NO.

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

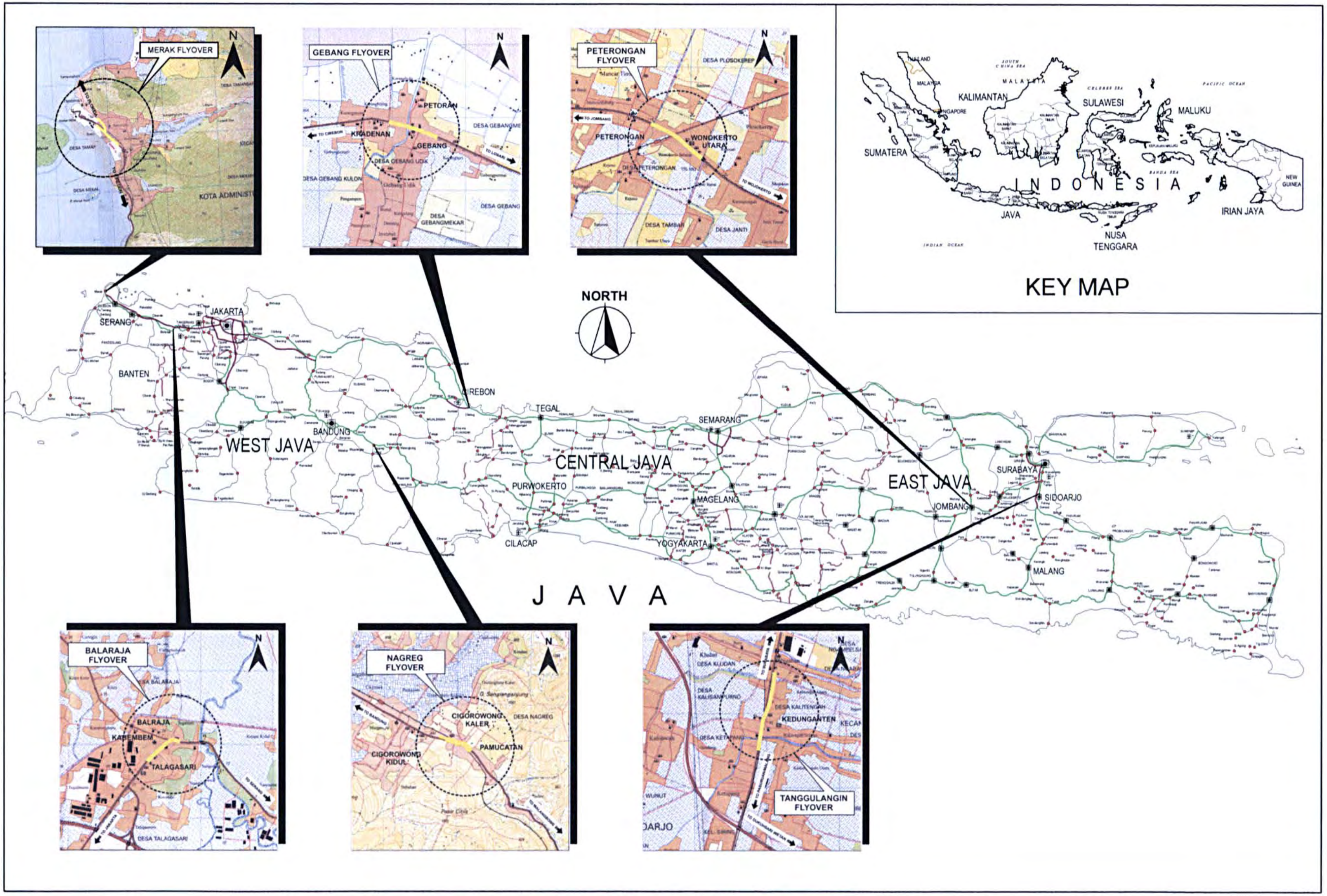
MINISTRY OF PUBLIC WORKS
REPUBLIC OF INDONESIA

DETAILED DESIGN STUDY
OF
NORTH JAVA CORRIDOR FLYOVER PROJECT
IN THE REPUBLIC OF INDONESIA

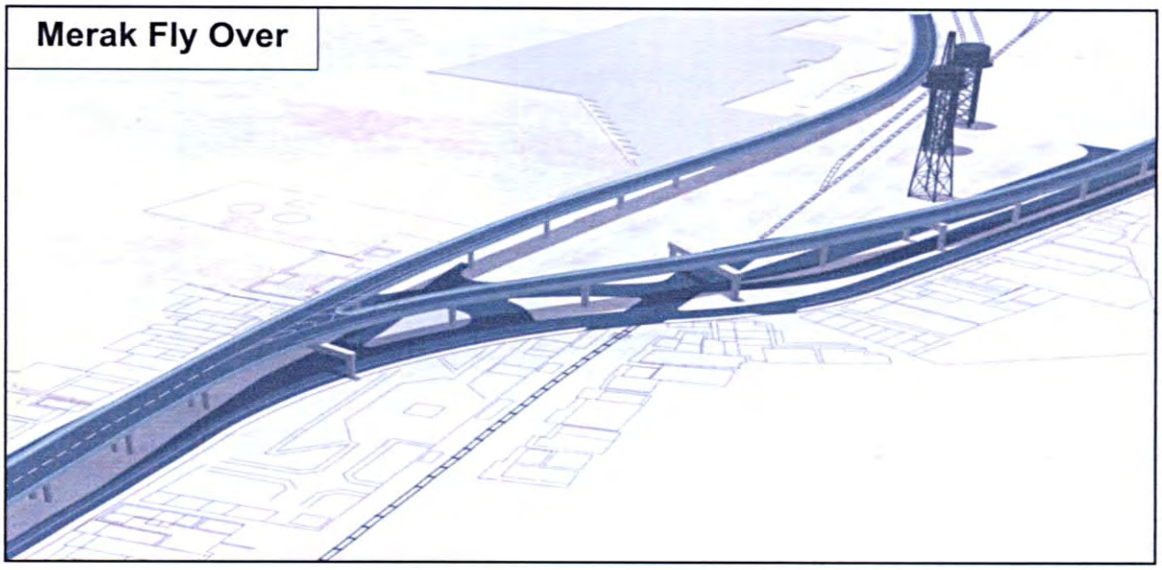
FINAL REPORT
MAIN TEXT

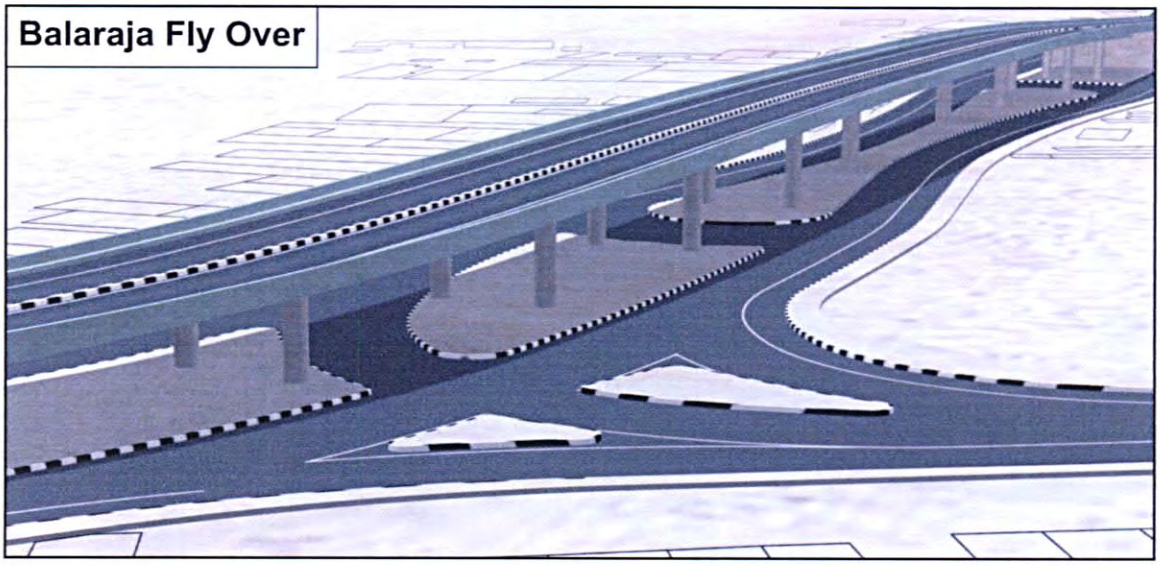
DECEMBER 2006

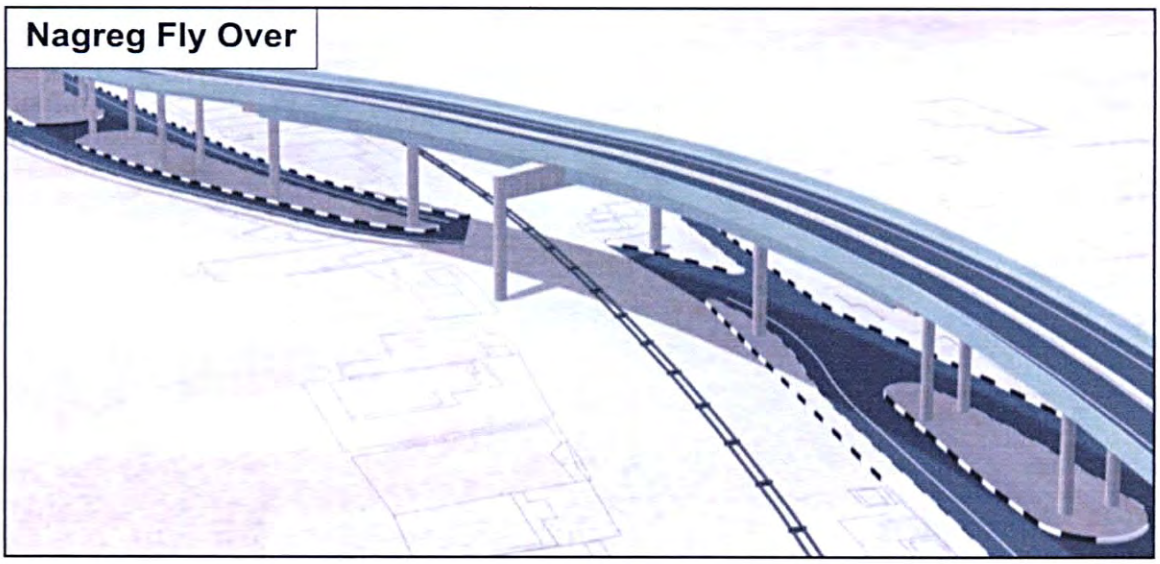
KATAHIRA & ENGINEERS INTERNATIONAL

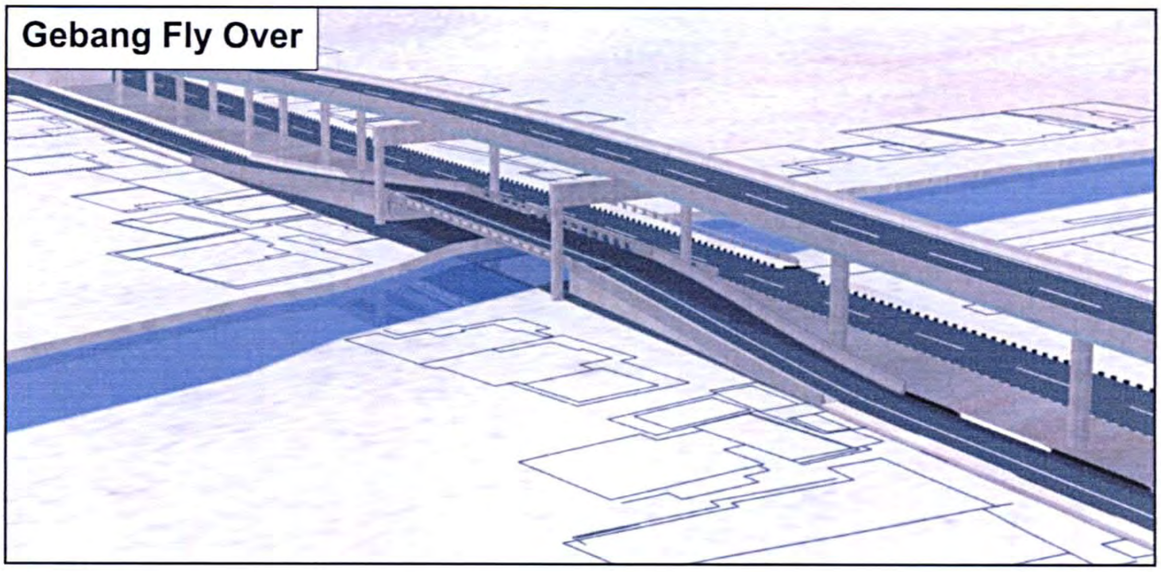


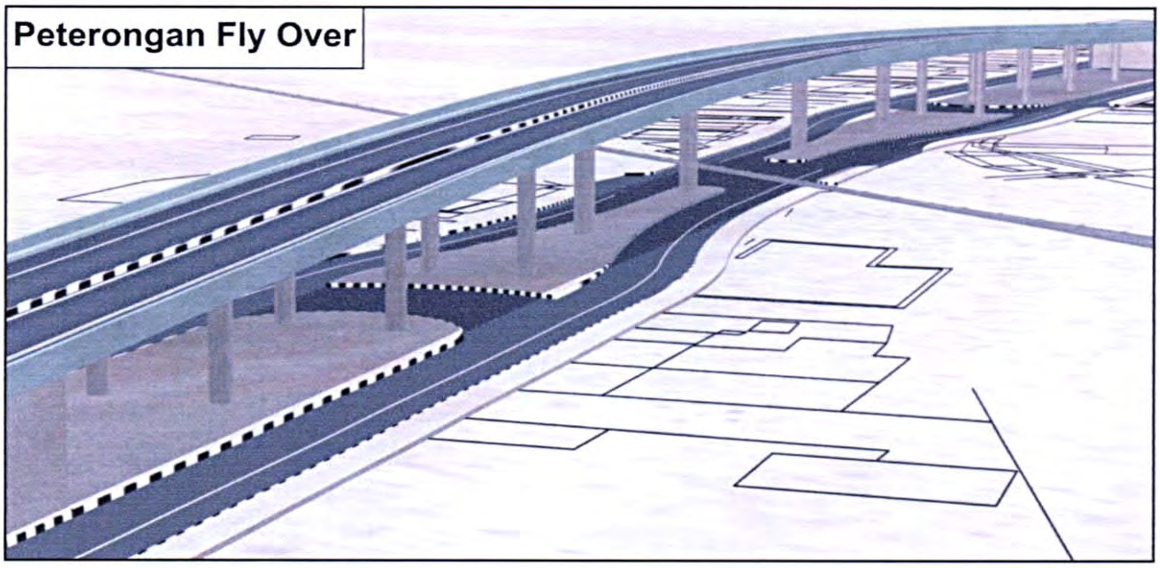
LOCATION MAP OF FLYOVERS FOR NORTH JAVA CORRIDOR PROJECT

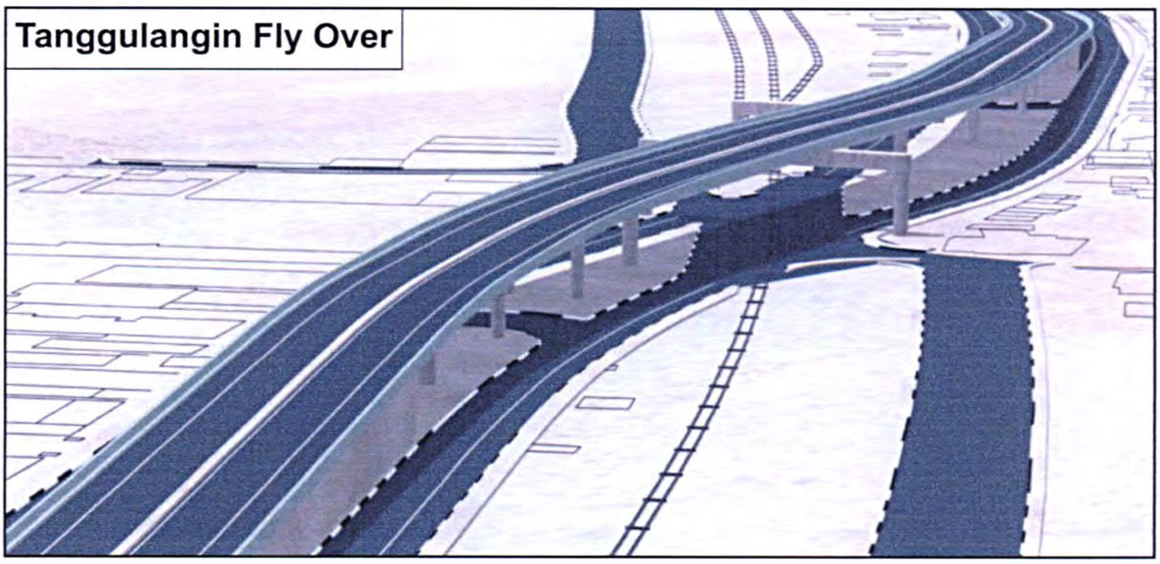

Merak Fly Over


Balaraja Fly Over


Nagreg Fly Over


Gebang Fly Over


Peterongan Fly Over


Tanggulangin Fly Over

DETAILED DESIGN STUDY
OF
NORTH JAVA CORRIDOR FLYOVER PROJECT
IN THE REPUBLIC OF INDONESIA

FINAL REPORT

TABLE OF CONTENT

LIST OF FIGURES **PAGE**

CHAPTER-1

CHAPTER-4

CHAPTER-6

CHAPTER-7

CHAPTER-8

CHAPTER-9

CHAPTER-11

CHAPTER-12

CHAPTER-13

CHAPTER-14

CHAPTER-17

CHAPTER-18

CHAPTER-21

CHAPTER-22

23.3 MAINTENANCE MANAGEMENT PLAN

CHAPTER-1

CHAPTER-3

CHAPTER-5

CHAPTER-6

CHAPTER-7

CHAPTER-8

CHAPTER-9

CHAPTER-10

CHAPTER-11

CHAPTER-12

CHAPTER-13

CHAPTER-14

CHAPTER-17

ABBREVIATIONS

AADT	:	Annual Average Daily Traffic
AASHTO	:	American Association of State Highway and Transportation Officials
AC	:	Asphalt Concrete
ADT	:	Average Daily Traffic
ASDP	:	Port Authority
B/C	:	Benefit / Cost Ratio
BAPPEDA	:	Badan Perencanaan Pembangunan Daerah (Regional Planning Agency)
BAPPENAS	:	Badan Perencanaan Pembangunan Nasional (Indonesia Central Planning Agency)
BMS	:	Bridge Management System
BOQ	:	Bill of Quantities
BPN	:	Badan Pertahanan Nasional (National Land Agency)
BPS	:	Badan Pusat Statistik (Central bureau of Statistic)
DGH	:	Directorate General of Highways, Ministry of Public Works
EAR	:	Economic Accounting Ratio
EIA	:	Environmental Impact Assessment
EIRR	:	Economic Internal Rate of Return
EPS	:	Expanded Polystyrene System Embankment
ESAL	:	Equivalent Single Axle Loads
FHWA	:	the American Federal Highway Authority
FIDIC	:	Federation Internationale des Ingeniurs-Conseils
FS	:	Feasibility Study
GDP	:	Gross Domestic Product
GOI	:	Government of Indonesia
GOJ	:	Government of Japan
GPS	:	Global Positioning System
GRDP	:	Gross Regional Domestic Product
IEE	:	Initial Environmental Examination
IHCM	:	Indonesian Highway Capacity Manual
J.V.	:	Joint Venture
JBIC	:	Japan Bank for International Cooperation
JICA	:	Japan International Cooperation Agency
JRA	:	Japan Road Association

KEL	:	Knife Edge Load
MOC	:	Ministry of Communication
MPW	:	Ministry of Public Works
MSE	:	Mechanically Stabilized Earth Wall
O-D	:	Origin- Destination
ODA	:	Official Development Assistance
PAFs	:	Project Afected Families
PAPs	:	Project Affected Persons
PCU	:	Passenger Car Unit
PQ	:	Prequalification
ROW	:	Right-of-Way
SAPROF	:	JBIC Special Assistance for Project Formation
SN	:	Structure Number
SPT	:	Standard Penetration Test
STEP	:	Special Term for Economic Partnership Loan
UKL	:	Environmental Management Plan
UPL	:	Environmental Monitoring Plan
VAT	:	Value Added Tax
V/C	:	Volume / Capacity Ratio
VOC	:	Vehicle Operating Cost

PART I

INTRODUCTION

Chapter 1
INTRODUCTION

1.1 BACKGROUND

Although Java Island shares only 6.7% of the country's land area, about 60% of country's populations are residing and about 58% of GDP are produced in the Island. Above facts clearly show that concentration of population and economic activities in the Island. North Java Road runs along the northern coast line of the Island and extends in the east-west direction. North Java Road connects major industrial cities such as Jakarta, Surabaya, Semarang, etc. each other and is vitally supporting the country's socio-economic and industrial activities.

With the increasing traffic volume along North Java Road, transport efficiency is rapidly decreasing due to traffic bottlenecks formed particularly at intersections in urban sections, railway crossings and along urban sections where many street stalls are concentrated along the road sides, which are affecting sound socio-economic and industrial development.

To cope with the above problems, the Government of Indonesia (hereinafter referred to as "GOI") has decided to construct flyovers at six priority locations along North Java Corridor in order to eliminate traffic bottlenecks and to achieve smooth traffic movements. The project is called "North Java Corridor Flyover Project". The project was appraised by the Japan Bank for International Cooperation (hereinafter referred to as "JBIC") and the loan agreement between GOI and JBIC applying the Special Term for Economic Partnership (hereinafter referred to as "STEP") was signed in March 2005.

In connection with the implementation of this STEP Loan,, GOI requested the Government of Japan (hereinafter referred to as "GOJ") to provide the technical assistance for the detailed design of the project.

In response to the request of GOI, GOJ has decided to conduct the Detailed Design Study of North Java Corridor Flyover Project in Indonesia (hereinafter referred to as "the Study"), and exchanged Notes Verbales with GOI concerning implementation of the Study.

Accordingly, the Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the implementation of the technical cooperation Projects of GOJ decided to undertake the Study in close cooperation with the authorities concerned of GOI.

On the part of GOI, Directorate General of Highways, Ministry of Public Works (hereinafter referred to as "DGH") acted as the counterpart agency to the Japanese study team and as the coordinating body in relation with other concerned governmental and non-governmental organizations for the smooth implementation of the Study.

1.2 OBJECTIVES OF THE STUDY

The objectives of the Study are:

1) to review previous studies and plans related to the project, analyze the most effective and efficient roads development of the project,
2) to carry out necessary engineering surveys,

3) to complete a detailed design for execution of the project
4) to carry out construction planning and cost estimate, and
5) to prepare draft tender documents for execution of the project

1.3 STUDY AREA

The study area shall cover the following construction sites of flyover along main roads in Java Island (refer to the location map):

1) Merak (Banten Province)
2) Baralaja (Banten Province)
3) Nagreg (West Java Province)
4) Gebang (West Java Province)
5) Peterongan (East Java Province)
6) Tanggulangin (East Java Province)

1.4 SCOPE OF THE STUDY

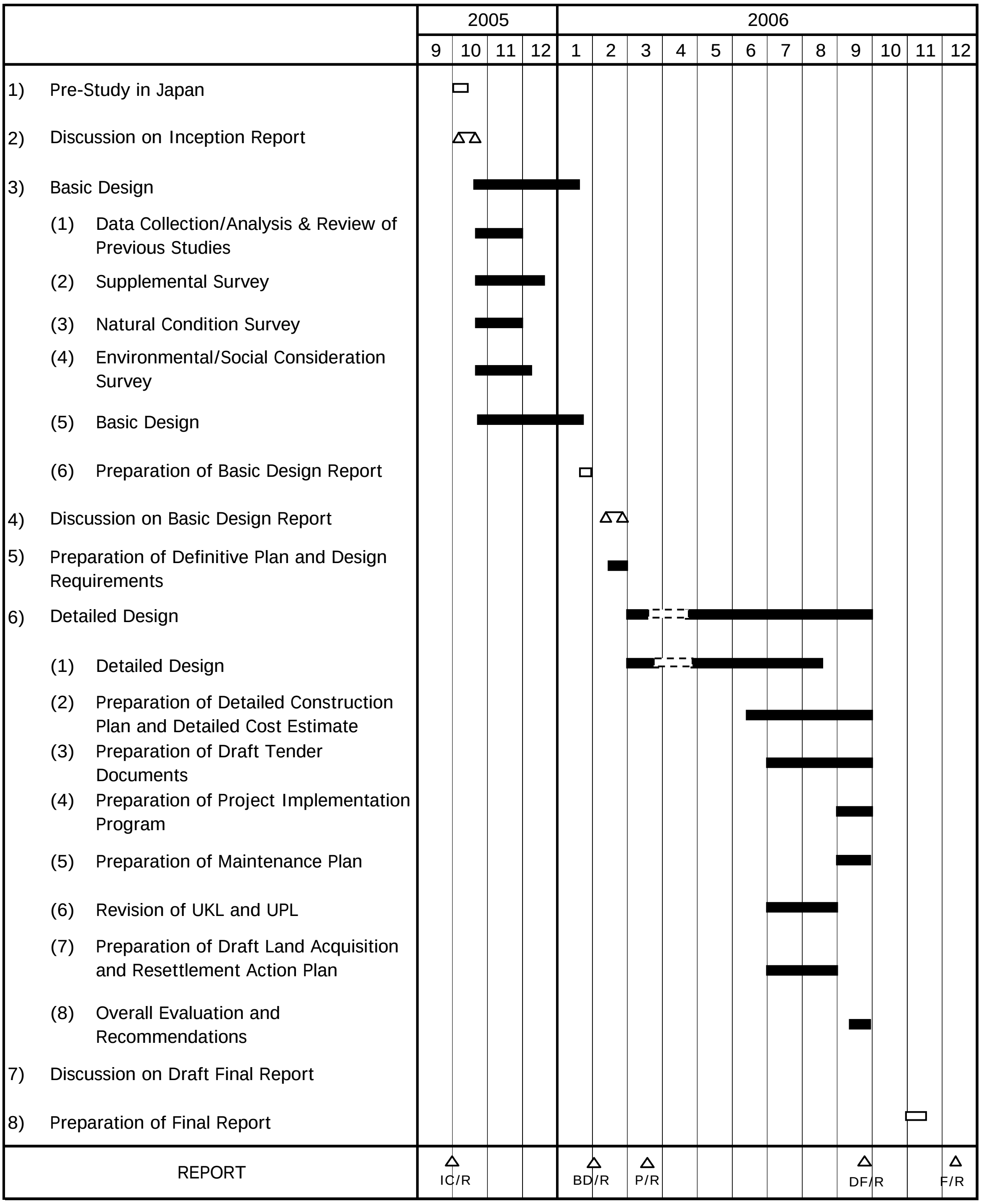
Scope of the Study shall covers the following:

1) Pre-Study in Japan
2) Discussion on Inception Report
3) Basic Design
    - Data Collection and Analysis and Review of Previous Studies
    - Supplemental Survey
    - Natural Condition Surveys
    - Environmental/Social Consideration Survey
    - Basic Design
    - Preparation of Basic Design Report
4) Discussion on Basic Design Report
5) Preparation of Definitive Plan and Design Requirements
6) Detailed Design
    - Detailed Design
    - Preparation of Detailed Construction Plan and Detailed Cost Estimate
    - Preparation of Draft Tender Documents
    - Preparation of Project Implementation Program
    - Preparation of Maintenance Plan
    - Revision of UKL and UPL
    - Preparation of Draft Land Acquisition and Resettlement Action Plan
    - Overall Evaluation and Recommendations
7) Discussion on Draft Final Report
8) Preparation of Final Report

1.5 STUDY SCHEDULE

The Study shall be carried out in accordance with the schedule shown in **Table 1.5-1.**

TABLE 1.5-1 STUDY TABLE



Note : Work in Japan / Work in Indonesia

IC/R : Inception Report
BD/R : Basic Design Report
P/R : Progress Report
DF/R : Draft Final Report
F/R : Final Report

1.6 ORGANIZATION FOR THE STUDY

JICA organized a JICA Study Team. DGH will organize a Counterpart Team to collaborate with the JICA Study Team in carrying out the Study, a Technical Committee for periodic discussion with the JICA Study Team and a Steering Committee to ensure smooth conduct of the Study. The Organization Chart is shown in **Figure 1.6-1.**

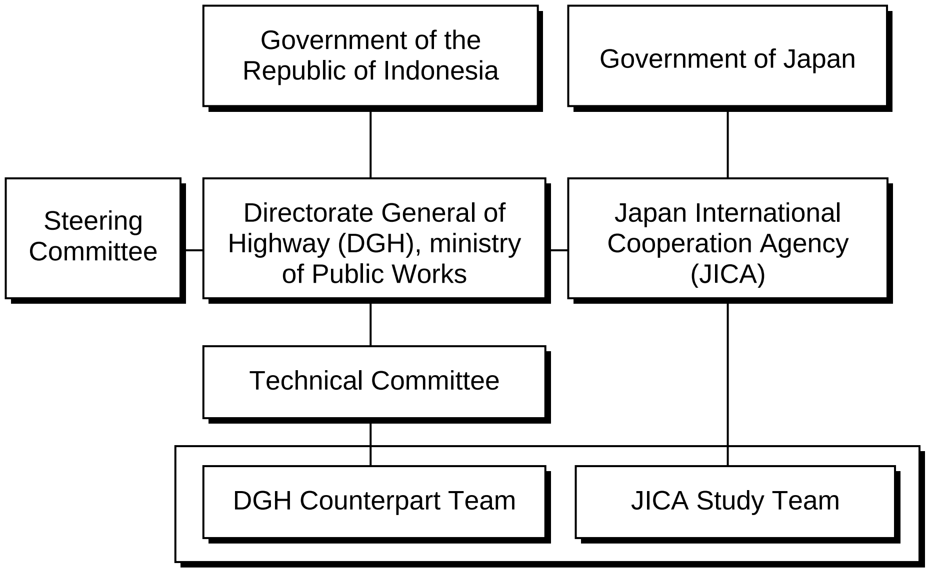


FIGURE 1.6-1 ORGANIZATION CHART FOR THE STUDY

The JICA staff for coordination between JICA Head Office, Indonesian Office, JICA Technical Supervisor, and the JICA Study Team are;

Mr. Akira NAKAMURA	:	Group Director, Group III (Transportation), Social Development Department
Mr. Yoshiro KURASHINA	:	Team Director, Group III (Transportation), Social Development Department
Mr. Shigeo HONZU	:	Transportation Team I, Group III (Transportation), Social Development Department
Mr. Tatsuhiko SUNOUCHI	:	Transportation Team I, Group III (Transportation) Social Development Department (from September 2006)

JICA Indonesia Office:

Mr. Keiichi KATO	:	Resident Representative
Mr. Shinji TOTSUKA	:	Deputy Resident Representative
Mr. Kozo NAGAMI	:	Assistant Resident Representative
Dr. Nobuyuki TSUNEOKA	:	JICA Expert (Road Policy)

The JICA Study Team is composed of the following members:

Mr. Mitsuo KIUCHI	:	Team Leader / Road & Bridge Planner
Mr. Takashi OKUMURA	:	Flyover / Transport Planner
Mr. Ryuichi UENO	:	Highway Engineer
Mr. Shigeru MATSUI	:	Bridge Engineer (Steel Bridge)
Mr. Hiroshi HONDA	:	Bridge Engineer (PC Bridge)
Mr. Anthony GOURLEY	:	Bridge Engineer (Substructure)
Mr. Takao MITSUISHI	:	Environmental Specialist
Mr. SUHARTO	:	Resettlement Specialist (Up to February, 2006)
Mr. Eros PALGUNADI	:	Resettlement Specialist (From May, 2006)
Mr. Chifuyu HORIUCHI	:	Natural Condition Survey Specialist
Mr. Kazufumi MATSUKAWA	:	Construction Planner / Cost Estimator
Ms. Lucila C. PERLADA	:	Document Specialist

The JICA Technical Supervisor is composed of the following members:

Mr. Shunji HATA	:	Director of Study Department, Infrastructure Development Institute (Up to March, 2006)
Mr. Kiyoshi DACHIKU	:	Director of 1st Research Department, Infrastructure Development Institute (From April, 2006)
Mr. Hiroo ODA	:	Senior Counselor of Infrastructure Development Institute

The Steering Committee is organized under the chairmanship of Director General of DGH and consisting of the following members:

Chairman	:	Mr. Hendrianto Notosoegondo, Director General of Highways, DGH
Vice Chairman	:	Ms. Sri Apriantini Soekardi, Director of Planning
Vice Chairman	:	Mr. Franky Tayu, Director of Technical Affairs
Vice Chairman	:	Mr. Purnarachman Hadipoerwono, Director of Road/Bridge, West Region
Member	:	Mr. R. Bambang Goeritno Sukamto, Head of Planning Bureau, MPW
Member	:	Mr. Herry Vaza, Chief Sub – Directorate of Bridge Engineering
Member	:	Ms. Jany Agustin, Chief Sub – Directorate of Environmental Engineering
Member	:	Mr. A. Gani Ghazaly Akman, Chief Sub – Directorate of West Region I
Member	:	Mr. A. Yusid Toyib, Chief Sub – Directorate of West Region V
Member	:	Mr. Palgunadi, Chief Sub – Directorate of Standard & Guideline
Member	:	Mr. Taufik Widjoyono, Chief Sub – Directorate of Programming & Budgeting
Member	:	Mr. Arif Witjaksono, Chief Sub – Directorate of Urban Road Network

The Technical Committee is composed of the following members:

Chairman	:	Mr. Herry Vaza, Chief Sub – Directorate o Bridge Engineering
Member	:	Ms. Jany Agustin, Chief Sub – Directorate of Environmental Engineering
Member	:	Mr. A. Gani Ghazaly Akman, Chief Sub – Directorate of West Region I
Member	:	Mr. A. Yusid Toyib, Chief Sub – Directorate of West Region V
Member	:	Mr. Palgunadi, Chief Sub – Directorate of Standard & Guideline
Member	:	Mr. Taufik Widjoyono, Chief Sub – Directorate of Programming & Budgeting
Member	:	Mr. Arif Witjaksono, Chief Sub – Directorate of Urban Road Network
Member	:	Mr. Jawali Marbun, Chief Sub – Directorate of Road Engineering
Member	:	Mr. Danis H Sumadilaga, Chief Sub – Directorate of Metropolitan and Big City
Member	:	Mr. Sjofva Rosliansjah, Head of Bridge Section for Western Region
Member	:	Mr. Djoko Sulistyono, Head of Bridge Section for Eastern Region
Member	:	Ms. Nonviani, PMU JBIC

The Counterpart Team members are as follows:

Team Leader	:	Mr. Herry Vaza, Chief Sub – Directorate o Bridge Engineering
Member	:	Mr. Sjofva Rosliansjah, Head of Bridge Section for Western Region
Member	:	Mr. Djoko Sulistyono, Head of Bridge Section for Eastern Region
Member	:	Mr. Dedi Soendjoto, Road Engineering Section
Member	:	Ms. Nurmala Sumanjuntak, Head of Environmental Engineering Section
Member	:	Mr. Wilan Oktavian, Head of Urban Bridge Section
Member	:	Mr. Yudo Muktiarto, Head of Section of Metropolitan I
Member	:	Mr. Tasripin Sartiyono, Head of Section of Banten and West Java
Member	:	Ms. Endang Priyustini, Staff of Section of Banten and West Java
Member	:	Mr. Widayanto, Head of Section of Western Region V

Chapter 2

OBJECTIVE OF THE PROJECT

The objective of the project defined by the Loan Agreement is

> *"To provide flyovers as the most appropriate countermeasures to achieve sound improvement of road transportation network and substantial enhancement of physical distribution along the North Java Corridor and in the inland areas of Java Island for vitalization of socio – economic activities in the pertinent regions through the establishment of smooth and reliable traffic network".*

Chapter 3
REVIEW OF PREVIOUS STUDIES

3.1 FEASIBILTY STUDY OF THE PROJECT

The feasibility study for North Java Corridor flyover project was completed in September, 2003. the feasibility study covered 14 flyovers including 6 flyovers which are subjected to this detailed design study. Major findings of the feasibility study of subject 6 flyovers are summarized hereunder.

3.1.1 Traffic Conditions and Estimated Future Traffic Count Survey results are summarized in Table 3.1.1-1

TABLE 3.1.1-1 TRAFFIC VOLUME IN 2003

No.	Location	Traffic Volume 2003 (Kabupaten/Kota Border)						
		Passenger Car	Small Bus	Medium & Large Bus	Small Truck	Medium Truck	Large Truck	TOTAL
1	Merak	1,813	3,528	270	634	882	226	7,353
2	Balaraja	4,814	4,119	1,676	1,496	1,573	144	13,822
3	Nagreg	4,178	1,972	836	1,267	2,393	20	10,666
4	Gebang	4,119	909	1,639	1,543	4,975	1,205	14,390
5	Peterongan	8,008	572	1,815	2,960	4,915	1,155	19,425
6	Tanggulangin	9,112	2,398	62	3,298	5,505	316	20,691

Source : Feasibility for North Java Corridor Flyover Project, 2003

Future traffic volume was forecasted by multiplying the existing traffic volume by the corresponding future traffic growth factor for each type of vehicle. Table 3.1.1-2 shows the future traffic growth factors determined based on “Heavy Loaded Road Improvement Project Phase II”

TABLE 3.1.1-2 FUTURE TRAFFIC GROWTH FACTORS

No.	Vehicle Type	Annual Growth (% p.a)				
		2001-2005	2005-2010	2010-2015	2015-2020	2020-2025
1	Passenger Car	3,71	4,42	3,34	2,21	2,46
2	Small Bus	3,79	4,91	4,02	4,32	3,33
3	Medium & Large Bus	4,13	4,95	3,82	3,56	3,17
4	Small Truck	4,16	4,52	3,12	2,78	2,67
5	Medium Truck	4,10	5,16	4,28	4,74	3,64
6	Large Truck	3,44	4,37	3,42	3,24	2,68

Source : Feasibility for North Java Corridor Flyover Project, 2003

Adopting the peak hour traffic ratio (K-factor) of 0.0821, future peak hour traffic volume was estimated as shown in **Table 3.1.1-3.**

TABLE 3.1.1-3 FUTURE PEAK HOUR TRAFFIC VOLUME

Unit : pcu/hr

No.	Location	2003	2010	2015	2020	2025
1	Merak	612	849	1,028	1,248	1,463
2	Balaraja	1,125	1,561	1,880	2,248	2,622
3	Nagreg	936	1,303	1,573	1,889	2,208
4	Gebang	1,661	2,310	2,812	3,442	4,063
5	Peterongan	1,983	2,746	3,322	4,008	4,700
6	Tanggulangin	1,894	2,629	3,174	3,816	4,464

Source : Feasibility for North Java Corridor Flyover Project, 2003

3.1.2 Geometric Design Standards

Recommended geometric design standards for this project is shown in **Table 3.1.2-1.**

TABLE 3.1.2-1 GEOMETRIC DESIGN STANDARDS RECOMMENDED By F/S

Criteria		Type II, Class I		Recommended for this Project
		Standard	Minimum	
Design Speed	(kph)	60	--	60
Lane Width	(m)		3.50	3.50
Median	(m)	2.0 min	1.00	0.50
			(exceptional)	for bridge
Marginal strip of median	(m)	0.50		0.50
Right shoulder width	(m)		0.50	Not required
Left shoulder width				with median
(with or without sidewalk)	(m)	0.50		--
Sidewalk width	(m)		1.50	--
Stopping distance	(m)		75	Min.75
Passing distance	(m)	350	250	
Curve radius	(m)	200 (desireable)	150	Min.150
Curve radius for				
normal cross fall	(m)	--	220	
Curve length				
(where intersection angle 'a' <7%)	(m)	--	700/a	
Cross fall	(%)	2	100	Min.100
			(exceptional)	
Curves not requiring transition	(m)		600	2
Curves not requiring				--
superelevation	(m)		2000	
Lane widening	(m)			Not required
Max. Gradient	(%)	5		5
Vertical curve radius	(m)			
a. crest		2000 (desireable)	1400	2000
b. sag		1500 (desireable)	1000	1500
Vertical curve length	(m)	50	--	50
Length of transition section	(m)		50	

Source : Feasibility for North Java Corridor Flyover Project, 2003

Number of lanes for flyovers was 2-way 2-lane.

3.1.3 Flyover Schemes, Type of Bridge, Construction Cost and Economic Viability

Flyover schemes, type of bridges, construction cost and economic viability are summarized in **Table 3.1.3-1.**

TABLE 3.1.3-1 FLYOVER SCHEMES, TYPE OF STRUCTURE, CONSTRUCTION COST AND ECONOMIC VIABILITY

Location	Flyover Length (m)			Typical Cross Section	Structure Type	Estimated Construction Cost Billion Rupiah (Million Yen)	Economic Viability EIRR (%)
	Bridge Section	Approach Section	Total				
Merak	330	235	565	Flyover : 2x3.5 + 2x0.25 + 2x0.5 = 8.50 m Service Road + Sidewalk : 0.5 + 4.5 + 1.5 = 6.50m Total Width = 21.50m	Case 1 : PC Slab + Steel I Girder + Steel Pier + RC Abutment	36.4 (510)	17.7
					Case 2 : PC Slab + Steel I Girder + Steel / RC Piers + RC Abutment	29.5 (413)	19.5
					Case 3 : PC Slab + PC Girder + RC Pier + RC Abutment	22.6 (317)	22.1
Balaraja	560	299	859	Same as above	Case 1 : Same as Merak	61.0 (855)	18.9
					Case 2 : Same as Merak	49.8 (698)	21.1
					Case 3 : Same as Merak	38.6 (541)	23.9
Nagreg	360	230	590	Same as above	Case 1 : Same as Merak	39.3 (550)	19.2
					Case 2 : Same as Merak	32.4 (454)	21.2
					Case 3 : Same as Merak	25.5 (357)	23.9
Gebang	280	255	535	Same as above	Case 1 : Same as Merak	30.0 (420)	19.7
					Case 2 : Same as Merak	24.9 (348)	21.7
					Case 3 : Same as Merak	19.7 (276)	24.2
Peterongan	280	285	565	Same as above	Case 1 : Same as Merak	31.4 (439)	17.5
					Case 2 : Same as Merak	26.2 (367)	19.3
					Case 3 : Same as Merak	21.0 (295)	21.6
Tanggulangin	336	276	612	Same as above	Case 1 : Same as Merak	37.1 (520)	18.4
					Case 2 : Same as Merak	30.2 (423)	20.5
					Case 3 : Same as Merak	23.3 (327)	23.3

Source: FeasibilityStudy for North Java Corridor Flyover Project, 2003

Note : 1) Exchange rate 1 Yen = 71.4 Rp
0.014 Yen = 1.0 Rp

2) Japan Portion
Case 1 43,7%(satisfies STEP Loan Requirement)
Case 2 32,3%(satisfies STEP Loan Requirement)
Case 3 14.6%(not satisfies STEP Loan Requirement)

3.2 SAPROF STUDY OF THE PROJECT

JBIC Special Assistance for Project Formation (SAPROF) for North Java Corridor Flyover Project was undertaken for 8 flyovers including 6 flyovers subjected to this detailed design study and completed in September 2004. Based on this SAPROF Study, the project was appraised by JBIC and Loan Agreement was signed by and between GOI and GOJ in March 2005. Major findings and recommendations of SAPROF Study for 6 flyovers are summarized hereunder.

3.2.1 Recommended Typical Flyover / Approach Cross Section

Recommended typical cross sections for a flyover and an approach section are shown in Figure 3.2.1-1.

3.2.2 Proposed Flyover Scheme and Estimated Cost

Proposed flyover scheme and estimated cost are summarized in **Table 3.2.1-1.**

TABLE 3.2.1-1 PROPOSED FLYOVER SCHME BY SAPROF STUDY

Flyover	Flyover Scheme (m)			Structure Type			Base Cost for Civil Work (2004) w/o Tax Billion Rap (Million Yen)	
	Bridge (Viaduct)	Approach	Total	Super-structure	Substructure	Foundation		
Merak	340	360	700	PC I Girder	Single Column Pier (RC)	Pile Cap + Multi-Bored Pile (1.5m)	42.86	(514.3)
Balaraja	225	295	520	Steel I Girder	Single Column Pier (Composite)	Large Diameter Single Bored (3m)	37.56	(450.9)
Nagreg	315	425	740	Steel I Girder	Single Column Pier (Composite)	Large Diameter Single Bored (3m)	49.73	(596.8)
Gebang	450	370	820	Steel I Girder	Single Column Pier (Composite)	Large Diameter Single Bored (2.5m)	53.45	(641.5)
Peterongan	275	325	600	PC I Girder	Single Column Pier (RC)	Pile Cap + Multi-Bored Pile (1.5m)	35.25	(423.0)
Tanggulangin	240	330	570	PC I Girder	Single Column Pier (RC)	Pile Cap + Multi-Bored Pile (1.5m)	30.63	(367.6)
Total	1,845	2,105	3,950	-	-	-	249.48	(2,994.1)

Exchange Rate : 1Rp = 0.012 Yen

PART II

TRAFFIC AND NATURAL CONDITION OF THE PROJECT AREA

CHAPTER 4

PROJECT SITE SETTING

4.1 MERAK FLYOVER

4.1.1 Flyover Location and Topography

The location of Merak Flyover is shown in **Figure 4.1.1-1**. It is located at almost west end of Java Island. Site condition of the flyover is shown in **Figure 4.1.1-2**. Characteristics of the project site are as follows:

- The 4-lane national road at Jakarta side ends before this railway crossing, and branches off into the 2-lane national road going to Pularida and the Merak Ferry Terminal Exit Road.

- Merak Ferry Terminal is quite important and strategic facility providing transport connection between Java Island and Sumatra Island.

- There are two gates related to Merak Ferry Terminal. One gate is located at the end of the 4-lane national road, which is mainly functioning as the exit from the Ferry Terminal and all vehicles from the Ferry Terminal go out from this gate to the national road. Only buses going to the existing Bus Terminal located near this gate and port official's vehicles enter into the Ferry Terminal at this gate.

  The other gate is located near the railway crossing. This gate is used only as entrance to the Ferry Terminal. All vehicles going to Sumatra Island enter to the Ferry Terminal at this gate. This gate is connected to the Ferry Terminal Waiting Area.

- The existing bus terminal is planned to be transferred towards the Jakarta side as shown in **Figure 4.1.1-2**. Construction of new bus terminal is scheduled to start in 2007.

- One side of the 2-lane national road is bounded by the fence of the Ferry Terminal Waiting Area. The other side is the built-up area of small scale commercial and business establishments where many cars, taxies, small buses, etc. stop at the road side causing heavy traffic frictions and traffic congestions.

- The railway ends at this location.

Topography of this flyover location is characterized as the narrow coastal plain which is followed by relatively steep mountain slopes.

4.1.2 Soil Condition

<u>Along National Road</u>

First layer up to 10 to 16m depth consists of sand mixed with silts with N-value of 4 to 20 and suspected by liquefaction during the second layer is silts/clay with varying thickness of 6 to 30m and varying N-value of 10 to 30. The third layer consists of cohesive soil with very stiff to hard consistency and found at the depth of 20 to 43m from the ground.

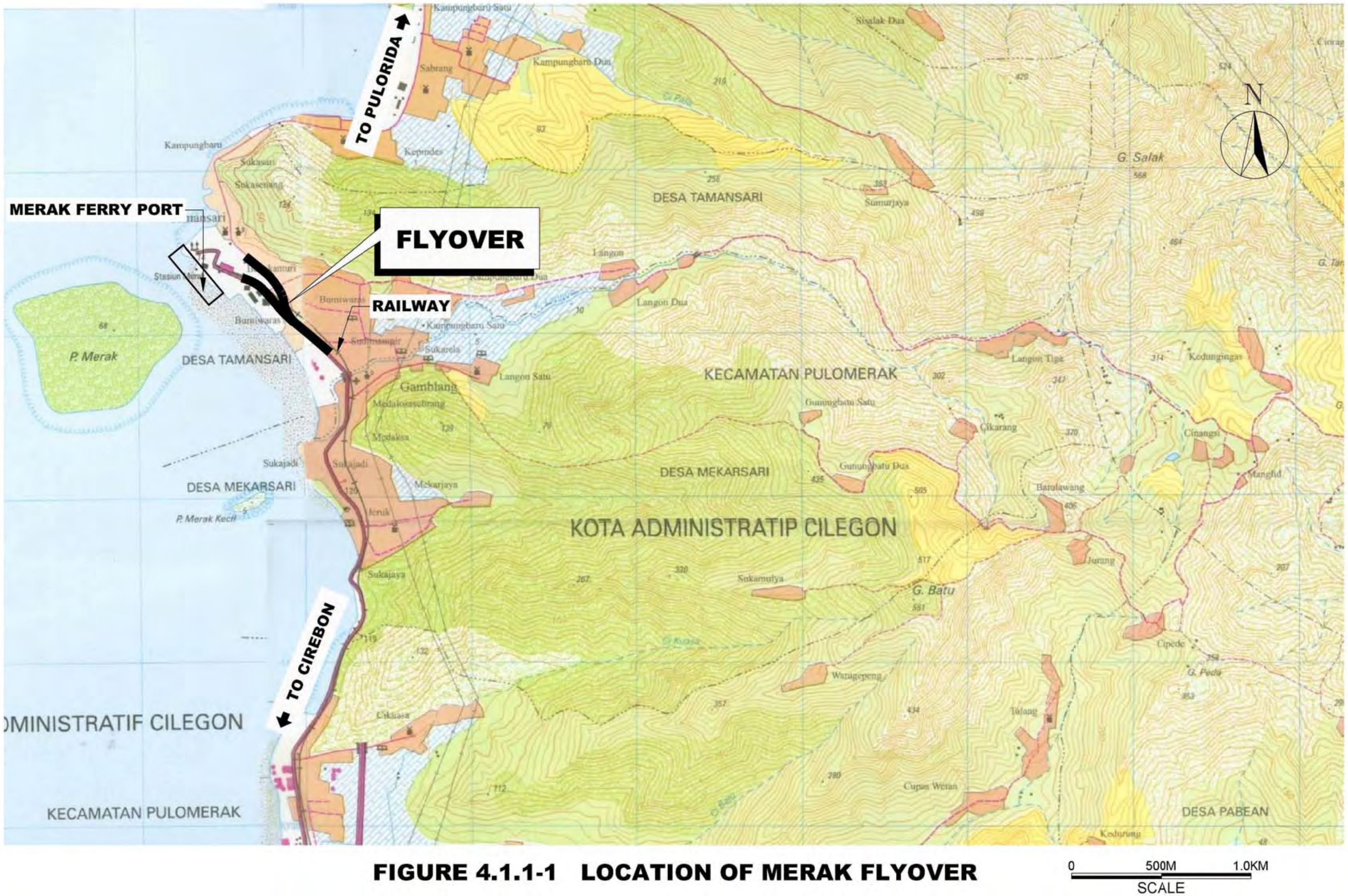


FIGURE 4.1.1-1 LOCATION OF MERAK FLYOVER

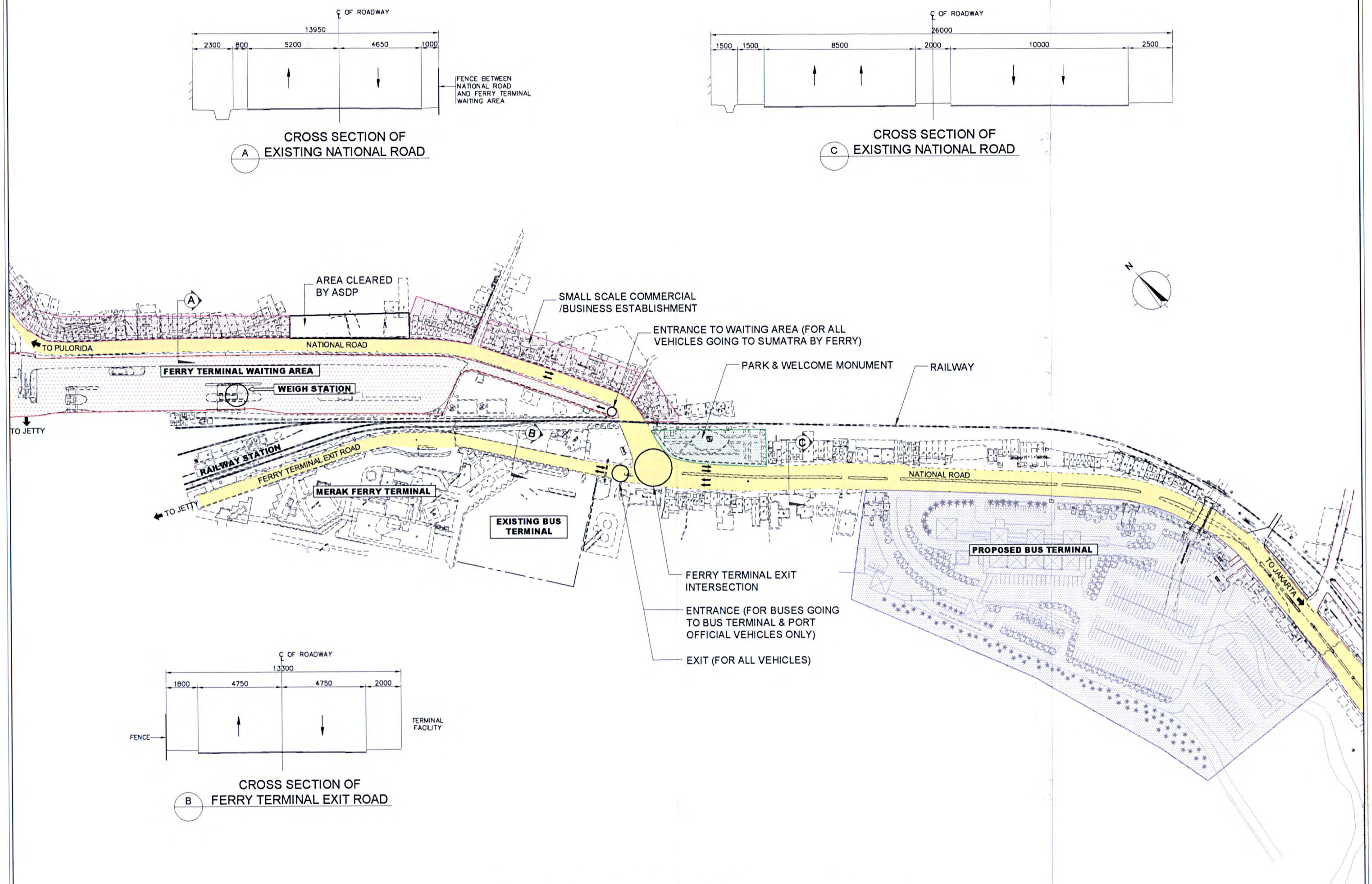


Figure 4.1.1-2 SITE CONDITION OF MERAK FLYOVER

Along Ferry Terminal Exit Road

First layer with thickness of 1~2m consists of sand mixed with silt and clay with N-value of 5 to 6. Second layer consists of fine sand and clayey silt with N-value of 1 to 5 and thickness of 6 to 8m. Third layer is cohesive soil with N-value of 10 to 30 and thickness of 10 to 12m. Fourth layer is the hard layer which consists of clayey silt with N-value of more than 50 and found at 22 to 25m below the ground level.

4.1.3 Land Use

Along the 4-lane national road, sea side is mostly reserved for the proposed Bus Terminal and still vacant. The other side is narrow area bounded by the railway and the national road and occupied by small scale commercial establishments and residential houses.

Along the 2-lane national road, one side is facing with the Ferry Terminal Waiting Area and the other side (mountain side) is the built-up area with small scale commercial/business establishment except the area cleared by ASDP. Ferry Terminal Exit Road passes through the compound of Merak Ferry Terminal.

4.1.4 Road Network

The subject road section is a part of Jakarta – Cirebon – Merak – Pulorida Road. This road is connected with the Merak Ferry Terminal which provides important transport linkage between Java Island and Sumatra Island by Ferry Service.

There is no other major road in the project area.

4.1.5 Existing Road Condition

Typical cross sections of the 4-lane national road, the 2-lane national road and the Ferry Terminal Exit Road are presented in **Figure 4.1.1-2**. The 4-lane national road has standard width of 26m divided by center median with 1.5 to 2.0m sidewalks. Pavement type is AC pavement in fair to good condition.

The 2-lane national road has standard width of 13.95 m with AC pavement of which condition is fair to bad.

The Ferry Terminal Exit Road has standard width of 13.3m with sidewalks on both sides. The carriageway is paved with concrete pavement of which condition is fair to good.

4.1.6 Physical Constraints and Major Control Points

1) Road Right-of-Way (ROW)

   Land taking of Ferry Terminal Waiting Area is not allowed by ASDP, since the waiting area is fully occupied by vehicles during Ramadan Holidays or when one of ferry boats stops its operation due to repair/maintenance. Instead, there is ASDP's land along the 2-lane national road and its utilization can be possible.

The park built by the Provincial Government at the end of the 4-lane national road can be affected.

2) Public Utilities

The most critical underground utility is the water pipeline (D=30 cm) which supplies water to the power plant. This water pipeline is located along the fence between the 2-lane national road and the Ferry Terminal Waiting Area.

Another underground utilities are:

Right Side	:	Telecommunication cable (D=4cm)
Left Side	:	Electrical cable (D=5 cm)
		Telecommunication cable (D=4cm)

4.2 BALARAJA FLYOVER

4.2.1 Topography

The location of Balaraja Flyover is shown in **Figure 4.2.1-1**. Serang side (or western side) of the Flyover up to the intersection with the road going to Kresek is flat. From the intersection, the road goes down at about 5% gradient up to the river.

4.2.2 Soil Condition

Soil conditions consist of medium stiff sandy and silty clays overlying very stiff to hard clays. The hard layer having N value > 50 at this site is in a relatively horizontal plane occurring between 8m to 14m deep below the existing ground surface. The upper layers between the surface and the hard layer consist predominantly of clays with medium stiff consistency. Soft layers were found at two (2) boreholes with thicknesses ranging from 3m to 5m. Silty sands were also encountered at two (2) boreholes with consistency ranging from loose to dense. Maximum borehole depth at this site was 30m.

4.2.3 Land Use

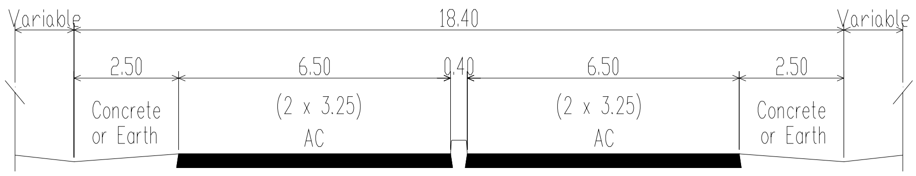
Industrial area has been developed in the west of the Flyover. Roadsides have been fully developed with commercial establishments and schools. At the western corner of intersection going to Kresek, large scale shopping mall is planned to be built.

4.2.4 Road Network

The Serang – Balaraja – Tangerang section constitutes a part of North Java Corridor. At the Flyover location, the road going to Kresek intersects with the North Java Corridor. Jakarta – Merak Toll Road runs in the southern side of the road.

4.2.5 Existing Road Condition

The existing road in the Flyover section is a 4-lane divided road with the asphalt concrete pavement for the carriageway and concrete or earth for shoulders.



TYPICAL CROSS SECTION OF EXISTING ROAD

AC Pavement condition is fair to good. Shoulder and a part of carriageway is used as loading / unloading of mini-buses, trucks and also as sidewalks. Side ditches are mostly covered, but some sections are open.

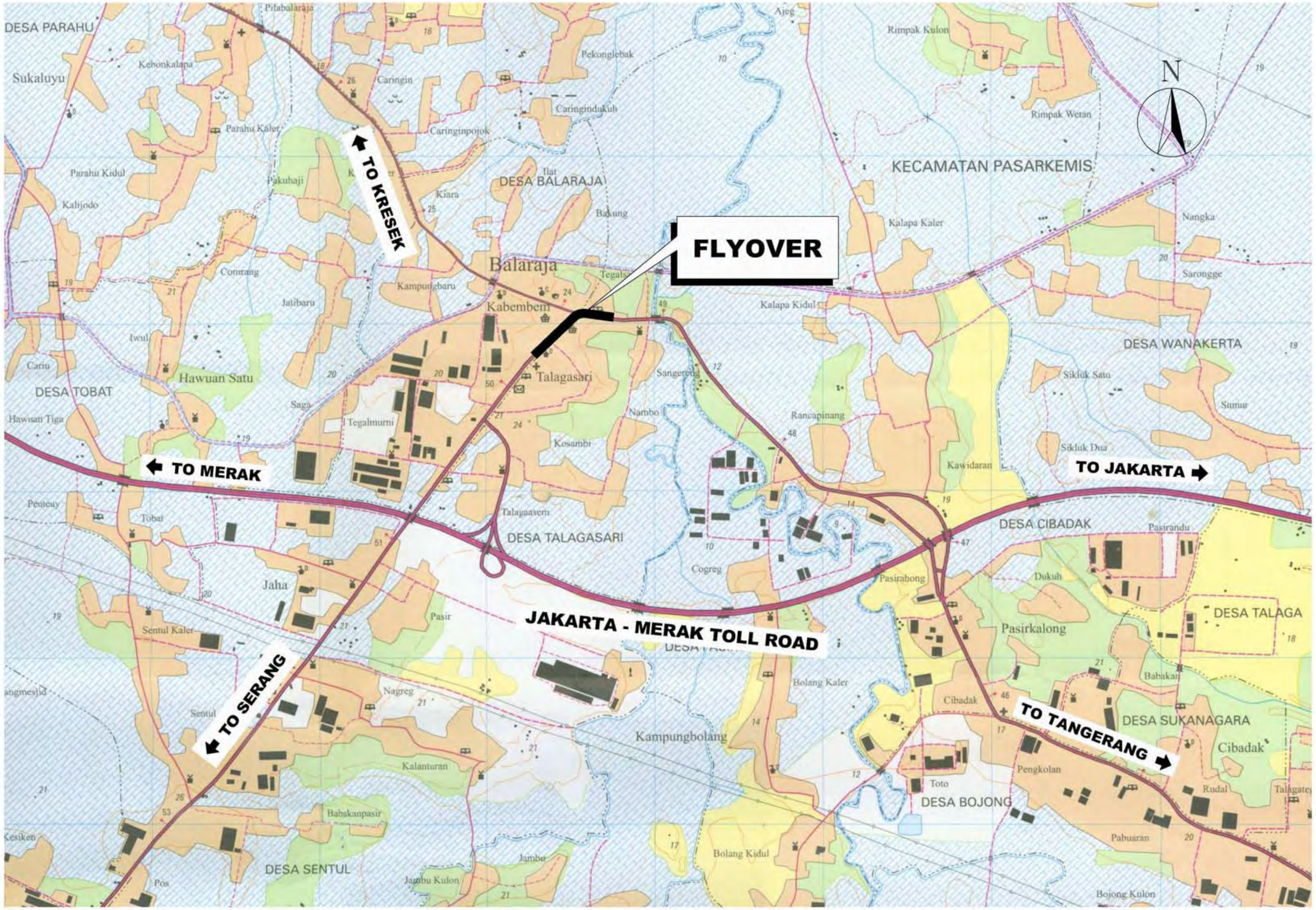


FIGURE 4.2.1-1 LOCATION OF BALARAJA FLYOVER

4.2.6 Physical Constraints and Major Control Points

1) Road Right-of-way (ROW)

Based basically on the SAPROF Study, new ROW to accommodate a flyover has been acquired as shown Figure 4.2.6-1. New ROW width ranges from 29.1 m (standard) to 18.0 m. The flyover had to be designed within the new ROW, thus nose location (or beginning and end points) was more or less determined.

2) Public Utilities

Most critical public utility is the gas pipe line (Diameter 20 cm) which is located at the right side of the road, and supplies gas to nearby industrial estates and residential houses. During the initial discussion with the gas company (Perum Gas), protection was recommended by the company because it is quite difficult to stop supply of gas.

Another underground utilities are:

Right side : Electrical Cable (3 lines, D=4cm), water pipe (D=25cm)
Left side : Electrical Cable (1 line), telecommunication cable (1 line)

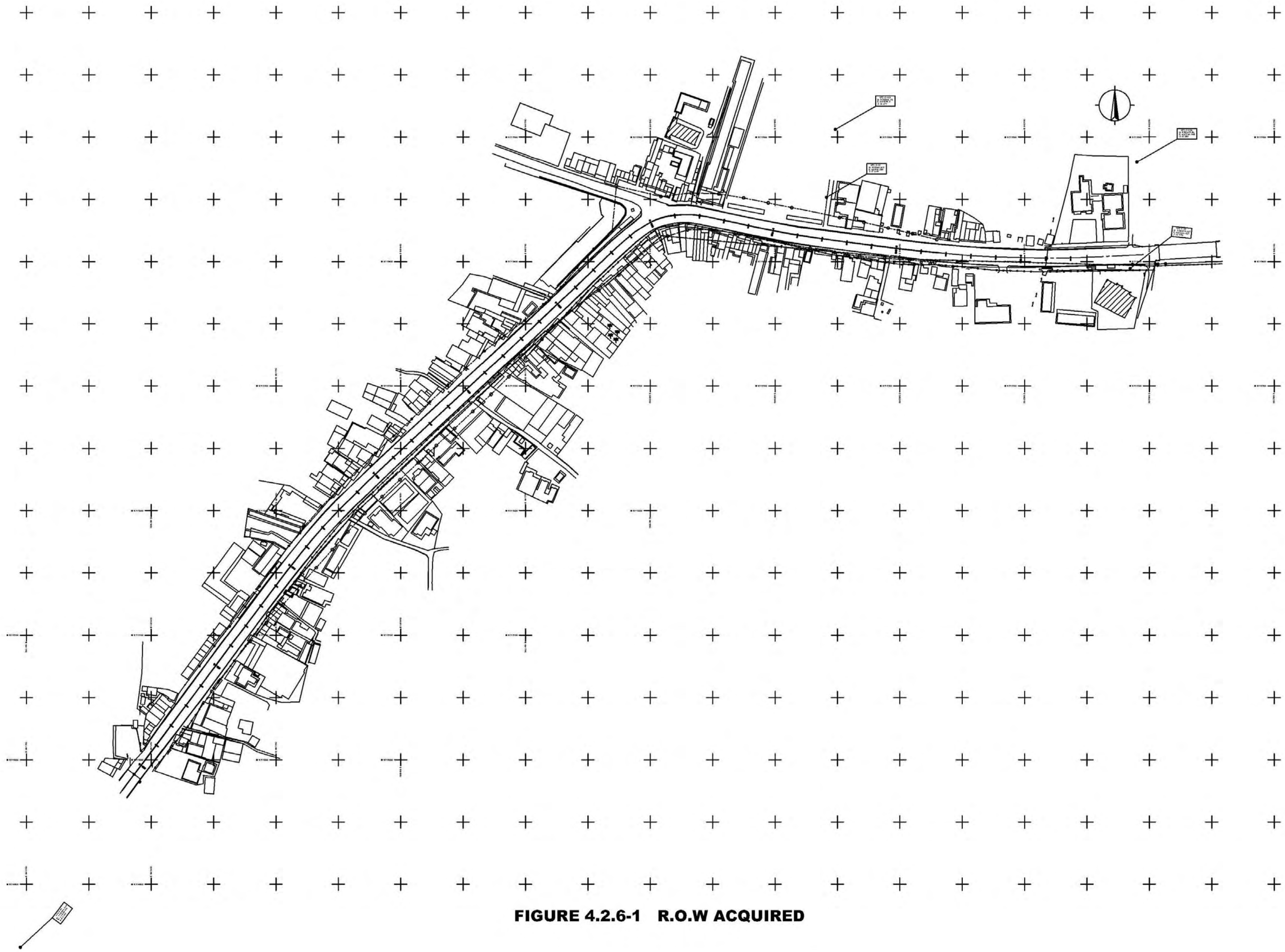


FIGURE 4.2.6-1 R.O.W ACQUIRED

4.3 NAGREG FLYOVER

4.3.1 Topography

The location of Nagreg Flyover is shown in Figure 4.3.1-1. The Flyover is located at the elevation of about 850m from the sea level. From the Bandung side, the road goes up with the gradient of about 5% up to the railway. From the railway, flat area continues for about 500m,then goes down with very steep gradient of 10-11% towards Malangbong.

4.3.2 Soil Condition

Soil conditions consist of silty clays with variable consistency overlying hard clays. The hard layer is not occuring in a horizontal plane at this site, with depths at which soil with N > 50 was encountered ranging from 20m to 30m below existing ground level. Dense sands were encountered at depth at four (4) boreholes. The upper clay layers vary in consistency from soft to medium stiff. The soft layers were encountered within 4m of the surface. Maximum borehole depth at this site was 44m.

4.3.3 Land Use

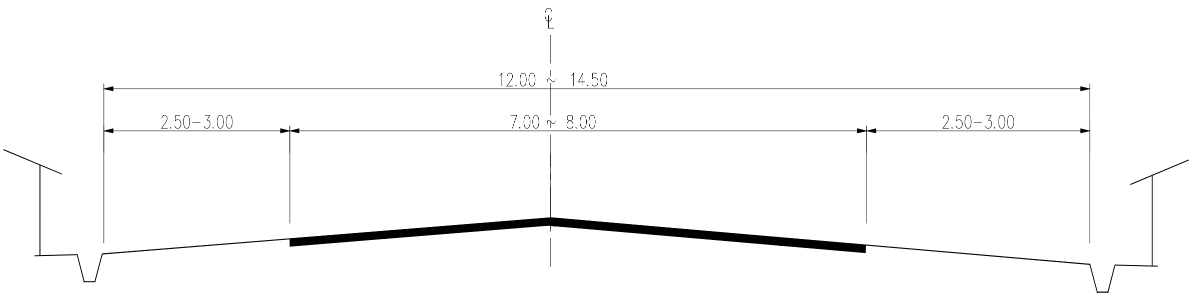
Roadsides are developed with residential areas and commercial establishments which are mostly semi-permanent stores selling vegetables. Some vegetable stalls are built within the road right-of-way.

4.3.4 Road Network

The Bandung – Nagreg – Malangbong section constitutes a part of important inland road network. The road is the only major road providing important access to the inland area.

4.3.5 Existing Road Condition

The existing road in the Flyover section is a 2-lane road with the asphalt concrete pavement for the carriageway and gravel for shoulders.



TYPICAL CROSS SECTION OF EXISTING ROAD

AC Pavement condition is fair. Open channel side ditches are provided at Bandung side. Flat section after the railway is provided with covered channel ditches.

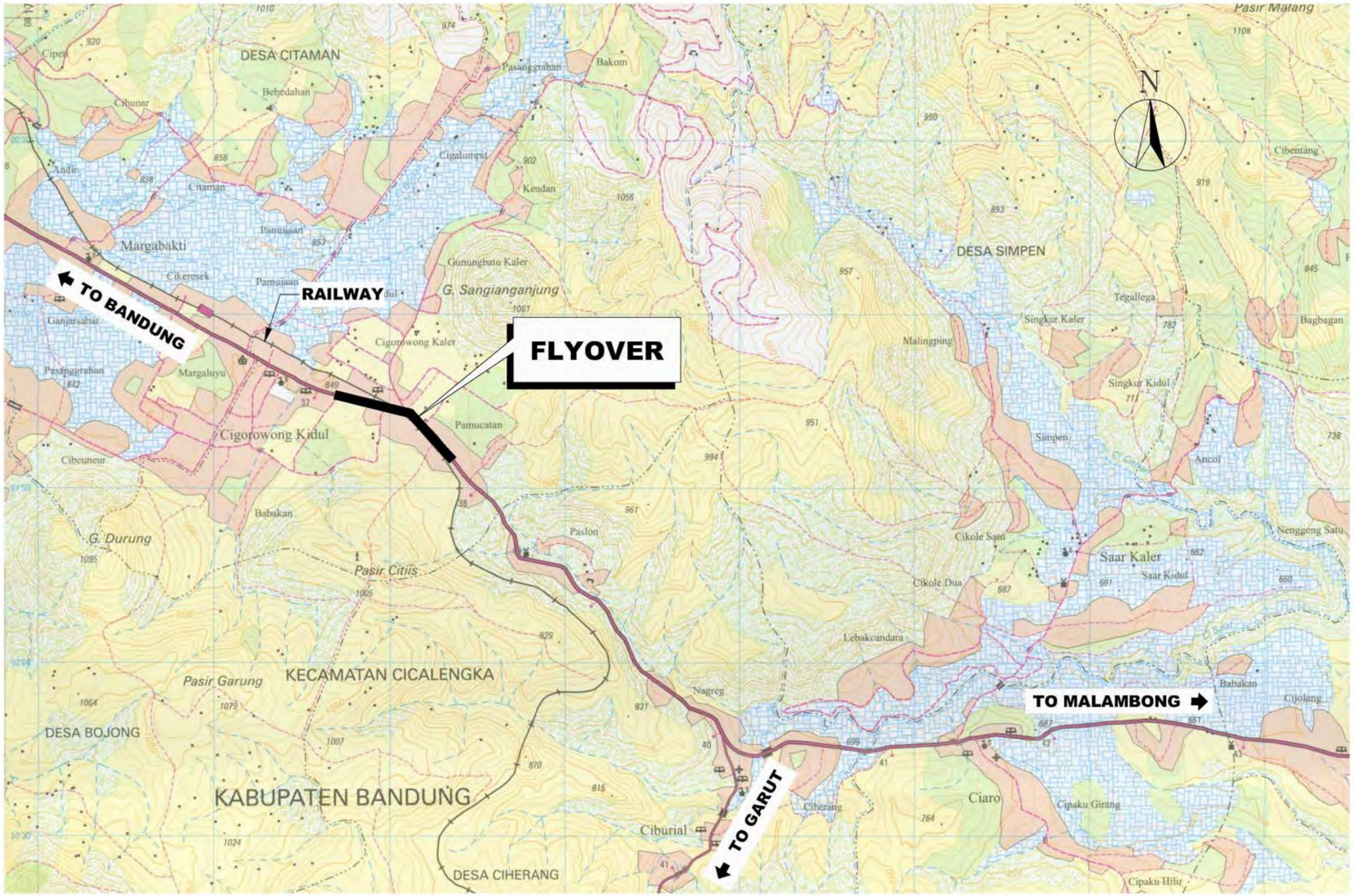


FIGURE 4.3.1-1 LOCATION OF NAGREG FLYOVER

4.3.6 Physical Constraints and Major Control Points

1) Road Right-of-way (ROW)

Based on the SAPROF Study, new ROW to accommodate a flyover was presented to local communities during the public hearing and negotiation with affected people is being undertaken. New ROW limits are shown in Figure 4.3.6-1 and ROW width ranges from 29.1 m (standard) to 18 m. From the beginning of a flyover to the railway, land area of right side of the existing road is planned to be acquired wider than the left side. After the railway, more land area at the left side is to be acquired than the left side.

The flyover had to be designed within the new ROW, thus nose location was more or less determined.

2) Public Utilities

Most critical public utility is the oil pipe line. There are two oil pipe lines, one at the right side (D = 40cm) and the other at the left side (D = 25cm) of the road. These oil pipe lines will be located under the approach embankment section, therefore, relocation or protection of pipe lines will be required.

Initial discussion with PERTAMINA was made whether to protect or relocate the oil pipe lines. PERTAMINA informed that the relocation is technically possible.

Another underground utility is telecommunication cable (1 cable with the diameter of 4cm) at the left side of the road.

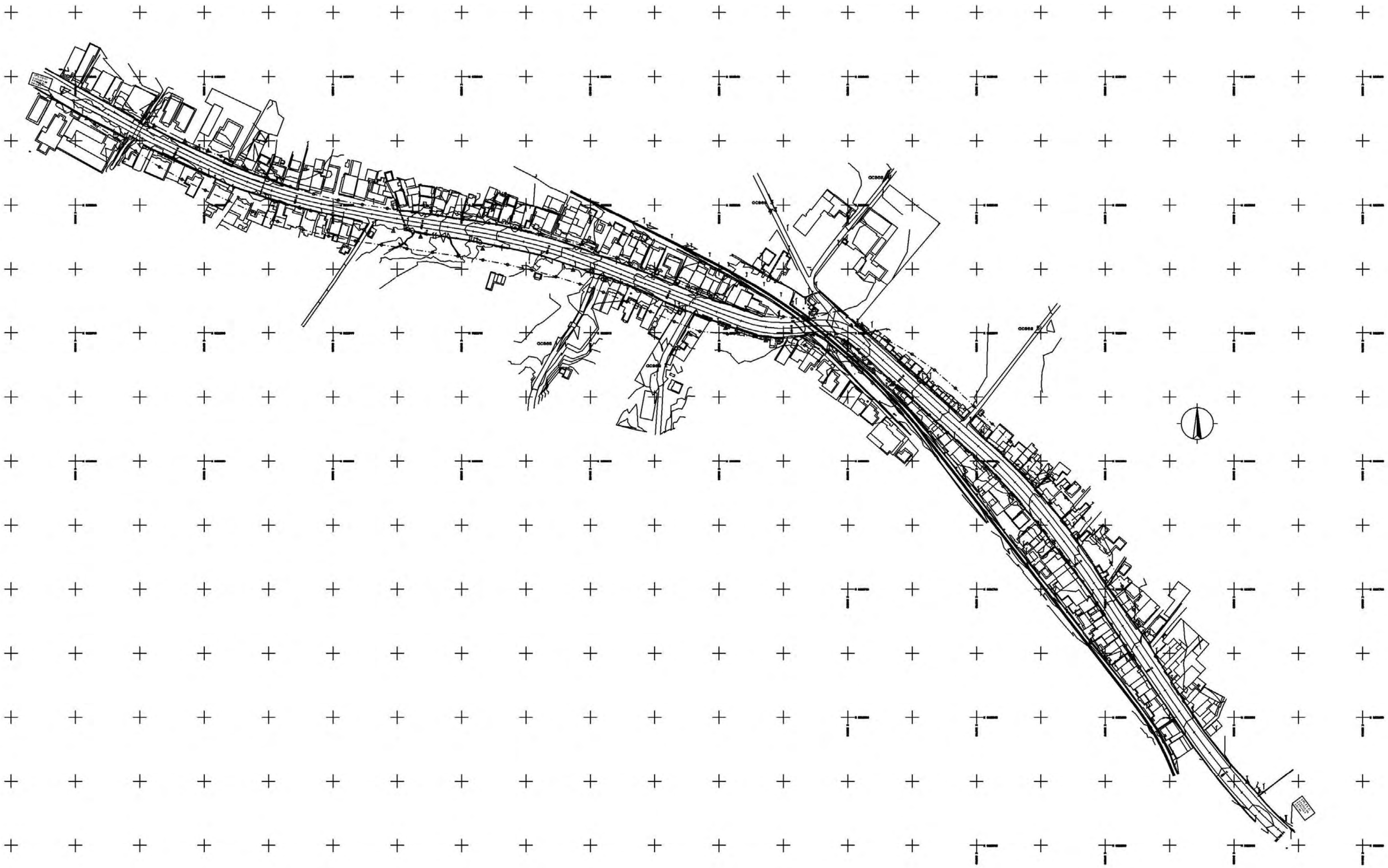


FIGURE 4.3.6-1 R.O.W ACQUIRED

4.4 GEBANG FLYOVER

4.4.1 Topography

The location of Gebang Flyover is shown in **Figure 4.4.1-1**. The Flyover is located at the flat area along the coast of Java Sea. Distances from the coast to the Flyover is about 1 km. There is one river crossing the road. The width of the river is about 30m at the Flyover site.

4.4.2 Soil Condition

Soil conditions consist of up to 6m of medium stiff to stiff silty clays and medium dense sands overlying 10m thickness of soft to very soft silty clays. Hard clays and dense sands were encountered at depth. The hard layer having N value > 50 at this site is in a relatively horizontal plane occurring typically 28m below the existing ground surface. Very dense sands predominate at this depth. The very soft clays (N values between 0 and 2) occur in a layer generally 2 to 6m thick at depths below 8m. Maximum borehole depth at this site was 64m

4.4.3 Land Use

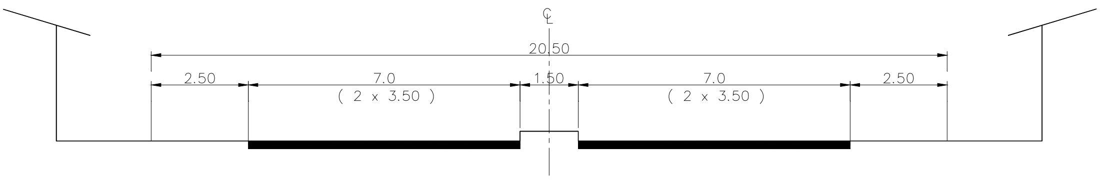
The roadsides have been developed with residential houses and commercial establishments. The market is located on the right side at about 140 m from the river. Many fishing boats are moored at the river. So many vendors open temporary stores along the road selling fishes, frits and others things. They usually occupy a part of the carriageway, obstructing traffic.

4.4.4 Road Network

The Cirebon - Nagreg - Losari road is a part of the North Java Corridor. There is no other major road except this road in this area. Traffic to/from Jakarta from/to Cirebon, Semarang and Surabaya is served by this road.

4.4.5 Existing Road Condition

The existing road is a 4-lane divided road with the asphalt concrete pavement. Typical cross section of existing road is shown below.



TYPICAL CROSS SECTION OF EXISTING ROAD

Existing pavement condition is good to fair.

FIGURE 4.4.1-1 LOCATION OF GEBANG FLYOVER

4.4.6 Physical Constraints and Major Control Points

1) Road Right-of-way (ROW)

Based on the SAPROF Study, new ROW to accommodate a flyover has already been acquired. New ROW limit is shown in Figure 4.4.6-1. Since the flyover is planned to be constructed by stages, 2-way 1-direction flyover is to be built under this project, thus, new ROW has been acquired at the right side of the road (or Cirebon bound direction). New ROW varies from 16.0 m to 13.3 m from the centerline of the existing road.

2) Public Utility

No critical underground public utilities were found.

Existing underground utilities are as follows:

Right side : Telecommunication (1-cable D = 4cm)
Left side : Water pipe line (D = 10cm)
Telecommunication (1-cable, D = 4cm)

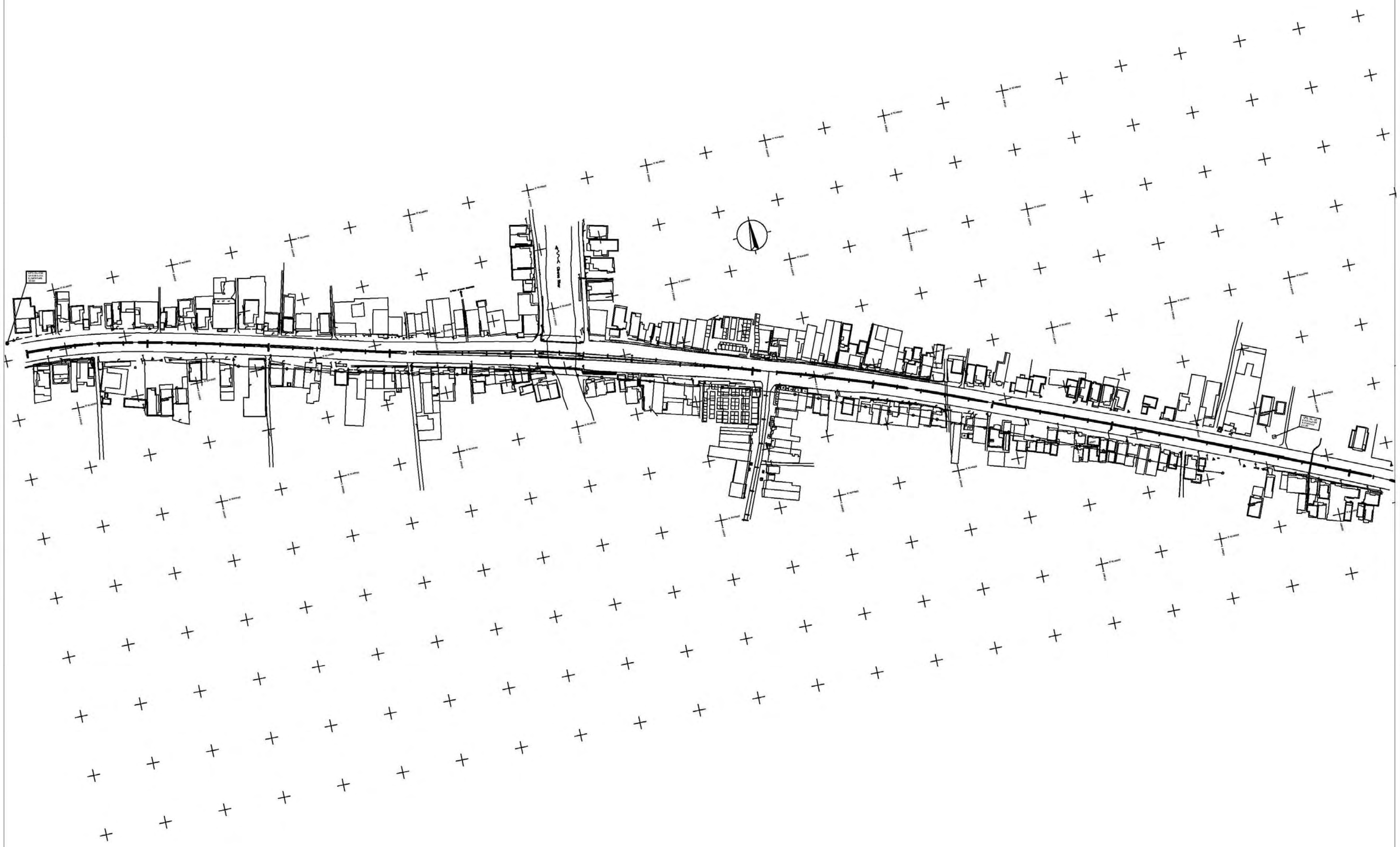


FIGURE 4.4.6-1 R.O.W ACQUIRED

4.5 PETERONGAN FLYOVER

4.5.1 Topography

The location of Peterongan Flyover is shown in **Figure 4.5.1-1**. The Flyover is located at the very flat area. There is a small river (about 10m in width) at the end side of the flyover (Mojokerto side).

4.5.2 Soil Condition

Soil conditions comprise both silty clays and sands of variable consistency overlying hard clays and dense sands. The hard layer having N value > 50 at this site is in a relatively horizontal plane occurring typically between 14m to 16m below the existing ground surface. Very dense sands predominate at this depth inter bedded with hard clays. The upper layers comprise soft clay at the surface with medium stiff and medium dense sands occurring beneath. Loose sands with thickness of about 2m were encountered at depths of 2 to 4m at two (2) adjacent boreholes. Maximum borehole depth at this site was 30m.

4.5.3 Land Use

Roadsides are mostly residential houses with some small commercial establishments. After the small river, there is a market at the right side of the road.

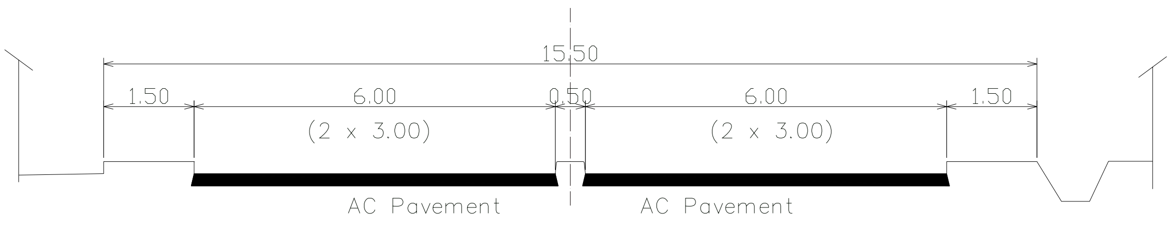
4.5.4 Road Network

Mojokerto – Peterongan – Jombang Road forms an important inland road network connecting Surabaya with inland cities such as Madiun, Kediri, etc. The road is functioning as a major road serving the inland area.

There is a plan to construct a toll road (Mojokerto – Kertosono Toll Road) which runs almost parallel to this road.

4.5.5 Existing Road Condition

The existing road is a 4-lane divided road with the asphalt concrete pavement for the carriageway. Typical cross section of the existing road is shown below.



TYPICAL CROSS SECTION : JOMBANG SIDE

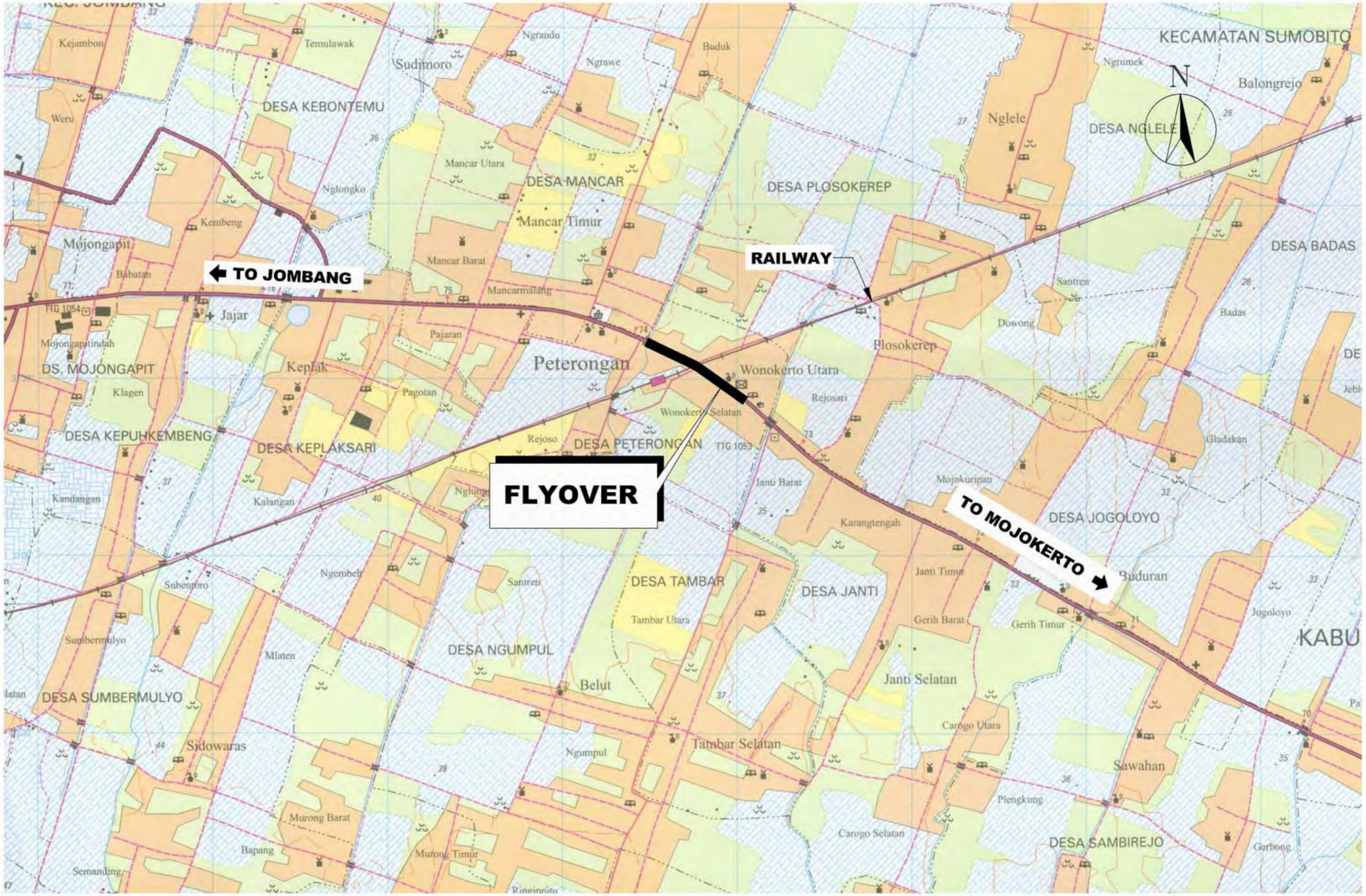
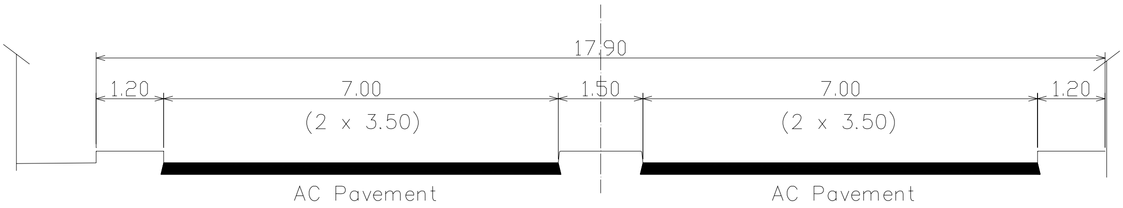


FIGURE 4.5.1-1 LOCATION OF PETERONGAN FLYOVER



TYPICAL CROSS SECTION : MOJOKERTO SIDE

AC Pavement condition is fair at Jombang side and good at Mojokerto side. The area is flat, therefore, large side ditches are provided.

4.5.6 Physical Constraints and Major Control Points

1) Road Right-of-way (ROW)

Actions to acquire ROW are not made yet. New ROW is to be determined by this study. Roadside development conditions are almost same throughout the flyover section. Thus, the centerline of the flyover is to be determined following the existing road centerline.

2) Public Utility

Existing underground public utilities are as follows:

Right side	:	Water pipe lines (2 lines, D = 15cm and 30cm)
		Telecommunication (1 cable, D = 4cm)
Left side	:	Water pipe line (1 line, D = 10cm)
		Electrical Cable (4 lines, D = 4cm)
		Telecommunication (2 lines, D = 4cm)

4.6 TANGGULANGIN FLYOVER

4.6.1 Topography

The location of Tanggulangin Flyover is shown in **Figure 4.6.1-1**. The Flyover is located at flat coastal plain.

4.6.2 Soil Condition

Soil conditions comprise medium stiff silty clays at shallow depth overlying soft to very soft clays encountered to a depth of between 30 to 32m. Medium stiff clays were encountered below the soft soil layer with hard bearing strata located at between 44m and 60m depth. The hard layer with N > 50m generally consists of very dense sands interbedded with clay layers. The very soft clay soils in the upper layer typically extend to a depth of approximately 20m. In addition loose to very loose sands of varying thickness were also encountered at four (4) boreholes at depths ranging from 4m to 14m. Maximum borehole depth at this site was 64m.

4.6.3 Land Use

Roadsides have been developed with residential area and small sized commercial establishments. At Pasuruan side, the road runs almost parallel to the railway and right side of the road is faced with the railway right-of-way. At Surabaya side, left side of the road is faced with the railway right-of-way.

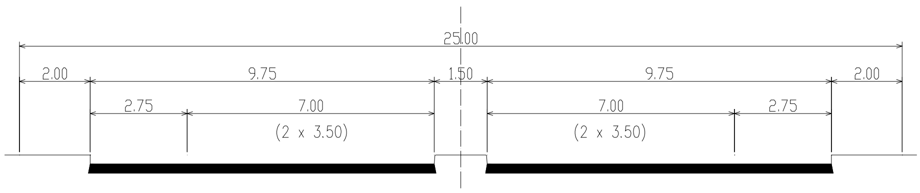
4.6.4 Road Network

Surabaya – Tanggulangin – Pasuruan road runs along the east coast of Java Island, then it runs along the northern coast up to the eastern end of Java Island.

Surabaya – Gempol Toll Road runs almost parallel to this road and crosses the road at about 1.5 km south of the Flyover location.

4.6.5 Existing Road Condition

The existing road is a 4-lane divided road with the asphalt concrete pavement for the carriageway. Typical cross section of the existing road is shown below.



TYPICAL CROSS SECTION OF EXISTING ROAD

Pavement condition is good to fair. Urban type of drainage facility (or covered side ditches) are provided.

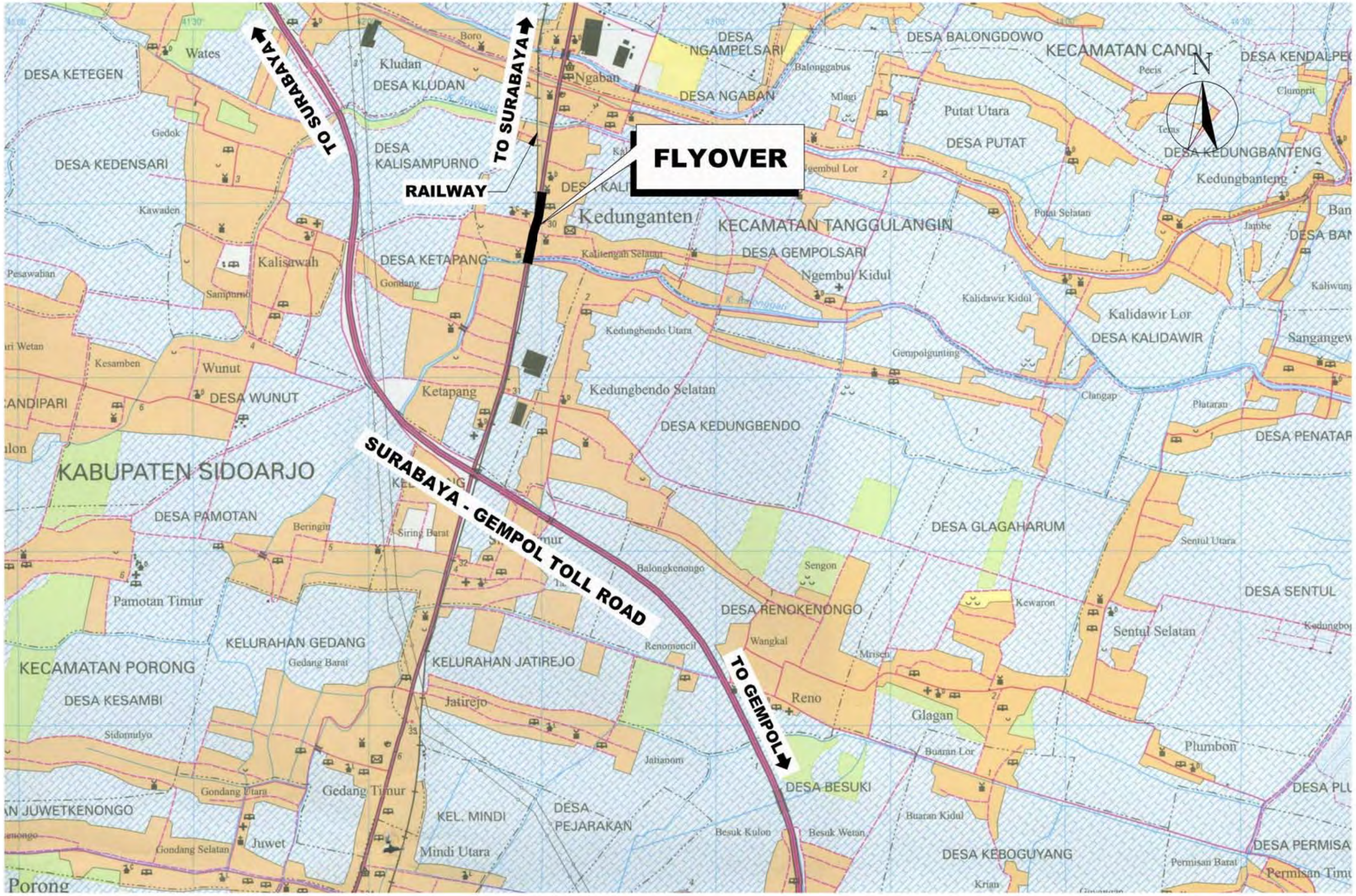


FIGURE 4.6.1-1 LOCATION OF TANGGULANGIN FLYOVER

4.6.6 Physical Constraints and Major Control Points

1) Road Right-of-Way (ROW)

Actions to acquire ROW are not made yet. New ROW is to be determined by this study. In determining new ROW, the following are the control points:

Pasuruan Side	:	The railway right-of-way shall not be encroached to maintain 10m horizontal clearance from the existing rail.
Subaraya Side	:	The right-of-way acquisition at the right side of a flyover shall be minimized.

2) Public Utility

Following underground utilities are found:

Right side	:	Water pipe lines D = (45cm and 7.5cm) Telecommunication (1 cable, D = 4cm)
Left side	:	Water pipe line (D = 45cm and D = 5cm)

Chapter 5

TRAFFIC SURVEYS AND ENGINEERING SURVEYS UNDERTAKEN

5.1 TRAFFIC SURVEYS

Traffic surveys as shown in **Table 5.1-1** were undertaken at each flyover location. Traffic surveys conducted on typical weekdays during November and December 2005.

TABLE 5.1-1 TRAFFIC SURVEYS UNDERTAKEN

Flyover	Type of Traffic Surveys (2 consecutive days)				
	1) 24-hour Traffic Count	2) 14-hour Roadside OD Survey	3) 14-hour Intersection Traffic Count	4) Travel Speed Survey	5) Vehicle Queue Length Survey
Merak	2 stations	2 stations	2 Intersections	2 Directions	2 Directions
Balaraja	2 stations	2 stations	1 Intersection	2 Directions	-
Nagreg	2 stations	2 stations	1 Intersection	2 Directions	2 Directions
Gebang	2 stations	2 stations	1 Intersection	2 Directions	-
Peterongan	2 stations	2 stations	2 Intersections	2 Directions	2 Directions
Tanggulangin	2 stations	2 stations	1 Intersection	2 Directions	2 Directions
Total	12 stations	12 stations	8 Intersections	12 Directions	8 Directions

At the Balaraja Flyover location, additional traffic surveys were undertaken as follows:

- U-turn traffic count survey (2 locations for 2 days)
- OD Survey of U-turn traffic (1 day)

5.2 TOPOGRAPHIC SURVEYS AND PUBLIC UTILITY SURVEY

Topographic surveys and public utility survey were undertaken for each flyover location. Area of survey covered for each flyover is shown in **Table 5.2-1**.

TABLE 5.2-1 AREA OF SURVEY

Flyover Location		Length (m)	Width (m)	Area (m^2)
Topo Surveys & Public Utility Survey	Merak	1,920	Minimum = 50m Average = 60m	107,600
	Balaraja	1,020		61,200
	Nagreg	1,160		69,600
	Gebang	1,140		68,400
	Peterongan	950		57,000
	Tanggulangin	1,130		67,800
	Total	**7,320**	**-**	**431,600**
River Survey	Gebang	7,000		

Types of surveys undertaken are shown in **Table 5.2-2**.

TABLE 5.2-2 TYPES OF SURVEYS UNDERTAKEN

	Type of Survey
Road Survey	• Horizontal control station survey (GPS and traverse survey) • Vertical control survey (establishment of Bench Mark) • Existing road centerline survey and staking out of the centerline • Profile survey along the centerline • Cross section survey • Topographic survey
Structure Survey	• Location survey of all structures • Number of stories and type of material
Public Utility Survey	• Location of overhead utilities • Trial digging for underground utilities • Collection of as-built drawings • Office address, person-in-charge, telephone number of public utility agency

5.3 GEO-TECHNICAL SURVEY

Geo-technical survey is summarized in **Table 5.3-1**.

TABLE 5.3-1 GEO-TECHNICAL SURVEY UNDERTAKEN

Geo-technical Survey		Flyover Location						
		Merak	Balaraja	Nagreg	Gebang	Pete-rongan	Tang-gulangin	Total
Boring	No. of Boreholes	22	14	16	19	14	11	96
	Drilling length	617	280	528	655	314	543	2,937
Sampling	Disturbed	75	32	50	68	48	39	312
	Undisturbed	14	4	8	9	8	10	53
Standard Penetration Test		304	137	260	323	154	267	1,445
Laboratory Test	Water Content	89	36	58	77	56	49	365
	Specific Gravity	89	36	58	77	56	49	365
	Sieve Analysis	89	36	58	77	56	49	365
	Unit Weight	89	36	58	77	56	49	365
	Consistency	89	36	58	77	56	49	365
	Consolidation Test	32	12	24	27	24	30	149
	Direct Shear Test	32	12	24	27	24	30	149
	Unconfined Compression Test	32	12	24	27	24	30	149
Cone Penetration	2,5 t (30 m)	-	-	-	4	-	4	8
	10 t (60 m)	-	-	-	2	-	2	4
Soil Test for Pavement Design including Test Pitting		8	4	4	4	4	4	28

5.4 METEOROLOGICAL AND HYDROLOGICAL DATA COLLECTION

Following data were collected from the Meteorology and Geophysics Agency:

- Daily rainfall data from 1980
- Monthly rainfall data from 1980
- Duration – Rainfall Intensity relation for various return periods

CHAPTER 6

TRAFFIC CONDITIONS AND PROBLEMS

6.1 PRESENT TRAFFIC CONDITION

6.1.1 Daily Traffic Volume

Traffic survey results are summarized in **Table 6.1.1-1**. Daily traffic volume including intersection traffic is graphically shown in **Figure 6.1.1-1**. Hourly variation of traffic volume is shown in **Figure 6.1.1-2**. It is noted that night time traffic at Gebang is quite high. Peak hour ratio ranges 6.1% to 10.5%

6.1.2 Travel Speed

Travel speeds at a flyover section and its adjacent areas are shown in **Table 6.1.1-1.**

6.1.3 Traffic Characteristics (Through and Local Traffic)

Based on the OD survey results, through traffic and local traffic were segregated and shown in **Table 6.1.1-1**.

	Merak	Balaraja	Nagreg	Gebang	Peterongan	Tanggulangin
Through Traffic Ration	70%	37~43%	62~64%	68%	69~73%	62~64%

6.1.4 Traffic Queue During Train Passing

Number of train passing, maximum and average traffic queue length are shown in **Table 6.1.1-1**.

TABLE 6.1.1-1 SUMMARY OF TRAFFIC SURVEY RESULTS

		Daily Traffic Volume (4-wheel or more) (Both Direction)							Peak Hour Ratio (%) (By Direction)	Daily Traffic Volume (3 wheels or less) (Both Direction)	Traffic Characteristics By Direction				Travel Speed (km/hr)						Railway Crossing		
											Through Traffic	Local Traffic			Morning		Day time		Evening		No. of Train Passing	Queue Length (m)	
		Car Jeep	Pick-up	Mini Bus (oplet)	Medium Bus	Large Bus	Truck Trailer	Total				4-wheels or more	3-wheels or less	Total	Flyover Section	Outside F.O. Section	Flyover Section	Outside F.O. Section	Flyover Section	Outside F.O. Section		Max	Average
Merak	Pulorida side (or from Pulorida)	1,306 (22%)	729 (12%)	2,016 (34%)	180 (3%)	101 (2%)	1,563 (27%)	5,895 (100%)	10.5	5,163	2,080 (70%)	878 (30%)	2,789	3,667	19.9	35.9	20.1	35.4	19.6	35.8	6	115	58
	Cilegon (or from Cilegon)	4,558 (24%)	1,633 (9%)	5,888 (31%)	581 (3%)	1,958 (10%)	4,410 (23%)	19,028 (100%)	6.4	12,109	2,344 (70%)	993 (30%)	2,357	3,350	19.1	34.4	20.8	35.9	20.7	36.7		80	48
Balaraja	Selang side (or from Selang)	2,083 (14%)	1,552 (10%)	8,443 (56%)	355 (2%)	523 (3%)	2,112 (14%)	15,068 (100%)	8.1	22,859	3,360 (43%)	4,490 (57%)	11,731	16,221	6.1	33.4	7.3	7.0	9.8	9.5			
	Tangerang side (or from Tangerang)	2,091 (18%)	1,591 (14%)	4,527 (40%)	466 (4%)	523 (5%)	2,240 (20%)	11,438 (100%)	9.7	18,900	2,100 (37%)	3,640 (63%)	11,129	14,769	4.8	24.2	4.8	29.4	9.8	33.4			
Nagreg	Bandung side (or from Bandung)	7,487 (39%)	2,879 (15%)	3,481 (18%)	88 (0%)	1,362 (7%)	3,688 (19%)	18,985 (100%)	7.4	8,895	5,920 (62%)	3,660 (38%)	4,307	7,967	23.9	49.0	29.1	56.6	23.9	49.9	18	430	258
	Malangbong (or from Malangbong)	5,765 (37%)	2,752 (18%)	1,755 (11%)	839 (5%)	1,295 (8%)	3,304 (21%)	15,710 (100%)	8.5	9,237	5,310 (64%)	2,950 (36%)	4,588	7,538	28.8	39.5	31.2	50.5	30.9	37.6		200	121
Gebang	Cirebon side (or from Cirebon)	4,636 (23%)	1,619 (8%)	1,823 (9%)	62 (0%)	2,923 (14%)	9,137 (45%)	20,200 (100%)	6.1	9,296	0	9,840 (100%)	3,471	13,311	22.9	44.9	24.8	43.7	28.6	43.9			
	Losari side (or from Losari)	3,466 (18%)	2,992 (15%)	1,394 (7%)	108 (1%)	3,468 (18%)	8,145 (42%)	19,573 (100%)	7.6	4,995	7,240 (68%)	3,400 (32%)	3,806	7,206	23.7	44.9	23.9	43.8	27.1	44.2			
Peterongan	Jombang side (or from Jombang)	5,686 (37%)	2,213 (14%)	867 (6%)	68 (0%)	1,356 (9%)	5,339 (34%)	15,529 (100%)	7.8	18,533	5,370 (69%)	2,360 (31%)	8,827	11,187	29.9	46.5	27.2	50.4	27.4	48.7	31	270	80
	Mojokerto side (or from Mojokerto)	6,568 (39%)	2,527 (15%)	1,059 (6%)	152 (1%)	1,332 (8%)	5,270 (31%)	16,908 (100%)	7.8	18,433	6,250 (73%)	2,330 (27%)	9,607	11,937	27.2	53.8	21.7	53.0	29.3	50.7		300	162
Tanggulangin	Porong side (or from Porong)	5,622 (36%)	2,578 (16%)	3,724 (24%)	30 (0%)	25 (0%)	3,706 (24%)	15,685 (100%)	7.1	50,692	5,060 (62%)	3,060 (38%)	34,999	38,059	60.0	62.5	52.5	60.6	54.8	59.0	28	110	42
	Sidoarjo side (or from Sidoarjo)	5,679 (36%)	2,753 (17%)	3,802 (24%)	54 (0%)	25 (0%)	3,656 (23%)	15,969 (100%)	8.5	55,783	4,900 (64%)	2,750 (36%)	28,385	31,135	48.5	57.3	43.4	60.2	49.4	59.3		160	56

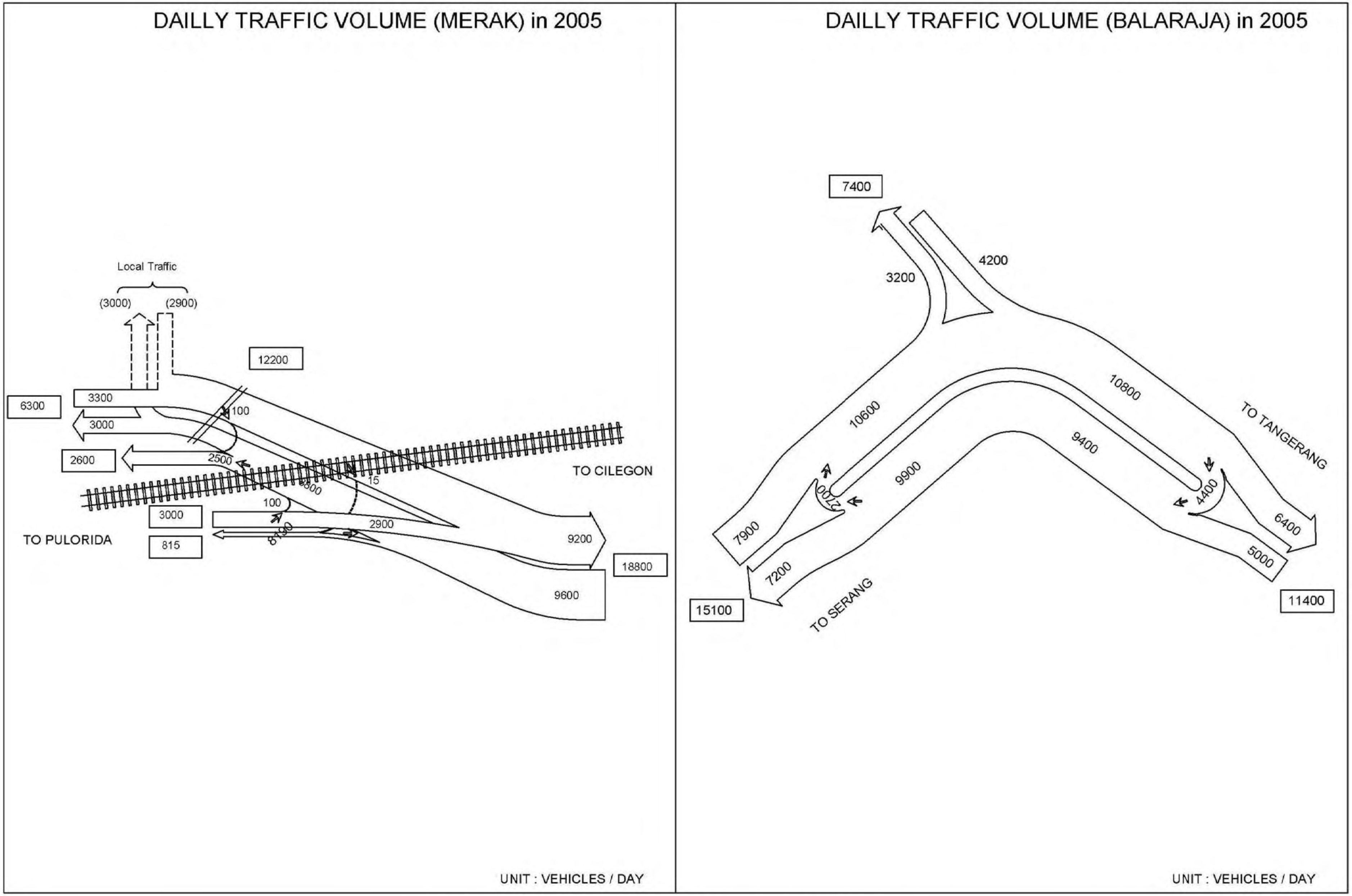


FIGURE 6.1.1-1 (1/3) DAILLY TRAFFIC VOLUME

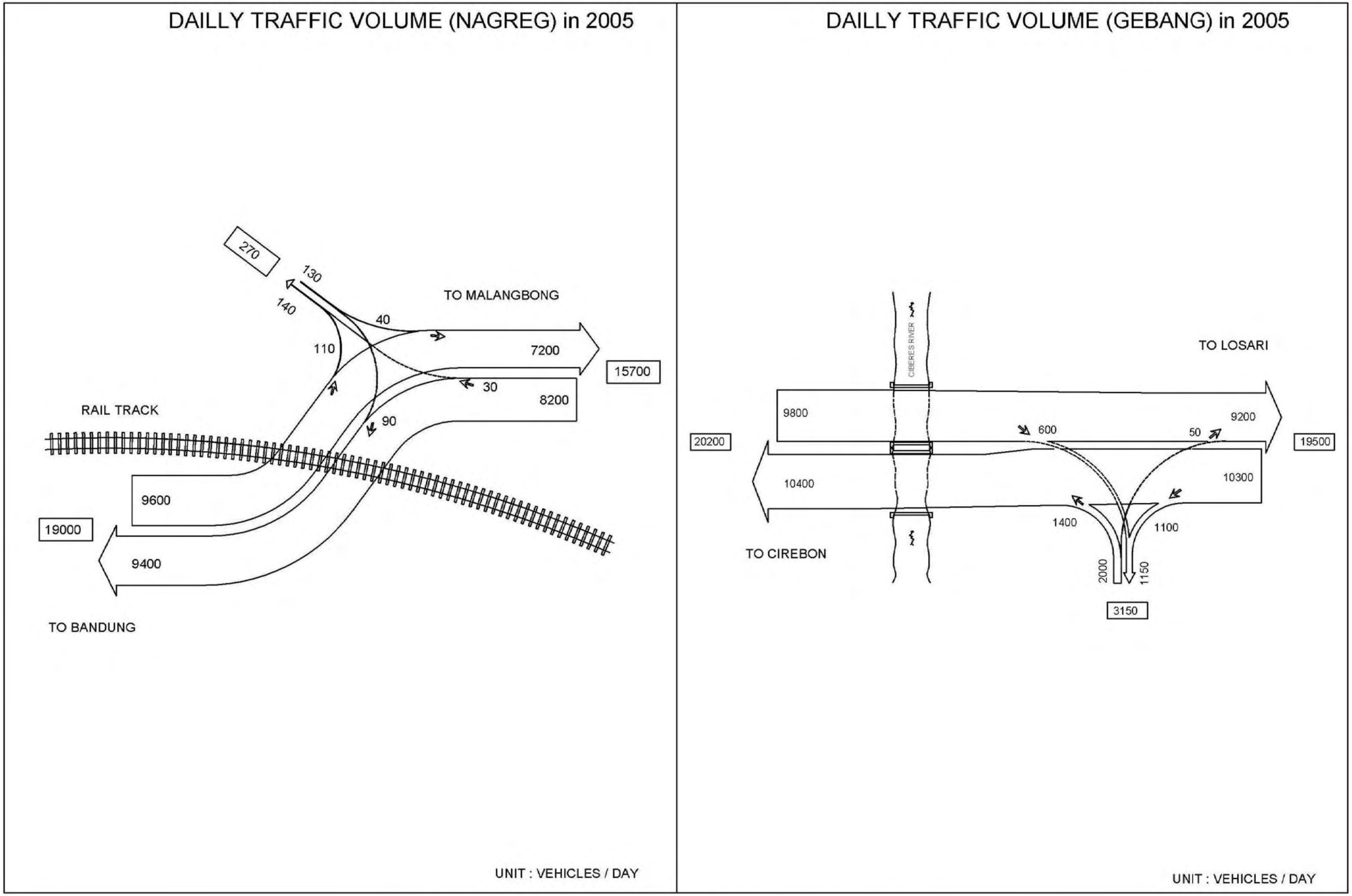


FIGURE 6.1.1-1 (2/3) DAILLY TRAFFIC VOLUME

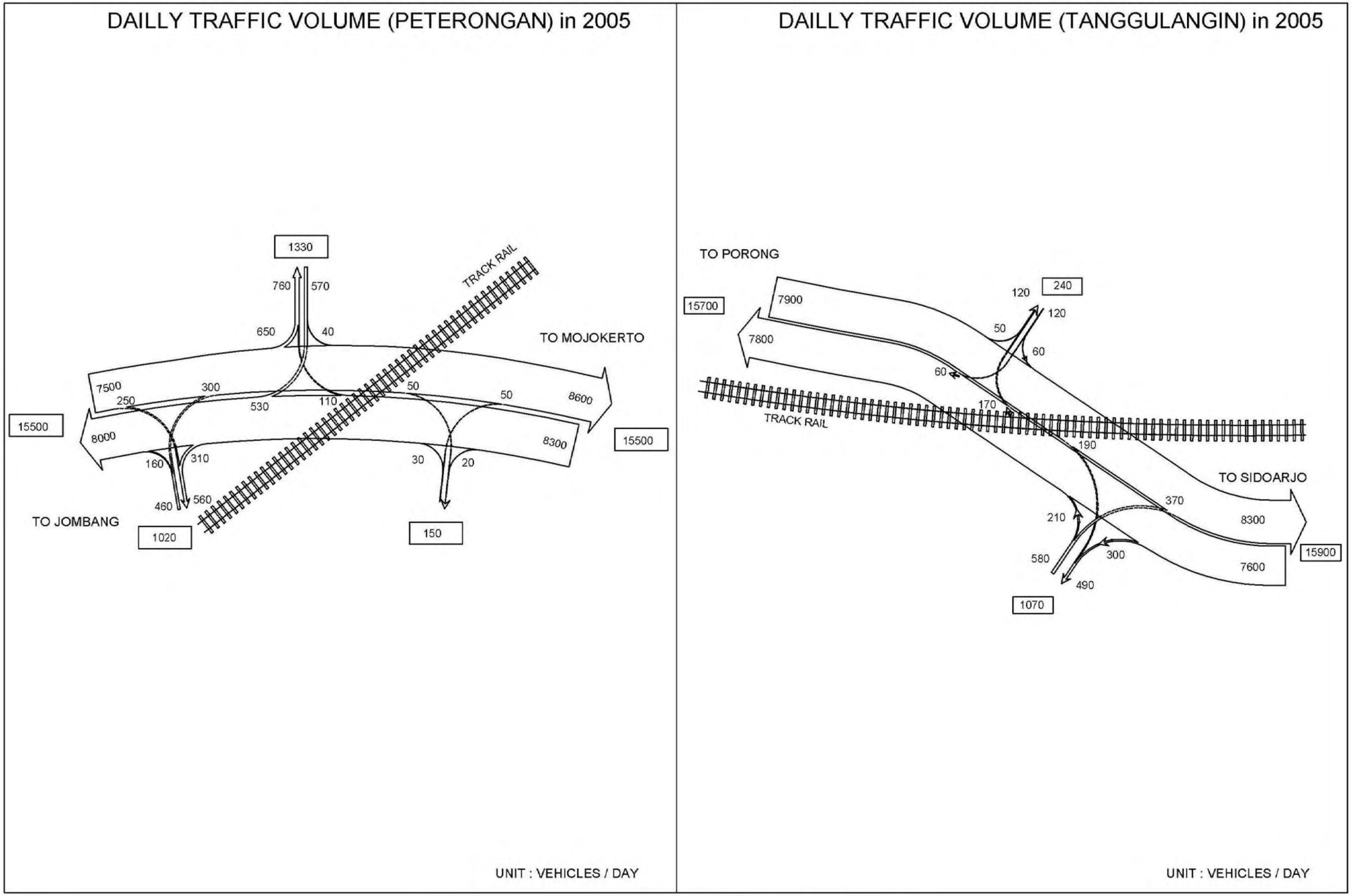
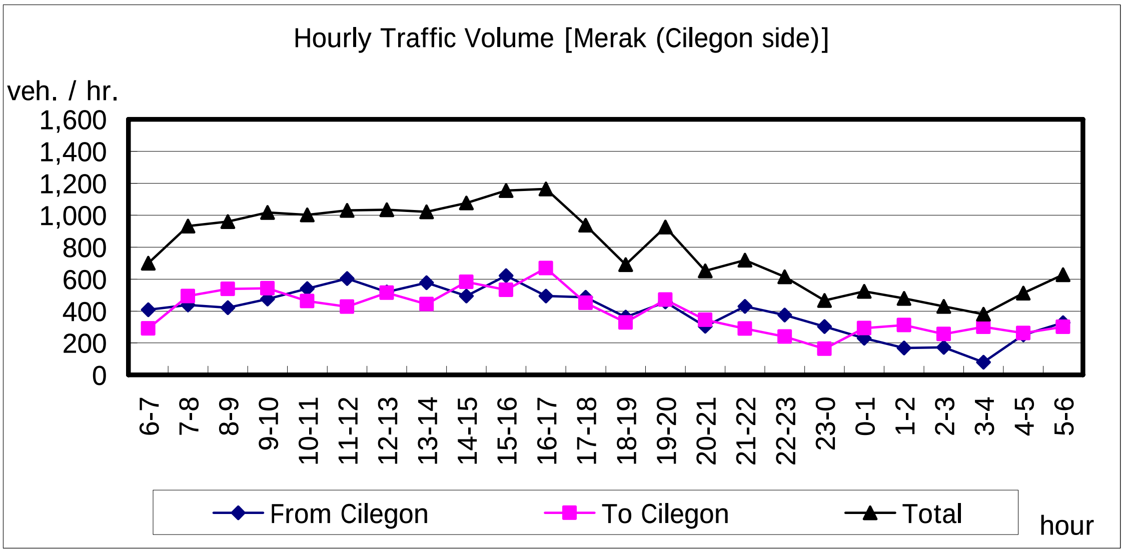
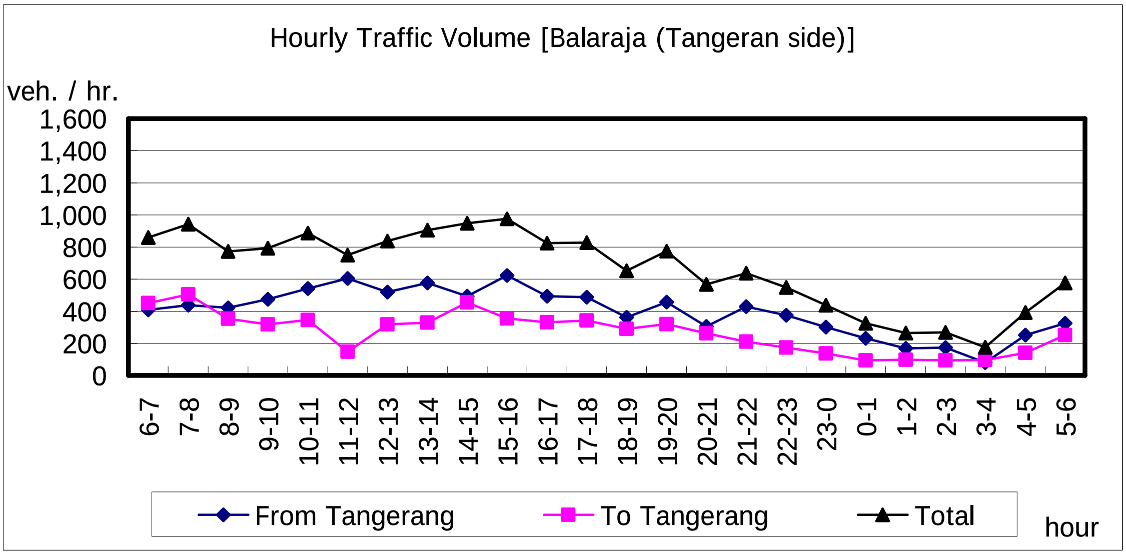


FIGURE 6.1.1-1 (3/3) DAILLY TRAFFIC VOLUME





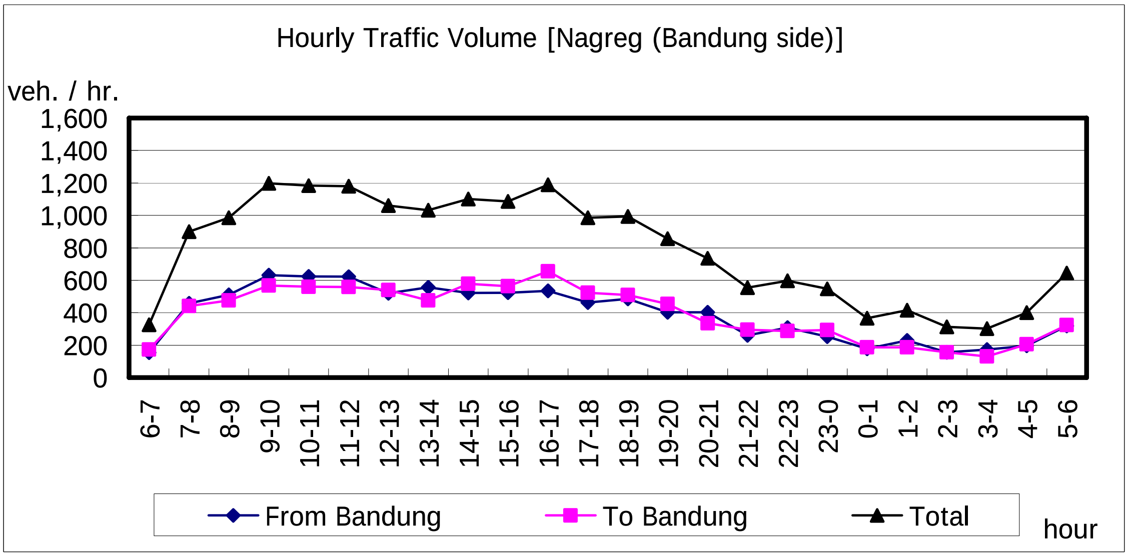
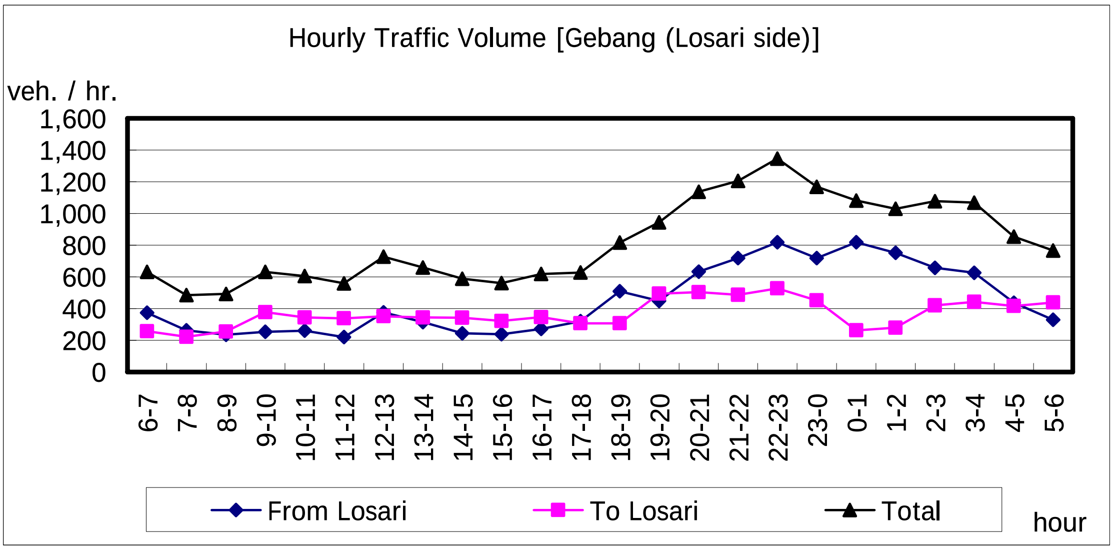
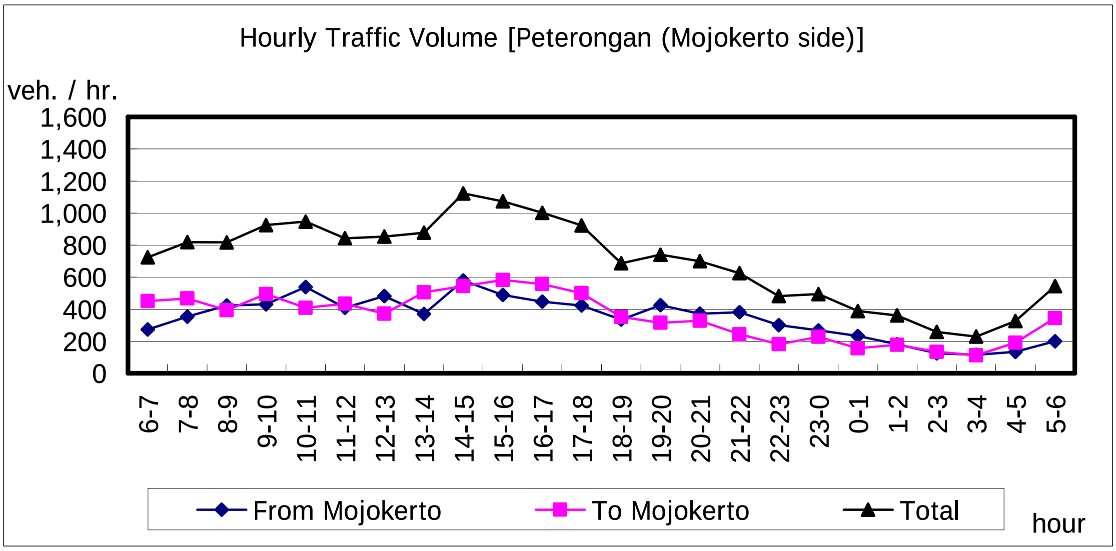


FIGURE 6.1.1-2 (1/2) HOURLY VARIATION OF TRAFFIC





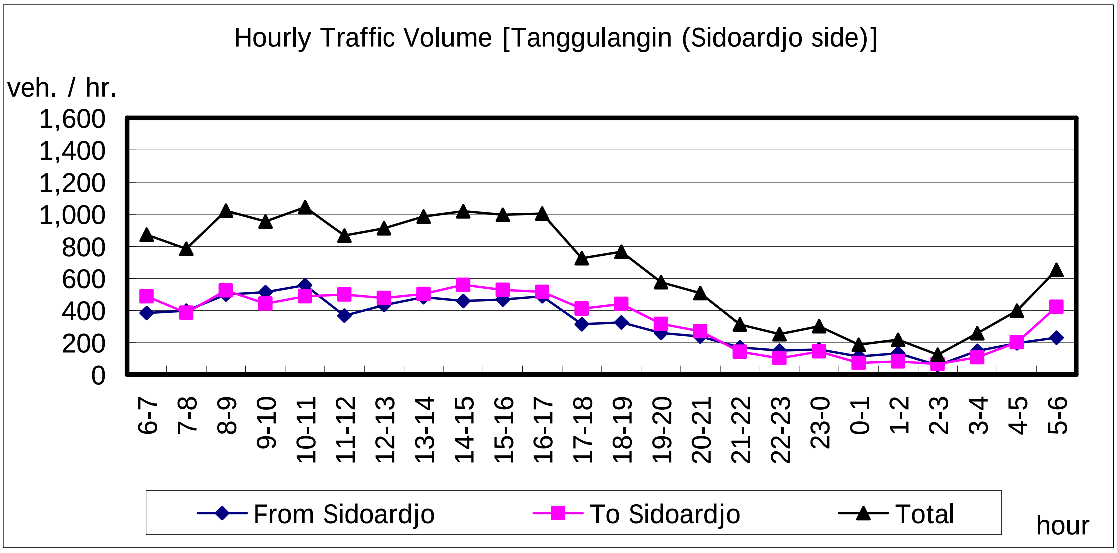


FIGURE 6.1.1-2 (2/2) HOURLY VARIATION OF TRAFFIC

6.2 TRAFFIC PROBLEMS

Existing traffic problems at each flyover location are summarized hereunder.

6.2.1 Merak Flyover

- Heavy roadside friction due to roadside business activities including illegal stalls/vendors within the road right-of-way, particularly at the opposite side of Ferry Terminal Waiting Area, causing traffic congestion and disturbing traffic flow.
- Illegal parking of a lot of mini-taxis waiting for passengers within the carriageway of the national road.
- Traffic congestion at the intersection at the exit of the Ferry Terminal. Traffic from the exit of Ferry Terminal concentrates at the intersection soon after a ferry boat arrives and conflicts with the traffic on the national road. The intersection is not channelized, either signalized, which aggravates traffic congestion.
- Traffic queue is formed at the railway crossing during train passing (maximum queue length is 115m at Pulorida side).
- Due to above conditions, travel speed of this section is reduced to 19.5km/hour from 35km/hour of adjacent section.

6.2.2 Balaraja Flyover

- Heavy local traffic concentrates at this section.
- Heavy roadside friction due to roadside business activities.
- At the intersection between the national road and the intersecting road going to Kresek, right turn from the intersecting road to the national road is prohibited (or closed). Right turn traffic utilizes U-turn slot along the national road where traffic on the national road is heavily disturbed.
- There is another U-turn slot along the national road where a turning radius is small, thus buses and tracks can not make smooth U-turn which is severely affecting traffic on the national road.
- Illegal parking of a lot of mini-buses and mini-taxis waiting for passengers along the national road.
- Due to effects of above problems, travel speed at this section is reduced to 5 to 10 km/hour from 30 to 35 km/hour of the adjacent section.

6.2.3 Nagreg Flyover

- Heavy roadside friction due to vegetable/fruit stands within the road right-of-way.
- Traffic queue is formed at the railway crossing during the train passing (maximum queue length is 430m at Bandung side). Number of train passing is 18 times a day.
- Travel speed of this section is reduced to 24 to 30 km/hour from 40 to 50 km/hour of adjacent section.

6.2.4 Gebang Flyover

- Fishing port is located near the site. There are many stalls/vendors occupying shoulders and sometimes outer carriageway lane, which drastically reducing traffic capacity and disturbing smooth traffic flow.
- Slow moving vehicles and pedestrians/shoppers are also causing heavy roadside friction.
- There is one T-shaped intersection accessing to the public market. Although traffic going to the public market is still light, this intersection will be a traffic bottleneck in near future.
- Due to effects of above conditions, travel speed of this section is reduced to 23 to 27 km/hour from 44 to 45 km/hour of the adjacent section.

6.2.5 Peterongan Flyover

- Due to roadside development and high composition of local traffic, travel speed of this section is reduced to 22 to 30 km/hour from 46 to 54 km/hour of adjacent section.
- Traffic queue is formed at the railway crossing during train passing (maximum queue length is 300m at Mojokerto side). Number of train passing is 31 times per day.

6.2.6 Tanggulangin Flyover

- Due to high composition of local traffic, particularly motor bikes, travel speed is slightly reduced to 43 to 60 km/hour from 57 to 62 km/hour of adjacent section.
- Traffic queue is formed at the railway crossing during train passing (maximum queue length is 160m at the Sidoarjo side). Number of train passing is 28 times per day.

MERAK(PORT EXIT ROAD)

GEBANG

BALARAJA(TRAFFIC CONGETION)

PETERONGAN (NEAR RAILWAY CROSS.)

NAGAREG(NEAR RAILWAY CROSSING)

TANGGULANGIN (RAILWAY CROSSING)

PICTURE 6.2-1 TRAFFIC CONGETION OF EACH LACATION

6.3 FLYOVER TRAFFIC AND AT-GRADE ROAD TRAFFIC

Flyover traffic was estimated on the assumption that through traffic will utilize a flyover and local traffic will utilize at-grade road (or service road) when a flyover construction is completed. Flyover traffic and at-grade traffic are graphically shown in **Figure 6.3-1**.

6.4 FUTURE TRAFFIC VOLUME

Adopting annual traffic growth rate by vehicle type used by the Feasibility Study, future traffic volume was estimated as shown in **Tables 6.4-1** and **2**. Annual traffic growth rate by vehicle type is presented in Chapter 3.

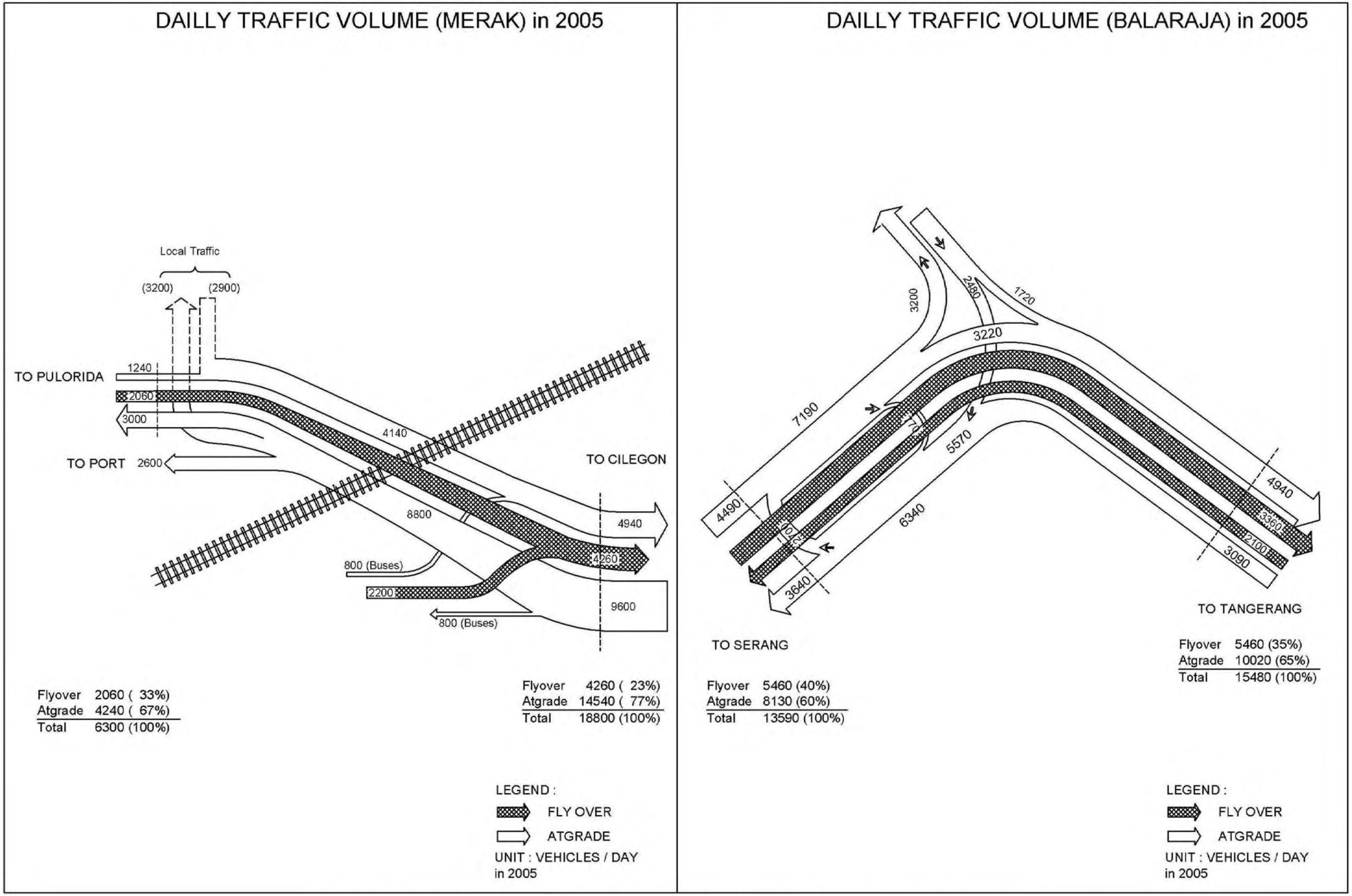
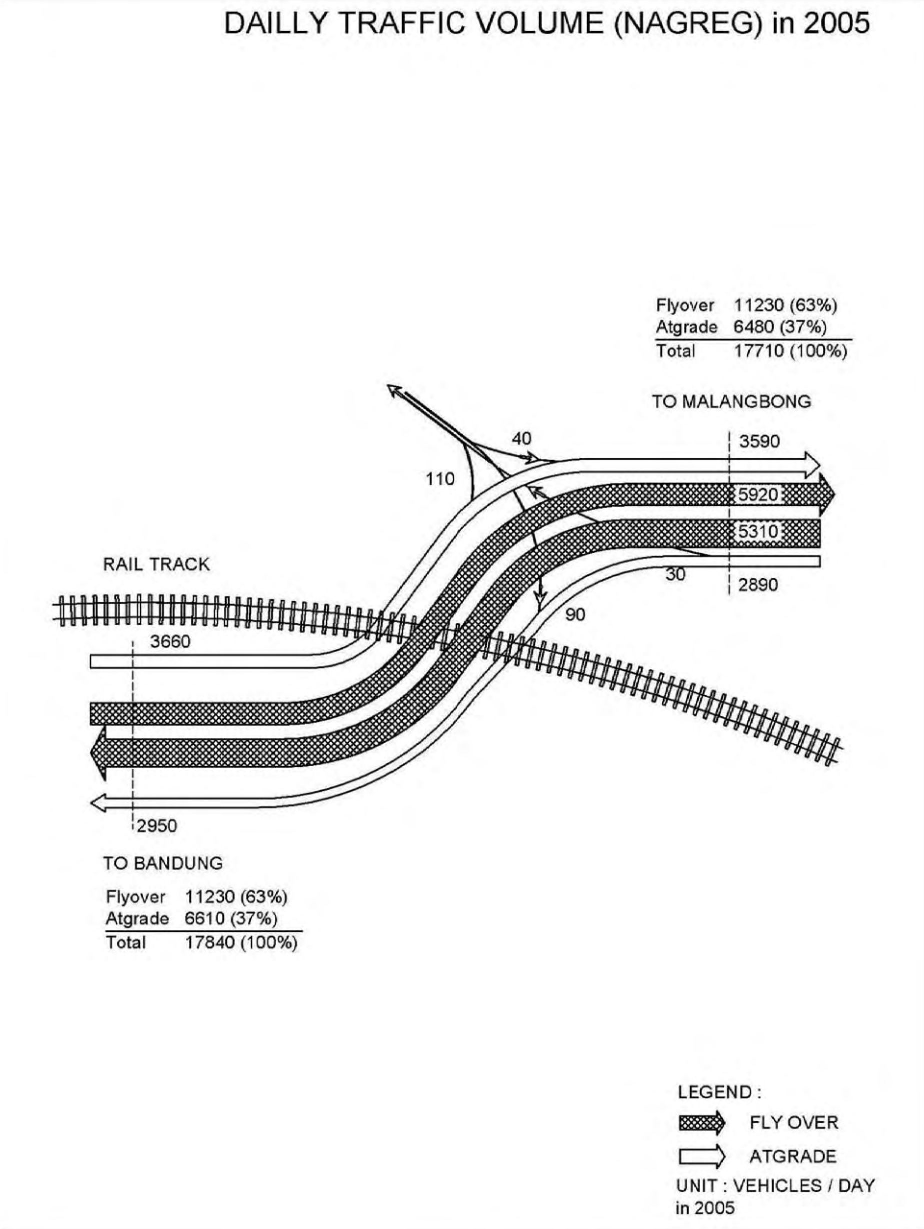


FIGURE 6.3-1 (1/3) FLYOVER TRAFFIC AND AT-GRADE ROAD TRAFFIC



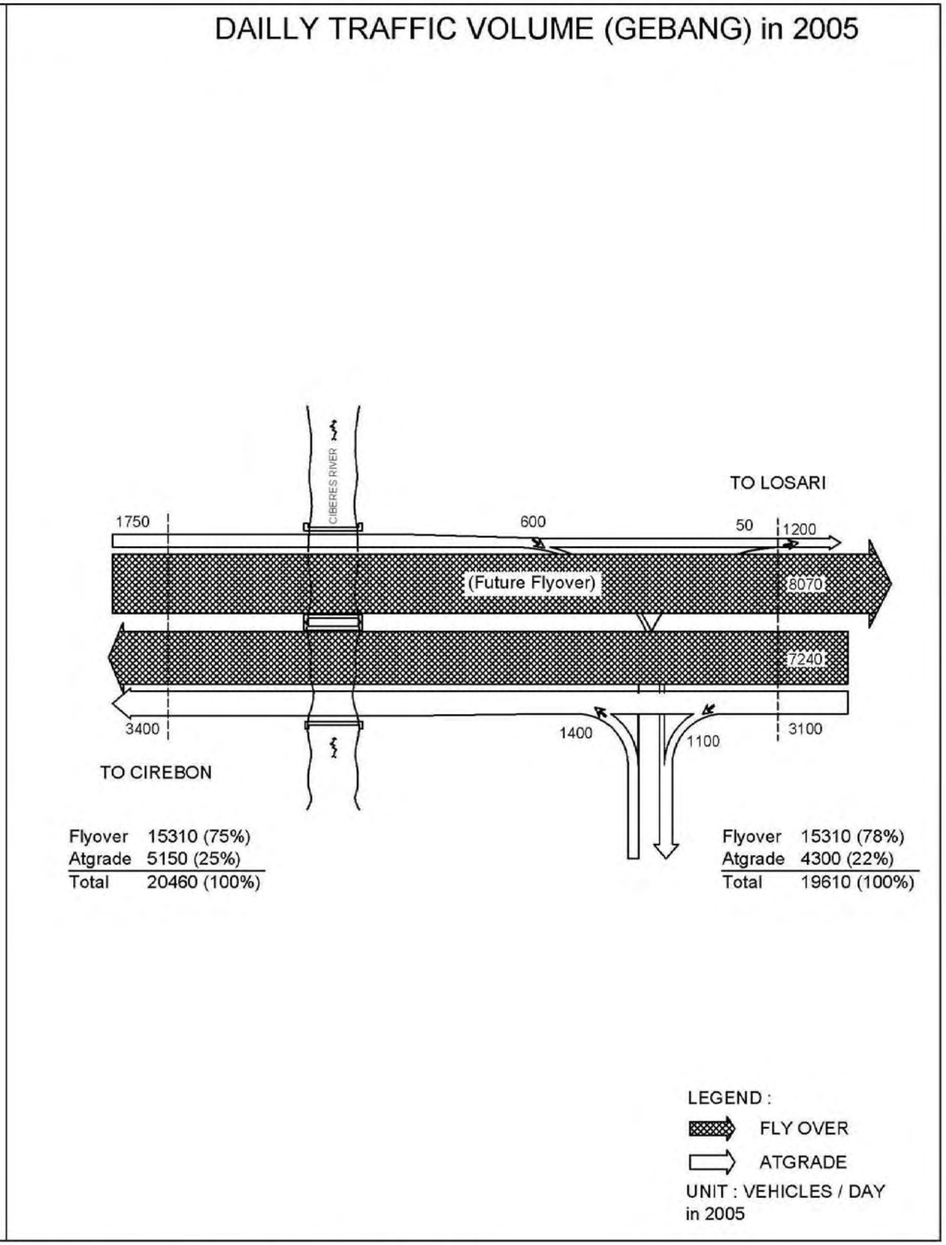
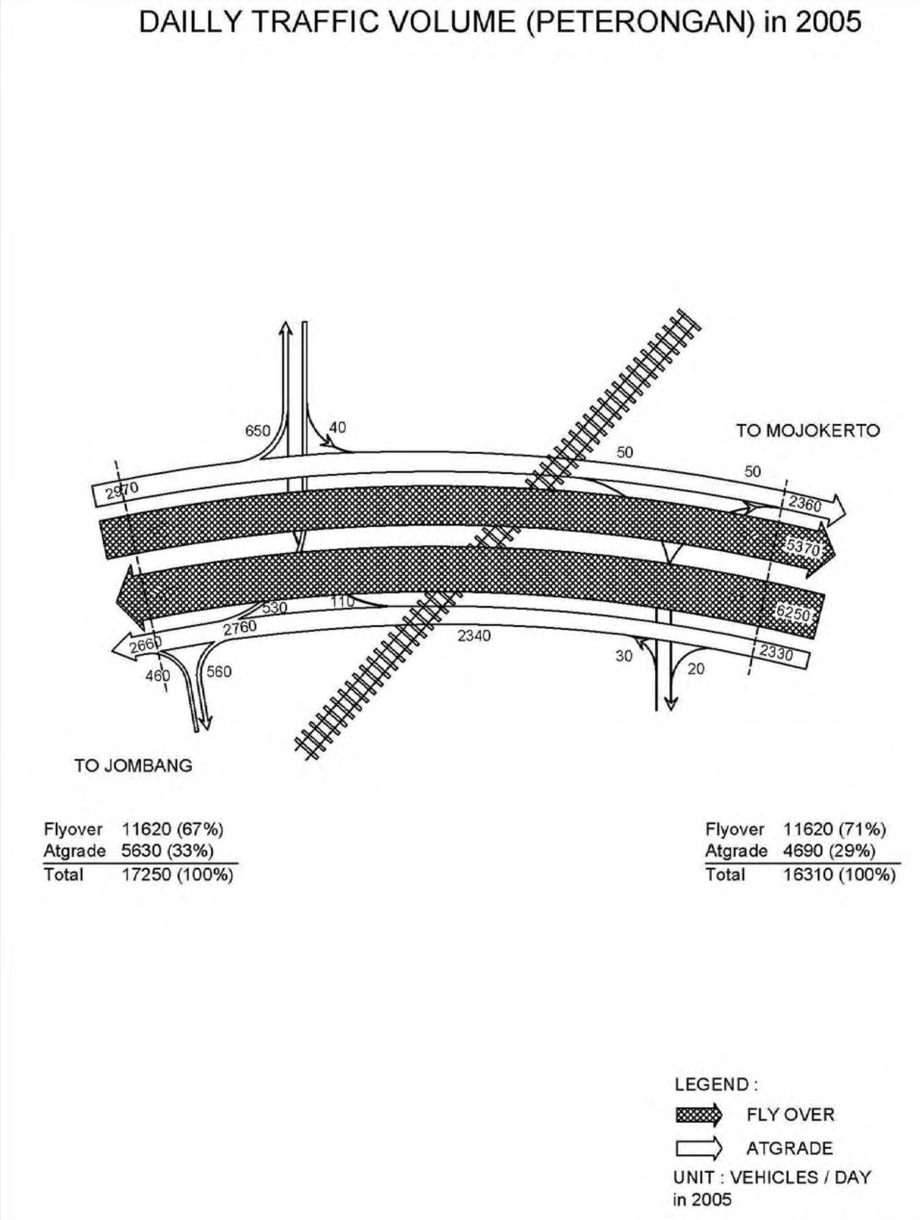


FIGURE 6.3-1 (2/3) FLYOVER TRAFFIC AND AT-GRADE ROAD TRAFFIC



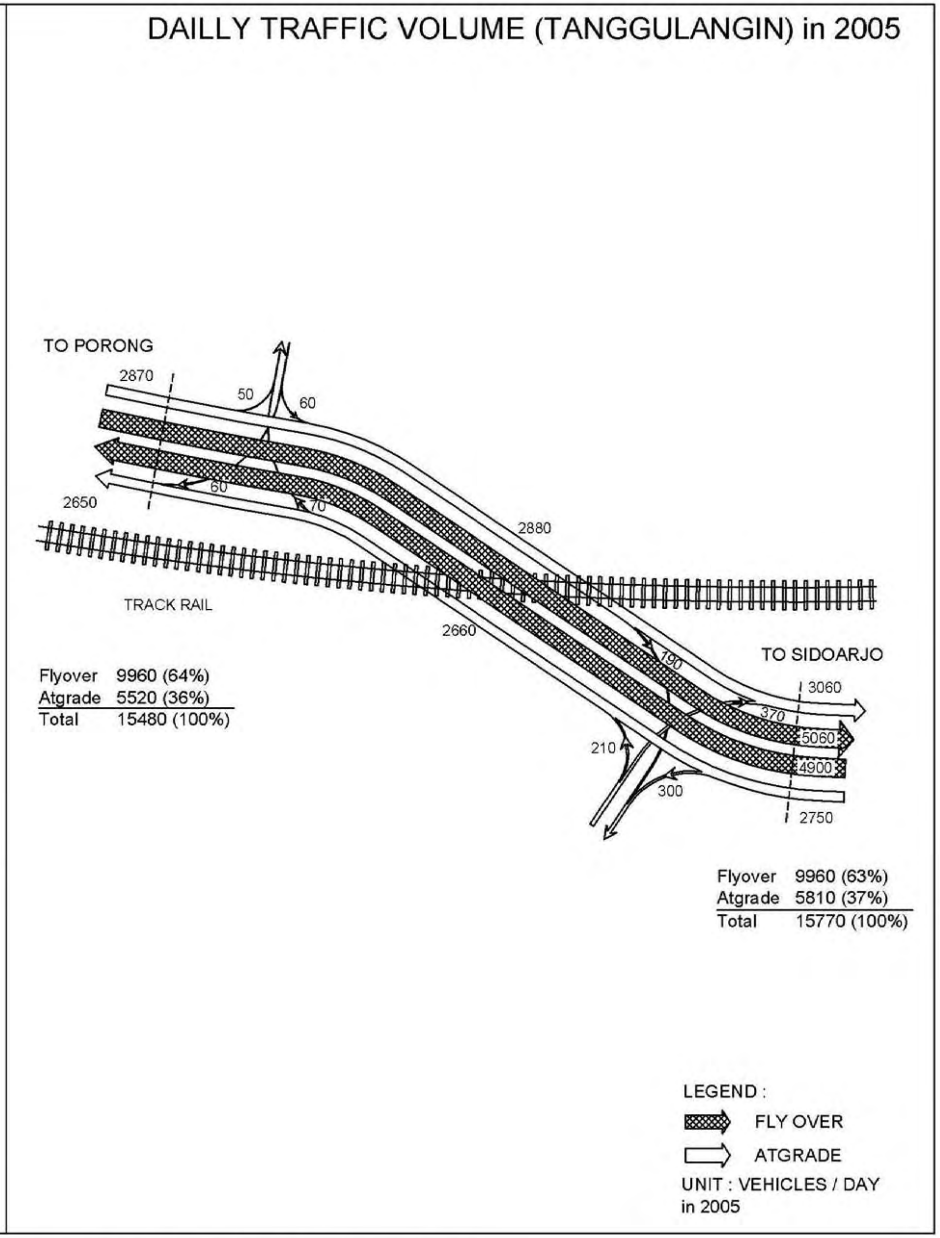


FIGURE 6.3-1 (3/3) FLYOVER TRAFFIC AND AT-GRADE ROAD TRAFFIC

TABLE 6.4-1 ESTIMATED FUTURE TRAFFIC VOLUME IN VEH./DAY

Site	Dir			Traffic Volume(vehicles/day) 2005	2010	2015	2020	2025	Peak Traffic (vehicles/hr) 2005	2010	2015	2020	2025	Growth Rate 2025/2005
Merak (National Road)	from Cilegon	at grade	4-wheel or more	2,958	3,730	4,704	5,652	6,746	237	298	376	452	540	2.28
			3-wheel or less	5,649	7,005	8,238	9,193	10,379	452	560	659	735	830	1.84
			Total	*8,607*	*10,734*	*12,941*	*14,846*	*17,125*	*689*	*858*	*1,035*	*1,187*	*1,370*	*1.99*
	from Pulorida	Flyover	4-wheel or more	1,977	2,485	3,123	3,736	4,413	158	199	250	299	353	2.23
			3-wheel or less	1,116	1,384	1,627	1,816	2,050	89	111	130	145	164	1.84
			Total	*3,093*	*3,869*	*4,751*	*5,553*	*6,463*	*247*	*310*	*380*	*444*	*517*	*2.09*
		at grade	4-wheel or more	1,357	1,715	2,169	2,619	3,162	109	137	174	209	253	2.33
			3-wheel or less	1,673	2,075	2,440	2,723	3,074	134	166	195	218	246	1.84
			Total	*3,030*	*3,790*	*4,609*	*5,341*	*6,236*	*243*	*303*	*369*	*427*	*499*	*2.06*
	Total	Flyover	4-wheel or more	1,977	2,485	3,123	3,736	4,413	158	199	250	299	353	2.23
			3-wheel or less	1,116	1,384	1,627	1,816	2,050	89	111	130	145	164	1.84
			Total	*3,093*	*3,869*	*4,751*	*5,553*	*6,463*	*247*	*310*	*380*	*444*	*517*	*2.09*
		at grade	4-wheel or more	4,315	5,445	6,873	8,271	9,908	346	435	550	661	793	2.30
			3-wheel or less	7,322	9,079	10,677	11,916	13,453	586	726	854	953	1,076	1.84
			Total	*11,637*	*14,524*	*17,550*	*20,187*	*23,361*	*932*	*1,161*	*1,404*	*1,614*	*1,869*	*2.01*
Merak (Terminal Road)	Exit Traffic	Flyover	4-wheel or more	2,153	2,690	3,189	3,691	4,231	172	215	255	295	338	1.97
			3-wheel or less	1,103	1,369	1,613	1,799	2,031	88	110	129	144	162	1.84
			Total	*3,256*	*4,059*	*4,802*	*5,490*	*6,262*	*260*	*325*	*384*	*439*	*500*	*1.92*
		at grade	4-wheel or more	845	1,075	1,294	1,534	1,788	68	86	104	123	143	2.12
			3-wheel or less	547	679	801	894	1,010	44	54	64	72	81	1.85
			Total	*1,392*	*1,754*	*2,095*	*2,428*	*2,798*	*112*	*140*	*168*	*195*	*224*	*2.01*
	Enrance Traffic	at grade	4-wheel or more	3,429	4,303	5,121	5,944	6,839	274	344	410	476	547	1.99
			3-wheel or less	3,528	4,380	5,162	5,758	6,502	282	350	413	461	520	1.84
			Total	*6,957*	*8,683*	*10,283*	*11,702*	*13,341*	*556*	*694*	*823*	*937*	*1,067*	*1.92*
	Total	Flyover	4-wheel or more	2,153	2,690	3,189	3,691	4,231	172	215	255	295	338	1.97
			3-wheel or less	1,103	1,369	1,613	1,799	2,031	88	110	129	144	162	1.84
			Total	*3,256*	*4,059*	*4,802*	*5,490*	*6,262*	*260*	*325*	*384*	*439*	*500*	*1.92*
		at grade	4-wheel or more	4,274	5,378	6,415	7,478	8,627	342	430	514	599	690	2.02
			3-wheel or less	4,075	5,059	5,963	6,652	7,512	326	404	477	533	601	1.84
			Total	*8,349*	*10,437*	*12,378*	*14,130*	*16,139*	*668*	*834*	*991*	*1,132*	*1,291*	*1.93*
Balaraja	from Tangerang	Flyover	4-wheel or more	2,101	2,648	3,338	3,999	4,751	204	257	324	388	461	2.26
			3-wheel or less	3,420	4,241	4,987	5,566	6,284	332	411	484	540	610	1.84
			Total	*5,521*	*6,889*	*8,325*	*9,565*	*11,035*	*536*	*668*	*808*	*928*	*1,071*	*2.00*
		at grade	4-wheel or more	4,903	6,218	7,886	9,557	11,658	476	603	765	927	1,131	2.38
			3-wheel or less	5,130	6,361	7,481	8,349	9,426	498	617	726	810	914	1.84
			Total	*10,033*	*12,579*	*15,367*	*17,906*	*21,084*	*974*	*1,220*	*1,491*	*1,737*	*2,045*	*2.10*
	from Serang	Flyover	4-wheel or more	3,201	4,043	5,108	6,146	7,369	259	327	414	498	597	2.30
			3-wheel or less	4,692	5,818	6,842	7,636	8,621	380	471	554	618	698	1.84
			Total	*7,893*	*9,861*	*11,950*	*13,782*	*15,990*	*639*	*798*	*968*	*1,116*	*1,295*	*2.03*
		at grade	4-wheel or more	4,403	5,542	6,977	8,357	9,859	357	449	565	677	799	2.24
			3-wheel or less	7,038	8,727	10,263	11,454	12,931	570	707	831	928	1,047	1.84
			Total	*11,441*	*14,269*	*17,240*	*19,810*	*22,790*	*927*	*1,156*	*1,396*	*1,605*	*1,846*	*1.99*
	Total	Flyover	4-wheel or more	5,301	6,691	8,446	10,146	12,120	463	584	738	886	1,058	2.29
			3-wheel or less	8,112	10,059	11,829	13,201	14,904	712	882	1,038	1,158	1,308	1.84
			Total	*13,413*	*16,750*	*20,276*	*23,347*	*27,024*	*1,175*	*1,466*	*1,776*	*2,044*	*2,366*	*2.01*
		at grade	4-wheel or more	9,306	11,760	14,863	17,914	21,517	833	1,052	1,330	1,604	1,930	2.31
			3-wheel or less	12,168	15,088	17,744	19,802	22,357	1,068	1,324	1,557	1,738	1,961	1.84
			Total	*21,474*	*26,848*	*32,607*	*37,716*	*43,874*	*1,901*	*2,376*	*2,887*	*3,342*	*3,891*	*2.04*
Nagreg	from Bandung	Flyover	4-wheel or more	5,867	7,367	9,252	11,042	12,884	434	545	685	817	953	2.20
			3-wheel or less	1,835	2,275	2,676	2,986	3,372	136	168	198	221	249	1.84
			Total	*7,702*	*9,642*	*11,928*	*14,028*	*16,256*	*570*	*713*	*883*	*1,038*	*1,202*	*2.11*
		at grade	4-wheel or more	3,714	4,690	5,923	7,128	8,511	275	347	438	527	630	2.29
			3-wheel or less	2,753	3,414	4,015	4,480	5,058	204	253	297	332	374	1.84
			Total	*6,467*	*8,104*	*9,938*	*11,608*	*13,570*	*479*	*600*	*735*	*859*	*1,004*	*2.10*
	from Malangbong	Flyover	4-wheel or more	5,289	6,643	8,346	9,956	11,634	450	565	709	846	989	2.20
			3-wheel or less	1,373	1,703	2,002	2,234	2,523	117	145	170	190	214	1.84
			Total	*6,662*	*8,346*	*10,349*	*12,191*	*14,157*	*567*	*710*	*879*	*1,036*	*1,203*	*2.13*
		at grade	4-wheel or more	2,913	3,679	4,647	5,580	6,626	248	313	395	474	563	2.27
			3-wheel or less	2,060	2,554	3,004	3,352	3,785	175	217	255	285	322	1.84
			Total	*4,973*	*6,233*	*7,651*	*8,933*	*10,411*	*423*	*530*	*650*	*759*	*885*	*2.09*
	Total	Flyover	4-wheel or more	11,156	14,010	17,599	20,998	24,519	884	1,110	1,394	1,663	1,942	2.20
			3-wheel or less	3,208	3,978	4,678	5,221	5,894	253	313	368	411	463	1.84
			Total	*14,364*	*17,988*	*22,277*	*26,219*	*30,413*	*1,137*	*1,423*	*1,762*	*2,074*	*2,405*	*2.12*
		at grade	4-wheel or more	6,627	8,369	10,570	12,708	15,138	523	660	833	1,001	1,193	2.28
			3-wheel or less	4,813	5,968	7,019	7,833	8,843	379	470	552	617	696	1.84
			Total	*11,440*	*14,337*	*17,589*	*20,541*	*23,981*	*902*	*1,130*	*1,385*	*1,618*	*1,889*	*2.10*
Gebang	from Cilebon	at grade	4-wheel or more	9,816	12,420	15,720	18,968	22,792	599	758	959	1,157	1,390	2.32
			3-wheel or less	3,470	4,303	5,060	5,647	6,376	212	262	309	344	389	1.84
			Total	*13,286*	*16,723*	*20,780*	*24,615*	*29,168*	*811*	*1,020*	*1,268*	*1,501*	*1,779*	*2.20*
	from Losari	Flyover	4-wheel or more	7,211	9,101	11,488	13,789	16,448	548	692	873	1,048	1,250	2.28
			3-wheel or less	1,035	1,283	1,509	1,684	1,902	79	98	115	128	145	1.84
			Total	*8,246*	*10,384*	*12,998*	*15,474*	*18,350*	*627*	*790*	*988*	*1,176*	*1,395*	*2.23*
		at grade	4-wheel or more	3,127	3,961	5,020	6,051	7,267	238	301	382	460	552	2.32
			3-wheel or less	1,552	1,924	2,263	2,526	2,852	118	146	172	192	217	1.84
			Total	*4,679*	*5,886*	*7,283*	*8,577*	*10,119*	*356*	*447*	*554*	*652*	*769*	*2.16*
	Total	Flyover	4-wheel or more	7,211	9,101	11,488	13,789	16,448	548	692	873	1,048	1,250	2.28
			3-wheel or less	1,035	1,283	1,509	1,684	1,902	79	98	115	128	145	1.84
			Total	*8,246*	*10,384*	*12,998*	*15,474*	*18,350*	*627*	*790*	*988*	*1,176*	*1,395*	*2.23*
		at grade	4-wheel or more	12,942	16,382	20,740	25,019	30,059	837	1,059	1,341	1,617	1,942	2.32
			3-wheel or less	5,022	6,227	7,323	8,173	9,227	330	408	481	536	606	1.84
			Total	*17,964*	*22,609*	*28,063*	*33,192*	*39,286*	*1,167*	*1,467*	*1,822*	*2,153*	*2,548*	*2.19*
Peterongan	from Morokerto	Flyover	4-wheel or more	6,110	7,676	9,647	11,526	13,528	477	599	752	899	1,055	2.21
			3-wheel or less	3,842	4,764	5,603	6,252	7,059	300	372	437	488	551	1.84
			Total	*9,952*	*12,440*	*15,249*	*17,778*	*20,587*	*777*	*971*	*1,189*	*1,387*	*1,606*	*2.07*
		at grade	4-wheel or more	2,209	2,778	3,494	4,175	4,898	172	217	273	326	382	2.22
			3-wheel or less	5,764	7,147	8,405	9,380	10,590	450	557	656	732	826	1.84
			Total	*7,973*	*9,926*	*11,899*	*13,555*	*15,488*	*622*	*774*	*929*	*1,058*	*1,208*	*1.94*
	from Jombang	Flyover	4-wheel or more	5,364	6,743	8,478	10,139	11,930	418	526	661	791	931	2.22
			3-wheel or less	3,801	4,713	5,543	6,186	6,984	296	368	432	482	545	1.84
			Total	*9,165*	*11,456*	*14,021*	*16,324*	*18,913*	*714*	*894*	*1,093*	*1,273*	*1,476*	*2.06*
		at grade	4-wheel or more	2,181	2,749	3,467	4,158	4,920	170	214	270	324	384	2.26
			3-wheel or less	5,701	7,069	8,313	9,278	10,475	445	551	648	724	817	1.84
			Total	*7,882*	*9,819*	*11,781*	*13,436*	*15,395*	*615*	*765*	*918*	*1,048*	*1,201*	*1.95*
	Total	Flyover	4-wheel or more	11,474	14,419	18,125	21,664	25,458	895	1,125	1,413	1,690	1,986	2.22
			3-wheel or less	7,643	9,477	11,145	12,438	14,043	596	740	869	970	1,096	1.84
			Total	*19,117*	*23,896*	*29,270*	*34,102*	*39,500*	*1,491*	*1,865*	*2,282*	*2,660*	*3,082*	*2.07*
		at grade	4-wheel or more	4,390	5,528	6,961	8,333	9,818	342	431	543	650	766	2.24
			3-wheel or less	11,465	14,217	16,719	18,658	21,065	895	1,108	1,304	1,456	1,643	1.84
			Total	*15,855*	*19,744*	*23,680*	*26,991*	*30,883*	*1,237*	*1,539*	*1,847*	*2,106*	*2,409*	*1.95*
Tanggulangin	from Porong	Flyover	4-wheel or more	4,935	6,212	7,822	9,365	11,045	350	441	555	665	784	2.24
			3-wheel or less	12,362	15,329	18,027	20,118	22,713	878	1,088	1,280	1,428	1,613	1.84
			Total	*17,297*	*21,541*	*25,849*	*29,482*	*33,758*	*1,228*	*1,529*	*1,835*	*2,093*	*2,397*	*1.95*
		at grade	4-wheel or more	2,990	3,775	4,767	5,743	6,898	212	268	338	408	490	2.31
			3-wheel or less	12,362	15,329	18,027	20,118	22,713	878	1,088	1,280	1,428	1,613	1.84
			Total	*15,352*	*19,104*	*22,794*	*25,860*	*29,611*	*1,090*	*1,356*	*1,618*	*1,836*	*2,103*	*1.93*
	from Sidoardjo	Flyover	4-wheel or more	4,759	5,988	7,537	9,015	10,620	405	509	641	766	903	2.23
			3-wheel or less	14,193	17,599	20,697	23,098	26,077	1,206	1,496	1,759	1,963	2,217	1.84
			Total	*18,952*	*23,587*	*28,233*	*32,112*	*36,697*	*1,611*	*2,005*	*2,400*	*2,729*	*3,120*	*1.94*
		at grade	4-wheel or more	2,888	3,646	4,603	5,542	6,653	245	310	391	471	566	2.30
			3-wheel or less	14,193	17,599	20,697	23,098	26,077	1,206	1,496	1,759	1,963	2,217	1.84
			Total	*17,081*	*21,245*	*25,300*	*28,640*	*32,731*	*1,451*	*1,806*	*2,150*	*2,434*	*2,783*	*1.92*
	Total	Flyover	4-wheel or more	9,694	12,201	15,359	18,379	21,665	755	950	1,196	1,431	1,687	2.23
			3-wheel or less	26,555	32,928	38,724	43,215	48,790	2,084	2,584	3,039	3,391	3,830	1.84
			Total	*36,249*	*45,129*	*54,082*	*61,595*	*70,456*	*2,839*	*3,534*	*4,235*	*4,822*	*5,517*	*1.94*
		at grade	4-wheel or more	5,878	7,421	9,370	11,285	13,551	457	578	729	879	1,056	2.31
			3-wheel or less	26,555	32,928	38,724	43,215	48,790	2,084	2,584	3,039	3,391	3,830	1.84
			Total	32,433	40,349	48,094	54,500	62,341	2,541	3,162	3,768	4,270	4,886	1.92

TABLE 6.4-2 ESTIMATED FUTURE TRAFFIC VOLUME IN PCU/DAY

Site	Dir			Traffic Volume(PCU/day)					Peak Traffic (PCU/hr)					
				2005	2010	2015	2020	2025	2005	2010	2015	2020	2025	2025/2005
Merak (National Road)	from Cilegon	at grade	4-wheel or more	4,240	5,352	6,758	8,141	9,788	339	428	541	651	783	2.31
			3-wheel or less	1,412	1,751	2,059	2,298	2,595	113	140	165	184	208	1.84
			Total	*5,652*	*7,103*	*8,817*	*10,440*	*12,382*	*452*	*568*	*706*	*835*	*991*	2.19
	from Pulorida	Flyover	4-wheel or more	3,678	4,627	5,821	6,990	8,359	294	370	466	559	669	2.27
			3-wheel or less	279	346	407	454	513	22	28	33	36	41	1.84
			Total	*3,957*	*4,972*	*6,228*	*7,444*	*8,872*	*316*	*398*	*499*	*595*	*710*	2.24
		at grade	4-wheel or more	1,427	1,805	2,284	2,757	3,327	114	144	183	221	266	2.33
			3-wheel or less	418	519	610	681	768	33	41	49	54	61	1.84
			Total	*1,846*	*2,324*	*2,894*	*3,437*	*4,095*	*147*	*185*	*232*	*275*	*327*	2.22
	Total	Flyover	4-wheel or more	3,678	4,627	5,821	6,990	8,359	294	370	466	559	669	2.27
			3-wheel or less	279	346	407	454	513	22	28	33	36	41	1.84
			Total	*3,957*	*4,972*	*6,228*	*7,444*	*8,872*	316	398	499	595	710	2.24
		at grade	4-wheel or more	5,667	7,157	9,042	10,898	13,114	453	572	724	872	1,049	2.31
			3-wheel or less	1,831	2,270	2,669	2,979	3,363	146	181	214	238	269	1.84
			Total	*7,498*	*9,427*	*11,711*	*13,877*	*16,478*	599	753	938	1,110	1,318	2.20
Merak (Terminal Road)	Exit Traffic	Flyover	4-wheel or more	4,351	5,440	6,458	7,565	8,700	348	435	517	605	696	2.00
			3-wheel or less	276	342	403	450	508	22	27	32	36	41	1.84
			Total	*4,627*	*5,782*	*6,861*	*8,015*	*9,208*	*370*	*462*	*549*	*641*	*737*	*1.99*
		at grade	4-wheel or more	1,370	1,743	2,100	2,494	43,631	110	139	168	200	3,490	31.85
			3-wheel or less	137	170	200	224	253	11	14	16	18	20	1.85
			Total	*1,507*	*1,913*	*2,300*	*2,718*	*43,884*	*121*	*153*	*184*	*218*	*3,510*	*29.12*
	Entrance Traffic	at grade	4-wheel or more	6,112	7,674	9,141	10,711	12,357	611	767	914	1,071	1,236	2.02
			3-wheel or less	882	1,095	1,291	1,440	1,626	88	110	129	144	163	1.84
			Total	*6,994*	*8,769*	*10,432*	*12,151*	*13,983*	*699*	*877*	*1,043*	*1,215*	*1,399*	*2.00*
	Total	Flyover	4-wheel or more	4,351	5,440	6,458	7,565	8,700	348	435	517	605	696	2.00
			3-wheel or less	276	342	403	450	508	22	27	32	36	41	1.84
			Total	*4,627*	*5,782*	*6,861*	*8,015*	*9,208*	370	462	549	641	737	*1.99*
		at grade	4-wheel or more	7,482	9,417	11,241	13,205	55,988	721	906	1,082	1,271	4,726	7.48
			3-wheel or less	1,019	1,265	1,491	1,663	1,878	99	124	145	162	183	1.84
			Total	*8,501*	*10,682*	*12,732*	*14,868*	*57,866*	820	1,030	1,227	1,433	4,909	*6.81*
Balaraja	from Tangerang	Flyover	4-wheel or more	3,117	3,944	4,993	6,021	7,260	302	383	484	584	704	2.33
			3-wheel or less	855	1,060	1,247	1,391	1,571	83	103	121	135	152	1.84
			Total	*3,972*	*5,004*	*6,239*	*7,413*	*8,830*	*385*	*486*	*605*	*719*	*856*	*2.22*
		at grade	4-wheel or more	5,724	7,264	9,221	11,181	13,644	555	705	894	1,085	1,323	2.38
			3-wheel or less	1,283	1,590	1,870	2,087	2,356	124	154	181	202	229	1.84
			Total	*7,006*	*8,855*	*11,091*	*13,268*	*16,000*	*679*	*859*	*1,075*	*1,287*	*1,552*	*2.28*
	from Serang	Flyover	4-wheel or more	4,597	5,825	7,383	8,926	10,816	372	472	598	723	876	2.35
			3-wheel or less	1,173	1,455	1,711	1,909	2,155	95	118	139	155	175	1.84
			Total	*5,770*	*7,280*	*9,093*	*10,835*	*12,971*	*467*	*590*	*737*	*878*	*1,051*	*2.25*
		at grade	4-wheel or more	5,400	6,818	8,610	10,349	12,306	437	552	697	838	997	2.28
			3-wheel or less	1,760	2,182	2,566	2,863	3,233	143	177	208	232	262	1.84
			Total	*7,160*	*9,000*	*11,176*	*13,213*	*15,538*	*580*	*729*	*905*	*1,070*	*1,259*	*2.17*
	Total	Flyover	4-wheel or more	7,714	9,769	12,375	14,948	18,075	674	855	1,082	1,307	1,580	2.34
			3-wheel or less	2,028	2,515	2,957	3,300	3,726	178	221	260	290	327	1.84
			Total	*9,742*	*12,284*	*15,333*	*18,248*	*21,801*	*852*	*1,076*	*1,342*	*1,597*	*1,907*	*2.24*
		at grade	4-wheel or more	11,124	14,082	17,830	21,530	25,949	992	1,257	1,591	1,923	2,320	2.33
			3-wheel or less	3,042	3,772	4,436	4,951	5,589	267	331	389	434	491	1.84
			Total	14,166	17,855	22,266	26,480	31,539	1,259	1,588	1,980	2,357	2,811	2.23
Nagreg	from Bandung	Flyover	4-wheel or more	7,980	10,080	12,737	15,327	18,251	591	746	943	1,134	1,351	2.29
			3-wheel or less	459	569	669	747	843	34	42	50	55	62	1.84
			Total	*8,439*	*10,649*	*13,406*	*16,074*	*19,094*	*625*	*788*	*993*	*1,189*	*1,413*	*2.26*
		at grade	4-wheel or more	4,701	5,952	7,538	9,097	10,927	348	440	558	673	809	2.32
			3-wheel or less	688	853	1,004	1,120	1,265	51	63	74	83	94	1.84
			Total	*5,389*	*6,805*	*8,541*	*10,217*	*12,192*	*399*	*503*	*632*	*756*	*903*	*2.26*
	from Malangbong	Flyover	4-wheel or more	7,581	9,568	12,080	14,516	17,275	644	813	1,027	1,234	1,468	2.28
			3-wheel or less	343	426	501	559	631	29	36	43	47	54	1.84
			Total	*7,924*	*9,994*	*12,580*	*15,074*	*17,905*	*673*	*849*	*1,070*	*1,281*	*1,522*	*2.26*
		at grade	4-wheel or more	4,187	5,299	6,708	8,078	9,653	356	450	570	687	820	2.31
			3-wheel or less	515	639	751	838	946	44	54	64	71	80	1.84
			Total	*4,702*	*5,938*	*7,459*	*8,916*	*10,599*	*400*	*504*	*634*	*758*	*900*	*2.25*
	Total	Flyover	4-wheel or more	15,561	19,649	24,817	29,843	35,526	1,235	1,559	1,970	2,368	2,819	2.28
			3-wheel or less	802	994	1,170	1,305	1,474	63	78	93	102	116	1.84
			Total	*16,363*	*20,643*	*25,986*	*31,148*	*37,000*	*1,298*	*1,637*	*2,063*	*2,470*	*2,935*	*2.26*
		at grade	4-wheel or more	8,888	11,251	14,246	17,175	20,580	704	890	1,128	1,360	1,629	2.32
			3-wheel or less	1,203	1,492	1,755	1,958	2,211	95	117	138	154	174	1.84
			Total	10,091	12,743	16,000	19,133	22,791	799	1,007	1,266	1,514	1,803	2.26
Gebang	from Cirebon	at grade	4-wheel or more	18,498	23,445	29,722	35,974	43,631	1,128	1,430	1,813	2,194	2,661	2.36
			3-wheel or less	868	1,076	1,265	1,412	1,594	53	66	77	86	97	1.84
			Total	*19,366*	*24,520*	*30,987*	*37,386*	*45,225*	*1,181*	*1,496*	*1,890*	*2,280*	*2,758*	*2.34*
	from Losari	Flyover	4-wheel or more	14,089	17,801	22,495	27,104	32,649	1,071	1,353	1,710	2,060	2,481	2.32
			3-wheel or less	259	321	377	421	475	20	24	29	32	36	1.84
			Total	*14,348*	*18,121*	*22,873*	*27,525*	*33,124*	*1,091*	*1,377*	*1,739*	*2,092*	*2,517*	*2.31*
		at grade	4-wheel or more	5,323	6,749	8,559	10,331	12,438	405	513	650	785	945	2.34
			3-wheel or less	388	481	566	631	713	29	37	43	48	54	1.84
			Total	*5,711*	*7,230*	*9,125*	*10,962*	*13,150*	*434*	*550*	*693*	*833*	*999*	*2.30*
	Total	Flyover	4-wheel or more	14,089	17,801	22,495	27,104	32,649	1,071	1,353	1,710	2,060	2,481	2.32
			3-wheel or less	259	321	377	421	475	20	24	29	32	36	1.84
			Total	*14,348*	*18,121*	*22,873*	*27,525*	*33,124*	*1,091*	*1,377*	*1,739*	*2,092*	*2,517*	*2.31*
		at grade	4-wheel or more	23,821	30,194	38,281	46,305	56,069	1,533	1,943	2,463	2,979	3,606	2.35
			3-wheel or less	1,256	1,557	1,831	2,043	2,307	82	103	120	134	151	1.84
			Total	25,077	31,751	40,111	48,348	58,375	1,615	2,046	2,583	3,113	3,757	2.33
Peterongan	from Morokerto	Flyover	4-wheel or more	10,284	12,960	16,337	19,632	23,433	802	1,011	1,274	1,531	1,828	2.28
			3-wheel or less	961	1,191	1,401	1,563	1,765	75	93	109	122	138	1.84
			Total	*11,244*	*14,151*	*17,738*	*21,196*	*25,198*	*877*	*1,104*	*1,383*	*1,653*	*1,966*	*2.24*
		at grade	4-wheel or more	3,200	4,034	5,088	6,105	7,242	250	315	397	476	565	2.26
			3-wheel or less	1,441	1,787	2,101	2,345	2,648	112	139	164	183	207	1.84
			Total	*4,641*	*5,821*	*7,190*	*8,451*	*9,890*	*362*	*454*	*561*	*659*	*772*	*2.13*
	from Jombang	Flyover	4-wheel or more	9,289	11,711	14,769	17,762	21,250	725	913	1,152	1,385	1,658	2.29
			3-wheel or less	950	1,178	1,386	1,546	1,746	74	92	108	121	136	1.84
			Total	*10,239*	*12,889*	*16,155*	*19,309*	*22,996*	*799*	*1,005*	*1,260*	*1,506*	*1,794*	*2.25*
		at grade	4-wheel or more	3,563	4,504	5,695	6,859	8,207	278	351	444	535	640	2.30
			3-wheel or less	1,425	1,767	2,078	2,319	2,619	111	138	162	181	204	1.84
			Total	*4,988*	*6,271*	*7,774*	*9,178*	*10,826*	*389*	*489*	*606*	*716*	*844*	*2.17*
	Total	Flyover	4-wheel or more	19,572	24,671	31,107	37,395	44,684	1,527	1,924	2,426	2,916	3,486	2.28
			3-wheel or less	1,911	2,369	2,786	3,110	3,511	149	185	217	243	274	1.84
			Total	*21,483*	*27,040*	*33,893*	*40,504*	*48,194*	*1,676*	*2,109*	*2,643*	*3,159*	*3,760*	*2.24*
		at grade	4-wheel or more	6,762	8,539	10,784	12,964	15,450	528	666	841	1,011	1,205	2.28
			3-wheel or less	2,866	3,554	4,180	4,665	5,266	223	277	326	364	411	1.84
			Total	9,629	12,093	14,963	17,629	20,716	751	943	1,167	1,375	1,616	2.15
Tanggulangin	from Porong	Flyover	4-wheel or more	7,100	8,992	11,391	13,759	16,568	504	638	809	977	1,176	2.33
			3-wheel or less	3,091	3,832	4,507	5,029	5,678	219	272	320	357	403	1.84
			Total	*10,191*	*12,825*	*15,898*	*18,788*	*22,246*	*723*	*910*	*1,129*	*1,334*	*1,579*	*2.18*
		at grade	4-wheel or more	3,413	4,317	5,463	6,598	7,971	242	307	388	468	566	2.34
			3-wheel or less	3,091	3,832	4,507	5,029	5,678	219	272	320	357	403	1.84
			Total	*6,503*	*8,149*	*9,969*	*11,627*	*13,649*	*461*	*579*	*708*	*825*	*969*	*2.10*
	from Sidoardjo	Flyover	4-wheel or more	6,781	8,583	10,867	13,112	15,766	576	730	924	1,115	1,340	2.32
			3-wheel or less	3,548	4,400	5,174	5,774	6,519	302	374	440	491	554	1.84
			Total	*10,329*	*12,983*	*16,041*	*18,887*	*22,285*	*878*	*1,104*	*1,364*	*1,606*	*1,894*	*2.16*
		at grade	4-wheel or more	3,283	4,153	5,253	6,342	7,656	279	353	447	539	651	2.33
			3-wheel or less	3,548	4,400	5,174	5,774	6,519	302	374	440	491	554	1.84
			Total	*6,832*	*8,553*	*10,428*	*12,116*	*14,176*	*581*	*727*	*887*	*1,030*	*1,205*	*2.07*
	Total	Flyover	4-wheel or more	13,882	17,576	22,259	26,871	32,334	1,080	1,368	1,733	2,092	2,516	2.33
			3-wheel or less	6,639	8,232	9,681	10,804	12,198	521	646	760	848	957	1.84
			Total	*20,520*	*25,808*	*31,940*	*37,675*	*44,531*	*1,601*	*2,014*	*2,493*	*2,940*	*3,473*	*2.17*
		at grade	4-wheel or more	6,696	8,470	10,716	12,940	15,627	521	660	835	1,007	1,217	2.33
			3-wheel or less	6,639	8,232	9,681	10,804	12,198	521	646	760	848	957	1.84
			Total	13,335	16,702	20,397	23,744	27,825	1,042	1,306	1,595	1,855	2,174	2.09

6.5 LEVEL OF SERVICE OF EXISTING ROAD WITHOUT FLYOVER

Based on the IHCM (Indonesian Highway Capacity Manual[1*]) method, volume / capacity ratio was analyzed for each location in case of without flyover project.

6.5.1 Existing Road Traffic Capacity

Traffic capacity is calculated as follows:

$$C = Co \times FCw \times FCsp \times FC\,sf \times FCcs$$

Where:

C	=	Capacity (pcu/h)
Co	=	Base Capacity = 1,650 pcu/h per lane or 2,900 pcu/h (2 lane undivided)
FCw	=	Adjustment factor for carriageway width of 3.5m = 1.00
FCsp	=	Adjustment factor for directional split
FCsf	=	Adjustment factor for side friction
FCcs	=	Adjustment factor for city size of 1.0~3.0 Million population = 1.00

TABLE 6.5.1-1 TRAFFIC CAPACITY OF EXISTING ROAD

Location	Type	No. of Lane	Base Capacity	Adjustment Factor				Capacity (pcu/hr.)
			Co (pcu/hr.)	FCw	FCsp	FCsf*	FCcs	
Merak	2/2 UD	2	2,900	1.14	1.00	0.68	1.00	2,250
	Two-lane undivided	(both)	(total)	(8.0m)		(0.5m [VH])		(Total)
Balaraja	4/2 D	2	1,650	0.82	-	0.60	1.00	1,620
	Four-lane devided	(per dir.)	(per lane)	(<3.0m)		(0m [VH])		(Per dir.)
Nagreg	2/2 UD	2	2,900	1.00	1.00	1.00	1.00	2,900
	Two-lane undivided	(both)	(total)	(7.0m)		(0m [H]		(Total)
Gebang	4/2 D	2	1,650	0.92	-	0.68	1.00	2,060
	Four-lane devided	(per dir.)	(per lane)	(3.0m)		(0m [VH])		(Per dir.)
Peterongan	4/2 D	2	1,650	0.92	-	0.65	1.00	1,970
	Four-lane devided	(per dir.)	(per lane)	(3.0m)		(0m [H])		(Per dir.)
Tanggulangin	4/2 D	2	1,650	1.00	-	0.65	1.00	2,150
	Four-lane devided	(per dir.)	(per lane)	(3.5m)		(0m [H])		(Per dir.)

Note: * FCsf: [VH] Very High Side friction, [M] Medium Side friction, [VL] Very Low Side friction

[*] Indonesian Highway Capacity Manual, Ministry of Public Works Directorate General of Highways, June1997 Chapter 5 Urban Roads p5-1 ~ p5-99

6.5.2 Volume / Capacity Ratio of the Existing Road without Flyover

Table 6.5.2-1 and **Figure 6.5.2-1** and **6.5.2-2** shows traffic capacity, estimated traffic volume and volume/capacity ratio in case without project. It is noted that Nagreg and Gebang will reach more than 1.5 times capacity in 2025.

TABLE 6.5.2-1 VOLUME CAPACITY RATIO OF THE EXISTING ROAD WITHOUT FLYOVER

Location	Direction	Capacity		Y2005	Y2010	Y2015	Y2020	2025
Merak	Both Direction	2,250	Volume	1,351	1,699	2,121	2,517	2,994
	(2/2 UD)	(Total)	V /C	0.60	0.76	0.94	**1.12**	**1.33**
Balaraja	from Tangerang	1,620	Volume	1,064	1,345	1,680	2,006	2,408
			V /C	0.66	0.83	**1.04**	**1.24**	**1.49**
	from Serang	1,620	Volume	1,047	1,315	1,639	1,950	2,333
			V /C	0.65	0.81	**1.01**	**1.20**	**1.44**
Nagreg	Both Direction	2,900	Volume	2,097	2,644	3,329	3,984	4,738
	(2/2 UD)	(Total)	V /C	0.72	0.91	**1.15**	**1.37**	**1.63**
Gebang	from Losari	2,060	Volume	1,525	1,927	2,432	2,925	3,500
			V /C	0.74	0.94	**1.18**	**1.42**	**1.70**
Peterongan	from Mojokerto	1,970	Volume	1,239	1,558	1,944	2,312	2,738
			V /C	0.63	0.79	0.99	**1.17**	**1.39**
	from Jombang	1,970	Volume	1,188	1,494	1,866	2,222	2,638
			V /C	0.60	0.76	0.95	**1.13**	**1.34**
Tanggulangin	from Porong	2,150	Volume	1,185	1,489	1,837	2,159	2,549
			V /C	0.55	0.69	0.85	**1.00**	**1.19**
	from Sidoardjo	2,150	Volume	1,458	1,831	2,251	2,636	3,099
			V /C	0.68	0.85	**1.05**	**1.23**	**1.44**

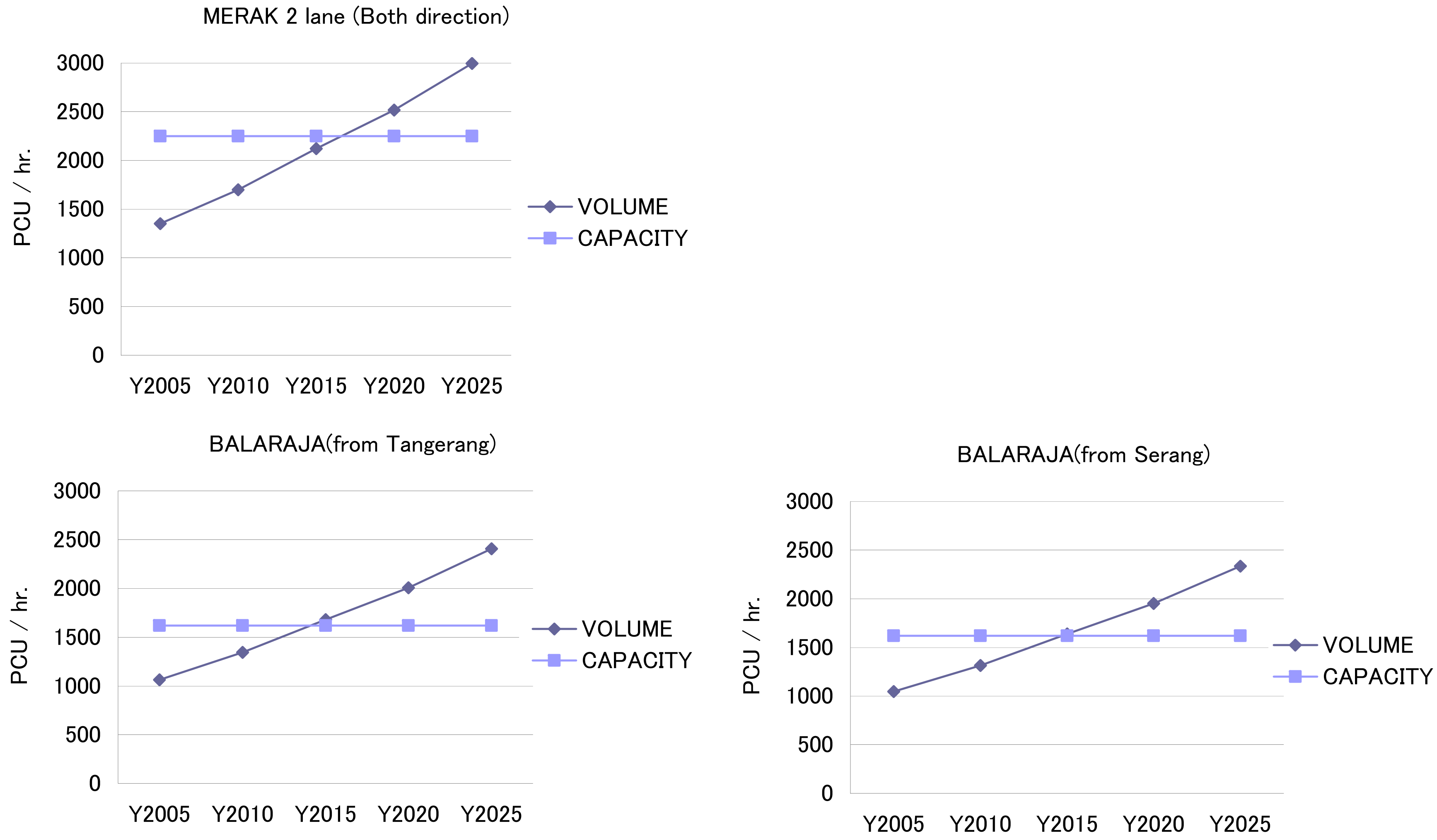
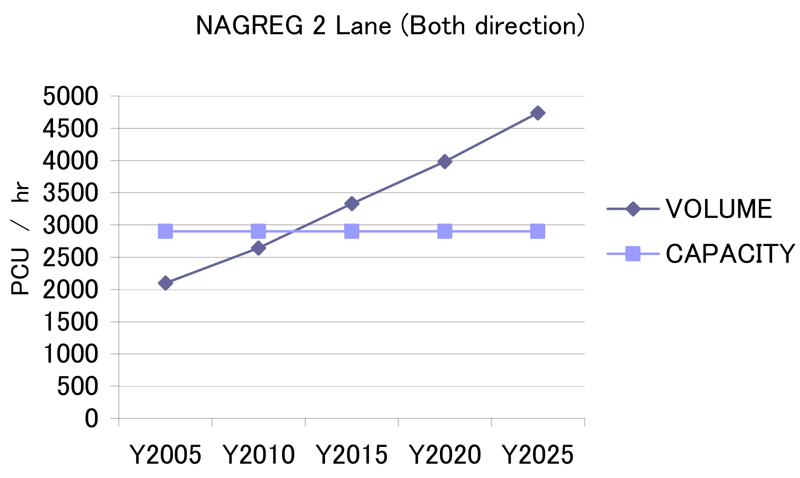
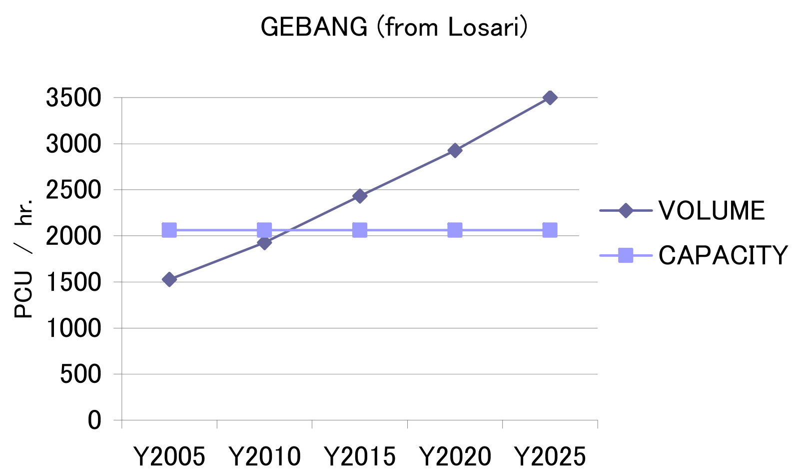


FIGURE 6.5.2-1 FUTURE TRAFFIC VOLUME AND CAPACITY WITHOUT PROJECT (MERAK AND BALARAJA)





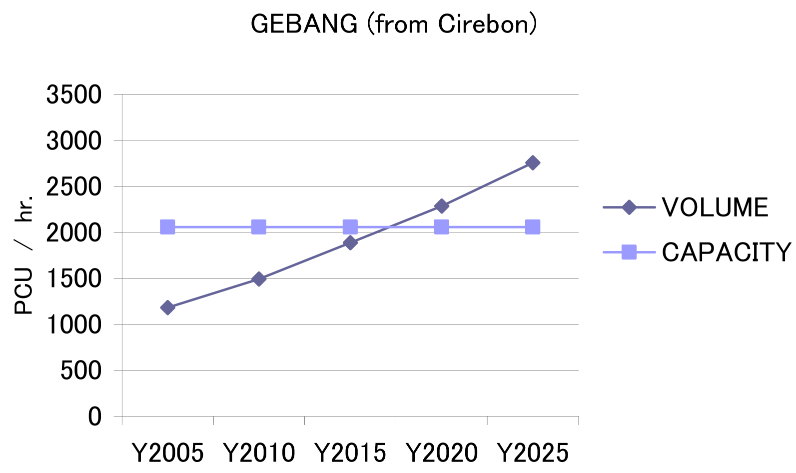


FIGURE 6.5.2-2 FUTURE TRAFFIC VOLUME AND CAPACITY WITHOUT PROJECT NAGREG AND GEBANG)

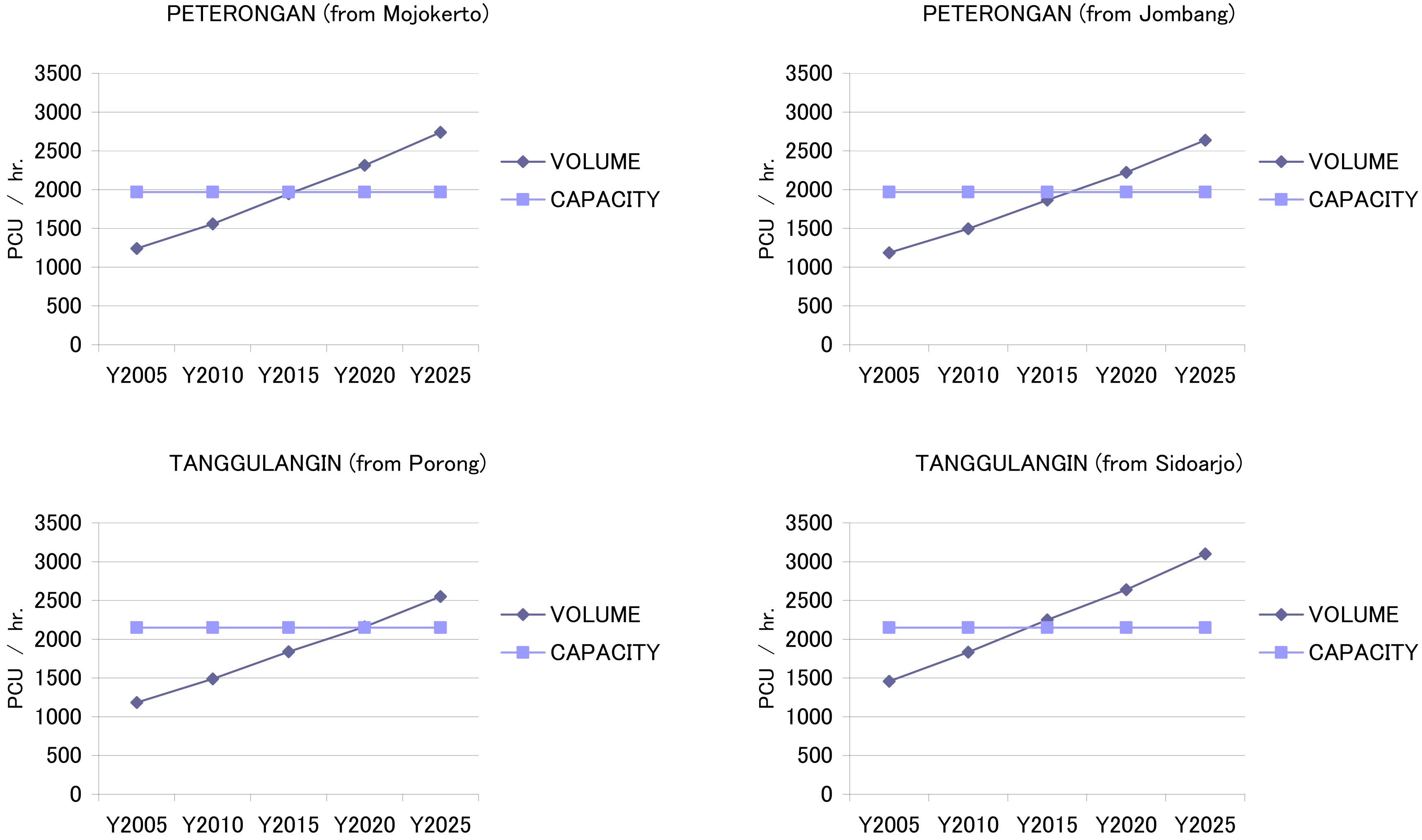


FIGURE 6.5.2-3 FUTURE TRAFFIC VOLUME AND CAPACITY WITHOUT PROJECT YANGGULANGIN AND PETERONGAN)

6.6 NUMBER OF LANES REQUIRED FOR FLYOVER

6.6.1 Flyover and Service Road Traffic Capacity

Table 6.6.1-1 and **6.6.1-2** shows the flyover traffic capacity and service road traffic capacity, respectively.

TABLE 6.6.1-1 TRAFFIC CAPACITY OF FLYOVER

Location	Type	No. of Lane (per dir.)	Base Capacity Co (pcu/hr.)	Adjustment Factor				Capacity (pcu/hr.)
				FCw	FCsp	FCsf*	FCcs	
Merak	1-lane, 1-way	1	1,650 (per lane)	1.00 (3.5m)	–	1.01 (2.0m) [VL]	1.00	1,670 (Per dir.)
	2-lane, 1-way	2	1,650 (per lane)	1.00 (3.5m)	–	0.95 (0.5m [VL])	1.00	3,140 (Per dir.)
Balaraja	2-lane, 2-way with centerline	1	1,650 (per lane)	1.00 (3.5m)	–	1.01 (2.0m) [VL]	1.00	1,670 (Per dir.)
Nagreg	2-lane, 2-way with centerline	1	1,650 (per lane)	1.00 (3.5m)	–	1.01 (2.0m) [VL]	1.00	1,670 (Per dir.)
Gebang	2-lane, 1-way with centerline	2	1,650 (per lane)	1.00 (3.5m)	–	0.95 (0.5m [VL])	1.00	3,140 (Per dir.)
Peterongan	2-lane, 2-way with centerline	1	1,650 (per lane)	1.00 (3.5m)	–	1.01 (2.0m) [VL]	1.00	1,670 (Per dir.)
Tanggulangin	2-lane, 2-way with centerline	1	1,650 (per lane)	1.00 (3.5m)	–	1.01 (2.0m) [VL]	1.00	1,670 (Per dir.)

Note: * FCsf: [VH] Very High Side friction, [M] Medium Side friction, [VL] Very Low Side friction

TABLE 6.6.1-2 TRAFFIC CAPACITY OF SERVICE ROAD

Location	No. of Lane (per dir.)	Base Capacity Co (pcu/hr.)	Adjustment Factor				Capacity (pcu/hr.)
			FCw	FCsp	FCsf*	FCcs	
Merak	1	1,650 (per lane)	1.00 (3.5m)	–	0.77 (1.5m [VH])	1.00	1,270 (Per dir.)
Balaraja	2	1,650 (per lane)	0.82 (<3.0m)	–	0.68 (0m [VH])	1.00	1,840 (Per dir.)
Nagreg	1	1,650 (per lane)	1.00 (3.5m)	–	0.84 (1.5m [H])	1.00	1,390 (Per dir.)
Gebang	1	1,650 (per lane)	1.00 (3.5m)	–	0.72 (1.0m [VH])	1.00	1,190 (Per dir.)
Peterongan	1	1,650 (per lane)	1.00 (3.5m)	–	0.84 (1.5m [H])	1.00	1,390 (Per dir.)
Tanggulangin	1	1,650 (per lane)	1.00 (3.5m)	–	0.84 (1.5m [H])	1.00	1,390 (Per dir.)

Note: * FCsf: [VH] Very High Side friction, [M] Medium Side friction, [VL] Very Low Side friction

6.6.2 Number of Lanes Required and Volume / Capacity Ratio

Table 6.6.2-1 shows number of lanes required and volume / capacity ratio. It is noted that traffic of Peterongan Flyover will reach to its capacity in 2020 and Tanggulangin Flyover exceeds capacity in 2025, thus they should be converted to a 4-lane flyover before year 2020. **Figure 6.6.2-1~6** shows the traffic volume and capacity.

TABLE 6.6.2-1 NUMBER OF LANES REQUIRED AND VOLUME/CAPACITY RATIO

			No.of Lane and Capacity (pcu/hr)	Year 2015		Year 2020		Year 2025	
				Traffic Volume (pcu/ hr)	V/C Ratio	Traffic Volume (pcu/ hr)	V/C Ratio	Traffic Volume (pcu/ hr)	V/C Ratio
Merak	From Pulorida (near Railway)	Flyover	1 1,670	499	0.30	595	0.36	710	0.43
		At-grade	1 1,270	564	0.44	669	0.53	796	0.63
	From Pulorida (Jakarta side)	Flyover	2 3,140	1,284	0.41	1,527	0.49	1,818	0.58
		At-grade	1 1,270	757	0.60	896	0.71	1,063	0.84
Balaraja	From Tangerang	Flyover	1 1,670	605	0.36	719	0.43	856	0.51
		At-grade	2 1,840	1,075	0.58	1,287	0.70	1,552	0.84
	From Serang	Flyover	1 1,670	737	0.44	878	0.53	1,051	0.63
		At-grade	2 1,840	902	0.49	1,072	0.58	1,282	0.70
Nagreg	From Bandung	Flyover	1 1,670	993	0.59	1,189	0.71	1,413	0.85
		At-grade	1 1,390	632	0.45	756	0.54	903	0.65
	From Malangbong	Flyover	1 1,670	1,070	0.64	1,281	0.77	1,522	0.91
		At-grade	1 1,390	634	0.46	758	0.55	900	0.65
Gebang	From Losari	Flyover	2 3,140	1,739	0.55	2,092	0.67	2,517	0.80
		At-grade	1 1,190	693	0.58	833	0.70	999	0.84
Peterongan	From Morokerto	Flyover	1 1,670	1,383	0.83	1,653	0.99	1,966	**1.18**
		At-grade	1 1,390	561	0.40	659	0.47	772	0.56
	From Jombang	Flyover	1 1,670	1,260	0.75	1,506	0.90	1,794	**1.07**
		At-grade	1 1,390	606	0.44	716	0.52	844	0.61
Tanggulangin	From Porong	Flyover	1 1,670	1,129	0.68	1,334	0.80	1,579	0.95
		At-grade	1 1,390	708	0.51	825	0.59	969	0.70
	From Sidoardjo	Flyover	1 1,670	1,364	0.82	1,606	0.96	1,894	**1.13**
		At-grade	1 1,390	887	0.64	1,030	0.74	1,205	0.87

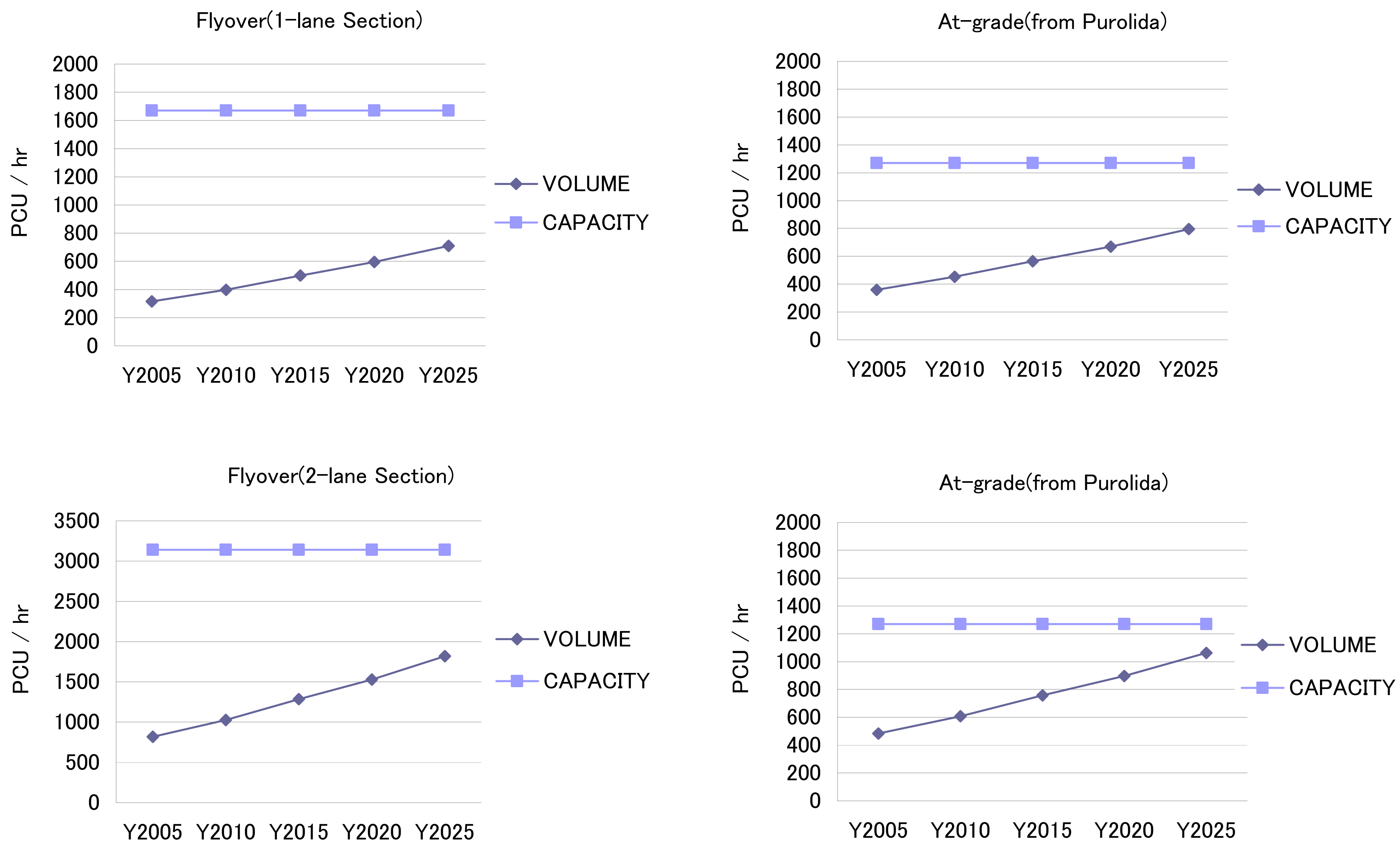


FIGURE 6.6.2-1 FUTURE TRAFFIC VOLUME AND CAPACITY WITH PROJECT (MERAK)

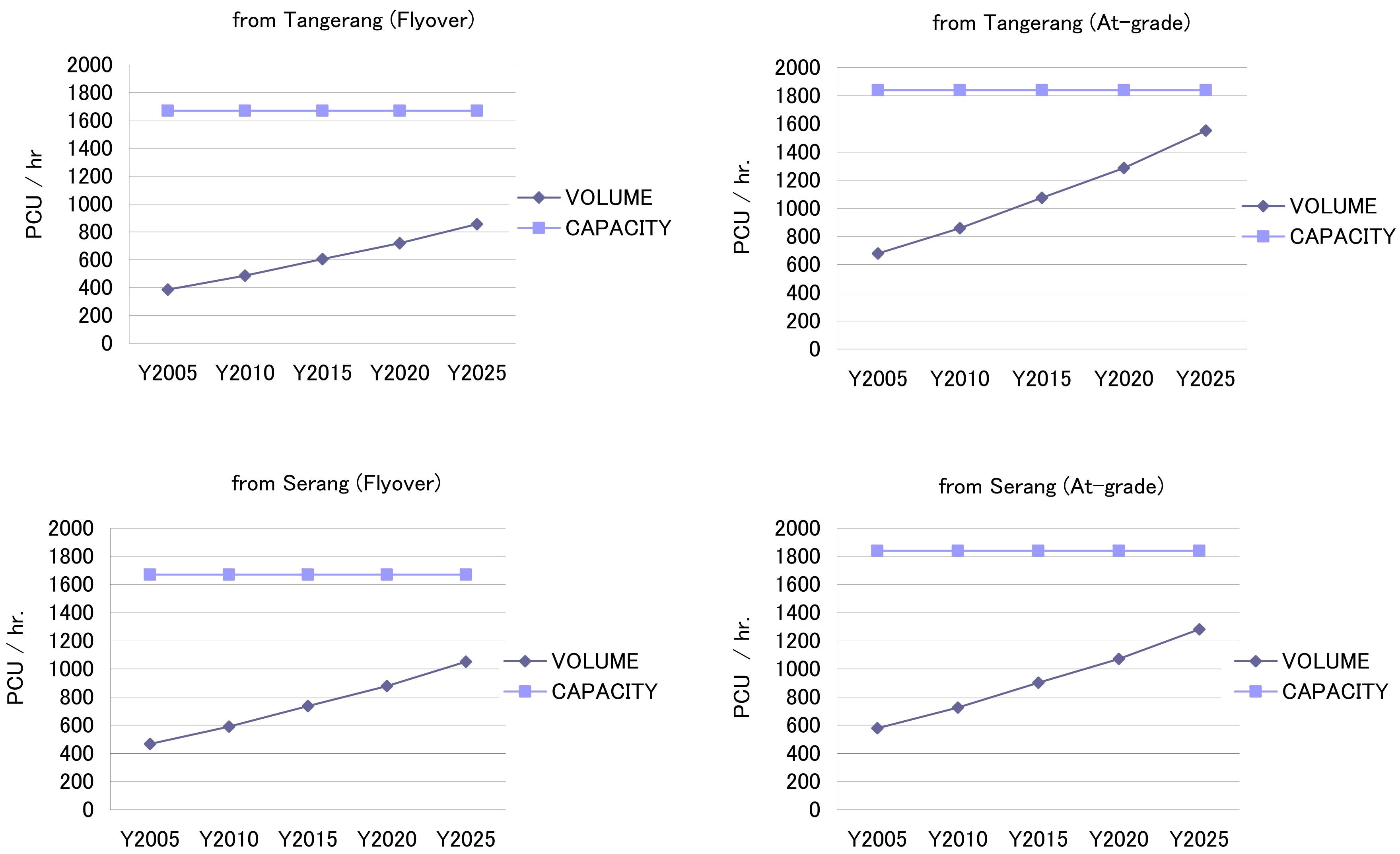
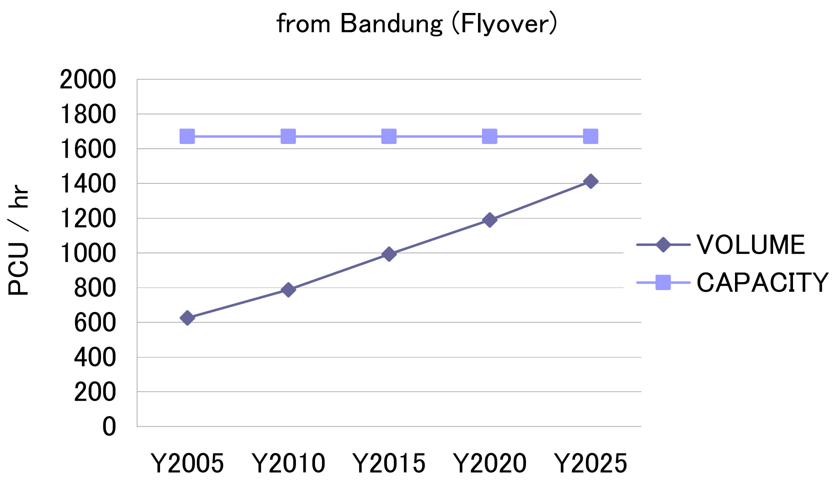
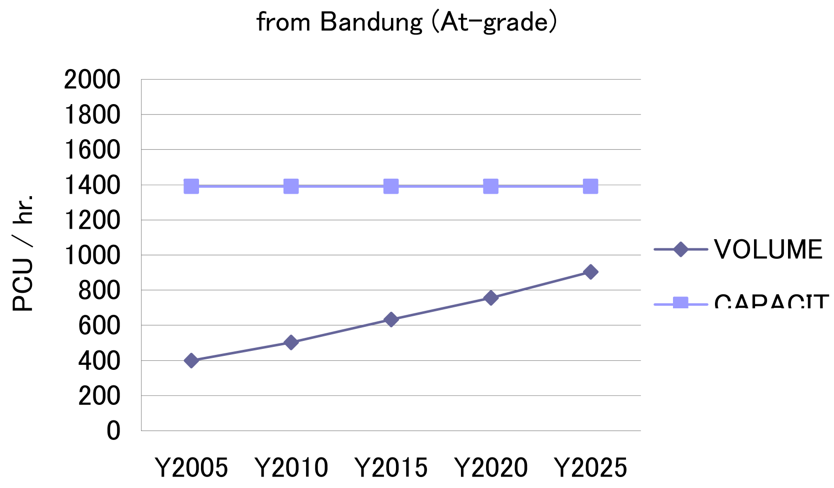
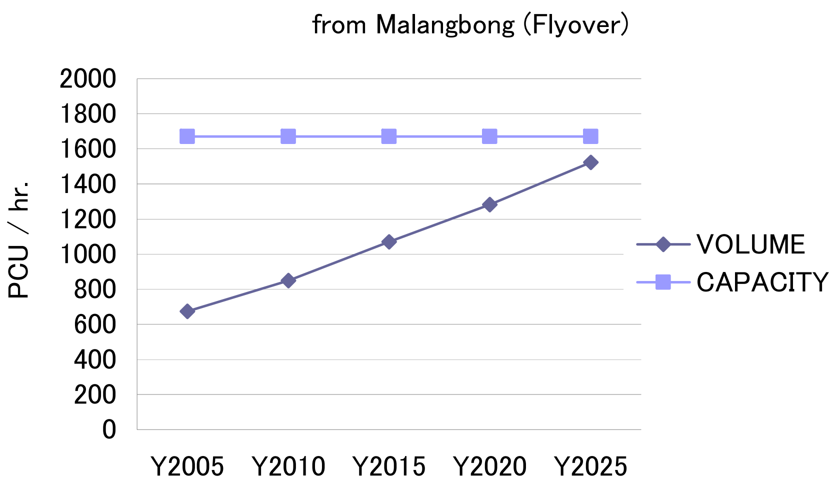


FIGURE 6.6.2-2 FUTURE TRAFFIC VOLUME AND CAPACITY WITH PROJECT (BALARAJA)







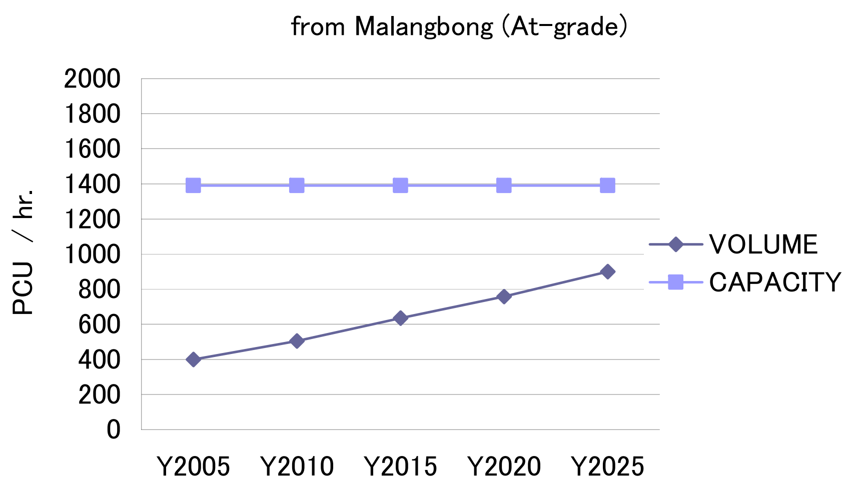


FIGURE 6.6.2-3 FUTURE TRAFFIC VOLUME AND CAPACITY WITH PROJECT (NAGREG)

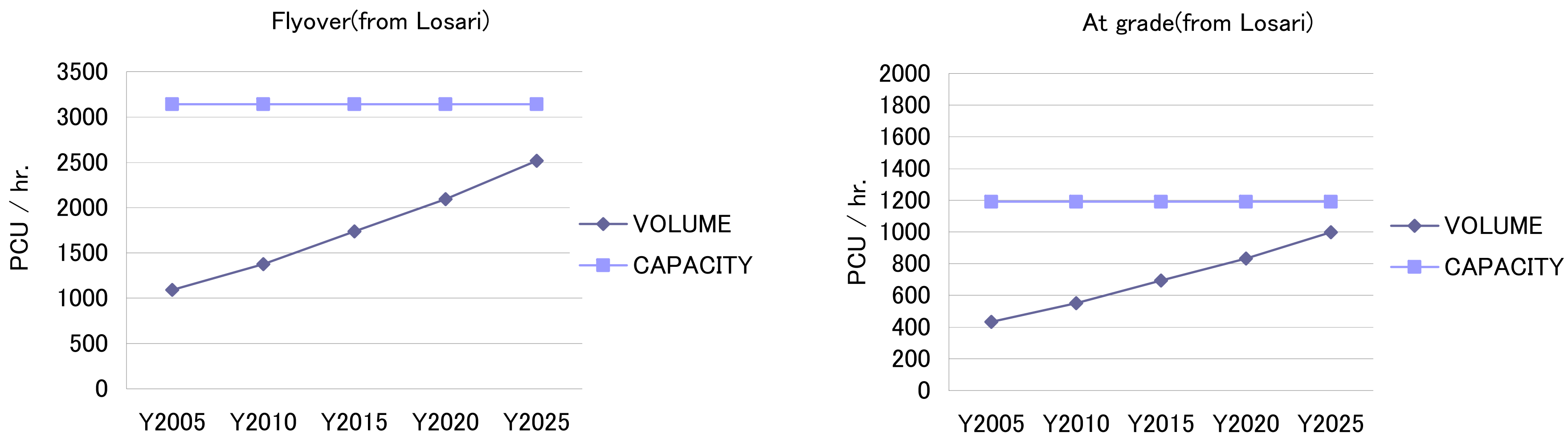


FIGURE 6.6.2-4 FUTURE TRAFFIC VOLUME AND CAPACITY WITH PROJECT (GEBANG)

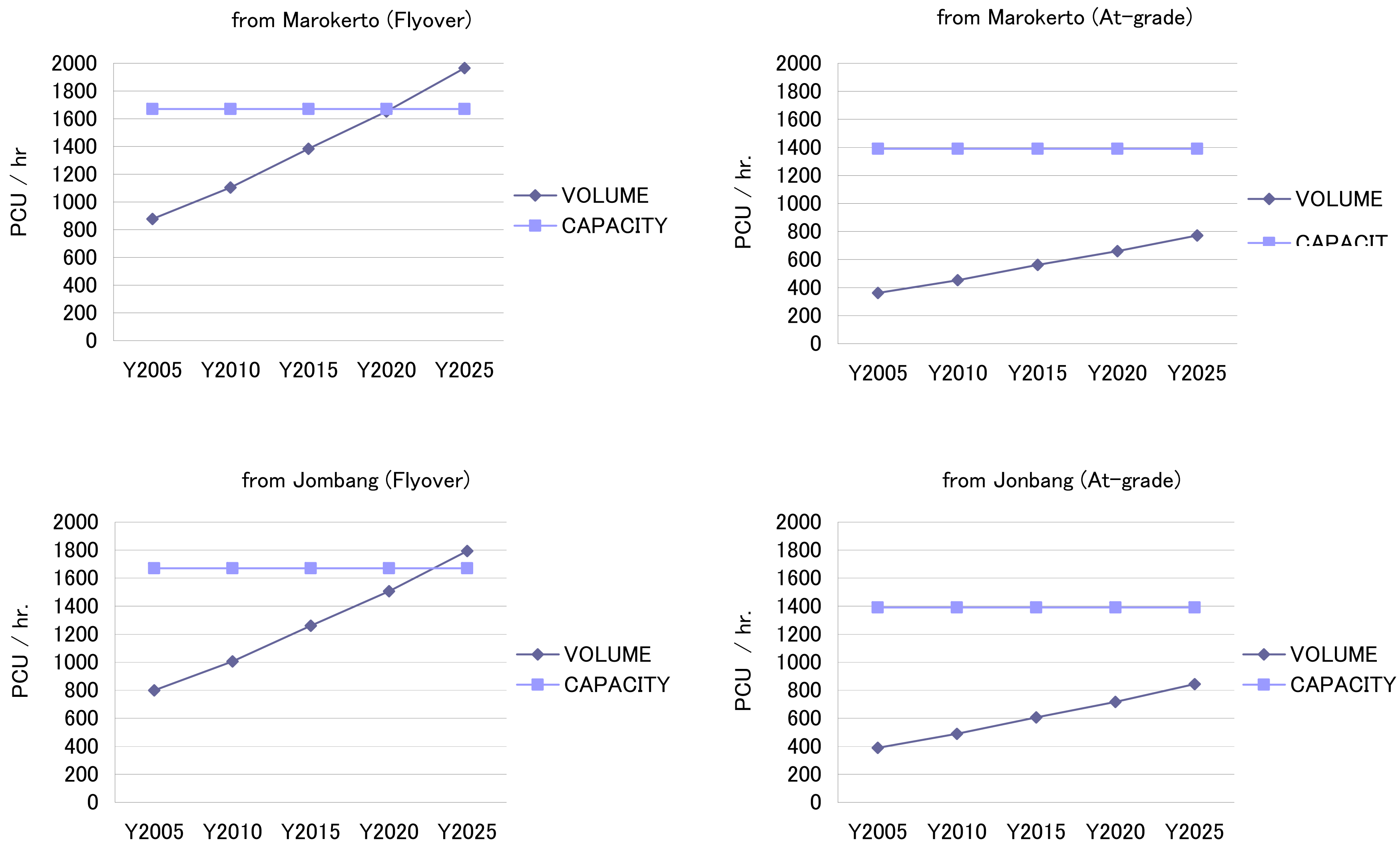


FIGURE 6.6.2-5 FUTURE TRAFFIC VOLUME AND CAPACITY WITH PROJECT (PETERONGAN)

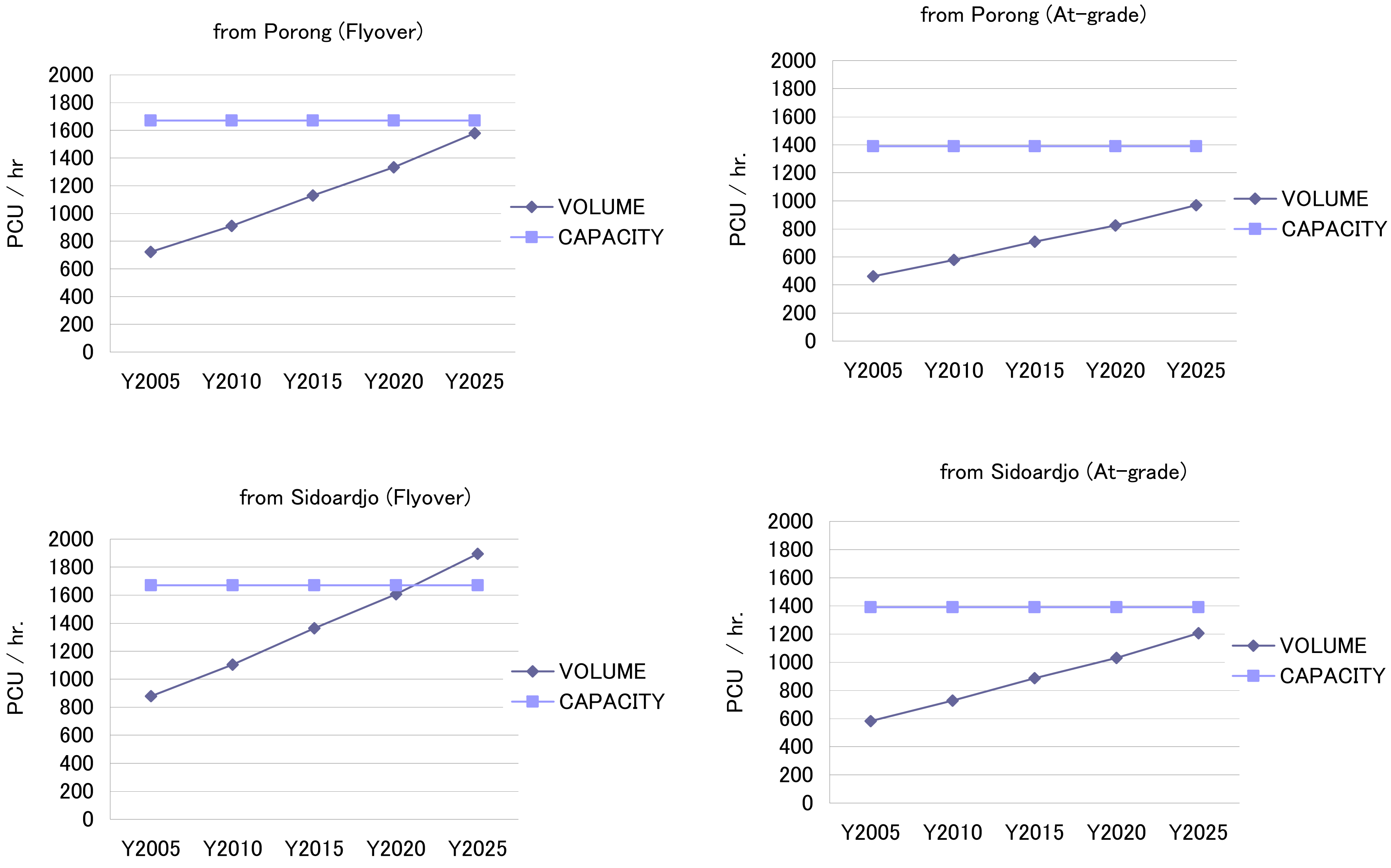


FIGURE 6.6.2-6 FUTURE TRAFFIC VOLUME AND CAPACITY WITH PROJECT (TANGGULANGIN)

PART III

DESIGN STANDARDS AND CRITERIA

CHAPTER 7

DESIGN STANDARDS AND CRITERIA

7.1 HIGHWAY DESIGN

7.1.1 Flyovers and Service Roads

The following Indonesian highway design standards and criteria were adopted:

- Standard Specifications for Geometric Design of Urban Roads, RSWI, T-14-2005
- Standard Specifications for Geometric Design of Urban Roads, 1992

In case that there were some lacking items or from the standpoint of economic consideration, other standards listed below were referred:

- A Policy on Geometric Design of Highways and Streets, 2004 (AASHTO)
- Road Structure Ordinance, Japan Road Association, 2004 (JRA)

Table 7.1-1 shows the geometric design standards of flyovers and service roads. The main points of the design were as follows:

- Flyovers are built over the existing road, therefore, the horizontal alignment was controlled by the existing road alignment.
- Design speed was also controlled by the existing road alignment. (The Feasibility study recommended 60km/hr. for a flyover, however, it was difficult for 3 flyovers to adopt the recommended design speed of 60km/hr.)
- Road right-of-way for Balaraja and Gebang was already acquired based on the SAPROF Study, and ROW acquisition negotiation has been started based on the SAPROF Study, therefore, flyovers were planned within the required or to-be-acquired ROW.
- Number of lanes recommended by the Feasibility Study was a 2-lane, 2-way flyover. The SAPROF Study also recommended a 2-lane 2-way flyover except Gebang which was proposed to be a 4-lane flyover with initial construction of a 2-lane 1-way flyover. This study adopted the recommendation of the SAPROF Study.
- Typical cross section of a flyover is shown in **Figure 7.1-1**.
    - ➢ Flyover requires sharp horizontal curve or S-curves
    - ➢ From the viewpoint of traffic safety, a mount-up center median is proposed.
    - ➢ Even a time of vehicle breakdown, space for another vehicle's passing was considered and carriageway width of 5.75m was proposed.

TABLE 7.1.1-1 GEOMETRIC DESIGN STANDARDS OF FLYOVERS AND SERVICE ROADS

Requiring Items for Geometric Design				Unit	Merak			Balaraja	Nagreg	Gebang	Peterongan	Tanggulangin
Road Function					Arterial			Arterial	Arterial	Arterial	Arterial	Arterial
Design Speed based on Existing Alignment				km/hr	40			40	50	80	80	80
Minimum Radius of Curvature : Rmin (Based on SAPROF Drawing)			Existing	m	65			75	55	∞	500	270
			Flyover	m	106			85	150	∞	800	250
FLYOVER	General	Design Vehicle Type		=	WB-15			WB-15	WB-15	WB-15	WB-15	WB-15
		Type of Pavement		=	ACP			ACP	ACP	ACP	ACP	ACP
		Design Speed (*Vr*)		km/hr	40			40	50	60	60	60
	Cross Section	Number of Lane		=	1 (One way) From Pulorida	1 (One way) From Harbour	2 (One way) To Jakarta	2 (Two way)	2 (Two way)	2 (One way)	2 (Two way)	2 (Two way)
		Total Flyover Width		m	6.75	7.00	9.00	13.00	13.00	9.00	13.00	13.00
		Total Roadway Width			5.75	6.00	8.00	5.75 + 5.75	5.75 + 5.75	8.00	5.75 + 5.75	5.75 + 5.75
		Traffic Lane Width		m	3.50	3.50	7.00	3.50	3.50	7.00	3.50	3.50
		Shoulder Width		m	2.00	2.25	0.50	2.00	2.00	0.50	2.00	2.00
		Median	Total Width	m	-	-	-	1.00	1.00	-	1.00	1.00
			Marginal Strip (One side)	m	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
		Cross Slope		%	2.0			2.0	2.0	2.0	2.0	2.0
	Horizontal	Minimum Radius of Horizontal Curve (*Rmin*)		m	55			55	90	135	135	135
		Minimum Length of Horizontal Curve (*Lh min*)		m	70			70	85	105	105	105
		Super-elevation	Maximum (*emax*)	%	6.0			6.0	6.0	6.0	6.0	6.0
			Runoff (Δ)	=	1/143			1/143	1/150	1/167	1/167	1/167
		Widening on Curve		m	3) 0.25	0.00	0.00	3) 0.75	3) 0.5	0.00	0.00	3) 0.25
		Minimum Spiral Curve Length (*Ls min*)		m	22			22	28	33	33	33
	Vertical	Maximum Grade (*Gmax*)		%	8.0			8.0	8.0	7.0	7.0	7.0
		Grade to be adopted for Flyover		%	5.0			5.0	5.0	5.0	5.0	5.0
		Critical Length of Grade (*Lc*)		m	400 (8.0 %)			400 (8.0 %)	400 (8.0 %)	400 (7.0 %)	400 (7.0 %)	400 (7.0 %)
		Stopping Sight Distance (*Ss*)		m	50			50	65	85	85	85
		Minimum Radius of Vertical Curve	Crest	m	450			450	800	1,400	1,400	1,400
			Sag	m	450			450	700	1,000	1,000	1,000
SERVICE ROAD	General	Design Speed (*Vr*)		km/hr	40			40	40	40	40	40
		Type of Pavement		=	ACP			ACP	ACP	ACP	ACP	ACP
	Cross Section	Number of Lane		=	1			2	1	1	1	1
		Roadway Width (One side)		m	5.50			6.00	5.50	5.00 ~ 5.50	5.50	5.50
		Traffic Lane Width		m	3.50			3.00	3.50	3.50	3.50	3.50
		Loading / Unloading Lane		m	2.00			0	2.00	1.50 ~ 2.00	2.00	2.00
		Sidewalk		m	1.50			1.55	2.05	1.50	1.50	1.50
		Cross Slope		%	2.00			2.00	2.00	2.00	2.00	2.00
R O W Width				m	12.5 ~ 27.6			1). 18.7 ~ 29.1	2). 19.1 ~ 29.1	1). 13.3 ~ 16.0	20.1 ~ 28.0	19.5 ~ 28.0

Note : 1). R O W acquitted 2). R O W being negotiated 3). Within Shoulder Width
Design Vehicle Type ; WB-15 = Intermediate Semi Trailer (l = 16.8 m, w = 2.5 m)

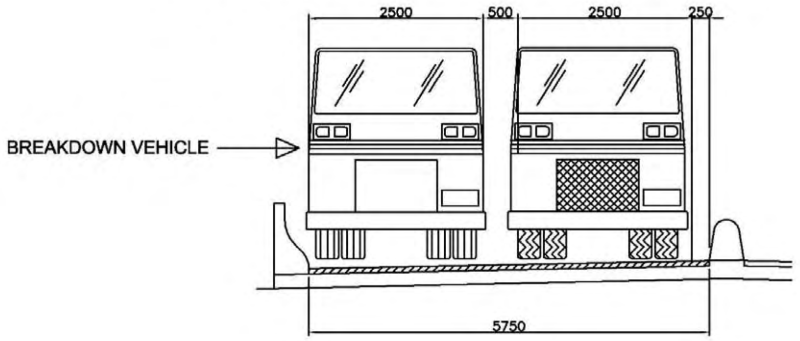
2 - LANE 2 - WAY WITH CENTER MEDIAN

1) EVEN IN CASE OF A VEHICLE BREAKDOWN, A SPACE THAT ANOTHER VEHICLE CAN PASS THROUGH MUST BE PROVIDED.

2) VEHICLE WIDTH
   Large Vehicle (Large Bus, Trucks etc.) = 2.5 m
   Small Vehicle (Cars, Small Trucks, etc.) = 1.7 m ~2.0 m

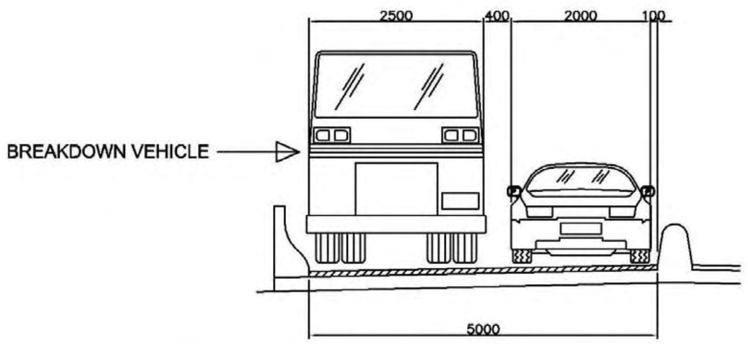
3) IN CASE OF VEHICLE BREAKDOWN :

CASE - 1 : LARGE VEHICLE + LARGE VEHICLE



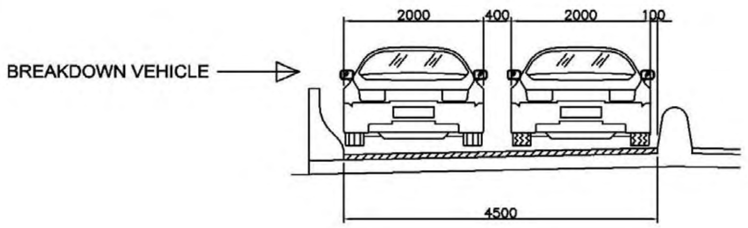
HIGH COMPOSITION OF LARGE VEHICLE

CASE - 2 : LARGE VEHICLE + SMALL VEHICLE



LOW COMPOSITION OF LARGE VEHICLE

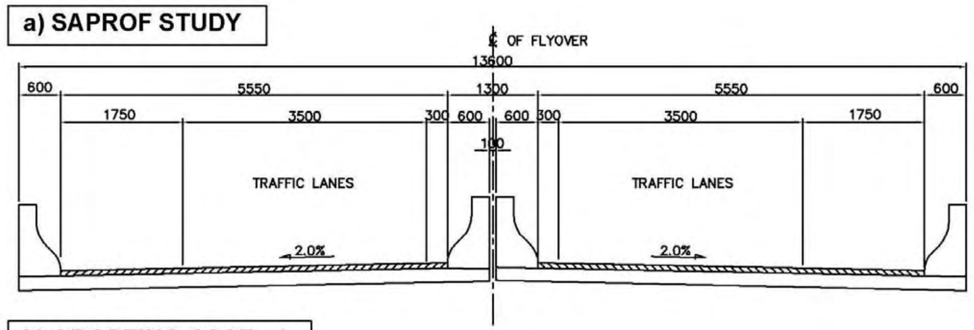
CASE - 3 : SMALL VEHICLE + SMALL VEHICLE



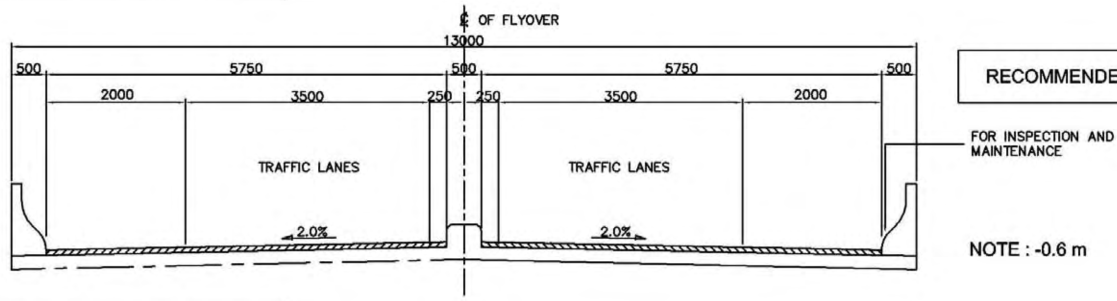
NO LARGE VEHICLE

2 - LANE 2-WAY FLYOVER TYPICAL CROSS SECTION

a) SAPROF STUDY



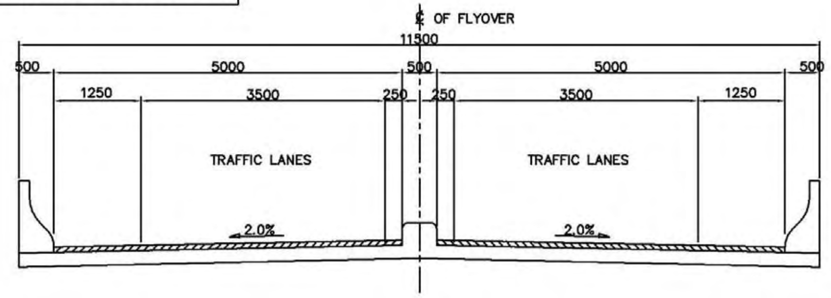
b) ADOPTING CASE - 1



RECOMMENDED

NOTE : -0.6 m

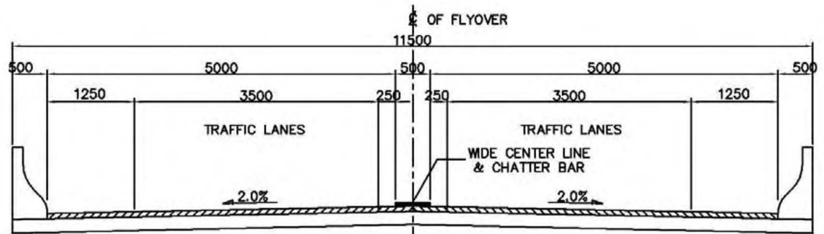
c) ADOPTING CASE - 2



SECONDARY RECOMMENDED

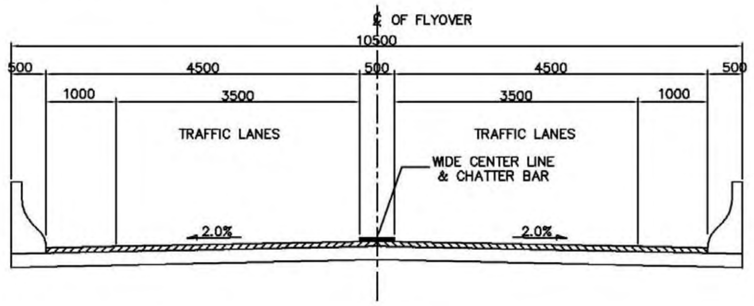
FOR CURVE SECTION (W/ MOUNT-UP CENTER MEDIAN)

NOTE : -2.1 m



FOR STRAIGHT SECTION (WITHOUT MOUNT-UP CENTER MEDIAN PROVIDE WIDE CENTER LINE AND CHATTER BARS)

d) NO CENTER MEDIAN SEPARATOR



NOT RECOMMENDED

VEHICLE BREAKDOWN
5.50 + 4.0 = 9.50 m

NOTE : -2.6 m

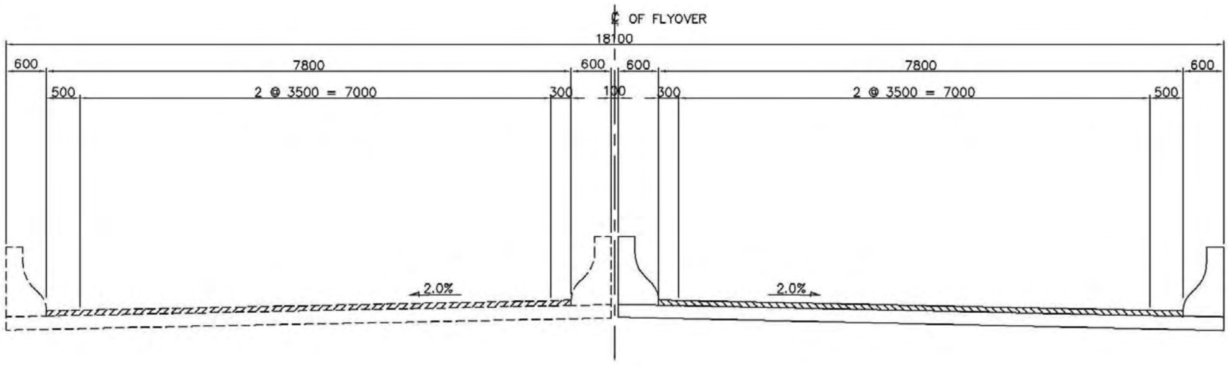
FIGURE 7.1.1-1 (1/3) TYPICAL CROSS SECTION OF FLYOVER

2-LANE 1-WAY FLYOVER : STAGE CONSTRUCTION

(GEBANG FLYOVER)

GEBANG FLYOVER IS PLANNED TO BE CONSTRUCTED BY STAGES

SAPROF STUDY



ALTERNATIVE

RECOMMENDED

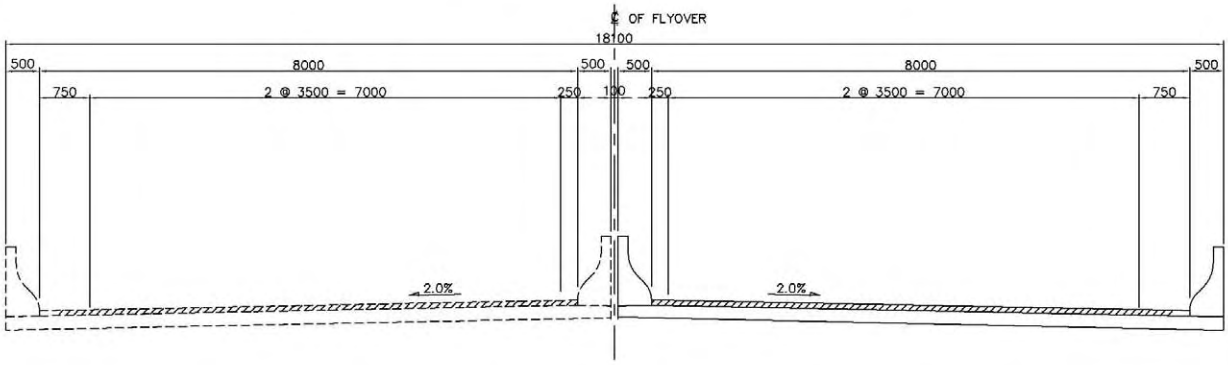
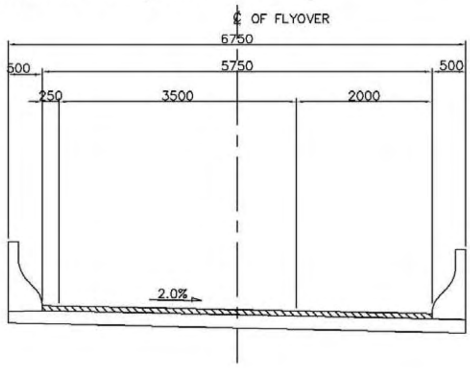


FIGURE 7.1.1-1 (2/3) TYPICAL CROSS SECTION OF FLYOVER

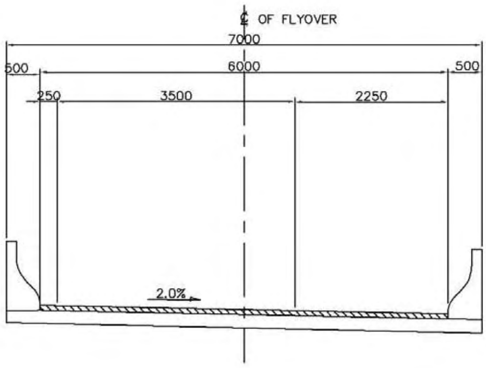
1-LANE 1-WAY, 2-LANE 1-WAY FLYOVER

(MERAK FLYOVER)

From Pulorida (National Road) 1-LANE 1-Way



Ferry Terminal Exit Ramp



To Jakarta 2-LANE 1-Way

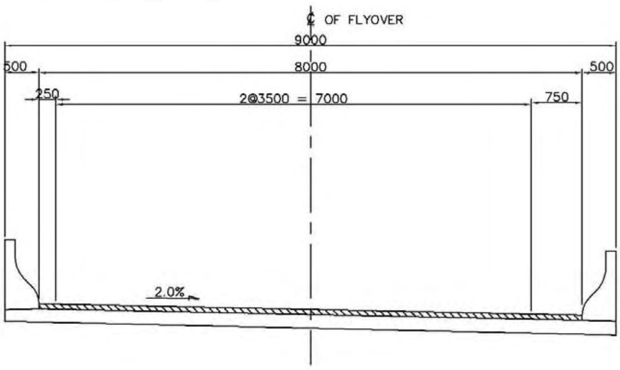


FIGURE 7.1.1-1 (3/3) TYPICAL CROSS SECTION OF FLYOVER

7.1.2 Intersection Design

The same standards described in 7.1.1 were followed. AASHTO and JRA standards were also referenced. Intersection geometric standards are shown in **Table 7.1.2-1**.

TABLE 7.1.2-1 GEOMETRIC DESIGN STANDARDS FOR INTERSECTIONS

DESIGN ELEMENTS/PARAMETERS		UNIT	INTERSECTION
MAIN ELEMENTS	Design Speed	kph	40
	Minimum Radius	m	55
	Maximum Superelevation Rate	%	4
	Minimum Visibility Distance for Traffic Signal	m	100
	Minimum Length of Level Section at the Intersection Approach	m	15
	Maximum Vertical Grade at Intersection Approach	%	2.5
	Storage Length	m	30
	Minimum Storage Lane Width	m	2.75
	Minimum Transition Length	m	30
	Minimum Taper Length	m	30
	Deceleration Length (including taper)	m	45
	Acceleration Length (including taper)	m	55
TURNING ELEMENTS	Design Vehicle		SU
	Design Turning Speed	kph	20
	Minimum Turning Radius (inner edge)	m	15
	Width of Turning Lane	m	4.5

Note; SU (Single Unit Truck)

7.2 PAVEMENT DESIGN

7.2.1 Design Standards

The following pavement design standards in Indonesia for flexible pavement and rigid pavement were adopted:

- Guide for Flexible Pavement Design (Pedoman Penentuan Tebal Perkerasan – Jalan Raja, No 01/PD/b/1983) published by Bina Marga.
- Guide for Rigid Pavement Design (Pedoman Perencanaan Perkerasan Kaku, No. 009/T/BNKT/1988) published by Bina Marga.
- Road Design System (RDS) ver.5, one of the software design pavement that developed by Bina Marga. That usually used in the pavement design to National and Provincial road.

7.2.2 Design Procedure

<u>Design Condition</u>

Design Period: 2008 ~ 2017 (10 years) for flexible pavement

Equivalent Singe Axle Loads (ESAL) (W_{18})

- Sedan 0.0012
- Oplet, Minibus 0.2165
- Small Bus 0.2458
- Bus 1.0413
- Truck 2As 2.9918
- Truck 3As 5.3443
- Semi Trailer 4.1269

Reliability: 90% (AASHTO standard for Arterial Road).
(Standard Normal Deviation Z_R = - 0.84)
(Standard Error S_O = 0.45)

Serviceability index: Initial Serviceability Po = 4.2 (AASHTO Road Test Result)
Final Serviceability Pt = 2.5 (AASHTO Standard Value for arterial road)
Δ Psi = Po – Pt = 1.7

Resilient Modulus: M_R = 1500 x CBR = 7500 (CBR Sub-grade 5%)

Structural Coefficient

- Structure Number A/C Wearing Course (MS/100kg) per cm = 0.410
- Structure Number A/C Binder Course (MS/100kg) per cm = 0.410
- Structure Number A/C Base (MS 900kg) per cm = 0.300
- Structure Number A/C Sub-base (class A) per cm = 0.132 (CBR = 80)
- Structure Number A/C Sub-base (class B) per cm = 0.110 (CBR = 30)

Drainage Coefficient

For Base course good condition (assumption)
Present of time pavement to moisture level > 25%

Design ESAL

$$W_{18} = D_D \times Di \times W_{18}$$

Where:

D_D	=	a directional distribution factor
D_L	=	a lane distribution factor
W_{18}	=	the predicted cumulative two-directional 18-kip ESAL units
	=	AADT x 365 x Tf x ESALF
AADT	=	an annual average daily traffic
Tf	=	a traffic growth factor
	=	$\frac{(1 + i/100)^n - 1}{i/100}$
i	=	a traffic growth rate (%)
n	=	analysis period (years)
ESALF	=	an equivalent single axle load factor

Structure Number.

$$\text{Log}_{10}(W_{18}) = Z_R \times S_O + 9.36 \times \log_{10}(SN+1) - 0.2 + \frac{\text{Log}_{10}\left(\triangle \text{Psi}/(4.2-1.5)\right)}{04 + \frac{1094}{(SN+1)}519} + 2.32 \times \text{Log}_{10}(M_R) - 8.07$$

SN is equal to the structure number indicative of the total pavement thickness required.

$$SN = a_1 D_1 + a_2 D_2 m_2 + a_3 D_3 m_3$$

Where

a_i = i th layer coefficient

D_i = i th layer thickness (inches), and

m_i = i th layer drainage coefficient

7.3 BRIDGE DESIGN STANDARDS AND CRITERIA

7.3.1 Design Standards and Specifications

The North Java Corridor Flyover Project shall be designed in accordance with the following Design Codes and Standards.

- Bridge Design Code, Draft, Volume 1 and Volume 2 – Bridge Management System 1992, Direktorat Jenderal Bina Marga Departemen Pekerjaan Umum.
- Bridge Design Manual, Draft, Volume 1 and Volume 2 – Bridge Management System 1992, Direktorat Jenderal Bina Marga Departemen Pekerjaan Umum.
- Pembebanan untuk jembatan, RSNI4.
  (Loading for Bridges)
- Standar perencanaan ketahanan gempa untuk jembatan, SNI.
  (Design Standard of Earthquake Resistance for Bridges)
- Perencanaan struktur beton untuk jembatan, RSNI
  (Design of Concrete Structure for Bridge)
- Perencanaan struktur baja untuk jembatan, ASNI4
  (Design of Steel Structure for Bridge)
- AASHTO LRFD Bridge Design Specifications, 3rd Edition.

For design requirements not covered by the above Codes and Standards the following references will be used as required:

- Japanese Specifications for Highway Bridges
- AS 5100, Bridge Design, Australian Standard, 2004
- FHWA-IF-99-025, "Drilled Shafts: Construction Procedures and Design Methods", 1999
- FHWA-NHI-00-043, "Mechanically Stabilized Earth Walls and Reinforced Soil Slopes, Design & Construction Guidelines", 2001
- NCHRP Report 529, "Guidelines and Recommended Standard for Geofoam Applications in Highway Embankments", Transport Research Board, 2004

7.3.2 Loads and Load Combinations

1) Live Load

a) General

Traffic load for bridge design consists of “D” lane load and the “T” truck load. The “D” loading applies across the full width of the bridge roadway and produces effects in the bridge equivalent to a queue of real vehicles. The total amount of “D” lane load applied depends on the width of the bridge roadway.

The “T” truck load is equivalent to load of a single heavy vehicle with three axles which is placed in any position in a Design Traffic Lane. Only one “T” truck may be applied per Design Traffic Lane.

In general, “D” lane load will determine medium to long span calculation, whereas T” load is used for short spans and deck systems.

b) Design Traffic Lane

Design traffic lanes shall be 2.75m wide. The maximum number of design traffic lanes to be used is shown in **Table 7.3.2-1**.

TABLE 7.3.2-1 NUMBER OF DESIGN TRAFFIC LANES

Bridge Type (1)	Bridge Roadway Width (m) (2)	No. Design Traffic Lanes
Single Lane	4.0 – 5.0	1
Two-way, no median	5-5 – 8.25	2 (3)
	11.3 – 15.0	4
Multiple-roadway	8.25 – 11.25	3
	11.3 – 15.0	4
	15.1 – 18.75	5
	18.8 – 22.5	6

Note:

(1) For other types of bridges the number of design traffic lanes shall be determined by the Authority.

(2) Roadway width is the minimum distance between kerbs or barriers for a single roadway bridge, or the distance between kerbs/barrier/median and median for a multiple-roadway bridge.

(3) The minimum safe width for a two-lane bridge is 6.0m.

c) “D” Lane Loading

- Uniformly Distributed Load (UDL)

$q = 9.0$ kPa for $L \leq 30$m
$q = 9.0 \times (0.5+15/L)$ kPa for $L > 30$m

where, q = Load Intensity (kPa)
L = Total loaded length (m)

The relationship is shown in **Figure 7.3.2-1**.

The UDL may be applied in broken lengths to maximize its effects on continuous bridges or unusual structures. Refer to **Figure 7.3.2-2**.

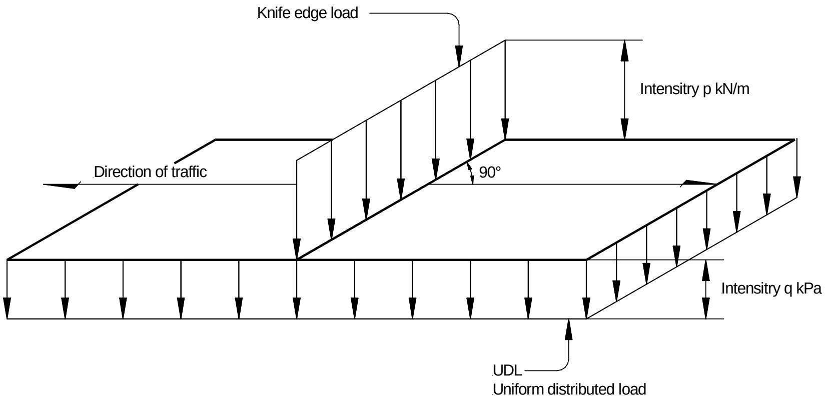


FIGURE 7.3.2-1 "D" LANE LOADING

- Knife Edge Load (KEL)

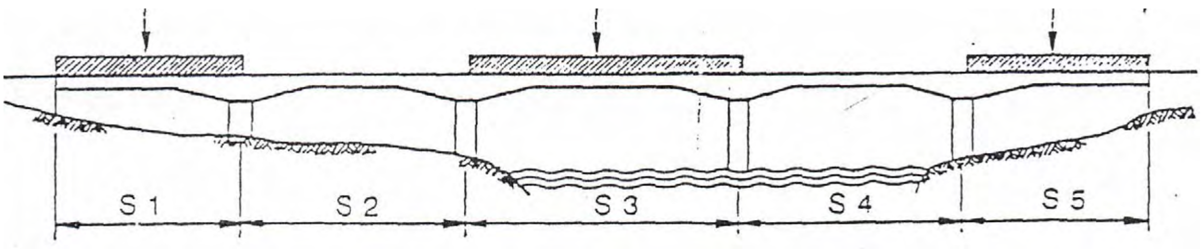
p = 49.0 KN/m

A single KEL perpendicular to the direction of traffic shall be placed in any position along the bridge. For continuous bridges, a second KEL shall be placed in the same lateral position on the bridge but in another span to produce the maximum negative bending moment.

- Lateral distribution of "D" loading

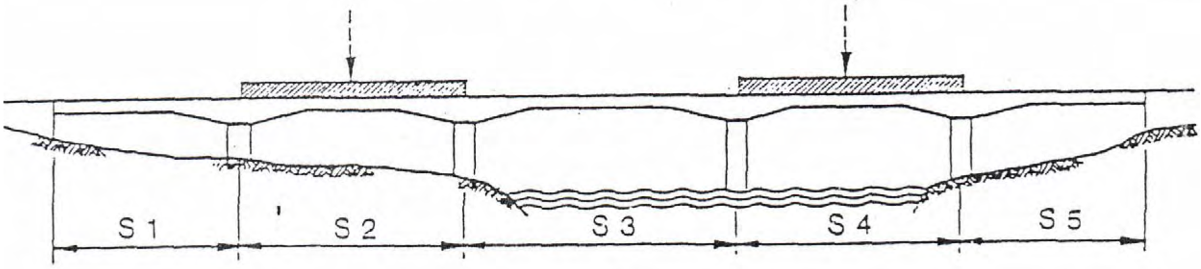
"D" loading shall be applied in transversal direction as such arrangement to produced maximum moment.

100 % "D" loading shall be applied for width of road way 5.5 m or less, then in case of more than 5.5 m for a width of road way, 100 % "D" loading shall be applied for width of road way depend on number of lanes which is n_i x 2.75 m (n_i = number of lanes), and 50 % on the remaining width of the road way. This arrangement is shown in **Figure 7.3.2-3**.



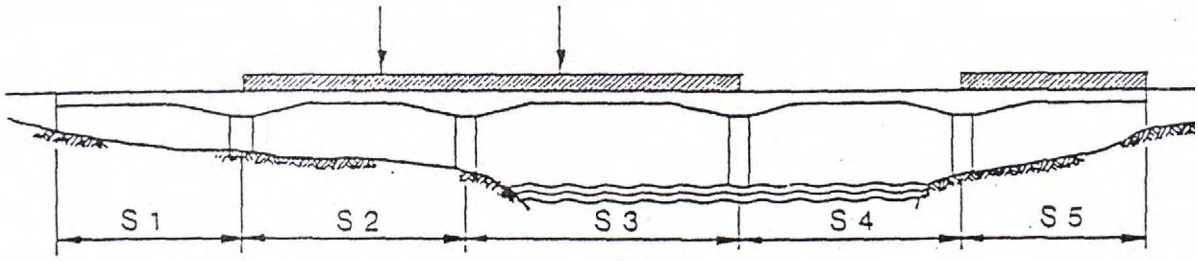
For maximum bending moment in Span 1: place KEL in Span 1;
(Span 5 similar) take L = worst effect from S_1; $S_1 + S_3$; or $S_1 + S_3 + S_5$
For maximum bending moment in Span 3: place KEL in Span 3;
take L = worst effect from S_3; $S_1 + S_3$; or $S_3 + S_5$

a. POSITIVE BENDING MOMENTS - SPANS 1, 3, 5



For maximum bending moment in Span 2: place KEL in Span 2;
take L = worst effect from S_2 or $S_2 + S_4$
For maximum bending moment in Span 4: place KEL in Span 4;
take L = worst effect from S_4 or $S_2 + S_4$

b. POSITIVE BENDING MOMENTS - SPANS 2,4



For maximum bending moment at Pier 2: place KEL in Spans 2 and 3;
take L = worst effect from $S_2 + S_3$ or $S_2 + S_3 + S_5$

c. NEGATIVE BENDING MOMENT AT PIER

Extent of UDL | Position of KEL | Alternative positions of KEL

FIGURE: 7.3.2-2 "D" LOADING ARRANGEMENT

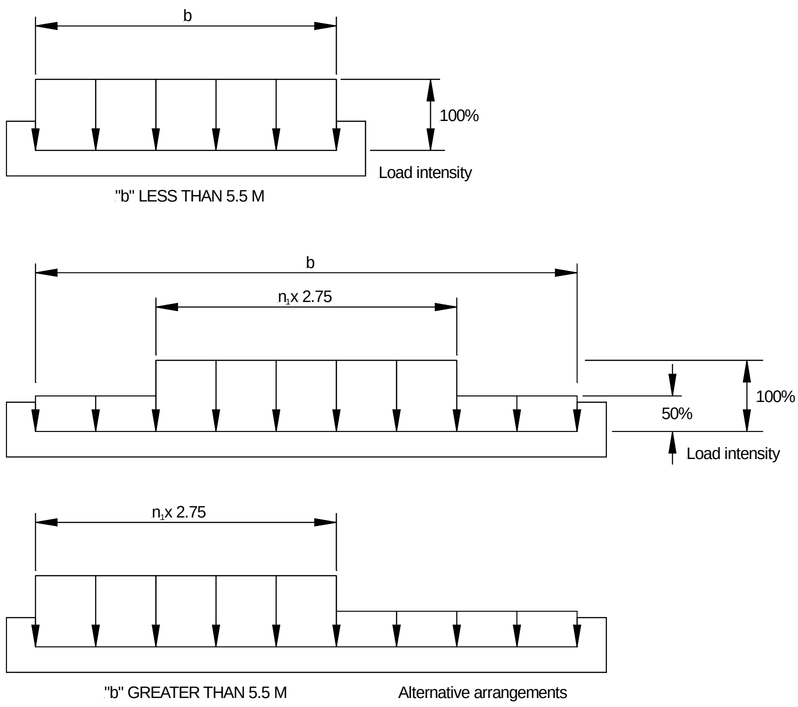


FIGURE: 7.3.2-3 LATERAL DISTRIBUTION OF "D" LOADING

d) **"**T" Truck Loading

The "T" truck loading is a single heavy vehicle with three axles shown in **Figure 7.3.2-4** and **Table 7.3.2-2** below, which shall be applied in any position in a design traffic lane.

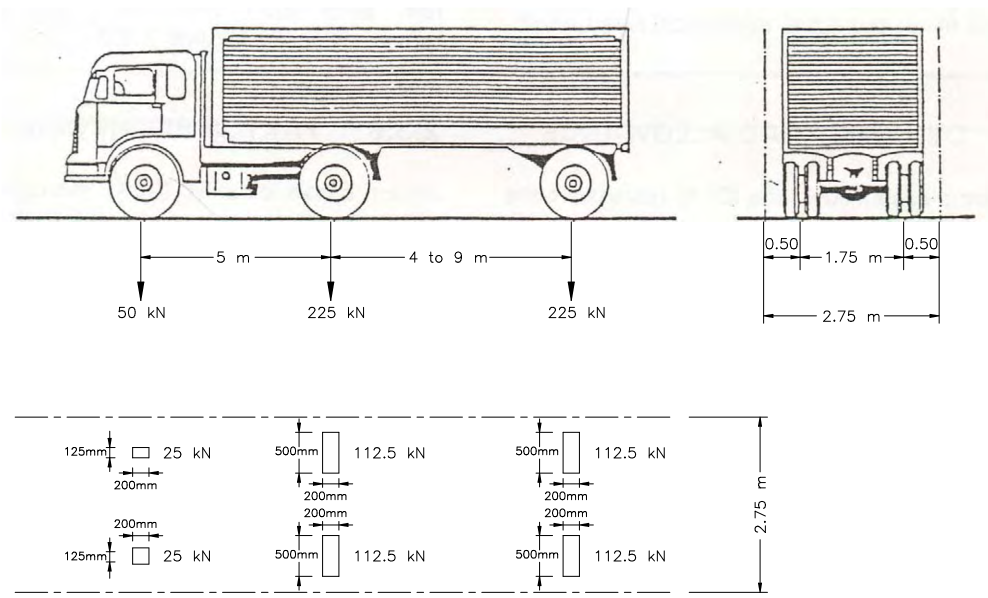


FIGURE 7.3.2-4 "T" TRUCK LOADING

TABLE 7.3.2-2 WHEEL LOAD

	Width (mm)	**Length (mm)**	**Load (kN)**
A Wheel	125	200	25
B Wheel	500	200	112.5

Only one "T" truck shall be placed in any design traffic lane, irrespective of the length of the bridge or the arrangement of spans.

e) Dynamic Load Allowance

For KEL of "D" loading, I = 0.4 – (LE – 50) / 400

However, $0.3 \leq i \leq 0.4$

Where,
i : Dynamic load allowance
L_E : Span length (m)

For continuous spans, $L_E = \sqrt{Lav \times L\max}$, with:

Lav : Average span length of a group of continuously connected spans (m)

Lmax : Maximum span length of a group of continuously connected spans (m)

For "T" truck loading, i = 0.3

For underground structures, i = 0.4 – 0.15 x D

However, $0.1 \leq i \leq 0.4$

Where, D: Depth from the ground surface (m)

f) Braking Force

Braking force (kN) should be considered as 5 % of "D" loading on each traffic lane, without being multiplied by dynamic allowance. The braking force acting in the horizontal axis direction on the bridge shall be assumed to act at position 1.8 m above the road surface. "D" loading for bridge span length more than 30 m shall not be reduced and shall be used as a value of q = 9 kPa.

g) Centrifugal Force

Bridges on curves shall consider subject to a radial horizontal force assumed act at 1.8 m above road surface in a radial outward direction.

Centrifugal force shall act in the same time with "D" load or "T" load with the same arrangement along the bridge.

Centrifugal force is determined with the formula as follows :

$$T_{TR} = 0.79 \cdot \frac{V^2}{r} \cdot T_T$$

Where,
T_{TR} : Centrifugal force acting on a section of the bridge
T_T : Total traffic loading acting on the same section on the bridge
(T_{TR} and T_T shall have same units)
V : Design traffic speed (km/h)
r : Radius of curve (m)

"D" loading for bridge span length more than 30 m shall not be reduced and shall be used as a value of q = 9 kPa.

h) Pedestrian Loading

Pedestrian loading shall be in accordance with **Table 7.3.2-3**.

TABLE 7.3.2-3 PEDESTRIAN LOADING

	Pedestrian Load (kPa)
• All elements of a sidewalk or pedestrian bridge which directly carry the pedestrian traffic.	W = 5
• For footbridges and sidewalks independent of the road bridge superstructure.	W = 1/15 x (160 – A) $4 \leq W \leq 5$
• For sidewalks attached to the road bridge superstructure	W = 1/30 x (160 – A) $2 \leq W \leq 5$

Where, A: Loaded area (m2)

Where it is possible for a vehicle to go atop the sidewalk, or for light vehicles or livestock to use the sidewalk, the sidewalk shall be designed to carry an isolated concentrated load of 20 kN.

2) Seismic Forces

a) Base Shear Coefficient

The peak ground accelerations of bedrock in Indonesia for a 500 year return period are given in **Figure 7.3.2-5**. For the purpose of mapping peak ground acceleration Indonesia is divided into six seismic zones.

The peak ground acceleration of bedrock at each of the Project Flyover sites, obtained from **Figure 7.3.2-5**, is presented in **Table 7.3.2-4.**

TABLE 7.3.2-4 SEISMIC ZONE AND PEAK GROUND ACCELERATION

Name of Flyover	Seismic Zone	Peak Ground Acceleration
MERAK	2	0.46 – 0.50
BALARAJA	3	0.36 – 0.40
NAGREG	3	0.36 – 0.40
GEBANG	3	0.36 – 0.40
PETERONGAN	4	0.26 – 0.30
TANGGULANGIN	4	0.26 – 0.30

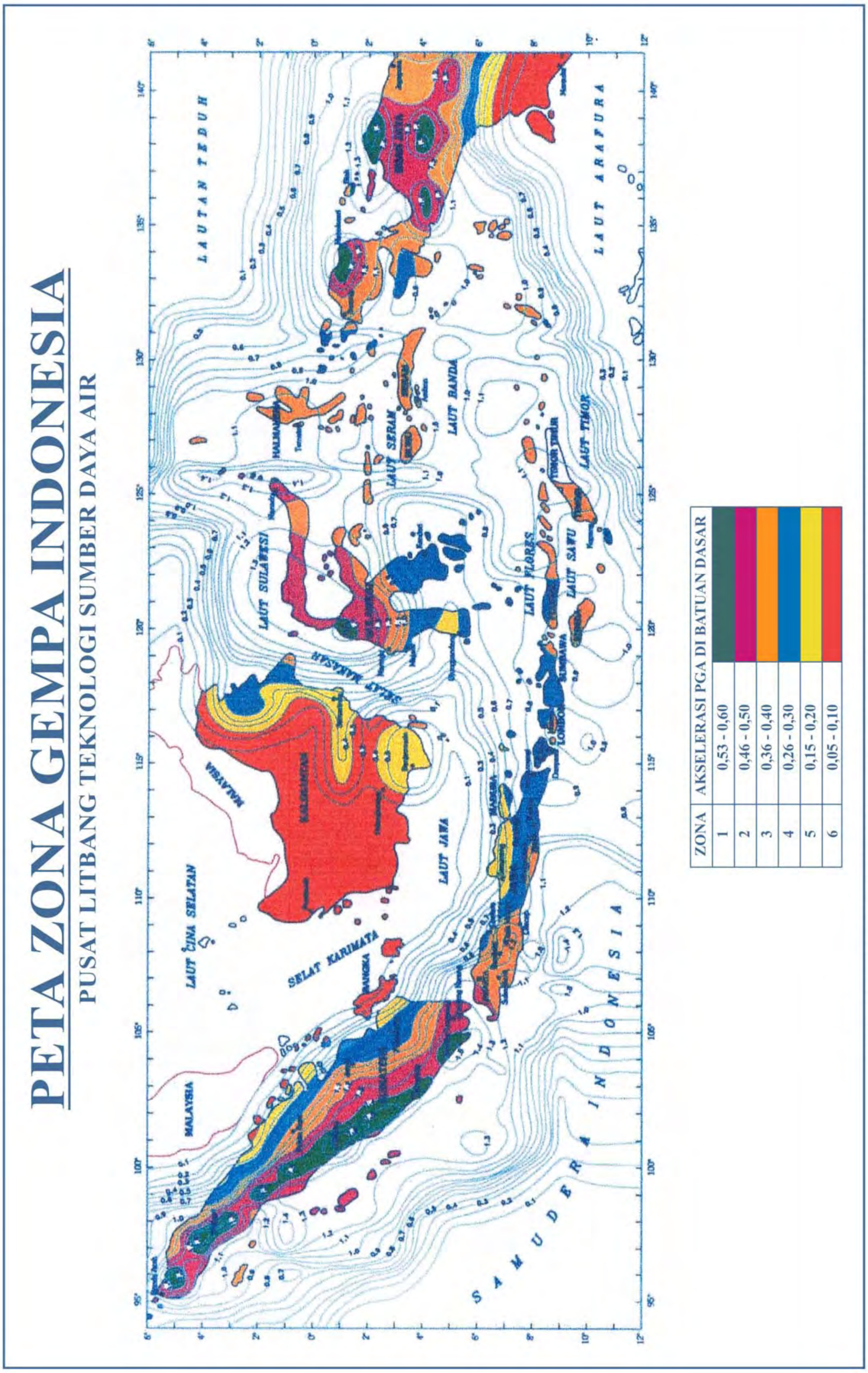
The elastic base shear coefficient $C_{elastic}$ can be calculated by the formula:

$$C_{elastic} = \frac{1.2 \cdot A \cdot S}{T^{2/3}}$$

with requirement Celastic ≤ 2.5 A

where:

A = Peak acceleration on the bed rock (gal)
T = Natural period of the structure (second)
S = Soil coefficient (refer to Table 7.3.2-5)



Gambar 6 Wilayah Gempa Indonesia untuk perioda ulang 500 tahun

FIGURE 7.3.2-5 MAP OF SEISMIC ZONES FOR INDONESIA WITH A 500 YEAR RETURN PERIOD

TABLE 7.3.2-5 SOIL COEFFICIENT (S)

S (Firm Soil)	S (Medium Soil)	S (Soft Soil)
S = 1.0	S = 1.2	S = 1.5

The type of soil is taken from **Table 7.3.2-6**.

TABLE 7.3.2-6 SOIL CONDITION FOR BRIDGE BASE SHEAR COEFFICIENT

Soil Type	Depth to Rock-like Material		
	Firm Soil	Medium Soil	Soft Soil
For all Soils	≤ 3m	> 3m up to 25m	> 25m
For a cohesive soil with an average undrained shear strength not exceeding 50 kPa	≤ 6m	> 6m up to 25m	> 25m
Any site where the overlying soils are either cohesive with an average undrained shear strength greater than 100 kPa, or a very dense granular material	≤ 9m	> 9m up to 25m	> 25m
For a cohesive soil with an average undrained shear strength not exceeding 200 kPa	≤ 12m	> 12m up to 30m	> 30m
For a very dense cemented granular soil	≤ 20m	> 20m up to 40m	> 40m

b) Response Modification Factor

The design seismic force shall be obtained by dividing the elastic response by a response modification factor (R) referring to degree of ductility.

Response modification factor for degree of ductility is as shown in **Table 7.3.2-7**.

TABLE 7.3.2-7 RESPONSE MODIFICATION FACTOR (R) FOR COLUMN AND CONNECTION WITH THE SUB-STRUCTURE

Type of Structures	Column or Pier	Connection with the sub-structure		
		Abutment (*2)	Column, Pier and Pile (*3)	Expansion Joint
Wall Pier Type (*1)	2 (Major Axis) 3 (Minor Axis)	0.8	1.0	0.8
Single Column	3-4			
Multiple Column	5-6			
Pile Cap Beam Concrete	2-3			

Note:

(*1) Wall pier type can be designed as single column on the direction of minor axis.

(*2) Simple span bridge in connection with abutment can use factor (R) as a value of 2.5.

(*3) As an alternative the column connection can be designed for maximum force produced by column plastic hinge.

For multiple pier column, response modification factor (R=5) shall be adopted for both octagonal axis and (R=0.8) shall be adopted for connection of superstructure with abutment, and also (R=1.0) shall be adopted for connection column on pile cap or superstructure and column on foundation.

For foundation design, one half of factor (R) shall be for seismic zone 5 and 6, but for zone 1 to 4 and for pile bent type, factor (R=1) shall be adopted.

3) Load Factors

The load factors used in the load combinations are in accordance with Indonesian Standard "Loading for Bridges" and AASHTO LRFD as given in **Table 7.3.2-8**.

TABLE 7.3.2-8 LOAD FACTORS

Load	Load Factors			
	Serviceability Limit State	Ultimate Limit State		
Dead	1.0	Steel	1.1 normal	0.90 relieving
		Pre cast Concrete	1.2 normal	0.85 relieving
		In situ Concrete	1.3 normal	0.75 relieving
Superimposed Dead	1.0	2.0 normal		0.7 relieving
Shrinkage and Creep	1.0	1.0		
Prestressing Effects	1.0	1.0 (1.15 at transfer)		
Settlement	1.0	Not applicable		
Traffic Load	1.0	1.8		
Braking	1.0	1.8		
Centrifugal	1.0	1.8		
Pedestrian	1.0	1.8		
Collision Loads	1.0	Not applicable		
Temperature	1.0	1.2 normal		0.8 relieving
Wind	1.0	1.2		
Earthquake	Not applicable	1.0		
Bearing Friction	1.0	1.3 normal		0.8 relieving

4) Load Combinations

a) General

This section is restricted to combination of actions for service ability limit state and the ultimate limit state.

Design actions are classified into permanent and transient actions, as listed in **Table 7.3.2-9**.

The load combinations are generally based on the probabilities of these different types of actions occurring simultaneously. The design actions are determined from the nominal actions by multiplying the nominal actions by the appropriate load factor.

All the effect from a design action must take the same load factor, whether normal or relieving. The worst case should be taken.

TABLE 7.3.2-9 TYPES OF DESIGN ACTIONS

Permanent Actions		Transient Actions	
Name	**Symbol**	**Name**	**Symbol**
Self Weight	P_{MS}	"D" Lane load	T_{TD}
Superimposed dead load	P_{MA}	"T" Truck Load	T_{TT}
Shrinkage / creep	P_{SR}	Breaking force	T_{TB}
Prestress	P_{PR}	Centrifugal force	T_{TR}
Permanent Construction Effect	P_{PL}	Pedestrian load	T_{TP}
Earth Pressure	P_{TA}	Collision load	T_{TC}
Settlement	P_{ES}	Wind load	T_{EW}
		Earthquake	T_{EQ}
		Vibration	T_{VI}
		Bearing friction	T_{BF}
		Temperature Effect	T_{ET}
		Stream/debris/log impact	T_{EF}
		Hydro/Buoyancy	T_{EU}
		Construction load	T_{CL}

b) Effect of design life

The load factors for the ultimate limit state are based on a bridge design life of 50 years. For bridges with a different design life, the ultimate load factor shall be varied by the factors given in the **Table 7.3.2-10.**

TABLE 7.3.2-10 EFFECT OF DESIGN LIFE ON ULTIMATE LOAD FACTOR

Bridge Classification	Design Life	Multiply K by	
		Permanent Action	**Transient Action**
Temporary Bridges	20 years	1.0	0.87
Normal Bridges	50 years	1.0	1.00
Special Bridges	100 years	1.0	1.10

c) Combination of Permanent Actions.

All permanent actions appropriate to particular bridge are expected to occur together. However where a permanent action acts to relieve the total effect, the load combination shall be considered with this action removed, if such removal can logically occur.

d) Variation of Permanent Action with Time.

Some permanent actions, such a superimposed dead load PMA, shrinkage and creep PSR, prestress effect PPR and settlement effect PES may change slowly by time. The load combinations considered shall include the maximum and minimum values of these actions to determine the worst total effect.

e) Serviceability Limit State Combinations

The primary serviceability limit state combinations consist of the effect of the permanent actions and one transient action.

At serviceability limit state, more than one transient action may occur simultaneously. A reduced load factor is applied to this occurrence, as given in **Table 7.3.2-11**, the usual load combinations are listed in **Table 7.3.2-12**.

TABLE 7.3.2-11 LOAD COMBINATION FOR SERVICE ABILITY LIMIT STATE

Primary Combination	**Permanent Actions + one transient actions**
Secondary Combination	Primary Combination + 0.7 x (one other trans actions)
Tertiary Combination	Primary Combination + 0.5 x (two or more trans actions)

Notes :

1) The “D” lane load T_{TD} or “T“ truck load T_{TT} is required to generate the breaking force T_{TB} and the Centrifugal force T_{TR} on the bridge. No reduction factor shall be applied when T_{TB} or T_{TR} occur in combination with T_{TD} or T_{TT} as a primary combination.
2) Bearing friction T_{BF} may occur together with temperature effects T_{ET} and shall be treated as a single action for the purposed of load combination.

f) Ultimate Limit State Combinations

The ultimate limit state combinations shall consist of the sum of the effects of the permanent actions and one transient effect.

Breaking force T_{TB} or centrifugal force T_{TR} may be combined with “D” lane loading T_{TD}, and the combination shall be considered as one action for load combination. Bearing friction T_{BF} and temperature effect T_{ET} may be combined in a similar manner. At the ultimate limit state, no other transient actions shall be combined with earthquake actions.

Some actions can possibly occur at a service ability level at the same time as another action occur at its ultimate level. These possible combinations shall be considered, but only one serviceability level action shall be included in any combination. A summary of the usual load combination is given in **Table 7.3.2-12**.

Items to be considered in determining the usual load combination for serviceability and ultimate limit state are as follows:

1) The design engineer shall be responsible for identifying and evaluating any combination not included in this table which may be critical for a particular bridge. For each load combination, all action have been included which can logically occur together. Beside these the design engineer shall evaluate the effect on a load combination of not including any of these contributing actions, provided that such non-inclusion is logical.
2) In the serviceability limit state part of this table, an action marked "X" for a particular combination is included in that combination at its full serviceability load factor. An item marked "o" may be included at a reduced serviceability load factor.
3) In the ultimate limit state part of the table, an action marked "X" for a particular combination is included in that combination and its full ultimate load factor. An item marked "o" may be included at a reduced value equal to its serviceability load.
4) Some permanent actions may be change slowly with time. The load combination shall be evaluated with these actions at both their maximum and minimum design values in determined the worst effects.
5) Limit state levels of centrifugal force and breaking force do not occur at the same time.
6) Temperature effects include the effects of differential temperature within the bridge, and the effect of temperature change on the whole bridge. Bearing friction is closely associated with temperature effect but the direction of action bearing friction will change, depending on the direction of movement of the bearings or in the other words, whether the temperature is rising or falling. Temperature effects are unlikely to be critical at the ultimate limit state except in association with other actions for this reason they are only considered to contribute at serviceability level.
7) Bearing friction must be considered whenever any other actions produce an effect which tends to cause horizontal motion of the bearings.
8) All water effect can be considered together
9) Earthquake effects are only considered in ultimate limit state.
10) Collision load may be serviceability loads or ultimate loads.
11) Vibration effect are only used in serviceability limit state

TABLE 7.3.2-12 LOAD COMBINATIONS FOR LIMIT STATES

Action		Load Combination											
		Serviceability						Ultimate					
Name	**Symbol**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
PERMANENT ACTIONS													
- Self weight	P_{MS}												
- Superimpose dead load	P_{MA}												
- Shrinkage and creep	P_{SR}												
- Prestress	P_{PR}	X	X	X	X	X	X	X	X	X	X	X	X
- Permanent Construction Effects	P_{PL}												
- Earth pressure	P_{TA}												
- Settlement	P_{ES}												
TRANSIENT ACTIONS													
"D"lane load or "T"truck load	T_{TD} T_{TT}	X	o	o	o	o		X	o	o	o		
Braking force or Centrifugal Force	T_{TB} T_{TR}	X	o	o	o	o		X	o	o	o		
Pedestrian Load	T_{TP}		X						X				
Bearing Friction	T_{BF}	o	o	X	o	o	o	o	o				
Temperature Effect	T_{ET}	o	o	X	o	o	o	o	o	o	o		o
Hydrostatic/Buoyancy	T_{EU}	o		o	X	o	o	o		X	o		o
Wind Load	P_{EW}			o	o	X	o	o		o	X		o
OTHER ACTIONS													
Seismic effect	T_{EQ}											X	
Collision Load	T_{TC}												
Vibration Effects	T_{VI}	X	X										
Construction Loads	T_{CL}						X						X
'X' Load always active 'o' Load can combine with single active load or as shown		(1) = Permanent action 'X' + Load active 'X' (2) = (1) + 0.7 Load 'o' (3) = (1) + 0.5 Load 'o'+ 0.5 Load 'o'						Permanent action 'X' + Load active 'X' + 1 Load 'o'					

7.3.3 Structural Analysis

1) Seismic Design

a) Analysis Procedure

The procedure for seismic resistance analysis is as follows:

- Static: semi dynamic/simple dynamic
  Procedure 1: Uniform Load/Seismic Coefficient
  Procedure 2: Single mode
- Space frame/semi dynamic
  Procedure 3: Multiple mode spectrum
- Dynamic
  Procedure 4: Time History

Procedures 1 and 2 are manual calculations for simple bridges, with vibration in the first mode.

Procedure 3 is applied for more complicated bridges with vibration in several modes, and requires a space frame and dynamic analysis (refer to **Table 7.3.3-1** and **7.3.3-2**).

Procedure 4 is required for main/major structures with complex geometry and/or near an active fault.

TABLE 7.3.3-1 SEISMIC PERFORMANCE CATEGORY

High Acceleration Coefficient in Bed Rock (A/g)	Important Classification I (Essential Bridge with Important Category 1.25)	Important Classification II (Simple Bridge with Important Category 1.00)
≥0.30	D	C
0.20 – 0.29	C	B
0.11 – 0.19	B	B
≤ 0.10	A	A

For this project all Flyovers are taken to be Essential Bridges with Importance Category 1.25.

TABLE 7.3.3-2 ANALYSIS PROCEDURE BASED ON SEISMIC PERFORMANCE CATEGORY

Number of Span	Seismic Performance Category			
	D	C	B	A
Simple single span	1	1	1	-
Two or more spans, continuous	2	1	1	-
Two or more spans, with one hinge	3	2	1	-
Two or more spans, with two or more hinges	3	3	1	-
Complicated structure	4	3	2	1

For this project all Flyovers are taken to fall into Seismic Performance Category D requiring Analysis Procedure 3 (Multi-mode spectrum analysis).

b) Minimum Support Length Criteria

Minimum support length requirements are given in **Table 7.3.3-3**.

TABLE 7.3.3-3 MINIMUM SUPPORT LENGTH CRITERIA

Minimum Support Length N (mm)	Seismic Performance Category
$N = (203 + 1.67 \times L + 6.66 \times H) \times (1 + 0.00125 \times S^2)$ $N = (305 + 2.50 \times L + 10.0 \times H) \times (1 + 0.00125 \times S^2)$	A and B C and D

Where:
L = Deck slab length (m)
H = Average height of column (m)
S = Skew Angle of Support (degree)

7.3.4 Structural Design

1) Material Properties

a) Structural steel

The type of structure steel shown in **Table 7.3.4-1** shall be used.

TABLE 7.3.4-1 CLASS, DESIGNATION AND STRENGTH OF STRUCTURE STEEL

JIS Standard			ASTM Standard		
Designation	Yield Point (N/mm^2)	Tensile Strength (N/mm^2)	Designation	Yield Point (N/mm^2)	Tensile Strength (N/mm^2)
G 3101					
SS 400	215 – 245	400 – 510	A 36	250	400-500
G 3106					
SM 400	215 – 245	400– 510	A 242	290 – 340	≥ 430
SM 490	295 – 325	490 – 610	A440	290 – 340	430 – 480
SM 490 Y	325 – 365	490 – 610	A 441	290 – 340	430 – 480
SM 520	325 – 365	520 – 640	A 588	290 – 340	430 – 480
SM 570	420 – 460	570 – 720	A 572	410 – 450	510 – 550
G 3114					
SMA 400W	215 – 245	400 – 540			
SMA 490W	325 – 365	490 – 610			
SMA 570W	420 – 460	570 – 720	A 514	620 – 690	690 – 900

JIS G 3101 : Rolled Steel of General Structure
JIS G 3106 : Rolled Steel for Welded Structure
JIS G 3114 : Hot-Rolled Atmospheric Corrosion Resisting Steels for Welded Structure

b) Concrete

Concrete Compressive strength:

The 28-days compressive strength and corresponding elastic modulus Ec, shall be as shown in **Table 7.3.4-2**:

TABLE 7.3.4-2 CLASSIFICATION OF CONCRETE CYLINDER STRENGTH

Concrete Class	Characteristic Compressive Strength MPa	Application of Structure
A-1	40	Pre-cast Pre-stressed Concrete Structure
A-2	35	Cast-in-situ Pre-stressed Concrete Structure
B-1	30	Deck slab, Pier heads and Columns, Diaphragms of P.C.I-Girder
B-2	30	Integral abutments, Cast-in-situ Reinforced Concrete Piles, Bored Piles
C	20	Massive Abutment, Footing and Retaining Walls
D	15	Gravity type Retaining Walls
E	8	Leveling Concrete

Characteristic compressive strength of concrete shall be based on standard compression test of cylinder specimens at the stage of 28 days, as specified in JIS or ASTM.

The coefficient of thermal expansion shall be 1.0 x 10^5 (per deg Celsius).

c) Reinforcing Steel

Reinforcing steel shall consist generally of high yield deformed steel bar of grade SD 40, and mild steel round bar SR 24 whenever bars must be bent / unbent and for special uses (dowels),

The type of reinforcement, yield point, and application standard as shown **Table 7.3.4-3**.

TABLE 7.3.4-3 TYPE OF REINFORCEMENT

Type	Grade	Yield Point (N/mm^2)	Application standard		
			SII	JIS	BS
Round Bars	SR 24	240	SII 0136	G 3112	BS 4449
Deformed Bars	SD 40	390	SII 0136	G 3112	BS 4449

d) Pre-stressing Tendons

The type of pre-stressing of tendons shown in **Table 7.3.4-4** shall be used.

TABLE 7.3.4-4 CLASSIFICATION OF PRE-STRESSING TENDONS

Notation	Utilization	Nominal Diameter (mm)	Yield Strength (kg/mm^2)	Braking Strength (kg/mm2)	Application Standard	
					JIS	ASTM
PC Wire SWPR 1A	PC Pile	Ø 7	135	155	G 3536	A 421
PC 7 Wire Strand SWPR 7B	PC Hollow Core Slab Unit, PC I-Girder and T-Girder, PC Double Girder Diaphragm of PC I-Girder and T-Girder	T 12.7	160	190	G 3536	A 416
PC 7 Wire Strand SWPR 7B	Transversal Cable for Deck Slab	T 15.2	160	190	G 3536	A 416
PC 19 Wire Strand SWPR 19	Diaphragm of PC I-Girder and T-Girder	T 19.3	160	190	G 3536	A 416

Modulus of elasticity: 2.0×10^5 MPa
Coefficient of thermal expansion = 1.2×10^5 (per deg Celsius).

e) Elastomeric Bearing Pads

Bearings shall be manufactured from natural rubber of IHRD 53 ± 5 hardness, having properties which comply with the Specification of Authority. The values of Shear Modulus and Bulk Modulus, based on the assumed properties as shown in **Table 7.3.4-5**, may be used for natural rubber (using current formulations) for calculating the strain.

TABLE 7.3.4-5 ELASTOMER PROPERTIES

Durometer Hardness IHRD ± 5	Shear Modulus G MPa	Bulk Modulus B MPa
53	0.69	2,000
60	0.90	2,000
70	1.20	2,000

2) Composite Columns

The design of the circular composite columns is in accordance with the design criteria established for the project. The design criteria are based upon the provisions of Australian Standard AS 5100 which itself is closely aligned with the provisions of Eurocode 4.

The steel section shall be symmetrical, be fabricated from steel with a maximum yield stress of 350MPa and have a wall thickness such that the plate element slenderness λ_e is less than the limit given below:

$$\lambda_e = \frac{d_0}{t} \cdot \left(\frac{f_y}{250} \right) < 82 \quad \text{for circular hollow sections}$$

where:

d_0	=	outside diameter of the section
t	=	wall thickness of the section
h	=	outside depth of the section

Concrete shall be of normal density and strength and have a maximum aggregate size of 20mm.

Positive shear connection shall be provided between the concrete and the steel for that proportion of the shear stress at the strength limit state that exceeds 0.4MPa.

In the design of composite columns, account will be taken of the confining effect of the steel tube, slenderness and imperfections.

In the design of members subject to combined compression and uniaxial bending, the resistance of the cross-section will be determined assuming full plastic stress distribution for both steel and concrete components. Rectangular stress blocks are assumed for both the steel and the concrete. The plastic compressive stress of the confined concrete is taken to be 1.00 x fc. The maximum concrete compressive stress is ∅cfc and the maximum steel stress is ∅fy for the steel section and ∅fyr for the reinforcement.

The section shall satisfy the following criterion:

$$M_x < 0.9M_{rx}$$

$$M_y < 0.9M_{ry}$$

where:

M_{rx} M_{ry}	=	section moment capacity, reduced by the effects of axial compression, slenderness and imperfections, determined from an interaction curve in the form of Figure 7.3.4-1
M_x M_y	=	design bending moments about the major and minor principal axes, respectively

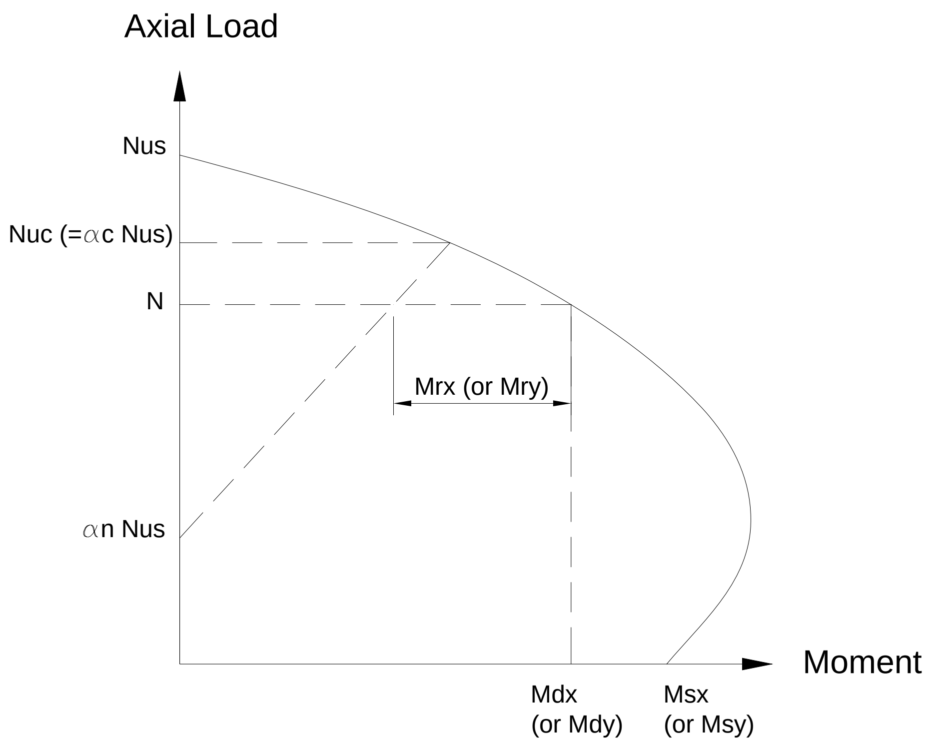


FIGURE 7.3.4-1 INTERACTION CURVE OF COMPRESSION AND UNIAXIAL BENDING FOR COMPOSITE COMPRESSION MEMBERS

In Figure 7.3.4-1:

N_{us} = ultimate section capacity

N_{uc} = ultimate member capacity

= $\alpha_c N_{us}$

α_c = compression member slenderness reduction factor

$M_{dx,}$ = total moment capacity of the section when the design axial force N is acting on the section

M_{dx}

α_n = factor for interaction curve

= $\alpha_c\left(\frac{1+\beta_m}{4}\right)$

β_m = ratio of the smaller to the larger end bending moments taken as positive when the member is bent in reverse curvature

3) Socket Type Connections

For the connection of composite columns to single large diameter bored pile foundations a socket type connection is proposed in the Basic Design. Socket type connections comprise the insertion of the composite column section into a larger diameter steel pipe pile with concrete filled between them. The arrangement has been tested in Japan and is approved by both JRA and Japan Railway Company.

A typical socket type connection is shown in **Figure 7.3.4-2**.

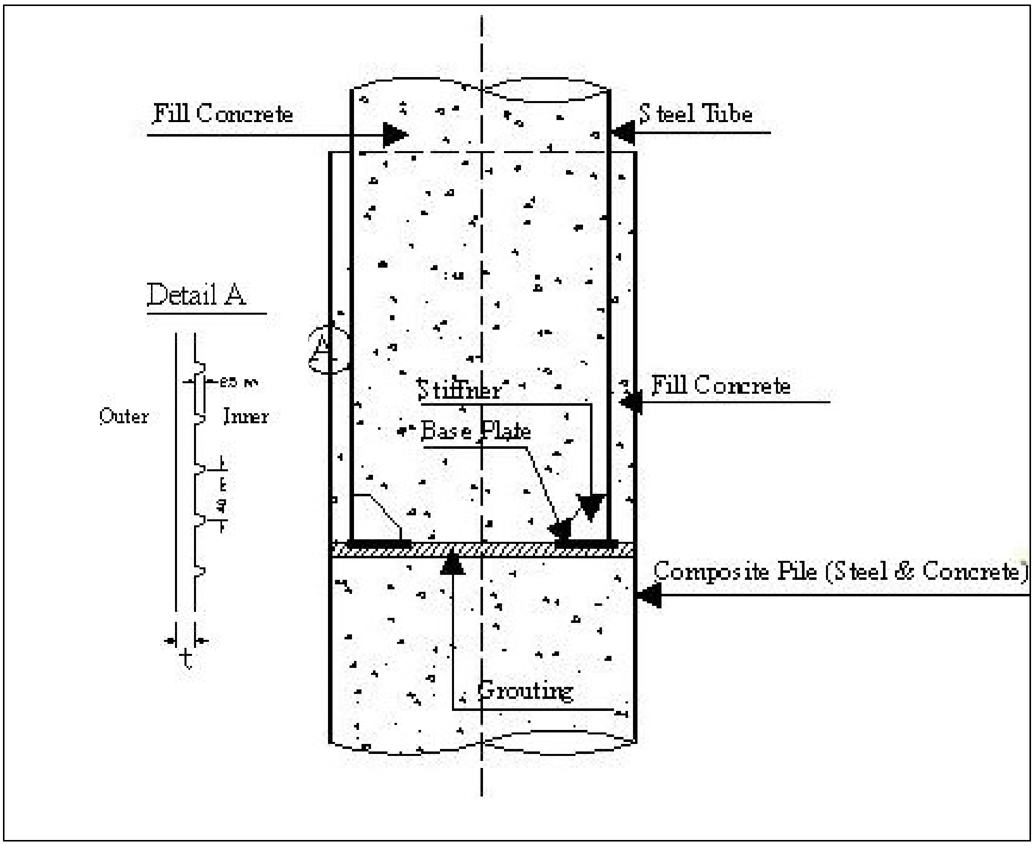


FIGURE 7.3.4-2 TYPICAL SOCKET TYPE CONNECTION

The load carrying model for predicting the ultimate load capacity of the socket type connection is shown in **Figure 7.3.4-3**.

For the calculation of socket capacity the frictional stresses developed between the column pipe and the concrete filled pipe pile are assumed to be subject to Coulomb's friction criteria. That is:

$$\tau_{\max} = c + \sigma_n \cdot \tan\phi$$

where:

$\tau_{\max}$	=	maximum frictional stress
c	=	cohesion of friction
σ_n	=	normal stress at interface
ϕ	=	friction angle

For the calculations, the cohesion c and friction angle ϕ are assumed as follows:

c	=	0.7N/mm^2	ϕ	=	20 degree	for ordinary pipe
c	=	8.0N/mm^2	ϕ	=	0 degree	for pipes with spiral ribs

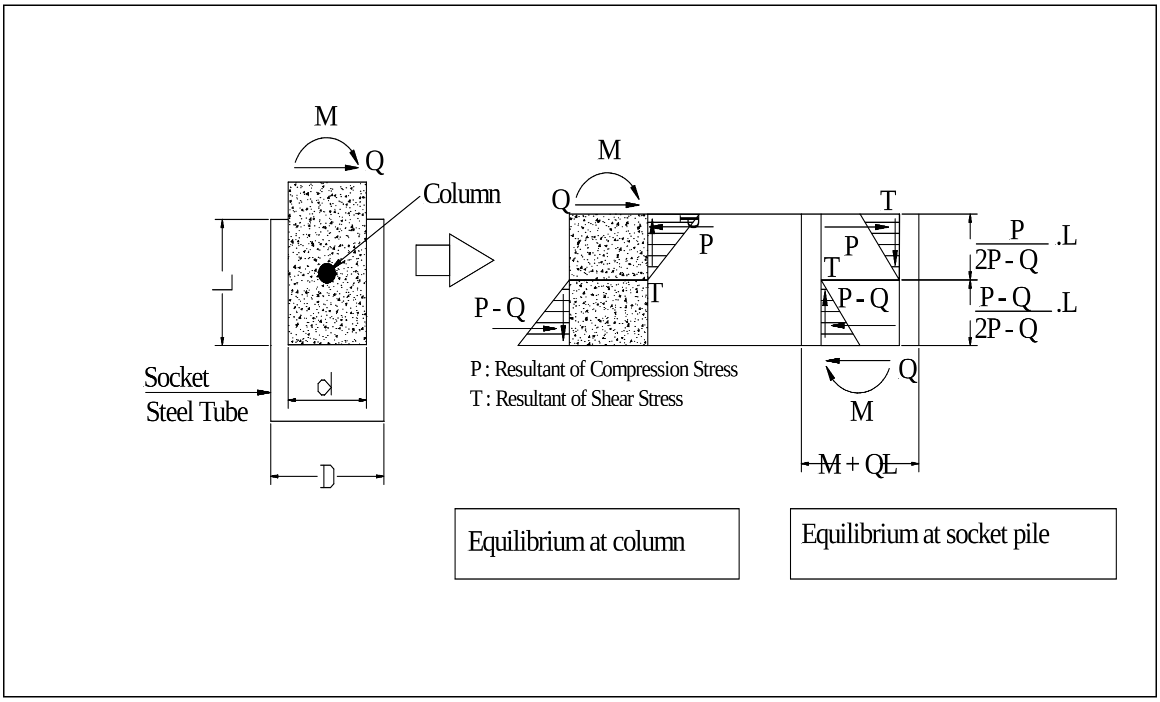


FIGURE 7.3.4-3 LOAD CARRYING MODEL FOR PREDICTING ULTIMATE LOAD CAPACITY

7.3.5 Geotechnical Design Criteria

1) Pile Bearing Capacity

The total ultimate bearing capacity Q_R of a pile shall be in accordance with the following:

$$Q_R := \eta \cdot (\phi p Q_p + \phi s Q_s)$$

where:

▪	=	efficiency of pile group
ϕ_p	=	resistance factor for base resistance
ϕ_s	=	resistance factor for shaft resistance
Q_p	=	ultimate base resistance $Q_p = q_p \cdot A_p$ q_p = unit base resistance
Q_s	=	ultimate shaft resistance $Q_s = \sum q_s \cdot C_P \cdot L_i$ q_s = unit shaft resistance
A_p	=	cross sectional area of pile
C_p	=	perimeter of pile
L_i	=	incremental length of pile included in summation

Where the methods to determine base or shaft resistance make reference to undrained shear strength, S_u, of cohesive soils, the following SPT correlations will be used, subject to confirmation through testing of undisturbed samples:

S_u = 5 x SPT "N" value for bored piles
S_u = 10 x SPT "N" value for driven piles

The following portion of a bored pile, illustrated in **Figure 7.3.5-1**, shall not be taken to contribute to the development of resistance through skin friction:

- At least the top 1500mm of any bored pile;
- For straight bored piles, a bottom length of the shaft taken as the shaft diameter;
- Periphery of belled ends, if used; and
- Distance above a belled end taken as equal to the shaft diameter.

In the case that un-drained shear strength has been determined from correlation the SPT, contributions from soil layers with SPT less than 2 will be ignored and the unit shaft resistance will be limited such that q_s < 100kN/m2.

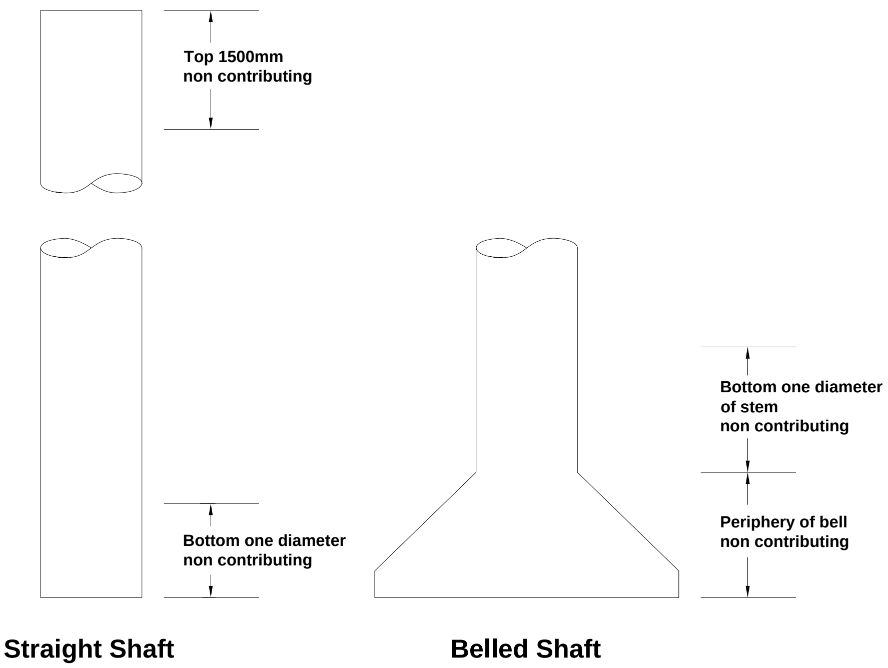


FIGURE 7.3.5-1 PORTIONS OF BORED PILE NOT CONSIDERED

2) Resistance Factors – Bored Piles

Resistance factors for geotechnical strength limit state for axially loaded bored piles are given in **Table 7.3.5-1**.

TABLE 7.3.5-1 RESISTANCE FACTORS FOR BORED PILES

Type of Loading	Component of Resistance / Geo-material	Resistance Evaluation Method	Resistance Factor
Compression for Single Bored Pile	Side / Clay	a method	0.65
	Base / Clay	N_c S_u	0.55
	Side / Sand	Reese and O'Neill method (β method)	0.65
	Base / Sand	Reese and O'Neill method	0.50
	Side / Rock	Carter and Kulhawy method	0.55
		Horvath and Kenny method	0.65
	Base / Rock	Canadian Geotechnical Society Method	0.50
Compression on a Bored Pile Group	Clay	Block Failure	0.65
Uplift for Single Bored Pile	Clay	a method – for straight shafts	0.55
	Sand	Reese and O'Neill method (β method)	0.65
Uplift for Single Bored Pile	Rock	Carter and Kulhawy method	0.45
		Horvath and Kenny method	0.55
Uplift on Bored Pile Group	Sand or Clay	Sum of individual pile uplift resistance or uplift resistance of pile group considered as a block.	0.55

3) Lateral Bearing Capacity

a) Coefficient of Lateral Sub-Grade Reaction (Soil Spring)

The coefficient of lateral sub-grade reaction of the pile shall be computed as given below (refer to JRA Specifications for Highway Bridges, Part IV):

$$k_H = k_{H0} \cdot \left(\frac{B_H}{30} \right)^{-\frac{3}{4}}$$

where:

k_H : coefficient of horizontal sub-grade reaction (kgf/cm^3)

k_{H0} : coefficient of horizontal sub-grade reaction (kgf/cm^3) equivalent to a value of plate bearing test using a rigid disk of 30cm in diameter, obtained by the following formula:

$$k_{HO} = \frac{1}{30} \cdot \alpha \cdot E_0$$

E_0 : modulus of deformation (kgf/cm^2) of a particular soil layer given by the following relation:

$$E_0 = 28 \cdot N$$

where N is SPT value for that soil layer

(Note: The above correlation has been found, following testing of undisturbed samples obtained for the project, to overestimate the modulus of deformation. The result obtained from the above correlation has therefore been reduced to 40% of its value for the detailed design)

α : coefficient as given below:

normal time	during earthquake
$\alpha = 1$	$\alpha = 2$

B_H : equivalent loading width of a foundation (cm) which intersects orthogonally a load-working direction and for a pile foundation is given by the following formula:

$$B_H = \sqrt{\frac{D}{\beta}}$$

D : loading width (cm) of a foundation intersecting orthogonally a load working direction

β : characteristic value (cm-1) of the foundation as given by the following formula:

$$\beta = \sqrt[4]{\frac{k_H \cdot D}{4 \cdot EI}}$$

EI : bending rigidity (kgf·cm2) of the pile

b) Lateral Bearing Capacity

The critical design condition for the bored piles under lateral loading will be the effects of plastic hinging of the columns or full elastic effects, during an earthquake. The horizontal bearing capacity will therefore be calculated considering conditions during an earthquake.

The horizontal bearing capacity of soil layers in front of the pile shall be determined as follows:

$$P_u = \left(K_{ep} \cdot \sigma_v^{'} \cdot K_\phi^R + 2 \cdot c \cdot \sqrt{K_{ep}} \cdot K_c^R\right) \cdot \eta_p$$

where:

K_{ep} = coefficient of passive earth pressure during an earthquake

$$K_{ep} = \frac{\cos(\phi)^2}{\cos(\delta_e)\cdot\left(1-\sqrt{\frac{\sin(\phi-\delta_e)\cdot\sin(\phi)}{\cos(\delta_e)}}\right)^2} \leq 6$$

σ_v = effective overburden pressure
ϕ = effective internal friction angle
δ_e = friction angle between bored pile and soil, during an earthquake
δ_e = - ϕ / 6
c = effective soil cohesion
η_p = correction factor for horizontal ground reaction around a single pile
η_p $_p$= 1.5
K_ϕ^R K_c^R = strength reduction factors for soil properties
K_ϕ^R = 0.80
K_c^R = 0.70

4) Liquefaction Potential

Potential for liquefaction exists for saturated alluvial soils having characteristic as follows:

- Ground water level less than 10 m from ground surface, and
- There are saturated soil sand layer on the depth less than 20m from ground surface, and
- With value of average aggregate size in between 0.02 and 2.0 mm, or
- Resistance ratio for liquefaction F_L ≤ 1

Resistance ratio for liquefaction is determined with the formula as follows :

F_L = R/L
R = $C_{w.}R_L$ (with C_W =1)
L = $r_d K_{hc} \sigma_V / \sigma'_V$
r_d = 1.0 – 0.015x
σ_V = $\{\gamma_{t1} h_W + \gamma_{t2}(x - h_W)\}/10$
σ'_V = $\{\gamma_{t1} h_W + \gamma_{t2}(x - h_W)\}/10$

where:
F_L = Resistance ratio for liquefaction
R = Dynamic shear strength ratio
L = Shear stress ratio during earthquake
R_L = Triaxial Cyclic ratio based on SPT and size of soil aggregate
r_d = Reduction coefficient in direction of shear stress depth during earthquake
K_{hc} = Horizontal seismic static equivalent coefficient
σ_V = Total pressure on the depth to be checked kgf/cm²
σ'_V = Effective pressure on the depth to be checked kgf/cm²
x = Depth from ground surface (m)
γ_{t1} = Weight per unit volume (tf/m³) of soil over the ground water level
γ_{t2} = Weight per unit volume (tf/m³) of soil under the ground water level

γ'_{t2} = Effective weight per unit volume (tf/m³) of soil under the ground water level

h_w = Depth of ground water level (m)

Bearing capacity of soil layer to be reduced by coefficient D_E given in **Table 7.3.5-2**

TABLE 7.3.5-2 REDUCTION COEFFICIENT OF SOIL BEARING CAPACITY, D_E

Value F_L	**Depth x (m)**	**R ≤ 0.3**	**R > 0.3**
$F_L \le 1/3$	0 ≤ x ≤ 10 10 < x ≤ 20	0 1/3	1/6 1/3
$1/3 < F_L \le 2/3$	0 ≤ x ≤ 10 10 < x ≤ 20	1/3 2/3	2/3 2/3
$2/3 \le F_L \le 1$	0 ≤ x ≤ 10 10 < x ≤ 20	2/3 1	1 1

The Triaxial Cyclic ratio, R_L, is determined with the formula (taken from JRA Part V: Seismic Design) as follows:

$$R_L = R_1 + R_2 + R_3$$

where:

$$R_1 = 0.0882 \cdot \sqrt{\frac{N}{\sigma'_V + 0.7}}$$

$$R_2 = \begin{cases} 0.19 & (0.02mm \le D_{50} \le 0.05mm) \\ 0.225\log_{10}(0.35/D_{50}) & (0.05mm < D_{50} \le 0.6mm) \\ -0.05 & (0.6mm < D_{50} \le 2.0mm) \end{cases}$$

$$R_3 = \begin{cases} 0.0 & (0\% < FC \le 40\%) \\ 0.004\,FC - 0.16 & (40\% < FC \le 100\%) \end{cases}$$

where:

N = *N*-value obtained from standard penetration test

D_{50} = average grain diameter of soil (mm)

FC = fine grain content (weight percentage of soil less than 74 ・m in diameter) (%)

7.4 DRAINAGE DESIGN

7.4.1 Design Standards and Guidelines

The following Indonesia drainage design standard and criteria were followed:

- Manual of Design for road surface drainage 1990, Directorate General of Highways, Directorate of Freeway and Urban Road.
- Guideline of Design for Road Surface Drainage, 1994, Council of Indonesian National Standard.
- Design of Road Drainage System, 2005, Department of Settlement and Infrastructure Region.
- Calculation Method of Overflow Debit, 1991, Council of Indonesian National Standard.

In case that there was some lacking information, other standards listed below were referred:

- Highway Engineering Seventh Edition, Paul H. Wright and Karen Dixon, 2003, John Wiley and Sons, Inc
- Hydrology Analysis, Sri Harto Br, 1993, Gramedia Pustaka Utama, Jakarta.
- Hydraulic for Open Channel, Ven Te Chow, 1992, Erlangga, Jakarta.
- Hydrology for Irrigation, Suyono Sosrodarsono, 1993, Pradrya Paramita, Jakarta.

7.4.2 Design Frequency (Return Period)

The design frequencies adopted in this project adhering to the recommendation found in Guidelines of Design for Road Surface Drainage as shown in **Table 7.4.2-1**.

TABLE 7.4.2-1 DESIGN FREQUENCIES

Type of Structure	Return Periods
Box Culvert	1 in 25 Years
Drain Pipe and Pipe Culverts	1 in 10Years
Side Ditches	1 in 5 Years
Surface Drainage	1 in 5 Years

7.4.3 Side Ditches / RC PC

Side ditches/RC PC are designed for 5 years return period. The maximum longitudinal slope is 4%, while the minimum is 0.3%. Basically side ditches/RC PC located along under sidewalk, in case that public utilities are occupied under whole sidewalk, side ditches/RC PC are located along under curb and gutter.

7.5 MISCELLANEOUS HIGHWAY FACILITIES DESIGN

Miscellaneous highway facilities to be designed for the flyover and service road includes the followings:

1) Guardrails
2) Road Signs
3) Pavement Marking
4) Traffic Signal
5) Street Lighting

The following Design Standards, Design Manual, Design Guidelines and specifications are referred for the design.

- Ministry of Communication Decree, No. KM 60 Tahun 1993 About Pavement Marking. (Department of Communication Directorate General of Land Transportation)
- Decree no. KM 3 Tahun 1994: Attachment Drawing No. 3 About Guardrail. (Department of Communication Directorate General of Land Transportation)
- Guidance for Location and Standard Specification of Road Side Protection (Guardrail) No. 13. (Department of Public Works Directorate General of Highways Directorate of Freeway and Urban Road)
- Ministry of Communication Decree, No. KM 61 Tahun 1993 About Road Traffic Sign. (Department of Communication Directorate General of Land Transportation)
- Ministry of Communication Decree, No. KM 62 Tahun 1993 About Traffic Signal. (Department of Communication Directorate General of Land Transportation)
- Ministry of Communication Decree, No. KM 65 Tahun 1993 About Traffic Activity Supporting Facility and Road Transportation, Street Lighting. (Department of Communication Directorate General of Land Transportation)

7.6 RAILWAY CROSSING REQUIREMENTS

7.6.1 Horizontal and Vertical Clearance for Permanent Structure

According to the Ministry of Transportation Decree No. KM52,2000, horizontal and vertical clearance for permanent structure is as follows (see **Figure 7.6.1-1**):

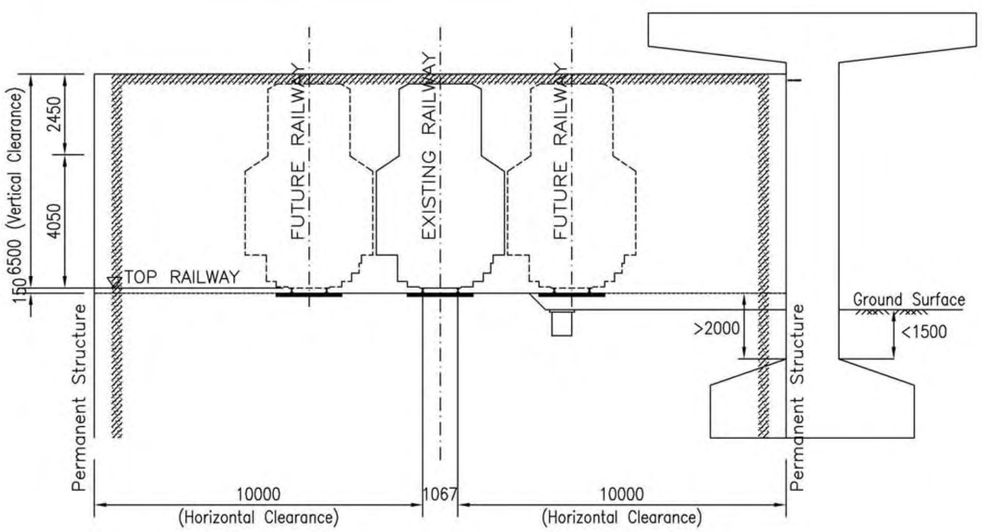
Horizontal Clearance	-	10.0 m from the rail to surface of pier or permanent structure for each side.
Vertical Clearance	-	6.5 m from the top of the rail.

7.6.2 Horizontal and Vertical Clearance During Construction

According to PT. KAI clearance can be reduced to the following (see **Figure 7.6.2-1**):

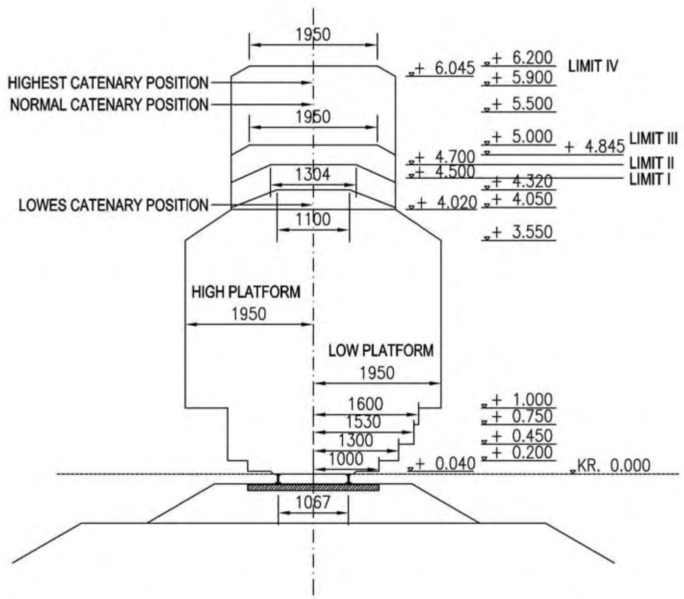
Horizontal Clearance	-	3.0 m from the centerline of the railway for each side.
Vertical Clearance	-	5.0 m from the top of the rail.

Horizontal Clearance From Rail to Surface of Pier = 10.000 m



MINIMUM CLEARANCE FROM RAILWAY

Vertical Clearance = 6.500 m



RAILWAY CLEARANCE IN STAIGHT ALIGNMENT
(FOR ELECTRICAL AND NON ELECTRICAL)

LEGEND :

Area where permanent structure shall not be built unless specifically approved by PT. KAI.

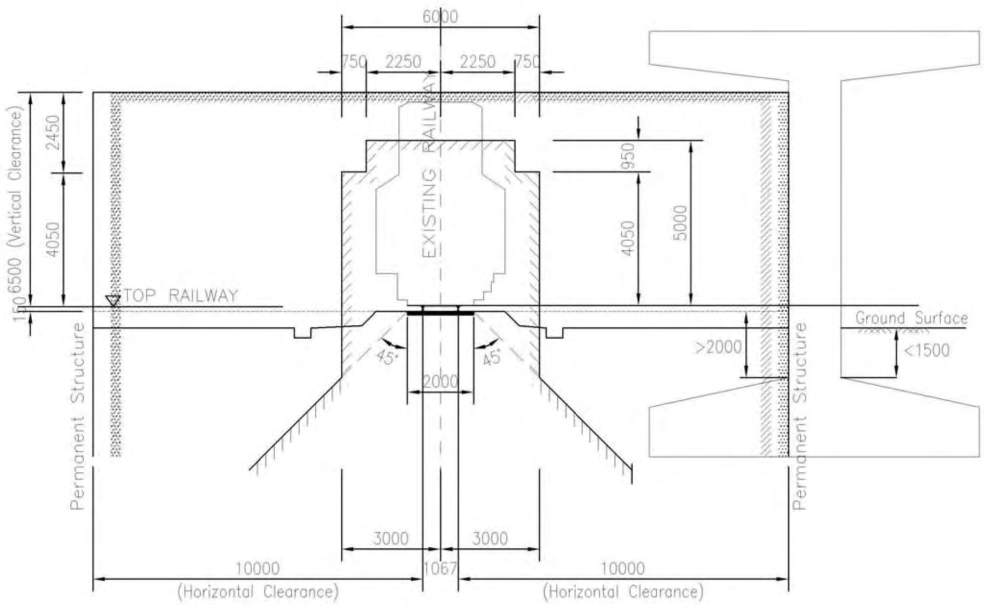
Note: Based on Ministry of Transportation Decree No. KM 52, 2000 regarding Railway Right of Way

FIGURE 7.6.1-1 HORIZONTAL AND VERTICAL CLEARANCE AT RAILWAY CROSSING

Vertical / Horizontal Clearance for New Structure Crossing Railway

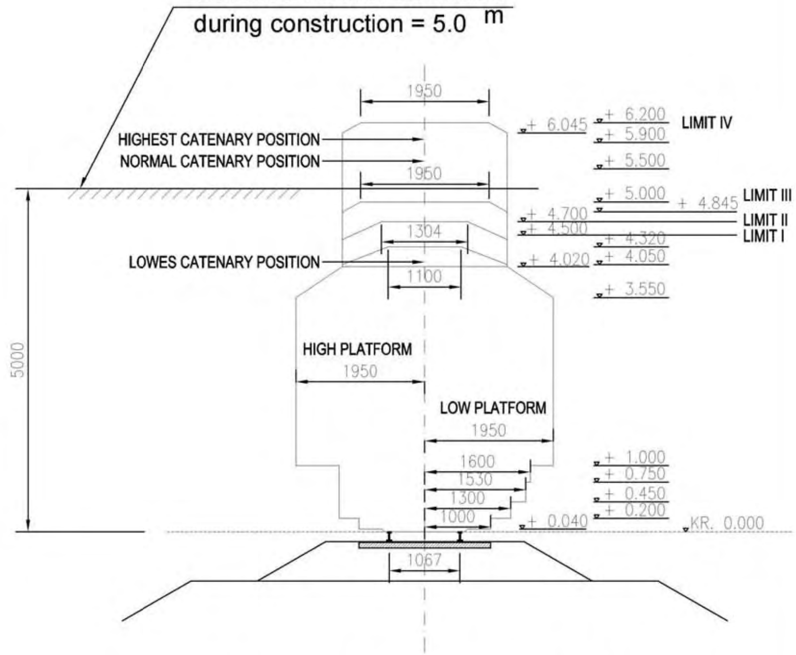
For during construction stage

Reduced Horizontal Clearance During Construction = 6.0 m (3.0 m each from center line)



MINIMUM CLEARANCE FROM RAILWAY

Reduced Vertical Clearance during construction = 5.0 m



RAILWAY CLEARANCE IN STAIGHT ALIGNMENT
(FOR ELECTRICAL AND NON ELECTRICAL)

LEGEND :

- Area where permanent structure shall not be built unless specifically approved by PT. KAI.
- Area where not to be used for working space or temporary structure such as sheet pile for excavation, erection girder, staging, etc. during construction, unless specifically approved by PT. KAI.

FIGURE 7.6.2-1 HORIZONTAL AND VERTICAL CLEARANCE DURING CONSTRUCTION

PART IV

BASIC DESIGN

CHAPTER 8

FLYOVER SCHEME SELECTED

8.1 BACKGROUND

Flyover scheme proposed by the previous study was as follows:

Flyover	Feasibility Study (Year 2003)	SAPROF Study (Year 2004)
Merak	2-lane 2-way flyover over the national road	2-lane 2-way flyover over the national road
Balaraja	2-lane 2-way flyover over the national road	2-lane 2-way flyover over the national road
Nagreg	2-lane 2-way flyover over the national road	2-lane 2-way flyover over the national road
Geban	2-lane 2-way flyover over the national road	2-lane 1 way (Cilebon Bound Direction) over the national road)
Peterongan	2-lane 2-way flyover over the national road	2-lane 2-way flyover over the national road
Tanggulangin	2-lane 2-way flyover over the national road	2-lane 2-way flyover over the national road

In accordance with the recommendations of the SAPROF Study, Directorate General of Highways (DGH) started preparation for the implementation including discussions with the concerned agencies. The flyover scheme of all flyovers except Merak Flyover was accepted by the concerned agencies. Actually, land acquisition activities at three (3) flyover locations (Balaraja, Nagreg and Gebang) have started.

Merak Flyover is strongly related with the Merak Ferry Terminal operated by ASDP under the Ministry of Communication (MOC). MOC and ASDP requested to DGH the following:

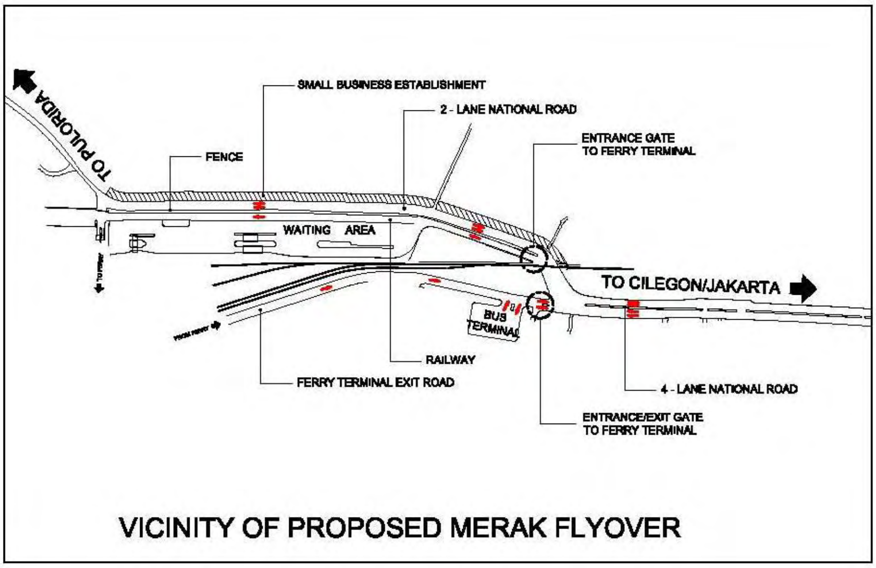
- Land taking of the Ferry Terminal Waiting Area is not acceptable.
- Exit ramp from the Ferry Terminal should be a part of Merak Flyover.

In view of above comments of MOC and ASDP, several flyover schemes were studies, which are presented hereunder. Memorandum of understanding on the agreed scheme between DGH and MOC/ASDP was signed in March 2006.

8.2 MERAK FLYOVER SCHEME

8.2.1 Vicinity and Traffic Situation

Merak Flyover recommended by the feasibility study and the SAPROF study is proposed to be constructed over the Cilegon-Pulorida Road where the railway is crossed. Merak Ferry Terminal is located within the project area which provides very important transport linkage between Java Island and Sumatra Island. Access to the Ferry Terminal is provided by this national road.



The road section suffers heavy traffic congestion throughout a day. Travel speed at the flyover section drops to 18 ~ 20 km/hr from 35 to 37 km/hr of adjacent road sections. Causes to traffic congestion are as follows:

- Very heavy side friction due to mini–buses stopping at road side for loading and unloading of passengers and street vendors.
- Heavy local traffic related to business activities besides the road.
- Train passing (6 times a day, traffic queue extends for about 60m in an average and 115m at maximum).
- Intersection at the exit of Ferry Terminal (intersection is not signalized traffic going to Pulorida side and outgoing traffic from the Ferry Terminal conflict each other)

Daily traffic volume is as follows (see Figure 8.2.2-2);

1) National road (before and after flyover)

   Pulorida side : 6,300 veh/day
   Cilegon side : 18,800 veh/day

2) Local traffic along National Road : 6,100 veh/day

3) Ferry terminal related traffic volume:

Entrance/Exit gate	To Ferry Terminal	800 veh/day
	Outgoing from Ferry Terminal	3,000 veh/day
Entrance Gate	To Ferry Terminal	2,600 veh/day

8.2.2 Alternative Flyover Schemes

The original scheme proposed by the feasibility study and the SAPROF Study is to construct a flyover along the national road over passing the railway, thus through traffic will utilize a flyover and local traffic and Ferry Terminal related traffic will utilize at-grade service road.

Comments on the original scheme of ASDP were as follows:

- The original scheme requires land acquisition of Ferry Terminal's waiting area.
- The original scheme is not beneficial to the Ferry Terminal

Schemes to minimize land taking of waiting area and provide direct access from the flyover to waiting area (or to provide exclusive lane) were proposed. On February 8, 2006, MOC sent a letter to DGH recommending to accommodate the outgoing exit ramp from the Ferry Terminal to the flyover.

In view of above development, five (5) alternative schemes of Merak Flyover were developed and evaluated.

Table 8.2.2-1 shows concept of each scheme. **Figure 8.2.2-1** shows the plan of each scheme. **Table 8.2.2-2** presents traffic volume of each scheme.

TABLE 8.2.2-1 CONCEPT OF EACH ALTERNATIVE SCHEME

Alter-native	Basic Concept	Direction of Flyover	Flyover Traffic	Grade Separation with the Railway	Local Traffic	Ferry Terminal Related Traffic
1	• Scheme recommended by F/S and SAPROF	• Along national road (2-lane 2 way flyover)	• All through traffic along national road	• All through traffic	• Utilize at-grade road	• Utilize at-grade road
2	• Revised scheme of Alternative-1. Flyover with an exclusive lane accessing to the waiting area.	• Along national road (2-lane 2-way flyover with an exclusive lane)	• All through traffic • Local traffic going to Pulorida side • Ferry Terminal traffic going to the waiting area	• All through traffic • Local traffic going to Pulorida side • Ferry terminal traffic going to the waiting area	• Local traffic going to Cilegon side will utilize at-grade road	• Traffic to and from Entrace/Exit Gate utilizes at-grade road
3	• Revised scheme of Alternative-1. No land acquisition of Ferry Terminal Waiting Area	• Along national road (2-lane 2-way flyover)	• All through traffic • Local traffic going to Pulorida side	• All through traffic • Local traffic going to Pulorida side	• Local traffic going to Cilegon side will utilize at-grade road	• Utilize at-grade road
4	• To provide Ferry Terminal Exit Ramp • Stage Construction • Phase-1 : Second level flyover • Phase-2 : Third level flyover	• One-lane 1-way flyover (Cilegon-bound direction) • One-lane 1-way Ferry Terminal Exit Ramp • Y-shared Flyover • Phase-2 : One-lane 1-way flyover (Pulorida-bound direction at 3rd level)	Phase 1 • Through traffic going to Cilegon side • Exit traffic from Ferry Terminal except buses from the bus terminal Phase 2 • All traffic going to Pulorida side	Phase 1 • Through traffic going to Cilegon side Phase 2 • Through traffic going to Pulorida side	Phase 1 • Utilize at-grade road (both directions) Phase 2 • Traffic going to Cilegon side utilizes at-grade road	Phase 1 & 2 • Exit traffic except buses from bus terminal utilizes the ramp • Traffic going to waiting area utilizes at-grade road
5	• Alternative-1 pules Ferry Terminal Exit Ramp at 3rd level	• Along National Road 2-lane 2-way flyover at 2nd level • Ferry Terminal Exit Ramp at 3rd level	• All through traffic • Local traffic going to Pulorida side • Exit traffic from Ferry Terminal except buses from bus terminal	• All through traffic • Local traffic going to Pulorida side	• Local traffic going to Cilegon side will utilize at-grade road	• Entrance traffic going to waiting area utilizes at-grade road

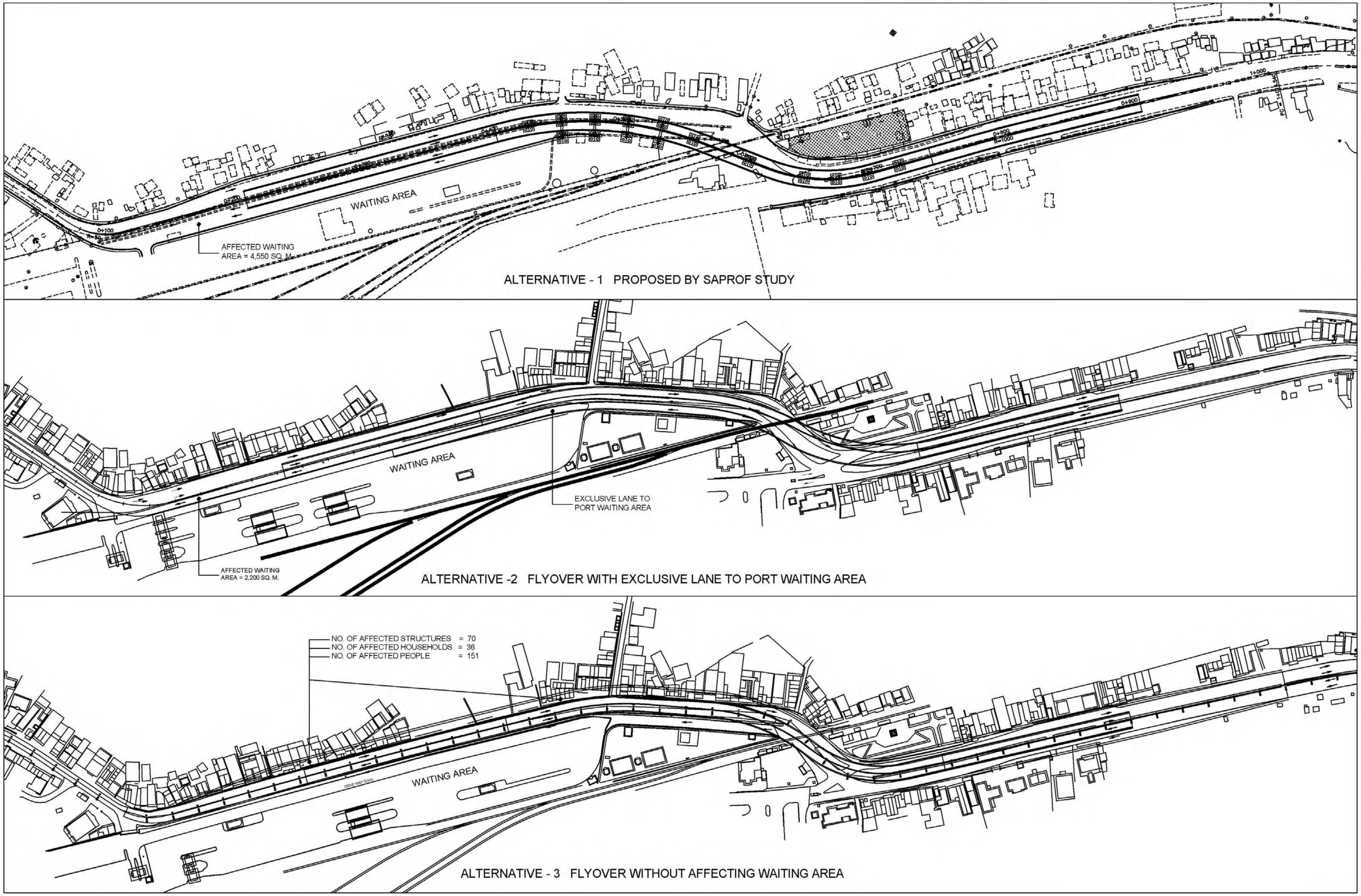


FIGURE - 8.2.2-1 (1/2) ALTERNATIVE FLYOVER SCHEMES

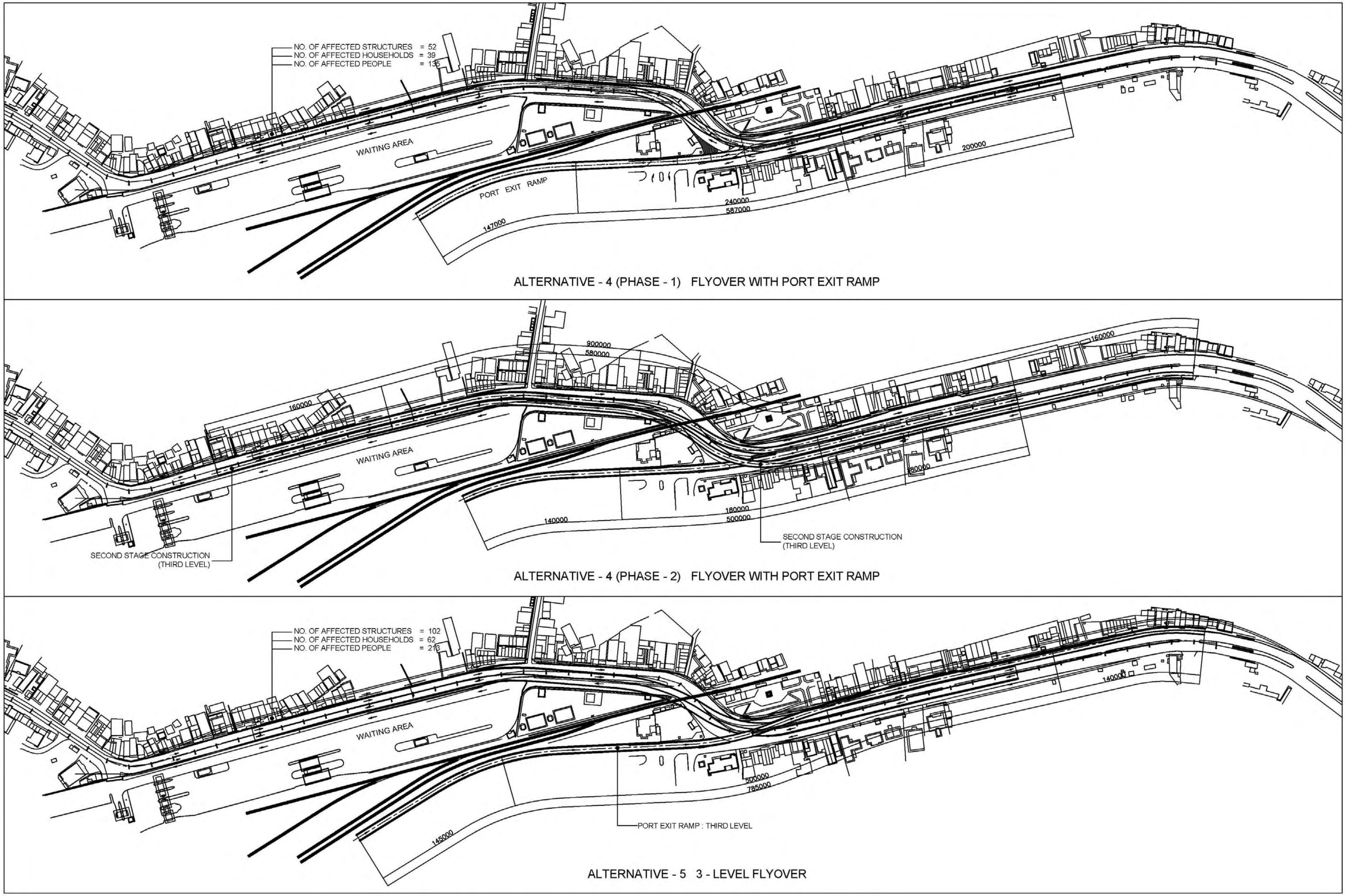


FIGURE - 8.2.2-1 (2/2) ALTERNATIVE FLYOVER SCHEMES

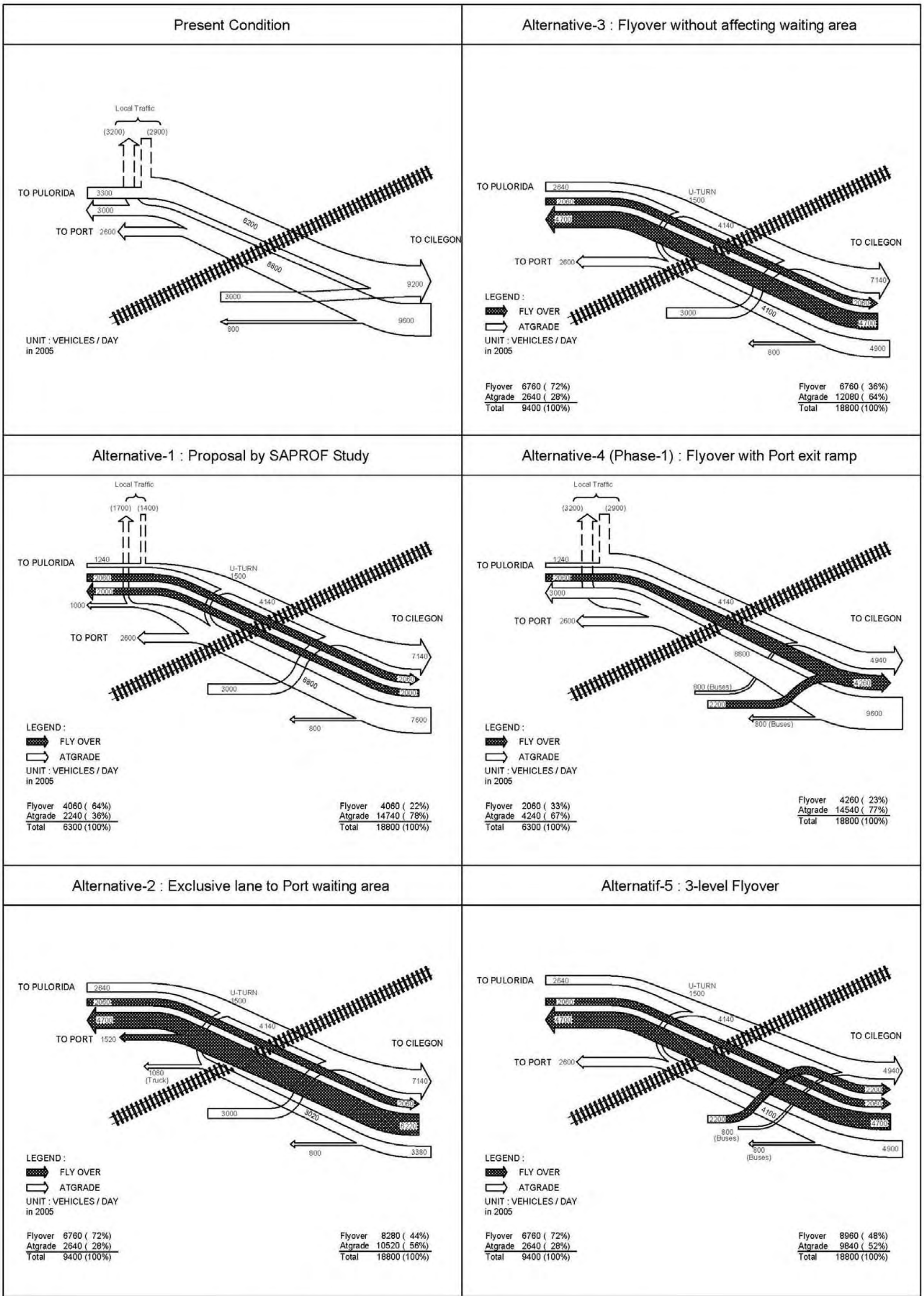


FIGURE 8.2.2-2 TRAFFIC FLOW OF EACH ALTERNATIVE SCHEMES

8.2.3 Evaluation of Alternative Schemes

Alternative schemes were evaluated on the following factors:

Evaluation Factor	Weight (points)
1. Transport Contribution of Flyover (traffic volume attracted to flyover)	10
2. Impact to de-congest at-grade road (traffic volume remaining at-grade road)	10
3. Achievement of grade separation with the railway (% of traffic volume grade-separated)	5
4. Intersection traffic capacity improvement at Ferry Terminal Exit Gate (Volume Capacity Ratio)	10
5. Land acquisition of Ferry Terminal Waiting Area	10
6. Social Impact (No. of household affected)	20
7. Construction cost	15
8. Acceptance of MOC/ASDP	15
9. Flyover Function as National Road	5
	100

Results of evaluation are summarized in **Table 8.2.3-1**.

TABLE 8.2.3-1 EVALUATION OF ALTERNATIVE SCHEMES

Alternative		EVALUATION FACTORS ① Transport Contribution of Flyover		② Impact to Decongest At-grade Road		③ Grade Separation with Railway		④ Intersection Trafic Capacity Improvement		⑤ Land Acquisition of Waiting Area		⑥ Social Impact		⑦ Construction Cost		⑧ Acceptance of MOC/ASDP		⑨ Flyover Function as National Road		Total Score	Ran-king	Remarks
Weight		10		10		5		10		10		20		15		15		5		100		
Alternative - 1		4,060 veh/day	Δ / 6	At-grade traffic = 10,940 veh/day	Δ / 6	30% grade-separated	Δ / 2	V/C = 0.94 (At present 1.10)	Δ / 2	4,550 sq.m	X / 4	Minimal	O / 18	Standard (Basis of JBIC Loan)	O / 12	Not Acceptable	X / 4	National Road Flyover	⊙ / 5	62	4	Not Recommended
Alternative - 2		8,280 veh/day	⊙ / 10	6,720 veh/day	⊙ / 10	5.5%	⊙ / 4	V/C = 0.63	⊙ / 8	2,200 sq.m	Δ / 5	Minimal	O / 18	About 50% higher than Alternative-1	Δ / 9	Not Fully Acceptable	X / 4	National Road Flyover	⊙ / 5	73	1	Recommended if NOC and ASDP accept.
Alternative - 3		6,760 veh/day	O / 8	8,240 veh/day	O / 8	45%	O / 3	V/C = 0.71	O / 7	No acquisition	⊙ / 10	70 Structures 36 Household 151 Persons	Δ / 8	Almost same as standard, but ROW cost is higher	O / 10	Not Fully Acceptable	Δ / 6	National Road Flyover	⊙ / 5	65	3	Not Recommended
Alter native 4	Phase -1	4,260 veh/day	Δ	12,940 veh/day	Δ	14%	X	V/C = 0.84	O	No acquisition	⊙	52 Structures 39 Household 135 Persons	Δ	Slightly higher than standard	O	Acceptable	⊙	Semi-National Road Flyover	Δ		2	Recommended, if DGH accepts, and Phase-2 will be implemented.
	Phase -1	8,690 veh/day	⊙ / 8	8,240 veh/day	O / 8	45%	O / 2	V/C = 0.43	⊙ / 7	No acquisition	⊙ / 10	Minor Additional ROW required	Δ / 10	High cost will be required	Δ / 10	Acceptable	⊙ / 15	National Road Flyover	⊙ / 3	72		
Alternative - 5		8,690 veh/day	⊙ / 10	8,240 veh/day	O / 8	45%	O / 3	V/C = 0.43	⊙ / 8	No acquisition	⊙ / 10	102 Structures 62 Household 213 Persons	X / 5	Very high	X / 3	Acceptable, provided construction is covered by loan	O / 10	National Road Flyover	⊙ / 5	62	4	Not Recommended

8.2.4 Recommendation and Selected Scheme

All alternative schemes were presented to DGH, MOC and ASDP. Following were determinant factors in selecting the final scheme for Merak Flyover:

Alternative-1 : land acquisition of the waiting area is not acceptable to MOC/ASDP.

Alternative-2 : although this scheme contributes to traffic condition improvement, land acquisition of the waiting is not acceptable to MOC/ASDP. The Ferry Terminal is quite important transport facility to provide continuous national road linkage via sea transport between Java Island and Sumatra Island, however, this scheme does not solve traffic problems at the exit of the ferry terminal.

Alternative-3 : Social impact is high and this scheme has the same problems as alternatives 1 and 2.

Alternative-4 : This scheme is the most preferred one by both DGH and MOC/ASDP, since ferry terminal traffic improvement contributes to overall national transport efficiency.

Alternative-5 : Exist ramp from the Ferry Terminal is located at the 3rd level, requiring long approaches with steep gradient. Most traffic utilizing this ramp is large vehicles such as trucks and buses, therefore, not preferred by MOC/ASDP. Construction cost will be very high and cannot be covered by the loan, thus not acceptable by DGH as well.

The selected scheme for the Merak Flyover is Alternative-4 and the phase 1 is implemented under this project.

8.3 REMAINING FIVE FLYOVER SCHEME

Flyover scheme recommended by the SAPROF Study was adopted for the remaining 5 flyovers as follows:

Flyover	Flyover Scheme
Balaraja	• 2-lane 2-way flyover over the national road
Nagreg	• 2-lane 2-way flyover over the national road
Gebang	• 2-lane 1-way flyover (Cilebon bound direction) over the national road
Peterongan	• 2-lane 2-way flyover over the national road
Tanggulangin	• 2-lane 2-way flyover over the national road

Recommended bridge length, bridge type, approach embankment type, etc. by the SAPROF Study were reviewed in the Basic Design.

CHAPTER 9

SELECTION OF BRIDGE TYPE

9.1 BRIDGE TYPE SELECTION PROCEDURE

Bridge type selection procedure is shown in **Figure 9.1-1** based on the preliminary planning of bridge spans and geological conditions of 6 flyovers, bridges were grouped into 4 (four) and the optimum type of bridge was selected for each group. Two-step evaluation procedure was adopted, namely initial screening of bridge types and the detailed comparative study of screened bridge types to select the optimum bridge type for each group.

9.2 PRINCIPLES IN SELECTING BRIDGES TYPE

Flyovers will be constructed in the urban areas with high traffic volume and narrow construction sites. Bridge type must be selected in due consideration of such conditions. Principles in selecting bridge type were established as follows :

Principles in Selecting Bridge Type

Primary Principles

- Must be economical.
- Fast construction is possible.
- Traffic disturbance can be minimized.
- Bridge system must be strong against earthquake.
  (integration of superstructure and substructure should be achieved as much as possible)

Secondary Principles

- Maintenance is easy and less costly.
- Aesthetic consideration. (match with urban scenery)
- Introduction of new technology.

Special Consideration

- STEP Loan requirement must be satisfied.

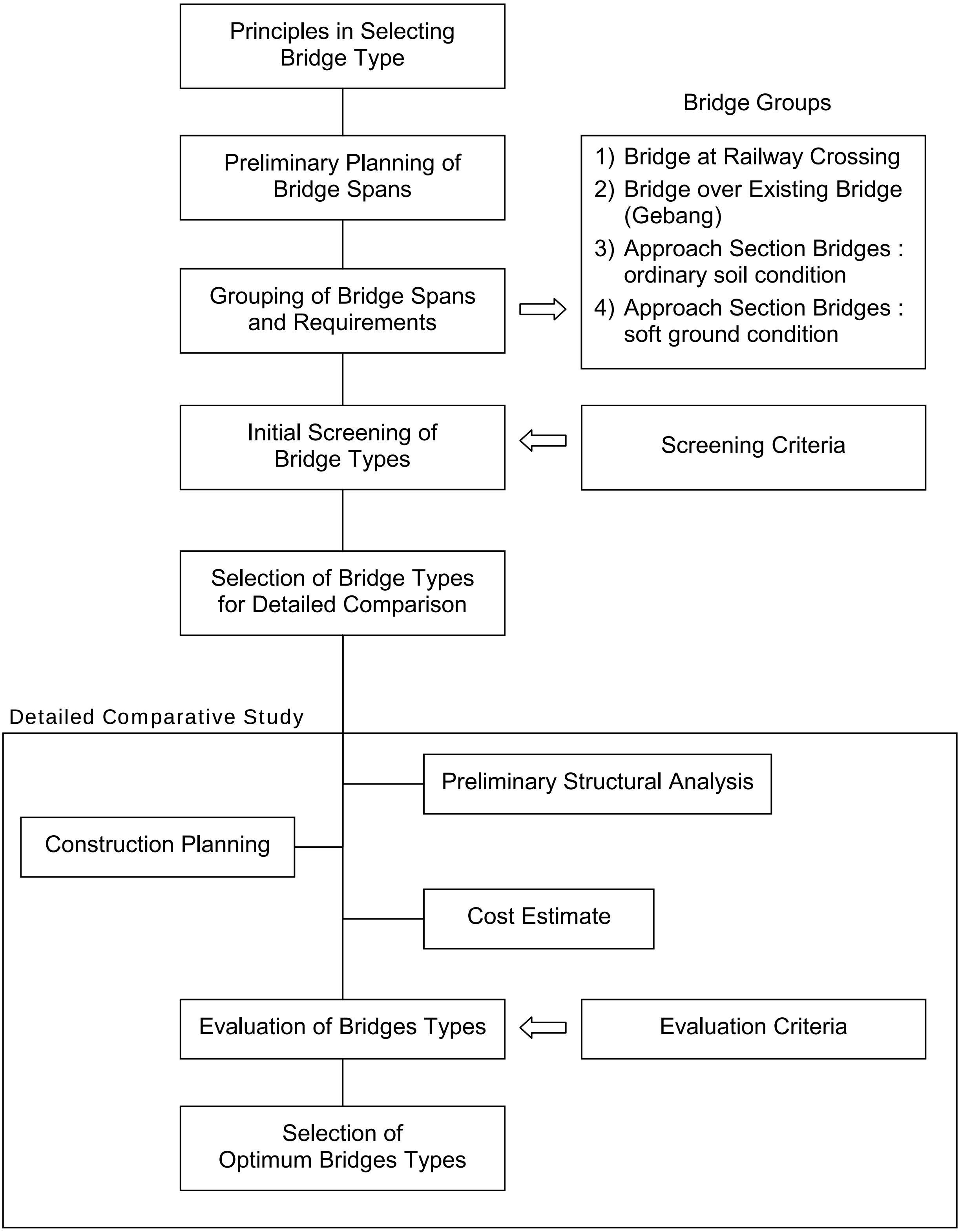


FIGURE 9.1-1 BRIDGE TYPE SELECTION PROCEDURE

9.3 PRELIMINARY PLANNING OF BRIDGE SPANS AND GROUPING OF BRIDGES

Preliminary planning of bridge spans was undertaken and bridges were grouped in consideration of requirement of span length, horizontal alignment (straight section or curved section) requirement and soil conditions. **Table 9.3-1** shows such bridge requirements by each flyover.

TABLE 9.3-1 BRIDGE REQUIREMENT

Flyover	Bridge Location	Horizontal alignment Requirement	Minimum Span Length Requirement	Soil Condition
Merak	Railway Crossing	Curved	25 m ~ 35 m	Ordinary
	Approach Bridge	Almost Straight	Any length (usually shorter span is more economical)	
Balaraja	Intersection	Curved	20 m ~ 30 m	Ordinary
	Approach Bridge	Almost Straight	Any length (usually shorter span is more economical)	
Nagreg	Railway Crossing	Curved	25 m ~ 30 m	Ordinary
	Approach Bridge	Almost Straight	Any length (usually shorter span is more economical)	
Gebang	Over Existing Bridge	Almost Straight	35 m ~ 45 m	Soft
	Intersection	Almost Straight	20 m ~ 30 m	
	Between Existing Bridge and Intersection	Almost Straight	Any length (usually shorter span is more economical)	
	Approach Bridge	Almost Straight	- do -	
Peterongan	Railway Crossing	Almost Straight	25 m ~ 35 m	Ordinary
	Approach Bridge	Almost Straight	Any length (usually shorter span is more economical)	
Tanggulangin	Railway Crossing	Curved	25 m ~ 30 m	Soft
	Approach Bridge	Almost Straight	Any length (usually shorter span is more economical)	

Based on the **Table 9.3-1**, bridges were classified into four groups as shown in **Table 9.3-2**.

TABLE 9.3-2 BRIDGE GROUPS

Bridge Group		Characteristics	Approximate share in Total Bridge Length
1.	Approach Bridge (Standard Soil Condition)	• Any span length will be applicable, however, shorter span length is usually more economical. • Almost straight alignment • Economical span length is usually 20 m ~ 30 m.	35%
2.	Approach Bridge (Soft Soil Condition)	• Any span length will be applicable. • Almost straight alignment • Economical span length need to be determined.	25%
3.	Railway Crossing	• Span length = 25m ~ 35m • Curved alignment	35%
4.	Over the Existing Bridge (Gebang Flyover)	• Span length = 35m ~ 45m • Almost straight alignment	5%

9.4 INITIAL SCREENING OF BRIDGE TYPES

Table 9.3-2 shows that applicable span length for the Project varies from 15 to 45 m. All applicable types of bridges for the said range of spans were listed and evaluated based on the following criteria :

Screening Criteria

- Not applicable
- Possible under some conditions
- Possible
- Appropriate

Table 9.4-1 shows the initial screening of bridge types for each bridge group, which are summarized as shown below :

Bridge Types for Detailed Comparative Study

Group 1 Approach Bridge (Standard Soil Condition)

- PC I-Girder or T-Girder
- PC Double Girder

Group 2 Approach Bridge (Soft Soil Condition)

- PC I-Girder or T-Girder
- PC Double Girder
- Steel I Girder (2-3 Girders)

Group 3 Railway Crossing

- Steel I Girder (2-3 Girders)
- Small Sized Steel Box Girder

Group 4 Over the Existing Bridge (Gebang Flyover)

- Steel I Girder (2-3 Girders)
- Small Sized Steel Box Girder

9.5 BRIDGE TYPE SELECTION FOR GROUP 1 (APPROACH BRIDGE, ORDINARY SOIL CONDITION)

9.5.1 Preliminary Structural Analysis

1) General

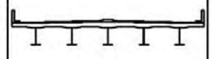
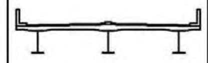
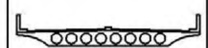
The type of substructure identified for the flyovers in the SAPROF study was single column piers supported on single large diameter bored piles. The advantages of single large diameter bored piles in providing a fast construction method, as identified by the SAPROF study, and the flexibility afforded to the structure in responding to seismic loading, led the Study Team to retain this foundation type for the Basic Design.

In identifying type of substructure for Basic Design, comparative studies were undertaken of the following:

a) Overall structure type
b) Single circular column and double circular column piers
c) Reinforced concrete and steel/concrete composite columns

Circular column piers were selected as these give the optimum section for providing a ductile response to earthquake loads, both as reinforced concrete and as composite concrete columns.

TABLE 9.4-1 INITIAL SCREENING OF SUPERSTRUCTURE TYPES

Type of Superstructure			Section	Economically Applicable Span Length (m) (15–45)	Girder Depth	Deck Slab	Applicability to Curved Section: Main Girder	Applicability to Curved Section: Slab	Fast Construction	Integration of Superstructure and Substructure	STEP Loan Requirement (JAPAN Products)
Steel		1. H-Girder		15–25	1/30 max. 1.0m	RC	× (Straight Girder)	○ (Adjustable by Cantilevered Slab)	△	△	○
Steel		2. Conventional I-Girder (Multi-Girders)		20–45	1/22~1/18	RC	△ (Curved Girder)	○ (Adjustable by Cantilevered Slab)	△	△	○
Steel		3. I-Girder (2-3 Girders)		20–45	1/20	Steel Composite or PC Slab	△ (Curved Girder)	○ (Adjustable by Cantilevered Slab)	○	○	◎
Steel		4. Small Sized Box-Girder		25–45	1/20 min. 1.2m	Steel Composite or PC Slab	◎ (Curved Box)	◎	○	◎	◎
Presstressed Concrete	Precast	5. Pre-tensioned Slab Beam		15–25	1/24	No Need	×	×	◎	×	○
Presstressed Concrete	Precast	6. I-Girder		20–40	1/16	RC	× (Straight Girder)	○ (Adjustable by Cantilevered Slab)	◎	△	○
Presstressed Concrete	Precast	7. U-Girder		20–45	1/16	PC	× (Straight Girder)	○ (Adjustable by Cantilevered Slab)	△	△	○
Presstressed Concrete	Cast-in-situ	8. Void Slab		20–30	1/22	No Need (RC for canti-levered slab)	◎	◎	△	◎	○
Presstressed Concrete	Cast-in-situ	9. Double T-Girder		20–35	1/16	PC	◎	◎	○	◎	○

Applicable Type of Bridge by Project Requirement

Type of Superstructure	Group - 1: Approach Section, Standard Soil Condition (Applicable Span Length = 20m ~ 30m)	Group - 2: Approach Section, Soft Soil Condition (Applicable Span Length = 20m ~ 30m)	Group - 3: Railway Crossing (Required Span Length = 25m ~ 35m)	Group - 4: Over River / Intersection at Gebang Flyover (Required Span Length = 35m ~ 45m)
1. H-Girder	- Difficult to apply for span length more than 25 m - Cost is higher than concrete type of bridge △	- Difficult to apply for span length more than 25 m - Cost is high △	- Difficult to apply for span length more than 25 m △	- Difficult to apply for span length more than 25 m ×
2. Conventional I-Girder (Multi-Girders)	- Cost is higher than concrete type of bridge △	- Not good for fast construction - Not good for integration of girder and pier - Cost is high △	- Not good for fast construction - Not good for integration of girder and pier △	- Not good for fast construction - Not good for integration of girder and pier ×
3. I-Girder (2-3 Girders)	- Cost is higher than concrete type of bridge △	- Possible to apply due to lighter weight than concrete bridge for soft ground ○	- Possible to apply for horizontal curve aligment - Good for integration of girder and pier ○	- Possible to apply for reqired span length - Good for soft ground due to lighter weight than PC-Girder ◎
4. Small Sized Box-Girder	- Cost is higher than concrete type of bridge △	- Cost is high △	- Good for horizontal curve aligment - Good for integration of girder and pier ◎	- Possible to apply for required span length - Good for soft ground due to lighter weight than PC-Girder ◎
5. Pre-tensioned Slab Beam	- Difficult to apply for span length more than 25 m - No. of factory limited, thus transportation problem △	- Difficult to apply for span length more than 25 m - No. of factory limited, thus transportation problem △	- Difficult to apply for span length more than 25 m - No. of factory limited, thus transportation problem ×	- Difficult to apply for span length more than 25 m - No. of factory limited, thus transportation problem ×
6. I-Girder	- Good for fast construction - Not good for integration of girder and pier ○	- Good for fast construction - Not good for integration of girder and pier ○	- Difficult to apply for horizontal curve aligment △	- Difficult to apply for span length more than 40m - Heavy superstructure, not appropriate for soft ground ×
7. U-Girder	- Not good for fast construction - Not good for integration of girder and pier △	- Not good for fast construction - Not good for integration of girder and pier △	- Difficult to apply for horizontal curve aligment △	- Difficult to apply for span length more than 40m - Heavy superstructure, not appropriate for soft ground ×
8. Void Slab	- Not good for fast construction - Heavier structural weight than other types ×	- Not good for fast construction - Heavier structural weight than other types △	- All staging construction method not appropriate for the railway crossing △	- Difficult to apply for span length more than 30m - Heavy superstructure, not appropriate for soft ground ×
9. Double T-Girder	- Fast construction by systematic form - Good for integration of girder and pier ◎	- Fast construction by systematic form - Good for integration of girder and pier ◎	- All staging construction method not appropriate for the railway crossing △	- Difficult to apply for span length more than 35m - Heavy superstructure, not appropriate for soft ground △

LEGEND :
- × : Not Applicable
- △ : Possible under some condition
- ○ : Possible
- ◎ : Appropriate

More Detailed Comparative Study ⇒	Group - 1	Group - 2	Group - 3	Group - 4
	6. PC I-Girder or T-Girder	3. Steel I-Girder (3 Girders)	3. Steel I-Girder (3 Girders)	3. Steel I-Girder (2-3 Girders)
	9. PC Double Girder	6. PC I-Girder	4. Small sized steel Box Girder	4. Small sized steel Box Girder
		9. PC Double T-Girder		

2) Overall Structure Type

The Indonesian Bridge Management System (Bridge Design Manual Volume 1) groups bridges into three (3) types, A, B and C, in accordance with their ductile seismic performance. These types and their characteristics are presented in **Table 9.5.1-1**.

The results of a comparative study of these three (3) types for adoption in this Flyover Project are presented in **Table 9.5.1-2**. As a result of this comparative study, the integrated type of structure (Type A) was basically considered for adoption as the bridge type applicable to this Project.

3) Single Column and Twin Column Piers

A comparative study was undertaken on the type of pier to be adopted for the approach sections of the Project Flyovers. The results of a comparative study of single column piers and twin column piers are presented in **Table 7.5.1-3**. As a result of this comparative study twin column piers were basically considered for adoption as the pier type applicable to the approach sections of the Project Flyovers.

4) Reinforced Concrete and Steel/Concrete Composite Columns

A comparative study was undertaken on the type of column to be adopted for the approach sections of the Project Flyovers. The results of a comparative study of reinforced concrete and composite columns are presented in **Table 9.5.1-4**. As a result of the comparative study, reinforced concrete columns were basically considered for twin column piers and composite columns were considered for single column piers as the column types applicable to the approach sections of the Project Flyovers.

TABLE 9.5.1-1 CLASSIFICATION OF BRIDGE PERFORMANCE (BMS)

BRIDGE TYPE A (Integrated)	BRIDGE TYPE B (Continuous with Bearing Support)	BRIDGE TYPE C (Simple Supports)
• Continuous superstructure • All columns framed into superstructure and foundations • Lateral forces resisted in flexure of pier columns	• Joints in the superstructure and between the superstructure and piers are permitted • All pier columns are framed into the foundations • Lateral forces resisted in flexure of pier columns	• Usually restricted to small bridges • Has no ductility in the post elastic range
Type A bridges have best seismic performance and should be chosen for important bridges in Zone 1.	Type B bridges are suitable for less severe earthquake zones but may suffer unacceptably large permanent deformations if used in Zone 1.	For small bridges where extra strength demanded can be easily provided at little cost, Type C bridges will be the most suitable.
Type A and Type B bridges will generally survive more intense shaking than calculated during design because the available ductility is usually greater than the reliable ductility assumed.		The lack of ductility in Type C bridges will result in collapse or extensive damage if the design load level is exceeded

TABLE 9.5.1-2 COMPARATIVE STUDY ON STRUCTURE TYPE

	Ductile Response	**Inspection and Maintenance**	**Constructability**	**Foundation Costs**	**Conclusion**
TYPE A (Integrated)	Excellent.	Inspection and maintenance obligation reduced to a minimum.	Requires least number of construction stages.	Lowest foundation cost for a given span length.	Recommended
TYPE B (Continuous)	Moderate	Bearings still required at every support with necessary inspection and maintenance.	Requires construction stage (and space) for pier crosshead.	Foundation costs similar to Type C bridges.	Not recommendable given headroom constraints on pier crosshead construction.
TYPE C (Simple Supports)	Very Poor	Bearings and expansion joints require significant inspection and maintenance obligation	Heavily dependent on access for crane to lift beams. Requires several stages of construction.	Highest foundation cost for a given span length.	Not Recommended

TABLE 9.5.1-3 COMPARISON OF PIER TYPE

	Ductile Response	Integration with Superstructure	Applicability of Composite Column Construction	Foundation Costs	Conclusion
TWIN COLUMN	Excellent (Highest Response Modification Factor R=5 in reducing elastic seismic demand)	Ideal for concrete double girder deck integration	Not recommended given that twin RC column construction already provides a competitive design.	Lowest foundation cost for a given span length.	Recommended unless construction space unavailable
SINGLE COLUMN	Moderate (R=3)	Most suitable for integration with steel decks as a composite column (with main girders offset from column).	Recommended where steel deck construction is adopted and to reduce foundation costs (plastic hinge demand lower than RC column)	Higher foundation costs than twin column. Still competitive compared to wall type piers.	Recommended where construction space is unavailable for twin columns.

TABLE 9.5.1-4 COMPARISON OF COLUMN TYPE

	Ductile Response	Applicability to Twin/Single Column Pier	Integration with Superstructure	Foundation Costs	Conclusion
REINFORCED CONCRETE COLUMN	Requires attention to detailing of confinement reinforcement to achieve ductile behavior.	Most applicable to twin column pier.	Ideal for concrete double girder deck integration	Highly competitive in combination as twin column piers.	Most recommendable for use in twin column piers to support concrete decks
COMPOSITE COLUMN	Excellent. Confining effect on concrete and post yield behavior of steel tube gives highly ductile column.	Most applicable to single column pier	Most suitable for integration with steel decks	Most competitive as a single column pier. The more compact section reduces minimizes plastic hinge demand	Most recommendable for use in single column piers to support steel decks

5) Detailed Analysis of Substructure for Comparative Study

As part of the comparative study, a detailed analysis was undertaken to identify foundation sizes of three (3) types of structure:

a) PC Double Girder Deck integrated with reinforced concrete double column piers
b) 3-I Steel Girder Deck integrated with reinforced concrete double column piers
c) Pre-stressed concrete T Girder Deck simply supported on reinforced concrete double column piers

The detailed analysis was carried out using a four (4) span frame with 20m, 25m and 30m spans, with 6m high pier columns, subject to seismic loads corresponding to Indonesian Seismic Zone 3. All piers were supported on single large diameter bored piles and average soil conditions were assumed in providing support to the piles in the analysis. The analysis worked to the limits of pier column diameter and pile diameter in each case, in order to fully expose differences in the designs. (Pier column diameters smaller than 900mm, however, were not selected given the substantial moment magnification effects encountered due to column slenderness for this small diameter column.) It is noted that the pier column diameters and pile diameters finally selected for the Basic Design are larger than those identified in this comparative study, given the range of pier column heights, the variable soil conditions and the different seismic zones encountered at each Flyover.

The results of the analysis for 20m spans are shown in **Table 9.5.1-5**.

As can be seen from the results of the detailed analysis, the integrated concrete deck structure requires smaller diameter columns than the simply supported concrete deck structure. This is because of two (2) factors:

(1) the structure integration results in the column responding to seismic loads with resisting moments at both the top and bottom of the column, whereas the column supporting the simply supported responds with maximum moments only at the base (in the longitudinal direction), and
(2) the slenderness of the columns supporting simply supported decks is greater for a given column diameter (in the longitudinal direction) than that of columns integrated with the deck, leading to larger moment magnification factors for columns with simple supports.

It is noted that the overall response to seismic loading is less for the simply supported deck (in the longitudinal direction) given that the structure is more flexible and therefore generates less demand during an earthquake. However, the influence of the two (2) factors mentioned above is such that finally the design moments in the columns of simply supported concrete decks are greater than for integrated concrete decks (with dead load for each type of deck not substantially different).

The pile diameters of the simply supported concrete decks are larger than for the integrated concrete decks. The larger demand at the base of the simply supported decks resulting in larger column sizes lead directly to larger plastic hinging effects at the column base and larger piles sizes as a result.

The steel deck case generated the lowest demand of all three types given that the dead load of the deck is comparatively light.

TABLE 9.5.1-5 COMPARISON STUDY ON SUBSTRUCTURE (TWIN COLUMN PIERS)

Plastic Hinging Effects - 20m Span case

		Column					**Pile**				
Deck	Mag. Factor	Dia mm	Mptop kNm	H m	Mpbase kNm	Vp kN	Dia m	Mmax kNm	Rebar	Disp cm	Rot rad
PC Double (Integrated)	1.14	900	3300.0	6.0	2300	933	1.3	5000.0	2.5%	12	0.025
Steel 3-I Girder (Integrated)	1.10	900	2720.0	6.0	2140	810	1.3	4130.0	2.0%	9	0.020
PC T Girder (Simply Supported)	1.18	1000	3400.0	6.0	4350	1292	1.5	8500.0	3.0%	15	0.028

NOTE: Mp = Plastic Moment Capacity of Column H = Column Height Mmax = Maximum moment in pile

Vp = Plastic Shear Capacity of Column

Displacements and rotations are at pile top

JRA Part V (Seismic Design) recommended allowable displacement of pier foundation is 0.02 rad (yielding foundation)

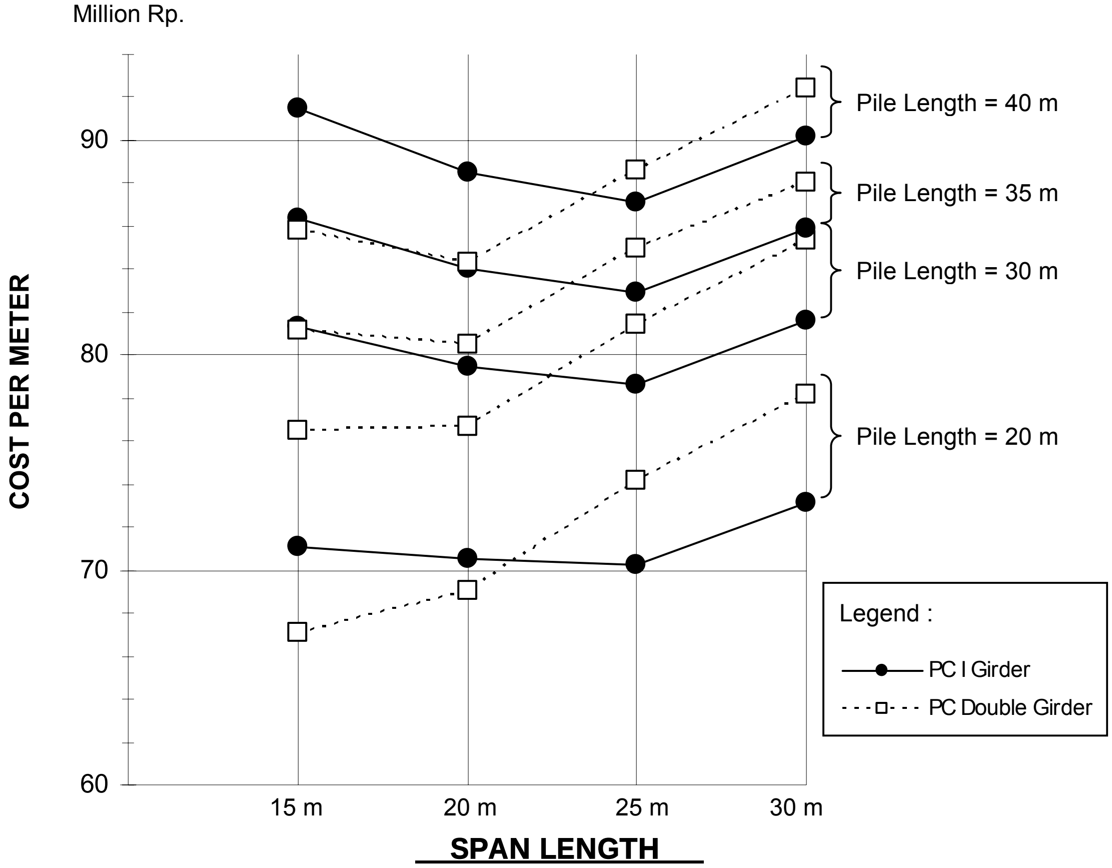
JRA Part IV (Substructures) recommended allowable displacement of pier foundation is 40cm and 0.025 rad (yielding foundation)

6) Cost Comparison by Span Length

Cost comparison by span length for bridge types of PC I Girder and PC Double Girder is shown in **Figure 9.5.1-1**. The cost includes superstructure, substructure and foundation and is shown in cost per meter of bridge.

PC I Girder : Although costs of 15, 20 and 25 meter-span are almost same, but 25 meter-span is most economical with slight advantage.

PC Double Girder : Costs of 15 and 20 m - span are almost same, but pile length increases, 20 m - span becomes most economical.



Pile Length	Bridge Type	Construction Cost per m (Million Rp.)			
		Span Length			
		15 m	20 m	25 m	30 m
20 m	PC I Girder	71.1	70.5	70.2	73.1
	PC Double Girder	67.1	69.0	74.2	78.2
30 m	PC I Girder	81.3	79.5	78.6	81.6
	PC Double Girder	76.5	76.7	81.4	85.3
35 m	PC I Girder	86.4	84.0	82.9	85.9
	PC Double Girder	81.1	80.5	85.0	88.0
40 m	PC I Girder	91.5	88.5	87.1	90.2
	PC Double Girder	85.8	84.3	88.6	92.4

FIGURE 9.5.1-1 COST COMPARISON BY SPAN LENGTH

9.5.2 Bridge Type Selection

Comparison of bridge types is shown in **Table 9.5.2-1**.

Evaluation was made adopting weighted point method and criteria are shown below :

Evaluation Criteria

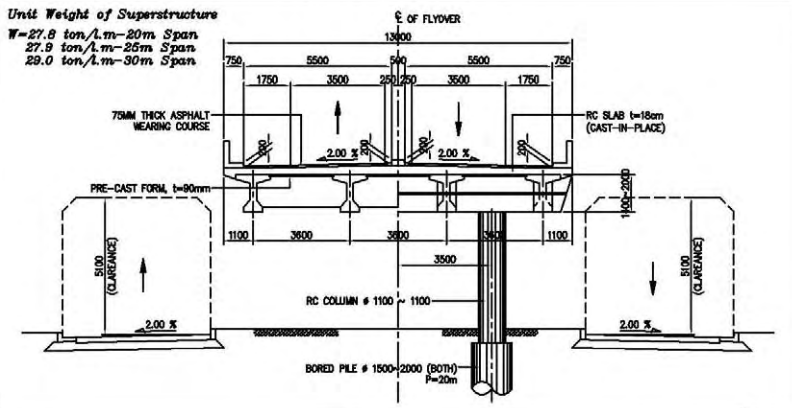
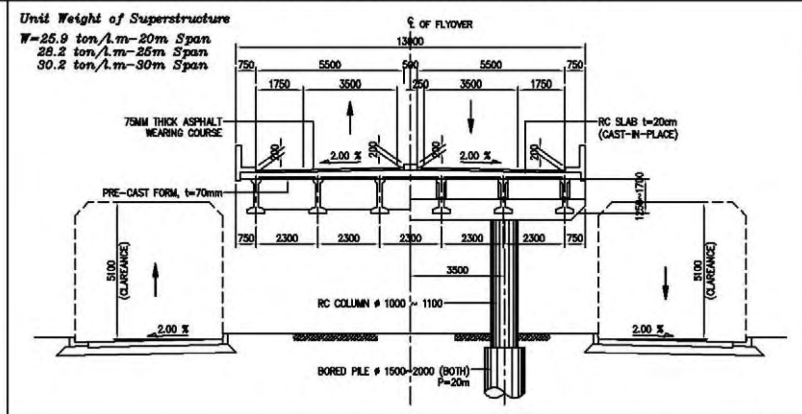
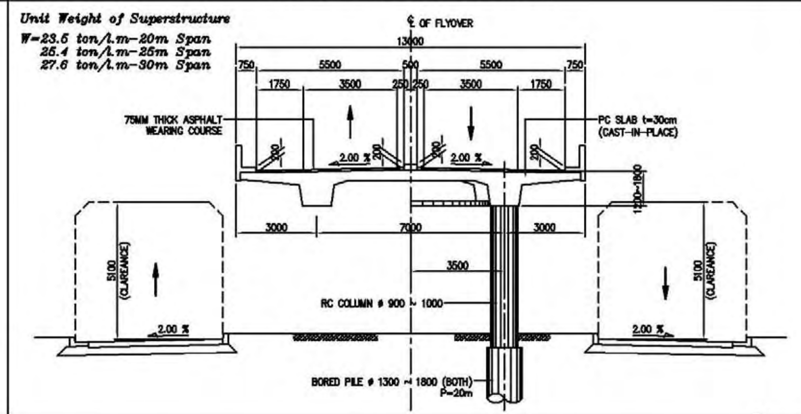
Factor		**Weight**
1.	Construction Cost	40
2-1	Construction Difficulty / Effective Traffic Management	10
2-2	Construction Period (Fast Construction)	12
3-1	Structural Aspect (Applicability to Horizontal Curvature)	5
3-2	Structural Aspect (Applicability to Integrated Pier and Earth-quake Resistance	10
4.	Maintenance	3
5.	Introduction of New Technology	5
6.	Aesthetics	10
7.	STEP Loan Requirement Consideration (Japanese Contents)	5
Total		**100 points**

Table 9.5.2-1 shows that

- All types are competitive in terms of construction cost.
- PC Double Girder has advantages in the following factors :
  - Construction period
  - Applicability to horizontal curvature
  - Applicability to integrated pier and earthquake resistance
  - Maintenance
  - Introduction of new technology
  - Aesthetic
  - STEP Loan Requirement

In view of above, <u>PC Double Girder</u> was recommended for Group 1 bridges.

TABLE 9.5.2-1 APPROACH SECTION OF FLYOVER AT STANDARD SOIL CONDITION, BALARAJA Flyover ; PILE LENGTH = 20m

DESCRIPTION	SCHEME 6 PC T-GIRDER	SCHEME 6' PC I-GIRDER (Indonesia Standard)	SCHEME 9 PC DOUBLE GIRDER
SECTION			

LM : linear meter

Item No.	Criteria		Max Point	Scheme 6 Evaluation	Point	Scheme 6' Evaluation	Point	Scheme 9 Evaluation	Point
1	Construction Cost / Economic Aspect (include substructure and pile foundation)		40	Span Length / Cost M Rp /span / Cost /LM / LM Cost Ratio / Remarks 20m Span / 1,378.5 / 68.93 / 1.00 / Girder Height = 1.40m 25m Span / 1,749.0 / 68.96 / 1.00 / Girder Height = 1.60m 30m Span / 2,171.3 / 72.38 / 1.00 / Girder Height = 2.00m	40	Span Length / Cost M Rp /span / Cost /LM / LM Cost Ratio / Remarks 20m Span / 1,386.8 / 69.34 / 1.01 / Girder Height = 1.25m 25m Span / 1,794.3 / 71.77 / 1.03 / Girder Height = 1.60m 30m Span / 2,130.1 / 71.00 / 0.98 / Girder Height = 1.70m	40	Span Length / Cost M Rp /span / Cost /LM / LM Cost Ratio / Remarks 20m Span / 1,361.9 / 68.10 / 0.99 / Girder Height = 1.20m 25m Span / 1,839.8 / 73.59 / 1.05 / Girder Height = 1.60m 30m Span / 2,439.4 / 81.31 / 1.12 / Girder Height = 2.00m	40
2	Construction Difficulty / Effective Traffic Managment		10	Easy – Erection of Girder by truck crane during night time. – Precast PC panel is used as forms for deck slab concreting between girders, which will also constitute a pant of deck slab. – Ordinary forms are used for cantilevered deck slab. – Several steps of concreting for coping, diaphragm and slab are involved.	8	Easy – Erection of Girder by truck crane during night time. – Precast PC panel is used as forms for deck slab concreting between girders. – Ordinary forms are used for cantilevered deck slab. – Several steps of concreting for coping, diaphragm and slab are involved.	8	Easy but traffic is disturbed more than other types – All concrete works are done by cast–in–situ using systematic form work (movable type), or by all–staging method. – Deck slabs is post–tensioned, girders is particial prestressed concrete. – Traffic will be disturbed not only night time but also day time.	6
	Construction Period (Fast Construction)		12	Need time for coping works – Girders can be manufactured during construction of substructure. – Night time traffic is disturbed during girder erection. – Traffic disturbance during coping construction is expected.	10	similar to T-girder – Girders can be manufactured during construction of substructure. – Night time traffic is disturbed during girder erection.	9	Faster than other schemes – Superstructure work can start after completion of column, since no coping is required. – By using fast setting concrete and systematic form work, duration of. construction may be reduced.	11
3	Structural Aspect	Applicability to Horizontal Curvature	5	Rather difficult for sharp curve section – Adjusted by width of cantilever portion of deck slab. – Trapezoidal shape (flared type) coping to be used for fitting curvature.	4	Rather difficult for sharp curve section – Adjusted by width of cantilever portion of deck slab, however its difficult due to short cantilever. – Trapezoidal shape (flared type) coping is needed for fitting curvature.	3	Easy – Curved girders can be possible. – Flyover can construct exactly with the smooth curve with stable flyover system.	5
		Applicability to Integrated Pier and Earthquake Resistance	10	Difficult – Integration of girder and pier difficult. – Girder falling prevention devices needed. – Not ideal system for Bridge Type A (Bina Marga requirement).	6	Difficult – Integration of girder and pier difficult. – Girder falling prevention devices needed. – Not ideal system for Bridge Type A (Bina Marga requirement)..	6	Easy – Integration of girder and pier. – This system is fully comply with Bina Marga Requirement "Bridge Type A" (Integrated Bridge System).	10
4	Maintenance		3	Fair – Expansion joint can be eliminated by connecting deck slab of neighbouring spans. – Need maintenance of bearing pads and girder falling prevention devices.	1	Fair – Expansion joint can be eliminated by connecting deck slab of neighbouring spans. – Need maintenance of bearing pads and girder falling prevention devices.	1	Good – Almost maintenance free. Structurally integrated, therefore after strong earthquake, damage of column will be located top of column where accessible and easy to repair.	3
5	Introduction of New Technology		5	No – Slab with reinforced concrete is not highly durable. – Composite deck slab with PC precast panel between girders which also works as a form for deck slab concreting.	3	No – Conventional type. – Slab with reinforced concrete is not highly durable. – Precast panel can be used as a form.	3	Yes – New concept of prestressed concrete slab and integrated with slab and girder by Double T–Type Girder System. – This system is also verified in Japan as appropriate seismic system in earthquake country.	5
6	Aesthetics		10	Fair – Commonly seen at flyover in the country, but not appreciated especially for STEP Loan Project Program.	5	Fair – Commonly seen at flyover in the country, but not appreciated especially for STEP Loan Project Program.	5	Good – Looks slender and gives impression of relived. Good view in urban area. – Using high strength concrete, view of concrete will be same as precast girder, solid and clean concrete colour.	8
7	STEP Loan Requirement Consideration (Japanese Contents)		5	Less Japan's Contents – PC strands/ anchors and girder falling prevention devices will be japanese. – Difficult to comply with STEP Loan Requirement contents on Japanese Technology application.	3	Less Japan's Contents – PC strands/ anchors & girder falling prevention devices will be Japanese contents – Difficult to comply with STEP Loan Requirement on Japanese Technology application.	3	Higher Japan's Contents than other types – PC strands/ anchors & both main girders & deck slab will be Japanese contents. – High strength concrete for fast construction is suitable for STEP. – Seismically highly stable structural system is one of the strongest justification of STEP Loan requirement.	5
	Total Point		100		80		78		93
	Evaluation			Not Recommended		Not Recommended		Recommended	
	Remarks			• Unless coping and slab are precasted and be installed by segment method, precasting girder only is not effective in terms of faster construction concept.		• Unless coping and slab are precasted and be installed by segment method, precasting girder only is not effective in terms of faster construction concept.		• As STEP Loan Project, this scheme is the best option to apply seismically most stable and integrated flyover system using Japanese Technology, such as composite column and single bored pile (large size). For faster construction high performance concrete will be recommended.	

9.6 BRIDGE TYPE SELECTION FOR GROUP 2 (APPROACH SECTION: SOFT SOIL CONDITIONS)

9.6.1 Preliminary Structural Analysis

1) General

Soft soil conditions are encountered at both Gebang and Tanggulangin Flyover sites. The very soft soils typically occur to depths of approximately 10m and 20m at Gebang and Tanggulangin, respectively.

The bridge types nominated at these soft soil types is the same as at sites with ordinary soil conditions, with counter measures required as necessary to mitigate the adverse effects of the soft soils.

A study on the response of the approach structures using both double column and single column piers was undertaken. The results of the study showed that the twin column design can be used at the soft soil sites without additional treatment, given that the demand on the pile foundations is reduced to a minimum by this type of substructure for the span lengths selected and the pile diameter is large enough to carry the demand to the lower stiffer soil layers.

However, for single column piers, the demand on the foundations typically is too great to be supported by the underlying soft soils at shallow depth, notwithstanding that larger diameter piles are adopted. Counter measures to mitigate the effects of the soft soils are therefore required at these locations.

It is also noted that bored pile foundations supporting the longer spans of both Gebang and Tanggulangin are also typically larger in diameter than the approach spans and will also require similar soft soil countermeasures.

2) Soft Soil Countermeasures

Three alternative (3) soft soil countermeasures were identified in the Basic Design as follows:

a) Steel Casing method used with single bored pile foundation
b) Soil Treatment method used with single bored pile foundation
c) Pile Cap to replace single bored pile with a pile group

The steel casing method makes use of the composite action of the steel casing and the concrete pile both to carry the demand down the pile to the stiffer layers below and to reduce displacements and rotations at the pile head.

The soil treatment method relies on soil mixing and jetting technology to incorporate cementitious materials into the soft soils at shallow depth surrounding the pile, thereby increasing the ultimate horizontal bearing capacity of the soils and offering increased direct support to the pile head.

The pile cap alternative replaces the flexible single pile with a much stiffer pile cap and group of smaller diameter piles. This type of foundation is substantially less sensitive to soft soil conditions at shallow depth, relying on the "push-pull" action within the pile group to transfer demand to the lower stiffer soils with very reduced bending moments generated in the piles themselves.

Figure 9.6.1-1 illustrates the three soft soil countermeasure methods. The analysis assumed the following characteristics for each alternative investigated:

Soft Soil Countermeasure	Characteristics
a) Steel Casing	• 12m long steel casing (Fy =250MPa) • Casing thickness 16mm acting compositely with reinforced concrete pile. (spirally wound steel pipe with internal ribs rolled into the section)
b) Soil Treatment	• Treatment achieves an unconfined compressive strength in the soil of 200kN/m^2 to a depth of 6m.
c) Pile Cap	• 7m x 7m x 2m pile cap supported on 4 No. 1.4m diameter reinforced concrete piles.

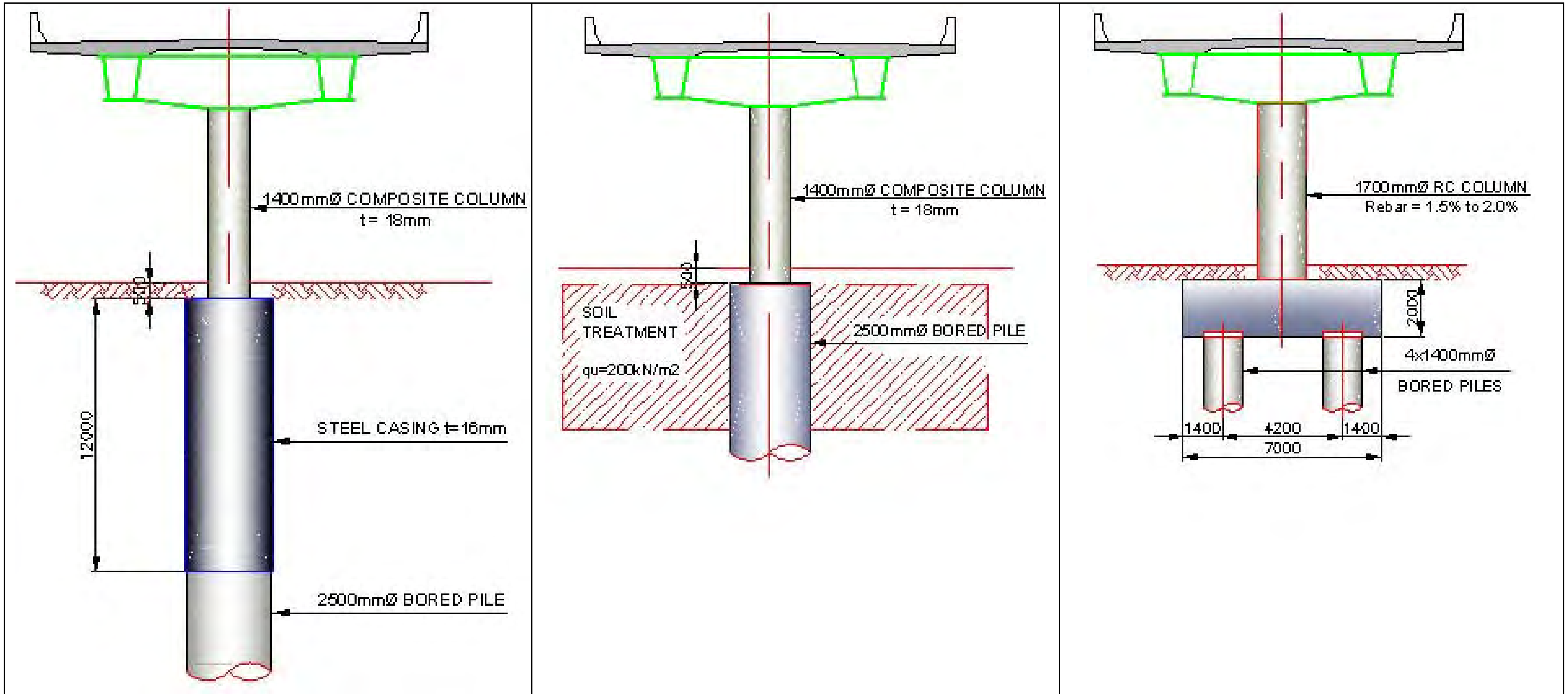
For the pile cap alternative, a reinforced concrete column with a similar plastic hinging capacity to the composite column is shown, given the difficulties of providing a connection for a composite column to a concrete pile cap.

Table 9.6.1-1 shows the results of the analysis of the single bored pile foundation, supporting both double column and single column type piers, without countermeasures against soft soil and also with each type of countermeasure identified above.

For the single column case without soil treatment, the maximum bending moments in the pile are more than double the applied moment at the pile head requiring an excessive amount of reinforcement. In addition the lateral displacement of the pile head is 16cm and the rotation at the pile head exceeds JRSA Part V (Seismic Design) recommendations. Counter measures to mitigate the lack of support provided by the soft soil are therefore considered necessary.

As can be seen from Table 9.6.1-1, each of the countermeasures identified improves the performance of the pile foundation under plastic hinging effects of the pier column to some degree.

The most substantial improvement in the response of the foundation to the plastic hinge demand from the pier column is the pile cap alternative. For this case the pile cap displacements are reduced to such an extent as to no longer be a critical design consideration. Bending moments in the individual piles can also comfortably be carried by the reinforced concrete section.



a) STEEL CASING METHOD	b) SOIL TREATMENT METHOD	c) PILE CAP METHOD

FIGURE 9.6.1-1 SOFT SOIL COUNTERMEASURES FOR FOUNDATIONS

TABLE 9.6.1-1 PLASTIC HINGING EFFECTS - SOFT SOIL LOCATION

Pier Type	Soft Soil Countermeasure	Column						Pile				
		Dia m	Type	Mptop kNm	H m	Mpbase kNm	Vp kN	Dia m	Mmax kNm	Rebar %	Disp cm	Rot rad
Double Column	None	1.00	RC	3100	7.5	3000	813	1.5	4900	1.5	7	0.015
Single Column	None	1.40	Comp (t=18)	15900	8.0	15900	3975	2.5	36500	2.5	16	0.021
Single Column	STEEL CASING (length = 12m) (t = 16mm)	1.40	Comp (t=18)	15900	8.0	15900	3975	2.5	36300	1.0	12	0.013
Single Column	SOIL TREATMENT	1.40	Comp (t=18)	15900	8.0	15900	3975	2.5	24800	1.5	7	0.012
Single Column	PILE CAP	1.70	RC	15900	8.0	15900	3975	4x1.4	2200	1.25	3	0.003

NOTE: Mp = Plastic Moment Capacity of Column H = Column Height Mmax = Maximum moment in pile
Vp = Plastic Shear Capacity of Column

JRA Part V (Seismic Design) recommended allowable displacement of pier foundation is 0.02 rad (yielding foundation)
JRA Part IV (Substructures) recommended allowable displacement of pier foundation is 40cm and 0.025 rad (yielding foundation)

Soil conditions are assumed averaged from Tanggulangin site. Displacements and rotations are at pile top.
For 1.5m Dia pile : 1 layer of 32mm bars at 120mm c/c is equivalent to 1.5% rebar.
For 2.5m Dia pile : 2 layers of 32mm bars at 120mm c/c is equivalent to 1.8% rebar.

The pile cap alternative, however, is not considered advantageous with regard to speed of construction, requiring several stages to complete, additional cost for pile cap construction, and impact on traffic management with the substantially larger space required for construction.

The soil treatment method has a substantial impact on reducing displacements at the pile head and bending moments in the single large diameter pile. However the extent of the treatment, the required quality control and testing of the treated soil, impact on traffic management during construction and the cost of the treatment all militate against this alternative as a preferred choice.

The steel casing method, although giving the least improvement in lateral displacements at the pile head, provides a similar level of improvement to the soil treatment method with regard to pile rotation. The lateral displacement, at 12cm, is substantial but considered not excessive considering the ultimate condition of the loading case. In addition the contribution of the steel casing to the bending capacity of the pile allows reinforcement levels at the maximum moment location to be reduced to 1%.

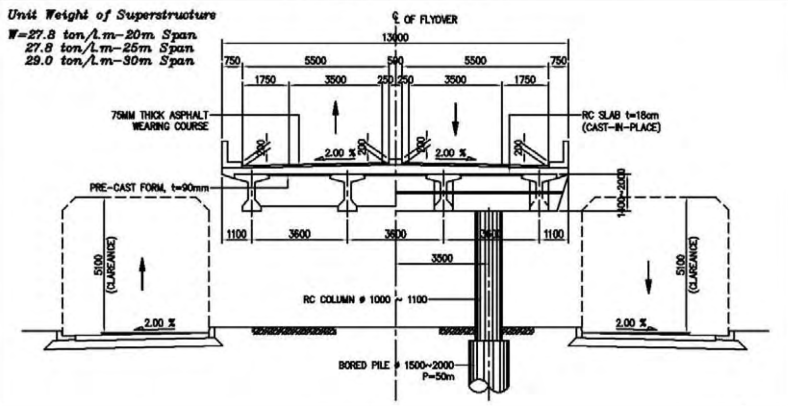
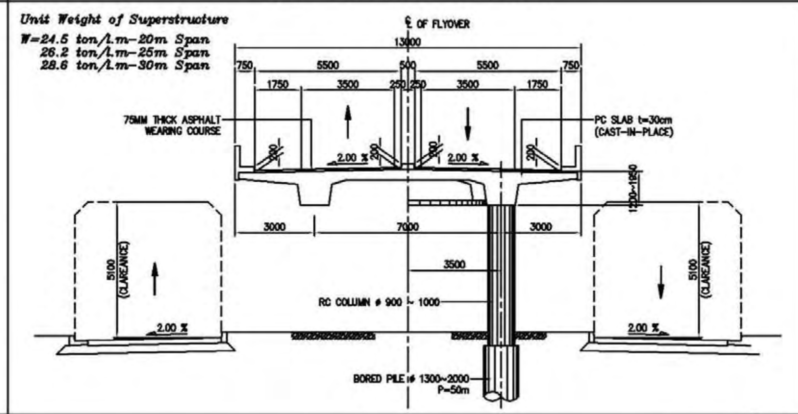
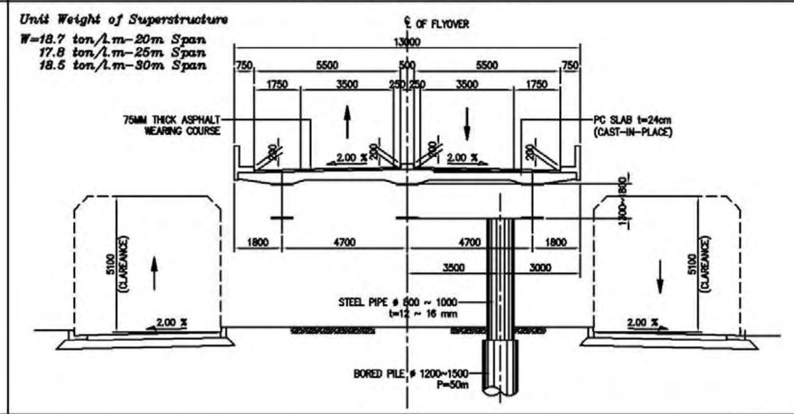
A composite steel casing of at least 6m in length and 9mm in thickness will be required to provide a socket type connection to composite column piers, irrespective of soil conditions. It is therefore recommended that this method is adopted as a soft soil countermeasure with the casing extended and made thicker as required in order to control pile head displacement and carry bending moments down the pile shaft.

9.6.2 Bridge Type Selection

Table 9.6.2-1 shows comparison of bridge types. The same evaluation criteria as shown in 9.5.2 were adopted.

PC Double Girder is more advantageous than other types and was recommended for Group-2 bridges.

TABLE 9.6.2-1 APPROACH SECTION OF FLYOVER AT SOFT SOIL CONDITION, TANGGULANGIN FLYOVER ; PILE LENGTH = 50m

DESCRIPTION	SCHEME 6 PC T-GIRDER	SCHEME 9 PC DOUBLE GIRDER	SCHEME 3 STEEL I-GIRDER
SECTION			

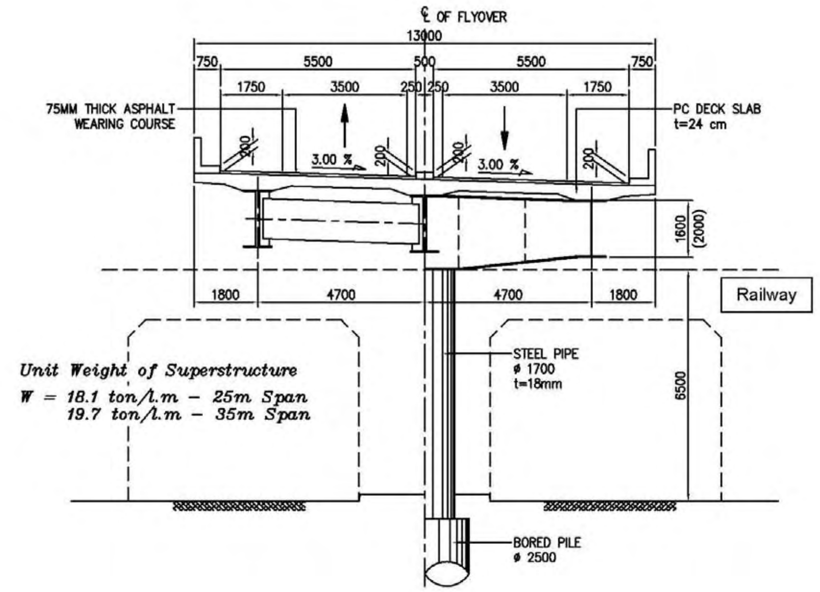
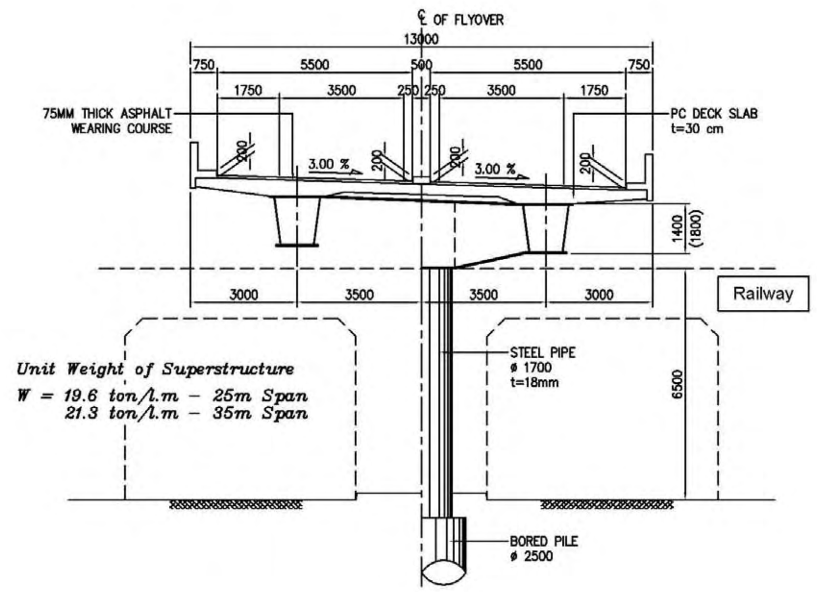
Item No.	Criteria		Max Point	Evaluation (LM : linear meter)	Point	Evaluation (LM : linear meter)	Point	Evaluation	Point
1	Construction Cost / Economic Aspect (include substructure and pile foundation)		40	Span Length / Cost (M Rp)/span / Cost /LM / LM Cost Ratio / Remarks 20m Span / 1,875.4 / 93.77 / 1.00 / Girder Height = 1.40m 25m Span / 2,383.4 / 95.34 / 1.00 / Girder Height = 1.60m 30m Span / 2,911.3 / 97.04 / 1.00 / Girder Height = 2.00m	40	Span Length / Cost (M Rp)/span / Cost /LM / LM Cost Ratio / Remarks 20m Span / 1,743.7 / 87.19 / 0.93 / Girder Height = 1.20m 25m Span / 2,336.7 / 93.47 / 0.98 / Girder Height = 1.60m 30m Span / 3,073.8 / 102.46 / 1.06 / Girder Height = 2.00m	40	Span Length / Cost (M Rp)/span / Cost /LM / LM Cost Ratio / Remarks 20m Span / 3,198.2 / 159.9 / 1.71 / Girder Height = 1.30m 25m Span / 4,329.1 / 173.2 / 1.82 / Girder Height = 1.60m 30m Span / 5,758.4 / 192.0 / 1.98 / Girder Height = 1.80m	23
2	Construction Difficulty / Effective Traffic Managment		10	Easy – Erection of Girder by truck crane during night time. – Precast PC panel is used as forms for deck slab concreting between girders, which will also constitute a pant of deck slab. – Ordinary forms are used for cantilevered deck slab. – Several steps of concreting for coping, diaphragm and slab are involved.	8	Easy but traffic is disturbed more than other types – All concrete works are done by cast–in–situ using systematic form work (movable type), or by all–staging method. – Deck slabs is post–tensioned, girders is particial prestressed concrete. – Traffic will be disturbed not only night time but also day time.	6	Easy – Erection of Girder by truck crane during night time. – Construction of PC deck slab will be by conventional method. – Traffic will be disturbed not only night time but also day time.	8
	Construction Period (Fast Construction)		12	Need time for coping works – Girders can be manufactured during construction of substructure. – Night time traffic is disturbed during girder erection. – Traffic disturbance during coping construction is expected.	10	Faster than PC T-Girder – Superstructure work can start after completion of column, since no coping is required. – By using fast setting concrete and systematic form work, duration of. construction may be reduced.	11	Faster than other schemes – Superstructure work is shortest scheme of construction period. – By using fast setting concrete and systematic form work, duration of. construction may be reduced.	12
3	Structural Aspect	Applicability to Horizontal Curvature	5	Rather difficult for sharp curve section – Adjusted by width of cantilever portion of deck slab. – Trapezoidal shape (flared type) coping to be used for fitting curvature.	4	Easy – Curved girders can be possible. – Flyover can construct exactly with the smooth curve with stable flyover system.	5	Rather difficult for sharp curve section – Steel girder shoul be applied curve shape due to easier construction of PC deck slab.	4
		Applicability to Integrated Pier and Earthquake Resistance	10	Difficult – Integration of girder and pier difficult. – Girder falling prevention devices needed. – Not ideal system for Bridge Type A (Bina Marga requirement).	6	Easy – Integration of girder and pier. – This system is fully comply with Bina Marga Requirement "Bridge Type A" (Integrated Bridge System).	10	Easy – Integration of girder and pier. – This system is fully comply with Bina Marga Requirement "Bridge Type A" (Integrated Bridge System).	10
4	Maintenance		3	Fair – Expansion joint can be eliminated by connecting deck slab of neighbouring spans. – Need maintenance of bearing pads and girder falling prevention devices.	1	Good – Almost maintenance free. Structurally integrated, therefore after strong earthquake, damage of column will be located top of column where accessible and easy to repair.	3	Fair – Almost maintenance free, but be worse than scheme 9.	2
5	Introduction of New Technology		5	No – Slab with reinforced concrete is not highly durable. – Composite deck slab with PC precast panel between girders which also works as a form for deck slab concreting.	3	Yes – New concept of prestressed concrete slab and integrated with slab and girder by Double T–Type Girder System. – This system is also verified in Japan as appropriate seismic system in earthquake country.	5	Yes – New concept of prestressed concrete slab and integrated with slab and steel I–Girder by Lesser Girder System. – This system is also verified in Japan as appropriate seismic system in earthquake country.	5
6	Aesthetics		10	Fair – Commonly seen at flyover in the country, but not appreciated especially for STEP Loan Project Program.	5	Good – Looks slender and gives impression of relived. Good view in urban area. – Using high strength concrete, view of concrete will be same as precast girder, solid and clean concrete colour.	8	Fair – Commonly seen at flyover, but not appreciated especially for STEP Loan Project Program.	5
7	STEP Loan Requirement Consideration (Japanese Contents)		5	Less Japan's Contents – PC strands/ anchors and girder falling prevention devices will be japanese. – Difficult to comply with STEP Loan Requirement contents on Japanese Technology application.	3	Fair Japan's Contents. – PC strands/ anchors & both main girders & deck slab will be Japanese contents. – High strength concrete for fast construction is suitable for STEP. – Seismically highly stable structural system is one of the strongest justification of STEP Loan requirement.	4	Higher Japan's Contents from other schemes – Steel girder & deck slab will be Japanese contents. – Seismically highly stable structural system is one of the strongest justification of STEP Loan requirement.	5
Total Point			100		80		92		75
Evaluation				Not Recommended		Recommended		Not Recommended	
Remarks				• Unless coping and slab are precasted and be installed by segment method, precasting girder only is not effective in terms of faster construction concept.		• As STEP Loan Project, this scheme is the best option to apply seismically most stable and integrated flyover system using Japanese Technology, such as composite column and single bored pile (large size). For faster construction high performance concrete will be recommended.		• As approach bridge for soft ground, this scheme is too expensive.	

9.7 BRIDGE TYPE SELECTION FOR GROUP 3 (RAILWAY CROSSING)

Similar preliminary structural analysis was undertaken. Comparison of bridge types is shown in **Table 9.7.1-1**.

Although construction cost of Small Size Steel Box Girder is slightly higher than Steel I Girder, other factors such as easy construction, construction period, aesthetics, etc., are more advantageous. Since PC Double Girder Type is recommended for approach section bridges, small size steel box girder provides the consistent view throughout the bridge section, thus this type is recommended for Group 3 bridges.

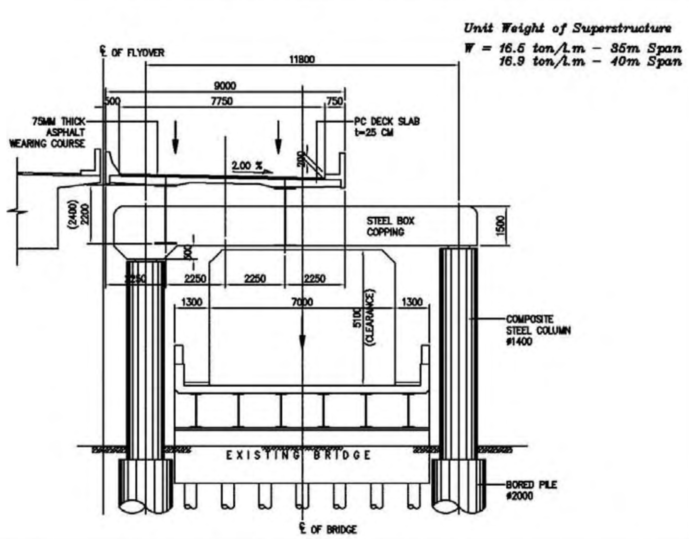
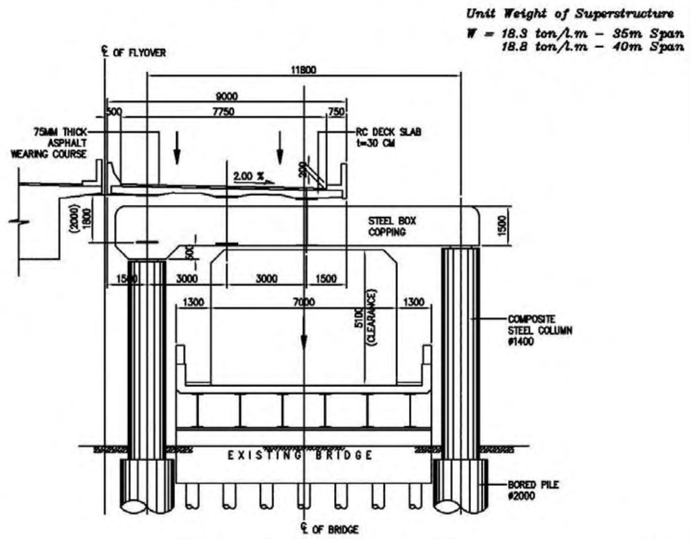
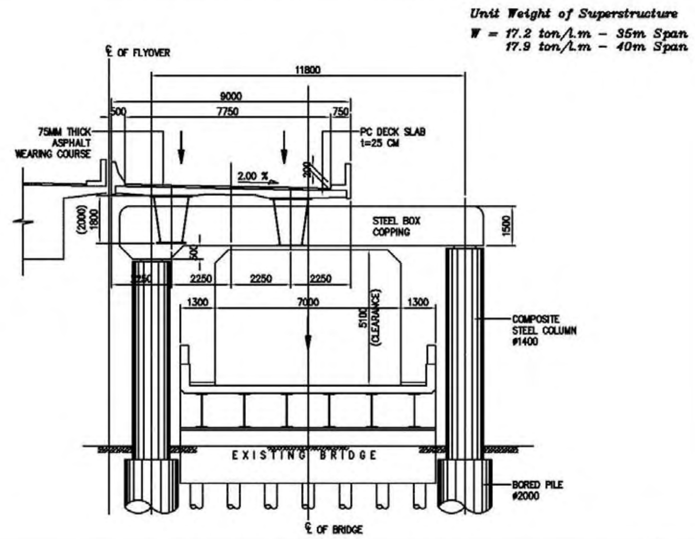
TABLE 9.7.1-1 RAILWAY CROSSING AT MERAK, NAGREG, PETERONGAN AND TANGGULANGIN FLYOVER

<table>
<tr><th colspan="4">DESCRIPTION</th><th colspan="3">SCHEME 1 STEEL I-GIRDER</th><th colspan="3">SCHEME 2 SMALL SIZE STEEL BOX GIRDER</th></tr>
<tr><td colspan="4">SECTION</td><td colspan="3">
</td><td colspan="3">
</td></tr>
<tr><th>Item No.</th><th colspan="2">Criteria</th><th>Max Point</th><th colspan="2">Evaluation</th><th>Point</th><th colspan="2">Evaluation</th><th>Point</th></tr>
<tr><td>1</td><td colspan="2">Construction Cost / Economic Aspect</td><td>40</td><td colspan="2"><table><tr><th>Span Length</th><th>Cost (M Rp)/span</th><th>Cost / LM</th><th>Cost Ratio</th><th>Remarks</th></tr><tr><td>25m Span</td><td>3,620.9</td><td>144.8</td><td>1.00</td><td>Girder Height = 1.60m</td></tr><tr><td>35m Span</td><td>6,390.7</td><td>182.6</td><td>1.00</td><td>Girder Height = 2.00m</td></tr></table></td><td>40</td><td colspan="2"><table><tr><th>Span Length</th><th>Cost (M Rp)/span</th><th>Cost / LM</th><th>Cost Ratio</th><th>Remarks</th></tr><tr><td>25m Span</td><td>3,699.5</td><td>148.0</td><td>1.02</td><td>Girder Height = 1.40m</td></tr><tr><td>35m Span</td><td>6,937.5</td><td>198.2</td><td>1.09</td><td>Girder Height = 1.80m</td></tr></table></td><td>36</td></tr>
<tr><td rowspan="2">2</td><td colspan="2">Construction Difficulty / Effective Traffic Management</td><td>10</td><td>Fair</td><td>Easy</td><td>9</td><td>Best</td><td>Suitable for curved girder and stable during erection, especially above railway.</td><td>10</td></tr>
<tr><td colspan="2">Construction Period (Fast Construction)</td><td>12</td><td>Fair</td><td>Needs longer construction period than scheme 2 due to increased small steel members.</td><td>7</td><td>Good</td><td>Less number of steel members for erection.</td><td>10</td></tr>
<tr><td rowspan="2">3</td><td rowspan="2">Structural Aspect</td><td>Applicability to Horizontal Curvature</td><td>5</td><td>Best</td><td>Need intermediate cross beam and full lower lateral bracing is required for curve section.</td><td>5</td><td>Best</td><td>No need intermediate diaphragm and most ideal structure system.</td><td>5</td></tr>
<tr><td>Applicability to Integrated Pier and Earthquake Resistance</td><td>10</td><td>Good</td><td>Easy to integrate between steel I girder ad box pier coping.</td><td>10</td><td>Good</td><td>Easy to integrate beetween box-girder and box-pier coping.</td><td>10</td></tr>
<tr><td>4</td><td colspan="2">Maintenance</td><td>3</td><td>Good</td><td>Presstresed concrete deck slab is durable and less maintenance.</td><td>2</td><td>Good</td><td>Appropriate slab system and less maintenance.</td><td>2</td></tr>
<tr><td>5</td><td colspan="2">Introduction of New Technology</td><td>5</td><td>Fair</td><td>Rigid connection of girder and pier.</td><td>3</td><td>Good</td><td>Small size box girder and less number of girders with prestressed concrete slab.
Rigid connection of girder and pier.</td><td>4</td></tr>
<tr><td>6</td><td colspan="2">Aesthetics</td><td>10</td><td>Bad</td><td>Not appropriated for urban flyover.</td><td>4</td><td>Good</td><td>Most simple and appreciated view underneath.</td><td>8</td></tr>
<tr><td>7</td><td colspan="2">STEP Loan Requirement Consideration (Japanese Contents)</td><td>5</td><td>Fair</td><td>Slightly heavier weight than straight girder for additional bracing member against tortional moment for curve girder.</td><td>3</td><td>Good</td><td>Slightly heavier weight than scheme 1 (5%).</td><td>4</td></tr>
<tr><td colspan="3">Total Point</td><td>100</td><td colspan="2"></td><td>83</td><td colspan="2"></td><td>89</td></tr>
<tr><td colspan="4">Evaluation</td><td colspan="3">Not Recommend</td><td colspan="3">Recommend</td></tr>
<tr><td colspan="4">Remarks</td><td colspan="3">Rather complicated erection condition due to curved I-girder above railway</td><td colspan="3">The best scheme for curve bridge over railway, and if bridge type which is PC 2-Girder is applied to approach section</td></tr>
</table>

9.8 BRIDGE TYPE SELECTION FOR GROUP 4 (OVER THE EXISTING BRIDGE AT GEBANG FLYOVER)

Comparison of bridge types is shown in **Table 9.8.1-1**. The same type as Group 3 which is Small Size Steel Box Girder was recommended.

TABLE 9.8.1-1 OVER EXISTING BRIDGE SECTION AT GEBANG FLYOVER

Item No.	DESCRIPTION / Criteria		Max Point	SCHEME 1a STEEL I-GIRDER (2 - Girder)	Point	SCHEME 1b STEEL I-GIRDER (3 - Girder)	Point	SCHEME 2 SMALL SIZE STEEL BOX GIRDER	Point
	SECTION								
Item No.	Criteria		Max Point	Evaluation (LM : linear meter)	Point	Evaluation (LM : linear meter)	Point	Evaluation (LM : linear meter)	Point
1	Construction Cost / Economic Aspect (include substructure and pile foundation)		40	Span Length / Cost (M Rp)/span / Cost /LM / LM Cost Ratio / Remarks 35m Span / 6,627.2 / 189.4 / 1.00 / Girder Height = 2.20m 40m Span / 8,323.0 / 208.1 / 1.00 / Girder Height = 2.40m	40	Span Length / Cost (M Rp)/span / Cost /LM / LM Cost Ratio / Remarks 35m Span / 6,855.1 / 195.9 / 1.03 / Girder Height = 1.80m 40m Span / 8,752.8 / 218.9 / 1.05 / Girder Height = 2.00m	38	Span Length / Cost (M Rp)/span / Cost /LM / LM Cost Ratio / Remarks 35m Span / 7,246.3 / 207.1 / 1.09 / Girder Height = 1.80m 40m Span / 9,162.4 / 229.1 / 1.10 / Girder Height = 2.00m	36
				Increasing Factor of Construction Cost Due to the Higher Girder Depth +0.05	-2				
2	Construction Difficulty / Effective Traffic Managment		10	Fair – Erection work is easier than Scheme 1b, however needs presstressing work of deck slab	10	Fair – Slightly to be worse than others scheme, however prestressing work is no need due to applied reinforcing concrete deck slab	10	Fair – Erection work is easier than Scheme 1b, however needs presstressing work of deck slab	10
	Construction Period (Fast Construction)		12	Fair – Need to apply prestressed concrete deck slab which take a longer construction period	10	Good – Deck Slab can apply rainforced concrete therefore this scheme is sortest construction period	12	Fair – Need to apply prestressed concrete deck slab which take a longer construction period	10
3	Structural Aspect	Effect of Flyover Planning	5	Bad – Girder height is higest scheme, especially affecting flyover's elevation	2	Good – Girder height is lower than scheme 1a 0.4 m in height, therefore flyover elevation can make lower	5	Good – Girder height is lower than scheme 1a 0.4 m in height, therefore flyover elevation can make lower	5
		Applicability to Integrated Pier and Earthquake Resistance	10	Good – Every scheme is good for integration system	10	Good – Every scheme is good for integration system	10	Good – Every scheme is good for integration system	10
4	Maintenance		3	Good – Most appropriate slab system and less maintenance	3	Fair – RC deck slab is need maintenance in the future	1	Good – Most appropriate slab system and less maintenance	3
5	Introduction of New Technology		5	Good – Less number of girders with prestressed concrete slab – Rigid connection of girder and pier	5	Fair – Rigid connection of girder and pier is applicable using latest new technology	4	Good – Small size of girder and less number of girders with prestressed concrete slab – Rigid connection of girder and pier	5
6	Aesthetics		10	Bad – Not appropriated for urban flyover	4	Bad – Not appropriated for urban flyover	4	Good – Most simple scheme and appreciated view underneath	10
7	STEP Loan Requirement Consideration (Japanese Contents)		5	Fair – Lightest steel weight and PC deck slab will be Japanese Contents	3	Good – Heavier steel weight than scheme 1a will be Japanese Contents, excluding deck slab due to conventional reinforced concrete	4	Good – Heavist steel weight and PC deck slab will br Japanese Contents	5
	Total Point		100		85		88		94
	Evaluation			Not Recommended		Not Recommended		Recommended	
	Remarks			• Elevation of flyover is heigher 0.4 m in height than other scheme		• Need maintenance of RC deck slab in the future		• The best scheme for over existing bridge, and if bridge type which is PC Double Girder is applied to approach section	

9.9 APPLICATION OF BRIDGE TYPE

The SAPROF Study recommended to adopt steel type of bridge for Balaraja, Nagreg and Gebang Flyovers due to the following reasons:

a) The construction site is quite narrow and ROW acquisition would take time. To construct a flyover within the existing narrow roadway space, foundation type which does not require wide space for construction should be selected candidate type of foundation to satisfy this requirement is a single large size bored pile. For this type of foundation, superstructure weight should be as light as possible, thus steel type of bridge was recommended.

b) Construction site is traffic congested area. To realize minimal traffic disturbance during construction, fast construction method should be pursued. One of the ways of fast construction is steel type of bridge.

During the Basic Design Stage, the following was found:

1) Payment of ROW acquisition cost for Balaraja and Gebang Flyovers were completed. ROW acquisition for Nagreg Flyover is progressing. Thus, by the time of start of construction, new ROW area will be cleared and wide space can be used during construction.

2) Soft ground exists at Gebang and Tanggulangin Flyovers.

3) There are many underground utilities, which need to be relocated or protected.

Under above new conditions, steel bridges are recommended for the following locations:

Recommended Location for Steel

- New ROW width is still narrow and a single bored pile is required for minimal traffic disturbance and fast construction.
- Sections over existing railway and existing bridge, where fast, safe and easy construction is required.

CHAPTER 10
BASIC DESIGN

10.1 BASIC DESIGN CONCEPT

10.1.1 Technical Requirement of STEP Loan

The Government of Japan has decided to introduce a new ODA loan scheme from July 2002, now called the Special Terms for Economic Partnership (STEP), which is expected to raise the visibility of Japan's ODA to the citizens in the recipient countries and Japan through utilizing and transferring excellent technologies and know-how of Japanese firms.

Project eligible for STEP will be limited to those which are in the sectors and fields mentioned below, and at the same time, for which Japanese technologies and equipment are substantially utilized;

Eligible Projects for STEP

1) Bridges and Tunnels
2) Ports
3) Airports
4) Urban mass transit system
5) Urban flood control projects
6) Oil/Gas transmission and distribution lines
7) Trunk roads/dams (limited to projects that substantially utilize anti-earthquake techniques, ground treatment techniques, first implementation techniques, first implementation techniques of Japan)
8) Environmental Projects (limited to projects that substantially utilize air-pollution prevention techniques, water-pollution prevention techniques, waste treatment and recycling techniques, and waste heat recycling technique of Japan.

10.1.2 Japanese Technologies to be Utilized for this Project

This project must be implemented under the following conditions:

- The project site is located in the busy urban area with concentration of vehicular traffic as well as pedestrians.
- The project site is narrow and a detour road is not available.
- Commercial and business activities are active along the project site.
- Four flyovers are to be built over the existing railway.
- All project sites are located within the seismic zone.
- Gebang and Tanggulangin Flyovers are located at the deep soft ground area.
- Merak Flyover is located at loose sandy layer which would cause liquefaction during the earthquake.

Following Japanese technologies are utilized for this project:

- Fast construction method to minimize traffic congestion as well as adverse economic impacts during construction.
- Efficient construction method applicable to narrow construction area under urban environment.

- Construction method to realize efficient traffic management during construction.
- Anti-earthquake technology.
- Soft ground treatment technique and treatment against liquefaction.
- Steel bridges for safe, fast and easy construction over the existing railway where the alignment is curved.

Table 10.1.2-1 summarizes Japanese technologies adopted for this project which show eligibility to STEP Loan technical requirements.

TABLE 10.1.2-1 JAPANESE TECHNOLOGY ADOPTED FOR THIS PROJECT

Objectives	Japanese Technology Adopted						
	Large Diameter Single Pile	**Steel and Concrete Composite Pier**	**Integration of Superstructure and Pier**	**PC Deck Slab**	**Curved Steel Bridge**	**Soft Soil Improvement Around Single Pile**	**Light Weight Embankment**
1. Fast Construction	○	○	△	○	○	-	○
2. Efficient construction at narrow area	○	○	△	-	○	-	○
3. Efficient traffic management	○	○	△	-	○	-	○
4. Improved seismic resistance	-	○	○	-	-	○	○
5. Efficient countermeasure against soft ground in urban area	-	-	-	-	-	○	○
6. Safe, fast and easy construction over railway	-	-	-	-	○	-	-
Applied section	• Section with narrow road ROW • Section near railway crossing to satisfy required horizontal clearance	• Pier with large diameter single pile	• All abutments and piers except pier with movable bearing shoe.	• All bridges	• Over the Railway	• Soft ground section	• Approach section at soft ground

10.1.3 Measures to Cope with External Condition Changes

The loan amount for the Project was determined based on the project appraisal undertaken in October 2004. There were some drastic changes in factors affecting construction cost as follows;

1) Drastic Increase of Domestic Construction Prices

- Fuel cost such as gasoline and diesel increased in 2005 by 2.5 times.
- Fuel cost increase affected labor cost, transport cost, etc. According to BPS statistics, the wholesale price index of public works on road, bridges and ports increased by about 1.4 times.

Year	Wholesale Price Index of Public Works
2004	148
Dec. 2005	209
Increase	1.41

2) Increase of Japan's Steel Material Price

- Japan's steel material price increased by about 1.2 times.

Year	Price Index of Standard Steel Plate 16-25m
2004	149.2
Dec. 2005	179.0
Increase	1.20

3) Depreciation of Yen Value

- Yen value depreciated by about 10%.

Exchange Rate	
Oct. 2004	1 Yen = 83 Rp.
Jan. 2006	1 Yen = 75 Rp.
Increase	0.90

4) Actual Geo-technical Condition

- The geo-technical investigation undertaken by this study revealed existence of soft ground at Gebang and Tanggulangin Flyovers and loose sandy layer which would cause liquefaction during an earthquake at Merak Flyover.

5) Underground Utilities

- During the feasibility study and the SAPROF Study, an underground utility survey was not undertaken.
- Many underground utilities were found during the Basic Design stage.

All above factors indicate increase of construction cost, whereas the loan amount has been fixed. To cope up with such changes as mentioned above, main points of the Basic Design was focused on the cost reduction.
Measures taken for cost reduction were as follows;

MEASURES FOR COST REDUCTION
• To reduce bridge length as much as possible (height of abutment was targeted between 6,5 m to 7.0 m)
• To reduce steel bridge length as much as possible (steel bridges are only adopted for limited sections such as railway crossing, and where single column pier with single pile is required due to narrow construction space.)
• To use short span length as much as possible (it was found that the shorter span length is more economical even at soft ground area.)
• To study reduction of bridge width from 13.0 m to 11.5 m

10.1.4 STEP Loan Requirements on Japan Portion

STEP Loan requirements on Japan portion are as follows:

- Total cost of goods procured from Japan shall be not less than 30% of the total amount of contract(s) (except consulting services).
- Goods procured from a manufacturing firm of the recipient country invested in by one or more Japanese companies will be regarded as goods procured from Japan, if they meet the following:
  - (a) Not less than 10% of the shares of the manufacturing firm of the recipient country are held by a Japanese firm; and
  - (b) The proportion of the shares held by the Japanese firm is the same as or greater than that of the shares held by any company of a third country.

  (Hereinafter referred to as an “Indonesia-Japan J.V. Company”)

Number of Indonesia-Japan J.V. company in Java Island is as follows:

	No. of Company
» Steel Bridge Fabrication	3
» PC strand manufacturing company	1
» Wedge for PC manufacturing company	1
» Precast concrete product manufacturing company	3

Candidates for Japan portion are shown in **Table 10.1.4-1**.

TABLE 10.1.4-1 CANDIDATES OF JAPAN PORTION

Item			Judgement	Condition
Steel Bridge	Steel Material		Yes	• Procured in Japan
	Shipping (Japan → Indonesia)		Yes	
	Fabrication	In Japan	Yes	• Fabricated in Japan
		In Indonesia	Yes	• Fabricated by Indonesia-Japan J.V. company
		In Indonesia	No	• Local company other than above
	Local Transportation		No	
	Erection		No	
PC Bridge	PC wire/tendon, anchor		Yes	• Procured in Japan • Procured from Indonesia-Japan J.V. company
	Admixture for concrete		Yes	• Same as above
Pier	Steel coping		Yes	• Same as steel bridge
	Inner ribbed casing for composite column		Yes	• Same as steel bridge
Large Diameter Bored Pile	Inner ribbed casing for pile head		Yes	• Same as steel bridge
Miscellaneous Bridge Parts	Bearing shoe		Yes	• Same as steel bridge
	Fall-down Prevention Devices		Yes	• Same as steel bridge
Drainage	Precast concrete pipe		Yes	• Procured from Indonesia-Japan J.V. company
	Precast catch basin		Yes	• Same as above
Approach Embankment	Mechanically Stabilized Earth Wall	Strip	Yes	• Same as steel bridge
		Concrete Panel	Yes	• Procured from Indonesia-Japan J.V. company
	Light Weight Embankment Wall		Yes	• Same as above

10.2 BASIC DESIGN

At the time of the basic design stage, Merak Flyover scheme was not determined yet, thus the basic design was undertaken for the remaining 5 flyovers. The basic design was undertaken for two cases of bridge widths of 13.0m and 11.5m.

10.2.1 Balaraja Flyover

Design concepts are as follows:

- The flyover centerline is selected at the center of acquired new road right-of-way.
- Existing U-turn traffic is disturbing traffic flow. In order to reduce U-turn traffic, right turn from the road going to Kresek to the subject road is allowed at the intersection.
- U-turn under the flyover is planned not to disturb traffic (sufficient radius and width are to be provided).
- Vertical alignment of a flyover is selected to satisfy the pre-determined nose locations.
- Existing road grade at Tangerang side is 5%. Flyover vertical alignment is selected to merge with the existing road grade.
- At-grade traffic lane passes under the flyover at the section of new ROW width of 18.0m, vertical clearance of 5.1m is provided.

- Local traffic volume is high, thus 6.0m service road at each side of flyover is provided.

Bridge components are as follows:

Bridge length = 220 m

Span composition

- 3-span continuous PC Double Girder integrated with two-column pier and two-bored piles

  3 span x 20 m = 60 m

- 3-span continuous Steel Box Girder integrated with single-column and single bored pile (narrow road ROW section)

  25 m + 30 m + 25 m = 80 m

- 4-span continuous PC Double Girder integrated with two-column pier and two-bored piles

  4 span x 20 m = 80 m

10.2.2 Nagreg Flyover

Design concepts are as follows:

- Horizontal alignment of a flyover is selected at the center of new ROW.
- Vertical alignment is selected to satisfy the pre-determined nose locations.
- Existing road grade at Bundung side is about 5%. Vertical grade flyover is planned to be 5% at Bundung side.
- At the railway crossing, vertical clearance of 6.5 m is provided.
- Where at-grade traffic lane passes under the flyover, vertical clearance of 5.1 m is provided.
- Horizontal clearance of 10 m each side from the rail (total 20 m) is provided.

Bridge components are as follows:

- Span composition at the railway crossing was planned in consideration of horizontal clearance requirement of the railway and pier locations which is related at-grade road alignment.

  Bridge length = 204 m

  Span composition

  - 3-span continuous PC Double Girder integrated with two-column pier and two-bored piles

    3 span x 20 m = 60 m

  - 4-span continuous Small Size Steel Box Girder integrated with two single column pier with single bored pile and one rigid frame type of pier with two bored piles (railway crossing section)

    4 spans : 25 m + 27 m + 27 m + 25 m = 104 m

  - 2-span continuous PC Double Girder integrated with two-column pier and two-bored piles

    2 span x 20 m = 40 m

10.2.3 Gebang Flyover

Design concepts are as follows:

- Centerline of future 4-lane flyover follows more or less the existing centerline of the existing road.
- Since new ROW has already been acquired, nose location (the beginning and the end of a flyover) is intersection near the public market is maintained even after the flyover is constructed. Vertical clearance of 5.1 m is provided.
- Between the existing bridge and the said intersection, traffic lane of at-grade road passes under the flyover, vertical clearance of 5.1 m is provided.

Bridge components are as follows

<u>Bridge length = 346 m</u>

Span composition

- 3-span continuous PC Double Girder integrated with two-column pier and two-bored piles

  3 span x 20 m = 60 m

- 3-span continuous Small Size Steel Box Girder with rigid frame type of pier with bored pile (over the existing bridge)
- 5-span continuous Small Size Box Girder integrated with single pier with single bored pile (narrow road ROW section)

  5 span x 27 m = 135 m

- 3-span continuous PC Double Girder integrated with two-column pier and two-bored piles

  3 span x 20 m = 60 m

Approach embankment type selected was the light weight embankment to cope with soft ground.

10.2.4 Peterongan Flyover

Design concepts are as follows:

- Centerline of flyover is selected to follow the centerline of the existing road.
- At the railway crossing, horizontal clearance of 10 m each from the rail and vertical clearance of 6.5 m are provided.
- Where at-grade traffic lane passes under the flyover, vertical clearance of 5.1 m is provided.

Bridge components are as follows:

Span composition at the railway was planned in consideration of horizontal clearance requirement of the railway and pier locations which are related at-grade road alignment.

<u>Bridge length = 285 m</u>

Span composition

- 4-span continuous PC Double Girder integrated with two-column pier and two-bored piles

  4 span x 20 m = 80 m

- 3-span continuous Small Size Steel Box Girder with two-column pier and two-bored piles (over the railway)

  25 m + 35 m + 25 m = 85 m

- 3-span continuous PC Double Girder integrated with two-column pier and two-bored piles

  3 span x 20 m = 60 m

- 3-span continuous PC Double Girder integrated with two-column pier and two-bored piles

  3 span x 20 m = 60 m

10.2.5 Tanggulangin Flyover

Design concepts are as follows:

- Centerline of flyover is selected to follow the centerline of the existing road.
- At the railway crossing, horizontal clearance of 10 m each side from the rail and vertical clearance of 6.5 m are provided.
- Where at-grade traffic lane passes under the flyover, vertical clearance of 5.1 m is provided.

Bridge components are as follows:

Span composition at the railway was planned in consideration of horizontal clearance requirement of the railway and pier locations which are related at-grade road alignment.

<u>Bridge length = 230 m</u>

Span composition

- 3-span continuous PC Double Girder integrated with two-column pier and two-bored piles

  3 span x 20 m = 60 m

- 4-span continuous Small Size Steel Box Girder integrated with one-single column pier and rigid frame type pier with bored piles (over the railway)

  20 m + 25 m + 25 m = 25 m = 85 m

- 4-span continuous PC Double Girder integrated with two-column pier and two-bored piles

  4 span x 20 m = 80 m

Approach embankment type selected was the light weight embankment to cope with soft ground.

10.2.6 Summary of Basic Design

Basic design results in comparison with the SAPROF Study are summarized below.

		Total Length (m)	Approach Length (m)	Bridge		
				Total Bridge Length (m)	PC Bridge Length (m)	Steel Bridge Length (m)
Balaraja	SAPROF	520	295	225	-	225
	B/D	515	295	220	140	80
Nagreg	SAPROF	740	425	315	-	315
	B/D	730	526	204	100	104
Gebang	SAPROF	820	370	450	-	450
	B/D	745	394	351	120	231
Peterongan	SAPROF	600	325	275	275	-
	B/D	620	335	285	-200	85
Tanggulangin	SAPROF	570	330	240	240	-
	B/D	590	360	230	140	90
Total for 5 Flyover	SAPROF	3,250	1,745	1,505	515	990
	B/D	3,200	1.910	1,290	700	590
	Difference	-50	+165	-215	+185	-400

In comparison with the SAPROF Study, bridge length was shortened by 215 m, instead approach length became longer by 165 m. Steel bridge length was shortened by 400 m, instead PC bridge length became longer by 185 m. These are the result to reduce construction cost to cope with construction price increase and yen depreciation.

10.3 PRELIMINARY COST ESTIMATE

Based on the basic design, preliminary cost for civil work and utility relocation/protection for five (5) flyovers were estimated as shown below:

	Preliminary Cost in Japanese Yen (Million Yen)			Preliminary Cost In Rupia (Billion Rp)		
	Civil Work	Utility	Total	Civil Work	Utility	Total
Bridge width = 13.0m (A)	3,317	301	3,618	248.8	22.6	271.4
Bridge width = 11.5m (B)	3,141	301	3,442	235.6	22.6	258.2
(A) – (B)	176	-	176	13.2	-	13.2
(B) / (A)	0.95	-	0.95	0.95	-	0.95

Note: (1) VAT is not included
(2) Exchange Rate 1 Yen = 75 Rp.

Japan portion was estimated at 32.4% for the case of bridge width of 13.0m and 32.9% for the case of bridge width of 11.5m, therefore, STEP Loan requirement of 30% is satisfied.

CHAPTER 11
FINDINGS OF BASIC DESIGN

11.1 ESTIMATED COST VS. LOAN AMOUNT

Breakdown of loan amount is shown in **Table 11.1-1**.

TABLE 11.1-1 BREAKDOWN OF LOAN AMOUNT

Unit : Million Yen

	Total	Merak Flyover	Other Five Flyovers
Civil Work (Basic Cost)	2,993	514	2,479
Contingency (19.3%)	578	99	479
Contingency (5%)	178	31	147
Total	3,749	644	3,165

Note: Exchange Rate used was 1 Yen = 83 Rp

Table 11.1-2 shows comparison between estimated preliminary cost and loan amount.

TABLE 11.1-2 LOAN AMOUNT VS. ESTIMATED PRELIMINARY COST

Unit : Million Yen

		Estimated Preliminary Cost	Loan Amount	Cost Overrun
Bridge width 13.0m	Civil work	3,317	3,105	212
	Utilities	301		301
	Total	3,618		513
Bridge width 11.5m	Civil work	3,141	3,105	36
	Utilities	301		301
	Total	3,442		337

Note : (1) VAT is not included
(2) Exchange rate 1 Yen = 75 Rp
(3) Utility relocation/protection cost not included in the loan

As discussed in Section 10.1.2, above cost over-run is due to the following reasons:

- Domestic construction prices increased by 1.4 times
- Japan's steel material prices increased by 1.2 times.
- Japanese yen value depreciated by 10%.
- Soft ground encountered at Gebang and Tanggulangin Flyovers.

Although efforts were made to reduce construction cost, however, above cost increase impacts are so high that these efforts could not fully absorb such impacts.

11.2 BRIDGE WIDTH

Two cases of bridge width were compared.

Bridge Width 13.0m : 2-lane 2-way flyover with mount-up center median. Even large vehicle stops due to vehicle breakdown, another large vehicle can pass the flyover (refer to **Figure 7.1.1-1** in Chapter 7)

Bridge Width 11.5 m : 2-lane 2-way flyover. For straight (or tangent) section, no mount-up center median, but centerline marking is provided. For curved section, mount-up center median is provided. When a large vehicle stops, only small vehicle can pass the flyover. (refer to **Figure 7.1.1-1** in Chapter 7)

As presented in Section 10.3, bridge width of 11.5m can reduce civil work cost by about 5% compared with bridge width of 13.0m.

DGH selected the bridge width of 13.0m due to the following reasons:

- Share of large vehicle is high, and possibility of large vehicle breakdown is also high, thus 13.0m is preferred, which is almost same as recommendation of the SAPROF Study.
- To avoid traffic accident within the flyover section, a mount-up center median even along the straight section should be provided.
- With regard to cost over-run, DGH will study to add local cost financing (GOI) portion) for the project.

11.3 STEP LOAN REQUIREMENT

As discussed in Section 10.1.2, Japanese technologies eligible for STEP Loan are fully utilized by this project. By utilizing goods and materials shown in **Table 10.1.3-1**, STEP Loan requirement on Japan portion can be satisfied as shown in Section 10.3.

11.4 FUTURE WIDENING OF FLYOVER

As discussed in Chapter 6, estimated future traffic volume on Peterongan and Tanggulangin Flyovers is expected to reach to the traffic capacity of the flyover around the year 2025, then widening to a 4-lane flyover will be required.

To be noted are as follows:

Peterongan Flyover : Construction of a toll road (Mojokerto – Kertosono) which runs almost parallel to this national road is planned to be implemented with high priority. When this toll road is completed, many vehicles will be diverted from the national road to the toll road. Therefore, timing of widening of this flyover may be deferred. Changes of traffic volume on this national road should be carefully observed.

Tanggulangin Flyover: Surabaya – Gempol Toll Road passes near the flyover. Traffic on the Toll Road is still light and more traffic may be attracted on this toll road. Timing of widening of this flyover should be carefully studied by observing traffic volume along this national road. Widening scheme of two flyovers is shown in **Figure 11.4-1** and **Figure 11.4-2**.

11.5 CLOSURE OF AT-GRADE ROAD AT RAILWAY CROSSING

During the meeting among DGH, PT. Kai and the Study Team, PT. Kai required closure of an at-grade road at the railway crossing.

The concept of PT. Kai to avoid traffic accident at the railway crossing is quite understandable, however, it is recommended that closure of an at-grade road at railway crossing under this project should not be done at this stage:

- Since the beginning of this project, closure of an at-grade road is not planned, therefore, the project was appraised by JBIC without provision for at-grade road closure such as pedestrian bridge over the railway, U-turn provision before and after the flyover, etc.
- Flyovers are located in the urban area and local traffic shares 30 to 40% of total traffic. If an at-grade road is closed without any provision for local traffic, local people will suffer inconvenience.
- Existing road is a 4-lane divided road at Peterongan and Tanggulangin Flyovers. If an at-grade road is closed at the railway, a 4-lane road becomes a 2-lane road at a flyover. Objective of the project to remove traffic bottleneck cannot be achieved.
- At Merak Flyover, an at-grade road is used to access to the Ferry Terminal Waiting Area. Therefore, another facility such as an entrance ramp is required to close an at-grade road, which is financially difficult to implement at this stage.
- It was proposed that closure of an at-grade road should be considered in such future stage when the flyover is widened to a 4-lane flyover in the case of Peterongan and Tanggulangin Flyovers and when the bypass road is constructed in the case of Nagreg Flyover. PT. Kai accepted this proposal.

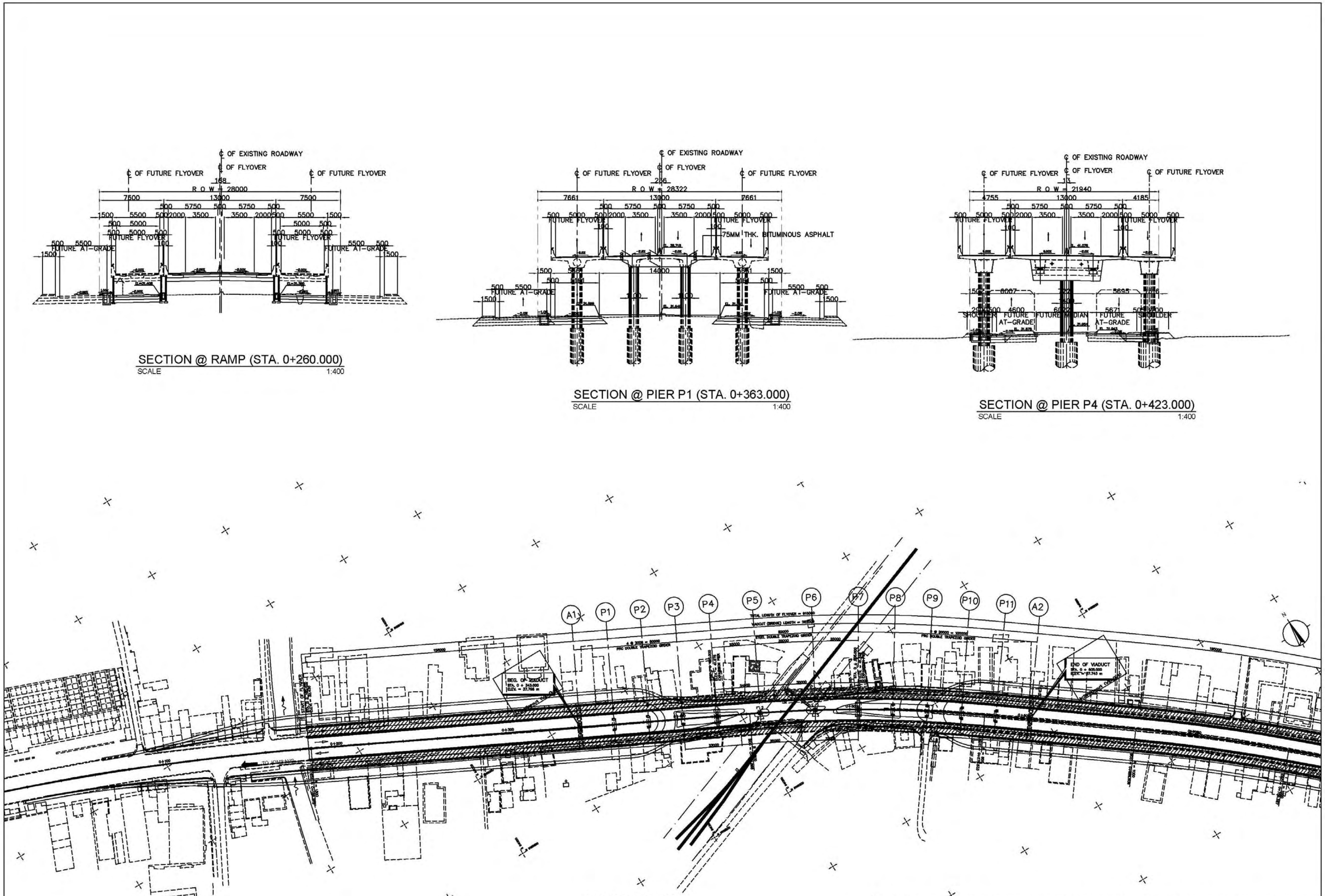


FIGURE 11.4-1 WIDENING SCHEME OF PETERONGAN

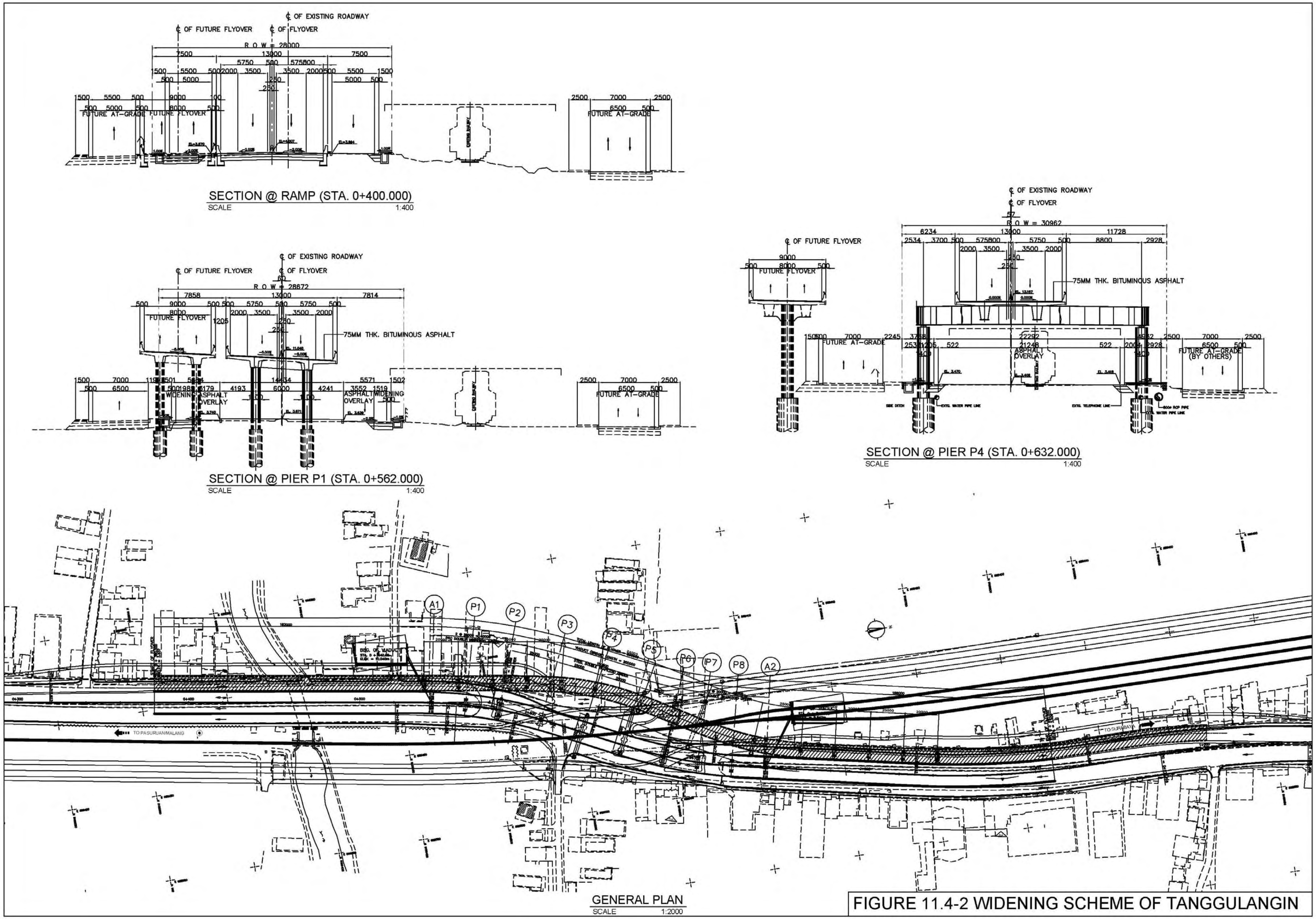


FIGURE 11.4-2 WIDENING SCHEME OF TANGGULANGIN