Chapter 5

Design Standard

CHAPTER 5 DESIGN STANDARD

5.1 Design Policy

The applicable criteria and elements of design of the roads have been decided based on the Bina Marga, AASHTO and Japanese design standards.

(1) Road Function and Design Speed

The future inter-regional road network consists of the four categories of road which currently function as road classifications i.e., arterial road and three categories of collector roads. The basic factors of road development for applying geometric design criteria are future traffic volume, road function, and terrain conditions. Of these, the most fundamental is future traffic volume and the role of road to accommodate traffic flows through roadway width, alignment, and other standards.

Standard road development should also follow the function of the road. Roads are classified into four categories. The geometric standard in road development needs to meet the functional requirement. The governmental regulation for road (No.26, 1986) mentions minimum design speeds and minimum roadbed width according to road function; design speed of 60km/h and 8m wide for arterial roads, 40km/h for collector roads. Applying design criteria to road development, it should be considered that terrain conditions have considerable influence on construction cost. Where topography becomes steeper, some reduction of the level of geometric design criteria should be acceptable. The standard for mountainous terrain has the same lane width and one rank of design speed lower than those for flat and rolling terrain. Table 5-1-1 shows the design speed of road to be used in the feasibility study by each road function.

Table 5-1-1 Design Speed According to Road Function

Traffic volume (pcu/day)	3000 to 20000		Less than 3000	
Terrain	Flat and rolling	Mountainous	Flat and rolling	Mountainous
Pavement width (m)	6.0	6.0	4.5	4.5
Design Speed (Km/h)				
Arterial Road	60	40	50	30
Collector 1	50	30	50	30(20)
Collector 2	50	30 (20)	40	30(20)
Collector 3	50	30 (20)	40	20

Note: ( ): special case

Source: Study Team

(2) Road Traffic

Study result of traffic demand forecast for feasibility study routes are as shown in Table 5-1-2. These values were reflected in the determination of pavement structure and road width.

Table 5-1-2 Future Traffic Volumes of F/S Routes

Link No. / Vehicle Type	Link 16 (veh/day)		Link 22 (veh/day)		Link 32 (veh/day)		Link 33 (veh/day)	
	2003	2018	2003	2018	2003	2018	2003	2018
Motorcycles	366	656	344	577	450	710	344	588
Passenger Cars	216	373	180	293	205	312	180	300
Buses	393	503	372	453	502	545	372	460
Trucks	643	1067	600	981	682	1013	600	1005
Total	1618	2597	1496	2304	1839	2580	1496	2353

Source: Study Team

5.2 Geometric Design Standard

Based on the above study, geometric design standards have been established for the feasibility study routes as shown in Table 5-2-1.

Table 5-2-1 Geometric Design Standard

Terrain	Unit	Flat, Rolling	Mountain	Mountain
Design Speed	Km/h	60	40	30
Lane Width	M	3.00 x 2	3.00 x 2	3.00 x 2
Shoulder Width	M	2.0 (1.0)	2.0 (1.0)	2.0 (1.0)
Crossfall of Pavement	%	2	2	2
Crossfall of Shoulder	%	4	4	4
Max. Superelevation	%	10	10	8
Min. Radius Curve	M	115	50	30
Min. Curve Length	M	100	70	50
Max. Gradient	%	5	7	8
Abs. Max. Gradient	%	9	11	12

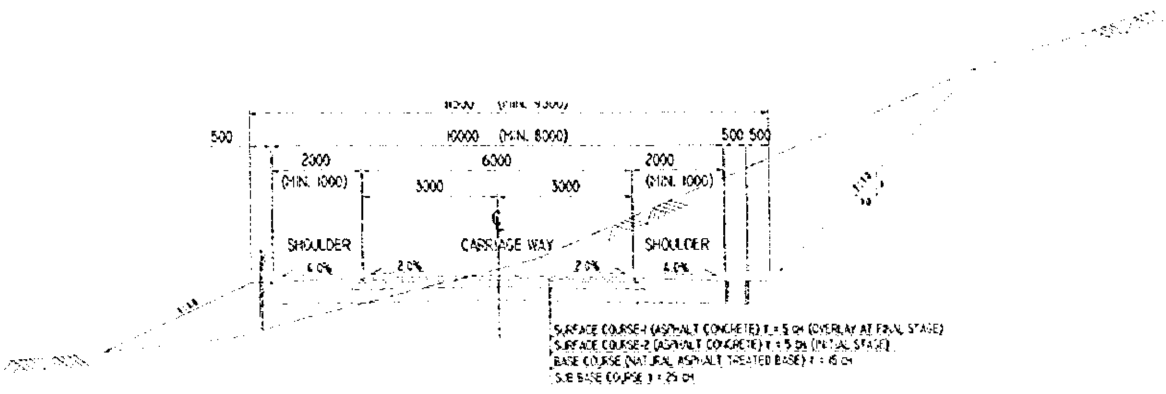
( ) showing the minimum width of shoulder

Source: Study Team

5.3 Typical Cross Section of Road

In general, a pavement width of 4.5 m, shoulder width of 1.75 m, and total width at more than 8.0 m has a capacity of 3,000 PCU/day or less. In case of future daily traffic volume of 3,000 to 20,000 PCU, total width of 10.0 m with a carriage-way of 3.0 m x 2 and shoulders of 2.0 m x 2 is needed. For the feasibility study routes, two-lane carriageways are applicable in terms of traffic volume as mentioned before.

Typical cross section of the feasibility study routes is shown in Figure 5-3-1.



Source: Study Team

Figure 5-3-1 Typical Cross Section of Road

5.4 Pavement Design Standard

For the pavement design, the following conditions should be considered:

- There are two types of design: that of flexible pavement and rigid (concrete) pavement;
- Two categories of road construction are involved in the project: widening or overlay of existing pavement, and new construction of bypass road;
- In the section of pavement type, investment efficiency sometimes should be considered in addition to the construction cost; and
- Construction aspects and local conditions sometimes govern the selection of pavement types when the reconstruction/adjustment of related roads is necessary.

(1) Method of Design

The guide for design of pavement structure by AASHTO and Japanese pavement design standard by the Japan Road Association were used for this design.

(2) Design CBR

Design CBR of 5% to 6 % was used based on the results of the CBR test for this study.

(3) Design Life Period

The design life period is to be 20 years.

(4) Design Traffic Volume for the Pavement

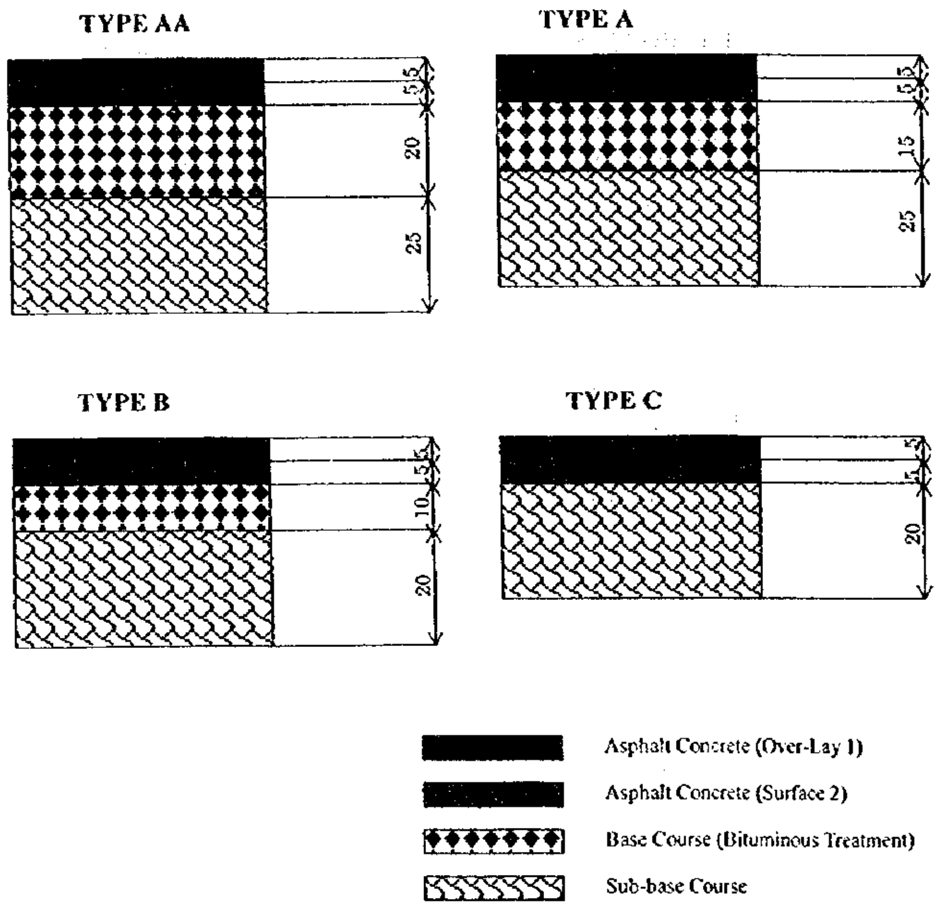
Design traffic volume for the pavement design is to be for a period of 20 years.

For the pavement structure, four types shown in Table 5-4-1 are proposed on the basis of the traffic volumes of heavy vehicles (buses and trucks) in the year 2018. The pavement surface is to be in two layers by considering the overlay to be provided in the future while using an asphalt surface course for the surface. Namely, the base course is treated with asphalt while the subbase consist of mechanical stabilized crushed stone.

Table 5-4-1 Pavement Types by Traffic Volumes of Heavy Vehicle

Pavement Type	Traffic Volume (Vehicles/Day)
AA	More than 3000
A	1000 – 3000
B	250 – 1000
C	Less than 250

Source: Study Team



Source: Study Team

Figure 5-4-1 Pavement Structure by Type

5.5 Bridge Design Standard

(1) General

The design work of the proposed bridge structures will basically be carried out in accordance with the "Bridge Design Code (Bina Marga, Indonesia)" (hereinafter referred to as "Indonesian Bridge Design Code (IBDC)") as the prime design standards. Although the principal design work was accomplished in accordance with the Indonesian Design Code, a bridge specification established by the American Association of State Highway and Transportation Officials (hereinafter referred to as "AASHTO") and a specification issued by the Japan Road Association as listed in (2) below were applied as the need arises.

According to IDBC, the limit state design, which consists of the ultimate limit states and the serviceability limit states, is provided as a prime design method. However, the working stress design is also prescribed as an alternative method.
Engineering design in this study is not to determine structural details. The working stress design is helpful in calculating rough configuration of bridges. In addition, Standard Design of Bridges by Bina Marga and previous construction data are also useful for the preliminary engineering design of the feasibility study.

(2) Bridge Design Standard

1) Authorized Design Standards to be applied

The following standards were applied for this study.

【The Republic of Indonesia】

- Bridge Design Code
  - Volume I (December, 1992)
  - Volume II (December, 1992)
- Standard Design of Bridge Superstructure (1993)
  (Reinforced concrete girder, prestressed concrete girder, composite girder)
- Standard Design of Box Culvert (1993)

【U.S.A】

[American Association of State Highway and Transportation Officials]

- Standard Specifications for Highway Bridges (Fifteenth Edition, 1992)

[American Concrete Institute] (hereinafter referred to as "ACI")

- Building Code Requirements for Reinforced Concrete (ACI 318-83)

【Japan】

[Japan Road Association]

- Specifications for Highway Bridges (February, 1996)
  - Part I, Part II, Part III, Part IV, Part V

[Japan Highway Public Corporation]

- Design Standard for Highway and Bridges (February, 1994)

2) Design Manuals

【The Republic of Indonesia】
[Directorate General of Highways]
• Bridge Design Manual

【Japan】
[Japan Road Association]
• Design Guideline for Concrete Highway Bridges (February, 1994)
• Construction Guideline for Concrete Highway Bridges (February, 1994)

(3) Loading Specifications

1) Bridge Loading Classification

Bridge design loadings to be applied are listed in Table 5-5-1 in accordance with the IDBC. Design loadings in the code are grouped according to their origin into three groups and also classified by duration into two categories. In addition, an overstress is permitted in the basic working stress for some load combinations since these combinations have a low probability of occurrence and a short duration. These load combinations for working stress design are listed in Table 5-5-2 and the permitted overstresses is also given in Table 5-5-2 as a percentage of the allowable working stress.

Detailed application is referred to the IDBC.

2) Application of Traffic Loads

Present traffic loads for design of road bridges consist of the "D" lane loading and the "T" truck loading. The "D" lane loading is applied across the full width of the bridge roadway and produces effects in the bridge equivalent to a queue of real of vehicles. The total amount of "D" lane loading applied depends upon the width of the bridge roadway.

The "T" truck loading is a single heavy vehicle with three axles which is applied in any position in a design truck lane. Each axis comprised of two patch loadings which are intended to simulate the effects of the wheels of heavy vehicles. Only one "T" truck may be applied per design traffic lane.

Design Traffic Lanes

Unit design traffic lane is to be 2.75m wide. The maximum number of design traffic lanes to be used for various bridge widths is shown in Table 5-5-3.

Table 5-5-1 Summary of Design Actions

Design load Name	Symbol	Duration	Group
Self Weight	P_{MS}	Permanent	Permanent action
Superimposed dead load	P_{MA}	Permanent	Permanent action
Shrinkage & creep	P_{SR}	Permanent	Permanent action
Prestress	P_{PR}	Permanent	Permanent action
Earth pressure	P_{TA}	Permanent	Permanent action
Permanent construction	P_{PL}	Permanent	Permanent action
'D' lane load	T_{1D}	Transient	Traffic load
'T' truck load	T_{1L}	Transient	Traffic load
Breaking force	T_{TB}	Transient	Traffic load
Centrifugal force	T_{TR}	Transient	Traffic load
Pedestrian load	T_{TP}	Transient	Traffic load
Collision load	T_{TC}	Transient	Traffic load
Settlement	P_{ES}	Permanent	Environmental action
Temperature	T_{ET}	Transient	Environmental action
Stream/Debris	T_{EF}	Transient	Environmental action
Hydro/Buoyancy	T_{EU}	Transient	Environmental action
Wind	T_{EW}	Transient	Environmental action
Earthquake	T_{EQ}	Transient	Environmental action
Bearing friction	T_{BF}	Transient	Other action
Vibration	T_{VI}	Transient	Other action
Construction	T_{CL}	Transient	Other action

Source: IDBC

Table 5-5-2 Load Combinations for Working Stress Design

Load combination	Combination No. 1	2	3	4	5	6	7
Permanent actions	O	O	O	O	O	O	O
Traffic loads	O	O	O	O			
Temperature effects		O					
Stream/Debris/Hydro/Buoyancy	O	O	O	O	O		
Wind load			O	O			
Earthquake effects					O		
Collision loads							O
Construction loads						O	
Permitted overstress	0%	25%	25%	40%	50%	30%	50%

Source: IDBC

Table 5-5-3 Number of Design Traffic Lanes

Bridge type	Bridge roadway width (m)	No. of design traffic lanes
Single lane	4.00 – 5.00	1
Two-way, no median	5.50 – 8.25	2
	11.30 – 15.00	4
Multiple-roadway	8.25 – 11.25	3
	11.30 – 15.00	4
	15.10 – 18.75	5
	18.80 – 22.50	6

Source: IDBC

(a) "D" Lane Loading

The "D" lane loading consists of a uniformly distributed load (UDL) combined with a knife-edge load (KEL) as shown in Figure 5-5-1.

- Uniformly distributed Load: the UDL has an intensity q kPa, where the value of q depends on the total length L as follows:

  $L \leq 30\ m$: $q = 8.0\ kPa$

  $L > 30\ m$: $q = 8.0\left(0.5 + \frac{15}{L}\right) kPa$

- Knife-edge load: a single KEL of p kN/m will be placed in any position along the bridge. The KEL shall be applied perpendicular to the direction of traffic on the bridge. The value of p shall be 44.0 kN/m.

- The "D" lane loading will be arranged laterally in such a way as to produce the maximum effect. The lateral arrangements of UDL and KEL components of the "D" lane loading are to be the same. The concept of lateral distribution of "D" lane loading is shown in Figure 5-5-2.

(b) "T" Truck Loading

The "T" truck loading consists of a tractor truck and semi-trailer with axle weights and configuration as shown in Figure 5-5-3. The weight from each axle is to be distributed equally between two uniformly loaded patches which represent the constant areas of the wheels. The spacing between the two heavy axles may vary from 4.0 m to 9.0 m in order to produce the maximum longitudinal effect.

(4) Seismic Design

Although a full dynamic analysis will be required for large, complex and important bridges, equivalent static analysis is appropriate for proposed bridges in this study area.
Equivalent static horizontal load for a bridge is calculated by following formula,

$$T_{EQ} = Kh * I * W_T$$

where:

$$Kh = C * S$$

and:

T_{EQ} : total base shear force in the direction being considered (kN);
Kh : coefficient of horizontal seismic loading;
C : basis shear coefficient for the appropriate zone, period and site conditions;
I : importance factor;
S : structural type factor;
W_T : total nominal weight of structure subject to seismic acceleration (kN).

According to IBDC, each coefficient in this Study is defined as follows;

a. Zone --------------------------------This study area is in the zone 4 as shown in Figure 5-5-4.

b. Basic shear coefficient (C) --------- Basic shear coefficient of bridge structure in the zone 4 ranges from 0.10 to 0.15 by Figure 5-5-6. Although the basic shear coefficient varies on structural period and site soil condition, the maximum value, 0.15, is appropriate for the feasibility study from the engineering judgement.

c. Importance factor (I) ------------- Importance factor of bridges for this study is defined as 1.2 in consideration of no alternative route. (Refer to Table 2.13, Sec 2.4.7 IBDC)

d. Structural type factor (S) ----------- Structural type factor will be different by bridges. (Refer to Table 2.14, Sec 2.4.7 IBDC)

Kh=0.15 is, therefore, adopted as the value of coefficient of horizontal seismic loading.

$K_h*I=0.15*1.2=0.18$

Equivalent static horizontal load is finally calculated in using the following fomula for this study.

$T_{EQ}=0.18*W_T$

(5) Design for Scour

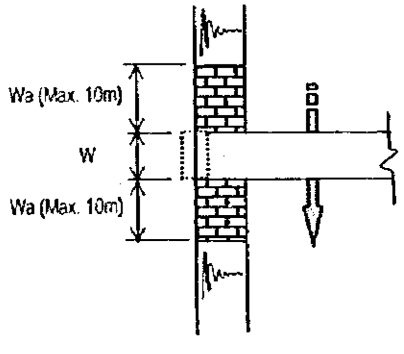
- Foundation depth to prevent undermining by scour

	Spread foundation	Pile foundation
Piers	Spread footings will be avoided, unless the base can be socked into firm rock.	Piles are generally founded much deeper than the design scour depth, however the following points will also be considered in the design: - The structural capacity of the unsupported length of scoured piles. - Backfilling of scoured piles at the abutments during maintenance will cause active earth pressures on the piles, over an effective width of twice the pile width. - Scored piles in stream flow may be subject to hydronamic and debris loads.
Abutments	The bearing depth of abutments placed on stable banks of minor streams on non-erodible material will be the greatest depth below the natural bank of: - The lesser of 2m or depth to firm rock - The design degradation depth at the abutment + twice the total design scour depth at the abutment.	

Source: Bridge Design Manual by Bina Marga

- Revetment

The required length of revetment for bridge construction is prescribed as follows:



W: Width of abutment
Wa: Required length of revetment
Wa=W
(Maximum 10m)

Source: Study Team

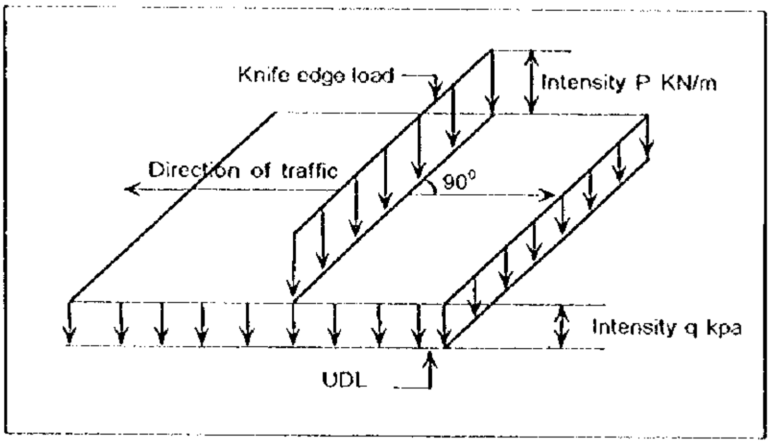


Figure 5-5-1 "D" Lane Loading

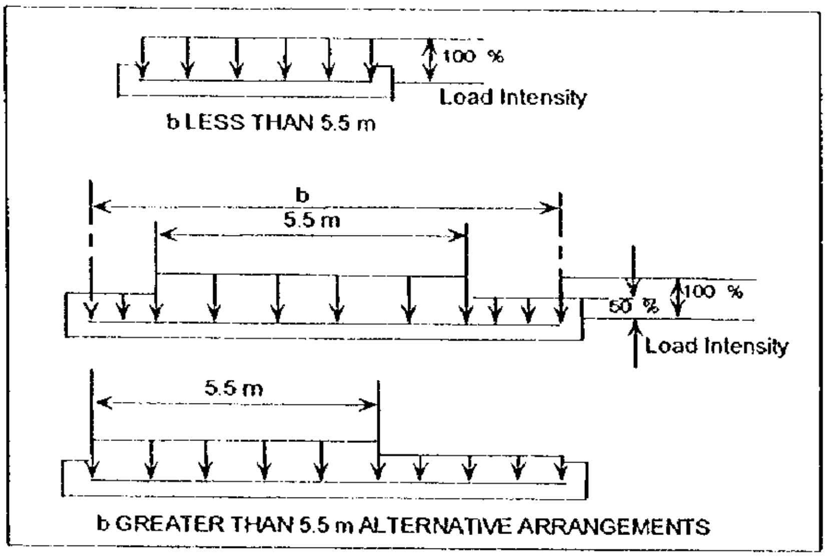


Figure 5-5-2 Lateral Distribution of "D" Lane Loading

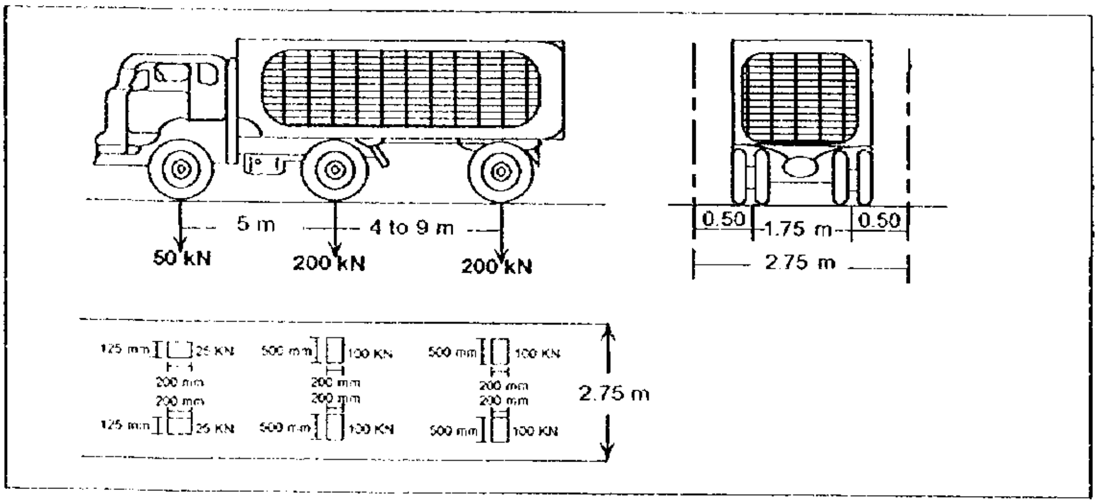
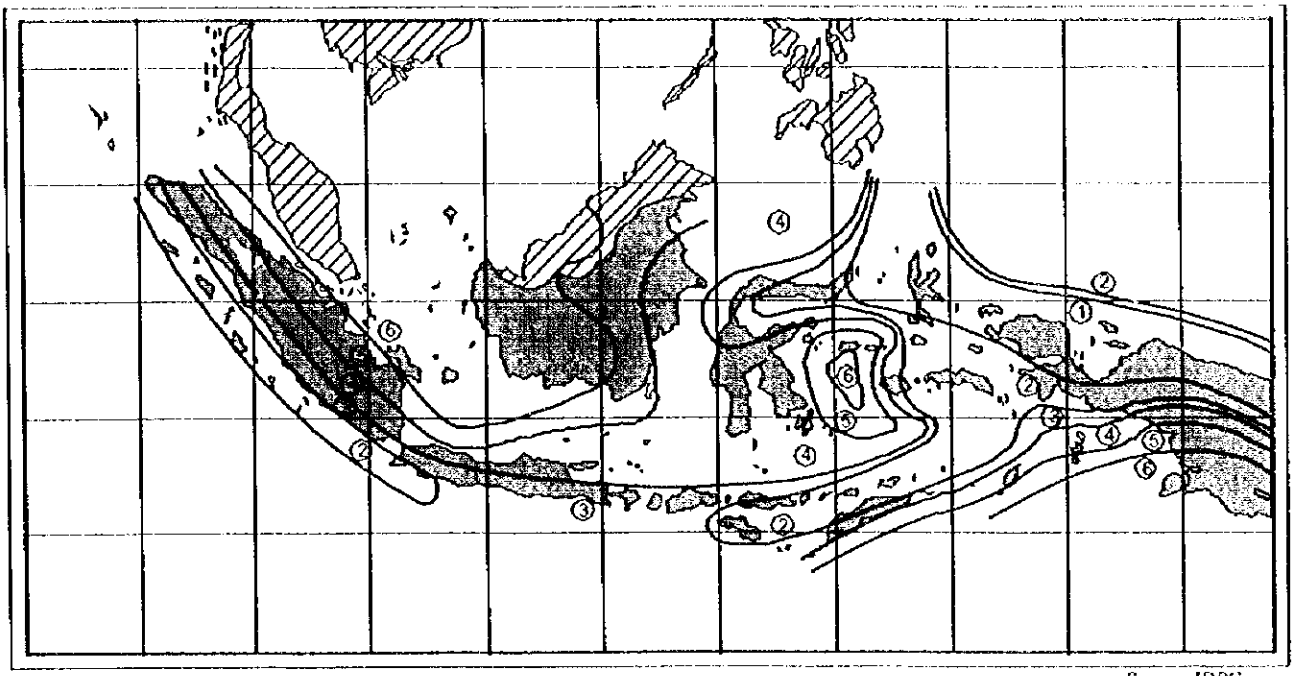
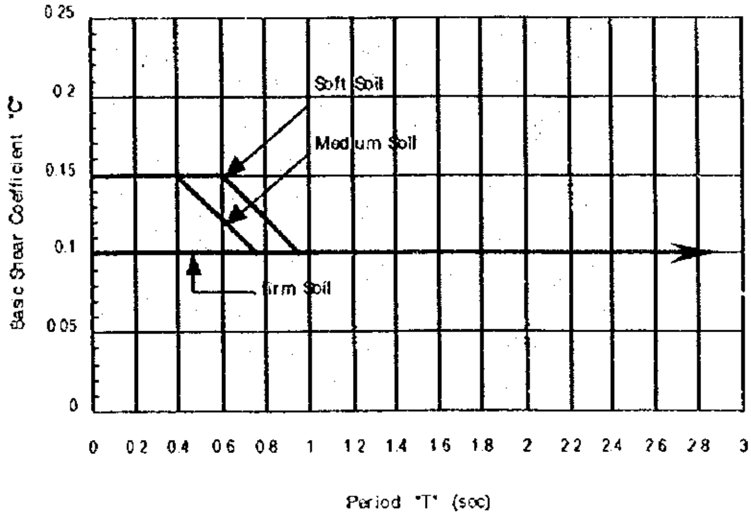


Figure 5-5-3 "T" Truck Loading



Source: IDBC

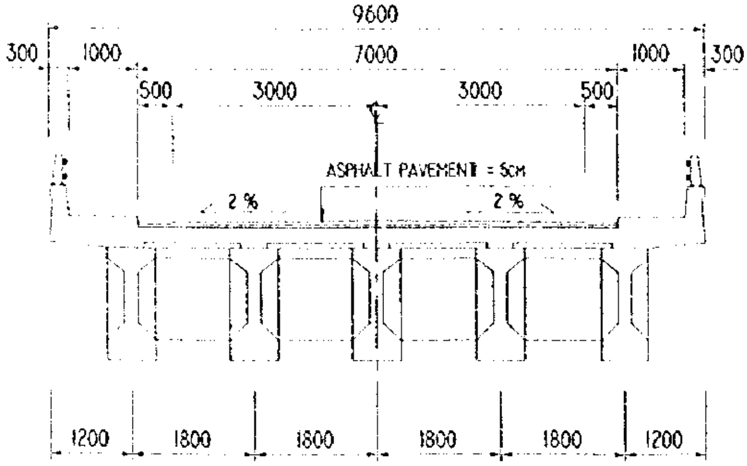
Figure 5-5-4 Zones for Basic Shear Coefficient in Indonesia



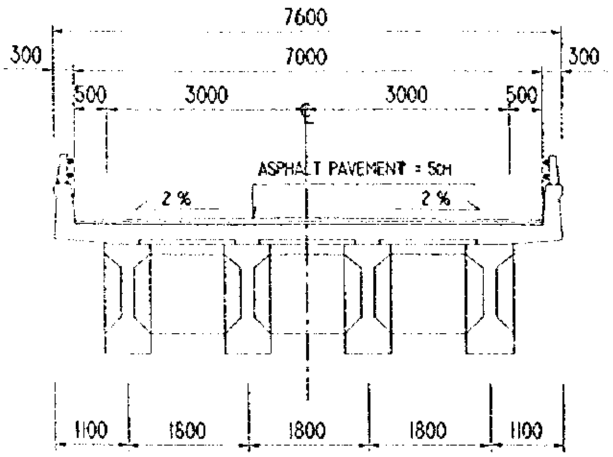
Source: IDBC

Figure 5-5-5 Basic Shear Coefficients in Zone 4

(6) Typical Cross Section of Bridge



(a) Type A: With Sidewalk



(b) Type B: Without Sidewalk

Source: Study Team

Figure 5-5-6 Typical Cross Sections of Bridge

Above two types of bridge width were considered for this Study.
Application of these types of bridge width was provided as follow:

- When the bridge is located in the village area, the type A bridge, which is with sidewalk, was adopted in consideration of ensuring pedestrians' safety.
- The type B bridge, which is without sidewalk was applied to bridges which is located in the non-village area.

5.6 Tunnel Design Standard

(1) General

Use of tunnels is an effective means of preventing slope failures and landslides, protecting present environmental conditions, and securing proper road alignment within the mountain range. However, there are some disadvantages to be considered such as:

- Construction cost is higher than that of roads and bridges
- Maintenance cost for ventilation system
- Psychological problem due to closed space
- Potential of secondary disaster following traffic accidents

At present, there is no design standard for road tunnels in Indonesia. For this study, there is a need to establish tunnel design standards for a two-lane traffic tunnel. "Specifikasi Standar Untuk Perencan Geometric Jalan Luar Kota" and "Bridge Design Code" by Bina Marga, and "Design standard for road tunnel" and "Standard specification for tunnel" by the Japan Road Association will be employed for the establishment of tunnel design standard for the study.

(2) Interior Section and Construction Clearance of Tunnel

The shape and dimensions of a tunnel should be determined based on the facilities required for the tunnel's interior and its structural stability.
Construction clearance for tunnel is not mentioned in the "Specifikasi Standar Untuk Perencan Geometric Jalan Luar Kota", but, concerning roads, it is mentioned that the roadway should be at least 5.0 m in width. Also, concerning vertical clearance at Bridge Design Code mentions that parts of the superstructure or substructure of bridge crossing over a road or a railway should be at least 100 mm greater than the operation vertical clearance to allow for settlement and road resurfacing. Considering the above two items, a construction clearance of 5.0 m for tunnels is applicable.
Shoulder width was selected to be 0.75 m, considering the Classes 3 to 4 of Bina Marga standards.
Shoulder height of tunnel is decided based on "A policy of geometric design of highway and streets 1994". In this material, a trailer height of 4.1 m plus 0.1 m freeway is the minimum construction clearnce for shoulder space. Therefore 4.2 m is applicable for shoulder height.

Also, a inspection way with a width of 0.75 m should be provided on both sides of the traffic lanes.

Lighting and ventilation facility should be provided between construction clearance and interior area of tunnel.

(3) Horizontal Alignment

Alignment standards should follow road alignment standard as the tunnel is a part of the road. Since traffic accidents are prone to occur at the entrance of the tunnel, an application of higher standards for the tunnel entrances is desirable.
Curves with small radii were not applicable for this tunnel, as wider section needs to be designed in order to accommodate minimum sight distance, thereby increasing construction cost. Necessary considerations for design of tunnel are as mentioned below:

- Tunnel should be straight since drivers in Indonesia are unaccustomed to tunnels.
- Relation between design speed and minimum radius are shown below:

Design Speed	40 km/h	R=800 m
Design Speed	30 km/h	R=500 m
Design Speed	20 km/h	R=300 m

(4) Vertical Alignment

Tunnel gradient should be minimized for the following reasons:

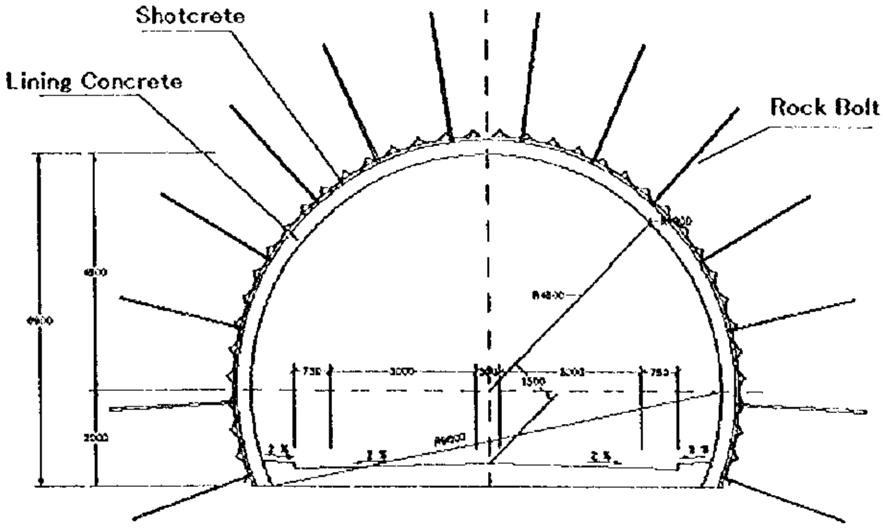
- In consideration of the use of rail haulage during excavation, a tunnel gradient of less than 2 % is preferable.
- As vehicle exhaust density will rise in proportion to tunnel gradient, it should be less than 3 %.
- A steep grade will cause excess driving speed as well as dangerous passing manoeuvres.

In consideration of the above, the following standards are established;

- 4 % gradient is applicable (the maximum grade that a truck can drive at half of design speed)
- Minimum gradient of tunnel is 0.3 % for drainage purpose.

(5) Tunnel Cross Section

Tunnel cross-section should be decided based on soil conditions, excavation method, width of traffic lane and type of tunnel support. Tunnel supports are a vital part of a tunnel structure, protecting the overall tunnel structure from failure of rock mass and earth pressure which constantly bears upon it. These tunnel supports will function to stabilize the excavated section.
A tunnel cross section was decided as shown in Figure 5-6-1.



Source: Study Team

Figure 5-6-1 Typical Cross Section of Tunnel

5.7 Design Concept of Disaster Prevention Work

(1) Type of Slope Protection

The main purpose of the slope protection works is to prevent weathering and erosion, therefore the design should be selected based on geological and topographical conditions. The study team recommended the types as shown in Table 5-7-1, for selection of type of slope protection works.

Table 5-7-1 Types of Slope Protection Works and their Purposes

Kind of Work	Purposes and Features
Shotcrete Stone pitching Block pitching	For preventing weathering and erosion
Concrete block cribworks	For preventing erosion when filled up with sediment or gravel
Concrete pitching Sprayed concrete cribworks Slope anchor works	For preventing collapse of surface layer of slope, preventing separation of bedrock, and retaining earth where there is earth pressure.
Wicker works Slope gabion works	For controlling erosion of surface layer of slope and outflow of surface layer due to spring water
Rockfall prevention nets Rockfall prevention fences Rockfall shed	For prevention of rockfall

Source: Study Team

(2) Concept of Application for Slope Protection Works

Countermeasures were required in areas of steep terrain where slope failure is prone to occur for the following reasons:

- Incremental quantity of cut volume will be required when the cutting slope is not at a safe gradient.
- In case of insufficient drainage facilities, slope failure will occur even if the required cut is conducted according to safe gradients.
- Due to geological conditions, quick erosion is to be expected.
- Slope failures will have serious impact on society, the economy and the environment.

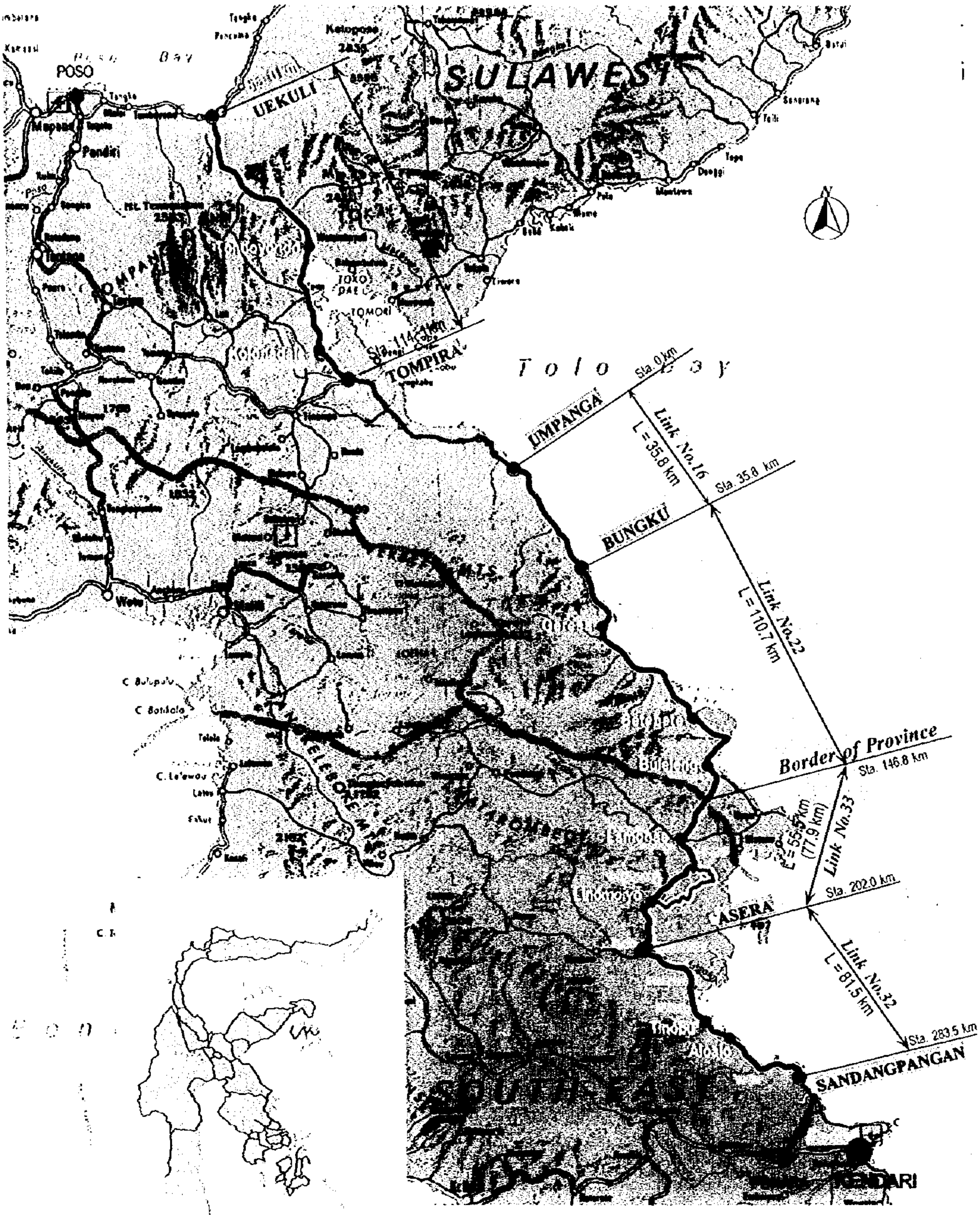
Countermeasure works were applied based on the following concepts;

- Countermeasure works should adopt semi-permanent materials for durability for all road classes of the roads concerned,
- When combining prevention countermeasures for works and surface drainage, run-off rain will not penetrate surface structures, therefore, durability of slope protection works will be long-lasting.
- Countermeasure works should use semi-permanent structures of the most economic type.

Chapter 6

Preliminary Engineering Design

MAP OF ROAD LINKS FOR FEASIBILITY STUDY



LOCATION MAP

MAP OF ROAD LINKS FOR FEASIBILITY STUDY

LOCATION MAP

CHAPTER 6 PRELIMINARY ENGINEERING DESIGN

6.1 General

Feasibility study route (link Nos. 15, 16, 22, 32 and 33) of Trans-Sulawesi East Road is located from the top of east Sulawesi peninsula to the east coast of lower east Sulawesi peninsula. In addition to the priority links of the recommended 300 km of the pre-feasibility study, link No. 15 of 114 km from Uekuli to Tompira was added to the feasibility study after considering its high priority and importance to support regional development in the eastern part of the region (strategic area of Luwuk).

Characteristic of these links can be divided into mountainous terrain and coastal flat terrain. A mountain range is located from Uekuli to Kolonadale. Kolonadale to Sandangpangan via Tompira, Umpanga, Bungku, Provincial border and Asera is located on the east coast of lower east Sulawesi peninsula. Most of the routes are located along the coastal area, but some parts have to cross the mountain ranges.

Most of the road sections follow the existing route locations, but the following two locations of proposed sections were newly selected by the study team.

- Section between Tondoyondo and Kolonadale (no existing road), link No. 15
- Section between Linomoiyo and Lamonae, link No. 33.

Regarding the sections between Betebete and Tangofa (link No. 22), a alternative study by route section was conducted for a peninsula crossing and peninsula coastal route.

A topographic map of 1:5,000 in scale was employed for the preliminary design of link Nos. 16, 22, 33, and 32, but an available topographic map of 1:50,000 in scale was used for link No. 15.

6.2 Umpanga - Bungku (35.8 km): Link No. 16

6.2.1 Selection and Description of Route Location (Link No. 16)

(1) Location of Existing Road
The road is located on an alluvial plain formed by many small rivers originating in the mountain ridges. The beginning point of this link is at station 0 km and the end point is at station 35.8 km.

(2) Existing Road Conditions
Of the total length of the road, a 30.8 km section is paved with asphalt of 3.5m wide. The remaining 5.0 km section is gravel road. Most of bridges are made from wood. For Ipi, there is no existing bridge to cross over the river which is a width of 30 m. The road alignment is satisfactory because the land is flat.

(3) Land Use
The land within 2 to 3 km from the shoreline is flat and arable. Most of the land is used for paddy fields and for cultivation of cotton and copra.

(4) Possibility of Development
The land is flat, has many medium and small rivers and is arable. It is expected that agricultural development will be promoted in the wide area of uncultivated land.

(5) Components of Construction Work
A proposed road alignment is shown in Appendix A-6.1 and the following major works are needed for the construction.

- Widening of carriage-way;
- Pavement;
- Bridges; and
- Drainage.

6.2.2 Preliminary Engineering Design (Link No. 16)

(1) Preliminary Engineering of Bridges

Adopted types for each structural part of bridge are summarized in Table 6-2-1.

There are following three kinds of standard bridge by Bina Marga.

- Reinforced Concrete T-Girder (RC T-girder)
- Prestressed Concrete I-Girder (PC I-girder)
- Composite Girder, which consists of steel girder and concrete slab

And recently a steel truss is also available for superstructure as a semi-standard bridge.
In this bridge planning, application of superstructure types basically follows the Bina Marga's standard design. However, new construction of composite girder is not recommendable in this study because the cost of composite girder is costly and transportation of steel girder is difficult. The cost of steel truss bridge is also costly but in case of 60m span, reinforced concrete girder is not applicable to be constructed and only prestressed concrete box-girder, which is not I-girder and constructed by cast-in-place, is available. In this case, the cost of concrete girder becomes expensive and difficulty of quality control will arise so that steel truss was applied to 60m bridge span.

For pile foundations, reinforced concrete piles was recommended. Prestressed concrete pile (PC piles) are pre-cast in factories which in Sulawesi Island are only in Ujung Pandang and Poso. There is about 200 km to a nearest bridge site from the factory. It is, therefore, difficult to transport the pre-cast PC piles to bridge sites from the factory in consideration of road conditions, their weight and length. On the other hand, reinforced concrete piles (RC piles) is available for cast-in-place so that pile works could be done by transporting materials of pile and construction equipment.

Table 6-2-1 Application of Bridge Types for New Construction

	Span Length	Applied Types
Superstructure	10m, 15m, 20m	Reinforced Concrete T-Girder
	25m, 30m, 40m	Prestressed Concrete I-Girder
	60m	Steel Truss
Substructure	Abutments	Cantilever Wall Abutment
	Piers	Wall Pier with Top Beam
Foundation	depending on soil condition at site	Spread Footing
		Pile Foundation (Reinforced concrete rectangular pile 40cm x 40cm)

Source: Study Team

Standard design of superstructures and substructures with foundation in this study are shown in Volume VI, drawings of this study report.

All bridges on link No.16 require pile foundations based on the result of soil investigation. Moreover, bearing layer for the bridge foundation is relatively deep and the length of piles is more than 20m at most bridge sites.

Most existing bridges are wooden bridges or there is no existing bridge at many locations. Therefore, bridges except six existing bridges are to be newly constructed. For bridges to be retained, BR16-7 (Sta.6+100) and BR16-14 (Sta.15+475) have recently replaced with 8m wide, and BR16-8 (Sta.7+000), BR16-15 (Sta.16+000), BR16-19 (Sta.20+530) and BR16-24 (Sta.29+525) has only 6m wide without sidewalk but have enough durability. The width of 6m is available for two lane traffic.

Summarized quantities of bridge improvement on link No. 16 are shown in Table 6-2-2. Proposed bridge list of link No. 16 is shown in Table 6-2-3

Table 6-2-2 Summary of Bridge Improvement Quantities of Link No.16

Classification		The Number of Bridges	Bridge Area (m^2)
New Construction	Bridge length ≦50m	20	4,224
	Bridge length >50m	0	0
	Total	20	4,224
Existing to be used as it is		6	1,590

Source: Study Team

(2) Cost Estimates

1) Estimated Project Cost

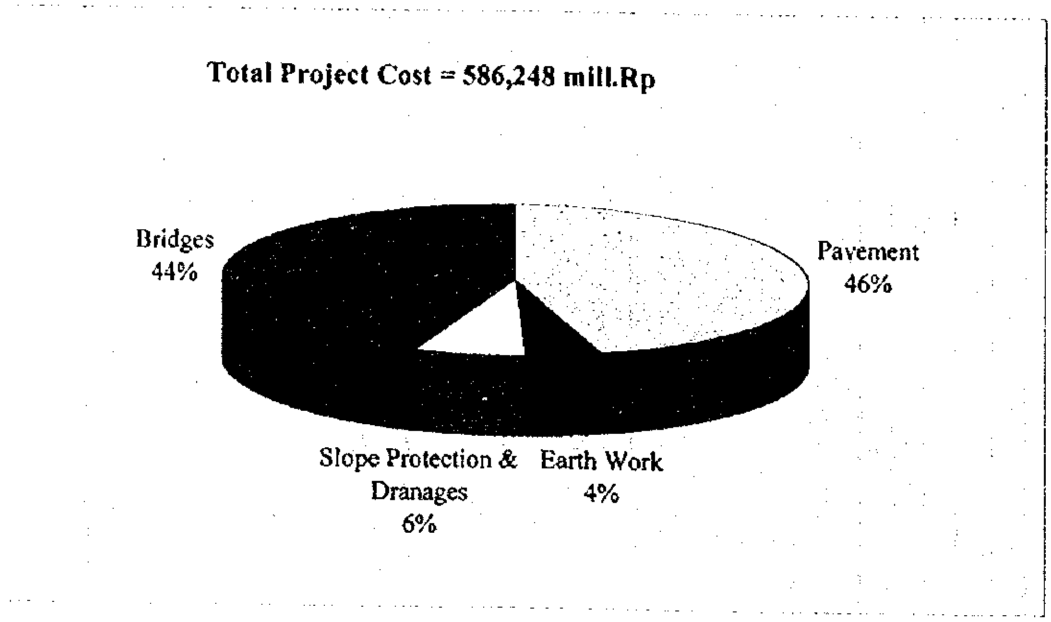
Cost items consist of preparation works, pavement, earth work, drainage, bridge, slope protection and safety facilities works. The cost for engineering service was estimated at 20% of the total construction cost consisting of direct and indirect cost. A contingency has been included in 10 % of the total of construction and engineering cost. The ratio of major item costs to the total cost is shown in Figure 6-2-1 and Table 6-2-4 shows estimated cost.

Table 6-2-3 Proposed Bridge List of Link No.16

Bridge No.	Location	Length	Nos. of Span	Span Arrangement	Bridge Width	Types of Super-structures	Types of Foundations	Sub-structures: Abutments: FIX: Nos.	FIX: ha(m)	FIX: Pile: La(m)	FIX: Pile: Nos.	MOVE: Nos.	MOVE: ha(m)	MOVE: Pile: La(m)	MOVE: Pile: Nos.	Piers: FIX+FIX: Nos.	FIX+FIX: hp(m)	FIX+FIX: Pile/ 1 pier: Lp(m)	FIX+FIX: Pile/ 1 pier: Nos.	MOVE+FIX: Nos.	MOVE+FIX: hp(m)	MOVE+FIX: Pile/ 1 pier: Lp(m)	MOVE+FIX: Pile/ 1 pier: Nos.	Boring Data
	km + m	(m)			(m)																			
BR 16 - 1	2 + 115	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	24	18	1	6	24	18	-	-	-	-	-	-	-	-	58,59
BR 16 - 2	3 + 300	15.0	1	1 @ 15.0	9.6	RC-T	Pile	1	6	24	16	1	6	24	16	-	-	-	-	-	-	-	-	58,59
BR 16 - 3	3 + 980	25.0	1	1 @ 25.0	9.6	PC-I	Pile	1	6	24	20	1	6	24	20	-	-	-	-	-	-	-	-	58,59
BR 16 - 4	4 + 760	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	24	18	1	6	24	18	-	-	-	-	-	-	-	-	58,59
BR 16 - 5	5 + 375	25.0	1	1 @ 25.0	9.6	PC-I	Pile	1	6	24	20	1	6	24	20	-	-	-	-	-	-	-	-	58,59
BR 16 - 6	6 + 100	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	24	18	1	6	24	18	-	-	-	-	-	-	-	-	58,59
BR 16 - 7	6 + 790	25.0	1	1 @ 25.0	9.6	RC-T	Pile	RETAIN EXISTING																58,59
BR 16 - 8	7 + 0	45.0	1	1 @ 45.0	6.0	Steel Truss	Pile	RETAIN EXISTING																58,59
BR 16 - 9	7 + 600	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	24	18	1	6	24	18	-	-	-	-	-	-	-	-	58,59
BR 16 - 10	7 + 640	25.0	1	1 @ 25.0	9.6	PC-I	Pile	1	6	24	20	1	6	24	20	-	-	-	-	-	-	-	-	58,59
BR 16 - 11	7 + 785	25.0	1	1 @ 25.0	9.6	PC-I	Pile	1	6	24	20	1	6	24	20	-	-	-	-	-	-	-	-	58,59
BR 16 - 12	10 + 970	30.0	1	1 @ 30.0	9.6	PC-I	Pile	1	6	24	22	1	6	24	22	-	-	-	-	-	-	-	-	56,57
BR 16 - 13	11 + 630	15.0	1	1 @ 15.0	9.6	RC-T	Pile	1	6	24	16	1	6	24	16	-	-	-	-	-	-	-	-	56,57
BR 16 - 14	15 + 475	25.0	1	1 @ 25.0	9.6	RC-T	Pile	RETAIN EXISTING																54,55
BR 16 - 15	16 + 0	40.0	1	1 @ 40.0	6.0	Steel Truss	Pile	RETAIN EXISTING																54,55
BR 16 - 16	16 + 490	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	24	14	1	6	24	14	-	-	-	-	-	-	-	-	54,55
BR 16 - 17	17 + 620	15.0	1	1 @ 15.0	9.6	RC-T	Pile	1	6	26	16	1	6	26	16	-	-	-	-	-	-	-	-	52,53
BR 16 - 18	18 + 590	25.0	1	1 @ 25.0	9.6	PC-I	Pile	1	6	26	20	1	6	26	20	-	-	-	-	-	-	-	-	52,53
BR 16 - 19	20 + 530	55.0	1	1 @ 55.0	6.0	Steel Truss	Pile	RETAIN EXISTING																50,51
BR 16 - 20	22 + 290	25.0	1	1 @ 25.0	9.6	PC-I	Pile	1	6	26	20	1	6	26	20	-	-	-	-	-	-	-	-	50,51
BR 16 - 21	22 + 830	15.0	1	1 @ 15.0	9.6	RC-T	Pile	1	6	26	16	1	6	26	16	-	-	-	-	-	-	-	-	50,51
BR 16 - 22	27 + 885	30.0	1	1 @ 30.0	9.6	RC-T	Pile	1	6	10	22	1	6	10	22	-	-	-	-	-	-	-	-	48,49
BR 16 - 23	29 + 250	30.0	1	1 @ 30.0	9.6	RC-T	Pile	1	6	12	22	1	6	12	22	-	-	-	-	-	-	-	-	46,47
BR 16 - 24	29 + 525	45.0	1	1 @ 45.0	6.0	Steel Truss	Pile	RETAIN EXISTING																46,47
BR 16 - 25	31 + 290	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	12	18	1	6	12	18	-	-	-	-	-	-	-	-	46,47
BR 16 - 26	35 + 420	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	12	18	1	6	12	18	-	-	-	-	-	-	-	-	46,47

2) Implementation Plan

As shown in Figure 6-2-2, the construction period is 5 years consisting of one year for preparation of project for fund raising plan, 1.5 years for detailed design of the roads and 2.5 years for construction. Also, the investment plan was set in accordance with the construction plan.



Source: Study Team

Figure 6-2-1 Construction Cost Ratio for Link No. 16

(3) Economic Analysis

1) Economic Project Costs

The economic investment costs were estimated in constant 1998 prices. The financial investment costs in terms of market price include the component of taxes. The economic costs for economic analysis were obtained by subtracting the portion of transfer payment such as taxes from financial costs. Implementation is scheduled over four years from 2000 to 2003. The phased financial and economic investment costs (initial investment) are summarized in Table 6-2-5.

Table 6-2-4 Total Construction Cost For Umpanga - Bungku Road (Link No.16)

Rate : 1US$ = 10600Rp = 140Yen

Item	Unit	Quantity	Unit Price: Foreign (US$)	Unit Price: Financial (Rp)	Unit Price: Economic (Rp)	Total Price: Foreign (US$)	Total Price: Local Financial (Rp)	Total Price: Local Economic (Rp)	Financial Total (Mill Rp)
1.Preparation Works									
Clearing and Grubbing	m2	193,185	0.23	1,867	2,099	44,433	360,676,395	405,495,315	832
2.Pavement									
New Road Asphalt Concrete + Sub base (Type A)	m	0	39.50	436,896	392,152	0	0	0	0
Widnning Road Asphalt Concrete + Sub base (Type A)	m	35,775	20.99	234,564	211,846	750,917	8,391,527,100	7,578,790,650	16,351
Transport for Pavement Material (L=9km)	m3	28,620	1.13	8,404	9,804	32,252	240,509,529	280,594,451	582
Sub-2						783,169	8,632,036,629	7,859,385,101	16,934
3.Earth Work									
Excavation (Common)	m3	30,752	0.92	7,407	8,213	28,292	227,780,064	252,566,176	528
Excavation (Sound Rock)	m3	0	4.12	33,605	36,492	0	0	0	0
Disposal soil (L=5km)	m3	10,148	1.20	8,610	10,050	12,178	87,375,658	101,989,008	216
Sub-3						40,470	315,155,722	354,555,184	744
4.Drainage									
Pipe Culvert (D=100cm)	m	380	44.35	634,758	554,426	16,853	241,208,040	210,681,880	420
Pipe Culvert (D=60cm)	m	716	15.28	202,787	184,640	10,933	145,094,099	132,109,920	261
Box Culvert (B=2.0m, H=2.0m)	m	120	325.89	3,064,762	2,510,606	39,107	367,771,440	301,272,720	782
U-ditch (U=50cm)	m	8,940	2.85	69,850	61,200	25,479	624,459,000	547,128,000	895
Sub-4						92,372	1,378,532,579	1,191,192,520	2,358
5.Slope Protection									
Sprayed Concrete Cribwork	m2	0	14.68	127,197	88,984	0	0	0	0
Shotcrete Work	m2	0	11.82	101,390	67,157	0	0	0	0
Stone Masonry	m2	0	6.91	116,286	109,711	0	0	0	0
Mat Gabion	m2	0	9.20	72,584	61,374	0	0	0	0
Sodding	m2	0	0.08	3,238	2,851	0	0	0	0
Sub-5						0	0	0	0
6.Tunnel	m	0	3,500.00	22,400,000	17,920,000	0	0	0	0
7.Bridges	No	20				869,966	7,774,848,307	6,232,039,661	16,996
8.Sefty Facilities Works									
Guard Railing	m	0	11.30	168,012	143,025	0	0	0	0
Traffic Sign	each	119	27.98	426,548	373,259	3,337	50,865,849	44,511,136	86
Line Marking	m	35,775	0.42	4,231	3,518	15,026	151,364,025	125,856,450	311
Sub-8						18,362	202,229,874	170,367,586	397
9.Mobilization & Temporally Works (20% of Total Cost)						360,948	3,826,045,659	3,328,659,723	7,652
10.Sub -Total						2,209,719	22,489,525,164	19,541,695,090	45,913
11.Land Acquisition	m2	30,000	0.00	20,000	20,000	0	600,000,000	600,000,000	600
12.Compensation	houses	9	0.00	15,000,000	15,000,000	0	135,000,000	135,000,000	135
13.Engineering Cost (20% of 10+11+12)						528,085	3,731,803,832	2,985,443,066	9,330
14.Contingency (10% of 10+11+12+13)						273,780	2,695,632,900	2,326,213,816	5,598
Ground Total Cost (10+11+12+13+14)						3,011,585	29,651,961,896	25,588,351,971	61,575

Item	Unit	Quantity	1999	2000	2001	2002	2003	Total
1. Preparation of Project								
2. Survey and Design	km	35.78						
3. Construction								
Earth Work	m3	30,752						
Slope Protection	m2	-						
Tunnel	m	0.0						
Bridges	No	20						
Pavement	km	35.78						
Foreign (US$)				145,223	399,509	988,609	1,478,243	3,011,585
Local Financial Cost (Rp)				1,430,496,054	4,161,652,062	9,062,213,452	14,997,600,328	29,651,961,896
Local Economic Cost (Rp)				1,225,246,843	3,741,961,492	7,461,829,064	13,159,314,573	25,588,351,971
Total Financial Cost (Mill. Rp)				2,970	8,396	19,541	30,667	61,575
Total Ecomomic Cost (Mill. Rp)				2,765	7,977	17,941	28,829	57,511

Figure 6-2-2 Implementation Schedule For Umpanga - Bungku Road (Link No.16)

Table 6-2-5 Phased Initial Investment Costs in 1998 Prices (F/S - Link No. 16)

(Million Rp.)

Year	Financial Prices	Economic Prices
2000	2,970	2,765
2001	8,396	7,977
2002	19,541	17,941
2003	30,667	28,829
Total	61,575	57,511

Source: Study Team

The maintenance cost of the proposed road follows the engineering study results of the cost estimates. Besides, the maintenance cost of the proposed road in the case of "without the improvement of the proposed road" was treated as a negative cost.

2) Economic Benefits

Benefits are classified into two types, one is the direct benefit and the other is the indirect benefit or intangible benefit.

The direct benefits which would be realized from the implementation of the Project are defined as the savings in travel costs, composed of the vehicle operating cost and vehicle time cost when comparing the "with" and "without" project conditions.

The benefit of vehicle operating costs was estimated as a difference of vehicle operating costs between "with" Project" case and "without" Project" case. The vehicle operating cost was derived from the obtained daily vehicle-kilometers and the unit vehicle operating cost by vehicle type. In addition, a promotion of traffic safety and a saving in accident costs were anticipated.

In this economic analysis, the above-mentioned direct benefits, e.g. the saving in vehicle operating cost was computed as a quantified benefit. The calculation of direct benefits were made for the planning year of 2003 and 2018.

As a result, the saving in vehicle operating cost is summarized as shown in Table 6-2-6.

Table 6-2-6 Estimated Economic Benefits (F/S - Link No. 16)

(Million Rp. at 1998 price)

Year	Benefit of Saving in VOC
2004	24,954
2018	56,433

Source: Study Team

3) Economic Cost-Benefit Analysis

The analysis follows the conventional discounted cash flow method in determining the economic internal rate of return (EIRR), the net present value (NPV) and the benefit cost ratio (B/C). (NPV and B/C are calculated at a discount rate of 15 percent.) The project life is assumed to be 20 years after the completion of the construction.

The benefits in the intermediate years were interpolated and those beyond 2018 were assumed to be fixed. The total economic project costs and benefits streams are presented in Table 6-2-7. The efficiency measures were calculated and the results are as follows:

Efficiency Measures	F/S - Link No. 16
EIRR	40.9%
NPV (Million Rp.)	84,660
B/C	3.89

Source: Study Team.

These results indicate that implementation of the project (road improvement of link No. 16) is economically feasible.

Table 6-2-7 Economic Analysis for F/S of Link No. 16

(Million Rp.)

	Year	Benefits VOC Saving	Total	Costs Invest. Costs	Maint. Cost (With)	Total	Maint. Cost (Without)	Net Cash Flow
1	1999			0	0	0	0	0
2	2000			2,765	65	2,830	65	-2,765
3	2001			7,977	65	8,042	65	-7,977
4	2002			17,941	65	18,006	65	-17,941
5	2003	0	0	28,829	65	28,894	65	-28,829
6	2004	24,954	24,954	0	65	65	4,499	29,388
7	2005	27,203	27,203	0	65	65	65	27,203
8	2006	29,451	29,451	0	65	65	65	29,451
9	2007	31,700	31,700	0	65	65	65	31,700
10	2008	33,948	33,948	0	65	65	65	33,948
11	2009	36,197	36,197	0	65	65	4,499	40,631
12	2010	38,445	38,445	0	6,736	6,736	65	31,774
13	2011	40,694	40,694	0	65	65	65	40,694
14	2012	42,942	42,942	0	65	65	4,499	47,376
15	2013	45,191	45,191	0	65	65	65	45,191
16	2014	47,439	47,439	0	65	65	65	47,439
17	2015	49,688	49,688	0	65	65	4,499	54,122
18	2016	51,936	51,936	0	65	65	65	51,936
19	2017	54,185	54,185	0	6,736	6,736	65	47,514
20	2018	56,433	56,433	0	65	65	4,499	60,867
21	2019	56,433	56,433	0	65	65	65	56,433
22	2020	56,433	56,433	0	65	65	65	56,433
23	2021	56,433	56,433	0	65	65	4,499	60,867
24	2022	56,433	56,433	0	65	65	65	56,433
25	2023	56,433	56,433	0	65	65	65	56,433
				57,512	14,902	72,414	28,164	

Source: Study Team

Assuming that the benefits and cost stream might alter ±10%, ±20%, the effect on the EIRR was tested and the results are summarized in Table 6-2-8. In the most severe case of -20% benefit and + 20% cost, the value of EIRR is 31.0%.

Table 6-2-8 EIRR by Altered Benefit and Cost (F/S - Link No. 16)

Cost	Benefit		
	Base	-10%	-20%
Base	40.9%	38.1%	35.1%
+10%	38.3%	35.7%	32.9%
+20%	36.1%	33.6%	31.0%

Source: Study Team

6.3 Bungku – Border of Province (110.7 km): Link No. 22

6.3.1 Selection and Description of Route Location (Link No. 22)

(1) Bungku - Oresa (17.9 km)

1) Location of Existing Road
Ridges originating in the mountains run to the shoreline. Portions projecting into the sea make up a steep limestone topography, with terraces formed by the upheaval of coral reefs in the coastal area. The road winds along the base of steep limestone mountains.

2) Existing Road Conditions
A very low-level standard has been employed for road sections in the steep topography, with the road width being less than 3 m in certain locations. Collapse of the surfase of slopes was also observed in a few places. The road was with gravel pavement and wooden bridges crossing small rivers.

3) Land Use
The topography is steep with a few flatlands. Cultivation of copra is common. Villages are distributed in the few flatland areas.

4) Possibility of Development
This section is the most difficult terrain to construct a paved road connecting Bungku and the southern border of province, which is positioned as a key for development of the Southern district. This district contains a wide agricultural production area and nickel deposits which are currently under development.

5) Components of Construction Work
A proposed road alignment is shown in Appendix A-6.1 and the following major works are needed for the construction;

- Improvement of road alignment;
- Widening of road way;
- Pavement;
- Bridges;
- Drainage; and
- Slope protection.

(2) Oresa - Betebete (45.8 km)

1) Location of Existing Road
The road is located in a relatively rolling area and in an alluvial plain formed by small rivers. The flatland contains 4 to 5 km of arable land. The coastal area from Sta.61.5 km to Betebete at Sta.99.5 km has terraces formed by the upheaval of coral reefs.

2) Existing road conditions
Most of the road sections are gravel road, with satisfactory road alignment except for a 3 km section between Dampala (Sta.65.2 km) and Lalampu (Sta.72.2 km). This 3 km section of the

road has lots of problems in terms of road alignment and slope protections.

3) Land Use
The flatland, which exists 4 to 5 km from the shoreline, consists of a wide expanse of uncultivated, though arable land.

4) Possibility of Development
The land along the road is flat and has many medium and small rivers, and it is arable, but the uncultivated area is spreading. A development project through migration is in progress, and agricultural production can be expected in the future.

5) Components of Construction Work
A proposed road alignment is shown in Appendix A-6.1 and the following major works are needed for the construction;

- Improvement of road alignment;
- Widening of road;
- Pavement;
- Bridges; and
- Drainage.

(3) Betebete – Border of Province (47.0 km)

1) Location of Existing Road
The Betebete - Tangofa section is located along steep slopes and virgin forest, running through the peninsula. The Tangofa - Buleleng section is located in a hilly area. The width of flatland is less than 1 km, with only a small area of arable land. The coastal portion of the hilly area has terraces formed by upheaval of coral reefs. The Buleleng - provincial border section runs through steep mountainous topography.

2) Existing Road Conditions
The entire road is dirt road without any drainage facilities or measures to protect the surface of slopes. The alignment of the trans-peninsula road is based on a low standard, and only vehicles with four-wheel drive or above can travel the road even during the dry season. No drainage ditches are provided, and the road surface is damaged in many locations. The road alignment of the Tangofa - Buleleng section is satisfactory thanks to the relatively flat land.
The road alignment of the Buleleng - provincial boundary section is based on a low standard. No drainage facilities are provided, and the road surface is damaged in many locations.

3) Land Use
The mountainous area along the trans-peninsula road is designated as limited production forest. The flatland portion is a cultivated area with slash-and-burn agriculture.
There are two protected forests (HL) near the border and the area from Buleleng towards the border.

4) Possibility of Development
The area ,where the flatland portion is narrow, along the trans-peninsula road is covered by virgin forest whose development is restricted. The Buleleng valley is suitable for paddy fields,

and development of the arable land is expected. The mountainous area to the south of Buleleng is covered by virgin forests, in which lumbering is restricted. This section is a bottleneck on the road connecting Southeast and Central Sulawesi. Connecting these provinces by road will offer considerable economic benefits.

5) Route Alternative

The two proposed routes described below were compared as route alternatives for the section between Betebete (Sta.99.5 km) and Tongofa (Sta.115.8 km).

Alternative 1. Peninsula Coastal Route

The existing road of 20 km is a peninsula route which vehicles can not enter.
The route is along the coast circling the main ridges in the middle of the peninsula. Geologically, ridges branched off from the main ridges connect directly to the coral reef coast, forming the cliff of rock in many places. Between branch ridges, there are steep valleys extending to the cove. Cliffs are made from limestone, rising to a height of tens of meters and directly rising out of the sea. Because of the precipitous terrain, the roadside area is covered with natural forests and there are almost no houses. Road construction must be appropriate for the geological conditions. Bridges should be constructed over sharp inlets and tunnels should be constructed in sections crossing limestone precipitous terrain.

Alternative 2. Trans-Peninsula Route

The existing route is entirely a six-meter-wide gravel road though there are steep slopes exceeding 20%. 4WD vehicles can pass through in the dry season. The route crosses the main ridges at 500 m above sea level which makes up the peninsula, with the roadside covered by natural forest. The existing road includes steep slopes exceeding 20% in many locations. Improvement of the vertical road alignment is needed to maintain its functions. Since the route crosses the central main ridges of the peninsula as described above, an appropriate improvement of the gradient is required to keep a design speed of 30 km/h. If the steepest grade of 12% or less is employed on the basis of the design speed of 30 km/h for the mountainous section, it is difficult to use a horizontal alignment for the existing road for most of the sections concerned. It was proposed to use the existing road as a construction road and to improve to the road with steepest gradient of 12% or less.

Table 6-3-1 Comparison of Alternative Routes

	Alternative 1	Alternative 2
Characteristic	Peninsula coastal route	Trans-peninsula route
Road length	20 km	16 km
Roadside	Natural forest	Natural forest
Route	Coast	Mountain
Condition of existing road	Not Passable to vehicles	Passable to vehicles in dry season
Engineering problems	Tunnel is needed due to precipitous coastal terrain	Improvement of steep slope section
Major construction work	Road, bridge, tunnel	Road
Environmental problems	Protection of coral reef and landscape	Measures to protect the natural forest
Construction cost	90.9 Billion Rp.	74.5 Billion Rp.
Rating	△	○

Source: Study Team

The peninsula crossing route was selected after consideration of road length, workability, and construction costs.

6) Components of Construction Work

A proposed road alignment is shown in Appendix A-6.1 and the following major works are needed for the construction.

- Improvement of road way;
- Widening of road;
- Pavement;
- Bridges;
- Drainage; and
- Slope protection.

6.3.2 Preliminary Engineering Design (Link No.22)

(1) Preliminary Engineering of Bridges

Application of types of bridge superstructures of link No. 22 is the same as description in clause 6.2.2 (1) before.

Most bridges of link No.22 are wooden bridges and there is no bridge at some locations. Moreover, bridges are seriously damaged even though they are of concrete. As a result, replacement of all bridges on link No.22 is recommended.

For a bridge which requires long length between abutments, bridge alternatives for different span arrangement are to be compared.
BR22-29 of 120m long bridge was studied in above mentioned way and a bridge of four spans of PC I-girder is adopted. Details of this comparison is described in section 6.7.3 as a typical comparison of this study. General view of proposed BR22-29 is shown in Figure 6-3-1.

For bridge foundations, bridges on this link until Buleleng (Sta.127+500) require pile foundations with about 15m-long-pile based on the soil investigation. However, locations of bearing layer for the bridge foundation are shallow on this route from Buleleng until the border of province. The type of spread footing is adopted for the bridge foundation in this area. To put it concretely, spread footing is recommended for bridges numbered from BR22-101 (Sta.131+450) until BR22-105 (Sta. 139+340) on this route.
Actually, depth of bearing layer based on boring data of bore-hole No.32 and 33 is 4m from the ground surface. In case that a pile structure is applied to this depth, pile length becomes very short and the bridge foundation being undesirable structure. Therefore, spread footing is suitable though the height of substructure becomes higher.

Quantities of bridge improvement on link No. 16 are summarized as shown in Table 6-3-2.
And proposed bridge list of link No. 22 is shown in Tables 6-3-3 (1) to 6-3-3 (4).

Table 6-3-2 Summary of Bridge Improvement Quantities of Link No. 22

Classification		The Number of Bridges	Bridge Area (m^2)
New Construction	Bridge length ≦50m	93	19,276
	Bridge length >50m	12	7,524
	Total	105	26,800
Existing to be used as it is		0	0

Source: Study Team

Table 6-3-3 (1) Propoed Bridge List of Link No.22 (1 of 4)

Bridge No.	Location (km + m)	Length (m)	Nos. of Span	Span Arrangement	Bridge Width (m)	Types of Super-structures	Sub-structures: Type of Foundation	Abutments FIX Nos.	Abutments FIX ha(m)	Abutments FIX Pile La(m)	Abutments FIX Pile Nos.	Abutments MOVE Nos.	Abutments MOVE ha(m)	Abutments MOVE Pile La(m)	Abutments MOVE Pile Nos.	Piers FIX+FIX Nos.	Piers FIX+FIX hp(m)	Piers FIX+FIX Pile/1 pier Lp(m)	Piers FIX+FIX Pile/1 pier Nos.	Piers MOVE+FIX Nos.	Piers MOVE+FIX hp(m)	Piers MOVE+FIX Pile/1 pier Lp(m)	Piers MOVE+FIX Pile/1 pier Nos.	Boring Data
BR 22 - 1	36 + 485	30.0	1	1 @ 30.0	9.6	PC-I	Pile	1	6	12	22	1	6	12	22	-	-	-	-	-	-	-	-	46,47
BR 22 - 2	36 + 850	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	12	18	1	6	12	18	-	-	-	-	-	-	-	-	46,47
BR 22 - 3	37 + 20	40.0	2	2 @ 20.0	9.6	RC-T	Pile	-	-	-	-	2	6	12	18	1	12	12	22	-	-	-	-	46,47
BR 22 - 4	37 + 650	15.0	1	1 @ 15.0	9.6	RC-T	Pile	1	6	12	16	1	6	12	16	-	-	-	-	-	-	-	-	46,47
BR 22 - 5	39 + 20	20.0	1	1 @ 20.0	7.6	RC-T	Pile	1	6	12	18	1	6	12	18	-	-	-	-	-	-	-	-	46,47
BR 22 - 6	39 + 280	20.0	1	1 @ 20.0	7.6	RC-T	Pile	1	10	12	18	1	10	12	18	-	-	-	-	-	-	-	-	46,47
BR 22 - 7	40 + 370	40.0	2	2 @ 20.0	7.6	RC-T	Pile	-	-	-	-	2	8	12	18	1	12	12	22	-	-	-	-	46,47
BR 22 - 8	40 + 760	20.0	1	1 @ 20.0	7.6	RC-T	Pile	1	8	12	18	1	8	12	18	-	-	-	-	-	-	-	-	46,47
BR 22 - 9	40 + 950	20.0	1	1 @ 20.0	7.6	RC-T	Pile	1	8	12	18	1	8	12	18	-	-	-	-	-	-	-	-	46,47
BR 22 - 10	41 + 530	15.0	1	1 @ 15.0	9.6	RC-T	Pile	1	6	12	16	1	6	12	18	-	-	-	-	-	-	-	-	46,47
BR 22 - 11	41 + 960	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	12	18	1	8	12	18	-	-	-	-	-	-	-	-	46,47
BR 22 - 12	42 + 650	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	12	18	1	8	12	18	-	-	-	-	-	-	-	-	46,47
BR 22 - 13	43 + 770	20.0	1	1 @ 20.0	7.6	RC-T	Pile	1	6	12	18	1	6	12	18	-	-	-	-	-	-	-	-	46,47
BR 22 - 14	44 + 470	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	12	18	1	6	12	18	-	-	-	-	-	-	-	-	46,47
BR 22 - 15	46 + 260	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	12	18	1	10	12	18	-	-	-	-	-	-	-	-	46,47
BR 22 - 16	46 + 800	60.0	3	3 @ 20.0	9.6	RC-T	Pile	-	-	-	-	2	8	12	18	1	12	12	22	1	12	12	18	46,47
BR 22 - 17	47 + 540	20.0	1	1 @ 20.0	7.6	RC-T	Pile	1	6	12	18	1	6	12	18	-	-	-	-	-	-	-	-	46,47
BR 22 - 18	48 + 80	20.0	1	1 @ 20.0	7.6	RC-T	Pile	1	8	12	18	1	10	12	18	-	-	-	-	-	-	-	-	46,47
BR 22 - 19	48 + 370	20.0	1	1 @ 20.0	7.6	RC-T	Pile	1	8	12	18	1	8	12	18	-	-	-	-	-	-	-	-	46,47
BR 22 - 20	48 + 840	40.0	1	1 @ 40.0	7.6	PC-I	Pile	1	6	12	25	1	6	12	18	-	-	-	-	-	-	-	-	46,47
BR 22 - 21	49 + 880	60.0	3	3 @ 20.0	9.6	RC-T	Pile	-	-	-	-	2	10	12	18	1	12	12	22	1	12	12	18	46,47
BR 22 - 22	50 + 340	40.0	2	2 @ 20.0	9.6	RC-T	Pile	-	-	-	-	2	8	12	18	1	10	12	22	-	-	-	-	46,47
BR 22 - 23	50 + 740	15.0	1	1 @ 15.0	9.6	RC-T	Pile	1	6	12	16	1	6	12	16	-	-	-	-	-	-	-	-	46,47
BR 22 - 24	50 + 960	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	12	18	1	6	12	18	-	-	-	-	-	-	-	-	46,47
BR 22 - 25	51 + 440	20.0	1	1 @ 20.0	7.6	RC-T	Pile	1	10	12	18	1	10	12	18	-	-	-	-	-	-	-	-	46,47
BR 22 - 26	52 + 150	20.0	1	1 @ 20.0	7.6	RC-T	Pile	1	10	12	18	1	10	12	18	-	-	-	-	-	-	-	-	46,47
BR 22 - 27	53 + 0	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	23	14	1	6	23	14	-	-	-	-	-	-	-	-	44,45
BR 22 - 28	54 + 125	30.0	1	1 @ 30.0	9.6	PC-I	Pile	1	6	23	18	1	6	23	18	-	-	-	-	-	-	-	-	44,45
BR 22 - 29	56 + 530	120.0	3	3 @ 40.0	9.6	PC-I	Pile	-	-	-	-	2	10	23	22	1	12	23	23	1	12	23	20	44,45
BR 22 - 30	57 + 215	40.0	1	1 @ 40.0	9.6	PC-I	Pile	1	6	23	20	1	6	23	20	-	-	-		-	-	-	-	44,45
BR 22 - 31	58 + 70	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	23	14	1	6	23	14	-	-	-	-	-	-	-	-	44,45
BR 22 - 32	59 + 760	40.0	2	2 @ 20.0	9.6	RC-T	Pile	-	-	-	-	2	6	23	14	1	8	23	16	-	-	-	-	44,45
BR 22 - 33	60 + 100	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	23	14	1	6	23	14	-	-	-	-	-	-	-	-	44,45

Table 6-3-3 (2) Propoed Bridge List of Link No.22 (2 of 4)

Bridge No.	Location km + m	Length (m)	Nos. of Span	Span Arrangement	Bridge Width (m)	Types of Super-structures	Type of Foundation	Sub-structures: Abutments FIX Nos.	Abutments FIX ha(m)	Abutments FIX Pile La(m)	Abutments FIX Pile Nos.	Abutments MOVE Nos.	Abutments MOVE ha(m)	Abutments MOVE Pile La(m)	Abutments MOVE Pile Nos.	Piers FIX+FIX Nos.	Piers FIX+FIX hp(m)	Piers FIX+FIX Pile/1 pier Lp(m)	Piers FIX+FIX Pile/1 pier Nos.	Piers MOVE+FIX Nos.	Piers MOVE+FIX hp(m)	Piers MOVE+FIX Pile/1 pier Lp(m)	Piers MOVE+FIX Pile/1 pier Nos.	Boring Data
BR 22 - 34	62 + 970	15.0	1	1 @ 15.0	9.6	RC-T	Pile	1	6	14	16	1	6	14	16	-	-	-	-	-	-	-	-	42,43
BR 22 - 35	64 + 160	15.0	1	1 @ 15.0	9.6	RC-T	Pile	1	6	14	16	1	6	14	16	-	-	-	-	-	-	-	-	42,43
BR 22 - 36	65 + 570	60.0	2	2 @ 30.0	9.6	PC-I	Pile	-	-	-	-	2	6	14	22	1	8	14	28	-	-	-	-	42,43
BR 22 - 37	68 + 20	15.0	1	1 @ 15.0	9.6	RC-T	Pile	1	6	14	16	1	6	14	16	-	-	-	-	-	-	-	-	42,43
BR 22 - 38	68 + 430	15.0	1	1 @ 15.0	9.6	RC-T	Pile	1	6	14	16	1	6	14	16	-	-	-	-	-	-	-	-	42,43
BR 22 - 39	70 + 590	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	14	18	1	6	14	18	-	-	-	-	-	-	-	-	42,43
BR 22 - 40	71 + 990	30.0	1	1 @ 30.0	9.6	PC-I	Pile	1	6	14	22	1	6	14	22	-	-	-	-	-	-	-	-	42,43
BR 22 - 41	74 + 30	30.0	1	1 @ 30.0	9.6	PC-I	Pile	1	6	16	24	1	6	16	24	-	-	-	-	-	-	-	-	40,41
BR 22 - 42	75 + 530	60.0	2	2 @ 30.0	9.6	PC-I	Pile	-	-	-	-	2	6	16	24	1	8	16	30	-	-	-	-	40,41
BR 22 - 43	76 + 420	15.0	1	1 @ 15.0	9.6	RC-T	Pile	1	6	16	18	1	6	16	18	-	-	-	-	-	-	-	-	40,41
BR 22 - 44	77 + 925	30.0	1	1 @ 30.0	9.6	PC-I	Pile	1	6	16	24	1	6	16	24	-	-	-	-	-	-	-	-	40,41
BR 22 - 45	78 + 240	60.0	2	2 @ 30.0	9.6	PC-I	Pile	-	-	-	-	2	6	16	24	1	8	16	30	-	-	-	-	40,41
BR 22 - 46	78 + 920	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	16	20	1	6	16	20	-	-	-	-	-	-	-	-	40,41
BR 22 - 47	80 + 80	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	16	20	1	6	16	20	-	-	-	-	-	-	-	-	40,41
BR 22 - 48	81 + 150	15.0	1	1 @ 15.0	9.6	RC-T	Pile	1	6	16	18	1	6	16	18	-	-	-	-	-	-	-	-	40,41
BR 22 - 49	81 + 360	15.0	1	1 @ 15.0	9.6	RC-T	Pile	1	6	16	18	1	6	16	18	-	-	-	-	-	-	-	-	40,41
BR 22 - 50	81 + 390	15.0	1	1 @ 15.0	9.6	RC-T	Pile	1	6	16	18	1	6	16	18	-	-	-	-	-	-	-	-	40,41
BR 22 - 51	81 + 630	30.0	1	1 @ 30.0	9.6	PC-I	Pile	1	6	16	24	1	6	16	24	-	-	-	-	-	-	-	-	40,41
BR 22 - 52	83 + 345	15.0	1	1 @ 15.0	9.6	RC-T	Pile	1	6	16	18	1	6	16	18	-	-	-	-	-	-	-	-	40,41
BR 22 - 53	83 + 620	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	8	16	20	1	8	16	20	-	-	-	-	-	-	-	-	40,41
BR 22 - 54	84 + 670	15.0	1	1 @ 15.0	7.6	RC-T	Pile	1	6	16	18	1	6	16	18	-	-	-	-	-	-	-	-	40,41
BR 22 - 55	85 + 310	20.0	1	1 @ 20.0	7.6	RC-T	Pile	1	6	16	20	1	6	16	20	-	-	-	-	-	-	-	-	40,41
BR 22 - 56	86 + 650	20.0	1	1 @ 20.0	7.6	RC-T	Pile	1	6	16	20	1	6	16	20	-	-	-	-	-	-	-	-	40,41
BR 22 - 57	87 + 640	20.0	1	1 @ 20.0	7.6	RC-T	Pile	1	6	16	20	1	6	16	20	-	-	-	-	-	-	-	-	40,41
BR 22 - 58	87 + 800	15.0	1	1 @ 15.0	7.6	RC-T	Pile	1	6	16	18	1	6	16	18	-	-	-	-	-	-	-	-	40,41
BR 22 - 59	88 + 750	30.0	1	1 @ 30.0	7.6	PC-I	Pile	1	6	16	24	1	6	16	24	-	-	-	-	-	-	-	-	40,41
BR 22 - 60	89 + 480	15.0	1	1 @ 15.0	9.6	RC-T	Pile	1	6	16	18	1	6	16	18	-	-	-	-	-	-	-	-	40,41
BR 22 - 61	90 + 575	30.0	1	1 @ 30.0	9.6	PC-I	Pile	1	6	15	22	1	6	15	22	-	-	-	-	-	-	-	-	38,39
BR 22 - 62	90 + 840	15.0	1	1 @ 15.0	9.6	RC-T	Pile	1	6	15	16	1	6	15	16	-	-	-	-	-	-	-	-	38,39
BR 22 - 63	90 + 980	15.0	1	1 @ 15.0	9.6	RC-T	Pile	1	6	15	16	1	6	15	16	-	-	-	-	-	-	-	-	38,39
BR 22 - 64	91 + 250	15.0	1	1 @ 15.0	9.6	RC-T	Pile	1	6	15	16	1	6	15	16	-	-	-	-	-	-	-	-	38,39
BR 22 - 65	92 + 200	40.0	2	2 @ 20.0	9.6	RC-T	Pile	-	-	-	-	2	6	15	18	1	8	15	22	-	-	-	-	38,39
BR 22 - 66	92 + 490	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	15	18	1	6	15	18	-	-	-	-	-	-	-	-	38,39

Table 6-3-3 (3) Propoed Bridge List of Link No.22 (3 of 4)

Bridge No.	Location			Length	Nos. of Span	Span Arrangement	Bridge Width	Types of Super-structures	Sub-structures																	Boring Data
									Type of Foundation	Abutments								Piers								
										FIX				MOVE				FIX+FIX				MOVE+FIX				
										Nos.	ha(m)	Pile		Nos.	ha(m)	Pile		Nos.	hp(m)	Pile/ 1 pier		Nos.	hp(m)	Pile/ 1 pier		
	km	+	m	(m)			(m)					La(m)	Nos.			La(m)	Nos.			Lp(m)	Nos.			Lp(m)	Nos.	
BR 22 - 67	93	+	760	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	15	18	1	6	15	18	-	-	-	-	-	-	-	-	38,39
BR 22 - 68	95	+	25	30.0	1	1 @ 30.0	9.6	PC-I	Pile	1	6	15	22	1	6	15	22	-	-	-	-	-	-	-	-	38,39
BR 22 - 69	95	+	970	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	15	18	1	6	15	18	-	-	-	-	-	-	-	-	38,39
BR 22 - 70	96	+	850	40.0	2	2 @ 20.0	9.6	RC-T	Pile	-	-	-	-	2	6	15	18	1	8	15	22	-	-	-	-	38,39
BR 22 - 71	97	+	440	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	15	18	1	6	15	18	-	-	-	-	-	-	-	-	38,39
BR 22 - 72	97	+	520	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	10	15	18	1	10	15	18	-	-	-	-	-	-	-	-	38,39
BR 22 - 73	97	+	840	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	10	15	18	1	10	15	18	-	-	-	-	-	-	-	-	36,37
BR 22 - 74	98	+	270	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	15	18	1	6	15	18	-	-	-	-	-	-	-	-	36,37
BR 22 - 75	98	+	450	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	15	18	1	10	15	18	-	-	-	-	-	-	-	-	36,37
BR 22 - 76	98	+	860	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	15	18	1	6	15	18	-	-	-	-	-	-	-	-	36,37
BR 22 - 77	99	+	150	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	10	15	18	1	10	15	18	-	-	-	-	-	-	-	-	36,37
BR 22 - 78	99	+	685	30.0	1	1 @ 30.0	9.6	PC-I	Pile	1	6	15	22	1	6	15	22	-	-	-	-	-	-	-	-	36,37
BR 22 - 79	101	+	40	30.0	1	1 @ 30.0	7.6	PC-I	Pile	1	10	15	22	1	10	15	22	-	-	-	-	-	-	-	-	36,37
BR 22 - 80	102	+	260	30.0	1	1 @ 30.0	7.6	PC-I	Pile	1	10	15	22	1	10	15	22	-	-	-	-	-	-	-	-	36,37
BR 22 - 81	102	+	775	30.0	1	1 @ 30.0	7.6	PC-I	Pile	1	12	15	22	1	12	15	22	-	-	-	-	-	-	-	-	36,37
BR 22 - 82	103	+	535	30.0	1	1 @ 30.0	7.6	PC-I	Pile	1	8	15	22	1	10	15	22	-	-	-	-	-	-	-	-	36,37
BR 22 - 83	103	+	670	20.0	1	1 @ 20.0	7.6	RC-T	Pile	1	6	15	18	1	6	15	18	-	-	-	-	-	-	-	-	36,37
BR 22 - 84	103	+	720	20.0	1	1 @ 20.0	7.6	RC-T	Pile	1	6	15	18	1	8	15	18	-	-	-	-	-	-	-	-	36,37
BR 22 - 85	104	+	440	20.0	1	1 @ 20.0	7.6	RC-T	Pile	1	6	15	18	1	6	15	18	-	-	-	-	-	-	-	-	36,37
BR 22 - 86	105	+	515	30.0	1	1 @ 30.0	7.6	PC-I	Pile	1	8	15	22	1	8	15	22	-	-	-	-	-	-	-	-	36,37
BR 22 - 87	108	+	685	90.0	3	3 @ 30.0	7.6	PC-I	Pile	-	-	-	-	2	10	15	22	1	12	15	30	1	12	15	26	36,37
BR 22 - 88	109	+	835	30.0	1	1 @ 30.0	7.6	PC-I	Pile	1	6	15	22	1	10	15	22	-	-	-	-	-	-	-	-	36,37
BR 22 - 89	114	+	360	30.0	1	1 @ 30.0	7.6	PC-I	Pile	1	6	15	22	1	8	15	22	-	-	-	-	-	-	-	-	36,37
BR 22 - 90	118	+	560	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	15	18	1	6	15	18	-	-	-	-	-	-	-	-	36,37
BR 22 - 91	118	+	600	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	15	18	1	6	15	18	-	-	-	-	-	-	-	-	36,37
BR 22 - 92A	121	+	240	30.0	1	1 @ 30.0	9.6	PC-I	Pile	1	6	15	22	1	6	15	22	-	-	-	-	-	-	-	-	36,37
BR 22 - 92B	121	+	930	30.0	1	1 @ 30.0	9.6	PC-I	Pile	1	10	15	22	1	10	15	22	-	-	-	-	-	-	-	-	36,37
BR 22 - 93	122	+	25	30.0	1	1 @ 30.0	9.6	PC-I	Pile	1	6	15	22	1	8	15	22	-	-	-	-	-	-	-	-	36,37
BR 22 - 94	122	+	535	30.0	1	1 @ 30.0	9.6	PC-I	Pile	1	8	15	22	1	8	15	22	-	-	-	-	-	-	-	-	36,37
BR 22 - 95	122	+	760	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	8	15	18	1	8	15	18	-	-	-	-	-	-	-	-	36,37
BR 22 - 96	122	+	950	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	8	15	18	1	8	15	18	-	-	-	-	-	-	-	-	36,37
BR 22 - 97	123	+	200	90.0	3	3 @ 30.0	9.6	PC-I	Pile	-	-	-	-	2	6	15	22	1	8	15	28	1	8	15	22	34,35
BR 22 - 98	126	+	810	60.0	3	3 @ 20.0	9.6	RC-T	Pile	-	-	-	-	2	6	15	18	1	8	15	22	1	8	15	18	34,35

Table 6-3-3 (4) Propoed Bridge List of Link No.22 (4 of 4)

Bridge No.	Location			Length	Nos. of Span	Span Arrangement	Bridge Width (m)	Types of Super-structures	Sub-structures																		Boring Data
									Type of Foundation	Abutments								Piers									
										FIX				MOVE				FIX+FIX				MOVE+FIX					
										Nos.	ha(m)	Pile		Nos.	ha(m)	Pile		Nos.	hp(m)	Pile/ 1 pier		Nos.	hp(m)	Pile/ 1 pier			
	km	+	m	(m)								La(m)	Nos.			La(m)	Nos.			Lp(m)	Nos.			Lp(m)	Nos.		
BR 22 - 99	128	+	200	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	15		1	6	15	18	-	-	-	-	-	-	-	-		34,35
BR 22 - 100	128	+	990	60.0	3	3 @ 20.0	7.6	RC-T	Pile	-	-	-	-	2	8	15	18	1	8	15	22	1	8	15	18		34,35
BR 22 - 101	131	+	450	20.0	1	1 @ 20.0	7.6	RC-T	Spread	1	8	-	-	1	8	15	-	-	-	-	-	-	-	-	-		32,33
BR 22 - 102	132	+	0	20.0	1	1 @ 20.0	7.6	RC-T	Spread	1	8	-	-	1	8	15	-	-	-	-	-	-	-	-	-		32,33
BR 22 - 103	135	+	680	60.0	2	2 @ 30.0	7.6	PC-I	Spread	-	-	-	-	2	8	15	-	1	12	-	-	-	-	-	-		32,33
BR 22 - 104	135	+	810	20.0	1	1 @ 20.0	7.6	RC-T	Spread	1	8	-	-	1	8	15	-	-	-	-	-	-	-	-	-		32,33
BR 22 - 105	139	+	340	60.0	3	3 @ 20.0	7.6	RC-T	Spread	-	-	-	-	2	8	15	-	1	12	-	-	1	12	-	-		32,33

GENERAL VIEW OF BR 22-29 (STA. 56+530)

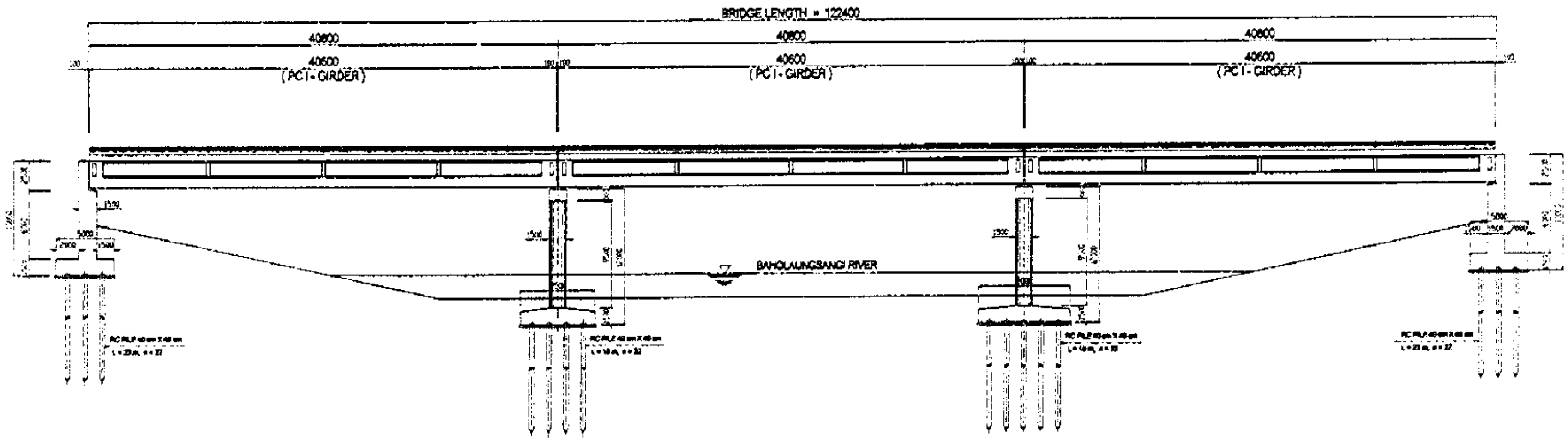


Figure 6-3-1 General View of BR 22-29

(2) Preliminary Engineering of Slope Protection Works

Slope protection works are constructed to protect the slopes from erosion or weathering by covering them with vegetation or structures and also to stabilize the slopes by means of drainage works or retaining structures. The following types of slope protection works were adopted for the feasibility route considering the terrain and geology, as shown in Table 6-3-4 and Table 6-3-5.
Required height of slope protection works for each link is shown in Figure 6-3-2.

Table 6-3-4 Adopted Slope Protection Type (Cutting Slope)

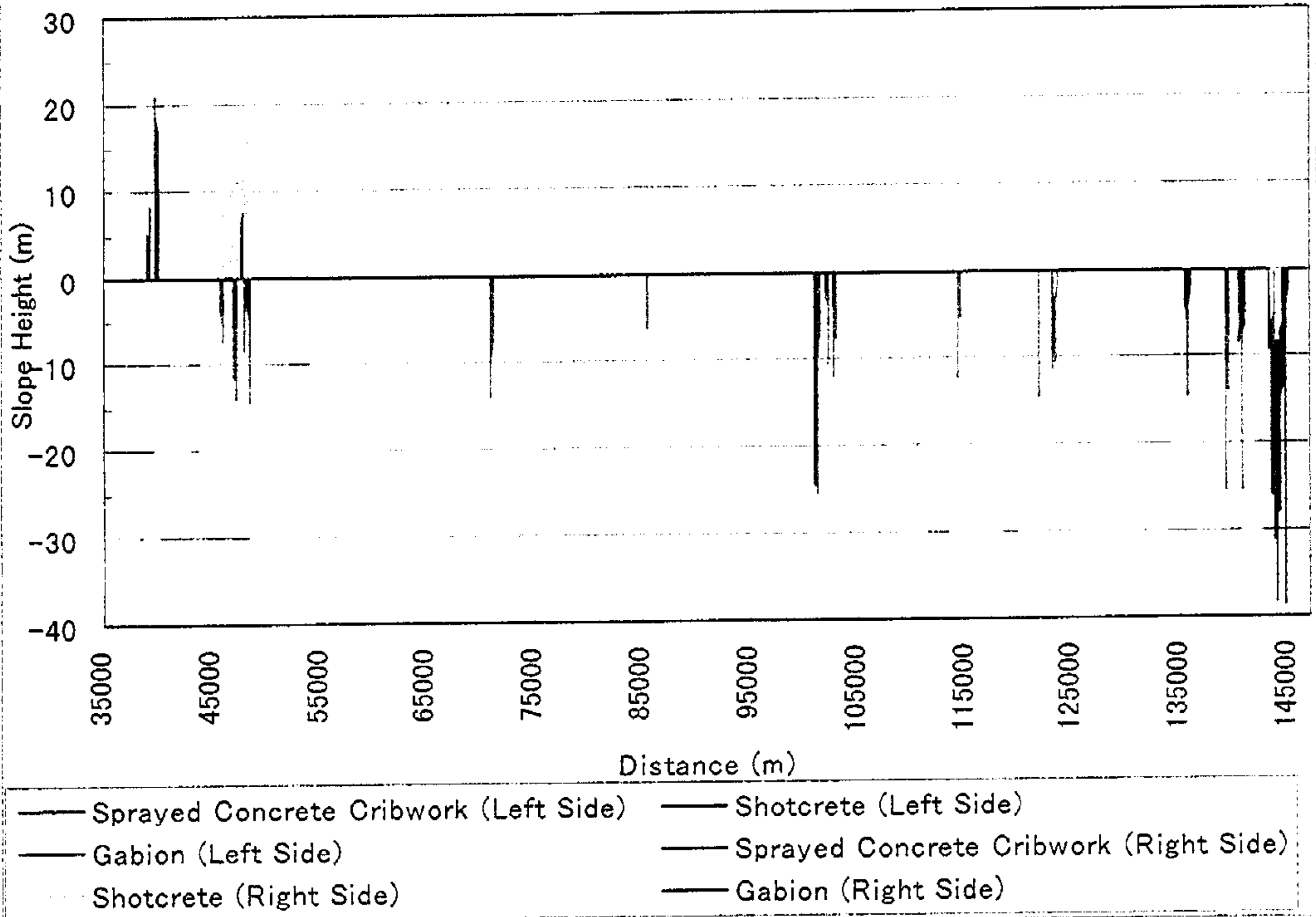
Station(km)	Geology	Slope Protection Type
36.4-41.4	Alluvium	Sprayed Concrete Cribwork
41.4-56.9	Tokala Formation	Shotcrete
56.9-66.4	Alluvium	Sprayed Concrete Cribwork
66.4-72.9	Alluvium	Sprayed Concrete Cribwork
72.9-75.4	Ultra Basic Rock	Shotcrete
75.4-78.9	Alluvium	Sprayed Concrete Cribwork
78.9-82.9	Diluvium	Sprayed Concrete Cribwork
82.9-87.9	Allvium	Sprayed Concrete Cribwork
87.9-89.9	Tomata Formation	Shotcrete
89.9104.9	Alluvium	Sprayed Concrete Cribwork
104.9-122.4	Tokala Formation	Shotcrete
122.4-126.9	Alluvium	Sprayed Concrete Cribwork
126.9-127.9	Tokala Formation	Shotcrete
127.9-128.4	Alluvium	Sprayed Concrete Cribwork
128.4-129.9	Diluvium	Sprayed Concrete Cribwork
129.9-130.4	Tokala Formation	Shotcrete
130.4-135.9	Alluvium	Sprayed Concrete Cribwork
135.9-140.9	Ultra Basic Rock	Shotcrete
140.9-146.5	Matano Formation	Shotcrete

Source: Study Team

Table 6-3-5 Quantities of Slope Protection

	Cut		Fill
	Sprayed Concrete Cribwork (m^2)	Shotcrete (m^2)	Mat Gabion (m^2)
Quantity	3,360	36,593	83,289

Source: Study Team



Sprayed Concrete Cribwork Type

Shotcrete Type

Figure 6-3-2 Location and Height of Slope Protection for Link No.22

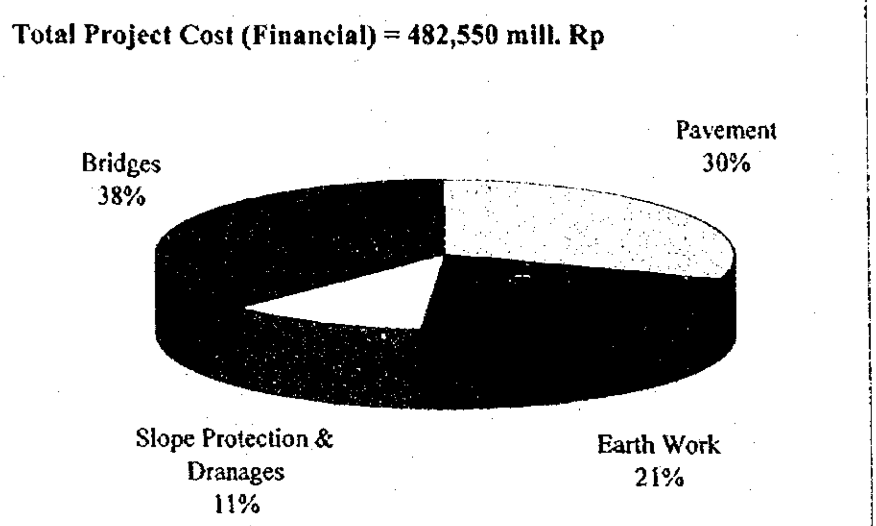
(3) Cost Estimates

1) Estimated Project Cost

Cost items consist of preparation works, pavement, earth work, drainage, bridge, slope protection and safety facilities works. The cost for engineering service was estimated at 20% of the total construction cost consisting of direct and indirect cost. A contingency has been included in 10 % of the total of construction and engineering cost. The ratio of major item costs to the total cost is shown in Figure 6-3-3 and Table 6-3-6 shows estimated cost.

2) Implementation Plan

As shown in Figure 6-3-4, the construction period is 5 years consisting of one year for preparation of project for fund raising plan, 1.5 years for detailed design of the roads and 2.5 years for construction. Also, the investment plan was set in accordance with the construction plan.



Source: Study Team

Figure 6-3-3 Construction Cost Ratio for Link No. 22

(4) Economic Analysis

1) Economic Project Costs

The economic investment costs were estimated in constant 1998 prices. The financial investment costs in terms of market price include the component of taxes. The economic costs for economic analysis were obtained by subtracting the portion of transfer payment such as taxes from financial costs. Implementation is scheduled over four years from 2000 to 2003. The phased financial and economic investment costs (initial investment) are summarized in Table 6-3-7.

Table 6-3-6 Total Construction Cost For Bungku - Border of Province Road (Link No.22)

Rate : 1US$ = 10600Rp = 140Yen

Item	Unit	Quantity	Unit Price Foreign (US$)	Unit Price Financial (Rp)	Unit Price Economic (Rp)	Total Price Foreign (US$)	Total Price Local Financial (Rp)	Total Price Local Economic (Rp)	Financial Total (Mill Rp)
1.Preparation Works									
Clearing and Grubbing	m2	1,268,127	0.23	1,867	2,099	291,669	2,367,593,109	2,661,798,573	5,459
2.Pavement									
New Road Asphalt Concrete + Sub base (Type A)	m	53,200	39.50	436,896	392,152	2,101,400	23,242,867,200	20,862,486,400	45,518
Widnning Road Asphalt Concrete + Sub base (Type A)	m	57,505	20.99	234,564	211,846	1,207,030	13,488,602,820	12,182,204,230	26,283
Transport for Pavement Material (L=28km)	m3	129,794	3.49	26,005	30,339	452,619	3,375,241,636	3,937,781,909	8,173
Sub-2						3,761,049	40,106,711,656	36,982,472,539	79,974
3.Earth Work									
Excavation (Common)	m3	1,280,095	0.92	7,407	8,213	1,177,687	9,481,663,665	10,513,420,235	21,965
Excavation (Sound Rock)	m3	271,087	4.12	33,605	36,492	1,116,878	9,109,878,635	9,892,506,804	20,949
Disposal soil (L=5km)	m3	720,627	1.20	8,610	10,050	864,752	6,204,598,901	7,242,301,853	15,371
Sub-3						3,159,318	24,796,141,201	27,648,228,892	58,285
4.Drainage									
Pipe Culvert (D=100cm)	m	2,120	44.35	634,758	554,426	94,022	1,345,686,960	1,175,383,120	2,342
Pipe Culvert (D=60cm)	m	2,214	15.28	202,787	184,640	33,831	448,990,697	408,811,424	808
Box Culvert (B=2.0m, H=2.0m)	m	260	325.89	3,064,762	2,510,606	84,731	796,838,120	652,757,560	1,695
U-ditch (U=50cm)	m	52,950	2.85	69,850	61,200	150,908	3,698,557,500	3,240,540,000	5,298
Sub-4						363,492	6,290,073,277	5,477,492,104	10,143
5.Slope Protection									
Sprayed Concrete Cribwork	m2	3,360	14.68	127,197	88,984	49,325	427,381,920	298,986,240	950
Shotcrete Work	m2	36,593	11.82	101,390	67,157	432,529	3,710,164,270	2,457,476,101	8,295
Stone Masonry	m2	0	6.91	116,286	109,711	0	0	0	0
Mat Gabion	m2	83,289	9.20	72,584	61,374	766,259	6,045,448,776	5,111,779,086	14,168
Sodding	m2	0	0.08	3,238	2,851	0	0	0	0
Sub-5						1,248,113	10,182,994,966	7,868,241,427	23,413
6.Tunnel	m	0	3,500.00	22,400,000	17,920,000	0	0	0	0
7.Bridges	No	105				5,818,563	51,494,060,501	41,144,674,275	113,171
8.Nefty Facilities Works									
Guard Railing	m	33,700	11.30	168,012	143,025	380,810	5,662,004,400	4,819,942,500	9,699
Traffic Sign	each	369	27.98	426,548	373,259	10,325	157,403,321	137,738,792	267
Line Marking	m	110,705	0.42	4,231	3,518	46,496	468,392,855	389,460,190	961
Sub-8						437,631	6,287,800,576	5,347,141,482	10,927
9.Mobilization & Temporally Works (20% of Total Cost)						2,843,129	30,137,163,121	26,219,331,915	60,274
10.Sub -Total						17,922,964	171,662,538,407	153,349,381,207	361,646
11.Land Acquisition	m2	178,120	0.00	20,000	20,000	0	3,562,400,000	3,562,400,000	3,562
12.Compensation	houses	24	0.00	15,000,000	15,000,000	0	360,000,000	360,000,000	360
13.Engineering Cost (20% of 10+11+12)						4,138,510	29,245,468,596	23,396,374,877	73,114
14.Contingency (10% of 10+11+12+13)						2,206,147	20,483,040,700	18,066,815,608	43,868
Ground Total Cost (10+11+12+13+14)						24,267,621	225,313,447,703	198,734,971,692	482,550

Item	Unit	Quantity	1999	2000	2001	2002	2003	Total
1. Preparation of Project								
2. Survey and Design	km	110.71						
3. Construction								
Earth Work	m3	1,551,182						
Slope Protection	m2	-						
Tunnel	m	0						
Bridges	No	105						
Pavement	km	110.71						
Foreign (US$)				1,138,090	4,438,953	9,300,345	9,390,233	24,267,621
Local Financial Cost (Rp)				10,199,823,864	40,951,887,391	81,420,055,647	92,741,680,802	225,313,447,703
Local Economic Cost (Rp)				8,591,323,091	39,352,203,105	70,209,709,522	80,581,735,974	198,734,971,692
Total Financial Cost (Mill. Rp)				22,264	88,005	180,004	192,278	482,550
Total Ecomomic Cost (Mill. Rp)				20,655	86,405	168,793	180,118	455,972

Figure 6-3-4 Implementation Schedule For Bungku - Border of Province Road (Link No.22)

Table 6-3-7 Phased Initial Investment Costs in 1998 Prices (F/S - Link No. 22)

(Million Rp.)

Year	Financial Prices	Economic Prices
2000	22,264	20,655
2001	88,005	86,405
2002	180,004	168,793
2003	192,278	180,118
Total	482,550	455,972

Source: Study Team.

The maintenance cost of the proposed road follows the engineering study results of the cost estimates. Besides, the maintenance cost of the proposed road in the case of "without the improvement of the proposed road" was treated as a negative cost.

2) Economic Benefits

Benefits are classified into two types, one is the direct benefit and the other is the indirect benefit or intangible benefit.

The direct benefits which would be realized from the implementation of the Project are defined as the savings in travel costs, composed of the vehicle operating cost and vehicle time cost when comparing the "with" and "without" project conditions.

The benefit of vehicle operating costs was estimated as a difference of vehicle operating costs between "with" Project" case and "without" Project" case. The vehicle operating cost was derived from the obtained daily vehicle-kilometers and the unit vehicle operating cost by vehicle type. In addition, a promotion of traffic safety and a saving in accident costs were anticipated.

In this economic analysis, the above-mentioned direct benefits, e.g. the saving in vehicle operating cost was computed as a quantified benefit. The calculation of direct benefits were made for the planning year of 2003 and 2018.

As a result, the saving in vehicle operating cost is summarized as shown in Table 6-3-8.

Table 6-3-8 Estimated Economic Benefits (F/S - Link No. 22)

(Million Rp. at 1998 price)

Year	Benefit of Saving in VOC
2004	71,585
2018	165,960

Source: Study Team.

3) Economic Cost-Benefit Analysis

The analysis follows the conventional discounted cash flow method in determining the economic internal rate of return (EIRR), the net present value (NPV) and the benefit cost ratio (B/C). (NPV and B/C are calculated at a discount rate of 15 percent.) The project life is assumed to be 20 years after the completion of the construction.

The benefits in the intermediate years were interpolated and those beyond 2018 were assumed to be fixed. The total economic project costs and benefits streams are presented in Table 6-3-9. The efficiency measures were calculated and the results are as follows:

Efficiency Measures	F/S - Link No. 22
EIRR	19.5%
NPV (Million Rp.)	89,869
B/C	1.37

Source: Study Team.

These results indicate that implementation of the project (road improvement of link No. 22) is economically feasible.

Table 6-3-9 Economic Analysis for F/S of Link No. 22

(Million Rp.)

	Year	Benefits VOC Saving	Total	Costs Invest Costs	Maint Cost (With)	Total	Maint. Cost (Without)	Net Cash Flow
1	1999			0	0	0	0	0
2	2000			20,655	201	20,856	13,922	-6,934
3	2001			86,405	201	86,606	201	-86,405
4	2002			168,793	201	168,994	201	-168,793
5	2003	0	0	180,118	201	180,319	201	-180,118
6	2004	71,585	71,585	0	201	201	201	71,585
7	2005	78,326	78,326	0	201	201	13,922	92,047
8	2006	85.067	85,067	0	201	201	201	85,067
9	2007	91,808	91,808	0	201	201	201	91,808
10	2008	98,549	98,549	0	201	201	201	98,549
11	2009	105,291	105,291	0	201	201	209	105,299
12	2010	112,032	112,032	0	20,846	20,846	13,922	105,108
13	2011	118,773	118,773	0	201	201	201	118,773
14	2012	125,514	125,514	0	201	201	201	125,514
15	2013	132,255	132,255	0	201	201	13,922	145,976
16	2014	138,996	138,996	0	201	201	201	138,996
17	2015	145,737	145,737	0	201	201	201	145,737
18	2016	152,478	152,478	0	201	201	13,922	166,199
19	2017	159,219	159,219	0	20,846	20,846	201	138,574
20	2018	165,960	165,960	0	201	201	201	165,960
21	2019	165,960	165,960	0	201	201	13,922	179,681
22	2020	165,960	165,960	0	201	201	201	165,960
23	2021	165,960	165,960	0	201	201	201	165,960
24	2022	165,960	165,960	0	201	201	13,922	179,681
25	2023	165,960	165,960	0	201	201	201	165,960
				455,971	46,114	502,085	100,879	

Source: Study Team

Assuming that the benefits and cost stream might alter ±10%, ±20%, the effect on the EIRR was tested and the results are summarized in Table 6-3-10. In the most severe case of - 20% benefit and + 20% cost, the value of EIRR is 13.9%.

Table 6-3-10 EIRR by Altered Benefit and Cost (F/S - Link No. 22)

Cost	Benefit		
	Base	-10%	-20%
Base	19.5%	17.9%	16.2%
+10%	18.1%	16.6%	15.0%
+20%	16.8%	15.4%	13.9%

Source: Study Team.

6.4 Border of Province - Asera (55.5 km): Link No. 33

6.4.1 Selection and Description of Route Location (Link No. 33)

(1) Border of Province - Lamonae (20.5 km)

1) Location of Existing Road
From Sta.156 km to the border of province (Sta.146.48 km), the road runs through the hilly area along the Lindu Valley. It continues to run along the lower area of the Lindu Valley and reach the Landawe River (Sta.156 km). The road from Lamonae (Sta.166 km) to Sta.200 km is in flat and gentle hilly areas. The road crosses the Lasolo River and then arrive at Asera.

2) Existing Road Conditions
The entire road is gravel or dirt road without any drainage facilities or measures to protect the surface of slopes. The alignment of the road sections in hilly areas is almost satisfactory. The section in the mountainous area is steep, and only vehicles with four-wheel drive can pass through even during the dry season.

3) Land Use
In the hilly area, deforestation is already completed, followed by the gradually increasing raising of mango, banana, copra, and palm oil. The mountainous area is covered with virgin forests up to the boundary of province.

4) Possibility of Development
The land is suitable for raising of mango, banana, copra, and palm oil, and their production is expected to grow.

5) Components of Construction Work
A proposed road alignment is shown in Appendix A-6.1 and the following major works are needed for the construction;

- Improvement of road alignment:
- Widening of roadway;
- Pavement;
- Bridges;
- Drainage; and
- Slope protection.

(2) Lamonae - Linomoiyo (18.0 km: 40.4 km along the existing road)

1) Location of Existing Road

The road crosses the Lindu River at Bolosu (Sta.205 km) and climbs a hilly area along the Lindu River and a branch (the Landawe River). The crossing point of the Landawe River is on the downstream side of the confluence of this river and a branch, the Langgikima River. After crossing the Landawe River, the road section runs across terrace-like developed areas positioned between the Landawe and Lindu Rivers, then reaching Lamonae by passing through hilly areas and the valley along the Lindu River. Except for the 2.5 km alluvial plain from Linomoiyo to Bolosu or the crossing point of the Lindu River, the entire section is located in hilly areas. The road section is located mainly in developed areas, and, except for the hilly area of Sta.212km to 197km, runs on a flat alluvial layer formed by the Lindu River and its tributaries.

2) Existing Road Conditions

The entire road is gravel or dirt road without any drainage facilities or measures to protect the face of slopes. The road alignment is generally satisfactory.

3) Land Use

The alluvial plain extending 2.5 km from Linomoiyo to Bolosu or the crossing point of the Lindu River is being developed for paddy fields. Except for the migration areas of Sta.191 km to 188 km and Sta.177.5 km to 172.5 km, most of the hilly areas along the road are covered with virgin forests. Settlers in hilly areas, raise cacao, banana, copra, and palm oil.

4) Possibility of Development

The land is suitable for the raising of mango, banana, cacao, and copra.

5) Route Alternatives

The existing 35.2 km of road takes a roundabout way between Linomoiyo and Lamonae to connect to the migration area. There are two alternatives: alternative A, using the existing road; and the alternative B, new road construction to connect Linomoiyo and Lamonae directly.

According to alternative B, a new road runs on the west side of the hill left in the valley, reaching Lamonae directly. The rating table below shows a comparison of these alternatives, indicating that the road length of the alternative B is 12.8 km, 22.4 km shorter than the length of the alternative A.

Table 6-4-1 Comparison of Route Alternatives

	Alternative A	Alternative B
Characteristics	Improvement of existing road	New road construction
Road length	35.2 km	12.8 km
Roadside	Lumber	Paddy fields development
Road construction	19 million Rp.	18 million Rp.
Major works of construction	Pavement	Embankments, bridge and pavement

Source: Study Team

The alternative B crosses large rivers at two locations. The alternative B is slightly advantageous in terms of construction cost. Besides, this alternative can reduce the distance between the area north of Lamonae and the provincial capital of Kendari by more than 10%. This road is, therefore, appropriate as the Sulawesi eastern coastal route. Since land is suitable for paddy fields, the construction of the new route promotes regional development for the use of roadside land.
In view of the above reasons, alternative B, or construction of a new road has been chosen.

6) Components of Construction Work
A proposed road alignment is shown in Appendix A-6.1 and the following major works are needed for the construction;

- New road construction for shortcut route;
- Widening of road way;
- Pavement;
- Bridges; and
- Drainage.

(3) Linomoiyo - Asera (17.0km)

1) Location of Existing Road
The road is located in the developed area in the valley along the Lindu River. The entire section, excluding the hilly area of Sta.197 km to 201 km, runs along a flat alluvial layer formed by the Lindu River and its tributaries.

2) Existing Road Conditions
The entire road section is gravel or dirt road without any drainage facilities or slope protection. The alignment of the road is satisfactory except for the section in the hilly area. The ferry facility to cross the Lasolo River because the bridge was washed away due to a flood. A new bridge is under construction at present.

3) Land Use
Along the road, development projects, mainly of paddy fields, are in progress.

4) Possibility of Development
There is a high possibility for large-scale development of paddy fields. Land suitable for cultivating mango, banana, cacao, and copra is spreading, and an increase in the production of these products is expected.

5) Components of Construction Work
A proposed road alignment is shown in Appendix A-6.1 and the following major works are needed for the construction.

- Improvement of road alignment;
- Widening of road;
- Pavement;
- Bridges; and

- Drainage.

6.4.2 Preliminary Engineering Design (Link No. 33)

(1) Preliminary Engineering of Bridges

Application of types of bridge superstructures of link No. 33 is the same as description in section 6.2.2 (1) before.

Most bridges of link No. 32 are wooden bridges and there is no bridge at some locations. Moreover, bridges are seriously damaged even though they are of concrete. As a result, replacement of bridges except only one bridge on link No. 33 was recommended.
BR33-27 (Sta.201+800) to be retained is now under construction and the type of structure is steel truss bridge which consists of 60m/span times two spans.

Two long span bridges to cross over the river were required for new road construction. There are two existing bridges, which cross the river, on existing route and both of bridges consists of 60m/span times two spans of steel truss bridge.
For a bridge which requires long distance between abutments due to crossing condition, alternative bridge study for different span arrangement was conducted as described in section 6.7.3. However, arrangement of substructure is restricted by topographical condition for these two bridges.

- BR33-6 (Sta.173+600)
  River width at BR33-6 is narrower than that at existing Lindu Bridge since BR33-6 is located at upper stream of Lindu River from the existing Lindu Bridge. Therefore, span length of 60 m is enough to pass over the river at this site. However, this area is a flood area of Lindu River so that additional side span is required. As a result, steel truss was recommended for the main span of this bridge and PC I-girder was recommended for both side spans.

- BR33-10 (Sta.183+600)
  Landewe River is about 80 m in width and its river bed is very deep. Therefore, it is difficult to build up high piers and to erect the concrete girder. A steel truss bridge with two spans of 60 m/span was recommended.

General views of proposed BR33-6 (Sta.173+600) and BR33-10 (Sta.183+060) are shown in Figure 6-4-1 and Figure 6-4-2 respectively.

For bridge foundations, spread footing is recommended for bridges in mountainous area near the Border of province based on the results of soil investigation. In addition, spread footings are applicable to bridges in mountainous area near the end of link No. 33.

Depth of bearing layer based on boring data is about 4m from the ground surface. Spread footing is suitable though the height of substructure becomes higher in the same manner as link No. 22. In other areas of this link, bridges require pile foundations with piles of 13 m to 20 m long based on the soil conditions.

Quantities of bridge improvement on link No. 33 are summarized as shown in Table 6-4-2. And proposed bridge list of link No. 33 is shown in Table 6-4-3

Table 6-4-2 Summary of Bridge Improvement Quantities of Link No.33

Classification		The Number of Bridges	Bridge Area (m^2)
New Construction	Bridge length ≦50m	22	5,012
	Bridge length >50m	4	3,336
	Total	26	8,348
Retain Existing		1	720

Source: Study Team

(2) Preliminary Engineering of Slope Protection Works

Slope protection works are constructed to protect the slopes from erosion or weathering by covering them with vegetation or structures and also to stabilize the slopes by means of drainage works or retaining structures. The following types of slope protection works are adopted for the feasibility route considering the terrain and geology, as shown in Table 6-4-4 and Table 6-4-5.
Required height of slope protection works for each link is Figure 6-4-3.

Table 6-4-4 Adopted Slope Protection Type (Fill Slope)

Station(km)	Geology	Slope Protection Type
196.2 -197.5	Allvium	Mat Gabion

Source: Study Team

Table 6-4-5 Quantities of Slope Protection

	Cut		Fill
	Sprayed Concrete Cribwork(m^2)	Shotcrete (m^2)	Mat Gabion (m^2)
Quantity	0	0	559

Source: Study Team

Table 6-4-3 Proposed Bridge List of Link No.33

Bridge No.	Location km	Location m	Length (m)	Nos. of Span	Span Arrangement	Bridge Width (m)	Types of Super-structures	Types of Foundations	Sub-structures: Abutments FIX Nos.	Abutments FIX ha(m)	Abutments FIX Pile La(m)	Abutments FIX Pile Nos.	Abutments MOVE Nos.	Abutments MOVE ha(m)	Abutments MOVE Pile La(m)	Abutments MOVE Pile Nos.	Piers FIX+FIX Nos.	Piers FIX+FIX hp(m)	Piers FIX+FIX Pile/ 1 pier Lp(m)	Piers FIX+FIX Pile/ 1 pier Nos.	Piers MOVE+FIX Nos.	Piers MOVE+FIX hp(m)	Piers MOVE+FIX Pile/ 1 pier Lp(m)	Piers MOVE+FIX Pile/ 1 pier Nos.	Boring Data
BR 33 - 1	147	+ 50	40.0	2	2 @ 20.0	7.6	RC-T	Spread	-	-	-	-	2	8	-	-	1	12	-	-	-	-	-	-	32,33
BR 33 - 2	151	+ 400	60.0	3	3 @ 20.0	7.6	RC-T	Spread	-	-	-	-	2	8	-	-	1	12	-	-	12	8	-	-	30,31
BR 33 - 3A	158	+ 710	20.0	1	1 @ 20.0	7.6	RC-T	Spread	1	8	-	-	1	8	-	-	-	-	-	-	-	-	-	-	30,31
BR 33 - 3B	159	+ 750	30.0	1	1 @ 30.0	7.6	RC-T	Spread	1	3	-	-	1	8	-	-	-	-	-	-	-	-	-	-	30,31
BR 33 - 4	165	+ 100	40.0	2	2 @ 20.0	9.6	RC-T	Spread	-	-	-	-	2	8	-	-	1	12	-	-	-	-	-	-	28
BR 33 - 5	173	+ 280	40.0	2	2 @ 20.0	9.6	RC-T	Spread	-	-	-	-	2	8	-	-	1	12	-	-	-	-	-	-	27B
BR 33 - 6	173	+ 600	120.0	3	30+60+30	9.6	PC+ST+PC	Spread	-	-	-	-	2	10	-	-	1	16	-	-	1	16	-	-	27B
BR 33 - 7	175	+ 80	20.0	1	1 @ 20.0	7.6	RC-T	Spread	1	8	-	-	1	8	-	-	-	-	-	-	-	-	-	-	27B
BR 33 - 8	177	+ 370	20.0	1	1 @ 20.0	7.6	RC-T	Spread	1	8	-	-	1	8	-	-	-	-	-	-	-	-	-	-	27B
BR 33 - 9	180	+ 710	20.0	1	1 @ 20.0	7.6	RC-T	Pile	1	6	17	16	1	6	17	16	-	-	-	-	-	-	-	-	20B
BR 33 - 10	183	+ 60	120.0	2	2 @ 60.0	9.6	Steel Truss	Pile	-	-	-	-	2	6	17	20	1	20	17	30	-	-	-	-	20B
BR 33 - 11	183	+ 710	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	17	16	1	6	17	16	-	-	-	-	-	-	-	-	20B
BR 33 - 12	184	+ 160	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	17	16	1	6	17	16	-	-	-	-	-	-	-	-	20B
BR 33 - 13	185	+ 790	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	13	16	1	6	13	16	-	-	-	-	-	-	-	-	19,20
BR 33 - 14	187	+ 510	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	13	16	1	6	13	16	-	-	-	-	-	-	-	-	19,20
BR 33 - 15	189	+ 100	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	12	16	1	6	12	16	-	-	-	-	-	-	-	-	18
BR 33 - 16	191	+ 490	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	8	20	16	1	8	20	16	-	-	-	-	-	-	-	-	16,17
BR 33 - 17	192	+ 170	20.0	1	1 @ 20.0	9.6	RC-T	Pile	1	6	20	16	1	6	20	16	-	-	-	-	-	-	-	-	15
BR 33 - 18	194	+ 350	20.0	1	1 @ 20.0	9.6	RC-T	Spread	1	8	-	-	1	8	-	-	-	-	-	-	-	-	-	-	14
BR 33 - 19	195	+ 760	30.0	1	1 @ 30.0	7.6	PC-I	Spread	1	10	-	-	1	10	-	-	-	-	-	-	-	-	-	-	14
BR 33 - 20	196	+ 835	30.0	1	1 @ 30.0	7.6	RC-T	Spread	1	8	-	-	1	8	-	-	-	-	-	-	-	-	-	-	14
BR 33 - 21	197	+ 620	20.0	1	1 @ 20.0	7.6	RC-T	Spread	1	8	-	-	1	8	-	-	-	-	-	-	-	-	-	-	13
BR 33 - 22	198	+ 360	20.0	1	1 @ 20.0	9.6	RC-T	Spread	1	10	-	-	1	10	-	-	-	-	-	-	-	-	-	-	13
BR 33 - 23	198	+ 520	60.0	3	3 @ 20.0	9.6	RC-T	Spread	-	-	-	-	2	10	-	-	1	16	-	-	1	16	-	-	13
BR 33 - 24	199	+ 340	20.0	1	1 @ 20.0	9.6	RC-T	Spread	1	8	-	-	1	10	-	-	-	-	-	-	-	-	-	-	13
BR 33 - 25	200	+ 35	30.0	1	1 @ 30.0	9.6	RC-T	Spread	1	10	-	-	1	10	-	-	-	-	-	-	-	-	-	-	13
BR 33 - 26	200	+ 35	30.0	1	1 @ 30.0	9.6	PC-I	Spread	1	10	-	-	1	10	-	-	-	-	-	-	-	-	-	-	13
BR 33 - 27	201	+ 800	120.0	2	2 @ 60.0	6.0	Steel Truss	Pile	RETAIN EXISTING																13

GENERAL VIEW OF BR 33-6 (STA. 173+600)

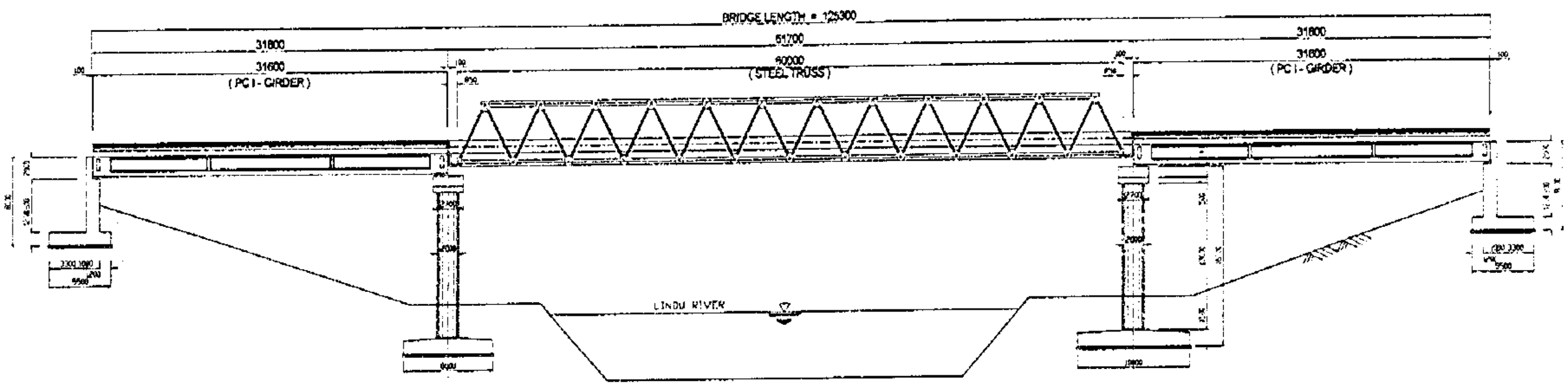


Figure 6-4-1 General View of BR 33-6

GENERAL VIEW OF BR 33-10 (STA. 183+060)

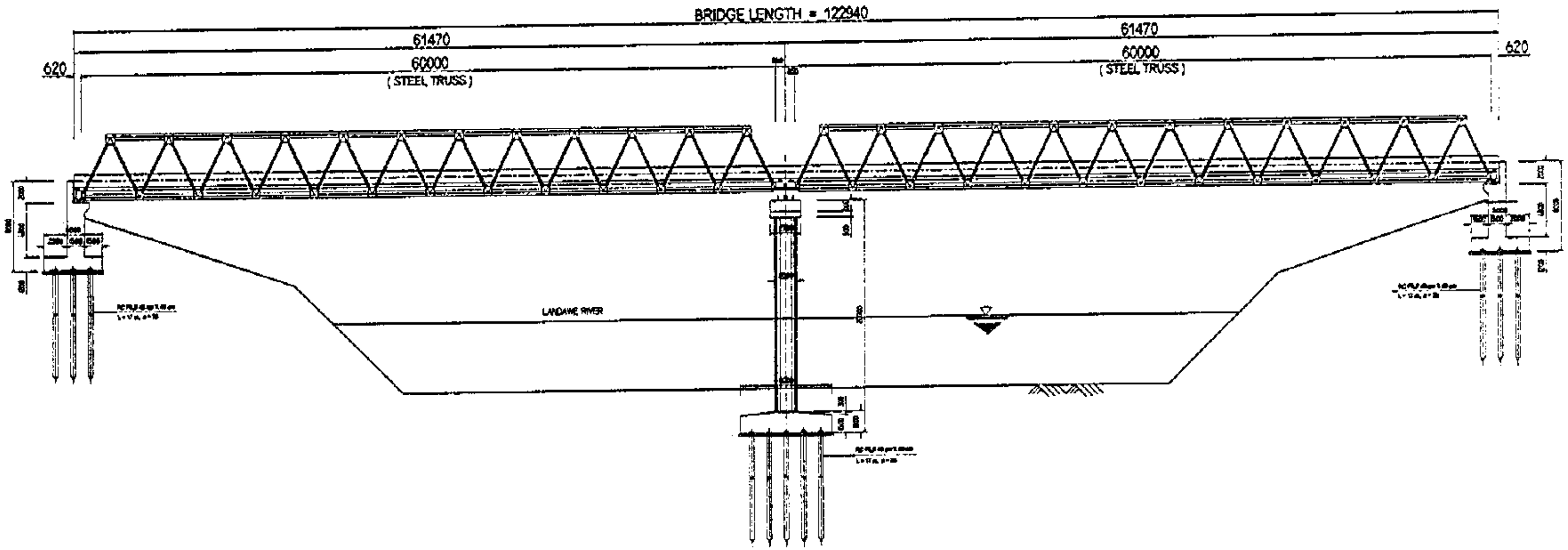
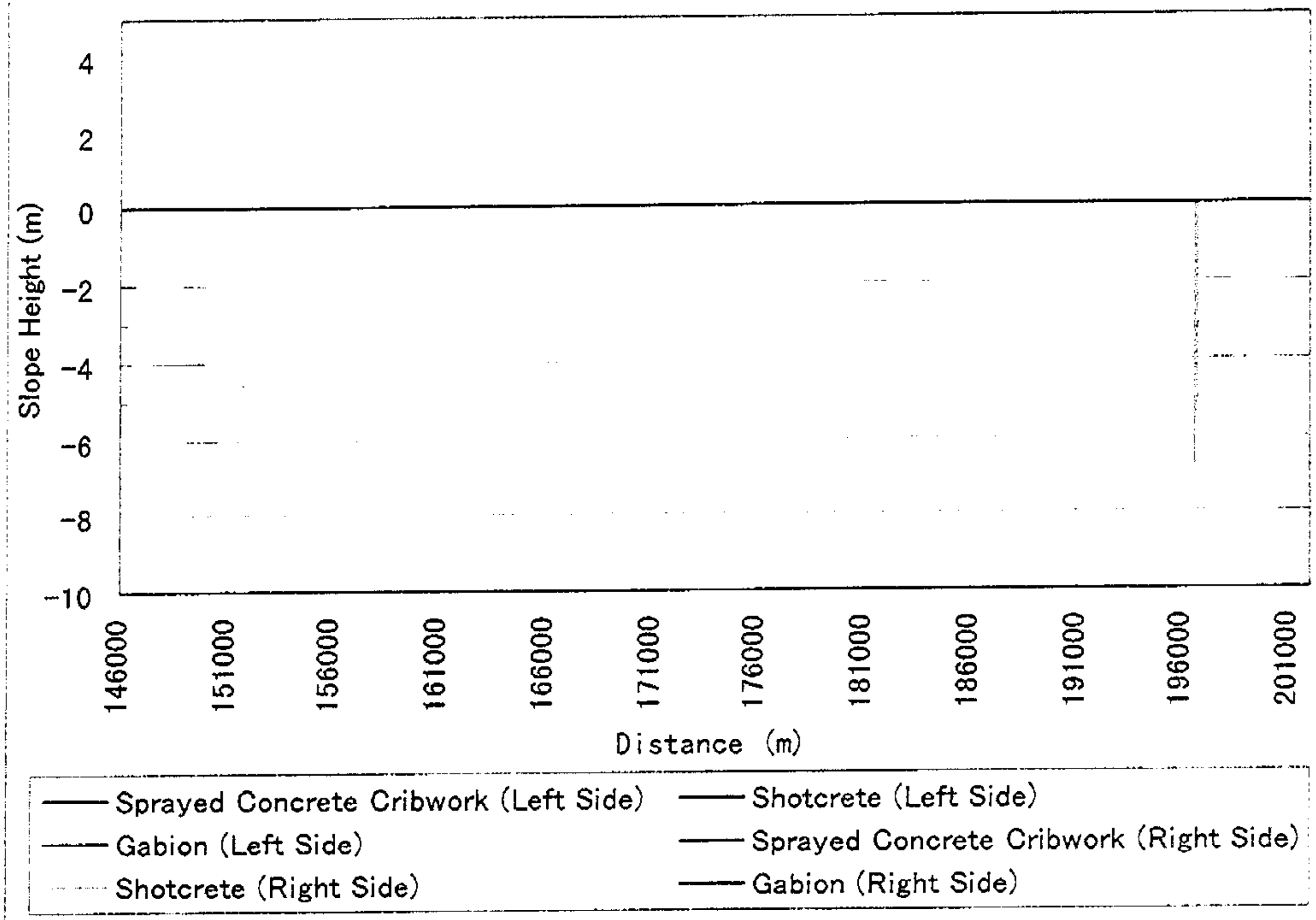


Figure 6-4-2 General View of BR 33-10



Gabion (Left Side) and Stone Masonry (Right Side)

Figure 6-4-3 Location and Height of Slope Protection for Link No.33

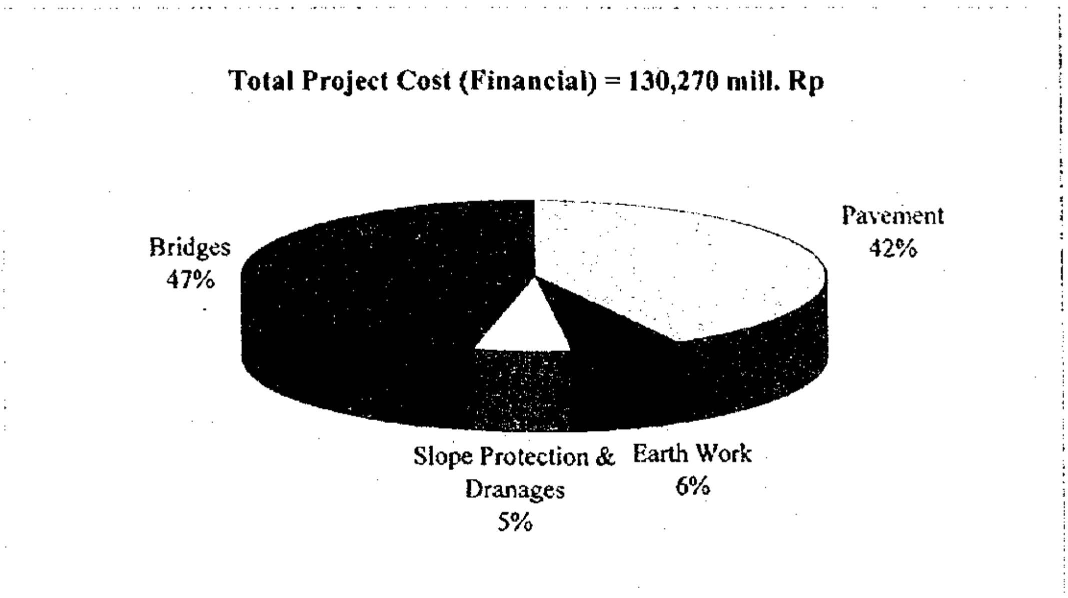
(3) Cost Estimates

1) Estimated Project Cost

Cost items consist of preparation works, pavement, earth work, drainage, bridge, slope protection and safety facilities works. The cost for engineering service was estimated at 20% of the total construction cost consisting of direct and indirect cost. A contingency has been included in 10 % of the total of construction and engineering cost. The ratio of major item costs to the total cost is shown in Figure 6-4-4 and Table 6-4-6 shows estimated cost.

2) Implementation Plan

As shown in Figure 6-4-5, the construction period is 5 years consisting of one year for preparation of project for fund raising plan, 1.5 years for detailed design of the roads and 2.5 years for construction. Also, the investment plan was set in accordance with the construction plan.



Source: Study Team

Figure 6-4-4 Construction Cost Ratio for Link No. 33

Table 6-4-6 Total Construction Cost For Border of Province - Asera Road (Link No.33)

Rate : 1US$ = 10600Rp = 140Yen

Item	Unit	Quantity	Unit Price: Foreign (US$)	Unit Price: Financial (Rp)	Unit Price: Economic (Rp)	Total Price: Foreign (US$)	Total Price: Local Financial (Rp)	Total Price: Local Economic (Rp)	Total Price: Financial Total (Mill.Rp)
1.Preparation Works									
Clearing and Grubbing	m2	477,144	0.23	1,867	2,099	109,743	890,827,848	1,001,525,256	2,054
2.Pavement									
New Road Asphalt Concrete + Sub base (Type A)	m	14,100	39.50	436,896	392,152	556,950	6,160,233,600	5,529,343,200	12,064
Widnning Road Asphalt Concrete + Sub base (Type A)	m	41,360	20.99	234,564	211,846	868,146	9,701,567,040	8,761,950,560	18,904
Transport for Pavement Material (L=14km)	m3	55,296	1.75	13,028	15,199	96,601	720,365,112	840,425,964	1,744
Sub-2						1,521,697	16,582,165,752	15,131,719,724	32,712
3.Earth Work									
Excavation (Common)	m3	113,665	0.92	7,407	8,213	104,572	841,916,655	933,530,645	1,950
Excavation (Sound Rock)	m3	883	4.12	33,605	36,492	3,638	29,673,215	32,222,436	68
Disposal soil (L=5km)	m3	38,481	1.20	8,610	10,050	46,177	331,319,258	386,731,538	821
Sub-3						154,387	1,202,909,128	1,352,484,619	2,839
4.Drainage									
Pipe Culvert (D=100cm)	m	1,260	44.35	634,758	554,426	55,881	799,795,080	698,576,760	1,392
Pipe Culvert (D=60cm)	m	1,109	15.28	202,787	184,640	16,949	224,931,340	204,802,688	405
Box Culvert (B=2.0m, H=2.0m)	m	140	325.89	3,064,762	2,510,606	45,625	429,066,680	351,484,840	913
U-ditch (U=50cm)	m	15,700	2.85	69,850	61,200	44,745	1,096,645,000	960,840,000	1,571
Sub-4						163,199	2,550,438,100	2,215,704,288	4,280
5.Slope Protection									
Sprayed Concrete Cribwork	m2	0	14.68	127,197	88,984	0	0	0	0
Shotcrete Work	m2	0	11.82	101,390	67,157	0	0	0	0
Stone Masonry	m2	0	6.91	116,286	109,711	0	0	0	0
Mat Gabion	m2	559	9.20	72,584	61,374	5,143	40,574,456	34,308,066	95
Sodding	m2	0	0.08	3,238	2,851	0	0	0	0
Sub-5						5,143	40,574,456	34,308,066	95
6.Tunnel	m	0	3,500.00	22,400,000	17,920,000	0	0	0	0
7.Bridges	No	23				2,054,381	16,037,591,538	12,759,747,162	37,814
8.Sefty Facilities Works									
Guard Railing	m	2,440	11.30	168,012	143,025	27,572	409,949,280	348,981,000	702
Traffic Sign	each	185	27.98	426,548	373,259	5,173	78,854,507	69,003,147	134
Line Marking	m	55,460	0.42	4,231	3,518	23,293	234,651,260	195,108,280	482
Sub-8						56,038	723,455,047	613,092,427	1,317
9.Mobilization & Temporally Works (20% of Total Cost)						765,213	8,111,259,054	7,056,795,377	16,223
10.Sub -Total						4,829,801	46,139,220,923	40,165,376,919	97,335
11.Land Acquisition	m2	52,700	0.00	20,000	20,000	0	1,054,000,000	1,054,000,000	1,054
12.Compensation	houses	20	0.00	15,000,000	15,000,000	0	300,000,000	300,000,000	300
13.Engineering Cost (20% of 10+11+12)						1,117,235	7,895,128,692	6,316,102,954	19,738
14.Contingency (10% of 10+11+12+13)						594,704	5,538,834,962	4,783,547,987	11,843
Ground Total Cost (10+11+12+13+14)						6,541,740	60,927,184,577	52,619,027,861	130,270

Item	Unit	Quantity	1999	2000	2001	2002	2003	Total
1. Preparation of Project								
2. Survey and Design	km	55.46						
3. Construction								
Earth Work	m3	114,548						
Slope Protection	m2	-						
Tunnel	m	0.0						
Bridges	No	23						
Pavement	km	55.46						
Foreign (US$)				307,240	883,207	2,272,807	3,078,485	6,541,740
Local Financial Cost (Rp)				2,915,860,390	8,934,240,318	19,000,284,748	30,076,799,121	60,927,184,577
Local Economic Cost (Rp)				2,481,628,312	8,133,301,631	15,669,231,016	26,334,866,901	52,619,027,861
Total Financial Cost (Mill. Rp)				6,173	18,296	43,092	62,709	130,270
Total Ecomomic Cost (Mill. Rp)				5,738	17,495	39,761	58,967	121,961

Figure 6-4-5 Implementation Schedule For Border of Province - Asera Road (Link No.33)

(4) Economic Analysis

1) Economic Project Costs

The economic investment costs were estimated in constant 1998 prices. The financial investment costs in terms of market price include the component of taxes. The economic costs for economic analysis were obtained by subtracting the portion of transfer payment such as taxes from financial costs. Implementation is scheduled over four years from 2000 to 2003. The phased financial and economic investment costs (initial investment) are summarized in Table 6-4-7.

Table 6-4-7 Phased Initial Investment Costs in 1998 Prices (F/S - Link No. 33)

(Million Rp.)

Year	Financial Prices	Economic Prices
2000	6,173	5,738
2001	18,296	17,495
2002	43,092	39,761
2003	62,709	58,967
Total	130,270	121,961

Source: Study Team

The maintenance cost of the proposed road follows the engineering study results of the cost estimates. Besides, the maintenance cost of the proposed road in the case of "without the improvement of the proposed road" was treated as a negative cost.

2) Economic Benefits

Benefits are classified into two types, one is the direct benefit and the other is the indirect benefit or intangible benefit.

The direct benefits which would be realized from the implementation of the Project are defined as the savings in travel costs, composed of the vehicle operating cost and vehicle time cost when comparing the "with" and "without" project conditions.

The benefit of vehicle operating costs was estimated as a difference of vehicle operating costs between "with" Project" case and "without" Project" case. The vehicle operating cost was derived from the obtained daily vehicle-kilometers and the unit vehicle operating cost by vehicle type. In addition, a promotion of traffic safety and a saving in accident costs were anticipated.

In this economic analysis, the above-mentioned direct benefits, e.g. the saving in vehicle operating cost was computed as a quantified benefit. The calculation of direct benefits were made for the planning year of 2003 and 2018.

As a result, the saving in vehicle operating cost is summarized as shown in Table 6-4-8.

Table 6-4-8 Estimated Economic Benefits (F/S - Link No. 33)

(Million Rp. at 1998 price)

Year	Benefit of Saving in VOC
2004	35,890
2018	83,205

Source: Study Team

3) Economic Cost-Benefit Analysis

The analysis follows the conventional discounted cash flow method in determining the economic internal rate of return (EIRR), the net present value (NPV) and the benefit cost ratio (B/C). (NPV and B/C are calculated at a discount rate of 15 percent.) The project life is assumed to be 20 years after the completion of the construction.

The benefits in the intermediate years were interpolated and those beyond 2018 were assumed to be fixed. The total economic project costs and benefits streams are presented in Table 6-4-9. The efficiency measures were calculated and the results are as follows:

Efficiency Measures	F/S - Link No. 33
EIRR	33.4%
NPV (Million Rp.)	106,586
B/C	2.79

Source: Study Team

These results indicate that implementation of the project (road improvement of link No. 33) is economically feasible.

Table 6-4-9 Economic Analysis for F/S of Link No. 33

(Million Rp.)

	Year	Benefits VOC Saving	Total	Costs Invest. Costs	Maint Cost (With)	Total	Maint. Cost (Without)	Net Cash Flow
1	1999			0	0	0	0	0
2	2000			5,738	101	5,839	6,975	1,136
3	2001			17,495	101	17,596	101	-17,495
4	2002			39,761	101	39,862	101	-39,761
5	2003	0	0	58,967	101	59,068	101	-58,967
6	2004	35,890	35,890	0	101	101	101	35,890
7	2005	39,269	39,269	0	101	101	6,975	46,143
8	2006	42,649	42,649	0	101	101	101	42,649
9	2007	46,029	46,029	0	101	101	101	46,029
10	2008	49,408	49,408	0	101	101	101	49,408
11	2009	52,788	52,788	0	101	101	101	52,788
12	2010	56,168	56,168	0	10,443	10,443	6,975	52,700
13	2011	59,547	59,547	0	101	101	101	59,547
14	2012	62,927	62,927	0	101	101	101	62,927
15	2013	66,307	66,307	0	101	101	6,975	73,181
16	2014	69,686	69,686	0	101	101	101	69,686
17	2015	73,066	73,066	0	101	101	101	73,066
18	2016	76,446	76,446	0	101	101	6,975	83,320
19	2017	79,825	79,825	0	10,443	10,443	101	69,483
20	2018	83,205	83,205	0	101	101	101	83,205
21	2019	83,205	83,205	0	101	101	6,975	90,079
22	2020	83,205	83,205	0	101	101	101	83,205
23	2021	83,205	83,205	0	3,515	3,515	2,392	82,083
24	2022	83,205	83,205	0	101	101	3,538	86,642
25	2023	83,205	83,205	0	101	101	101	83,205
				121,961	26,522	148,483	49,396	

Source: Study Team

Assuming that the benefits and cost stream might alter ±10%, ±20%, the effect on the EIRR was tested and the results are summarized in Table 6-4-9. In the most severe case of -20% benefit and + 20% cost, the value of EIRR is 24.8%.

Table 6-4-9 EIRR by Altered Benefit and Cost (F/S - Link No 33)

Cost	Benefit		
	Base	-10%	-20%
Base	33.4%	30.9%	28.4%
+10%	31.1%	28.8%	26.4%
+20%	29.2%	27.0%	24.8%

Source: Study Team