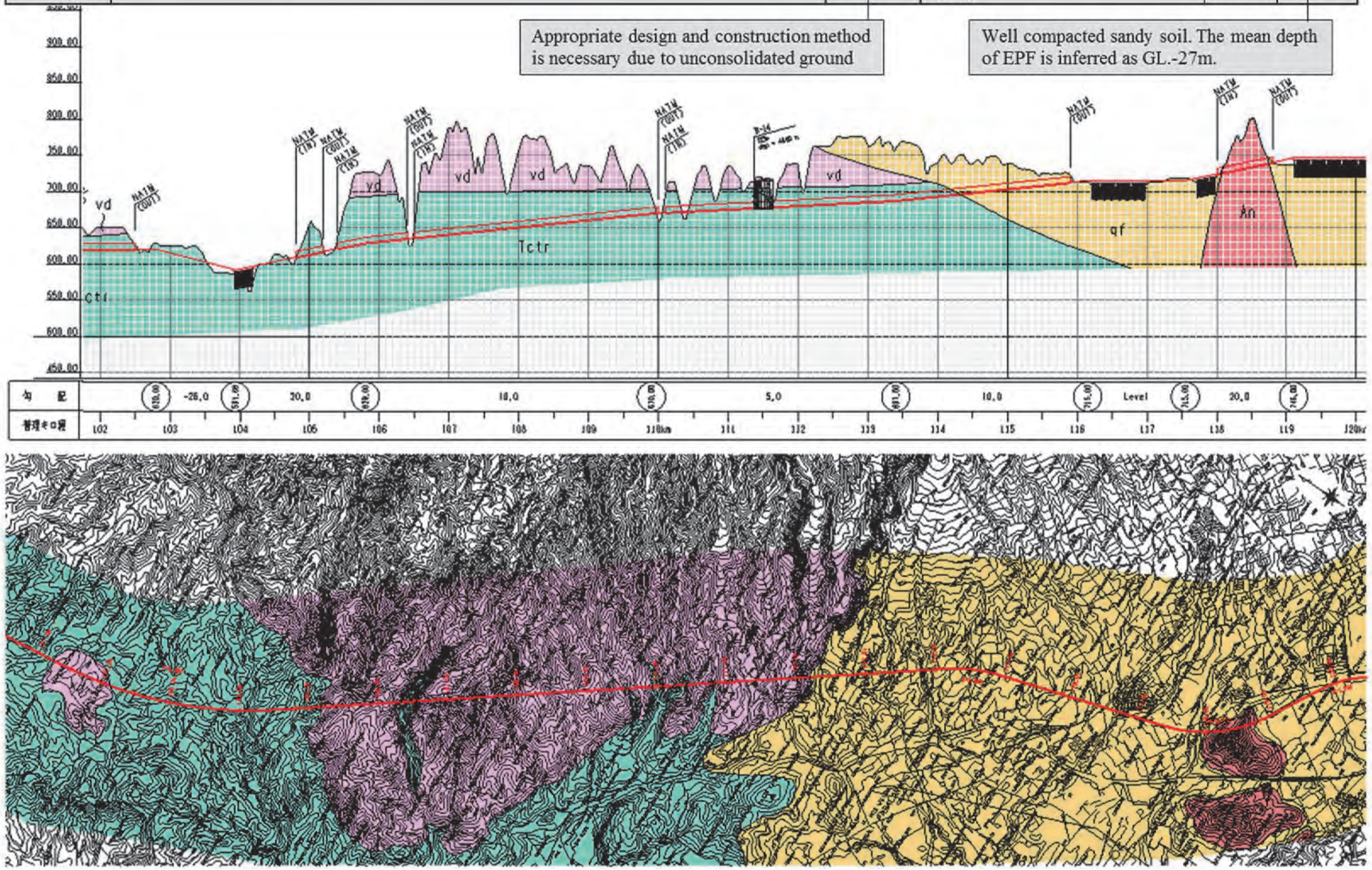
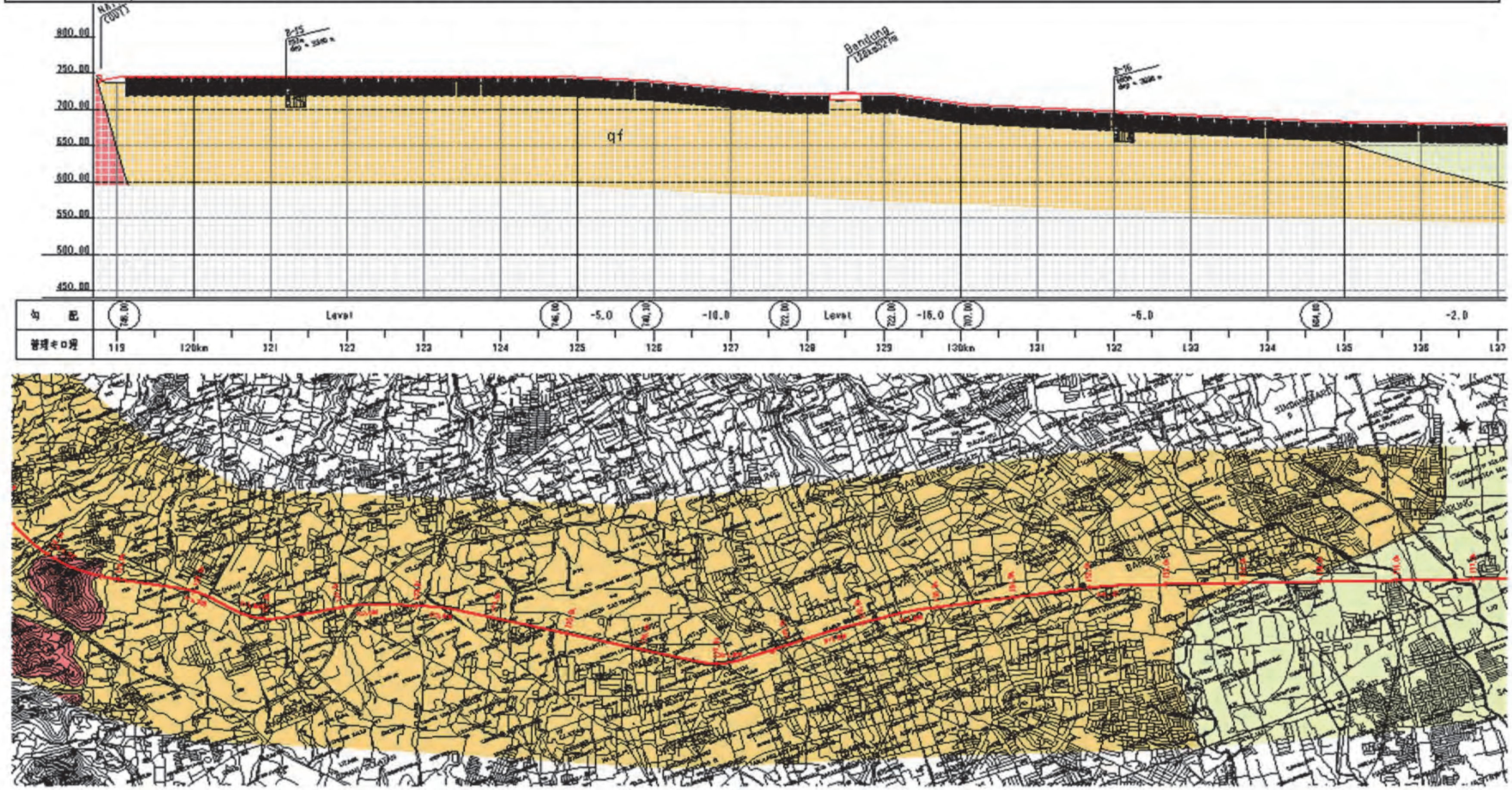


Figure 7.3-7 Geological Section (7/9)

Source: JICA Study Team

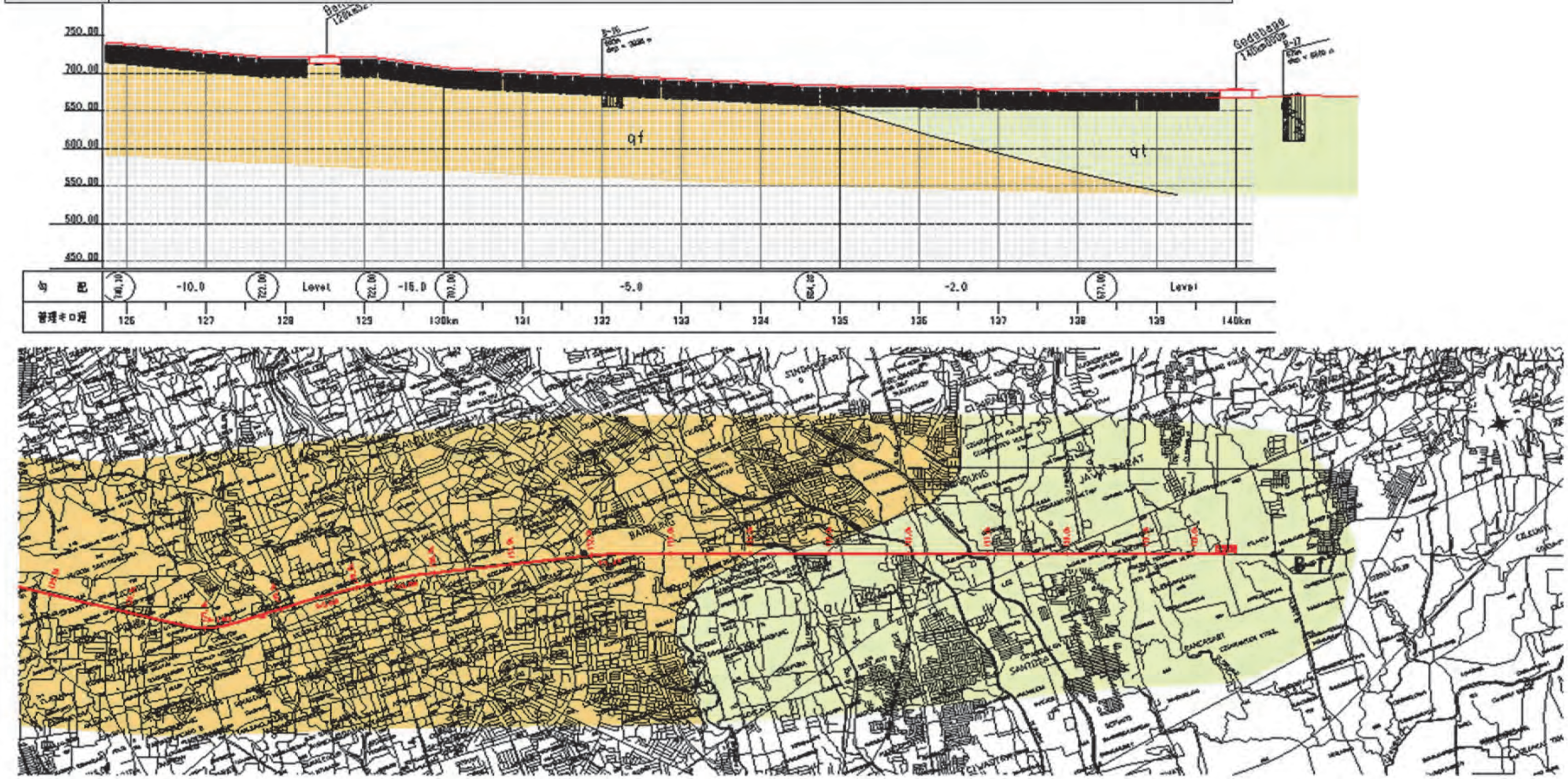
Structure	Viaduct except section between 118.8 and 119.1km (Embankment)	
Landform	Flat plain (there is slight undulation in the section of fan deposit)	
Geology	Fan deposit on the foot of mountain	Lake deposit
Comments	Sediment of fan deposit on the foot of mountain is relatively compacted and composed of sandy soil. The mean depth of earthquake proof foundation (EPF) is estimated as; GL.-27m section between Sta.119～136.1km, GL-30m section between Sta.136.1～136.4km, GL.-35m section between Sta.136.4～136.6km, GL.-40m section between Sta.136.6～136.8km, GL.-45m section between Sta.136.8～136.9km and GL.-50m Section between Sta.136.9～137.0km	



Source: JICA Study Team

Figure 7.3-8 Geological Section (8/9)

Structure	Viaduct	
Landform	Flat plain (there is slight undulation in the section of fan deposit)	
Geology	Fan deposit on the foot of mountain	Lake deposit
Comments	Sediment of fan deposit on the foot of mountain is relatively compacted and composed of sandy soil. Sediment of lake deposit is mainly composed of soft clay. At B-17 boring point (Sta.140.7km), depth of earthquake proof foundation is GL.-52m and sediment is composed of soft clay until the depth of GL.-17m. Deeper than 29m from ground surface, sediment is composed of clay (silty) with N-value more than 20. Between the section of GL.-17 and 29m, soft clay destributes partially.	



Source: JICA Study Team

Figure 7.3-9 Geological Section (9/9)