CHAPTER 11 ENGINEERING SURVEY

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11.1 Physical Conditions of the Project Area

11.1.1 Climate

The seasons are influenced by the monsoons which generally blow from the east from May to October and from the west from November to April. During the east monsoon, the average rainfall in Surabaya is around 50 mm per month with August usually the driest. The west monsoon brings heavy rainfalls which average over 235 mm per month. The heaviest rainfalls occur mostly in January and average about 340 mm per month. The average total yearly rainfall in Surabaya is approximately 1,700 mm.

The maximum temperature in Surabaya recorded in 1988 was 36.2°C in October and the minimum was 20.0°C in July. The average humidity is in the range of 65% to 85%.

11.1.2 Topography

The topography is favorable in the Project Area which is divided into two terrain conditions, flat and rolling. The flat terrain area is spread out in the Brantas Delta which is enclosed by the Surabaya river and the Porong river with an altitude of less than 10 m. The flat terrain area covers the most part of Surabaya city. The area is mainly an urban area. The rolling terrain area is situated in the western part of the City of Surabaya and to the north of Surabaya river in Gresik regency, with an altitude of less than 50 m.

11.1.3 Geology

Geologically, the flat terrain area is of Alluvium Formation of Holocene Age composed of alluvial soil of loam, silt and clay. Soft ground areas are common in the eastern part of the Brantas Delta. According to the soil investigation by the Study Team and current soil investigation data, the thickness of soft ground layer (N-value less than 4) ranges from 7 to 20 m. The bearing strata for the construction of pile foundation for bridge structures are situated at 30-50 m deep from the existing ground level, in the flat area.

The rolling terrain is mainly of Pucangan Formation and Kabuh Formation in the Middle to Lower Pleistocene Age. The soils in the Pucangan Formation are composed of clay, tuffaceous clay and tuffaceous sandy clay classified as CH according to the AASHTO soil classification. This soil is unsuitable as embankment material because of its swelling nature even if the dried condition resembles clay stone.

11.1.4 River System

Surabaya river and Lamong river flow in the Project Area.

Surabaya river branches with Porong river from Brantas river, at Mojokerto. Brantas river is the second largest river in Java Island, having a total catchment area of about 12,000 km^2 and being about 320 km in main course length. Surabaya river branches into Mass river and Wonokromo river, at Wonokromo. Since the first comprehensive development plan of the Brantas river basin was formulated in 1961 several sizeable projects of water resources development for hydroelectric power generation, flood control and water supply have been successively implemented. The flood control scheme of Surabaya river is formulated by the Surabaya River Improvement Project Stage I (1981) and the Surabaya River Improvement Project Stage II (1988). The design flood discharges of Surabaya river, Mass river and Wonokromo river have been estimated for 50 years return period. It is noted that the flood control project for Surabaya river and Mass river has been completed.

Lamong river is located in the north west fringe of Surabaya forming a border with Kabupaten Gresik flowing into Lamong Bay. There is no development plan for the Lamong River.

11.2 Topographic Survey

11.2.1 Preparation of Uncontrolled Aerial Photo Mosaics

Uncontrolled aerial photo mosaics of the Project Area to a scale of 1 : 5,000 were prepared by a local consulting firm, P.T. Exsa International Co., Ltd., Jakarta supervised by the Study Team to prepare a bases for the preliminary design using the current aerial photography (scale = 1:30,000, photography : 1993/1994, BAKOSURTANAL).

11.2.2 Topographic Survey

The following topographic survey was carried out by a local consulting firm, P.T. BIEC International Inc., Surabaya, supervised by the Study Team, along the project roads to establish the topographical conditions.

- Bench Mark Setting : 32 points
- Longitudinal Level Survey : 100 km
- Cross Section Level Survey : 250 section

(1) Bench Mark Setting

Bench mark setting was carried out using the existing national bench marks as datum points. The locations of bench marks and datum points are shown in Figure 11.2.1. The accuracy of the leveling fell within the following limit:

$$\text{Error limit} = 2\text{cm} \times \sqrt{S} \quad (S = \text{survey single distance in km})$$

(2) Longitudinal Level Survey

The longitudinal level survey was conducted along the center lines of the selected roads at around 100 m intervals. The results of the survey are shown as plan and profile in the drawings.

(3) Cross Section Survey

At 400 m intervals of the center lines of the selected roads, the cross section level survey was conducted for a width of 200 m.

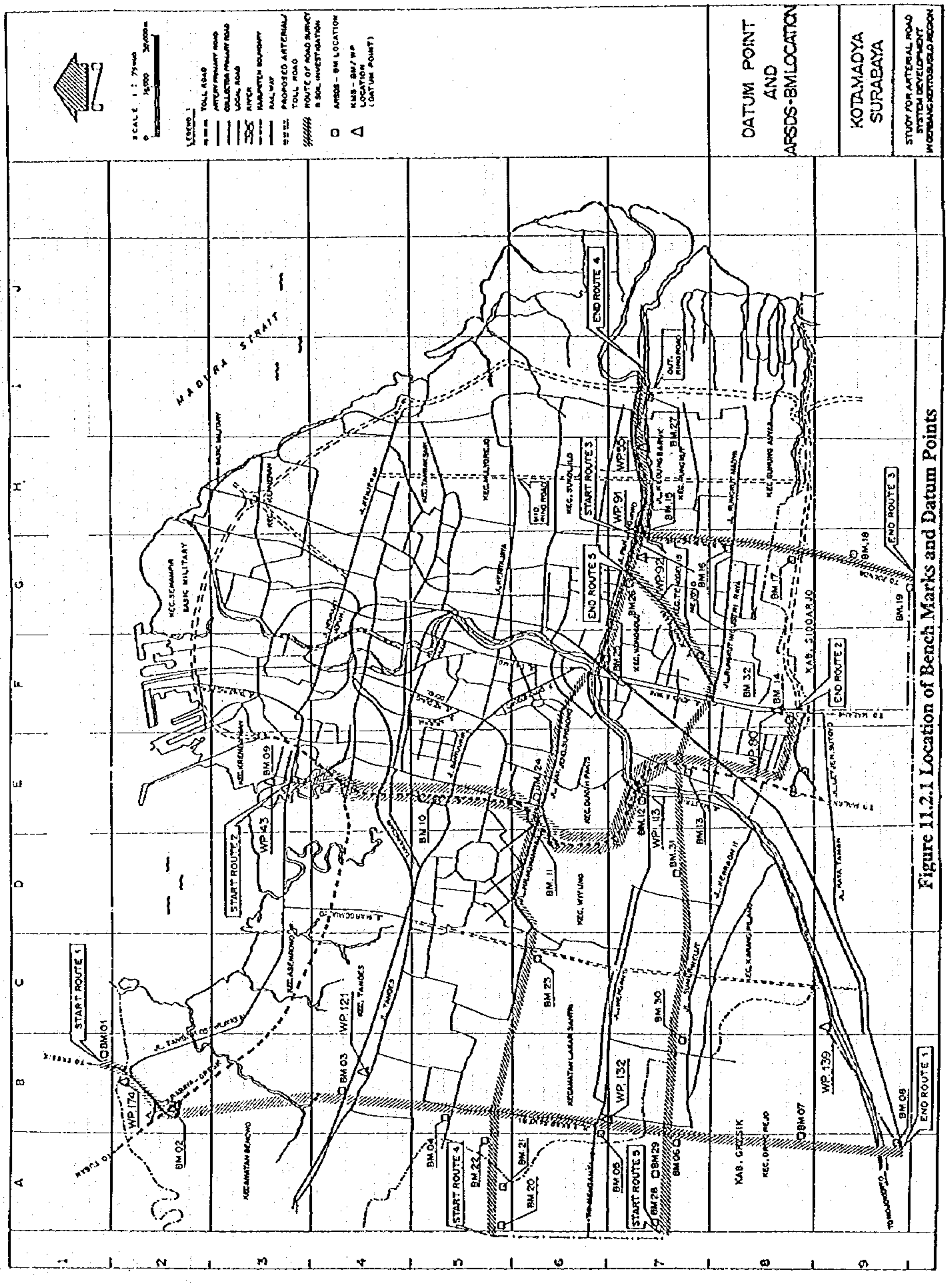


Figure 11.2.1 Location of Bench Marks and Datum Points

11.2.3 Collection of Existing Topographic Maps

The following topographic maps were collected early January 1997 by the Study Team according to suggestions by local Government agencies, to support the uncontrolled aerial photo mosaic. These topographic maps are old as described below but cover all the selected routes except a few kilometers at the beginning of Routes 4 & 5. The topographic maps were therefore used for the feasibility route study updated by using the uncontrolled aerial photo mosaics mentioned above.

Peta Garis Projek Drainasi Surabaya;
Photography :Nov.'82 S=1/10,000 Mapping: Mar. '83 S=1/2500

Peta Garis Kali Surabaya Phase II;
Photography : May '88 S=1/10,000 , Mapping: May '89
S=1/2,500 by DPU Directorate Jenderal Pengairan, Badan Pelaksana
Projek Induk Pengembangan Wiraha Sungai Kali Brantas

Peta Garis Surabaya Skala 1:5,000
Photography: S=1/5,000 , Mapping S=1/1,000
by Pemerintah Kotamadya DT II Surabaya

As a result, the aerial photo mosaic 1/5,000 was used for the "Alternative Route Study" of Phase I stage and for the "Feasibility Route Study" of Phase II stage to cover the beginning of Routes 4 & 5, and to update the topographic map for judging control points or to study land use etc.

11.3 Soils Investigation

11.3.1 Soils Investigations and Current Soil Data Collection

(1) Purpose of the Soils Investigations

The purpose of the soils investigations is to obtain data for the preliminary design of embankment, bridges and other structures.

(2) Field Work and Laboratory Testing

The field work and laboratory testing was executed by a local consulting firm, P.T. BIEC International Inc., Surabaya. The Study Team planned and supervised the investigations. Machine boring with standard penetration tests (1 m interval) was conducted at 9 bore holes, total 300 m (Location of bore holes is shown in Figure 11.3.1(a) and Figure 11.3.1(b), boring logs are shown in the Appendix). Thin wall tube sampling (30 each) was conducted for the soils in the soft ground layers.

The following laboratory testing was conducted for the collected samples.

1. Unit Gravity : 30 nos.
2. Specific Gravity : 30 nos.
3. Water Content : 30 nos.
4. Liquid Limit : 30 nos.
5. Plastic Limit and Index : 30 nos.
6. Sieve Analysis : 30 nos.
7. Unconfined Compression Test : 30 nos.
8. Triaxial UU Compression Test : 30 nos.

9. Triaxial CU Pore-pressure Measurement : 30 nos.
10. Consolidation Test : 30 nos.
11. CBR Test : 20 nos.

(3) Current Soil Data Collection

The following current soil data were collected by the Study Team. The location of current bore holes are shown in Figure 11.3.1(a).

1. SUDP Road Sector Project : Bina Marga
2. Surabaya – Gempol Toll Road Project : Jasa Marga
3. Surabaya – Gresik Toll Road Project : Jasa Marga
4. Surabaya – Mojokerto Toll Road Feasibility Study : JICA
5. SUDP Drainage Sector Project : Brantas Office

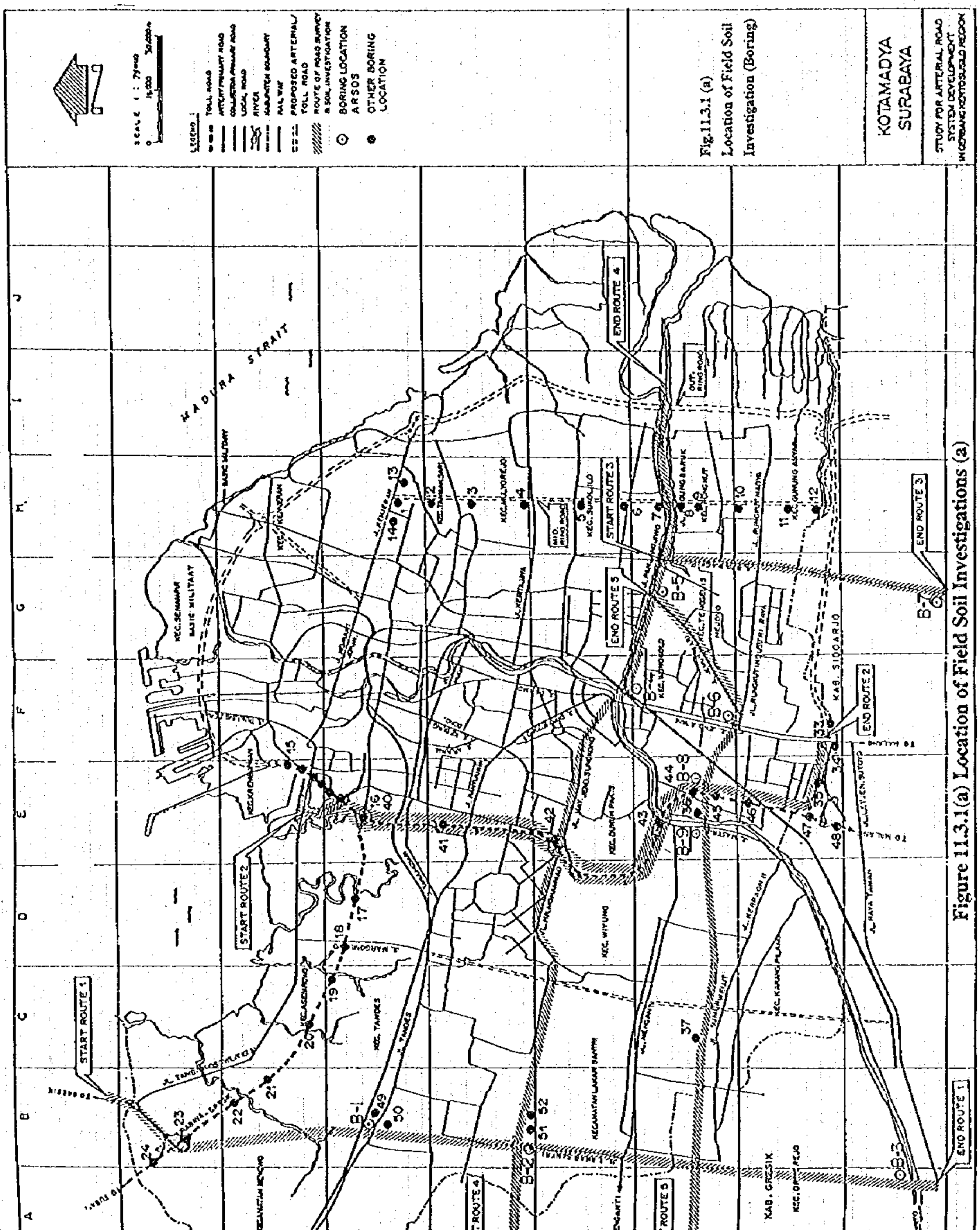


Figure 11.3.1(a) Location of Field Soil Investigations (a)

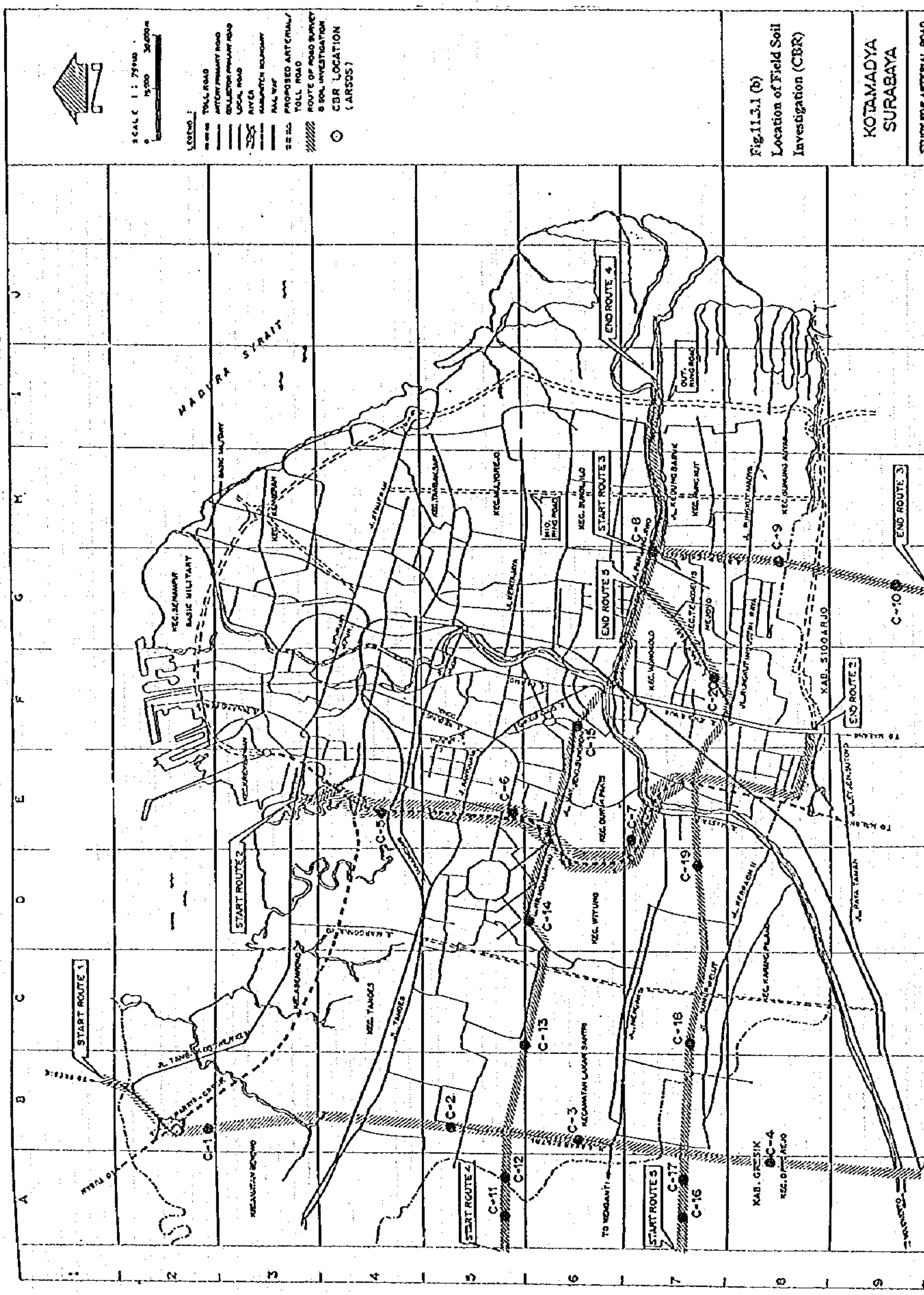


Figure 11.3.1(b) Location of Field Soil Investigations (b)

11.3.2 Geological Description of the Project Area

Soil profiles of the planned routes are shown in Figure 11.3.2 - Figure 11.3.6. These profiles include the results of the existing boreholes.

Geological classification of the whole study area is summarized below.

Table 11.3.1 Geological Classification

Geological Age		Formation	Facies
Quaternary	Holocene	Alluvium	Most part of alluvium deposit is composed of clay, which includes silty layers and little thin sandy layers.
	Pleistocene	Kabuh	Most part of alluvium deposit is composed of clay, which includes silty layers and thin sandy layers.
		Upper Pucangan	
		Lower Pucangan	
Tertiary		Kalibeng	Mudstone and Limestone. This formation was not drilled in this study.

(1) Alluvium

Characteristics of Alluvium

Distribution area and thickness of the Alluvium in the planned routes are shown in Figure 11.3.2 - Figure 11.3.6. Elevation of the Alluvial plane is usually less than 10m. As shown in the Figures, the thickness of the Alluvial deposit is variable along the planned routes because the surface of the underlying Diluvium is wavy by erosion. The maximum thickness of Alluvial deposit is about 30m, usually it is less than 15 - 20 m. Most of the Alluvium is composed of clayey deposit and little sand.

N-value of Alluvium

Figure 11.3.7 show N-values of the Alluvial clay, silt and sand. As shown in the Figure, more than 80% of the Alluvial clay shows an N-value less than 6, which means the consistency of the clay is Very Soft to Medium. About 30% of the Alluvial deposit is composed of very soft clay with N-value less than one (1). N-value of sand distributed in small scale in clayey deposits is less than six (6).

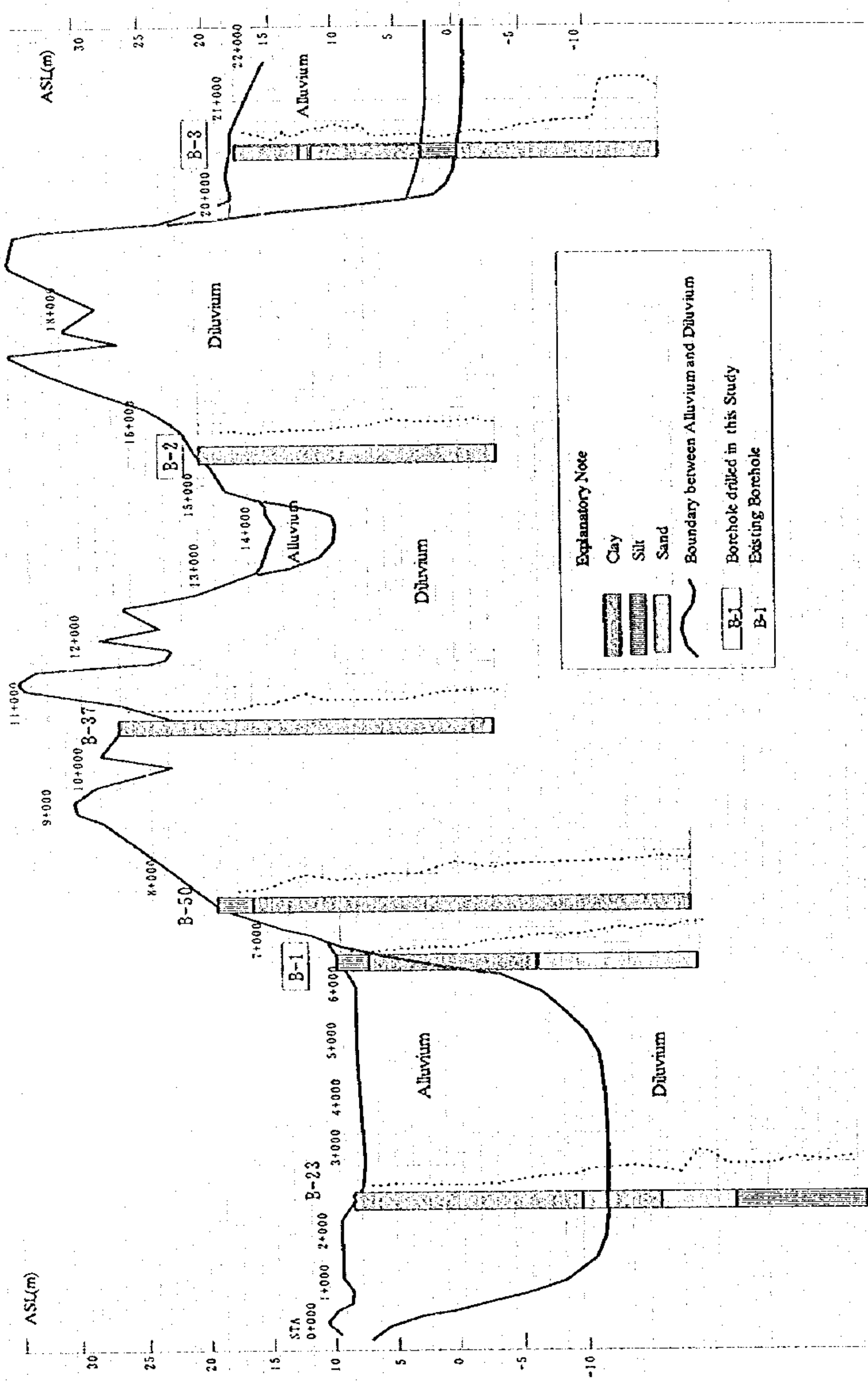
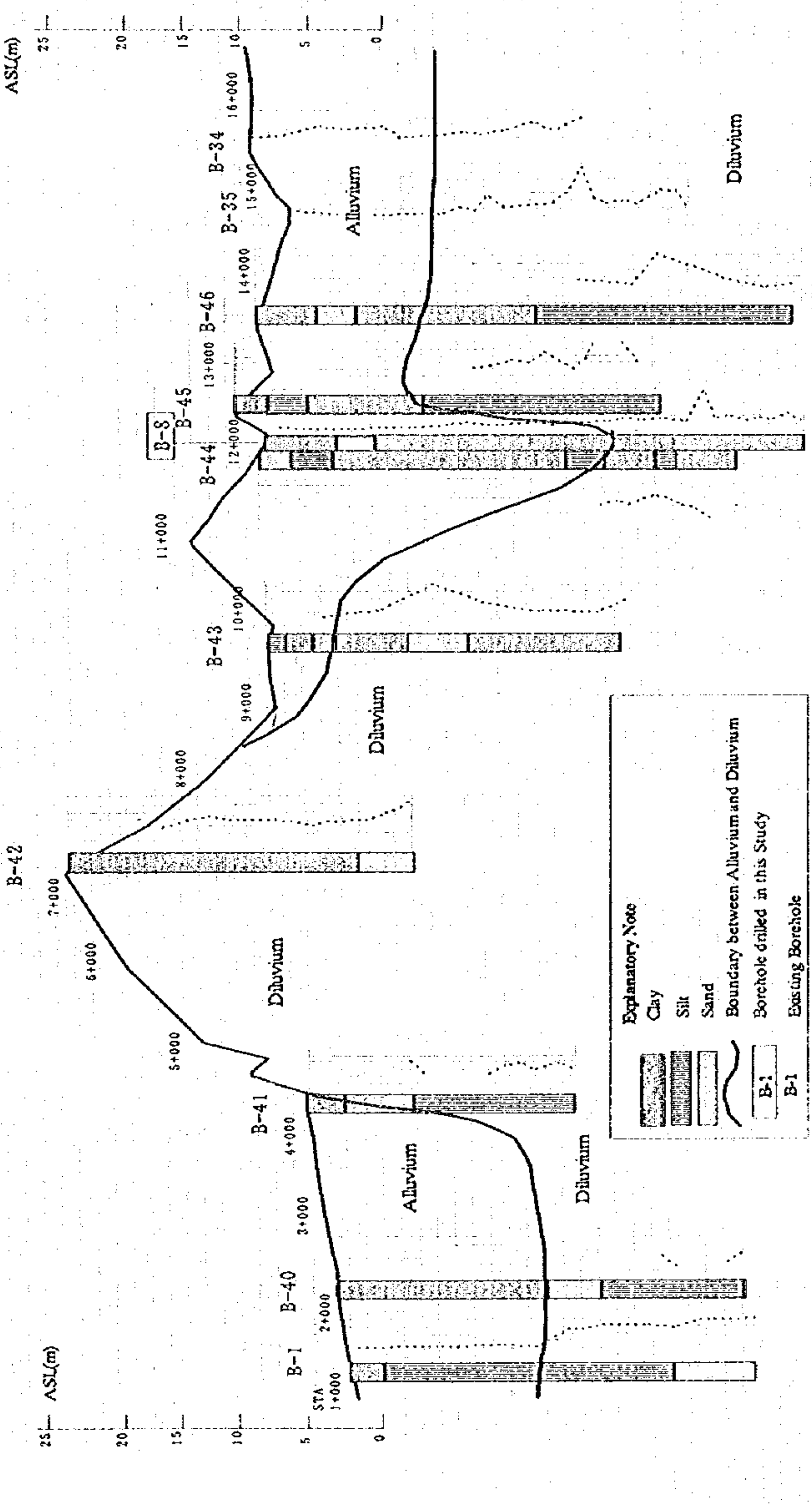


Fig. 11.3.2 Geological Profile along Route-1

Source: JICA Study Team



Source: JICA Study Team

Fig. 11.3.3 Geological Profile along Route-2

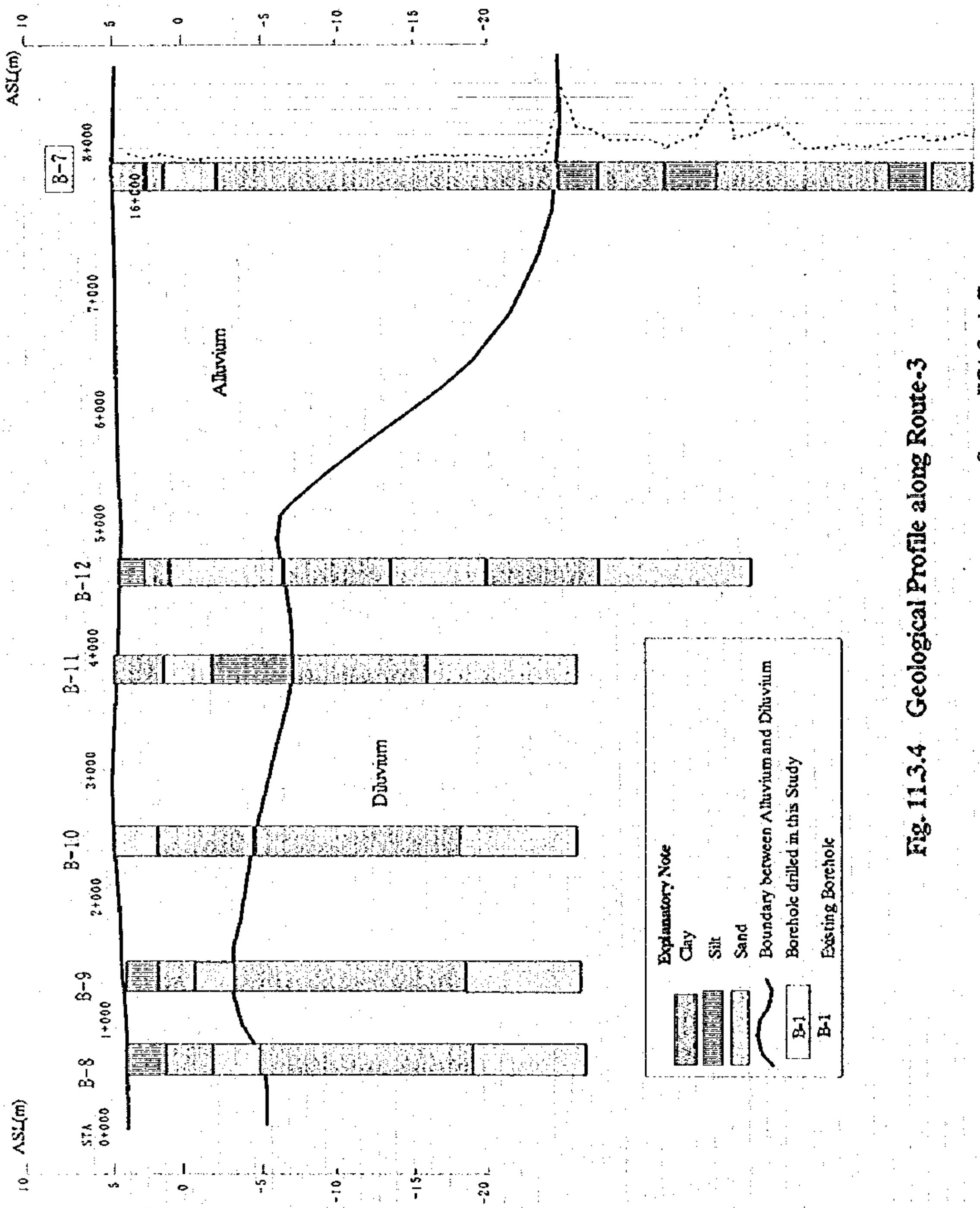


Fig. 11.3.4 Geological Profile along Route-3

Source: JICA Study Team

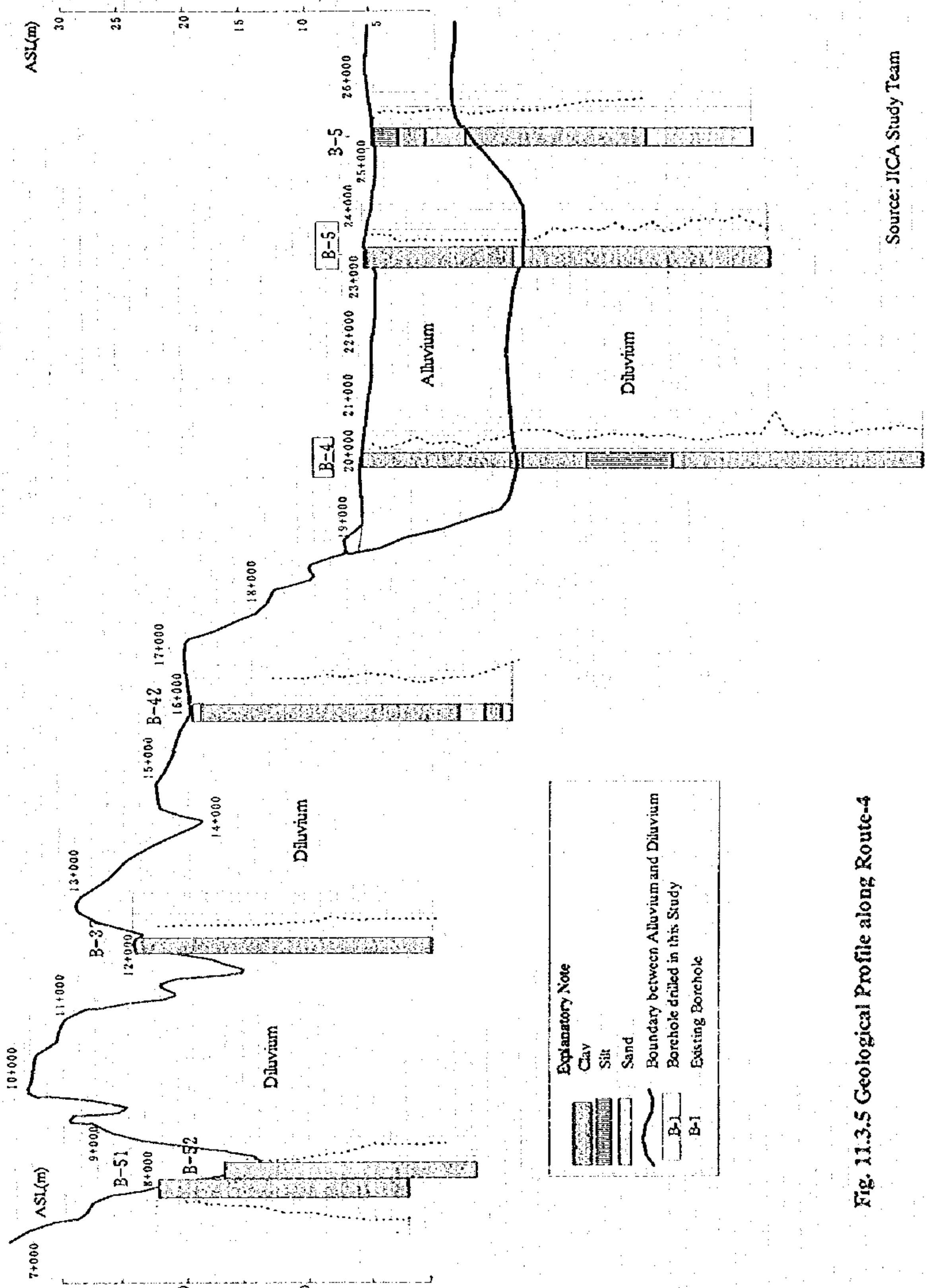
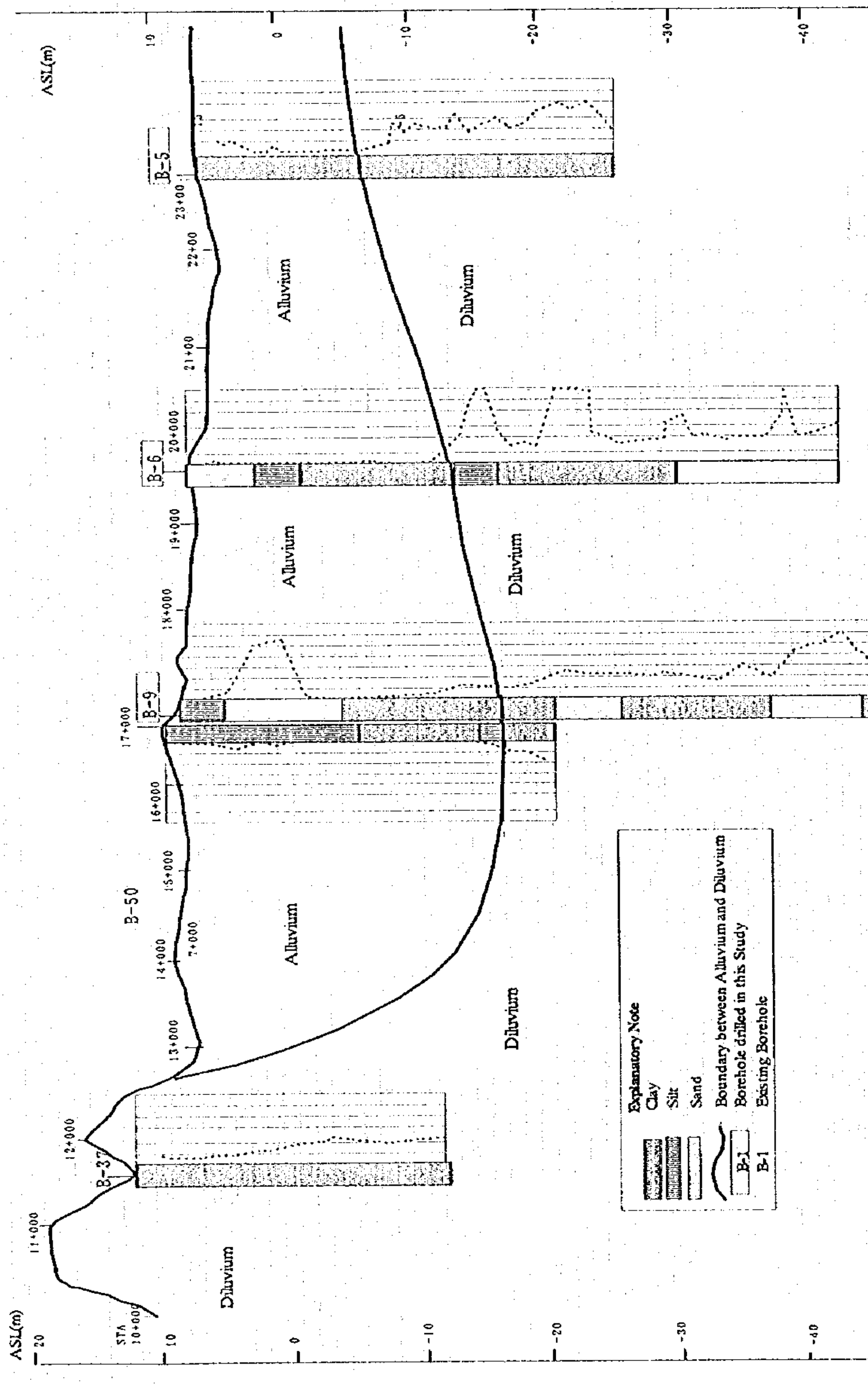


Fig. 11.3.5 Geological Profile along Route-4

Source: JICA Study Team



Source: JICA Study Team

Fig. 11.3.6 Geological Profile along Route-5

(2) Diluvium

Characteristics of Diluvium

Distribution area and thickness of the Diluvium in the planned routes is shown Figure 11.3.2 - Figure 11.3.6. As shown in these Figures, the Diluvium is distributed in the whole of the Study area. The Diluvial deposit outcrops in the hills in the west of the Study area, and is overlaid by the Alluvium where the Alluvium is distributed at the ground surface. Most of the Diluvium is composed of clayey and silty deposit and relatively little sand.

N-value of Diluvium

Figure 11.3.7 shows the N-values of the Diluvial clay, silt and sand. As shown in the Figure, Diluvial clay and silt usually have N-values of 10 to 25 showing a consistency of Very Stiff and Hard. On the other hand, the N-value of sand distributed in the clayey deposit is about 30 to 50.

(3) The Result of Laboratory Test

The results of laboratory tests are summarized in Table 11.3.3. Engineering properties of the soil in the Study Area are summarized as follows;

Classification of Cohesive Soil

Figure 11.3.8(a) shows the plasticity chart of the cohesive soil of the Alluvium and Diluvium. As shown in the Figure, most of the cohesive soil of the Alluvium and Diluvium is classified into CH and C'H (high liquid limit cohesive soil) indicating that these soils have high compressibility. Figure 11.3.8(b) shows the relationship between unit weight and N-value of the cohesive soil.

Water Content

Table 11.3.2 shows water content, plastic limit and liquid limit of the cohesive soils. Though water content of most of the cohesive soils in the study area is less than the liquid limit, some soils with high sensitivity have a high water content near its liquid limit.

Table 11.3.2 Water Content of Cohesive Soil

Classification	Water Content (wn)		Plastic Limit (w_P)	Liquid Limit (w_L)
	Range (%)	Average (%)	Average (%)	Average (%)
Alluvial Cohesive Soil	45101	68	37	88
Diluvial Cohesive Soil	3447	42	32	77

Unconfined Compressive Strength (qu)

Figure 11.3.8(c) shows the relationship between unconfined compressive strength (qu) and N-value. Average of qu of the Alluvial cohesive soil is 0.33 (kg/cm^2), and that of the Diluvial cohesive soil is 0.57 (kg/cm^2).

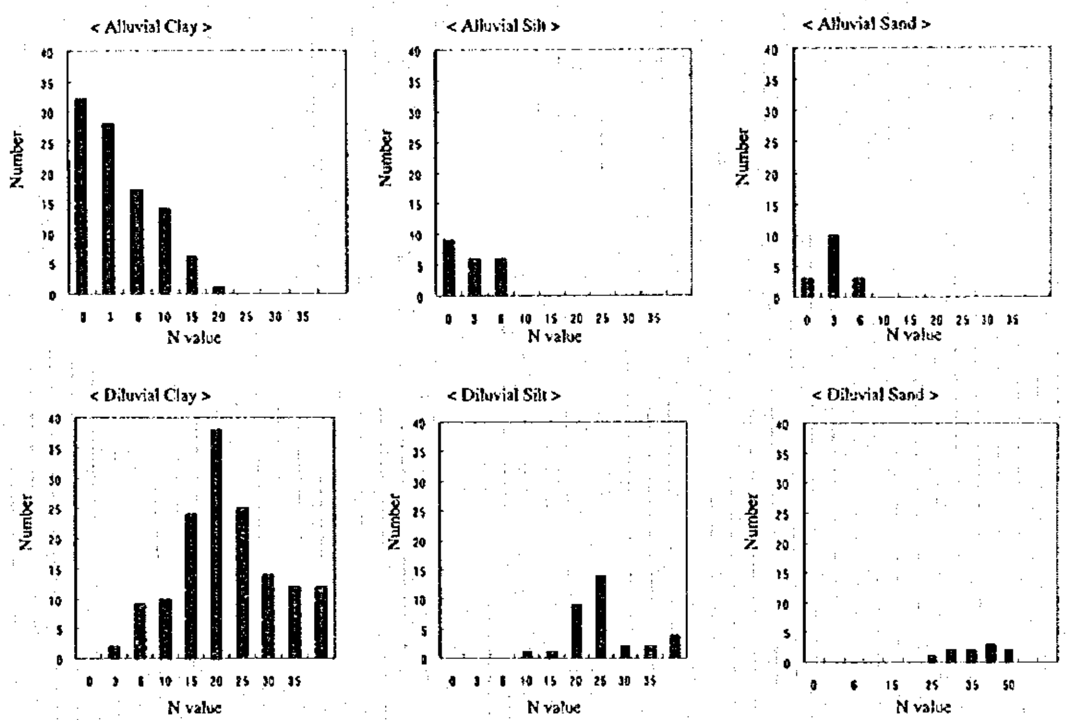
Unconsolidated - undrained Strength (UU-Cu,)

Figure 11.3.8(d) shows the relationship between cohesion of UU strength (Cu) and unconfined compressive strength (qu). It is concluded that the relationship between them is approximated Cu = qu/2. On the other hand, internal friction of UU strength () is zero (0) as shown in Figure 11.3.8.

Table 11.3.3 Result of Laboratory Test

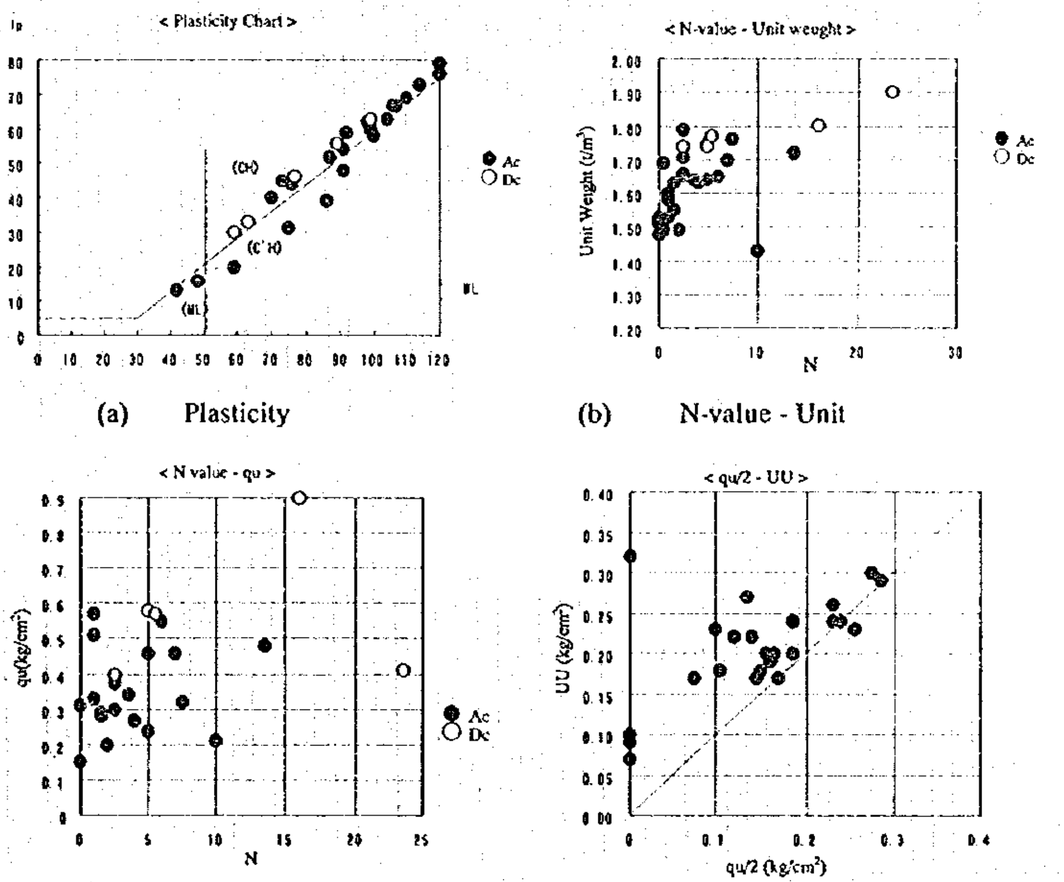
Borehole No	Soil	Formation	Depth (m)	N value	unit weight (t/m3)	water content(wn) (%)	plastic limit(wp) (%)	liquid limit (w_L) (%)	unconfined strength(qu) (kg/cm2)	UU C (kg/cm2)	CU (degree)	CU' Consolidation Test C (kg/cm2)	(degree)	eo	po (kg/cm2)	py (kg/cm2)	Cc
B-1	clay	Alluvium	2.5-3.5	2-3	1.71	52	28	73	0.30	0.18	0.00	0.17	16.00	1.39	0.26	1.00	0.50
		Alluvium	5.5-6.5	5	1.75	49	41	104	0.46	0.24	0.00	0.05	17.00	1.35	0.47	2.00	0.52
		Diluvium	8.5-9.5	16	1.80	41	33	89	0.90	0.45	0.00	0.14	13.00	1.09	0.67	0.90	0.41
B-2	clay	Diluvium	1.0-2.0	2-3	1.74	47	31	77	0.40	0.14	0.00	0.07	19.00	1.27	0.15	0.40	0.56
		Diluvium	3.0-4.0	5	1.74	46	30	63	0.58	0.28	0.00	0.19	13.00	1.20	0.30	1.50	0.41
		Diluvium	5.0-6.0	5-6	1.77	42	36	99	0.57	0.32	0.00	0.18	18.00	1.09	0.45	0.80	0.47
B-3	clay	Alluvium	2.0-3.0	4-6	1.64	60	33	92	0.24	0.22	0.00	0.17	17.00	1.59	0.19	1.20	0.75
	silt	Alluvium	5.5-6.5	5-9	1.70	52	44	75	0.46	0.26	0.00	0.29	19.00	1.38	0.43	0.80	0.57
	clay	Alluvium	9.0-10.0	13-14	1.72	50	28	73	0.48	0.24	0.00	0.31	14.00	1.34	0.68	0.75	0.57
B-4	clay	Alluvium	9.0-10.0	9-11	1.43	101	39	99	0.21	0.18	0.00	0.15	14.00	2.57	0.51	0.95	1.23
	clay	Diluvium	12.5-13.0	18-29	1.90	34	29	59	0.41	0.22	0.00	0.50	17.00	0.70	0.78	1.10	0.53
B-5	silt/clay	Alluvium	3.5-4.0	2-3	1.66	59	47	86	0.37	0.20	0.00	0.13	18.00	1.64	0.26	1.40	0.92
	clay/silt	Alluvium	8.5-9.0	0	1.48	93	36	98	0.15	0.17	0.00	0.51	9.00	2.47	0.65	0.75	1.36
	clay	Alluvium	12.0-12.50	2	1.49	90	41	110	0.20	0.23	0.00	0.25	13.00	2.38	0.74	0.90	1.41
B-6	sand	Alluvium	3.5-4.5	0-1	1.69	55	-	-	-	0.07	21.00	0.02	15.00	1.48	-	-	-
	silt	Alluvium	7.5-8.0	0-1	1.49	90	43	91	-	0.09	0.00	0.29	14.00	2.34	0.46	0.68	0.80
	clay	Alluvium	11.50-12.50	0	1.51	86	30	70	-	0.10	0.00	0.17	17.00	2.24	0.68	0.90	1.00
	clay	Alluvium	15.5-16.5	1	1.58	71	41	120	0.51	0.23	0.00	0.10	12.00	1.91	0.90	0.90	0.82
	clay	Alluvium	19.5-20.5	1	1.60	67	41	114	0.57	0.29	0.00	0.21	18.00	1.82	1.10	1.10	1.03
B-7	clay	Alluvium	9.0-9.5	0	1.52	83	37	91	-	0.09	0.00	0.07	13.00	2.20	0.49	0.59	1.06
	clay	Alluvium	15.0-15.5	0	1.53	80	40	107	0.31	0.20	0.00	0.20	13.00	2.06	0.80	0.80	1.14
	clay	Alluvium	20.0-20.5	0-2	1.53	78	44	120	0.33	0.20	0.00	0.22	11.00	1.99	1.00	1.60	1.23
B-8	clay	Alluvium	3.0-3.50	0-3	1.63	60	32	76	0.28	0.22	0.00	0.24	17.00	1.60	0.19	1.70	0.54
	sand	Alluvium	6.5-7.5	2-3	1.79	43	-	-	-	0.32	-	0.32	27.00	1.16	-	-	-
	clay	Alluvium	10.5-11.0	1-2	1.55	70	42	100	0.29	0.17	0.00	0.04	17.00	1.77	0.76	1.00	0.35
	clay	Alluvium	14.5-15.5	6	1.65	55	39	106	0.55	0.30	0.00	0.07	14.00	1.39	1.00	1.00	0.55
	clay	Alluvium	18.5-19.0	7-8	1.76	45	35	87	0.32	0.19	0.00	0.18	16.00	1.19	1.30	1.70	0.53
B-9	silt	Alluvium	2.5-3.5	3-4	1.64	57	29	42	0.34	0.17	0.00	0.46	14.00	1.48	0.22	1.50	0.63
	silt	Alluvium	5.5-6.5	3-5	1.63	58	39	59	0.27	0.27	0.00	0.30	19.00	1.49	0.42	1.30	0.63
	silt	Alluvium	8.5-9.5	1-4	1.65	56	32	48	0.37	0.24	0.00	0.34	11.00	1.46	0.63	1.30	0.51

UU; Unconsolidated undrained triaxial compression test CU'; Unconsolidated undrained triaxial compression test with measuring pore water pressure



Source: JICA Study Team

Figure 11.3.7 N-Value by Geological Unit



(a) Plasticity (b) N-value - Unit

(c) N-value-qu (d) qu/2-UU

Figure 11.3.8 Result of Laboratory Test (1)

Source: JICA Study Team

Consolidation Yield Stress (py)

Figure 11.3.9(a) shows the relationship between consolidation yield stress (py) and effective over burden pressure (po). As shown in the Figure, most of the cohesive soil in the Study area are over consolidated, while some are normally consolidated.

Compression Index (Cc)

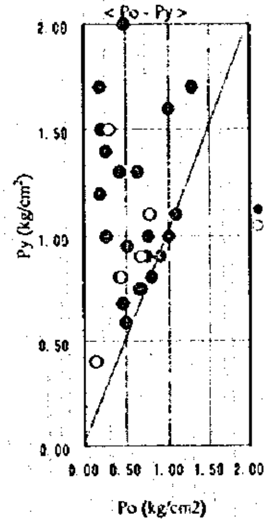
Figure 11.3.9(b) shows the relationship between compression index (Cc) and N-value. As shown in the Figure, values of Cc differ. Average Cc of Alluvial cohesive soil is 0.81, and that of Diluvial cohesive soil is 0.476. Figure 11.3.9(c) shows the relationship between Cc and initial void ratio (eo). Average eo of the Alluvial deposit is 1.78, and that of the Diluvial deposit is 1.07.

Coefficient of Consolidation(Cv)

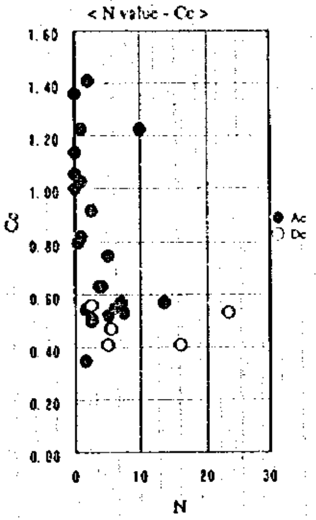
The relationship between coefficient of consolidation(Cv) of the Alluvial cohesive soil and load (p) is shown in Figure 11.3.9(d), and that of the Diluvial cohesive soil in Figure 11.3.9(e), As shown in these Figures, Cv of the Alluvial cohesive soil is about $2 \times 10^{-4} \sim 4 \times 10^{-4}$ (cm^2/sec), and that of the Diluvial cohesive soil is about $2 \times 10^{-4} \sim 4 \times 10^{-4}$ (cm^2/sec) in accordance with the load step.

Coefficient of Volume Compressibility (mv)

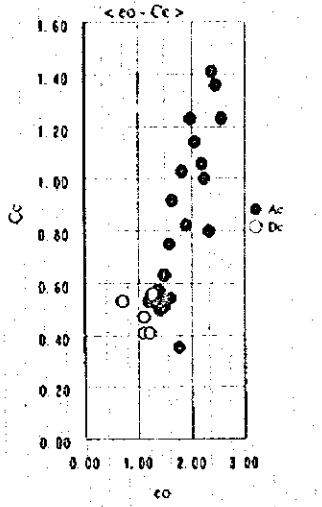
The relationship between coefficient of volume compressibility (mv) of the Alluvial cohesive soil and load (p) is shown in Figure 11.3.9(f), and that of the Diluvial cohesive soil in Figure 11.3.9(g). As shown in these Figures, mv of the Alluvial cohesive soil is about 0.01~0.3 (cm^2/kg), and that of the Diluvial cohesive soil is about 0.01~0.3(cm^2/kg) in accordance with the load step.



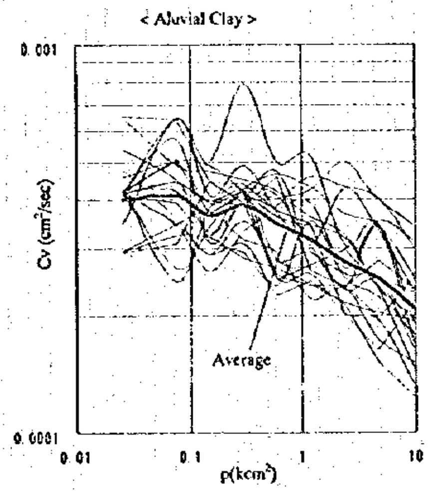
(a) Po - Py



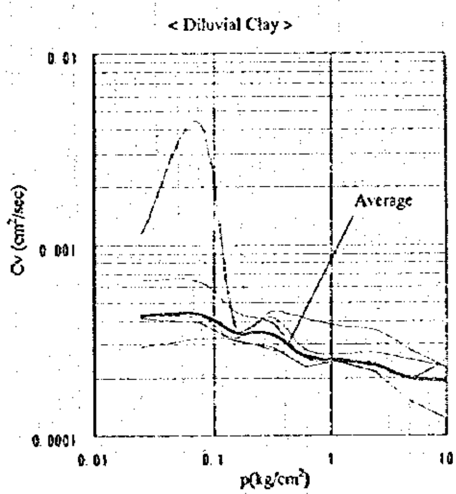
(b) N-value - Cc



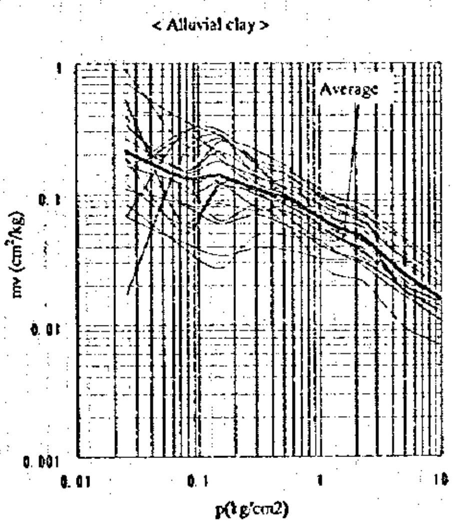
(c) eo - Cc



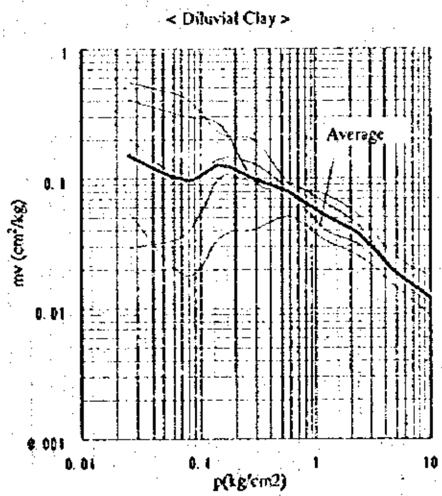
(d) Cv - p



(e) Cv - p



(f) mv - p



(g) mv - p

Source: JICA Study Team

Figure 11.3.9 Result of Laboratory Test (2)

Result of Test for Banking Material

The result of tests for banking material is shown in Table 11.3.4.

Table 11.3.4 Result of CBR Test

Classifi-cation	Number of Samples	Type of Soil	CBR (%)		Max Dry Density (t/m^3)		Optimum Water Content (%)	
			Range	Average	Range	Average	Range	Average
Alluvial Soil	11	Clay, Silt, Sand	2.49 - 39.52	8.64	1.4 - 2.03	1.55	10.11 - 27.37	23.38
Diluvial Soil	9	Clay, Silt, Sand	2.18 - 25.85	6.71	1.37 - 1.67	1.52	19.24 - 26.34	23.66

Source: JICA Study Team

Most of the soil samples collected in the field for CBR test were clay and silt, and only two samples were sand. These two sand samples show much higher CBR values of 39.52(%) and 25.85(%) respectively than those of the clay and silt samples. It is considered that expansive clay included in the Diluvial soil gave low CBR values.

(4) Geological Characteristics of the Planned Routes

Alluvial deposits are is distributed in the area of the planned routes so that some problems caused by soft ground are likely to occur. These soft grounds are considered to need some treatment for road construction. Another problem is likely to occur where Diluvial soil is distributed due to the expansive clay in the Diluvium.

Route 1

As shown in Figure 11.3.2, soft ground is distributed at STA.0+000 - 6+500, STA.13+300 - STA.14+300 and STA.19+700 - STA.22+000. In particular soft clay with N-value less than one (1) is distributed at STA.0+000 - 6+500 where the thickness of soft ground is more than 10m.

Diluvial clay with high ground strength outcrops along the planned route at the areas other than those mentioned above. However, the Diluvial clay along the planned route includes expansive clay which causes slaking. This makes the slope of cuttings soft and causes the slope to collapse when rain infiltrates into the ground.

Route 2

As shown in Figure 11.3.3, soft ground with N-value less than one (1) is distributed at STA.0+000 - STA.4+400 where the thickness of soft ground is more than 13 m, and soft ground with N-value less than three (3) is distributed at STA.9+000 - STA.16+000 where thickness of soft ground is about 10 m. As shown in Figure 11.3.3, the thickness of the Alluvial deposit differs by site along the planned route, which will cause difference of total consolidation settlement at each site. Diluvial clay with high ground strength but including expansive clay outcrops along the planned route at areas other than those mentioned above.

Route 3

As shown in Figure 11.3.4, soft ground is distributed in the whole area along route 3. Soft clay with N-value less than three (3) is distributed around STA.8+000 where the thickness of soft ground is about than 30 m. Soft clay with N-value around five (5) is distributed at the other areas where thickness of soft ground is 10m to 30 m.

Route 4

As shown in Figure 11.3.5, soft ground is distributed at STA.18+600 - STA.26+000 where the thickness of soft ground is about 13m. N-value of soft clay along this route is variable. The area with the smallest N-value is around STA.23 - STA.24 where soft clay with N-value of one (1) and thickness of 12m is distributed.

Diluvial clay with high ground strength but including expansive clay outcrops along the planned route at areas other than those mentioned above.

Route 5

As shown in Figure 11.3.6, soft ground is distributed at STA.12+600 - STA.23+000 where the N-value of clay is zero (0) to three (3) and its thickness is 10m to 20, maximum 26 m.

Diluvial clay with high ground strength and including expansive clay outcrops along the planned route at areas other than those mentioned above.

(5) Comparison between existing soil data and results of this Study

The results of the existing soil investigation are included in Figure 11.3.2 - Figure 11.3.6 together with the results of this Study. The comprehensive conclusion of the soil investigation is as follows;

- Soft ground is distributed in the Alluvial plain in the northern part of the Study area and the central to eastern part of the Study area. Soft ground distributed in the northern part is especially soft.
- The thickness of soft ground consisting of Alluvial deposits is usually 15 - 20m.
- There are some exceptions to the above where the thickness is locally deeper.
- Engineering properties of soft ground show almost the same tendency between the existing data and the results of this Study, though there are some differences between them.
- The limit height of embankment is considered to be less than 2 m according to the existing reports.

(6) Soft Ground Treatment

As shown in Figure 11.3.2 - Figure 11.3.6, soft ground consisting of Alluvial deposits is distributed in the areas of planned Route-1 to Route-5. Problems in high-way construction caused by soft ground are as follows;

- Ground failure by highway load due to the lack of bearing capacity of soft ground
- Long term consolidation settlement

Route-1 and Route-2

As shown in Figure 11.3.2 and Figure 11.3.3, soft ground distributed in the alluvial plain near the sea in the northern part of the Study area is especially soft, where even the low banking load of the existing highway has caused the soft ground to settle. This means that even low banking load causes long term consolidation settlement due to the very soft property of the soft ground. Taking the geological condition into account, that Diluvial clay with N value more than 20 is underlying the soft ground consisting of Alluvial clay with N value less than 4 and thickness of 15 - 20 m, it is proposed that banking load should be supported by piles reaching the Diluvial clay which is considered to have enough strength as a bearing stratum. Other than the area mentioned above, the same method, using piles reaching the Diluvial deposit through the Alluvial deposit which is considered practical enough for the pile method to be employed.

Route 4

As shown in Figure 11.3.5, soft ground is distributed in the eastern part of Route - 4 along which Wonokromo River is flowing. Banking load is likely to cause consolidation settlement and sliding failure of the soft ground under the highway embankment. Soft ground treatment is proposed for this area as mentioned below.

Vertical drain with sand mat

Vertical drain (sand drain etc.) with sand mat is expected to quicken consolidation settlement and to increase ground strength.

Retaining wall with piles

Retaining wall with piles reaching the Diluvial deposit is expected to support the banking load and to avoid sliding failure of the soft ground by the lateral bearing capacity of the piles.

CHAPTER 12 PRELIMINARY ENGINEERING DESIGN

CHAPTER 12

PRELIMINARY ENGINEERING DESIGN

12.1 General

This chapter describes the results of the preliminary engineering design prepared for the selected optimum routes based on the results of traffic demand forecast, aerial photography mosaic (1:5,000 scale), road survey and soils investigation, covering the following:

- Design Standards
- Highway Capacity and Number of Lanes
- Cross Section Design
- Route Selection
- Preliminary Design of Interchanges
- Preliminary Design of Bridges
- Preliminary Design of Pavement
- Road Supporting Facilities
- Current ROW Situation and Required ROW

12.2 Design Standards

This section discusses the design standards to be applied for the design of the Project Roads.

The design standards are divided into the following four sections:

- Geometric Design Standard
- Structural Design Standard
- Pavement Design Standard
- Drainage Design Standard

The Government's standards are used to a maximum extent where available. USA and Japanese standards are referred to for items not covered by the Government's standards.

12.2.1 Geometric Design Standard

The following Government standards are related to the design of highway.

- Spesifikasi Standar untuk Perencanaan Geometrik Jalan Luar Kota; December 1990 (Bina Marga) (Standard Specifications for Geometric Design Standard of Rural Roads)
- Standard Specifications for Geometric Design of Urban Roads : March 1992 (Bina Marga)

The former standard (hereinafter called the R.R. Design Standard) covers the design of rural roads to provide design criteria and controls for new construction or improvement projects of Arterial, Collector and Local Roads which are in rural areas (inter–city roads) and are not access–controlled (expressways are excluded).

The latter standard (hereinafter called as the U.R. Design Standard)covers the design of urban roads to provide design criteria and controls to be applied to new construction or improvement projects of urban roads including access control and non access control roads.

The geometric design standard used shall be the U.R. Design Standard since the Project Roads are located in the Surabaya Metropolitan area i.e. urban area and are not inter-city roads.

(1) Design Classification

The U.R. Design Standard classifies the road into two types i.e. Type I (Full Access Control) and Type II (Partial or Non Access Control) roads. Each Type of road is divided to two Classes and four Classes respectively according to their functional classification and design traffic volume. The design class for the relation between access control and functional classification is shown in Table 12.2.1.

Arterial roads of the Project Roads are Type II, Class I roads of which the nature is defined as "The highest standard streets of four or more lanes to serve inter–city or intra–city, high speed, through traffic with partial access control", and to provide a frontage-road for partial access control. However due to very limited ROW, a frontage road is not provided on the arterial roads except for Route-1 and a part of Route-2.

Table 12.2.1 Design Classification

Type	Function		DTV(pcu/day)	Class
I	Primary	Arterial	-	I
		Collector	-	II
	Secondary	Arterial	-	II
II	Primary	Arterial	-	I
		Collector	-	I
			-	II
	Secondary	Arterial	20,000 or more	I
			less than 20,000	II
		Collector	6,000 or more	II
			less than 6,000	III
		Local	500 or more	III
			less than 500	IV

Note: In calculating design traffic volume (DTV) for determining the highway design classification, un-motorized vehicles (including bicycle/becak) are not taken into consideration.

The Type and the Class applied for the Project Roads are shown in Table 12.2.2.

Table 12.2.2 Type and Class for the Project Roads

Project Roads		Road Function	Type	Class
Route-1	Toll Road	Primary Arterial	I	I
	Arterial Road		II	
Route-2 Route-3 Route-4 Route-5		Secondary Arterial		

The nature of each design classification is shown in Table 12.2.3.

Table 12.2.3 The Nature of Road Classification

Type I	Class I	The highest standard road to serve inter-region or inter-city high speed traffic <u>with full access control</u>.
Type II	Class I	The highest standard street of four or more lanes to serve inter-city or intra-city, high speed, through traffic <u>with partial access control</u>.
Type II	Class II	High standard street of two or more lanes to serve inter/intra-city, (intra-district), high speed, mainly through traffic <u>with/without partial access control</u>.

(2) Design Speed

U.R. Design Standard provides for Design Speed as shown in Table 12.2.4 according to the Type and Class of road.

Table 12.2.4 Design Speed

Type	Class	Design Speed (km/h)
I	I	100 or 80
	II	100 to 60
II	I	60
	II	60 or 50
	III	40 or 30
	IV	30 or 20

The design speeds adopted for the Project Roads are shown in Table 12.2.5.

Table 12.2.5 Design Speed for the Project Roads

Project Roads		Design Speed
Route-1	Toll Road	100 km/h
	Arterial Road	60 km/h
Route-2 Route-3 Route-4 Route-5		

For reference, the design speed of existing and planned toll roads in East Java are shown in Table 12.2.6.

Table 12.2.6 Toll Road Design Speed in East Java

Name of Toll Road	Section	Design Speed (km/h)	Nos. of lanes
Surabaya - Gempol	Urban	100	4-lane/2-way
	Rural	120	
Surabaya - Gresik	Urban	80	4-lane/2-way (6-lane/2-way)
	Rural	100	2-lane/2-way (4-lane/2-way)
Surabaya-Mojokerto	Urban	100	4-lane/2-way (8-lane/2-way)
	Rural	120	4-lane/2-way (6-lane/2-way)
Gempol-Pandaan	Rural	120	4-lane/2-way
Pandaan-Pasuruan	Rural	120	4-lane/2-way
Surabaya-Madura Br.	Urban	80	4-lane/2-way
Gresik-Tuban	Rural	100	4-lane/2-way
Mantingan-Mojokerto	Rural	120	4-lane/2-way
Pandaan-Malang	Rural	100	4-lane/2-way
Pasuruan-Probolinggo	Rural	120	4-lane/2-way
Surabaya E.Ring Road	Urban	100	4-lane/2-way (6-lane/2-way)
Probolinggo-Banyuwangi	Rural	80	4-lane/2-way
Ngawi-Babat	Rural	100	4-lane/2-way
Surabaya N-S Corridor	Urban	80	4-lane/2-way
Bulu-Tuban	Rural	100	4-lane/2-way

(3) Recommended Geometric Design Standard for Throughway

The recommended elements of geometric design standard such as "Cross Section", "Sight Distance", "Horizontal Alignment" and "Vertical Alignment" for throughway of the Project Roads are shown in Table 12.2.7.

The design elements of the Project Roads follow this Geometric Design Standard to its full extent except for locations where the road alignment follows the existing road alignment such as part of Route-2, Route-3 and Route-4.

Table 12.2.7 Geometric Design Standard for Throughway of the Project Road

Item	Unit	U.R. Design Standard		Recommendation	
		Type I, Class I	Type II, Class I	Route-1, Toll Road As of Type I, Class I	Route- 1,2,3,4,&5, Arterial Road As of Type II, Class I
Cross Section					
Lane width	m	3.50	3.50	3.50	3.50
Median					
Standard Min.	m	2.50	2.00	5.50	2.00
Exceptional Min.	m	2.50	1.00	3.50	-
Right Shoulder Width					
Standard Min.	m	1.00	0.50	1.00	0.50
Exceptional Min.	m	0.75	0.50	-	-
Left Shoulder Width					
Desirable Min.	m	3.25	2.50	3.25	-
Standard Min.	m	2.00	2.00	2.00	-
Exceptional Min.	m	1.75	1.50	-	1.50
With Side Walk	m	-	0.50	-	0.50
Parking Lane				-	-
Standard Min.	m	-	2.50	-	-
Exceptional Min.	m	-	2.00	-	-
Side Walk				-	
Standard Min.	m	-	3.00	-	3.00
Exceptional Min.	m	-	1.50	-	-
Max. Super Elevation	%	7.0	6.0	4.0	6.00
Vertical Clearance	m	5.10	5.10	5.10	5.10
Minimum Stopping Sight Distance	m	160	75	160	75
Horizontal Alignment					
Minimum Radii	m	380	150	-	200
Desirable Minimum Radii	m	700	200	1,000	-
Min. Radii for Normal Crossfall	m	5,000	220		
Minimum Curve Length					
Standard Minimum	m	1,200/Θ	700/Θ	1,200/Θ	700/Θ
Exceptional Minimum	m	170	100	-	-
Min. Transition Curve Length	m	85	50	-	50
Min. R. Without Trans. Curve	m	1,500	600	1,500	600
Vertical Alignment					
Max. Grade	%	3.00	5.00	2.00	4.83
Min. Vertical Curve Radii					
Crest (Desirable)	m	6,500(10,000)	1,400(2,000)	5,000	2,000
Sag (Desirable)	m	3,000(4,500)	1,000(1,500)	5,000	1,900
Min. Vertical Curve Length	m	85	50	390	60

Source: JICA Study Team

(4) Recommended Geometric Design Standard for Interchange Ramps

The recommended geometric design standard for interchange ramps of the Project Roads is shown in Table 12.2.8. The values in the table are based on "Standard Specifications for Geometric Design of Urban Roads : March 1992 (Bina Marga)".

Table 12.2.8 Ramp Way Design Standard

Item	Unit	Design Standard	
		1 Lane 1 Way	2 Lanes 1 way
Design Speed	km/h	40	40
Cross Section Element			
Lane Width	m	3.50	3.50
Left Shoulder Width	m	2.50	0.75
Right Shoulder Width	m	1.00	0.75
Marginal Strip Width	m	0.50	0.50
Maximum Super-elevation	%	8.0	8.0
Vertical Clearance	m	5.10	5.10
Minimum Stopping Sight Distance	m	40	40
Horizontal Alignment			
Min. Radii	m	50	50
Min. Radii for Normal Cross-fall	m	800	800
Min. Radius Without Transition Curve	m	140	140
Min. Parameter of Transition Curve	m	35	35
Vertical Alignment			
Max. Grade	%	6	6
Min. Vertical curve Radii			
Crest	m	450	450
Sag	m	450	450
Min. Vertical Curve Length	m	35	35

Source: Standard Specifications for Geometric Design of Urban Roads : March 1992 (Bina Marga)

For the Design Speed of ramp ways, U.R. Design Standard provides as shown in Table 12.2.9.

Romo Kalisari interchange which connects Surabaya-Gresik Toll Road (hereinafter referred to as Sby-Gre Toll Road) and the Project Road Route-1 is an interchange connecting Type I road to Type I road. The design speed according to the U.R Design Standard is any one of 80, 60 or 50 km/h. However Romo Kalisari interchange was designed for 40 km/h during construction of Sby-Gre Toll Road with fixed ROW and there is no room to modify the design speed of the interchange. The other interchanges are connecting Type II Road to Type II Road. With these considerations, a 40 km/hr design speed for ramp ways is recommended for the Project Roads.

Table 12.2.9 Ramp Way Design Speed

Unit Km/h

Major Road / Crossing Road		Type I and Type II Road		
		100	80	60
Type I	100	80, 60, 50	-	-
	80	60, 50, 40	60, 50, 40	-
	60	60, 50, 40	60, 50, 40	60, 50, 40
Type II	60	40, 35, 30	40, 35, 30	40, 35, 30, 25
	50	40, 35, 30	40, 35, 30	40, 35, 30, 25

The design elements for ramp terminal provided by the U.R. Design Standard are as shown in Table 12.2.10.

Table 12.2.10 Geometric Design Standard for Ramp Terminal

Item	Unit	Design Speed	
Throughway Design Speed	km/h	100	60
Ramp-way Design Speed	km/h	40	40
For throughway			
Min. Horizontal Curve Radius	m	1,500(1,000)	450(200)
Max. Grade	%	2.0(3.0)	5.0(6.0)
Min. Vertical Curve			
Crest	m	25,000(15,000)	4,500(2,500)
Sag	m	12,000(8,000)	3,000(1,500)
For Ramp Way Adjacent to Nose			
Min. Horizontal Curve Radius	m	200	100
Min. Parameter of Clothoid Curve	m	70(60)	50(40)
Min. Vertical Curve			
Crest	m	1,000	450
Sag	m	850	450
Acceleration Lane Length			
One lane: Acceleration Lane + Taper	m	180 + 60	120 + 45
Two lanes: Acceleration Lane + Taper	m	270 + 60	180 + 45
Deceleration Lane Length			
One lane: Deceleration Lane + Taper	m	90 + 60	70 + 40
Two lanes: Deceleration Lane + Taper	m	135 +60	105 + 45

(5) Recommended Geometric Design Standard for Busway

There is no geometric design standard for busway in Indonesia. A busway width of 8.0m (0.5+2×3.5+0.5) is recommended based on design vehicle width of 2.5m.

As shown in Outline of the New Transport Systems Development in Japan, Table 12.2.11, a design speed of 60 km/hr is acceptable for geometric design of busway considering future conversion to a new transport system.

Table 12.2.11 Outline of the New Transport Systems Developed in Japan

Name of System	DMBS (Dual Mode Bus System)	FAST (Fuji Advanced Systems of Transportation)	KCV (Kawasaki Computer-Controlled Vehicle System)	KRT (Kobe Rapid Transit)	MAT (Mitsubishi Automatic Transportation system)	NYS (Newtran System)	PARATRAN (Public and Automated Rapid Transportation System9	VONA (Vehicles of New Age)
Guidance	Side-guided	Side-guided	Side-guided	Side-guided	Central-guided	Side-guided	Side-guided	Central-guided
Pass. Capacity /Car	40～70	50 (16 seated) 75 (24 seated) 135 (40 seated)	30 (16 seated) 75 (24 seated)	75 (24 seated) 30 (8 seated)	32 (16 seated) 75 (24 seated)	75 (22 seated)	75 (24 seated)	40 (14 seated)
Car Size : m (L×W×H)	12×2.5×3.8	6.4×2.15×3.07 7.8×2.15×3.07 13.0×2.45×3.15	6.35×2.35×3.15 9.1×2.35×3.15	8.0×2.3×3.17 4.7×2.03×2.67	5.7×2.2×2.9 7.8×2.46×3.25	8.0×2.3×3.05	8.0×2.4×3.19	5.3×2.0×3.1
Dead Load : ton	7.5	6.5 7.5 12.0	5.0 9.0	10.5 4.1	5.0 9.5	10.5	9.5	4.5
Max. Speed : kph	60	60	70	60 50	60	60	60	60
Min. Curvature : m	35 (guideway) 12 or less (road)	23	20	15 9.14	15	20	25 (when articulated)	20
Max. Gradient : %	10	10	10	9 10	10	9	10	7
Electric System	DC 430V	AC 3 phase 440/400V	AC 3 phase 440/400V	AC 3 phase 550V	AC 3 phase 550V	AC 3 phase 600V	AC 3 phase 440/400V	DC 600V
Switching System	On-board Selection	Vertical Diverting	Vertical Diverting	Swing Arm (On-board Selection)	180° Rotation	Movable Guidance Brade	Movable Guidance Brade	Turn Table
Operation Control	Speed Instructed	Central Computer Control	Central Computer Control	Central Computer Control	Central Computer Control	Central Computer Control	Central Computer Control	Central Computer Control
Min. Headway : second	10	90	90	90 15	90	90	90	90
Max. Transport Capabilities : pass/h	15,000	12,000	3,000～18,000	1,600～18,000 7,200	4,000～12,000	3,000～20,000	5,000～15,000	3,000～19,000

12.2.2 Structure Design Standards

(1) Loading

The loading specifications for the design of structures are as follows :

- Peraturan Perencanaan Teknik Jembatan May 1992 BINA MARGA (BMS) (Bridge Design Code)
- Design Manual, December 1992 BINA MARGA

However for requirements of design not covered by the above specifications AASHTO or Japanese Specifications for Highway Bridges as well as Japanese Specifications for Pedestrian Bridges will be applied.

According to the above specifications, basic design standards are as follows :

1) Traffic Loads

(a) Intensity of "D" Lane Loading

The "D" lane loading consist of uniformly distributed load (UDL) combined with a knife edge load (KEL) as shown in Figure 12.2.1 and Figure 12.2.2.

UDL load intensity: q (kPa)

Where $L \leq 30m$ $q = 8.0$ (kPa)

$L \geq 30m$ $q = 8.0\,(0.5 + 15/L)$ (kPa)

L: Loaded Length (m)

KEL load intensity: p (kN/m)

$p = 44$ (kN/m)

(b) Magnitude of "T" Truck Loading

The "T" truck loading is a single heavy vehicle with three axles as shown in Figure 12.2.3. "D" loading is applied to the design of bridges in this project except for small span bridges.

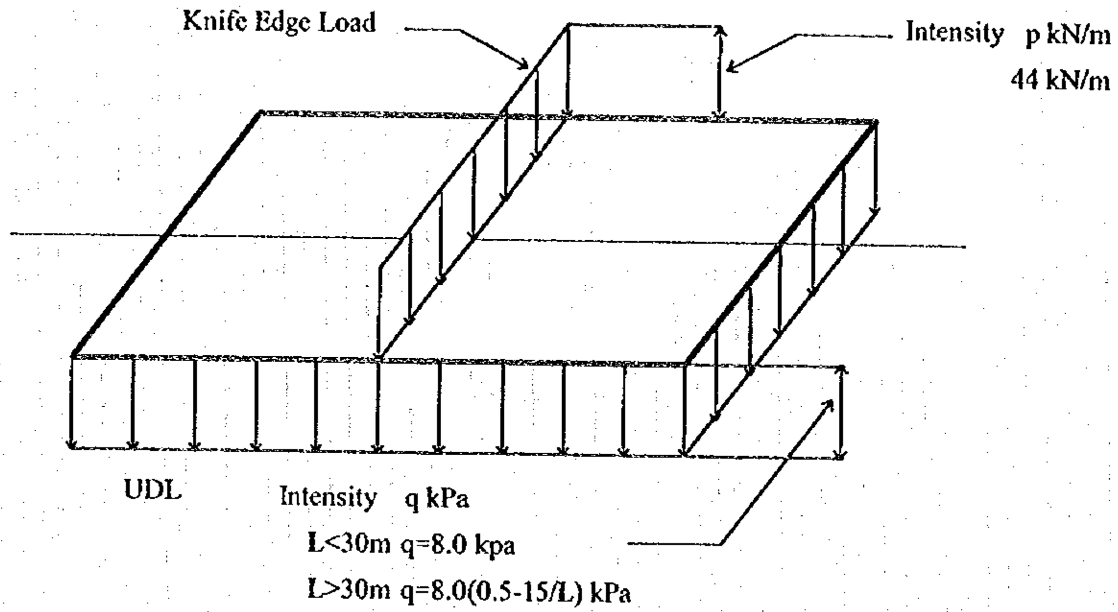


Figure 12.2.1 "D" Lane Loading

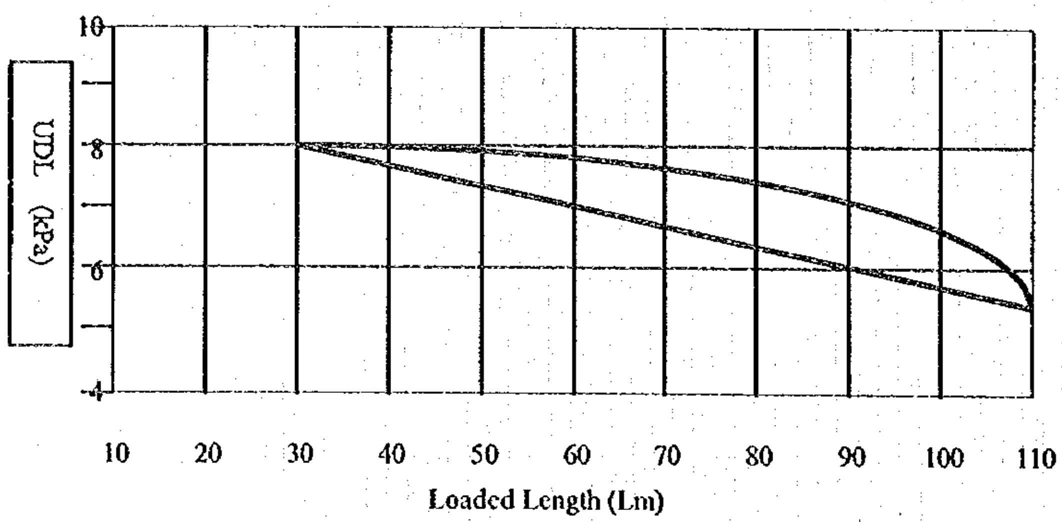


Figure 12.2.2 "D" Loading: UDL vs. Loaded Length

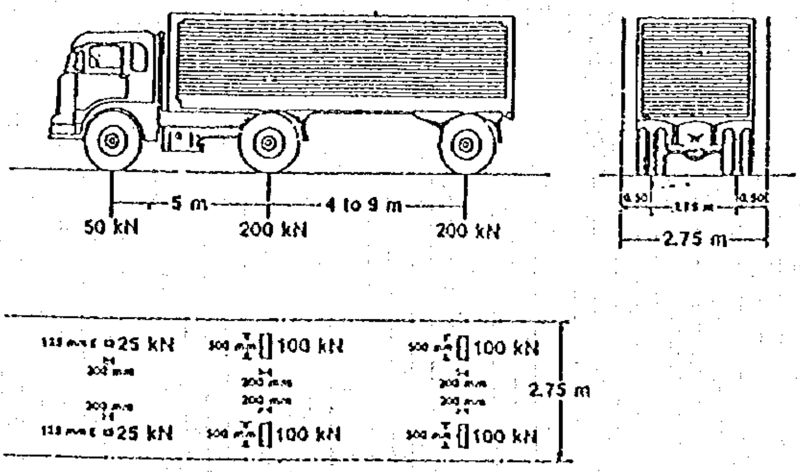


Figure 12.2.3 "T" Truck Loading

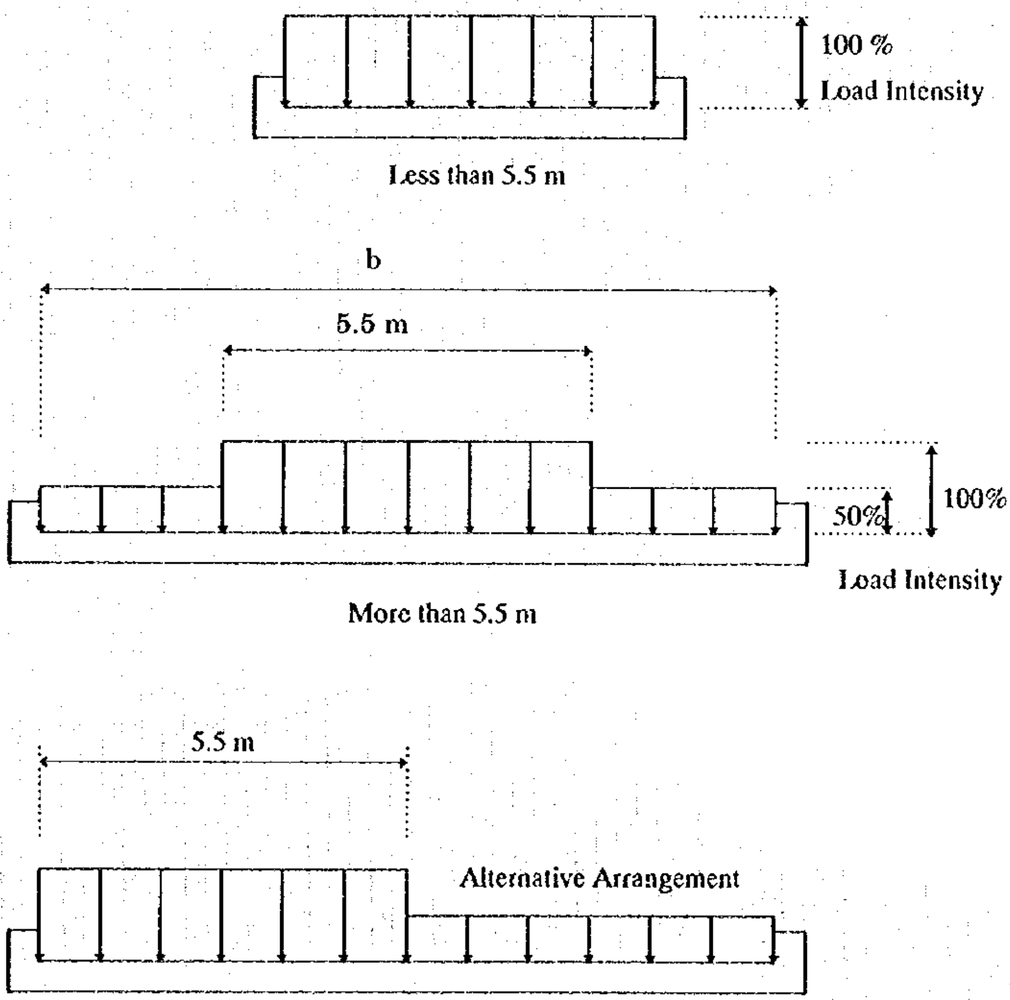


Figure 12.2.4 Lateral Distribution of "D" Lane Loading

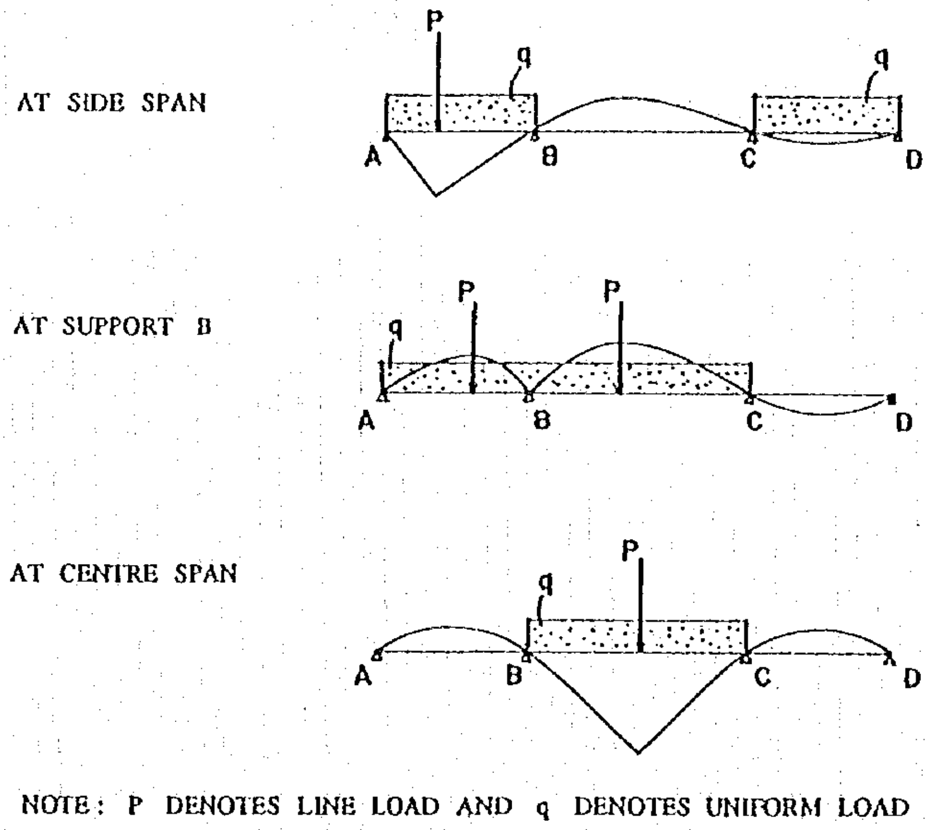


Figure 12.2.5 Maximum Positive and Negative Bending Moment

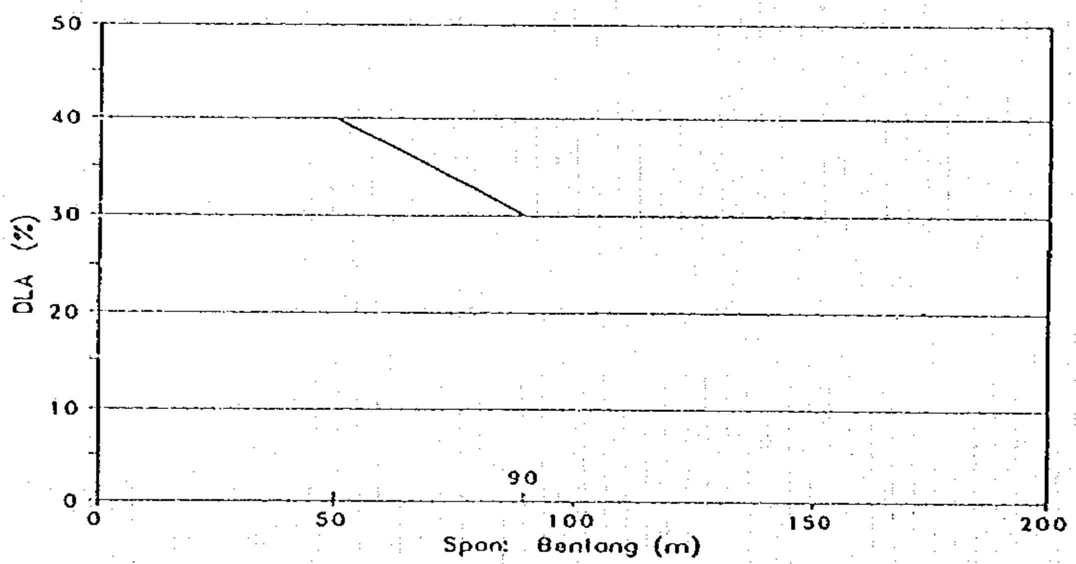


Figure 12.2.6 Dynamic Load Allowance for KEL of "D" Lane Load

(c) Application of "D" Lane Loading

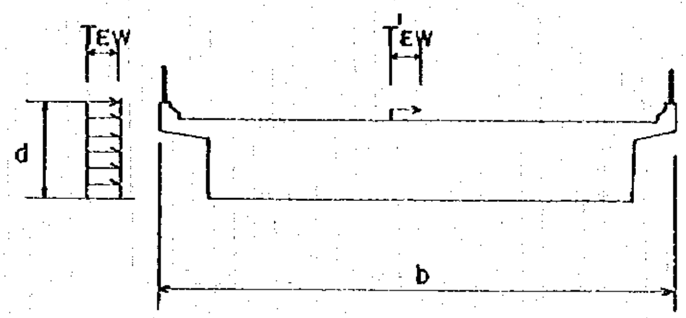
The reduction in "D" load intensity is illustrated in Figure 12.2.2 and Figure 12.2.4 for computing the maximum positive and negative bending moments due to "D" load. On a continuous beam with multi support the loading is as illustrated in Figure 12.2.5.

(d) Dynamic Loading Allowance (DLA)

To provide the dynamic strength and vibration influence, stresses produced by the "D" loading are multiplied by an impact coefficient. DLA is applied only to the Knife Edge load p = 44 Kn/m. Dynamic load allowance is shown in Figure 12.2.6.

(e) Wind Load

1. Wind load given by formula (4.1) is applied to the vertical exposed area.
2. If consideration for the wind load on a vehicle is necessary an additional uniform horizontal line load is applied at deck level given by formula (4.2)



b : Overall width of bridge
d : Depth of superstructure plus solid parapet

$T_{EW} = 0.0006\ Cw\ (Vw)^2 \cdot Ab$ kN (4.1)
$T_{EW} = 0.0012\ Cw\ (Vw)^2$. kN/m (4.2)

Where
Vw : Design wind velocity
Cw : Drag coefficient
Ab : Equivalent side area of the bridge (m^2)

Design Wind Velocity

Design wind velocity is 25m/sec in service stage and 30 m/sec in the ultimate stage.

Drag Coefficient

Solid Superstructure (PC Box and I-girder) is 1.25 for b/d > 6.0.

(f) Breaking Force

Notwithstanding the width of the bridge, breaking and acceleration forces are obtained from Figure 2.9 of the code as follows :

Bridge length : 0 < L < 80m Breaking Force 250 kN

Bridge length : 80 < K < 180m Breaking Force 2.5L + 50 kN

The longitudinal force is assumed to act at bridge surface level

(g) Vehicle Impact

To resist the collision forces on a pier due to a vehicle, a collision force of 1000 kN is applied at an angle of 10^{deg} from the direction of the center line of the road.

Design force for concrete barrier, 10 ton is obtained from the Japanese Standard.

The collision force is considerate as being applied at a height of 1.80m above the roadway surface.

(h) Centrifugal Force

$$Ttr = 0.006\frac{V^2}{r}Tr$$

Where,

Ttr : Centrifugal force acting on a section of the bridge
Tr : Total traffic loading acting on the same section of the bridge
V : Design traffic speed (km/h)
r : Radius of curve (m)

2) Environmental Action

(a) Thermal Forces

The assumed ambient temperature for design purposes is 30°C. Concrete structures are designed for a variation of minimum 15°C to maximum 40°C.

(b) Earthquake Forces

Earthquake force is applied in accordance with "Peraturan Perencanaan Teknik Jembatan Tahun 1992" (hereinafter called the Code). The minimum earthquake design load is derived from the following formula :

$$T_{EQ} = K_h I W_t$$

Where :

K_h = CS
T_{EQ} = Total base shear force in the direction being considered (kN)
K_h = Coefficient of horizontal seismic loading
C = Base shear coefficient for the appropriate zone, period and site condition
I = Important factors
S = Structural type factor
W_t = Total nominal weight of structure subject to seismic acceleration taken as dead load superimposed dead load (kN)

<u>Base Shear Coefficient</u>

i) Seismic Zone Number

The Seismic Zone Number for Surabaya is 4 from Figure 12.2.7.

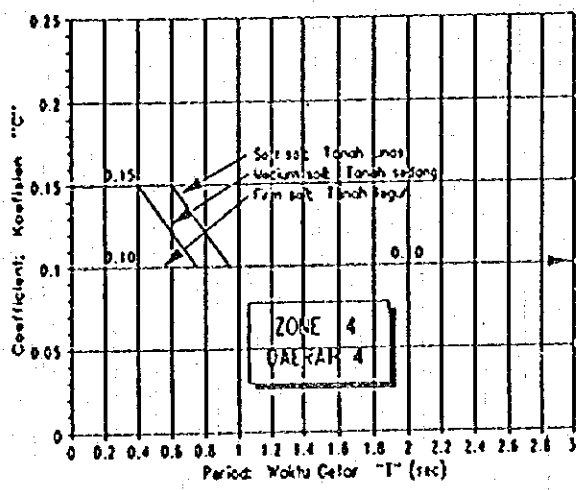


Figure 12.2.7 Basic Earthquake Coefficients for Seismic Zone

ii) Soil Condition

The soil condition has been determined as follows in compliance with Table 12.2.12 of the Code and the Soil Investigation Report.

Table 12.2.12 Soil Condition

Route-1	Medium soil	gn = 0.27 ~ 0.90 a /cm²
Route-2	Soft soil	gn = 0.13 ~ 0.19
Route-3	Soft soil	gn = 0.15 ~ 0.16
Route-4	Soft soil	gn = 0.17 ~ 0.23
Route-5	Soft soil	gn = 0.15 ~ 0.16

iii) Important Factors

The Important Factor is 1.2 obtained from Table 2.13 of the Code.

iv) Structural Type Factor

The Structural Type Factor is governed from clause 1.8.3 Selection of Structural Type in the Code.

Type A : continuous / integrated framed bridge

Type B : single span bridge

v) Period of Vibration (in seconds)

For a simple single degree of freedom structure (i.e. simple span) the following formula may be used.

$$T = \sqrt{\frac{Wtp}{gKp}}$$

Where ;

T = Period of vibration in seconds

g = Acceleration due to gravity (m/s^2)

Wtp = Total nominal weight of superstructure including superimposed dead load plus half the weight of the pier and adjusted by judgment as appropriate (kN)

Kp = Combined stiffness of bridge pier expressed as the horizontal force required to produce a unit deflection at the pier top (kN/m)

Route	Soil condition	Period	Base Scheme	Structure Type Factor	Important Factor	Kh= S.I
1	medium soft	0.95	0.10	1.15	1.120	0.14
2, 3, 4, 5	soft soil	0.75	0.10	1.15	1.120	0.14

12.2.3 Material and Strength for Structure

(1) Concrete Strength

The use of each class of concrete and required strength are as shown in Table 12.2.13.

Table 12.2.13 Class of Concrete and Application

Class of Concrete	Compressive Strength	Application
A - 1	40 Mpa	Precast prestressed concrete structure
A - 2	35 Mpa	Cast insitu prestressed concrete structure
B - 1	30 Mpa	Deck slab, pier head and column
B - 2	30 Mpa	Cast insitu reinforced concrete pile
C	21 Mpa	Abutment, footing, retaining wall
D	13 Mpa	Gravity type retaining wall
E	8 Mpa	Leveling concrete
AA	50 Mpa	Prestressed concrete pile

(2) Reinforcement

The designation and strength of reinforcement are given in Table 12.2.14.

Table 12.2.14 Designation and Strength of Reinforcement

Type	JIS G 3112		ASTM A 615		
	Designation	Yield Strength	Designation	Yield Strength	Indonesian Standard
Round Bar	SR 24	24	Grade 40	2800	as applicable
Deformed Bar	SR 24	24	Grade 40	2800	as applicable

(3) Prestressing Steel

Each type of prestressing steel and the strength is shown in Table 12.2.15.

Table 12.2.15 Strength of Prestressing Steel

Notation	Utilization	Nominal Diameter (mm)	Yield Strength (kg/mm^2)	Breaking Strength (kg/mm^2)	Applicable Standard	
					JIS	ASTM
PC Wire SWPR 1	PC Pile	Ø 7	135	155	G 3536	A 421
PC Wire SWPR 1	Diaphragm for PC Box Girder	Ø 8	130	150	G 3536	A 421
PC 7 - Wire Strand SWPR 7A	PC Box Girder PC Hollow Slab and Diaphragm for PC Box Girder	T 12.4	150	175	G 3536	A 416
PC 7 - Wire Strand SWPR 7B	PC Hollow Core Slab Unit, PC I-Girder and PC T-Girder	T 12.7	160	190	G 3536	A 416
PC 7 - Wire Strand SWPR 7B	PC I-Girder	T 15.3	160	190	G 3536	A 416
PC 19 - Wire Strand SWPR 19	Diaphragm for PC I-Girder, Diaphragm for PC T-Girder	T 19.3	162	189	G 3536	A 416
PC Bar SBPR 80 / 95	Diaphragm for PC Box Girder	Ø 23	80	95	G 3109	A 722

12.2.4 Pavement Design Standard

The following Government pavement design standards are for flexible pavement and rigid pavement.

- Guide for Flexible Pavement Design (Petunjuk Perencanaan Tebal Perkerasan Lentur Jalan Raya Dengan Metode Analisa Komponen : SKBI – 2.3.26.1987 UDC:625.73(02), Bina Marga)
- Guide for Rigid Pavement Design (Pedoman Perentuan Kaku : Beton Semen, 1985, Bina Marga)

Flexible pavement is recommended to make maximum use of the existing flexible pavements.

12.2.5 Drainage Design Standard

Drainage facilities design is based on Rainfall Intensity in a 5 Year Return Period as stipulated in Bina Marga Standard (Petunjuk Desain Drainase Permukaan Jalan No. 008/T/BNKT/1190). To determined the flow in the road drainage facilities the Modified Rational Formula is used and the dimensions of the road drainage facilities are determined using Manning's Formula.

(1) Rainfall Intensity

The rainfall intensity has been established by Brantas Flood Control & Water Resources Management Office as follows.

$$I_5 = \frac{6965}{t \times a + 36}$$

Where : I_5 = 5 year rainfall intensity (mm/hr)
t = time of concentration (10 min.)
a = retarding coefficient (1.27)

(2) Rational Formula

The discharge flow is calculated as follows :

$$Q = \frac{C \times I_5 \times A}{3.6 \times 10^6}$$

Where : Q = discharge (m^3/sec)
C = run off coefficient
commercial area : 0.8
industrial area : 0.5
residential area : 0.5
village and military area : 0.4
open space : 0.1
road surface : 0.9
I_5 = 5 year rainfall intensity (mm/hr)
A = drainage area (m^2)

(3) Manning's Formula

The dimensions of the road side drainage facilities are determined using the following formula :

$Q = 1/n \times R^{2/3} \times I^{1/2} \times A$

Where : Q = discharge (m^3/sec)
n = Manning's roughness coefficient
cast in place concrete : 0.015, pre-cast concrete : 0.013,
mortared rubble : 0.025
R = hydraulic mean depth (m)
I = water surface slope
A = area of flow (m^2)

12.3 Highway Capacity and Number of Lanes

12.3.1 Highway Capacity Analysis

The highway capacity of the Project Roads was examined based on the following Highway Capacity Manual.

"Indonesian Highway Capacity Manual (IHCM) Draft Final Report : October 1996 Directorate General BINA MARGA, Directorate of Urban Road Development (BINKOT)"

The results of the highway capacity analysis are shown in Table 12.3.1 and Table 12.3.2.

Table 12.3.1 Analysis of Highway Capacity for Toll Road

DESCRIPTION	ROAD SEGMENT	
Road Type: Motorways	6-Lane,2-way	4-Lane,2-way
Design Classification: Type I	Class I	Class I
Design Speed (km/h)	100	100
Width of Lane	3.50	3.50
Adjustment Factor for Carriageway: FCw	1.00	1.00
Base Capacity (pcu/h/lane)	2,300	2,300
Capacity (pcu/h/lane)	2,300	2,300
Peak Hour Factor: K (%)	9	9
Directional Factor: D (%)	55	55
Daily Traffic Capacity (pcu/day)	139,394	92,929
Degree of Saturation(Average LV Speed=80 km/h)	0.58	0.58
Traffic Performance(pcu/day)	80,848	53,899

Source: JICA Study Team

Table 12.3.2 Analysis of Highway Capacity for Arterial Road

DESCRIPTION		ROAD SEGMENT									
Road Type : Urban Roads		6-lane, 2-way					4-lane, 2-way				
Design Classification : Type II, Class I		A	B	C	D	E	A	B	C	D	E
Frontage Road (m)		-	-	-	6.00	-	-	-	-	6.00	-
Width of Median (m)		2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Width of Lane (m)		3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Lateral Clearance	Outer Shoulder (m)	2.50	2.00	1.50	0.50	0.50	2.50	2.00	1.50	0.50	0.50
	Inner Shoulder (m)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Adjustment Factors	FCw : Carriage Width	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	FCsp : Directional Split	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	FCsf : Side Friction	1.00	0.99	0.98	0.97	0.95	1.00	0.99	0.97	0.96	0.94
	FCcs : City Size	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.01	1.04
	Total (Fw×Fks×Fsp×Fsf×Fcs)	1.04	1.03	1.02	1.01	0.99	1.04	1.02	1.01	1.00	0.98
Base Capacity (pcu/hr/lane)		1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650
Peak factor K (%)		9	9	9	9	9	9	9	9	9	9
Directional factor D (%)		55	55	55	55	55	55	55	55	55	55
Daily Traffic Capacity (pcu/day)		104,000	102,752	101,504	100,672	99,008	69,333	68,293	67,253	66,560	65,173
Degree of Saturation (Average LV Speed = 50 km/hr)		0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Traffic Performance (pcu/day)		78,000	77,064	76,128	75,504	74,256	52,000	51,220	50,440	49,920	48,880

Note : Design Classification A, B, C, D and E depend on outer shoulder width.

Source: JICA Study Team

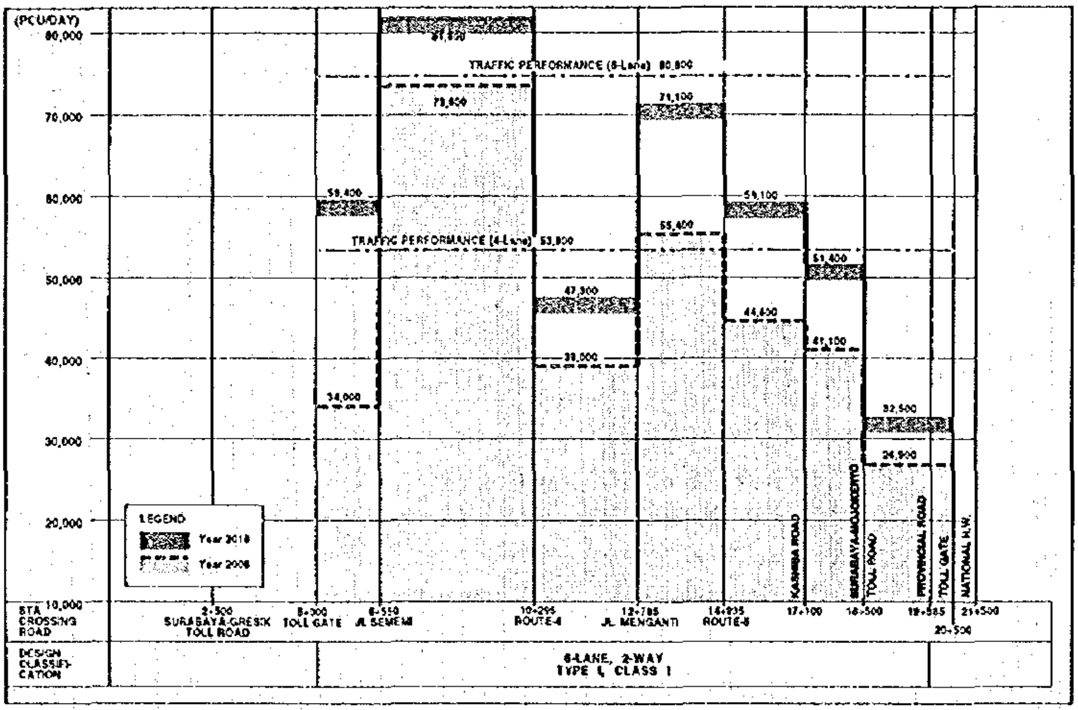


Figure 12.3.1 Traffic Demand and Highway Capacity for Route-1; Toll Road

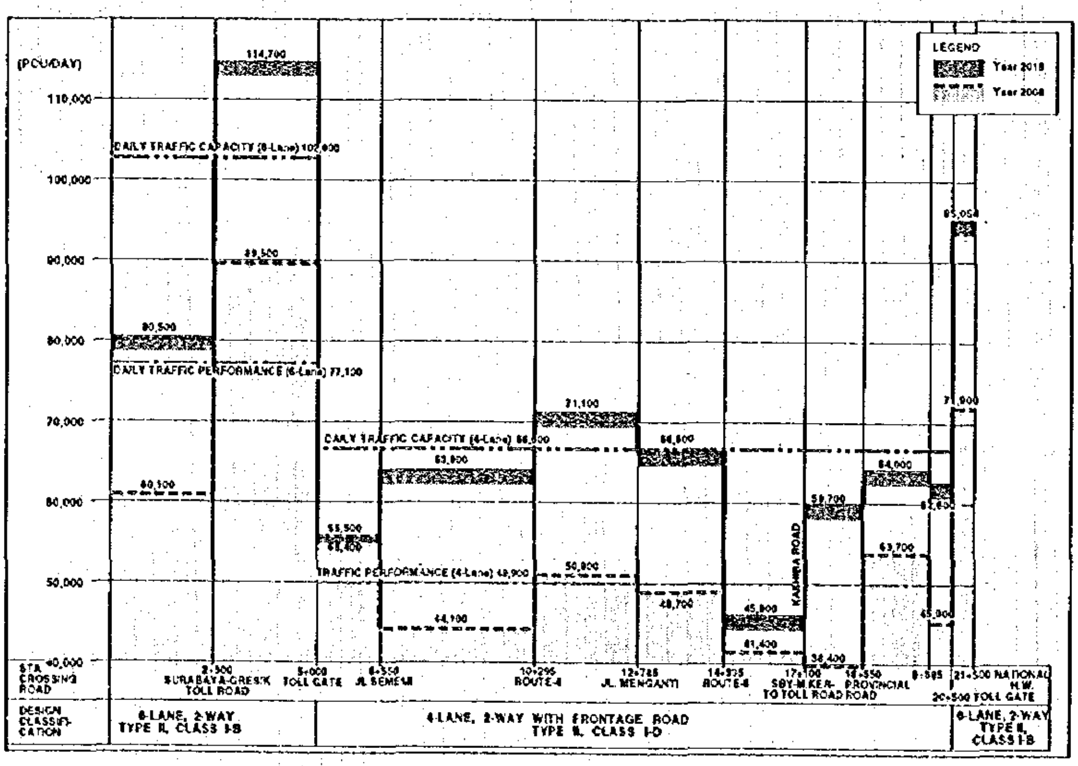


Figure 12.3.2 Traffic Demand and Highway Capacity for Route-1; Arterial Road

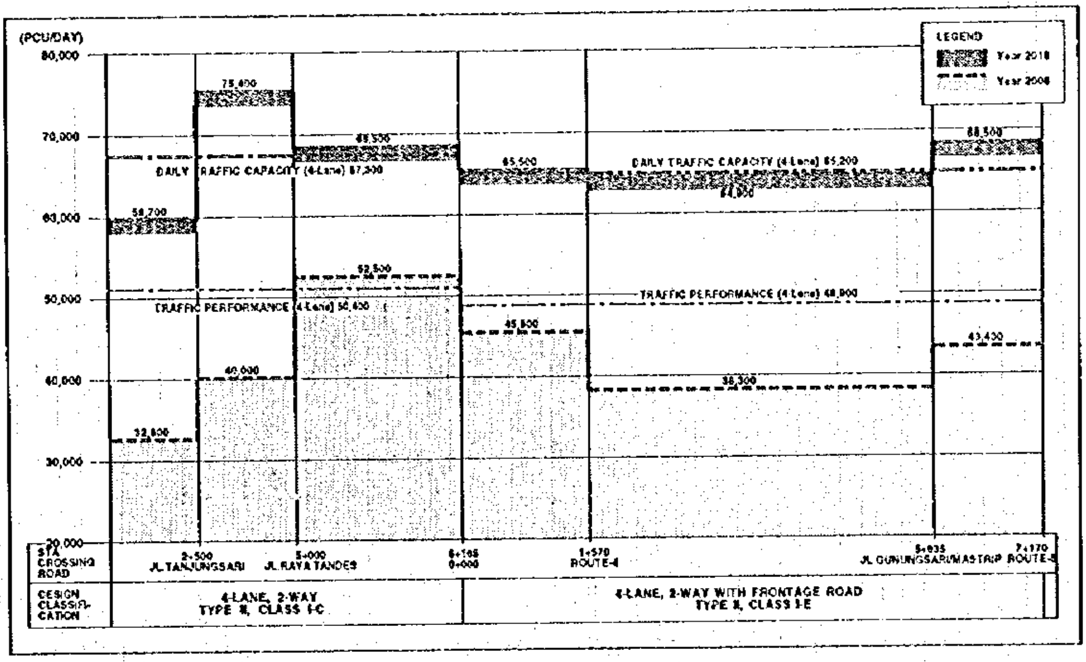


Figure 12.3.3 Traffic Demand and Highway Capacity for Route-2

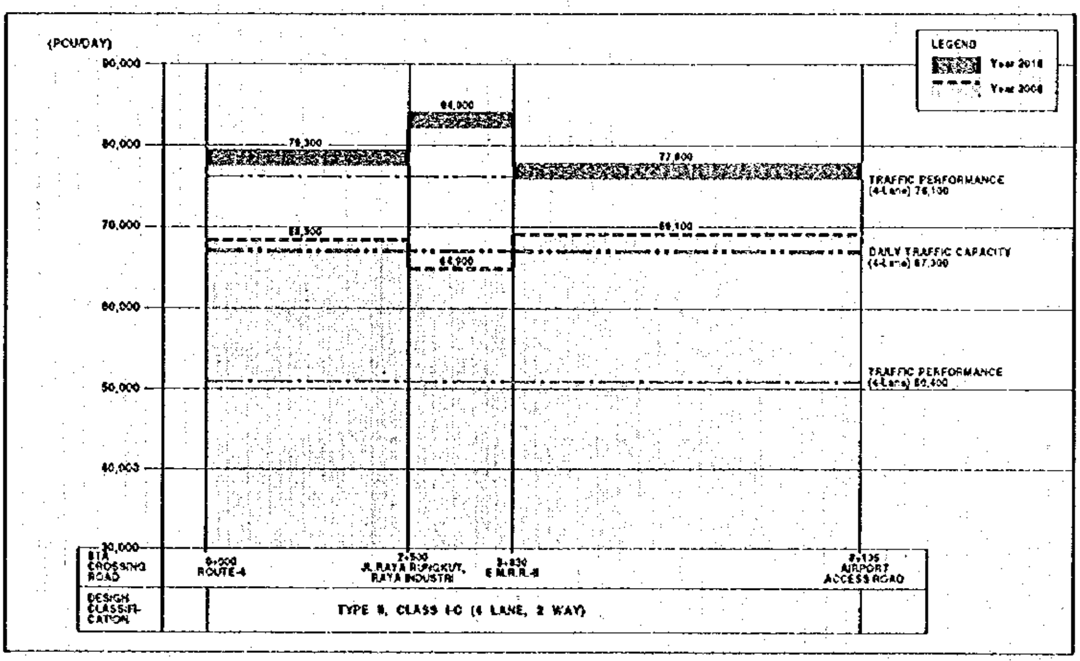


Figure 12.3.4 Traffic Demand and Highway Capacity for Route-3

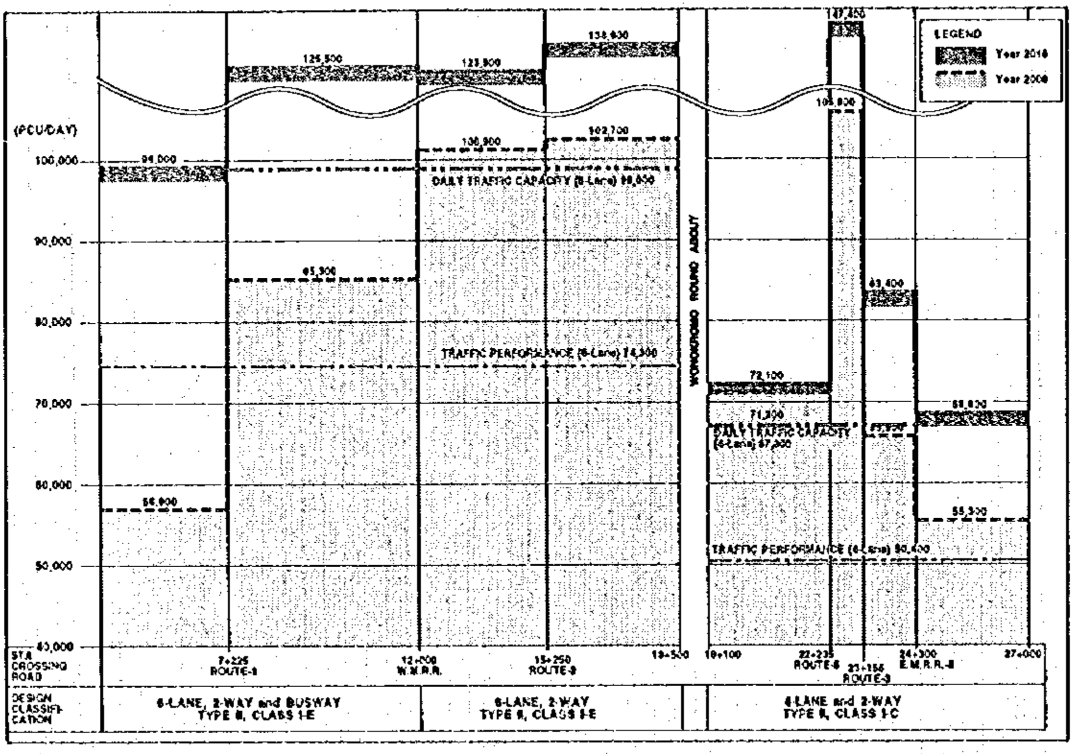


Figure 12.3.5 Traffic Demand and Highway Capacity for Route-4

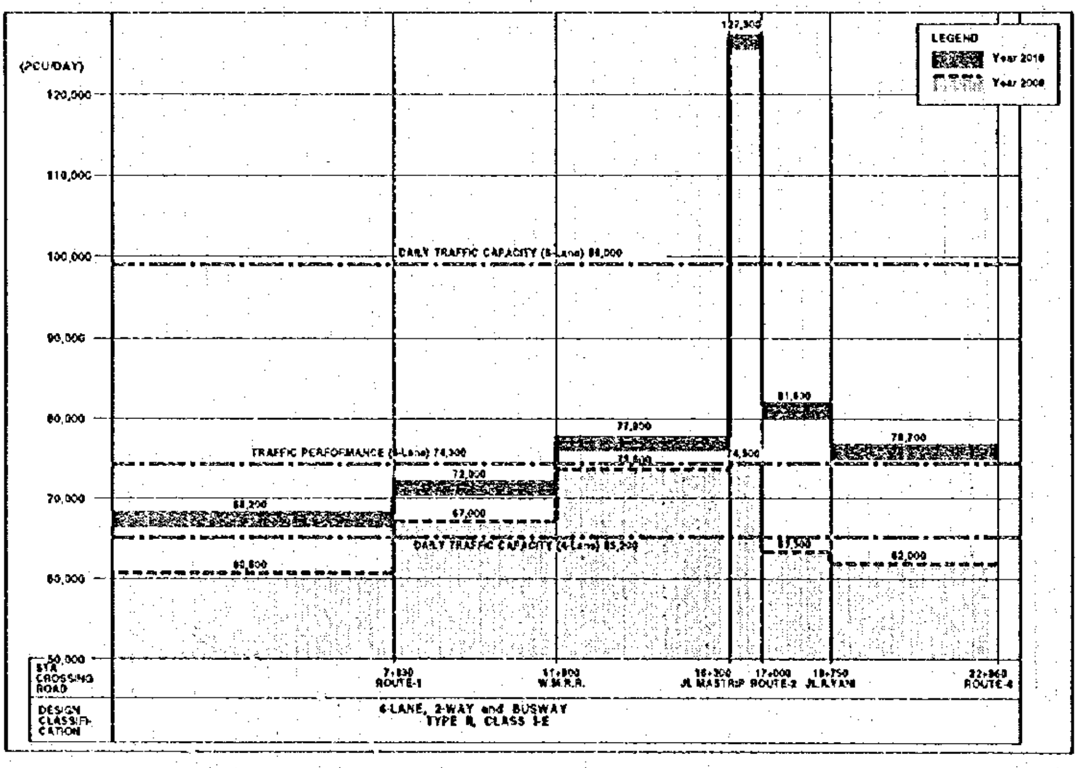


Figure 12.3.6 Traffic Demand and Highway Capacity for Route-5

12.3.2 Number of Lanes

Figure 12.3.1 to Figure 12.3.6 show the traffic forecast in 2008 and 2018 for both directions for each design classification and compares these with the analyzed traffic capacity.

Comparing the traffic forecast with the analyzed capacity for each design classification the number of lanes required can be determined.

12.4 Cross Section Design

Typical cross section determined for the Project Roads are shows in Figure 12.4.1 to Figure 12.4.5.

In determining the typical cross sections the following aspects were considered.

- To maintain the traffic demand forecast.
- To minimized the required ROW
- To provide landscaped area in the project roads

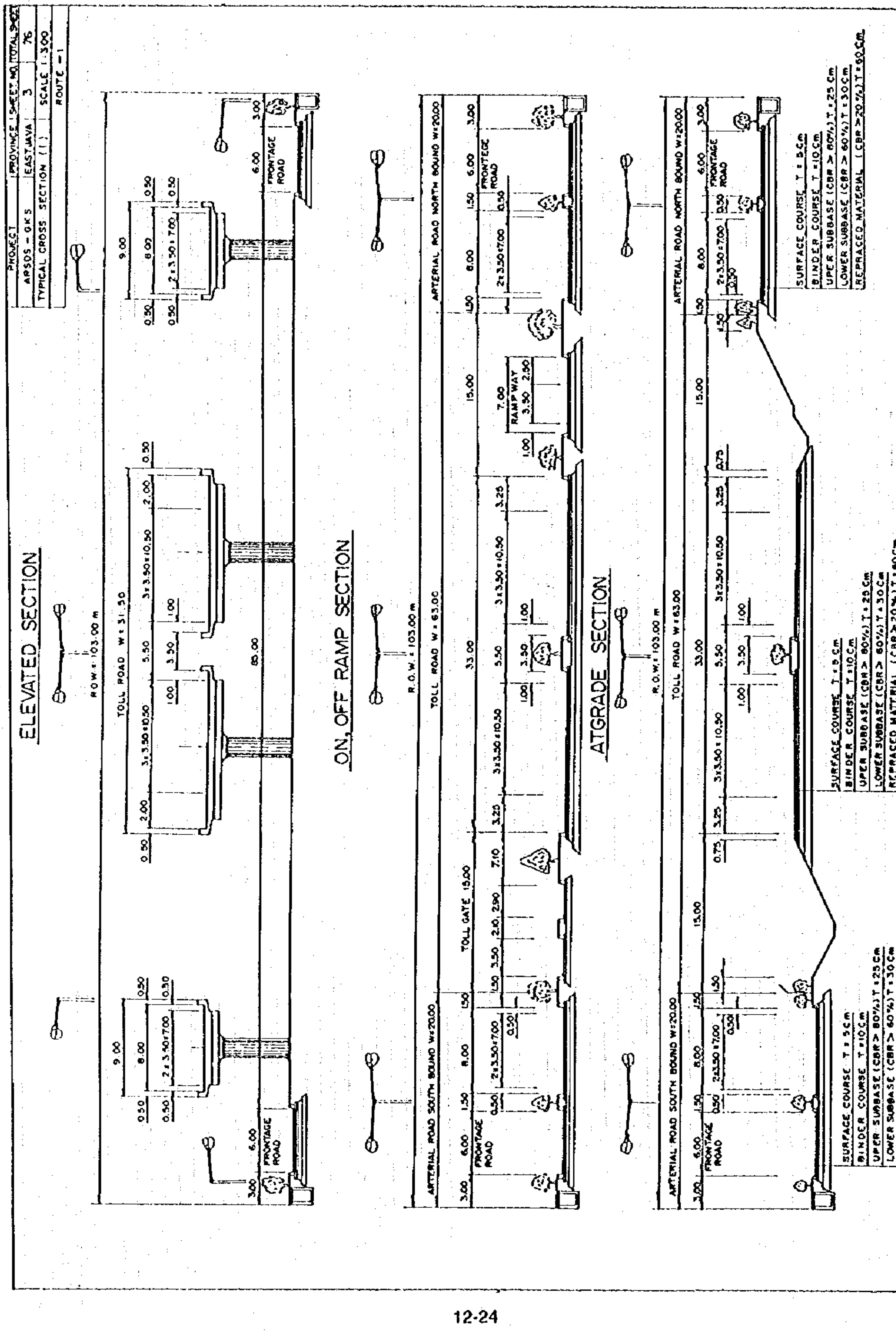


Figure 12.4.1 Typical Cross Sections for Route-1(1/2)

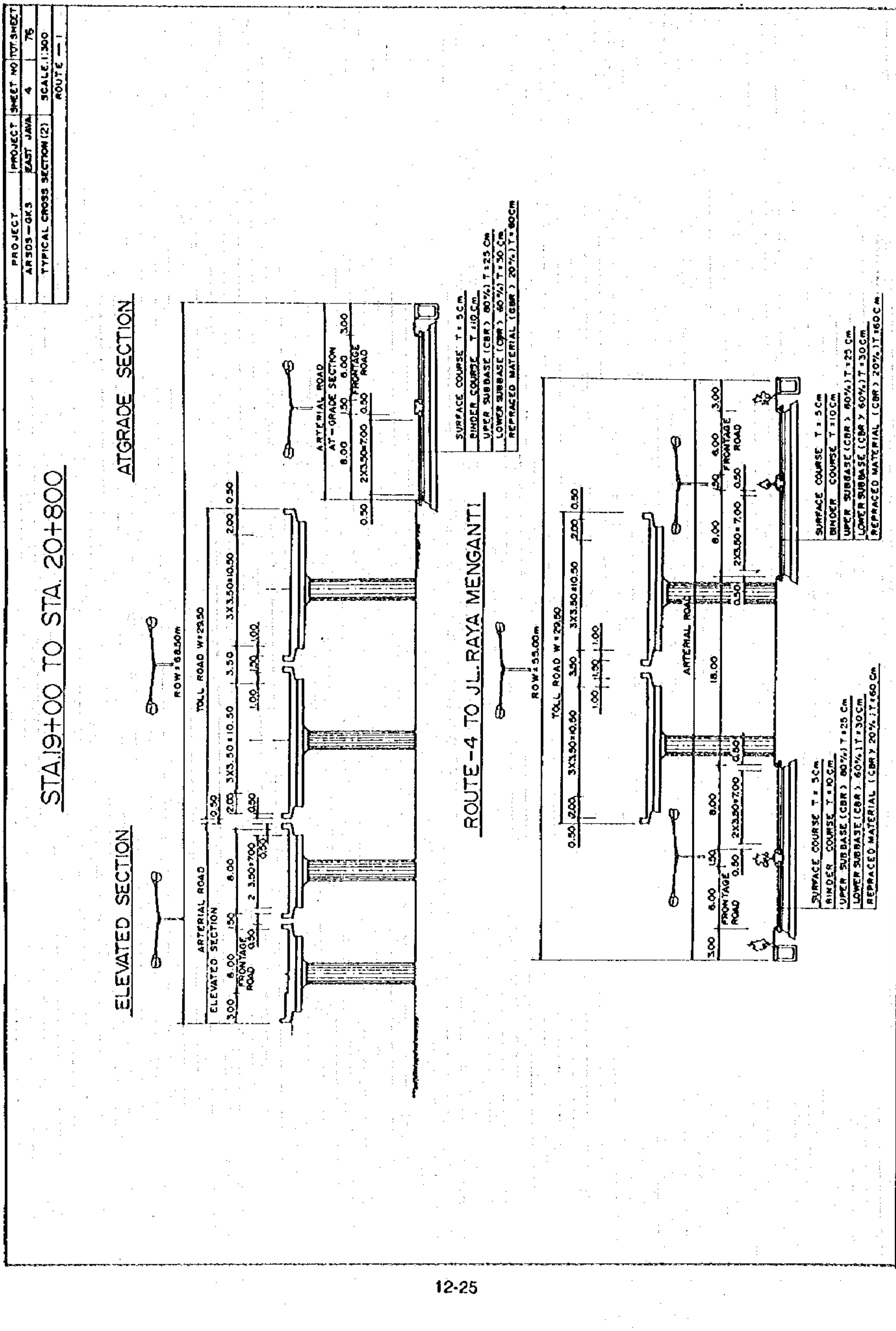


Figure 12.4.2 Typical Cross Sections for Route-1(2/2)

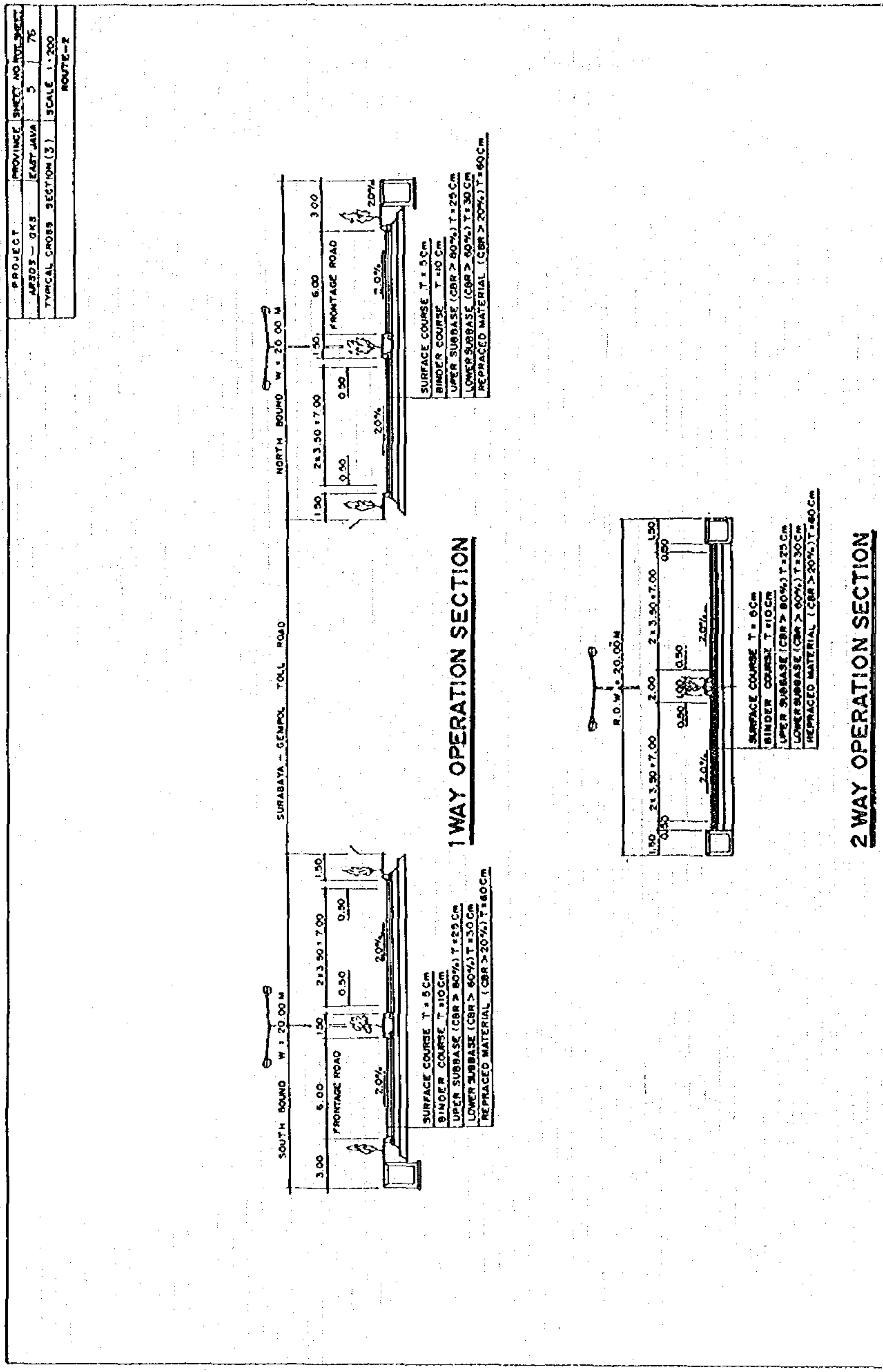


Figure 12.4.3 Typical Cross Sections for Route-2

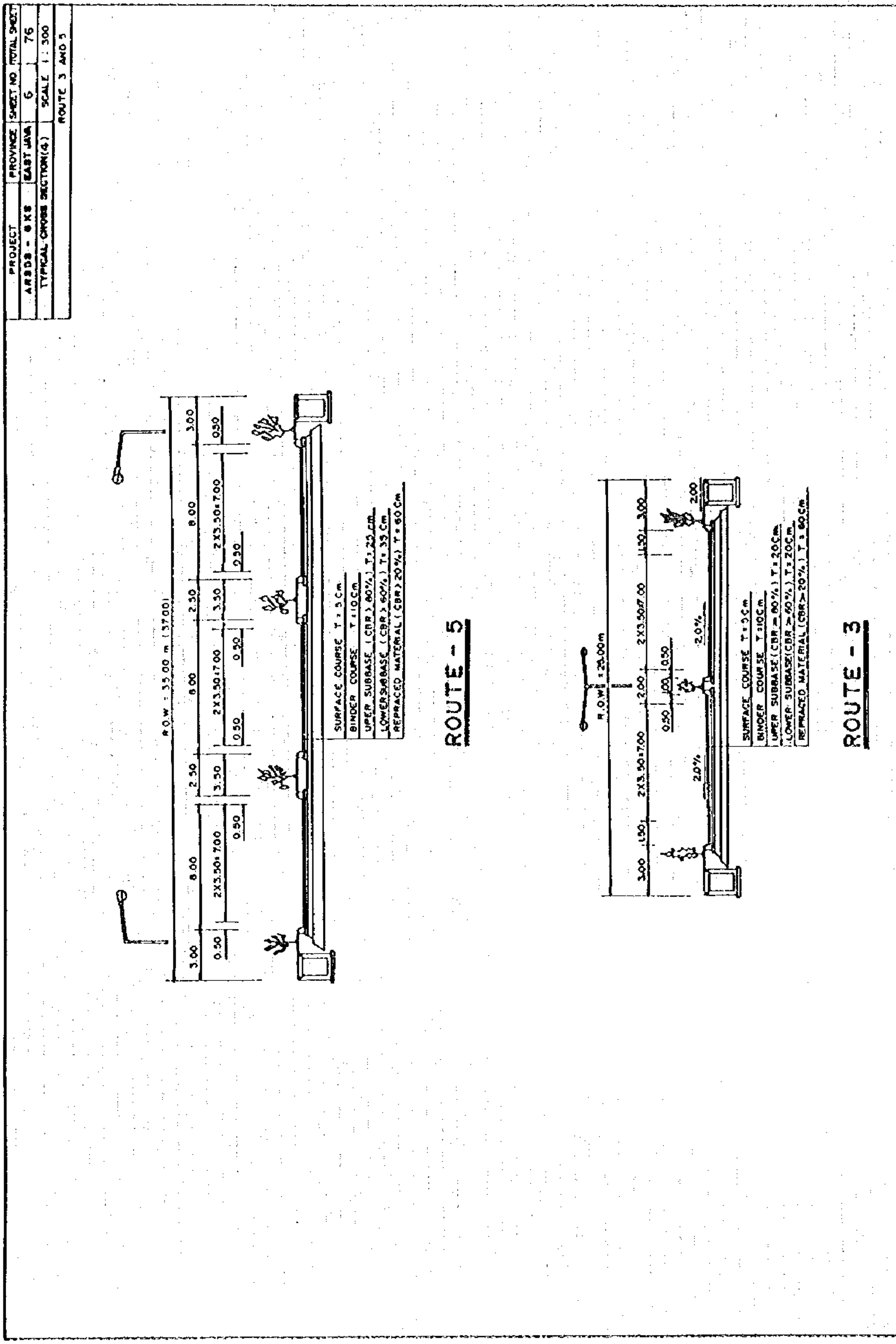


Figure 12.4.4 Typical Cross Sections for Route-3 and Route-5

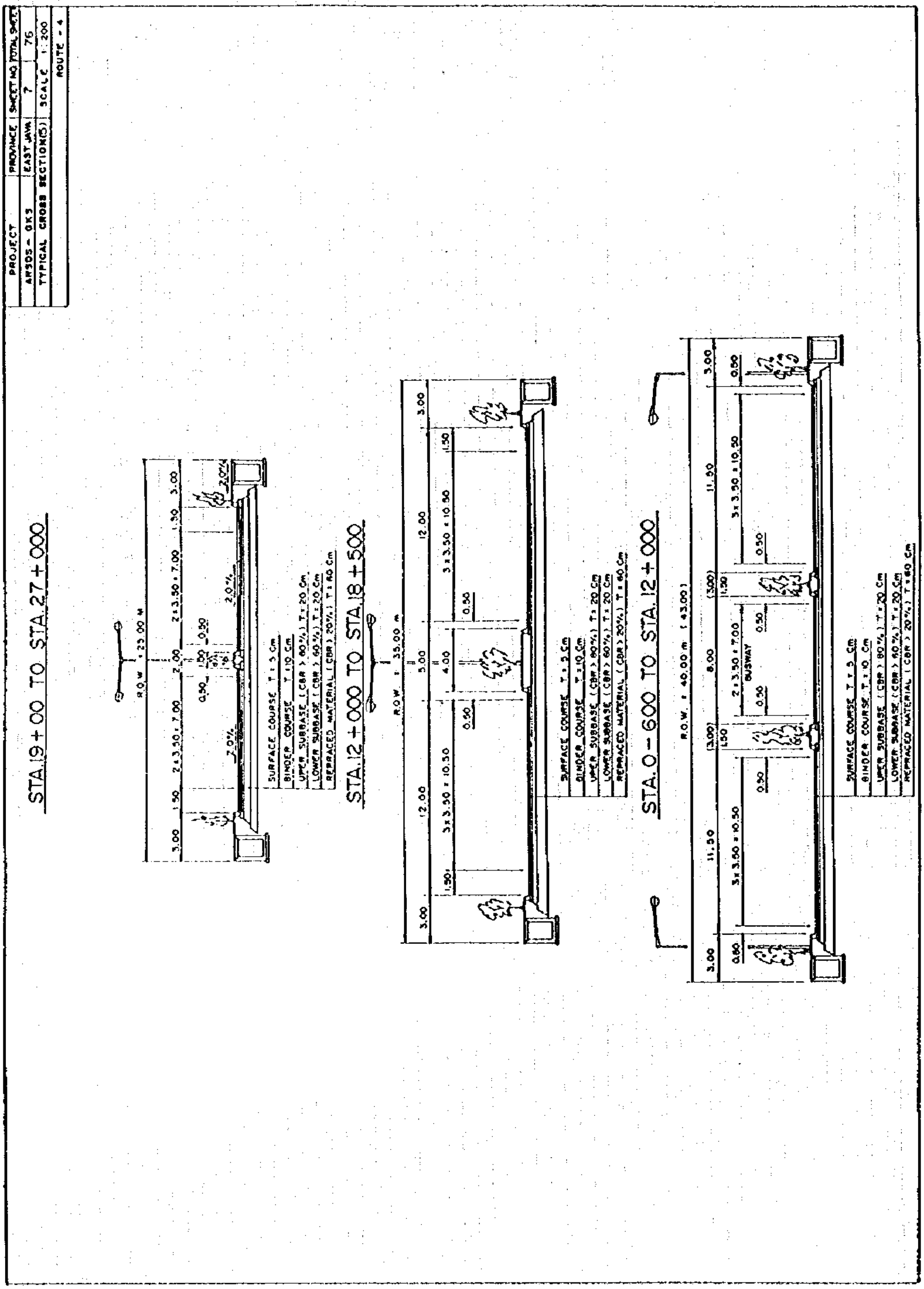


Figure 12.4.5 Typical Cross Sections for Route-4

12.5 Route Selection

12.5.1 Basic Policies for Route Selection

Basic policies for route selection to be applied to the Project Roads were established after detailed study of the surrounding conditions. Route selection was achieved by carrying out integral studies on the geometric, structural, hydrological/drainage and geological aspects and by maintaining close contact and cooperation with the concerned local government (Tk. II) and other authorities.

The existing Right of Way (ROW) and resettlement are the most important aspects in selecting the alignment of the Project Roads. Where the ROW situation does not allow widening, sub-standard cross-sections are applied to meet the current ROW situation. Even if there is sufficient ROW, if the social impact is so big that many resettlements are required, the new alignment is selected so as to minimize the resettlement as much as possible.

12.5.2 The Project Roads

A summary of the Project Roads is shown in Table 12.5.1. and Figure 12.5.1.

Table 12.5.1 Project Roads

Project Road			Length (km)	Road Function	Type and Class of Road	Design Speed (km/h)
Route -1	Toll Road	Surabaya	8.9	Primary Artery	Type I Class I	100
		Gresik	6.1			
		Sidoarjo	0.5			
	Arterial Road	Surabaya	13.7		Type II Class I	60
		Gresik	6.1			
		Sidoarjo	1.0			
Route-2		Surabaya	13.3	Secondary Artery	Type II Class I	60
Route-3		Surabaya	3.5			
		Sidoarjo	4.6			
Route-4		Gresik	6.4			
		Surabaya	21.2			
Route-5		Gresik	9.2			
		Surabaya	13.4			

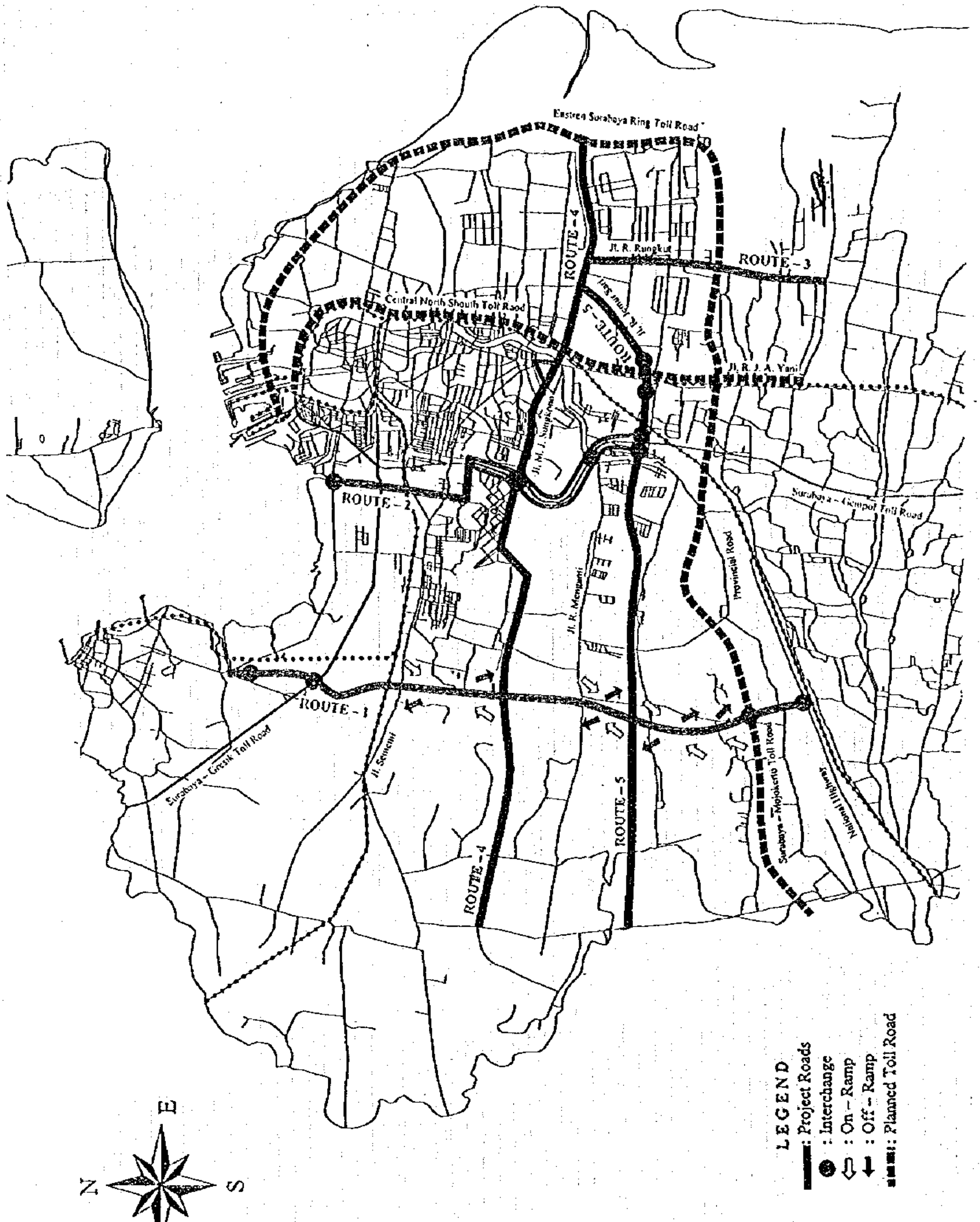


Figure 12.5.1 Project Roads

12.5.3 Route-1

The basic policies used in selecting Route-1 are described as follows:

- Reinforce north and south connection.
- Contribute industrial development at Tandes and Gresik area.
- Support new port development at Gresik Port and Kali Lamong Site.
- Give mobility to West Surabaya and South Gresik Development.
- Apply access control and grade separation as much as possible.

Route-1 consists of two types of road, i.e. toll road and arterial road.

The Project Toll Road is a primary arterial Type I and Class I road with design speed of 100 km/h. Full access control and grade separation are required. By the nature of a toll road, the Project Toll Road is a highest standard road serving intra-city high speed traffic with full access control. These requirements are fulfilled.

The Project Arterial Road is a primary arterial Type II and Class I road with design speed of 60 km/h. Partial access control and grade separation are required. Partial access control is designed by means of frontage road and access points are limited to certain locations such as at main crossings. However regarding grade separation, due to the limited ROW condition, Route-4 and Jl. Menganti crossings are at grade intersections.

Arterial road is the highest standard street of four lanes to serve intra-city, high speed, through traffic with partial access control.

The following are the main issues in determining the Project Road Route-1.

Toll Road

To adjust the road alignment according to housing estate development, modification of Driyorejo IC, two mainline barrier type toll gates, weaving lane between On/Off ramps.

Arterial Road

Reconstruction of Romo Kalisari IC, construction of new toll gates for Romo Kalisari IC, construction of Benowo IC and reform of NH. Sby-Gre, relocation of existing operation office and toll gate for Sby-Gre Toll Road, arterial road fly-over at main road crossing (Jl. Sememi, Route-4, Jl. Menganti, Route-5, trunk road in Kashiba, Sby-Moj Toll Road, Provincial road Surabaya-Mojokerto).

Local Government, Kab. Sidoarjo requested Route-1 to be extended eastwards beyond NH. Surabaya-Mojokerto through the existing well irrigated farm land since there is new city plan for Sidoarjo. However it is national policy to reserve such irrigated farm land and Central Government did not agree to provide a road network in this area. This is a road network matter which is discussed in Part I of this Report.

Also Local Government Kab. Gresik requested adjustment of the road alignment in accordance with an on going housing estate development. This matter is studied in this section.

(1) STA 0+200 - STA 5+000 (Arterial Road Segment)

On this segment, the following major subjects are discussed.

- Construction of Benowo IC and reform of NH. Sby-Gre,
- Relocation of existing operation office and toll gate for Sby-Gre Toll Road,
- Reconstruction of Romo Kalisari IC, and
- Construction of new toll gates for Romo Kalisari IC

For construction of Benowo interchange, please refer to "12.6 Preliminary Design of Interchange" hereinafter. Regarding this interchange construction the study proposes that the existing NH. Sby-Gre will be shifted to the south and the present location of the existing toll gate and operation office will be utilized for this interchange to avoid much resettlement of two villages on NH. Sby-Gre.

Regarding the reconstruction of Romo Kalisari IC and construction of new toll gates please refer to "12.6 Preliminary Design of Interchange".

At the West side of this segment a sports park and stadium with commercial facilities such as hotel, shopping center etc. are planned. These facilities may attract and generate much traffic. Access road to these facilities may be a branch from this segment as access traffic can use not only NH. Surabaya-Gresik but also Sby-Gre Toll Road. For the access point to this segment careful studies are required together with direct access road to Tambak Oso Bus-terminal which is located on Jl. Tambak Osowilangon.

On this segment the future traffic projection is from 54,000 to 66,000 pcu/day and this traffic volume requires six lanes for both directions. If weaving movement is considered between the relocated Romo Kalisari Interchange toll gate and the mainline barrier toll gate, an additional weaving lane is required. Thus eight lanes for two ways are necessary on this arterial segment.

This is a very soft ground area over "tamak (salt farm)" or fish ponds, and piled slab structure is applied referring to the past record of Sby-Gre Toll Road construction.

(2) STA 5+000 - STA 10+300

On this segment a mainline barrier type toll gate for the Project Toll Road will be constructed at STA. 5+500. At STA 6+250 and STA 6+550, both the Project Toll Road and the arterial road are grade separated from the railway and Jl. Sememi. For Jl. Sememi an access ramp way from the arterial road will be constructed for both north and south direction. At STA 10+300 the Project road crosses Route-4 and the Toll Road is grade separated from this planned crossing road. However the arterial road may be an at grade intersection because the ROW of the southern part of this segment (the following segment) is limited to fifty five meters which is not enough to construct an artery fly-over. At STA 7+300 and STA 9+800, On/Off ramps which connect the toll road and the arterial road are arranged to approach Jl. Sememi and Route-4 from/to the toll road. This segment has a very standard cross section with six lanes toll road and four lanes arterial road with frontage road. ROW width is 103 meters.

(3) STA 10+300 - STA 12+800

On this segment the ROW is limited to fifty five meters because on both sides of this area housing estate development is underway. Under this situation the Project Toll Road will be elevated above the arterial road. At both the north and south ends of this segment where the arterial road crosses Route-4 and Jl. Menganti, the arterial road will not have flyovers. These crossing roads are major arterial roads for which grade separation is stipulated by U.R. Design Standard. Within this segment, no On/Off ramp to connect toll road with arterial will be provided. Required numbers of lanes for the toll road is six and for the arterial road is four with frontage road.

(4) STA 12+800 - STA 15+280

The Project Road crosses Jl. Menganti and Route-5 at the north and south ends of this segment. The arterial road has no fly-over bridge because land is not available on the northern segment mentioned in the above section. For Route-5 a fly-over bridge will be constructed on the arterial road and an access ramp will be provided since the two crossing roads are major arterial roads having four lanes each and for which grade separation is stipulated by U.R. Design Standard. On/Off ramps will be provided at STA 13+500 and STA 14+250. Between this two points it is necessary to provide a weaving lane to allow weaving movement among on and off traffic. On this segment six lanes for toll road and four lanes with frontage road for arterial road are required except at the weaving section. At the weaving section totally eight lanes are necessary for the toll road.

(5) STA 15+280 - STA 17+450

Local Government Kab. Gresik requested adjustment of the alignment of the Project Road according to a housing development plan in this area. The alignment was set according to the drawings as indicated by the developer. Because the Project arterial road is Type II, Class I road with partial access control, direct access points by local roads in the development plan should be limited to around STA. 16+050 and STA. 17+000. Other accesses are limited to only the frontage road. In particular the location where On/Off ramps are provided should not be accessed by local roads. The arterial road operates one way on both sides of the toll road, and a round about is designed at STA 17+100 to allow U-turn movement. Another U-turn facility will be provided under the fly-over at Route-5 crossing. This roundabout will also be accessed by the local road which connects the divided east and west areas. According to the developer's plan an over-bridge is planned at around STA 16+200 utilizing undulation of the geographical features. On/Off ramps are provided at STA 15+700 and STA 16+500. Between these two points, a weaving lane is provided for smooth weaving movements among the on and off traffic. On this segment six lanes for the toll road and four lanes with frontage road for the arterial road are required except at the weaving section where totally eight lanes for the toll road are necessary.

(6) STA 17+450 - STA 19+900

The Project Road crosses the provincial road Surabaya-Mojokerto at STA. 19+880. Along this provincial road industrial development is underway in this corridor on the north bank of Kali Surabaya River. Many factories occupy the belt line along this corridor and crossing this belt line is very difficult. Fortunately a long free zone from north to south is there and Local Government Kab. Gresik has agreed to set out the ROW on this free zone. This is the main control point on Route-1. The width of this zone is 105 to 110 meters and is just enough for the Project Road.

On this segment the Project Road crosses Sby-Moj Toll Road at STA. 18+550. It is recommended that the planned Driyorejo Interchange at this point should be modified as a double trumpet interchange. For details refer to "12.7 Preliminary Design of Interchange".

On/Off ramps are provided at STA 18++100 through which the Project Toll Road connects to Sby-Moj Toll Road by a parallel arterial road.

(7) STA 19+900 - STA 21+015

Within this segment the mainline barrier type toll gate is designed. At the end point of the route the Project Road connects with NH. Surabaya-Mojokerto by a single type trumpet.

(8) Necessity of 103-meter ROW for Route-1

The existing ROW of Route-1 has been set at 55 meters in width by Kotamadya Surabaya without allowing for a toll road plan.

There are six(6) major arterial roads that intersect with Route-1 and play an important role for the strategic regional development of GKS region. They are:

- Jl. Sememi (Secondary Arterial Road)
- Route-4 (Secondary Arterial Road)
- Jl. Menganti (Secondary Arterial Road)
- Route-5 (Secondary Arterial Road)
- Planned Arterial Road (Secondary Arterial Road)
- Ramp Way for Surabaya-Mojokreto Toll Road (Primary Arterial Road)

In general an elevated toll road is recommended to minimize the ROW. However, the length of intersection interval is a critical factor in determining the geometric design of Route-1, provided that on/off ramps should be provided at those major intersections.

The following geometric elements were studied to determine the minimum intersection interval.

1. Intersection Fly-over length
2. Weaving length
3. Speed changing length
4. Toll Plaza length
5. Ramp Way length

In order to provide on/off ramps at the intersections, a ROW width of 103 meters is required for a minimum standard length of 2,320 meters as shown in Figure 12.5.2. Therefore, the road section for the elevated structure (only using the existing ROW of 55 meters) is only confined to the location of intersection interval over 2,320 meters. As the result, a 55 meter ROW section applicable for the elevated toll road is assessed as presented in Table 12.5.2 and Figure 12.5.3.

Where the ramp way is constructed to the proposed toll road, it is impossible to limit the ROW to 55 meters in the section (6,140 meters) between Jl. Menganti and Ramp Way for Surabaya-Mojokerto Toll Road.

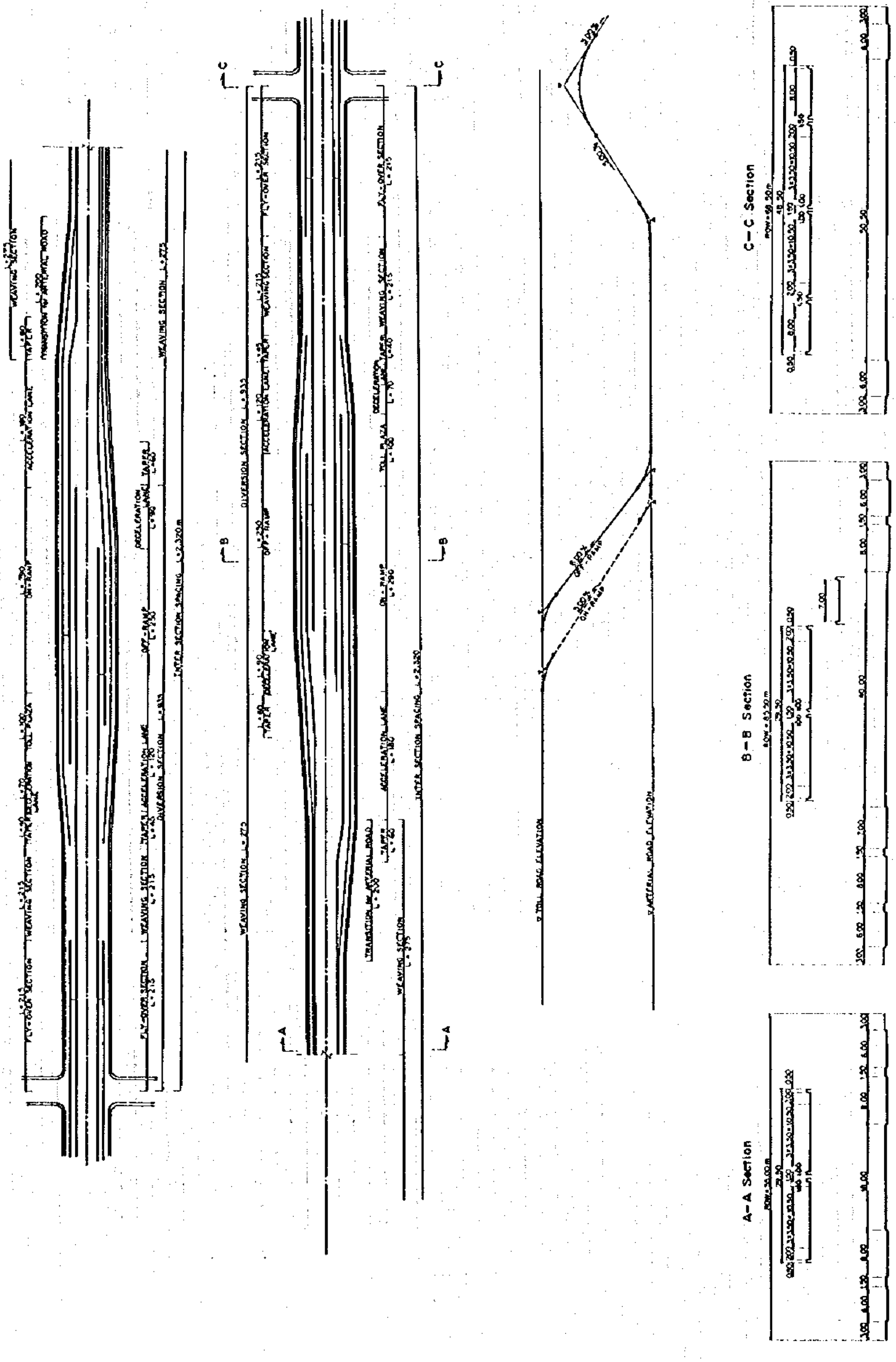


Figure 12.5.2 Intersection Interval

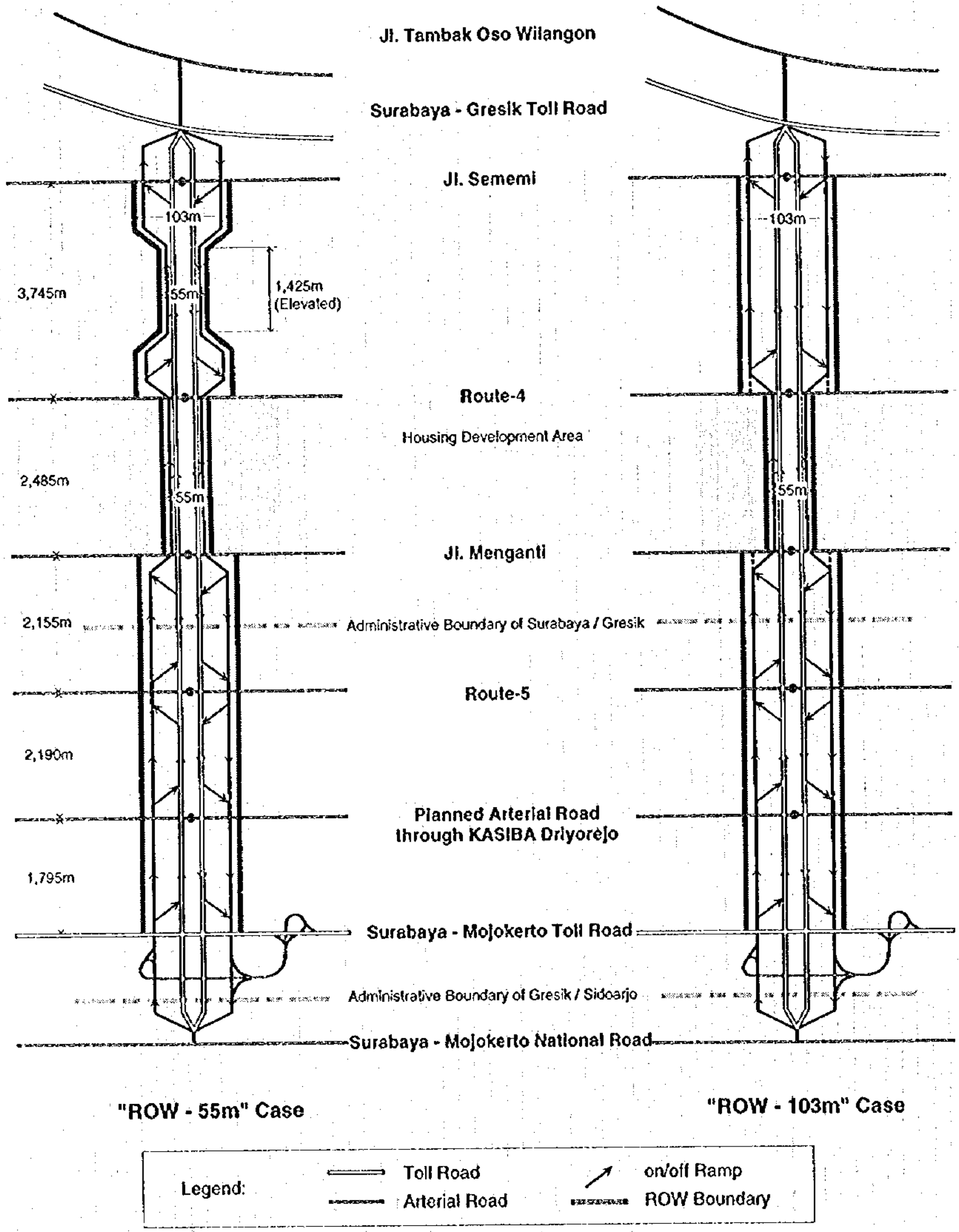


Figure 12.5.3 Intersection Interval and ROW Width of Route-1

Table 12.5.2 Intersection Interval and Assessment Result

Name of Roads For Intersection	STA	Intersection Interval (m)	Remarks	ROW=55 m Section (m)
Jl. Sememi	6 +550			
		3,745	More than 2,320 m	1,425
Route-4	10 +295			
		2,485	More than 2320 m	165
Jl. Menganti	12 + 780			
		2,155	Less than 2,320 m	No space
Route - 5	14 + 935			
		2,190	Less than 2,320 m	No space
Planned Arterial Road	17 + 125			
		1,795	Less than 2,320 m	No space
Ramp Way for Surabaya-Mojokerto	18 + 920			

It should be noted that the road section between Route-4 and Jl. Menganti can not be widened, since this road section area has been developed by a private housing developer and has been already sold to people leaving only 55 meters in width for the arterial road construction.

To determine the ROW width for the section between Jl. Sememi and Route-4, a cost comparison was made for the alternative cases of "ROW=55 m" and "ROW=103 meter" as shown in Table 12.5.3.

Table 12.5.3 Cost Comparison for ROW=55 m and ROW=103 m

Unit : 1,000 Rp.

	DESCRIPTION	ROW=55 m	ROW=103 m
1	**TOLL ROAD**		
	Construction Cost	181,628,973	53,819,758
	Land Acquisition Cost	12,930,838	24,393,600
	Sub-Total	194,559,811	78,213,358
	Cost Index	249	100
2	**ARTERIAL ROAD**		
	Construction Cost	30,205,792	30,205,792
	Land Acquisition Cost	12,345,575	14,791,000
	Sub-Total	42,551,367	44,996,792
	Cost Index	100	106
3	**TOTAL**		
	Construction Cost	211,834,765	84,025,550
	Land Acquisition Cost	25,276,416	39,184,600
	Sub-Total	237,111,178	123,210,150
	Cost Index	192	100

Although the land acquisition cost of ROW=55 m is cheaper for the toll road than that of ROW=103 m. The total construction cost of ROW=55 m is nearly 2.5 times as high as ROW=103 m. Accordingly, the ROW=103 m is recommended for Route-1.

12.5.4 Route-2

The basic policies used in selecting Route-2 are described as follows:

- Reinforce north and east connection.
- Support industrial development at Tandes area.
- Connect community split by Kali Surabaya River and toll road.
- Form continuous chain of U-turn facilities along existing toll road.
- Apply access control and grade separation as much as possible.

- Sub-standard for typical cross section is applied to meet current ROW situation.

Route-2 is a secondary arterial, Type II and Class I road with design speed of 60 km/h. Partial access control and grade separation are required. However due to limited ROW situation there is no access control or grade separation and sub-standard cross section is applied.

(1) Two Way Operation Section

Due to very limited ROW situation in Tandes Industrial area and Darmo Satellite City area, this segment does not have a frontage road for access control and a sub-standard typical cross section is applied.

Main crossings such as Jl. Kali Anak, Sby-Gre Toll road, Railway, Jl. Raya Tandes and Sby-Gmp Toll Road are grade separated. Other minor roads on which only small traffic is projected have at grade intersections.

At the beginning point the route branches from Jl. Kali Anak by Kali Anak interchange. Jl. Kali Anak is one of the main arterial roads in Kod. Surabaya and grade separation is required. The route passes through areas of factories or warehouses. The area is swampy and lowland but is being developed as an industrial zone. Sub-soils in the area are very soft and "piled slab structure" is applied. The route provides flyovers for Surabaya-Gresik Toll Road, the railway and Jl. Tandes but intersects Jl. Tanjungsari at grade. At STA 5+000, the Route turns to the left at a right angle on the intersection of Jl. Raya Kupang Jaya. The segment from STA 5+000 to STA 6+160 follows the existing Jl. Raya Kupang Jaya and crosses Sby-Gmp Toll Road.

This section is for two way operation with divided four lanes but without a frontage road. That is to say without access control. The road width is twenty five meters.

(2) One Way Operation Section; North Bound

A frontage road is provided in this segment for access control.

Main crossings such as Jl. May. Jend. Sunkono and Route-5 are provided with grade separation. For Jl. Mastrip crossing, which connects the community split by Kali Surabaya River, the intersection is planned as an at grade intersection.

The route passes parallel to the west side of the exiting Sby-Gmp Toll Road . This section operates as a north bound one way arterial road with two lanes and a frontage road. From STA 1+000 to STA 1+600 the route is shifted about two hundred meters to the west and crosses Jl. May. Jend. HR Mohamad by grade separation and then runs parallel to the existing Sby-Gmp Toll Road. Part of the road alignment does not meet the requirements of U.R. Design Standard due to following the existing ROW along the said toll road. At STA 2+900 an over bridge connecting north bound and south bound will be constructed to allow a U-turn.

The existing Gunung Sari Interchange on Sby-Gmp Toll Road will be modified to a diamond type interchange as shown in Figure 12.5.4. After the intersection with Jl. Gunung Sari the route crosses Kali Surabaya River. This intersection is an at grade intersection. Through this intersection and bridges, the community split by the river will have a new connection with each other. After the bridge a new off ramp from the south will be constructed. At STA 6+180, another over bridge will be constructed as an alternative to the existing over bridge at this point. The existing over bridge is not wide enough and will be demolished when Sby-Gmp is widened to 6 lane toll road.

(3) One Way Operation Section; South Bound

The provisions regarding access control and grade separation are the same as above.

This route passes parallel to the east side of the exiting Sby-Gmp Toll Road . This section operates as a south bound one way arterial road with two lanes and a frontage road. Thus, together with the prescribed Route-2; South Bound, Route-2 has a complete function.

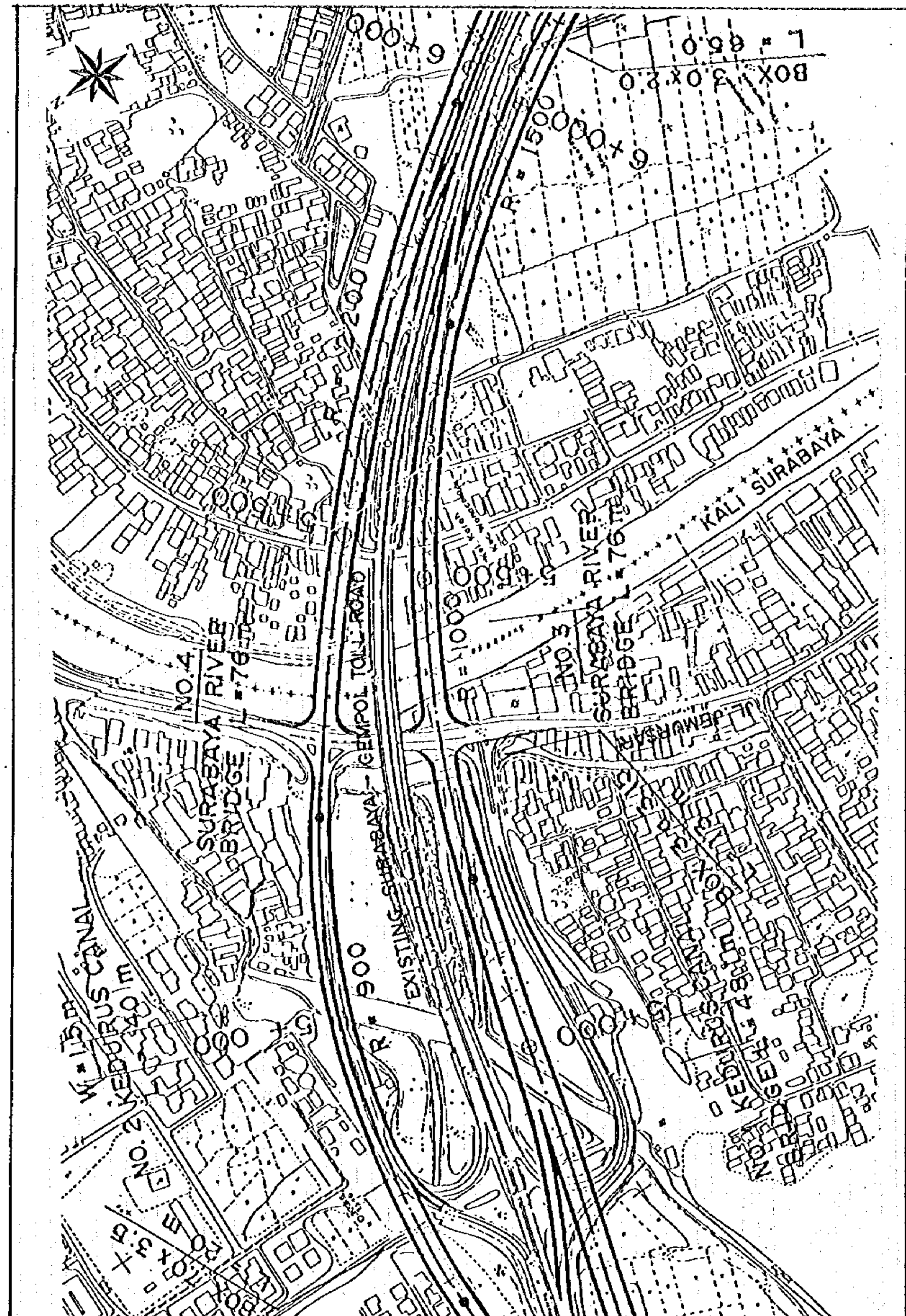


Figure 12.5.4 Gunung Sari Interchange

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12.5.5 Route-3

The basic policies used in selecting Route-3 are described as follows:

- Support Rungkut Industrial Estate.
- Study counter measures to solve traffic congestion at the major traffic node of Jemur Sari.
- Keep current ROW and follow the existing road alignment as much as possible.
- Apply access control and grade separation if possible.

Route-3 is a secondary arterial Type II and Class I road with design speed of 60 km/h. Partial access control and grade separation are required.

Due to very limited ROW conditions resulting from passing through industrial estates and densely inhabited villages, and due to the relatively short length of this route, partial access control and grade separation are not adopted.

Route-3 covers two administrations, Kod. Surabaya and Kab. Sidoarjo. The Project Road is located in the southern central part of Kod. Surabaya and the north east part of Sidoarjo. Rungkut Industrial Estate is within Kod. Surabaya area and the Project Road passes the eastern outskirts of the industrial estate. The estate is a core of industrialization in this area and many factories overflow to the surrounding area over the boundary of two administrations. Beside these circumstances, housing development is also underway in the area. Existing narrow local roads are congested every morning and evening peak hour.

The objective of this route is to connect this industrial zone to the "Eastern Part of Surabaya Ring Road", the "Eastern Middle Ring Road" and as an access road for Juanda air port which is in the southern part of this area, by strengthening the existing local road as an arterial road. Fundamentally the road construction consists of widening the existing road and there are no major control points except the shopping center building at STA 4+800. The alignment follows the existing road alignment as much as possible. Some parts do not meet the U.R. Design Standard because of the widening requirement.

The Local Government Sidoarjo requested that Jl. Brig. Jend. Katamso is included in this study. However the objective of this study is primary arterial roads, primary collector roads and secondary arterial roads. Jl. Brig. Jen. Katamso is a secondary collector road and is therefore not an objective of the study. These matters are discussed in Part I, "Road Network Master Plan".

12.5.6 Route-4

The basic policies used in selecting Route-4 are as follows:

- Reinforce east and west connection.
- Give mobility to West Surabaya and South Gresik development
- Study mass transportation system.
- Study counter measures to solve traffic congestion at the major traffic node of Wonokromo.
- Connect community split by Kali Surabaya River, the railway and the toll road.
- Apply access control and grade separation as much as possible.

Route-4 is a secondary arterial Type II and Class I road with design speed of 60 km/h. Partial access control and grade separation are required.

Because more than 40 percent of the total length is already completed or is at the construction/land acquisition stage, it is now almost impossible to widen the ROW. Access control is not introduced on this route.

Grade separation is only adopted at the very important traffic node of Wonokromo crossing and Route-5 crossing.

The objective of Route-4 is to connect the southern part of Kab. Gresik (western part of Kod. Surabaya) to the eastern part of Kod. Surabaya. In the southern part of Kab. Gresik extensive development permits have been issued, totaling 12,000 ha or more. In Kod. Surabaya housing development is underway on the route.

Route-4 is partly new construction, partly under-construction or completed construction by a developer, and partly still in the stage of land acquisition. It is an obligation of the developer to construct new roads as a condition for the development. After completion of the new roads they are transferred to the city administration and maintenance will be the obligation of the administration.

A Busway is proposed for public transportation on this route. For this purpose, widening, re-arrangement of carriageway or overlaying of the pavement will be carried out. However in the urbanized area, where ROW extension seems almost impossible, the Busway may be modified and traffic control will be imposed by traffic signals or priority will be given to the public transportation in limited peak hours.

(1) STA 0-600 - STA 7+220

This section is completely new construction with six lanes/two ways, a Busway and sidewalk, but without frontage road for partial access control. The existing land use is farmland without irrigation and there are no major control points. The route passes through hilly terrain avoiding splitting existing villages or huge embankments or cuttings.

At STA 7+220, Route-4 crosses Route-1. The intersection with the arterial road of Route-1 is described for Route-1 above.

(2) STA 7+220 - STA 12+000

This segment is partly completed (STA 7+220 to STA 8+460; 1,140 m) while land acquisition is being processed for the other part. Within this segment, the road alignment just follows the completed road or as planned by the developer, so the geometric design elements do not meet the requirement of U.R. Design Standard as a Type II, Class I road with design speed of 60 km/h.

Up to the end of this segment a Busway will be provided together with six lanes/two ways and a sidewalk. The completed road and the part under land acquisition processing, carriageway width is ten meters with two lanes, right and left shoulder for one direction. This width is not enough for three lanes with an exclusive Busway. Widening, extension of pavement and overlay pavement will be necessary. Since this segment has a forty meters ROW there is no problem for widening.

(3) STA 12+000 - STA 13+060

This segment is a newly completed road under existing electric power transmission line in the center of road. The carriageway width is ten meters for one direction with two lanes, right and left shoulder. This segment will be extended to three lanes with right and left shoulder but without a Busway since the ROW for this part is not enough to include an exclusive Busway.

(4) STA 13+060 - STA 18+750

A part of this segment (STA 13+060 to STA 15+200) is under-construction and the other part is a new urbanized area after completion of Jl. May. Jend. Sungkono. The completed or under construction road width on this section is thirty five meters with six lanes for both directions. Since ROW extension seems almost impossible, the Busway may be modified and traffic control will be imposed by traffic signals or priority will be given to the public transportation in limited peak hours.

The existing Kotasatelit interchange is a single trumpet interchange with a roundabout. In the roundabout, weaving lengths are not enough even now. Considering future traffic demand on this segment it is necessary to modify this interchange to a double trumpet type interchange as shown in Figure 12.6.8.

(5) Jl. Kutai and Jl. Bengawan (Wonokromo Roundabout)

Wonokromo is one of the key traffic nodes in Kod. Surabaya. At Wonokromo the following facilities are concentrated.

- Roads: Jl. Raya Wonokromo (Jl. A. Yani), Jl. Ngagel, Jl. Raya Darmo, Jl. Diponegoro, Jl. Joyoboyo
- Railways: Surabaya-Malang Railway, Surabaya-Mojokerto Railway
- Rivers: Kali Surabaya River divided with Kali Mas River and Kali Wonokromo River
- Public Facilities: Wonokromo Railway Station, Water Purification Plant, Surabaya Zoo, Joyoboyo Mini Bus Terminal, Wonokromo Market, Museum, Mosque, Water Gates, Water Supply Pipe
- Future Programs: Route-4, Light Rail Transit (LRT) by SITNP, Central North South Toll Road (CNS Toll Road)

Route-4 is strategically planned to connect Surabaya East Sub-center and West Sub-center passing through this strategic location. To keep traffic flowing at this point "Wonokromo Roundabout" is proposed which is shown in Figure 12.5.5. The following are key elements of this plan.

1. Shift Jl. Raya Wonokromo North Bound to the north west and cross Kali Surabaya River
2. Construct new road as a part of Route-4 at the south west outskirts of Surabaya Zoo.
3. Connect Jl. Raya Darmo and the above new road
4. Widen Jl. Kutai and Jl. Bengawan
5. Construct continuous fly-over for west bound traffic to Kali Surabaya River, Jl. Raya Darmo, Jl. Ngagel, Railway
6. Construct east ward fly-over from Jl. Raya Darmo to south bank of Kali Wonokromo River
7. Operate Wonokromo Round about by clockwise one-way operation
8. South end of Jl. Diponegoro will only serve local traffic within the roundabout

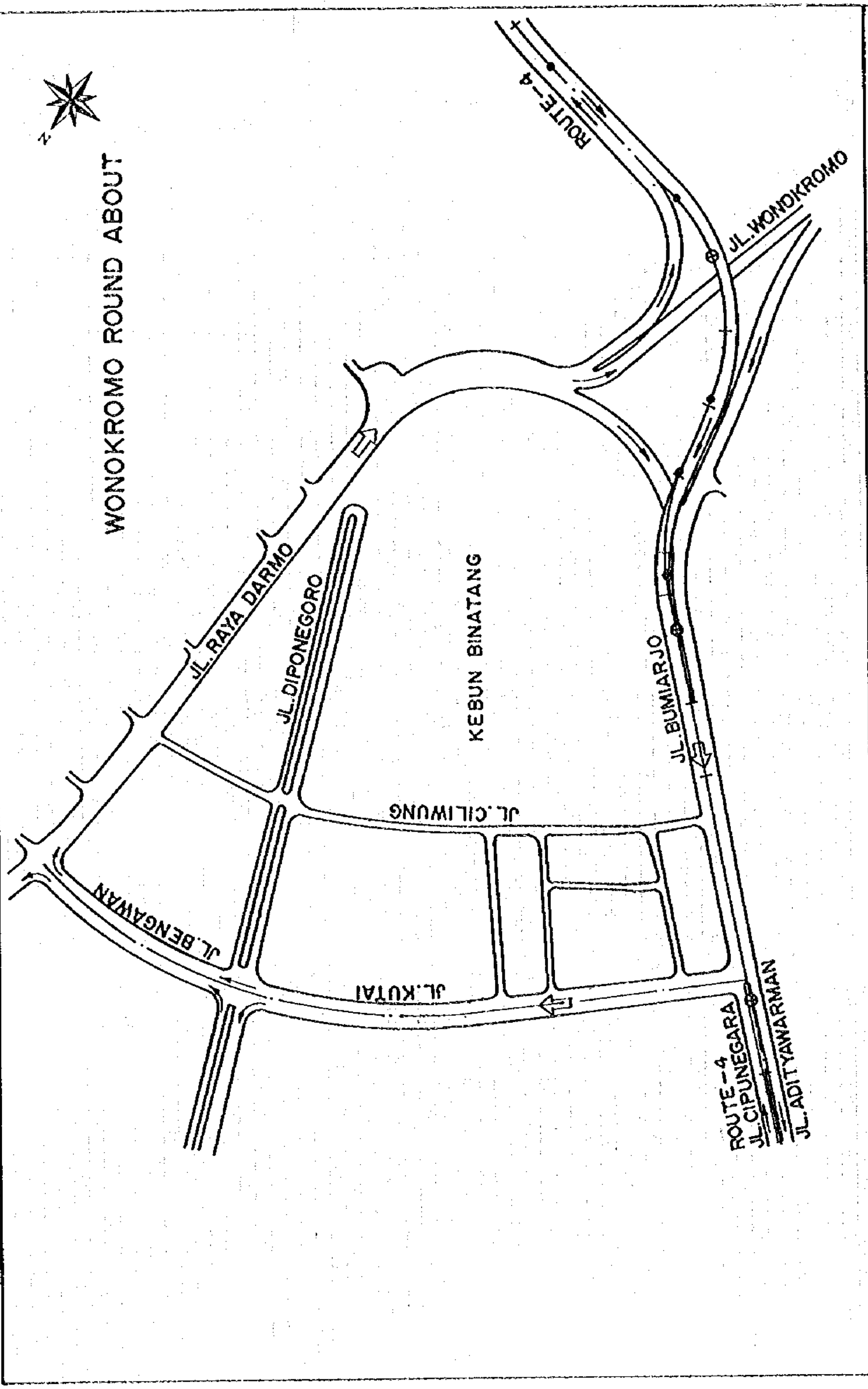

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Figure 12.5.5 Wonokromo Roundabout