10.8.3 Design of Special Bridge (Thai Binh River Bridge)

(1) General

1) Definition of Special Bridge

"Special Bridge" is the terminology for the stypical Thai Binh river bridge which is depicted in Figure 10.5, consisting of eleven (11) spans. This bridge can be divided into two distinct portions when viewed in terms of structural characteristics :

- One (1) prestressed concrete continuous box girder bridge (65 m + 105 m + 65 m) for main spans with effective width of 11.0 meters; and

- Two (2) prestressed concrete simple box girder bridges (4 x 43.0 m + 4 x 43.0 m) for approaches each with an effective width of 11.0 meters.

It should be noted that the above-mentioned Thai Binh River Bridge will constitute an integral part of Pha Lai Bridge. The Pha Lai Bridge consists of the Thai Binh bridge and two types of viaducts to avoid flooding. The overall length will be 1,433 m (575 m + 858 m).

2) Background

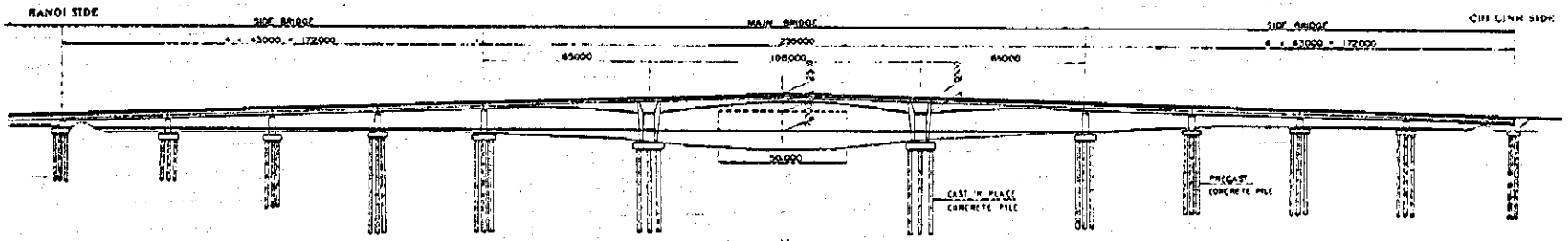
Preliminary design of the Pha Lai bridge was carried out by TEDI in 1994. The study team collected relevant data and analyzed the technical problems conceived in the preliminary design. TEDI's design is systematic involves answers for the matters to be clarified in the feasibility study stage. However, the study team carried out a review of TEDI's design in the light of the following conditions.

- Adopted design standard;
- Results of supplemental surveys (i.e. soil investigations);
- Ease of construction and construction economy;
- Bridge aesthetics.

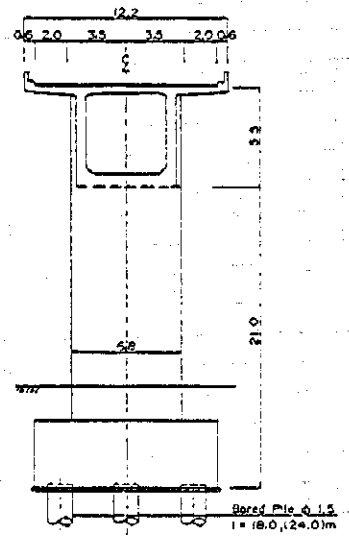
(2) Site Conditions

1) Terrain and Hydrological Conditions

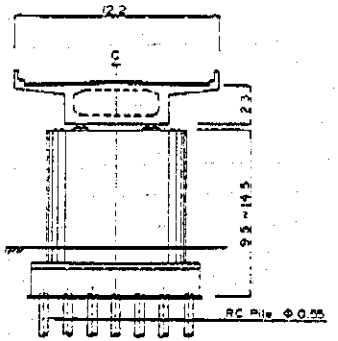
The Thai Binh River, which the special bridge crosses, is approximately 550m wide and has dikes on both sides. The river course is almost straight at the proposed bridge site. At a point about 1 km north of the proposed bridge site, the Thuong River and the Cau River flow into the Thai Binh River. In the south, the Thai Binh River meets the Duong River, which carries the water from the Hong River (Red River), at a point 5 km



ELEVATION



CROSSSECTION OF MAIN BRIDGE



CROSSECTION OF SIDE BRIDGE

HIGHWAY NO. 18 IMPROVEMENT

Figure 10.6 General View of Thai Binh River Bridge

downstream of the proposed bridge site. The location of the bridge was selected due to the complicated nature of these tributaries.

In the rainy season from June to August, the water level of the Thai Binh River rises nearly to the top of the dikes and the water depth reaches approximately 13 m. In the dry season, the water level comes down to approximately 5m water depth and the width of the water surface becomes approximately 230m.

Flood water level and discharge at 100 years frequency are given as follows:

- Flood Water Level : +7.94 m
- Discharge : 4,860 m^3

At present, as there is no bridge crossing for the Thai Binh River and a ferry is being operated at a place 500 m upstream of the proposed bridge site. Thai Binh River is relatively busy, as there is a large scale coal thermal power plant on the east bank upstream.

2) Geological and Soil Conditions

According to the soil investigations carried out by the study team and the information from TEDI's Feasbility Study, geological conditions at the proposed bridge site are shown as follows:

- The bearing stratum, which consists of sandstone, is located approximately 15 - 20m below the existing ground level near the dikes. The bearing strata incline toward the center of the river and the depth from the ground level reaches 30 m at the middle of the river.

- The layers above the sandstone consist of several loose layers of sandy soil and silty soil with N-values ranging from 3 to 6.

(3) Design Conditions

1) Design Load

a. Design Live Load

Design live load to be applied is 125% of HS 20 - 44 (Truck loading) or 125% of HS 20 - 44 (Lane loading) whichever produces the maximum stress. These live loads slightly exceed Vietnamese standard H30 or XB 80.

b. Seismic Force

As shown in Paragraphs 7.3.2, an acceleration coefficient of 0.07 is applied.

c. Other Design Loadings

Other design loadings follow the standards mentioned in Paragraph 7.3.1.

2) Design Flood Water Level

a. Frequency of Design Flood

In accordance with the government standard the design frequency of 100 years is applied (refer to Paragraph 7.4.1 for further descriptions).

b. Design Flood Water Level

According to the data from Ministry of Water Resources, the design flood water level of 7.94m (100 years frequency) is applied.

3) Navigation and Flood Clearance

a. Navigation Clearance

In accordance with TCVN -5664 -1992, the Thai Binh River is classified as Class III and navigation clearance is specified as follows :

- Horizontal Clearance : 50 m
- Vertical Clearance : 7 m (from + 7.05 of flood water level at 20 years frequency)

b. Flood Clearance

Provided clearance between design flood water level and the lower surface of girder is at 0.5 m in accordance with the government standard (refer to Paragraph 7.4.2).

4) Cross Section of Bridge Decks

See Figure 10.7 for the recommended typical cross section.

a. Highway Class : Class III in flat terrain
b. Number of Traffic Lanes : 2 - lane 2 - way
c. Lane Width : 3.5 m
d. Shoulder/Bicycle Lane : 2.0 m

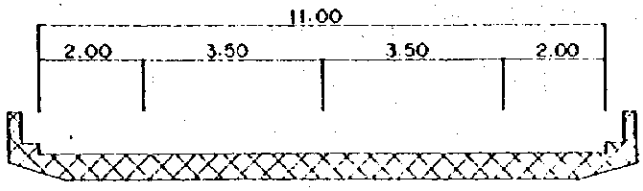


Figure 10.7 Cross Section of Bridge Deck, Special Bridge

(4) Bridge Length and Span Arrangement

1) Bridge Length

The total bridge length is 579 m to clear existing dikes.

2) Main Spans and Approach Bridges

The width of water surface in the Thai Binh River fluctuates from 230 m to 550 m annually as mentioned before. Therefore, the bridge is divided into a main bridge and two approach bridges. The main spans are required to provide navigation clearances.

3) Factors Governing the Span Arrangement of Main Spans

The factors governing the determination of span arrangement of the main spans are as follows:

- The center span must have sufficient width to ensure navigation clearance and the fluctuation of channel must also be taken into account;
- Navigation clearances should be maintained during the construction period of approximately 3 years;
- Future change of the position of main flow of the river must be taken into account if the expensive dredging work to maintain navigation channel should be avoided;
- Construction cost including substructures and foundations, is also an important factor to determine the span arrangement because the bearing strata are found at a depth around 30 m.

4) Factors Governing Span Arrangement of Approach Bridges

The approach bridges are planned on the sections where the river bed is exposed in the dry season. Therefore, span length of approach bridges has no limitation from the view point of navigation clearance. However, considering the obstruction ratio by piers to the sectional area of the river and harmony with the main spans, span length may vary from 30 m to 50 m.

The span arrangement of side bridges is recommended in Paragraph 8.7.3. (5) because it is necessary to consider construction cost.

(5) Design of Special Bridge

1) Superstructure

Based on the relationship between span length and normal bridge types, the superstructure types for the main spans and approach bridges are selected as follows:

Main Spans	:	PC Continuous Box Girder Type
Approach Bridges	:	PC Simple Box Girder or PC I- Girder Type

In order to determine the span arrangement for the main spans and the approach bridges, three alternatives with different span arrangement were compared, from the view points of ease of construction, construction cost and period, aesthetics, navigation safety, and maintenance (Table 10.24).

Alt. - A	:	31 m x 5 + (40 m + 63 m x 3+40 m) + 31 m x 5
Alt. - B	:	39.5 mx 5 + (50 m + 80 m + 50 m) + 39.5 m x 5
Alt. - C	:	43 m x 3 + (65 m + 105 m + 65 m) + 43 m x 3

As a result of the comparison, Alternative-C is recommended because of superior navigation safety, maintenance and ease of construction and is flexible to the change of the position of main flow of the river.

The study team recommends an adoption of double walled piers for the center span of 3-span continuous bridge to mitigate negative maximum bending moment.

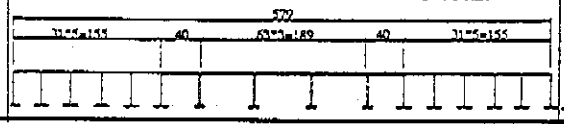
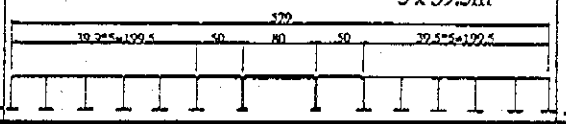
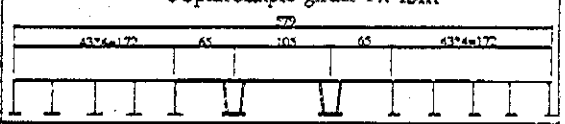
The PC box girder type is adopted for the approach bridges for the aesthetics which are superior compared to PC I-girder type in constant girder depth and design.

2) Substructure

a. Abutment

The height of the abutments will be 10 m to 12 m (at the east bank). Therefore, the reversed-T type is adopted.

Table 10.24 Comparison of Alternatives, Special Bridge

Description		Alternative - A	Alternative - B	Alternative - C
Profile		Main Bridge : 5 Span Continuous Rigid Frame 40m + 3 x 63m + 40m Approach : 5 Span Simple girder 5 x 30m, 5 x 30m 	Main Bridge : 3 Span Continuous Rigid Frame 50m + 80m + 50m Approach : 5 Span Simple girder 5 x 39.5m, 5 x 39.5m 	Main Bridge : 3 Span Twin wall Rigid Frame 65m + 105m + 65m Approach : 4 Span Simple girder 4 x 43m, 3 Span Simple girder 4 x 43m 
Comparative Items	1. Ease of Construction (point 5)	Many piers in the water Poor 2.5 △	Many piers in the water Poor 2.5 △	Smaller number of piers in the water Good 5 ◎
	2. Economy (point 50)	Lower cost 50 ◎	Normal cost 37 ○	Higher cost 25 △
	3. Aesthetic (point 15)	Too many piers Poor 7.5 △	Fair 11 ○	Twin wall gives slender design good appearance. Good 15 ◎
	4. Construction period (point 10)	Longer construction period 5.0 △	Normal construction period 7.5 ○	Shorter construction period 10 ◎
	5. Navigation Clearance (point 10)	Poor 5.0 △	Fair 7.5 ○	Good 10 ◎
	6. Maintenance (point 10)	Poor 5.0 △	Fair 7.5 ○	Good 10 ◎
Recommended Priority		2 (75.0)	3 (73)	1 (75) Recommended

Scores : ◎ : 100%
○ : 75%
△ : 50%

b. Piers

The wall type is adopted for piers to provide smooth flow of water.

3) Foundation

a. Main Spans

The depth to the bearing layer ranges from 15m to 30m. Therefore, a type of pile foundations is adopted. Caisson type will not be suitable because of excessive economical and expeditious horizontal forces. It is also inferior in terms of construction cost compared with pile type foundations.

In case of the superstructure with a long span and larger dead weight, utilisation of large diameter pile is preferable, as it would save construction cost and time. This is considering that the current, cast-in-place RC piles (Dia. 1.5m) are adopted

b. Footing Type for Main Spans (Figure 10.8)

As the water depth in the dry season is around 5m, the following alternatives are compared.

Alternative - A : Footings below the river bed
Alternative - B : Footing above the water level in dry season

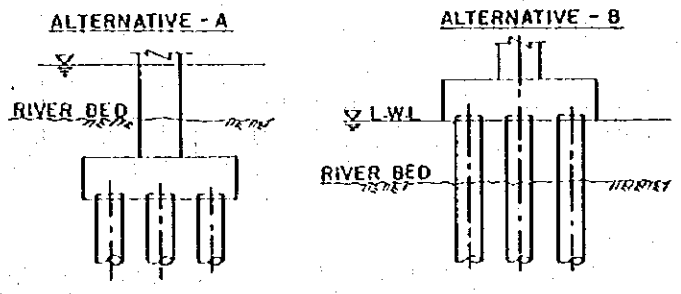


Figure 10.8 Footing Type for Main Spans

Alternative-B is superior in ease of construction because the construction of sheet pile cofferdams are not required, however the Study Team recommends Alternative - A based on the following reasons;

- Alternative - B requires fender systems to protect footings from collision by ships;

- Alternative - B is inferior in the aesthetic aspect due to the footings exposure above water level in dry seasons;
- Cost-saving is negligible in Alternative - B.

c. Approach Bridges

The precast RC pile is adopted considering the nature of superstructure, construction cost and ease of construction. This type is widely utilized in Vietnam.

(6) Construction Plan

1) Construction Method and Procedure

a. Superstructure

The adoption of precast block erection method is recommended for the erection of PC box girders to shorten the construction period.

b. Substructure and Foundation

The piers for main spans will be built in a cofferdams after piling from pontoon is completed. The piers of side bridges will be built when the river bed is exposed during the dry season.

2) Construction Period

The construction period of the special bridge is estimated at approximately 28 months based on the construction method mentioned above.

10.9 Preliminary Pavement Design

10.9.1 Design Conditions

The pavement layers and their thickness should be determined based on the following factors governing the design (flexible pavement design) :

- Traffic;
- Strength of subgrade; and
- Construction materials adopted to the pavement layers.

In most of the prevailing pavement design guides, traffic is expressed in terms of the cumulative single axle loads of 8,200 kg (18-kip), over the design life of the road. The number of equivalent axles is computed mainly based on the number of commercial vehicles, in particular, heavy vehicles such as buses and trucks.

The truck factor per vehicle computed from the equivalent single axle is assumed to be 1.0 up to the year 2000 since an axle load of 6.0 tons is generally the acceptable maximum on Vietnamese roads, and a total vehicle weight of more than 13 tons is allowed only by permission of MOT. It is expected that

these limitations will be revised to adopt larger axle load limit by the year 2000 to meet the improvement of roads and bridges. The truck factor will also be increased to 3.0 by the year 2015. A value of 2.5 for truck factor has been applied for the computation of cumulative 18-kip equivalent single axle loads (ESAL). In case of bus factor, 0.7 has been used for the computation.

The strength of subgrade will govern the thickness design of pavement. Commonly the strength is expressed by California Bearing Ratio (CBR) value determined by laboratory testing. A CBR value of 4.0 to 6.0% is adopted in the computation of pavement thicknesses.

As for the pavement surface, asphalt concrete is employed in the pavement design, since bituminous surface treatment is only applicable for the roads which have less traffic, that is, those carrying less than 0.5 million equivalent single axle loads over the road lifetime.

There are three types of materials suitable for the base course, i.e., asphalt treated, cement treated and graded crushed-stone base courses. Asphalt treated base course is applied in this study. River gravel is usually used for the subbase course.

10.9.2 Design Features

Based on the above discussion, AASHTO (1972 and 1986) and Japan Road Association standards have been used to design the thickness of the pavement layers. The design condition is indicated as follows:

- Design life	:	20 years
- Regional factor	:	5 (Roadbed materials wet)
- Terminal serviceability index	:	2.5
- Truck factor	:	2.5
- Bus factor	:	0.7
- CBR of Subgrade	:	4 ~ 6 %
- Cumulative 18-kip equivalent Single axle loads	:	12.5×10^6

The result of the computation requires the pavement thickness as shown in Figure 10.8.

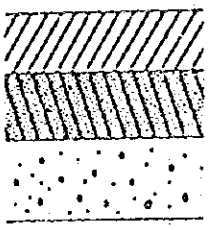


Figure 10.9 Recommended Pavement Layer Thicknesses

Chapter 11

CONSTRUCTION PLANNING

CHAPTER 11 CONSTRUCTION PLANNING

11.1 General

The construction planning study is mainly comprised of i) establishment of construction method and ii) preparation of construction time schedule. The result of the study will be utilized in the construction cost estimates and further reflected in the establishment of a project implementation schedule.

11.2 Basic Conditions of Construction Planning

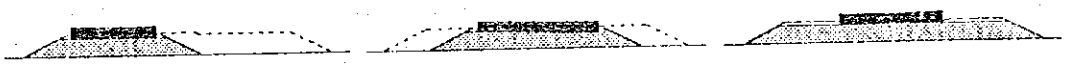
(1) Stage Construction

Since the project necessitates large scale construction work, it is desirable both economically and technically to phase the construction over a period of time. Stage construction approach has been exercised in the early stage of the study, in case of Noi Bai - Bac Ninh section. As the result of the study, the development of a new highway between Noi Bai and Bac Ninh has been planned in two stages in order to optimize the investment schedule :

Initial Stage : Construction of a 2-lane 2-way highway for the entire length.

Final Stage : Widening from 2-lane to 4-lane for the entire length to attain higher speed and greater capacity.

There are three alternative methods to widen the initial 2-lane carriageway to the final 4-lane carriageway as shown below.



METHOD - 1 METHOD - 2 METHOD - 3

Method - 1 : Both earthwork and paving executed only for 2-lane cross-section in the initial stage. Future widening of earthwork and pavement on one side.

Method - 2 : Both earthwork and paving executed only for 2-lane cross-section in the initial stage. Future widening of earthwork and pavement on both sides.

Method - 3 : Initially earthwork for the final stage construction and 2-lane pavement at the center. The future pavement widening to outer lanes.

Among these 3 methods, Method - 3 has the higher degree of completion in the initial stage construction, but the initial investment would be too large and difficult to attain a reasonable economic return.

When the forecast traffic volume in the initial stage is at a modest level, Method-1 or Method-2 is normally adopted. Considering the following advantages compared with Method-2, it was concluded to adopt Method-1.

- Elimination of bridge widening difficulty in adverse subsoil conditions;
- Enhancement of traffic safety during final construction stage; and
- Less demolition and reconstruction of slope protection facilities.

(2) Framework of Construction Planning

Construction planning is developed in the framework of the following constructions taking into account the Highway No.18 improvement strategy.

Section No.	Section	Construction Phase
1	Noi Bai - Bac Ninh	Initial Stage
2	Bac Ninh - Chi Linh	Initial Stage
3	Hong Gai - Cua Ong	Initial Stage
4	Cua Ong - Tien Yen	Final Stage
5	Tien Yen - Bac Luan	Final Stage

(3) Quantities of Major Work Items

Selection of construction method is based on the actual work quantities and site conditions.

(4) Road Network for Hauling Materials

The construction involves the hauling of a large quantity of embankment/ pavement materials. Basically the project area is provided with a sufficient road network. However, the pavement conditions of the existing local roads sometimes lack strength. Pavement strengthening/repair will be necessary but construction of new roads is unlikely.

In the Noi Bai - Bac Ninh section, the construction should be executed in sequence in order to use the new road as a pilot to so that it may be utilized in transportation of materials, also using the parallel provincial highways in order to expedite the construction.

11.3 Construction Method

11.3.1 Equipment Intensive Construction

To attain construction economy and to realize the improvement with a shorter construction period, the equipment intensive construction method will be adopted.

11.3.2 Earthwork

(1) Major Equipment

The use of the following major earthwork equipment is considered in the planning (Table 11.1).

Table 11.1 Earthwork Equipment

Main Works	Equipment	
	Hauling distance less than 100m	Hauling distance more than 100m
Clearing and Grubbing	Bulldozer	
Excavation	Bulldozer	Tractor Shovel
Loading	-	Tractor Shovel/Payloader
Hauling	Bulldozer	Dump Truck
Spreading	Bulldozer/ Motor grader	
Compaction	Tamping Roller/ Tire Roller	

(2) Outline of Earthwork Planning

Table 11.2 shows the sources of embankment materials for the improvement. The hauling distance is generally not more than 7 km.

Table 11.2 Borrow Material Sources

Section No.	Section	Sources
1	Noi Bai - Bac Ninh	Ca Lo River, Ngu Huyen Khe River and their tributaries (river sand).
2	Bac Ninh - Chi Linh (bypasses)	Neighboring hills, Thai Binh River and Duong River (river sand).
3	Hong Gai - Cua Ong (bypasses)	Neighboring hills and excavated materials from roadway improvement.
4 & 5	Cua Ong - Bac Luan	Neighboring hills, existing rivers (sandy gravel) and excavated materials from roadway improvement.

11.3.3 Paving Work

(1) Main Equipment

The use of the following equipment is considered (Table 11.3).

Table 11.3 Paving Work Equipment

Main Work	Equipment
Subgrade Preparation	Motor Grader, Tire Roller, Macadam Roller
Sub-base	Motor Grader, Tire Roller, Macadam Roller
Prime/Tack Coat	Asphalt Distributor
ATB/Surface Course	Asphalt Mixing Plant, Asphalt Finisher, Macadam Roller, Tire Roller

Note : ATB denotes Asphalt Treated Base Course.

(2) Material Sources

The sources of paving materials are shown in Table 11.4.

Table 11.4 Sources of Paving Materials

Materials	Location of Quarry	Remarks
Gravel and Sand	Trung Gia	Deposit : 500,000m^3
Sand	Bat Cap	Deposit : 250,000m^3
Coarse Aggregate	Dong Tieu	Limestone
Coarse Aggregate	Trang Kenh	Limestone
Coarse Aggregate	Yen Cu	Limestone

(3) General Descriptions of Materials

1) Sub-base Course Materials

Sub-base course materials from the existing rivers will require processing for gradation control, considering the nature of deposit.

2) Base Course Materials, Coarse and Fine Aggregate

A number of aggregate producers are in operation in the north of Noi Bai - Bac Ninh corridor. The contractor will be able to establish his own quarries and gravel pits and to operate his own crushing/screening plant.

3) Asphalt Mixture

Procurement of hot-mix asphaltic concrete is possible for the construction of asphalt treated base course and surface course.

11.3.4 Bridge and Viaduct Construction

(1) Main Equipment

The equipment used for bridge construction is shown in Table 11.5.

Table 11.5 Bridge Construction Equipment

Main Work	Equipment
Foundation	Diesel Pile Hammer, Pile Driver, Truck Crane, Floating Crane (TBB), Reverse Circulation Drilling Machine. (TBB)
Structure Excavation	Clamshell, Dump Truck, Barge (TBB)
Substructure	Transit Mixer, Concrete Pump Truck
Superstructure	Crawler Crane, Erection Truss, Launching Girder (TBB)
Superstructure	Floating Crane (TBB)

Note: TBB denotes Thai Binh River Bridge.

(2) Construction of Thai Binh River Bridge

Cofferdams with steel sheet piling in the water will be required for the substructure construction. Cast-in-place concrete piling will be executed by a reverse-circulation-drill method. The adoption of cantilever erection is recommended for continuous main spans. Erection truss method will be applied for the erection of simple PC box girders (refer to Volume II : Drawings for Schematic Explanations).

(3) Other Bridges and Viaducts

No major problems are anticipated in the construction of bridge foundations and substructures. PC I-girders will be erected by means of conventional crane erection method or erection girder method.

11.4 Construction Time Schedule

11.4.1 Conditions for Scheduling

(1) Maximum Construction Period

Taking into account the scale of the construction and the urgency of the Highway No. 18 improvement, the maximum possible construction period was set at 2.5 years.

(2) Weather Conditions

According to rainfall data, the number of working days for earthwork and the construction of pavement was estimated as shown in Table 11.6.

Table 11.6 Number of Working Days

Item	Dry Season Nov. - Apr. (6 months)	Rainy Season May - Oct. (6 months)	Annual
Number of rainy days	10.1 days/month	14.0 days/month	145 days
Working efficiency on a rainy day	65%	35%	52.5%
Number of holidays	5.0 days/ month	4.3 days/ month	60 days
Number of working days	21.5 days/month	16.6 days/month	229 days
Working efficiency	72%	55%	63%

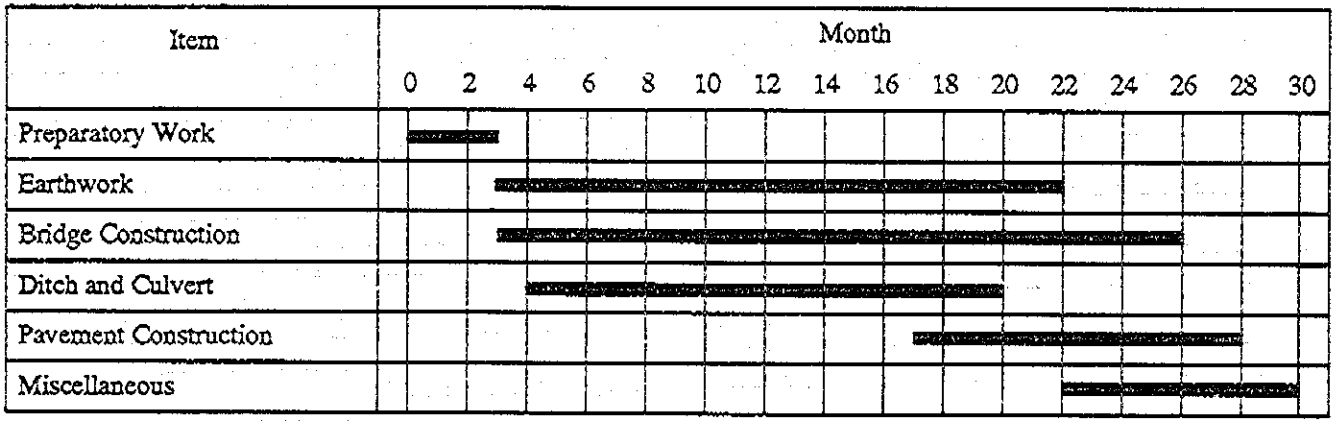
11.4.2 Time Schedule

The construction time schedule for each construction section was prepared based on the conditions described in Subsection 11.4.1 above, as shown in Fig 11.1.

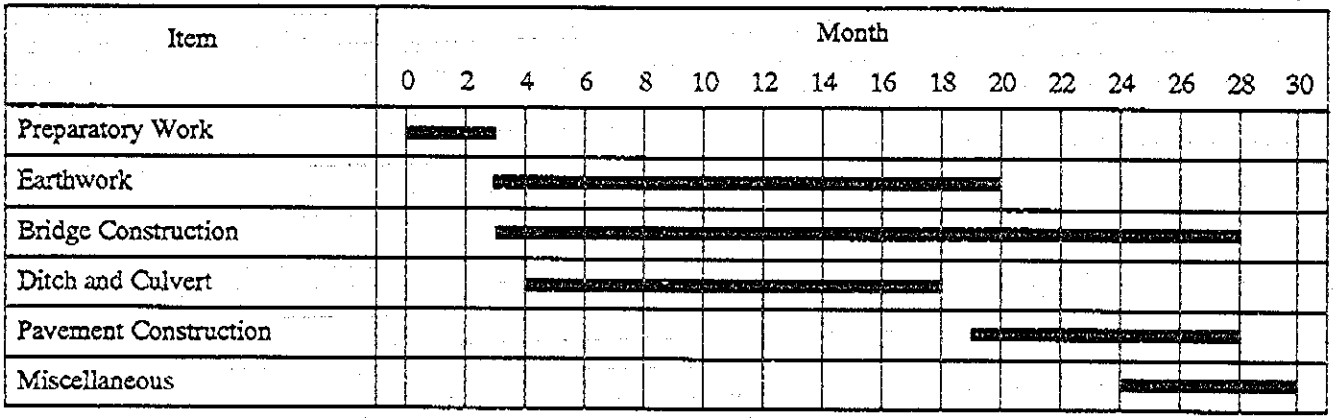
11.5 Implementation Schedule

The project implementation schedule has been prepared for both initial and final stages of the Highway No. 18 improvement. The detailed design for the initial stage improvement will be begun by the beginning of 1997 for 1.0 - 1.5 year period, and construction will be executed in 2.0 - 2.5 years from the beginning or middle of 1998. The beginning of the final stage construction is dependent on traffic requirement and the optimization policy of project costs investment (refer to Figure 11.2).

Section 1 (Noi Bai - Bac Ninh : 31.3km) Initial Stage



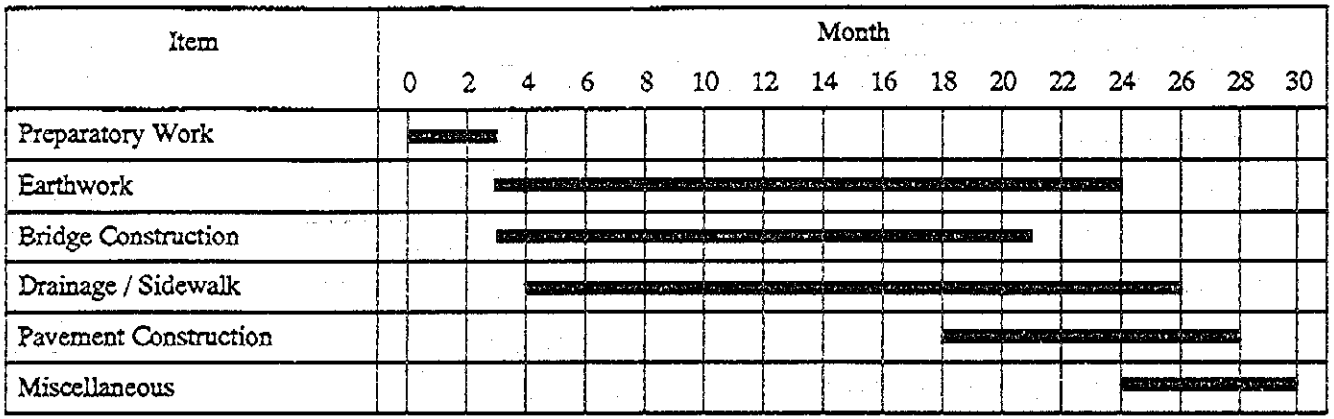
Section 2 (Bac Ninh - Chi Linh : 36.4km) Initial Stage



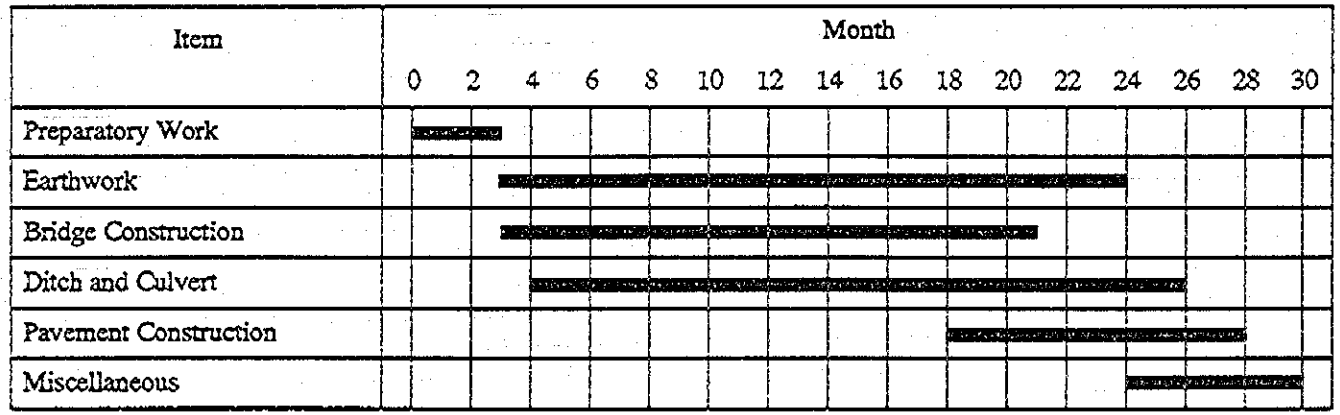
HIGHWAY NO. 18 IMPROVEMENT

Figure 11.1 (1) Construction Time Schedule

Section 3 (Hong Gai - Cua Ong : 38.7km) Final Stage

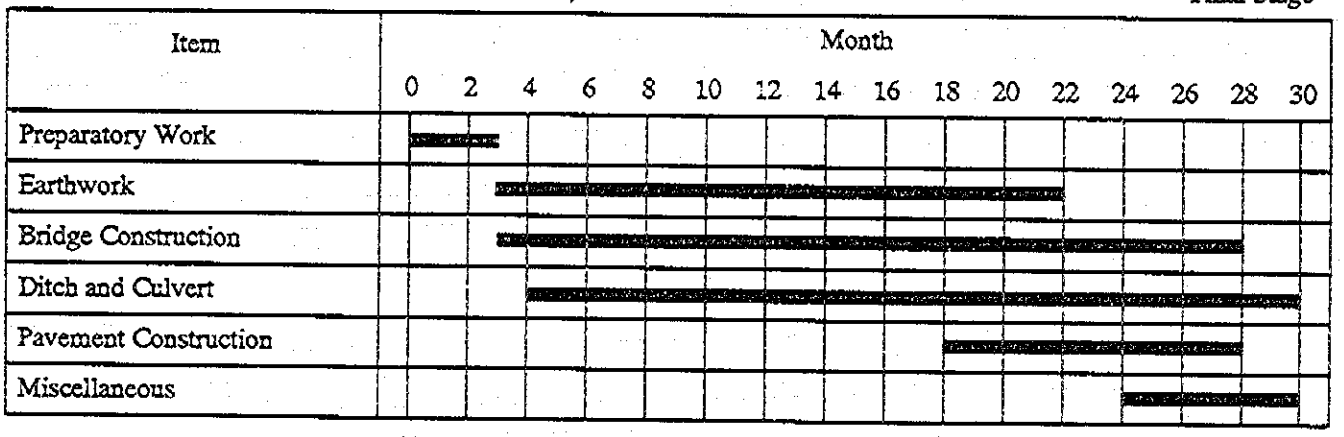


Section 4 (Cua Ong - Tien Yen : 43.5km) Final Stage



HIGHWAY NO. 18 IMPROVEMENT | Figure 11.1 (2) Construction Time Schedule

Section 5 (Tien Yen - Bac Luan : 86.9km) Final Stage



HIGHWAY NO. 18 IMPROVEMENT | Figure 11.1 (3) Construction Time Schedule

Section 1 : Noi Bai - Bac Ninh (Initial Stage)

Description	1997	1998	1999	2000
Detailed Design	90	10		
Land Acquisition/Resettlement	50	50		
Construction		10	50	40

Section 1 : Noi Bai - Bac Ninh (Final Stage)

Description	2009	2010	2011	2012
Detailed Design	90	10		
Construction		10	50	40

Section 2 : Bac Ninh - Chi Linh (Initial Stage)

Description	1997	1998	1999	2000
Detailed Design	90	10		
Land Acquisition/Resettlement	50	50		
Construction		10	50	40

Section 2 : Bac Ninh - Chi Linh (Final stage)

Description	2003	2004	2005	2006
Detailed Design	80	20		
Land Acquisition/Resettlement	50	50		
Construction		10	50	40

Section 3 : Hong Gai - Cua Ong (Final Stage)

Description	1997	1998	1999	2000
Detailed Design	90	10		
Land Acquisition/Resettlement	50	50		
Construction		10	50	40

HIGHWAY NO. 18 IMPROVEMENT

Figure 11.2 (1) Implementation Schedule

Section 4 : Cua Ong - Tien Yen (Initial stage)

Description	1997	1998	1999
Detailed Design	100		
Construction		40	60

Section 4 : Cua Ong - Tien Yen (Final Stage)

Description	2007	2008	2009
Detailed Design	100		
Land Acquisition/Resettlement	100		
Construction		40	60

Section 5 : Tien Yen - Bac Luan (Initial Stage)

Description	1997	1998	1999
Detailed Design	100		
Land Acquisition/Resettlement	100		
Construction		40	60

Section 5 : Tien Yen - Bac Luan (Final Stage)

Description	2006	2007	2008	2009
Detailed Design	90	10		
Land Acquisition/Resettlement	90	10		
Construction			50	40

HIGHWAY NO. 18 IMPROVEMENT	Figure 11.2(2) Implementation Schedule

Chapter 12

MANAGEMENT AND MAINTENANCE PLAN

CHAPTER 12 MANAGEMENT AND MAINTENANCE PLAN

12.1 General

The study of the management and maintenance for Highway No. 18 is broadly divided into four main categories:

a. Present Situation of Highway Maintenance and Management

- Present organization;
- Highway management and maintenance;
- Present work forces of RRMU No. 2

b. Basic Principles of Highway Maintenance

- Minimum interference with Traffic;
- Importance of correcting basic cause of failures;
- Categories of maintenance work.

c. Maintenance Inspections

- Pavement;
- Drainage;
- Cut and fill slopes; and
- Bridges

d. Management and Maintenance Plan

- Organization;
- Management systems; and
- Maintenance work.

12.2 Present Situation of Highway Maintenance and Management

12.2.1 Present Organization

Road administration exists within the jurisdiction of the Ministry of Transportation (MOT). MOT consists of 5 Vice Ministers, 7 Departments, 5 Bureaus and 4 Institutions, including the Vietnam Road Administration Bureau. Under the Government Decree No. 07, the Road Administration Bureau (RAB) was formed on 30 January 1993 and commenced operation on 26 May 1993.

The VRAB has four levels of administrative groups as shown in the following:

- Management section;
- Transport companies;
- Road management units.

The management is divided into 9 offices:

- Planning and Investment Section;
- Traffic Section;
- Financing and Accounting Section;
- Infrastructure Construction Section;
- Transport Section;
- Science, Technology and Technique Section;
- Personnel and Labor Management Section;
- Inspection Section;
- Administrative Office;
- Traffic Safety Section;
- Means of Transport & Driver Management Section;
- International Relations Group.

The comprehensive organization of the VRAB is shown in Figure 12.1 together with the number of employees for each group.

Transportation companies have taken charge of the previously state-owned property and assets of MOT, but salaries for the employees and operation costs of the companies have not been subsidized from the state budget since 1993.

Regional Road Management Unit No. 2 (Figure 12.1), is responsible for road management and maintenance of national highways in the northern part in Vietnam, and has the following divisions:

- 10 divisions of road management;
- Equipment and Materials Company;
- Materials Production Company;
- Mechanical Enterprise;
- Transport Rehabilitation Center No. 2.

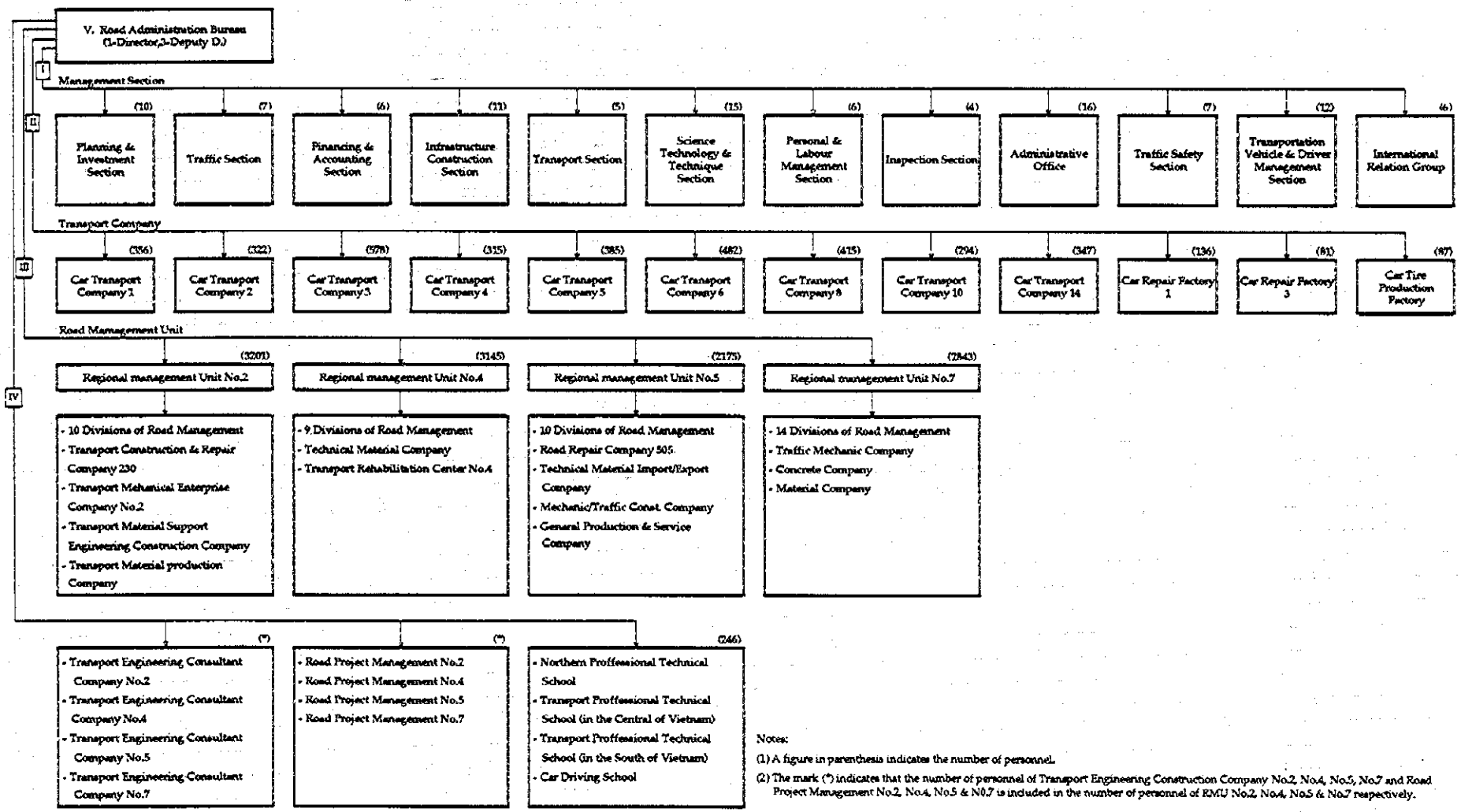


Figure 12.1 Organization Chart of Vietnam Road Administration Bureau (VRAB)

12.2.2 Highway Maintenance Management

RRMU No. 2 is located in Ha Noi and is at present mainly responsible for the maintenance of the following national highways:

National Road No.	Length (km)
1	285.0
2	289.0
3	33.5
4 E	46.0
5	94.0
6	379.0
15	20.0
70	190.0
183	24.0
279	116.0
Total	1,476.5 km

RRMU 2 presently is comprised of 10 Road Management Divisions and 4 autonomous enterprises as mentioned above. Road Management Divisions (RMD) are responsible for the routine maintenance of various lengths of national highway and receive an annual budget allocation from the MOT.

Many bridges have suffered from lack of maintenance and repair work. Severe defects include damaged bridge surfaces, concrete handrails and expansion joints. Most of the steel structures have not been painted to protect against corrosion for a long time. Steel bridge members are rusted and corroded. The RRMU 2 is not functioning properly in terms of bridge maintenance.

12.2.3 Present Work Forces of RRMU No. 2

(1) Organization

The organization of RRMU No. 2 is shown in Table 12.1.

Table 12.1 Organization of RRMU No. 2

Function	Organization units	Staff	No. of units	Note
RMU No. 2 Management Departments	1. Traffic Management Dept. 2. Planning Economic Dept. 3. Financial Accounting Dept. 4. Science and Technology Dept. 5. Personnel and Labor Dept. 6. Administrative Dept. 7. Traffic Safety Dept. 8. RMU No. 2 Engineering Center	70	8	

Function	Organizational Units	Staff	Section	Team	Length
Production	1. Transport Construction and Repair Company 230	283	4	4	-
Repair and Business	2. Transport Mechanical Enterprise No. 2	122	3	3	-
	3. Transport Material Support Engineering Construction Company	213	3	3	-
	4. Transport Material Production Company	457	5	4	-
Road Management Division (RMD)	1. Road Management Division (RMD) No. 222	241	4	7	173
	2. RMD No. 224	246	4	9	224
	3. RMD No. 226	257	4	5	136
	4. RMD No. 232	249	4	6	198
	5. RMD No. 234	387	4	4	20.6
	6. RMD No. 236	302	4	6	270
	7. RMD No. 238	137	4	5	148.5
	8. RMD No. 240	131	4	4	117
	9. RMD No. 242	300	4	5	210
	10. Management Division of Bridge and Ferry on Red River	180	4	4	6 standby ferries
Health Education Research	1. Transport Rehabilitation Center No. 2	41	2	3	

(2) Budget Allocations

In the case of RRMU No. 2, only routine maintenance budget has been allocated to RMD and the other budgets for medium and large scale maintenance/repair has been allocated mostly to the Transport Construction and Repair Company (refer to Table 12.2).

Table 12.2 Allocated Budget for Maintenance and Repair

Category of Maintenance/Repair	Allocated Budget (million Dong) 1994	1995
Routine Maintenance	12,886	16,136
Medium Scale Repair	23,712	24,484
Large Scale Repair	14,912	17,327

Notes 1) Routine Maintenance: Pavement, potholes, drainage, signs, lane markings, weeds
2) Medium Repair: Pavement overlay (2 cm ~ 4 cm), 163 km/year
3) Large Scale Repair: Pavement overlay (15 cm ~ 20 cm), 29 km/year

(3) Vehicles and Equipment Presently Possessed

1) Transport Construction and Repair Company

Transport construction and repair company possesses the following vehicles and equipment for road maintenance and repair (refer to Table 12.3).

Table 12.3 Vehicles and Equipment Possessed by Transport Construction and Repair Company

Type of Equipment	Amount
Concrete mixing pland	1
Heavy truck, 10 tons	10
Steel wheel roller	1
Tire roller	1
Macadam roller	3
Passenger Car	3

2) RMDs

RMDs suffer from lack of routine maintenance equipment. In most cases, available equipment consists only of a grader, pick-up truck, and roller.

12.3 Basic Principles of Highway Maintenance

(1) Purpose

The purpose of maintenance activity is to keep the roadway, surfaces, bridges and other installations in as usable and as safe a condition as situation permits. Certain basic principles and ideas can help to achieve this purpose.

(2) Minimum Interference with Traffic

In conformance with the idea of keeping surfaces usable, maintenance activities should interfere as little as possible with the normal flow of traffic at the facility.

When it does become necessary to close the facility to all traffic, alternate facilities, such as a detour route, should be selected, and all haste should be made to reopen the facility as soon as practicable.

(3) Importance of Correcting the Basic Cause of Failures

Any maintenance job should involve a investigation to find the cause of the particular damage or deterioration which is to be corrected. That cause must be remedied before the repair is made. To ignore the cause of the damage is to invite prompt reappearance of the damage. This is wasteful, and justifiable only when making temporary repairs to meet immediate minimum needs under urgent conditions.

(4) Categories of Maintenance Work

Categories of highway maintenance can be divided into routine maintenance, periodic maintenance and incidental maintenance.

Routine maintenance is based on routine (daily) inspection of the condition of pavement, cut and fill slopes, drainage, bridges and other structures and facilities to monitor any defects and damages to them. The results of routine inspection should be promptly reported to the maintenance office for follow-up maintenance works as required.

Periodic maintenance is based on detailed inspection to be performed at certain time intervals such as weekly, monthly or yearly depending on the type and kind of facilities, including checking and testing the condition of various structures and facilities. Defects and damages must be reported for repairs or remedies. Periodic maintenance also covers such works as maintenance of road marking and painting.

Incidental maintenance is basically the work to be carried out to restore the highway and the related facilities to their normal operating condition after they are damaged by road accident or natural causes.

12.4 Maintenance Inspections

12.4.1 Purpose

The purpose of maintenance inspections is to detect early evidences of defects before actual failure occurs. Frequent inspections and effective follow-up procedures prevent minor defects from becoming serious and casing major repair. Special vigilance must be exercised during rainy seasons, and after every heavy storm or flooding.

12.4.2 Pavement Inspections

Surface defects can usually be attributed to poor subgrade or base condition, inadequate drainage, or both. An inspection of surface defects should include a careful inspection and investigation of the causes of those surface defects. No surface repair is profitable unless the cause is first corrected. Another reason for surface defects is the excessive load or use to which a particular area may be subjected.

12.4.3 Drainage Inspections

Inspections of drainage systems should assure that all drainage channels and structures are unobstructed by debris of any sort. Culverts should be checked for structural damage. Checkdams should be inspected for debris and excessive erosion conditions. The reasons for water pounding on, or adjacent to, the surfaced areas should be determined. Drainage inspections should be made during or following every storm.

12.4.4 Cut and Fill Slopes Inspections

Due to the adverse soils and weather conditions prevailing in the area, the frequent inspections of cut and fill slopes are extremely important. At major landslide areas, sometimes observation using transit and other surveying equipment and tools will be necessary to identify the potential landslide at an early stage.

12.4.5 Bridges Inspections

Generally, bridge inspection is carried out in various categories, according to the situation and purpose.

(1) Routine Inspection

All bridges are included in the routine inspection, which is conducted in conjunction with the routine road inspection. This is for early discovery of any defects and is conducted as a solely visual inspection.

(2) Periodic Inspection

All bridges are included in the periodic inspection, which is conducted at regular intervals of time to ensure overall structural safety. This is chiefly a visual inspection but sometimes includes the use of simple tools or instruments.

(3) Emergency Inspection

An emergency inspection is necessary when any bridge experiences an earthquake, a heavy wind (typhoon), unusual flooding or other incident; or if such is predicted. When an emergency situation has been detected in the process of routine or periodic inspection, a special check-up is required to confirm the safety of the bridge in question.

12.5 Management and Maintenance Plan

12.5.1 System to Operate Highway Maintenance

(1) General

Basic principles of highway maintenance and the outline of maintenance inspections were discussed in Sections 12.3 and 12.4, including the categories of maintenance work (Paragraph 12.3 (4)).

The following describes i) Overall system of highway maintenance, ii) Maintenance operation system, iii) Equipment workshops, iv) Data base and management system, keeping in mind the present organization situation mentioned above in Section 12.2.

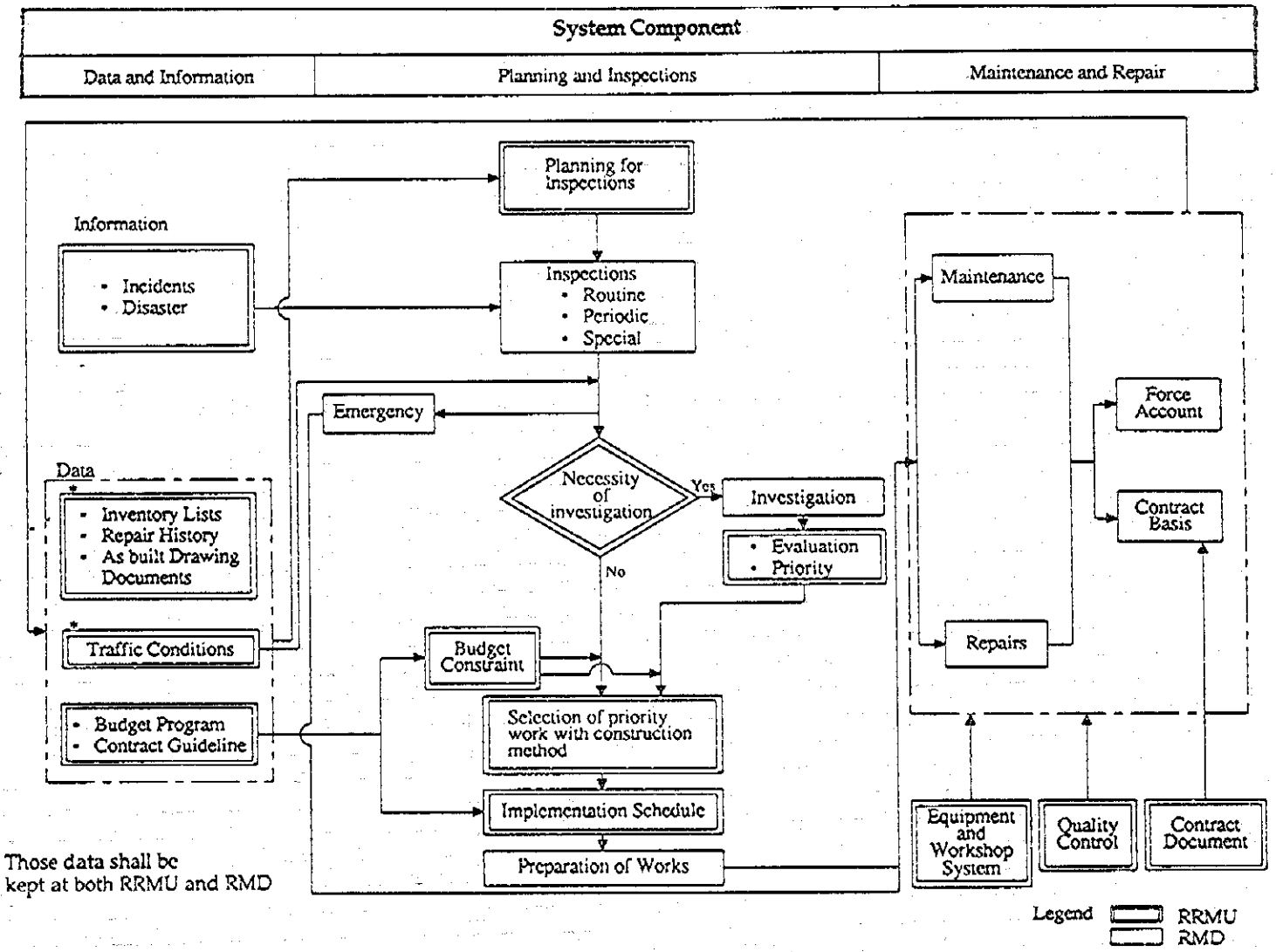
(2) Overall System of Highway Maintenance

In order to attain proper highway management and maintenance, all systems of highway maintenance have to be carried out orderly and in a proper manner, and established organization must be consistent with the requirement of work components and needed capacities. Figure 12.2 shows the general flow chart of the recommended overall highway maintenance works.

(3) Maintenance Operating System

Highway maintenance covers various activities related to inspections, maintenance and repairs, which require quick response and are appropriate to keep the highway open to traffic.

RRMU should be responsible for the following activities of highway maintenance by force account or on contract basis, depending on the nature of the work:



HIGHWAY NO. 18 IMPROVEMENT

Figure 12.2 Flow Chart of Highway Maintenance Works

a. Inspections by maintenance patrol unit;
b. Road surface cleaning;
c. Vegetation control;
d. Repairs of traffic safety and management facilities;
e. Pavement maintenance and repairs;
f. Maintenance and repair of bridges;
g. Maintenance and repair of other structures;
h. Disaster prevention and restoration; and
i. Others.

The following matters must be specified to implement the above operations:

- Communications system (instruction, response, duty, decision and coordination) between headquarters of RRMU and RMD; and
- Extent of activities and responsibility of each agency.

Due to budget constraint for RRMU staff and workers, maintenance on a contract basis should be gradually increased to cope with an increase of such work to promote technical advances of contractors and/or concession companies. The following should be considered to encourage the use of contractors to carry out highway maintenance activities :

- Maintenance activities based on a monthly and annual program;
- Clarification of working criteria of maintenance and repairs;
- Formulation of contracts, supervision and acceptance system for highway maintenance work;
- Establishment of a contract system between RRMU and private firms (including road repair companies) to rent RRMU's equipment;
- Provision of guidance to the contractors as to the significance of highway maintenance.

(4) Equipment and Workshops

1) Equipment

The types and number of maintenance equipment required at each RRMU and maintenance divisions (RMUs) are closely related to the intended service levels of the highway, the weather conditions, the types of major road structures (bridge, pavement type, etc.) and the traffic volume. Consideration whether the work will be done by force account or on a contract basis is also necessary for such determination.

2) Workshops and Depots

Workshops and depots will be located at each RRMU. However, they might be of small scale since major maintenance and repair work will be done by contractors under the supervision of RRMU.

(5) Data Base and Management System

Data base and management system is indispensable for highway maintenance. One of the most important activities is to collect reliable data, in particular, to collect and keep as-built drawings and documents including design reports and specifications, construction record, and historical repair records. These records must include inspector's observation of a non-routine incident, the related work carried out due to it, and the interference to traffic, particularly in relation to vehicular accidents and the causes of their occurrence. This function is to determine any previous incident that may relate to the present condition. Various inventories for road structures, bridges and road furnishings will be developed to maintain the highway properly.

12.5.2 Planning to Operate Highway Maintenance

Highway maintenance consists of many types of work for which the scope and scale are involved, but at the same time ambiguous. Therefore, it is important to prepare a detailed work plan for each category of work in advance so that the implementation of similar works can be carried out effectively. Since inspections, maintenance and repairs are performed on the highway open to public traffic, it is necessary that the coordination should be effectively handled between RMD and RRMU headquarters. It is also necessary that a notice should be forwarded to the police office in advance and that public announcement activities are made to highway users and residents along the highway.

12.5.3 Activities and Tasks of Highway Maintenance

The activities and tasks of the highway maintenance are shown in Figure 12.3. A brief description of each activity of highway maintenance is given in three (3) components; inspection, maintenance and repairs:

(1) Inspections

Inspections are performed to identify the needs of maintenance and repair works so that timely maintenance and repairs could be made and highways be free from traffic hindrance.

(2) Maintenance

Maintenance consists of the following activities :

1) Road Cleaning

Road cleaning involves removing dirt and trash from the road and adjacent facilities to eliminate traffic obstructions.

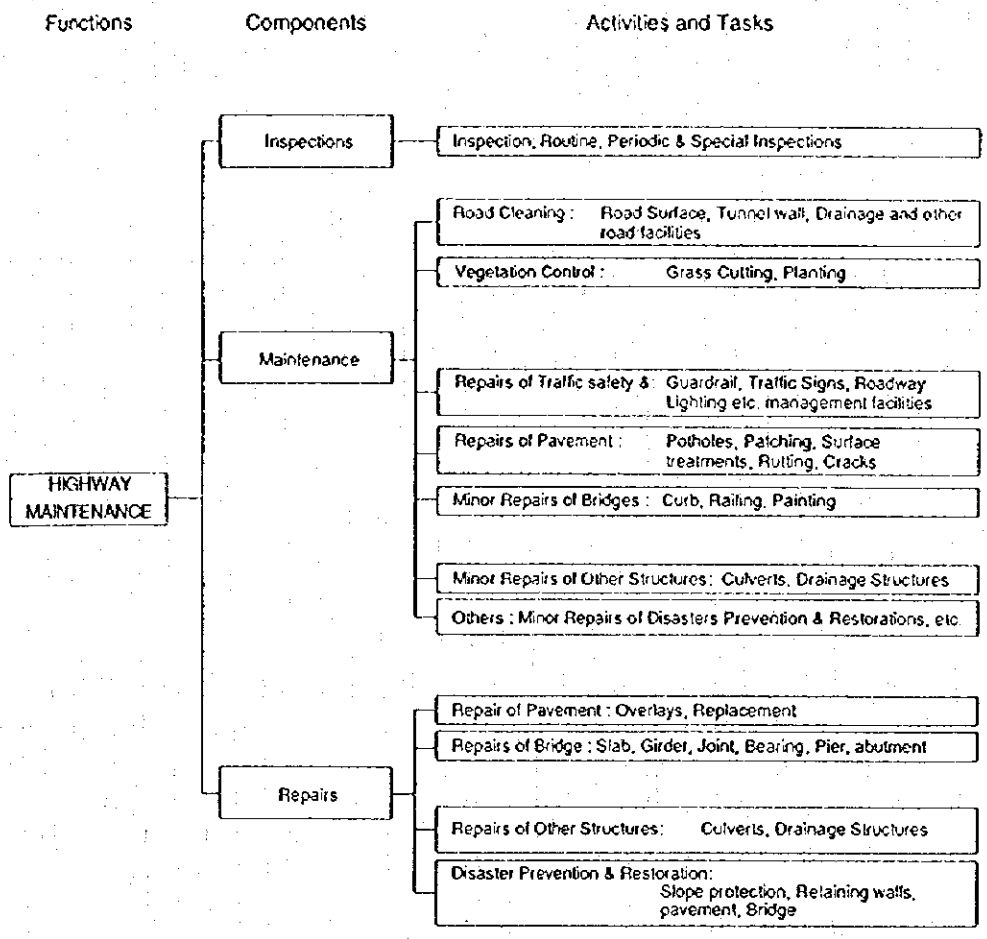


Figure 12.3 Activities and Tasks of Highway Maintenance

2) Vegetation Control

Vegetation control consists of planting new growth, maintaining established vegetation, and removing old or objectionable vegetation to the end that grass, plants and trees may be well maintained to provide a pleasing ambiance for users.

3) Repairs of Traffic Safety and Management Facilities

Traffic safety and management facilities are directly related to traffic safety and management. The following are the facilities to be maintained and repaired:

- Guardrail and guard post
- Traffic signs
- Roadway lighting
- Traffic markings
- Kilometer post

4) Minor Repairs of Pavement

Pavement maintenance consists of pothole repair, crack sealing and patching of small area of damaged pavement and adjustments of gaps on roadway surface.

5) Minor Repairs of Bridges

Minor repairs to bridges include curbs, railings, and necessary repainting.

6) Others (Maintenance)

- Maintenance of buildings, machinery, and electrical equipment as well as communication facilities is required to operate the highway maintenance activities in a proper manner.
- Small scale repairs of disaster prevention and restoration work.

(3) Repairs

1) Repairs of Pavement

Asphalt overlay or replacement will be required when identified severe cracking and rutting caused by heavy traffic and asphalt deterioration is identified. Overlay and replacement may entail the patching and pothole repairs. An evaluation method shall be established to determine the required thickness of overlay, based on a survey and analysis of the existing pavement roughness, cracking ratio and depth of rutting.

2) Repairs of Bridges

Repair of superstructures and substructures is needed due to the damage caused by heavy traffic, accidents, weathering, scouring, etc.

Replacement and strengthening of bridge slabs, expansion joints and bearings based on the identification and evaluation of causes and defects are also required due to the damage caused by heavy traffic, accidents, etc.

3) Repairs of Other Structures

Repair of special ditches and other drainage facilities will be needed to protect the road structures.

The repairs and restoration of slope failures in cut-and-fill sections are accomplished by execution of slope protection such as construction of retaining walls, concrete cribs, mortar spraying, anchorage, vegetation, etc.

4) Disaster Prevention & Restoration of Damages Caused by Disasters

Slope failures, and pavement and structure damages can be caused by heavy rainfall, earthquakes and boat collision (in the case of navigable

rivers). Slope failures are normally related to heavy rainfall, inadequate surface drainage, or water seepage. Work includes both prevention and restoration.

12.5.4 Maintenance Operations

(1) System for Operating Highway Maintenance

Basic plan for the system was discussed in Subsection 12.5.1. The system is also applicable to the 10 concerned maintenance divisions. Within the formulated system, the following matters are emphasized to achieve efficient and economic highway maintenance.

- The force account activities of the highway maintenance (medium repair) shall be reduced gradually in scope and volume, in consideration of the technical capability of contractors. However, RRMU must undertake information collection & dissemination as well as activities requiring quick response.
- A data-base and management system is the major component for planning any maintenance work, as it is the source of all historical knowledge concerning any road structure or facility. It is also important to collect as-built drawings and documents including engineering design documents.
- Training of inspectors is important to keep the optimum highway maintenance levels. The inspectors should be trained to be responsible for inspections, recording observations and preparing inspection reports in an efficient manner.

(2) Planning of Highway Maintenance

Provided herewith is a breakdown of the planning, implementation methods, inspections, maintenance and repairs.

1) Programming

Highway maintenance programs will be made on annual, monthly and weekly bases, considering job priority, available resources, past work records, road inventories, road structure inventories, traffic volumes, meteorological data, etc.

2) Annual Program

Annual program will be planned to allocate the scope and scale of monthly work. The following matters will be included based on the annual budget:

- Appropriate monthly activities for inspection, maintenance and repairs will be planned based on the characteristics of the work and

traffic conditions. The volume of work shall be allocated carefully so as not to concentrate on a certain period;

- Personnel, equipment and materials will be assigned properly.

- The programming will consider local meteorological conditions (temperature, rainfall, etc.);

- Maintenance and repairs of pavement will be undertaken before damage become serious. Cracks, potholes and corrugation should be repaired before the rainy season, since these worsen with rainfall;

- For the drainage system to function properly the cleaning and repairs of drainage facilities shall be conducted at an appropriate time.

3) Monthly Program

A monthly program will be planned to allocate daily maintenance and repairs. Changes to the programs can be made flexibly in case a particular repair work is judged to have a higher priority during the actual implementation of the plan.

A monthly program will be established based on the annual program, considering the following:

- Appropriate daily activities for inspection, maintenance and repairs will be assigned throughout the month.

- Appropriate traffic control will be arranged for the maintenance and repairs, considering the characteristics of the work, month, date and time-frame.

- Coordination with other jobs will be made to ensure smooth operation.

4) Weekly Program

Weekly program will be planned to allocate and adjust daily activities for inspections, maintenance and repairs. A weekly program will be made based on the monthly program, considering the following:

- Monthly activities will be broken down into weekly and daily activities;

- The amount of the previous weeklies work accomplishment will be checked and reflected in the following week;

- The accumulated amount of weekly work accomplishment in a month will be reviewed for updating the weekly program of the following month.

(3) Implementation of Highway Maintenance

1) General

Highway maintenance will be conducted, in careful consideration of traffic regulations, traffic safety and circumstances along the highway.

2) Safety During Maintenance and Repairs

Attention should be paid to the following items during maintenance and repairs:

- Personnel in charge of traffic control will be assigned on-site for the safety of workers and motorway users;
- Guide signs and traffic markings will be installed to clearly mark lanes restricted to highway users.
- Lighting facilities will be provided during night maintenance and repairs.
- Equipment, facilities and materials will be neatly located in the work area for efficient and safe work operations.
- Excavated and excess materials will be disposed of immediately so that the highway surface is always free from obstacles during the work activities.

Personnel in charge of traffic control will be assigned during the maintenance and repairs. They will ensure smooth and safe traffic flow and worker's safety.

(4) Traffic Control Measures

The date, time-frame, construction methods and proposed traffic control measures will be analyzed for the highway maintenance activities based on traffic volumes, number of traffic lanes and detours.

12.6 Recommendations

12.6.1 Organization

(1) Presently maintenance of Highway No. 18 is excluded from the national highways which RRMU No. 2. No is responsible. No appropriate division exists for Highway No. 18 and provincial department of people's committee has been undertaking maintenance.

It is recommended that a new RMD appropriate to the maintenance of the Highway No. 18 should be set up at an early date to enable the technical transfer and on-the-job training concerning highway maintenance through the execution of the Highway No. 18 improvement.

(2) The force account activities of highway maintenance (medium and large repair) will be reduced in scope and volume, in consideration of the technical capability of contractors. However, RMU must undertake information collection & dissemination, and activities requiring a quick response.

(3) A data-base and management system is the major component for planning any maintenance work as it is the record of all past experience concerning all road structures and facilities. It is also important to collect as-built drawings and documents including engineering design documents.

12.6.2 Required Vehicles and Equipment for Maintenance Operations

(1) Required Vehicles and Equipment

Maintenance and minor repairs will normally require the following vehicles and equipment (refer to Table 12.4).

Table 12.4 Required Vehicles and Equipment for Maintenance and Minor Repair

Highway maintenance	Vehicles and equipment required
1. Inspections	•Inspection car (land cruiser type) • Sedan
2. Road cleaning	•Truck •Sprinkler truck
3. Vegetation control	•Truck • Mower
4. Asphalt pavement and shoulders	•Grader •Kettle •Generator •Vibration roller •Loader •Compressor •Steel wheel roller •Truck •Pavement breaker •Asphalt distributor •Compactor
5. Bridge	•Truck with small crane •Truck • Welding machine
6. Cut slopes and disaster	•Bulldozer • Loader • Truck

(2) Number of Vehicles and Equipment

Table 12.5 shows the recommended type and number of vehicles and equipment for the routine maintenance and minor repairs of RMU No. 2 which has ten (10) road maintenance divisions.

Table 12.5 Vehicles and Equipment for RRMU No. 2

Vehicles and Equipment	Amount
1. Sedan	22
2. Inspection Vehicles (Land Cruiser Type)	12
3. Pick up Truck	10
4. Truck	20
5. Sprinkler Truck	5
6. Asphalt Distributor	5
7. Steel Wheel Roller	10
8. Loader	10
9. Tamper	20
10. Generator	2
11. Bulldozer	5

12.6.3 Training of Inspectors and Engineers

(1) Training of inspectors and engineers for the maintenance is important to keep optimum highway maintenance levels. The inspectors and engineers should be trained to be responsible for inspectors, recording observations, preparing inspection reports planning maintenance works and managing operations in an efficient manner.

(2) To upgrade management capability of PMU No. 18, efforts are required to develop expertise in budget planning and management, as well as in project planning and realization. To alleviate the present conditions, hiring of professionals and staff training will be necessary.

Chapter 13

PROJECT COST ESTIMATE

CHAPTER 13 PROJECT COST ESTIMATES

13.1 General

The estimate of the project cost was based on the results of preliminary engineering design, quantity take-off of each work item, and the studies on construction method and operation and maintenance of Highway No.18 as described in the preceding chapters.

The project cost discussed in this chapter consists of the following items.

- Initial Investment Cost
  - Construction;
  - Land Acquisition and Resettlement;
  - Engineering Services;
  - Supervision Services; and
  - Physical Contingency.
- Additional Investment Cost
  - Overlay.

The basic premises in estimating the project cost are as follows :

1) All the construction work will be executed by contractor(s) to be employed for the highway improvement.

2) The unit cost of each cost component was determined based on the economic conditions prevailing in January 1996 (USD $ 1.0 = 10,950 Dong).

3) Engineering services cost is assumed to be 4% of the construction cost and land acquisition and resettlement cost.

4) Supervisory service cost is assumed to be 6% of construction cost.

5) Physical contingency is estimated to be 10% of the total of construction cost, land acquisition and resettlement cost, engineering services cost and supervisory services cost.

The project cost is estimated in financial cost.

13.2 Construction Cost

13.2.1 Unit Cost of Construction Works

The unit cost of construction works are analyzed based on the labor cost, material costs, equipment cost, overhead and profit for chief work items. The analyzed unit cost are compared with current bid prices and adjusted as required to obtain the most realistic prices.

(1) Unit Cost of Labor

Table 13.1 shows the unit cost of labor applied in the construction cost estimate, which include such allowances as social benefits, insurance, etc. and are based on an eight-hour work day.

Table 13.1 Unit Cost of Labor

Classification	Unit Cost per Hour (Dong)
Senior Field Engineer	32,300
Junior Field Engineer	19,700
Foreman	22,700
Driver	10,800
Equipment Operator	14,700
Skilled Labor	21,000
Unskilled Labor	9,000

(2) Unit Cost of Materials

Table 13.2 shows the unit cost of major construction materials. The cost of imported materials is based on the CIF Hai Phong including port handling and clearance charges and import duties. The cost of local materials is based on the market prices in Ha Noi area.

Table 13.2 Unit Cost of Major Materials

Description	Unit	Unit Cost (Dong)	Tax/Duty Component (Dong)
Portland Cement	kg	900	90
Asphalt	ton	2,400,000	240,000
Reinforcing Steel	ton	3,5000,000	350,000
Prestressing Strand	kg	26,700	2,670
Gasoline	liter	3,300	330
Diesel	liter	2,800	280
Fine Aggregate	cu.m	54,000	5,400
Coarse Aggregate	cu.m	70,200	7,020
Timber	cu.m	2,100,000	210,000

(3) Unit Cost of Equipment

Table 13.3 shows the unit cost of major construction equipment. The costs of imported equipment are based on the CIF Hai Phong including port handling and clearance charges and import duties.

Table 13.3 Unit Cost of Major Equipment

Equipment	Capacity	Unit Cost (Million Dong)	Import Duty (Million Dong)
Dump truck	8 ton	968	88
Dump truck	10 ton	1,441	131
Truck crane	8 ton	1,320	120
Crawled crane	20 ton	4,818	438
Concrete pump truck	80m3/hr	3,619	329
Transit mixer	6m3	1,441	131
Back hoe	1.2m3	2,409	219
Motor grader	3.6m	1,804	164
Macadam road roller	10 ton	1,441	131
Asphalt finisher	3.5m	5,423	493
Asphalt mixing plant	40 t/hr	8,437	767
Concrete mixing plant	30m3/hr	4,213	383
Floating crane	60 ton	18,040	1,640

(4) Overhead and Profit

Overhead and profit were estimated as 25% of the sum of labor, material and equipment costs (i.e., direct cost).

(5) Unit Cost for Major Construction Work Items

Table 13.4 shows unit cost for major construction work items based on the unit cost mentioned above.

Table 13.4 Unit Cost for Major Construction Work Items

Item	Unit	Unit Cost (Dong)
1. Earthwork		
Soil Excavation	cu.m	18,000
Embankment (Borrow Material)	cu.m	60,000
2. Pavement		
Aggregate Subbase Course	cu.m	100,000
Asphalt Treated Base Course	cu.m	750,000
Asphalt Concrete Surface (t = 10 cm)	sq.m	110,000
Overlay (t = 10 cm)	sq.m	130,000
3. Drainage Structures		
Pipe Culvert (D = 1.0 m)	l.m	1,200,000
Box Culvert (3.0 x 3.0)	l.m	10,300,000
4. Bridges		
RC Slab Bridge (L < 10 m)	sq.m	6,000,000
RC Slab Bridge (with Piling)	sq.m	8,000,000
RC T-Beam Bridge (10 m < L < 20 m)	sq.m	8,000,000
RC T-Beam Bridge (with Piling)	sq.m	10,000,000
PCI-Beam Bridge (20 m < L)	sq.m	11,000,000
PCI-Beam Bridge (with Piling)	sq.m	13,000,000

13.2.2 Estimated Construction Cost

The summary of estimated construction cost by each construction section and by each construction stage is shown in Table 13.5.

Table 13.5 Summary of Estimated Construction Cost in 1996 Prices

Section No.	Section	Initial Stage (Million Dong)	Final Stage (Million Dong)
1	Noi Bai - Bac Ninh	517,789	488,516
2	Bac Ninh - Chi Linh	432,063	-
3	Hong Gai - Cua Ong	610,797	-
4	Cua Ong - Tien Yen	51,212	173,619
5	Tien Yen - Bac Luan	122,144	363,352

See Appendices 13.1 and 13.2 for the breakdowns of estimated construction cost and estimated land acquisition and resettlement cost respectively.

13.3 Land Acquisition and Resettlement Cost

Land acquisition and resettlement cost is estimated based on the area of required land acquisition estimated in the preliminary engineering design and the estimated number of resettled families in the environmental study.

Unit costs are estimated in accordance with the following criteria :

a) Unit costs of land acquisition are decided based on the "Regulating Price Frame of Various Kinds of Land", Decrees No.87/CP, August 17, 1994.

b) Resettlement costs are estimated based on discussion with PMU 18 and houses up to 7.0m from the toe of embankment or upper edge of cut were counted.

c) Compensation cost for production is based on the following criteria :

2kg paddy/sq.m/year x 1,800 dong/kg x 2 years = 7,200 dong/sq.m

d) Other compensation (cost for preparing new house lots, paying 3 months subsistence allowance, relocating house materials to new site, providing training for one person of each household) is estimated as follows :

(Number of households) x 6,000,000 dong/each

Unit costs of land acquisition and resettlement are shown in Table 13.6, and the summary of estimated land acquisition and resettlement cost by each section

and by each improvement stage is shown in Table 13.7. Refer to Appendix 13.2 for the breakdown of estimated land acquisition and resettlement cost.

Table 13.6 Unit Costs for Land Acquisition and Resettlement

	Description	Unit	Unit Cost (Dong)
(1)	Land Acquisition/Compensation		
	Inhabited Land along Existing Road	sq.m	150,000
	Inhabited Land in Rural Area	sq.m	19,400
	Rice Field/Cultivated Area	sq.m	12,100
	Forest Area	sq.m	8,920
(2)	Crop Compensation		
	Rice	sq.m	7,200
(3)	Resettlement/Compensation		
	Permanent House	sq.m	1,300,000
	Temporary House	sq.m	400,000
(4)	Other Compensation		
	Cost Relevant to Relocating House	nos.	6,000,000

13.4 Estimated Project Cost

13.4.1 Estimated Project Cost in the Initial and Final Improvement Stages

The summary of project cost in 1996 prices is shown in Table 13.8 together with foreign and local currencies of financial cost shown in Table 13.9. The project cost is expressed in terms of financial cost and is divided into the investment cost in initial and final stages by each highway improvement section.

13.4.2 Additional Investment Cost

Table 13.10 shows summary of additional investment cost of each section. The additional investment costs are the cost of pavement overlay which is to take place every 6 years after the completion of construction.

Table 13.7 Summary of Estimated Land Acquisition and Resettlement Cost (Cost in Million Dong)

Section 1: Noi Bai - Bac Ninh

Description	Initial Stage
(1) Land Acquistion/Compensation	23,880
(2) Crop Compensation	8,322
(3) House Resettlement/Compensation	870
(4) Other Compensation	18
Total	33,090

Section 2: Bac Ninh - Chi Linh

Description	Initial Stage	Final Stage
(1) Land Acquistion/Compensation	3,060	20,293
(2) Crop Compensation	321	1,731
(3) House Resettlement/Compensation	3,980	3,729
(4) Other Compensation	192	240
Total	7,553	25,993

Section 3: Hong Gai - Cua Ong

Description	Initial Stage
(1) Land Acquistion/Compensation	36,180
(2) Crop Compensation	325
(3) House Resettlement/Compensation	46,047
(4) Other Compensation	2,208
Total	84,760

Section 4: Cua Ong - Tien Yen

Description	Final Stage
(1) Land Acquistion/Compensation	2,384
(2) Crop Compensation	220
(3) House Resettlement/Compensation	5,709
(4) Other Compensation	0
Total	8,313

Section 5: Tien Yen -Bac Luan

Description	Initial Stage	Final Stage
(1) Land Acquistion/Compensation	1,161	6,529
(2) Crop Compensation	397	1,442
(3) House Resettlement/Compensation	1,103	3,276
(4) Other Compensation	90	264
Total	2,751	11,511

Table 13.8 (1) Summary of Project Costs in 1996 Prices

Section 1 : Noi Bai - Bac Ninh (Initial Stage)

Description	Financial Cost (Million Dong)
(1) Construction	517,789
(2) Land Acquisition and Resettlement	33,090
(3) Engineering Services	22,035
(4) Supervision Services	31,067
(5) Physical Contingency (10%)	60,398
Total	664,379

Section 1 : Noi Bai - Bac Ninh (Final Stage)

Description	Financial Cost (Million Dong)
(1) Construction	488,516
(2) Land Acquisition and Resettlement	0
(3) Engineering Services	19,541
(4) Supervision Services	29,311
(5) Physical Contingency (10%)	53,737
Total	591,105

Section 2 : Bac Ninh - Chi Linh (Initial Stage)

Description	Financial Cost (Million Dong)
(1) Construction	432,063
(2) Land Acquisition and Resettlement	7,553
(3) Engineering Services	17,585
(4) Supervision Services	25,924
(5) Physical Contingency (10%)	48,313
Total	531,438

Table 13.8 (2) Summary of Project Costs in 1996 Prices

Section 2 : Bac Ninh - Chi Linh (Final Stage)

Description	Financial Cost (Million Dong)
(1) Construction	415,923
(2) Land Acquisition and Resettlement	25,993
(3) Engineering Services	17,677
(4) Supervision Services	24,955
(5) Physical Contingency (10%)	48,455
Total	533,003

Section 3 : Hong Gai - Cua Ong (Initial Stage)

Description	Financial Cost (Million Dong)
(1) Construction	610,797
(2) Land Acquisition and Resettlement	84,760
(3) Engineering Services	27,822
(4) Supervision Services	36,648
(5) Physical Contingency (10%)	76,003
Total	836,030

Section 4 : Cua Ong - Tien Yen (Initial Stage)

Description	Financial Cost (Million Dong)
(1) Construction	51,212
(2) Land Acquisition and Resettlement	0
(3) Engineering Services	2,048
(4) Supervision Services	3,073
(5) Physical Contingency (10%)	5,633
	61,966

Table 13.8 (3) Summary of Project Costs in 1996 Prices

Section 4 : Cua Ong - Tien Yen (Final Stage)

Description	Financial Cost (Million Dong)
(1) Construction	173,619
(2) Land Acquisition and Resettlement	8,313
(3) Engineering Services	7,277
(4) Supervision Services	10,417
(5) Physical Contingency (10%)	19,963
	219,589

Section 5 : Tien Yen - Bac Luan (Initial Stage)

Description	Financial Cost (Million Dong)
(1) Construction	122,144
(2) Land Acquisition and Resettlement	2,751
(3) Engineering Services	4,996
(4) Supervision services	7,329
(5) Physical Contingency (10%)	13,722
Total	150,942

Section 5 : Tien Yen - Bac Luan (Final Stage)

Description	Financial Cost (Million Dong)
(1) Construction	363,352
(2) Land Acquisition and Resettlement	11,511
(3) Engineering Services	14,995
(4) Supervision Services	21,801
(5) Physical Contingency (10%)	41,166
Total	452,825

Table 13.9 Summary of Project Costs of Foreign and Local Currency in 1996 Prices

(Unit : Million Dong)

		Financial Cost			
		Total	Foreign Currency	Local Currency	
Section 1 : Noi Bai - Bac Ninh	Initial Stage	664,379	382,629	281,750	(75,338)
	Final Stage	591,105	360,037	231,068	(70,993)
Section 2 : Bac Ninh - Chi Linh	Initial Stage	531,438	318,664	212,774	(62,776)
Section 3 : Hong Gai - Cua Ong	Ininal Stage	836,030	452,768	383,262	(89,135)
Section 4 : Cua Ong - Tien Yen	Initial Stage	61,966	37,743	24,223	(7,436)
	Final Stage	219,589	128,213	91,376	(25,253)
Section 5 : Tien Yen - Bac Luan	Initial Stage	150,942	90,105	60,837	(17,750)
	Final Stage	452,825	268,145	184,680	(52,820)

Note : ( ) Tax amount included in Local Currency.

Table 13.10 Summary of Additional Investment Cost

Description	Assumed Year of Construction	Financial Cost (Million Dong)
(1) Section 1		
Overlay for 2-Lane	2006	16,608
	2012	16,608
Overlay for 4-Lane	2018	33,261
(2) Section 2		
Overlay for 2-Lane	2006	17,109
Overlay for 4-Lane	2012	31,081
	2018	31,081
(3) Section 3		
Overlay for 4-lane	2006	33,302
	2012	33,302
	2018	33,302
(4) Section 4		
Overlay for Existing Road	2005	9,667
Overlay for 2-Lane	2015	17,468
(5) Section 5		
Overlay for 2-Lane (B.P.)	2005	3,184
	2011	3,184
Overlay for 2-Lane	2015	29,108
Overlay for 2-Lane (B.P.)	2017	3,184

Chapter 14

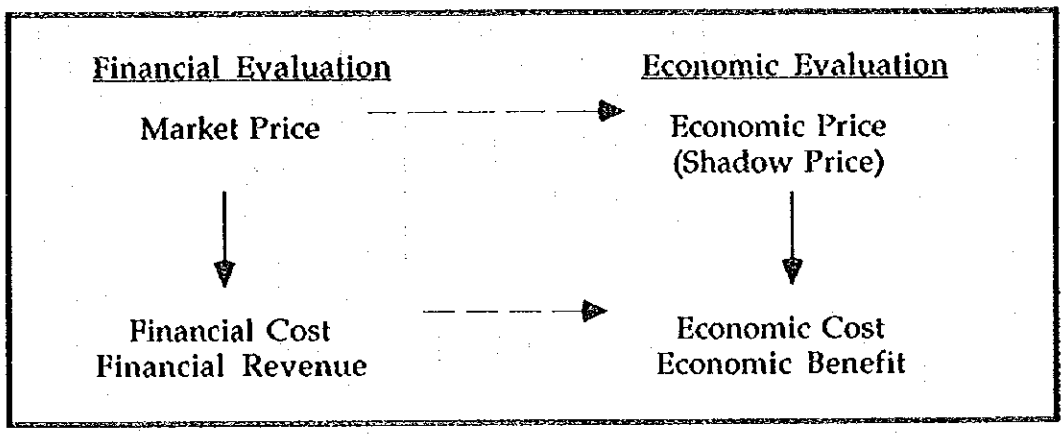
ECONOMIC PROJECT ANALYSIS

14 ECONOMIC PROJECT ANALYSIS

14.1 Estimation of Economic Project Cost

The costs estimated in Chapter 13 are based on the market prices. Here these will be corrected to the economic price (shadow price) in order to compare costs and benefits.

Structure of Project Evaluation



Economic costs were calculated by correcting distorted prices. (Refer to Table 14.1). Thus the current actual value of resources is expressed for imported materials, domestic materials, labors and right-of-way. This makes possible comparisons for optimum use of domestic resources.

Table 14.1 Items to be Corrected to Economic Price from Market Price

Resources	Market Price Distortion	Correction to Economic Price
1. Cost not related to project	Miscellaneous cost not related to project consumption such as taxes and subsidies	To be deleted because not related to competitive market economic activities
2. Foreign materials	Official foreign exchange rate and tariffs are distorted	To use international price in US$ determined by international competitive market
3. Domestic materials	Price is distorted by regional difference, monopoly and partial competition	To remove influence of tax imposed on exports, to make price closer to international free competitive market.
4. Laborers	Wage is distorted by minimum wage, the unemployed, and labor union.	To apply shadow wage rate to unskilled laborers to bring the wage closer to real value of workers.
5. Right-of-Way	Land price and ground rent distorted by speculation and policies.	To calculate marginal productivity in order to bring the price closer to free competition.
6. Capital market	Unsuitability of interest rate and financing for enterprise with good conditions limits selection of optimum capital investment.	To allocate optimum investment rescues by capital opportunity cost.

(1) Elimination of Cost of Unrelated Items of the Project

Taxes, construction fund interest, and subsidies, etc., are not direct costs (not direct consumption of resources): they simply represent money transfers and thus are eliminated from cost and benefit.

Vietnam's economic renovation program, which covers all the major sectors of the economy, began in 1989 and was accelerated in 1989. In December 1989, it was decided by Congress to implement import and export tax, real estate tax, special sales tax, individual income tax and others. Since then some additional taxes have been added. Tax rate differs depending on construction material and construction-related transactions.

Amount to be Deducted from Financial Cost as Tax

12 % of maintenance cost and of construction cost
12 % of engineering cost
12 % of supervision cost

The 10 % figure is based on recent data provided by MOT from the tender document for Highway No. 5, and on the recent estimate from the World Bank's appraisal report of highway rehabilitation report.

(2) Economic Cost of Foreign Costs

Foreign fund of construction cost in Chapter 13 is converted to dong at 1 US$ = 10,950 dong. At construction cost estimation of the project, domestic and foreign ratio is estimated at 40 : 60. The real price of dong is calculated in Table 14.2. There is not much deference between the actual exchange rate and the shadow price.

Table 14.2 Correction Index of Economic Price of Foreign Materials

(million dong)

Items	1990	1991	1992	1993	1994
(1). Total Import	2,752.4	2,338.1	2,540.7	3,924.0	5,000.0
(2). Total Export	2,404.0	2,087.1	2,580.7	2,985.2	3,600.0
(3). Total Import Tax	81.8	67.3	175.2	-	-
(4). Total Export Tax	39.7	48.3	170.4	-	-
(5). Export Subsidies					
(6). (1) + (2)	5,156.4	4,425.2	5,121.4	6,909.2	8,600.0
(7). (6) + (3) - (4) + (5)	5,198.5	4,444.2	5,126.2	-	-
(8). (6) + (7)	0.992	0.996	0.998	-	-
(9). Foreign Exchange Rate (dong)	5,018	9,080	11,209	10,950	10,950

(Source : Statistical Year Book 1994 by Statistical Publishing House)

Foreign funds are expressed in domestic currency

Shadow Exchange Rate
10,950 Dong x 1 / 0.998 = 11.060 Dong

(3) Economic Cost of Domestic Materials

In order to express values of domestic materials in currency, they are corrected into shadow price which is determined by the international free market. In this study, however, local materials are considered as economic cost after tax is exempted. Shadow price of domestic materials will be covered by the difference of plus and minus of the sensitivity cost.

$$\text{Market price} = \frac{\text{Price of domestic materials}}{\text{Transfer Items}} = \text{Economic Price}$$

(4) Economic Cost of Laborers

Labor cost consist of two factors: (a) unskilled labor cost for the project (8 % of construction cost in this study), and (b) skilled labor cost of engineering services (4% of construction cost).

In this study, as adopted in an ordinary feasibility study, shadow price is not applied to costs of foreign engineers or domestic engineers, as their fees will be determined by competitive market.

Economic Cost of Engineers
Value of Engineers = Free Market Competitive price = Economic Price

Usually, as these unemployed people come from agriculture regions, the opportunity cost of unskilled labor is considered equal to per capita income of agricultural sector.

Income Per Capita in Agricultural Sector

Labor force (population)	29,998,000
Income	30,333,000 Million Dong
Per Capita Income	580,000 Dong

This is approximately equal to 0.25 % of the ordinary wage.

Shadow Wage of Unskilled Labor
Labor Cost x 0.25 = Economic Cost

(5) Economic Cost of Right-of-Way Cost

In principle, the economic cost of right-of-way is calculated by productivity of right-of-way. For example, in the case that rice production was stopped for road construction, the cost is calculated as an added value of the production of a rice field. In the case of using public land, there will be no acquisition involved, but the economic cost is calculated at estimated value of productivity of the land for economic project analysis.

Table 14.3 Cost of Right-of-Way and Percentage Occupied in Construction Cost

(Million Dong)

Section	Construction Stage	Land Acquisition Cost	%
Section 1	Initial stage	33,090	5.0 %
	Final stage	0	
Section 2	Initial stage	7,553	1.4 %
	Final stage	25,992	4.8 %
Section 3	Initial Stage	84,760	10.1 %
Section 4	Final stage	8,313	3.8 %
Section 5	Initial stage	2,751	1.8 %
	Final stage	11,259	2.5 %

Land acquisition cost is compensated at resettlement cost which is equal to the land productivity. This study, therefore calculated as follows:

Land Acquisition Cost of Market Price = Resettlement Cost = Economic Cost

(6) Estimation of Total Economic Cost of the Project

Table 14.4 shows economic cost corrected from project capital cost at market price. In the next subsection, benefit - cost comparison analysis is used to find this economic cost. Annual allocation of costs will be calculated according to construction plan in Chapter 10.

Table 14.4 Financial and Economic Cost

(Unit : Million Dong)

Section	Initial Stage		Final Stage	
	Financial Cost	Economic Cost	Financial Cost	Economic Cost
Section 1: 2 + 2 lanes	664,379	554,082	591,105	487,210
Section 2: 2 + 2 lanes	531,438	439,509	533,003	444,408
2 lanes	531,438	439,509	-	-
Section 3: 4 lanes	836,030	705,676	-	-
Section 4: Overlay + 2 lanes	61,966	51,075	219,589	182,620
Section 5: Overlay + 2 lanes	150,942	124,950	452,825	375,488

14.2 Estimation of Economic Benefit

14.2.1 Road Users and Road Benefits

(1) Effects of Constructing Project Road

Table 14.5 Effects by Constructing Project Road

1.	The project increases work for construction companies, construction material companies and truck transport companies.---**Positive effect**
2.	Driving time and cost will decrease.---**Direct user effect**
3.	Traffic accidents and casualties will decrease.---**Prevention of loss**
4.	Decrease of road maintenance cost; abandonment of ferry crossing.---**Saving of capital**
5.	Driving will be more comfortable.---**Increase of Comfort**
6.	Rice production, mining exploitation and tourism development will be enhanced.---**Development effect**
7.	Increase of employment, improvement of social level of life, enhancement of equitable income distribution, and increase of foreign currency.---**Social and economic effect**
8.	Decrease of rice production by the use of land for roads.---**Negative economic effect on production**
9.	Increase of air pollution and vibration due to increased traffic.---**Negative environmental effect from pollution**

1) The positive effect is indirect. Indirect effect is not estimated due to lack of input - output table.

2) The direct users' effects constitutes the greater part of benefits analysis of the present study.

3) Prevention of loss is measurable. However the amount is so small that it was not included in the calculation.

4) As for saving of capital cost, the road maintenance cost is so small that it was not included here. Only the capital saving of Pha Lai ferry is accounted in project section 2.

5) Driving comfort is not calculated.

6) As for effects from development, increase from development-related traffic volume is included in the calculation.

7) Social and economic effects are considered in sensitivity analysis.

8) Negative effects on production are taken into account as land cost in benefit cost analysis.

9) Negative effects from road environmental pollution are calculated in cost estimation for installing cost of noise pollution prevention facilities.

(2) Beneficiaries and Types of Benefits of Highway Project

Accordingly, measurable effects of the road project are called "benefits" hereafter. Measurable benefits will be calculated according to (1) the beneficiaries, and (2) benefit units. The relationship between (1) and (2) is as the Table 14.6.

Table 14.6 Types of Benefits of Highway No. 18 Project

1. Normal Traffic :	
Without project	Slow running speed, High running cost
With project	High running speed, Lower running cost
Types of Benefits	Saving in driving time and cost
2. Diverted Traffic :	
Without project	Use of other road, of railroad, or ship
With project	Less distance, faster, less cost
Types of Benefit	Difference of saving compared with detour route Difference of saving compared with railroad and ship
3. Generated and Induced Traffic :	
Without project	Bicycles and pedestrians, could not use the road
With project	New potential users of road
Types of Benefit	Additional half of the normal traffic benefit
4. Development Related Traffic :	
Without project	Resources remain undeveloped
With Project	Production and development realizable
Type of benefits	Development benefits
5. Ferry boat user:	
Without project	Not time-economic
With project	Time-economic
Type of benefits	Saving of ferry boat cost

1) The benefits to normal traffic in regards to running time and cost saving are explained more fully in following passages on vehicle unit cost estimation.

2) Out of diverted traffic benefits, the saving benefit of detouring is calculated in benefits costs analysis of section 1, Noi Bai - Bac Ninh and section 2, Bac Ninh - Chi Linh. Saving benefits from railroad and ship is included in the OD (Origin Destination) traffic volume estimate among 33 zones of normal traffic, in "Transport Modeling and Demand Forecasts" of Chapter 5.

3) Generated and induced traffic benefits are calculated as a half of the normal traffic benefits in section 3, Hong Gai - Cua Ong, section 4, Cua Ong - Tien Yen, section 5, Tien Yen - Bac Luan,

4) Benefit of development-related traffic is calculated including estimation of origin/destination volume of normal traffic among 33 zones.

5) Saving benefits of ferry are calculated for Pha Lai ferry in section 2.

14.2.2 Passenger Time Cost Saving

Improvement of the project road will enhance driving speed, and save time for passengers of all vehicles. When saved time is used productively, it can be considered as a benefit brought about by the project.

(1) Annual income per passenger

Time value differs according to income of passengers. Passenger time value is a function of the wage rate. Thus, annual income per worker is calculated as 1,290,446 dong by dividing the wage per passenger of the study area by number of workers.

Table 14.7 GDP per Worker of the Study Area

Items	GDP and Worker
GDP of the Study Area 1994	5,197,000 Million Dong
GDP Growth Rate 1994 - 1995	10.93%
GDP in the Study Area 1995	5,765,032 Million Dong
Population of the Study Area 1995	9,927,714
Percentage of Workers	45%
Number of Workers 4,467,471	4,467,471
GDP per worker of the study area	1,290,446 Dong

Source : Chapter 4 of this report

(2) Time Value Based Upon Annual Income per Passenger

Time value of car and bus passengers was calculated separately according to their differing incomes. Based upon the "Statistical Data on Labor and Social Affairs 1994", the average income of the wealthier classes who are car users amounts to 4.53 times more than the average income (Appendix A - 14.1). Thus this class of people is considered as car passengers.

Average income of motorcycle users is considered in between car passengers and bus passengers. Accordingly the time value of income per hour for annual working hours of 1,800 is as in Table 14.8.

Table 14.8 Time Value Based on Income

Items	Income/Year	Time Value/Hour
Income level of car passenger	5,845,722 Dong	3,248 Dong
Income level of bus passenger	1,290,446 Dong	717 Dong
Income level of motor cycle passenger	3,568,084 Dong	1,982 Dong

(3) Time Value of Trips by Type of Vehicles

The time value of trips ought to be deferent from time value of working hours. Time value of trips is estimated in accordance with trip purpose. In general, business trips are normally valued 100 % of wage rate for all vehicles while other bus trips are valued at 60 % in this study.

Table 14.9 Value Composition of Trip Time

	Trip Purpose			Value Composition Ratio of Trips			
	Work	Non-leisure	Leisure	Work	Non leisure	Leisure	Total
Passenger car	35 %	50 %	15 %	35 %	50 %	0 %	85 %
Bus	15 %	65 %	20 %	15 %	39 %	0 %	54 %
Motorcycle	35 %	50 %	15 %	35 %	50 %	0 %	85 %

Drivers of passenger cars and motorcycles are considered as passengers. In the case of bus drivers, they are excluded from passengers as they are included in vehicle operating costs as crew cost under restriction. Trip time value based on income and trip purpose is calculated.

Table 14.10 Time Value of Trips by Vehicle Types

Vehicle	No. of passengers	/hour	/minute
Passenger car	2.80	7,730 Dong	128.8 Dong
Bus	29.30	11,344 Dong	189.1 Dong
Motorcycle	1.06	1,685 Dong	28.1 Dong

Time value is assumed to be the same throughout the project life. The future growth rate of GDP is a factor of traffic increase.

14.2.3 Vehicle Operating Cost Saving Benefit

14.2.3.1 Introduction

(1) Types of Benefits Resulting from Savings in Vehicle Operating Cost

There are ten types of vehicle operating cost (V.O.C) benefits (Refer to Table 14.11). V.O.C for project benefit calculation can be divided into two main groups; fixed and variable. Running cost is complied into the unit cost per travel distance (1 km), which fixed cost into the cost per running hour. The

fixed cost does not vary according to the travel distance and speed, in short, this can be called a kind of "Property Possession Fee".

Table 14.11 Types of Benefits of V.O.C Saving

Variable costs saving (Running costs)	(1)	Fuel cost saving benefit
	(2)	Lubricant oil cost saving benefit
	(3)	Tyres cost saving benefit
	(4)	Maintenance (spare parts) cost saving benefit
	(5)	Maintenance (labor) cost saving benefit
	(6)	Depreciation (distance related) cost saving benefit
Fixed costs saving	(7)	Depreciation (time related) cost saving benefit
	(8)	Interest cost saving benefit
	(9)	Crew cost saving benefit
	(10)	Overhead cost saving benefit

(2) Selection of Typical Vehicle

The grounds for V.O.C. computation can be divided into two categories: factors which are unique to the locality (in this case, Vietnam), and factors which are universal. Factors of the former group include: available vehicle types, fuel, tires, parts and their respective prices, as well as personnel expenses. Factors of the latter group include: car longevity, amount of kilometers driven, car mileage, and number of wheels per vehicle. The most important factor of the first group is vehicle type and cost, which dictate running expense to a large degree.

There are different kinds of cars : imported cars, cars of local production and assembly, cars produced by different manufacturers, cars of various models, new cars, etc. The prices, of course, are also varied, as does vehicle operating cost.

The fourteen (14) types of vehicles used as the basic data for the study area are in accordance with vehicle, registration classification and classification ratio and with Registration Tax Department classification (See Appendix A-14.2)

Seven (7) types of vehicles were selected for the basic data for base speed, which is considered to represent V.O.C. Therefore V.O.C of medium-size trucks represent trucks under 1 ton, trucks of 1 - 3 tons, and those of 3 - 5 tons (See Appendix A - 14.2).

Types of vehicles presently prevalent in Vietnam were mostly manufactured in the former Soviet Union: UAZ automobiles, Xarosa buses, ZIL 130 medium-size trucks, Kamaz large-size trucks. Motorcycles mostly consist of Honda and other Japanese makers, while at present all types of vehicles of European or Japanese origin are on the increase.

A hearing was conducted with Ha Noi dealers, but due to the high number of vehicle types, widely varying prices, and differing importers, appropriate data

was unobtainable, so vehicle types and prices as registered by the Ha Noi Vehicle Taxation Department were adopted. This registration class is revised every two years and can be considered as representing the correct financial cost as it is the foundation of automobile taxation.

Four (4) types of vehicles used for V.O.C estimation of different speeds are based upon actual traffic composition of the field study of the area.
Particularly motorcycles are common in the area. Accordingly V.O.C calculation was undertaken for motorcycle separately.

Table 14.12 Selection of Typical Vehicle for V.O.C

Basic Data	Base Speed	Traffic Estimation	V.O.C Estimation
(1) Passenger car	Passenger car	Passenger car	Passenger car
(2) Van	Van		
(3) Under 12 seats (4) 12 - 36 seats	Medium Bus	Bus	Bus
(5) Over 36 seats	Large Bus		
(6) Under 1 ton (7) 1 - 3 ton (8) 3 - 5 ton	Medium Truck	Truck	Truck
(9) 5 - 7 ton (10) 7 - 10 ton (11) Over 10 ton	Heavy Truck		
(12) Honda Dream (13) 70 cc (14) Under 50 cc	Motorcycle	Motorcycle	Motorcycle

Note: Refer to Appendix A-14.2. Vehicle Price for Vehicle Operation Cost Calculation

(3) Division of Market Price and Economic Price of Vehicle Operating Cost

Vehicle operating costs are calculated in two parts : economic vehicle operating cost and financial vehicle operating cost. Economic V.O.C is artificially derived by eliminating all the transfer items from the financial V.O.C expressed at the market price. All the taxes are deducted from the market price of materials concerned, and subsidies are added to the market price.

This economic V.O.C reflects real cost of vehicle travel and is equivalent to marginal productivity of each market.

14.2.3.2 Unit V.O.C by Base Speed

Table 14.14 and 14.15 show unit V.O.C of 7 vehicle types according to base speed.

Table 14.13 Base Speed for Unit V.O.C Calculation

Vehicle Classification	Base Speed
1. Passenger car	70 km/hour
2. Van	60 km/hour
3. Small Bus	50 km/hour
4. Large Bus	45 km/hour
5. Medium Truck	50 km/hour
6. Heavy Truck	40 km/hour
7. Motor Cycle	40 km/hour

For each vehicle type, annual mileage and life span have been estimated for a "base speed", and for a flat, tangent and paved road in good condition. The "base speed" must be interpreted as the average year-round speed. When this speed decreases, the annual mileage will decrease as will the life-span mileage; speed increase will have similar increasing effects. However, linear proportionality does not exist.

1) Table 14.15 shows unit V.O.C per vehicle per km calculated based upon the data of Table 14.14. Calculation method of each item is shown in Appendix A - 14.3.

2) The running unit cost is calculated as running cost per km per vehicle, and as fixed cost per vehicle per hour.

3) For the data of fixed cost, the total running cost was calculated at base speed.

In this study many different sources have been used in order to arrive at a reliable and moderate base value. Table 14.5 is based upon the following data; also hearings with vehicle dealers, transport companies, and from users.

1) Transport Cost, National Transport Sector Review of Vietnam (UNDP project, prepared by BCEOM)

2) Feasibility Report for National Road Route No.18 and No. 1 prepared by consultant.

3) Research Papers prepared specially by the World Bank.

4) Data from several organizations within the Vietnamese government.

Table 14.14 Input Data for Unit Vehicle Operating Cost Calculation by Base Speed

Unit : Dong

Items	Passenger Car	Van	Med-Bus	Large Bus	Medi. Truck	Hvy. Truck	Motor Cycle
Vehicle Price(excl. Tyres)Fin-Dong	214, 000, 000. 00	236, 300, 000. 00	262, 000, 000. 00	945, 000, 000. 00	277, 200, 000. 00	558, 000, 000. 00	19, 760, 000. 00
Vehicle Price(excl. Tyres)Econ-Dong	173, 205, 000. 00	200, 855, 000. 00	227, 939, 000. 00	822, 149, 000. 00	252, 252, 000. 00	505, 680, 000. 00	17, 629, 500. 00
Vehicle Life-Years	8. 00	8. 50	8. 50	8. 00	8. 00	7. 50	6. 00
Vehicle Life Km	104, 000. 00	255, 000. 00	382, 500. 00	320, 000. 00	224, 000. 00	322, 500. 00	150, 000. 00
Vehicle Annual Km	13, 000. 00	30, 000. 00	45, 000. 00	40, 000. 00	28, 000. 00	43, 000. 00	15, 000. 00
Vehicle Life Operating Hours	4, 000. 00	10, 200. 00	12, 750. 00	12, 800. 00	9, 600. 00	11, 250. 00	3, 600. 00
Vehicle Annual Operating Hours	500. 00	1, 200. 00	1, 500. 00	1, 600. 00	1, 200. 00	1, 500. 00	600. 00
Fuel Price Fin-Dong/Liter	3, 300. 00	3, 300. 00	2, 700. 00	2, 700. 00	2, 700. 00	2, 700. 00	3, 300. 00
Fuel Price Econ-Dong/Liter	2, 337. 00	2, 337. 00	2, 025. 00	2, 025. 00	2, 025. 00	2, 025. 00	2, 337. 00
Fuel Consumption -Liter/Km	0. 13	0. 14	0. 18	0. 25	0. 27	0. 30	0. 03
Tyre Unit Price Fin-Dong/Piece	855, 460. 00	855, 460. 00	1, 657, 636. 00	2, 334, 321. 00	2, 334, 321. 00	2, 334, 321. 00	855, 460. 00
Tyre Unit Price Econ-Dong/Piece	777, 691. 00	777, 691. 00	1, 823, 400. 00	2, 122, 110. 00	2, 122, 110. 00	2, 122, 110. 00	777, 691. 00
Number of Tyres	4. 00	4. 00	4. 00	6. 00	6. 00	10. 00	2. 00
Tyre Life -Km	30, 000. 00	30, 000. 00	30, 000. 00	40, 000. 00	40, 000. 00	40, 000. 00	30, 000. 00
Lubricants Price Fin-Dong/Liter	3, 300. 00	9, 417. 00	13, 320. 00	20, 038. 00	9, 417. 00	18, 067. 00	3, 300. 00
Lubricants Price Econ-Dong/Liter	2, 310. 00	6, 592. 00	9, 324. 00	14, 026. 00	6, 592. 00	13, 550. 00	2, 310. 00
Lubri. Oil Consmption-Liter/100km	1. 20	1. 30	2. 00	2. 20	3. 00	3. 40	0. 20
Maintenance Spares/Year-%	7. 00	8. 00	8. 00	10. 00	8. 00	8. 00	3. 00
Maintenance Labor-Hour/1000km	3. 00	7. 00	15. 00	15. 00	12. 00	15. 00	2. 00
Maintenance Labor Cost Fin-Dong/Hou	10, 293. 00	10, 393. 00	11, 837. 00	10, 837. 00	13, 381. 00	20, 586. 00	10, 393. 00
Maintenance Labor Cost Econ-Dong/Ho	8, 234. 00	8, 234. 00	9, 469. 00	9, 469. 00	10, 705. 00	16, 468. 00	8, 234. 00
Depreciation. Distance Related-%	60. 00	70. 00	80. 00	85. 00	70. 00	70. 00	60. 00
Depreciation. Time Related-%	40. 00	30. 00	20. 00	15. 00	30. 00	30. 00	40. 00
Opportunity Cost of Capital-%	12. 00	12. 00	12. 00	12. 00	12. 00	12. 00	12. 00
Real Rate of Interest of Capital-%	8. 00	8. 00	8. 00	8. 00	8. 00	8. 00	8. 00
Overhead Cost /Annum Fin-Dong	0. 00	3, 285, 000. 00	7, 391, 250. 00	6, 570, 000. 00	3, 066, 000. 00	7, 062, 750. 00	0. 00
Overhead Cost /Annum Econ-Dong	0. 00	3, 285, 000. 00	7, 391, 250. 00	6, 570, 000. 00	3, 066, 000. 00	7, 062, 750. 00	0. 00
Crew-Number(Driver)	0. 00	1. 00	1. 00	1. 00	1. 00	1. 00	0. 00
Crew-Number(Assistant)	0. 00	0. 00	1. 00	1. 00	1. 00	1. 00	0. 00
Crew Unit Cost Fin-Dong /Hour	0. 00	9, 112. 00	9, 112. 00	10, 478. 00	10, 478. 00	10, 478. 00	0. 00
Crew Unit Cost Econ-Dong/Hour	0. 00	8, 200. 00	8, 300. 00	9, 430. 00	9, 430. 00	9, 430. 00	0. 00

Table 14.15 Unit Vehicle Operating cost Per Km by Base Speed

Unit: Dong

	Passenger Car	Van	medium Bus	Large Bus	Medi. Truck	Hvy. Truck	Moto Cycle
Basic Financial Running Costs							
Fuel Costs	429.00	462.00	486.00	675.00	729.00	810.00	99.00
Lubricant Costs	3.96	12.24	26.64	44.08	28.25	61.43	0.66
Tyre Costs	114.06	114.06	221.02	350.15	350.15	583.58	57.03
Maintenance Spares Costs	144.04	74.13	54.80	295.31	99.00	138.42	3.95
Maintenance Labor Costs	30.88	72.75	177.56	162.56	160.57	308.79	20.79
Depreciation Costs	1,234.62	648.67	547.97	2,510.16	866.25	1,211.16	79.04
Total Costs/vehicle-km	1,956.55	1,383.85	1,513.98	4,037.26	2,233.22	3,113.38	260.47
Basic Financial Fixed Costs							
Capital Costs(Depreciation-Time rel	21,400.00	6,950.00	4,109.80	11,074.22	8,662.50	14,880.00	2,195.56
Long Term Interest Costs	51,360.00	23,630.00	20,960.00	70,875.00	27,720.00	44,640.00	3,952.00
Overhead Cost	0.00	2,737.50	4,927.50	4,106.25	2,555.00	4,708.50	0.00
Crew Costs	0.00	9,112.00	18,224.00	20,956.00	20,956.00	20,956.00	0.00
Fixed Costs, All	72,760.00	42,429.50	48,221.30	107,011.47	59,893.50	85,184.50	6,147.56
Factor	0.50	0.70	0.70	0.70	0.70	0.70	0.70
Total Costs/Vehicle-hour	36,380.00	29,700.65	33,754.91	74,908.03	41,925.45	59,629.15	4,303.29
Costs/Vehicle-km	519.71	424.30	482.21	1,070.11	598.94	851.85	61.48
Total Financial Cost/Vehicle-km	2,476.27	1,808.15	1,996.20	5,107.37	2,832.16	3,965.22	321.94
Basic Economic Running Costs							
Fuel Costs	303.81	327.18	364.50	506.25	546.75	607.50	70.11
Lubricant Costs	2.77	8.57	18.65	30.86	19.78	46.07	0.46
Tyre Costs	103.69	103.69	243.12	318.32	318.32	530.53	51.85
Maintenance Spares Costs	116.58	63.01	47.67	256.92	90.09	125.44	3.53
Maintenance Labor Costs	24.70	57.64	142.04	142.04	128.46	247.02	16.47
Depreciation Costs	999.26	551.37	476.74	2,183.83	788.29	1,097.60	70.52
Total Costs/vehicle-km	1,550.82	1,111.46	1,292.71	3,438.21	1,891.68	2,654.16	212.93
Basic Economic Fixed Costs							
Capital Cost(Depreciation-time rela	17,320.50	5,907.50	3,575.51	9,634.56	7,882.88	13,484.80	1,958.83
Opportunity Cost of Capital	41,569.20	20,085.50	18,235.12	61,661.18	25,225.20	40,454.40	3,525.90
Overhead Cost	0.00	2,737.50	4,927.50	4,106.25	2,555.00	4,708.50	0.00
Crew Costs	0.00	8,200.00	16,600.00	18,860.00	18,860.00	18,860.00	0.00
Fixed Costs, All	58,889.70	36,930.50	43,338.13	94,261.98	54,523.08	77,507.70	5,484.73
Factor	0.50	0.70	0.70	0.70	0.70	0.70	0.70
Total Costs/Vehicle-hour	29,444.85	25,851.35	30,336.69	65,983.39	38,166.15	54,255.39	3,839.31
Cost/Vehicle-km	420.64	369.31	433.38	942.62	545.23	775.08	54.85
Total Economic Costs/Vehicle-km	1,971.46	1,480.76	1,726.09	4,380.83	2,436.91	3,429.23	267.78

14.2.3.3 Estimate of V.O.C by Type of Vehicles and by Speed

(1) Factors and Their Relation to Vehicle Operation Cost Calculation

Vehicle operating costs are determined by various factors, the most important of which are the following:

1. Road :	alignments, surface type and condition
2. Traffic :	volumes in relation to capacity, traffic composition
3. Vehicle :	type, age, general condition, load
4. Driver :	skill, mentality, mood
5. Climate	temperature, humidity

These factors mentioned above are closely related to each other. For example, the speed is often used as a main variable in V.O.C calculation and is then related to fuel consumption, tire wear, maintenance, capital costs, etc. Improvement of a road may then result in higher average speed, and thus lead toward a higher annual mileage. However, another problem consequence of this is also the shortening of the lifetime of vehicle, although this is not completely proportionally inversed. Thus, when the influence of individual variable is estimated, possible interrelations should be identified.

Table 14.16 shows economic V.O.C by vehicle type and by driving speed. Fuel consumption, lubricant oil consumption, tire wear, maintenance costs (parts, labor, depreciation, interest, crew wage, and overhead cost) are all related to driving speed. See Appendix A - 14.3 as to the relevant formula of vehicle types and driving speed and V.O.C

Table 14.16 Composite Unit V.O.C (Economic)

(Dong)

Km/Hour	Passenger Car	Bus	Truck	Motorcycle
10.00	4,081.02	5,328.61	5,780.43	394.98
15.00	3,746.12	4,955.83	5,267.57	367.69
20.00	3,436.94	4,620.32	4,803.32	344.56
25.00	3,153.49	4,322.09	4,387.69	325.57
30.00	2,895.76	4,061.13	4,020.67	310.74
35.00	2,663.76	3,837.45	3,702.27	300.05
40.00	2,457.48	3,651.04	3,432.48	293.52
45.00	2,276.93	3,501.91	3,211.31	291.13
50.00	2,122.10	3,390.05	3,038.75	292.90
55.00	1,993.00	3.315.47	2,914.81	298.81
60.00	1,889.62	3,278.16	2,839.48	308.87
65.00	1,811.97	3,278.13	2,812.77	323.09
70.00	1,760.04	3,315.37	2,834.67	341.45
75.00	1,733.84	3,389.89	2,905.19	363.97
80.00	1,733.36	3,501.68	3,024.32	390.63
85.00	1,758.61	3,650.75	3,192.07	421.45
90.00	1,809.58	3,837.09	3,408.43	456.41
95.00	1,886.28	4,060.71	3,673.41	495.53
100.00	1,988.70	4,321.60	3,987.00	538.79

14.3 Economic Cost Benefit Analysis

The result of the economic cost and benefit calculation is as shown in the following table.

Table 14.17 Summary of Benefit Cost Comparison Analysis

(NPV = Million Dong)

Section	Project	IRR	NPV	B/C
Section 1	2 lanes + 2 lanes	15.11	387,194	1.70
Section 2	2 lanes + 2 lanes	17.36	611,026	2.02
	2 lanes	15.42	274,826	2.00
Section 3	4 lanes	20.64	720,926	2.28
Section 4	Overlay + 2 lanes	19.74	183,501	2.67
Section 5	Overlay + 2 lanes	18.34	339,567	2.47

NPV and B/C were calculated based on a discount rate of 10 % p.a.

14.3.1 Section 1 : Noi Bai - Bac Ninh

(1) Result of Benefit Cost Analysis

The result is as shown in Table 14.18. IRR is higher than the opportunity cost of capital. Thus investment of 1,041.3 billion dong as the project cost is economically feasible.

Table 14.18 Result of Benefit Cost Analysis

	Investment Indicator
Internal Economic Rate of Return (IRR)	15.11 %
Net Present Value (NPV)	387,194 Million Dong
Benefit Cost Ratio (B/C)	1.70

(NPV and B/C were calculated by discount rate of 10 %)

(2) Road for Benefit Cost Comparison

The existing 31.3 km road runs parallel with the project road; therefore the distance is similar. The average driving speed on the existing road in the year 2000 is assumed to be 19 km/h. In absence of the project, it would be 11 km/h when traffic volume approaches capacity in the year 2010.

The first stage project road with two lanes will exceed capacity in the year 2012, with traffic demand of PCU 15,263. The second stage project (addition of two more lanes) will also be over capacity in the year 2020. The average driving speed will decrease to 52 km/h, and there will be no more increase in benefit.

(3) Traffic Volume Used for Benefit Cost Calculation

Traffic volume (and driving speed) estimated for the project road is based upon Chapter 5 "Transportation Modeling and Demand Forecast". Annual increase rate of traffic volume for the last ten years of the project life is forecast as follows:

Passenger car	4.9 %
Bus	4.9 %
Truck	3.4 %
Motorcycle	3.8 %

Table 14.19 Expected Traffic Volume (Average Daily Vehicle)

	Traffic	1995	2000	2005	2010	2015	2020	2025
P. Car	Normal	125	225	408	652	1044	1664	1860
	Diverted		165	809	1316	2144	3003	3814
Bus	Normal	104	174	292	486	809	1112	1413
	Diverted		105	456	802	1410	2020	2566
Truck	Normal	193	252	330	443	595	786	898
	Diverted		162	558	803	1154	1404	1690
M. Cycle	Normal	1769	3812	8219	13978	23782	33037	38352
	Diverted		0	0	0	0	0	0

Normal traffic means future traffic volume which will increase "without project". Diverted traffic means diverted traffic "with project" (Refer to Table 14.19).

(4) Benefit on the Project

Normal traffic benefit is produced from savings in driving cost and time when comparing existing Highway No. 18 and 31.3 km project road. Diverted traffic benefit is calculated from savings in driving cost and time when comparing the 26 km project road with 18.5 km National Highway No. 3 bypass, and with National Highway No. 1 (17.2 km). Motorcycle use is assumed only on the project road, supposing that the bypass will not be used even if the road is congested.

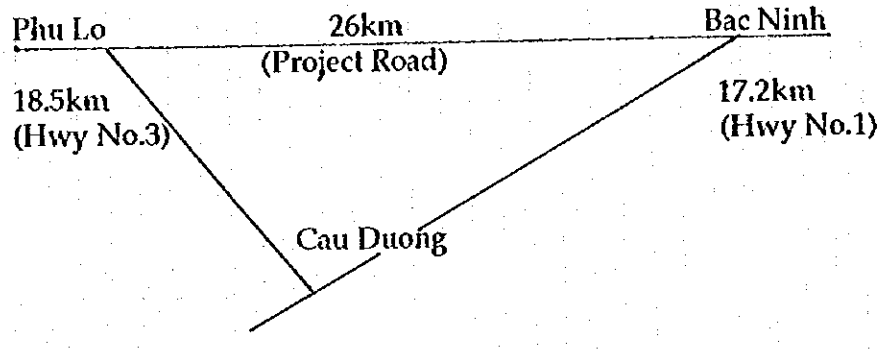


Table 14.20 Cost Benefit Analysis of Cection 1: Noi Bai - Bac Ninh

Case: 2 Lane + 2 Lane
Design length : 31.3 km
IERR : 15.11%
Unit : 1 Million Dong

	year	Cost			Benefit					B/C Analysis		
					VOC		Time Saving		Total	Discount Factor	Cost	Benefit
		Capital	Mainte-nance	Total	Normal Traffic	Diverted Traffic	Normal Traffic	Diverted Traffic			Present Value	Present Value
1	1997	37.366	0	37.366	0	0	0	0	0	0.869	32.461	0
2	1998	69.969	0	69.969	0	0	0	0	0	0.755	52.806	0
3	1999	248.194	0	248.194	0	0	0	0	0	0.656	162.724	0
4	2000	198.554	0	198.554	0	0	0	0	0	0.570	113.091	0
5	2001	0	509	509	17.312	11.708	4.999	2.324	36.343	0.495	252	17.983
6	2002	0	509	509	19.717	15.675	6.217	3.102	44.712	0.430	219	19.220
7	2003	0	509	509	22.443	20.376	7.765	4.082	54.665	0.373	190	20.414
8	2004	0	509	509	25.555	26.630	9.740	5.233	67.157	0.324	165	21.787
9	2005	0	509	509	29.469	33.651	12.329	6.519	81.966	0.282	143	23.100
10	2006	17.685	509	18.194	33.389	34.974	15.127	6.925	90.414	0.245	4.454	22.136
11	2007	0	509	509	36.082	36.619	16.720	7.261	96.681	0.213	108	20.564
12	2008	0	509	509	40.890	38.680	20.634	7.577	107.781	0.185	94	19.915
13	2009	0	509	509	46.375	40.803	25.648	7.874	120.701	0.161	82	19.375
14	2010	63.830	509	64.339	50.148	40.848	28.358	7.837	127.191	0.139	8.972	17.737
15	2011	236.050	509	236.559	54.235	43.174	31.353	8.058	136.820	0.121	28.658	16.575
16	2012	203.407	509	203.916	68.879	79.799	36.150	12.797	197.626	0.105	21.461	20.799
17	2013	0	989	989	75.450	87.924	40.081	13.744	217.199	0.091	90	19.858
18	2014	0	989	989	82.510	94.905	44.376	14.853	236.643	0.079	79	18.796
19	2015	0	989	989	90.265	101.905	49.148	15.962	257.279	0.069	68	17.752
20	2016	0	989	989	95.982	105.853	52.209	16.594	270.638	0.060	59	16.223
21	2017	0	989	989	102.017	110.650	55.458	17.361	285.486	0.052	52	14.867
22	2018	35.417	989	36.406	107.966	114.874	58.827	18.044	299.710	0.045	1.647	13.559
23	2019	0	989	989	113.802	118.233	61.543	18.615	312.193	0.039	39	12.269
24	2020	0	989	989	118.485	121.395	64.181	19.180	323.241	0.034	34	11.036
25	2021	0	989	989	122.605	124.322	66.656	19.733	333.316	0.030	29	9.886
26	2022	0	989	989	126.811	123.697	69.224	19.855	339.586	0.026	25	8.750
27	2023	0	989	989	131.101	127.484	71.886	20.544	351.016	0.022	22	7.857
28	2024	35.417	989	36.406	135.473	129.213	74.647	20.981	360.314	0.019	708	7.007
29	2025	0	989	989	139.923	130.507	77.509	21.362	369.301	0.017	17	6.239
30	2026	0	989	989	145.607	131.309	80.639	21.670	379.225	0.015	15	5.566
31	2027	0	989	989	145.615	127.593	80.639	21.131	374.978	0.013	13	4.781
32	2028	0	989	989	145.615	115.429	80.639	19.327	361.009	0.011	11	3.999
33	2029	0	989	989	145.615	108.820	80.639	18.250	353.323	0.010	10	3.400
34	2030	35.417	989	36.406	145.615	108.820	80.639	18.250	353.323	0.008	304	2.953
35	2031	0	989	989	145.615	108.820	80.639	18.250	353.323	0.007	7	2.566
36	2032	0	989	989	145.615	108.820	80.639	18.250	353.323	0.006	6	2.229
	Total	1.181.306	25.888	1.207.194	2.906.181	2.723.506	1.565.257	451.542	7.646.486		429.114	429.195

(5) Composition of Benefit

Table 14.21 Composition of Benefit

Billion Dong

	Normal Traffic	Diverted Traffic	Total
V.O.C Saving Benefit	2906	2723	5.629 (73 %)
Time Cost Saving Benefit	1565	451	2016
	4471	3174	7646 (100 %)

14.3.2 Section 2 : Bac Ninh - Chi Linh

(1) Result of Benefit Cost Analysis

Result of benefit cost analysis is shown in Tables 14.22, 24 and 25. All alternatives resulted in IRR higher than the opportunity cost of capital. Therefore they are all economically feasible.

Table 14.22 Result of Benefit Cost Analysis

Investment Indicator	Case - 1	Case - 2
Internal Economic Rate of Return (IRR)	17.36 %	15.42 %
Net Present Value (NPV = Million Dong)	611,026	274,826
Benefit Cost Ratio B/C	2.02	2.00

(NPV and B/C were calculated by discount rate of 10 %)

(2) Road for Benefit Cost Analysis

Two basic alternatives are as shown according to considerations of different stage construction.

Table 14.23 Project Alternatives for Benefit Cost Analysis

Case	Stage	Condition
Case - 1	1st stage	Improvement of existing road to two-lane; The construction will start in 1998.. open in 2001
	2nd stage	Widening of two-lane road to four-lane road; The construction will start in 2004.. open in 2007
Case - 2	1st stage	Improvement of existing road to two-lane; The construction will start in 1998.. open in 2001 Under the condition that the construction of the alternate four-lane highway will take place between 2004 and 2007.

Table 14.24 Cost Benefit Analysis of Section 2 : Bac Ninh - Chi Linh

Case - 1 : 2 Lanes + 2 Lanes
Design length : 36.4 km

IRR : 17.36%
Unit : Million Dong

	Year	Cost			Benefit						B/C Analysis		
					V.O.C Saving		Time Saving		Ferry Cost Saving	Total	Discout Factor	Discounted Cost	Discounted Benefit
		Capital	Mainte-nance	Total	Normal Traffic	Diverted Traffic	Normal Traffic	Diverted Traffic					
1	1997	19,450	0	21,395	0	0	0	0	0	0	0.8521	18,230	0
2	1998	47,275	0	52,003	0	0	0	0	0	0	0.7260	37,756	0
3	1999	207,103	0	227,813	0	0	0	0	0	0	0.6186	140,935	0
4	2000	165,682	0	182,250	0	0	0	0	0	0	0.5271	96,070	0
5	2001	0	425	468	12,300	17,439	1,757	630	15,184	47,311	0.4492	210	21,250
6	2002	0	425	468	14,636	25,029	2,295	916	5,470	48,345	0.3827	179	18,503
7	2003	27,964	425	31,228	14,370	34,951	2,621	1,285	5,836	59,064	0.3261	10,184	19,261
8	2004	57,587	425	63,813	15,122	46,853	3,354	1,711	11,402	78,443	0.2779	17,732	21,797
9	2005	199,366	425	219,770	17,208	60,618	4,150	2,158	10,214	94,347	0.2368	52,034	22,338
10	2006	192,616	425	212,345	20,247	67,379	5,109	2,452	14,826	110,012	0.2017	42,839	22,194
11	2007	0	833	916	33,035	71,767	7,196	2,563	16,232	130,793	0.1719	158	22,483
12	2008	0	833	916	38,084	100,067	8,784	3,900	11,598	162,433	0.1465	134	23,792
13	2009	0	833	916	43,885	117,491	10,748	4,731	12,684	189,540	0.1248	114	23,656
14	2010	0	833	916	50,573	137,687	13,187	5,754	18,296	225,497	0.1063	97	23,981
15	2011	0	833	916	58,228	154,782	16,221	6,579	16,982	252,792	0.0906	83	22,907
16	2012	33,095	833	37,321	64,348	167,422	18,143	7,151	16,788	273,852	0.0772	2,882	21,144
17	2013	0	833	916	70,972	180,373	20,288	7,743	26,000	305,376	0.0658	60	20,124
18	2014	0	833	916	78,128	195,241	22,681	8,401	21,732	326,183	0.0561	51	18,285
19	2015	0	833	916	85,840	210,478	25,350	9,077	22,824	353,568	0.0478	44	16,889
20	2016	0	833	916	91,440	221,471	27,405	9,601	27,716	377,633	0.0407	37	15,370
21	2017	0	833	916	97,190	232,725	29,618	10,112	25,328	394,972	0.0347	32	13,698
22	2018	33,095	833	37,321	103,067	244,320	31,996	10,670	28,260	418,313	0.0296	1,103	12,361
23	2019	0	833	916	109,041	256,088	34,551	11,204	35,712	446,596	0.0252	23	11,245
24	2020	0	833	916	115,076	268,027	37,291	11,744	31,084	463,222	0.0215	20	9,938
25	2021	0	833	916	121,128	280,062	40,226	12,285	31,550	485,251	0.0183	17	8,871
26	2022	0	833	916	127,144	292,100	43,364	12,820	32,024	507,451	0.0156	14	7,904
27	2023	0	833	916	133,059	304,030	46,712	13,340	32,504	529,645	0.0133	12	7,030
28	2024	33,095	833	37,321	138,798	315,718	50,276	13,836	32,991	551,619	0.0113	422	6,238
29	2025	0	833	916	144,271	327,009	54,058	14,294	33,486	573,118	0.0096	9	5,523
30	2026	0	833	916	144,263	337,723	54,057	14,697	33,989	584,729	0.0082	8	4,801
Total		1,016,328	19,210	1,139,092	1,941,453	4,667,351	611,436	199,656	570,712	7,990,607		421,488	421,583

Table 14.25 Cost Benefit Analysis of Section 2 : Bac Ninh - Chi Linh

Case - 2 : 2 Lanes (60% to be Diverted to Alternate Highway after 2007)
Design length : 36.4 km

IRR : 15.42%
Unit : Million Dong

	Year	Cost			Benefit						B/C Analysis		
					V.O.C Saving		Time Saving		Ferry Cost Saving	Total	Discout Factor	Cost	Benefit
		Capital	Maintenance	Total	Normal Traffic	Diverted Traffic	Normal Traffic	Diverted Traffic				Present Value	Present Value
1	1997	19,450	0	21,395	0	0	0	0	0	0	0.8664	18,537	0
2	1998	47,275	0	52,003	0	0	0	0	0	0	0.7507	39,036	0
3	1999	207,103	0	227,813	0	0	0	0	0	0	0.6504	148,162	0
4	2000	165,682	0	182,250	0	0	0	0	0	0	0.5635	102,694	0
5	2001	0	425	468	12,300	17,439	1,757	630	15,184	47,311	0.4882	228	23,097
6	2002	0	425	468	14,636	25,029	2,295	916	5,470	48,345	0.4230	198	20,449
7	2003	0	425	468	14,370	34,951	2,621	1,285	5,836	59,064	0.3665	171	21,645
8	2004	0	425	468	15,122	46,853	3,354	1,711	11,402	78,443	0.3175	148	24,906
9	2005	0	425	468	17,208	60,618	4,150	2,158	10,214	94,347	0.2751	129	25,954
10	2006	0	425	468	20,247	67,379	5,109	2,452	14,826	110,012	0.2383	111	26,220
11	2007	18,217	425	20,506	13,399	36,361	2,873	1,415	6,493	60,546	0.2065	4,234	12,502
12	2008	0	425	468	15,439	40,204	3,513	1,544	4,639	65,339	0.1789	84	11,690
13	2009	0	425	468	17,782	47,171	4,298	1,870	5,074	76,194	0.1550	72	11,811
14	2010	0	425	468	20,482	55,245	5,272	2,271	7,318	90,588	0.1343	63	12,166
15	2011	0	425	468	23,572	62,086	6,485	2,594	6,793	101,530	0.1164	54	11,813
16	2012	0	425	468	27,121	67,063	8,007	2,803	6,715	111,710	0.1008	47	11,261
17	2013	18,217	425	20,506	32,472	72,408	11,031	3,019	10,400	129,330	0.0873	1,791	11,296
18	2014	0	425	468	37,322	78,177	13,840	3,259	8,693	141,291	0.0757	35	10,692
19	2015	0	425	468	41,267	84,366	15,533	3,505	9,130	153,802	0.0656	31	10,084
20	2016	0	425	468	44,343	88,941	16,869	3,695	11,086	164,935	0.0568	27	9,369
21	2017	0	425	468	49,540	93,726	20,639	3,880	10,131	177,916	0.0492	23	8,756
22	2018	0	425	468	53,262	98,776	22,415	4,087	11,304	189,844	0.0426	20	8,095
23	2019	18,217	425	20,506	57,279	104,053	24,344	4,288	14,285	204,249	0.0369	758	7,546
24	2020	0	425	468	61,616	109,590	26,440	4,497	12,434	214,576	0.0320	15	6,868
25	2021	0	425	468	66,298	115,398	28,717	4,714	12,620	227,747	0.0277	13	6,316
26	2022	0	425	468	71,353	121,489	31,190	4,939	12,809	241,781	0.0240	11	5,809
27	2023	0	425	468	76,814	127,873	33,878	5,171	13,002	256,737	0.0208	10	5,344
28	2024	0	425	468	82,713	134,562	36,797	5,411	13,197	272,680	0.0180	8	4,918
29	2025	18,217	425	20,506	89,087	141,567	39,970	5,659	13,395	289,677	0.0156	320	4,527
30	2026	0	425	468	89,082	148,399	39,969	5,914	13,595	297,459	0.0135	6	4,027
	Total	512,378	11,050	575,771	1,064,127	2,080,224	411,371	83,688	266,044	3,905,454		317,037	317,160

Infomation Table Cost Benefit Analysis of Section 2: Bac Ninh - Chi Linh

Case : 2 Lane + Alernate Highway
Design length : 36.4 km

IRR : 15.04%
Unit : Million Dong

	Year	Cost			Benefit						B/C Analysis		
					V.O.C Saving		Time Saving		Ferry		Discout	Cost	Benefit
		Capital	Maintenance	Total	Normal Traffic	Diverted Traffic	Normal Traffic	Diverted Traffic	Cost Saving	Total	Factor	Present Value	Present Value
1	1997	19.450	0	19.450	0	0	0	0	0	0	0.8693	16.907	0
2	1998	47.275	0	47.275	0	0	0	0	0	0	0.7556	35.722	0
3	1999	207.103	0	207.103	0	0	0	0	0	0	0.6568	136.032	0
4	2000	165.682	0	165.682	0	0	0	0	0	0	0.5710	94.598	0
5	2001	16.602	425	17.027	12.300	17.439	1.757	630	15.184	47.311	0.4963	8.451	23.481
6	2002	16.602	425	17.027	14.636	25.029	2.295	916	5.470	48.345	0.4314	7.346	20.858
7	2003	38.700	425	39.125	14.370	34.951	2.621	1.285	5.836	59.064	0.3750	14.673	22.150
8	2004	128.030	425	128.455	15.122	46.353	3.354	1.711	11.402	78.443	0.3260	41.876	25.572
9	2005	488.156	425	488.581	17.208	60.618	4.150	2.158	10.214	94.347	0.2834	138.451	26.736
10	2006	423.647	425	424.072	20.247	67.379	5.109	2.452	14.826	110.012	0.2463	104.460	27.099
11	2007	0	1.425	1.425	33.498	90.904	7.194	3.538	16.232	151.366	0.2141	305	32.411
12	2008	0	1.425	1.425	38.597	100.510	8.782	3.861	11.598	163.347	0.1861	265	30.404
13	2009	0	1.425	1.425	44.454	117.928	10.744	4.675	12.684	190.486	0.1618	231	30.820
14	2010	0	1.425	1.425	51.205	138.112	13.180	5.677	18.296	226.471	0.1406	200	31.851
15	2011	0	1.425	1.425	58.929	155.215	16.212	6.486	16.982	253.824	0.1223	174	31.031
16	2012	18.217	1.425	19.642	67.804	167.657	20.017	7.008	16.788	279.274	0.1063	2.087	29.679
17	2013	0	1.425	1.425	81.180	181.021	27.577	7.546	26.000	323.324	0.0924	132	29.868
18	2014	0	1.425	1.425	93.306	195.443	34.600	8.147	21.732	353.229	0.0803	114	28.365
19	2015	0	1.425	1.425	103.168	210.915	38.834	8.764	22.824	384.504	0.0698	99	26.839
20	2016	90.368	1.425	91.793	110.858	222.352	42.173	9.237	27.716	412.336	0.0607	5.570	25.019
21	2017	0	1.425	1.425	123.849	234.314	51.598	9.700	25.328	444.790	0.0527	75	23.460
22	2018	18.217	1.425	19.642	133.156	246.940	56.038	10.217	28.260	474.611	0.0458	901	21.760
23	2019	0	1.425	1.425	143.199	260.131	60.861	10.721	35.712	510.623	0.0399	57	20.351
24	2020	0	1.425	1.425	154.040	273.974	66.100	11.243	31.084	536.441	0.0346	49	18.584
25	2021	0	1.425	1.425	165.744	288.496	71.792	11.785	31.550	569.366	0.0301	43	17.146
26	2022	0	1.425	1.425	178.383	303.723	77.975	12.347	32.024	604.451	0.0262	37	15.823
27	2023	0	1.425	1.425	192.035	319.683	84.694	12.928	32.504	641.843	0.0228	32	14.605
28	2024	18.217	1.425	19.642	206.782	336.405	91.993	13.528	32.991	681.700	0.0198	389	13.484
29	2025	0	1.425	1.425	222.718	353.917	99.924	14.147	33.486	724.192	0.0172	25	12.452
30	2026	90.368	1.425	91.793	222.705	372.247	99.922	14.785	33.989	743.648	0.0149	1.372	11.115
	Total	1,786.634	31.050	1,817.684	2,519.492	4,822.156	999.497	195.492	570.712	9,107.350		610.672	610.963

(3) Traffic Volume Used for Benefit Cost Analysis

Estimation of traffic volume to use project road is based upon Chapter 5 "Transportation Modeling and Demand Forecast". Annual traffic volume increase rate after the year 2015 is assumed as 70% of the previous ten years increase rate, as shown below.

Passenger car	5.9 %
Bus	6.3 %
Truck	5.6 %
Motorcycle	8.1 %

In Case 1 the road will reach its capacity in the year 2026, the last year of the project life. In Case 2, users of the alternate highway would not be required a toll fee. In all cases, expected traffic volume is estimated to be the same.

"Normal traffic" indicates future traffic volume estimated in the absence of the project. "Diverted traffic" indicates traffic estimation considering implementation of project, in which ferry traffic is diverted (or generated) to road traffic by construction of the bridge.

Table 14.26 Traffic Volume Used in B.C. Analysis (Average Daily Vehicle)

	Traffic	1995	2000	2005	2010	2015	2020	2025
P.Car	Normal	134	219	356	619	1076	1596	2369
	Diverted		226	1179	1708	2455	3108	3898
Bus	Normal	95	137	196	371	698	1104	1746
	Diverted		179	851	1242	1783	2263	2824
Truck	Normal	213	306	436	618	875	1117	1425
	Diverted		452	2242	3339	4962	6548	8639
M.Cycle	Normal	978	2136	4664	8233	14518	21718	32506
	Diverted		197	911	1458	2342	3159	4216

(4) Benefit of the Project

Table 14.27 Types of Project Benefits

Benefits	Remarks
1) Benefits of normal traffic:	Saving of running cost and time comparing existing Highway No.18 (without project), and the project road (with project)
2) Benefit of diverted traffic:	Saving of running cost and time of the project road section, comparing the total 80.8 km of National By-pass No. 5 and provincial road No. 183, with the total 61 km of the project road and National Highway No. 1
3) Pha Lai ferry investment cost saving:	The investment scale of ferry boat proven economically feasible, consists of V.O.C and time saving benefit of normal traffic and diverted, as a benefit for bridge. (See Table 14.28)

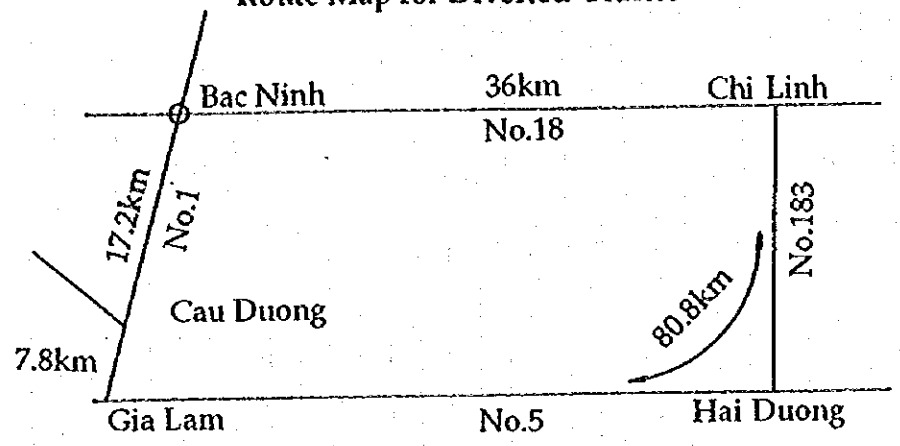
Table 14.28 Cost Benefit Analysis of Pha Lai Ferry(Economic Price)

Section 2 : Bac Ninh - Chi Linh

Unit : 1000 Dong
IRR : 22.28%

	Year		Ferry	Other Costs	Total	Waiting Hour Saving		Flood Stop Saving		Total Savings	Discoun Factor	Discouted Cost	Discounted Benefit
						Nomal T.	Diverted T	Nomal Traffic					
						Time	Time	VOC	Time				
1	2,000	7	8,400	6,784	15,184	2,817	1,572	904	56	5,350	0.8178	12,417	4,375
2	2,001	9	2,400	3,070	5,470	3,084	2,262	1,010	65	6,420	0.6688	3,658	4,294
3	2,002	11	2,400	3,436	5,836	3,381	3,149	1,132	76	7,738	0.5469	3,192	4,232
4	2,003	14	3,600	7,802	11,402	3,709	4,305	1,274	88	9,375	0.4473	5,100	4,192
5	2,004	17	3,600	6,614	10,214	4,075	5,805	1,441	104	11,425	0.3658	3,736	4,179
6	2,005	22	6,000	8,826	14,826	4,483	7,747	1,638	122	13,990	0.2991	4,435	4,185
7	2,006	24	9,400	6,832	16,232	4,961	8,379	1,847	141	15,328	0.2446	3,971	3,750
8	2,007	26	4,400	7,198	11,598	5,501	9,057	2,090	162	16,809	0.2001	2,320	3,363
9	2,008	28	4,400	8,284	12,684	6,101	9,787	2,370	190	18,447	0.1636	2,075	3,018
10	2,009	31	6,600	11,696	18,296	6,771	10,573	2,666	217	20,227	0.1338	2,448	2,706
11	2,010	34	6,600	10,382	16,982	7,519	11,418	3,008	253	22,198	0.1094	1,858	2,429
12	2,011	36	7,400	9,388	16,788	8,349	12,330	3,360	287	24,326	0.0895	1,502	2,177
13	2,012	40	13,800	12,200	26,000	9,276	13,312	3,730	327	26,645	0.0732	1,903	1,950
14	2,013	44	8,800	12,932	21,732	10,310	14,368	4,136	367	29,181	0.0598	1,301	1,746
15	2,014	48	8,800	14,024	22,824	11,465	15,502	4,597	419	31,984	0.0489	1,117	1,565
16	2,015	52	10,800	16,916	27,716	12,756	16,721	5,102	471	35,050	0.0400	1,109	1,403
17	2,016	55	9,600	15,728	25,328	13,772	17,618	5,510	520	37,420	0.0327	829	1,225
18	2,017	59	11,800	16,460	28,260	14,872	18,560	5,938	565	39,934	0.0268	756	1,069
19	2,018	63	17,800	17,912	35,712	16,064	19,547	6,416	625	42,653	0.0219	782	934
20	2,019	67	12,800	18,284	31,084	17,356	20,583	6,918	679	45,536	0.0179	556	815
21	2,020	71	12,900	18,650	31,550	18,756	21,668	7,439	738	48,600	0.0146	462	712
22	2,021	76	12,500	19,524	32,024	20,275	22,804	8,001	801	51,881	0.0120	383	621
23	2,022	81	12,800	19,704	32,504	21,921	23,993	8,608	870	55,393	0.0098	318	542
24	2,023	86	13,300	19,691	32,991	23,707	25,237	9,264	945	59,153	0.0080	264	474
25	2,024	91	14,000	19,486	33,486	25,644	26,539	9,972	1,026	63,181	0.0065	219	414
26	2,025	97	14,100	19,889	33,989	27,747	27,898	10,766	1,115	67,525	0.0054	182	362
27	2,026	104	15,400	19,098	34,498	30,028	29,318	11,625	1,211	72,181	0.0044	151	316
		1,292	254,400	350,810	605,210	334,699	400,049	130,762	12,441	877,951		57,046	57,047

Route Map for Diverted Traffic



Presuppositions of benefit-and-cost calculation : The alternative highway in case 2 will make speedier driving possible. However at the present vehicle competency level, higher speed will increase running cost. And the following speed level was used as economic speed in the analysis.

Passenger car	82 km/h
Bus	66 km/h
Truck	65 km/h
Motorcycle	47 km/h

Benefits Cost calculation was carried out assuming 36.4 km for case 1 and 37.5 km for case 2. For comparison under the same conditions, traffic allocation between the project road No. 18 and the alternative highway was not undertaken.

(5) Composition of Benefit

In the two cases the completion year differs. This influences statistics on driving speed, and benefits differ. IRR will also differ, due to the fact that investment time varies, present net value differs, and IRR varies. In all cases, ferry boat users of diverted traffic are the same. Accordingly, the benefits will be the same.

Table 14.29 Comparison of Benefit of Two Cases

Billion Dong

Case	V.O.C Benefit		Time Benefit			
	N.Traffic	D.Traffic	N.Traffic	D.Traffic	Ferry	Total
Case 1	1941	4667	611	199	570	7988
Case 2	1064	2080	411	83	266	3904

14.3.3 Section 3 : Hon Gai - Cua Ong

(1) Result of Benefit Cost Analysis

The result of benefit-and-cost is shown in Table 14.30 and 14.31. IRR is higher than the opportunity cost of capital. Thus investment of 705.7 billion dong as the project cost is economically feasible.

Table 14.30 Result of Benefit Cost Analysis

	Investment Indicator
Internal Economic Rate of Return (IRR)	20.64%
Net Present Value (NPV)	720,926 Million Dong
Benefit Cost Ratio (B/C)	2.28

(NPV and B/C were calculated by discount rate of 10 %)

(2) Road for Benefit Cost Analysis

The project road runs parallel with the coast; the distance being almost the same as that of the existing road (38.5 km). By the year 2004, the existing road is to reach capacity. Analyzing from the expected traffic volume, the project road needs 4 lanes from the beginning.

Capacity of 4 lane road is PCU 61,500 (in case urbanization progresses more rapidly, it will be PCU 52,275) and it is estimated that traffic will not reach capacity until the year 2020, 20 years after completion. Average driving speed is estimated at 56 km/h at the beginning of the operation, and at 42 km/h, 20 years later.

(3) Traffic Volume Used for Benefit Cost Analysis

In the year 2000, the first year of completion, the estimated traffic volume is 7,595: 700 passenger cars, 1,078 buses, 1,482 trucks and 4,336 motorcycles (See Chapter 5 Transportation Modeling and Demand Forecast) (Refer to Table 14.31).

Table 14.32 Traffic Volume Used in B/C Analysis (Average Daily Vehicle)

	Traffic	1995	2000	2005	2010	2015	2020
P.Car	Normal	423	665	1103	1566	2349	3614
	Induced		35	58	174	261	402
Bus	Normal	671	1024	1645	2314	3434	4817
	Induced		54	87	257	282	535
Truck	Normal	604	1408	3460	5124	8294	11364
	Induced		74	182	579	992	1263
M.Cycle	Normal	1615	4119	11066	15152	21908	29318
	Induced		217	582	1684	2434	3258

Table 14.31 Cost Benefit Analysis of Section 3: Hong Gai - Cua Ong

Case : 4 Lane
Design Lengh : 38.7 km

Discount Rate : 20.64%
Unit : 1 Million Dong

	year	Cost			Benefit					B/C Analysis		
		Capital	Mainte-nance	Total	VOC Saving		Time Saving		Total	Discount Factor	Cost Present Value	Benefit Present Value
					Normal Traffic	Generated Traffic	Normal Traffic	Generqated Traffic				
1	1997	70.818		70.818	0	0	0	0	0	0.829	58.704	0
2	1998	107.862		107.862	0	0	0	0	0	0.687	74.118	0
3	1999	292.775		292.775	0	0	0	0	0	0.570	166.768	0
4	2000	234.221		234.221	0	0	0	0	0	0.472	110.594	0
5	2001	0	600	600	62.771	1.652	4.835	165	69.422	0.391	235	27.173
6	2002	0	600	600	85.938	2.262	6.983	236	95.417	0.324	195	30.959
7	2003	0	600	600	115.039	3.027	10.070	336	128.472	0.269	161	34.554
8	2004	0	600	600	145.992	3.842	13.556	447	163.836	0.223	134	36.528
9	2005	0	600	600	168.979	4.447	15.530	507	189.463	0.185	111	35.016
10	2006	35.460	600	36.060	184.088	4.844	16.763	548	206.244	0.153	5.524	31.597
11	2007	0	600	600	198.249	5.217	17.982	588	222.037	0.127	76	28.198
12	2008	0	600	600	216.045	5.685	19.413	635	241.779	0.105	63	25.453
13	2009	0	600	600	232.458	6.117	20.823	681	260.080	0.087	52	22.696
14	2010	0	600	600	236.687	13.149	21.149	1.460	272.446	0.072	43	19.708
15	2011	0	600	600	254.106	14.117	22.665	1.564	292.452	0.060	36	17.537
16	2012	35.460	600	36.060	267.750	14.875	24.092	1.659	308.376	0.050	1.792	15.329
17	2013	0	600	600	280.940	15.608	25.077	1.735	323.361	0.041	25	13.324
18	2014	0	600	600	293.453	16.303	26.564	1.834	338.154	0.034	20	11.550
19	2015	0	600	600	304.587	16.921	28.081	1.933	351.522	0.028	17	9.953
20	2016	0	600	600	325.272	18.071	29.910	2.068	375.321	0.023	14	8.809
21	2017	0	600	600	347.384	19.299	31.859	2.213	400.755	0.019	12	7.797
22	2018	35.460	600	36.060	371.023	20.612	33.935	2.368	427.939	0.016	582	6.902
23	2019	0	600	600	396.295	22.016	36.148	2.535	456.995	0.013	8	6.110
24	2020	0	600	600	423.317	23.518	38.506	2.713	488.054	0.011	7	5.409
	Total	812.056	12.000	824.056	4.910.373	231.583	443.940	26.226	5.612.122		419.293	394.602

(4) Benefit of the Project

The benefit of the project is the saved running costs and time yielded from the difference between driving on the existing road at an average speed of 30 - 20 km/h and on the projected road at 56 - 42 km/h. In B/C calculation the traffic consists of normal traffic and induced traffic, which makes up 5% of normal traffic during the first ten years and 10 % during the last ten years.

(5) Composition of Benefit

Composition of the total benefit (unit: billion dong) shows V.O.C saving at 91 %, with time saving at 9 %. Whether the project is undertaken or not, benefit of normal traffic increase by the development of coal resources, sightseeing, and industries in the region, amounts to 95 %, the greatest benefit of the project.

Table 14.33 Composition of Benefit

	Normal Traffic	Diverted Traffic	Total
V.O.C Saving Benefit	4910	231	5141(91 %)
Time Cost Saving Benefit	443	26	469
	5353(95 %)	257	5610(100 %)

Benefits of trucks resulting from to coal resources are the greatest.

Table 14.34 Benefit Composition by Vehicle Types

	P.Car	Bus	Truck	M.Cycle	Total
V.O.C (Normal Traffic)	619	848	2702	764	4936
	(12 %)	(17 %)	(54 %)	(17 %)	(100 %)

14.3.4 Section 4 : Cua Ong - Tien Yen

(1) Result of Benefit Cost Analysis

The result of benefit-and-cost analysis for this section is shown in Table 14.35 and 14.36. IRR is higher than the opportunity cost of capital. Thus, investment of 233.7 billion dong as the project cost is economically feasible.

Table 14.35 Result of Benefit Cost Analysis

	Investment Indicator
Internal Economic Rate of Return (IRR)	19.74%
Net Present Value (NPV)	183,501 Million Dong
Benefit Cost Ratio (B/C)	2.67

(NPV and B/C were calculated by discount rate of 10 %)

Table 14.36 Cost Benefit Analysis of Section 4 : Cua Ong - Tien Yen

Case : 2 Stage Improvement
Design Length : 43.5 km

Discount Rate : 19.74%
Unit : 1 Million Dong

	year	Cost			Benefit					B/C Analysis		
		Capital	Mainte-nance	Total	VOC		Time Saving		Total	Discount Factor	Cost Present Value	Benefit Present Value
					Normal Traffic	Generated Traffic	Normal Traffic	Generated Traffic				
1	1997	1,983	0	1,983	0	0	0	0	0	0.8351	1,656	0
2	1998	21,020	0	21,020	0	0	0	0	0	0.6975	14,661	0
3	1999	31,528	0	31,528	0	0	0	0	0	0.5825	18,364	0
4	2000	0	54	54	2,395	2	238	0	2,635	0.4865	26	1,282
5	2001	0	54	54	2,948	4	285	0	3,238	0.4063	22	1,315
6	2002	0	54	54	4,076	5	379	0	4,460	0.3393	18	1,513
7	2003	0	54	54	5,567	8	495	1	6,071	0.2834	15	1,720
8	2004	0	54	54	6,914	12	590	1	7,516	0.2366	13	1,779
9	2005	10,293	54	10,347	8,603	12	706	1	9,322	0.1976	2,045	1,842
10	2006	0	54	54	10,873	20	902	2	11,798	0.1650	9	1,947
11	2007	16,178	54	16,232	17,226	35	1,408	2	18,671	0.1378	2,237	2,574
12	2008	66,578	54	66,632	20,954	37	1,739	3	22,733	0.1151	7,670	2,617
13	2009	99,866	54	99,920	25,365	46	2,141	3	27,555	0.0961	9,606	2,649
14	2010	0	225	225	31,715	52	2,796	4	34,566	0.0803	18	2,775
15	2011	0	225	225	38,087	69	3,430	5	41,592	0.0671	15	2,789
16	2012	0	225	225	45,629	74	4,204	6	49,914	0.0560	13	2,795
17	2013	0	225	225	52,753	90	5,024	9	57,877	0.0468	11	2,707
18	2014	0	225	225	67,033	112	6,732	11	73,889	0.0391	9	2,886
19	2015	18,600	225	18,825	79,630	129	8,254	12	88,025	0.0326	614	2,871
20	2016	0	225	225	87,886	142	9,519	14	97,561	0.0272	6	2,658
21	2017	0	225	225	96,913	157	11,006	16	108,091	0.0227	5	2,459
22	2018	0	225	225	109,808	178	12,979	19	122,983	0.0190	4	2,337
23	2019	0	225	225	120,937	196	15,090	22	136,244	0.0159	4	2,162
24	2020	0	225	225	130,877	212	17,383	26	148,497	0.0133	3	1,968
25	2021	18,600	225	18,825	145,438	235	20,393	30	166,097	0.0111	208	1,838
26	2022	0	225	225	157,236	254	23,674	35	181,198	0.0092	2	1,675
27	2023	0	225	225	161,318	305	23,778	50	185,452	0.0077	2	1,431
28	2024	0	225	225	161,305	315	23,779	50	185,449	0.0064	1	1,195
29	2025	0	225	225	161,305	315	23,779	50	185,449	0.0054	1	998
30	2026	0	225	225	161,305	315	23,779	50	185,449	0.0045	1	834
31	2027	18,600	225	18,825	161,305	315	23,779	50	185,449	0.0038	71	696
32	2028	0	225	225	161,305	315	23,779	50	185,449	0.0031	1	582
33	2029	0	225	225	161,305	315	23,779	50	185,449	0.0026	1	486
	Total	303,246	5,040	308,286	2,398,013	4,274	315,817	574	2,718,678		57,332	57,379

(2) Road for Benefit Cost Analysis

The distance of the project road is the same as the existing road; 43.5 km. The project road runs parallel with the existing road. The project road will reach capacity in the year 2023. The average running speed will decrease to 40 km/h.

(3) Traffic Volume Used for Benefit Cost Analysis

The expected traffic volume used for B/C analysis in the first year of operation, is 852 vehicles in total; 140 passenger cars, 211 buses, 258 trucks and 245 motor cycles.

Table 14.37 Traffic Volume Used in B/C Analysis (Average Daily Vehicle)

Year	1995	2000	2005	2010	2015	2019	2025
P.Car	84	140	236	415	733	1035	1243
Bus	120	211	370	681	1254	1644	1978
Truck	83	258	800	1372	2351	3014	3607
M.Cycle	84	245	724	1045	1512	1909	2250
Total	371	852	2130	3513	5850	8456	9028

(4) Benefit of the Project

The benefit of the project is the saved running cost and time yielded by the difference between driving on the existing road at an average speed of 39 - 15 km/h; and on the project road at 46 - 40 km/h. There is no benefit of shortened distance. Saving cost of road maintenance cost is so small that it is not considered as a saving.

(5) Content of Benefit Composition

Composition of the total benefit shows V.O.C saving at 88 %. Benefit of time saving is only 12 %, because there is little difference in driving speed between the existing road and the project road.

Table 14.38 Composition of Benefit (Unit : Billion Dong)

	Normal Traffic	Generated Traffic	Total
V.O.C Saving Benefit	2398	4	2402 (88 %)
Time Cost Saving Benefit	315	0.5	316
	2713(99 %)	5	2718(100 %)

Benefit composition by vehicle types shows trucks as receiving the greatest benefit.

Table 14.39 Benefit Composition by Vehicle Type

	P.Car	Bus	Truck	M.Cycle	Total
V.O.C (Normal Traffic)	378	600	1387	32	2398
	(16 %)	(25)	(58)	(1 %)	(100 %)

14.3.5 Section 5 : Tien Yen - Bac Luan

(1) Result of Benefit Cost Analysis

The results of benefit-and-cost analysis for this section is shown in Table 14.40 and 14.41. IRR is higher than the opportunity cost of capital. Thus investment of 500.4 billion dong as the project cost is economically feasible.

Table 14.40 Result of Benefit Cost Analysis

	Investment Indicator
Internal Economic Rate of Return (IRR)	18.34 %
Net Present Value (NPV)	339,567 Million Dong
Benefit Cost Ratio (B/C)	2.47

(NPV and B/C were calculated by discount rate of 10%)

(2) Road for Benefit Cost Comparison

In light of the fact that the existing road at present has extra capacity, traffic congestion is not yet serious, and the road surface is well maintained well enough for traffic for the time being, the construction will basically be carried out in stages.

Second stage of construction: to undertake the second investment to widen the road to 2 lanes at the time it reaches capacity. The project road extends over 86.9 km parallel with the existing road. And the distance does not differ greatly. As a basic plan, the second investment period is suggested for the year 2007 - 2009.

(3) Traffic Volume Used for Benefit Cost Analysis

The traffic volume capacity of the project road will reach its capacity in the year 2025, 16 years after completion of the second stage construction. After that, the benefit will not increase.

Traffic volume up to 2015 for the project road is based upon Chapter 5, "Transportation Modeling and Demand Forecast". Annual increase rate of traffic after year 2015 is set as: passenger cars, buses, and trucks at 7 % and motorcycles at 5 %.

Induced traffic is estimated at 2 % of the total traffic.

Table 14.42 Traffic Volume Used in B/C Analysis (Average Daily Vehicle)

Year	1995	2000	2005	2010	2015	2019	2025-2029
P.Car	83	139	235	407	705	989	1387
Bus	152	256	432	747	1292	1812	2542
Truck	56	192	666	1168	2051	2877	4035
M.Cycle	230	624	1696	2451	3542	4521	5770
Total	521	1211	3029	4773	7590	10199	13734

Table 14.41 Cost Benefit Analysis of Section 5 : Tien Yen - Bac Luan

Case : 2 Stage Improvement
Design length : 86.9 km
Discount Rate : 18.34%
Unit Unit: 1 Million Dong

	year	Cost			Benefit					B/C Analysis		
		Capital	Mainte-nance	Total	Vehicle Operating Saving		Time Saving		Total	Discout Factor	Cost	Benefit
					Normal Traffic	Generated Traffic	Normal Traffic	Generated Traffic			Present Val	Present Value
1	1997	7.855	0	7.855	0	0	0	0	0	0.845	6.638	0
2	1998	46.839	0	46.839	0	0	0	0	0	0.714	33.446	0
3	1999	70.258	0	70.258	0	0	0	0	0	0.603	42.394	0
4	2000	0	120	120	4.931	50	572	6	5.559	0.510	61	2.834
5	2001	0	120	120	6.642	68	742	8	7.459	0.431	52	3.214
6	2002	0	120	120	7.263	74	775	8	8.121	0.364	44	2.957
7	2003	0	120	120	9.864	101	1.011	10	10.985	0.308	37	3.380
8	2004	0	120	120	14.002	143	1.407	14	15.566	0.260	31	4.047
9	2005	3.390	120	3.510	17.690	181	1.720	18	19.608	0.220	771	4.308
10	2006	24.439	120	24.559	20.668	211	2.045	21	22.945	0.186	4.559	4.260
11	2007	37.547	120	37.667	24.117	246	2.429	25	26.817	0.157	5.909	4.207
12	2008	174.166	120	174.286	33.196	339	3.379	34	36.948	0.133	23.104	4.898
13	2009	139.334	120	139.454	38.590	394	3.996	41	43.020	0.112	15.621	4.819
14	2010	0	477	477	61.662	629	5.995	61	68.347	0.095	45	6.470
15	2011	3.390	477	3.867	78.764	804	7.838	80	87.486	0.080	309	6.998
16	2012	0	477	477	93.719	956	9.421	96	104.193	0.068	32	7.043
17	2013	0	477	477	108.921	1.111	11.117	113	121.263	0.057	27	6.926
18	2014	0	477	477	129.223	1.319	13.358	136	144.036	0.048	23	6.952
19	2015	30.995	477	31.472	161.909	1.947	17.397	178	181.430	0.041	1.284	7.400
20	2016	0	477	477	173.160	1.767	18.542	189	193.658	0.034	16	6.674
21	2017	3.390	477	3.867	181.576	1.853	19.484	199	203.112	0.029	113	5.915
22	2018	0	477	477	194.195	1.982	20.768	212	217.156	0.025	12	5.344
23	2019	0	477	477	215.211	2.196	23.697	242	241.346	0.021	10	5.019
24	2020	0	477	477	238.224	2.431	27.087	276	268.019	0.018	8	4.710
25	2021	30.995	477	31.472	254.773	2.600	28.874	295	286.540	0.015	467	4.255
26	2022	0	477	477	281.703	2.875	33.072	337	317.987	0.013	6	3.990
27	2023	3.390	477	3.867	311.161	3.175	37.968	387	352.691	0.011	41	3.740
28	2024	0	477	477	332.769	3.396	40.473	413	377.050	0.009	4	3.378
29	2025	0	477	477	367.206	3.747	46.583	475	418.012	0.008	4	3.165
30	2026	0	477	477	367.248	3.747	46.590	475	418.061	0.006	3	2.675
31	2027	30.995	477	31.472	367.248	3.747	46.590	475	418.061	0.005	170	2.260
32	2028	0	477	477	367.248	3.747	46.590	475	418.061	0.005	2	1.910
33	2029	3.390	477	3.867	367.248	3.747	46.590	475	418.061	0.004	15	1.614
	Total	610.373	10.740	621.113	4.830.133	49.582	566.109	5.777	5.451.600		135.259	135.361

(4) Composition of Benefit

As for the ratio of total benefit and cost over the 30 years of assumed project life, saving of V.O.C will amount to 90 % of the total benefit. As for the vehicle-type benefit composition, trucks shows the most benefit (Refer to Table 14.43).

Table 14.43 Composition of Benefit

Billion Dong

	Normal Traffic	Generated Traffic	Total
V.O.C. Saving Benefit	4830	50	4880 (90%)
Time Cost Saving Benefit	566	5	571
	5396 (99%)	55	5451 (100%)

Benefit composition by vehicle types shows trucks as receiving the greatest benefit.

Table 14.44 Benefit Composition by Vehicle Types

	P.Car	Bus	Truck	M.Cycle	Total
V.O.C (Normal Traffic)	712 (15 %)	1222 (25 %)	2767 (57 %)	128 (3 %)	4830 (100 %)

14.4 Sensitivity Analysis

14.4.1 Selection Criteria for the Project

In order to select or prioritize a project in supposition of a certain amount of budget, there are three indicators: (a) Internal Rate of Return (IRR), (2) Net Present Value (NPV), (3) Benefit Cost Ratio (B/C).

1) IRR is an indicator of benefit ratio to investment capital (cost). However no matter how different the investment amount, the rate may result in the same figure.

   For example, a project of 1000 dong scale, a project of 150 billion dong scale, and also a project of 20 million dong scale could all show an IRR of 15 %.

2) NPV indicator is usually used to analyze the amount of benefit exceeding the investment cost. For the selection of projects, in order of the amount of benefits, this NPV comparison is used.

3) On the other hand, even if NPV is small and project scale is small, some projects show high efficiency. These are expressed in benefit-and-cost ratio. That is, high B/C ratio means high benefit in relation to small investment cost. This is similar to IRR indicator.

NPV indicator and IRR indicator show different results depending upon which discount rate is to use, 10 % or 12 %. In the case of public facilities such as a road project, high benefit is not always necessary to decide investment priority.

IRR which can obtain the indicator (%) automatically by the calculation is used as project selection and priority indicator in this report.

14.4.2 Analysis of Investment Feasibility of Base Case

Table 14.45 Sensitivity Analysis by Using IRR (%)

Section	Base Plan	Cost +10 % up	Benefit -10 % down	Combination +10. -10 %
Section 1. Noi Bai - Bac Ninh	15.11	14.07	13.97	13.03
Section 2. Bac Ninh - Chi Linh				
Case - 1 2 + 2	17.36	16.25	16.13	15.07
Case - 2 2	15.42	14.38	14.26	13.28
Section 3. Hon Gai - Cua Ong	20.64	18.50	18.37	17.14
Section 4. Cua Ong - Tien Yen	19.74	18.69	18.58	17.55
Section 5. Tien Yen - Bac Luan	18.34	17.37	17.27	16.33

Cases were analyzed to find IRR for 10 % increase of cost, for 10 % decrease of benefit, and for the combination of 10 % increase of cost and 10 % decrease of benefit. The result is seen in Table 14.45.

In order to decide investment feasibility, opportunity cost of capital is used as an indicator. Opportunity Cost of Capital shows high figure when economic growth is high and when there is high investment demand of social infrastructure. Opportunity cost of capital in Japan is about 5 %, while Vietnam is 10 - 12 %. IRR is higher than opportunity cost of investment of all case that were proven as economically feasible. The later the undertaking of the highway improvement project, the higher the IRR and Benefit Cost will become.

14.4.3 Sensitivity Analysis of Positive Alternatives

Sensitivity analysis of positive alternatives is discussed as follows (Refer to Table 14.46):

- Base case plans to add the second stage construction when the traffic volume reaches road capacity. As a result the IRR was comparatively high. Thus some more positive alternatives were studied.
- When construction is undertaken sooner, section 1, 2 and 5 showed IRR of less than 12 %, thus not economically feasible when considering the cost increase and the benefit decreases. This is due to the fact that the discounted present value of cost in comparison with benefit becomes more than the Base Case.
- Construction of alternate highway of Section 2: it is difficult to conclude early stage construction of the toll highway for the following reasons :

  1. This project basically presupposes a toll-free road.
  2. For capital recovery, it will be necessary to study the case of toll road, in which another traffic volume estimate is required.

Table 14.46 Sensitivity Analysis of Positive Alternatives

Section	Condition	Construction Period	(B)
Section 1. Noi Bai - Bac Ninh	1 stage improvement (4 lane)	1997 - 2000	10.94 %
Section 2. Bac Ninh - Chi Linh	Overlay + Alt. Highway	1998 - 2003	13.23 %
Section 4. Cua Ong - Tien Yen	1 stage improvement (2 lane)	1997 - 1999	11.23 %
Section 5. Tien Yen - Bac Luan	1 stage improvement (2 lane)	1997 - 1999	10.95 %

Noe: All calculations are listed in Appendix A - 14.5

14.5 Conclusions

Results of benefit cost analysis according to the sensitivity statement are as follows:

(1) Section 1 Noi Bai - Bac Ninh

1) 2-lane road to be completed for use by the year 2001
2) Additional 2 lanes to be completed for use by the year 2013.

(2) Section 2 Bac Ninh - Chi Linh

1) In the first stage, 2-lane (widening of the present road) road to be completed by the year 2001, giving consideration to construction timing to connect both ends of the road.
2) The alternate highway is to be constructed by the year 2007, following a detailed feasibility study.

(3) Section 3 Hon Gai - Cua Ong

4-lane road construction will be undertaken from the outset of initial stage to be open in the year 2001.

(4) Section 4 Cua Ong - Tien Yen

Construction for stage 1 and stage 2 is to be undertaken separately.

- Stage 1 is to complete overlay and construction of presently-dangerous bridges by the year 2000.
- Stage 2 is to complete widening to 2-lane road and remaining works by the year 2010.

(5) Section 5 Tien Yen - Bac Luan

Construction is to be undertaken in the same manner as section 4.