4.5 Zonal Planning Parameters

4.5.1 Population

The population breakdown of the 7 development regions into 12 (No. 2 to 13 in Table-4.5.1) traffic zones in West Java was made through the estimates of Kabupaten level population. The Kabupatens located in the same development region have comparatively similar characteristics, therefore the growth rates of Kabupatens of the same development region were regarded to be the same.

The number of households by zone was estimated based on the projected population in line with the trend of the number of persons per household.

Table-4.5.1 Zonal Population

Unit: 1,000

Zone NO.	Population		
	1989	2000	2010
1	9,015	10,934	12,508
2	3,743	4,507	5,448
3	901	1,094	1,250
4	1,079	1,311	1,497
5	1,645	1,910	2,101
6	4,953	6,078	7,068
7	5,056	5,431	5,635
8	2,081	3,020	3,978
9	1,625	2,592	3,660
10	3,034	3,654	4,154
11	2,048	2,446	2,758
12	1,235	1,373	1,462
13	6,246	7,418	8,327
14	64,375	83,237	96,498

4.5.2 Employment

The breakdown of employment in West Java into 7 development regions was made by referring to the distribution ratio obtained through analysis on GRDP of each development region. The further breakdown to kabupaten/kotamadya was made by using projected population as distribution factor. This explains why Kabupaten included in the same development region have comparatively similar characteristics. Zonal employment figures obtained in such a manner are shown in Table-4.5.2.

Meanwhile for DKI Jakarta each sectorial employment was projected through the trend analysis.

Table-4.5.2 Zonal Employment by Industry Sector

Unit: 1,000

Zone No.	Total 2000	Total 2010	Primary 2000	Primary 2010	Secondary 2000	Secondary 2010	Tertiary 2000	Tertiary 2010
1	3,893	4,978	57	53	743	910	3,093	4,015
2	1,748	2,349	423	486	498	686	827	1,177
3	473	587	209	236	36	45	228	306
4	567	704	251	283	43	54	273	367
5	744	807	252	252	134	152	358	403
6	2,367	2,716	802	849	425	510	1,140	1,357
7	2,172	2,406	908	915	334	378	930	1,113
8	1,172	1,716	284	355	334	501	554	860
9	1,006	1,578	244	326	286	461	476	791
10	1,361	1,618	532	575	286	349	543	694
11	1,051	1,269	506	566	71	89	478	614
12	590	673	282	301	40	47	268	325
13	2,596	2,818	1,329	1,326	211	229	1,056	1,263
14	83,237	96,498	-	-	-	-	-	-

PART Ⅱ

ROAD DEVELOPMENT PLAN & EVALUATION

CHAPTER 5 ROAD DEVELOPMENT ALTERNATIVES

5.1 Alternatives Formation

5.1.1 Road Development Criteria

The activities and analyses undertaken in this Study and outlined in this Report identified the basis for formulating the road development alternatives. The basic considerations are as follows;

- This Study is for road networks between Bogor and Bandung, not for any other cities such as Jakarta.
- For analysis purposes, the Study takes into account other road networks extending as far as Jakarta, Cikampek and other areas when it is necessary.
- The study shall reflect the development proposed in the Regional Plan for the Study Areas and contribute to its realization. The study shall also address the projected transport demand in the area.
- Most arterial road links in the Study Area are facing a fast growth of traffic which will exceed the capacity of theroads in the near future thereby causing congestion, reduciton in travel speeds, and poor service levels.

5.1.2 Formation Procedure

A standard procedure for road development is applicable to this Study, and the following matters are influential to the consideration process.

a. Standard of road network
  Access-controlled highway
  Primary national/provincial road
  Other rural road, etc.

b. Characteristics of road traffic in the network
  Vehicle Composition
  Trip Purpose
  Fluctuation of Traffic Volume
  Trip Length
  Peak Hour and Duration, etc.

c. Traffic Conditions
  Existing Traffic Volume
  Traffic Capacity
  Traffic Congestion Ratio

d. Regional Development direction
  Urbanization
  Industrial Structure
  Distance between Cities

According to the existing traffic survey the characteristics of each road section in the Study Area are summarized in Table-5.1.1.

Table-5.1.1 Characteristics of Each Section

Section	Traffic Volume	Trip Length	Capacity (v/d)	Travel Speed (km/h)	H.truck Ratio	Main OD Pair
1 (Ciawi-Puncak)	16,469	Medium Long	16,000	30	5.4%	JKT-BDG JKT-CJR
2 (Puncak-Cianjur)	12,246	Medium Long	16,000	30	5.8%	JKT-BDG BGR-CJR
3 (Sukabumi-Cianjur)	4,087	Local Medium	15,500	40	27.5%	SKB-CJR SKB-BDG
4 (Cibadak-Sukabumi)	9,447	Local Medium	16,000	30	16.6%	JKT-SKB BGR-SKB
5 (Ciawi-Cibadak)	9,847	Local Medium	16,000	30	27.6%	JKT-SKB BGR-SKB
6 (Cianjur-Padaralang)	9,895	Medium Long	16,000	40	17.0%	JKT-BDG CJR-BDG

Section 1: This section has a high traffic volume and low heavy truck percentage. The traffic between BDG and CJR and JKT occupied about 36% of the total traffic volume. The section functions as an inter-major city road.

Section 2: This section has a high traffic volume and low heavy traffic percentage, same as Section 1. The main OD pairs in the section are both JKT-BDG and BGR-CJR. Therefore the section serves both as an inter-major city and inter-local city road.

Section 3: The traffic volume is very low and main OD pairs are very local such as SKB-CJR and SKB-BDG. This section serves inter-local city traffic.

Section 4: The traffic volume is comparatively high and is composed of medium distance trips such as JKT-SKB and BGR-SKB. This section serves inter-local city traffic.

Section 5: The characteristics of this section are almost the same as that of Section 4, however Heavy Truck Ratio is higher. This fact shows that Cibadak is comparatively a large traffic generating city. The section serves inter-local city traffic.

Section 6: The main OD pairs of this section are JKT-BDG and CJR-BDG. The section serves as both inter-major and inter-local road.

As analyzed so far, both corridors of Puncak route and Sukabumi route function as inter-regional roads rather than as inter-local roads. In addition both sections are expected to have a traffic demand beyond capacity in the near future.

The low road density in the Study Area shall have negative effects upon the region. The traffic demand within the region shall not be satisfied, development shall slow down or come to a stop in some areas, and the lack of road space may create many social and environmental problems.

The road density must be increased through road development. This development can be realized through two methods; new road construction or widening of existing roads. The effects of both road development methods are summarized in Table-5.1.2. The road development alternatives proposed in this Study are derived from these two methods.

Table-5.1.2 Road Development Methods and their Effects

Development Methods	Strengthen of Road Network	Increase of Capacity	Increase of Speed	Regional Develop-ment
A. New Road Construction				
1. Inter-city highway	5	5	5	5
2. Bypass of urban area	4	4	4	4
3. Local road	4	4	4	3
B. Widening				
1. Increase of lanes	3	4	3	3
2. Additional lane	2	2	2	1
3. Lane width	1	2	2	1

Note: Numerical evaluation of effect from 5 to 1, descending as the effect comparatively decreases.

5.1.3 Improvement of Existing Road and New Road Construction

The density of the present road network in the Study Area is low, resulting in traffic congestion along the arterial roads and this situation is forecast to worsen in the future.

The traffic function of the road network can be considered in terms of both mobility and accessibility. The type of road development method may favor one over the other. Therefore a comparison of both items is necessary to determine priority in light of the conditions in the Study Area. Subsequently the improvement method satisfying the higher priority item should be selected.

Adoption of the new road construction method will ensure the mobility of the long distance traffic and its separation from local traffic. This development alternative will also substantially benefit original road links where the daily hazard of local and long distance travel mixture will be eliminated and road accidents will be reduced.

On the other hand the method of improvement of existing road will ensure accessibility, but its effect on mobility will be limited. Although capacity will be increased, however in terms of speed during congested traffic service level shall be low and therefore traffic function problems shall remain unsolved.

When studying a new road construction project for the Study Area, many routes can be proposed, though, a most probable one is that found to be going south from Ciawi through Cibadak, and then east to Sukabumi, Cianjur and Citatah toward Cikampek - Padaralang toll road because of the following considerations;

- New road development projects in adjacent areas which are,
  Cikampek - Padaralang toll road construction
  Ciranjang - Cibubur rural road construction
  Any alternative formulation which may conflict with other on-going programs shall be avoided.
- Terrain conditions and environmental considerations in the area of Puncak and north of it.
- Regional development directions pointing toward south.

The Directorate General of Highways (Bina Marga) has recently adopted a policy that when a new road development is considered, the improvement of an existing road shall also be studied as an alternative to it. This policy suits the Study and in this case, a chain of road links connecting Ciawi, Cibadak, Sukabumi, Cianjur and Citatah is taken as the alternative.

5.1.4 Puncak Route (Ciawi - Puncak - Cianjur - Citatah)

Several routes have been studied for this route and the process and results are presented in detail in Section 5.2 of this Chapter. Two alternatives are studied for the Puncak route, Alternative 1 for improvement of existing Puncak route, and Alternative 3 is for the construction of a new road north of the existing Puncak route. The alternative routes are shown in Fig.-5.1.1.

5.1.5 Sukabumi Route (Ciawi - Sukabumi - Cianjur - Citatah)

The alternative routes studied for the Sukabumi route are shown in Fig.-5.1.1. Details of the study are presented in Sections 5.5 and 5.7; Alternative 2 for improvement of existing route, and Alternative 4 for a new Sukabumi road, respectively.

The route of Alternative 4 was located taking into consideration terrain conditions, land use, prevailing area development plans and future development plans.

At the section between Ciawi and Cibadak, the route snakes through rice paddy-fields and dry cultivation on the east side of the existing road avoiding difficult terrain, forests and other conservation areas and dwellings. At Sukabumi, the route was located north of the city in the same manner as the previous section. Particularly, the city area was avoided in order to reduce land acquisition cost and eliminate the risk of dividing city activities into two.

Near Cianjur, the route was located south of the existing road mostly in order to reduce the distance using a short cut.

In the case of the alternative proposing the improvement of the existing road, widening to divided four lane road was fundamentally adopted except at congested areas where bypass was studied.

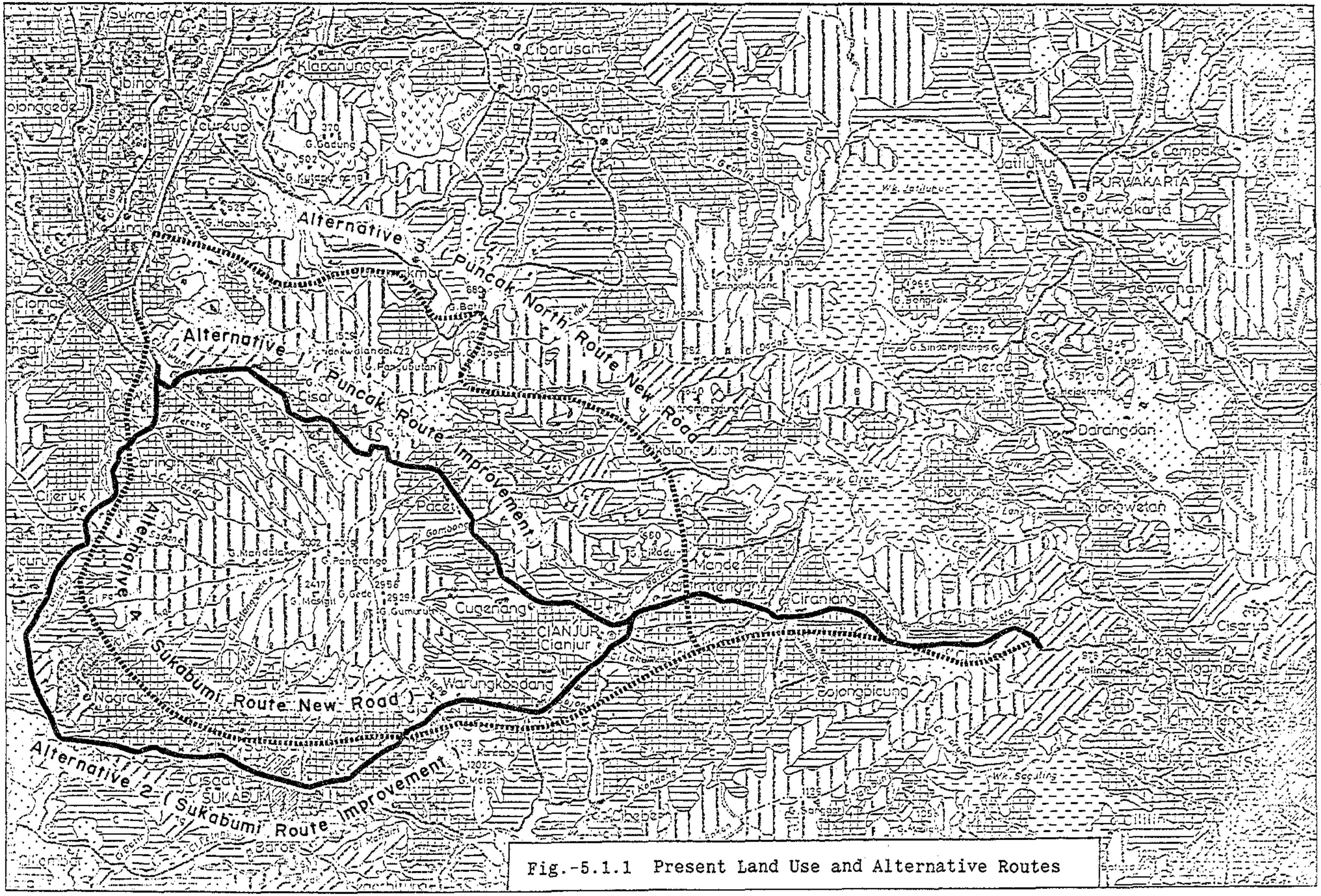


Fig.-5.1.1 Present Land Use and Alternative Routes

5.2 Design Criteria

5.2.1 General

The applicable criteria and elements of design for the new road alternative and existing road widening alternative are in conformity with the latest requirements of the Directorate General Bina Marga.

Unless otherwise stated, all design criteria are in conformity with the standard specification for geometric design of rural highways as published by Bina Marga (Code No. 13/1970).

Tables-5.2.1 and 5.2.2 show the geometric design standards for both new road construction alternative and road widening alternative.

5.2.2 Road design standard

Three types of terrain are found in the Study Area; flat, rolling, and mountainous, and therefore road design standards are recommended for each type of terrain.

1) Design Speeds

The following design speeds were applied taking into consideration types of terrain in each alternative route. Particularly in the case of widening alternative the design speeds applied are determined based on the existing topography. Therefore design speeds in this alternative are reduced due to already existing steep slopes and steep curves. Design speeds by alternative and terrain type are as follows;

New Road alternative (Tollway)

Flat area	:	100 KM/h
Rolling area	:	80 KM/h
Mountainous area	:	60 KM/h

Widening alternative

Flat area	:	60 KM/h
Rolling area	:	40 KM/h
Mountainous area	:	30 KM/h

2) Reserved R.O.W. Width

Right-of-Way width assigned to the project should anticipate all practical future expansion. Standard R.O.W. criteria is consulted for design planning, however, at present, the R.O.W. widths recommended for each alternative are as follows;

New road alternative: 60 m
Widening alternative: 30 m

3) Land Width

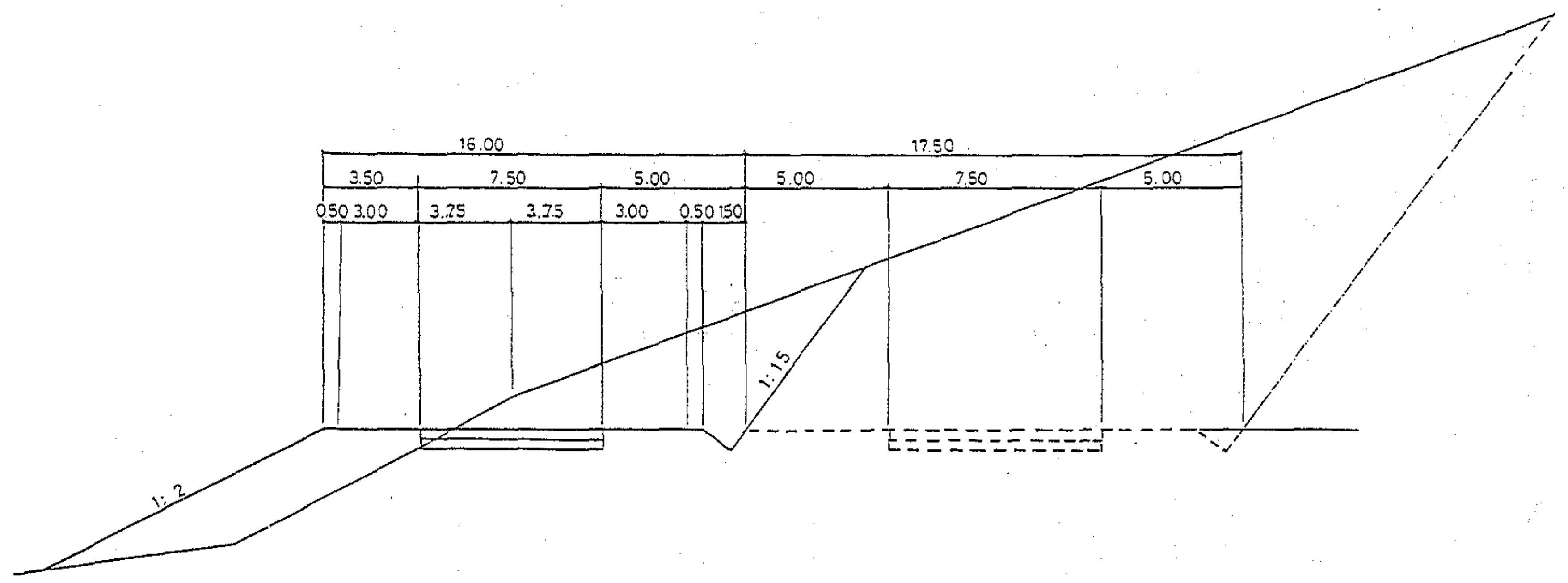
No modifications or changes were made to the current Government standard, therefore the lane width of new road alternative is 2 x 3.75 m, and that of widening alternative is 2 x (2 x 3.50 m).

Table-5.2.1 Geometric Design Standard (New Road Alternative)

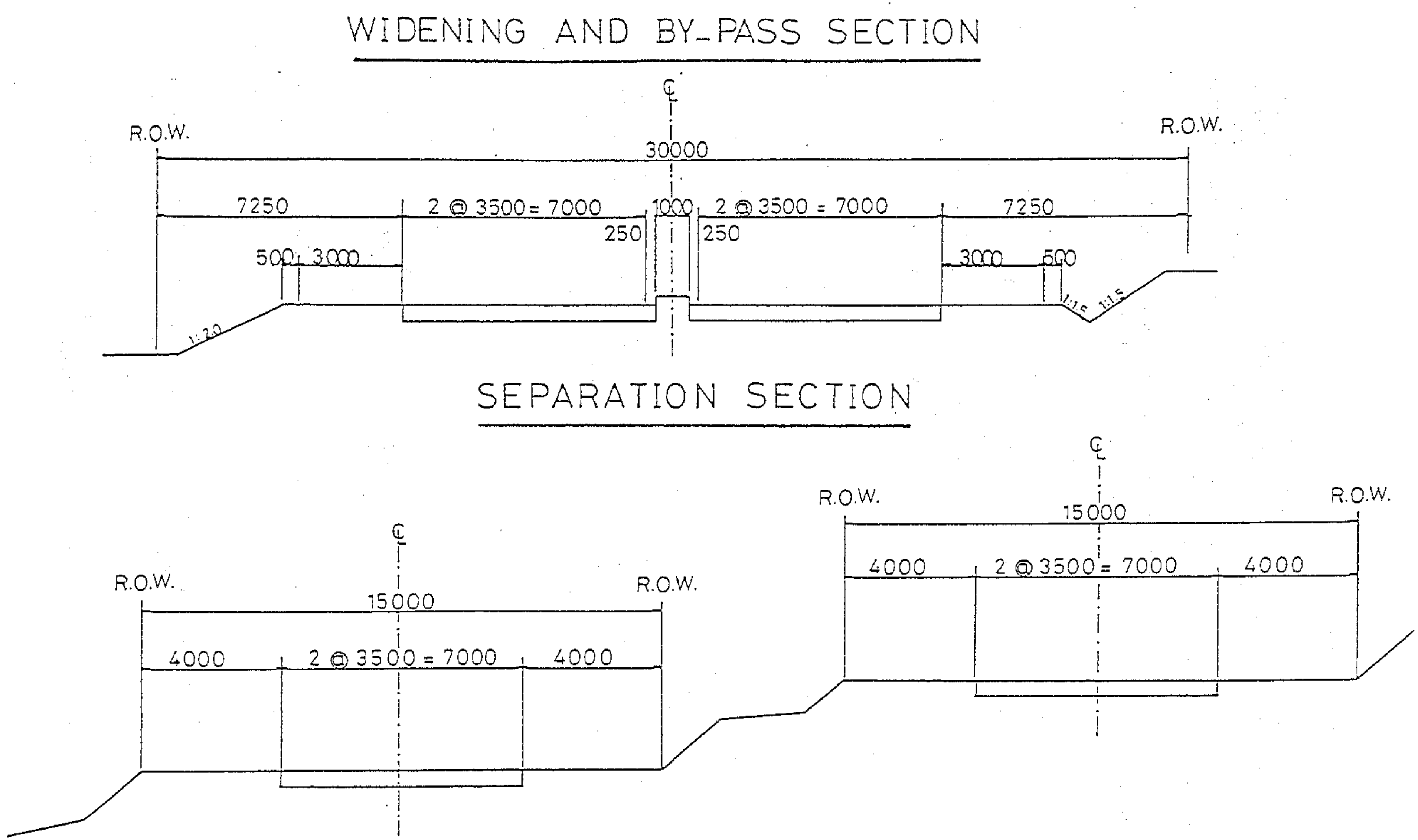
ITEM	UNIT	RECOMMENDED DESIGN CRITERIA		
Terrain		Flat	Rolling	Mountainous
Design Speed	km/h	100	80	60
Reserve R.O.W. width	meter	60	60	60
Carriageway width	meter	2x3.75	2x3.75	2x3.75
Outer shoulder width	meter	3.0	3.0	3.0
Median width	meter	10.0	10.0	10.0
Cross slope of pavement	%	2.0	2.0	2.0
Type of pavement		Cement Concrete		
Maximum Superelevation	%	10	10	10
Maximum Radii	meter	350	210	115
Maximum Gradient	%	4	6	7
Stopping sight distance Meter	meter	165	115	75
Minimum vertical curve Meter Length	meter	See Fig. 5.2.1		

Table-5.2.2 Geometric Design Standard (Widening Alternative)

ITEM	UNIT	RECOMMENDED DESIGN CRITERIA		
Terrain		Flat	Rolling	Mountainous
Design Speed	km/h	60	40	30
Reserve R.O.W. width	meter	30	30	30
Carriageway width	meter	2x(2x3.5)	2x(2x3.5)	2x(2x3.5)
Outer shoulder width	meter	3.0	2.5	2.5
Median width	meter	1.5	1.5	1.5
Cross slope of pavement	%	2.0	2.0	2.0
Type of pavement		Cement Concrete		
Maximum Superelevation	%	10	10	10
Maximum Radii	meter	115	50	30
Maximum Gradient	%	6	8	10
Stopping sight distance Meter	meter	75	40	30
Minimum vertical curve Meter Length	meter	See Fig. 5.2.2		



Feasibility Study on Bogor- Bandung Road Project | Fig.-5.2.1 Typical Cross Section - New Road Alternative



Feasibility Study on Bogor- Bandung Road Project

Fig.-5.2.2 Typical Cross Section - Widening Alternative

4) Pavement and Shoulder

The pavement planned for both the new road and widening alternatives is cement concrete pavement. This is due to the cheaper construction cost of cement concrete pavement compared to asphalt pavement and the fact that cement concrete pavement has been recently applied in other road projects in the country.

The recommended shoulder width is 3.0 m, and in future, the shoulder in the case of the widening alternative will be located along the side strips.

5) Median width

Since the new road alternative is located in rural area, the recommended median width is 10.00 m. However in the case of widening alternative, the existing road passes through some small and large cities with many houses situated along it and so the recommended median width is reduced to 1.50 m to decrease land acquisition.

6) Typical Cross Section

The typical cross section of the new road alternative at the first stage and ultimate stage are shown in Fig.-5.2.1. The cross section of the widening alternative is shown in Fig.-5.2.2.

5.2.3 Bridge Design Standard

1) Design Standards

Specifications for Highway Bridges, Indonesian Codes, No. 12/1970 (Rev. 1988) are applied for the design of bridges. However, for those design requirements not covered in the above specifications, AASHTO or Japanese Specifications for Highway Bridges are applied.

2) Bridge Structure Types

(a) Adoption of concrete bridges

From the technical standpoint both steel and concrete bridge types are suitable, however both types should be compared from the economical viewpoint, in terms of construction and maintenance costs. Under such comparison it is clear that concrete bridges are more economical than steel bridges.

Considering the above, concrete bridges will be adopted for the preliminary design.

(b) Superstructure

Superstructures are usually classified by the materials used; reinforced concrete (RC) bridges, prestressed concrete (PC) bridges, and steel bridges.

The type of superstructure presented in Table-5.2.3, according to required span length, is adopted in this Study.

Only short spans are used in RC bridges, and medium to long spans are used in PC bridges.

Table-5.2.3 Bridge Type and Standard Span

Type of Superstructure	Span Length (m) 10	20	30	40
RC T-Beam				
RC Hollow Slab				
Pre-tension Girder				
Post-tension I-Girder				
Steel I-Girder				

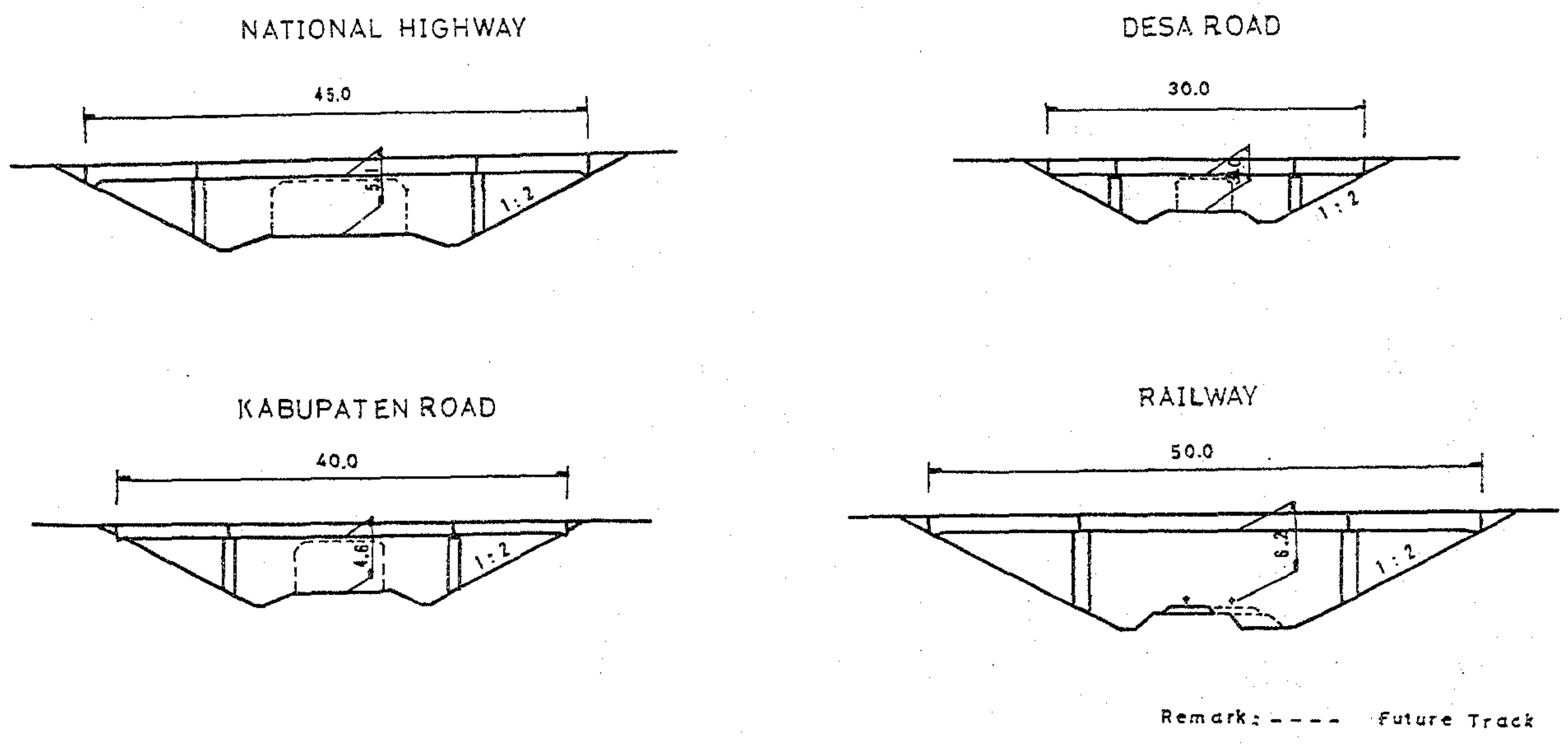
(c) Foundation

The type of foundation is determined in accordance to boring data obtained from the bridge construction site locations.

Generally, spread foundation shall be used where the bearing layer is not more than 4 m from the ground surface, and pile foundation and caisson foundation shall be adopted where the bearing layer is deeper than 4 m from the ground surface.

3) Planned Bridge Cross Sections for the Study

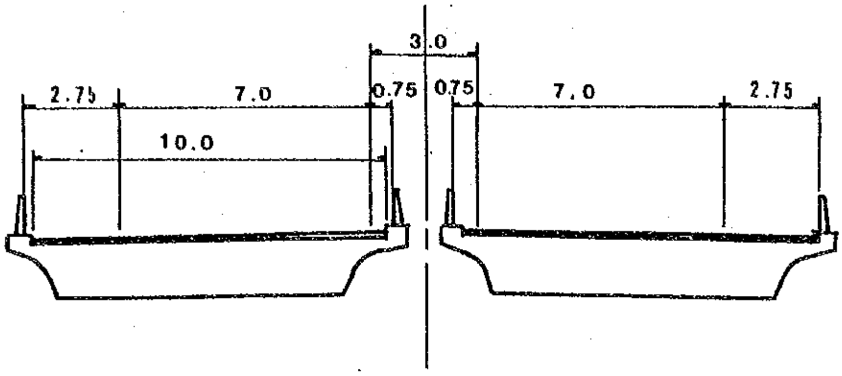
Figures-5.2.3 to 5.2.6 show the typical cross sections that are planned for the bridges of the Study project road.



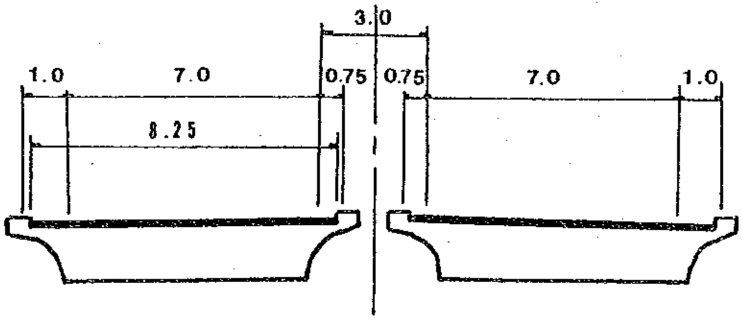
Feasibilty Study on Bogor-Bandung Road Project

Fig.-5.2.3 Standard Modules of Overpass

STANDARD (SHORT SPAN)

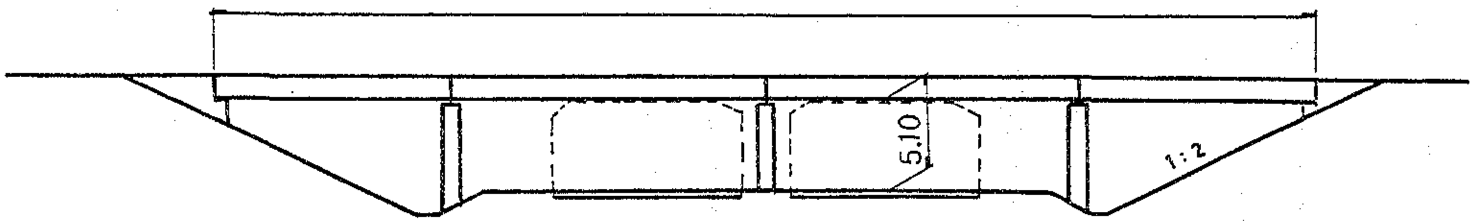


PARTICULAR (BRIDGE OVER 100 M)



Feasibility Study on Bogor-Bandung Road Project	Fig.-5.2.4 Standard Modules of Tollway

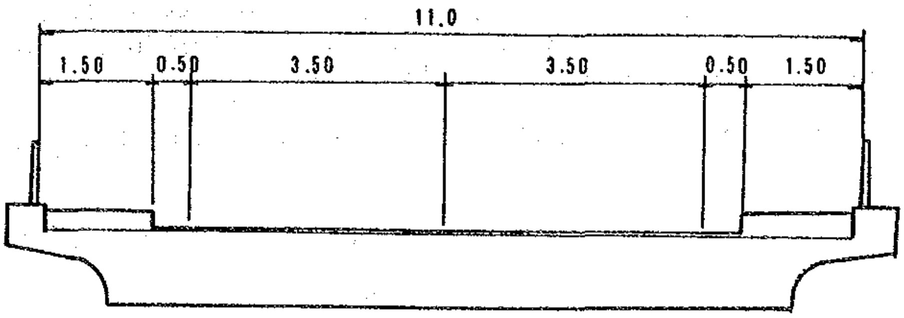
STANDARD MODULE OF UNDERPASS



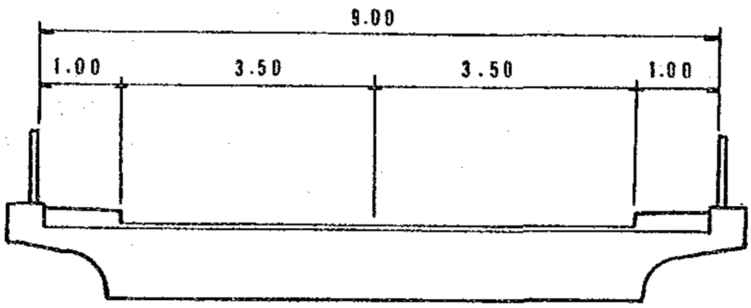
Feasibility Study on Bogor- Bandung Road Project

Fig.-5.2.5 Standard Module of Underpass

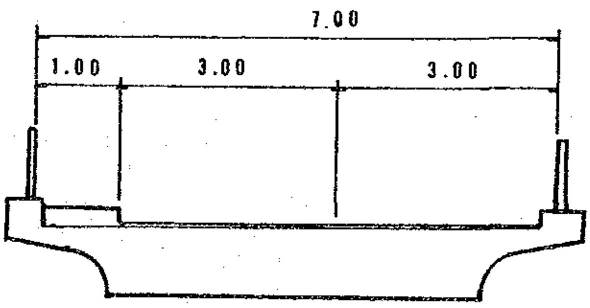
NATIONAL ROAD AND MAJOR ROAD



MAJOR LOCAL ROAD



MINOR LOCAL ROAD



FEASIBILITY STUDY ON BOGOR – BANDUNG ROAD PROJECT	Fig.-5.2.6 Typical Cross Section of Overpass

5.2.4 Pavement Design Standards

1) Design Standards

Standards for the design of pavement thickness in both cases of flexible and rigid pavements were adopted from "AASHTO Guide for Design of Pavement Structures, 1986". The Standards are shown in Table-5.2.4.

Table-5.2.4 Applied AASHTO Standards for Pavement Design

Design Items	Flexible Pavement	Rigid Pavement
1 Reliability	90%	
2 Overall Standard Deviation	So = 0.45	So = 0.35
3 Serviceability	PSI = 4.6 - 2.0 = 2.6	
4 Effective Roadbed Soil Resilient Modulus (Flexible)	Mr = 5500 psi (Wet season 8 months, dry season 4 months)	--
5 Pavement Layer Materials Characterization (layer coefficients for flexible p.)	Asphalt Concrete Eac=400,000 psi, A1=0.42 Granular Base (1) Esb= 30,000 psi, A2=0.14 Granular Subbase Esb = 11,000 psi, A3=0.08	Portland Cement Conc. Ec = 4,200,000 psi Granular Subbase Esb = 15,000 psi
6 PCC Modulus of Rupture (Rigid)	--	Fc(28) = 578 psi
7 Drainage Coeff.	M = 0.9	
8 Structural Number (Flexible P.)	Maximum Initial Structural Number, SN = 5.3	--
9 - Load Transfer	--	J = 2.8
- Loss of Support	--	LS = 2.0
- Reinforcement	--	FF = 1.5
- Effective Modulus of Subgrade Reaction (Rigid P.)	--	K = 32 pci

Note (1): "AASHTO Guide for Design of Pavement Structures, 1986" used by the Study Team contained no standards for Bituminous Base Course which was judged more appropriate in design of flexible pavement in order to reduce thickness. Subsequently guidelines were approximated from present practice in Indonesia and past experience.

Using the design methods in the aforesaid guide, for rigid pavement the slab thickness was calculated as 23 cm, and the granular subbase thickness as 15 cm. In the case of flexible pavement the thicknesses for the asphalt wearing, binder and base courses were 6, 8, and 15 cm respectively and for the granular subbase course 30 cm.

2) Selection of Pavement Type

Based on the forementioned standards, and in line with the practices in Indonesia, the cross sections adopted for comparison for each of rigid pavement and flexible pavement were as follows:

- Rigid Pavement
  Concrete pavement = 23 cm
  Aggregate Subbase Course = 15 cm

- Flexible Pavement
  Asphalt Surface = 10 cm
  Bit. Base Course = 20 cm
  Aggregate Base Course = 25 cm

The construction costs for both pavement types were compared as shown in Table-5.2.5.

Table-5.2.5 Rigid and Flexible Pavement Construction Costs

Pavement Type and Layer	Unit	Q'ty cm	Unit Price	Total
1. Rigid Pavement (Portland Cement Concrete Pavement)				
Concrete pavement	CUM	0.23	136,400	31,372
Agg. subbase course	CUM	0.15	53,100	7,965
TOTAL				39,337
2. Flexible Pavement (Asphalt Concrete Pavement)				
Asphalt surface	CUM	0.10	101,970	10,197
Bit. base course	CUM	0.20	91,210	18,242
Prime coating	SQM	1.0	100	100
Seal coating	SQM	1.0	360	360
Agg. subbase course	CUM	0.25	53,100	13,250
TOTAL				42,149

From the Table, it is clear that the construction cost for rigid pavement is less than that for flexible pavement. Furthermore the production of materials for the construction of rigid pavement, and its maintenance are less complex than that for flexible pavement. Taking into consideration the above, and the expected light load, rigid pavement was selected for the road project.

5.3 Geological and Topographical Condition

Herein the geological and topographical features shall be considered for the four road development alternatives. As explained previously the four alternatives are divided into two alternatives running through Sukabumi (southern direction) and two alternatives running through and near Puncak (northern direction).

The routes of the two alternatives in the southern direction are running close to each other so their features will be dealt with under the same heading, ie. the southern direction. In the case of the northern direction, the existing road runs through Puncak Pass, while the route proposed for the new road construction is north of Puncak. Therefore description of features for alternatives in the northern direction which are those of mountain areas, will be discussed separately.

5.3.1 Southern Direction

In relation to the routes in the southern direction, the geological and topographical characteristics may be divided into the following four groups;

1) Areas of complex narrow and meandering valleys

An example of the features of such areas is shown in Fig.-5.3.1. Areas may be defined as complex meandering but the stream of valleys cannot be distinguished from aerial photographs and existing topographical maps (scale 1:50,000). Selection of a route similar to that depicted in the figure as case A will necessitate the construction of a long-span bridge, however a route similar to case B will call for the construction of short-span bridges with many abutments. Such factors have a significant impact on the economic studies pertaining to construction thereby highlighting the need to know the detailed topographical conditions of the areas under investigation.

It has been claimed that the area consists of older volcanic sediments, however such strata were not evident during site observations which revealed the existence of only tuffaceous earth. Further information was obtained during the soil survey and the results are described in Chapter 8.

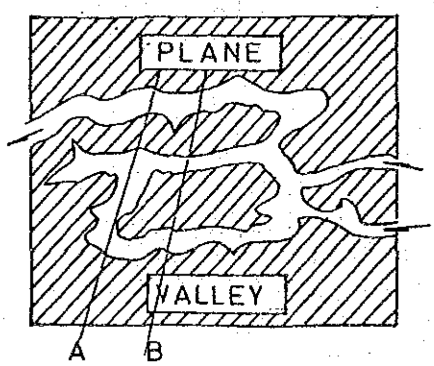


Fig.-5.3.1 Sketch of Meander

2) Areas of alternating deep and wide valleys and ridges

These topographic features occurred in the youngest deposits from G. Pangrange. The widths of valleys are larger than that of ridges, and the distance between ridges appearing on one plane are about 1 km.

In such areas the proposed height of road route will determine the plans for long-span bridges and tunnels. Geological maps show partial older volcanic rocks, however most sediments are younger volcanic from G. Pangrange.

Through surface geological surveying partially tuffaceous breccia may be observed at existing road side. In most of the area only tuffaceous earth may be seen and sound rock is not observed. Furthermore it is impossible to distinguish between younger and older deposits.

It is deemed necessary to examine the physical properties of the soil by deep boring, and in the case of bridge pier plans the probability of mud flow occurrence due to torrential rain must be investigated so as to provide pier protection.

Aerial photographs interpretation show that upstream ridges are very sharp shaped and depths of valleys are deeper compared to downstream where valley widths tend to be somewhat narrow, especially near the Cileuleu River in the west where ridges take the form of plateaux. Such facts must be referred to in the route planning.

3) Areas of development of parallel narrow valleys

Such topography exists in the northern part from Cibadag to Sukabumi. Such areas are characterized by the development of parallel narrow valleys upstream and midstream, with many narrow streams joining into one or two valleys downstream.

Towards Sukabumi the number of valleys decrease at midstream and upstream but the tendency of joining at downstream continues unchanged. Such topographic features are important factors to be considered during route planning. Near Soekalarang the route being considered crosses the existing road, then enters into a gully area. At this location it is necessary to consider drainage from high elevation during the detail design.

Geological features consist of older deposits from G. Pangrange and tuffaceous breccia and lahar from G. Gede. Judging from topographical and geological features, there are no problems considering route planning except for the numerous valleys.

4) Areas of conical hills

There are many conical hills in Cianjur basin covered by breccia and lahar from G. Gede. Judging by the cutting of outcrops and quarries south of Cianjur uppermost parts are composed of reddish brown tuffaceous earth of several meters thickness, underneath which there are layers consisting of andesitic or basatic breccia materials. These same stratigraphic conditions may be seen in the cliffs of Cisokan River near Cirandjang.

Such conditions lead to the belief that Cianjur Basin is covered by reddish brown tuffaceous earth of several meters thickness underneath which are andesitic or basaltic breccia, independent of hills or planes.

The breccia matrix is rather soft in hills due to the weathering process but gradually hardens with depth. There are no weathering zones at the cliffs of Cisokan River which are used as foundation for abutments and piers, so it can be considered that hills are effected by weathering but such effect does not exist beneath plane areas.

A newly constructed road connecting Cianjur with Cirandjang is passing through some conical hills.

From the abovementioned it is considered that there are no problems in route planning and foundation rocks for the construction of bridges. However the proposed road height is several meters lower than the plane elevation thereby requiring the use of explosives during construction, so attention must be paid to the proposed height of the route.

Two routes may be considered in the stretch originating near Cimerang to Padalarang, the first to the north and the second south of it. The south route runs south of the national railway line and crosses it in the east, while the north route crosses the railway line in the west and runs through a plateau north of the line.

5.3.2 Northern Direction: Near Puncak Pass

The existing road from Bogor to Puncak Pass passes on older deposits consisting of lahar and andesitic lava from G. Pangrange. Beyond puncak Pass the road passes over tuffaceous breccia and lahar deposits from G. Gede.

Near the top of Puncak Pass along the Cianjur side there is a landslide area and from existing landslide data, the scale of landslide is said to be about 150 m in length, 100 m in width and the sliding surface is considered to form a boundary between weathered bedrock and colluvial deposits or falling within the zone of colluvial deposit.

Interpretation of aerial photography shows that the valley along which the national road runs features typical landslide characteristics, and that the national road runs through the middle of the main scarp and moving mass (Fig.-5.3.2).

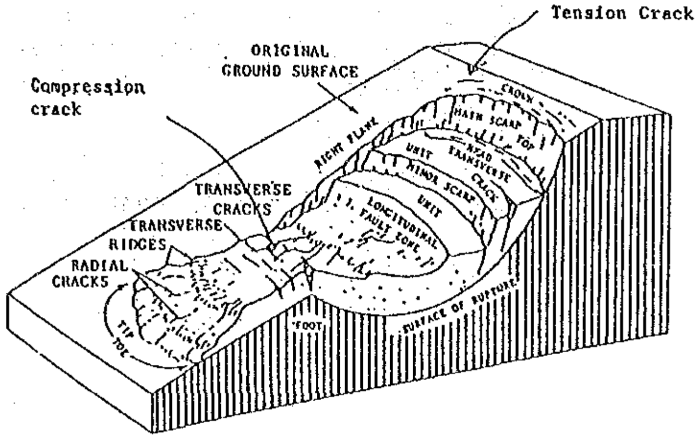


Fig.-5.3.2 Term (Nomenclature) of Landslide

Aerial photographs show several features of scarp and moving mass but most are the result of ancient landslides and conditions are now stable as judged by the plants in the area.

In Japan it is said that one must beware of ancient landslides because they are evidence of unstable conditions, and the conditions near Puncak Pass are considered to be the same.

Along the Bogor side, erosion in the gully is now in progress and detritus and possible scarp may be partially observed.

When considering progressive erosion, the stability of the mountain calls for caution. Subsequently if a new road is planned, in order to avoid the landslide a tunnel should be constructed, which is also considered suitable when considering the planned road grade and the higher ground surface elevations north and south of the pass. From the geological standpoint, conditions north of the pass are better than those south of it because there are older volcanic products and tertiary strata which are more suitable for construction.

However selection of sites for tunnel entrances on both sides are considered to be very difficult due to the conditions described above.

5.3.3 Northern Direction: North of Puncak Route

This route covers the new road construction alternative. The route branches east from Jagorawi highway near Citarunggui along Ciherang River, changing south-east entering the mountain area, and once more east near langis, south near Majalaja reaching east of Cianjur. The planned route can be seen on the geological map to be mostly passing through tertiary strata from near Sukamant to north of Cianjur.

The tertiary strata consists mainly of marl, clayshale, quartzite, sandstone, etc., but in the middle part near G. Karanggentoengen there are quarternary strata of breccia and lava. After that the route enters into the Cianjur basin which consists of older volcanic products of quarternary age.

Topographical features include some failure sites and steep slopes. From the geological standpoint the distribution of sound rocks is supposed so the use of explosives during road construction is deemed necessary, and many bridges and tunnels will be required. Nevertheless road construction is possible.

When evaluating the best route to adopt, priority in comparison of alternative should be on the basis of economical cost rather than geological and topographical features.

5.4 Alternative 1 (Puncak Route Improvement)

5.4.1 Route Location

Alternative 1 suggests the widening of the existing road from Ciawi, through Puncak, which has developed as a resort area, to Cianjur and Cipatat, to connect with the planned new road. The length of this route is 80.40 km, and includes one (1) separation section and two (2) bypass sections as shown in Fig.-5.4.1.

The bypass sections are planned at Cianjur and Ciranjang where many houses are located alongside most of the existing road.

A tunnel is planned for the separation section in the mountainous Puncak area where there are many steep curves and slopes, in order to improve the horizontal and vertical alignments.

5.4.2 Appreciation of the Route

This route connects Ciawi and Cianjur (about 400 m above sea level), passing through the Puncak Pass (about 1,500 m above sea level). The exisitng road along this route has a grade of more than 4.2%, therefore this alternative route alignment will be inevitably poor.

The results of the survey of the existing road widths are shown in Fig.-5.4.2. In the Ciawi - Cianjur section the average road width is 11.0 m, although the first 10 km from Ciawi have a comparatively large average width of 15.0 m. The width along the Cianjur - Citatah section of the road is between 13 and 18.5 m.

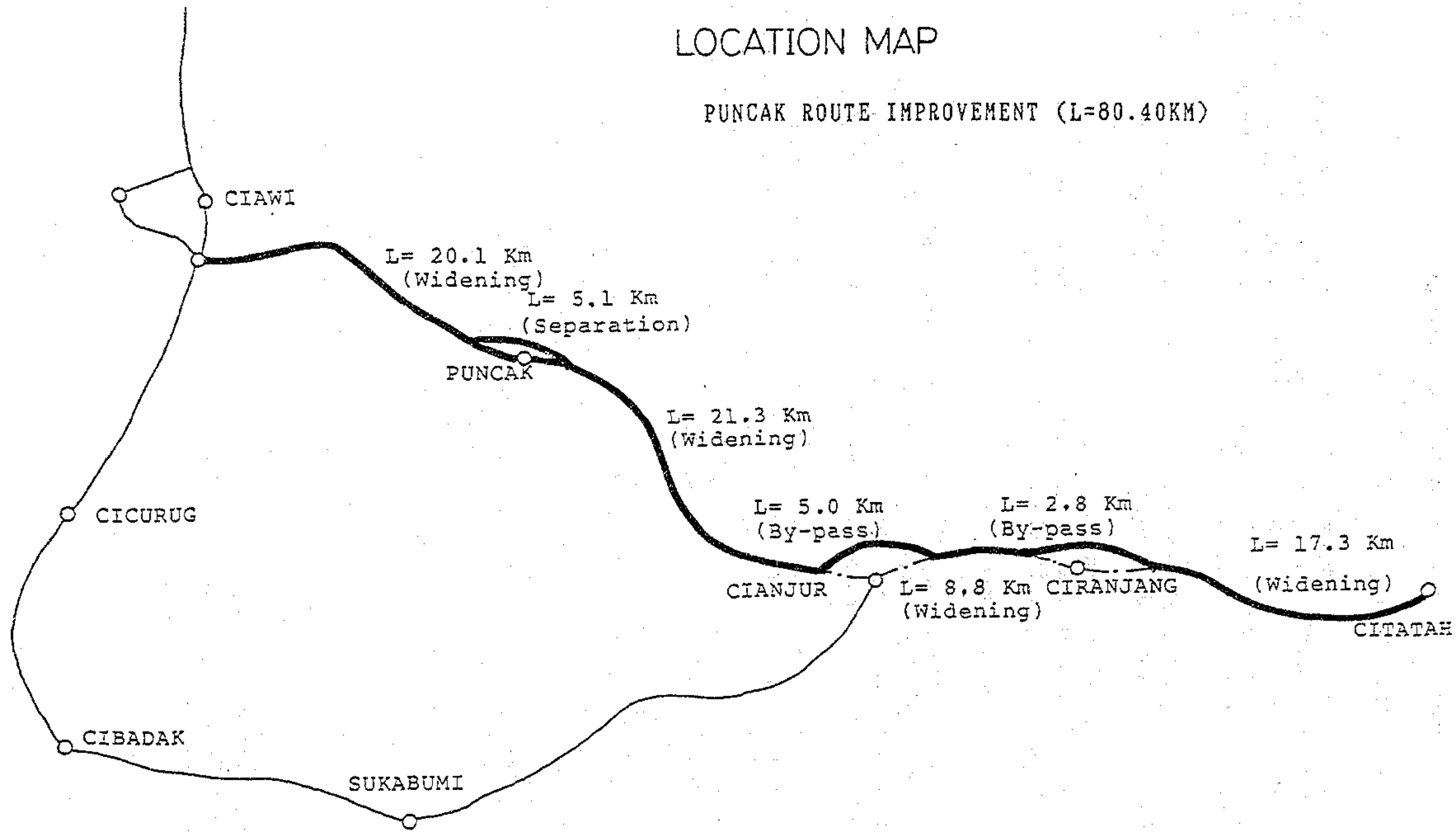
The land use activities along the route are shown in Table-5.4.1. Social and economic activities extend along the road, with the built-up area and agriculture activities occupying about 48% and 36% of the area along the route respectively. It is obvious that widening of the existing road will have a large influence on such activities and land acquisition costs and compensations will be high. Fig.-5.4.3 shows the estimated number of houses that will be removed.

Table-5.4.1 Land Use along Alternative 1 Route

Section	Housing (km)	Paddy Field (km)	Plantation (km)	Others (km)	Total (km)
Ciawi-Puncak	10.5	5.2	3.2	6.3	25.2
Puncak-Cianjur	14.0	9.8	-	2.5	26.3
Cianjur-Citatah	14.0	10.9	-	4.0	28.9
Total	38.5	25.9	3.2	12.8	80.4

LOCATION MAP

PUNCAK ROUTE IMPROVEMENT (L=80.40KM)



Feasibility Study on Bogor- Bandung Road Project	Fig.-5.4.1 Alternative 1 Location Map

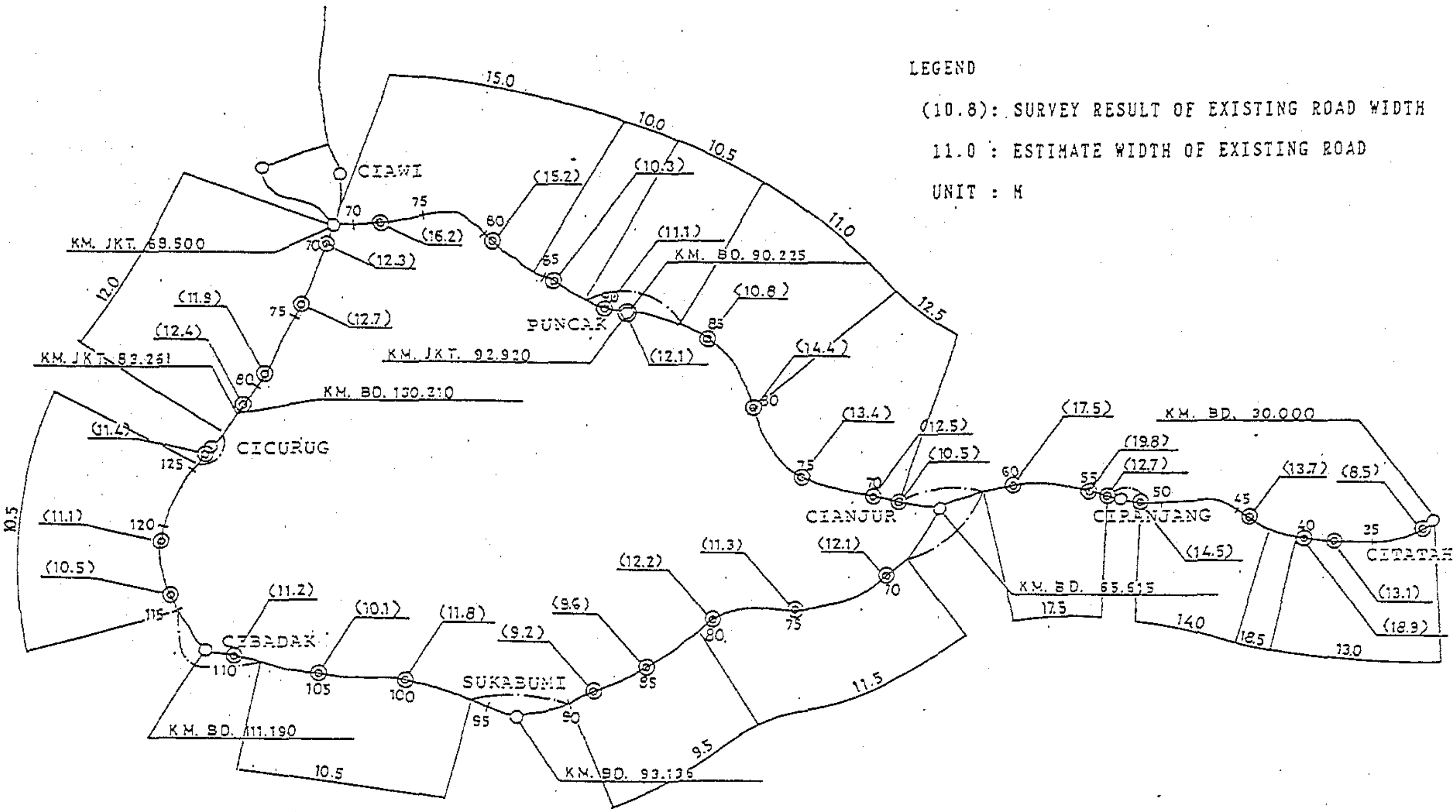
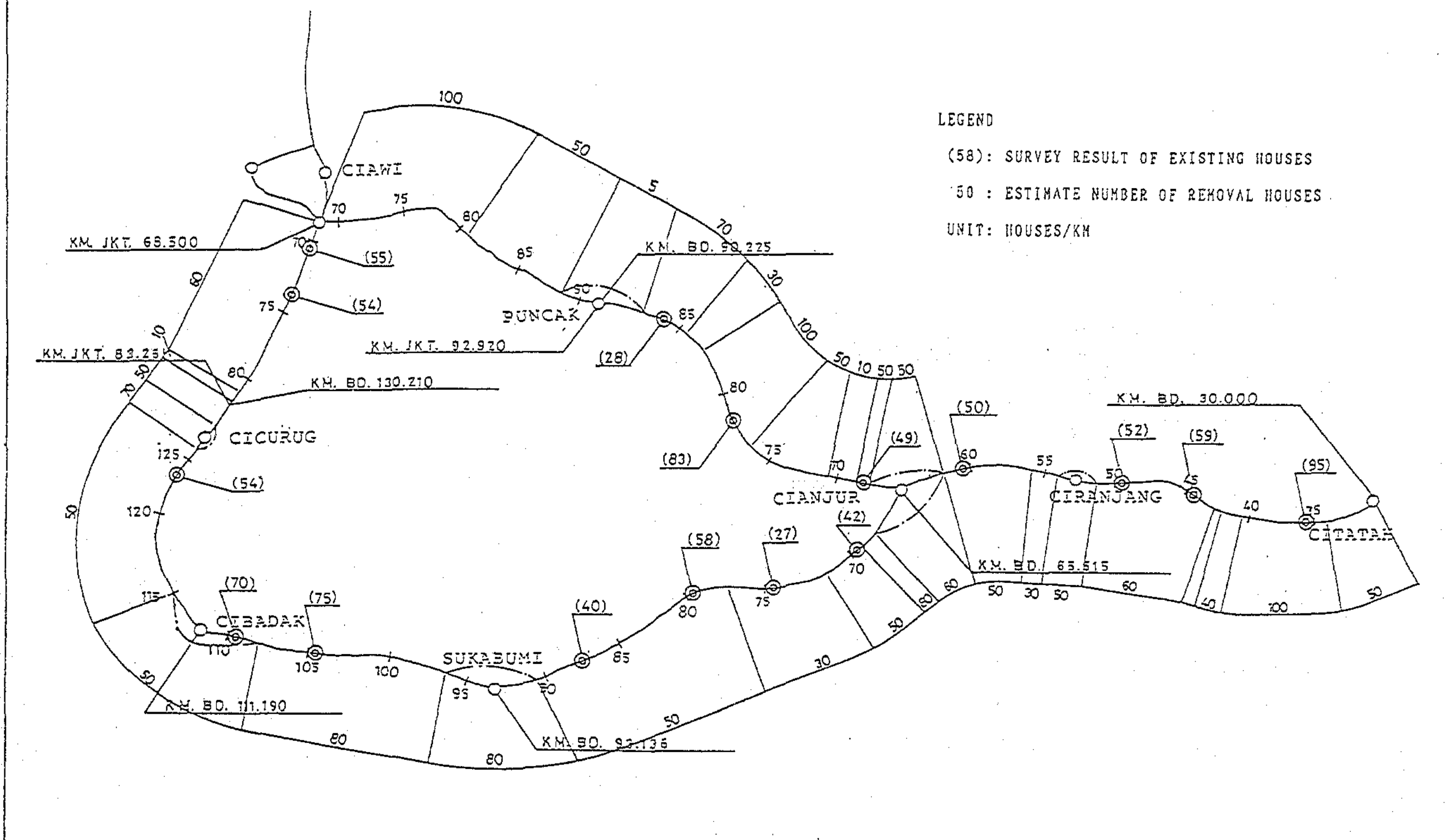


Fig.-5.4.2 Survey Results and Estimates of Existing Road Widths

Feasibility Study on Bogor - Bandung Road Project



Feasibility Study on Bogor- Bandung Road Project	Fig.-5.4.3 Survey Results and Estimates of Number of Houses to be Removed

The environmental conditions will also be adversely effected in that many trees lining the existing road will be cut, especially along Cianjur and Citatah.

5.4.3 Traffic Demand

The volume of traffic in the target year 2010 assigned to the widening section from Ciawi to Citatah is shown in Fig.-5.4.4.

A traffic volume of 25,000 vehicles per day in 2010 is estimated at the section from Ciawi to Cianjur. This value excludes internal zonal traffic.

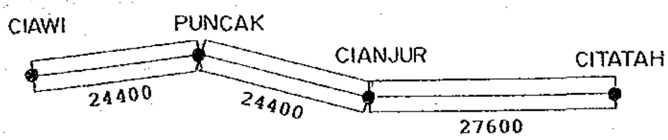


Fig.-5.4.4 Traffic Demand on Alternative 1 in 2010

5.4.4 Engineering Features

This route poses the following problems.

Between Ciawi and Cianjur, the route passes through mountainous and rolling areas, therefore along this section the design speeds are reduced due to the existence of steep curves and slopes.

In addition, it is recommended to review the horizontal and vertical alignments for some sections along the existing road.

Since Puncak area is located in a mountainous area, a tunnel scheme is planned to revise the horizontal and vertical alignments.

The steep topography of the route is expected to make the construction work of bridges a hard task. In particular, attention should be paid to the following points;

- Separate new bridges from existing ones

Many bridges were constructed before 1920 as arch structure and slab bridge with short span length. If old and new bridges are combined into one structure, that structure will be weak in resisting stresses, and also difficult to construct. It is therefore recommended that old and new bridges be separate structures.

- Simple spans for medium and short bridges

Simple spans shall be adopted for medium and small bridges, as much as possible, for the following reasons;

- decrease blocking rate of pier,
- decrease stream disturbances created by numerous piers, and,
- avoid excessive pier construction in steep topography, which is hard work.

5.4.5 Construction Aspects

The data of the bridges that are planned along this route, regarding numbers of bridges, superstructure, abutments and piers are shown in Tables-5.4.2 to 5.4.5.

Table-5.4.2 Bridges Number

Length	Number
- 10 m	44
10 - 20 m	1
20 - 30 m	2
40 - 50 m	1
50 - 60 m	2
100 - 150 m	1
TOTAL	51

Table-5.4.3 Superstructures Number

Span (m)	Number
5.0	44
14.5	1
24.0	6
37.5	0
45.0	4

Note: Span is average span

Table-5.4.4 Abutments Number

Height (m)	Number
5.0	82
8.0	15
10.0	5

Table-5.4.5 Piers Number

Height (m)	Number
20.0	2
30.0	2

Most of the bridges are short span, with 85% of the bridges having spans of less than 10 m, and 5% between 10 to 30 m.

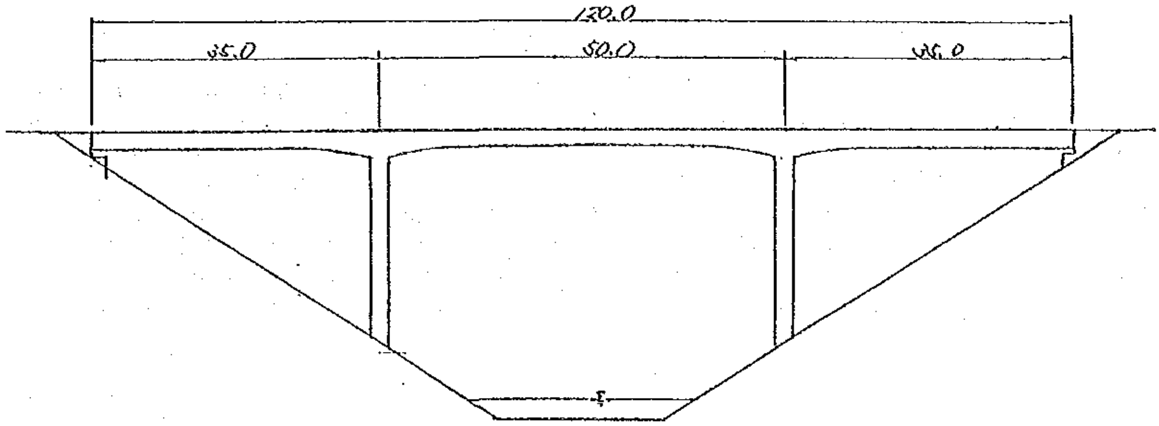
The three alternatives that are being considered for the Cisokan Bridge near Ciranjang are shown in Fig.-5.4.5.

5.4.6 Construction Cost Estimates

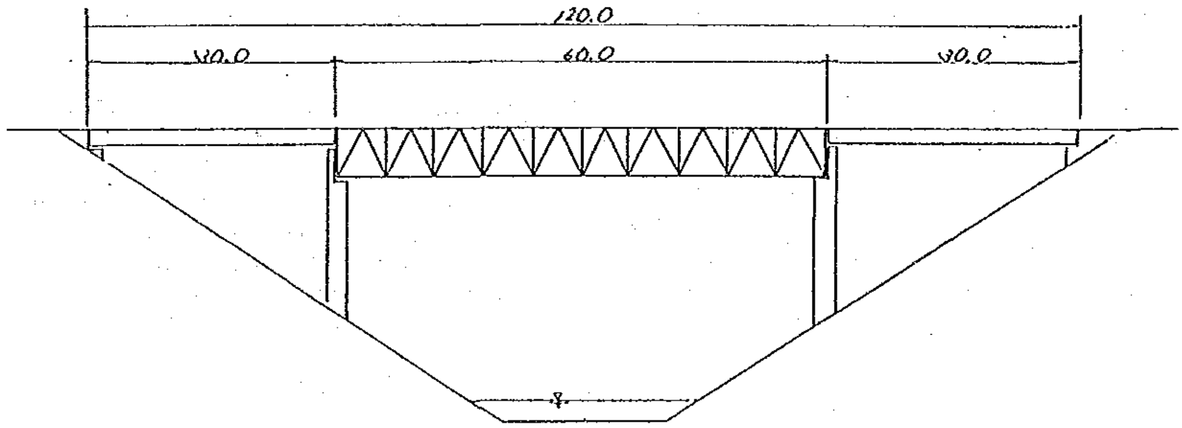
The total project cost is approximately 423,799 million Rupiah. Compensation cost for land acquisition and removal of houses is about 56,500 million Rupiah, or 14.7% of the total project cost.

Therefore, the average cost for widening of the existing road, including the cost for construction of Puncak Tunnel, is estimated as 5,271 million Rupiah per kilometer.

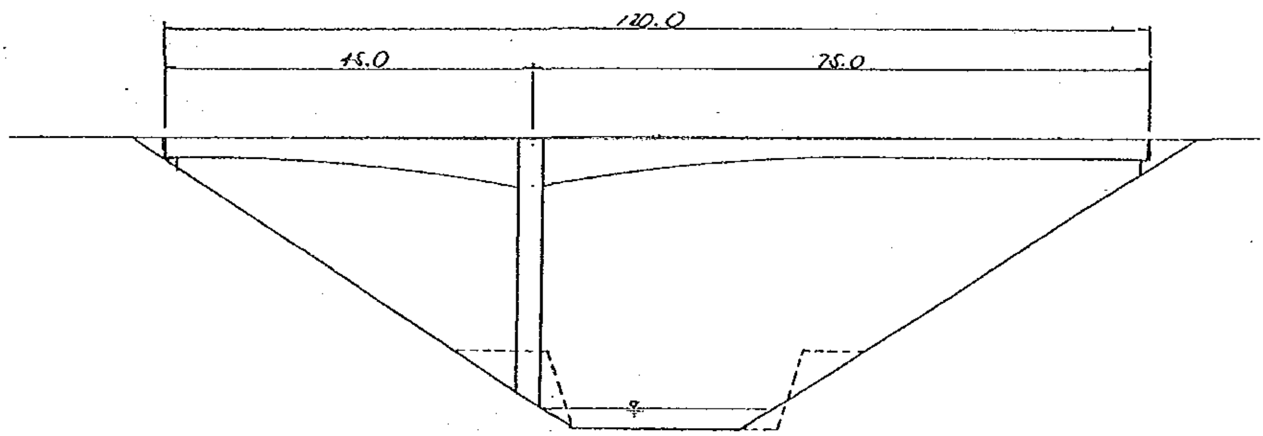
Alternative A PC Continuous Box Girder



Alternative B Steel Simple Truss and Plate Girder



Alternative C PC Continuous BOx Girder



Feasibility Study on Bogor-Bandung Road Project	Fig.-5.4.5 Cisokan Bridge

5.5 Alternative 2 (Sukabumi Route Improvement)

5.5.1 Route Location

Alternative 2 calls for the widening of the existing road from Ciawi, through Cibadak, Sukabumi, Cianjur and Cipatat, to connect with the planned new road. The length of this route is 113.40 km and five (5) bypass sections are planned along it, to bypass the large cities of Cicurug, Cibadak, Sukabumi, Cianjur and Ciranjang, as shown in Fig.-5.5.1. In these cities many houses are located along the existing road, and if the road is widened, without the construction of bypasses it will be necessary to remove a large number of existing houses, resulting in higher construction costs.

5.5.2 Appreciation of the Route

Between Cianjur and Cibadak the route of this alternative passes through many ridges, and the existing road alignment is inevitably poor due to such severe topographic conditions. Along this section travel speed is less than 35 km/hr (non-peak hours).

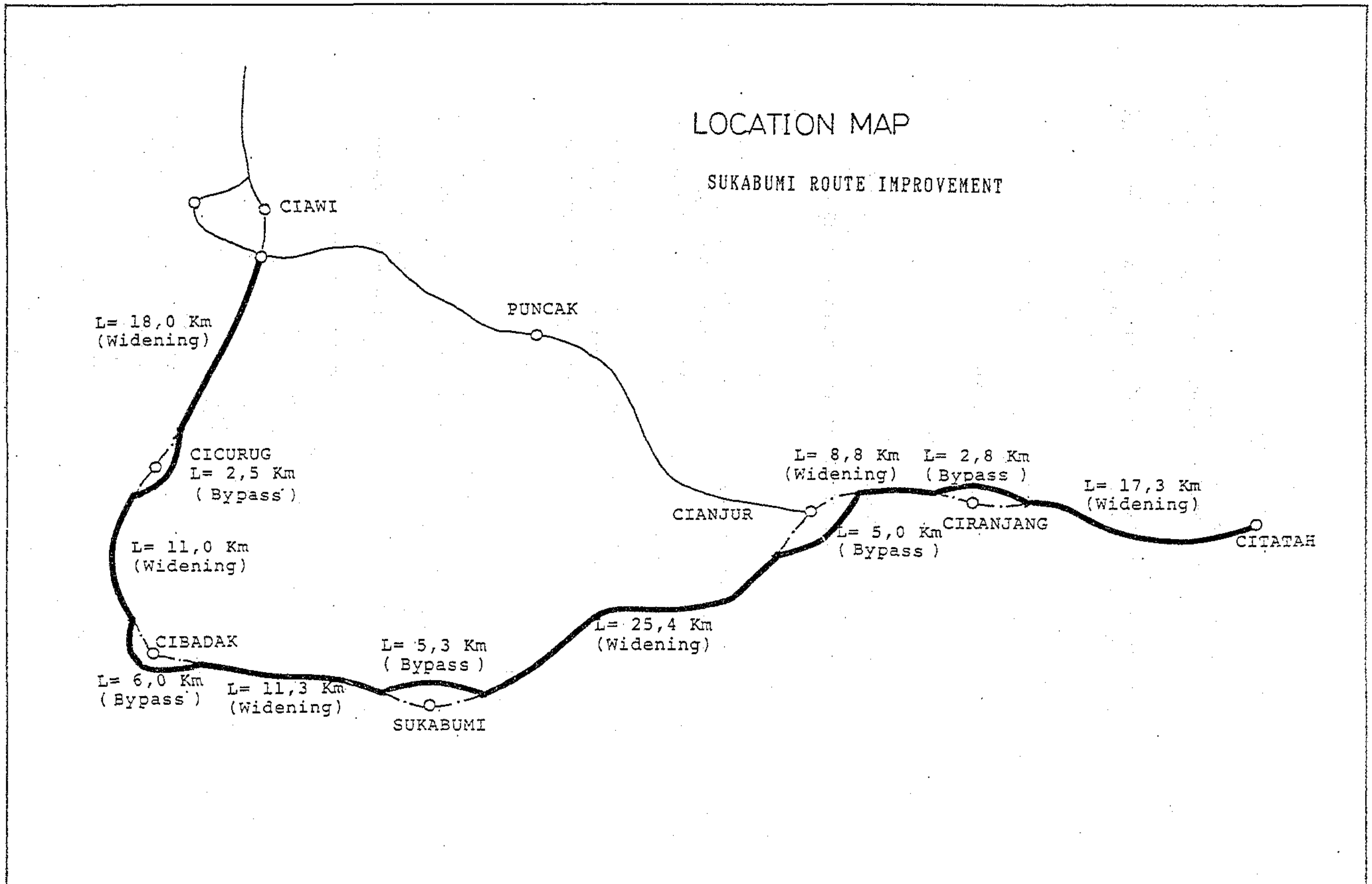
The section of the existing road between Sukabumi and Cianjur has elevations of 900 m above sea level, and there is a stretch of more than 10 km having a grade of 5%.

The widths of the existing road are shown in Fig.-5.4.2, of the previous section. The widths average between 10 to 11 meters.

Table-5.5.1 shows the land use activities along the existing road. Built-up area and agriculture activities utilize 51% and 32% of the road side space respectively, thus road widening may cause much social unrest. Fig.-5.4.3 shows the estimated number of houses that would have to be removed for road widening.

Table-5.5.1 Land Use along Alternative 2 Route

Section	Housing (km)	Paddy Field (km)	Plantation (km)	Others (km)	Total (km)
Ciawi-Cibadak	13.5	9.3	-	14.7	37.5
Cibadak-Sukabumi	12.3	3.9	-	0.4	16.6
Sukabumi-Cianjur	18.3	12.0	-	0.6	30.9
Cianjur-Citatah	14.0	10.9	-	4.0	28.9
Total	58.1	36.1	0.0	19.7	113.9



Feasibility Study on Bogor- Bandung Road Project	Fig.-5.5.1 Alternative 2 Location Map

5.5.3 Traffic Demand

Fig.-5.5.2 shows the inter-city traffic volumes estimated along the existing Ciawi-Sukabumi-Cianjur-Ciloto road in the year 2010 after its widening.

Traffic volume on the Ciawi-Sukabumi section is estimated at about 20,000 vehicles per day, of which 25% shall be trucks.

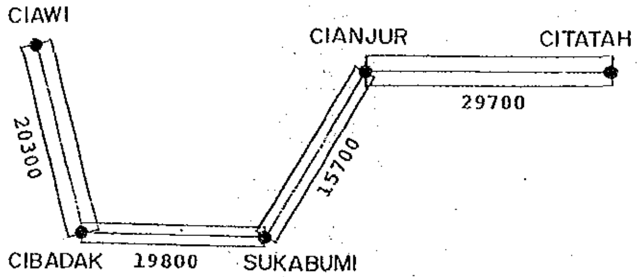


Fig.-5.5.2 Traffic Demand on Alternative 2 Route in 2010

5.5.4 Engineering Features

Since this route passes five (5) large cities, bypasses are planned to decrease the number of houses to be removed. Furthermore, in some sections where there are steep curves and slopes, it is recommended to review the horizontal and vertical alignments.

The topographical conditions along this route make bridges construction an easier task when compared to the route of Alternative 1. However the number of bridges required for this route are twice that number for Alternative 1.

5.5.5 Construction Aspects

The data of the bridges that are planned along this route, regarding numbers of bridges, superstructures, abutments and piers are shown in Tables-5.5.2 to 5.5.5.

Table-5.5.2 Bridges Number

Length	Number
- 10 m	67
10 - 20 m	23
20 - 30 m	6
30 - 40 m	2
40 - 50 m	1
50 - 60 m	3
70 - 80 m	1
100 - 150 m	1
TOTAL	104

Table-5.5.3 Superstructures Number

Span (m)	Number
5.0	67
14.5	23
24.0	12
37.5	4
45.0	4

Note: Span is average span.

Table-5.5.4 Abutments Number

Height (m)	Number
5.0	166
8.0	32
10.0	10

Table-5.5.5 Piers Number

Height (m)	Number
10.0	1
20.0	3
30.0	2

Most of the bridges are short span, with the spans of 65% of the bridges being less than 10 m, and 30% between 10 to 30 m.

5.5.6 Construction Cost Estimates

The total project cost is approximately 458,275 million Rupiah. Compensation cost for land acquisition and removal of houses is about 73,800 million Rupiah, or 16.1% of the total project cost.

Comparing the costs by sections, Section 4 (Cibadak - Sukabumi) has the highest cost at 4,481 million Rupiah per kilometer, inclusive of the compensation cost which is 12,000 million Rupiah for the whole section.

5.6 Alternative 3 (Puncak Route New Road)

5.6.1 Route Location

Alternative 3 proposes the construction of a new road along a route to be located north of the existing Ciawi - Puncak - Cianjur road (Alternative 2). Fig.-5.6.1 shows the suggested route. The route will connect directly with Jagorawi Highway at its starting point, extending to Citatah by way of Cianjur.

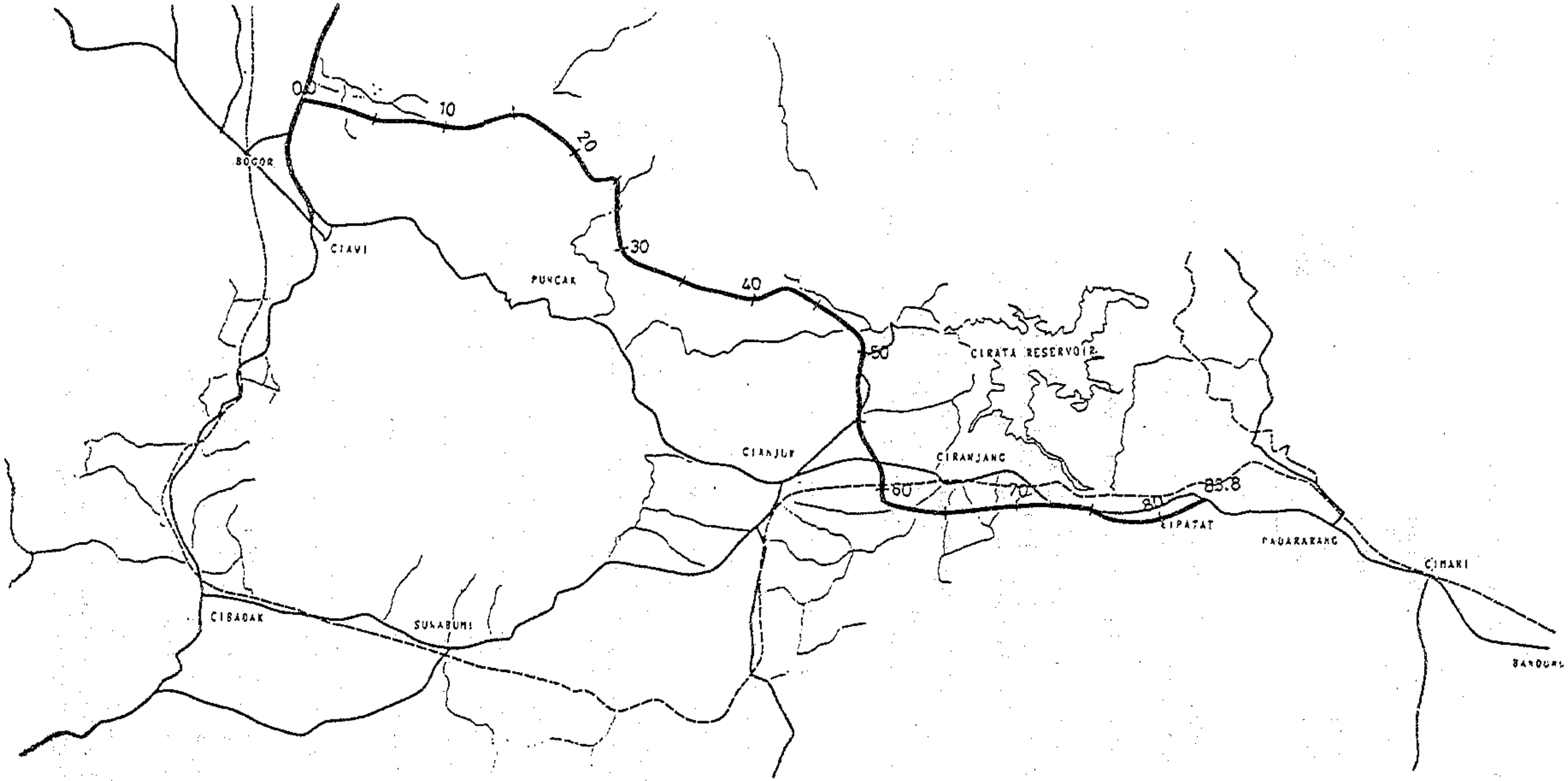
Between Jagorawi Highway and Cianjur the route traverses and passes through many ridges and valleys north of Puncak. Adoption of high standard alignment along this section will be difficult due to the prevailing topographic conditions.

5.6.2 Appreciation of the Route

The total length of the route is 83.8 km, which makes it the shorter of the two new road alternatives.

The route passes in a mountainous area between Jagorawi Highway and Cianjur, and such topographic conditions will force the adoption of the maximum grade of 5% along many sections, in addition to tunnel construction. The vertical alignment is shown in Fig.-5.6.2.

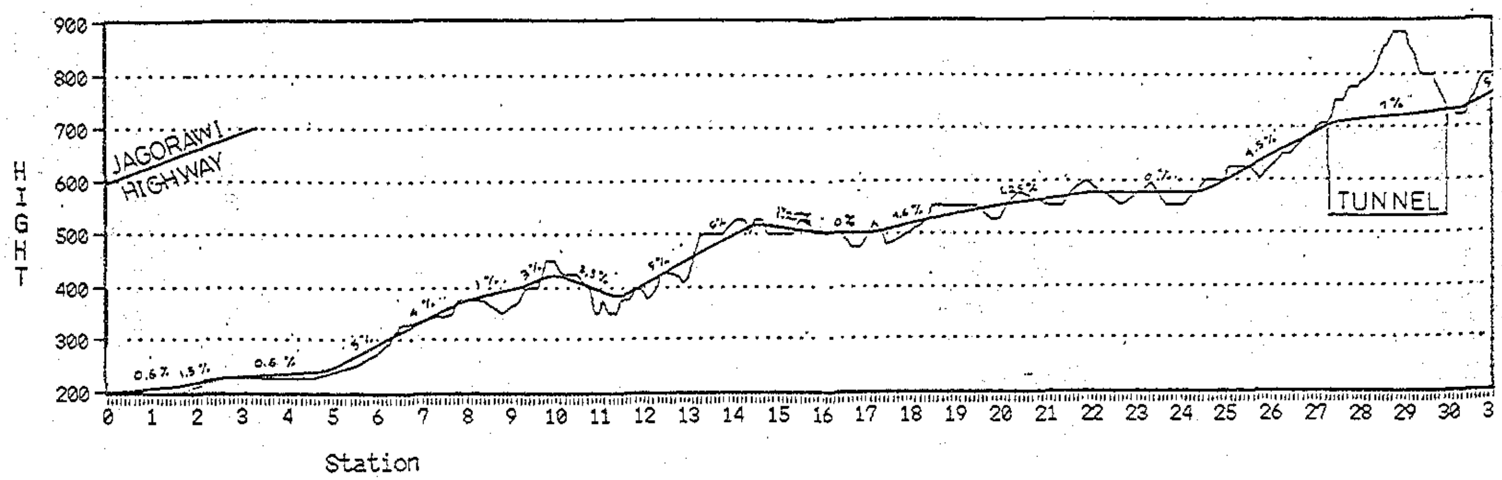
Table-5.6.1 shows that the route does not pass through built-up area, however compensations may have to be paid for expropriation of rice paddy-fields which occupy 52% of the proposed road side area.

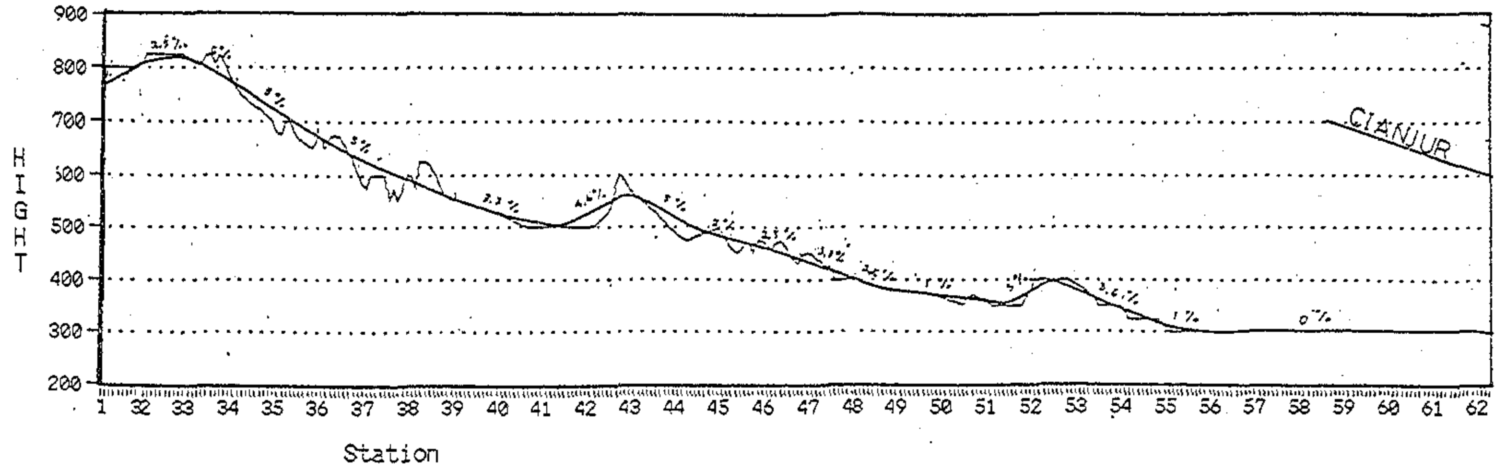


Feasibility Study on Bogor - Bandung Road Project

Fig.-5.6.1 Alternative 3 Route Location Map

BOGOR - BANDUNG ROAD PROJECT
VERTICAL ALIGNMENT





Feasibility Study on Bogor - Bandung Road Project	Fig.-5.6.2 Alternative 3 Vertical Alignment

Table-5.6.1 Land Use along Alternative 3 Route

Section	Housing (km)	Paddy Field (km)	Plantation (km)	Others (km)	Total (km)
Ciawi-Puncak	-	8.0	-	20.8	28.8
Puncak-Cianjur	-	20.8	-	13.0	33.8
Cianjur-Citatah	-	14.5	-	6.7	21.2
Total	0.0	43.3	0.0	40.5	83.8

5.6.3 Traffic Demand

Traffic volumes along the sections of the new road proposed in Alternative 3 in the year 2010 are shown in Fig.-5.6.3.

Traffic volume along the Jagorawi Highway-Cianjur section reaches 12,000 vehicles per day, of which truck share accounts for 24.3%.

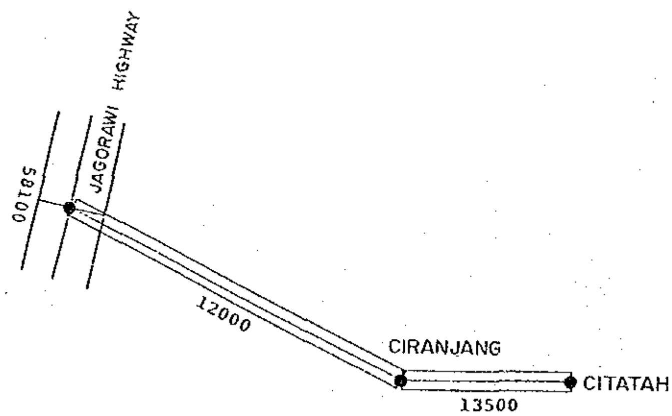


Fig.-5.6.3 Traffic Demand on Alternative 3 Route in 2010

5.6.4 Engineering Features

The route of this alternative passes through steep topography and mountainous area between Sta. 5 and Sta. 50, therefore long span bridges and viaducts are required.

The main issues concerning long span bridges are erection and material types. Concrete bridge is adopted, as discussed in section 5.2.3 of this Chapter. The erection of concrete bridge is conceived as follows; the long span length shall be erected by the cantilever method, which has already been applied in the case of a PC box girder bridge (center span length 130 m) near Ciranjang in the Study Area.

5.6.5 Construction Aspects

The planned route of the new road passes through steep topography in mountainous area (Sta. 5 to Sta. 55) and some bridges, overpasses and viaducts are planned with long span lengths. A tunnel of approximately 2.7 km length is also planned.

The numbers of overpasses, bridges and viaducts and related data are shown in Tables-5.6.2 to 5.6.4.

Table-5.6.2 Overpass, Bridge and Viaduct Numbers

Structure	Length	Number
Overpass	60 m	23
Viaduct	45 m	8
	40 m	6
	30 m	12
Bridge	- 10 m	22
	10 - 20 m	1
	20 - 30 m	2
	40 - 50 m	7
	50 - 60 m	1
	90 - 100 m	10
	100 - 150 m	2
	150 - 200 m	1
	200 - 250 m	1
	250 - 300 m	1
TOTAL		97

Table-5.6.3 Superstructures Number

Structure		Span (m)	Number
Overpass		60.0	23
Viaduct	National Road	45.0	8
	Kabupaten Road	40.0	9
	Desa Road	30.0	12
Bridge		5.0	22
		14.5	2
		24.0	4
		37.5	3
		45.0	40

Note: Span represents average span

Table-5.6.4 Number of Abutments and Piers

Structure		Abutment Number Height (m)	Number	Pier Number Height (m)	Number
Overpass	National Road	4.0	62	7.0	85
and	Kabupaten Road	4.0	12	6.5	12
Viaduct	Desa road	4.0	24	5.0	24
Bridge		5.0	76	10.0	9
		8.0	14	20.0	9
		10.0	6	30.0	7

5.6.6 Construction Cost Estimates

The total project cost for the construction of a new road comes to approimately 565,299 million Rupiah, inclusive of the cost of a 3 kilometer tunnel. The average cost per kilometer is 6,746 million Rupiah.

5.7 Alternative 4 (Sukabumi Route New Road)

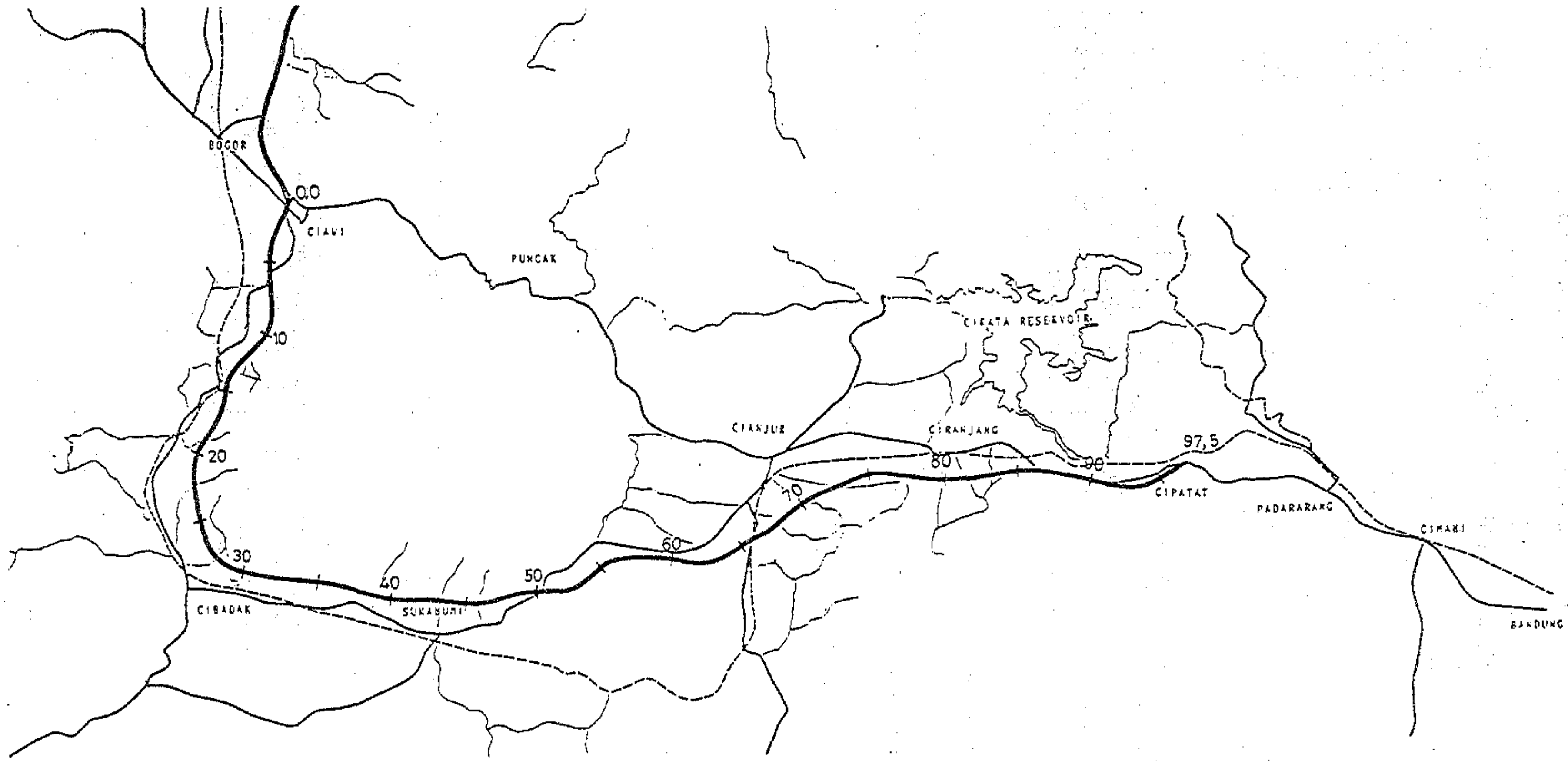
5.7.1 Route Location

Alternative 4 calls for the construction of a new road which will link the cities of Ciawi, Cibadak, Sukabumi, Cianjur, and Citatah. Between Ciawi and Cibadak the route passes through many ridges and valleys of Mt. Gede.

Fig.-5.7.1 shows the suggested route. The route section, from its starting point, at the Jagorawi Highway to Sta. 7 will be located west of the existing road. The route will then cross the existing road and run between Mt. Gede and the existing road up to Sta. 50. At Sta. 50, east of Sukabumi, the route will once more cross the existing road running south of Cianjur up to Rajamandala toll bridge (4 km) where it is proposed that the route uses that bridge. After the bridge the route will travel south of the existing road up to Citatah, its ending point.

5.7.2 Appreciation of the Route

The extension of the new road proposed in Alternative 4 is 97.5 km, and according to Table-5.7.1, the land use activity along the suggested route is mainly that of rice paddy-fields with 62% of the total. Between Ciawi and Cibadak the route passes through mountainous land where the main activitiy along the route is agriculture, mainly casaba cultivation, followed by rice paddy-fields.



Feasibility Study on Bogor - Bandung Road Project	Fig.-5.7.1 Alternative 4 Route Location Map

Table-5.7.1 Land Use along Alternative 4 Route

Section	Housing (km)	Paddy Field (km)	Plantation (km)	Others (km)	Total (km)
Ciawi-Cibadak	-	8.0	-	18.5	26.5
Cibadak-Sukabumi	-	11.3	-	6.7	18.0
Sukabumi-Cianjur	-	27.1	-	4.7	31.8
Cianjur-Citatah	-	14.5	-	6.7	21.2
Total	0.0	60.9	0.0	36.6	97.5

The highest elevation of the route is located west of Sukabumi, at an elevation of 825 meters above sea level, while the lowest elevation is south of Cianjur, at 500 meters above sea level (Fig.-5.7.2). The average grade of the route is 2.5% and the maximum grade of 4.5% will be applied in areas where the topographic conditions are severe.

5.7.3 Traffic Demand

Fig.-5.7.3 shows the daily traffic volumes along the new road proposed in Alternative 4 in the year 2010.

The traffic volume at the Ciawi-Cibadak section is estimated at 19,900 vehicles per day, and the truck share is 20.9%.

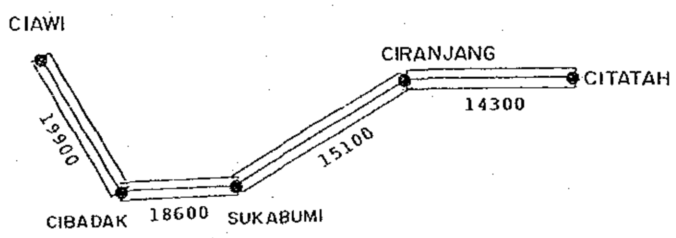
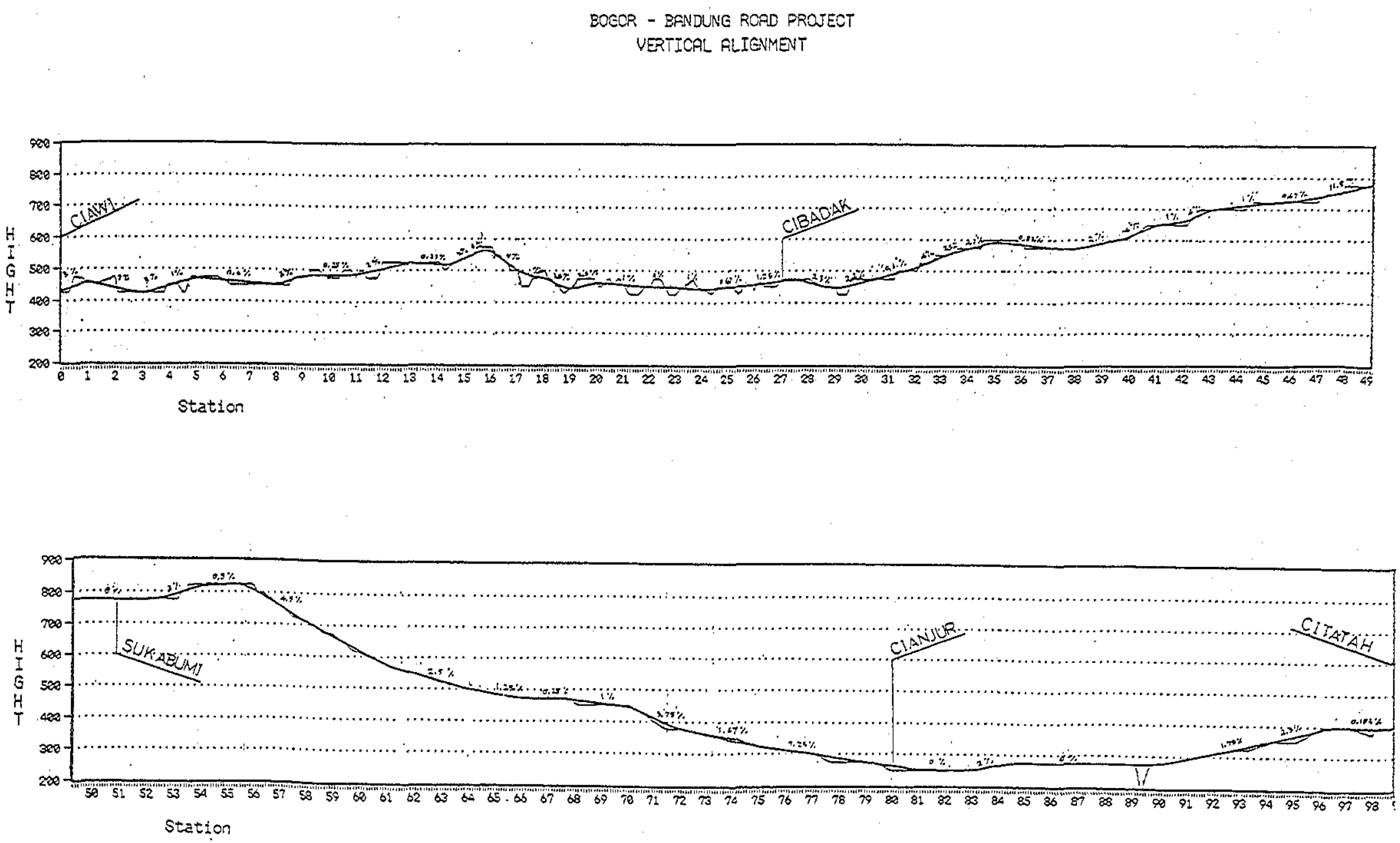


Fig.-5.7.3 Traffic Demand on Alternative 4 Route in 2010

5.7.4 Engineering Features

The route of this alternative passes through steep topography and mountainous area between Sta. 9 and Sta. 12, and Sta. 17 and Sta. 27 therefore a number of long span bridges and viaducts are required. The topography of the area which this route passes is better than that in the case of Alternative 3.



Feasibility Study on Bogor - Bandung Road Project

Fig.-5.7.2 Alternative 4 Vertical Alignment

5.7.5 Construction Aspects

The planned route of the new road passes through steep topography in mountainous area (Sta. 9 to Sta. 12, and Sta. 17 to Sta. 27) and some bridges, overpasses and viaducts are planned with long span lengths. The numbers of overpasses, bridges and viaducts and related data are shown in Tables-5.7.2 to 5.7.4.

Table-5.7.2 Overpass, Bridge and Viaduct Numbers

Structure	Length	Number
Overpass	60 m	40
Viaduct	45 m	8
	40 m	13
	30 m	22
Bridge	- 10 m	46
	10 - 20 m	17
	20 - 30 m	5
	30 - 40 m	2
	40 - 50 m	7
	50 - 60 m	2
	70 - 80 m	1
	90 - 100 m	4
	100 - 150 m	2
	150 - 200 m	3
	200 - 250 m	1
TOTAL		173

Table-5.7.3 Superstructures Number

Structure		Average Span (m)	Number
Overpass		60.0	40
Viaduct	National Road	45.0	8
	Kabupaten Road	40.0	13
	Desa Road	30.0	22
Bridge		5.0	46
		14.5	18
		24.0	7
		37.5	5
		45.0	38

Note: Span represents average span

Table-5.7.4 Number of Abutments and Piers

Structure		Abutment Number Height (m)	Number	Pier Number Height (m)	Number
Overpass	National Road	4.0	96	7.0	136
and	Kabupaten Road	4.0	26	6.5	26
Viaduct	Desa road	4.0	44	5.0	44
Bridge		5.0	144	10.0	8
		8.0	28	20.0	9
		10.0	8	30.0	6

5.7.6 Construction Cost Estimates

The total project cost for the construction of a new road comes to approximately 429,201 million Rupiah. The average cost per kilometer is 4,279 million Rupiah.

Comparing the cost by unit section, Section 9 (Ciawi - Cibadak) is the highest at 6,258 million Rupiah per kilometer, and the cost of bridge construction in that section is 25,769 million Rupiah.

CHAPTER 6 FUTURE TRAFFIC DEMAND FORECAST

6.1 Method of Traffic Demand Forecast

6.1.1 Vehicle Trip Generation/Attraction Sub-model

To establish the vehicle trip generation/attraction sub-model, the relationship between generation/attraction of present OD tables and socio-economic indicators was analyzed.

Indicators which were collected by zone for the analysis are as follows;

- Population
- Economic activity
- Number of employees
  Primary, secondary, tertiary
- Number of households
- Number of registered vehicles
  Car, Bus, Truck

As a result of the analysis, variables were selected and parameters were calculated as shown in Table-6.1.1.

Table 6.1.1 Parameters of Generation/Attraction Sub-model

Vehicle Type	Generation/ Attraction	Parameter					Multiple Correlation Coefficient	Standard Error (F Value)
		Population	Number of Employees			Constant		
			Primary	Secondary	Tertiary			
Angkutan Kota	Generation	-1.6607			11.0570	1752.04	0.869	1952.5
	Attraction	-1.6607			11.0570	1752.04	0.869	1952.5
Bus	Generation	-0.6207			4.8804	390.21	0.947	585.0
	Attraction	-0.6211			4.8784	392.52	0.947	582.2
Passenger Car	Generation	-1.2354			9.1623	1230.64	0.912	1388.9
	Attraction	-1.2365			9.1776	1228.24	0.911	1403.4
Light Truck	Generation	-0.4619			3.1610	600.31	0.870	568.3
	Attraction	-0.4644			3.1899	594.19	0.873	565.4
Heavy Truck	Generation		-3.9931	6.7922	2.9246	684.98	0.980	685.0
	Attraction		-4.0163	6.7712	2.9671	673.70	0.981	683.9

At the time models were determined, the following points were considered.

- Higher figure of regression coefficient
- Easy understanding of the equation meaning
- Availability of indicators in future

Every model can be considered statistically sufficient enough to explain the relationship as multiple regression coefficient and standard error show. However, Fig.-6.1.1 displays the difference between the real value and estimated figure by zone. Therefore, this difference by zone will be applied to estimate future vehicle trip generation/attraction as a zonal adjustment coefficient.

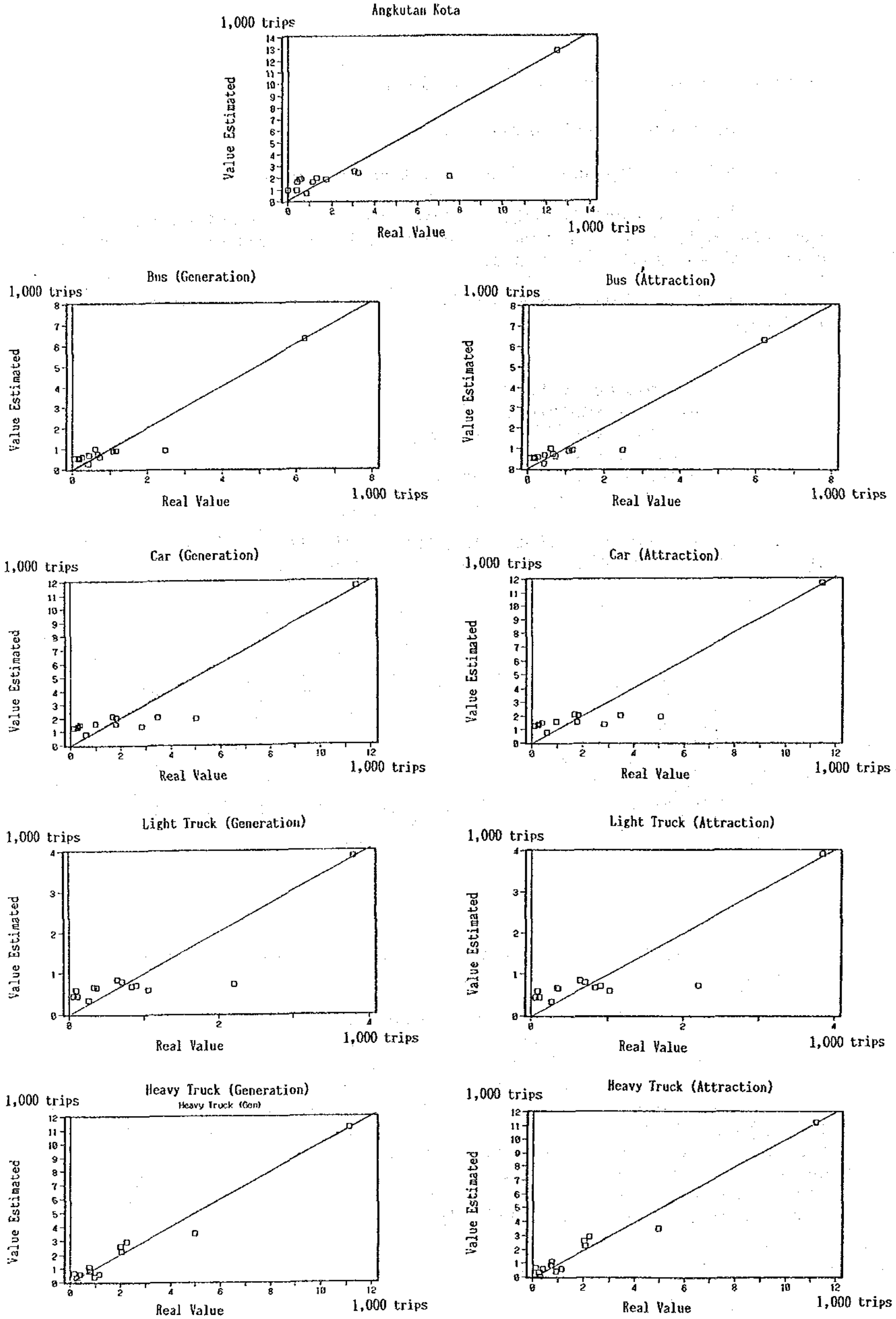


Fig.-6.1.1 Comparison of Real Value and Estimated Figure

6.1.2 Vehicle Trip Distribution Sub-model

Inter-zonal vehicle trips, actual generation/attraction and distance between zones were analyzed in order to obtain the vehicle trip distribution sub-model.

The distances between zones measured along the shortest route on a map were used.

Table-6.1.2 shows the analysis results and good fitness is indicated by the high correlation coefficients.

Table-6.1.2 Parameters of Vehicle Trip Distribution Sub-model

Vehicle Type	Parameter				Correlation Coefficient
	K	α	β	γ	
Angkutan Kota	258.0329	0.4912	0.3408	-1.5326	0.80
Bus	0.3359	0.6944	0.6840	-0.8292	0.87
Passenger Car	296.2717	0.4309	0.4887	-1.7545	0.94
Light Truck	39.1972	0.4892	0.4735	-1.3298	0.88
Heavy Truck	3.1524	0.6287	0.5465	-1.2169	0.83

Note: Formula of models is as follows;

$$Tij = K * \frac{(Gi^{**}\alpha)*(Aj^{**}\beta)}{Dij^{**}\gamma}$$

Where Tij : Vehicle trips distributed between i zone and j zone
Gi : Generation of i zone
Aj : Attraction of j zone
Dij : Distance traveled between i zone and j zone
K, α, β, γ : Parameters of models

6.1.3 Traffic Assignment Sub-model

1) OD Assignment to links

The process by which traffic between zones will be assigned to the links is shown in Fig.-6.1.2.

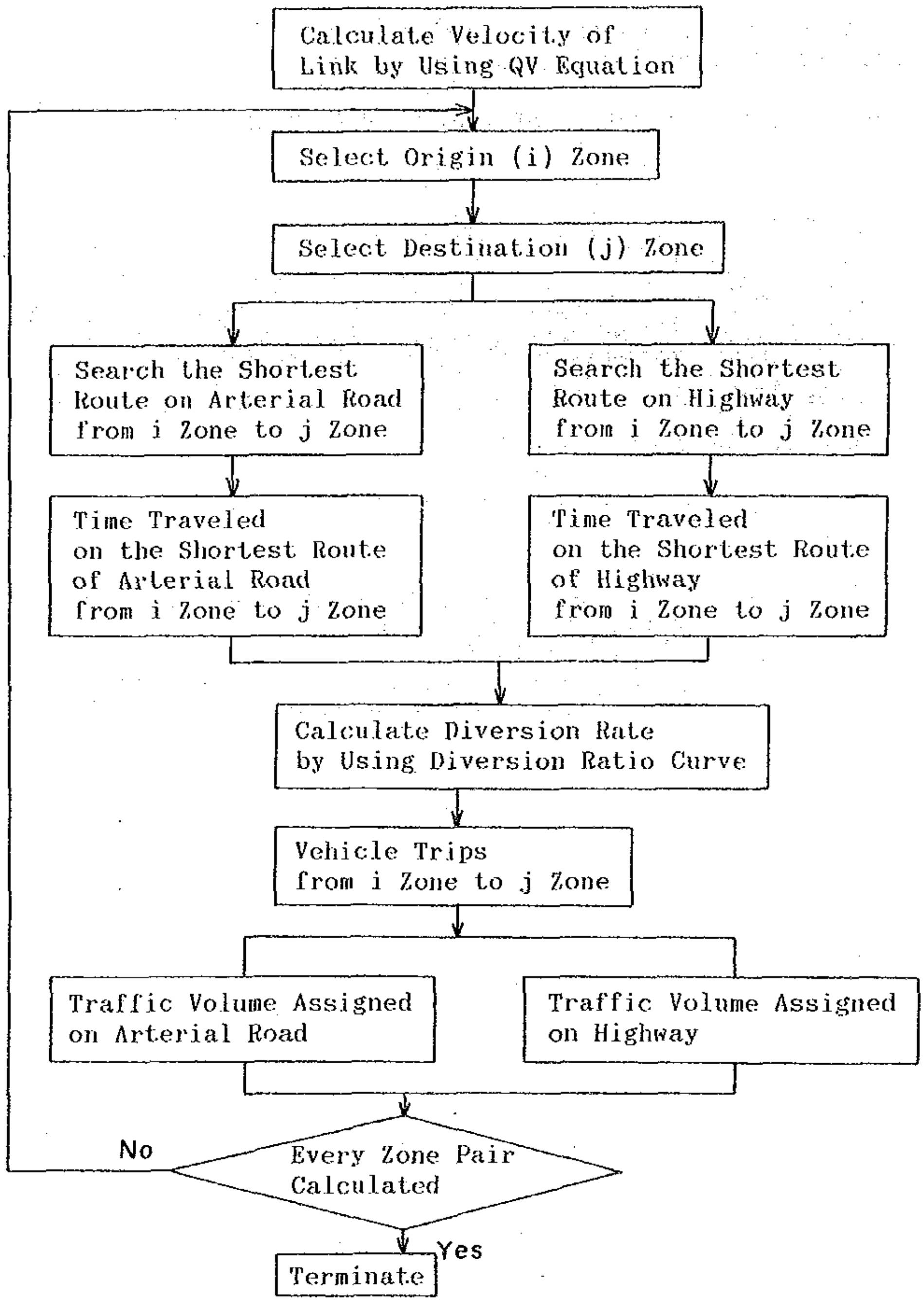


Fig-6.1.2 Process of Traffic Assignment

2) Toll Road Diversion Ratio Curve

In the traffic assignment process explained in the foregoing, a key point is the toll road diversion ratio curve. The toll road diversion ratio curve calculates how many vehicle trips will be operated on a toll road and how many on an arterial road.

Generally, the diversion rate can be decided by the toll and travel time difference between a highway and an arterial road. If a driver is willing to pay toll, he can reach his destination faster using the toll road. Therefore, the diversion rate can be described as a proportion of toll and travel time difference.

Fig.-6.1.3 indicates the relationship between diversion rate and proportion of toll and travel time difference by vehicle type. This data was obtained from the road side OD survey which was carried around Jagorawi Highway. Travel time difference was calculated by comparing that of the shortest route on a highway and on an arterial road. Figures for angkutan kota and bus are not included because they are assumed not to be diverted to the toll road.

The following three equations were calculated using this data and the diversion ratio curves are shown in Fig.-6.1.4 respectively for each vehicle type.

$$P = \frac{1.0}{1.0 + 2.855E\text{-}5 \times (X/T)^{2.27684}} \quad \text{(Passenger car)}$$

$$P = \frac{1.0}{1.0 + 5.870E\text{-}4 \times (X/T)^{1.74818}} \quad \text{(Light truck)}$$

$$P = \frac{1.0}{1.0 + 6.078E\text{-}5 \times (X/T)^{2.34860}} \quad \text{(Heavy truck)}$$

where P: Diversion rate
X: Toll rate (Rp.)
T: Travel time difference (minute)

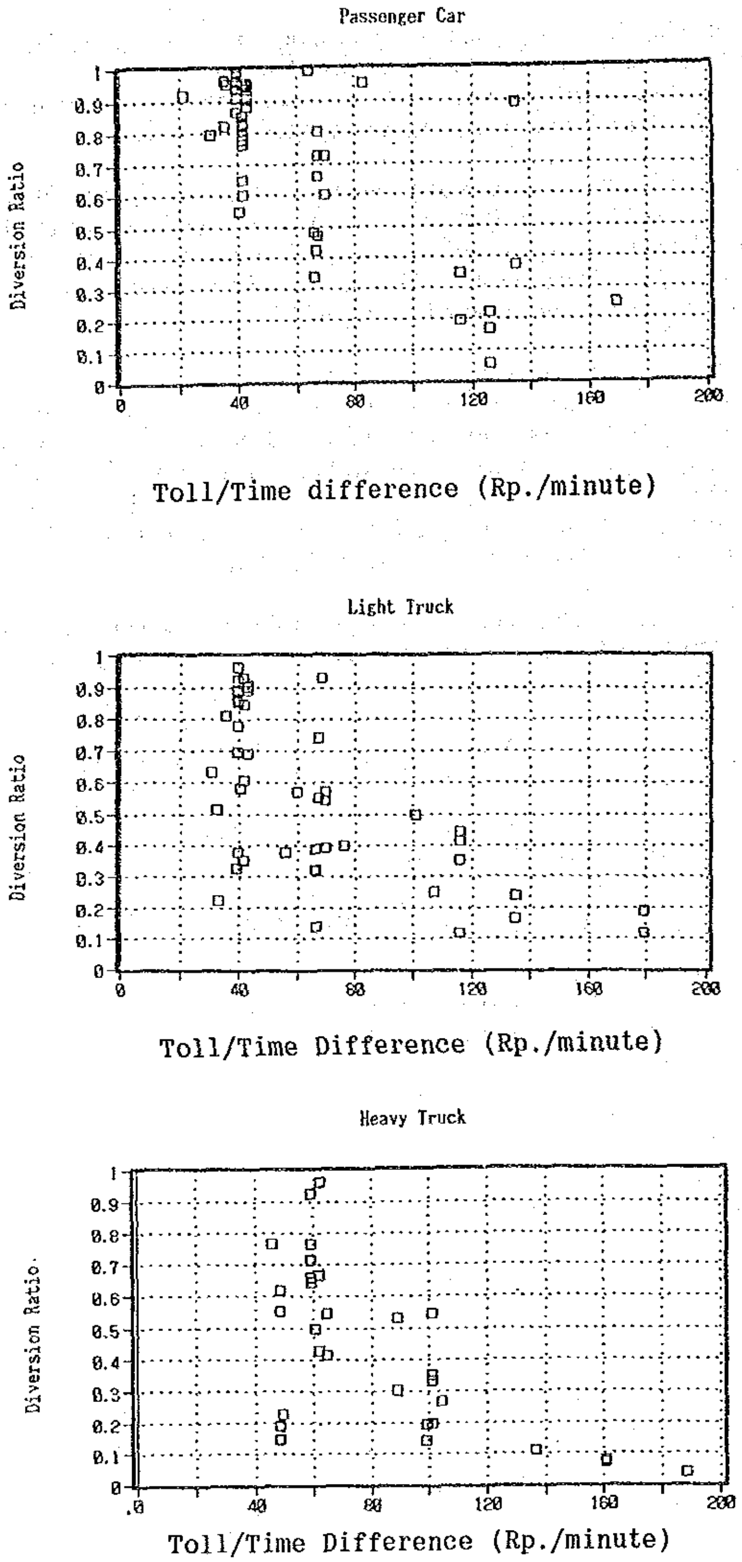
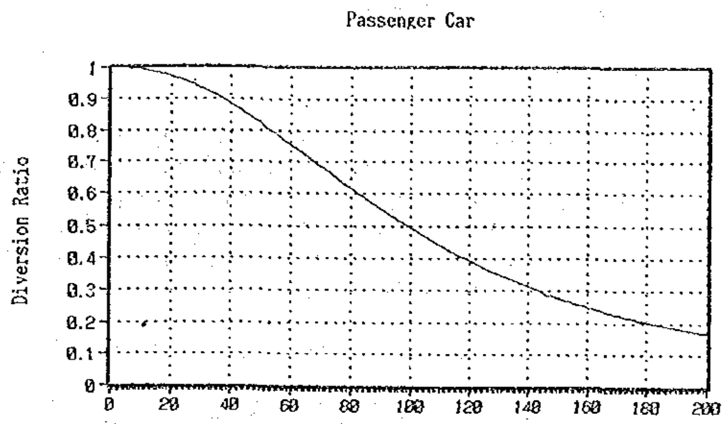
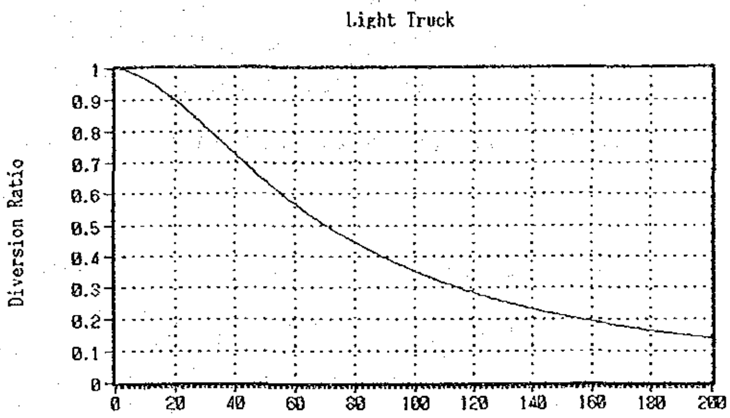


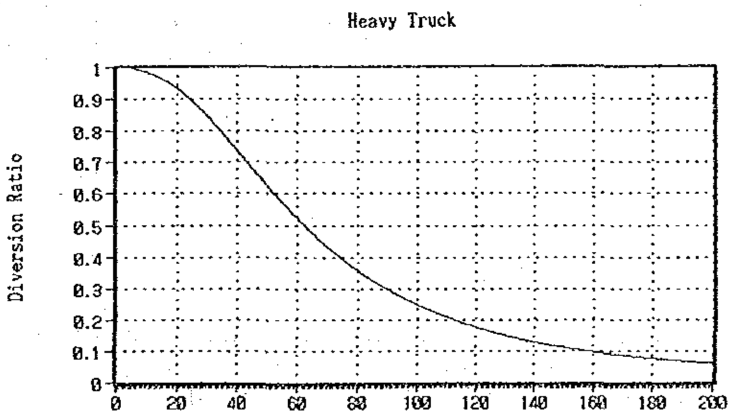
Fig.-6.1.3 Relationship between Diversion Rate and Toll/Time Difference



Toll/Time difference (Rp./minute)



Toll/Time Difference (Rp./minute)



Toll/Time Difference (Rp./minute)

Fig.-6.1.4 Diversion Ratio Curve

6.2.1 Future OD Tables

1) Future Trip Generation/Attraction

(1) Trip Production

Comparing generation of existing OD tables with vehicle ownership, the units of vehicle trip production can be obtained (see Table-6.2.1). Multiplying future vehicle ownership figures with these trip production units, the future trip production by vehicle type, which will be a control total of generation/attraction in the forecast area, can be calculated as shown in Table-6.2.2.

Table-6.2.1 Unit of Vehicle Trip Production

Type of Vehicle	Total Amount of Generation in 1989	Vehicle Ownership of Jawa in 1989	Unit of Vehicle Trips Generated
Angkutan Kota	33,000		0.189
Bus	14,500	174,540	0.083
Passenger Car	30,500	623,245	0.049
Light Truck	11,000		0.029
Heavy Truck	27,000	375,396	0.072
Total	116,000	1,173,181	0.099

Note: Existing vehicle ownership was estimated by JICA team.

Table-6.2.2 Future Trip Production in the Forecast Area

Type of Vehicle	Vehicle Ownership (*1,000Veh.)		Generation/ Attraction	
	2000	2010	2000	2010
Angkutan Kota			60,700	69,900
Bus	321	370	26,600	30,700
Passenger Car	1,256	1,942	61,500	95,200
Light Truck			18,800	23,500
Heavy Truck	648	811	46,700	58,400
Total	2,225	3,123	214,300	277,700

(2) Generation/Attraction

Future socio-economic indices indicated in Table-6.2.3 will be input in the vehicle trip generation/attraction sub-model so that future generation/attraction by zone can be calculated.

Table-6.2.3 Future Socio-economic Indices

Zone No.	2000					2010				
		Number of Employee					Number of Employee			
	Population (*1,000)	Total (*1,000)	Primary (*1,000)	Secondary (*1,000)	Tertiary (*1,000)	Population (*1,000)	Total (*1,000)	Primary (*1,000)	Secondary (*1,000)	Tertiary (*1,000)
1	10,934	3,893	57	743	3,093	12,508	4,978	53	910	4,015
2	4,507	1,748	423	498	827	5,448	2,349	486	686	1,177
3	1,094	473	209	36	228	1,250	587	236	45	306
4	1,311	567	251	43	273	1,497	704	283	54	367
5	1,910	744	252	134	358	2,101	807	252	152	403
6	6,078	2,367	802	425	1,140	7,068	2,716	849	510	1,357
7	5,431	2,172	908	334	930	5,635	2,406	915	378	1,113
8	3,020	1,172	284	334	554	3,978	1,716	355	501	860
9	2,592	1,006	244	286	476	3,660	1,578	326	461	791
10	3,654	1,361	532	286	543	4,154	1,618	575	349	694
11	2,446	1,051	502	71	478	2,758	1,269	566	89	614
12	1,373	590	282	40	268	1,462	673	301	47	325
13	7,418	2,596	1,329	211	1,056	8,327	2,818	1,326	229	1,263
Total	51,768	19,740	6,075	3,441	10,224	59,846	24,219	6,523	4,411	13,285

Table-6.2.4 shows the estimation result which is a controlled total with the trip production mentioned above. In Central Java the trip generation/attraction was estimated by the growth rate of vehicle ownership and existing trip generation/attraction because it is outside of the forecast area.

Table-6.2.4 Future Trip Generation/Attraction by Zone

Zone	Generation					Attraction				
	1989	2000	Growth Rate	2010	Growth Rate	1989	2000	Growth Rate	2010	Growth Rate
1	45,081	83,116	1.84	103,762	2.30	45,209	82,526	1.83	102,507	2.27
2	22,176	34,401	1.55	49,868	2.25	22,208	36,458	1.64	53,490	2.41
3	1,834	3,097	1.69	3,486	1.90	1,866	3,123	1.67	3,506	1.88
4	5,825	10,266	1.76	12,327	2.12	5,815	10,124	1.74	12,103	2.08
5	5,830	12,029	2.06	12,873	2.21	5,792	11,745	2.03	12,491	2.16
6	7,501	18,879	2.52	22,458	2.99	7,542	18,635	2.47	22,037	2.92
7	586	1,938	3.31	2,524	4.31	571	1,878	3.29	2,428	4.25
8	9,100	14,847	1.63	21,189	2.33	9,080	14,703	1.62	20,900	2.30
9	8,572	12,716	1.48	18,492	2.16	8,582	12,630	1.47	18,301	2.13
10	2,881	8,692	3.02	11,143	3.87	2,861	8,580	3.00	10,941	3.82
11	4,465	9,637	2.16	11,639	2.61	4,425	9,470	2.14	11,402	2.58
12	1,226	2,561	2.09	2,758	2.25	1,191	2,483	2.08	2,658	2.23
13	1,766	6,154	3.48	9,839	5.57	1,753	6,048	3.45	9,672	5.52
14	3,172	4,103	1.29	4,745	1.50	3,120	4,033	1.29	4,667	1.50
Total	120,015	222,436	1.85	287,103	2.39	120,015	222,436	1.85	287,103	2.39

Note: Growth rate is calculated by dividing future figures with existing figures.

2) Future OD Tables

Inputting the figures for trip generation/attraction calculated in the former section in the vehicle trip distribution sub-model, the future OD table by type of vehicle can be obtained. These tables are displayed in Appendixes B and C at the end of this Report.

The distance between zones is assumed to be the same as that which was used when the vehicle trip distribution model was made. This assumption is made on the following basis. It may be said that distance between zones should be changed for each alternative because it depends on the network which is different in each alternative. However, if different figures are applied for the distance between zones, the future OD tables should be estimated by alternative. Consequently, in such a situation results in the alternatives can not be evaluated under the same conditions.

The traffic volumes crossing the screen lines A, B and C in the future are shown in Fig.-6.2.1. The figure shows that the traffic volumes crossing screen lines A, B, C will increase by growth rates of 2.27, 2.39, and 2.61 in 2010 respectively compared to the corresponding 1989 volumes.

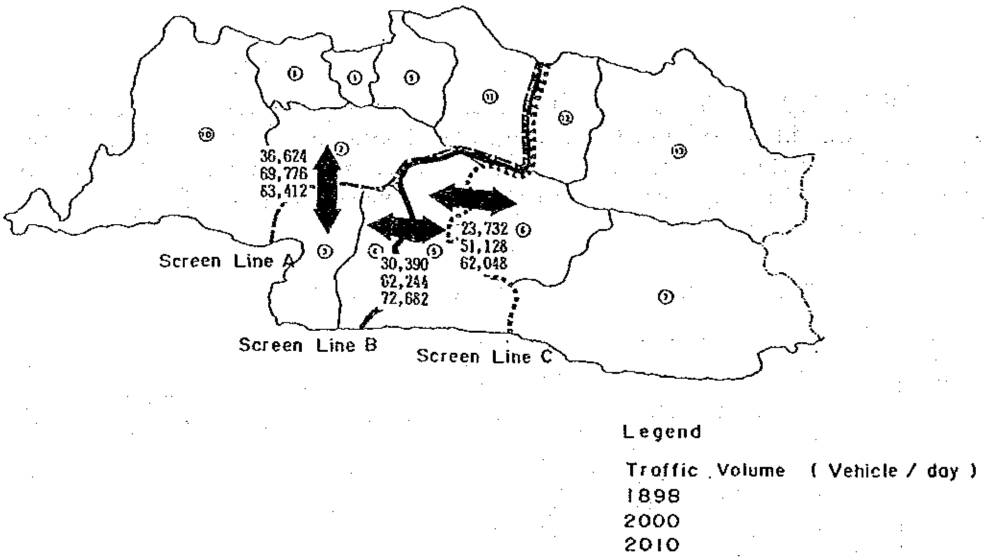


Fig.-6.2.1 Growth of Traffic Volume across the Screen Lines

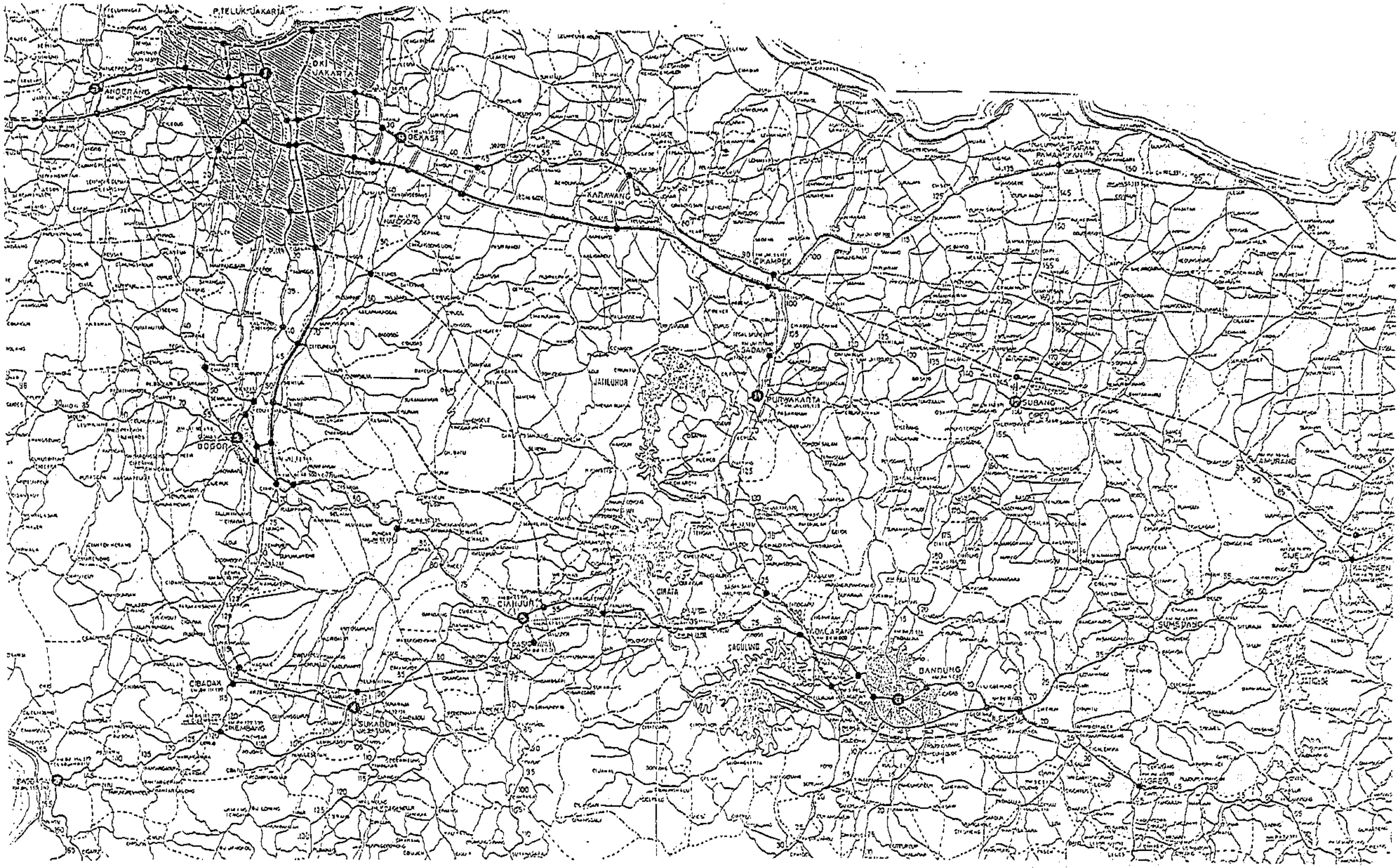
It is evident that road development methods are necessary in order to cope with this increase in the future.

6.2.2 Future Traffic Volume Assignment

1) Presupposition

(1) Network

The network included in the estimation consists of National Highways, state roads and provincial roads covering all of West Java.

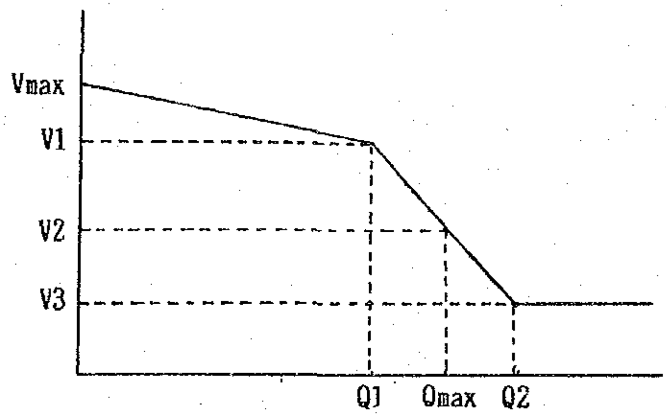


Feasibility Study on Bogor-Bandung Road Project | Fig.-6.2.2 Network Included in the Estimation

The link lengths are taken from the road network inventory prepared by Bina Marga (See Table-3.1.1, Chapter 3), and are measured off a map when not listed in the inventory.

(2) QV Equation

In the traffic assignment sub-model, the "QV Equation" function will be used in order to calculate travel speed on each link. QV equation which has the curve shape shown in Fig.-6.2.3, defines the relationship between capacity of road and velocity. As shown in the figure, the velocity is assumed to be decreasing according to the increase in traffic volume, up to a point where the traffic volume reaches a certain figure beyond which the velocity will be a constant value.



Note: Qmax : Design capacity
Vmax : Design speed
Q1 = Qmax x 0.8
Q2 = Qmax x 1.2
V1 = Vmax x 0.8
V2 = Vmax x 0.5

Fig.-6.2.3 Shape of QV Equation

Thirty six different parameters of the types of QV equation were set up as shown in Table-6.2.5, considering the following items.

- Result of travel speed survey
- Result of traffic count survey
- Road inventory
- Result of site observation

Table-6.2.5 QV Curves

Q-V Equation Number	Survice Level	Number of Lanes	Median Divided	Capacity (Veh/day)		Speed (km/h)		
				Qmax	Q2	Vmax	V2	V3
1	AA	2	Non-divided	7,000	8,400	30.0	15.0	5.0
2	AB	2	Non-divided	8,000	9,600	30.0	15.0	5.0
3	AC	2	Non-divided	8,000	9,600	40.0	20.0	10.0
4	AD	2	Non-divided	8,000	9,600	50.0	25.0	15.0
5	AE	2	Non-divided	9,000	10,800	30.0	15.0	5.0
6	AF	2	Non-divided	10,000	12,000	30.0	15.0	5.0
7	AG	2	Non-divided	11,000	13,200	40.0	20.0	10.0
8	AH	2	Non-divided	12,000	14,400	30.0	15.0	5.0
9	AI	2	Non-divided	12,000	14,400	40.0	20.0	10.0
10	AJ	2	Non-divided	12,000	14,400	50.0	25.0	15.0
11	AK	2	Non-divided	13,000	15,600	40.0	20.0	10.0
12	AL	2	Non-divided	13,000	15,600	45.0	25.0	10.0
13	AM	2	Non-divided	13,000	15,600	60.0	30.0	15.0
14	AN	2	Non-divided	15,000	18,000	40.0	20.0	10.0
15	AO	2	Non-divided	15,000	18,000	60.0	30.0	15.0
16	AP	2	Non-divided	16,000	19,200	80.0	40.0	20.0
17	AQ	2	Non-divided	17,000	20,400	40.0	20.0	10.0
18	AR	2	Non-divided	18,000	21,600	40.0	20.0	10.0
19	AS	2	Non-divided	18,000	21,600	60.0	30.0	15.0
20	AT	2	Non-divided	18,000	21,600	80.0	40.0	20.0
21	AU	4	Divided	34,000	40,800	50.0	25.0	15.0
22	AV	4	Divided	39,000	46,800	30.0	15.0	5.0
23	AW	4	Divided	39,000	46,800	80.0	40.0	20.0
24	AX	2	Separated	45,000	54,000	30.0	15.0	5.0
25	AY	4	Divided	47,000	56,400	40.0	20.0	10.0
26	BA	4	Divided	47,000	56,400	45.0	25.0	10.0
27	BB	4	Divided	47,000	56,400	60.0	30.0	15.0
28	BC	4	Divided	48,000	57,600	40.0	20.0	10.0
29	BD	4	Divided	49,000	58,800	80.0	40.0	20.0
30	BE	4	Divided	49,000	58,800	100.0	50.0	25.0
31	BF	4	Divided	53,000	63,600	50.0	25.0	15.0
32	BG	4	Divided	53,000	63,600	60.0	30.0	15.0
33	BH	4	Divided	55,000	66,000	80.0	40.0	20.0
34	BI	4	Divided	56,000	67,200	60.0	30.0	15.0
35	BJ	4	Divided	59,000	70,800	60.0	30.0	15.0
36	BK	6	Divided	74,000	88,800	100.0	50.0	25.0

Note: Qmax is the design capacity. Q2 is calculated by multiplying Qmax by 1.2

(3) Toll Rate

The future network in the forecast area includes six toll roads as follows;

- Jagorawi Toll Road
- Jakarta-Tangerang Toll Road
- Jakarta-Cikampek Toll Road
- Cikampek-Padalarang Toll Road
- Cikampek-Cirebong Toll Road
- Citarum-Rajamandala Toll Bridge

Drivers must pay toll. This toll price is the most important factor which influences the decision of diversion from arterial road to toll road.

The future toll rate should be input in the traffic assignment sub-model. However, it is very difficult to determine the future toll system. Therefore, the present toll rate is assumed to be continuously used in the future. Besides, the following toll rate will be applied to the planned road development projects such as Cikampek-Padalarang Toll Road. This rate is obtained by inflating that authorized in the 1987 report of "Cikampek Padalarang Tollway Feasibility Study" to the present price.

- Toll rate in 1987 : 45 Rp./km of passenger car
- Inflator from May 1987 to June 1989: 1.182
- Toll rate in 1989 : 53 Rp./km

The toll rate for truck is assumed to be twice the above mentioned value.

2) Assignment

(1) Traffic Volume Assigned and Traffic Congestion

The summary of the estimation result in 2010 is described in Table-6.2.6. The calculation of "Do nothing" case which includes the established projects was done for the purpose of comparison with the results of the alternatives.

Table-6.2.6 Summary of Estimation Results

Route				Do Nothing			Alternative 1			Alternative 2			Alternative 3			Alternative 4		
City		City	Type of Road	Traffic Volume (veh/day)	Truck Ratio	*1 Cong. Rate	Traffic Volume (veh/day)	Truck Ratio	Cong. Rate	Traffic Volume (veh/day)	Truck Ratio	Cong. Rate	Traffic Volume (veh/day)	Truck Ratio	Cong. Rate	Traffic Volume (veh/day)	Truck Ratio	Cong. Rate
Ciawi	~	Cianjur	Arterial Road	15,000	21.7%	1.15	24,400	23.0%	0.52	12,400	22.6%	0.95	12,600	20.2%	0.97	12,000	20.9%	0.92
Ciawi	~	Cianjur	Highway										12,000	24.3%	0.26			
Ciawi	~	Cibadak	Arterial Road	17,000	22.5%	1.42	14,800	21.9%	1.23	20,300	22.2%	0.52	14,600	22.8%	1.22	7,600	9.5%	0.64
Ciawi	~	Cibadak	Highway													19,900	27.6%	1.11
Cibadak	~	Sukabumi	Arterial Road	11,900	21.4%	1.08	11,800	21.4%	1.08	19,800	21.1%	0.41	11,400	22.5%	1.04	6,400	10.7%	0.58
Cibadak	~	Sukabumi	Highway													15,100	21.1%	0.84
Sukabumi	~	Cianjur	Arterial Road	11,700	14.6%	1.47	14,000	16.8%	1.75	15,700	15.6%	0.46	14,000	15.7%	1.75	7,100	11.5%	0.89
Sukabumi	~	Cianjur	Highway													15,100	21.1%	0.84
Cianjur	~	Cipatat	Arterial Road	23,200	17.9%	1.93	27,600	19.5%	0.52	29,700	19.3%	0.56	13,700	18.1%	1.14	13,300	18.5%	1.11
Cianjur	~	Cipatat	Highway										13,500	19.9%	0.75	14,300	19.8%	0.80
Jakarata	~	Bogor	Highway	60,600	31.7%	0.82	59,800	31.5%	0.81	56,800	32.0%	0.77	58,100	31.8%	0.79	57,300	31.9%	0.77
Jakarta	~	Cikampek	Highway	31,100	33.9%	0.64	27,300	33.9%	0.56	32,100	32.4%	0.65	26,400	34.9%	0.54	27,000	34.7%	0.55
Cikampek	~	Padalarang	Highway	20,400	29.2%	0.52	17,400	28.9%	0.44	22,000	27.8%	0.56	16,200	29.9%	0.41	16,800	29.7%	0.43

Note: *1 Congestion Rate = Traffic Volume Assigned / Capacity

From this table, the following is pointed out.

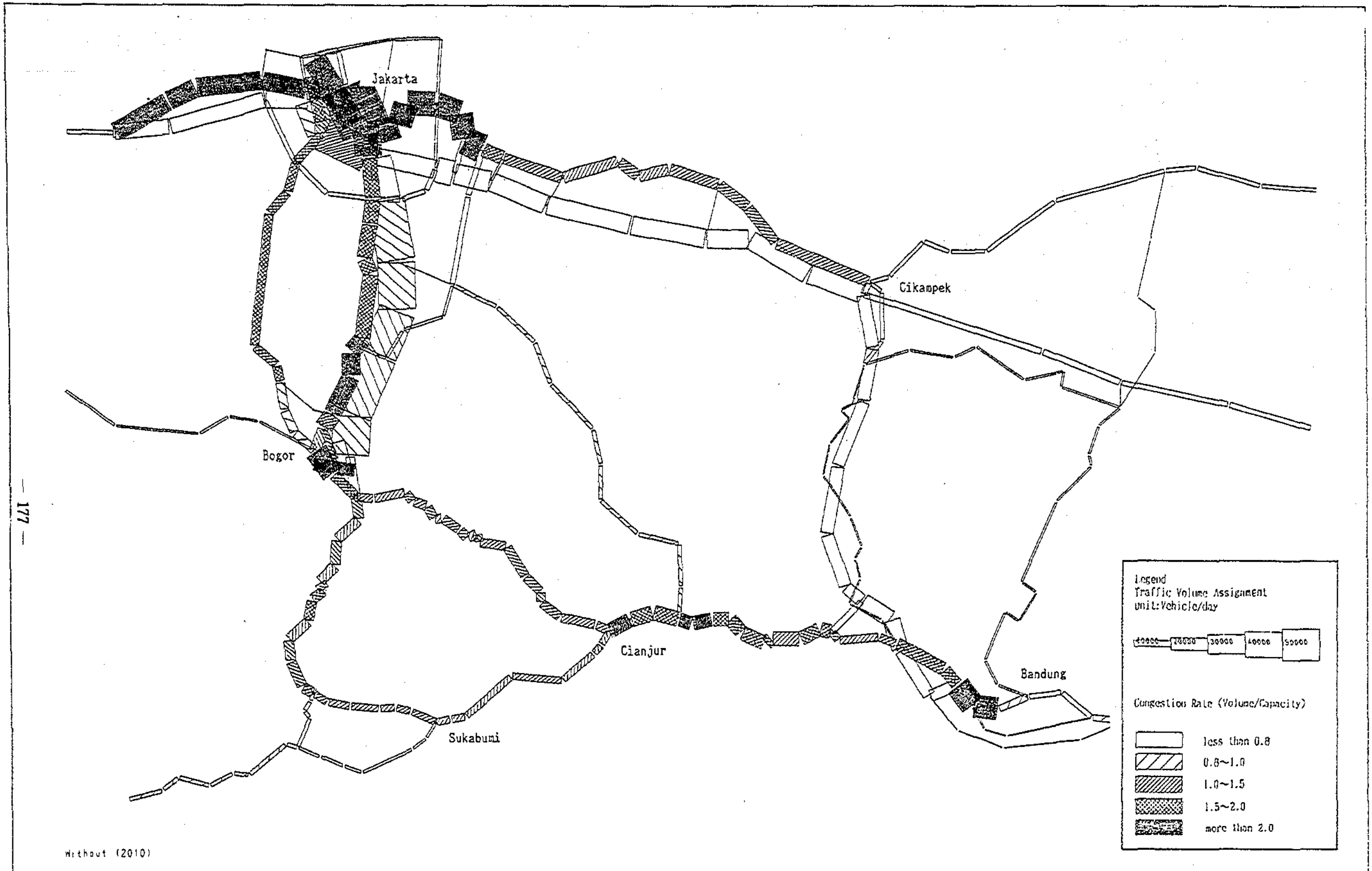
- If no road project is constructed between Bogor and Bandung, congestion rate of all roads between the two cities will exceed 1.0.
- It can be said that alternative 1 and alternative 4 reduce the congestion between Bogor and Bandung.
- The truck ratio of Ciawi - Puncak - Cianjur route is slightly higher than that of other roads. This is because no regulation for truck control was considered in this estimation. Therefore, if inflow of trucks will continuously be controlled without improvement of roads in the future, this may cause congestion of other links.

The traffic volume assignment in 2010 and congestion level of each alternative are shown in Fig.-6.2.4 to Fig.-6.2.8.

Applying the QV equation definition, the congestion rate can be understood as shown in Table-6.2.7.

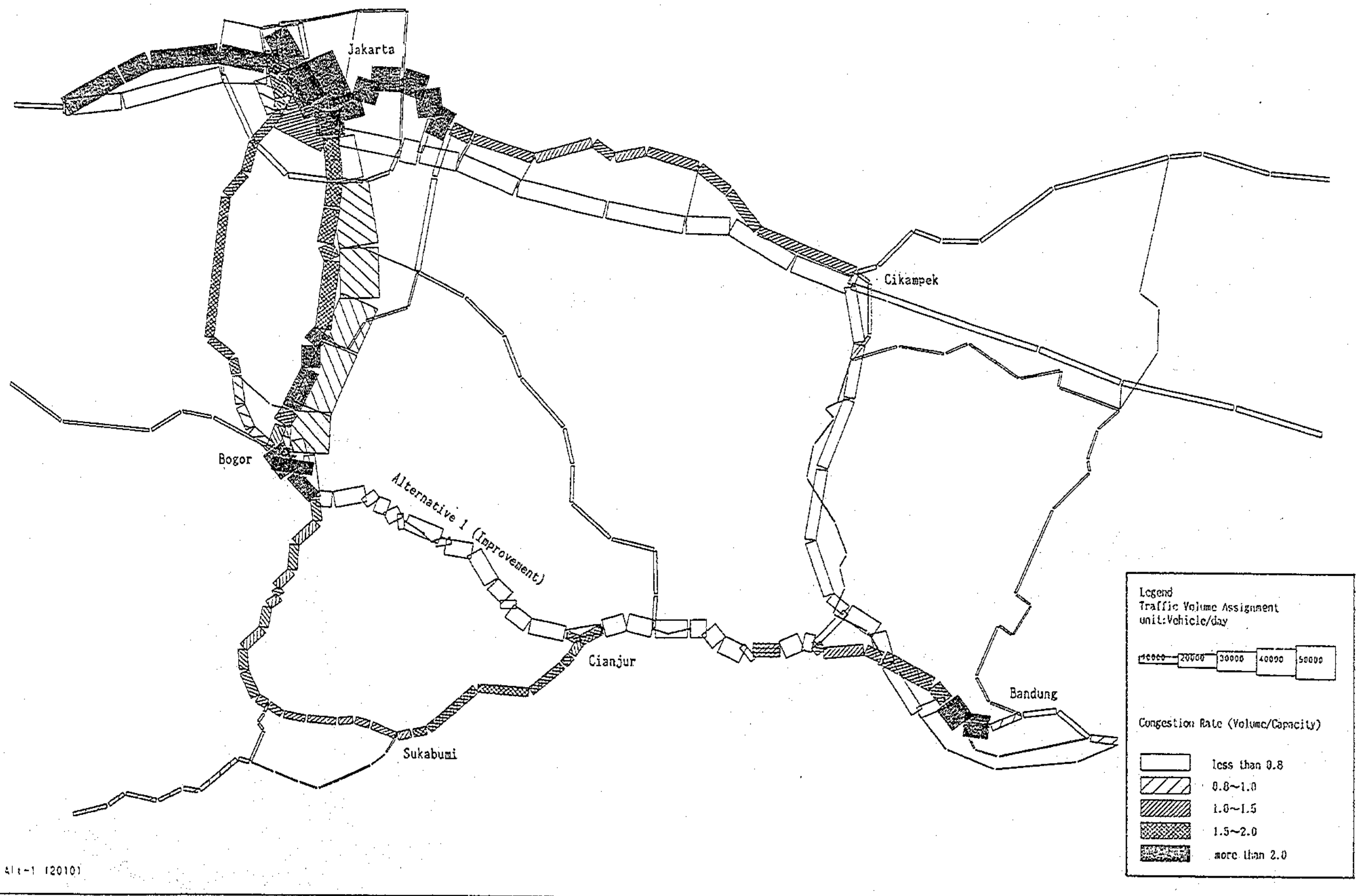
Table-6.2.7 Congestion Rate Interpretation

Congestion Rate	Capacity Conditions	Travel Speed
- 0.8	Not congested	Roughly design speed
0.8 - 1.0	Almost congested	1/2 of design speed
1.0 - 1.2	Congested	20 km/h - 40 km/h
1.2 -	Heavily congested	10 km/h - 20 km/h



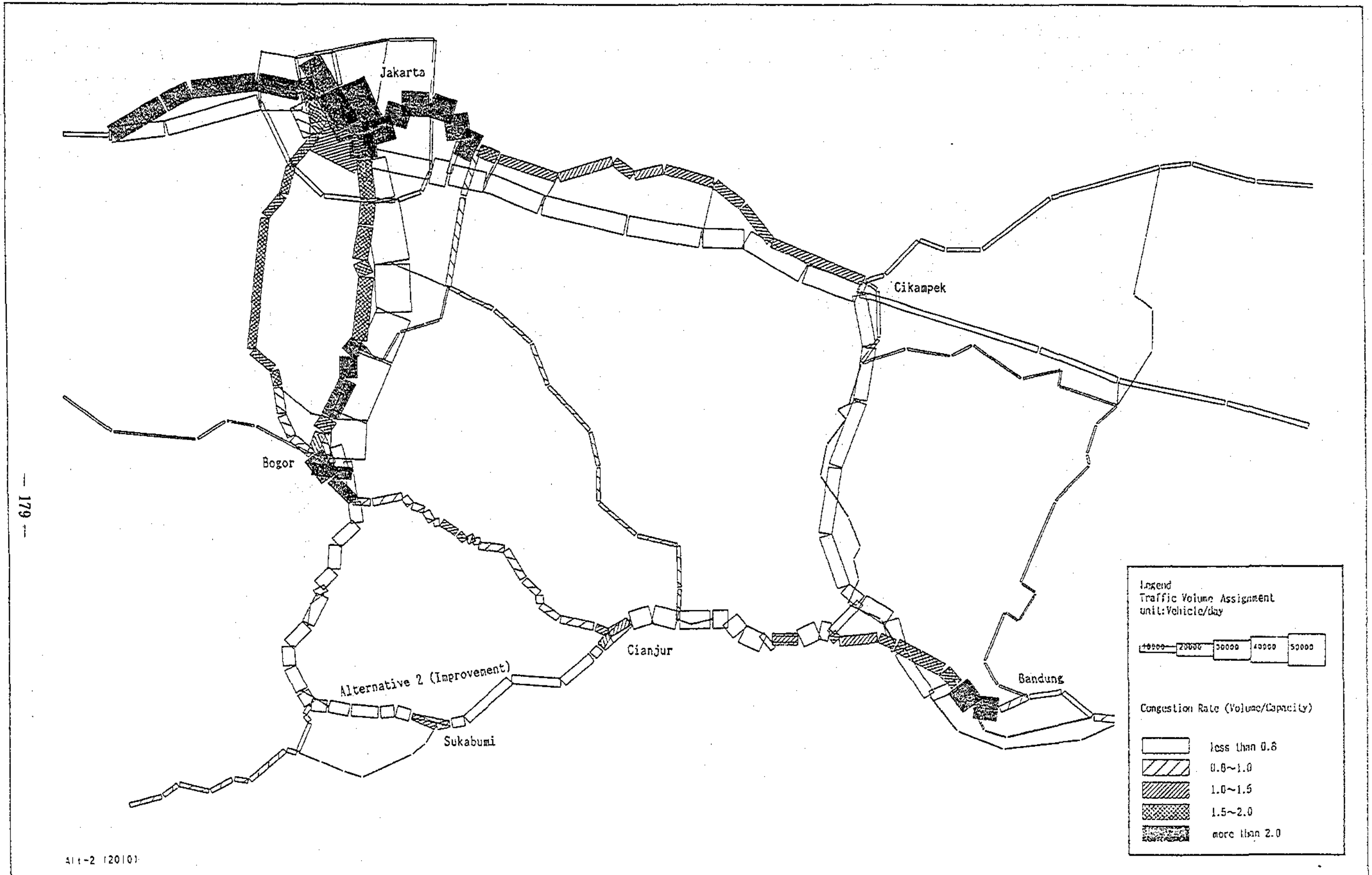
Feasibility Study on Bogor-Bandung Road Project

Fig.-6.2.4 Traffic Volume Assignment and Congestion Rate (Do nothing case in 2010)

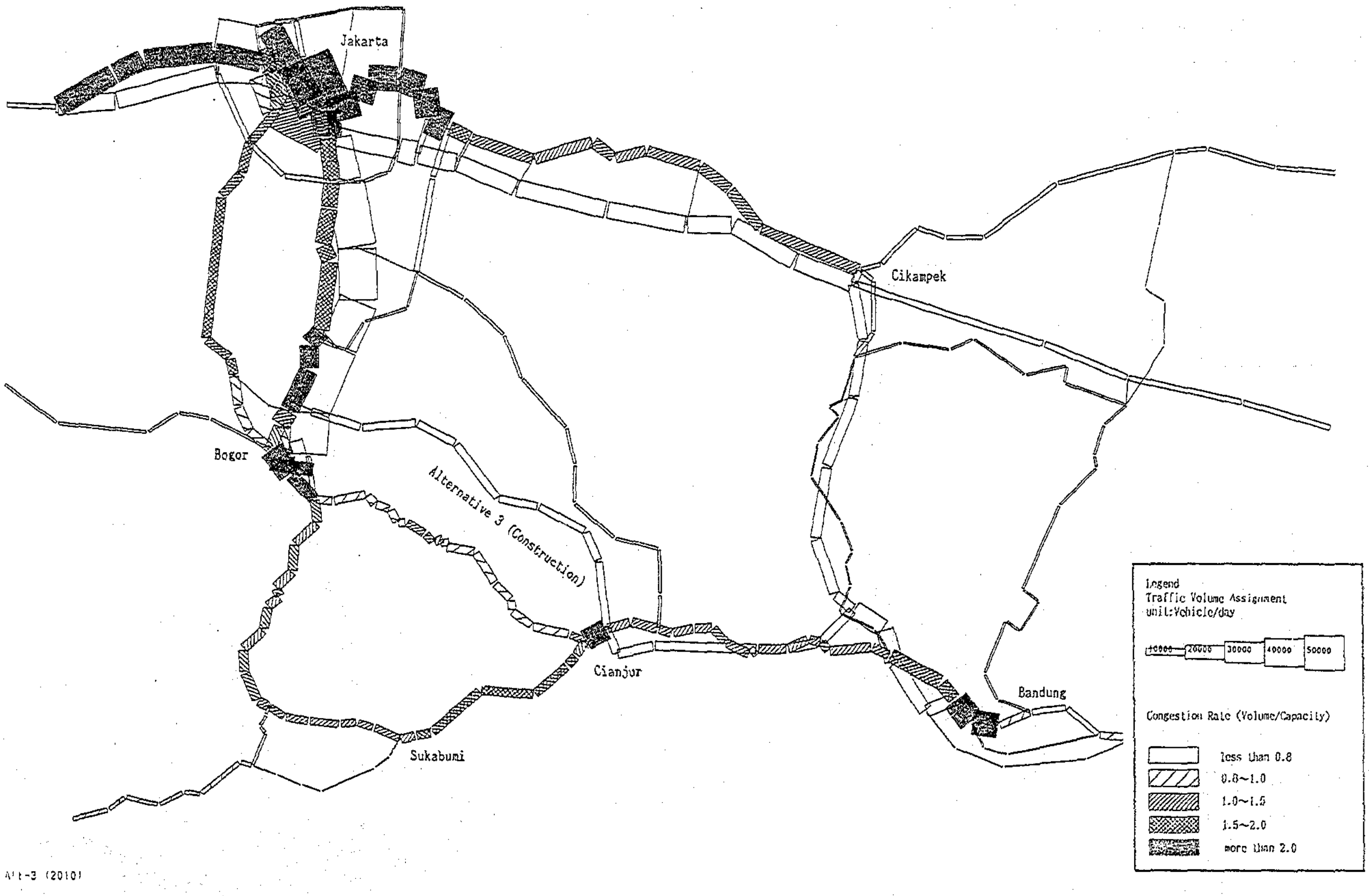


Feasibility Study on Bogor-Bandung Road Project

Fig.-6.2.5 Traffic Volume Assignment and Congestion Rate (Alternative 1 in 2010)

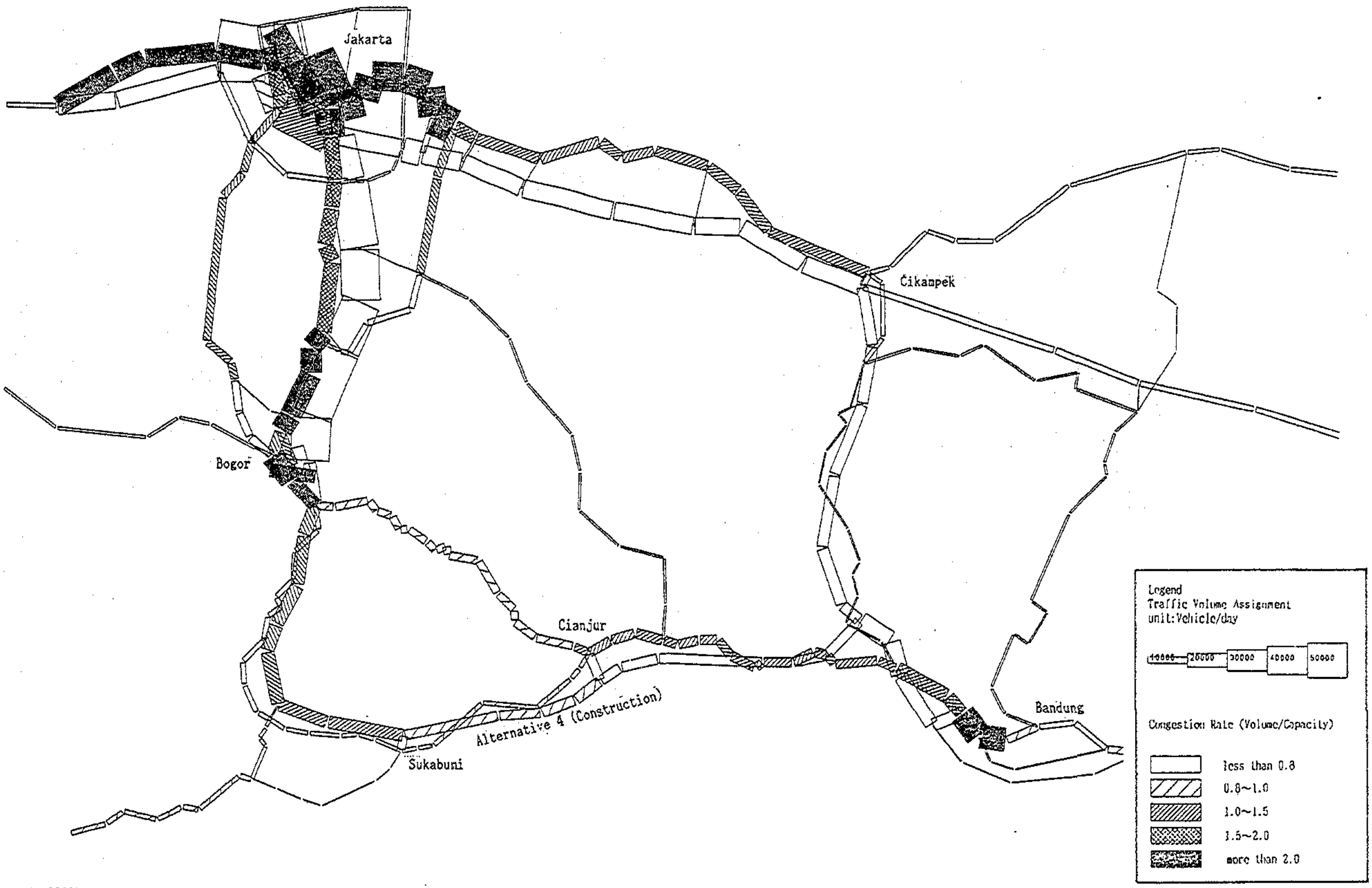


Feasibility Study on Bogor-Bandung Road Project	Fig.-6.2.6 Traffic Volume Assignment and Congestion Rate (Alternative 2 in 2010)



Feasibility Study on Bogor-Bandung Road Project

Fig.-6.2.7 Traffic Volume Assignment and Congestion Rate (Alternative 3 in 2010)



Feasibility Study on Bogor-Bandung Road Project

Fig.-6.2.8 Traffic Volume Assignment and Congestion Rate (Alternative 4 in 2010)

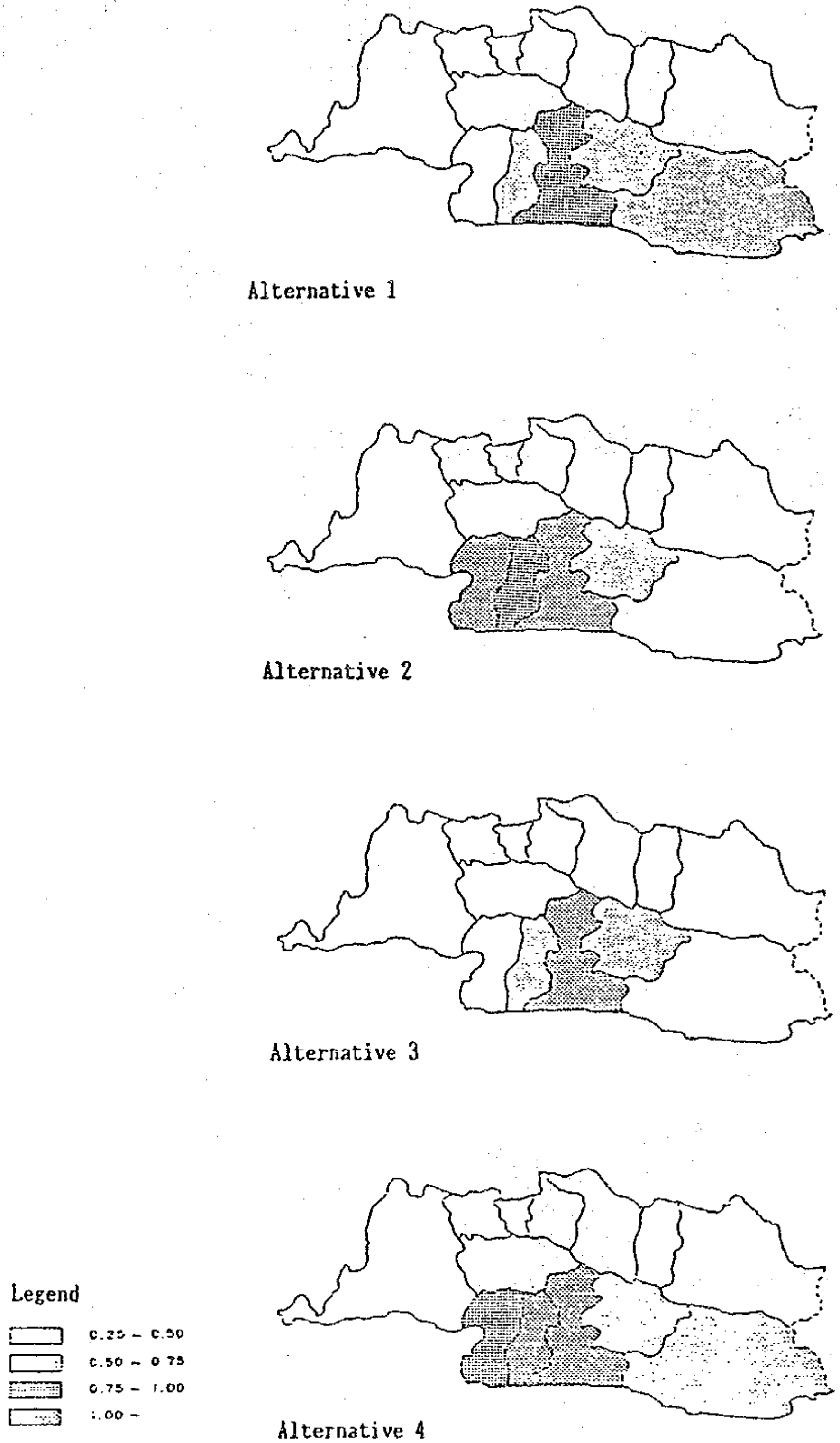


Fig. 6.2.9 Improvement of Accessibility

(2) Accessibility

The indicator "Accessibility" reflects the effects of the road improvement.

Accessibility is defined by the following formula.

$$A_i = \frac{V_{ij} \times T_{ij}}{V_{ij}}$$

where A_i : Accessibility of i zone
V_{ij}: Number of vehicle trips from i zone to j zone
T_{ij}: Time traveled from i zone to j zone

This indicator is the average time traveled weighted by the number of vehicle trips. Therefore, the average ease of reaching the destination of traffic generated from i zone can be evaluated by using the accessibility.

Table-6.2.8 describes the improvement of accessibility by zone and alternatives. Zones in which improvement of accessibility is significant when compared with that of "Do nothing" case were plotted in Fig.-6.2.9.

Table-6.2.8 Accessibility by Zone and Alternative

	Year									
	2000					2010				
	Do	Alternative				Do	Alternative			
Zone	Nothing	1	2	3	4	Nothing	1	2	3	4
1	2.80	2.75	2.76	2.77	2.72	2.78	2.71	2.71	2.75	2.71
2	2.26	2.21	2.20	2.23	2.18	2.48	2.36	2.37	2.41	2.35
3	4.45	4.39	4.10	4.38	3.91	4.67	4.44	4.07	4.50	3.82
4	3.16	3.00	2.73	3.06	2.47	3.41	3.07	2.66	3.15	2.27
5	2.70	2.34	2.45	2.47	2.33	2.99	2.15	2.30	2.25	1.98
6	3.10	3.07	3.03	3.11	3.09	3.25	2.98	2.96	2.95	2.82
7	5.60	5.50	5.55	5.59	5.57	5.57	5.30	5.33	5.37	5.31
8	1.77	1.75	1.76	1.76	1.75	1.87	1.85	1.85	1.86	1.84
9	1.49	1.47	1.48	1.49	1.48	1.66	1.64	1.64	1.64	1.63
10	4.07	4.04	4.05	4.05	4.04	4.16	4.11	4.11	4.14	4.11
11	3.13	3.03	3.09	3.13	3.11	3.24	3.02	3.03	3.16	3.11
12	3.09	3.01	3.05	3.09	3.06	3.16	2.96	2.97	3.06	3.01
13	5.97	5.94	5.93	5.97	5.95	6.31	6.17	6.16	6.23	6.17
14	10.49	10.47	10.49	10.49	10.49	10.97	10.92	10.93	10.94	10.95

In all the alternatives, accessibility of zones along Bogor to Bandung has generally improved. However, accessibility improvement in case of alternative 3 is not so significant and therefore alternative 3 is considered to be an ineffective route in the forecast area.

The accessibility in case of alternative 4 has highly improved. For example, accessibility indicators of Sukabumi and Cianjur are over 1.0.

(3) Vehicle Distance and Vehicle Time

Table-6.2.9 indicates vehicle distance traveled in each alternative.

Table-6.2.9 Vehicle Distance Traveled

Calculation Case	Year		
	1989	2000	2010
Existing	10,824.7	-	-
Do Nothing	-	21,888.3	28,157.4
Alternative 1	-	21,907.0	27,819.0
Alternative 2	-	21,921.2	28,261.4
Alternative 3	-	21,846.1	27,814.6
Alternative 4	-	21,818.5	27,835.8

Note: unit is 1,000 vehicle*km per day

The figures for vehicle distance traveled do not differ much among the alternatives. This is because the project is not a short cut route.

On the other hand, vehicle time traveled figures shown in Table-6.2.10 clearly display the effect of the improvement induced by the alternative. In particular alternative 4 shows a saving in vehicle time traveled of 150 vehicle.hour when compared to the corresponding value of the "Do nothing" case in the year 2010.

Table-6.2.10 Vehicle Time Traveled

Calculation Case	Year		
	1989	2000	2010
Existing	443.9	-	-
Do Nothing	-	1,183.7	1,537.7
Alternative 1	-	1,107.9	1,454.0
Alternative 2	-	1,072.4	1,405.9
Alternative 3	-	1,113.0	1,460.9
Alternative 4	-	1,061.4	1,382.9

Note: unit is 1,000 vehicle*hour per day

CHAPTER 7 EVALUATION OF ALTERNATIVES

7.1 General

Evaluation of alternatives are conducted based on the following four viewpoints;

- Traffic Assessment

The alternatives have been assessed in terms of existing traffic conditions and response to future traffic demand in Chapters 3 and 6 respectively.

- Economic cost - benefit analysis

Economic balance of project cost and benefit is analyzed for each alternative. Construction cost used is on a simplified implementation schedule basis. Time staged construction and implementation schedule are not finalized in this phase but in the next one. Result of this analysis, therefore, can only be used as an indicator of economic balance among alternatives studied.

- Environmental and socio-economic impact

Those factors are studied in order to identify dangerous impacts each alternative may have on the environment and society. Environmental assessment is scheduled to be carried out for a final alternative at a later stage during this Study. Only limited factors are taken up in this phase such as water and forest conservation areas.

- Engineering assessment

Engineering studies presented in Chapter 5 are summarized to compare each alternative on the same scale.

Final comparisons and overall evaluations are presented in the last section of this chapter.

7.2 Preliminary Economic Analysis

7.2.1 Methodology

The basic purpose of the economic appraisal in this section is to screen the alternatives from the economic point of view of the country as a whole. For this purpose cost-benefit analysis is used. The streams of future economic costs and benefits among alternatives are discounted by an appropriate rate.

7.2.2 Preliminary Economic Cost Analysis

1) Preliminary Construction Costs

The preliminary construction cost estimation is already discussed in Chapter 5. In this section the cost is converted from financial terms to economic terms by applying a conversion factor of 0.85 in order to deduct the transfer items (import tariff and other taxes).

2) Preliminary Operation and Maintenance Costs

The annual preliminary operation and maintenance cost is assumed to be five percent of the total construction cost excluding earthwork, bridge work and tunnel construction. This amount is also converted to the economic cost using the same conversion rate.

3) Preliminary Construction Schedule

Preliminary construction schedule of each section is shown below. This is determined based on the results of future traffic volume and its distribution on the road network.

Table-7.2.1 Preliminary Construction Schedule of Each Section

Alternatives	Section	First Stage (- 1999)	Second Stage (- 2009)
Alternative 1	Ciawi-Puncak	o	-
	Puncak-Cianjur	o	-
	Cianjur-Citatah	-	o
Alternative 2	Ciawi-Cibadak	o	-
	Cibadak-Sukabumi	o	-
	Sukabumi-Cianjur	o	-
	Cianjur-Citatah	-	o
Alternative 3	Jagorawi Highway	o	-
	Cianjur-Citatah	-	o
Alternative 4	Cianjur-Citatah	-	o
	Ciawi-Cibadak	o	-
	Cibadak-Sukabumi	o	-
	Sukabumi-Cianjur	o	-

Note : o denotes that the construction shall be executed in the corresponding stage.

7.2.3 Preliminary Economic Benefit Analysis

The economic benefits consist of (a) reduced vehicle operating costs through comparing the with-project case (construction of the new roads or the widening of existing roads) to the without-project case; and (b) time savings for passengers in the same manner.

In this chapter, the representative vehicles, unit prices of the components of vehicle operating costs and time cost of passengers are based on Bina Marga report - Pembaharuan Perhitungan Biaya Operasi Kendaraan (VOC) Berdasarkan Data Dasar, 1988/1989 and other relevant reports. The results of the economic benefits are summarized by alternatives in Table-7.2.2.

Table-7.2.2 Economic Benefit by Alternatives
(Unit: Rp Million/year in economic terms)

Alternatives	Year	VOC	VTC	Total
Alt. 1	2000	9,854.7	33,125.0	42,979.7
	2010	22,185.1	44,609.0	66,794.1
Alt. 2	2000	14,463.3	49,954.2	64,417.5
	2010	16,820.8	63,577.3	80,398.1
Alt. 3	2000	8,660.6	29,377.1	38,037.7
	2010	17,138.1	32,854.0	49,992.1
Alt. 4	2000	15,416.4	50,100.6	65,517.0
	2010	25,084.4	64,286.5	89,370.9

Notes: VOC means the reduced vehicle operating cost.
VTC means the savings of vehicle time cost.

Of the benefits, a share of about 20-30 percent is derived from the vehicle operating cost savings and the rest from the time savings in each alternative. Thus the time savings are much larger than the savings of vehicle operating cost. This is partly because the proposed road alternatives are not short-cuts in terms of road network in the Study Area.

7.2.4 Preliminary Cost Benefit Analysis

1) Basic Assumptions for Cost Benefit Analysis

The basic assumptions of the preliminary cost benefit analysis are shown in Table 7.2.3. For the purpose of screening alternatives, the assumptions are simplified especially in the investment schedule of construction. Furthermore, the benefits during the 2000-2010 period are interpolated based on the benefits in 2000 and in 2010. Over the analysis period after 2010, the benefits are assumed to be the same as in 2010.

Table 7.2.3 Basic Assumptions for Cost Benefit Analysis

Project Life	: 2010-2040 30 years after completion of the construction in second stage
Analysis Period	: 1999-2040
Investment for Construction	: Distributed in 1999 and 2009
Prices	: 1989 prices in economic terms
Residual Value	: None

2) Results of Preliminary Cost Benefit Analysis

The expected returns are shown in Table 7.2.4. The economic internal rate of return (EIRR) in alternative 4 is highest although the rates in alternatives 1 and 2 remain acceptable adopting a cutoff rate of 15 percent. Taking into consideration the net present value (NPV) and B/C ratio, alternative 4 shows the most favorable results. Overall, alternative 4 is most recommendable from the viewpoint of preliminary economic appraisal.

Table 7.2.4 Results of Cost Benefit Analysis

Unit: Rp Million for NPV

Alternatives	NPV	B/C ratio	EIRR
1.	41,982	1.13	17.20%
2.	113,201	1.31	20.68%
3.	-170,379	0.63	8.97%
4.	161,340	1.46	22.33%

Note: Net present value and B/C ratio are discounted at 15 percent per year.

7.3 Environmental and Socio-economic Impact

7.3.1 General

Since the limited land area of the ROI is for all the people living there, any new development project should contribute to the improvement of the quality of living standards of the majority of the people in the ROI. In order to maintain this mechanism forever, the ecological equilibrium must be considered first of all. In the ROI several problems, such as deforestation, the extinction of endangered species, air and water pollution, ozone layer depletion, over population, etc., have been gradually disclosed and followed by eager research and survey by the specialists concerned.

The ROI established The Environmental Act in Indonesia (National Act No. 29 in 1986) and the Ministry of Population and Environment has been working very actively to enhance the awareness on environmental problems and negative impacts.

These environmental problems have generally surfaced only lately, therefore foresighted decision making, based on careful consideration is needed at the stage of project formation.

During Phase I of the Study, precise information on environmental conditions of each alternative was not available, so only general assessment was conducted at that time, with more information provided in the following phase.

Considering the route location selected, each alternative has different features from the environmental viewpoint. In the urbanized area, pollution and pollution control should probably be considered, and in the undeveloped area preservation and conservation of natural resources should be mainly discussed. In DKI Jakarta and other developed cities, air and water pollution, and over population are becoming very severe problems. Meanwhile a common issue in Java Island, the preservation of forestries, is at present another severe problem.

The target year of the project evaluation is 2010, however environmental and socio-economic impacts should be considered far beyond that year because of the irreversible effects they may have on the environment.

Considering the natural and induced development situation throughout the alternatives, the following environmental and socio-economic items should be assessed.

7.3.2 Environmental Impact

1) Forest Preservation

In West Java, some 20.7% of the area is forest area (refer to Table-2.3.17). According to government policy it is desired to increase this area by 30% and therefore in developing a new major project, alternative land for greening must be secured in place of that used for the project. Vast tracts of forests are scattered throughout the Study Area, particularly in the mountainous areas.

According to the land classification forest land is divided into three types of forests; protected governmental forest, protected public forest and restricted forest. Fig.-2.3.7 shows the locations of forest area. Alternatives 2 and 4, unlike alternatives 1 and 3 do not cause destruction to preserved forests.

The area to be deforested in alternative 1 is not so wide because of the nature of the project, which is widening work, but nevertheless deforesting shall be required. Considering both Presidential decrees, No. 48 in 1983 and No. 79 in 1985, this alternative should not be recommended.

2) Conservation of Water Resource

Puncak and its surroundings function as a water reservoir area, which extends just short of Cianjur city as shown in Fig.-2.3.7. The existing road, which would be widened in line with Alternative 1, passes in this conservation area.

Alternative 3 also passes through more than 15 km in the north of the area and is expected to have large cut sections due to severe terrain conditions. Thus this alternative can not be recommended as a favorable alternative.

Routes of alternatives 2 and 4 hardly pass in the area, therefore both alternatives will not alter the existing conditons of the water conservation area.

3) Preservation of Valuable Flora and Fauna Species

The areas designated for preservation of valuable species of flora and fauna are almost the same as the forest preservation areas. Therefore there is no fear that alternatives 2 and 4 would cause destruction to the designated preservation area.

4) Pollution (Air, Water, Noise)

Progressive air, water and noise pollution are usually common in highly urbanized areas such as DKI Jakarta. Main causes of air pollution in Indonesia are the smoke from factories and the exhaust gas from vehicles. There is no legally effective regulation currently concerning exhaust gas and noise generated from vehicles, therefore it is urgently needed to establish such regulations.

Judging by standards of developed countries, the air pollution problem is deemed not to become serious in the Study Area because there is sufficient open space.

Water pollution (contamination) resulting from the project is also considered not to be a serious problem, however careful attention should be paid to the excavation of harmful minerals at the construction stage.

The influence area of noise pollution is usually limited within a narrow zone, 200 m of roadside area at the utmost. As the routes of the proposed new roads pass at a sufficient distance from existing settlements, the problem of noise pollution is hardly expected in alternatives 3 and 4. Meanwhile in case of alternatives 1 and 2 where there are heavily populated settlements on the roadside zone the noise problem will become more severe as the increase of traffic volume and development continue.

5) Aesthetic Influence

From the aesthetic standpoint, the destruction of landscape is the most unpardonable act in developed countries. The Study Area enjoys a parabolic view featuring a wide open country sight. The development of a new road will cause slight sight destruction mainly in the mountainous area. Landscaping techniques aided by visual design should be applied at the detail design stage to protect this spectacular view. In particular alternatives 1 and 3 pass in an area of immense natural beauty, therefore recovery work must be considered in advance of the construction stage.

7.3.3 Socio-economic Impact

1) Severing of Social Communication

The routes of the proposed new roads pass between developed settlements and mountains, and are therefore hardly expected to sever or divide the existing communication zones. Meanwhile alternatives 1 and 2 require additional land for widening of existing roads, and the residents in the roadside area must move from social conditions familiar to them and search for alternative housing land. The necessity of land acquisition will weaken the unity of the district's communication and create social disruption.

2) Over Population

Over populated areas can be observed in some developed towns. The improvement of accessibility caused by road development will result in movement action to roadside zones from undeveloped area, although along the Jagorawi Highway between Jakarta and Bogor, this has not always held true. In particular access-controlled roads such as alternatives 3 and 4 are not expected to result in population movement to the road zone.

As the improvement of accessibility will create some accumulation of industrial and commercial industries near interchanges, advanced city development planning is necessary in order to avoid undesirable scrawl development.

3) Regional Equality

The improvement of accessibility and time value will contribute to a rise in investment opportunity, leading to a gradual change in industrial structure. Such a chain reaction will surely contribute to the improvement of job opportunities. Well-balanced industrial structure will in turn create regional equality in physical and social-welfare aspects.

Alternatives 1 and 2 are expected to contribute little in this regard, however alternative 4 will contribute much because of the existence of some developed towns along its route. Meanwhile alternative 3 passes in the preserved area, therefore will hardly contribute to the development of the related area.

7.4 Engineering Assessment

Major physical and social features of the alternative routes are shown in Table-7.4.1.

Table-7.4.1 Features of Alternative Routes

ITEMS		ALTERNATIVE ROUTE			
		PUNCAK	SUKABUMI	PUNCAK	SUKABUMI
LENGTH		80,4 Km	113,4 Km	83,8 Km	100,3 Km
TYPE OF WORK		IMPROVEMENT ROAD		NEW CONSTRUCTIONS ROAD	
TOPOGRAPHY	Flat Rolling Mountainous	52 Km 179 Km 10,5 Km	74 Km 15,65 Km 23,75 Km	7,5 Km 40,3 km 36 Km	74 km 5,3 Km 21 Km
LAND USE	Setlement Rice fild Other	38,5 Km 25.9 Km 16 Km	58.1 Km 36.1 Km 19.7 Km	- 43,3 Km 40,5 Km	- 60,9 Km 36,6 Km
REGULATED AREA	Water Resource forest	39 Km	18 Km	13 Km	15 Km
TRAFFIC DEMAND V/day	Year 2000 2010	2000 V/day 24000-28000 V/day	15000-18000 V/day 1600-3000 V/day	7000 V/day 12000-14000 V/day	9000-15000 V/day 20000-15000 V/day
VOLUME OF LOCAL TRAFFIC		Mixture		No Mixture	
DESIGN SPEED	Km/hour	40 Km/hour	40 Km/hour	60 Km/hour	80 Km/hour
MAXIMUM GRADE		10 %	7 %	5 %	5 %
RIGHT OF WAY		30 M	30 M	60 M	60 M

In the case of alternatives 1 and 2 the traffic is a mixture of local and inter-city traffic, because the two alternatives only propose road widening, and adoption of high standard alignment is difficult since it will create the need to relocate a large number of houses and also for topographical reasons.

Alternatives 3 and 4, calling for construction of a new road will separate the local traffic and inter-city traffic. Either of the two routes of both alternatives shall function as a vital trunk road in the road network serving the Bogor - Bandung area.

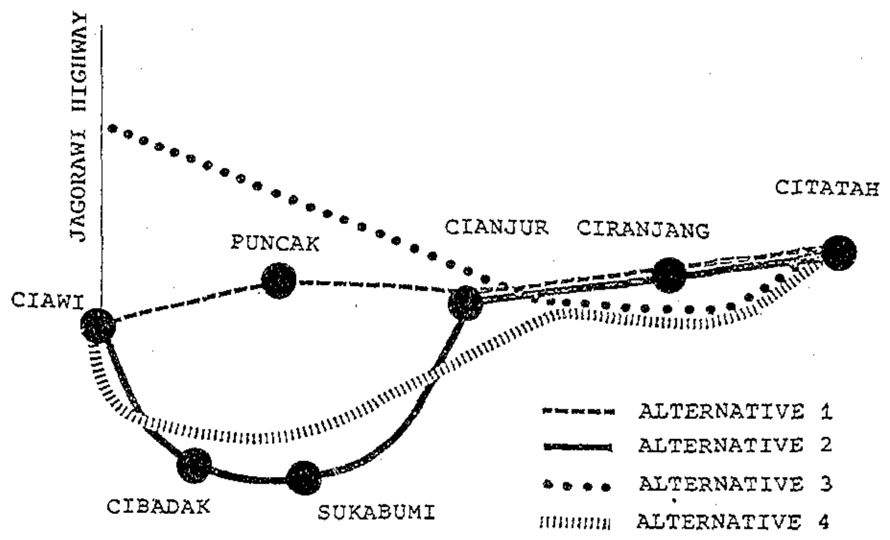
The route in alternative 3, running north of the existing Puncak Pass is the shortest of the four. However topography along the route is very steep, the most severe of all four alternatives, and about 3 kilometers of bridges and tunnel must be included in the road design.

The route of alternative 4 travels north of Cibadak and Sukabumi. The Ciawi - Sukabumi section of the route will require many bridges to cross the valleys and ridges of Mt. Gede.

Table-7.4.2 shows the construction costs of the four alternatives. Of the two new road construction projects, alternative 4, at a total cost of 429,201 million Rupiah is the lower. Construction cost per kilometer is comparatively low on three of the sections of Alternative 4 when considering corresponding cost of sections of the other three routes. However the Ciawi - Cibadak section shows a high construction cost per kilometer because of the many ridges and valleys there and the subsequent need for bridges.

Table-7.4.2 Construction Costs of the Four Alternatives

	NO SECTION	KM	TOTAL KM	C O S T *10^6 RP	T O T A L	COST/KM *10^6 RP
Alternative 1 (Puncak Route Improvement)	1. CIAWI-PUNCAK	25.20	80.4	209,574.0	423,799.0	8,316.43
	2. PUNCAK-CIANJUR	26.30		97,812.7		3,719.11
	6. CIANJUR-CITATAH	28.90		116,412.3		4,028.11
Alternative 2 (Sukabumi Route Improvement)	3. CIAWI-CIBADAK	37.50	113.4	143,039.8	458,275.0	3,814.39
	4. CIBADAK-SUKABUMI	16.60		74,380.1		4,480.73
	5. SUKABUMI-CIANJUR	30.40		124,442.8		4,093.51
	6. CIANJUR-CITATAH	28.90		116,412.3		4,028.11
Alternative 3 (Puncak North Route New Road)	7. JAGORAWI HIGHWAY	62.60	83.8	494,258.0	565,299.1	7,895.50
	8. CIANJUR-CITATAH	21.20		71,041.1		3,351.00
Alternative 4 (Sukabumi Route New Road)	8. CIANJUR-CITATAH	21.20	100.3	71,041.1	429,201.0	3,351.00
	9. CIAWI-CIBADAK	26.50		165,833.2		6,257.86
	10. CIBADAK-SUKABUMI	24.40		92,620.5		3,795.92
	11. SUKABUMI-CIANJUR	28.20		99,706.2		3,535.68



7.5 Overall Evaluation

The overall evaluation has been carried out for various items classified under the divisions of road function, road construction aspects, economic viability of investment plans, and the environment.

Table-7.5.1 summarizes the outcome of the evaluation for each alternative studied.

Alternative 4 showed the best overall performance. Compared to it, the other alternatives are quite inferior.

Particularly, Puncak route alternatives, Alternatives 1 and 3, do not quite agree with central government policies and they also proved lacking in performances in such vital evaluation items as geometry of road, travel time, congestion ratio, cost/benefit balance with other road development and environmental consideration.

Evaluation of Alternative 2 proved it to have somewhat medium performance though, it is also far behind Alternative 4 in such items as; geometry of road, conflict of local, long distance, and tourism traffic, impact of construction on roadside society, and conflict with road side activities.

Table-7.5.1 Summary of Evaluation

Item	Alt. 1	Alt. 2	Alt. 3	Alt. 4
Road Network (network accessibility)	B	B	C	A
Road Geometry; Horizontal Alignment	C	C	B	A
Vertical Alignment	C	B	C	A
Travel Time (evaluation on whole network)	C	B	C	A
Congestion Ratio (on Study Area)	C	A	C	B
Improvement on Congestion of Puncak Pass	A	C	C	B
Economic Viability; Construction Cost	A	B	C	A
Benefit/Cost Balance	C	B	C	A
In-line with Other road Development	C	B	C	A
Conflict of Local and Tourism Traffic	C	C	A	A
Impact of Construction on Roadside Society	C	C	A	A
Conflict with Roadside Living Activities	C	C	A	A
Contribution to Area Development	B	B	C	A
Environment Consideration (conservation area)	C	B	C	B

Note: Evaluation scale is in three grades of which "A" is the highest.
Alt.1: Puncak Route Improvement.
Alt.2: Sukabumi Route Improvement.
Alt.3: Puncak Route New Road.
Alt.4: Sukabumi Route New Road.

Alternative 4, the new road construction alternative from Ciawi through Cibadak, Sukabumi, Cianjur reaching Citatah to connect Jagorawi toll road with Cikampek - Padaralang toll road (under planning), received the highest evaluation of all the alternatives studied.

7.6 Conclusion

Of all the alternatives, Alternative 4 scored the highest marks on all the evaluation items except for travel distance. The Puncak pass route, on the other hand, provides the shortest connection between the two cities of Bogor and Bandung.

Alternative 4 proposes the construction of a new road starting at Ciawi at the southern end of Jagorawi toll road. It goes through Ciawi, Cibadak, Sukabumi, Cianjur, Ciranjang reaching Citatah. The planned toll road of Cikampek - Padaralang has a spur at Citatah and therefore the new road can in reality connect those two toll roads.

Project length is approximately 97.5 kilometers between Ciawi and Citatah. High rate of economic return is expected when an appropriate implementation schedule is adopted.

Further study on Alternative 4 is presented in part II of this Report, with emphasis on in-depth analysis to determine the appropriate implementation schedule and resulting economic and financial cost-benefit balance of project.

The selection of Alternative 4 satisfies the objectives of providing a road development plan between Bogor and Bandung, and the development of the Study Area's southern part, the Sukabumi Region. However, in terms of Study Area, the important resort city of Puncak, situated in the northern part should not be overlooked. A direct road improvement plan for the area should be considered. Therefore an action program for limited scale improvement of the existing Puncak Pass connecting Jagorawi Toll road at Bogor with Puncak has also been studied and the results incorporated in this Report, in Part III.

CHAPTER 8 ROUTE SELECTION & ENGINEERING STUDY

8.1 Soil and Material Survey

8.1.1 General

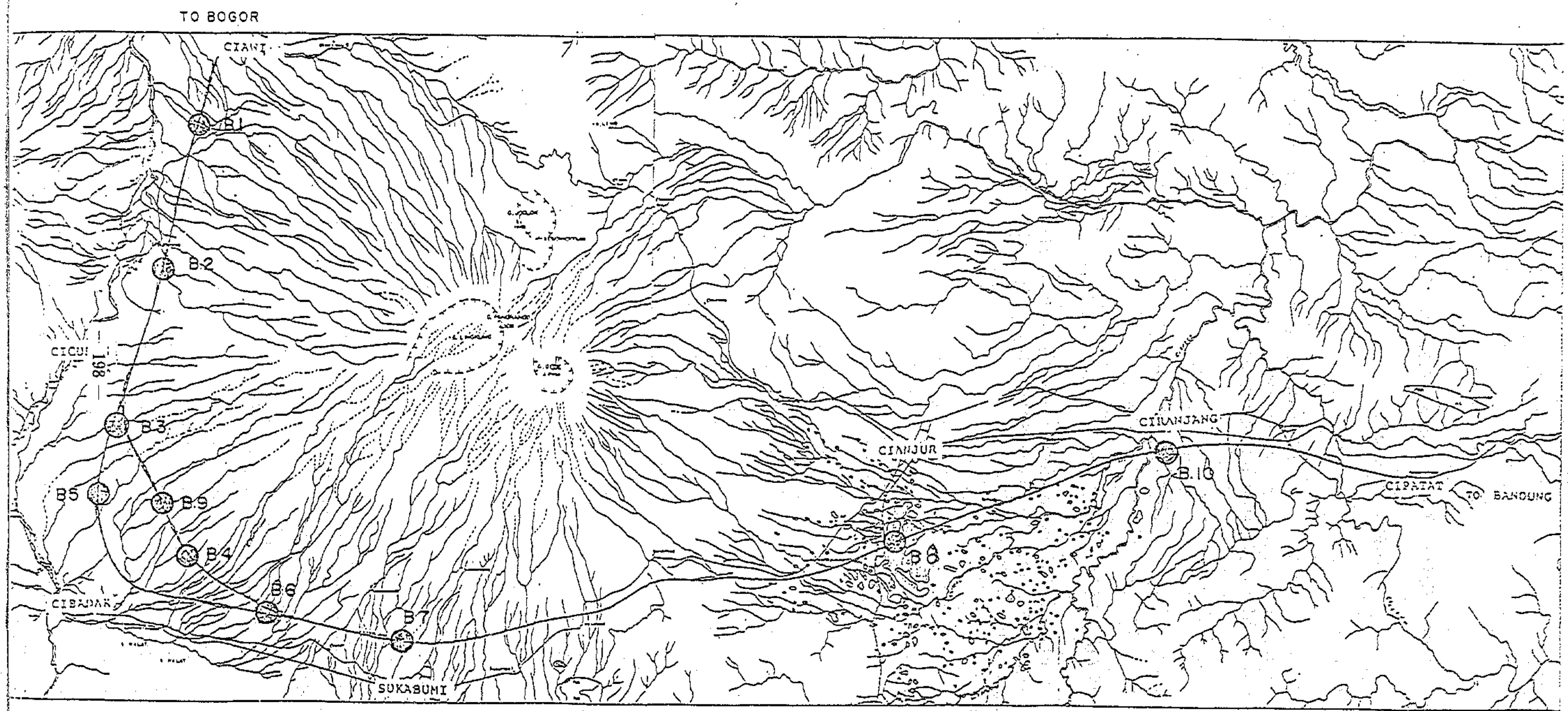
The soil and material survey for the proposed new road was executed along the potential alignment, in order to obtain the necessary data for preliminary design and cost estimation.

8.1.2 Location of Survey

Boring surveys took place along the road alignment under study, as indicated in Fig.-8.1.1.

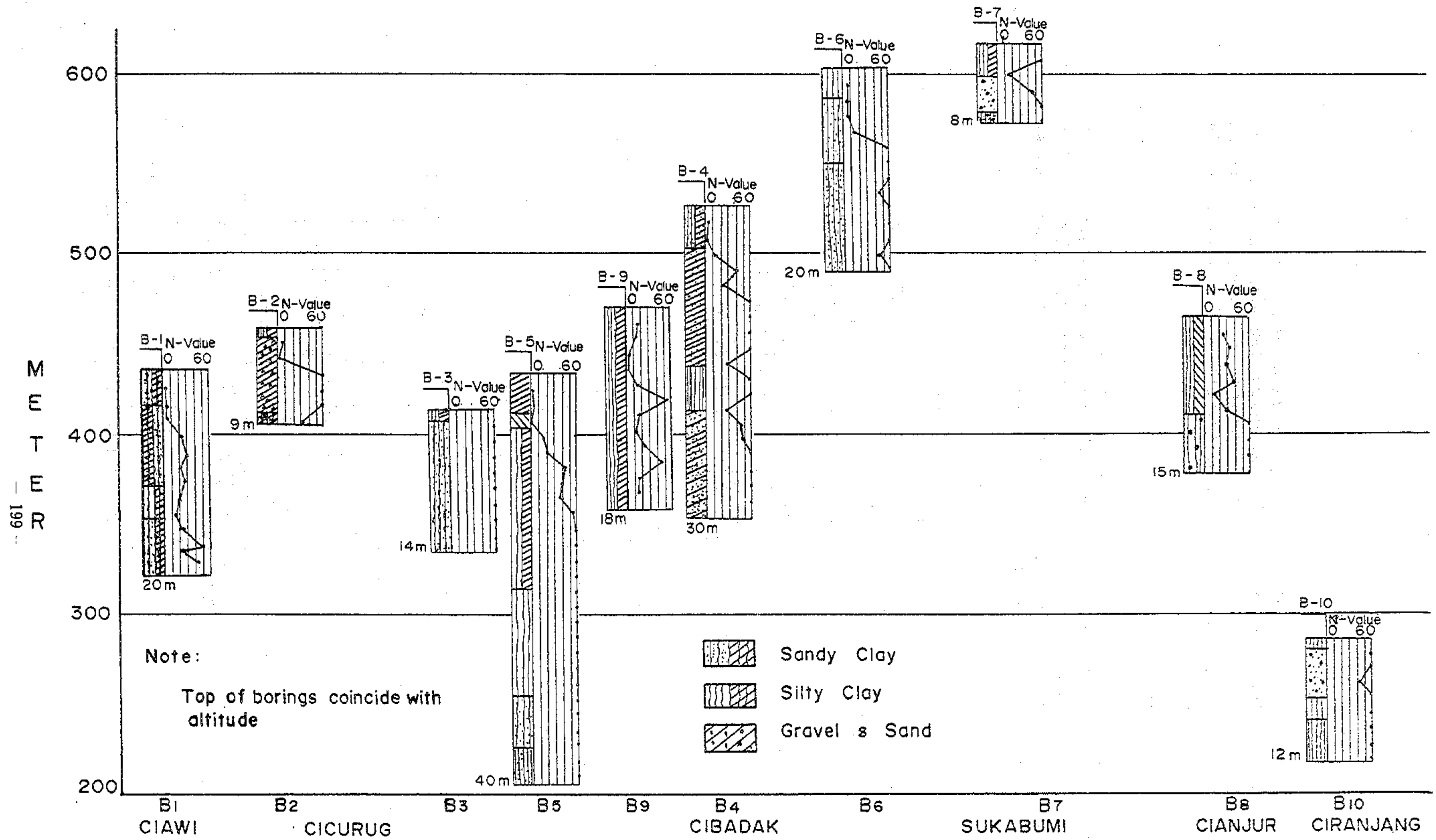
8.1.3 Boring Survey

Borings with standard penetration tests were carried out to clarify the condition of the bearing layer for the embankment, pavement and foundations (Fig.-8.1.2).



o Borehole Location
—— Proposed Road Alignment

Fig.-8.1.1 Boring Location Map



Feasibility Study on Bogor - Bandung Road Project	Fig.-8.1.2 Results of Boring and Dutch Cone Sounding

8.1.4 Laboratory Testing

To clarify the soil property of subgrade and embankment material, laboratory soil tests including compaction and CBR test were executed. Most of the material for embankment and subgrade will be claylу silt and silty sand. The characteristics of the material, in accordance with laboratory soil test, is as follows;

1) Consistency

The liquid limit ranges from 60 to 100%, and the plastic limit from 40 to 70%. As to the consistency, the soil is classified as high plasticity soil (see Fig.-8.1.3 for plasticity chart). However, the soil is considered to be in stable condition because the natural water content ranges to nearly that of the plastic limit.

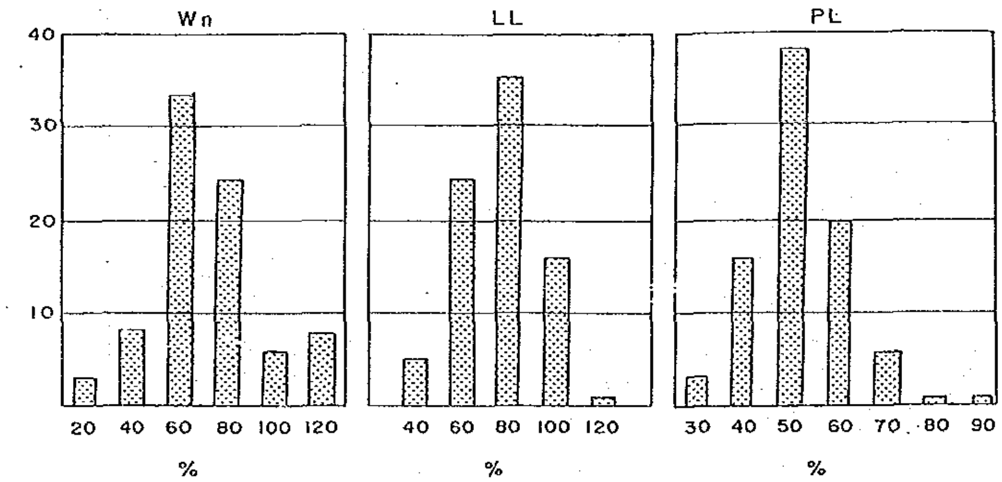


Fig.-8.1.3 Plasticity Chart

On the plasticity chart (Fig.-8.1.4), the liquid limit and plasticity index are distributed below the A line and liquid limit is greater than 50%. Accordingly, the soil is classified as MH (high plasticity silt) on the basis of Unified Soil Classification.

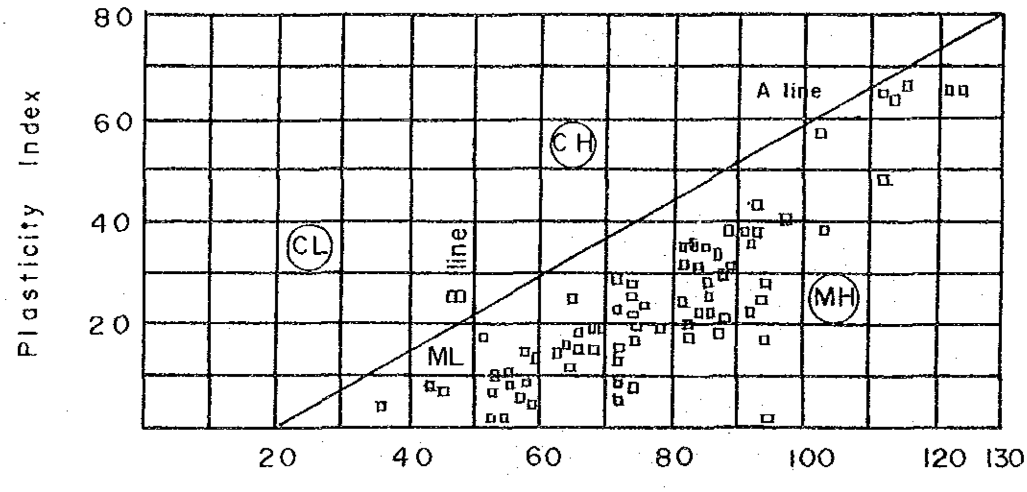


Fig.-8.1.4 Liquid Limit WL (%)

2) Particle Size Distribution

Fig.-8.1.5 shows the particle size distribution curve. The material contains 0 to 10% gravel, 20% to 50% sand and 20% to 40% silt.

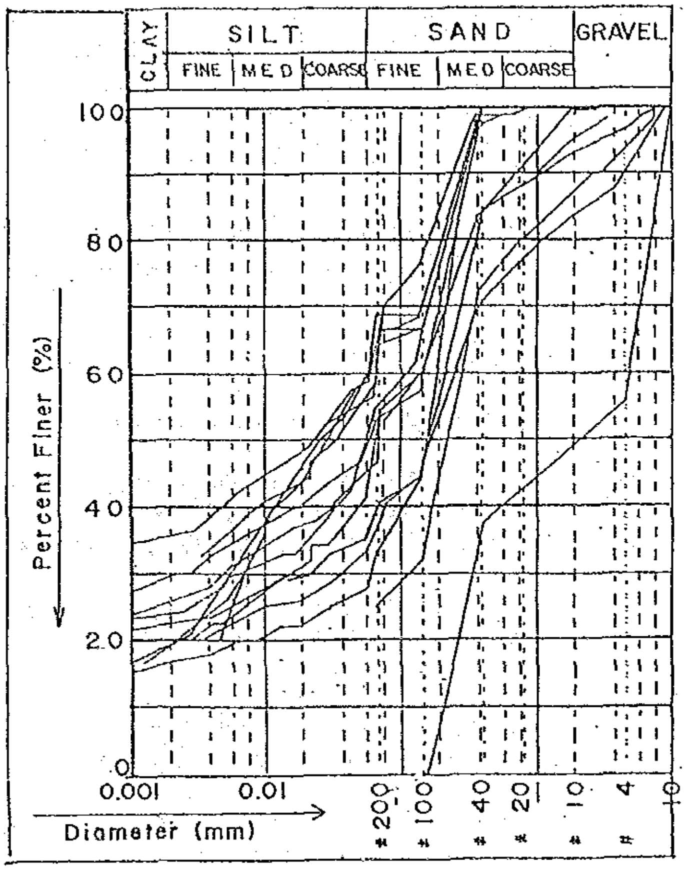


Fig.-8.1.5 Particle Size Distribution Curve

3) Moisture Content

Table-8.1.1 shows the optimum moisture content, maximum dry density and CBR. Dry density and CBR are tested by the ASTM T-180 method. Optimum moisture content ranges from 1.21 to 1.33 g/cm^3 except for sand soil. Compaction work using the material of optimum moisture content will be possible on condition that the earthwork is executed during the dry season. As CBR value related to 95% of maximum dry density ranges from 5 to 7%, and in-situ dry density corresponds with 95% of maximum dry density, 5% of design CBR value could be utilized for subgrade material for both embankment and cutting areas.

Table-8.1.1 Optimum Moisture Content and CBR

Sample No.	O.M.C (%)	Maximum Dry Density (g/cm^3)	CBR (%)
1	43.4	1.215	7.40
2	43.3	1.213	9.10
3	44.0	1.200	5.80
4	34.9	1.326	6.80
5	43.1	1.215	6.40

OMC; Optimum Moisture Content
CBR; California Bearing Ratio

8.1.5 Quarry Sites

Quarry for road construction consist of 3 quarry types:

1st Quarry as alluvial deposit with boulder sand gravels of andesitic and basaltic rock. Volume of this quarry type is not so much, spread along some big river basins

2nd Quarry as volcanic breccia component, Qyc in the shape of hills spreading at the Cianjur plate

3rd Quarry as hornblende andesite intrusion at Pasir Geulis, Bojong Gantung, Pasir Susuru and Pasir Masigit. Estimate for the entire volume of the quarry is about 100,000,000 tons

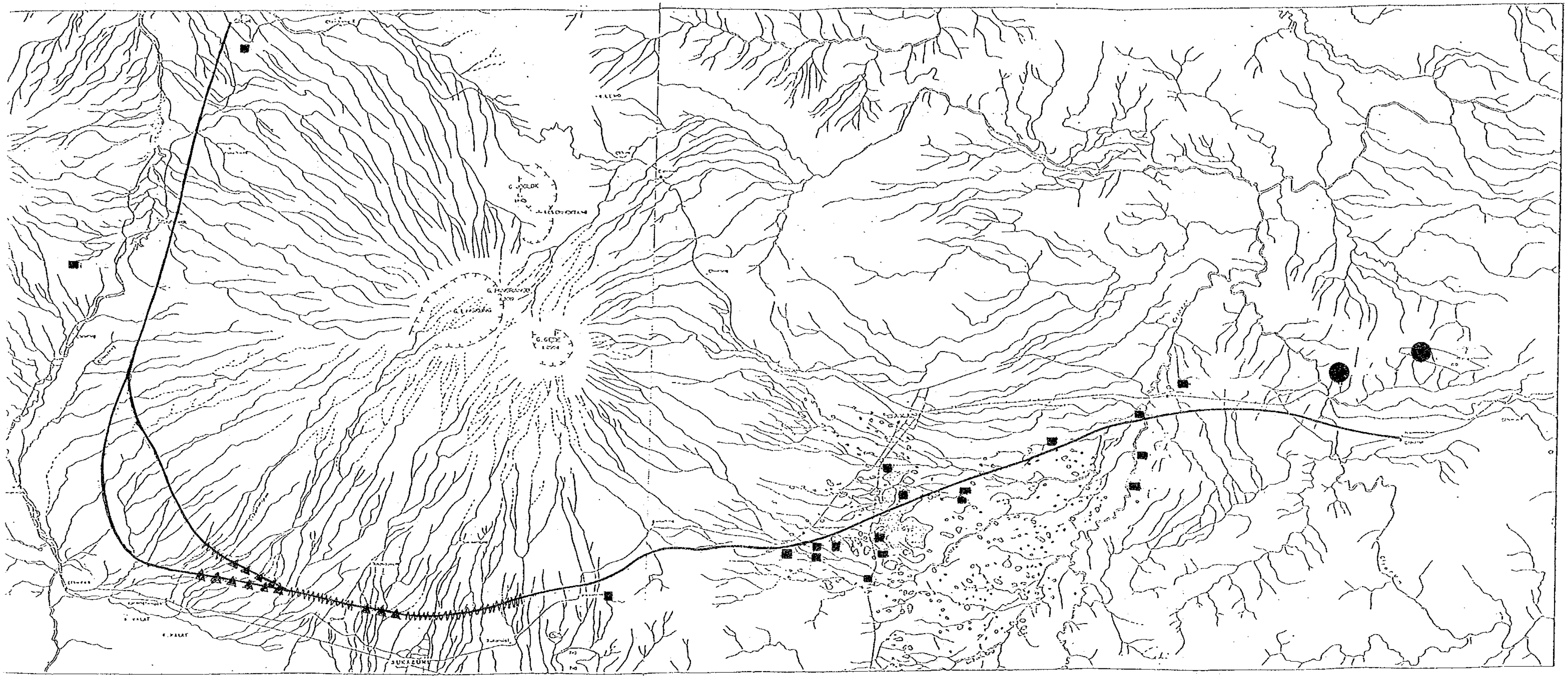
Quarry sites of the 2nd and 3rd types are located at Cianjur, Ciranjang, Cipatat, Ciawi and Cicurug. But it is difficult to find a quarry site between Cicurug and Sukabumi (Fig.-8.1.6). Therefore, during the road construction it will be necessary to consider transportation of stone and gravel on ordinary roads or haul roads between Cicurug and Sukabumi.

8.1.6 Engineering Assessment

There are three degrees identifying the degree of stability of the investigated area, namely;

1st Stable area
2nd Rather stable area
3rd Unstable area

The degree of stability is determined by the possibility of slidings occurrence, when balance condition is disturbed during and after the construction. An unstable area has been identified between Cibadak and Sukabumi, see Fig.-8.1.6, and is comparatively unstable. The earthworks are therefore designed for minimum embankment and cutting to maintain the present equilibrium of the earth in landslide areas. A closer survey would be needed at the detailed design stage to determine if stabilization work is required using such method as, for instance, the lime stabilization method in local unstable areas.



———	STABLE AREA
/\/\/\/\/\/\	RATHER STABLE AREA
△△△	UNSTABLE AREA OR LABILE AREA
● Ha	HORNBLENDE ANDESITE
■ QYC	BASALT BOULDERS

Fig.-8.1.6 Quarry Site and Unstable Area

8.2 Route Selection

8.2.1 General

A new access controlled road through Sukabumi to form a part of the road network between Bogor and Bandung was identified in Part I of this Report, as a result of conducting studies on existing physical, socio-economic, engineering and transportation conditions, development frames, formation of development alternatives, engineering aspects, and various evaluations including economic analysis and environmental impact factors.

The route of the new road was initially located on 1:50,000 topographic map using what available data there was at that time. Along the determined corridor, various additional information was collected such as a series of aerial photographic surveys, a production of a new set of 1:5,000 topographic maps, soil and material surveys and ground reconnaissance surveys.

8.2.2 New Road Route

In broad terms, the route to be located starts at Ciawi, directly extended from the Jagorawi Toll Road, and travels east of Cicurug, north of Cibadak and Sukabumi, south of Cianjur and Ciranjang and ends at Citatah, again directly connected with the Cikampek - Padalarang Toll Road by means of the Padalarang Spur.

8.2.3 Available Basic Data

1) General Data

Generally available and existing data to conduct this Study was collected during the Phase One Study, such as physical and socio-economic information, engineering conditions, transportation situations, design standard, and other similar fundamental information.

All the data was reviewed and utilized during the process of the route location. In particular, emphasis was placed on data relating to environmental problems such as land use, forest preservation, fauna and flora protection, etc.

2) Aerial Photographs

An Aerial Photographic Survey was conducted in August 1989 by the Study Team along the route designated during the Phase One Study. The survey produced aerial photographs of 1:25,000 on which the Study Team was able to make a detailed three dimensional study of the ground and obtain, at the same time, various types of information covering a much wider area.

3) Topographic Maps

Using the newly obtained aerial photographs, topographic maps of 1:5,000 were produced by the Study Team. The Study Team was supplied with 1:50,000 topographic maps by the Bina Marga at the start of the Study and used them until the production of the much more detailed maps.

During the topographic survey, a traverse survey and a leveling survey were conducted by the Study Team. Important landmarks and abrupt changes in terrain conditions were more accurately understood by those additional surveys.

4) Soil and Material Survey

Underground conditions along the route were confirmed by the soil survey carried out by the Study Team. A total of ten borings were executed at depths varying from 7 to 40 meters.

The survey results were summarized in the preceeding section of this Report.

5) Site Reconnaissance Survey

The Study Team visited the site often in order to confirm data and information obtained by other means before determining the route for the new road. The Study Team was attentive to important landmarks, villages, land use, river crossings and other significant terrain conditions.

8.2.4 Methodology of Route Selection

Based on the information gathered through the site investigations and the examination of maps and aerial photographs, all possible alternative locations (routes) were studied for the new road, paying special attention to the social, environmental, economic and technical points of view. Among others, the Study focussed on the main check items described below:

(1) Contribution to regional development
(2) Land acquisition and compensation
(3) Control points
(4) Location of interchanges
(5) Land use
(6) Topography
(7) Horizontal and vertical alignments
(8) Length of route

1) Contribution to Regional Development

From the beginning of the Study, it has been expected that this new road going through Sukabumi shall contribute greatly towards the regional development by producing benefits to traffic conditions such as:

- Reduce traffic on existing roads between Bogor and Bandung (including Puncak Pass road)
- Reduce traffic congestion and accidents by virtue of the above traffic reduction
- Increase travel speed
- Reduce journey time between large cities with the effect of providing comfortably secure travel and,
- Other similar benefits

In order to maximize the expected benefits, special care was taken to realize the following:

- The establishment of good access to and from the existing road network.
- The expected future direction of development (particularly towards south of Sukabumi and the Indian Ocean).
- The placement of an appropriate number of interchanges at reasonable intervals.

2) Land Acquisition and Compensation

The optimum route with regard to land acquisition and compensation was adopted, avoiding passing through existing commercial centers and with the least intervention to existing roads and railways.

3) Control Points

The following were considered as the primary control points in the route selection and locations for on/off ramps:

- Locations of existing interchanges
- Mosques, temples, churches and other religious facilities
- Cultural assets
- Public facilities and buildings
- Military facilities
- Permanent buildings with more than 4 stories
- Cities and villages
- Important buildings and valuable residential areas
- Major roads, railways, and irrigation canals
- Existing/planned public utilities, power transmission pylons, etc.
- Reservoirs, ponds and other water resources
- Rivers, lakes and major channels and their crossing points

4) Location of Interchanges

A large area is needed for an interchange. A sparsely populated area with fewer control points is considered as the most suitable location without sacrificing the function of an interchange.

Interchange locations were also selected according to the expected traffic demand and taking into consideration continual regional developmental factors.

5) Land Use

Weaving through the commercial and residential areas while considering the effective land use and environmental problems is the best way to select the route. Attention was duly paid to the area's present and future land use and possible environmental impact in order to select the most favorable route.

6) Topography

In setting the route for the new road, attention was paid to the following:

- Balancing earthworks of cut and fill and viaduct length
- Avoidance of river crossing at an acute angle

7) Horizontal and Vertical Alignments

Horizontal and vertical alignments were determined so as to satisfy the established geometric design standard for the safety and comfort of users. Highway aesthetics were also considered.

8) Length of Route

The shortest possible route was considered to be preferable.

8.2.5 Selected Route Location

In Part I of this Report, alternative 4 (Sukabumi route new road) was selected as the most preferable route between Bogor and Bandung.

The new road travels south-west around Mt. Pangrango and links the cities of Ciawi, Cibadak, Sukabumi, Cianjur and Citatah. Between Ciawi and Cibadak the route passes through many ridges and valleys of Mt. Pangrango.

The process of route location can be divided into three stages which are; the first stage of roughly locating on 1:50,000 topographic map; second stage of roughly locating on 1:5,000 topographic map from which several conceivable routes were considered; and the final third stage of locating precisely on 1:5,000 map as described in the next Section 8.3.

The outcome of the route selection process is shown in Fig. 8.2.1 for horizontal geometry together with the location of interchanges, and in Fig. 8.2.2 for vertical alignment.

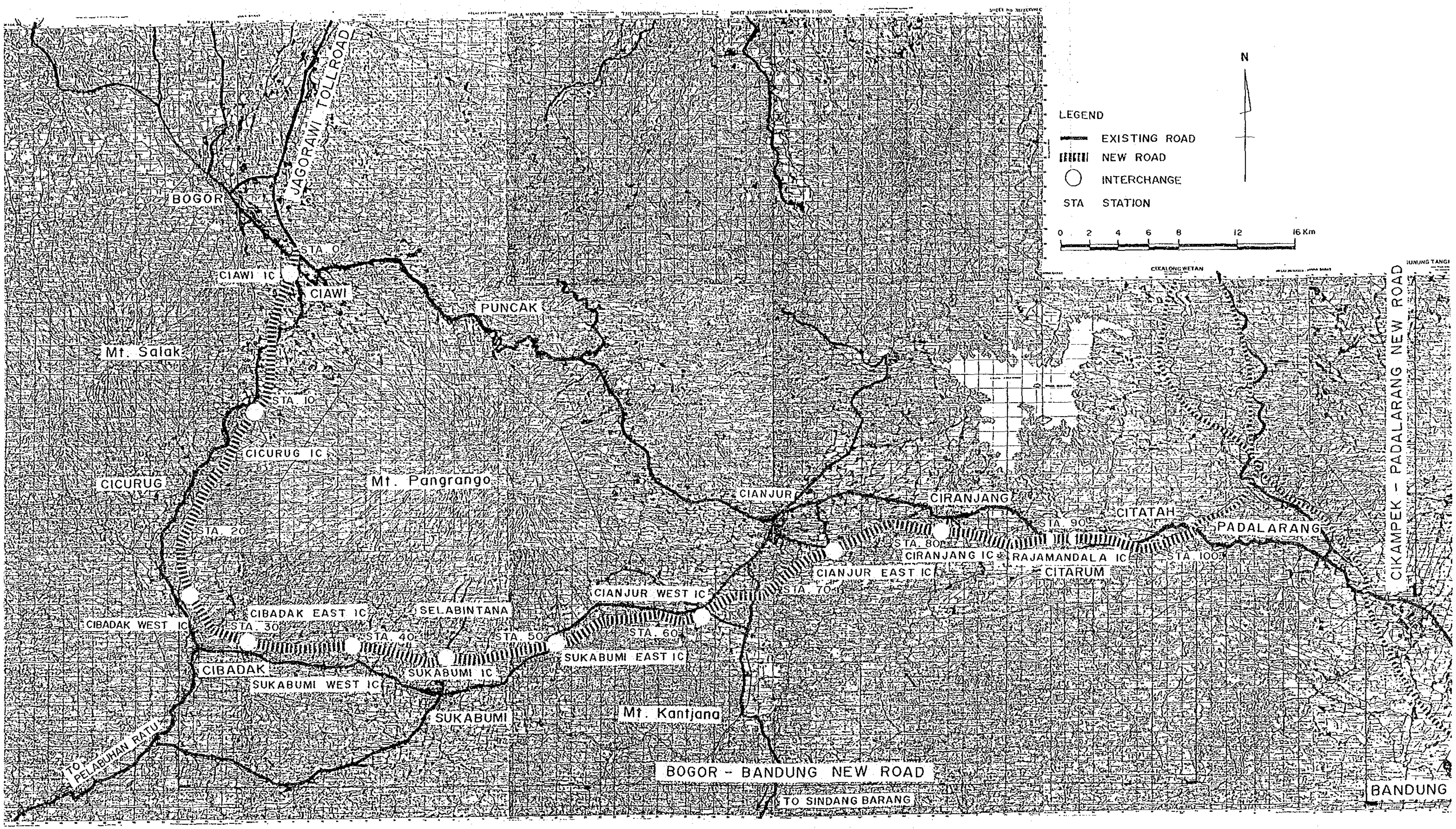


Fig.-8.2.1 Route Location

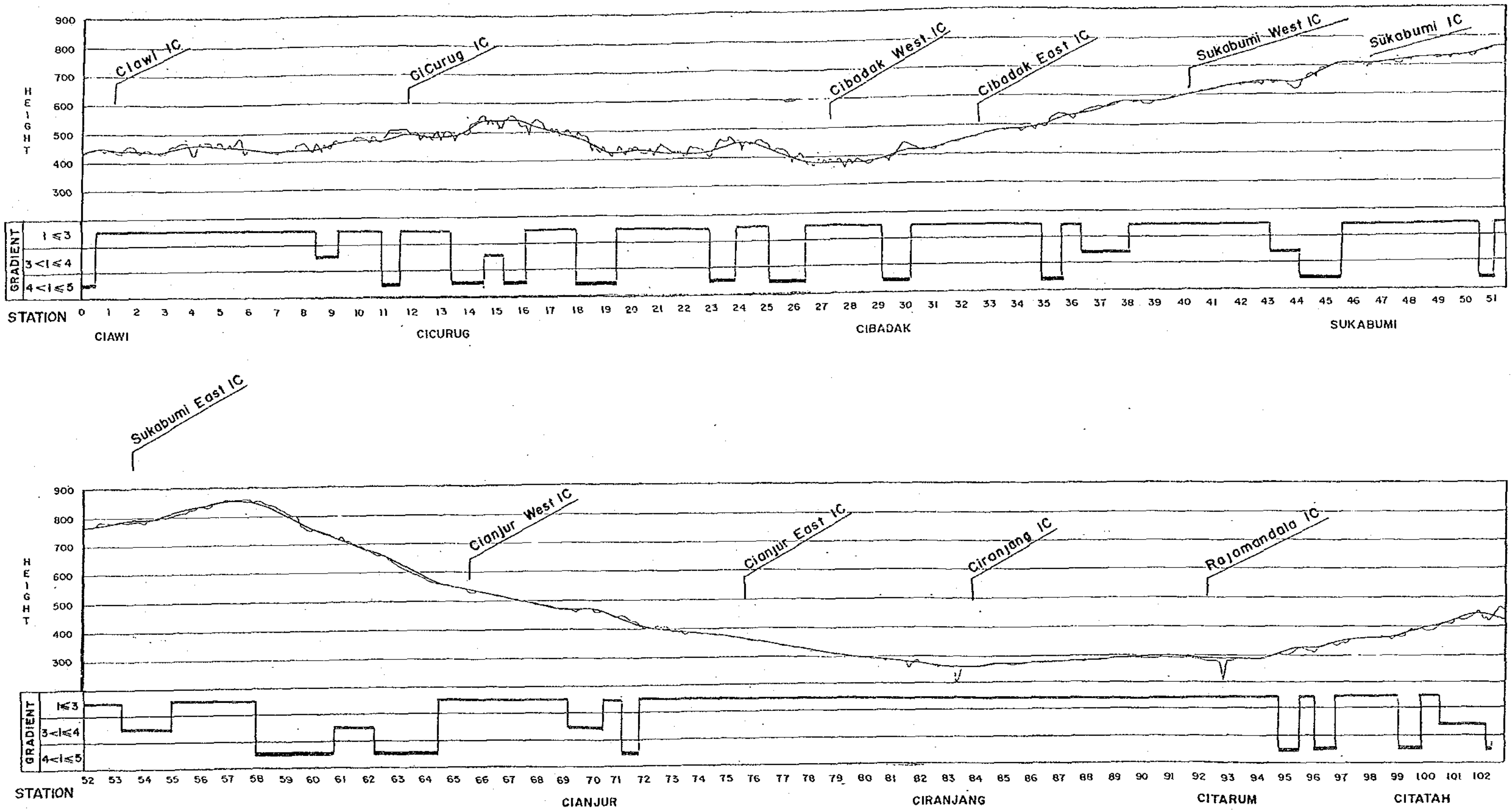


Fig.-8.2.2 Bogor - Bandung New Road Profile

1) First Stage Considerations

In the first stage the route was located on existing topographic maps (scale 1:50,000) which were partly revised by the Study Team, using aerial photographs and other general available data.

General considerations for determining basic control points during the first stage are summarized as follows;

(a) Ciawi (Sta. 0)

The beginning of the route should be at the Jagorawi Toll Road.

(b) Cibadak (Sta. 27)

The route should be located northeast of Cibadak city to reduce the route length between Ciawi - Cibadak - Sukabumi.

(c) Mountain Pass East of Sukabumi (Sta. 57)

The highest point of the route is at the mountain pass, east of Sukabumi at an elevation of approximately 870 meters. This point is selected as the lowest convenient place for the route to pass through.

The route begins its ascent from the lowest point west of this point of approximately 400 meters at Station 28 west of Cibadak. On the east side, the route descends to approximately 260 meters at Station 83 south of Cianjur. The peak of the route, therefore, has to be as low as possible.

(d) Rajamandala Bridge area (Sta. 90)

The route shall use the existing Rajamandala Toll Bridge as per the general consent of Bina Marga.

(e) Citatah (Sta. 102)

The end of the route shall be connected with the Cikampek-Padalarang new toll road by means of the Padalarang Spur of that road.

2) Second Stage Route Selection

(a) Ciawi - Cibadak

Between Ciawi and Cibadak, the route is generally located on the east side of a provincial/arterial road where there are no residential areas. The section of the route located west of Ciawi avoids the residential development there. Although the terrain conditions on both sides of the road are almost similar, there are more paddy fields at the foot of Mt. Salak on the west side. In order to reduce the extent of paddy fields that shall be affected, the east side of the road was selected as the site for the new road. The length of the new road is also made shorter by going along the east side.

The severe terrain conditions in this section, mainly complex meandering and narrow valleys, result in many problems during the road construction. The Study Team examined several conceivable routes in order to arrive at the most reasonable one from the viewpoints of reducing an excess need for structures, earthworks, balance of cut and fill, and other engineering considerations, together with socio-economic and environmental factors. The route located under such considerations runs very near the existing provincial road.

(b) Cibadak - Mountain pass east of Sukabumi (Sta. 57)

This section contains very fertile farm land. The city of Sukabumi is situated at the center of the area and there are tourist highland attractions north of the city.

The route was selected by taking the following into consideration:

- Take the shortest alignment
- Avoid the city area of Sukabumi
- Reduce passage through paddy fields
- Stay away from dwelling areas and houses

As a result, the route in this section is almost straight and crosses the provincial road at Station 50.

(c) Mountain Pass east of Sukabumi (Sta. 57) - Existing Rajamandala Toll Bridge (Sta. 90)

The largest rice paddy fields to be found in the Study Area are located in this section. Cianjur rice is very famous in Java island for its quality. There are two city areas in this section namely Cianjur in the northeast and Ciranjang in the northwest. Other obstacles such as a provincial road from Cianjur to Cibeber, a national railway and the Kondang River and its branches also exist.

Several conceivable routes were tried using selection factors such as:

- Adopting the shortest alignment
- Avoiding the city areas
- Reducing use of paddy fields
- Staying away from important buildings and houses
- Crossing obstacles at suitable points

In particular the crossing points with major roads, railways and rivers were carefully selected after repeated site reconnaissances and observations.

The located route is almost straight with a northern inclination to be as near to Cianjur and Ciranjang as possible without disturbing dwelling areas. This alignment was also affected by the location of crossing points of railway and rivers.

(d) Existing Rajamandala Toll Bridge (Sta. 90)

The route ends at Sta. 90 where it connects to the Padalarang Spur (Sta. 102). The route was located south of the existing national road due mainly to difficult terrain conditions on its northern side. The Indonesian Army practices shooting along the national road near Citatah. This training site is situated south of the road and very close to it, and the Study Team had to squeeze the new road just south of the existing road between the road and the camp. This location should be