ADB

Technical Assistance Consultant's Report

FINAL REPORT

VOLUME 1: MAIN REPORT

Project Number: TA 7155-VIE
February 2010

Socialist Republic of Viet Nam: Preparing the Ben Luc-Long Thanh Expressway Project

(Financed by the Japan Special Fund)

Prepared by
Katahira & Engineers International, Japan
Joint Venture with
Oriental Consultants Co. Ltd., Japan
In association with
Asia Pacific Engineering Consultants, Viet Nam

For: Asian Development Bank

CURRENCY EQUIVALENTS

(as of December 2009)

Currency Unit	–	Vietnamese Dong
VND1.00	=	$ 0.000056
$1.00	=	VND 17,800

ABBREVIATIONS

ADB	=	Asian Development Bank
AIDS	=	Acquired Immune Deficiency Syndrome
AP	=	Affected Person
ASEAN	=	Association of Southeast Asian Nations
BOD5	=	Biological Oxygen Demand (5 day)
CBTA	=	Cross-Border Transport Agreement
CO	=	Carbon Monoxide
COD	=	Chemical Oxygen Demand
COF	=	Co-Financier
CPC	=	Commune People's Committee
CQS	=	Consultants’ Qualifications Selection
CSP	=	Country Strategy and Program
CSW	=	Commercial Sex Worker
DPC	=	District People's Committee
DSCR	=	Debt Service Coverage Ratio
EIA	=	Environmental Impact Assessment
EIRR	=	Economic Internal Rate of Return
EMA	=	External Monitoring Agency
EMDP	=	Ethnic Minority Development Plan
EMP	=	Environmental Management Plan
EMSA	=	Ethnic Minority Specific Action
FFC	=	Fatherland Front Committee
FIRR	=	Financial Internal Rate of Return
FSW	=	Female Sex Worker
GAD	=	Gender and Development
GDP	=	Gross Domestic Product
GMS	=	Greater Mekong Subregion
GRDP	=	Gross Regional Domestic Product
GZAR	=	Guangxi Zhuang Autonomous Region
HCMC	=	Ho Chi Minh City
HH	=	Households
HIV	=	Human Immunodeficiency Virus
IDU	=	Injectable Drug User

ILO	=	International Labour Organization
LOL	=	Inventory of Losses
IOM	=	International Office of Migration
JBIC	=	Japan Bank for International Cooperation
KEI	=	Katahira & Engineers International
MFC	=	Motherland Front Committee
MOLISA	=	Ministry of Labour, Invalids and Social Affairs
MOT	=	Ministry of Transport
MT	=	Motorized Transport
NGO	=	Non Government Organization
NH	=	National Highway
NMT	=	Non-Motorized Transport
NO_2	=	Nitrogen Dioxide
NO_x	=	Nitrogen Oxides
O&M	=	Operation and Maintenance
PIU3	=	Project Implementation Unit No. 3
PPC	=	Provincial People's Committee
PPP	=	Public–Private Partnership
PPP	=	Purchasing Power Parity
PRC	=	People’s Republic of China
PSB	=	Public Security Bureau
QCBS	=	Quality- and Cost-Based Selection
RP	=	Resettlement Plan
SEIA	=	Summary Environmental Impact Assessment
SEPMU	=	South Expressway Project Management Unit of VEC
SEPP	=	Summary Erosion Protection Plan
SES	=	Social-Economic Survey
SOE	=	State-Owned Enterprise
SS	=	Suspended Solids
STI	=	Sexually Transmitted Infections
TA	=	Technical Assistance
TSP	=	Total Suspended Particulates
TSSS	=	Transport Sector Strategy Study
UNAIDS	=	United Nations Agency for AIDS
US$	=	United States Dollars
UXO	=	Unexploded Ordinance
VEC	=	Vietnam Expressway Corporation
VOC	=	Vehicle Operating Costs
WACC	=	Weighted Average Cost of Capital
WB	=	World Bank

WEIGHTS AND MEASURES

dB(A) (decibel)	–	decibels measured in audible noise bands
ha (hectare)	–	10,000 square metres
mieng	–	= 36 square metres
sao	–	= 360 square metres
mau	–	= 3,600 square metres
km (kilometre)	–	1,000 metres
m (metre)	–	the distance travelled by light in vacuum in 1⁄299,792,458 of a second
m^2 (square metre)	–	
m^3 (cubic metre)	–	1,000 litres
MTE (Medium Truck Equivalent)	–	standard unit for measuring traffic volumes in the PRC
PCU (Passenger Car Units)	–	is a metric used in Transportation Engineering, to assess traffic-flow rate on a highway

NOTE

(i) In this report, "$" refers to US dollars.

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Figure 1: Ben Luc-Long Thanh Expressway Project Map

I. INTRODUCTION

A. Project Background

1. In the southern area of HCMC, east–west traffic is restricted due to the lack of adequate river crossing facilities, forcing vehicles into the center of HCMC. A modal shift from motorcycles to passenger cars has already been substantial in the project area and is likely to accelerate as an increasing number of higher income Vietnamese families are also purchasing 4-wheel motor vehicles, notably sedans but also SUVs. The construction of HCMC ring roads to establish connectivity with neighboring cities by expressway links is considered a high priority by the Government. In this regard, the proposed expressway will have significant impacts, albeit in some instances indirect, on socioeconomic activities in the cities and towns around HCMC including much of the Southeastern Region and Mekong Delta Region., The Project will also go quite a long way to resolving some of the traffic problems in the center of HCMC by diverting the through traffic to the expressway, especially trucks carrying containers.

2. The expressway will be used as freight route to and from the HCMC river port. The Nha Be and Long Tau rivers in the project area are used as navigation channels for large cargo ships accessing the HCMC river port. Two bridges or tunnels need to be constructed across the rivers. If bridges are selected, these will have to be long-spanned bridges with a 55 meter (m) navigational clearance.

3. The Mekong Delta Region is home to Vietnam's major food producing areas and is the source of rice exports that has turned Vietnam into the world's second largest rice exporter after Thailand. The proposed expressway will be used as a freight route to transport food produced in the Mekong Delta to the rest of the country by land, ensuring even greater levels of food security in food-deficit areas of Vietnam and also to international markets where there is an increasing demand for different rice varieties produced by farmers in the Mekong Delta. Industrial parks are being rapidly established in hi-tech sectors such as manufacturing of computer fan motors, desktops, step motors and optical pick-up devices and this is consistent with the GoV plans to promote five key industries – mechanics, electricity, information technology, and chemical manufacturing – to replace processing industries using low-skilled workers as Ho Chi Minh moves up the global value chain. However, the expressway will also facilitate the transfer to the hinterland of these lower value industries that will ensure greater off-farm employment opportunities for rural people. Industrial parks, such as in food processing, are being developed in the project area.

4. The East-West Highway is under construction and will direct traffic through and near the center, from Highway 1A in the south-west of Ho Chi Minh to the Hanoi road just east of Saigon Bridge. The southern link of Ring Road No 2 will also serve to allow traffic to pass around the city using the existing Saigon South Parkway and the Phu My Bridge, which is under construction. This will link to the already designed Ho Chi Minh – Long Thanh – Dau Giay Expressway.

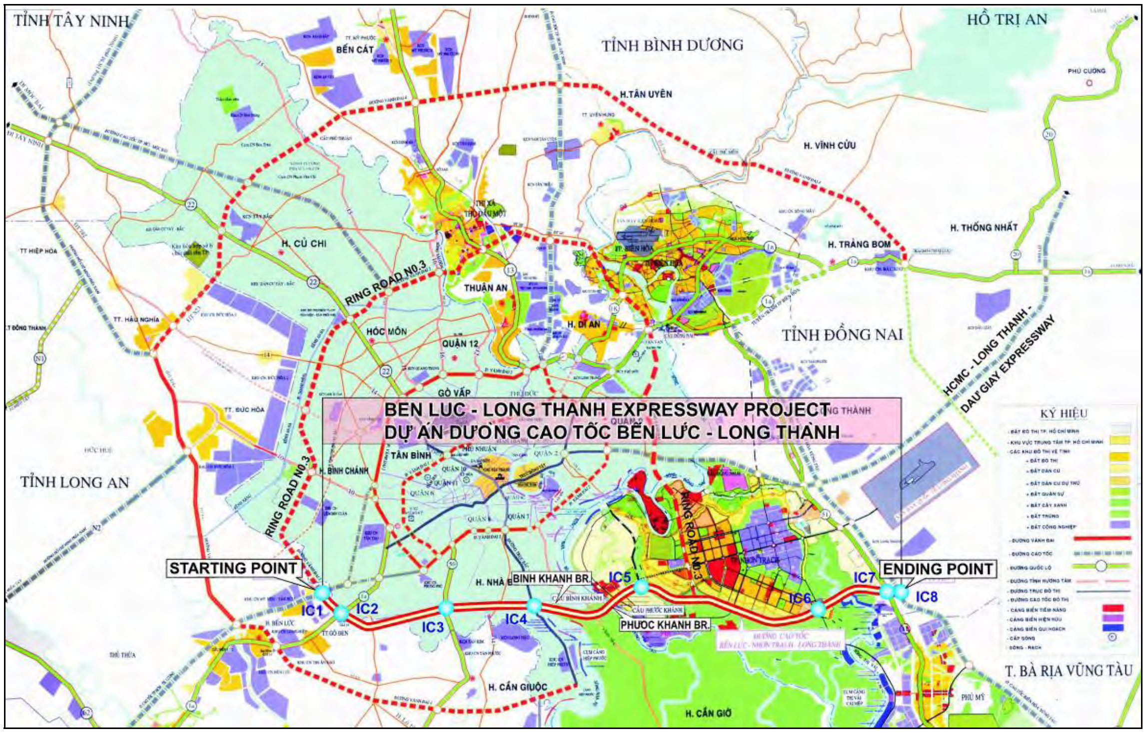

Figure 2: Development Map of the HCMC Road Network

B. Description of the Project

5. The Ben Luc–Long Thanh Expressway will be a southern link of the HCMC Outer Ring expressway (Third Ring Road) as well as a short link of the North–South Expressway in Viet Nam, and will be connected to the planned HCMC–Vung Tau Expressway. The expressway forms part of the GMS southern economic corridor route from Bangkok, Thailand to Phnom Penh, Cambodia, HCMC, and Vung Tau, as well as the GMS eastern economic corridor from Nanning to Ha Noi and HCMC.

6. ADB is providing technical assistance (TA) for the preparation of Ben Luc – Long Thanh Expressway Project (hereinafter referred to as "the Project"), to be financed by a grant from the Japan Special Fund. The consulting services (hereinafter referred to as the Services) have been employed for the following project components:

- Feasibility study of the planned 58 km long Ben Luc – Long Thanh Expressway
- Engineering, economic, financial, social and environmental studies on the alignment
- Preparation of environmental impact assessment, environmental management plan, resettlement plan, and ethnic minority development plan for the Project

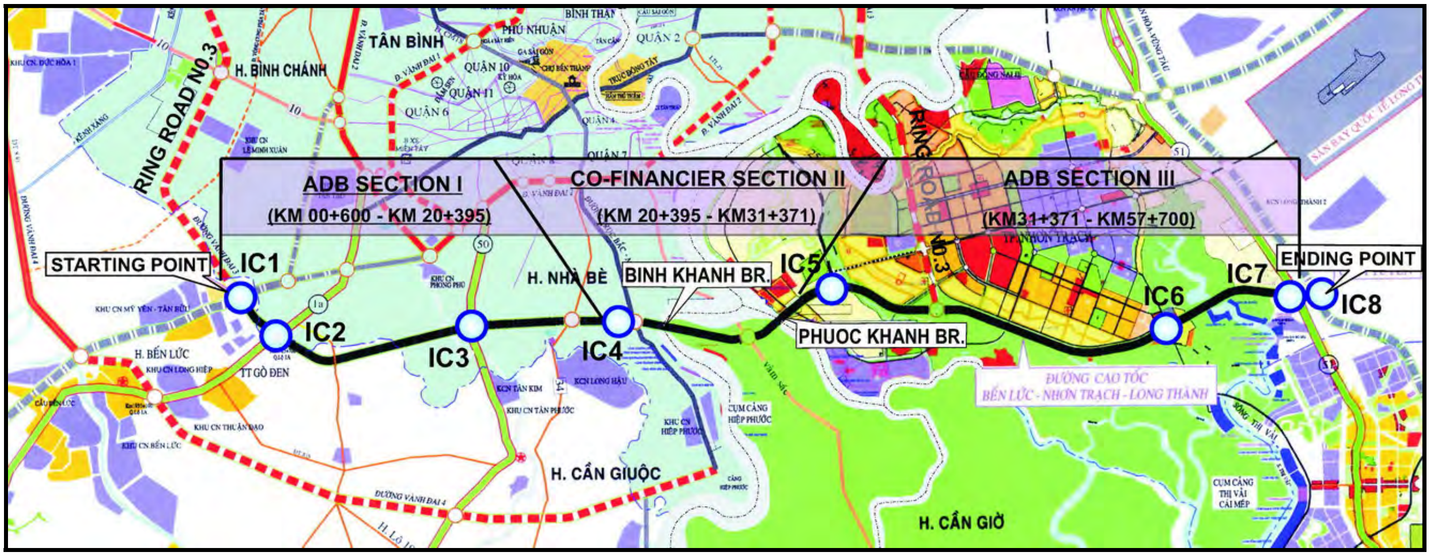

Figure 3: General Alignment of Ben Luc-Long Thanh Expressway

7. The Ben Luc – Long Thanh Expressway forms the southern section of the outer ring of the HCMC Urban Expressway (Third Ring Road), together with a spur connection towards Long Thanh. It connects to the HCMC – Trung Lung Expressway in the west, which is under construction, to the existing NH51, and the planned Bien Hoa – Vung Tau Expressway in the east. The proposed expressway width is 4 lanes in the first phase, with future expansion to 8 lanes, and design speed of 120 km/h.

C. Goals and Objectives of the Project

8. The objective of the services is to examine the suitability of the Project for financing by an ADB loan, with possible co-financing by JICA. Outputs of the services will be a final report prepared in accordance with ADB guidelines. The output must also form the basis for application for project approval by the Vietnamese government, and must be in accordance with the Vietnamese Decision 48/2008/QD-TTg on Guidance for Preparation of Feasibility Study Reports.

9. Previous studies have already been carried out, including:

- Pre-feasibility study for Ben Luc – Long Thanh Expressway, TEDI South, March 2008
- JETRO study for Ben Luc – Long Thanh Expressway (entitled Study on Southern Inter-Regional Highway including Binh Khanh and Phuc Khanh Bridge), Nippon Steel and Nippon Engineering Consultants (NEC), March 2008
- Pre-feasibility study for HCMC outer ring road (RR3 & RR4), TEDI South, 2006

10. The Project will:

i. Improve economic efficiency, encourage trade and facilitate port traffic and inter-regional integration by reducing vehicle congestion and vehicle operating costs (VOCs);

ii. Reduce travel times for expressway users;

iii. Facilitate economic development and social benefits over a wide cross-section of local communities in southern Ho Chi Minh City where there are few existing bridges across the numerous waterways;

iv. Contribute to greater levels of economic and social development in both the Southeastern Region and Mekong Delta region of Southern Vietnam.

11. The Project comprises:

i. Approximately 58-kilometres of expressway

ii. Two major cable-stay bridges over shipping channels

iii. Eight interchanges

iv. Land acquisition and resettlement.

12. The Project cost including land acquisition and resettlement is estimated at approximately US$ 1.6 billion. VEC has set up an implementing entity to manage the feasibility studies and the design. Eventually the construction, operation, maintenance and toll collection activities will be handled by VEC.

D. Reporting

13. There are seven deliverables required in this TA, that is:

- Inception Report (IR), Completed 29-May-09
- Interim Report (ITR), Completed 03-Sep-09
- Draft Final Reports (DFR) Completed 30-Nov-09
- Draft EIA Completed 30-Nov-09
- Draft Resettlement Plan Completed 30-Nov-09
- Final Report (FR). due 28-Feb-10
- Final EIA due 30-Apr-10 (after comments)
- Final Resettlement Plan due 30-Apr-10 (after comments)
- Consulting Services Completion Report June or July 2010

14. The Inception Report was submitted on the 29th of May 2009. This report outlined the Project background, Project objectives, study team members, current study status, personnel schedule, proposed study tasks, activity work schedule and any anticipated problems that need to be overcome. The Interim Report was submitted on the 3rd of September 2009.

E. Report Organization

15. This Final Report is produced in both English and Vietnamese and contains two parts. The first part is the main body which outlines the Project background, objectives, study team

members, personnel schedule and a summary of the findings of each specialty. The second part of the report is in the Appendices which provide more details of each specialty and some their findings.

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II. TRAFFIC

A. Collect Data and Information

16. The following reports and studies were used extensively:

- HOUTRANS Model: The traffic demand forecast was based on the Study on Urban Transport Master Plan and Feasibility Study in Ho Chi Minh Metropolitan Area which is commonly known as HOUTRANS. This model was produced using JICA funds in June 2004. The HOUTRANS model predicts person trips. HOUTRANS study has set 30% and 50% target for public transport use by 2020. This model was kindly lent to the project by JICA so that it could be adapted for the traffic forecast of the Ben Luc – Long Thanh Expressway Project.
- JETRO Study on Southern Inter-Regional Highway: The Study on Southern Inter-Regional Highway including Binh Khanh and Phuoc Khanh Bridge, in the Socialist Republic of Vietnam was produced using funds from the Japan External Trade Organization (JETRO) in March 2008.
- ADB TA No. 4695 –VIE : HCMC – Long Thanh - Dau Giay PPTA (Finnroad in association with Bacco)
- Study on the terminal operation for Cai Mep/Thi Vai ports in Vietnam (JETRO, March 2007)
- The Comprehensive Study on the Sustainable Development of Transport System in Vietnam (VITRANSS2) Draft Interim Report (JICA, August 2008).
- National and Provincial Socio-economic data
- Historic traffic counts and ferry traffic data

1. Traffic Surveys

17. For the purpose of obtaining the traffic data for the traffic demand forecast, traffic surveys were conducted in July 2009.

a. Types of Traffic Surveys

18. The traffic surveys consisted of the following two surveys:

Table 1: Types of the Survey

Survey Name	Survey Period [Date]	Survey Time
(1) Traffic Count Survey	3 days (Weekday) [22/June/2009~24/June/2009]	24 hours (6:00 ~ 6:00)
(2) Roadside OD Interview Survey	1 day (Weekday) [23/June/2009]	24 hours (6:00 ~ 6:00)

b. Locations of the Surveys

19. Traffic surveys were carried out on two major roads near the start and end of the Project, i.e., National Highway No.1 and No.51. These roads are to be connected by the proposed Project as shown in the map in Figure 4 below.

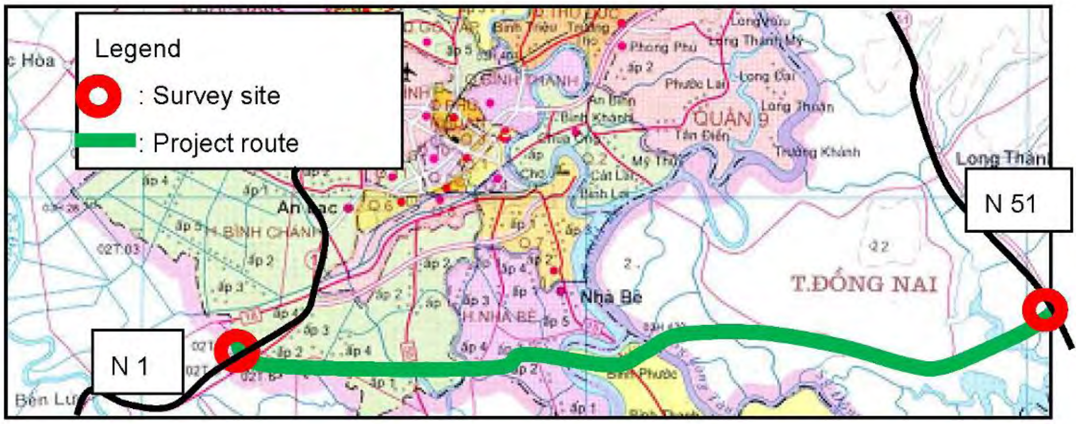


Figure 4: Traffic Survey Location

c. Results of the Survey

20. Daily through traffic volumes on N1a and N51 are shown in the following tables.

Table 2: Traffic Count Survey Results Highway N1A (Vehicle/day)

Direction	Date	Motorcycle	Passenger Car	Taxi	Minibus	Standard Bus	Small Truck	Big Truck	Container Truck
HCM-Longan	22-Jun-09	22,452	2,465	295	2,361	1,437	2,313	2,678	769
	23-Jun-09	25,579	1,795	243	2,319	1,204	2,481	2,993	679
	24-Jun-09	26,423	2,692	282	2,384	1,433	2,511	2,640	788
	Ave	24,818	2,317	273	2,355	1,358	2,435	2,770	745
Longan-HCM	22-Jun-09	29,856	2,248	262	2,758	1,164	3,058	3,438	1,101
	23-Jun-09	26,882	3,010	260	2,184	1,144	2,980	2,801	393
	24-Jun-09	27,221	2,835	262	2,762	1,197	2,456	2,422	432
	Ave	27,986	2,698	261	2,568	1,168	2,831	2,887	642
Both Directions		52,804	5,015	535	4,923	2,526	5,266	5,657	1,387

Table 3: Traffic Count Survey Results Highway N51 (Vehicle/day)

Direction	Date	Motorcycle	Passenger Car	Taxi	Minibus	Standard Bus	Small Truck	Big Truck	Container Truck
Dong Nai-	22-Jun-09	12,669	2,012	216	1,013	550	807	2,205	434
Vung Tau	23-Jun-09	14,129	1,759	165	970	370	404	1,810	387
	24-Jun-09	14,541	1,857	237	976	363	819	2,559	372
	Ave	13,780	1,876	206	986	428	677	2,191	398
Vung Tau -	22-Jun-09	13,288	1,912	180	582	194	1,928	1,056	541
Dong Nai	23-Jun-09	11,104	1,914	207	624	215	1,899	1,367	411
	24-Jun-09	11,724	1,983	214	659	230	1,689	1,475	449
	Ave	12,039	1,936	200	622	213	1,839	1,299	467
Both Directions		25,818	3,812	406	1,608	641	2,515	3,491	865

Note: Vehicle/day Source: Consultant

d. Fluctuation of Hourly Traffic Volume and Origin-Destination (OD) survey

21. The peak hourly traffic derived from the traffic count surveys is discussed in detail in Appendix B: Traffic Demand and Flow Analysis. The Origin-Destination (OD) survey is also detailed.

B. Traffic Demand and Flow Analysis

22. Traffic demand was forecasted for target years 2016 (start of operations), 2026 and 2036. The traffic model is based on HOUTRANS data. The study team used the JICA STRADA software package for traffic demand analysis which HOUTRANS also used for the demand forecasts. The JICA STRADA is computer software developed for the JAPAN ODA project by JICA for application in transport demand analysis and assignment. The STRADA is adapted for many traffic demand forecasts for transport projects.

1. Socio –economic Framework

23. Traffic volume has relationship with socio-economic indicators such as GRDP and GRDP per capita. Thus GRDP and GRDP per capita were estimated for demand forecasts. Each district has population and GRDP data for 2020. This study basically used those data.

24. HOUTRANS study area is HCMC and some adjoining areas such as Binh Dong, Dong Nai and Long An. On the other hand, the end of the project is located near the boundary of Ba Ria - Vung Tau. Ba Ria area economic activity will influence traffic volume of the project. Therefore, This study set socio economic frame of Ho Chi Minh and adjoining area, including HCMC, Binh Dong, Dong Nai, Long An and Ba Ria - Vung Tau.

a. Population

25. Ho Chi Minh City and adjoining provinces have been increasing rapidly. The annual average growth rate (2002 – 2009) of Binh Dong and Ho Chi Minh City has been high. This trend will probably be maintained in the near future. However, in the more distant future, the growth rate will probably level out. Ho Chi Minh City expects a population of ten-million in 2020. Other districts also have a 2020 population plan. These areas forecast that in 2020 they will maintain similar average growth rates as the present. On the other hand, Ba Ria - Vung Tau's growth rates have been more than 5% per year. This is too high a growth rate to be maintained. Therefore it is assumed that Ba Ria - Vung Tau population growth rate will be 2.0%. After 2020, it is assumed that growth rates will be reduced further.

26. These future growth rates are acceptable considering past trends. Population growth rates are set as shown in Table 4.

Table 4: Population of Ho Chi Minh City and Adjoining Area 2002 to 2009

	2002	2003	2004	2005	2006	2007	2009*	Annual. Growth 2002 – 2009
Ho Chi Minh City	5,479	5,555	5,731	5,912	6,108	6,347	6,807	3.1%
Dong Nai	2,096	2,143	2,172	2,195	2,225	2,253	2,330	1.5%
Binh Duong	788	851	886	923	967	1,023	1,134	5.3%
Ba Ria - Vung Tau	856	885	898	914	935	947	986	2.0%
Long An	1,364	1,392	1,401	1,412	1,423	1,431	1,465	1.0%
Adjoining Provinces	5,103	5,271	5,357	5,444	5,550	5,654	5,915	2.1%

Note: Source: General Statistic Office of Vietnam,
*: estimated by consultant
Unit: Thousand

Table 5: Estimated Population of Ho Chi Minh City and Adjoining Area 2009-2020

	2009	2010	2015	2016	2020	Average Growth 2002-2007
Ho Chi Minh City	6,807	7,049	8,396	8,695	10,000	3.6%
Dong Nai	2,330	2,369	2,576	2,619	2,800	1.7%
Binh Duong	1,134	1,194	1,545	1,627	2,000	5.3%
Ba Ria-Vung Tau	986	1,006	1,113	1,136	1,231	2.0%
Long An	1,465	1,483	1,574	1,592	1,670	1.2%
Adjoining Provinces	5,915	6,052	6,807	6,974	7,701	2.4%

Note: Source: Ho Chi Minh City in 2020= Masterplan of socio - economic up to 2020 of HCM city, by Economic Institute of HCM city, 2006. Dong Nai in 2020 = Prime Minister Decision No. 73/2008/QĐ-TTg. Prime Minister Decision No. 81/2007/QD-TTg. Binh Duong = Long An in 2020 = www. longan.gov.vn. Rest of the populations were estimated by consultants.

b. After 2020

27. The consultant has assumed that the population growth rate will be reduced. The expected growth rates are as shown below;

Table 6: Future Population Growth Rate

	2010-2020	2020-2030	2030-2036
Ho Chi Minh City	3.6%	3.1%	2.6%
Adjoining Provinces	2.4%	2.0%	1.5%

Source: Consultant

c. Gross Regional Domestic Product (GRDP)

28. The Gross Regional Domestic Product of Ho Chi Minh City and adjoining area have had large increases. The Ho Chi Minh City average growth rate has been 12.5% and the adjoining Provinces also 12.5% from 2002 to 2007. Forecasts to 2010 were used as GRDP for the demand forecast assuming that Ho Chi Minh will keep high growth rate, but adjoining area's growth rate will decrease. In the future, the increasing trend will be maintained but the growth rates will be leveled out.

Table 7: GRDP of Ho Chi Minh and Adjoining Area

Unit: VMD Billion at 1994 constant price

	2002	2003	2004	2005	2006	2007	2008	2009*	Average Growth 2002 – 2009
Ho Chi Minh City	63,670	70,947	79,237	88,866	99,672	112,258	124,220	132,294	11.0%
Dong Nai	13,058	14,798	16,813	19,179	21,941	24,850	n/a	n/a	
Binh Duong	5,557	6,359	6,973	8,482	9,757	11,225	n/a	n/a	
Ba Ria-Vung Tau	27,844	30,836	36,903	39,235	42,244	48,045	n/a	n/a	
Long An	5,617	6,132	6,728	7,461	8,294	9,784	n/a	n/a	
Adjoining Prov.	52,076	58,125	67,417	74,357	82,236	93,904	n/a	106,508	10.8%

Source: Statistic book and plan 2005-2010 of all provinces in southeast key economic zone (Development Strategy Institute in the South of MPI)

Note: *=estimation by consultant

29. The consultant assumed the growth rate as shown below:

Table 8: Future GRDP Growth Rate

	2010-2020	2020-2030	2030-2036
Ho Chi Minh City	8.5%	7.8%	7.0%
Adjoining Provinces	8.5%	7.8%	7.0%

Source: Consultant

d. Gross Domestic Product per capita of Region

30. The Gross Domestic Product per capita of Ho Chi Minh City and adjoining area are shown in the following tables:

Table 9: Gross Domestic Product per capita of Ho Chi Minh City and adjoining area

	2002	2003	2004	2005	2006	2007	2009	Average Growth 2002 – 2009
Ho Chi Minh City	11.6	12.8	13.8	15.0	16.3	18.1	21.3	9.1%
Dong Nai	6.2	6.9	7.7	8.7	9.9	11.0	14.0	12.3%
Binh Duong	7.1	7.5	7.9	9.2	10.1	11.0	12.2	8.2%
Ba Ria-Vung Tau	32.5	34.8	41.1	42.9	45.2	50.7	60.3	9.2%
Long An	4.1	4.4	4.8	5.3	5.8	6.8	8.7	11.3%
Adjoining Provinces	10.2	11.0	12.6	13.7	14.8	16.6	20.1	10.1%

Source: Consultants

Table 10: Future GDP per Capita Growth Rate

	2010-2020	2020-2030	2030-2036
Ho Chi Minh City	6.2%	5.2%	4.3%
Adjoining Provinces	7.4%	6.4%	5.4%

Source: Consultant

C. Traffic Model

1. Base Year (2009) Validation

a. Road Network

31. The 2009 road network was updated using the 2002 to 2010 HOUTRANS road network and current road network information. Our study adopted HOUTRANS road data such as capacity and operating speed.

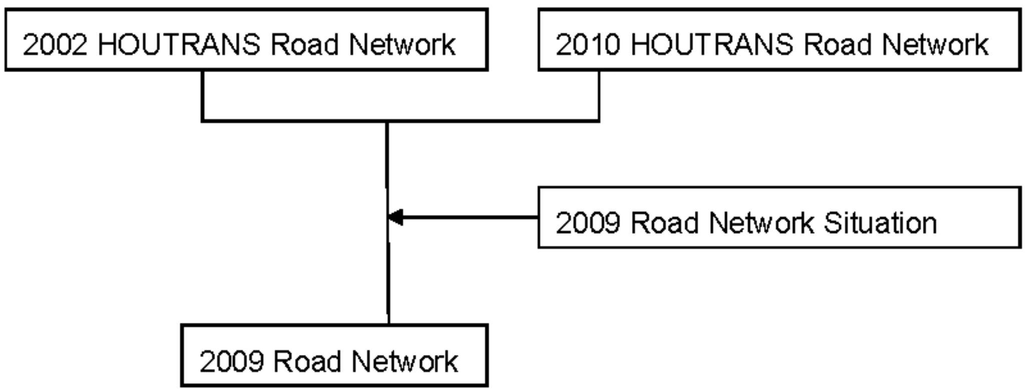


Figure 5: Updating the Traffic Model

32. The Major Differences of 2010 and 2009 are as follows;

- West East Highway is not open yet (still under construction) in 2009.
- Arraignment of North section of Nguyen Huu Tho road
- Ho Hoc Lam road doesn’t connect Trinh Quang Nghi in 2009

b. Road Capacity of the Model

33. The road capacity assumptions employed in the HOUTANS were based on Japanese standards and the assumption according to the situation observed in HCMC. This study accepts the capacity. The HOUTRANS road capacity is shown in Appendix B.

c. The 2009 OD matrices

34. The 2009 OD tables were established with 2009 draft OD matrices based on HOUTRANS’s OD tables, and the results of the traffic count survey. There are combination of 2009 adjusted 2009 HOUTRANS based OD matrices, OD matrices on N1a and N51.

35. Process of establishing the 2009 OD matrices are shown below.

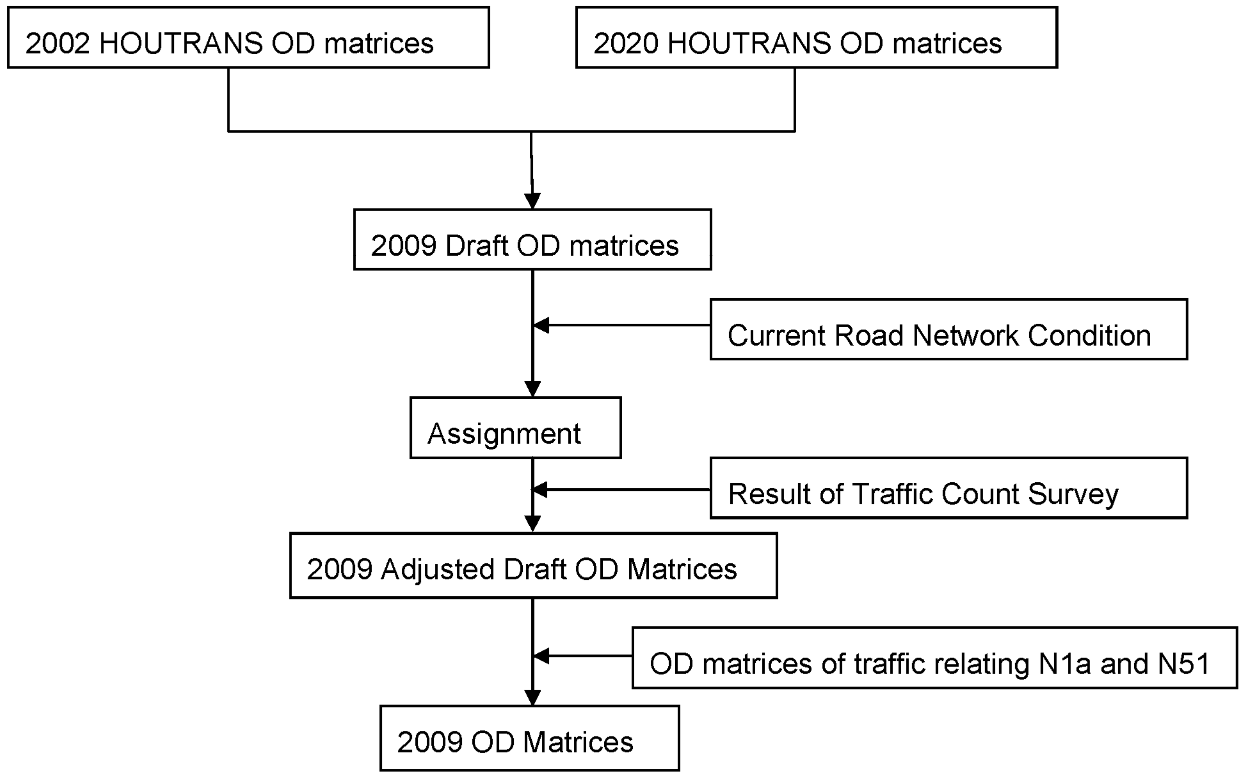


Figure 6: Process of Establishing the 2009 OD Matrices

d. 2009 Draft OD matrices

36. The 2020 Car OD matrix of HOUTRANS includes cars and trucks. Therefore, 2020 HOUTRANS Car OD matrix was divided into Car and Truck. Ratio of Car and Truck was used 52:48, person trip base in 2002.

37. The Draft 2009 OD matrix was calculated by interpolation between the 2002 OD and the 2020 OD.

38. The number of HOUTRANS OD zones is 270, but this study has adopted three extra zones for a total of 273 zones, to enable detailed analysis of area along the project. Zone 2 zones along the project area were divided for detailed analysis using ratios of population in 2008. Zone 216 in HOUTRANS was divided into 216 and 273 and Zone 265 into 265,271 and 272.

e. 2009 Adjusted Draft OD Matrices

39. The Assignment was done with the draft 2009 OD matrices and 2009 network. Difference between results of assignment and traffic count surveys of N1A and N51 was analyzed. The difference ratio is used for adjustment of the 2009 draft OD matrices.

40. The difference in rates after the adjustment is 0.96 and 1.02. These differences are acceptable as 2009 Adjusted Draft OD Matrices. These are shown in Table 11 which show the

difference in ratio between Traffic Count Survey Result and Traffic Volume of Assignment in 2009 (Using Adjusted Draft 2009 OD matrices)

Table 11: Difference Ratio between the Traffic Count Survey and Assignment

	Survey	Assignment	B/A
	A	B	
N1A	52,900	50,587	0.96
N51	21,799	22,338	1.02

Unit : PCU/Day
Source: Consultant

f. OD matrices of traffic relating N1a and N51

41. OD matrices of traffic on National Highway 1A (near the starting point of the project) and 51 (near the end point of the project) were established using results of OD and Traffic count survey. Some trips may pass through two traffic survey sites. Thus double counted trips were corrected on the theoretical procedure.

42. The OD matrices relating NH1A and NH51 were adopted for part of 2009 OD matrices. The 2009 Adjusted OD matrices relating trips NH1A and NH51 were then inserted in the OD matrices.

g. Distribution pattern

43. The HOUTRANS distribution patterns were adopted and modified to the 2009 OD matrices, using the traffic data that was obtained on the traffic surveys for NH1A and NH51.

h. Calibration of the OD matrices

44. Incremental assignment was carried out using above road network and OD matrices. The differences between results of assignment and traffic count survey were 0.90 – 1.03 as shown in the table below, these differences are acceptable for the traffic demand model.

Table 12: Ratio between Traffic Count Survey Result & Volume of Assignment in 2009

N1A	Survey	Assignment	B/A	N51	Survey	Assignment	B/A
	A	B			A	B	
MC	52,804	50,745	0.96	MC	25,818	25,480	0.99
Car	5,550	5,373	0.97	Car	4,219	4,244	1.01
Bus	7,449	6,729	0.90	Bus	2,249	2,219	0.99
Truck	12,311	12,695	1.03	Truck	6,872	6,816	0.99

Unit : Vehicle/Day
Source: Consultant

2. Future OD and Road Network

a. Future Demand Forecast

i. Future Road Network:

45. Future road network is based on the HOUTRANS future road network was modified considering the latest Road Network Development Plan shown in Figure 2. This study used HOUTRANS data such as road capacity and operating speed for the Future Road Network.

46. The Ben Luc – Long Thanh Expressway will be part of Ring Road 3 and connect with National Highway 51 and Bien Hoa to Vung Tau expressway.

47. Road networks in 2026 and 2036 are assumed to be the same as the 2020 road network for the assignment. The 2016 road network is established considering the collected opening year (plan) information shown in Table 13. The opening date is assumed by consultants considering information from some organization such as DOT. All projects will be complete as per the 2020 master-plan

Table 13: Opening Dates & Service of New Major Roads

Highway	Opening Date	Situation		
		2016	2026	2036
Ho Chi Minh-Trung Luong Expressway	2009	✓	✓	✓
Trung Luong-Can Tho Expressway	2015	✓	✓	✓
Ring Road #4, HTL to RR#2	2015	✓	✓	✓
Ring Road #4, HTL to Southern HCMC Expy	2020		✓	✓
Ring Road #4, Southern HCMC Expy to N1	2020		✓	✓
Ring Road #4, N1 to Hwy 20	2020		✓	✓
Ring Road #4, Hwy 20 to Hwy 13	2015	✓	✓	✓
Ring Road #4, Hwy 13 to HLN Expy	2015	✓	✓	✓
Ring Road #4, HLN Expy to Hwy 1A	2015	✓	✓	✓
Ring Road #3, HTL to Hwy 20	2013	✓	✓	✓
Ring Road #3, Hwy 20 to HLN Expy	2013	✓	✓	✓
Ring Road #3, HLN Expy to Hwy 1A	2013	✓	✓	✓
Ring Road #3, Hwy 1A to HLD Expy	By 2020		✓	✓
Ring Road #3, HLD Expy to BT-LT Expy	By 2020		✓	✓
Southern Ho Chi Minh Expy Long An	2011	✓	✓	✓
Southern Ho Chi Minh Expy Tay Ninh	2015	✓	✓	✓
N1 National Highway	Existing	✓	✓	✓
Ho Chi Minh-Moc Bai Expressway	2015	✓	✓	✓
Ho Chi Minh-Loc Ninh Expressway	2015	✓	✓	✓
East-West Highway	2010	✓	✓	✓
Ring Road #2, SSP to Hwy 1A	2012	✓	✓	✓
Ring Road #2, Hwy 1A to HLN Expressway	Existing	✓	✓	✓
Ring Road #2, HLN Expressway to Q9	2010	✓	✓	✓
Ring Road #2, Q9 to SSP	2010	✓	✓	✓
Ring Road #2, South Saigon Parkway	Existing	✓	✓	✓

Highway	Opening Date	Situation		
		2016	2026	2036
Ho Chi Minh-Long Thanh-Dau Giay Expressway	Detail Design	✓	✓	✓
Ho Chi Minh-Lien Khuong Expy			✓	✓
Bien Hoa-Vung Tau Expressway	By 2020		✓	✓

Note: ✓= in service

48. According to the HOUTRANS concept, a mass transit system will be introduced by 2020, and public transportations such as the mass transit and bus will take 30% of the passenger traffic. However, the development of the mass transit system is delayed. Therefore, it is assumed that the Network in 2016 does not have a mass transit but the mass transit system will be developed for 2026 and 2036 network.

b. Future Toll

49. Currently in Vietnam tolls are charged as per an open system where each type of vehicle is charged as shown in Table 14. This derives a toll index for each type of vehicle. A closed type of toll system is proposed for the Project so that each type of vehicle will be charged the distance traveled at the rate shown for Toll Regime A: the base case.

Table 14: Current Tolls & the Proposed Toll Regime A: Base Case

Toll Rate Regime	Passenger Car	Minibus	Standard Bus	Small Truck	Big Truck	Container Truck
Current Toll	10,000 VND	15,000 VND	22,000 VND	22,000 VND	40,000 VND	80,000 VND
Toll Index	1.00	1.50	2.20	2.20	4.00	8.00
A: Base Case	685 VND/km	1,028 VND/km	1,507 VND/km	1,507 VND/km	2,740 VND/km	5,480 VND/km

50. The assumptions of toll system are;

- Base Case Toll for the BLLT project is Toll Regime A: 685 VND per kilometer for “Passenger Car” and the others shown in Table 14.
- Current toll of existing road will be as existing current toll
- Ho Chi Minh-Long Thanh-Dau Giay Expressway toll is Toll Regime A: 685 VND per kilometer for “Passenger Car” and the others shown in Table 14.
- Toll of Ring road 3, Ho Chi Minh – Trung Lung Expressway and Bien Hoa – Vung Tau Expressway are Toll Regime A: 685 VND per kilometer for “Passenger Car” and the others shown in Table 14.

3. Future OD matrices

a. Traffic Generation and Attraction Trip Volume

51. The generation and attraction trip volumes of Motorcycle, Car and Bus have relationship with GDP per capita, the generation and attraction volumes of Truck have relationship with GDP. Thus traffic forecasts were based on the elasticity of traffic volume growth rate to the

growth rates of GDP per capita and GDP. This study uses this relationship for demand forecast.

b. Transport Facilities Development Plan and Major Development

i. Port Relocation Expansion and Development Plan:

52. The HOUTRANS considered this matter. In addition JICA study forecast annual cargo Volume. On the other hand JETRO study estimated the traffic volume of Nha Be Port, Cat Lai Port Hiep Phuoc Port and Cai Mep –Thi Vai Port in 2010 2020 and 2030.

53. Total traffic volume is estimated considering JETRO estimation, and composition of each port is estimated from JICA study.

Table 15: Demands Forecast of Cargo through each port in the Region in 2020

	2020	2020
	Non Container	Container
	1000ton	1000TEU
Sai Gon/Tan Cang/Ben Nghe/VICT	7,500	760
Other Ports in HCMC Port Group	4,800	0
Cat Lai IZ Port	400	300
Hiep Phuoc Port	6,600	380
Cai Mep Thi Vai Port	9,500	4,750

Table 16: Cargo Traffic Demands Forecast through each port

	2016	2026	2036
Saigon and other Ports in HCMC	8,625	11,759	14,712
Cat Lai IZ Port	258	333	372
Hiep Phuoc Port	4,209	6,057	8,244
Cai Mep Thi Vai Port	29,831	40,853	51,530

Unit: PCU/Day
Source: Consultant

ii. Long Thanh International Airport:

54. According to the Prime Minister's Decision No. 703/QD-TTg dated 20/7/2005 on approving the plan of location, scale and functions of Long Thanh International Airport, the capacity of the airport is proposed to be 100 million passengers/year and 5 million tons of cargo per year. The time for operation is proposed to be about 2015. Construction and development of Long Thanh Airport will create car, bus, and truck traffic flows.

Table 17: Planning of Air Transportation in Southern Viet Nam

	2015	2020	2030
Total passenger: (Million pax)	13.657	20.279	43.800
- International pass. (Million pax)	8.683	12.758	28.032
- Domestic pass. (Million pax)	4.974	7.521	15.768
Total Cargo: (Million T)	0.400	0.600	1.500

Source: Long Thanh Airport Planning, Vietnam Civil Aviation Bureau.

55. Consultant estimated the traffic volume based on the forecast of the Vietnam Civil Aviation Bureau' Plan.

56. Assuming that:

- About 80% of the air passengers will be to and from Ho Chi Minh City, Mekong Delta and other province. 20% will go to inter zonal or near zones trips.
- 80% of above passengers will use public transport such as bus and 20% will use the Taxi or private cars.
- Cargo truck average capacity is 10ton.

57. The results of the estimation, developed traffic volume is as follow;

Table 18: Estimation of the developed traffic volume

	2016	2026	2036
Bus	2,592	4,148	12,190
Car(Taxi)	4,319	6,913	20,317
Truck	4,952	8,227	29,672
Total PCU	11,863	19,288	62,180

Unit PCU/day
Source: Consultant

iii. Other developments such as Nhon Trach Industrial Park:

58. The HOUTRANS model considered the industrial park development such as Nhon Trach and Hiep Phuoc Port. predicted that the population will increase. Our study accept this trend for the traffic forecast.

4. Total Generation and Attractions Trips

59. The total number of generation and attraction trips in the Study Area is shown in the table below. Distribution pattern is based on HOUTRANS Distribute Pattern.

Table 19: Generation and Attraction Trips

	2002	2009	2016	2020	2026	2036
MC	10,173,480	11,222,010	12,064,826	12,575,302	13,375,726	14,823,378
Car	262,312	610,261	1,230,787	1,690,368	2,580,520	4,197,197
Bus	597,668	1,506,765	3,334,308	4,819,735	7,940,687	14,430,295
Truck	242,805	556,903	1,257,512	1,835,293	3,005,001	5,246,697
Total	11,278,267	13,897,948	17,889,449	20,922,718	26,903,960	38,699,603

Unit: Person trip/day
Source: Consultant

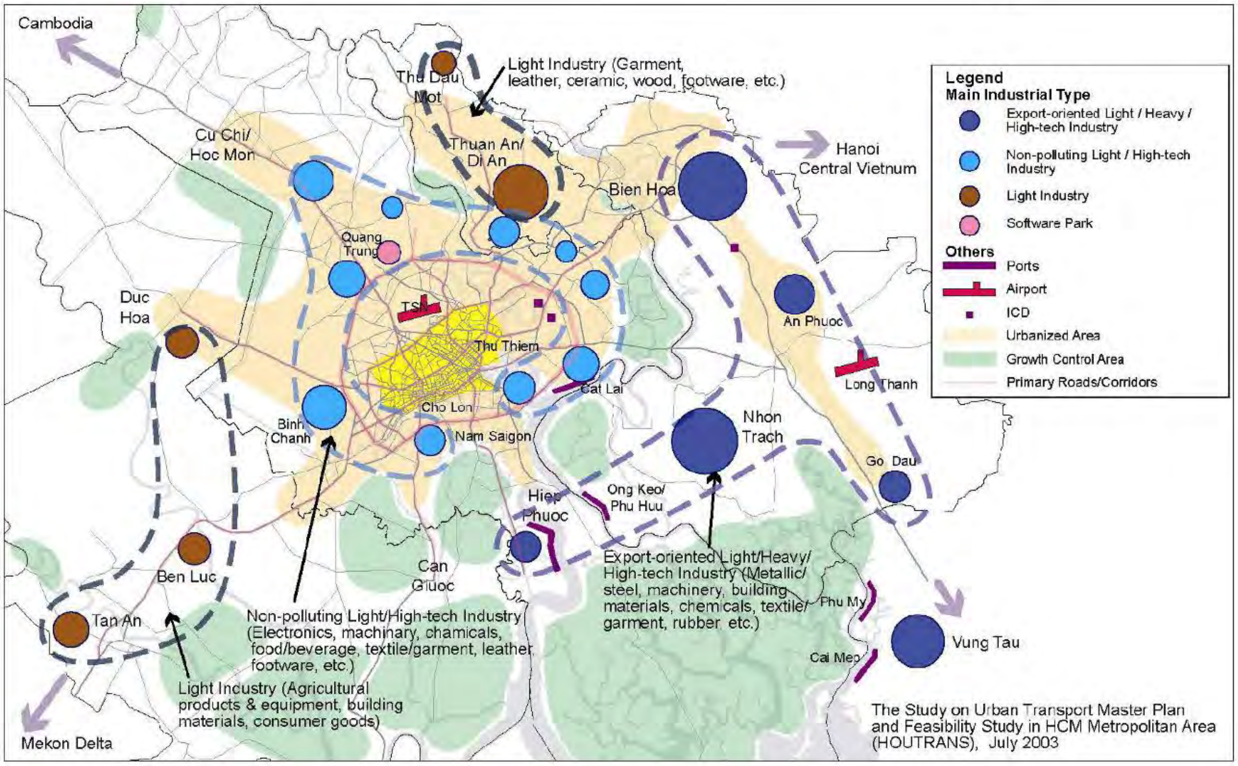


Figure 7: Location of industrial Parks in the HOUTRANS Study Area

Source: HOUTRANS

5. Assignment and Traffic Demand Analysis Software Package

60. The study team has used the HOUTRANS model for the traffic assignment model. Incremental assignment with method of ascertaining minimum pass has been carried out and the model run for a range of toll rates.

61. The study team has also used the JICA STRADA software package for traffic demand analysis which HOUTRANS also used for the demand forecasts. The JICA STRADA soft ware was developed by JICA

D. Traffic Forecast Output

1. Future Traffic Volume

62. The case of traffic volume forecast of the Project (Base Case Toll Regime A: 685VND/Km for car) in future are shown in the table below.

Table 20: Future Daily Traffic Volume in 2016 (Toll Regime A: 685VND/Km for Car)

Unit: PCU/Day

	IC1- IC2	IC2- IC3	IC3- IC4	IC4- IC5	IC5- IC6	IC6- IC7	IC7- IC8
Car	2,848	754	136	320	320	192	
Bus	1,160	1,012	216	242	242	166	
Truck	18,732	11,300	6,340	17,274	17,274	8,792	
2016	22,740	13,066	6,692	17,836	17,836	9,150	0
	IC1- IC2	IC2- IC3	IC3- IC4	IC4- IC5	IC5- IC6	IC6- IC7	IC7- IC8
Car	9,777	4,541	4,189	8,444	5,243	2,553	266
Bus	1,662	2,965	2,069	1,291	1,293	927	553
Truck	52,776	36,075	30,637	55,203	51,893	45,009	24,878
2026	64,215	43,581	36,895	64,938	58,429	48,489	25,697
	IC1- IC2	IC2- IC3	IC3- IC4	IC4- IC5	IC5- IC6	IC6- IC7	IC7- IC8
Car	19,452	13,168	12,411	17,512	11,971	5,023	1,015
Bus	2,651	6,254	4,150	2,374	2,104	1,464	906
Truck	83,890	90,195	79,857	108,364	94,929	84,075	46,868
2036	105,993	109,617	96,418	128,250	109,004	90,562	48,789

Source: Consultant

a. With and Without Project Network Results

63. The HOUTRANS Model calculated the total network kilometres and hours travelled by each type of vehicle in the "With Projects Case (Base Case)" and then again the "Without Project Case". The project expressway benefits are derived directly by traffic being diverted from QL 1A and QL 51 so shorting the distance travelled and also by relieving congestion generally on the HCMC traffic network. Please note that as the expressway reaches capacity there is a saturation point reached. The results of calculation are shown in the two following tables. Table 21 gives the kilometres saved in the total network between the two cases.

Table 21: Network Kilometres Saved between With Project (Base Case) and Without Project Cases

Year	Passenger Car	Minibus	Standard Bus	Small Truck	Big Truck	Container Truck
2016	248,480	157,867	67,224	195,967	203,538	54,270
2017	346,443	220,106	93,727	273,227	283,783	75,665
2018	444,406	282,345	120,230	350,486	364,027	97,061
2019	542,369	344,584	146,733	427,746	444,272	118,457
2020	640,332	406,823	173,236	505,005	524,517	139,853
2021	738,295	469,062	199,739	582,265	604,761	161,248
2022	836,258	531,301	226,242	659,525	685,006	182,644
2023	934,221	593,540	252,745	736,784	765,251	204,040
2024	1,032,183	655,779	279,248	814,044	845,495	225,436
2025	1,130,146	718,018	305,751	891,304	925,740	246,831
2026	1,228,109	780,257	332,254	968,563	1,005,985	268,227
2027	1,341,762	852,464	363,002	1,058,197	1,099,081	293,050
2028	1,430,264	908,693	386,946	1,127,995	1,171,576	312,379
2029	1,506,126	956,890	407,469	1,187,825	1,233,717	328,948
2030	1,575,883	1,001,209	426,341	1,242,839	1,290,858	344,183

Year	Passenger Car	Minibus	Standard Bus	Small Truck	Big Truck	Container Truck
2031	1,639,894	1,041,877	443,659	1,293,322	1,343,291	358,164
2032	1,676,769	1,065,305	453,635	1,322,404	1,373,496	366,217
2033	1,691,297	1,074,535	457,566	1,333,862	1,385,397	369,391
2034	1,702,120	1,081,411	460,494	1,342,398	1,394,262	371,754
2035	1,712,589	1,088,063	463,326	1,350,654	1,402,838	374,041
2036	1,722,754	1,094,520	466,076	1,358,671	1,411,164	376,261

64. Table 22 gives the hours saved in the total network between the two cases.

Table 22: Network Hours Saved between With Project (Base Case) and Without Project Cases

Year	Passenger Car	Minibus	Standard Bus	Small Truck	Big Truck	Container Truck
2016	7,965	5,060	2,155	6,281	6,524	1,740
2017	15,533	9,869	4,202	12,250	12,723	3,392
2018	23,101	14,677	6,250	18,219	18,923	5,045
2019	30,669	19,485	8,297	24,188	25,122	6,698
2020	38,238	24,294	10,345	30,157	31,322	8,351
2021	45,806	29,102	12,392	36,126	37,521	10,004
2022	53,374	33,910	14,440	42,094	43,721	11,657
2023	60,943	38,719	16,488	48,063	49,920	13,310
2024	68,511	43,527	18,535	54,032	56,120	14,963
2025	76,079	48,336	20,583	60,001	62,319	16,616
2026	83,648	53,144	22,630	65,970	68,519	18,269
2027	103,623	65,835	28,034	81,723	84,881	22,632
2028	121,218	77,013	32,794	95,600	99,293	26,475
2029	137,155	87,139	37,106	108,169	112,348	29,955
2030	151,974	96,554	41,115	119,856	124,487	33,192
2031	165,737	105,298	44,839	130,710	135,761	36,198
2032	176,218	111,957	47,674	138,977	144,346	38,487
2033	183,729	116,729	49,706	144,900	150,499	40,128
2034	190,237	120,863	51,467	150,032	155,829	41,549
2035	196,189	124,645	53,077	154,727	160,705	42,849
2036	201,669	128,127	54,560	159,048	165,193	44,046

2. Other Two Scenarios

65. Two cases for the traffic volume in 2026 (10years after opening) are forecasted for comparison between three road development scenarios. The results are as shown in below.

- **Case 1.** The Bien Hoa-Vung Tao Expressway is not constructed
- **Case 2.** Ring Road #3 is not constructed (or delayed) so the BL-LT Expressway is not connected to RR#3 and the HCMC-LT-DG Expressway

Table 23: Traffic Volume by Sections in 2026

	IC1- IC2	IC2- IC3	IC3- IC4	IC4- IC5	IC5- IC6	IC6- IC7	IC7- IC8
Base Case	64,215	43,581	36,895	64,938	58,429	48,489	25,697
Case 1	61,185	47,860	41,826	61,155	46,808	34,387	-
Case 2	61,474	49,262	40,005	70,487	50,913	37,129	21,026

Unit : PCU/Day

Table 24: Traffic Volume Comparison between Network Cases in 2026

	PCU*km	Ratio to Base case
Base Case	3,032,192	1.00
Case 1	2,738,134	0.90
Case 2	2,980,808	0.98

E. Traffic Flow at different Tolls

66. The traffic forecast model was rerun under various toll rate regimes as shown below:

Table 25: Toll Rate in VND per km by type of vehicle used to Calculate Toll Revenue

Toll Rate Regime	Passenger Car	Minibus	Standard Bus	Small Truck	Big Truck	Container Truck
Current	10,000 VND	15,000 VND	22,000 VND	22,000 VND	40,000 VND	80,000 VND
Toll Index	1.00	1.50	2.20	2.20	4.00	8.00
A Base Case	685 VND/km	1,028 VND/km	1,507 VND/km	1,507 VND/km	2,740 VND/km	5,480 VND/km
B	754 VND/km	1,131 VND/km	1,659 VND/km	1,659 VND/km	3,016 VND/km	6,032 VND/km
C	800 VND/km	1,200 VND/km	1,760 VND/km	1,760 VND/km	3,200 VND/km	6,400 VND/km
D	890 VND/km	1,335 VND/km	1,958 VND/km	1,958 VND/km	3,560 VND/km	7,120 VND/km
E	959 VND/km	1,439 VND/km	2,110 VND/km	2,110 VND/km	3,836 VND/km	7,672 VND/km
F	1,000 VND/km	1,500 VND/km	2,200 VND/km	2,200 VND/km	4,000 VND/km	8,000 VND/km
G	1,096 VND/km	1,644 VND/km	2,411 VND/km	2,411 VND/km	4,384 VND/km	8,768 VND/km

67. As the toll rate increases the traffic demand will decrease as shown in the following chart.

68. These traffic numbers are used to calculate the toll revenue per year for each of the six toll regimes. Please note that once the traffic forecast reaches 70,000 pcu’s per day for each section then that is the saturation point and traffic cannot go above this amount. In the following Tables once the number is shaded it indicates that saturation has been reached.

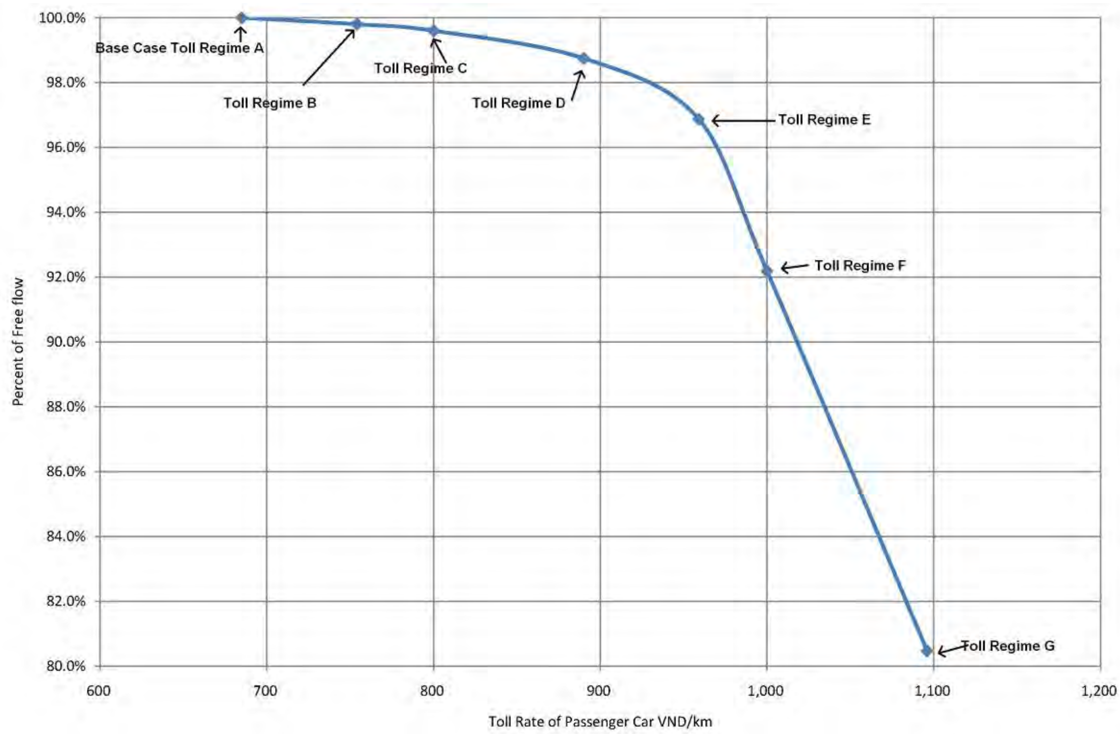


Figure 8: As the Toll Rate Increases the Traffic Decreases

Table 26: Traffic Forecast in PCU's per day for Toll Regime A (Car = 685 VND/KM)

Year	IC1- IC2	IC2- IC3	IC3- IC4	IC4- IC5	IC5- IC6	IC6- IC7	IC7- IC8
2016	22,740	13,066	6,693	17,836	17,836	9,150	
2017	26,873	14,520	8,393	21,817	21,446	12,960	0
2018	31,011	16,326	10,387	25,959	25,157	16,798	0
2019	35,149	18,490	12,674	30,265	28,966	20,665	0
2020	39,293	21,009	15,255	34,731	32,876	24,559	10,617
2021	43,439	23,884	18,128	39,362	36,885	28,478	13,204
2022	47,590	27,112	21,296	44,151	40,993	32,427	15,767
2023	51,740	30,696	24,755	49,106	45,203	36,402	18,301
2024	55,895	34,636	28,509	54,221	49,511	40,403	20,811
2025	60,054	38,931	32,557	59,498	53,920	44,433	23,294
2026	64,214	43,582	36,896	64,939	58,430	48,490	25,753
2027	68,379	48,587	41,530	70,000	63,038	52,574	28,184
2028	70,000	53,947	46,455	70,000	67,745	56,684	30,589
2029	70,000	59,662	51,675	70,000	70,000	60,826	32,968
2030	70,000	65,734	57,187	70,000	70,000	64,991	35,322
2031	70,000	70,000	62,993	70,000	70,000	69,183	37,648
2032	70,000	70,000	69,093	70,000	70,000	70,000	39,949
2033	70,000	70,000	70,000	70,000	70,000	70,000	42,225
2034	70,000	70,000	70,000	70,000	70,000	70,000	44,475
2035	70,000	70,000	70,000	70,000	70,000	70,000	46,697
2036	70,000	70,000	70,000	70,000	70,000	70,000	48,894

Table 27: Traffic Forecast in PCU's per day for Toll Regime B (Car = 754 VND/KM)

Year	IC1- IC2	IC2- IC3	IC3- IC4	IC4- IC5	IC5- IC6	IC6- IC7	IC7- IC8
2016	22,695	13,040	6,678	17,800	17,800	9,133	
2017	26,821	14,490	8,377	21,775	21,404	12,935	0
2018	30,948	16,294	10,366	25,909	25,107	16,765	0
2019	35,081	18,454	12,650	30,206	28,909	20,624	0
2020	39,216	20,968	15,224	34,662	32,810	24,508	10,595
2021	43,352	23,836	18,093	39,284	36,812	28,421	13,177
2022	47,494	27,059	21,254	44,066	40,914	32,362	15,734
2023	51,638	30,635	24,707	49,009	45,113	36,329	18,266
2024	55,784	34,567	28,452	54,112	49,413	40,323	20,771
2025	59,935	38,855	32,491	59,381	53,813	44,345	23,249
2026	64,087	43,495	36,824	64,810	58,313	48,394	25,701
2027	68,243	48,491	41,448	70,000	62,912	52,470	28,128
2028	70,000	53,841	46,362	70,000	67,610	56,573	30,529
2029	70,000	59,544	51,572	70,000	70,000	60,704	32,904
2030	70,000	65,602	57,075	70,000	70,000	64,861	35,252
2031	70,000	70,000	62,867	70,000	70,000	69,048	37,574
2032	70,000	70,000	68,955	70,000	70,000	70,000	39,871
2033	70,000	70,000	70,000	70,000	70,000	70,000	42,142
2034	70,000	70,000	70,000	70,000	70,000	70,000	44,386
2035	70,000	70,000	70,000	70,000	70,000	70,000	46,606
2036	70,000	70,000	70,000	70,000	70,000	70,000	48,798

Table 28: Traffic Forecast in PCU's per day for Toll Regime C (Car = 800 VND/KM)

Year	IC1- IC2	IC2- IC3	IC3- IC4	IC4- IC5	IC5- IC6	IC6- IC7	IC7- IC8
2016	22,648	13,013	6,665	17,765	17,765	9,113	0
2017	26,766	14,460	8,359	21,730	21,360	12,910	0
2018	30,886	16,261	10,345	25,856	25,056	16,733	0
2019	35,011	18,416	12,622	30,143	28,849	20,581	0
2020	39,136	20,925	15,195	34,592	32,744	24,460	10,574
2021	43,265	23,788	18,056	39,203	36,738	28,363	13,152
2022	47,397	27,004	21,211	43,977	40,830	32,296	15,704
2023	51,533	30,573	24,657	48,908	45,022	36,255	18,229
2024	55,672	34,498	28,396	54,004	49,315	40,242	20,727
2025	59,814	38,776	32,426	59,260	53,705	44,255	23,203
2026	63,957	43,407	36,748	64,679	58,196	48,296	25,648
2027	68,104	48,392	41,362	70,000	62,785	52,364	28,071
2028	70,000	53,732	46,268	70,000	67,474	56,459	30,467
2029	70,000	59,424	51,468	70,000	70,000	60,582	32,836
2030	70,000	65,470	56,958	70,000	70,000	64,731	35,181
2031	70,000	70,000	62,740	70,000	70,000	68,908	37,498
2032	70,000	70,000	68,815	70,000	70,000	70,000	39,791
2033	70,000	70,000	70,000	70,000	70,000	70,000	42,056
2034	70,000	70,000	70,000	70,000	70,000	70,000	44,296
2035	70,000	70,000	70,000	70,000	70,000	70,000	46,511
2036	70,000	70,000	70,000	70,000	70,000	70,000	48,699

Table 29: Traffic Forecast in PCU's per day for Toll Regime D (Car = 890 VND/KM)

Year	IC1- IC2	IC2- IC3	IC3- IC4	IC4- IC5	IC5- IC6	IC6- IC7	IC7- IC8
2016	22,455	12,902	6,609	17,612	17,612	9,036	
2017	26,537	14,337	8,288	21,543	21,178	12,799	0
2018	30,623	16,121	10,257	25,635	24,841	16,589	0
2019	34,710	18,260	12,517	29,887	28,603	20,405	0
2020	38,802	20,746	15,063	34,296	32,465	24,250	10,484
2021	42,896	23,584	17,903	38,869	36,422	28,122	13,040
2022	46,993	26,773	21,030	43,601	40,481	32,021	15,568
2023	51,093	30,312	24,446	48,492	44,639	35,945	18,073
2024	55,196	34,203	28,153	53,543	48,893	39,897	20,551
2025	59,301	38,445	32,148	58,753	53,246	43,877	23,003
2026	63,411	43,035	36,434	64,126	57,698	47,882	25,430
2027	67,523	47,979	41,009	69,657	62,249	51,916	27,831
2028	70,000	53,273	45,875	70,000	66,899	55,976	30,207
2029	70,000	58,916	51,028	70,000	70,000	60,064	32,556
2030	70,000	64,911	56,471	70,000	70,000	64,178	34,879
2031	70,000	70,000	62,206	70,000	70,000	68,318	37,179
2032	70,000	70,000	68,227	70,000	70,000	70,000	39,450
2033	70,000	70,000	70,000	70,000	70,000	70,000	41,696
2034	70,000	70,000	70,000	70,000	70,000	70,000	43,918
2035	70,000	70,000	70,000	70,000	70,000	70,000	46,112
2036	70,000	70,000	70,000	70,000	70,000	70,000	48,282

Table 30: Traffic Forecast in PCU's per day for Toll Regime E (Car = 959 VND/KM)

Year	IC1- IC2	IC2- IC3	IC3- IC4	IC4- IC5	IC5- IC6	IC6- IC7	IC7- IC8
2016	22,029	12,658	6,483	17,278	17,278	8,865	
2017	26,033	14,065	8,131	21,135	20,775	12,555	0
2018	30,042	15,816	10,062	25,149	24,369	16,273	0
2019	34,052	17,913	12,278	29,319	28,061	20,019	0
2020	38,065	20,352	14,779	33,646	31,848	23,791	10,285
2021	42,082	23,137	17,562	38,131	35,732	27,587	12,791
2022	46,101	26,265	20,631	42,772	39,713	31,413	15,272
2023	50,122	29,737	23,983	47,570	43,789	35,264	17,729
2024	54,149	33,554	27,620	52,526	47,965	39,140	20,161
2025	58,175	37,715	31,539	57,639	52,236	43,044	22,566
2026	62,207	42,220	35,743	62,909	56,603	46,974	24,948
2027	66,243	47,068	40,231	68,335	61,067	50,931	27,303
2028	70,000	52,260	45,003	70,000	65,629	54,913	29,632
2029	70,000	57,798	50,060	70,000	70,000	58,924	31,939
2030	70,000	63,678	55,400	70,000	70,000	62,960	34,219
2031	70,000	69,904	61,023	70,000	70,000	67,021	36,471
2032	70,000	70,000	66,932	70,000	70,000	70,000	38,702
2033	70,000	70,000	70,000	70,000	70,000	70,000	40,905
2034	70,000	70,000	70,000	70,000	70,000	70,000	43,084
2035	70,000	70,000	70,000	70,000	70,000	70,000	45,240
2036	70,000	70,000	70,000	70,000	70,000	70,000	47,366

Table 31: Traffic Forecast in PCU's per day for Toll Regime F (Car = 1,000 VND/KM)

Year	IC1- IC2	IC2- IC3	IC3- IC4	IC4- IC5	IC5- IC6	IC6- IC7	IC7- IC8
2016	20,961	12,045	6,169	16,442	16,442	8,435	
2017	24,773	13,384	7,737	20,111	19,771	11,948	0
2018	28,586	15,052	9,574	23,930	23,192	15,486	0
2019	32,403	17,045	11,685	27,899	26,703	19,049	0
2020	36,224	19,368	14,063	32,018	30,307	22,639	9,788
2021	40,046	22,017	16,712	36,286	34,003	26,253	12,173
2022	43,870	24,993	19,632	40,703	37,791	29,893	14,534
2023	47,697	28,298	22,822	45,269	41,670	33,557	16,872
2024	51,527	31,929	26,282	49,984	45,643	37,246	19,185
2025	55,361	35,890	30,012	54,850	49,708	40,961	21,475
2026	59,198	40,175	34,014	59,865	53,863	44,700	23,740
2027	63,036	44,790	38,284	65,029	58,112	48,467	25,980
2028	66,876	49,732	42,824	70,000	62,453	52,256	28,200
2029	70,000	55,000	47,637	70,000	66,885	56,071	30,393
2030	70,000	60,597	52,717	70,000	70,000	59,913	32,562
2031	70,000	66,521	58,070	70,000	70,000	63,778	34,707
2032	70,000	70,000	63,692	70,000	70,000	67,670	36,828
2033	70,000	70,000	69,585	70,000	70,000	70,000	38,926
2034	70,000	70,000	70,000	70,000	70,000	70,000	40,998
2035	70,000	70,000	70,000	70,000	70,000	70,000	43,049
2036	70,000	70,000	70,000	70,000	70,000	70,000	45,075

Table 32: Traffic Forecast in PCU's per day for Toll Regime G (Car = 1,096 VND/KM)

Year	IC1- IC2	IC2- IC3	IC3- IC4	IC4- IC5	IC5- IC6	IC6- IC7	IC7- IC8
2016	18,298	10,513	5,384	14,353	14,353	7,363	
2017	21,626	11,683	6,754	17,556	17,257	10,430	0
2018	24,953	13,137	8,359	20,889	20,243	13,518	0
2019	28,285	14,879	10,200	24,353	23,309	16,628	0
2020	31,618	16,905	12,275	27,947	26,454	19,762	8,543
2021	34,954	19,218	14,589	31,672	29,682	22,915	10,624
2022	38,292	21,816	17,137	35,528	32,987	26,093	12,687
2023	41,634	24,700	19,921	39,514	36,374	29,292	14,727
2024	44,977	27,871	22,941	43,630	39,841	32,512	16,746
2025	48,323	31,326	26,196	47,878	43,387	35,753	18,745
2026	51,672	35,070	29,689	52,254	47,017	39,019	20,722
2027	55,022	39,097	33,417	56,762	50,725	42,304	22,679
2028	58,377	43,410	37,381	61,401	54,512	45,614	24,614
2029	61,732	48,010	41,580	66,168	58,382	48,943	26,529
2030	65,089	52,894	46,018	70,000	62,332	52,298	28,422
2031	68,452	58,065	50,688	70,000	66,360	55,670	30,296
2032	70,000	63,523	55,598	70,000	70,000	59,067	32,148
2033	70,000	69,263	60,741	70,000	70,000	62,486	33,977
2034	70,000	70,000	66,120	70,000	70,000	65,926	35,787
2035	70,000	70,000	70,000	70,000	70,000	69,389	37,575
2036	70,000	70,000	70,000	70,000	70,000	70,000	39,344

69. The toll revenues per year are shown in Table 33 below.

Table 33: Total Toll Revenue by year in Million VND

Year No.	Year	Toll Rate Regime A	Toll Rate Regime B	Toll Rate Regime C	Toll Rate Regime D	Toll Rate Regime E	Toll Rate Regime F	Toll Rate Regime G
1	2016	312,153	343,033	362,857	400,263	423,327	419,684	401,674
2	2017	375,382	412,547	436,404	481,386	509,117	504,748	482,983
3	2018	442,142	485,900	514,092	567,065	599,652	594,526	568,886
4	2019	512,480	563,223	595,783	657,271	695,008	689,059	659,425
5	2020	589,855	648,195	685,762	756,449	799,879	793,017	758,896
6	2021	668,125	734,231	776,757	856,902	906,039	898,180	859,612
7	2022	749,863	824,111	871,865	961,752	1,016,914	1,008,060	964,875
8	2023	835,208	917,880	970,979	1,071,181	1,132,588	1,122,778	1,074,585
9	2024	924,056	1,015,432	1,074,281	1,185,155	1,253,053	1,242,145	1,188,855
10	2025	1,016,431	1,117,030	1,181,702	1,303,678	1,378,328	1,366,394	1,307,754
11	2026	1,112,361	1,222,430	1,293,179	1,426,620	1,508,330	1,495,273	1,431,127
12	2027	1,209,438	1,329,761	1,407,497	1,554,182	1,643,107	1,628,950	1,559,026
13	2028	1,284,877	1,412,744	1,495,392	1,653,970	1,758,364	1,765,075	1,691,527
14	2029	1,345,244	1,480,089	1,567,709	1,738,745	1,859,984	1,872,432	1,828,524
15	2030	1,393,249	1,532,875	1,623,472	1,800,374	1,925,024	1,966,243	1,962,645
16	2031	1,435,493	1,579,875	1,673,797	1,858,771	1,992,980	2,033,610	2,073,452
17	2032	1,454,085	1,600,683	1,696,195	1,885,589	2,026,696	2,089,135	2,180,478
18	2033	1,457,048	1,604,343	1,700,495	1,892,360	2,038,687	2,121,229	2,250,671
19	2034	1,457,642	1,604,993	1,701,179	1,893,111	2,039,470	2,123,559	2,292,544
20	2035	1,458,288	1,605,708	1,701,932	1,893,940	2,040,339	2,124,404	2,324,062
21	2036	1,458,924	1,606,404	1,702,665	1,894,745	2,041,178	2,125,224	2,327,406
Total Revenue		**21,492,344**	**23,641,487**	**25,033,995**	**27,733,511**	**29,588,064**	**29,983,725**	**30,189,008**

70. The maximum total toll revenue amount is actually produced by Toll Regime G but we have recommended using Toll Regime F as the optimum rate. It produces a similar total amount as G but in the critical early years also produces more revenue.

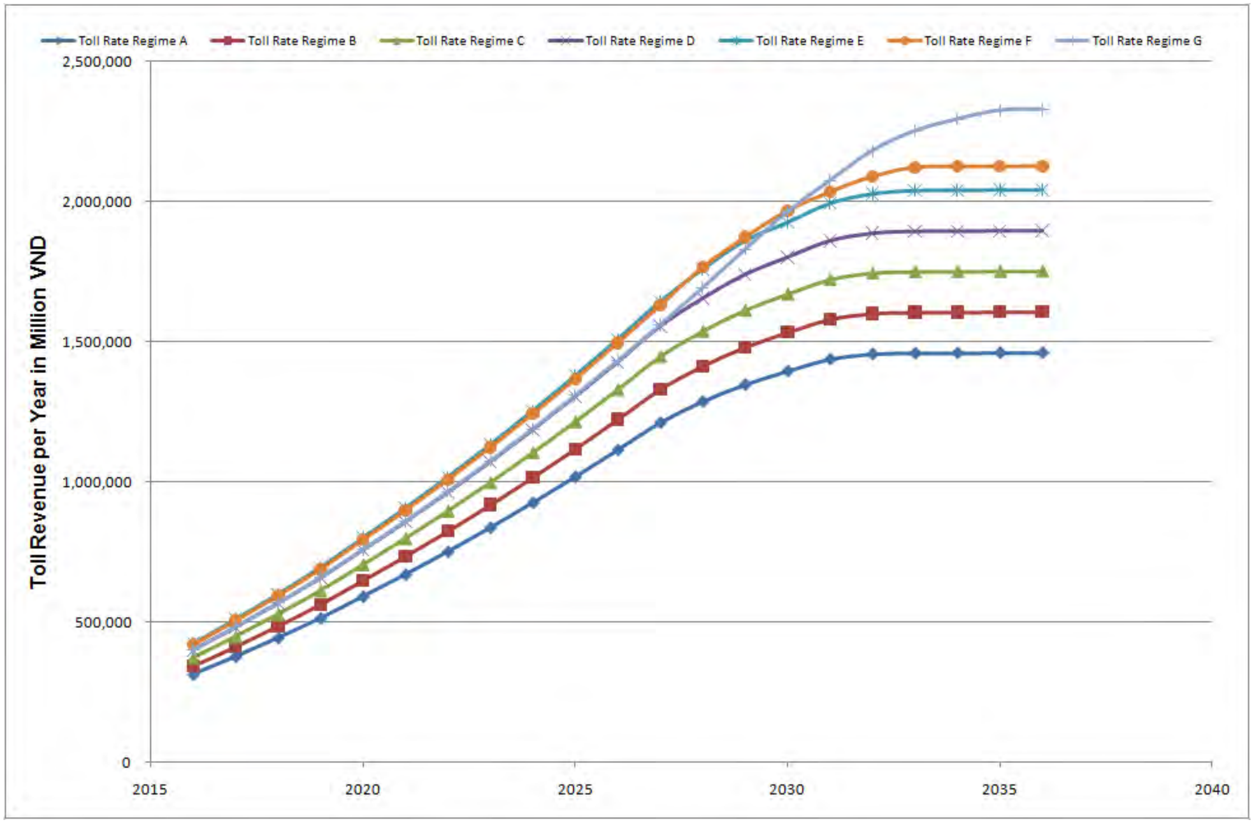


Figure 9: Toll Revenue per year by toll rate regime

F. Traffic Flow at Interchanges

71. Traffic Flows at the interchange were calculated in 2026 and 2036. These are shown in detail in Appendix B: Traffic Demand and Flow Analysis.

III. HIGHWAY ENGINEERING

A. Alignment Selection

72. There are two original and separate reports on the Ben Luc – Long Thanh Expressway. The "Project Investment Report" that was undertaken by TEDIS, and the JETRO study that was carried out by Nippon Engineering Consultants. Both were completed in 2008. The general alignment common to both reports starts from an interchange point with Ho Chi Minh–Trung Luong expressway and connects with RR3 at Ben Luc district, Long An province, and ends at the intersection point with the proposed Bien Hoa – Vung Tau expressway in Long Thanh District, Dong Nai province. The alignment runs from the West to the East, crosses Long An province, Ho Chi Minh City and Dong Nai province. Total length of the expressway is about 58km.

73. The previous documents of TEDIS and NEC were carefully reviewed. The information in these documents was updated using other relevant data that was collected and with all the master plans along the project alignment. The project area was surveyed by the TA staff. , purchased 3D digital map and satellite map with the parameters of coordinate and elevation as follows:

74. The most important task is to set out the previously studied alignments on the 3-D mapping to refine the alignment and to ensure that the comments made by the authorities are respected and action taken. Based on study of satellite photos, topographic and geological maps, and master-plans, the suitability of the proposed corridor and alignment will be considered and alternatives drawn up if appropriate.

75. The Project Coordinate System is shown in Table 34 that was used in the satellite and 3-D maps. The collected and updated master plans along the project area have been incorporated to the project map. The alignment was reviewed and adjusted so that locally the sensitive locations were avoided. Generally the crossing of planned areas, dense residential areas, temples, pagodas, cemetery, religious areas along the alignment were avoided as much as possible. The Consultant has already reported the alignment to TA Inception Mission of ADB, Ministry of Transport and relevant departments: Departments of Transport of Long An Province, Ho Chi Minh City and Dong Nai Province. The result of this was that alignment alternative 1 has been selected and agreed to, specifically as follows:

Table 34: Project Coordinate System

Coordinate system	Central meridian	Zone	Deformation coefficient K	Elevation system
VN2000	105^0 45'	30	0.9999	National Hon Dau Island

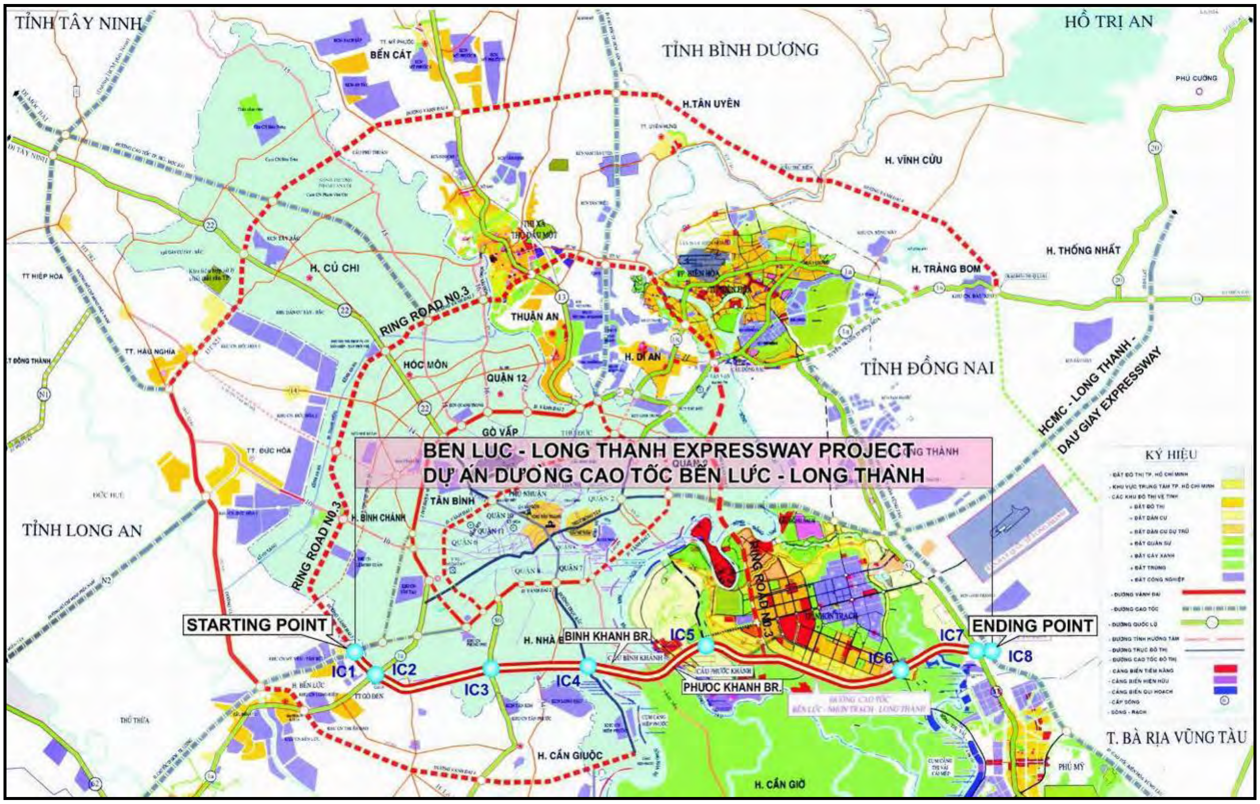


Figure 10: Ben Luc Long Thanh Expressway and the 2020 Highway Network

1. Alignment in Long An Province

76. The alignment runs intermittently through Long An province from Km 0 – Km 10. The starting point is located in Ben Luc district on the HCMC-Trung Luong expressway and connects to Ring Road No.3. From here the alignment goes to the south-east direction and crosses National Highway NH1A at Km 3+400 where there are the least number of houses on the both sides of the alignment (at Km1923+700 on NH1A). From Km 4 to Km 10, the alignment goes parallel with the border between Binh Chanh and Can Giuoc Districts, at Km 6 the alignment was adjusted to avoid the resettlement area that is under construction by the Five Stars International JSC (50m away from the right side of the alignment). At Km 8+200 the alignment crosses a residential area and the Hai Son Industrial Zone whose master plans were approved and land acquisition has already been carried out. As the expressway is designed based on strict design criteria and control points, it is not possible to avoid the whole Hai Son planning area. The alignment was adjusted so the smallest area was impacted.

77. Katahira & Engineers International (KEI) presented the alignment in Long An province in the meeting chaired by Long An Department of Transport on 04th June 2009. Participants of the meeting comprised of provincial agencies and departments of Long An and People's Committees of Ben Luc and Can Giuoc districts. Basically, the alignment proposed by the Consultant has been agreed by all the participants of the meeting (as per the Notice No. 74/TB-SGTVT dated 08th June 2009) and approved by the Letter No. 3219/UBND-CN dated 22nd September 2009 of Long An People's Committee.

78. The total length within Long An Province is 4.6km including:

- Ben Luc district, L = 2.20km
- Can Giuoc district, L = 2.40km
- There is one interchange at HCMC - Trung Luong Expressway.

2. Alignment in Ho Chi Minh City

79. In HCMC the alignment runs through Binh Chanh, Nha Be and Can Gio districts from Km 2+200 to Km 30+500, specifically:

80. At Binh Chanh district: from Km 2+200 to Km 17+100 crossing Binh Chanh, Tan Quy Tay, Hung Long and Da Phuoc Communes, the alignment is basically in accordance with the master plan of Binh Chanh District. The alignment was modified to avoid the Da Phuoc Waste Treatment Complex as requested by HCMC People's Committee (Letter No. 8197/UBND-DT dated 16th December 2005).

81. At Nha Be and Can Gio districts from Km 17+100 to Km 30+500 where there are several existing works as well as complicated and sensitive master plans. The alignment goes through the following communes: Nhon Duc (the alignment was revised to avoid the Nhon Duc Cemetery as requested by People's Committee of Nha Be District at Letter No. 643/CV-UBND dated 28th July 2006). Long Thoi, Binh Khanh. At the location for crossing over the Soai Rap and Long Tau rivers, according to the previous study by TEDIS and JETRO the alignment ran between the 220KV and 500KV overhead transmission lines (OTL). The distance between the two OTL lines is about 100m on the West bank of Soai Rap River (dense population location) and 180m in the middle and the opposite bank of the river in Can Gio District. Thus, the alignment location is not convenient for the construction of long span bridge as well as operation of the bridge in future. On the East side of the Long Tau river (Dong Nai province side), the alignment crosses Phu Huu 1 port and Dong Nai People's Committee had issued the letter No. 8156/TTr-UBND dated 01/10/2008 requesting for the adjustment of the project alignment to avoid the Port.

82. At the river crossing locations, The TA has studied three alternative alignments, specifically as follows:

a. Alternative 1 (South alignment alternative)

83. To overcome the disadvantages of the previous alignment studied by TEDIS and JETRO, and avoid conflict with the water pipelines in Can Gio area, avoid affecting the 500KV and 220KV OTL power lines, and Phu Huu 1 port and the existing dense residential area on Nguyen Van Tao street. The alignment runs on the south side and 120m away from the existing 500KV OTL power line. There is an overlap of about 20m-30m of the area being studied for the project by Vietnam Maritime Administration (from Km 22 to Km 23) thus its master plan can be adjusted (Letter No. 517/UBND-PCT dated 16/6/2009 of People's Committee of Nha Be District).

i. Advantages:

- In accordance with HCMC master plan up to 2020 approved by the Prime Minister at the Decision No.101/QD-TTg dated 22 Jan. 2007.
- The alternative has been agreed to by TA Inception Mission of ADB, Ministry of Transport and HCMC Department of Transport as per the Notice No. 301/TB-BGTVT dated 30/6/2009 of MOT and Notice No. 270/TB-SGTVT dated 09/6/2009 of HCMC Department of Transport.
- In accordance with comments from HCMC People's Committee by letter No. 207/TB-VP dated 11 April 2006.
- Avoids running between 500KV and 220KV OTL power lines, which is very dangerous during construction as well as operation of bridges.
- Avoids the Phu Huu 1 Port as requested by Dong Nai People's Committee at the Letter No. 8156/TTr-UBND dated 01 Oct. 2008.
- Does not impact on the master plan of Nha Be Area.

ii. Disadvantages

- The alignment runs through the Transition zone of Can Gio Biosphere Reserve, however, has no impact on the growing process of the mangrove forest as well as the protection of Can Gio Protection Forest (Letter No. 622/UBND dated 10/6/2009 of People's Committee of Can Gio District).
- There are two long high bridges with navigation clearance (about 300x55m).
- In soft soil area.
- The overhead transmission lines are visible from the bridge which does not present a nice vista.

b. Alternative 2 (North alignment alternative)

84. To avoid the disadvantages of alternative 1, alternative 2 runs to the North of alternative I crossing through Nhon Duc – Phuoc Kien Urban area (Km 20+800-Km 21+100), crossing Muong Chuoi river at Km 21+500 and running overlaid to an internal road and Phu Xuan residential area (Km 21+900-Km 22+700), going in the between of Techim Petrolimex and Saigon Metrolimex Store. However, the alignment of alternative II was not agreed to by HCMC Department of Transport and People's Committee of Nha Be district (through the letter No. 517/UBND-PCT dated 16/6/2009 of Nha Be PC and the Notice No. 270/TB-SGTVT dated 09/6/2009 of HCMC DOT).

i. Advantages:

- Construction site is easier than alternative I.
- Horizontal alignment is smooth.

- Only one long high bridge with navigation clearance required (about 300x55) or tunnel at Nha Be river.

ii. Disadvantages:

- The alignment runs through Nhon Duc - Phuoc kien urban area (which has been approved by HCM PC).
- May affect the future Phu Dong port.
- In soft soil area.
- Still run under the 500KV and 220KV power lines (may have to heighten electric poles).
- Affects many houses (particularly at Huynh Tan Phat street).
- Affects Phap Vo Pagoda (25m away from left side of the centerline).

c. Alternative 3 (North alignment alternative)

85. To avoid the disadvantages of the above two alternatives, alternative 3 runs to the North of alternative I crossing through Nhon Duc – Phuoc Kien Urban area (Km20+800-Km21+100), crossing Muong Chuoi river at Km21+500 and running avoided Phu Xuan residential area (Km22+00-km23+300), avoiding Phap Vo Pagoda, then going through Saigon Petrolimex Port. However, the alignment of alternative III was not agreed to by HCMC Department of Transport and People's Committee of Nha Be district (through the letter No. 517/UBND-PCT dated 16/6/2009 of Nha Be PC and the Notice No. 270/TB-SGTVT dated 09/6/2009 of HCMC DOT).

i. Advantages:

- Construction site is easier than alternative 1.
- Horizontal alignment is smooth.
- Crossing at the narrowest location of Soai Rap river (perpendicular with river) so has the shortest crossing of the three alternatives.

ii. Disadvantages:

- The alignment runs through Nhon Duc – Phuoc kien urban area (which has been approved by HCM PC).
- May affect the Master plan of port of other side of river (Dong Nai side).
- In soft soil area.
- Affects many houses (particularly at Huynh Tan Phat street).
- Affects Saigon Petrolimex port.

86. There are tentatively three interchanges in HCMC: NH1A, NH50, and Nguyen Huu Tho Road.

87. Total length in HCM City is about 26km.

88. Katahira & Engineers International (KEI) has presented in detail the alignment in HCMC to the HCMC Department of Transport at the meeting on 03/6/2009 with the participants of the city agencies and departments, and People's Committee of Binh Chanh, Nha Be and Can Gio districts. Basically, the meeting has agreed to the alignment alternative 1 recommended by the Consultant (as per the Notice No. 270/TB-SGTVT dated 09th June 2009).

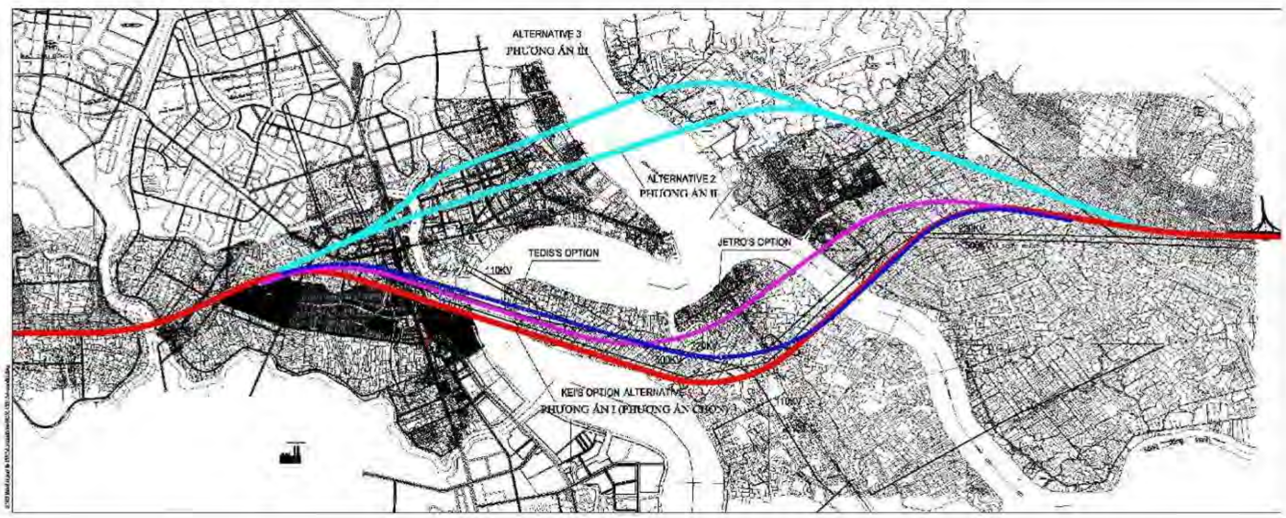
89. Findings: The Alignment Alternative 1 (the southern alignment alternative) has been approved by HCMC People's Committee by letter No. 5652/UBND-DTMT dated the 29th October 2009.

3. The Alignment in Dong Nai Province

90. In Dong Nai province the alignment runs through Nhon Trach district (Km 30+500- Km 53+100) and Long Thanh district (Km 53+100-Km 58+500). The Alignment avoids Phu Huu I port at Km 30+750 (as requested by Dong Nai PC) and running parallel on the north side of 500 KV power line (away 130 m from the 500KV), crossing 500 KV and 220 KV at Km 32+000. From Km 32+000– Km 52+500 the alignment runs in between the south side of 110 KV and Nhon Trach outer road in accordance with Nhon Trach Master Plan as approved by the Prime Minister (the alignment runs in the high land border of Nhon Trach area, where geotechnical condition is good for embankments). The alignment avoids the Phuoc An port from Km 49+500-Km 52+500, crosses Thi Vai river at Km 53+100, crosses NH51 at Km 57+500 and connects to future Bien Hoa-Vung Tau expressway by an interchange.

91. There are four tentative interchanges in Dong Nai province at: Inter-ports road (about km33), Nhon Trach city road, National Highway No. 51, Bien Hoa-Vung Tau Expressway. The total length in Dong Nai Province is about 28km.

92. Katahira & Engineers International (KEI) has presented in detail the alignment in Dong Nai Province to Dong Nai Department of Transport at the meeting on 02/6/2009 with the participants of the provincial agencies and departments, and People's Committee of Nhon Trach and Long Thanh districts. Basically, the meeting has agreed on the alignment recommended by the Consultant (as per the Notice No. 1020/TB-SGTVT dated 18th June 2009 of Dong Nai DOT) and has been approved by Dong Nai's People's Committee by letter No. 8709/UBND-CNN dated the 26th October 2009.

	Alternative I	Alternative II	Alternative III
Advantages	+ Avoid disadvantage of the previously studied alternatives that is causing effects on 500KV and 220KV power lines. + Avoid crossing Phu Huu 1 port as requested by Dong Nai People's Committee (Letter No. 8156/TTr-UNBD dated 1/10/2008) + Selected and agreed to by MOT and relevant agencies and departments of HCMC (Notice No. 301/TB-BGTVT dated 30/6/2009 of MOT and Notice No. 270/TB-SGTVT dated 9/6/2009 of HCMC DOT) + Recommended by Nha Be PC (at the letter No. 517/UBND-PCT dated 16/6/2009 of Nha Be PC) + Has lower construction cost than other alternatives.	+ The alignment is about 600m shorter than Alternative I + Only 1 large bridge to cross over Nha Be river required + Construction cost of bridges is higher due to large bridge with long spans and long span viaduct so as to cross over rivers and existing infrastructures. + Geometry of the alignment is better than Alternative I.	+ The alignment is about 500m shorter than Alternative I + Crossing river at the narrowest location + Construction cost of bridges is higher due to large bridge with long spans and long span viaduct + Geometry of the alignment is better than Alternative I
Disadvantages	+ The alignment runs through buffer zone of Can Gio Biosphere Reserve, however, has no impact on Can Gio Protection Forest (Letter No. 622/UBND dated 10/6/2009 of People's Committee of Can Gio District, and letter No. 126/CV-BQL dated 29/7/2009 of Can Gio Protection Forest Management Board). + Outlook of the bridge is less nice than other aternatives.	+ The alignment breaks through Nha Be Planning areas (not agreed by Nha Be PC at the letter No. 517/UBND-PCT dated 16/6/2009) + Affect the future Phu Dong port + Run under the 500KV and 220KV power lines (may have to heighten electric poles) + Cross through Phap Vo Pagoda + Cross through the existing dense residential area in Huynh Tan Phat street + Construction cost is higher than Alternative I (due to having to construct large span viaducts to cross residential areas, existing roads)	+ The alignment breaks through Nha Be Planning areas (not agreed by Nha Be PC at the letter No. 517/UBND-PCT dated 16/6/2009) + Crossing Saigon Petrolimex Store + Crossing the existing dense residential area in Huynh Tan Phat street + Construction cost is higher than Alternative I + Run under the 500KV and 220KV power line (may have to heighten electric poles) +Affect the river port (Dong Nai side)
Alternative alignments crossing rivers			

No.	Province	The alignment previously studied by TEDIS and JETRO	Studied by KEI	Relevant legal documents
1	LONG AN	- The alignment starts at the intersection point with HCM-Trung Luong expressway and connects to Ring Road 3. The alignment goes through: Tan Buu and My Yen communes of Ben Luc district , Phuoc Ly and Long Thuong communes of Can Giuoc district. Total length of the alignment in Long An is about 4.5km. - The alignment crosses NH 1 at dense residential location. - The alignment crosses Phuoc Ly Resettlement area and Hai Son Industrial park.	- Collect data and update the alignment with the master plans along the alignment and adjust the alignment in partial so as to avoid the dense residential area in NH 1 and Phuoc Ly Resettlement area. - Study types of the first interchange at the starting point of the alignment to avoid Dai Dao Tam Ky Church and Xuan Hoa Temple	- Notice No. 301/TB-BGTVT dated 30 /6/2009 of MOT Deputy Minister Ngo Thinh Duc on the inception report of the Ben Luc-Long Thanh Expressway. - Notice No. 74/TB-SGTVT dated 8/6/2009 of Long An DOT on agreement of the alignment of the Ben Luc-Long Thanh Expressway. - Notice No. 01/TB-BGTVT dated 02/1/2008 of MOT Deputy Minister Ngo Thinh Duc on the alignment of the Ben Luc-Long Thanh Expressway. - Notice No. 2005/TB-CĐBVN dated 7/6/2007 of Vietnam Road Administration on the Ben Luc-Long Thanh Expressway. - Letter No. 4965/CDBVN-TĐ dated 5/12/2007 of Vietnam Road Administration regarding contribution of comment on the Ben Luc-Long Thanh Expressway. - Letter No. 5414/UBND-CN dated 3/11/ 2006 of Long An PC regarding agreement on the alignment.
2	TPHCM	- In HCMC, the alignment goes through: Tan Quy Tay, Hung Long, Da Phuoc communes of Binh Chanh district; Nhon Duc , Long Thoi communes of Nha Be district; Binh Khanh commune of Can Gio district. Total length is about 26km. - The alignment crosses Pho Quang Pagoda. - The alignment runs between the 500kv và 220kv power lines (distance between the two power lines is 100m on the West bank and 180m at the center of Soai Rap river). - Crosses Phu Huu 1 Port, Dong Nai Province side. - Runs through buffer zone of Can Gio Biosphere Reserve.	- Collect data and update the alignment with the master plans along the alignment and adjust the alignment in partial so as to avoid Pho Quang Pagoda, Da Phuoc Waste Treatment Complex, Nhon Duc cemetery. - At the location crossing Soai Rap river, the previous alignment goes between the sensitive area of 500KV và 220KV power lines, crosses Phu Huu 1 port at Dong Nai Province side. Therefore, the alignment has been adjusted to run towards the South and about 110m away from the 500KV power line (to avoid relocation of the power line and avoid crossing Phu Huu 1 port -Please refer to the comparision table of river crossing alternative alignments) - Runs through buffer zone of Can Gio Biosphere Reserve.	- Notice No. 301/TB-BGTVT dated 30 /6/2009 of MOT Deputy Minister Ngo Thinh Duc on the inception report of the Ben Luc-Long Thanh Expressway. - Notice No. 270/TB-SGTVT dated 9/6/2009 of HCM DOT regarding contents of meeting on the Ben Luc-Long Thanh Expressway. - Letter No. 622/UBND dated 10/6/2009 of Can Gio PC regarding agreement on the alignment going through Can Gio. - Letter No. 126/CV-BQL dated 29/7/2009 of Can Gio Protection Forest Management Board confirming that the alignment runs through the buffer zone of Can Gio Biosphere Reserve and has no impact on Can Gio Protection Forest. - Letter No. 517/UBND-PCT dated 16/6/2009 of Nha Be PC contributing comments on the Ben Luc-Long Thanh Expressway. - Letter No. 1534/CHHVN-KHTC dated 24/7/2009 of Vietnam Maritime Administration on navigation clearance of Binh Khanh and Phuoc Khanh Bridges. - Letter No. 3996/TNMT-QHSDD dated 11/5/2006 of DONRE of HCMC on the alignment options of the Ben Luc-Long Thanh Expressway. - Notice No. 207/TB-VP dated 11/4/2006 by HCMC PC on consideration of alignment of the Ben Luc-Long Thanh Expressway. - Letter No. 8197/UBND-Đt dated 16/12/2005 of HCMC PC on the plan for the Ben Luc-Long Thanh Expressway.
3	DONG NAI	-In Dong Nai province, the alignment goes through: Phuoc Khanh, Vinh Thanh, Phuoc An communes of Nhon Trach district; Long Phuoc, Long Thai communes of Long Thanh district. Total length in Dong Nai is about 28km. - The alignment crosses Phu Huu 1 port (Dong Nai People's Committee had issued the letter requesting for the adjustment of the alignment to avoid the Port). - The alignment runs parallel and about 70m-100m away from the 220KV power line on the north - The alignment runs parallel and crosses Phuoc An port - Crosses over Thi Vai river and go into soft soil area - The end point of the alignment follows the master plan of Long Thanh town.	- The alignment goes in accordance with the master plan of Nhon Trach district which was approved by the Prime Minister . - Collect data and update the master plans along the alignment and adjust the alignment in partial so as to avoid cemetery, Phuoc An port, Ba Truong temple.	- Notice No. 1020/TB-SGTVT dated 18/6/2009 of Dong Nai DOT on the alignment of the Ben Luc-Long Thanh Expressway. - Letter No. 8156/TTr-UBND dated 1/10/2008 of Dong Nai PC regarding the additional sea ports in Nhon Trach area, Dong Nai Province. - Letter No. 861/SGTVT-KH dated 27/9/2006 of Dong Nai DOT contributing comments on the alignment of Ben Luc-Long Thanh Expressway. - Notice No. 288/DC-SGTVT dated 1/2/2008 of Dong Nai DOT regarding comments on the alignment of Ben Luc-Long Thanh Expressway.

93. Cost estimates were prepared for the three alternative options for both bridge and tunnel options and are shown in Table 35.

Table 35: Cost estimate of three alternative alignments for both bridges & tunnels

	Bridge A1	Tunnel A1	Bridge A2	Tunnel A2	Bridge A3	Tunnel A3
Land Acquisition	$235.87	$235.87	$284.22	$284.22	$284.22	$284.22
General Items	$54.21	$90.05	$58.75	$72.20	$55.37	$71.14
Earthworks	$45.96	$45.96	$45.06	$45.06	$45.96	$45.96
Drainage Works	$15.09	$15.09	$14.79	$14.79	$15.09	$15.09
Bridge & Tunnel Works	$641.10	$1,192.62	$713.34	$920.34	$659.03	$901.58
Interchange Works	$74.04	$74.04	$74.04	$74.04	$74.04	$74.04
Pavement Works	$38.48	$38.48	$37.72	$37.72	$38.48	$38.48
Miscellaneous Works	$19.26	$19.26	$18.88	$18.88	$19.26	$19.26
Construction Cost	**$888.13**	**$1,475.49**	**$962.57**	**$1,183.03**	**$907.22**	**$1,165.54**
Total Other Costs	$45.82	$45.82	$45.82	$45.82	$45.82	$45.82
Total Taxes	$91.61	$150.35	$99.06	$121.10	$93.52	$119.35
Sub-Total Project Cost A	**$1,261.43**	**$1,907.52**	**$1,391.66**	**$1,634.17**	**$1,330.78**	**$1,614.93**
Total Contingency	$249.45	$377.22	$275.20	$323.16	$263.17	$319.36
Sub-Total Project Cost B	**$1,510.88**	**$2,284.74**	**$1,666.87**	**$1,957.33**	**$1,593.95**	**$1,934.28**
FCDD	$105.62	$159.72	$116.53	$136.83	$111.43	$135.22
Total Project Cost	**$1,616.50**	**$2,444.47**	**$1,783.40**	**$2,094.16**	**$1,705.38**	**$2,069.51**
Cost Index	1.00	1.51	1.10	1.30	1.05	1.28

Note: costs shown in US$ millions

These are the preliminary costs which have been modified

94. After reporting the alignment to Departments of Transport of Long An Province, Ho Chi Minh City and Dong Nai Province, on 20/6/2009 KEI had reported the alignment to the TA Inception Mission of ADB, Ministry of Transport (MOT) and relevant departments of MOT. The alignment alternative 1 recommended by KEI Consultant has been selected and agreed to by all parties for carrying out the Project.

B. Civil Engineering Designs

1. Horizontal Alignment Design

95. The horizontal alignment has been designed based on the Alignment 1 which has been selected and agreed to by all the relevant authorities where the alignment passes through (Long An province, Ho Chi Minh city, Dong Nai Province) and by the Ministry of Transport.

a. The main control points and outline of the alignment

Table 36: Main Control Points

No.	Description of control points	Photos
1	The alignment starts at the Ho Chi Minh–Trung Luong expressway (to be opened in 2010) and connects with RR3 at Ben Luc district, Long An province.	
2	Crossing NH1A at Km3+400, Binh Chanh Commune, Binh Chanh District, HCMC (around Km1923+850)	
3	Crossing NH 50 at Km13+500, Da Phuoc Commune, Binh Chanh District, HCMC (around Km9+400 – NH 50)	
4	Crossing Nguyen Van Tao street at Km21+900 (North-South Arterial road), Long Thoi Commune, Nha Be District, HCMC	
5	Crossing over Soai Rap river (Km23+500) and Long Tau river (Km30+400), HCMC (the alignment runs towards the South and 120m away from the existing 500KV power line). (Then the alignment runs along the master plan of Nhon Trach city from Km38 to Km48, Vinh Thanh Commune, Phuoc An Commune, Nhon Trach District).	
6	Crossing NH 51 at Km57+600 (Km35+350-NH51) Phuoc Thai Commune, Long Thanh District. The alignment ends at the intersection point with NH 51 and connects to the planned Bien Hoa–Vung Tau expressway at Phuoc Thai Commune under Long Thanh district, Dong Nai province.	

b. Description of the alignment

96. From the starting point at Ho Chi Minh–Trung Luong expressway, the alignment starts running from West to East, crosses NH 1A at Km 3+400 (around Km1923+850 on NH1A Binh Chanh Commune, Binh Chanh District) where there is only a few houses and utility works, (on

the right side of the alignment is Phu Trieu Shoes Company), then goes parallel with the border between Binh Chanh and Can Giuoc Districts.

97. From Km 5+800 – Km 6+300, the alignment is designed to avoid the Phuoc Ly resettlement area on the right side under construction (60m distant) in Phuoc Ly Commune, Can Giuoc District.

98. From Km 8+200-Km 8+700 the alignment crosses residential area and Hai Son Industrial Zone whose land acquisition is being carried out, in Long Thuong Commune, Can Giuoc District (as the expressway is designed based on many control points, it is not possible to avoid this area), then crosses Doan Nguyen Tuan street at Km 9+200, avoids Pho Quang Pagoda on the left side of the alignment at Km 9+500, the alignment runs towards the East to cross over the Ong Thin river at Km 12+700 and crosses NH 50 at Km 13+500 (around Km 9+400 on QL50 Binh Chanh District).

99. From Km 14+700-Km 16+700 the alignment runs on the right side and 60m away from the Da Phuoc Waste Treatment Complex in Da Phuoc Commune, Binh Chanh District (Letter No. 8197/UBND-DT dated 16/12/2005 of HCMC People’s Committee), crosses Ba Lao river at Km 17+100, avoids the Nhon Duc Cemetery on the left side of Km 17+300 by 50m. The alignment goes through and in accordance with the master plan of Nha Be district, crosses North-South Arterial road (Nguyen Trong Tao road) at Km 21+900 and runs parallel on the South and about 120m away from the 500KV power line, crosses over Soai Rap and Long Tau rivers at Km23+500 and 30+400.

100. From Km 24+000 – Km 30+000 (6km) the alignment runs through buffer zone of Can Gio Biosphere Reserve, however, has little impact on the growing process of the mangrove forest as well as the protection of Can Gio Protection Forest (but is in a soft soil area), as per Letter No. 126/CV-BQL dated 29/7/2009 of Can Gio Protection Forest Management Board, and Letter No. 622/UBND dated 10/6/2009 of People’s Committee of Can Gio District.

101. The alignment runs under the 500KV and 220KV power lines at Km 32+000 to go on the right side of 220KV power line and runs in accordance with Nhon Trach Master Plan approved by the Prime Minister (Km 38 to Km 49), from Km 49+400 – Km 52+700 the alignment runs avoiding the Phuoc An Port logistics area on the right side and also avoiding the Ba Truong Temple at Km 49+100 on the left side.

102. The alignment crosses Thi Vai river at Km 53+050, then crosses NH51 at Km 57+600 (Km 35+350 on NH51) and then connects to the planned Bien Hoa-Vung Tau in Phuoc Thai Commune, Long Thanh District, Dong Nai Province.

c. Horizontal Alignment Design

103. The geometric elements of the alignment are designed based on Vietnamese Standard TCVN 5729-97. The Ben Luc-Long Thanh Expressway is a class “A” expressway with a design speed of 120km per hour because of the daily traffic volume. The centerline of the road is designed to locate at the Central Reserve for the completion phase. At the location of large cable-stayed Binh Khanh and Phuoc Khanh Bridges, the Phase 1 bridge structure will be constructed at centre-line with emergency lane.

Table 37: Main geometric parameters in accordance with TCVN 5729-97

No.	Main geometric parameters		Unit	Number of lanes 4-lane	8-lane
1	Design speed		Kph	120 kph	120 kph
2	Class of Road		Class	A	A
3	Subgrade width		m	27.50	42.50
4	Carriage Way Width		m	2×7.50	2x15.00
5	Emergency Lane Width		m	3.00	3.00
6	Soil Shoulder Width		m	2×1.00	2x1.00
7	Width of Central Reserve		m	3.00	3.00
8	Navigation Clearance of Binh Khanh & Phuoc Khanh bridges		m	250X55	250X55
9	Maximum superelevation		%	7.0%	7.0%
10	Absolute Minimum Horizontal Radius		m	650	650
11	Normal Minimum Horizontal Radius		m	1,000	1,000
12	Radius without superelevation		m	4,000	4,000
13	Length of transition curve with Rmin		m	210	210
14	Length of transition curve with R = 1000		m	150	150
15	Maximum Longitudinal Grade (%) %		%	4.0%	4.0%
16	Stopping sight distance		m	230.00	230.00
17	Minimum Desirable Vertical Curve Radius	Crest	m	12,000	12,000
18	Minimum Sag Vertical Curve Radius	Sag	m	5,000.00	5,000.00

104. There are total 13 curves on the whole alignment one with a minimum radius of 1,000 m at the interchange point with NH51. The remaining radii are from 2,200 m to 18,000 m. With the curve radius of more than 10,000 m and small deviation angle, it is considered necessary to have a transition curve (with those curves, function of transition curve is not efficient).

Table 38: Result of alignment design

No.	Radius (m)	Quantity	Length (m)	Rate (%)	Remark
1	R < 650 m	0	0 m	0.00%	
2	650 m ≤ R < 1,000 m	0	0 m	0.00%	
3	1,000 m ≤ R ≥ 4,000 m	5	10,475 m	17.92%	
4	4,000 m ≤ R < 10,000 m	6	13,344 m	22.83%	
5	10, 000 m ≤ R	2	3,826 m	6.55%	
6	Tangent Section		30,801 m	52.70%	
Total Curves		13	58,446 m	100.00%	

2. Vertical Alignment Design

105. The finished grades of the highway having medians will be defined at centerlines edges of the pavement and controlled by the followings:

- Elevation system used for the project is the Vietnamese National Elevation System with Hon Dau's Level. Existing ground elevation is formed from 3D digital map data at 1:10,000 scale. Average elevation is from 0.5 to 1.5m and was updated using the additional survey data provided by VEC in October (the VEC recruited a local consultant for additional technical surveys and provided the additional data to the TA Consultant).

- The Control Elevations of the road profile are calculated based on the calculated height of water level with frequency H1% or observed water levels, the locations crossing existing roads, rivers with required navigation clearances and the height of the crossing structures. In order to minimize construction cost, for the crossing locations between expressway and the existing roads (provincial roads, national highways or major arterial roads), the Consultant has considered to apply the design with flyover arranged on the crossing roads (for the crossing locations with sparse population along both sides of the alignment) and construction of frontage roads at the locations crossing residential areas or reinstatement of existing roads. For the sections in soft soil area, the design of viaduct is considered to ensure long-term stability of the road.

- The finished grade is defined from the calculated water level H1% plus the required safety height of 0.5m (and if required, plus the height of waves), and plus the difference from road shoulder of the completion phase to outer edge of median. In addition, the outer edge of bottom of the pavement structure must be maintained above the permanent flooding water level at least 30 cm.

Table 39: Design water level along the alignment

No	Chainage	WL (m)	No	Chainage	WL (m)	No	Chainage	WL (m)
1	Km 00+000	1.70	22	Km 21+000	1.63	42	Km 41+000	1.78
2	Km 01+000	1.70	23	Km 22+000	1.63	43	Km 42+000	1.80
3	Km 02+000	1.70	24	Km 23+000	1.63	44	Km 43+000	1.82
4	Km 03+000	1.70	25	Km 24+000	1.63	45	Km 44+000	1.83
5	Km 04+000	1.69	26	Km 25+000	1.63	46	Km 45+000	1.85
6	Km 05+000	1.68	27	Km 26+000	1.63	47	Km 46+000	1.86
7	Km 06+000	1.67	28	Km 27+000	1.63	48	Km 47+000	1.88
8	Km 07+000	1.66	29	Km 28+000	1.63	49	Km 48+000	1.90
9	Km 08+000	1.65	30	Km 29+000	1.63	50	Km 49+000	1.91
10	Km 09+000	1.64	31	Km 30+000	1.63	51	Km 50+000	1.93
11	Km 10+000	1.63	32	Km 31+000	1.64	52	Km 51+000	1.95
12	Km 11+000	1.63	33	Km 32+000	1.66	53	Km 52+000	1.95
13	Km 12+000	1.63	34	Km 33+000	1.67	54	Km 53+000	1.95
14	Km 13+000	1.63	35	Km 34+000	1.68	55	Km 54+000	1.95
15	Km 14+000	1.63	36	Km 35+000	1.70	56	Km 55+000	1.95
16	Km 15+000	1.63	36*	Km 35+689	1.88	57	Km 56+000	1.95
17	Km 16+000	1.63	37	Km 36+000	1.71	58*	Km 56+838	2.14
18	Km 17+000	1.63	38	Km 37+000	1.72	59	Km 57+000	5.20
19	Km 18+000	1.63	39	Km 38+000	1.73	60	Km 58+000	7.50
20	Km 19+000	1.63	40	Km 39+000	1.75			
21	Km 20+000	1.63	41	Km 40+000	1.76			

i. *Note : (*) Design maximum water level at Bau Sen and Rach Ngoai bridges.*

106. The finished grade is defined based on height of structures. For flyover bridges crossing existing roads, the finished grade is defined by required clearance of crossing roads plus height of structure. For bridges crossing rivers or channels, the finished grade is defined by navigation

clearance plus height of structure (clearance of crossing roads and navigation clearances shall be agreed by local authorities or authorized management units). The finished grade must enable the arrangement of underpass and horizontal drainage system.

Table 40: Height of water level at large bridge locations

No.	Name	Station	Qmax (m3/s)	Vmax (m/s)	Minimum length required (m)	Maximum water level (m)		Minimum water level (m)
						1%	5%	1%
1	Ong Thoan	Km 02+200	74	1.00	35.00	1.70	1.57	-2.91
2	Ong Thin	Km 12+609	590	1.25	250.00	1.63	1.54	-2.91
3	Ba Lao	Km 17+145	1,296	1.25	250.00	1.63	1.54	-2.91
4	Binh Khanh	Km 23+450	11,500	1.25	1,200.00	1.63	1.54	-2.91
5	Cha River	Km 26+183	852	1.25	185.00	1.63	1.54	-2.91
6	Phước Khanh	Km 30+300	11,500	1.65	700.00	1.63	1.54	-2.91
7	Ong Keo	Km 34+700	200	1.25	230.00	1.68	1.59	-3.06
8	Bau Sen	Km 35+689	80	2.02	24.00	1.88	-	-0.58
9	Vung Gam	Km 43+126	87	1.86	24.00	1.82	-	-0.99
10	Thi Vai	Km 53+042	3,748	1.25	300.00	1.95	1.87	-3.69
11	Tac Ca Tang	Km 54+220	294	1.25	125.00	1.95	1.87	-3.69
12	Bun Ngu	Km 55+700	125	1.00	75.00	1.95	1.87	-3.69
13	Rach Ngoai	Km 56+838	39	1.33	12.00	2.14	2.00	0.78

Note: Please refer to the Hydrology calculation statement for navigation clearance of the bridges.

b. Results of vertical alignment design:

107. In Long An province and Ho Chi Minh City, the average existing ground elevation is about 1 m, and having soft soil area with thickness from 5 m to 25 m. Therefore, the average embankment height will be from 1.5 m to 2.5 m, at the area of soft soil with thickness greater than 20 m a viaduct option will be considered. In Dong Nai Province, the alignment goes along Nhon Trach City with an existing ground elevation of 1 m to 2.5 m, and soil profile is rather better for embankment construction. The average embankment height is from 1m to 2m.

Table 41: Average height of embankment

Station	Soil upper layer	Embankment difference (m)	Remark
Km 00 – Km 02	Soft soil upper layer 0 m	1.5 – 2.5	Embankment
Km 02 – Km 12.5	Soft soil layer 4 m	1.5 – 2.3	Embankment
Km 12.5 – Km 14	Soft soil layer 0 m	1.0 – 2.0	Embankment
Km 14 – Km 16	Soft soil upper layer 10 m	1.5 – 2.5	Embankment
Km 16 – Km 31	Soft soil upper layer 14 m-24 m	8.0 - 10	Bridge/Viaduct
Km 31 – Km 36	Soft soil upper layer 6 m	2.0 – 2.5	Embankment
Km 36 – Km 51	Good soil upper layer	1.5 – 2.5	Embankment
Km 51 – Km 55.5	Soft soil upper layer 12 m	6	Bridge/Viaduct
Km 55.5 – Km 58	Soft soil upper layer 0 m	1.0 – 1.5	Embankment

108. Since the Expressway generally runs in flat terrain, longitudinal grade of embankment is from 0% to 0.5%. However at the locations of Binh Khanh and Phuoc Khanh bridges which are

large bridges with the required vertical clearance of 55m and in order to reduce construction cost, the maximum longitudinal grade is designed at 4%.

Table 42: Result of Vertical alignment design

No.	Longitudinal grade (%)	Length (m)	Rate (%)
1	0 < i ≤ 0,5	45,000 m	78.95%
2	0,5 < i ≤ 2,0	2,000 m	3.51%
3	2,0 < i ≤ 4,0	10,000 m	17.54%
4	i > 4,0	0 m	0.00%
Total		57,000 m	100.00%

3. Typical Cross section

109. Based on the results of traffic demand forecast, the number of lanes of the expressway will be 4 in phase 1 and expanded to 8 lanes in the future which is in accordance with the Decision No. 1734/QĐ-TTg dated 01/12/2008 by the Prime Minister on road network development plan up to 2020, and the Orientation after 2020. In PPTA stage, it is assumed that the ROW will be 73 metres wide in embankments sections and 56 metres wide in bridge and viaduct sections.

110. Three alternatives for cross section are as follows:

111. **Alternative I:** 4 lanes in phase 1 with width of central reserve of 3m, total width of subgrade of 27.5m. In phase 2, this will be expanded into 8 lanes at both sides with total width of subgrade of 42.5m.

Table 43: Alternative I Cross Section

No.	Cross section parameters, alternative I	Unit	Number of lanes	
			4-lane	8-lane
	Subgrade width	m	27.50	42.50
1	Carriageway Width	m	2 × 7.50	2 x 15.00
2	Emergency lane Width	m	2 x 3.00	2 x 3.00
3	Soil Shoulder Width	m	2 × 1.00	2 x 1.00
4	2 safety strips at Central reserve	m	2 x 0.75	2 x 0.75
5	Width of Central Reserve	m	3.00	3.00

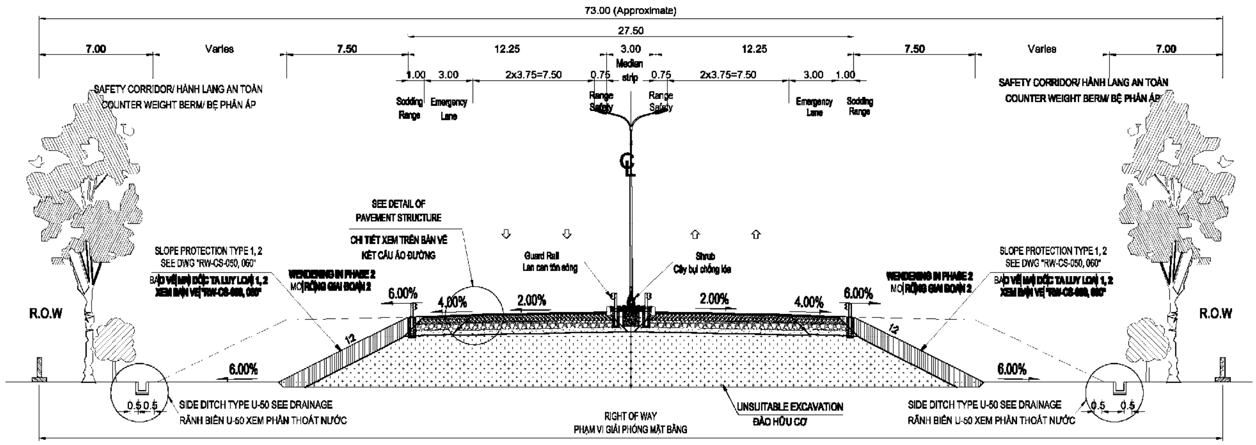


Figure 11: 4-lane typical cross section (Phase 1)

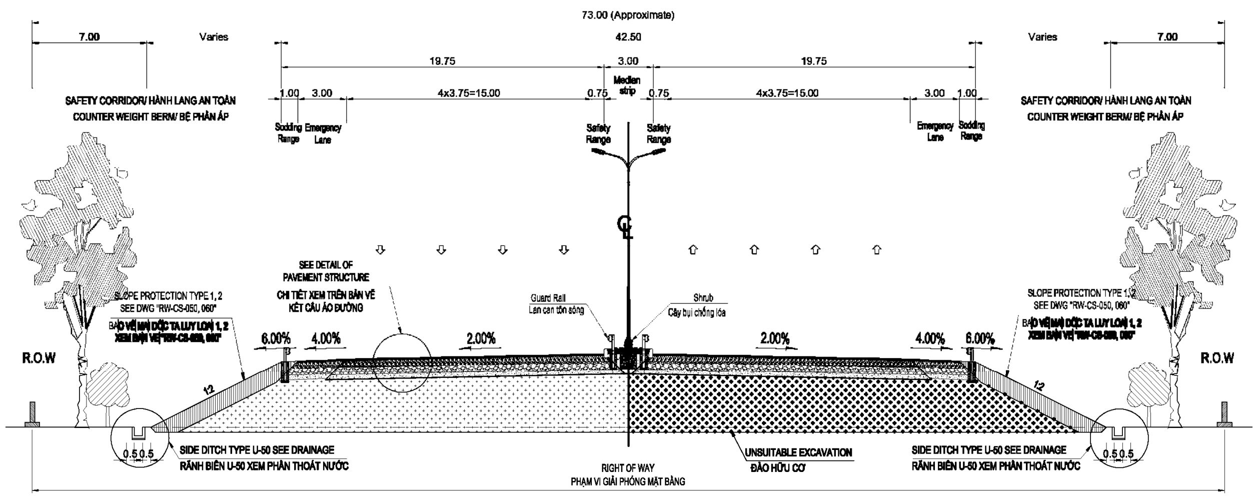


Figure 12: 8-lane typical cross section (Phase 2)

112. **Alternative II**: 4 lanes in phase 1 with width of central reserve of 1m, total width of subgrade of 25.5m. In phase 2, this will be expanded into 8 lanes at both side with total width of subgrade of 40.50m.

Table 44: Alternative II Cross Section

No.	Cross section parameters, alternative II	Unit	Number of lanes	
			4-lane	8-lane
	Subgrade width	m	25.50	40.50
1	Carriageway Width	m	2 × 7.50	2 x 15.00
2	Emergency lane Width	m	2 x 3.00	2 x 3.00
3	Soil Shoulder Width	m	2 × 1.00	2 x 1.00
4	2 safety strips at Central reserve	m	2 x 0.75	2 x 0.75
5	Width of Central Reserve	m	1.00	1.00

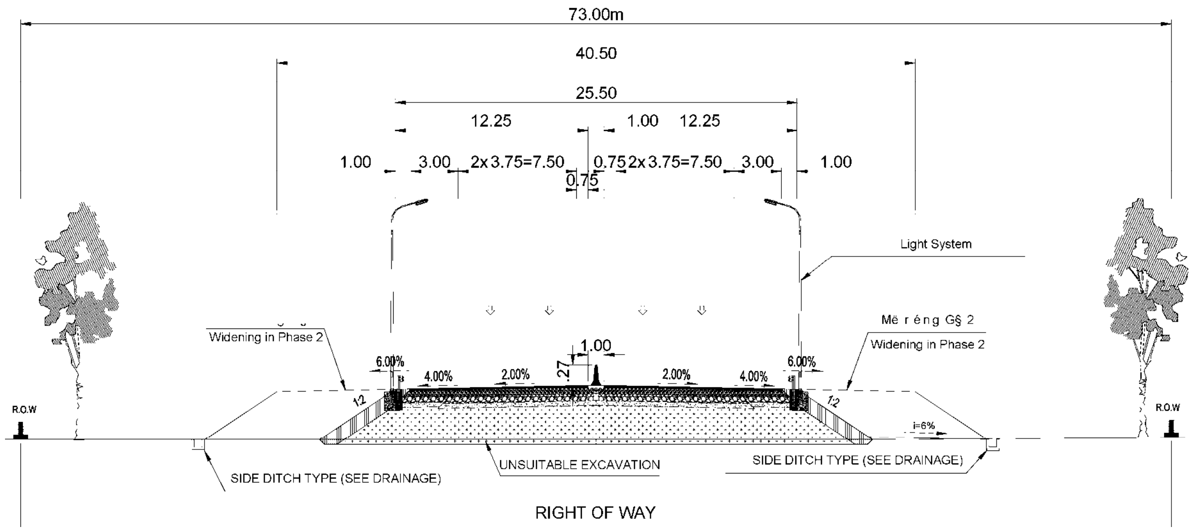


Figure 13: 4-lane cross section Phase 1- expanded into 8 lanes Phase 2

113. **Alternative III**: in phase 1 construct 4 lanes from both sides to the center with width of central reserve of 16.50m. In phase 2, this will be expanded into 8 lanes towards the central reserve with total width of subgrade of 42.50m.

Table 45: Alternative II Cross Section

No.	Cross section parameters, alternative III	Unit	Number of lanes 4-lane	8-lane
	Subgrade width	m	42.50	42.50
1	Carriageway Width	m	2 × 7.50	2 x 15.00
2	Emergency lane Width	m	2 x 3.00	2 x 3.00
3	Soil Shoulder Width	m	2 × 1.00	2 x 1.00
4	2 safety strips at Central reserve	m	2 x 0.75	2 x 0.75
5	Width of Central Reserve	m	16.50	3.00

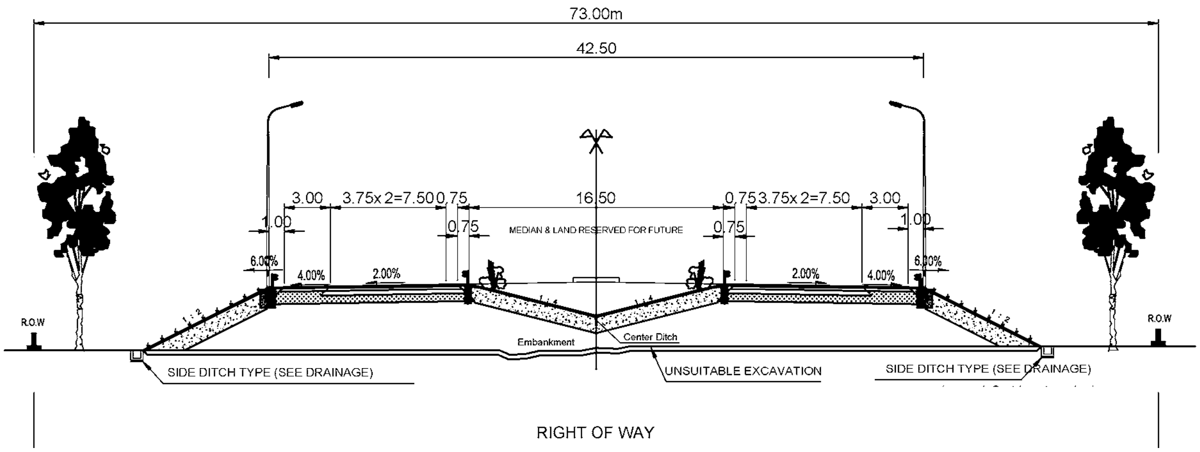


Figure 14: 4-lane typical cross section for Phase 1 and 8-lane for Phase 2

Table 46: Comparison of cross section alternatives

Alternative	Advantages	Disadvantages	Recommended
I	• In synchronous with the cross section of HCMC-Trung Luong and HCMC-Long Thanh-Dau Giay Expressways (central reserve of 3m). • Easy for construction phase 2 towards both sides of slope. • Possible to arrange columns as well as utility works in the central reserve	• The design of some interchanges must be widened for 8-lane scope. • It is required to keep construction land for next phase.	**YES**
II	• Reduce subgrade width as reducing width of central reserve to 1m. • Reduce right of way (ROW)	• It is not possible to arrange columns as well as utility works in the central reserve.	NO
III	• The best cross section to keep construction land for Phase 2, avoid the re-occupation of land after land acquisition. • Easy to design interchanges suitable for phase 1.	• Construction cost of subgrade is more expensive due to having to construct for both phases. • Narrow construction area for bridge locations in phase 2 .	NO

114. As per the above analysis, the Consultant has recommended to select the alternative 1 for carrying out the subsequent steps.

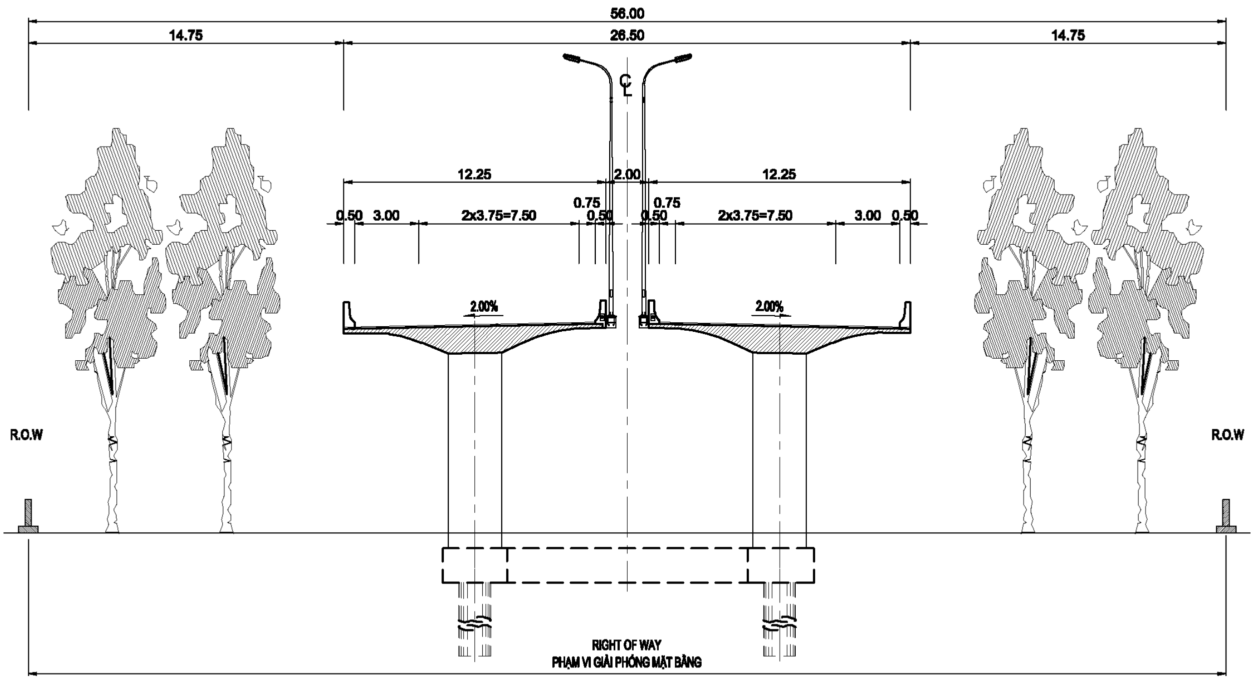


Figure 15: Typical 56-m width ROW in the Viaduct & Bridge Sections Phase 1

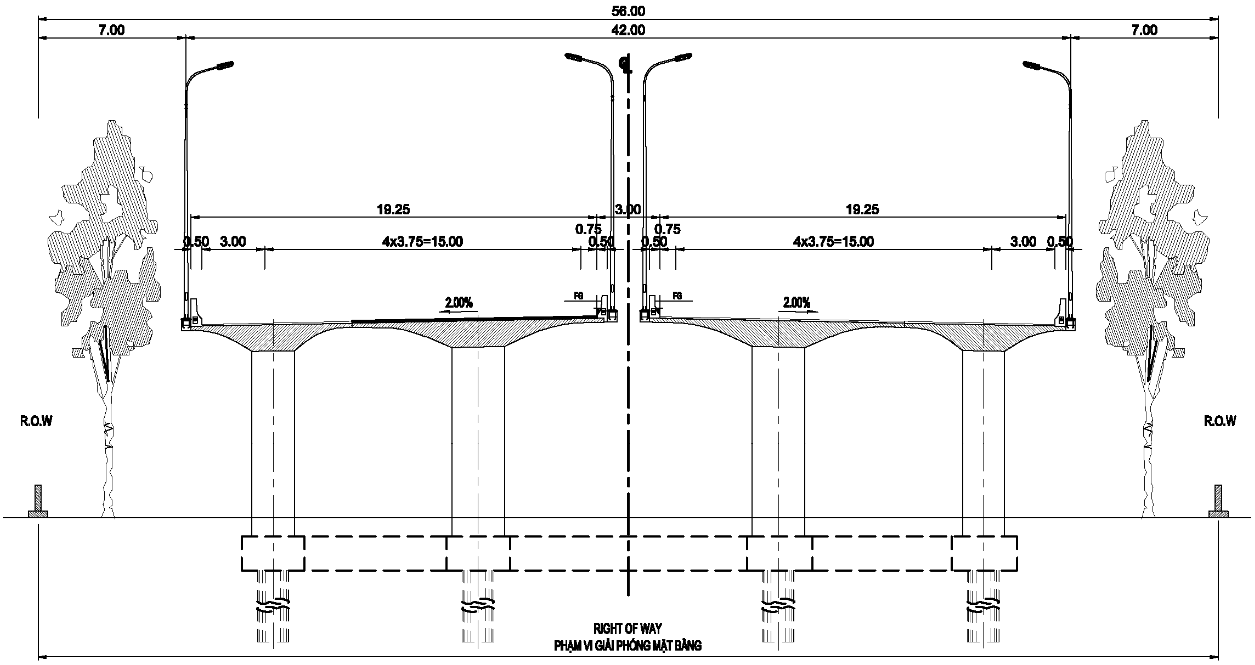


Figure 16: Typical 56-m width ROW in the Viaduct & Bridge Sections Phase 2

4. Soft Soil Treatment and Embankments

a. Embankment Design Criteria

115. Basic requirements and criteria for the embankment design are done according to 22TCN262-2000 are summarized as follows:

i. Slope stability:

- Minimum Factor of Safety (FS) is greater than 1.2 during construction, and greater than 1.4 after the completion of construction
- Settlement rate ≤ 10mm/day, and horizontal displacement rate≤5mm/day

ii. Residual settlement in 15 years:

- ≤ 10cm for bridge approach
- ≤ 20cm for culvert and underpass
- ≤ 30cm for road embankment
- Degree of consolidation ≥90% or with settlement rate < 2cm per year

iii. Monitoring settlement:

- Length of section < 100m; 1 cross section with 3 settlement plate (SP)
- Length of section >100m; min. 2 section with 3 SP and 1 additional per 100m

b. Site & Soil Conditions

116. In General, the project area belongs to the low basin of the Vam Co River and the Dong Nai River systems distributed at south-east of Highway 1. This is an accumulative delta slightly rising from the adjacent area. The existing ground level normally varies from 0.5 m to +1m except at Nhon Trach area which is a hillock area with the elevation varies from +5m to +15m.

117. The ground water is at an elevation of about ±0.0m.

118. Most of the route is covered by very soft clay layer that have high void ratio, high compressibility, low shear strength except at some area at Nhon Trach District, Dong Nai Province.

119. The right of way is order of 73 metres wide in the embankment sections, all the way from Ben Luc to Long Thanh, will be taken into account during establishing the soil treatment plan.

120. The soil profile and data was based on the 29 boreholes of the completed site investigation. Please see the list of boreholes at the appendix. That is the only available geotechnical data at time of the TA. More boreholes will be needed for the next stage of the project development.

121. Fluctuation in the thickness of the soft soil layer: There is large variation in thickness of soft soil layer along the alignment from 0 m to 30 m thick. The depth of soft soil is deepest at Can Gio area.

122. The relevant subsoil profile for soft ground treatment can be divided into three basic soil layers:

i. Soil Layer 1:

- The upper soil layer with thickness of 5 to 25 m (depending on the location), consists of green grey to dark grey, with organic matter or shells in places, very soft CLAY with high plasticity.
- The natural water content of the upper part of this layer varies from 80% to 130%, while that of the lower part is in the range of from 60% to 80%.
- The liquid limit of the upper part of this layer varies from 90% to 130%, while that of the lower part is in the range of from 65% to 75%.
- The SPT of this layer is in the range from 0 to 2.
- Since this layer has very high water content and low shear strength, it needs to be improved for supporting the roadway as well as for reducing the post construction settlement.

ii. Soil Layer 2:

- At greater depths, the soft soil layer consists of light grey, yellow grey, yellow brown, medium stiff to very stiff sandy CLAY with low plasticity. This layer was encountered in boreholes. Its thickness varies from 5 to 17 m.
- The natural water content in the range of from 15% to 45%. The liquid limit varies from 20 % to 70%.
- The SPT of this layer is in the range from 5 to 29.
- In general, the ground treatment will not be required for this layer. Since it will not contribute any significant long term settlement.

iii. Soil Layer 3:

- Silty SAND or clayey SAND, fine to coarse in grain size, with some gravel, yellow, light grey, grey in color.
- This loose to dense sand layer was encountered in all boreholes. The thickness of this layer varies from 11 to 50 m.
- The SPT of this layer is in the range from 8 to 50.

123. **In summary**, the upper very soft clay layer will dominate the ground settlement and its stability & lateral movement. Therefore it has to be treated to make it able to support the load of roadway embankment.

124. The next two soil layers are much better. They can be the foundation layers for the piles used in the RC pile slab system.

125. Based on the soil condition, the alignment was divided into 12 Geotechnical Sections (GS). A list of boreholes & location and a summary of soil layers properties can be seen in the appendix.

c. Soil Profile & Proposed Soft Soil Treatment for each Geotechnical Section

Table 47: Soil Profile by Geotechnical Section: Part 1 (GS 1 to GS 6)

		Avearage Layer Thickness (m)					
Soil	Discription	1	2	3	4	5	6
Layer		Km0-Km2	Km2-Km12.5	Km12.5-Km14	Km14-Km15.5	km15.5-km17.5	Km17.5-Km31
K2	Silty Sand						
1	Very Soft Clay		4		10	16	24
TK1	Sandy Soft Clay						
TK	Silty Clayey Sand						
2	Stiff to very stiff Clay	9	7	5	5	5	11
3	Medium to dense Sand	36	40	30	30	29	29
Borehole No (first campaign)			BH1, BH2 & CG			BL	PK1 & PK2
Borehole No (second camgaign)		VD	BR-OV & FL-DDT	BR-CG2			FL-LVL, VD-CC3, BR-(BK1, BK3, SC2)
Proposed Soft Soil Treatment Method		Soil Replacement	Soil Replacement + Preloading	Soil Replacement	PVD + Preloading	PVD + Vaccuum; & Cement Deep Mixing + Preloading	Viaduct, Bridge

Table 48: Soil Profile by Geotechnical Section: Part 2 (GS 7 to GS 12)

		Avearage Layer Thickness (m)					
Soil	Discription	7	8	9	10	11	12
Layer		Km31-Km36	Km36-Km43	Km43-Km48	Km48-Km50.5	Km50.5-Km56	Km56 -the End
K2	Silty Sand				5		
1	Very Soft Clay	6		2		12	
TK1	Sandy Soft Clay			2			
TK	Silty Clayey Sand			6			
2	Stiff to very stiff Clay	6	11	9	17	9	7
3	Medium to dense Sand	50	45	30	28	11	22
Borehole No (first campaign)		BH3	BH4	BH5	NG	BH6	
Borehole No (second camgaign)		BR-OK01 & BR-OK02	EB35			BR-TV02, BR-V01	BR-BN02, BR-RN01, BR-RN02, IG-NH51
Proposed Soft Soil Treatment Method		PVD + Preloading	Soil Replacement	Soil Replacement + Preloading	No Treatment	PVD + Vaccuum; & Cement Deep Mixing + Preloading	Soil Replacement

d. Soft Soil Treatment

126. The soft soil strata thickness in this project varies from place to place. At some sections the soft soil could be in the range of 10~25m in thickness from ground surface, consists mostly of very soft to soft clay.

127. In order to cope with this disadvantageous soil condition for construction of embankment, say 2.0m to 5.0 m in height according to proposed vertical alignment, then the required Fill Height will be from 3 to 8.0 m approximately to compensate the settlement during construction period. Therefore soft soil treatment countermeasures are essentially needed.

128. According to the soil condition, the embankment height and other factors such as budget, RoW, technique as well as construction time for soft soil treatment, the following methods are proposed as soft soil treatment methods for this project.

- Soil Replacement without Preloading
- Soil Replacement of limited thickness with Preloading.
- Vertical Drain (PVD) with preloading
- PVD with Vacuum Induced Preloading plus reduced fill Preloading
- Deep Mixing of Dry Cement with Preloading
- Piled Slab in areas having soft soil to large depth, or in a area just behind a bridge abutment.

- Adding some soil reinforcement like geotextile or geogrid layers
- Counterweight Berm

129. In order to ensure stability and limit the lateral movement of the foundation of the road embankment, a Counterweight Berm is sometimes be used when necessary.

130. In case of very good subsoil conditions as in geotechnical section (GS) No. 10 at Nhon Trach area, no soft soil treatment is necessary.

i. Soft Soil Replacement without Preloading

131. For localized areas with soft soils of very limited depth and soft soil layer thickness of less than 2 m, removal of all unsuitable material and replacement with suitable fill should be carried out. This method will be suitable for application at geotechnical section (GS) No. 1, 3, 8 & 12.

ii. Soft Soil Replacement with Preloading

132. For localized areas with soft soils of limited depth and thickness, partial removal of unsuitable material and replacement with suitable fill should be carried out. Excavation and replacement could be carried out up to 2m to 3m. This method will be suitable for application at geotechnical section (GS) No. 2 & 9.

133. As the soft clay layer is of limited thickness and shall be partially replaced by sand fill, this clay layer is then, capable of compressing more rapidly under load of preload fill. Preloading of soft soils is based on the consolidation concepts, whereby, pore water is squeezed from the voids until the water content and the volume of the soil are in equilibrium under the loading stresses imposed by the surcharge. This is usually accompanied by gain in shear strength of soil. To a certain extent, the primary consolidation under final loading can be achieved during construction and hence post construction settlement reduces.

iii. Vertical Drain (PVD) with Preloading

134. However, with increased thickness of the soft clay where the consolidation period is too long for full consolidation of primary settlements, vertical drainage may be incorporated in conjunction with preloading in order to accelerate the settlement. This method will be suitable for application at geotechnical section (GS) No. 4 & 7.

- **Sand Blanket:** Clean coarse to medium Sand with fine content of less than 5% could be used as a drainage layer above the ground water table for carrying the water out of the PVDs during preloading. The thickness of this sand mat will depend on the expected rate of settlement, its permeability, and the drainage distance or path etc. Typically, a minimum thickness of 0.75 m is used. The sand mat of the main embankment with PVDs will have to be extended beyond the berms for drainage purpose during preloading. it would be useful to place the perforated drainage pipes or horizontal drains at a certain distance within this sand mat blanket, so that the water inside can be drained out more easily.

- **Prefabricated Horizontal Drains** (other names: PHD, Strip Drains, SB Drains) should be used in instead of the Sand Blanket. Strip drains (PHD) are larger prefabricated drains. These drains were similar to vertical drains but have higher flow capabilities and higher compressive strengths. Strip drains have been used alone (without any sand blanket) in vertical drain installations. See pictures of PHD bellows.

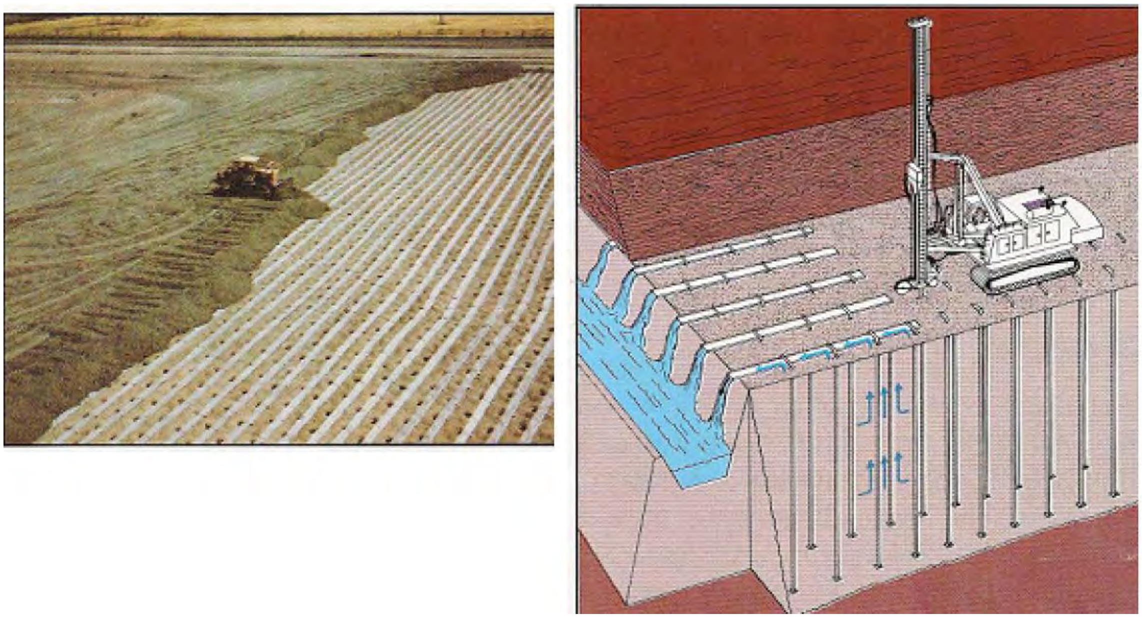


Figure 17: Typical Vertical Drain & Strip Drain Installation

135. Strip drains offer four advantages over a sand blanket in a vertical drain installation.

- First, strip drains are less expensive. Both materials, freight and installation costs are usually lower for the prefabricated drains.

- Second, strip drains may be installed more quickly and with less manpower and equipment.

- Third, strip drains provide better drainage as their flow capacity is more predictable, less subject to clogging.

- Furthermore, coarse or medium sand may be hard to get in this region when large amount in need.

Figure 18: Connection of PVD to SB Drain

136. The purposes of vertical drains installation are as follows:

1. To accelerate consolidation settlement,

2. To decrease post-construction settlement accordingly, and

3. To increase rate of strength gain due to consolidation.

137. The purposes of item 1 and 2 will be applied for settlement problems, and the purpose of item 3 will be for stability problems.

138. Hansbo (1979) modified Barron's equation for prefabricated vertical drain as presented below:

$$U_h = 1 - \exp(\frac{-8T_h}{F})$$

$$F = F(n) + F_s + F_r$$

139. where F is the factor which expresses the additive effect due to the spacing of the drains, F(n); smear effect, F_s; and well-resistance, F_r .To take account the effectiveness of soil disturbance during installation, a zone of disturbance with a reduced permeability is assumed around the vicinity of the drain as shown below and the smear effect factor is given as :

$$F_s = [(\frac{k_h}{k_s}) - 1]\ln(\frac{d_s}{d_w})$$

140. Where:d_s is the diameter of the disturbed zone around the drain;

k_s is the coefficient of permeability in the horizontal direction in the disturbed zone.

141. Since the prefabricated vertical drains have limited discharge capacities, Hansbo developed a drain resistance factor, F_r, assuming that Darcy's law can be applied for flow along the vertical axis of the drain. The well-resistance factor is given as:

$$F_r = \pi z(L - z)\frac{k_h}{q_w}$$

142. where z is the distance from the drainage end of the drain; L is the length of the drain when drainage occurs at one end only; L is half the length of the drain when drainage occurs at both ends; k_h is the coefficient of permeability in the horizontal direction in the undisturbed soil; and q_w is the discharge capacity of the drain at hydraulic gradient of 1.

143. The factors and/or problems indicated by Hansbo for prefabricated vertical drain can also exist for sand drain design.

$$U = 1 - (1 - U_v)(1 - U_h) = U_h$$

144. The consolidation degree, the time for consolidation settlement is dependent on the horizontal coefficient of consolidation Ch and the PVD pattern and spacing.

iv. Counterweight Berm

145. The counterweight berm is normally introduced when the main embankment does not meet the stability requirements during preloading.

146. Height of Berm should not exceed 2.5 m in order to ensure its stability.

147. The weight of berms increases the force resisting slope movement and reduces the net driving force for the critical failure surface by increasing the length and depth of potential failure surfaces.

148. Berms are designed and analyzed with different slopes and cross-sectional dimensions to give the best solution.

149. Berms constructed on soft soils will increase the total settlement, especially of the outer edges of the embankment.

150. Other related concern is the lateral movement of the subsoil foundation. It is common problem encountered in soft ground. If this magnitude is too large. It can cause some serious problems during construction and also after construction.

151. In essence, Counterweight Berm could make the main embankment more stable. Furthermore it could simultaneously reduce the lateral movement of the underlying subsoils.

v. Vacuum Preloading with PVD plus Reduced Fill Load

152. In most cases, vacuum consolidation has been used as a replacement for or supplement to the conventional practice of placing surcharge fills. Though the mechanism of consolidation of these two techniques may be different, the results are rather similar. The rate of settlement in

vacuum consolidation is similar to the surcharge fills with vertical drains. In essence, geotechnical design analyses used to evaluate vertical drain spacing, settlement rate and strength gain for surcharge fills with vertical drains are equally applicable to vacuum consolidation. However, unlike surcharge fills, which may cause lateral spreading of the underlying soft soil and pose stability concerns, vacuum consolidation does not pose any stability problem since the treated block of soil is “loaded” laterally as well as vertically by the vacuum pressure i.e. vacuum consolidation process is isotropic.

vi. Mechanism of vacuum consolidation

153. Instead of increasing the effective stress in the soil mass by increasing the total stress as in the case of placing surcharge fills, vacuum consolidation relies on increasing effective stress by decreasing the pore water pressure while maintaining a constant total stress. This is effect is in the form of a vacuum. That is, removing atmospheric pressure from a sealed membrane system covering the soil to be consolidated and maintain the vacuum effect for a pre-determined period of time. The vacuum causes water to drain out from the soil and creates negative pore pressures in the soil.

154. This technique is most suitable for very soft soils with high ground water table where stability and speed of construction is of major concern. Its isotropic consolidation eliminates the risk of shear failure. The vacuum generates in the sand blanket an apparent cohesion due to the increase of the effective stress. This provides the stability to enable almost immediate loading on very soft soils. Experience indicates that within days after commencement of vacuum pumping, loading can be applied. Vacuum consolidation is often combined with surcharge fill by placing fill material on top of the impervious membrane when the equivalent surcharge height exceeds the vacuum pressure.

vii. Implementation of vacuum consolidation

155. There are two generic methods of Vacuum Consolidation used for preloading and consolidating of soft and very soft saturated clayey soils.

156. **For the membrane system**, the procedure consists of installing vertical and horizontal vacuum transmission pipes under an airtight impervious membrane and evacuating the air below the membrane producing an atmospheric pressure on the soil. This loading process creates an accelerated isotropic consolidation in the soil mass in a relatively short time. This reduces the need for potentially unstable surcharge loads.

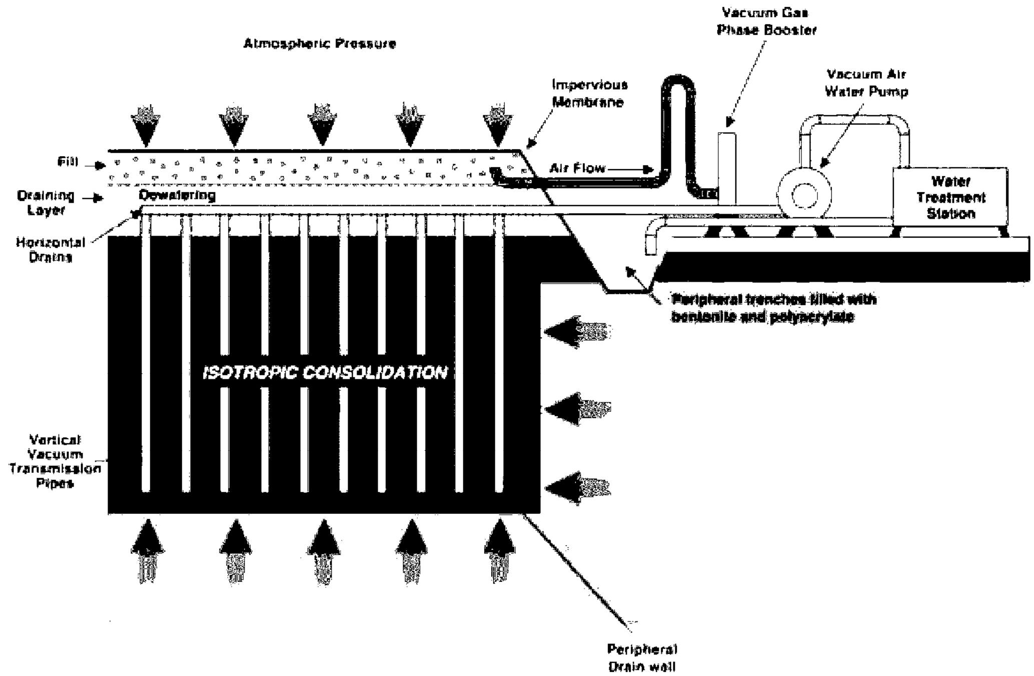


Figure 19: Vacuum Preloading with membrane system

157. In the second system, the membrane is omitted and replaced by a direct connection of the vertical drain to a series of pipes and ultimately a vacuum pump.

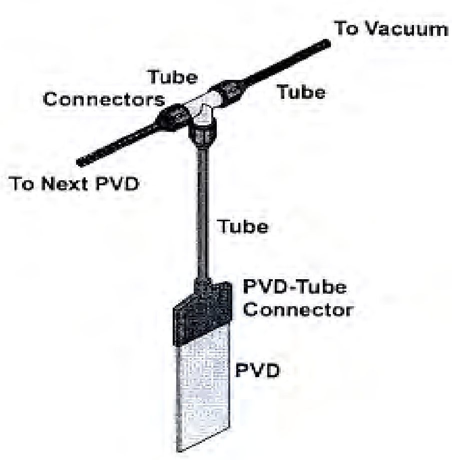


Figure 20: PVD and tubing for vacuum with membrane-less system

viii. Advantages of Vacuum Consolidation:

- Significant time savings over other consolidation methods
- Loading and construction can proceed as early as two weeks after the membrane is installed, which usually takes 3 to 4 weeks to install

- Isotropic consolidation reduces the risk of failure under additional loading of the permanent construction
- Less risk of slope instability beyond boundaries
- Ease in controlling rate and magnitude of loading and settlement
- Lower surcharge; require small space; less problem with ROW
- Less likely to use counterweight berm in the membrane system
- No Clean Coarse Sand Blanket required in the membrane system
- Less lateral movement, and movement is inward

158. Typically, seven tonnes per square metre to eight tonnes per square metre of vacuum for the membrane system (or 5 to 6 tonnes/m2 for the pipe system) can be applied to the depressurized improved area, and this vacuum pressure can be treated as a 4-m surcharge. The effectiveness of the method depends greatly on the sealing or isolation of vacuum within the depressurized zone and the distribution of vacuum in the drains. Therefore, the drains have to be designed to withstand the vacuum pressure; any collapse of flow channel within the drains will result in catastrophic consequences, such as embankment failure or unacceptable degree of consolidation. As a result, this type of work is normally executed by ground improvement specialists. Each specialist firm will adopt his own vacuum application system ranging from the type of drains to connections and vacuum pumps. Hence, the work is usually carried out according to the performance basis with guidelines specified by the client.

159. Apart from applying the vacuum pressure, it is also common to place additional surcharge fill on top of the depressurized zone to increase the total stress of the soil, resulting in acceleration of consolidation and reduction in the consolidation time. But it should be noted that there is also a limit in placing the surcharge due to stability as in PVD preloading method, once 4 m have been installed. Therefore for high surcharge load (higher than 4 m), there will be a need to perform staged/slow continuous loading or to introduce counterweight berm for improving stability during consolidation.

160. To achieve sufficient gain in strength of the improved soft clay during filling, the filling rate will have to be controlled at an average filling rate of about 5 cm per day under full vacuum pressure. This will ensure that the degree of consolidation will reach at least 40% at the maximum surcharge height. To minimize the pumping period, the degree of consolidation for the vacuum consolidation is limited to 85% instead of 90% in the conventional PVD method. Additional waiting period of 6-8 months will be needed in achieving the degree of consolidation of 85%.

ix. Cement Deep Mixing

161. Deep Mixing with Dry Cement uses cement to mix with soft soil by a treatment mixing equipment to improve the strength of soft ground.

162. The strength of treated soil is increased by hydration reaction of cement-base solidifier and water and by pozzolanic reaction of calcium hydroxide produced by hydration reaction and cohesive soil.

163. The main use of this method is to transfer the surface loading (including embankment, pavement and traffic load) to the soil cement columns in the same way as the piled foundation

164. The deep mixing method consists of two components, namely the soil cement columns for load transfer and a cement stabilized mat for better distribution of embankment load to the columns, similar to the slab of the piled foundation.

165. After the soil-cement mix is set in the ground, a semi-rigid column will be formed acting as a supporting member. For soft soil treatment by means of this deep mixing method, the design strength of the column will be limited to 40-100 t/m2 with cement content of 150 to 250 kg for one cubic meter of in-situ soil. The practical diameter of column used in the soft ground condition will be around 0.5 m to 1 m with a maximum installation depth of around 20 m.

166. At this stage, the proposed soil cement columns properties and dimensions will be as below:

- Column diameter, d = 0.7 m
- Column length, L = 15 to 20 m
- Design unconfined compressive strength, qu = 80 ton/m2
- Column Spacing, S = 1.5 m to 1.8 m (square pattern)

167. For the cement stabilized mat, the following properties and dimensions have been adopted:

- Mat thickness, t = 1.0 m
- Design unconfined compressive strength, qu = 200 ton/m2

168. For global stability and settlement of the embankment, the soil cement columns have to be considered as a composite mass. The average shear strength "cavg" of the composite block can be expressed as a weighed value based on the area ratio "a" (stabilized/unimproved) by the following equation:

$$c_{avg} = c_u\ (1 - a) + S_{col} \text{ x } a$$

169. Where:

c_u : is the undrained shear strength of the unimproved soil,

S_{col} : is the shear strength of the soil cement column,

a : is area ratio

170. The following parameters have been adopted:

- Column diameter, d = 0.7 m
- Undrained shear strength of column, Scol = 40 ton/m2
- Column spacing, s = 1.5 to 1.8 m from center to center in square grid.
- Width of column block, w = 45 m approximately.

171. The method of settlement analysis for the deep mixing method is similar to that used in the pile foundation. It is assumed that the load will be transferred to a depth equal to two-third of column length, followed by a load distribution of 1H:2V down to firm soil layer.

x. RC Pile-Supported Embankments

172. In soft soil areas with large depth, plus high embankment will give rise to excessive settlement. This can be avoided by means of structural solutions such as viaduct or piled embankment. Structural solution is recommended in soft ground conditions with depths exceeding 20 m. Structural solution is also required where settlement requirement is very strictly like at the approach to bridge.

173. Where height of embankment is more, cost of pilled embankment may be higher and Viaduct may have to be provided.

174. The trade off option between viaduct and piled embankment is governed by the embankment height. Economical analysis indicates that viaduct is more feasible for embankment in excess of about 5.0 m, below which piled embankment is favorable.

175. Since the piles are used as a transition unit, the pile lengths will have to vary in accommodating the differential settlement between the bridge abutment and the embankment beyond the RC pile slab structure. The method of settlement analysis of bearing unit is similar to that used in the pile foundation. It is assumed that the load will be transferred to a depth equal to two-third of column length with consideration of average load over the entire embankment and the side friction of the block. The remaining load will be transferred by a load distribution of 1H:2V down to the firm soil layer.

176. Recently, geogrids have been introduced to replace the concrete slab at bridge approaches as an alternative solution. A small pile cap is needed on each pile in improving the load transfer from the fill embankment to the piles through the geogrids. Please see the figure below for more details.

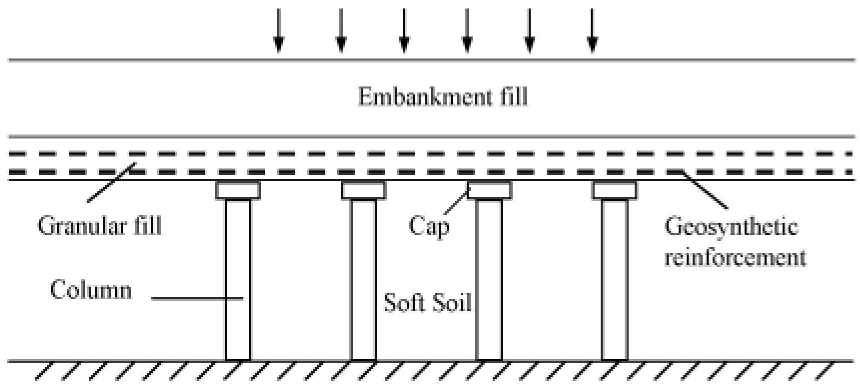


Figure 21: Pile Supported Embankments Using two Geogrids Layers

xi. Benefits of Pile Supported Embankments:

- The Pile Supported Embankment method is a very rapid technique for constructing embankment over soft soils. The mechanics of the technique allow for immediate embankment construction in a single placement stage.

- No instability issues (the embankment load is transferred to the stiff piles and not the soft soils).

- Unlike most of the other non-wick drain accelerated ground improvement techniques, pile supported embankment technology uses conventional practice for all aspects of design, specification and construction.

- More reliability; Simplicity in installation & QC (quality control)

xii. Field Monitoring & Instrumentation

177. Monitoring system has been employed to compensate uncertainties in design and control the construction process; Surface Settlement Plate, Deep settlement plates, piezometers, inclinometers, Observation well and Alignment stakes are included. This observational method might be helpful to control stability of embankment and to estimate time-settlement relationship during the construction and residual settlement (post-construction).

e. Embankment Settlement Analysis

178. **Residual settlement:** Generally, settlement comes from three major components; immediate settlement, primary, and secondary consolidation.

179. **Immediate settlement:** Immediate settlement of all clayey layers and sand layers shall be calculated. As the amount of immediate settlement will affect on actual embankment fills, so it would affect on the load of actual fills and also the estimation of fills volume (quantity).

180. **Considerations for settlement:** settlement during construction period shall be estimated. The required fill height will be equal to embankment height plus some extra amount to compensate the settlement that would occur during construction period.

181. The total settlement S can be given as:

$S = S_e + S_c + S_{creep}$

Where:
S_e: Immediate Settlement
S_c: Consolidation Settlement
S_{creep}: Creep Consolidation. This will be ignored

182. Immediate settlement takes place as the load is applied or within a time period of about seven days. Consolidation settlement takes months to years to develop.

i. Estimation of Immediate Settlement

183. Immediate settlement of soil layer j will be estimated as follows:

$$S_e j = \frac{\Delta P}{E_S} \times hj$$

Where: E_s = elastic modulus of the soil layer

For clayey soil:

$$E_S = \frac{15{,}000}{PI} \times S_U$$

PI = Plasticity Index
For sandy soil:
Es =650 x N_{70}, kPa
N_{70} = corrected SPT value
$N_{70} = N_x C_N$

$$C_N = \left(\frac{95.76}{p_o^{'}}\right)^{0.5} \text{ (kPa)}$$

ii. Estimation of Consolidation Settlement

184. The total settlement due to consolidation can be expressed as:

Total settlement of clay,

$$\rho_{clay} = H\left[RR \log\frac{\sigma'_p}{\sigma'_{vo}} + CR \log\frac{\sigma'_{vf}}{\sigma'_p}\right]$$

Where:
H is the thickness of clayey soil;

RR is the recompression ratio;
CR is the compression ratio,
σ'_{vo} is the effective overburden stress;
σ'_{p} is the pre-consolidation pressure; and
σ'_{vf} is the final vertical stress.

f. Embankment Stability Analysis

185. The Factor of Safety against the embankment stability shall be calculated by Bishop or Janbu Method, or using some software. It also could be estimated using the following equation:

$$q_{ult} = 5.7S_u$$

Where S_u is the undrained shear strength of the clayey subsoil.
Then the limit embankment height will be estimated:
H_{limit}=q_{ult}/(FS x unit weight of fill)

186. In case the fill height is greater than the limit, then some countermeasures must be applied. Counter Measures to Overcome Instability Problem:

- Reduce the filling rate
- Wait for some months between the two filling stages
- Geotextile or Geogrids can be used to increase stability of the embankment on soft ground.
- All existing ponds within 100m ROW should be filled up
- Counterweight Berm
- Change to another soil treatment method

187. Fill rate is an important factor that maintains the stability of embankment as in the very soft soil areas like sections from Km 14 to Km 31, and Km 50.5 to Km 56. The fill rate shall be 5 cm per day or 0.5m in 10 days. This rate will be verified by stability analysis. The strength gain during the soil treatment shall be calculated using SHANSEP formula.

188. To estimate the gain in undrained shear strength of the soft soils due to consolidation, the SHANSEP method proposed by Ladd and Foott (1974) is adopted, which can be expressed as:

Normalized strength ratio,

$$\frac{c_u}{\sigma'_{vo}} = S\,(OCR)^m \text{ or } \frac{c_u}{\sigma'_{vc}} = S\,(OCR)^m$$

Where σ'_{vo} = Effective overburden tress,
OCR = Over consolidation ratio

189. The above equation is particularly useful in staged construction, where the gain in undrained shear strength due to consolidation of the soils can be estimated. When the vertical

effective stress is greater than its pre-consolidation pressure, that is, the soil is the normally consolidated state, then the above equation becomes:

$$\frac{c_u}{\sigma'_{vc}} = S \text{ or } c_u = S\,\sigma'_{vc}$$

190. Applied loads for calculation: fill height including settlement compensation are used in calculation for settlement & stability. Traffic load during construction is considered only for stability evaluation.

g. Results of Engineering Analysis

i. Results of Settlement Analysis Typical Sections

191. All of residual settlements have to meet the design criteria. If this is not met or it must take too much of time or space (ROW) the designs must be modified. We will, during our analysis, change to another soil treatment method until it being satisfied. Soil Properties Input and 12 Geotechnical Sections could be found in the appendix.

192. With fill height varies from 2 m to 5 m , the settlement during construction will varies from 10 to 300 cm, depending on subsoil condition and the applied soil treatment method.

ii. Results of Stability Analysis of Typical Sections

193. All of Factor of Safety must meet the design criteria. If this is not met or it must take too much of time or space (ROW) the designs must be modified. We will, during our analysis, change to another soil treatment method until it being satisfied.

194. The following methods are presented in their order of priority.

1) Reduce the filling rate
2) Divide into 2 stages and wait for some months between the two filling stages
3) Adding some soil reinforcements like one or two layers of Geogrids
4) Counterweight Berm
5) Change to another soil treatment method

195. Please see the Stability Analysis of some typical sections in the appendix.

iii. Choice of Soil Treatment Method

196. Base on the two analyses above, we propose soil treatment that best suitable for each portion of the expressway.

iv. Time Frame for Soil Treatment

197. Based on the available soil data, and our initial our estimation. It will take about 3 months for preparation, mobilization, and 3 to 4 months for filling, instrumentation installation, and about 6 to 12 months of waiting for consolidation. The total time for soil treatment could be in the order of 12 to 18 month time.

h. Summary

198. About half of the Ben Luc – Long Thanh expressway is on soft to very soft soils. These soil layers have a low bearing capacity and exhibit large settlements or failure when subjected to loading. It is therefore inevitable to treat soft soil deposits prior to placement of the final road surface layer in order to prevent large settlement, differential settlements and subsequently potential damages to structures.

199. Different ground improvement techniques are available today. Every technique should lead to an increase of soil shear strength, a reduction of soil compressibility and a reduction in the time for construction.

200. The choice of ground improvement technique depends on geological formation of the soil, soil characteristics, cost, availability of backfill material and experience in the past.

5. Pavement Design

a. Pavement Design Standards

201. Specification for design Pavement Structure:

a) Pavement Design Standards (22TCN211-06), 2006.

b) Pavement Design Standards (22TCN274-01), 2001 (for reference).

- Established design standards for pavement design Vietnamese Design Standard
  - Standard axle load P = 100 kN.
  - Define calculated traffic volume
  - Numbers of axle N_{tt}:
    $N_{tt} = N_{tkxf1}$ (axles/lane.day) – See 22TCN211-06 for more detail.
- Define the accumulating standard axles N_e with average grown coefficient of traffic volume q (%)

$$N_e = \frac{\left[(1+q)^t - 1\right]}{q(1+q)^{t-1}}.365.N_{tt}$$

- Define the required Elastic Modulus

Based on N_{tt} and Table 3.4/page 39 of 22TCN211-06, = the value of E_{yc}

- Define Parameters of Road-bed and Pavement structure
- Checking the strength of pavement and shoulder following the standard of limiting flexible state Condition:

  $E_{ch} \geq K_{cd}^{dv} * E_{yc}$ – See 22TCN211-06 for more detail

- Checking the strength of pavement and shoulder structure following to the standard of shear limiting state in roadbed and layers that are insufficient for agglutination Conditon:

  $$\tau_{ax} + \tau_{av} \leq \frac{C_{tt}}{K_{cd}^{tr}}$$ – See 22TCN211-06 for more detail

- Checking the strength of pavement and shoulder following to the standard of flexural strength state in correlative layers Condition:

  $$\sigma_{ku} \leq \frac{R_{tt}^{ku}}{K_{cd}^{ku}};$$ – See 22TCN211-06 for more detail

202. The design input requirements by AASHTO method of design are;

1. Design Variables
2. Performance Criteria
3. Material Properties for Structural Design and,
4. Pavement Structural Characteristics

203. The following design standards for pavement design have been established and given in Table 49.

Table 49: Design Standard for Pavement Design by AASHTO DESIGN

Design Input Requirements			Value	Reference
1	Design Variables	Performance Period (years)	15	22TCN-274-01
		Traffic		
		Equivalent Single Axle Load (ton)	8.2	22TCN-274-01
		Directional Distribution Factor, D_D	0.5	22TCN-274-01
		Lane Distribution Factor, D_L	0.8 (2x2lane)	22TCN-274-01
		Reliability	99	22TCN-274-01
		Overall Standard Deviation	0.45	22TCN-274-01
2	Performance Criteria	Initial Serviceability Index, p_0	4.2	22TCN-274-01
		Terminal Serviceability Index, p_t	2.5	22TCN-274-01
		Design Serviceability Loss, ΔPSI	1.7	22TCN-274-01
3	Material Properties	Effective Roadbed Soil Resilient Modulus, M_R (psi)	1500 × CBR	22TCN-274-01
		Layer Coefficient for Asphalt Concrete, a_1	Figure 1.6	22TCN-274-01
		Layer Coefficient for Base Course, a_2	Figure 1.7	22TCN-274-01
		Layer Coefficient for Subbase Course, a_3	Figure 1.8	22TCN-274-01
4	Pavement Characteristics	Drainage Coefficients for Base Course and Subbase Course, m_2, m_3	1.0	22TCN-274-01

See 22TCN274-01 for more detail

b. Basic Data for Thickness Design

i. Design Period

204. The Vietnamese Standard requires design of pavement structure for 15 years. The opening to traffic is considered at the year 2016 and 15 years of traffic is taken up to the end of year 2031. Accordingly, following concept is used in considering the Design Period of pavement design. The pavement design will be considered 4-lanes (2 x 2 lanes) for the year from 2016 to 2031, a total of 15 years as required by the Vietnamese Design Standard of Pavement Design.

ii. Design Traffic

205. The Traffic volume study report has provided the traffic forecast for different years for Ben Luc (Long An Province) – Long Thanh (Dong Nai Province) as given in Table 50, this is the heaviest traffic on the project between Interchange IC#4 and IC#5 which is used for the pavement design.

Table 50: Traffic Forecast in Traffic volume Study Report

Year #	Year	Vehicle Type						
		Passenger Car & Van	Medium Bus	Standard Bus	Small Truck	Big Truck	Container Truck	Total
1	2016	320	68	29	2,330	3,780	800	7,327
2	2017	731	100	43	2,746	4,455	942	9,017
3	2018	1,160	132	56	3,173	5,148	1,089	10,758

Year #	Year	Vehicle Type						
		Passenger Car & Van	Medium Bus	Standard Bus	Small Truck	Big Truck	Container Truck	Total
4	2019	1,607	164	70	3,611	5,860	1,240	12,552
5	2020	2,073	194	82	4,061	6,590	1,394	14,394
6	2021	2,556	224	95	4,522	7,338	1,552	16,287
7	2022	3,057	253	108	4,995	8,105	1,714	18,232
8	2023	3,577	281	120	5,479	8,890	1,880	20,227
9	2024	4,114	309	132	5,974	9,694	2,050	22,273
10	2025	4,669	336	143	6,481	10,516	2,224	24,369
11	2026	5,243	363	154	6,999	11,356	2,402	26,517
12	2027	5,835	388	166	7,528	12,215	2,584	28,716
13	2028	6,444	414	176	8,069	13,092	2,770	30,965
14	2029	7,072	438	186	8,621	13,988	2,959	33,264
15	2030	7,718	462	197	9,184	14,902	3,152	35,615
16	2031	8,381	485	206	9,759	15,835	3,350	38,016
17	2032	9,063	507	216	10,345	16,786	3,551	40,468
18	2033	9,763	529	225	10,942	17,756	3,756	42,971
19	2034	10,481	550	234	11,551	18,743	3,965	45,524
20	2035	11,217	570	243	12,172	19,750	4,178	48,130
21	2036	11,971	590	251	12,803	20,774	4,394	50,783

c. Thickness Design by Vietnamese Method

i. Standard Axle Load

206. Total axles converted from different vehicle types to standard axle load at the end of 15th year are given in Table 51.

Table 51: Standard axles (load/ 2lanes.day) at the end of 15th year

Type of Vehicle		P_i (kN)	No. of axles of each heavy axle group	No. of axles	Distance between heavy axles (m)	C_1	C_2	n_i	$C_1.C_2.n_i.(Pi/100)^{4,4}$
Mini Bus	Light axle	11.53	1	1	0.0	1.0	6.40	485	0
	Heavy axle	17.30	2	1	0.0	1.0	1.00	485	0
Standard Bus	Light axle	31.78	1	1	0.0	1.0	6.40	206	9
	Heavy axle	47.67	2	1	0.0	1.0	1.00	206	8
Truck (2- axles)	Light axle	24.49	1	1	0.0	1.0	6.40	9,759	0
	Heavy axle	57.14	2	1	0.0	1.0	1.00	9,759	832
Truck medium (3-axles)	Light axle	27.29	1	1	0.0	1.0	6.40	0	0
	Heavy axle	63.68	2	1	0.0	1.0	1.00	0	0
Big Truck (>3 axles)	Light axle	27.29	1	1	0.0	1.0	6.40	15,835	334
	Heavy axle	63.68	2	2	0.0	2.2	1.00	15,835	4,782
Container	Light axle	26.89	1	1	0.0	1.0	6.40	3,350	66
	Heavy axle	62.74	2	3	1.4	3.4	1.00	3,350	1,465

207. The number of standard axles per lane:

$N_{tt} = N_{tk}*f_l = 7,496 * 0.35 = 2,624$ (axles/lane.day)

ii. Cumulative Standard Axles

208. With average growth coefficients from Table 50

$$N_e = \frac{\left[(1+q)^t - 1\right]}{q(1+q)^{t-1}}.365.N_{tt}$$
,

209. Ben Luc – Long Thanh Section N_e = 5,318,326 (cumulative axles/lane)

iii. Required Elastic Modulus

210. Based on these, the required E_{yc} is calculated as in Table 52.

Table 52: Required Elastic Modulus (E_{yc} or M_R)

Section	Year	N_{tt} (veh/day/lane)	Type of Surfacing	E_{yc} (MPa)	E_{yc}^{min} (MPa)	$E_{yc}^{chọn}$ (MPa)
Ben Luc –Long Thanh	15th (2031)	2,624	A1	211	180	211

211. Parameters for Pavement Material Types

Roadbed soil is type II,
Moisture W= 0.65.
E = 53 MPa; φ = 21 degree; c = 0.028 MPa

Table 53: Parameters of Pavement Material Types

Type of Material	Elastic Modulus E (Mpa) at (30^0C)	(60^0C)	($10\text{-}15^0$C)	Flexural strength (Mpa)
Bituminous layer type I (Surface)	420	300	1,800	2.8
Bituminous layer type I (Binder)	350	250	1,600	2.4
Asphalt treated Base	350		800	
Aggregate Base type I	300	300	300	
Aggregate Sub-base type II	250	250	250	

iv. Thickness Design

212. The calculated thicknesses of pavement layers for various combinations are given in Table 54.

Table 54: Thicknesses of Pavement Layers

Section	Design Thickness (cm)						
	Asphalt Concrete						
	Rough.	Surface	Binder	ATB	Base	Subbase	Total
Ben Luc – Long Thanh	3	5	7	13	35	40	103

d. Thickness Design by AASHTO METHOD

i. Design Cumulative Equivalent Single Axle Load (ESAL)

213. The design procedures are based on cumulative expected Equivalent Single Axle Loads (ESAL) during the design period.

214. Based on the traffic volume forecast from Table 50, the traffic volume from the year 2016 to 2031 has been estimated. The design cumulative equivalent single axle load for the project is given in Table 55, which has been calculated after applying the directional and lane distribution factors.

Table 55: Design Cumulative ESAL

Section	Design Cumulative ESAL (millions)
Ben Luc – Long Thanh Section	4.723

ii. Design Variables

215. The design input requirements to pavement design equations in AASHTO design method for asphalt concrete pavements are;

1. Design Variables
2. Performance Criteria
3. Material Properties for Structural Design, and,
4. Pavement Structural Characteristics

216. The performance period refers to the period of time that an initial pavement structure will last before it needs rehabilitation. It is taken as 15 years as discussed earlier.

217. The total number of application of equivalent single axle load is obtained for the design lane by the following expression;

$W_{18} = D_D \times D_L \times w_{18}$

where:
Directional Distribution Factor, $D_D = 0.5$
Lane Distribution Factor, $D_L = 0.8$
Directional distribution factor (traffic per direction) used in Vietnamese Standard is

iii. Reliability and Overall Standard Deviations

Proposed Level of Reliability, R = 99%
Proposed Overall Standard Deviation, S_0

e. Performance criteria

i. Serviceability

218. The input parameter for the pavement design equation is the total change in serviceability index, that is given by:

$\Delta PSI = p_0 - p_t$

where,
ΔPSI = total change in serviceability index, or design serviceability loss
p_0 = original or initial serviceability index
p_t = terminal serviceability index, before any rehabilitation
Following values are proposed for this Project;
Design Serviceability Loss, ΔPSI = 1.7
Initial Serviceability Index, p_0 = 4.2
Terminal Serviceability Index, p_t = 2.5

ii. Material properties for structural design

219. CBR tests are proposed for this project also, by which resilient modulus can be calculated as,

M_R (psi) = 1500 x CBR

Based on this, the design CBR value of subgrade is taken as ≥ 8%.

The Structural Layer Coefficient a_1 for asphalt concrete surface course is a function of Elastic Modulus of asphalt concrete as given in the charts.
The Layer Coefficient for granular base course a_2 is obtained from its CBR value as given in the charts.
Layer Coefficient for sub-base course, a_2 is obtained from its CBR value as given in the charts.
Proposed drainage coefficients, m2, m3 = 1.0

f. Designed Thickness

Table 56: Designed Pavement Thickness AAHSTO

Section	Structural No. (SN)	Design Thickness (cm)					
		Asphalt Concrete					
		Roughness layer	Surface	Binder	Base	Sub-base	Total
BL-LT	5.27	3 cm	5 cm	7 cm	30 cm	35 cm	80 cm

g. Recommendations

i. Conditions of Design

220. Pavement thickness design will be done by using Vietnamese Design Standard. However, the design will be checked from AASHTO method also as many of the tests required during construction also refers to international standard.

Traffic volume is based on the forecasted results from Traffic volume Report.
TCN211-06 requires design with asphalt concrete roughness layer for expressway with thickness of 3cm.
TCN211-06 stipulates that the base and subbase course materials shall be of CBR≤80% and CBR≤30% respectively.

Table 57: Comparison of Results from Vietnamese Standard and AASHTO Standard

Standard	Design Thickness (cm)						
	Asphalt Concrete			ATB	Base	Subbase	Total
	Roughness layer	Surface	Binder				
Vietnamese E_{yc}>200MPa Axle Load=100KN	3 cm	5 cm	7 cm	13 cm	35 cm	40 cm	103 cm
AASHTO CBR>8%	3 cm	5 cm	7 cm	12 cm	20 cm	26 cm	73 cm
Recommended Pavement	3 cm	5 cm	7 cm	13 cm	35 cm	40 cm	103 cm

Figure 22: Recommended Pavement Structure

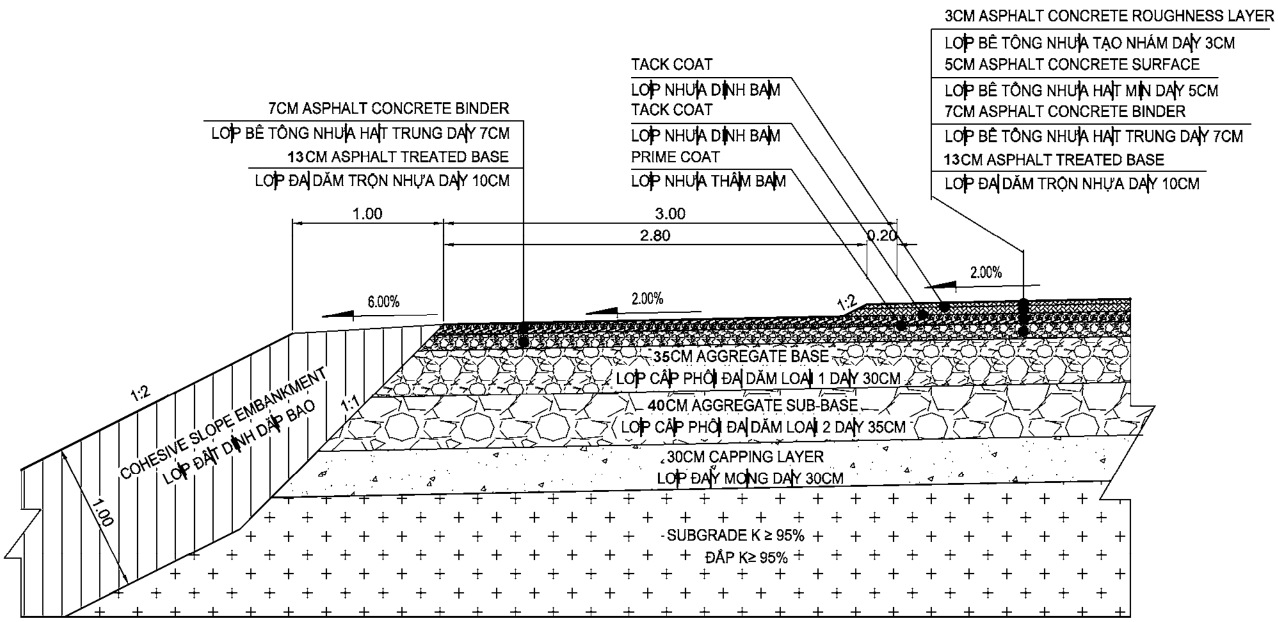


Figure 23: Pavement Structure for traveled way

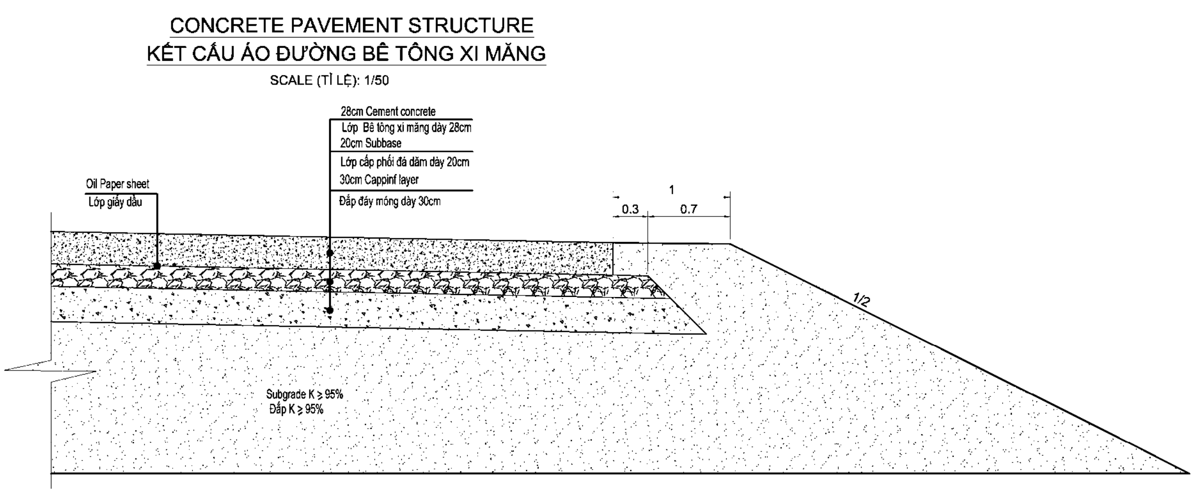


Figure 24: Concrete Pavement Structure for Toll Plaza Areas

6. Interchange Design

221. Ben Luc – Long Thanh Expressway is designed according to" A" Type Expressway Standard (speed level 120km/h), all used on the Project are interchanges. There are eight interchanges on the Project as shown in Figure 25and as listed in Table 58.

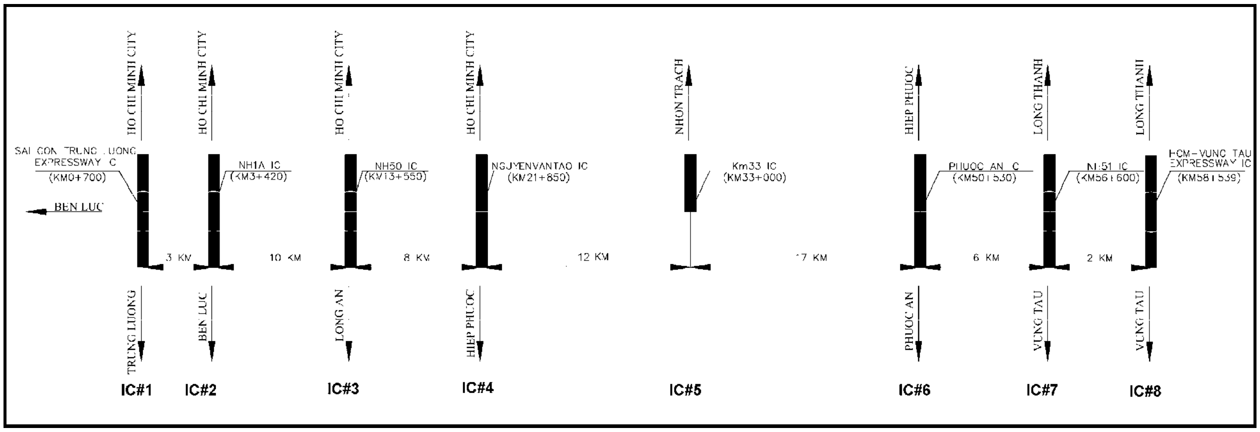


Figure 25: Plan of interchanges on Ben Luc-Long Thanh Expressway Project

Table 58: Summary table of interchanges

No	Name of IC	Station	Type of IC	Cross road		
				Name	Width	Speed
IC#1	HCMC Trung Luong IC	Km 00+700	Double Trumpet	HCMC TL	32 (m)	80 kph
IC#2	NH1A IC	Km 03+420	Diamond	NH1A	43 (m)	80 kph
IC#3	NH50 IC	Km 13+550	Trumpet	NH50	40 (m)	80 kph
IC#4	Nguyen Van Tao IC	Km 21+850	Trumpet	Nguyen Van Tao	15 (m)	60 kph
IC#5	Km 33 IC	Km 38+370	Trumpet	Ring Road #3	22.5 (m)	60 kph
IC#6	Phuoc An IC	Km 50+530	Diamond	Phuoc An Port	61(m)	80 kph
IC#7	NH 51 IC	Km 56+600	Diamond	NH51	64 (m)	80 kph
IC#8	HCMC Vung Tau IC	Km 58+538	Trumpet	BH – Vung Tau	37 (m)	120 kph

222. The roads that connect IC#5 (Ring Road #3) and IC#8 (Bien Hoa – Vung Tau Expressway) will be constructed after the completion of the expressway but before 2020 as per the HCMC Masterplan.

223. The Intersection design is based on following criteria:

1. Economical impact
2. Approaching surrounding areas
3. Efficiency of traffic treatment
4. Traffic volume of access road
5. Traffic safety
6. Easy management

a. Standard to design intersections

224. The Standards applied in the interchange design of the Ben Luc-Long Thanh Expressway Project included the following:

Vietnam Criteria

- 22 TCN 273-01
- TCVN 5729; 1997

AASHTO 2004 Criteria

Japanese Criteria (reference)

i. Criteria for ramps design of intersection

225. The design team prioritized the Vietnamese Criteria. If there are no applicable Vietnamese criteria, the Japanese criteria and the AASHTO were applied comparing and evaluation of the criteria.

226. If there are same criteria which are defined in the different way in 22TCN 273-01 and TCVN 5729;1997, the consultant applied the most reasonable criteria between them after reviewing Japanese criteria and AASHTO criteria

Table 59: Proposed design standards for interchanges

Item			TCVN 5729;97	TCVN 4054;05	22TCN 273-01	Japanese Criteria	AASHTO 2004	Proposal	Remark
Design Speed									
Direct Km/h			60-35	50	70	50	60	50	
Loops Km/h			60-35	40	70	40	40	40	
Maximum Super-Elevation (%)				6%	8%	8%	8%	8%	
Min. Radius (m)	V=40 km/h			60 m	50 m	50 m	41 m	50 m	
	V=50 km/h				80 m	80 m	73 m	80 m	
	V=60 km/h			125 m	125 m	130 m	113 m	125 m	
Min. Length of Curve (m)	V=40 km/h		=1.67xV (km/h)			50 m	=3 x V (km/h)	50 m	
	V=50 km/h					60 m		60 m	
	V=60 km/h					70 m		70 m	
Min. Length of Spiral (m)	V=40 km/h		L=R/9			25 m	22 m	25 m	AASHTO
	V=50 km/h					30 m	28 m	30 m	
	V=60 km/h					35 m	33 m	35 m	
Stopping sight distance	V=40 km/h			40 m	44.4 m	40 m	as Horizontal sight line	44.4 m	
	V=50 km/h				62.8 m	55 m		62.8 m	
	V=60 km/h		75 m	75 m	84.6 m	75 m		84.6 m	
Maximum Grades (%)	V=40 km/h			6% - 11%	7%	11%	8%	7%	
	V=50 km/h				6%	10%		6%	
	V=60 km/h				6%	10%		6%	
Min. length of VC (m)	V=40 km/h			35 m	24 m	35 m		24 m	
	V=50 km/h				30 m	40 m		30 m	
	V=60 km/h		50 m	50 m	36 m	50 m		36 m	
Min. K of VC	Crest	V=40 km/h			5	4	4	5	
		V=50 km/h			10	8	7	10	
		V=60 km/h			18	15	11	18	
	Sag	V=40 km/h			8	6	9	8	

Item			TCVN 5729;97	TCVN 4054;05	22TCN 273-01	Japanese Criteria	AASHTO 2004	Proposal	Remark
		V=50 km/h			12	10	13	12	
		V=60 km/h			18	15	18	18	
Min. Acceleration Length (m)	V=120 km/h	V=40 km/h	200 m		470 m	470 m	490 m	200 m	
		V=50 km/h	200 m		445 m	445 m	460 m	200 m	
		V=60 km/h	200 m		400 m	400 m	410 m	200 m	
	V=80 km/h	V=40 km/h	160 m		135 m	135 m	145 m	160 m	
		V=50 km/h	160 m		100 m	100 m	115 m	160 m	
		V=60 km/h	160 m		55 m	55 m	65 m	160 m	
Min. Deceleration Length (m)	V=120 km/h	V=40 km/h	100 m		175 m	175 m	175 m	100 m	
		V=50 km/h	100 m		170 m	170 m	170 m	100 m	
		V=60 km/h	100 m		155 m	155 m	155 m	100 m	
	V=80 km/h	V=40 km/h	80 m		100 m	100 m	100 m	80 m	
		V=50 km/h	80 m		90 m	90 m	90 m	80 m	
		V=60 km/h	80 m		80 m	80 m	80 m	80 m	
Min. Taper Length (m)	V=120 km/h		75 m				75 - 90 m	75 m	
	V=100 km/h		60 m					60 m	
	V=80 km/h		50 m					50 m	
Ramp Terminal Spacing (m)	successive exits expressway				350 m	300 m	300 m	300 m	
	successive exits ramp				300 m	240 m	240 m	240 m	
	exit followed by entrance				200 m	150 m	150 m	150 m	
	successive entrances expressway				350 m	300 m	300 m	350 m	
	successive entrances ramp				300 m	240 m	240 m	300 m	
Toll Plaza	Minimum Radius					200 m		200 m	
	Maximum Grade					< 2		< 2	
	Minimum K for crest					10 ≥ 7		10 ≥ 7	
	Normal crown					1.5 ≥ 2		1.5 ≥ 2	
	Connection to taper					1:5		1:5	
	length of entrance section to expressway					90 m		90 m	
	length of exit to expressway					60 m		60 m	
	length of entrance section from road					60 m		60 m	
	length of exit section from road					60 m		60 m	

227. Typical cross section of ramps: (Following TCVN5729-1997)

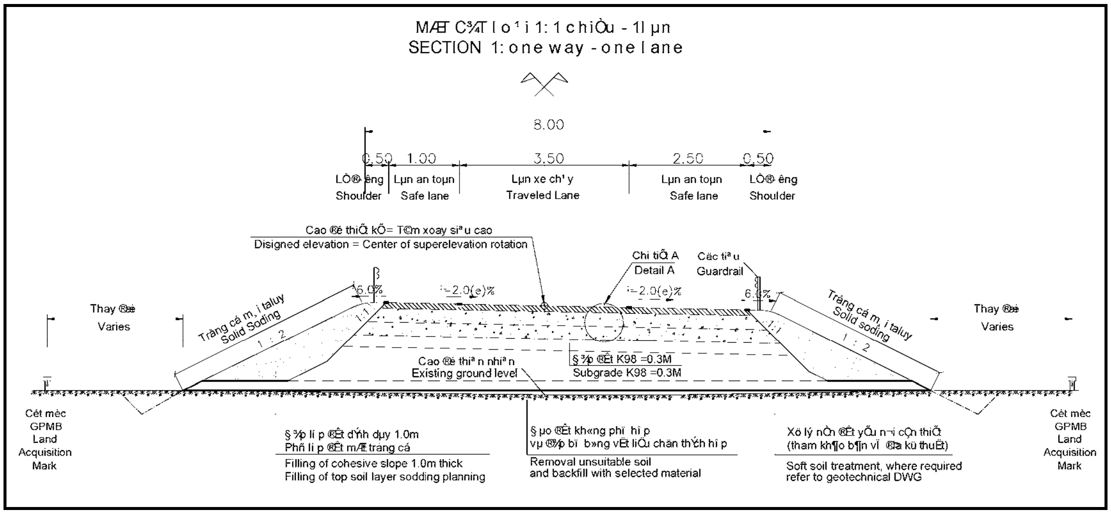


Figure 26: Cross section of 1 way - 1 lane ramp

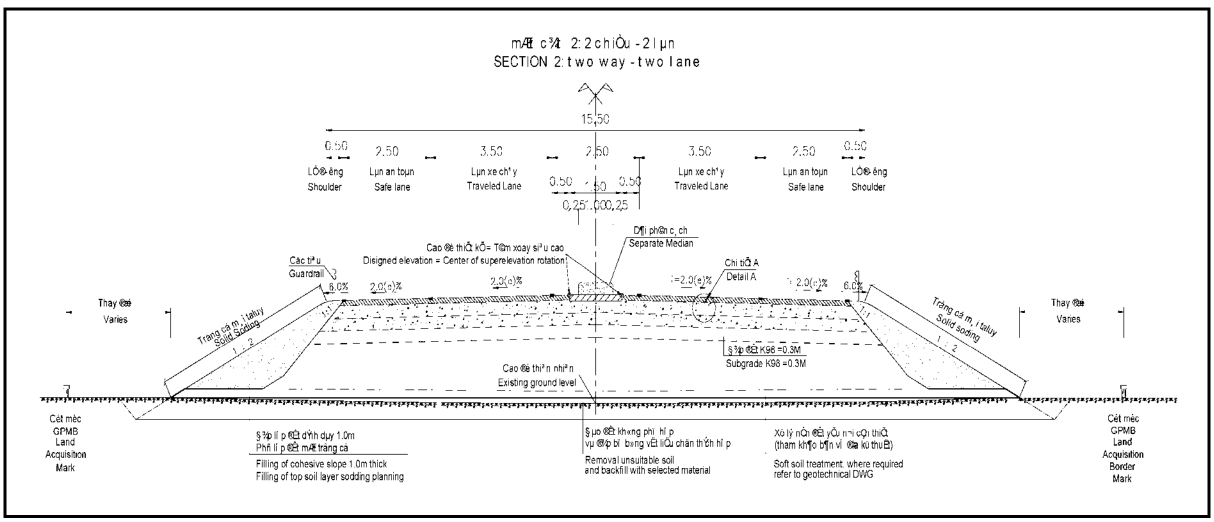


Figure 27: Cross section of 2 ways- 2 lanes ramp

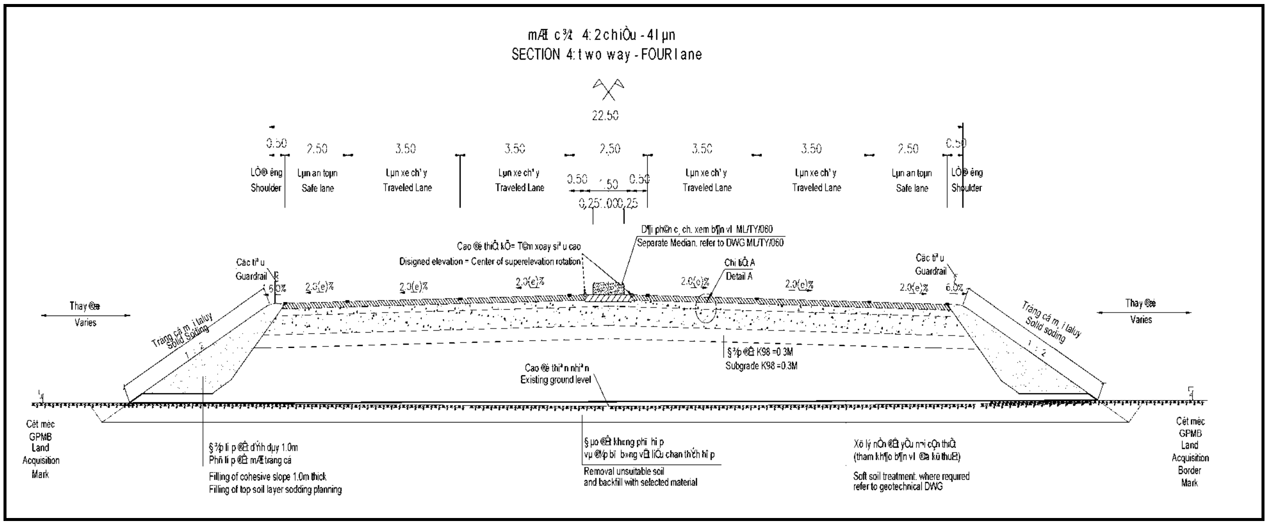


Figure 28: Cross section of 2 ways - 4 lanes ramp

b. Interchange IC#1 with the HCMC-Trung Luong Expressway

228. To establish the Project Alignment the TA Consultants reviewed the two original and separate reports on the Ben Luc – Long Thanh Expressway. The "Project Investment Report" that was undertaken by TEDIS, and the JETRO study that was carried out by Nippon Engineering Consultants. Both were completed in 2008. The general alignment common to both reports starts from an interchange point with Ho Chi Minh–Trung Luong expressway and connects with RR3 at Ben Luc district, Long An province.

229. Both these two consultants had done a lot of work to establish the proposed alignment prior to the start of the TA. The Ben Luc – Long Thanh Expressway is to be part of the HCMC area road network and to be part of Ring Road #3. Ring Road #3's exact alignment has not been set but generally it has to be between Ring Road #2 and Ring Road #4. RR#4 has been drawn on many master plans requiring it to intersect with the Ho Chi Minh–Trung Luong expressway at the Ben Luc Interchange. The set location of RR#2 & RR#4 limits the possible locations of RR#3. The proposed alignment from the previous studies was first reviewed and other possible alignments were investigated. There is a toll booth on the Ho Chi Minh–Trung Luong expressway approximately 1.8 kms east from the proposed BL-LT alignment. This distance is adequate but it was thought that it should not be less than this distance. That meant the alignment could not go any further east towards HCMC. The area to the west was examined. Moving the road west would mean a longer alignment and thus possible extra cost so there would have to be a compelling reason to move in that direction. No such compelling reason was found.

230. The original alignment was half way between two parallel local roads therefore would have less impact on local traffic patterns. There are also Industrial Parks to the west area that must be avoided. The Pre-F.S. Consultants did a good job in locating the BL-LT alignment in their study so the original alignment was deemed to be the best place.

231. The Interchange #1 is at Km12+100 on HCMC - Trung Luong expressway (HTL Viaduct section is from Km10+655 - Km23+323) and 2.5 kms west of the Cho Dem IC and 8 kms east of the Ben Luc IC. The alignment of BL-LT in this area crosses paddy fields which minimizes the

resettlement and environmental impacts. A church, industrial zones and residential areas are avoided.

232. Connecting to the Ben Luc Interchange on the HTL would require at least an additional 8kms of expressway thus additional cost without the benefit of additional traffic.

233. The proposed alignment and interchange location follows Decision 101/QD-TTg dated 11/January/2007 on HCMC transport master plan up to 2020. According to this decision the Ben Luc interchange is the connection point for RR4 & HTL. The proposed alignment and interchange location is also in conformation of the construction Master plan of HCMC up to 2020 year and onward to 2050 year (589/QD-TTg dated 20/5/2008. This is approximately the same proposed alignment and interchange location as the Pre FS has done by TEDIS and JETRO consultant from 2005 to 2008 which had been agreed by MOT, PPCs, PDoT.

234. The proposed alignment and interchange location in Long An has been agreed by Long An province by letter 3219/UBND-CN dated 22/9/2009. The TA Consultants have presented this proposed alignment and interchange location to MOT, ADB, PPCs and has been has agreed by most of the stakeholders

235. Local problems such as the church and temple were studied and it was found a change in the type and layout of the interchange could limit the impacts.

236. Please note that as the Ho Chi Minh–Trung Luong (HTL) Expressway will be open to traffic in the very near future it would an operating road when the BL-LT Expressway would be constructed therefore Interchange #1 was designed so that it could built in these conditions with the smallest possible impact on the traffic using the HTL Expressway. The widening of the existing viaduct would be done beyond the parapet walls of the current structure and only time traffic would be affected would be for a very limited time to remove the existing parapet and join the existing and new structure. This could require reducing the traffic to one lane in one direction from the current two. And this traffic restriction would only last a few days at most. Please also note that the design includes toll booths for traffic entering and leaving the HLT Expressway. Revenue from these toll stations on IC#1 will be for the HLT Expressway not the BL-LT Expressway.

Figure 29: Interchange 1 Location Map

237. The HCMC – Trung Luong Interchange between Ben Luc – Long Thanh Expressway is in Long An province, interchange at section Km 00+700. In the pre-feasibility study the interchange was designed as a clover leaf type. The TA has proposed a double trumpet type instead. It will be constructed by 2 phase. The Phase1 construction is 4-lanes on both the Ben Luc – Long Thanh Expressway and the HCMC – Trung Luong Expressway. Phase 2 will be 8-lanes on both the Ben Luc – Long Thanh Expressway and the HCMC – Trung Luong Expressway.

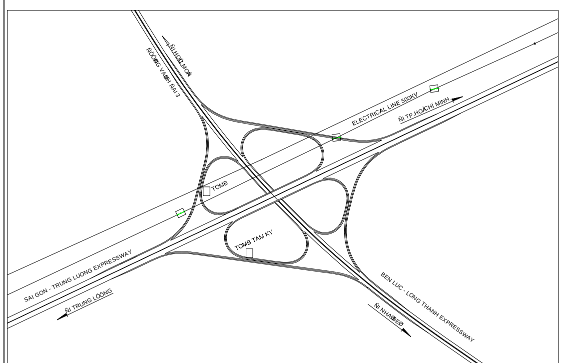
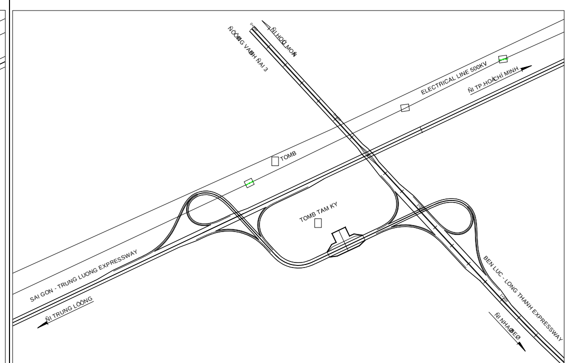
i. Interchange calculation data:

- On the Ben Luc – Long Thanh Expressway : Speed = 120km/h
- On the HCMC – Trung Luong Expressway: Speed =120km/h
- Interchange ramp : - Direct: Speed=50km/h
- Interchange loops: Speed=40km/h

238. Based on design schedule for main road and ramp design, we determine design geometric features of the interchange (cross section, radius of curve, super elevation, expanding, acceleration and deceleration section, separation and combination of lanes) according to the design standards in Table 59.

239. During design process, the TA supposed many solutions to compare and choose, due to the location of the interchange has several control points: The overhead transmissions lines Electric lane 500KV, Tam Ky tomb in My Yen town, My Nhan Bridge, local road and masonry ditch.

Table 60: Alternative Designs for Interchange IC#1

Items	***Alternative 1***	***Alternative 2***
Outline drawing		
Features	Type of interchange is cloverleaf full. The ramps of interchanges connecting HCMC – Trung Luong by viaduct (8 viaducts). According to this shape, there are 2 weaving points → function of these weaving points are to reduce conflicts which have worst affect on traffic organization on the main route. Traffic organization is convenient and clear. Increasing traffic capacity and traffic safety. Decreasing management efficiency due to 4 toll plazas installed. Scope of ramps can prolong on My Nhan bridge by acceleration and deceleration lane. Impacts the Tam Ky tomb and a nearby, can be moving, may be move tombs. Special, Scope of ramps affect column electric lane 500kV. Construction cost is higher because of larger occupation and land acquisition area. Construction 4 toll plaza and 8 viaducts.	Type of interchange is double trumpet. The ramps of the interchange connects to HCMC – Trung Luong by viaduct (4 viaducts). Ramps of interchanges connecting Ben Luc – Long Thanh by one flyover . According to this shape, there are no weaving points so traffic organization is convenient and clear. Increasing traffic capacity and traffic safety. Driver easily type of interchanges. Increasing management efficiency due to only one toll plaza installed. Scope of ramps can't prolong on My Nhan bridge, able to position first project will shorten the 500m. Does not impact the Tam Ky tomb and column electric lane 500kV. Construction cost is lower because of less occupation and land acquisition area. Construction 1 toll plaza and 4 viaducts In phase 1, when the next of Ring road 3 are not constructed yet, the road will replace the main line of the flyover bridge. This bridge will be constructed when getting through to ring road 3.
		RECOMMEMEND ALTERNATIVE

c. Interchange IC# 2

240. National Highway 1A Interchange is in Ho Chi Minh City, and links the expressway at Km3+420 to National Highway 1A. The pre-feasibility study did not have an interchange at this location only a flyover. After studying the traffic flow in the local area it became clear that an interchange was required to serve the great number of factories and industrial estates located nearby. Without an interchange at NH1A traffic would have to travel at least 12 kilometres on very congested roads to access the expressway. To simply costs and impacts the TA has proposed a diamond type of interchange.

- Phase1: Constructing 4 lanes with Ben Luc – Long Thanh Expressway.
- Phase 2: Constructing 8 lanes with Ben Luc – Long Thanh Expressway.

i. Interchange calculation data:

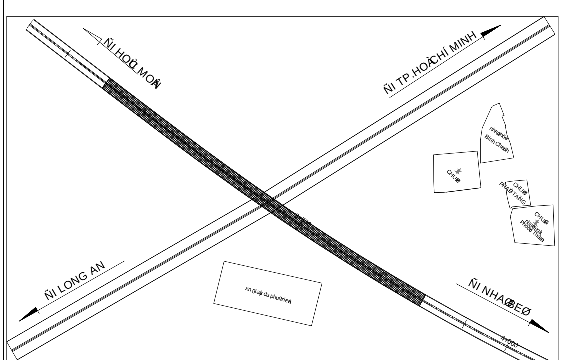
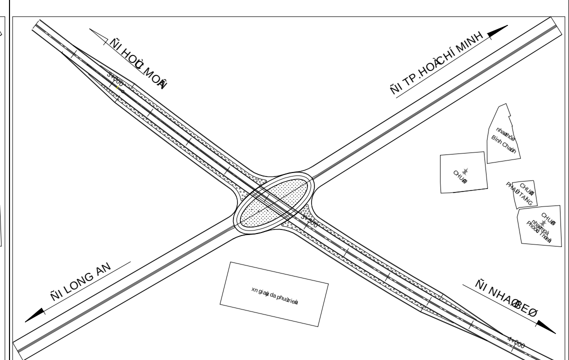
- On the Ben Luc – Long Thanh Expressway : Speed = 120km/h
- On the National Highway NH1A: Speed =80km/h
- Interchange ramp : - Direct: Speed=50km/h
- Interchange loops: Speed=40km/h

241. During design process, there were many solutions were compared and choose, due to the location of the interchange has several control points:

242. As system traffic of this region is very complex, the HCMC– Trung Luong Expressway after completion some of the traffic volume on NH1A will be attracted to HCMC – Trung Luong Expressway. This should reduce some of the congestion but the local area contains many industries such as the My An and Hiep Luong industrial estates which are currently expanding. There is also the Phu Trieu shoe factory and residential area located nearby.

243. Basic advantages and disadvantages for choosing design two alternatives:

Table 61: Alternative Designs for Interchange IC#2

Items	Alternative 1	Alternative 2
Outline drawing		
Features	• No interchange only a flyover. Ben Luc – Long Thanh Expressway is over National Highway 1A. No connection between the two roads. • Transport on National Highway 1A that	• Type of interchange is diamond type, Ben Luc – Long Thanh Expressway is over NH1A, under the flyover with a roundabout. • Transport on National Highway 1A to travel on Ben Luc-Long Thanh Expressway easily.

Items	Alternative 1	Alternative 2
	wants to travel on Ben Luc-Long Thanh Expressway must go through HCMC-Trung Luong by the road quite a distance about 12km. Especially in the future of this region has some industrial My Yen, Long Hiep. So will cause traffic problems, and have fuel and time costs. • Imp[acts less on the neighbourhood and residential areas nearby. • Organized transportation simple and convenient as there two separate roads. • Construction costs will be lower because of smaller occupation and land acquisition area.	Therefore the transport of industrial zones will be convenient, saving significant fuel costs and time for drivers. The building of interchange will attract traffic volume increased significantly so large traffic volume of NH1A. In planning future road base width is 120m. • Impacts on part of a shoe factory in Phu Trieu and some residents of nearby. • More complex because there is one roundabout the bottom. • Construction cost is higher because of larger occupation and land acquisition area, must to building ramp of interchange and one roundabout.
Propose		**RECOMMEMEND ALTERNATIVE**

d. Interchange IC#3 with National Highway 50

244. Interchange #3 is in Ho Chi Minh City and links the expressway at Km 13+550 with National Highway 50. In pre-feasibility study this interchange was designed as a clover leaf type with NH50 over the expressway. The TA has proposed a trumpet type again with NH50 over the expressway.

- Phase1: Constructing 4 lanes with Ben Luc – Long Thanh Expressway, between ramp of interchange with National Highway 50 is intersection.
- Phase 2: Constructing 8 lanes with Ben Luc – Long Thanh Expressway, the interchange is designed in Double trumpet type.

i. Interchange calculation data:

- On the Ben Luc – Long Thanh Expressway : Speed = 120km/h
- On the National Highway NH50: Speed =80km/h
- Interchange ramp : - Direct: Speed=50km/h
- Interchange loops: Speed=40km/h

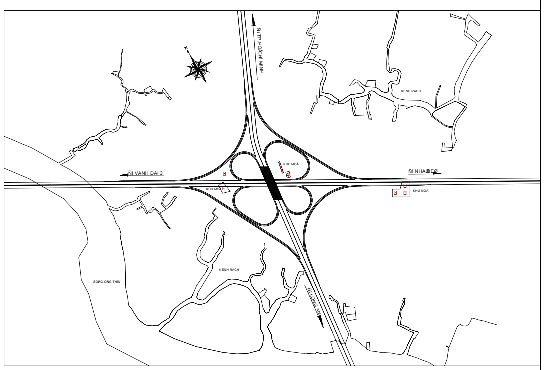
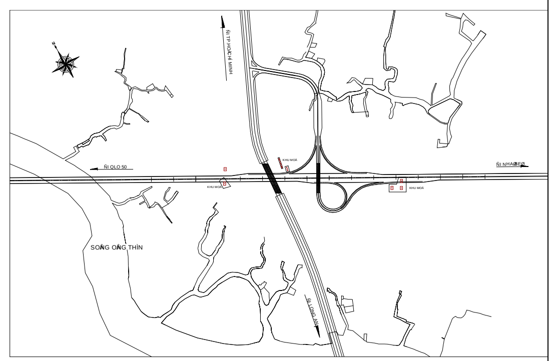
245. During design process many things were studied due to the location of the interchange has several control points:

- The east and south of interchanges is the Mr. Thin river and system of interlacing canals.

- North of the interchange there is a regional resettlement area.
- West of the interchange is a system of interlacing canals and some tombs.
- The interchange is near residential areas.

246. Basic advantages and disadvantages for choosing design two alternatives:

Table 62: Alternative Designs for Interchange IC#3

Items	Alternative 1	Alternative 2
Outline drawing		
Features	• Clover leaf type. NH 50 over the expressway. • According to this shape, there are 2 weaving points → function of these weaving points are to reduce conflicts which have worst affect on traffic organization on the main route. Traffic organization is convenient and clear. Increasing traffic capacity and traffic safety. • Decreasing management efficiency due to 4 toll plazas installed. • Scope of ramps can prolong on Ong Thin bridge by acceleration and deceleration lane. • Great impacts on the tombs nearby, must be moved. Impacts Area residents more. • Construction costs are higher because of larger occupation and land acquisition area, Length of viaduct on ramp the longer.	• Trumpet type, NH 50 over the expressway. • No weaving points so traffic organization is convenient and clear. Increasing traffic capacity and traffic safety. Driver easily type of interchanges. Phase 2, the interchange is designed in double trumpet type. • Increasing management efficiency due to only one toll plaza installed. • Ramps do not lengthen the Ong Thin bridge. • No impact on the tomb nearby. Less impacts on area residents. • Construction costs are lower because of smaller occupation and land acquisition area. Length of viaduct on ramp the shorter.
Propose		**RECOMMENDED ALTERNATIVE**

e. Interchange IC#4 with Nguyen Van Tao Road (North-South Road)

247. Interchange #4 is in Ho Chi Minh City and links the expressway at Km21+850 with Nguyen Van Tao Road. This Road is also known as the North-South Road and connects the expressway with the new Hiep Phuoc Port. In the pre-feasibility study the interchange was designed as a half clover leaf type. The TA has proposed a trumpet type.

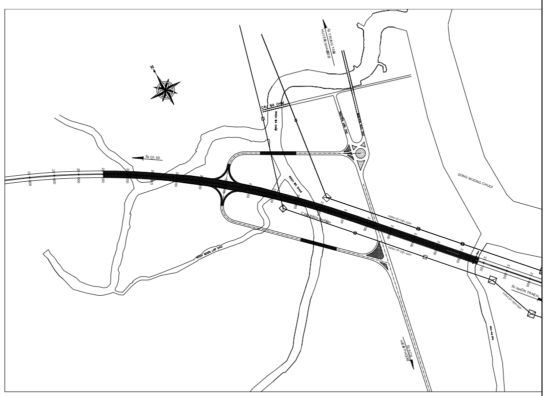
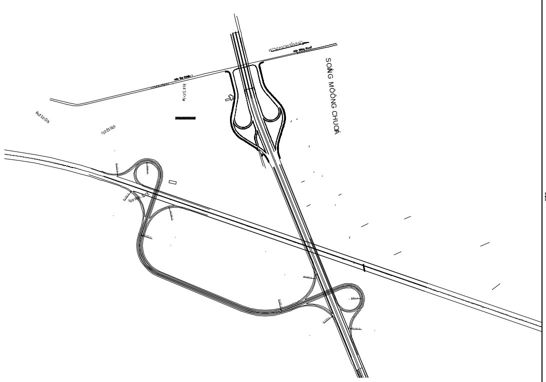
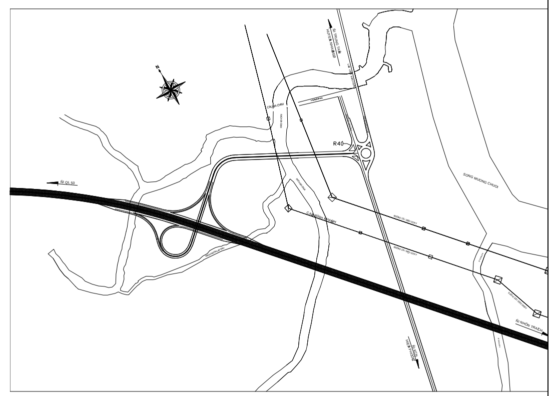
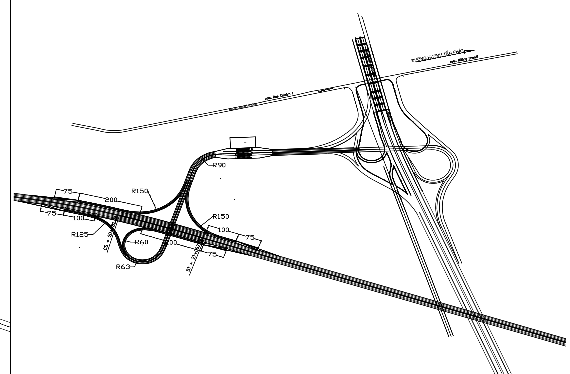
- Phase1: Constructing 4 lanes with Ben Luc – Long Thanh Expressway, between ramp of interchange with Nguyen Van Tao road is intersection.
- Phase 2: Constructing 8 lanes with Ben Luc – Long Thanh Expressway.

i. Interchange calculation data

- On the Ben Luc – Long Thanh Expressway : Speed = 120km/h
- On the Nguyen Van Tao road: Speed = 60km/h
- Interchange ramp : - Direct: Speed= 50km/h
- Interchange loops: Speed= 40km/h
- The area east and south of the interchanges was been planned by HCMC.,
- There are a number of canals in the area (Ca noc, Ngon lap dau, Ba Minh).
- North of the interchange is a shrimp pond, Ba Chua, Ba chiem waterway .
- West of the interchange is the Muong Chuoi river.
- The Interchange is near residential areas.
- This is the way North-South axis, where the large amount of traffic.
- Electric line 500KV and 220KV go in parallel with line.

248. Basic advantages and disadvantages for choosing design two alternatives:

Table 63: Alternative Designs for Interchange IC#4

Items	Alternative 1	Alternative 2
Outline drawing	Alternative 1A: Half clover leaf type.   Alternative 1B: double trumpet type	Interchange in phase 1   Interchange in phase 2
Features	• Half clover leaf type. With the expressway over Nguyen Van Tao road. Ramp of interchanges connecting with Nguyen Van Tao road by two separate ramps. Ramp of interchanges connecting with the expressway by viaduct (4 viaducts). • According to this shape, there are 2 intersection of Nguyen Van Tao road. Traffic organization isn't convenient and clear. Decreasing traffic capacity and traffic safety. • Decreasing management efficiency due to 2 toll plazas installed. • Construction of two bridges over Ba Chua waterway. • Impacts residential area nearby.	• Trumpet type, With the expressway over Nguyen Van Tao road. Ramps of connect with Nguyen Van Tao road by intersection. Ramp of interchanges connecting with Ben Luc – Long Thanh Expressway by viaduct (4 viaducts). • According to this shape, there are 1 intersection of Nguyen Van Tao road. Connecting with present intersection create roundabout. Traffic organization is more convenient and clear. Increasing traffic capacity and traffic safety. Driver easily type of interchanges. • Increasing management efficiency due to only one toll plaza installed. • Construction of one bridge over Ba Chua

Items	Alternative 1	Alternative 2
	• Construction cost is higher because of larger occupation and land acquisition area, must to building two bridge on ramp and two intersection, Length of viaduct on ramp the longer. With alternative 1B: double trumpet type. Its disadvantage is to infringe master plan of Nha Be District, influence on dense resident area at Nguyen Van Tao road	waterway. • Impacts less on the residential area nearby. • Construction cost is lower because of smaller occupation and land acquisition area. Building one bridge on ramp and one intersection. Length of viaduct on ramp the shorter. Interchange will be constructed with different level in comparison with Nguyen Van Tao road. It will be constructed following to plan and connected with Hiep Phuoc road.
Propose		**RECOMMEMEND ALTERNATIVE**

f. Interchange # IC5 with Ring Road 3 and Nhon Trach

249. The originally proposed location of IC#5 in the Pre-feasibility study was at the base of the extension of the proposed RR#3. This location though proved to have impacts on some sensitive buildings such as a church and temple and an existing village of Thanh Cong. After a number of discussions with local officials and the DOT of Dong Nai Province it was decided to move IC#5 from Km 38 to Km 33. This location allowed connection to the planned roads in Nhon Trach City Master-plans. The connection with Ring Road #3 would be a 90 degree left turn which would require a flyover for both North-bound and South-bound RR#3 traffic. The Interchange at Km 33 also proved very good for connect to the Dong Nai Ports and Industrial Estates along the Nha Be & Long Tau Rivers.

250. The negative aspect of the Km 33 location is that traffic from RR#3 that intends to go to or from the Vung Tau direction must either travel further or use the Nhon Trach road network to enter at IC#6. This is the minor flow direction but could be helped by having an additional 3-way Interchange IC5B in phase #2 at Km 41. This additional Interchange could be added in the design stage for Phase 1 or Phase 2.

251. The Master plan of Nhon Trach city has approved by Prime Minister (284/2006/QD-TTg dated 21/12/2006) and the location of RR3 has agreed by Dong Nai Province by letter 8709/UBND-CNNN dated 26/10/2009.

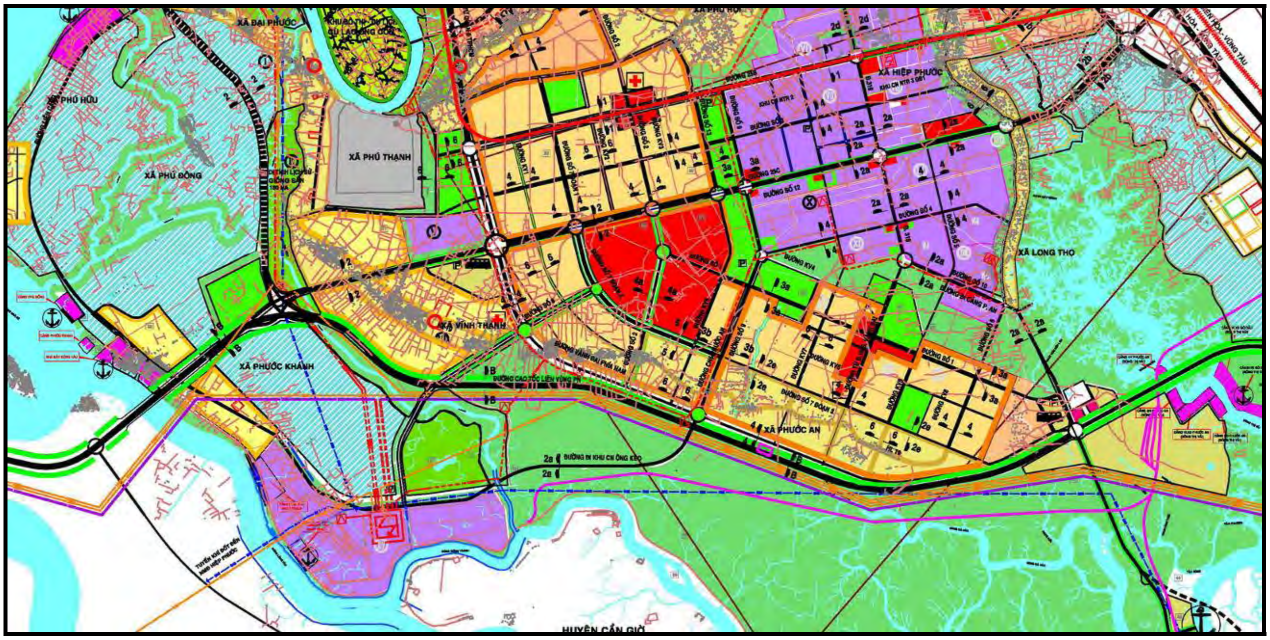


Figure 30: Nhon Trach Road Network Master-Plan

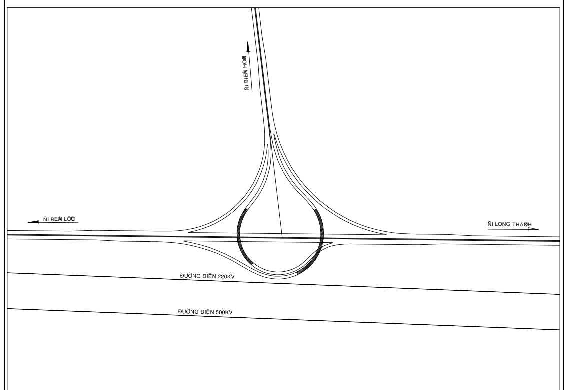
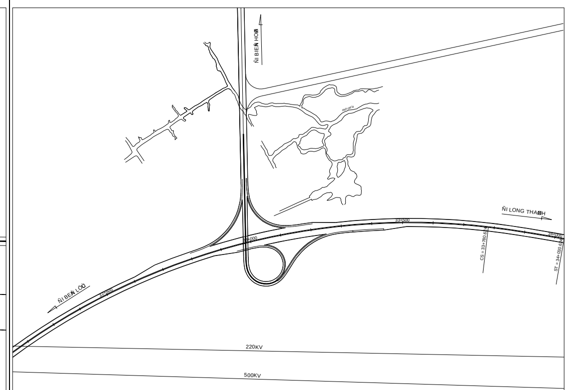
252. The TA has proposed a trumpet type with the ramps over the expressway, this interchange is contributed at the same time as Ring Road 3 and 12A Connecting road.

i. Interchange calculation data:

- On the Ben Luc – Long Thanh Expressway : Speed = 120km/h
- On the Planned Road: Speed = 60km/h
- Interchange ramp : - Direct: Speed= 50km/h
- Interchange loops: Speed= 40km/h
- Based on analysis of network traffic of Dong Nai as planned, we propose replace Ring road 3 interchange (Km38+370) for Km33 interchange to fit in the planning of the province.
- Electric lane 500KV and 220KV go in parallel with line.
- This area has many large and interlacing waterways: Cai Tu, Cai Tom, Tac keo.

253. Basic advantages and disadvantages for choosing design two alternatives:

Table 43: Alternative Designs for Interchange #IC 5

Items	Alternative 1	Alternative 2
Outline drawing		
Features	•Type of interchange is Y type. The planning road is over Ben Luc–Long Thanh Expressway by two flyover. • According to this shape, traffic organization is convenient and clear. • Not affect the residential area nearby, church and religion. • Construction two flyover Ben Luc – Long Thanh Expressway. The flyover is curve and longer. • Construction cost is higher because of larger occupation and land acquisition area, building two flyover, Length of ramp the longer.	•Type of interchange is trumpet, The planning road is over Ben Luc–Long Thanh Expressway by one flyover to fit in the planning of the Nhon trach city of Dong Nai province. • According to this shape, traffic organization is convenient and clear. • Not affect the residential area nearby, church and religion. • Construction one flyover Ben Luc – Long Thanh Expressway. The flyover is straight and shorter. • Construction cost is lower because of smaller occupation and land acquisition area. Building one intersection. Length of viaduct on ramp the shorter.
Propose		RECOMMENDED ALTERNATIVE

g. Interchange # IC 6 with Ring Road #3 and Phuoc An New Port

254. Interchange #IC 6 is in Dong Nai province and links the expressway at Km 50+530 with the Phuoc An ports. The pre-feasibility study the interchange is designed as a diamond type with the expressway is over road to Phuoc An port. The TA also designed as a diamond type with the expressway is over road to Phuoc An port.

255. Expressway has been designed in to 2 phases:

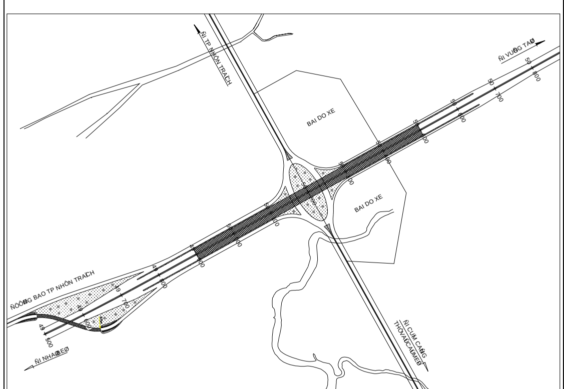
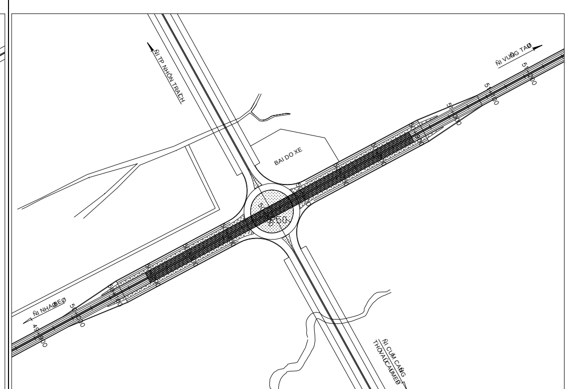
- Phase1: Constructing 4 lanes with Ben Luc – Long Thanh Expressway.
- Phase 2: Constructing 8 lanes with Ben Luc – Long Thanh Expressway.

i. Interchange calculation data:

- On the Ben Luc – Long Thanh Expressway : Speed = 120km/h
- On the road to Phuoc An Port: Speed = 80km/h
- Interchange ramp : - Direct: Speed= 50km/h
- Interchange loops: Speed= 40km/h
- OTL 500KV and 200KV go in parallel with line.
- Near the underground gas line.
- This is the main road out of Thi Vai port and Phuoc An port, traffic volume is very large.
- Near the planned area and transport services.

256. Basic advantages and disadvantages for choosing design two alternatives:

Table 44: Alternative Designs for Interchange #IC6

Items	Alternative 1	Alternative 2
Outline drawing		
Features	• Type of interchange is diamond, Ben Luc – Long Thanh Expressway is over road to Phuoc An port, under flyover construction roundabout, road to Phuoc An port connecting Ben Luc – Long Thanh Expressway by ramp of turn right. Roundabout is an ellipse. • Transport on road to Phuoc An port to travel on Ben Luc-Long Thanh Expressway easily. Organized transport more complex because there is one roundabout the bottom.	• Type of interchange is diamond, the expressway is over road to Phuoc An port, under flyover contruction roundabout, road to Phuoc An port connecting Ben Luc – Long Thanh Expressway by ramp of turn right. Roundabout is a circle. • Transport on road to Phuoc An port to travel on Ben Luc-Long Thanh Expressway easily. Organized transport more complex because there is one roundabout the bottom. • Roundabout is circle make traffic safety is

Items	Alternative 1	Alternative 2
	• Roundabout is an ellipse make traffic safety is low, due to radius small. But with this form to overcome the above reduce length of flyover. • The cost to build each equivalent.	high, due to radius big. But with this form to overcome the above prolonged length of flyover. • The cost to build each equivalent.
Propose		**RECOMMEMEND ALTERNATIVE**

h. Interchange # IC7 with National Highway 51

257. Interchange #7 is in Dong Nai province and links the expressway at Km 56+600 with National Highway 51. In the pre-feasibility study the interchange is designed as a diamond type with the expressway is over National Highway 51. The TA has proposed also using the same type of interchange.

258. Expressway has been designed in 2 phases:

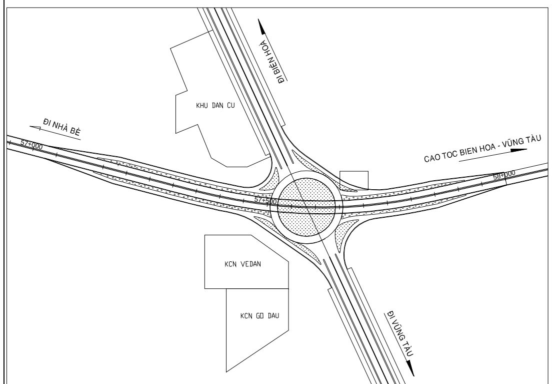
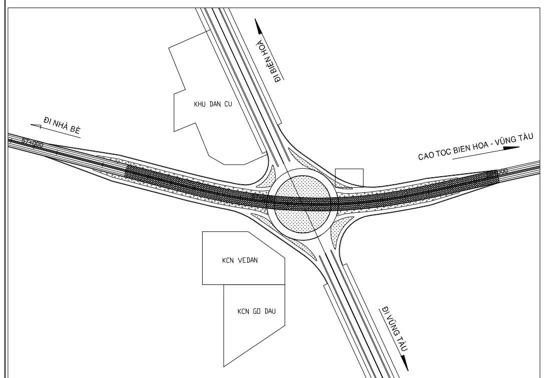
- Phase1: Constructing 4 lanes with Ben Luc – Long Thanh Expressway and the end point is interchange at National Highway 51 and links with Bien Hoa – Vung Tau Expressway when it is constructed.
- Phase 2: Constructing 8 lanes with Ben Luc – Long Thanh Expressway.

i. Interchange calculation data:

- On the Ben Luc – Long Thanh Expressway : Speed = 120km/h
- On the road to NH51: Speed = 80km/h
- Interchange ramp : - Direct: Speed= 50km/h
- Interchange loops: Speed= 40km/h
- Near the dense residential areas, Phuoc Thai school.
- Areas with many systems on two sides.
- The East of interchange, in the future is Vedan and Go Dau industry, Go Dau port fuel.

259. The TA considered two alternatives. One the expressway goes underneath the NH51 and the other over. The basic advantages and disadvantages for choosing design two alternatives:

Table 45: Alternative Designs for Interchange #IC 7

Items	Alternative 1	Alternative 2
Outline drawing		
Features	• Type of interchange is diamond, the expressway under NH51, there is a roundabout on NH51 connecting Ben Luc – Long Thanh Expressway by ramp of turn right. Roundabout is circle. • Organized transport relatively convenient and clear, increasing traffic and traffic safety. • Construction retaining walls tunnel complex and more difficult. But reduce heighten embankment of 2km the last of project. • Construction cost is higher because building retaining walls.	• Type of interchange is diamond, Ben Luc – Long Thanh Expressway is over National Highway 51, under flyover construction roundabout, National Highway 51 connecting Ben Luc – Long Thanh Expressway by ramp of turn right. Roundabout is circle. • Organized transport more complex because there is roundabout through the bottom. Vision for the limited. • Construction interchanges is easily. But the last of project is heighten embankment . • Construction cost is lower
Propose		**RECOMMEMEND ALTERNATIVE**

i. Interchange # IC8 with the Bien Hoa – Vung Tau Expressway

260. Interchange #IC8 is in Dong Nai province and links the expressway at Km58+420 with the proposed Bien Hoa - Vung Tau Expressway at section Km58+420. In the pre-feasibility study the interchange is designed as a trumpet type with the Ben Luc – Long Thanh Expressway over the Bien Hoa - Vung Tau Expressway. The TA has proposed a similar arrangement. Construction duration of this interchange is as the same time as Bien Hoa – Vung Tau Expressway.

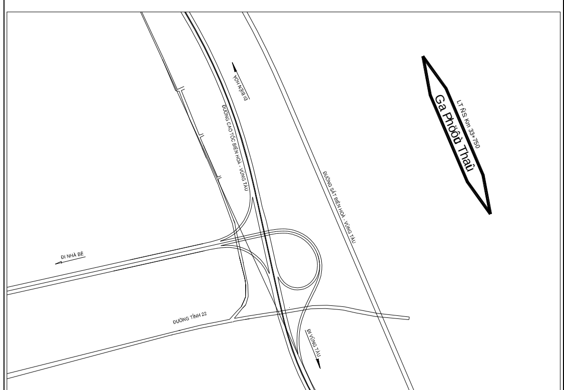
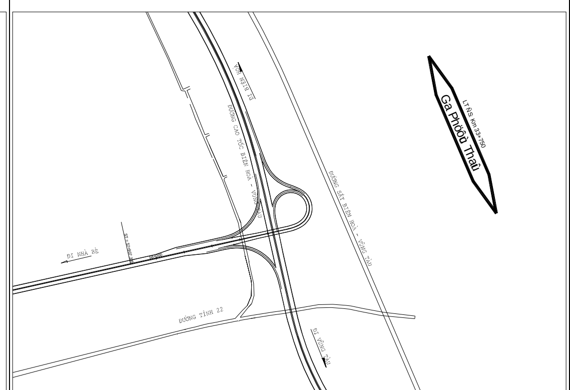
- Phase1: Constructing 4 lanes with Ben Luc – Long Thanh Expressway and Bien Hoa - Vung Tau Expressway.
- Phase 2: Constructing 8 lanes with Ben Luc – Long Thanh Expressway, 6 lanes with Bien Hoa - Vung Tau Expressway.

i. Interchange calculation data:

- On the Ben Luc – Long Thanh Expressway : Speed = 120km/h
- On the road to Bien Hoa - Vung Tau Expressway: Speed = 120km/h
- Interchange ramp : - Direct: Speed= 50km/h
- Interchange loops: Speed= 40km/h
- Railway proposed for Bien Hoa - Vung Tau
- Province Road 22
- My Xuan Industry.
- Electric line 220 KV.

261. Basic advantages and disadvantages for choosing design two alternatives:

Table 64: Alternative Designs for Interchange #IC 8

Items	Alternative 1	Alternative 2
Outline drawing		
Features	• Type of interchange is a trumpet, the trumpet toward Vung Tau. Bien Hoa – Vung Tau Expressway is over Ben Luc–Long Thanh Expressway. • According to this shape, Traffic organization is convenient and clear. • Impacts province road 22. So need making culvert and viaduct. • Reduce embankment height the final line, but construction flyover on Bien Hoa - Vung Tau Expressway with 6 lane. • Construction cost is higher because building flyover with 6 lane.	• Type of interchange is a trumpet, The planning road is over Ben Luc–Long Thanh Expressway by one flyover to fit in the planning of the Nhon trach city of Dong Nai province. • According to this shape, Traffic organization is convenient and clear. • Does not impact province road PR 22 and is in accordance with planned residential Phuoc Thai Commune. • Embankment height the final line, but the construction flyover on Ben Luc– Long Thanh Expressway with width 19.5m. • Construction cost is lower.
Propose		**RECOMMEMEND ALTERNATIVE**

C. Project Hydrology

1. Introduction

262. The proposed alignment traverses through Long An Province, Ho Chi Minh City and Dong Nai Province. The entire terrain is on low land with intermittent small high grounds. The alignment passes across paddy field and marsh/mangrove wetland areas. Over the last two kilometre section of the alignment that is located on the left bank of Thi Vai river, close to the end point of the alignment elevations are comparatively higher. Here there are more residential houses and shops and evidence of ongoing construction. Water levels in the river channels vary significantly as a result tidal fluctuations and during periods of heavy rain and seasonally high tides there is a significant amount of localized flooding but the alignment will be of sufficiently high elevation to avoid being impacted upon by flooding based on utilization of hydrological data collected in the Project area since 1883.

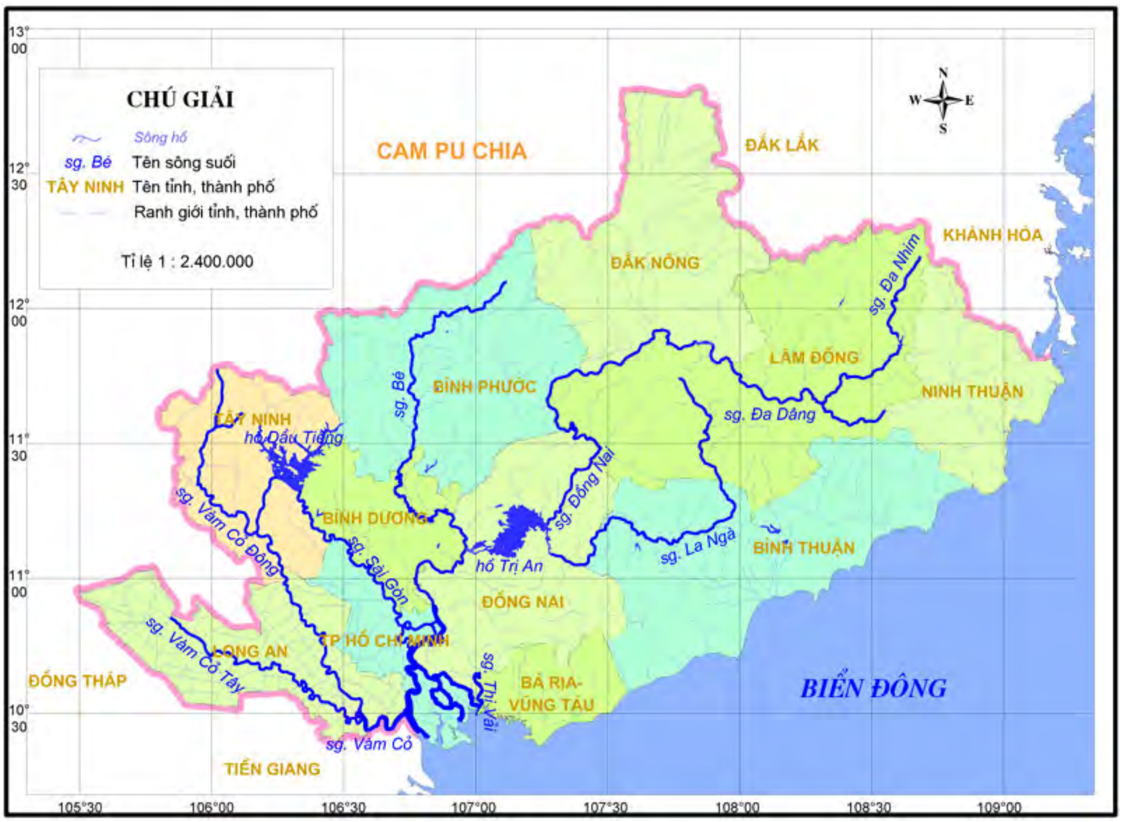


Figure 31: River Systems in the Project Area

263. Ben Luc - Long Thanh Expressway crosses the three main river branches of Dong Nai River system; Soai Rap River, Long Tau River and Thi Vai River. Dong Nai river system is a very important water resource in Southern Viet Nam with a length of 635 kilometres and total catchment basin area of 44,100 km^2. This watershed also extends into a small area in Eastern Cambodia.

264. The main flow of Dong Nai River originates in Nhon Giao at an elevation of approximately 1,700m in the Lang Biangs and flows in a NE-SW direction, and after intersecting

with the Nha Be River and Sai Gon River, the Dong Nai River flows in a NW-SE direction into the sea at Ganh Rai Bay through the Xoai Rap, Dong Tranh and Long Tau Estuaries. The network of rivers and streams develops fairly well with the density 0.64Km/km2.

265. The total system has as many as 265 estuaries, which develop to grade 4 and nearly 50% of the estuaries develop to grade 2. Some important grade 1 estuaries are La Nga with a length of 272 Km and the basin area of 4,170 km2, Nha Be River with a length of 344 Km and the basin area of 7,170 km2, Sai Gon River with a length of 256 Km and the basin area of 5.560 km2 and Vam Co River with a length of 218 Km and the basin area of 12,800 km2.

266. The soil layer in Dong Nai River is thick weathered strata, abundant, and with fairly-developed vegetation cover. The proportion of forest is about 40% in Da Dung and La Nga Basins, and about 20% in Sai Gon and Vam Co Basins.

267. In addition, the alignment intersects several other rivers and channels, among them Can Giuoc, Ba Lao, Ong Keo are medium size and important waterways in the area. The main features of the rivers in this area are that the water flow is frequent and the slope of the riverbed and water surface is small. As it is a marsh area, riverbanks consist of easily erodible muddy soil. There are locations where sign boards displayed at the riverbank indicate areas impacted upon by erosion.

2. Hydro-Metrological Features

268. The Project area is located in a typical equatorial zone with a pronounced wet and dry season, low diurnal range in air temperature although some variation in humidity levels between the hot wet season, drier cool season and hot dry season.Monthly mean temperatures vary from a high of 29°C in April to a low of 26°C in January but the average mean temperature is 27°C. Temperatures as low as 8°C have been recorded for the Project provinces, especially in the upland areas of Dong Nai. The monthly mean humidity is lowest in February at 76% and highest in August at 88% and the average mean humidity is in excess of 80%. Generally there is no monthly rainfall in January and February but rainfall is in excess of 200mm for 4 months of the year and 100mm for another three months of the year. Monthly sunshine figures are highest in May with an average of 284 hours and lowest in July with an average of 169 hours.

269. In the lowlands of Dong Nai River, flood season starts from July to November and the dry season starts from December to April the following year. In rainy season, the flow volume takes up about 85% of the whole year’s flow volume. The biggest, average, and smallest values of hydrological factors depend much on the flow value from upstream and tidal water levels. According to hydrological investigation data, in the flood rain in 1952 (at that time, Dong Nai River system didn’t have any works to control the flow from upstream) the heavy rainfall in a vast area made the water level reach the frequency of 1% to 1.5%. At that time, the water level in Phu An and Nha Be stations reach to 1.53m.

270. The oceanographic factors of this coastal area directly affect the hydrological system of the lowlands in Dong Nai River – water level variation. The water level variation in this area is mixed tide, mainly in semi-diurnal tide. The variation amplitude of water level reaches 3.5m to 4.0m, belong to the highest in the coastal area of Vietnam. Because the Soai Rap River and Long Tau River are both fairly wide and deep, tidal variations in the Dong Nai River may impact on the Tri An River and the tidal variation of other rivers, including the Sai Gon River and Vam Co River.

3. Hydrological Analysis

a. Elevations System

271. One of the characteristic of these works are their low frequency (low return period). They are mainly for the maintenance of water supply, water for daily activities and contribution in the restraint of salinity in dry season, and to control the flood volume in rainy and flood season. According to the result of hydraulic modeling in the lowlands of the Dong Nai River system the flood discharge release condition (0.1%) of Tri An Lake and Dau Tieng Lake combined with the Nha Be River has a frequency of 0.1% and the water level in the center of Ho Chi Minh City only raises from 20cm to 25cm, compared with normal conditions. An example to illustrate the point in included below:

Table 65: Total Flood Volume and Discharge of Tri An Lake via the Spillway

Year	$W \times 10^6$ m^3		Q m^3/s		Year	$W \times 10^6$ m^3		Q m^3/s	
	To lake	Overflowing	To lake	Overflowing		To lake	Overflowing	To lake	Overflowing
1988	11330	4879	1725	1475	1994	19113	3656	2343	2250
1989	15385	4754	2071	1500	1995	13733	1927	2050	1600
1990	18173	4620	2964	2800	1996	17417	2920	2049	1930
1991	15732	2446	2123	2050	1997	17745	4070	2363	2075
1992	14682	1213	2549	1460	1998	13907	1341	1930	1725
1993	15352	143	1753	1300	1999	23296	4156	3360	2956

b. Design Water Level at Bridges

i. Highest water level at bridges

272. The Binh Khanh bridge is four kilometres from the Nha Be hydrological station therefore the difference of maximum water level in the area is very small (about 3mm/km), it can be conservatively considered that the highest water level at Binh Khanh bridge is the highest water level at Nha Be station.

273. The Phuoc Khanh bridge is three and a half kilometres downstream from the Nha Be hydrological station. As similar to Binh Khanh bridge, the highest water level at Phuoc Khanh bridge is the highest water level at Nha Be station.

274. Thi Vai bridge is about thirty-five kilometres from the Vung Tau hydrological station (on East Sea) and is fifteen kilometres from the Thi Vai hydrological station. Along the Thi Vai river from Vung Tau station, tidal amplitude increases following the linear correlate equation as detailed in the Hydrological Report in the Appendix.

275. At Vung Tau station : H_{max} 1% = 1.60m, H_{max} 5% = 1.52m. Therefore the highest water level at Thi Vai bridge H_{max} 1% = 1.95m and H_{max} 5% = 1.87m.

276. All the bridges on Ben Luc – Long Thanh expressway are affected by East Sea tide through Soai Rap, Nha Be and Long Tau and Thi Vai rivers, the highest water level along the alignment at the bridges are given in table 25.

ii. Lowest water levels at bridges

277. The lowest water level at Binh Khanh and Phuoc Khanh bridges are taken equal to the lowest water level at Nha Be station.

278. Thi Vai bridge low water can be calculated using tidal amplitude increases following the linear correlate equation as described in the Hydrological Report. At Vung Tau station: H_{min} 1% = -3.41m, H_{min} 5% = -3.31m. Therefore the lowest water level at Thi Vai bridge H_{min} 1% = -3.69m and H_{min} 5% = -3.59m.

279. Other bridges: The lowest water level at the bridges in the section from the beginning point to km30 of the route are taken the same lowest water level at Nha Be station (if the elevation of riverbed is higher than the lowest water level at Nha Be station; then elevation of riverbed is taken as the lowest water level)

280. The lowest water levels at the bridges in the section from km30 to Thi Vai bridge are taken gradually decreased from the lowest water level at Nha Be station to the lowest water level at Thi Vai bridge (if the elevation of riverbed is higher than the lowest water level; then elevation of riverbed is taken as the lowest water level)

iii. Minimum Length Required for Bridge Opening

281. In the proposed alignment, the number of bridges mainly affected by floods is five and minimum opening length required for these bridges are calculated according to the formula. However, according to the existing topographical conditions and other technical reasons, the actual bridge design length selected is longer than the calculated minimum required opening length.

282. There are 18 bridges in the tide-affected area and the minimum opening lengths required for these bridges are calculated according to accepted hydrological formulae. In general, at the average water level of about 0.2m (at the maximum discharge), discharge over the banks is very small. Therefore, the minimum length required for bridge opening is the same width of the main stream. Depending on the other factors such as soil condition and navigational clearance, the actual bridge design length selected is longer than the calculated minimum required opening length.

Table 66: Minimum Bridge Openings Required

No.	Name	Station	Qmax (m3/s)	Vmax (m/s)	Minimum length required (m)	Maximum water level (m)		Minimum water level (m)
						1%	5%	1%
1	Ong Thoan	Km 02+200	74	1.00	35.00	1.70	1.57	-2.91
2	Ong Thin	Km 12+609	590	1.25	250.00	1.63	1.54	-2.91
3	Ba Lao	Km 17+145	1,296	1.25	250.00	1.63	1.54	-2.91
4	Binh Khanh	Km 23+450	11,500	1.25	1,200.00	1.63	1.54	-2.91
5	Cha River	Km 26+183	852	1.25	185.00	1.63	1.54	-2.91
6	Phươc Khanh	Km 30+300	11,500	1.65	700.00	1.63	1.54	-2.91
7	Ong Keo	Km 34+700	200	1.25	230.00	1.68	1.59	-3.06
8	Bau Sen	Km 35+689	80	2.02	24.00	1.88	-	-0.58

No.	Name	Station	Qmax (m3/s)	Vmax (m/s)	Minimum length required (m)	Maximum water level (m)		Minimum water level (m)
						1%	5%	1%
9	Vung Gam	Km 43+126	87	1.86	24.00	1.82	-	-0.99
10	Thi Vai	Km 53+042	3,748	1.25	300.00	1.95	1.87	-3.69
11	Tac Ca Tang	Km 54+220	294	1.25	125.00	1.95	1.87	-3.69
12	Bun Ngu	Km 55+700	125	1.00	75.00	1.95	1.87	-3.69
13	Rach Ngoai	Km 56+838	39	1.33	12.00	2.14	2.00	0.78

iv. Estimation of Scour Depths at Main Bridges

283. The causes of scouring at bridge crossings are due to the erosive action of flowing water, excavating and carrying away materials from the riverbed and its banks. The scour process is cyclic in nature which makes it complicated to determine the magnitude of scour. Scour can be deepest near the peak of a flood; however it is hardly visible since scour holes refill with sediment during receding stage of flood. In general, several floods may be needed to attain maximum scour under typical flow conditions at bridge crossings.

284. This section presents the evaluation of scour potential at bridge based on Hydraulic Engineering Circular No 18 (HEC 18) published by Federal Highway Administration, USA. The equations recommended in this document are considered to be the most applicable for estimating scour depths and are widely applied in Vietnam and many other countries.

Contraction Scour

285. Contraction scour at a bridge crossing, involves the removal of material from the streambed and banks across the channel width, as a result from a contraction of the flow area and an increase in discharge at the bridge.

286. In case of highway construction, common causes for contraction of flows are constriction (encroachment) of highway embankment onto the floodplain and/or into the main channel or piers blocking a portion of flow. As a result, flow area decreases that causes an increase in velocity and bed shear stress. Hence, more bed material is removed from the contracted reach than transported into the reach. As bed elevation is lowered, the flow area increases, velocity reduces and a situation of relative equilibrium is reached.

287. Contraction scour can be either clear-water or live-bed, depending on the ability of the upstream approach reach to transport bed material. Live-bed scour occurs when material is being transported into the contracted bridge section from the upstream approach section. Clear-water contraction scour occurs when there is no bed material transport in the approach reach or the bed material being transported in the upstream reach is so fine that it washes through the contracted section.

288. Local scour by way of contrast at piers or abutments is due to the removal of river bed material as a result of formation of vortices known as the horseshoe vortex and wake vortex at their base. The horseshoe vortex results from the pileup of water on the upstream surface of the obstruction and subsequent acceleration of the flow around the nose of the pier or abutment. The action of the vortex removes bed material around the base of the obstruction. In addition to the horseshoe vortex around the base of a pier, there are vertical vortices downstream of the

pier called the wake vortex. Both the horseshoe and wake vortices remove material from the pier base region. The intensity of wake vortices diminishes rapidly as the distance downstream of the pier increases. As a result, immediately downstream of a long pier there is often deposition of material.

289. Factors which affect the magnitude of local scour depth at piers and abutments are;

- Velocity of the approach flow,
- Depth of flow,
- Width of the pier,
- Discharge intercepted by the abutment and returned to the main channel at the abutment,
- Length of the pier if skewed to flow,
- Size and gradation of bed material,
- Angle of attack of the approach flow to a pier or abutment,
- Shape of a pier or abutment,
- Bed configuration, and
- jams and debris.

Local Scour at Piers

290. The contraction and local scour caused by piers at main bridges was analyzed by model simulations of HEC-RAS 3.1.3 which is built up with 'Bridge Scour' under 'Hydraulic Design Functions' based on Hydraulic Engineering Circular No. 18 (HEC 18) of Federal Highway Administration (FHWA), USA.

291. Scour estimations were carried out for the main bridges where piers are located within the rivers, namely Ba Lao Bridge, Binh Khanh Bridge, Phuoc Khanh Bridge and Thi Vai Bridge. The discharge adopted for computation is 1% frequency or available/estimated historical maximum. As there are no data of particle size analysis available during this feasibility study, particle size D50 and D95 were assumed as 0.015mm and 0.5mm referring the data used for Long Thanh bridge design (Hydrological Study Report of Ho Chi Minh City-Long Thanh-Dau Giay Expressway), considering the similarity in nature. However, during the detail design, scour estimations should be updated with relevant particle sizes of D50 and D95 at each bridge site.

Scour Results

292. Estimated scour at bridges are given below and were used in the design of the bridges. The calculation details are presented in Appendix C3.

Table 67: Scour at bridges

Station	Bridge	Scour Depth (m)		
		Contraction Scour	Local Scour	Total Scour
12+600	Can Giouc	-	-	-
17+100	Ba Lao	0.16	4.38	4.54
23+400	Binh Khanh	0.29	6.86	7.15
26+150	Song Cha	-	-	-
34+700	Ong Keo	-	-	-
30+300	Phuoc Khanh	0.26	9.51	9.76
53+100	Thi Vai	0.34	5.07	5.41

D. Overhead Transmission Lines (OTL)

293. In Appendix C4 on Overhead Transmission lines (OTL) there is a detailed discussion of the Pre FS and the JETRO Study alignments and the problems encountered with the OTL. These problems have effectively ruled out some alignments in the area of the Binh Khanh Bridge location and resulted in Alignment A1 which is 120-metres south and parallel to the 500 Kv OTL.

1. Vertical safe distance regulation in Vietnam

294. The vertical distance from transmission lines in static position to any part of houses and road surface must not less than vertical safety distance specified in Table 68. The figures of vertical distance originate from Decree No. 54/1999/ND-CP of July 8, 1999 on “Safety Protection of High-Voltage Power Grids” and CTN18-19-20-2006 “Electrical installation regulations in Vietnam”.

Table 68: Vertical Safety Distance (VSD) from Houses and Road Surface

Voltage Class	Up to 22Kv	35Kv	66Kv	110Kv	220Kv	500Kv
VSD from houses	2.0 m	3.0 m	4.0 m	4.0 m	6.0 m	7.0 m
VSD from road surface	5.5 m	5.5 m	6.0 m	6.0 m	7.0 m	10.0 m

Note: 1. Reference Standard: 11 TCN 18-19-20-2006 Code for electrical installation in Vietnam.

2. Safety corridor of electric is stipulated at Article No.4 of Decree Mo ND106/2005/ND-CP dated 17 Aug.2005 of Prime Minister, stipulating and instructing implementation some of Electrical Law’s Articles in protection of Safety corridor for high voltage line.

3. Electrical specification Section II of Electrical System 11 TCN-19-2006, Chapter II.5 Item DDK crossing or near the highway, Item II.5.148 stipulated minimum distance from any part of the electrical column to edge of roadbed when crossing and parallel with highway.

Source: 1. Subject: Parameters of safety corridor of 500Kv, 220Kv for Ben Luc – Long Thanh Expressway Project: Ref. No. 5953/TTD4-KTAT dated 17 Dec. 2007 by Electrical Corporation of Vietnam Electrical Company No.4.

2. Lighting and Power Supply Report Ho Chi Minh City - Long Thanh- Dau Giay Expressway Project, Page-14

295. The regulated vertical safe distance (VSD) between the OTL and intersecting road is laid out n the Decree No. 54/1999/ND-CP of July 8, 1999 on Safety Protection of High-voltage Power Grids dated 08 July 1999. The regulated vertical safety distance between overhead transmission Lines (OTL) and a road is shown in Table 69.

Table 69: Regulated VSD between OTL and Intersecting Traffic Road

Voltage Class	Up to 22Kv	35Kv	66Kv	110Kv	220Kv	500Kv
VSD from road surface	5.5 m	5.5 m	6.0 m	6.0 m	7.0 m	10.0 m
Minimum VSD	3.0 m	3.0 m	4.0 m	4.0 m	5.0 m	6.0 m
Vertical safe electrical discharge distance	1.5 m	1.5 m	2.0 m	2.0 m	3.0 m	4.0 m

Note: 1. Refer to note 3 of Table 68, 1 = 2 + 3

2. Refer to Decree No. 54/1999/ND-CP Article 8. Figure (6.0) estimates in Article 7.

3. Refer to Decree No. 54/1999/ND-CP Article 9.

296. VSEDD: Vertical safe electric discharge distance over the water way is the lowest point of wires of 500Kv OTL at a waterway is required the VSD as minimum 59m, where 55m of technical static height of waterway plus 4m of safe electric discharge distance.

a. Estimated sag by Overhead Transmission Lines (OTL)

297. At the crossing of OTL and the river the sag of each line is estimated as follows:

Table 70: Estimated Sag of OTL at crossing river

Voltage Class (Kv)	Weight of wire (w) (Kg/m)	Rated Strength of wire (T) (Kg)	Span of wire (S) (m) /3	Sag (d) (m) /4	Max. Swing Distance (m)
500	1.3 /1	10,759.8 /1	991 m	14.8 m	5.9 m
220	1.2 /2	7,260 /2	830 m	14.2 m	5.6 m

Note: 1. Maker's catalog ACSR 666.6MCM 8 (Given data)

2. Maker's catalog ACSR 402.8 mm2 instead of 380mm2 (Given data).

3. Given data.

4. Sag Calculation Formula: d= (w x S2) / 8 x T (m) Standard Handbook for Electrical Engineers, U.S.A.

b. Supposition of maximum swing distance of OTL above the section

298. In the Table 70, the sag of OTL at crossing river is calculated as 14.8m for 500Kv OTL and 14.2m for 220Kv. By a pressure generated from continuous strong wind (for example 40m/s), the wire will swing the distance of sag in theoretical sense. However, 4-wire per circuit, which combining by a wire separator for 500Kv OTL and 3-wire for 220Kv are used at the Site. Plus anti-swing protections are installed at each tower and each wire due to avoid failure of shortage between wires. Drawing a conclusion from experience on the OTL in Japan, the maximum distance of wire's swing is estimated 5.9m at 500Kv OTL and 5.6m for 220Kv.

2. Safety distance to wires at bridge construction stage

299. During construction of the Binh Khanh bridge on the approved alignment all accidents or occurrences were considered. For details please see Appendix C.4 but the 550Kv OTL should have no effect to the construction due to wide space available.

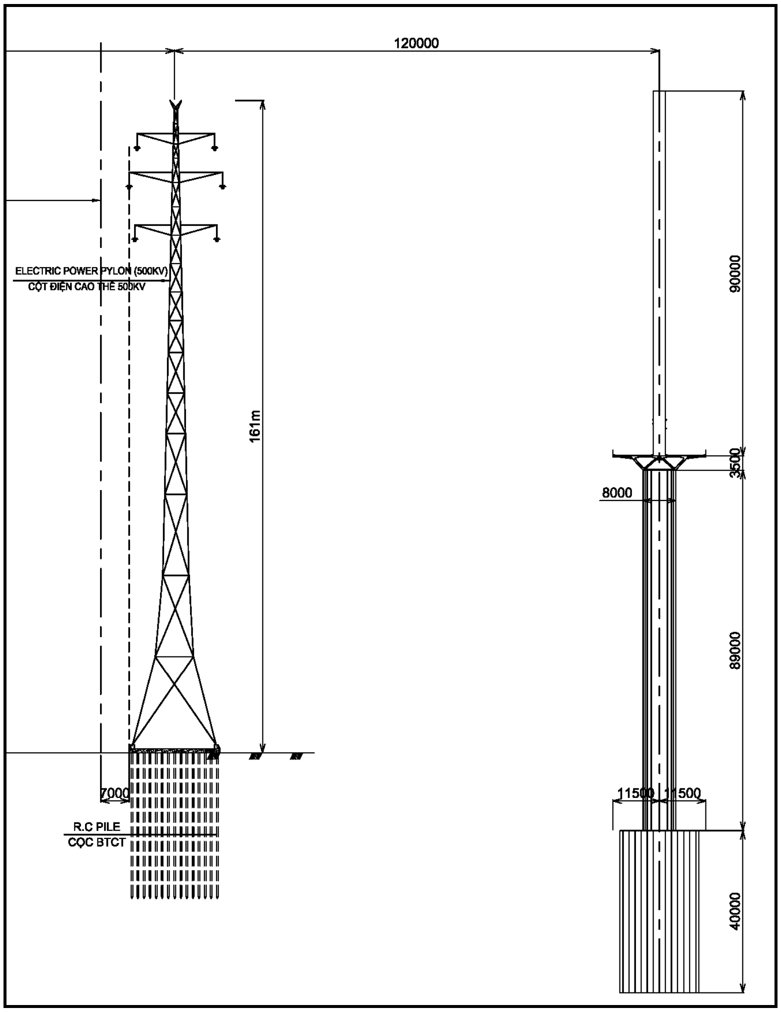


Figure 32: Cross Section at Binh Khanh Bridge

3. Electrostatic induction (ESI) & Electromagnetic induction (EMI)

300. The field limiting values of continued exposure in Electrostatic induction (ESI) and Electromagnetic induction (EMI) for Human health are regulated in as following Table 71.

Table 71: Exposure Limits based on Acute Effects on Electric and Magnetic Fields

Effected to		Exposure Limit by ICNIRP /1 /2		ICNIRP Guideline	IEEE Standard - 2002 60Hz /3	Technical Regulation for Electrical Equipment Japan	Notes
Item	**For**	**50Hz**	**60Hz**	**General Figures**			
EF Kv/m	Workers	100V/cm	83V/cm	4.16Kv/m (41.6V/cm)	20Kv/m	3Kv/m (30V/cm) /4	OTL 0.1-3Kv/m above ground 1m
		10Kv/m	8.3Kv/m				
	General Public	50V/cm	42V/cm		5Kv/m		
		5Kv/m	4.2Kv/m				
MF µT	Workers	5,000mG 500µT	4,157mG 416.7µT	883mG 83.3µT	2,710µT	X	OTL 200mG 20µT
	General Public	1,000mG 100µT	833mG 83.3µT		904µT		

Note: 1. (ICNIRP) International Commission on Non-Ionizing Radiation Protection.
2. Environmental Health Criteria 238 Extremely Low Frequency Fields Risk Characterization.
3. IEEE: Institute of Electrical and Electronics Engineers.
4. 30V/cm (3Kv/m) or under value of ESI on 1m above from the road surface

4. Possible conflicts with OTL on Approved Alignment

301. After the Inception Mission in June 2009 Alignment A1 was approved for further study. All possible existing and future conflicts were studied and are in Table 72.

Table 72: Conflicts with OTL on Approved Alignment (A1)

Station	Voltage Class (Kv)	Elevation of Road	VSD from Road Surface	Safe OTL Elevation	Actual Lowest OTL	Note
Km 02+400	110 Kv	5.08	6.00	11.08	11.80	OK
Km 10+800	110 Kv	5.48	6.00	11.48		must check in field
Km 18+550	500 Kv	9.17	10.00	19.17		Proposed OTL
Km 22+200	110 Kv	23.74	6.00	29.74		possibly go under road
Km 28+050	110 Kv	4.84	6.00	10.84		must check in field
Km 31+950	500 Kv	8.34	10.00	18.34		must check in field
Km 32+060	220 Kv	5.72	7.00	12.72		must check in field
Km 35+220	110 Kv	5.77	6.00	11.77		must check in field

302. From Table 72 there are a number of places that will be checked to ensure that a safe VSD distance is maintained. The proposed future placement of the 500 Kv OTL at Km 18+950 should be constructed to the safe elevation.

E. Large River Crossing

303. There were three alternative alignments considered as discussed in section 3.1 Alignment Selection. Alternative A1 crosses two large rivers (the Soai Rap River and the Long Tau River) while Alternative A2 & A3 cross only one but much wider Dong Nai River. The

previous JETRO study took as a starting premise that bridges will be constructed to accomplish the crossing, and also proposed steel composite type superstructure. There was no discussion of alternative crossing types such as bored or immersed tube tunnels nor were alternative alignments considered. Given that the report was prepared by a steel manufacturer, greater impartiality and reasoned presentation is required before an investment decision can be made. The large river crossings were studied for the three alternative alignments. The first possible choice is type of crossing. The road could either run below the rivers in the tunnel option or above in the bridge option. Each of the two types of crossing were studied carefully for each of three alignments.

1. The Tunnel Option

a. Tunnel Types

304. There two types of tunnels that will be considered for the Project. The immersed tube tunneling method (IMT) and the tunnel boring machine (TBM) method. For a more details of tunneling methods and construction please see Appendix

i. Immersed Tube Tunneling Method (IMT)

305. The immersed-tube, or sunken-tube, method, used principally for underwater crossings, involves prefabricating long tube sections, floating them to the site, sinking each in a previously dredged trench, and then covering with backfill.

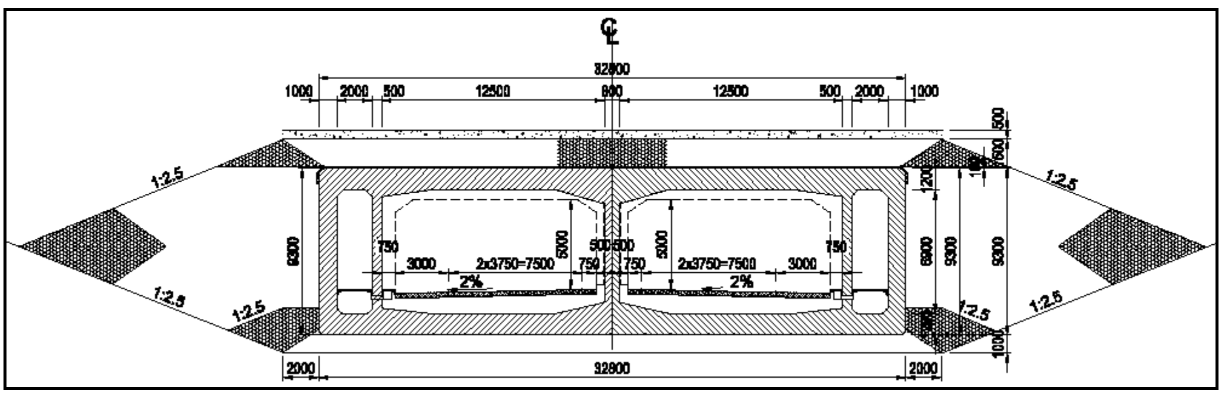


Figure 33:Cross-Section of 4-Lane Immersed Tube Tunnel

ii. Tunnel Boring Machine (TBM) Method

306. Tunnel boring machines (TBM) are used as an alternative to drilling and blasting (D&B) methods in rock and conventional 'hand mining' in soil. A TBM has the advantages of limiting the disturbance to the surrounding ground and producing a smooth tunnel wall. This significantly reduces the cost of lining the tunnel, and makes them suitable to use in heavily urbanized areas. The major disadvantage is the upfront cost. TBMs are expensive to construct, difficult to transport and require significant infrastructure. A TBM is a machine used to excavate tunnels with a circular cross section through a variety of soil and rock strata. They can bore through hard rock, sand, and almost anything in between.

iii. Choice of Type of Tunnel

307. According to the horizontal route alignment, tunnel option is to be profiled beginning with large river crossings. Mekong River delta is formed by large rivers consisting of soft soil ground so as to span the approaching section on both side bridges by viaduct in principle crossing small rivers and roads with clearance lower than 6m. Immersed tunnel section meets cut and cover tunnel at coastal line with minimal soil cover containing underground common ducts followed by U shaped retaining wall or retaining wall separated into both lane side before transition to viaduct section. However it is most economical that the deepest sag point of immersed tunnel would be determined by fairway depth and soil cover influenced from shipping capacity, countermeasure to mitigate score should be examined to raise the profile by considering stable river bottom. Geometrical restrictions are shown as below.

308. The TBM method if used would be the first experience in Vietnam. Considering unfamiliarity to the application on soft soil as well as the method, recommended is with full circumference shielded in circular section. Tunnel arrangement to enclose lanes in one bore or two bores is to be examined its applicability. In our case the diameter of tunnel structure is to be assumed 15m for 2 lanes plus emergency lane per tube. Detailed costing of both types of tunnels is shown in Appendix C.5.

Table 73: Summary of Alignment 1 Tunnels by Type

Tunnel	Length	Type	Amount	Cost per m
Song Soai Rap IMT	4,086 m	IMT Alignment 1	$512,913,375	$125,529
Song Long Tau IMT	2,640 m	IMT Alignment 1	$302,919,801	$114,742
Alignment 1 IMT	**6,726 m**	**IMT Alignment 1**	**$815,833,176**	**$121,295**
Song Soai Rap TBM	4,387 m	TBM Alignment 1	$1,536,823,804	$350,313
Song Long Tau TBM	3,726 m	TBM Alignment 1	$1,285,255,033	$344,942
Alignment 1 TBM	**8,113 m**	**TBM Alignment 1**	**$2,822,078,836**	**$347,847**

309. From Table 73 above it can be seen that the Immersed Tube Tunnels cost much less than the Tunnel Boring Machine type. This eliminates the TBM type from further consideration. The cost of IMT tunnels will be calculated for Alignments 2 and 3 to compare with the cost of bridges for these alignments.

Table 74: Summary of all IMT Type Tunnels all Alignments

Tunnel	Length	Type	Amount	Cost per m
Song Soai Rap IMT	4,086 m	IMT Type Alignment 1	$512,913,375	$125,529
Song Long Tau IMT	2,640 m	IMT Type Alignment 1	$302,919,801	$114,742
Alignment 1 IMT	**6,726 m**	**IMT Type Alignment 1**	**$815,833,176**	**$121,295**
Nha Be 1 Tunnel IMT	3,067 m	IMT Type Alignment 2	$475,320,017	$154,979
Nha Be 2 Tunnel IMT	2,966 m	IMT Type Alignment 3	$450,358,827	$151,840

310. The costs in Table 74 were then brought forward into the alignment selection costs.

2. The Bridge Option

a. Bridge Type

311. For the three possible alignments there are Cable-stayed bridges have been selected for this Project because they are considered (a) economically more feasible; (b) aesthetically more

pleasing; and, (c) easier to construct than either cantilever or suspension bridges. Suspension bridges generally require more cable than a cable-stayed bridge while a full cantilever bridge would require more material and substantially heavier. A cantilever bridge also has a more noticeable impact on water turbidity than either the suspension bridge or a cable-stayed bridge and hence on environmental grounds, especially in relation to water resource issues there are clear environmental advantages in constructing cable-stayed bridges. A cable-stayed bridge is a bridge that consists of one or more columns (normally referred to as towers or pylons) with cables supporting the bridge deck.

Table 75: Cable Stay Bridges in Vietnam

Name	Year Open	Main Span Length	Tower Type	Deck Width	Deck Type
My Thuan Bridge	2000	350 m	H Shaped	23.7 m	PC Box
Binh Bridge	2005	250 m	Double A	22.5 m	Composite
Bai Chay Bridge	2006	435 m	Single	25.3 m	PC Box with internal steel strut
Rach Mieu	2009	270 m	Double A	15.7 m	Composite
Phu My	2009	380 m	H Shaped	27.5 m	Concrete with double "T" Beams
Cuu Long	u/c	550 m	Double A	23.1 m	Hybrid (PC Box & Steel Girder)
Nhat Tan	u/c	300 m	Double A	33.0 m	Composite (300 x 4 main spans)

Note: u/c = under construction or design

312. Alternative A1 crosses two large rivers (the Soai Rap River and the Long Tau River) while Alternative A2 & A3 cross only one but much wider Dong Nai River. Each of these rivers crossings was studied and length of possible bridges proposed. The first task was to recommend the best alignment of there. Outline designs were done to obtain the cost of each possible bridge.

Table 76: Summary of all outline Bridges all Alignments

Bridge	Length	River	Amount	Cost per m
Binh Khanh Bridge	861 m	Song Soai Rap	$94,449,978	$109,698
Phuoc Khanh Bridge	745 m	Song Long Tau	$68,509,973	$114,742
Alignment 1	**1,606 m**	**Bridges Alignment 1**	**$162,959,951**	**$101,469**
Nha Be Bridge 1	1,750 m	Nha Be River Alignment 2	$242,243,750	$138,425
Nha Be Bridge 2	1,370 m	Nha Be River Alignment 3	$176,216,250	$128,625

313. The costs in Table 76 were then brought forward into the alignment selection costs.

314. Once the Alignment 1 was chosen as the preferred alignment in June the two river crossings on this alignment were studied in much more detail.

b. Type of Towers

315. Three types of towers have been considered for the cable-stay bridge options a single tower, a double “A” tower and an inverted “Y” tower. These are shown in Figure 34.

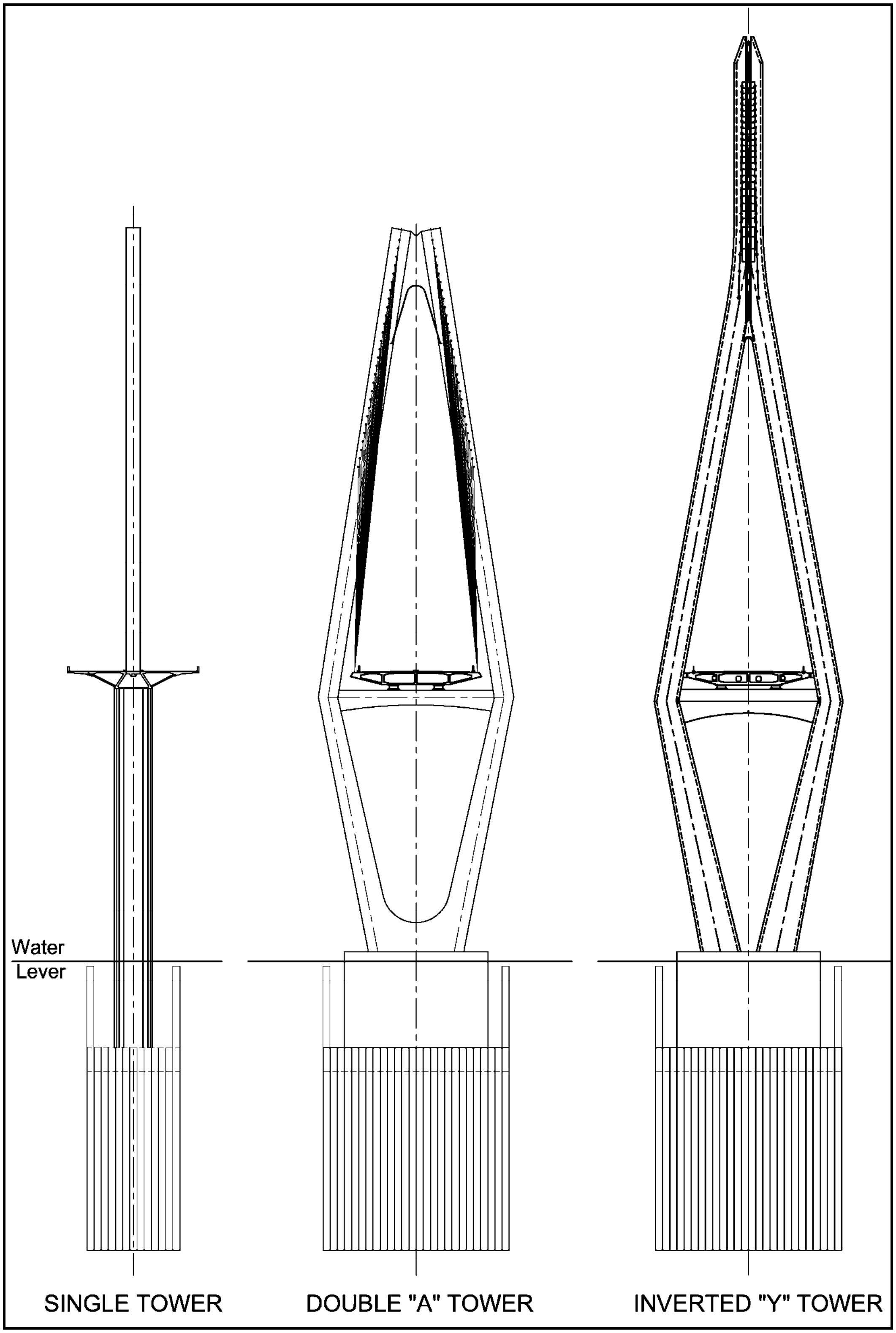


Figure 34: Types of Towers for Bridges

c. Type of Bridge Deck

316. There are a number of types of bridge decks to be considered for the cable-stay bridge options. Some of these decks are shown in the flowing figures.

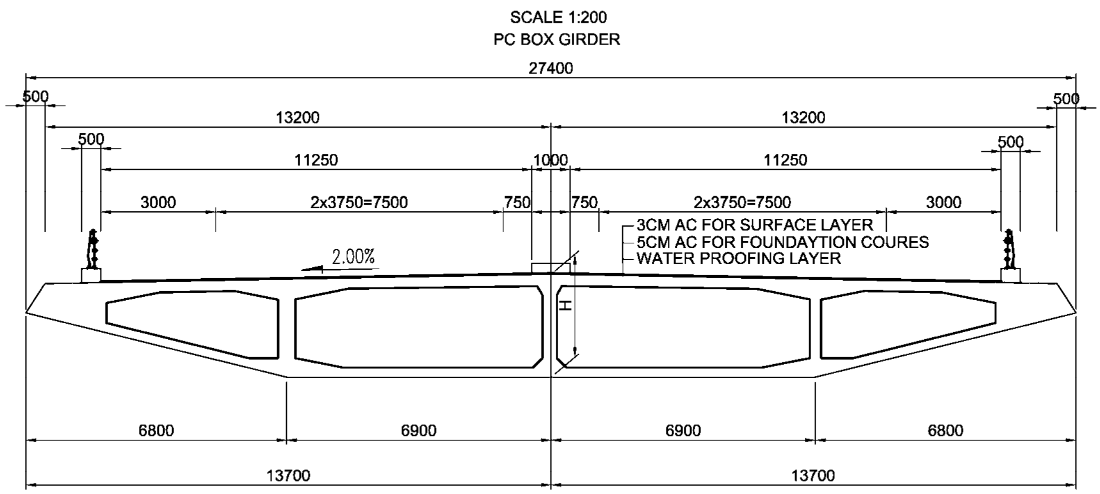


Figure 35: PC Box Girder Bridge Deck

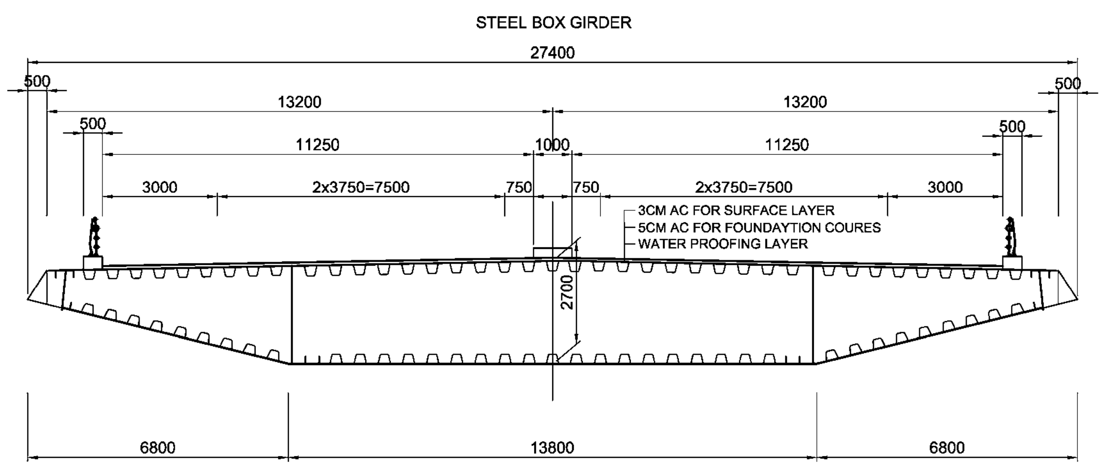


Figure 36: Steel Box Girder Bridge Deck

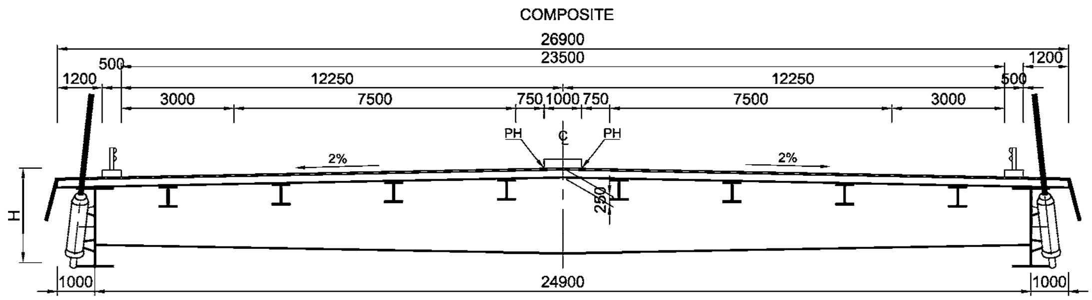


Figure 37: Composite Steel & Concrete Bridge Deck

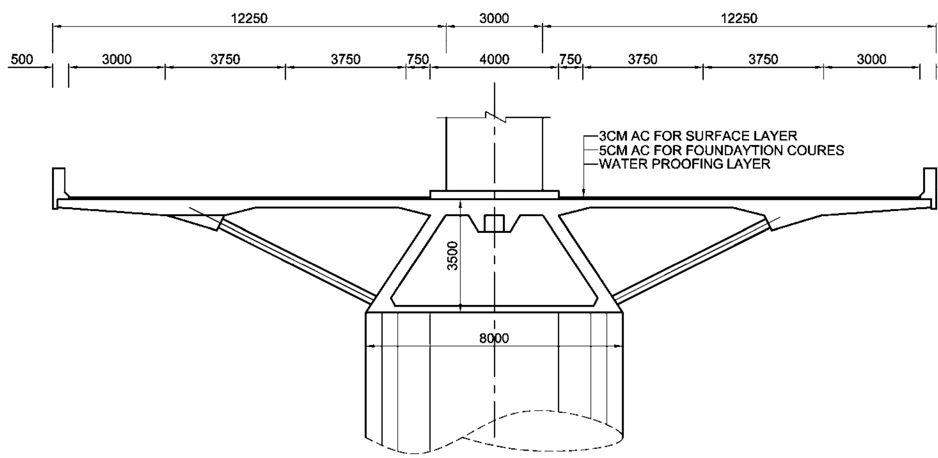


Figure 38: PC Concrete with external steel strut Bridge Deck

i. Navigation Clearance

317. The vertical clearance of 55-metres and a horizontal clearance of 242-metres were required by the Vietnam Maritime Administration for the Soai Rap and Long Tau Rivers for navigation clearance. This requirement will affect the overall cost of these bridges and so was carefully studied. The dimensions of the ships estimated by the proposed navigation clearance are as follows:

- Vertical Clearance of 55-metres is for a container ship of 40,000 DWT
- Horizontal Clearance of 242-metres indicates a length of ship of 200-metres.

It should be noted that the vertical clearance of 55-metres is the largest for any bridge currently in Vietnam.

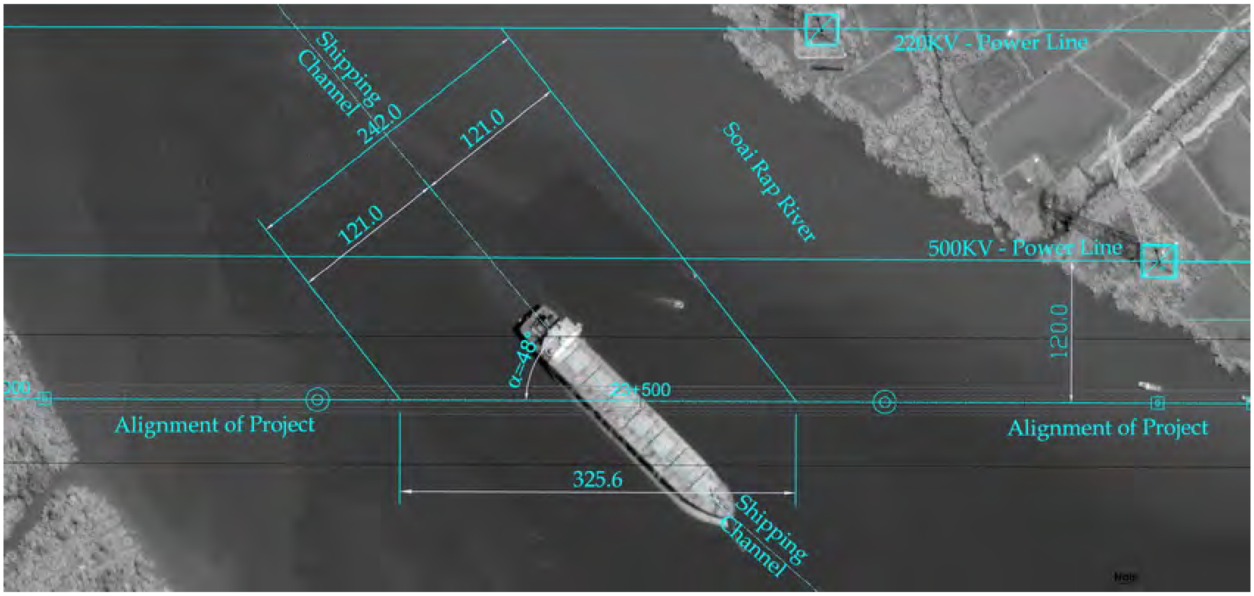


Figure 39: Binh Khanh Bridge Clearance

318. As can be seen in Figure 39 the shipping channel is at a 48° skew to the axis of the bridge and highway. The axis of the bridge and highway was chosen through the alignment selection process as described in section and is primarily required to be parallel to the high voltage overhead transmission lines (500KvA).

ii. Design Standards

319. The bridge design standards for large bridges and structures in this project shall be the following:

- Vietnamese Design Standard (22TCN272-05),
- AASHTO-LRFD (Load and Resistance Factor Design, 4th Edition 2009).
- "Recommendations for Stay Cable Design, Testing and Installation, 5th Edition, 2007" issued by PTI.

320. The optimum height of the abutment was determined in accordance with the following studies:

- Construction cost of the abutment and superstructure
- Evaluation for the horizontal and vertical deformation of the abutment at the level of the bridge seat.
- Stability for the backfilling of the abutment.

iii. Main Bridge Structure

321. The navigation channel on the Soai Sap River was studied very extensively and taking into account the location of the navigation channel on the Soai Sap River the optimum span length and position of the piers identified accordingly. As the bridge structures as mentioned above has a span length that is greater than is feasible for steel arch bridge or girder truss bridge so a cable stay type bridge has been chosen. A cable stay type of bridge is superior in aspects of economy, construction and maintenance. Consequently the bridge structure for the Binh Khanh Bridge must be a cable stay bridge.

- Span Arrangement and Alternative Superstructures

- The span arrangement is assumed as a parameter which is a pier numbers constructed in the river.

Table 77: Options Studied for Binh Khanh Bridge

	Main Span Length	Bridge Length	Navigation Clearance		Tower Type	Deck Type	Remarks
			Width	Height			
Option BK1	143.5 m	861.0 m	100.0 m	30.0 m	N/A	PC Box Girder	Does not meet Nav. Regulations
Option BK2	300.0 m	594.0 m	200.0 m	30.0 m	Single	PC Girder with strut	Does not meet Nav. Regulations
Option BK3	435.0 m	861.0 m	242.0 m	55.0 m	Single	PC Girder with strut	
Option BK4	435.0 m	861.0 m	242.0 m	55.0 m	Double A	PC Box Girder	
Option BK5	435.0 m	861.0 m	242.0 m	55.0 m	Double A	Composite Deck	
Option BK6	550.0 m	1,090.0 m	242.0 m	55.0 m	Inverted Y	Hybrid Deck	

322. In Table 77 there were six options studied for the Binh Khanh Bridge crossing of the Soai Rap River. It must be noted that the first two options are for navigation clearances that were considerably less than the regulations. These were studied to check to see if it was feasible to seek modification of the regulations for the navigation clearances. It should be noted that the longest bridge is Option 6. In order to have the same equivalent bridge length the length of the approach bridge is added so that the total lengths are same for comparing the costs.

Option BK 1: Traditional Concrete Box Bridge

323. This Option is using a concrete box with a series of six 143.5-metre spans to cross the Soai Rap River. It could not be used unless there was a radical change in the navigation clearances and has been studied to investigate if the effort to change the regulations will bring much reduced costs.

Table 78: Cost Estimate for Option BK 1 Binh Khanh Bridge 143.5 metre spans

	Unit	Quantity	Unit Rate	Amount
Superstructure				**31,862,824**
Girder Reinforcing Steel	Tonne	5,118	1,100.00	5,629,800
Girder Strand Tendon Steel	Tonne	2,218	2,400.00	5,323,200
Girder Fabrication Concrete	m3	25,588	340.00	8,699,920
Solid Slab Concrete	m3	14,181	300.00	4,254,300
Solid Slab Reinforcing Steel	Tonne	1,701	2,200.00	3,742,200
Cable Material	Tonne			0

	Unit	Quantity	Unit Rate	Amount
Accessories, Bearings Etc	m2	21,095	41.52	875,844
Deck Works & Pavement	m2	21,095	80.00	1,687,560
Maintenance Facilities	Unit	1	1,650,000.00	1,650,000
Foundation				**52,019,400**
Cast-in-place Piles 1500mm	M	27,600	1,000.00	27,600,000
Substructure Concrete	m3	86,410	210.00	18,146,100
Substructure Reinforcing Steel	Tonne	5,703	1,100.00	6,273,300
Temporary Works				**7,241,920**
Temporary Piers & Jetty	m2	7,844	680.00	5,333,920
Temporary Road	m2	28,000	42.25	1,183,000
Tower Crane Elevator	LS	1	725,000.00	725,000
Approach Bridge	Lm	229		**4,968,098**
Approach Bridge Nha Be	Lm	115	21,315.00	2,440,568
Approach Bridge Can Gio	Lm	115	22,074.50	2,527,530
Total Equivalent Bridge Length = 1,090 metres				**96,092,242**

324. The first problem with this bridge is that there are six piers in the deep water of the river. These piers are difficult and expensive to construct. Once the foundations are completed however, the bridge construction then becomes a normal long span bridge.

Option BK 2: 300-metre main span Cable Stay Bridge

325. Again this option as Option 1 does not meet the navigation clearance requirements but has been proposed to discover the cost of such a crossing.

Table 79: Cost Estimate for Option BK 2 Binh Khanh Bridge 300 metre main span

	Unit	Quantity	Unit Rate	Amount
Superstructure				**24,809,603**
Girder Reinforcing Steel	tonne	926	5,350.00	4,951,425
Girder Fabrication Steel	tonne	70	5,750.00	401,063
Girder Fabrication Concrete	m3	6,338	590.00	3,739,568
Main Tower Concrete	m3	2,026	1,200.00	2,430,900
Main Tower Reinforcing Steel	tonne	926	5,350.00	4,951,425
Cable Material	tonne	530	9,800.00	5,196,450
Accessories, Bearings Etc	m2	12,251	41.52	508,672
Deck Works & Pavement	m2	12,251	80.00	980,100
Maintenance Facilities	Unit	1	1,650,000.00	1,650,000
Foundation				**56,249,000**
Steel Pile Sheet Piles	tonne	8,002	5,575.00	44,611,150
Cast-in-place Piles 1500mm	M	7,726	700.00	5,408,200
Footing Concrete	m3	11,866	525.00	6,229,650
Temporary Works				**7,241,920**
Temporary Piers & Jetty	m2	7,844	680.00	5,333,920
Temporary Road	m2	28,000	42.25	1,183,000
Tower Crane Elevator	LS	1	725,000.00	725,000
Approach Bridge	Lm	496		**10,760,596**
Approach Bridge Nha Be	Lm	248	21,315.00	5,286,120

	Unit	Quantity	Unit Rate	Amount
Approach Bridge Can Gio	Lm	248	22,074.50	5,474,476
Total Equivalent Bridge Length = 1,090 metres				**99,061,119**

326. Again the problem with this Option is the number of piers in the water.

Option BK 3: 435-metre span Cable Stay Bridge PC Girder Deck with strut

327. This is the first Option that does actually meet the navigation clearance requirements. This Option uses a single tower and only one set of cable stays to support the PC Girder Deck.

Table 80: Cost Estimate for Option BK 3 Binh Khanh Bridge 435 Meter Main Span

	Unit	Quantity	Unit Rate	Amount
Superstructure				**46,438,061**
Girder Reinforcing Steel	tonne	1,790	5,350.00	9,576,500
Girder Fabrication Steel	tonne	135	5,750.00	776,250
Girder Fabrication Concrete	m3	12,250	590.00	7,227,500
Main Tower Concrete	m3	3,916	1,200.00	4,699,200
Main Tower Reinforcing Steel	tonne	1,790	5,350.00	9,576,500
Cable Material	tonne	1,026	9,800.00	10,054,800
Accessories, Bearings Etc	m2	23,678	41.52	983,111
Deck Works & Pavement	m2	23,678	80.00	1,894,200
Maintenance Facilities	Unit	1	1,650,000.00	1,650,000
Foundation				**40,770,000**
Steel Pile Sheet Piles	tonne	5,800	5,575.00	32,335,000
Cast-in-place Piles 1500mm	M	5,600	700.00	3,920,000
Footing Concrete	m3	8,600	525.00	4,515,000
Temporary Works				**7,241,920**
Temporary Piers & Jetty	m2	7,844	680.00	5,333,920
Temporary Road	m2	28,000	42.25	1,183,000
Tower Crane Elevator	LS	1	725,000.00	725,000
Approach Bridge	Lm	229		**4,968,098**
Approach Bridge Nha Be	Lm	115	21,315.00	2,440,568
Approach Bridge Can Gio	Lm	115	22,074.50	2,527,530
Total Equivalent Bridge Length = 1,090 metres				**99,418,079**

Option BK 4: 435-metre main span Cable Stay Bridge PC Box Deck

328. This Option also meets the navigation clearance requirements. It uses a concrete Double “A” tower and therefore has two cable stays to support the PC Box Girder Deck.

Table 81: Cost Estimate for Option BK 4 Binh Khanh Bridge 435 Meter Main Span

	Unit	Quantity	Unit Rate	Amount
Superstructure				**73,850,150**
Girder Reinforcing Steel	tonne	4,248	5,350.00	22,726,800
Girder Fabrication Steel	tonne		5,750.00	0
Girder Fabrication Concrete	m3	20,230	590.00	11,935,700
Main Tower Concrete	m3	9,240	1,200.00	11,088,000
Main Tower Reinforcing Steel	tonne	1,570	5,350.00	8,399,500

	Unit	Quantity	Unit Rate	Amount
Cable Material	tonne	1,560	9,800.00	15,288,000
Accessories, Bearings Etc	m2	22,730	41.52	943,750
Deck Works & Pavement	m2	22,730	80.00	1,818,400
Maintenance Facilities	Unit	1	1,650,000.00	1,650,000
Foundation				**40,770,000**
Steel Pile Sheet Piles	tonne	5,800	5,575.00	32,335,000
Cast-in-place Piles 1500mm	m	5,600	700.00	3,920,000
Footing Concrete	m3	8,600	525.00	4,515,000
Temporary Works				**7,241,920**
Temporary Piers & Jetty	m2	7,844	680.00	5,333,920
Temporary Road	m2	28,000	42.25	1,183,000
Tower Crane Elevator	LS	1	725,000.00	725,000
Approach Bridge	lm	229		**4,968,098**
Approach Bridge Nha Be	lm	115	21,315.00	2,440,568
Approach Bridge Can Gio	lm	115	22,074.50	2,527,530
Total Equivalent Bridge Length = 1,090 metres				**126,830,168**

Option BK 5: 435-metre main span Cable Stay Bridge with a composite deck

329. This Option meets the navigation clearance requirements and uses a concrete Double "A" tower that has two cable stays to support the composite deck.

Table 82: Cost Estimate for Option BK 5 Binh Khanh Bridge 435 Metre Main Span

	Unit	Quantity	Unit Rate	Amount
Superstructure				**64,024,185**
Girder Reinforcing Steel	tonne		5,350.00	0
Girder Fabrication Steel	tonne	6,458	5,750.00	37,130,625
Girder Fabrication Concrete	m3	579	590.00	341,610
Main Tower Concrete	m3	6,930	980.00	6,791,400
Main Tower Reinforcing Steel	tonne	1,178	5,350.00	6,299,625
Cable Material	tonne	918	9,800.00	8,996,400
Accessories, Bearings Etc	m2	23,161	41.52	961,645
Deck Works & Pavement	m2	23,161	80.00	1,852,880
Maintenance Facilities	Unit	1	1,650,000.00	1,650,000
Foundation				**36,693,000**
Steel Pile Sheet Piles	tonne	5,220	5,575.00	29,101,500
Cast-in-place Piles 1500mm	m	5,040	700.00	3,528,000
Footing Concrete	m3	7,740	525.00	4,063,500
Temporary Works				**7,241,920**
Temporary Piers & Jetty	m2	7,844	680.00	5,333,920
Temporary Road	m2	28,000	42.25	1,183,000
Tower Crane Elevator	LS	1	725,000.00	725,000
Approach Bridge	lm	229		**4,968,098**
Approach Bridge Nha Be	lm	115	21,315.00	2,440,568
Approach Bridge Can Gio	lm	115	22,074.50	2,527,530
Total Equivalent Bridge Length = 1,090 metres				**112,927,203**

Option BK 6: 550-Meter Main Span Cable Stay Bridge Hybrid Deck

330. This Option meets the navigation clearance requirements and uses a steel fabricated Inverted "Y" tower that has two cable stays to support the hybrid deck. This deck uses a PC Box Deck foe part of the length and then uses a steel box girder deck in the centre sections of the span.

Table 83: Cost Estimate for Option BK 6 Binh Khanh Bridge 550 Meter Main Span

	Unit	Quantity	Unit Rate	Amount
Superstructure				**105,254,235**
Girder Reinforcing Steel	tonne	3,305	5,350.00	17,681,750
Girder Fabrication Steel	tonne	2,700	5,750.00	15,525,000
Girder Fabrication Concrete	m3	15,742	590.00	9,287,780
Main Tower Concrete	m3		980.00	0
Main Tower Steel	tonne	7,887	5,350.00	42,196,520
Cable Material	tonne	1,560	9,800.00	15,288,000
Accessories, Bearings Etc	m2	29,832	41.52	1,238,625
Deck Works & Pavement	m2	29,832	80.00	2,386,560
Maintenance Facilities	Unit	1	1,650,000.00	1,650,000
Foundation				**32,616,000**
Steel Pile Sheet Piles	tonne	4,640	5,575.00	25,868,000
Cast-in-place Piles 1500mm	m	4,480	700.00	3,136,000
Footing Concrete	m3	6,880	525.00	3,612,000
Temporary Works				**7,241,920**
Temporary Piers & Jetty	m2	7,844	680.00	5,333,920
Temporary Road	m2	28,000	42.25	1,183,000
Tower Crane Elevator	LS	1	725,000.00	725,000
Approach Bridge	lm	0		**0**
Approach Bridge Nha Be	lm	0	21,315.00	0
Approach Bridge Can Gio	lm	0	22,074.50	0
Total Equivalent Bridge Length = 1,090 metres				**145,112,155**

331. This is the longest of the six options and to ensure a comparison with the other five options the design of this option does not include an approach bridge.

Table 84: Summary of Binh Khanh Bridge Options

	Option BK 1	Option BK 2	Option BK 3	Option BK 4	Option BK 5	Option BK 6
Tower Type	N/A	Single	Single	Double A	Double A	Inverted Y
Deck Type	PC Box Grider	PC with strut	PC with strut	PC Box Grider	Composite Deck	Hybrid Deck
Main Span Length	143.5 m	300.0 m	435.0 m	435.0 m	435.0 m	550.0 m
Bridge Length	861.0 m	594.0 m	861.0 m	861.0 m	861.0 m	1,090.0 m
Approach Bridge	229.0 m	496.0 m	229.0 m	229.0 m	229.0 m	0.0 m
Equilavent Length	1,090.0 m	1,090.0 m	1,090.0 m	1,090.0 m	1,090.0 m	1,090.0 m
Superstructure US$	$31,862,824	$24,809,603	$46,438,061	$73,850,150	$64,024,185	$105,254,235
Foundation	$52,019,400	$56,249,000	$40,770,000	$40,770,000	$36,693,000	$32,616,000
Temporary Works	$7,241,920	$7,241,920	$7,241,920	$7,241,920	$7,241,920	$7,241,920
Approach Bridge	$4,968,098	$10,760,596	$4,968,098	$4,968,098	$4,968,098	$0
Total Bridge Cost	$96,092,242	$99,061,119	$99,418,079	$126,830,168	$112,927,203	$145,112,155
Cost Index	**0.97**	**1.00**	**1.00**	**1.28**	**1.14**	**1.46**
Recommended			**OK**			

332. As can be seen in Table 84 the cost of the first three Options are very similar. The first two Options are eliminated because they do not meet the navigation requirements and do not provide enough cost savings to have these requirements revised. So the lowest cost Option is No. 3, which is using a single tower and a PC Deck with steel strut supports. During the Detailed Design Phase the problem of ship collision loads and scouring effects in particularly the western pylon at 23+232.5 will be a subject of further study and review.

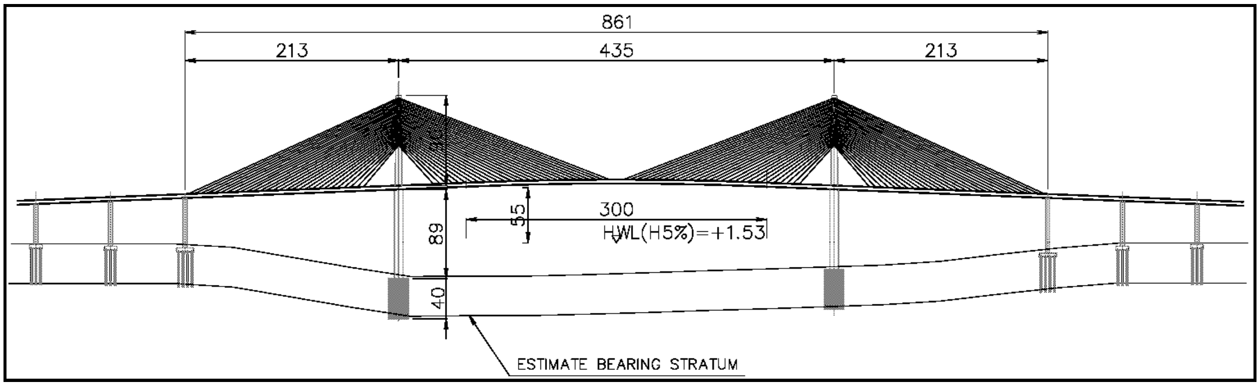


Figure 40: Profile of Binh Khan Bridge

333. In the same process three different bridge Options were considered for the Phuoc Khanh Bridge.

Table 85: Options Studied for Phuoc Khanh Bridge

	Main Span Length	Bridge Length	Navigation Clearance		Tower Type	Deck Type	Remarks
			Width	Height			
Option PK 1	375.0 m	742.0 m	242.0 m	55.0 m	Single	PC Girder with strut	
Option PK 2	375.0 m	742.0 m	242.0 m	55.0 m	Single	PC Box Girder	
Option PK 3	375.0 m	742.0 m	242.0 m	55.0 m	Single	Composite Deck	

Option PK 1: 375-Metre Span Cable Stay Bridge with a PC deck with steel strut

334. This Option meets the navigation clearance requirements and uses a single concrete tower that has one row of stay cables to support the PC girder with steel strut deck.

Table 86: Cost Estimate for Option PK 1 Phuoc Khanh Bridge Single Tower

	Unit	Quantity	Unit Rate	Amount
Superstructure				**38,488,606**
Girder Reinforcing Steel	tonne	1,781	5,350.00	9,528,350
Girder Fabrication Steel	tonne	120	5,750.00	690,000
Girder Fabrication Concrete	M3	11,872	620.00	7,360,640
Main Tower Concrete	M3	3,100	1,200.00	3,720,000
Main Tower Reinforcing Steel	tonne	820	5,350.00	4,387,000
Cable Material	tonne	885	9,800.00	8,673,000
Accessories, Bearings Etc	M2	20,405	41.52	847,216
Deck Works & Pavement	M2	20,405	80.00	1,632,400
Maintenance Facilities	Unit	1	1,650,000.00	1,650,000
Foundation				**26,500,500**

	Unit	Quantity	Unit Rate	Amount
Steel Pile Sheet Piles	tonne	3,770	5,575.00	21,017,750
Cast-in-place Piles 1500mm	M	3,640	700.00	2,548,000
Footing Concrete	M3	5,590	525.00	2,934,750
Temporary Works				**4,635,152**
Temporary Piers & Jetty	M2	4,706	680.00	3,200,352
Temporary Road	M2	16,800	42.25	709,800
Tower Crane Elevator	LS	1	725,000.00	725,000
Total Equivalent Bridge Length = 742 metres				**69,624,258**

Option PK 2: 375m Span Cable Stay Bridge PC Box deck & Double "A" Tower

335. This Option meets the navigation clearance requirements and uses a Double "A" concrete tower that has two rows of stay cables to support the PC Box Girder deck.

Table 87: Cost Estimate for Option PK 2 Phuoc Khanh Bridge Double Tower

	Unit	Quantity	Unit Rate	Amount
Superstructure				**61,519,874**
Girder Reinforcing Steel	tonne	3,514	5,350.00	18,799,900
Girder Fabrication Steel	tonne		5,750.00	0
Girder Fabrication Concrete	m3	16,732	620.00	10,373,840
Main Tower Concrete	m3	8,870	1,200.00	10,644,000
Main Tower Reinforcing Steel	tonne	1,508	5,350.00	8,067,800
Cable Material	tonne	980	9,800.00	9,604,000
Accessories, Bearings Etc	m2	19,588	41.52	813,294
Deck Works & Pavement	m2	19,588	80.00	1,567,040
Maintenance Facilities	Unit	1	1,650,000.00	1,650,000
Foundation				**26,500,500**
Steel Pile Sheet Piles	tonne	3,770	5,575.00	21,017,750
Cast-in-place Piles 1500mm	m	3,640	700.00	2,548,000
Footing Concrete	m3	5,590	525.00	2,934,750
Temporary Works				**4,635,152**
Temporary Piers & Jetty	m2	4,706	680.00	3,200,352
Temporary Road	m2	16,800	42.25	709,800
Tower Crane Elevator	LS	1	725,000.00	725,000
Total Equivalent Bridge Length = 742 metres				**92,655,526**

Option PK 3: 375m Span Cable Stay, Composite deck and Double "A" Tower

336. This Option meets the navigation clearance requirements and uses a Double "A" concrete tower that has two rows of stay cables to support the Composite deck.

Table 88: Cost Estimate for Option PK 3 Phuoc Khanh Double Tower Composite Deck

	Unit	Quantity	Unit Rate	Amount
Superstructure				**66,946,349**
Girder Reinforcing Steel	tonne		5,350.00	0
Girder Fabrication Steel	tonne	6,400	5,750.00	36,800,000
Girder Fabrication Concrete	m3	499	590.00	294,410
Main Tower Concrete	m3	8,870	980.00	8,692,600

	Unit	Quantity	Unit Rate	Amount
Main Tower Reinforcing Steel	tonne	1,508	5,350.00	8,067,800
Cable Material	tonne	920	9,800.00	9,016,000
Accessories, Bearings Etc	m2	19,960	41.52	828,739
Deck Works & Pavement	m2	19,960	80.00	1,596,800
Maintenance Facilities	Unit	1	1,650,000.00	1,650,000
Foundation				**26,500,500**
Steel Pile Sheet Piles	tonne	3,770	5,575.00	21,017,750
Cast-in-place Piles 1500mm	m	3,640	700.00	2,548,000
Footing Concrete	m3	5,590	525.00	2,934,750
Temporary Works				**4,635,152**
Temporary Piers & Jetty	m2	4,706	680.00	3,200,352
Temporary Road	m2	16,800	42.25	709,800
Tower Crane Elevator	LS	1	725,000.00	725,000
Total Equivalent Bridge Length = 742 metres				**98,082,001**

Table 89: Summary of Phuoc Khanh Bridge Options

	Option PK 1	Option PK 2	Option PK 3
Tower Type	Single	Double A	Double A
Deck Type	PC with strut	PC Box Girder	Composite Deck
Main Span Length	375.0 m	375.0 m	375.0 m
Bridge Length	742.0 m	742.0 m	742.0 m
Superstructure US$	$38,488,606	$61,519,874	$66,946,349
Foundation	$26,500,500	$26,500,500	$26,500,500
Temporary Works	$4,635,152	$4,635,152	$4,635,152
Total Bridge Cost	$69,624,258	$92,655,526	$98,082,001
Cost Index	**1.00**	**1.33**	**1.41**
Recommended	**OK**		

337. As can be seen in Table 89 the cost of the first Option is the less and therefore is the recommended option.

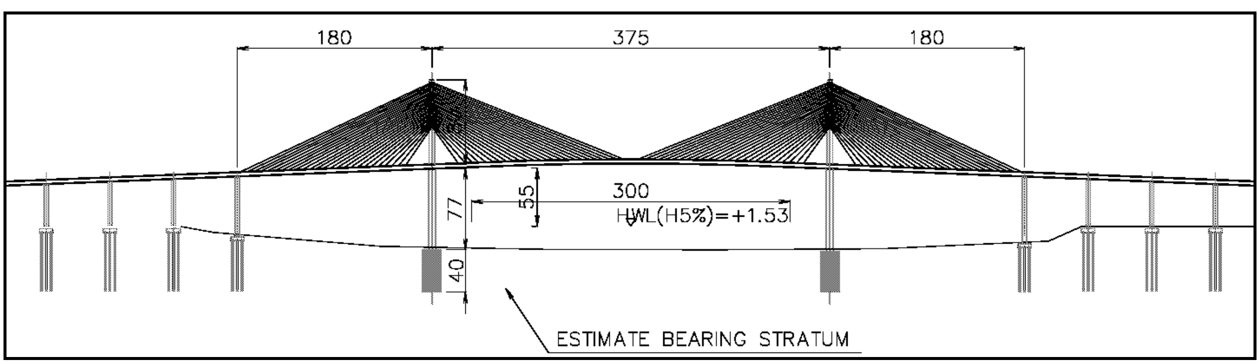


Figure 41: The Phuoc Khanh Bridge Profile

338. Two four-lane cable-stayed bridges with a safety lane on either side of each of the bridges will be constructed. The Binh Khanh Bridge, the first of these two bridges will span the Nha Be River between kilometer 23+019.5 and kilometer 23+867, while Phuoc Khanh, the second of these two cable-stayed bridges will span the same river between 30+000 and

30+30+375. The Binh Khanh Bridge will be 861 meters in length with the main span being 435 meters and will be 92.5 meters high and 27.5 meters wide. Approaches to this bridge from both directions will be 5 kilometers in length via a raised viaduct that will enable bridge users, especially heavy container trucks to embark upon the trip across the bridge. The Phuoc Khanh Bridge has a similar width to the Binh Khanh Bridge but it will be only 375 meters in length and 80.0 meters high. Approaches to the Phuoc Khanh Bridge will be significantly shorter at 1.6 kilometers in length.

339. Both bridges draw on the accepted design principles of several other cable-stayed bridges in Vietnam including Rach Miew, Phu My, My Thuan, and the Cuu Long Bridges which are broadly within the Project zone, and the Bai Chay Bridge abd the Binh Bridge are also considered. The two bridges are more similar in design to the Bai Chay single cable-stayed bridge than the double cable-stayed A-shaped bridges. The technical rationale for this is that a single cable-stayed bridge will require less construction materials and hence it will lower actual construction costs.

iv. Safety Issues

340. Both bridges have been designed to ensure there is a safety lane on each side of the bridge for which can only be used in emergencies although realistically based on other bridges in Vietnam without adequate policing traffic will also attempt to use this safety lane to overtake or as a supplementary lane during peak traffic times. There are no footpaths on the bridge, which is consistent with the principles of expressway design in Vietnam and this will ensure motorized bridge users do not place themselves or NMT users at risk (although in the absence of NMT access it will be necessary to design access for bridge maintenance workers). It also will minimize the incidence of bridge jumping although determined people will still probably find ways to commit suicide or do harm to themselves and others. Bridges the world over are used for such purposes.

341. To ensure that over-loaded vehicles do not pose any safety risk maximum vehicle weights of 45 tonnes will be imposed on bridge users. Other forms of transportation, notably river transportation can be used for bulkier and more hazardous cargoes as indeed is increasingly the case today. In relation to marine vessels colliding with the bridge structure anti-collision barriers will be designed and constructed to prevent fully laden container shipping vessels of up to 40,000 tonnes from generating any damage to bridge structures. Finally, both bridges have been designed to withstand wind gusts of up to 83 meters per second (300 kph) even though wind gusts in the Project area rarely exceed more than 55 meters per second (200 kph). This has been based on criteria used in the construction of the Bai Chay Bridge in Ha Long Bay.

342. The two bridges are the best possible design option under the present circumstances because the bridges are an essential component of the Project. They will represent real value for money once completed. However, they also represent very serious attempts to ensure bridge safety issues have been taken into consideration and have also addressed resettlement and environmental issues.

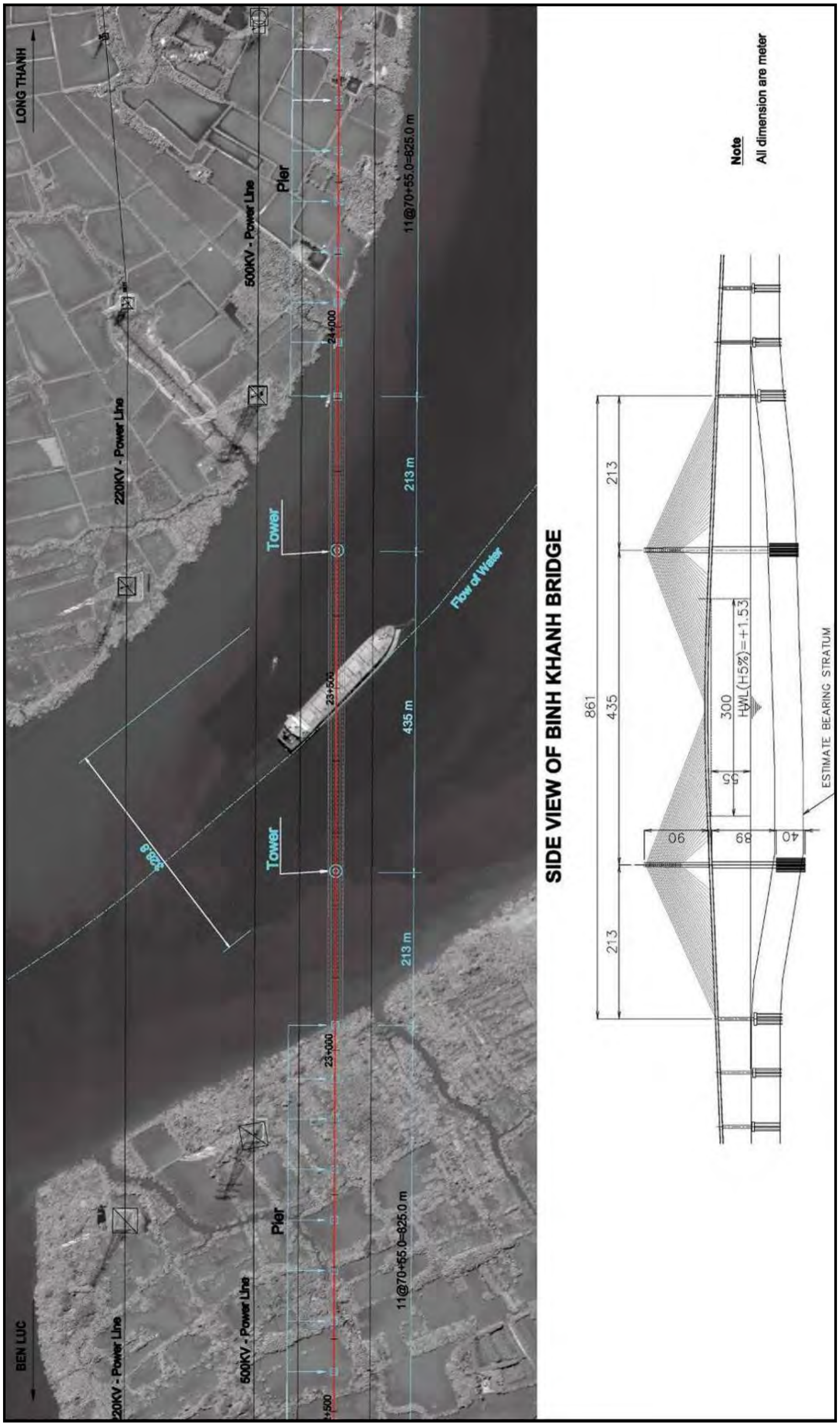


Figure 42: Layout of Binh Khanh Cable Stay Bridge

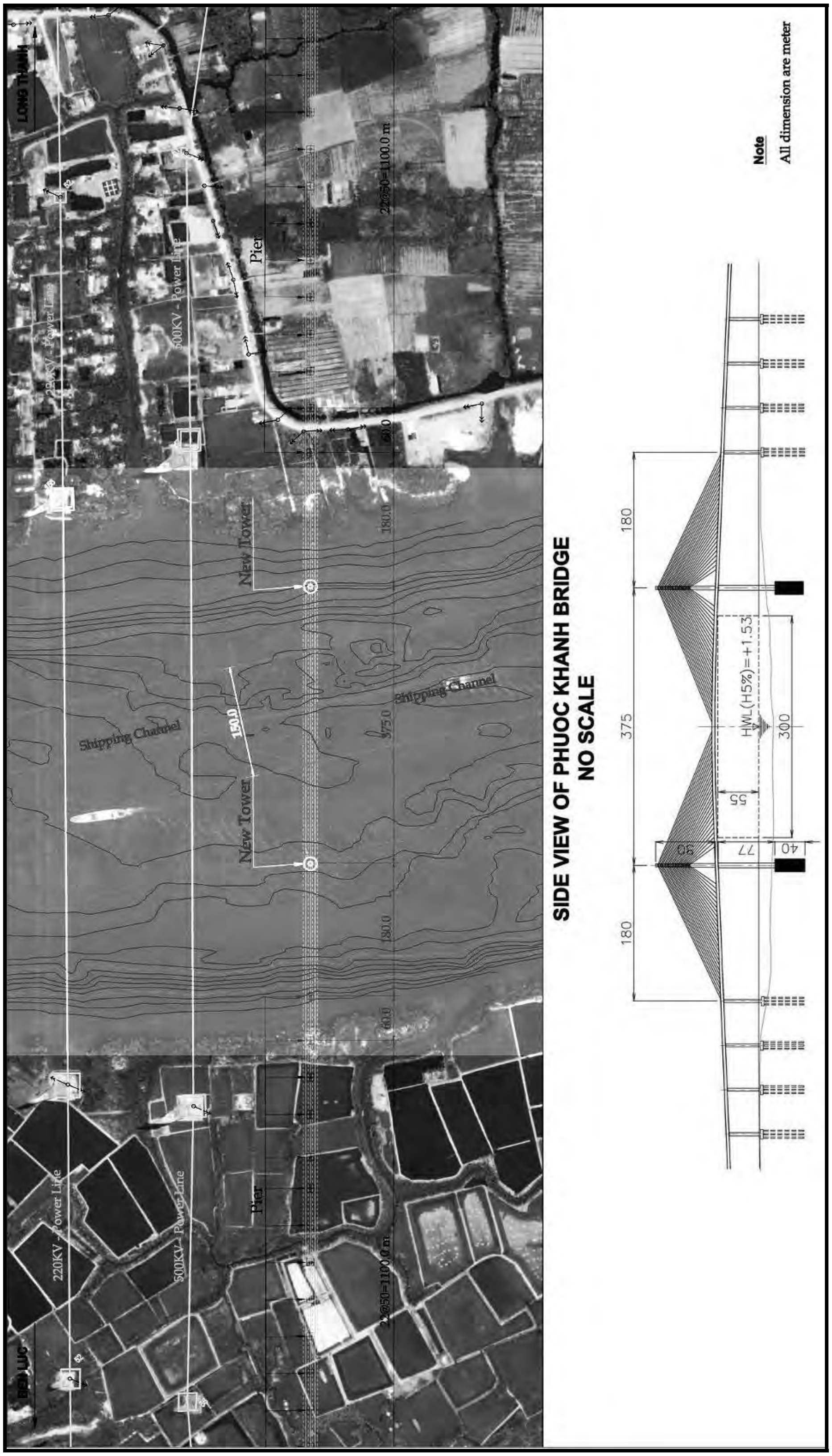


Figure 43: Phuoc Khanh Cable Stay Bridge

F. Structures

343. The bridge structures are planned according to the following principles.

a. Position of Abutment

344. The position of abutment should be decided in consideration of economy, deformation of abutment and stability of back filling of the abutment, However because the limited soil investigation available at the Interim stage, the position of abutment was decided so that the maximum height of embankment would be 4.0 metres. The span arrangement of superstructure is then designed to be optimum.

b. Overburden Thickness of Pile Cap

345. The overburden of pile cap shall be as follows.

- ▪ Ground (general) ----------------- 0.5m
- ▪ Ground (intersection, etc)------ 1.0m
- ▪ River --------------------------------- 1.5m

c. Minimum Space for Clearance Limit

346. The minimum space between clearance limit and structure shall be as follows.

- ▪ Vertical Space --------------------- 0.2m
- ▪ Horizontal Space ----------------- 0.5m

d. Application of Pile Foundation

347. The pile foundation is applied as follows.

- ▪ Bridge --------------------------------------- Concrete Bored Pile
- ▪ Anti earth pressure structure--------- RC precast square piles (pile length 40m)

Table 90: Tower Location of Cable Stay Bridges

Piers	Binh Khanh-1	Phuoc Khanh-1
Pier #1	23+019.5	30+029.0
Pier #2	23+232.5	30+212.5
Pier #3	23+667.5	30+587.5
Pier #4	23+880.5	30+771.0

e. Examination of Cable Stay Bridge

348. Structural analysis was done considering with the construction procedure and time schedule.

349. The loads to be considered are as follows.

- Own weight
- Super imposed dead load
- Live load and impact
- Temperature difference and gradient
- Creep and Shrinkage of concrete
- Pre-stressing force due to internal pre-stressing and stay cable
- Earthquake
- Ship impact loading
- Wind loadings.

350. The seismic response coefficient (Csm) is estimated following equation.

$$4.0 \geqq T \geqq 0.3 \qquad Csnm = \frac{1.2AS}{T^{2/3}} \leqq 2.5A$$

$$T > 4.0 \qquad Csnm = \frac{3AS}{T^{4/3}}$$

Where A: = acceleration coefficient = 0.0747 (from VN 22TCN272-05)

S = 2.0 (Type)
T: natural period is determined by SSDYNAA

351. The Csm is calculated is shown in below.

Table 91: Seismic Response Coefficient

		L=435m		L=375m	
		SPSPW	**MPF**	**SPSPW**	**MPF**
Longitudinal	T	5.565	4.365	4.921	3.766
	Csm	0.040	0.050	0.040	0.060
	Csm,α	0.100	0.130	0.100	0.130
Transverse	T	8.487	6.655	6.449	4.890
	Csm	0.020	0.030	0.030	0.050
	Csm,α	0.050	0.080	0.060	0.050

Note: SPSPW : Steel-Pipe-Sheet-Pile Well
MPF : Multi-Pile Foundation

Csm, α = 2.5Csm

352. As the results, Csm to be used in design calculation is decided as follows.

SPSPW : Csm,α=0.10 and 0.05

MPF : Csm,α=0.13 and 0.07

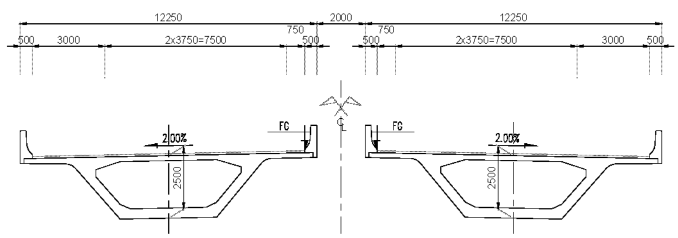
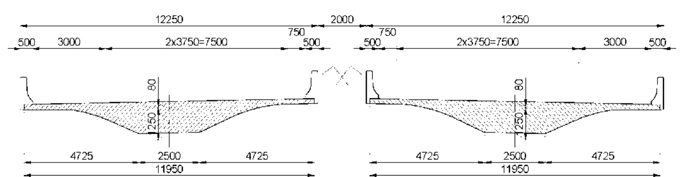
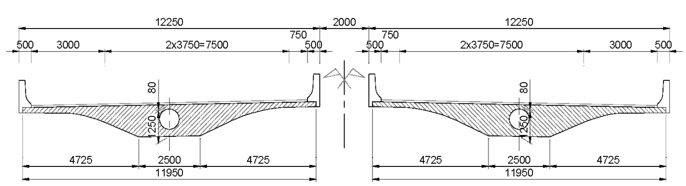
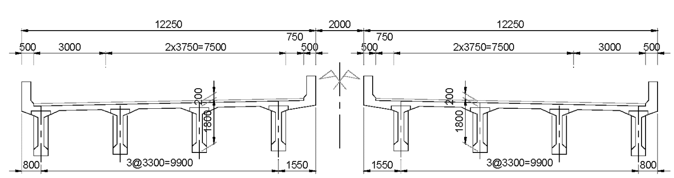
f. Shipping Channel

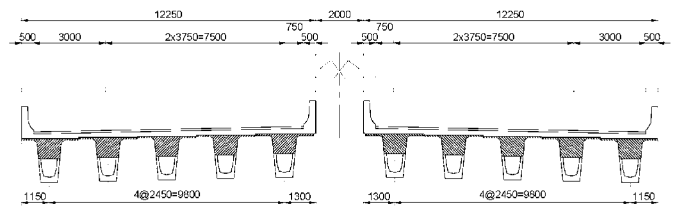
353. The TA Engineers met with the Vietnam Maritime Safety Company No. 2 based in Vung Tau. They are responsible for shipping and ports in the Ho Chi Minh City area. After a detailed review of the proposed bridge layout and designs the location of the piers of the Binh Khanh Bridge was approved as is and they requested that the major pylons of the Phuoc Khanh Bridge be moved 100 metres to the east from the preliminary position. This was done to reflect the actual shipping channel.

g. Medium and Short Span Bridges

354. Alternative bridge types for Medium and Short Span Bridges were selected from Table 92. Basically, concrete bridges should be selected because of low construction cost and minimized maintenance cost. This table is based on the previous experiences in Vietnam from the economical viewpoint.

Table 92: Alternative Bridge Types Medium & Short Spans

	Bridge Type	Appropriate Span Length
Medium Span Bridge	PC Box Girder 	50 m – 100 m
Viaduct, Short Span Bridge, Ramp Bridge	PC Solid Slab 	30 m
	PC Hollow Slab 	30 m
	PC I Girder 	33 m, 40 m

	Bridge Type	Appropriate Span Length
	PC Super Tee Girder 	40 m

h. Comparative Study on Viaduct and Short Span Bridge

355. Bridge type for Medium Span Bridge with span length from 50 m to 100 m, such as existing road flyover and river crossing, should be selected PC Box Girder. However, bridge type for Viaduct or Short Span Bridge should be selected based on a comparative study for the following five Alternatives.

- Option 1: PC Solid Slab with span length of 30 m
- Option 2: PC Hollow Slab with span length of 30 m
- Option 3: PC I Girder with span length of 33 m
- Option 4: PC I Girder with span length of 40 m
- Option 5: PC Super Tee Girder with span length of 40 m

356. The comparative study was done over a typical distance of 2,640 metres of which half was spanning water and the other half land. The foundations were designed using soils typical to Section 2 from Km 15 to Km 23. The studied designed foundations, substructures and superstructures for each option considered. The ease and type of construction was also an important factor. The summary costs for all the options is shown in Table 93 and in detail for each option are shown in Table 94 to Table 98. The optimum bridge type should be selected by overall evaluation in terms of economic efficiency, property of structure, constructability, maintenance and aesthetics.

Table 93: Summation of Short Span Bridge Options

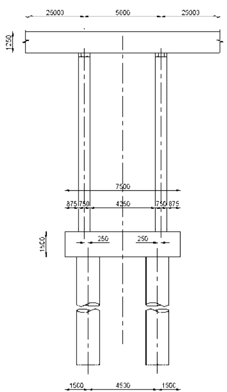
	Option 1	Option 2	Option 3	Option 4	Option 5
	Solid Slab	Hollow Slab	PCI 33m	PCI 40m	Super T
# of Piers	89	89	81	67	67
Superstructure	$18,241,039	$19,840,502	$16,358,811	$18,672,692	$16,906,080
Substructure	$25,102,913	$25,022,000	$25,944,822	$25,982,391	$26,656,164
Total Cost	$43,343,952	$44,862,502	$42,303,633	$44,655,083	$43,562,244
Cost Index	1.02	1.06	1.00	1.06	1.03
Depth of Structure	1.25 m	1.25 m	1.80 m	2.20 m	1.75 m
Recommended	**OK**		**OK**		**OK**

Table 94: Cost Comparison Study of Bridge Types Option 1 Solid Slab

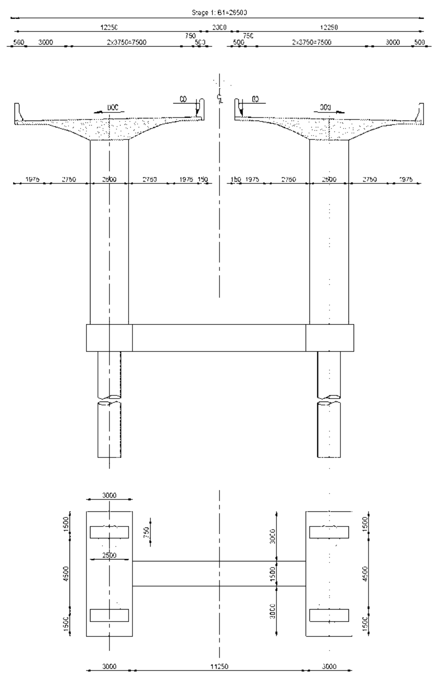
SOLID SLAB BRIDGE

Bridge 2640 m **Station**

SIDE VIEW OF PIER - TYPE 1



SOLID SLAB CROSSECTION



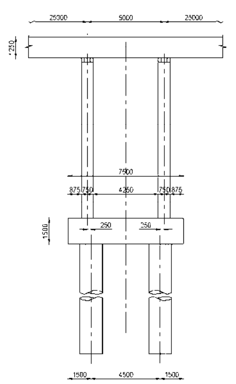
N₀.	ITEMS	UNIT	QUANTITIES	UNIT PRICE (USD)	TOTAL COST (USD)
I	**SUPERSTRUCTURE**				**18,241,039**
1	**Girder type of main bridge**	**Solid Slab**			**11,429,211**
1.1	Concerete of girder with Class 35Mpa	m^3	38,654.88	124.58	4,815,652
1.2	Reinforcement	ton	4,638.59	1,013.82	4,702,685
1.3	Tendon with strand's diameter 15.2 mm	ton	889.06	2,149.31	1,910,874
2	**Parapet**				**712,180**
5.1	Concerete of parapet with class 30Mpa	m^3	3,237.83	102.21	330,949
5.2	Reinforcement	ton	388.54	981.19	381,231
3	**Pavement construction**	m2	59,400.00	23.07	**1,370,489**
4	**Formwork and Scaffolding; Auxiliary Work**	%	25.00	13,511,880.73	**3,377,970**
5	**Miscellaneous Works**	%	10.00	13,511,880.73	**1,351,188**
II	**SUBSTRUCTURE**				**25,102,913**
2	**Pier on land**				**7,873,281**
2.1	Concrete with class 30Mpa	m^3	5,526.56	92.39	510,589
2.2	Reinforcement	ton	718.45	1,013.82	728,381
2.3	Blinding concrete with class 10Mpa	m^3	855.00	45.49	38,890
2.5	Bored Pile D = 1.5m	m	8,820.00	747.78	6,595,421
3	**Pier in water**				**11,436,651**
3.1	Concrete with class 30Mpa	m^3	5,526.56	119.87	662,484
3.2	Reinforcement	ton	773.72	1,040.87	805,340
3.3	Blinding concrete with class 10Mpa	m^3	855.00	45.49	38,890
3.4	Seal concrete with class 20Mpa	m^3	12,825.00	90.09	1,155,452
3.6	Bored Pile D = 1.5m	m	8,820.00	994.84	8,774,485
6	**Auxiliary Work**	%	30.00	19,309,932.78	**5,792,980**
	TOTAL				**43,343,952**

Table 95: Cost Comparison Study of Bridge Types Option 2: Hollow Slab

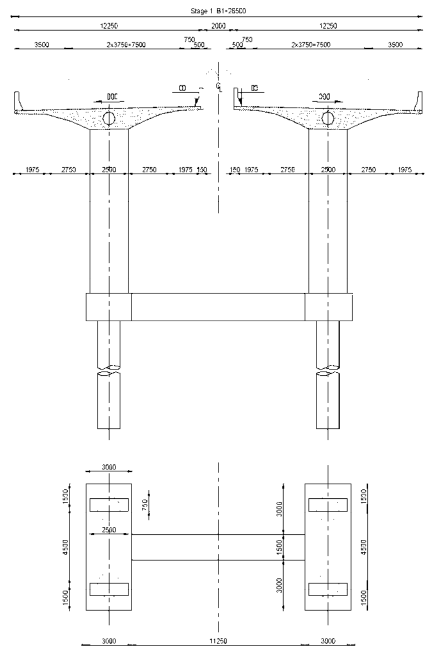
HOLLOW SLAB BRIDGE

Bridge 2640 m **Station**

SIDE VIEW OF PIER - TYPE 1



HOLLOW SLAB CROSSECTION



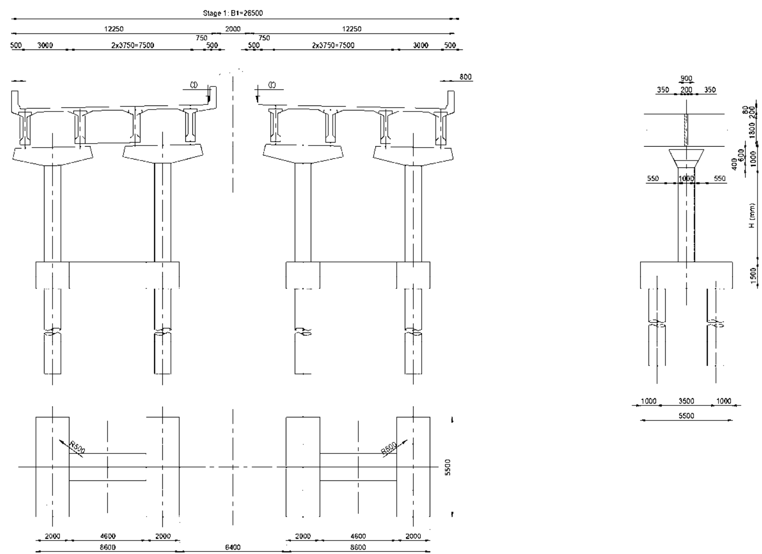
N₀.	ITEMS	UNIT	QUANTITIES	UNIT PRICE (USD)	TOTAL COST (USD)
I	**SUPERSTRUCTURE**				**19,840,502**
1	**Girder type of main bridge**	**Hollow Slab**			**12,613,999**
1.1	Concerete of girder with Class 35Mpa	m^3	37,327.87	135.34	5,052,055
1.2	Reinforcement	ton	5,599.18	1013.82	5,676,555
1.3	Tendon with strand's diameter 15.2 mm	ton	877.20	2149.31	1,885,389
5	**Parapet**				**712,180**
5.1	Concerete of parapet with class 30Mpa	m^3	3,237.83	102.21	330,949
5.2	Reinforcement	ton	388.54	981.19	381,231
6	**Pavement construction**	m2	59,400.00	23.07	**1,370,489**
7	**Formwork and Scaffolding; Auxiliary Work**	%	25.00	14,696,668	**3,674,167**
8	**Miscellaneous Works**	%	10.00	14,696,668	**1,469,667**
II	**SUBSTRUCTURE**				**25,022,000**
2	**Pier on land**				**7,811,041**
2.1	Concrete with class 30Mpa	m^3	5,526.56	92.39	510,589
2.2	Reinforcement	ton	663.19	1013.82	672,352
2.3	Blinding concrete with class 10Mpa	m^3	718.45	45.49	32,679
2.6	Bored Pile D = 1.5m	m	8,820.00	747.78	6,595,421
3	**Pier in water**				**11,436,651**
3.1	Concrete with class 30Mpa	m^3	5,526.56	119.87	662,484
3.2	Reinforcement	ton	773.72	1040.87	805,340
3.3	Blinding concrete with class 10Mpa	m^3	855.00	45.49	38,890
3.4	Seal concrete with class 20Mpa	m^3	12,825.00	90.09	1,155,452
3.7	Bored Pile D = 1.5m	m	8,820.00	994.84	8,774,485
6	**Auxiliary Work**	%	30.00	19,247,693	**5774307.77**
	TOTAL				**44,862,502**

Table 96: Cost Comparison Study of Bridge Types Option 3: PCI Girder 33 m

PCI 33 BRIDGE

Bridge 2640 m **Station**

PCI 33 CROSSECTION



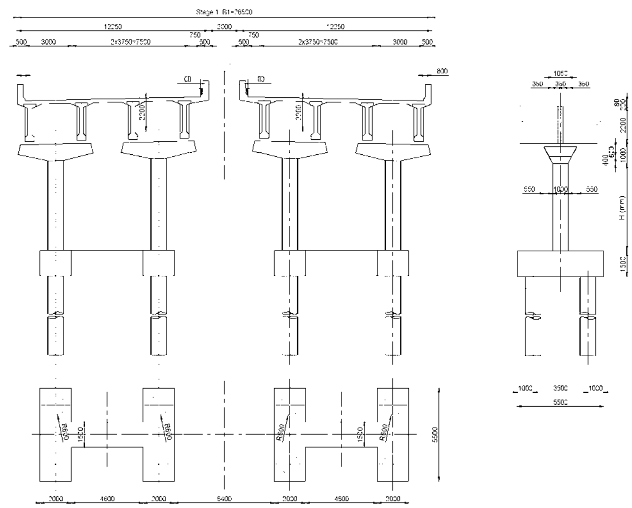
N0.	ITEMS	UNIT	QUANTITIES	UNIT PRICE (USD)	TOTAL COST (USD)
I	SUPERSTRUCTURE				16,358,811
1	Girder type of main bridge	PCC I			6,636,516
1.1	Concerete of girder with Class 40Mpa	m^3	14,388.00	125.48	1,805,439
1.2	Reinforcement	ton	3,165.36	954.04	3,019,876
1.3	Tendon with strand's diameter 15.2 mm	ton	842.69	2,149.31	1,811,201
2	Deck Slab				3,530,151
2.1	Concerete of slab with Class 30Mpa	m^3	13,589.27	102.21	1,389,002
2.2	Reinforcement	ton	2,174.28	984.76	2,141,149
3	Transverse beam				143,703
3.1	Concerete of transverse beam with class 30	m^3	554.40	102.21	56,667
3.2	Reinforcement	ton	88.70	981.19	87,036
5	Parapet				712,180
5.1	Concerete of parapet with class 30Mpa	m^3	3,237.83	102.21	330,949
5.2	Reinforcement	ton	388.54	981.19	381,231
10	Pavement construction	m2	59,400.00	23.07	1,370,489
	Formwork and Scaffolding; Auxiliary Work	%	20.00	12,393,038.72	2,478,608
11	Miscellaneous Works	%	12.00	12,393,038.72	1,487,165
II	SUBSTRUCTURE				25,944,822
2	Pier on land				9,201,158
2.1	Concrete with class 30Mpa	m^3	5,331.82	92.39	492,598
2.2	Reinforcement	ton	639.82	1,013.82	648,660
2.3	Blinding concrete with class 10Mpa	m^3	561.19	45.49	25,526
2.4	Bored Pile D = 1.0 m	m	16,072.00	499.90	8,034,374
3	Pier in water			-	10,756,398
3.1	Concrete with class 30Mpa	m^3	5,331.82	119.87	639,140
3.2	Reinforcement	ton	639.82	1,040.87	665,968
3.3	Blinding concrete with class 10Mpa	m^3	651.90	45.49	29,652
3.4	Seal concrete with class 20Mpa	m^3	9,778.50	90.09	880,981
3.5	Bored Pile D = 1.0 m	m	16,072.00	531.40	8,540,656
6	Auxiliary Work	%	30.00	19,957,555.32	5,987,267
	TOTAL				42,303,633

Table 97: Cost Comparison Study of Bridge Types Option 4: PCI Girder 40 m

PCI 40 BRIDGE

Bridge 2640 m **Station**

PCI 40 CROSSECTION



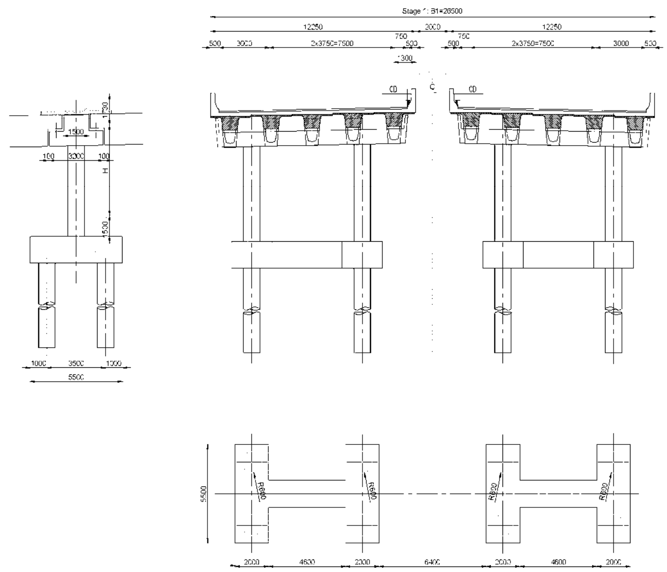
N₀.	ITEMS	UNIT	QUANTITIES	UNIT PRICE (USD)	TOTAL COST (USD)
I	**SUPERSTRUCTURE**				**18,672,692.09**
1	**Girder type of main bridge**	**PCC I**			**8,000,387.21**
1.1	Concerete of girder with Class 40Mpa	m^3	17,608.80	125.48	2,209,592.32
1.2	Reinforcement	ton	3,873.94	954.04	3,695,884.69
1.3	Tendon with strand's diameter 15.2 mm	ton	974.69	2,149.31	2,094,910.21
2	**Deck Slab**				**3,938,075.01**
2.1	Concerete of slab with Class 30Mpa	m^3	13,660.48	102.21	1,396,281.34
2.2	Reinforcement	ton	2,581.13	984.76	2,541,793.67
3	**Transverse beam**				**124,847.11**
3.1	Concerete of transverse beam with class 30	m^3	567.60	102.21	58,016.21
3.2	Reinforcement	ton	68.11	981.19	66,830.90
5	**Parapet**				**712,180.19**
5.1	Concerete of parapet with class 30Mpa	m^3	3,237.83	102.21	330,948.74
5.2	Reinforcement	ton	388.54	981.19	381,231.45
10	**Pavement construction**	m2	59,400.00	23.07	**1,370,489.33**
	Formwork and Scaffolding; Auxiliary Work	%	20.00	14,145,978.86	**2,829,195.77**
11	**Miscellaneous Works**	%	12.00	14,145,978.86	**1,697,517.46**
II	**SUBSTRUCTURE**				**25,982,390.90**
2	**Pier on land**				**9,295,891.19**
2.1	Concrete with class 30Mpa	m^3	4,421.51	92.39	408,495.74
2.2	Reinforcement	ton	530.58	1,013.82	537,913.36
2.3	Blinding concrete with class 10Mpa	m^3	465.38	45.49	21,167.79
2.5	Bored Pile D = 1.2 m	m	13,328.00	624.87	8,328,314.30
3	**Pier in water**			-	**10,690,563.34**
3.1	Concrete with class 30Mpa	m^3	4,421.51	119.87	530,018.82
3.2	Reinforcement	ton	530.58	1,040.87	552,266.09
3.3	Blinding concrete with class 10Mpa	m^3	540.60	45.49	24,589.44
3.4	Seal concrete with class 20Mpa	m^3	8,109.00	90.09	730,569.73
3.6	Bored Pile D = 1.2 m	m	13,328.00	664.25	8,853,119.27
6	**Auxiliary Work**	%	30.00	19,986,454.54	5,995,936.36
	TOTAL				**44,655,082.99**

Table 98: Cost Comparison Study of Bridge Types Option 5: Super T

SUPER - T BRIDGE

Bridge 2640 m **Station**

SUPER-T CROSS SECTION



N0.	ITEMS	UNIT	QUANTITIES	UNIT PRICE (USD)	TOTAL COST (USD)
I	**SUPERSTRUCTURE**				**16,906,080**
1	**Girder type of main bridge**	**Super T**			**8,190,121**
1.1	Concrete of girder with Class 50Mpa	m^3	18,612.00	152.54	2,839,052
1.2	Reinforcement	ton	2,977.92	979.78	2,917,695
1.3	Tendon with strand's diameter 15.2 mm	ton	1,319.34	1844.39	2,433,374
2	**Deck Slab**				**2,926,665**
2.1	Concrete of slab with Class 30Mpa	m^3	11,480.70	102.21	1,173,479
2.2	Reinforcement	ton	1,780.32	984.76	1,753,186
3	**Transverse beam**				**112,418**
3.1	Concrete of transverse beam with class 30	m^3	442.20	102.21	45,199
3.2	Reinforcement	ton	68.51	981.19	67,219
5	**Parapet**				**712,180**
5.1	Concrete of parapet with class 30Mpa	m^3	3,237.83	102.21	330,949
5.2	Reinforcement	ton	388.54	981.19	381,231
10	**Pavement construction**	m2	59,400.00	23.07	**1,370,489**
	Formwork and Scaffolding; Auxiliary Work	%	15.00	13,311,874	**1,996,781**
11	**Miscellaneous Works**	%	12.00	13,311,874	**1,597,425**
II	**SUBSTRUCTURE**				**26,656,164**
2	**Pier on land**				**9,539,503**
2.1	Concrete with class 30Mpa	m^3	5,543.65	92.39	512,168
2.2	Reinforcement	ton	665.24	1013.82	674,431
2.3	Blinding concrete with class 10Mpa	m^3	540.60	45.49	24,589
2.5	Bored Pile D = 1.2 m	m	13,328.00	624.87	8,328,314
3	**Pier in water**				**10,965,238**
3.1	Concrete with class 30Mpa	m^3	5,543.65	119.87	664,533
3.2	Reinforcement	ton	665.24	1040.87	692,427
3.3	Blinding concrete with class 10Mpa	m^3	540.60	45.49	24,589
3.4	Seal concrete with class 20Mpa	m^3	8,109.00	90.09	730,570
3.6	Bored Pile D = 1.2 m	m	13,328.00	664.25	8,853,119
6	**Auxiliary Work**	%	30.00	20,504,742	6151422.46
	TOTAL				**43,562,244**

357. According to the cost estimation, PC I Girder 33 as shown in has the lowest construction cost. However there is no significant cost difference between PC I Girder, PC Solid Slab and the Super T Option. Therefore all three options should be considered. It should be noted that the PC Solid Slab is preferred in the case of flyovers because the depth of structure is the lowest and the length of bridge could be shortened by small height of the girder to keep clearance of crossing road. In the case of crossing water bodies the Super T option should be considered because of the reduction in scaffolding. PC Solid Slab also should be selected for some curve bridges, such as Ramp Bridge of interchange. These three bridge types have the following advantages,

- The lowest construction cost
- Reliability for structural stability
- Good constructability (including widening in the future)

2. Selection of Foundation Type

358. The alternative foundation types for viaducts, short span bridges and ramp bridges should be made in consideration of geological conditions and characteristic of structure as follows:

- The depth of the bearing stratum, Sand, ranges from 40 m to 60 m.
- Very soft soil exists in the intermediate layer.
- The bearing stratum has SPT blow counts of 50 or greater.
- The groundwater level is near the ground surface.
- Vertical load is dominant, and seismic horizontal load is comparatively small.

359. Therefore, pile foundation should be used and alternative types of pile foundation are shown in Table 99 below.

Table 99: Alternative Types of Pile Foundation

Pile Type		Diameter (mm)	Evaluation
Steel Pile	Driving Method	Φ600～φ1000	× *1
	Inner Excavation Method	Φ600～φ1000	
Precast-Concrete Pile	Driving Method	RC 400X400	× *2
		PC φ600～φ800	×*3
Cast-in-Place Concrete Pile	Reverse-Circulation Method	Φ1000～φ1500	○

*1: Cost of Steel Pile is quite high compared to Concrete Pile. As to Steel Pile by inner excavation method is not recommended due to the great depth of pile with 50m or greater in consideration of economic efficiency.

*2: RC Pile should be connected with each pile for long pile with length of more than 40 m. The connection part has some problems of reliability for structural stability

*3: PC Pile is comparatively new type in Vietnam. The experience of using for bridge foundation is very few. Reliability is inferior to Cast-in-Place Concrete Pile.

360. A comparison study on pile types for the selection of foundation type for viaducts, short span bridges and ramp bridges was done. In conclusion the foundation type should be Cast-in-Place Concrete Pile with diameter of 1000 mm to 1500 mm by reverse circulation method in terms of economic efficiency. Basic relations between pile diameter and span length of bridge are shown in Table 100.

Table 100: Relations between Diameter of Pile and Span Length of Bridge

Diameter of Concrete Pile	Span Length of Bridge
1000 mm	Less than 40 m
1200 mm	From 40 m to 60 m
1500 mm	More than 60 m

a. Foundation Types for Medium Span Bridge in the River

361. The water depths to the river bed for medium span bridges are not deep as they are between 6 m to 15 m as shown below.

Table 101: Water Depth of the River for Medium Span Bridges

#	Name of the River	Maximum Water Depth
1	Ong Thin River (STA.12+650)	7 m
2	Balao Channel (STA.17+100)	9 m
3	Cha River (STA.26+180)	8 m
4	Ong Keo Channel (STA.34+700)	6 m
5	Thi Vai River (STA.52+970)	15 m

362. Basically, the foundation type in the River should be selected as the Cast-in-Place Concrete Pile with diameter of 1500 mm by reverse circulation method. The elevation of the top of the Pile Cap should be 0.5 m below under the Low Water Level.

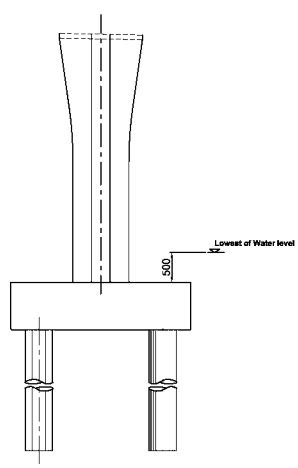


Figure 44: Typical Foundation in River

b. Typical Cross Section Medium Bridge (PC Box Girder L=50 - 90 m)

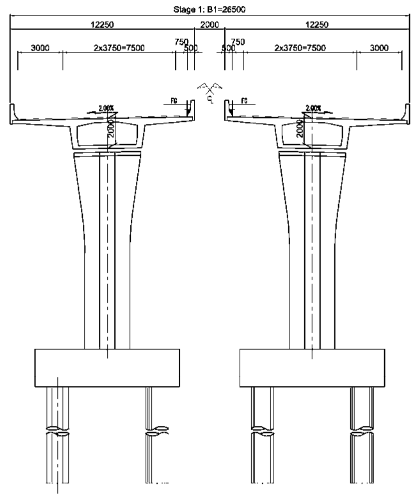


Figure 45: Medium Span Bridge (PC Box Girder L=50 - 90 m) Phase 1.

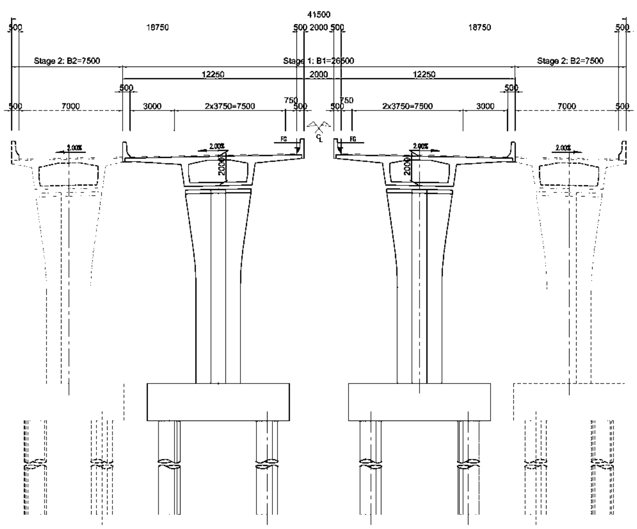


Figure 46: Medium Span Bridge (PC Box Girder L=50 - 90 m) Phase 2.

c. Viaduct, Short Span Bridge (PC Solid Slab L=30 m)

363. In the First Phase with 4 Lanes

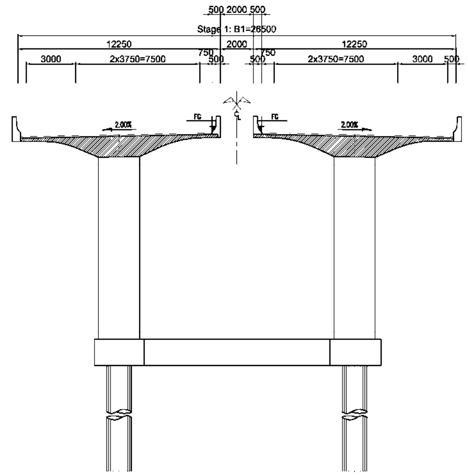


Figure 47: Viaduct, Short Span Bridge (PC Solid Slab L=30 m) Phase 1.

364. In the Future with 8 Lanes:

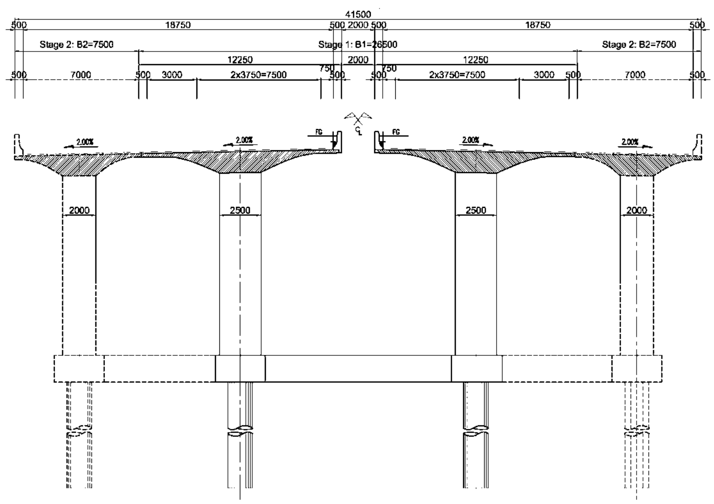


Figure 48: Viaduct, Short Span Bridge (PC Solid Slab L=30 m) Phase 2.

d. Viaduct, Short Span Bridge (PC I Girder L=33 m)

365. In the First Phase with 4 Lanes

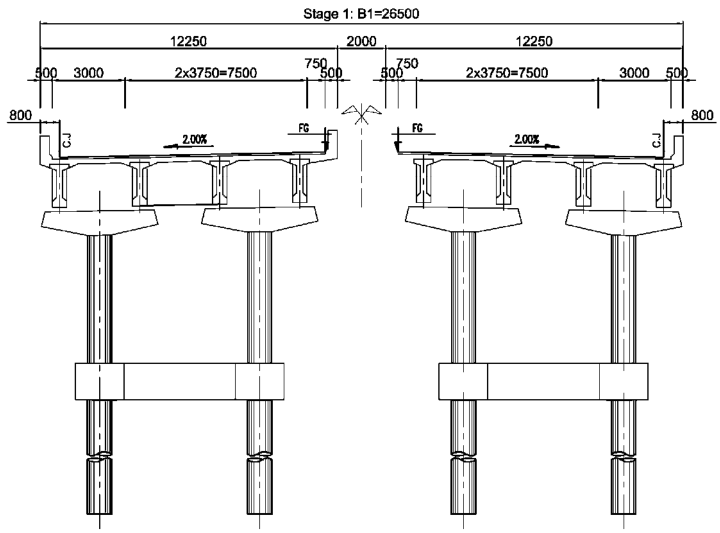


Figure 49: Viaduct, Short Span Bridge (PC I Girder L=33 m) Phase 1

366. In the Future with 8 Lanes:

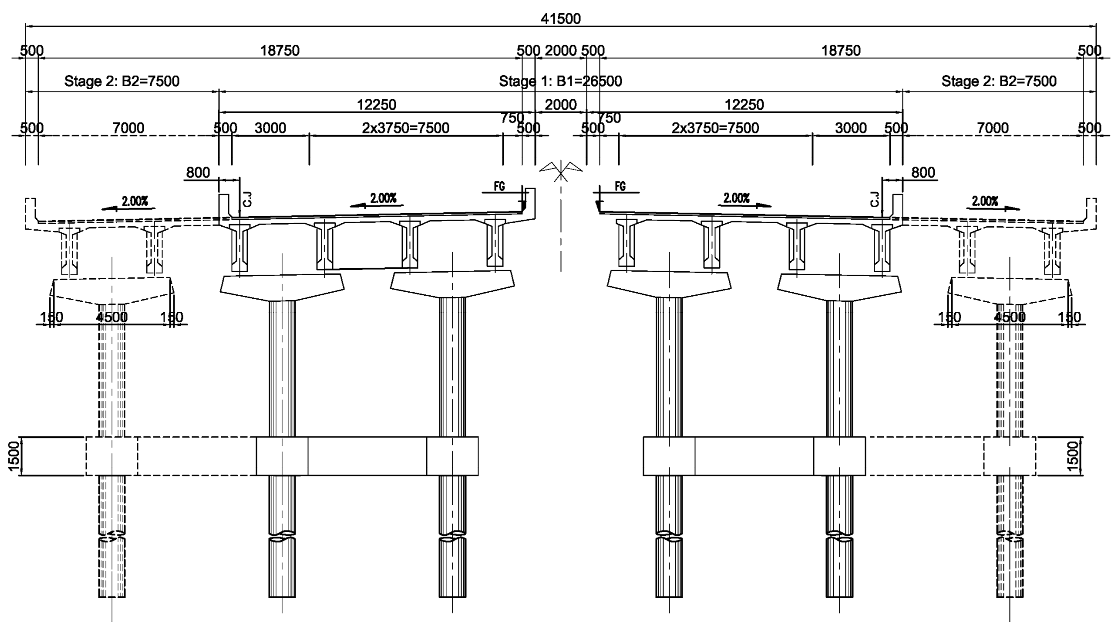


Figure 50: Viaduct, Short Span Bridge (PC I Girder L=33 m) Phase 2

e. Viaduct, Short Span Bridge (Super T L=40 m)

367. In the First Phase with 4 Lanes

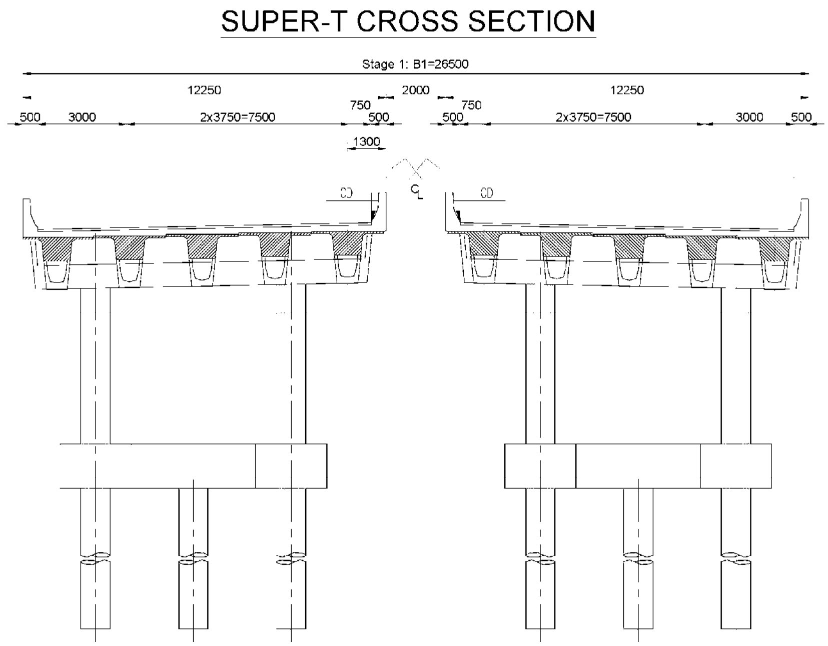


Figure 51: Viaduct, Short Span Bridge (Super T L=40 m) Phase 1

368. In the Future with 8 Lanes:

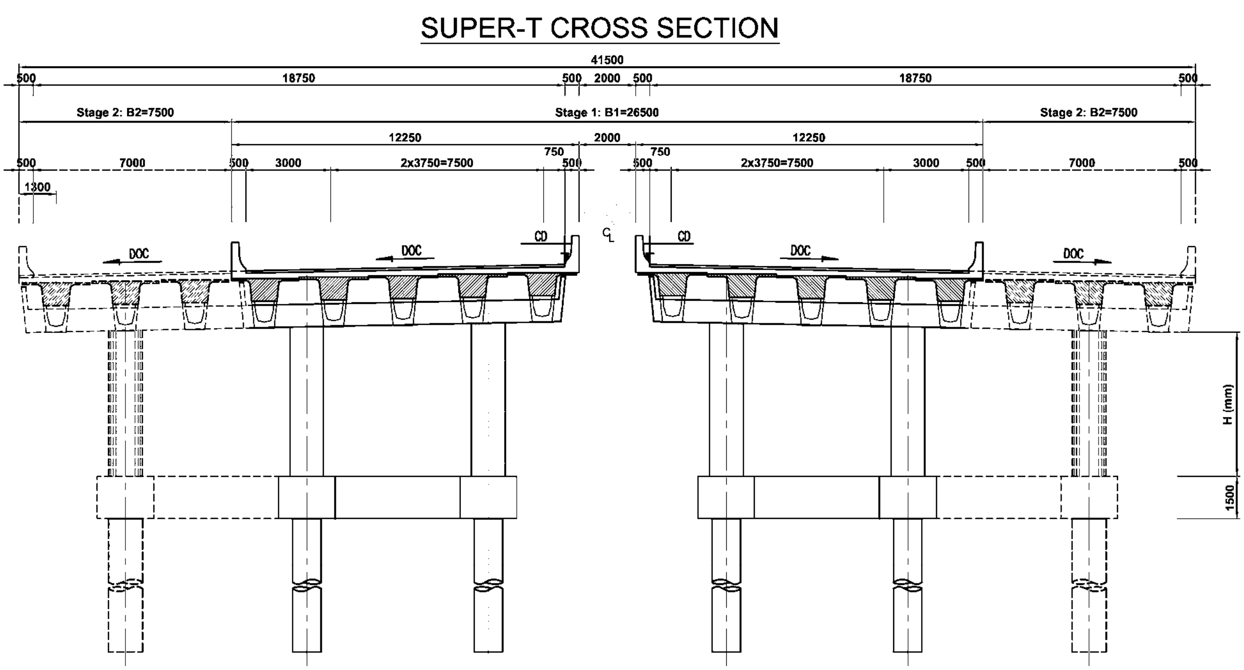


Figure 52: Viaduct, Short Span Bridge (Super T L=40 m) Phase 2

f. Typical Interchange Ramp Bridge (PC Solid Slab L=25 m)

369. Ramp A two way

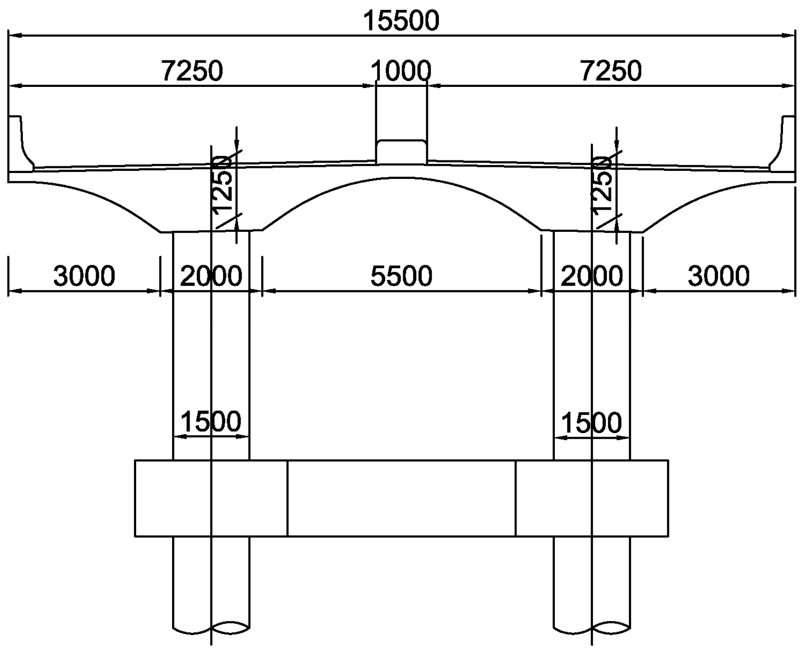


Figure 53: Typical Interchange Ramp A (2-way) Bridge (PC Solid Slab L=25 m)

370. Ramp B

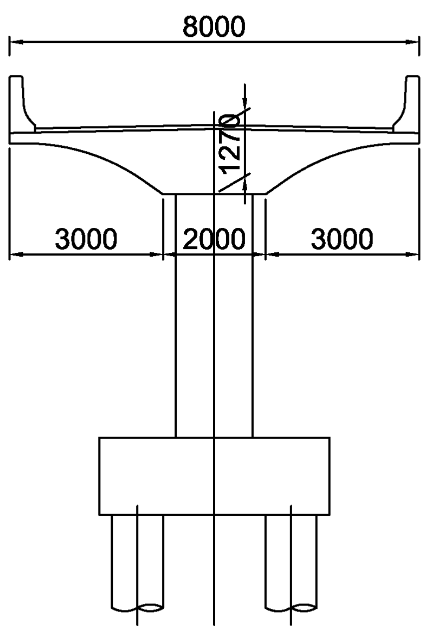


Figure 54: Typical Interchange Ramp B (1-way) Bridge (PC Solid Slab L=25 m)

3. Bridge Layout

371. There are eleven bridges on the main line that are medium and short span bridges. The recommendation is based on PC Solid Slab, and the alternative is based on PC Super Tee Girder. Table 3.6.3.5 shows the list of bridges of the consultant's recommendation and the alternative including bridge location, bridge length, span layout and bridge type for each bridge. General views of each bridge are shown in Appendix C2.

Table 102: List of Bridges

DESCRIPTION	Note	From Km	To km	Bridge Length m	Bridge Type	Span Configuration	Bridge Width m
BR 1 Ong Thoan		02+090.0	02+350.0	260.0 m	Solid Slab	25+7x30+25	24.5 m
BR 2 NH1A Flyover		03+070.0	03+770.0	700.0 m	Solid Slab	25+10x30+2x25+10x30+25	24.5 m
BR 3 Phuoc Ly Flyover		06+050.0	06+610.0	560.0 m	Solid Slab	25+17x30+25	24.5 m
BR 4 Haison Viaduct		07+995.0	09+565.0	1,570.0 m	Solid Slab	25+12x30+50+36x30+25	24.5 m
BR 5 Ong Thin	Approach	12+094.0	12+479.0	385.0 m	Solid Slab	25+13x30	24.5 m
	Main	12+479.0	12+679.0	200.0 m	Box Girder	55+90+55	24.5 m
	Approach	12+679.0	13+064.0	385.0 m	Solid Slap	13x30+25	24.5 m
BR 6-1 Viaduct #01		16+690.0	17+045.0	355.0 m	Solid Slab	25+11x30	24.5 m
BR 6-2 Viaduct #02		17+045.0	17+245.0	200.0 m	Box Girder	55+90+55	24.5 m
BR 6-3 Viaduct #03		17+245.0	21+445.0	4,200.0 m	Solid Slab	31x30+4x25+5x30+2x25+99 x30	24.5 m
BR 6-4 Viaduct #04		21+445.0	23+019.5	1,574.5 m	PC-Box	49.5+5x50+5x40+7x50+12x 50+55+70	24.5 m
BR 6-5 Binh Khanh	Main	23+019.5	23+880.5	861.0 m	Cable Stay	213+435+213	23.5 m
BR 6-6 Viaduct #06		23+880.5	25+305.5	1,425.0 m	PC-Box	70+55+8x50+8x50+10x50	24.5 m
BR 6-7 Viaduct #07		25+305.5	26+017.8	712.3 m	Solis slab	24.8+25x30	24.5 m
BR 6-8 Viaduct #08	Main	26+017.8	26+342.8	325.0 m	Box Girder	55+90+55	24.5 m
BR 6-9 Viaduct #09		26+342.8	28+529.0	2,186.0 m	Solid Slab	74x30+28.7	24.5 m
BR 6-10 Viaduct #10		28+529.0	30+029.0	1,500.0 m	PC-Box	30x50	24.5 m
BR 6-11 Phuoc Khanh	Main	30+029.0	30+771.0	742.0 m	Cable Stay	183.5+375+183.5	23.5 m
BR 6-12 Viaduct #12		30+771.0	32+021.0	1,250.0 m	PC-Box	25x50	24.5 m
BR 6-13 Viaduct #13		32+021.0	32+376.0	355.0 m	Solid Slab	11x30+25	24.5 m
BR 7 Ong Keo	Approach	34+305.0	34+600.0	295.0 m	Solid Slab	25+11x30	24.5 m
	Main	34+600.0	34+800.0	200.0 m	Box Girder	55+90+55	24.5 m
	Approach	34+800.0	35+155.0	355.0 m	Solid Slab	11x30+25	24.5 m
BR 8 Bau Sen		35+672.5	35+705.5	99.0 m	PCI 33	3x33	24.5 m
BR 9 Vung Gam		43+110.0	43+143.0	33.0 m	PCI 33	33	24.5 m
BR 10 Phuoc An		50+192.5	50+867.5	675.0 m	Solid Slab	25+8x30+25+8x30+25	24.5 m
BR 11 Thi Vai River	Approach	52+419.2	52+894.2	475.0 m	Solid Slab	25+13x30	24.5 m
	Main	52+894.2	53+189.2	295.0 m	Box Girder	40+70+75+70+40	24.5 m
	Approach	53+189.2	56+134.2	2,945.0 m	Solid Slab	30x30+3x30+3x25+25+3x30 +55x30+3x30+25	24.5 m
BR 12 Ngoai River		56+823.5	56+856.5	33.0 m	PCI 33	33	24.5 m
IC#01 Interchange Bridges	Ramp A	00+920.0	01+235.0	310.0 m	Box Girder	35+6x40+35	15.5 m
	Ramp B	00+000.0	00+360.0	350.5 m	Box Girder	6x40+40.538+40+30	8.0 m
	Ramp C	00+160.0	00+551.2	391.2 m	Box Girder	30+41.162+8x40	8.0 m
	Ramp D	00+080.0	00+047.0	390.0 m	Box Girder	30+9x40	8.0 m
	Ramp E	00+080.0	00+680.0	590.5 m	Box Girder	30+4x40+40.518+9x40	8.0 m
	Widen BC	00+000.0	00+200.0	200.0 m	Box Girder	5x40	3.8 m
	Widen ED	00+000.0	00+200.0	200.0 m	Box Girder	5x40	3.8 m
IC#03 Interchange Bridges	Ramp A	00+000.0	00+250.0	250.0 m	Solid Slab	10x25	15.5 m
	NH50 flyover	00+000.0	00+355.0	355.0 m	Solid Slab	6x25+2x27.5+6x25	19.0 m
IC#04 Interchange Bridges	Ramp B	00+000.0	00+125.0	125.0 m	Solid Slab	5x25	8.0 m
	Ramp C	00+000.0	00+125.0	125.0 m	Solid Slab	5x25	8.0 m
	Ramp D	00+000.0	00+252.4	252.4 m	Solid Slab	8x25+2x26.19	8.0 m
	Ramp E	00+000.0	00+195.0	195.0 m	Solid Slab	2x23.81+22.38+5x25	8.0 m

Table 103: List of Bridges

DESCRIPTION	Note	From Km	To km	Bridge Length m	Bridge Type	Span Configuration	Bridge Width M
BR 1 Ong Thoan		02+090.0	02+350.0	260.0 m	Solid Slab	25+7x30+25	24.5 m
BR 2 NH1A Flyover		03+070.0	03+770.0	700.0 m	Solid Slab	25+10x30+2x25+10x30+25	24.5 m
BR 3 Phuoc Ly Flyover		06+050.0	06+610.0	560.0 m	Solid Slab	25+17x30+25	24.5 m
BR 4 Haison Viaduct		07+995.0	09+565.0	1,570.0 m	Solid Slab	25+12x30+50+36x30+25	24.5 m
BR 5 Ong Thin	Approach	12+094.0	12+479.0	385.0 m	Super T	39.25+8x40+39.25	24.5 m
	Main	12+479.0	12+679.0	200.0 m	Box Girder	55+90+55	24.5 m
	Approach	12+679.0	13+064.0	385.0 m	Super T	39.25+8x40+39.25	24.5 m
BR 6-1 Viaduct #01		16+685.0	17+045.0	360.0 m	Super T	39.25+9x40	24.5 m
BR 6-2 Viaduct #02		17+045.0	17+245.0	200.0 m	Box Girder	55+90+55	24.5 m
BR 6-3 Viaduct #03		17+245.0	20+365.0	3,120.0 m	Super T	10x40+2x27+40+26+2x40+3x29.2+40+3x37.5+45x40+3x36.32+40+3x30.33+6x40	24.5 m
BR 6-4 Viaduct #04		20+365.0	21+325.0	960.0 m	Solid Slab	32x30	24.5 m
BR 6-5 Viaduct #05		21+325.0	21+805.0	480.0 m	Super T	12x40	24.5 m
BR 6-6 Viaduct #06		21+805.0	23+019.5	1,214.5 m	Box Girder	24.4+35+2x40+19x50+55+70	24.5 m
BR 6-7 Binh Khanh	Main	23+019.5	23+880.5	861.0 m	Cable Stay	213+435+213	23.5 m
BR 6-8 Viaduct #08		23+880.5	25+097.8	1,217.3 m	Box Girder	70+55+21x50+42.3	24.5 m
BR 6-9 Viaduct #09		25+097.8	26+080.0	982.2 m	Super T	23x40+35+27.5	24.5 m
BR 6-10 Viaduct #10		26+080.0	26+275.0	195.0 m	Box Girder	55+90+55	24.5 m
BR 6-11 Viaduct #11		26+275.0	28+527.0	2,252.0 m	Super T	27.5+35+54x40+26.2	24.5 m
BR 6-12 Viaduct #12		28+527.0	30+027.0	1,500.0 m	Box Girder	30x50	24.5 m
BR 6-11 Phuoc Khanh	Main	30+027.0	30+771.0	744.0 m	Cable Stay	183.5+375+183.5	23.5 m
BR 6-14 Viaduct #14		30+771.0	31+971.0	1,200.0 m	Box Girder	33x50	24.5 m
BR 6-15 Viaduct #15		31+971.0	32+371.8	400.8 m	Super T	9x40+39.25	24.5 m
BR 7 Ong Keo	Approach	34+249.8	34+600.0	350.3 m	Super T	39.25+6x40+40+39.25	24.5 m
	Main	34+600.0	34+800.0	200.0 m	Box Girder	55+90+55	24.5 m
	Approach	34+800.0	35+150.3	350.3 m	Super T	39.25+40+6x40+39.25	24.5 m
BR 8 Bau Sen		35+672.5	35+705.5	99.0 m	PCI 33	3x33	24.5 m
BR 9 Vung Gam		43+110.0	43+143.0	33.0 m	PCI 33	33m	24.5 m
BR 10 Phuoc An		50+192.5	50+867.5	675.0 m	Solid Slab	25+8x30+25+8x30+25	24.5 m
BR 11 Thi Vai River	Approach	52+494.2	52+894.2	400.0 m	Super T	39.25+9x40	24.5 m
	Main	52+894.2	53+189.2	295.0 m	Box Girder	40+70+75+70+40	24.5 m
	Approach bridges	53+189.2	54+149.2	960.0 m	Super T	24x40	24.5 m
		54+149.2	54+309.2	160.0 m	Solid Slab	2x25+30+2x25+30	24.5 m
		54+309.2	55+629.2	1,320.0 m	Super T	33x40	24.5 m
		55+629.2	55+779.2	150.0 m	Solid Slab	5x30	24.5 m
		55+779.2	56+138.5	359.3 m	Super T	8x40+39.25	24.5 m
BR 12 Ngoai River		56+823.5	56+856.5	33.0 m	PCI 33	33m	24.5 m
IC#01 Interchange Bridges	Ramp A	00+920.0	01+235.0	310.0 m	Box Girder	35+6x40+35	15.5 m
	Ramp B	00+000.0	00+360.0	350.5 m	Box Girder	6x40+40.5+40+30	8.0 m
	Ramp C	00+160.0	00+551.2	391.2 m	Box Girder	30+41+8x40	8.0 m
	Ramp D	00+080.0	00+047.0	390.0 m	Box Girder	30+9x40	8.0 m
	Ramp E	00+080.0	00+680.0	590.5 m	Box Girder	30+4x40+40.5+9x40	8.0 m
	Widen BC	00+000.0	00+200.0	200.0 m	Box Girder	5x40	3.8 m
	Widen ED	00+000.0	00+200.0	200.0 m	Box Girder	5x40	3.8 m
IC#03 Interchange Bridges	Ramp A	00+000.0	00+250.0	250.0 m	Solid Slab	10x25	15.5 m
	NH50 FO	00+000.0	00+355.0	355.0 m	Solid Slab	6x25+2x27.5+6x25	19.0 m
IC#04 Interchange Bridges	Ramp B	00+000.0	00+125.0	125.0 m	Solid Slab	5x25	8.0 m
	Ramp C	00+000.0	00+125.0	125.0 m	Solid Slab	5x25	8.0 m
	Ramp D	00+000.0	00+252.4	252.4 m	Solid Slab	8x25+2x26.19	8.0 m
	Ramp E	00+000.0	00+195.0	195.0 m	Solid Slab	2x23.81+22.38+5x25	8.0 m

Table 104: Estimated Bridge Costs

Bridge	From	To	Length	Width	Area	Unit Rate	Amount
BR 01 Ong Thoan Channel	02+090.0	02+350.0	260.0 m	24.5 m	6,370	850.00	5,414,500
BR 02 NH1A Flyover	03+070.0	03+770.0	700.0 m	24.5 m	17,150	645.00	11,061,750
BR 03 Phuoc Ly Flyover	06+050.0	06+610.0	560.0 m	24.5 m	13,720	649.00	8,904,280
BR 04 Haison Viaduct	07+995.0	09+565.0	1,570.0 m	24.5 m	38,465	649.00	24,963,785
BR 05 Ong Thin River	12+094.0	13+124.0	1,030.0 m	24.5 m	25,235	810.00	20,440,350
BR 06-01 Viaduct #01	16+690.0	17+045.0	355.0 m	24.5 m	8,698	709.00	6,166,528
BR 06-02 Viaduct #02	17+045.0	17+245.0	200.0 m	24.5 m	4,900	1,448.00	7,095,200
BR 06-03 Viaduct #03A	17+245.0	20+395.0	3,150.0 m	24.5 m	77,175	670.00	51,707,250
BR 06-03 Viaduct #03B	20+395.0	21+445.0	1,050.0 m	24.5 m	25,725	670.00	17,235,750
BR 06-04 Viaduct #04	21+445.0	23+019.5	1,574.5 m	24.5 m	38,575	910.00	35,103,478
BR 06-05 Binh Khanh	23+019.5	23+880.5	861.0 m	23.5 m	20,234	4,920.00	99,548,820
BR 06-06 Viaduct #06	23+880.5	25+305.3	1,424.8 m	24.5 m	34,908	940.00	32,813,144
BR 06-07 Viaduct #07	25+305.3	26+020.3	715.0 m	24.5 m	17,518	815.00	14,276,763
BR 06-08 Viaduct #08	26+020.3	26+340.3	320.0 m	23.5 m	7,520	1,635.00	12,295,200
BR 06-09 Viaduct #09	26+340.3	28+529.0	2,188.7 m	24.5 m	53,623	690.00	36,999,974
BR 06-10 Viaduct #10	28+529.0	30+029.0	1,500.0 m	24.5 m	36,750	1,030.00	37,852,500
BR 06-11 Phuoc Khanh	30+029.0	30+771.0	742.0 m	23.5 m	17,437	4,136.00	72,119,432
BR 06-12A Viaduct #12A	30+771.0	31+371.0	600.0 m	24.5 m	14,700	1,025.00	15,067,500
BR 06-12B Viaduct #12B	31+371.0	32+021.0	650.0 m	24.5 m	15,925	1,025.00	16,323,125
BR 06-13 Viaduct #13	32+021.0	32+376.0	355.0 m	24.5 m	8,698	670.00	5,827,325
BR 07 Ong Keo	34+245.0	35+155.0	910.0 m	24.5 m	22,295	670.00	14,937,650
BR 08 Bau Sen	35+639.4	35+738.6	99.0 m	24.5 m	2,426	730.00	1,770,615
BR 09 Vung Gam	43+110.0	43+143.0	33.0 m	24.5 m	809	897.00	725,225
BR 10 Phuoc An	50+279.2	50+834.2	555.0 m	24.5 m	13,598	610.00	8,294,475
BR 11 Thi Vai River	52+479.2	56+134.2	3,655.0 m	24.5 m	89,548	560.00	50,146,600
BR 12 Ngoai River	56+823.5	56+856.5	33.0 m	24.5 m	809	909.00	734,927
IC#01 Bridges			2,432.2 m	8.3 m	20,103	878.00	17,650,153
IC#03 Bridges			605.0 m	18.1 m	10,975	890.00	9,767,750
IC#04 Bridges			697.4 m	8.0 m	5,579	1,050.00	5,858,160
Total Bridge Works			**28,825.6 m**	**22.5 m**	**649,463**	**987.13**	**641,102,209**

G. Road Furniture

1. Signs & Road Markings

372. The signage and road marking requirements of the expressway will be designed in the detail design phase. The signing and markings of the interchanges and connecting local road network will be studied and designed. Where local roads are to be flown over or under the expressway the required signs and markings are to be designed in the detail design phase.

2. ITS

373. The Ben Luc-Long Thanh Expressway (BLLT) is one of the twenty-one (21) expressways planned in the Short Term (2006-2015) Expressway Network Program established by the Master plan for the Vietnam road network.

374. Noteworthy, BLLT, being 58 kilometers in length, is one among twelve planned expressways falling in the 'less-than-100- kilometer' category. Thus, the institution, development, and installation of the Intelligent Transport System (ITS) could serve as a valuable model for the other expressways in this category.

375. Nevertheless, BLLT is an important link of other expressways serving the outer ring of the Ho Chi Minh City (HCMC) Urban Expressway. Its radial configuration will be a key link of the HCMC outer ring (being a short link) to the north-south expressway connected to the HCMC-Vung Tau Expressway which is a component of the Greater Mekong Sub-region's Southern Economic Corridor route. Thus, the ITS for BLLT could be the litmus test to determine ITS's efficiency in relieving the congestion within the intercity traffic of HCMC and reducing travelling costs; with particular emphasis in that BLLT will skirt the environmentally sensitive Gau Gio Protected Area.

376. It is within this backdrop that objectives; that of being a useful template, being cost effective as a means of reducing travel costs, and being environmentally reconciled; that the development of ITS for BLLTEX will be undertaken.

a. Development Framework for BLLT-ITS

377. ITS in Vietnam is in its nascent stages. Comparative system analysis will therefore be a process that will be conducted after its conceptual development. This approach will allow a freehand to search out for the optimum system rather than be constrained by what is existing or planned. The review of the existing and planned traffic control and operation system for the HCMC urban expressway will thereafter be conducted in order to completely validate the proposed system.

378. By itself, basic designs for guide signs, traffic flow counters, information boards, toll collection system, and communication systems will be prepared. These will be accomplished in a manner that would ensure easy upgradeability, extensibility, with attention given to connections to the other systems within reasonable cost.

379. The ITS development would be based on a systematic and well-organized approach and will not be piece-meal nor fragmented to ensure its value as a template-model. Inter-operability, compatibility, and cost implications to other expressways towards a nationwide ITS system will be prime considerations.

b. Target Entities-of-Concern

380. ITS has pervasive impacts on different sectors given the variety of services that it accords. Among others, the ITS for BLLT will address road administrators, road users, transport operators, cargo and the general public.

c. The ITS Technologies for BLLT

381. The ITS for BLLT will be focusing on four (4) major fields. These are: Toll Collection System, Expressway Management System, User Services Application System, and Traffic Control System.

382. These fields will involve technologies that are continually evolving. Thus a five-step-look-ahead on these technologies is imperative. And in order for the ITS system to possess features of expandability, extensibility, and upgradeability, its base-case application will consider Vietnam's: expressway environment, its expressway practices, and culture; for example: profile of transport means, use of integrated circuit cards, and need for lane barriers, respectively.

383. Given the complexity of ITS systems and considering its formative stages in Vietnam, the level of technologies that will be applied and installed in the BLLT Expressway will be: "state-of-the-practice" rather than "state-of-the-art." However the technologies evolve, it is foreseen that its effects on are as follows:

- ETC System – Expansion (nominal technology advances).
- Communication System – Expansion (nominal technology advances.
- Traffic Control System – Upgrades on basic system.

384. Nationwide digital communication system will be the objective for exchange of information among systems, equipment and organizations to support ITS applications and expressway operations, and is a major consideration of the ITS for BLLT. The ITS for BLLT will be set up to be ready for compatibility with other services offered beyond expressway utilization such as the use of 'Smart Money', parking, rail ticketing, and other general commercial transactions.

d. Organizational Setup for the Operations & Maintenance

385. An addendum to the development of the ITS System for BLLT is the structuring for the organization to implement the O&M; not of the system alone, but of the expressway. Each functional requirement of the 4 major fields, namely: Toll Collection System, Expressway Management System, User Services Application System, and Traffic Control System will have an organizational lineup that will be matched with the installed system to operate and maintain the expressway at maximum efficiencies.

386. Together with these, the establishments of Traffic Control Centers and O&M Offices, their respective quantities, including locations will be designed and specified.

e. Base Case ITS – the Initial Stage

387. The initial stage will involve the following:

- Basic system for O&M and primary services for expressway users.
- Technology application for:
- Vehicle Detection

- Digital Transmission
- Travel Time Estimation
- Internet usage, and
- User Services involving:
- Variable Message Signs
- Travel Time Displays
- Variable Speed Limit Signs
- Communications through Website

388. On this basis the ITS will have the following components:

- Toll Collection System (TCS). The TCS will be based on a ‘Closed’ system where tolls are collected on the basis of distance travelled. The TCS should be able to handle Manual transactions which are toll collector-assisted and Electronic Toll Collection transactions with nominal assistance from the toll collector. This will be supported with data processing by the Plaza Server System and at the Administrative Center.
- The Toll Collection System will account for the toll rates prescribed by the Ministry of Finance under Circular No. 90/2004/TT-BTC.

389. Traffic Control System will be designed to ensure the safety, comfort and smooth flow of traffic within the expressway. These will be achieved through the following five (5) sub-system functions:

- Incident Detection
- Information Dissemination
- Traffic Surveillance and weather monitoring
- Response Implementation, and
- Data Logging

390. The level of sophistication and complexity will be considered heavily and the system will be designed and matched accordingly. The ITS for BLLT will have the following sub-systems for Traffic Control:

- Vehicle Detection System,
- Closed Circuit TV System,
- Emergency Telephone System,

- Weather Monitoring System,
- Variable Messaging System,
- Information System: for Travel Time, Speed Limit, and,
- Central Server System located in the Traffic Control Center with easy access to the expressway and cabling for transmission.
- The Traffic Control System will house the Computer Room, Control Room, Power Supply Room and Storage.
- The ITS for BLLT will call out system requirements for the firmware including its respective quantities.

f. Communication System

391. While the number of ITS equipment installed on BLLT Expressway is not extensive, being fifty-seven kilometres in length, the communication system will be designed in such a way that the system can be expanded to be integrated to the entire expressway network in Vietnam. All terminal equipment will be connected to the digital loop installed along the expressway.

392. In the case of fiber optic cabling, BLLT can be viewed as a right-of-way on which independent carriers can lay their cables and instead of a lease collected from them, usage by BLLT of a number of cores could be arranged as an alternative.

393. The Communications System will handle basic data transmissions, video imaging transmissions, emergency communications, in-house telephone communications, and wireless communications.

g. Future Stages of ITS

394. Development of the ITS for BLLT Expressway will address the its flexibility in terms of expansions, extensions, compatibility with other expressways and utilization of advanced technologies and its practical implementations. The basic ITS design will be adaptable to these advances as well as advances in commercial transactions in Vietnam. Redundancies and obsolescence will be kept to a minimum so that migration costs and write-off costs will be bearable.

395. In general, the ITS system for BLLT contributes largely to efficient and safe expressway operation and should be introduced. In the design of ITS for BLLT Expressway, the utilization of advanced and established technologies based on global standards tempered by economics and suitability to Vietnamese environment is recommended.

396. Also, it is the objective of the design of ITS for BLLT to be the template model for succeeding similar expressways.

397. A list of typical ITS facilities for highway projects in Japan is shown in Table 105.

Table 105: Typical ITS facilities for highway projects in Japan

Subsystem		Item No.	Name of Facility	Description	Action for the Project
Traffic Control System	Data Collection System	1.01	Emergency Telephone	Emergency telephone is the equipment for people involved in accidents to report to traffic control center by telephone.	Yes. Tunnel Section and Rest area only.
		1.02	Traffic Detector	The objective of traffic detector system is to monitor traffic data; traffic volume, congestion, etc.	Yes. Beginning Off Ramp and Tunnel Section only.
		1.03	Metrological Station	Meteorological observation system collects the weather condition on road such as rainfall, wind velocity and fog which are likely to interrupt traffic flow.	No. O&M persons decide at the O&M stage by own budget.
		1.04	CCTV Camera	CCTV camera is installed on main lane or near toll plaza in order to monitor accidents, fire and falling object visually.	Yes. Beginning Off Ramp and Tunnel Section only.
		1.05	Overload & Over-height Monitoring System	Overload monitoring system (Axle load scales) is installed to check the axle load of vehicle and over-height monitoring system is installed to check the height of vehicle	Yes. Toll Plaza only.
		1.06	Wireless Radio System	To cope with traffic obstacles, the communication between traffic control center and patrol cars is implemented through wireless radio system .	No. O&M persons decide at the O&M stage by own budget.
	Information Circulation System	1.07	Variable Message Sign	Variable message sign is used to provide drivers with the information such as accidents, congestion, weather condition, and disaster to ensure the safety of drivers and the comfortable driving.	Yes. Beginning Off Ramp and Tunnel Section only.
		1.08	Variable Speed-limit Sign	Variable speed limit sign provides the information about the variable speed limit corresponding to the change of driving condition.	No. O&M persons decide at the O&M stage by own budget.
		1.09	Highway Radio	Highway radio provides information in voice about the traffic condition ahead of the section through in-vehicle radios.	No. O&M persons decide at the O&M stage by own budget.
		1.10	VICS	VICS (Vehicle Information and Communication System) provides drivers with various real-time traffic information such as congestion and travel time from radio beacons installed on the shoulder of main lanes.	No. O&M persons decide at the O&M stage by own budget.
		1.11	Information Exchange System	Information exchange system is installed for integration of highway traffic information together with other road operating organizations.	No. O&M persons decide at the O&M stage by own budget. However output terminals will be provided for in future.
		1.12	Internet-used Circulation System	Internet dissemination system is used in order to disseminate road situation drivers through internet.	No. The work will belong to other organization who to place and control them.
	Center System	1.13	Traffic Management System	Traffic management system collect the various incidents on the expressway such as accidents, congestion and disaster to inform to drivers.	Yes.
		1.14	Facilities Management System	Facilities management system is used to monitor the various facilities failures to support prompt response.	Yes.
	Other	1.15	Incident Detection & Information (CCTV & VSM)	Incident detection & information system consists of CCTV camera, image processing equipment and variable message sign. In case of accident at choke point, incident will be found out	Yes.

Subsystem		Item No.	Name of Facility	Description	Action for the Project
				immediately and information will be provided after coming vehicle in order to prevention of secondary accident.	
		1.16	Bus Location System	Bus location system is to monitor and inform bus location to passenger as well as estimate travel time and congestion from bus on-board sensor data.	No. The work will belong to other organization who to place and control them.
Toll Collection System		2.01	Manual Toll Collection System	Manual toll collection system is for toll collection manually by cash or ticket through road staff engaged in toll booth.	Yes.
		2.02	ETC System	Electronic toll collection system (ETC) is a non-stop automatic payment system by telecommunication between roadside antenna at the tollgate and on-board unit with IC card.	Yes
Communication System		3.01	Fiber Optic Cable & Metallic Cable	Fiber optic cable is used for data transmission line between traffic control center and O&M office or roadside facilities, metal cable is used as royal network.	Yes.
		3.02	Network Facility	Network facility consists of optical transmission equipment and switching equipment through the network cable mentioned above.	Yes.
Others		4.01	Lighting Facility	Lighting facility is installed on merging and diversion section or ramp way or interchange main lane to be secured safety driving condition by giving visual information.	Yes.
		4.02	Power Supply Facility	Power supply facility is indispensable to supply electric power to interchange, toll booth, roadside facilities, etc. The system consists of engine generator, transformer, uninterruptible power supply, etc.	Yes.
		4.03	Tunnel Safety Facilities	Tunnel safety facilities consists of tunnel lighting and ventilation facilities to keep the traffic safe and efficient as well as emergency facilities to guard drivers and prevent the enlargement of the fire in emergency.	Yes.

Source: Modified based on ITS Handbook issued by HIDO (Highway Industry Development Organization)HIDOHI

3. ITS & Toll System for Ben Luc – Long Thanh Expressway

398. It has been determined that the Toll System for the Ben Luc – Long Thanh Expressway will be a closed ticketed system. There will be an option for the installation e-tolls and electronic tolling.

a. Administrative Centre

399. After a number of discussions with VEC the Administrative Centre has been proposed to be located at Interchange IC#3 at the intersection of Highway NH50.

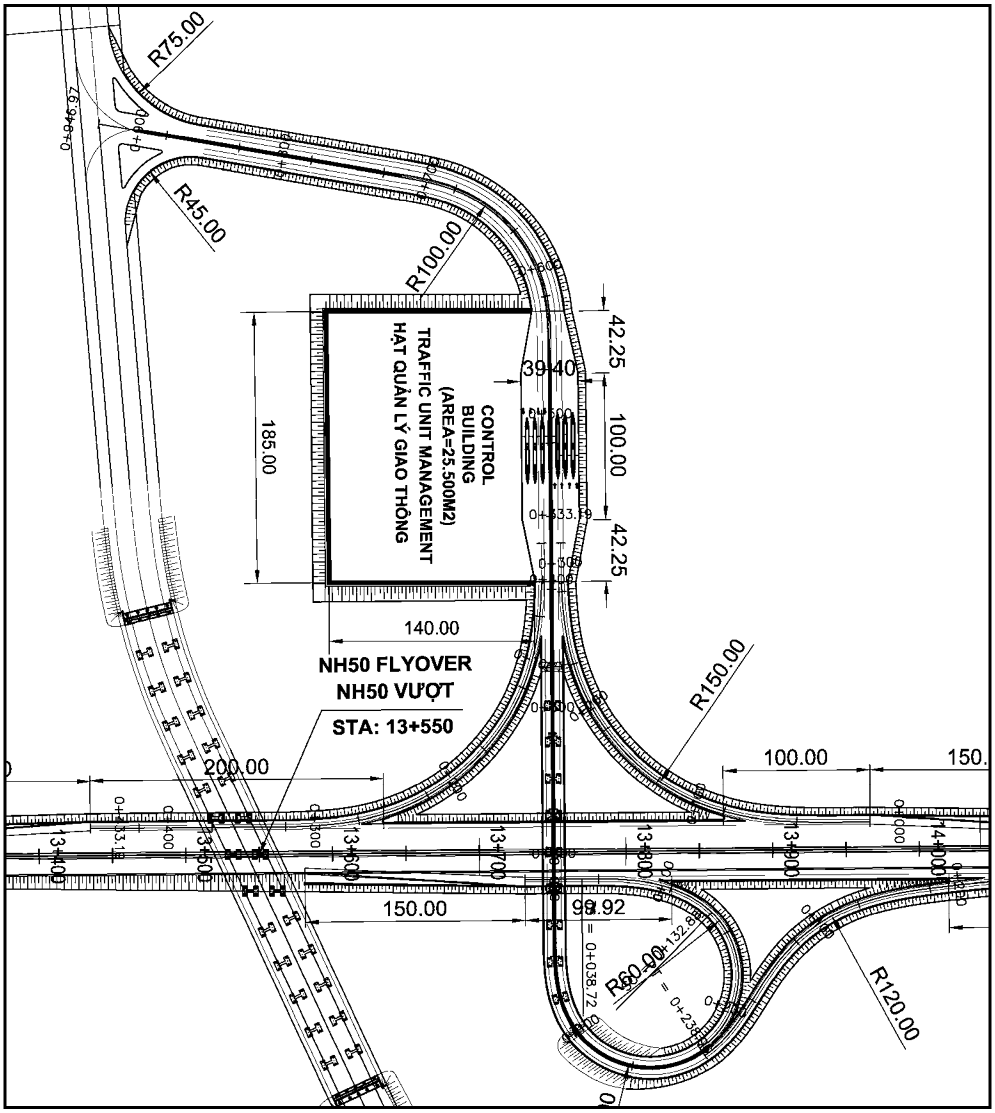


Figure 55: Proposed Administrative Centre for Expressway IC#3

b. Service Centre

400. There is proposed to be a Service Centre at Km 36 where travelers can pull over and either rest, fill up with petrol, use the restaurants or shops or repair their vehicle. This location was chosen because it would be about half way between the proposed service centre on the Ho Chi Minh – Long Thanh – Dau Giay Expressway and the open on the Ho Chi Minh – Trung Long Expressway. Another advantage to this location is the reduced land costs in Dong Nai.

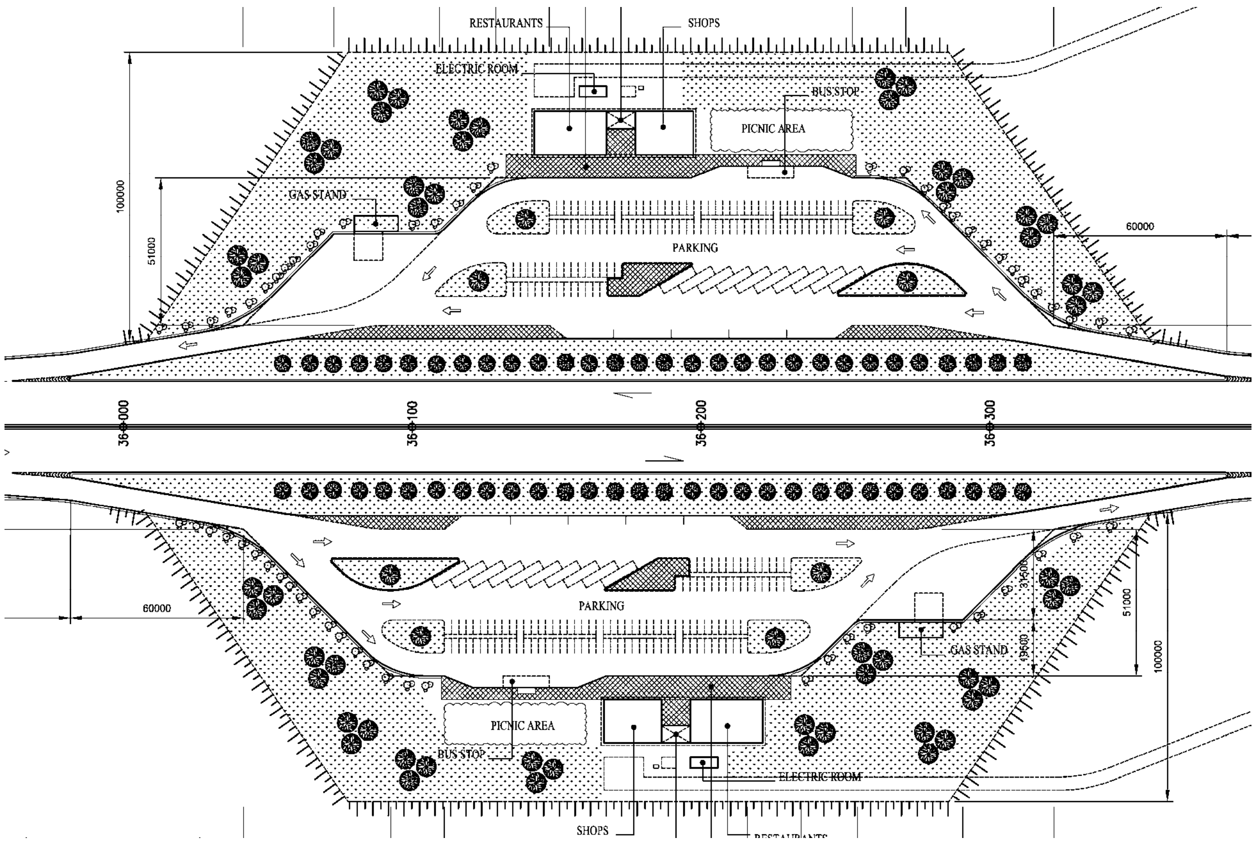


Figure 56: Proposed Service Centre

401. Please note that there is also an alternative location proposed for the Service Centre at Km 12. This was proposed because it offered a better view on the Can Giuoc River than the location in Dong Nai. The disadvantages would be the increased land cost and the more difficult construction.

c. Traffic Administration Unit

402. The traffic administration unit (TAU) offices are part of the whole administration and toll System of the expressway. VEC requires there be two TAU and these have been proposed for Interchange IC#3 which will incorporated into the Administration Centre and one for IC#6.

H. Estimated Costs

403. Care was taken at the preliminary cost estimate stage. There was always great pressure to have the lowest possible project cost so that the project is attractive to investors. The preliminary cost estimate must also be accurate and be a reasonable estimate of the final cost. Because the design has not been finalized nor detailed the preliminary cost estimate must be based on only thirty-two items. These thirty items must represent the hundreds of items in the final bill of quantity. Therefore comparing a unit rate in a preliminary estimate with a unit rate on a final BOQ is a false comparison. The item unit rate on the preliminary BOQ must be higher than the any final rate.

404. The basics elements of the Cost Estimate are:

Earthworks

- Clearing and grubbing unit ha
- Excavation unit m3
- Embankment unit m3
- Surplus Soils unit m3
- Sodding unit m2
- Treatment for Soft Soil Areas unit lm
- Other Earthworks costs

Drainage Works

- Side Ditch & Chutes unit lm
- Pipe Culverts unit lm
- Box Culverts & Underpasses unit each
- Other Drainage Works unit lm

Bridge Works

- For each bridge an estimated cost was done

Interchanges & Other Costs

- Complete Interchange unit each
- Realign Existing Roads unit lm
- Service Centre unit LS

Pavement Works

- Subgrade unit m3
- Subbase unit m3
- Base unit m3
- Asphalt Pavement unit m3
- Other Pavement Works unit lm

Miscellaneous Works

- Guardrail unit lm
- Traffic Signboard unit m2
- Line markings unit lm
- Expressway lighting unit lm

- Noise Barrier unit lm
- Center Median unit lm

Expressway Facilities

- General Items for Expressway Facilities unit %
- ITS & Toll Facilities System unit LS
- Administration Centre unit LS
- Technical equipment for environmental protection unit LS

Other Costs

- Unexploded Ordnance Clearance unit LS
- Supervision Cost unit LS
- VEC Project Administration Costs unit LS
- VEC Laboratory Equipment unit LS

405. Please note that the Detail Design Costs are covered under another loan so are not included in the cost summary The following are some of important items that must be covered by the above preliminary items unit rates:

- Mobilization of the Contractor
- The Contractor's Facilities: (installation, operation and maintenance)
- The Engineer's Facilities: (installation, operation and maintenance)
- Quality Control System (Laboratory installation, operation & maintenance)
- Traffic diversions and detours
- Environmental mitigation measures
- Temporary drainage facilities
- Moving public utilities

406. The unit costs are derived from typical cost in Vietnam and international Projects. The construction cost of the bridges was estimated in detail for the whole project.

Table 106: The Estimated Costs

	Description	Unit	Unit Rate	TOTAL		TAX VAT 10%	Total with Tax
				Quantity	Amount		
General Items	Mobilization of Contractor	%	1.0%	784,924,701	7,849,247	784,925	8,634,172
	Facilities for the Contractor	%	1.0%	784,924,701	7,849,247	784,925	8,634,172
	Performance Bonds & Insurance	%	3.5%	784,924,701	27,472,365	2,747,237	30,219,602
	Quality Control & Laboratories	%	1.0%	784,924,701	7,849,247	784,925	8,634,172
	Total General Items				**51,020,106**	**5,102,012**	**56,122,118**
Earthworks	Clearing and Grubbing	m2	0.07	2,540,200	177,814	17,781	195,595
	Topsoil Removal & Storage	m3	1.75	487,000	852,250	85,225	937,475
	Excavation & Realign Channels	m3	1.75	366,700	641,725	64,173	705,898
	Embankment	m3	8.00	1,980,200	15,841,600	1,584,160	17,425,760
	Surplus Soils	m3	1.75	366,700	641,725	64,173	705,898
	Cohesive Soil for slope	m3	7.50	436,800	3,276,000	327,600	3,603,600
	Soft Soil treatment	m2	60.00	360,000	21,600,000	2,160,000	23,760,000
	Sodding	m2	1.00	362,500	362,500	36,250	398,750
	Other Earthworks	Lm	45	57,100	2,569,500	256,950	2,826,450
	Total Earthworks				**45,963,114**	**4,596,312**	**50,559,426**
Drainage Works	Side Ditch & Chutes	Lm	60.00	63,958	3,837,480	383,748	4,221,228
	Pipe Culverts	Lm	360.00	7,727	2,781,720	278,172	3,059,892
	Box Culverts & Underpasses	each	110,000.00	64	7,040,000	704,000	7,744,000
	Other Drainage Works	Lm	25.00	57,100.00	1,427,500	142,750	1,570,250
	Total Drainage Works				**15,086,700**	**1,508,670**	**16,595,370**
Bridge Works	BR 01 Ong Thoan Channel	m2	850.00	6,370	5,414,500	541,450	5,955,950
	BR 02 NH1A Flyover	m2	645.00	17,150	11,061,750	1,106,175	12,167,925
	BR 03 Phuoc Ly Flyover	m2	649.00	13,720	8,904,280	890,428	9,794,708
	BR 04 Haison Viaduct	m2	649.00	38,465	24,963,785	2,496,379	27,460,164
	BR 05 Ong Thin River	m2	810.00	25,235	20,440,350	2,044,035	22,484,385
	BR 06-01 Viaduct #01	m2	709.00	8,698	6,166,528	616,653	6,783,181
	BR 06-02 Viaduct #02	m2	1,448.00	4,900	7,095,200	709,520	7,804,720
	BR 06-03 Viaduct #03	m2	670.00	102,900	68,943,000	6,894,300	75,837,300
	BR 06-04 Viaduct #04	m2	910.00	38,575	35,103,478	3,510,348	38,613,826
	BR 06-05 Binh Khanh	m2	4,920.00	20,234	99,548,820	9,954,882	109,503,702
	BR 06-06 Viaduct #06	m2	940.00	34,908	32,813,144	3,281,314	36,094,458
	BR 06-07 Viaduct #07	m2	815.00	17,518	14,276,763	1,427,676	15,704,439
	BR 06-08 Viaduct #08	m2	1,635.00	7,520	12,295,200	1,229,520	13,524,720
	BR 06-09 Viaduct #09	m2	690.00	53,623	36,999,974	3,699,997	40,699,971
	BR 06-10 Viaduct #10	m2	1,030.00	36,750	37,852,500	3,785,250	41,637,750
	BR 06-11 Phuoc Khanh	m2	4,136.00	17,437	72,119,432	7,211,943	79,331,375
	BR 06-12 Viaduct #12	m2	1,025.00	30,625	31,390,625	3,139,063	34,529,688
	BR 06-13 Viaduct #12	m2	670.00	8,698	5,827,325	582,733	6,410,058
	BR 07 Ong Keo	m2	670.00	22,295	14,937,650	1,493,765	16,431,415
	BR 08 Bau Sen	m2	730.00	2,426	1,770,615	177,062	1,947,677
	BR 09 Vung Gam	m2	897.00	809	725,225	72,523	797,748
	BR 10 Phuoc An	m2	610.00	13,598	8,294,475	829,448	9,123,923
	BR 11 Thi Vai River	m2	560.00	89,548	50,146,600	5,014,660	55,161,260
	BR 12 Ngoai River	m2	909.00	809	734,927	73,493	808,420
	IC#01 Bridges	m2	878.00	20,103	17,650,153	1,765,015	19,415,168
	IC#03 Bridges	m2	890.00	10,975	9,767,750	976,775	10,744,525
	IC#04 Bridges	m2	1,050.00	5,579	5,858,160	585,816	6,443,976
	Total Bridge Works		**987.13**	**649,463**	**641,102,209**	**64,110,223**	**705,212,432**

Description		Unit	Unit Rate	TOTAL		TAX VAT 10%	Total with Tax
				Quantity	Amount		
IC & Other Costs	Interchanges & Weight Station	PS	1,750,000	6	10,500,000	1,050,000	11,550,000
	Realign Existing Roads	lm	620	17,000	10,540,000	1,054,000	11,594,000
	Service Centre	ls	4,000,000	1	4,000,000	400,000	4,400,000
	Total Interchange & Other Works				**25,040,000**	**2,504,000**	**27,544,000**
Pavement Works	Subgrade	m3	8.50	343,000	2,915,500	291,550	3,207,050
	Subbase	m3	12.50	458,500	5,731,250	573,125	6,304,375
	Base	m3	20.00	317,200	6,344,000	634,400	6,978,400
	Asphalt Concrete Wearing & Binder	m3	180.00	113,600	20,448,000	2,044,800	22,492,800
	Other Pavement Works	lm	95.00	31,979.00	3,038,005	303,801	3,341,806
	Total Pavement Works				**38,476,755**	**3,847,676**	**42,324,431**
Miscellaneous Works	Guardrail	lm	55.00	127,916	7,035,380	703,538	7,738,918
	Traffic Signboard	m2	260.00	1,800	468,000	46,800	514,800
	Line Marking	m2	12.00	69,400	832,800	83,280	916,080
	Expressway Lighting	lm	125.00	39,000	4,875,000	487,500	5,362,500
	Noise Barrier	lm	300.00	15,800	4,740,000	474,000	5,214,000
	Center Median	lm	40.80	31,979	1,304,743	130,474	1,435,217
	Total Miscellaneous Works				**19,255,923**	**1,925,592**	**21,181,515**
Construction Cost					**835,944,807**	**83,594,485**	**919,539,292**
Expressway Facilities	General Items for Expressway Facilities	%	6.5%	49,000,000	3,185,000	318,500	3,503,500
	ITS & Toll Facilities System	LS	45,000,000	1	45,000,000	4,500,000	49,500,000
	Technical equipment for environ. Protection	LS	2,528,000	1	2,528,000	252,800	2,780,800
	Administration Centre	ls	4,000,000	1	4,000,000	400,000	4,400,000
	Total Expressway Facilities				**54,713,000**	**5,471,300**	**60,184,300**
Other Costs	Unexploded Ordnance Clearance	LS	4,000,000	1.00	4,000,000		4,000,000
	Construction Supervision Cost	LS	31,818,182	1.00	31,818,182	3,181,818	35,000,000
	Supervision Cost ADB Section	LS	16,818,182	1.00	16,818,182	1,681,818	18,500,000
	Supervision Cost Co-Financier Section	LS	15,000,000	1.00	15,000,000	1,500,000	16,500,000
	VEC Laboratory	LS	1,000,000	1.00	1,000,000	100,000	1,100,000
	VEC Project Administration Costs	LS	12,400,000	1.00	12,400,000		12,400,000
	Total Other Costs				**81,036,364**	**6,463,636**	**52,500,000**
R	Resettlement & Utility Relocation	**LS**	**1.00**	215,700,004	215,700,004		215,700,004
Project Cost before Contingency					**1,132,681,175**	**90,058,121**	**1,247,923,596**

407. It has been determine that there will be three funding agencies for the expressway.

- The ADB
- An International Co-financier
- The Government of Vietnam

408. The Government of Vietnam (GOV) will fund the taxes on the co-financiers sections, the unexploded ordinance clearance and all the resettlement costs and utility relocations costs. The ADB will fund civil works costs for Section 1 and Section 3, half the supervision consultants costs, the environmental monitoring plan, VEC Administration costs and the taxes due on these items. The Co-Financier will fund the civil works on Section 2, Expressway facilities which includes the ITS and Toll System costs and the other half of the supervision consultant costs.

409. The Sections are shown in the following table.

Table 107: Section Locations

	From	To	Length	Bridges	Embank
Section 1	00+600.0	20+395.0	19,795.0 m	7,825.0 m	11,970.0 m
Section 2	20+395.0	31+371.0	10,976.0 m	10,976.0 m	0.0 m
Section 3	31+371.0	57+700.0	26,329.0 m	6,290.0 m	20,039.0 m
Total	**00+600.0**	**57+700.0**	**57,100.0 m**	**25,091.0 m**	**32,009.0 m**

Table 108: The Costs between the Funding Agencies

					Total			
Item	**From**	**To**	**W/O Tax**	**Tax**	**Total**	**ADB**	**GoV**	**Co-F**
A. Base Costs								
Civil Works A-1 Package A	00+600	07+995	$69.053	$6.905	$75.959	$75.959		
Civil Works A-2 Package B	07+995	16+690	$83.548	$8.355	$91.902	$91.902		
Civil Works A-3 Package C	16+690	20+395	$78.961	$7.896	$86.857	$86.857		
Civil Works A-4 Package D	20+395	21+445	$27.229	$2.723	$29.952		$2.723	$27.229
Civil Works A-5 Package E	21+445	31+371	$386.502	$38.650	$425.152		$38.650	$386.502
Civil Works A-6 Package F	31+371	35+900	$54.713	$5.471	$60.185	$60.185		
Civil Works A-7 Package G	35+900	52+400	$55.455	$5.546	$61.001	$61.001		
Civil Works A-8 Package H	52+400	57+700	$80.484	$8.048	$88.532	$88.532		
1. Total Civil Works			**$835.945**	**$83.594**	**$919.539**	**$464.436**	**$41.373**	**$413.730**
B-1 VEC Laboratory			$1.000	$0.100	$1.100	$1.100		
B-2 Expressway Facilities			$54.713	$5.471	$60.184		$5.471	$54.713
2. Total Equipment			**$55.713**	**$5.571**	**$61.284**	**$1.100**	**$5.471**	**$54.713**
C-1 Construction Supervision ADB Components			$16.818	$1.682	$18.500	$18.500		
C-2 Construction Supervision CoF Components			$15.000	$1.500	$16.500		$1.500	$15.000
3. Total Consulting Services			**$31.818**	**$3.182**	**$35.000**	**$18.500**	**$1.500**	**$15.000**
4. Land Acquisition and Resettlement			**$215.700**		**$215.700**		**$215.700**	
5. UXO Clearance			**$4.000**		**$4.000**		**$4.000**	
7. VEC Incremental Administration Cost			**$12.400**		**$12.400**	**$12.400**		
Sub-Total (A) Base Costs			**$1,155.576**	**$92.348**	**$1,247.924**	**$496.436**	**$268.044**	**$483.443**
B. Contingencies								
Physical Contingencies					$66.800	$24.800	$13.800	$28.200
Price Contingencies					$203.100	$80.100	$41.900	$81.100
Sub-Total (B) Contingencies					**$269.900**	**$104.900**	**$55.700**	**$109.300**
Sub-Total (C) FCDD					$77.900	$35.400	$0.000	$42.500
Total Project					**$1,595.724**	**$636.736**	**$323.744**	**$635.243**
					100%	40%	20%	40%

Note: The Contingencies and FCDD costs can vary depending on inflation and lending rates.

410. The operating and maintenance costs are shown in Table 109.

Table 109: Estimated Operating and Maintenance Costs

Description		**Unit**	**Unit Rate**	**Quantity**	**Amount**	**$/km**
Routine Maintenance	Patch Bituminous Pavement	Km	20	1,600	32,000	560
	Repair & Replace Guardrail	Lm	42	3,000	126,000	2,207
	Replace Light Blubs	each	350	30	10,500	184
	Repair or Replace Light Standards	each	2,500	20	50,000	876
	General Roadway Maintenance	km	480	58	27,840	488
	Clean Ditches	Km	0.15	232,000	34,800	609
	Clean Culverts	Ea	75	200	15,000	263
	Repair Culverts	Ea	525	20	10,500	184

Description		Unit	Unit Rate	Quantity	Amount	$/km
	Inspect Bridge	Lm	3	29,000	87,000	1,524
	Repair Bridge	m2	42	2,000	84,000	1,471
	Repaint Lines	Km	2,750	12	33,000	578
	Repair Signs	each	390	200	78,000	1,366
	Control Vegetation	Km	850	58	49,300	863
	Pickup Litter	Km	475	58	27,550	482
	Miscellaneous Maintenance	Km	1,500	58	87,000	1,524
	Maintenance Management 10%	%	10%	752,490	75,249	1,318
	Routine Maintenance				827,739	14,496
	Electricity for Highway Lighting	**KwH**	**0.10**	**5,475,000**	**547,500**	**9,588**
Toll System	Cost of Staff	each/yr	5,000	746	3,730,000	65,324
	Running Offices & Toll Booths	m2	160	3,140	502,400	8,799
	Maintaining Toll System	month	12	25,000	300,000	5,254
	Total Toll System				**4,532,400**	**79,377**
Periodic Maintenance	Pavement	Year	2,250,000	7	15,750,000	275,832
	Bridges	Year	575,000	7	4,025,000	70,490
	Toll System	Year	350,000	7	2,450,000	42,907
	Lighting	Year	250,000	7	1,750,000	30,648
	Periodic Maintenance Per Year				**23,975,000**	**419,877**

I. Applied Standards and Specifications Framework

411. The following are the applied standards and specifications framework that have been and will be applied to the design.

Table 110: Standards and Specifications

No.	STANDARDS/ SPECIFICATIONS	Ref No.
	<u>Standards/ Specifications applied for the survey:</u>	
1	Standard for topographical mapping 1:500; 1:1000; 1:2000; 1:5000 (outdoors)	96TCN 43-90
2	Geodesic work in project construction – general requirements	TCXDVN 309:2004
3	Standard for highway survey	22TCN 263-2000
4	Standard for survey and design of highway embankment on soft soil foundation	22TCN 262-2000
5	British Practical standard of soil and other reinforced materials	**BS8006-1995**
6	Standard for soil investigation	22TCN 259-2000
7	Standard for soil investigation and treatment design for embankment stabilization	22TCN 171-87
8	Standard for Cone Penetration Test (CPT) and CPTU	22TCN 320-04
9	Standard for defining general elastic module of pavement structure with Benkelman beam	22TCN 251-98
10	Technical survey for piles foundation construction	20TCN 160-87
11	Calculation of flood and current properties	22TCN 220-95
12	Standard for soil investigation for waterway projects	22TCN 260-2000
	<u>Standards/Specifications applied for the design:</u>	
	a. Expressway design standards/ specifications	
1	Expressways – design specifications	**TCVN 5729 -97**
2	Signs in Expressways	22TCN 331-05
3	Specifications for lighting	CIE TCV259-2001
	b. Bridges and culverts design standards/ specifications	
1	Bridge design standard	**22TCN 272 -05**

No.	STANDARDS/ SPECIFICATIONS	Ref No.
2	Standard of bridge and culvert design (applied for culverts design)	22TCN 18-79
	c. General design standards/ specifications	
1	Highways – design specifications (applied for connections, collector roads)	**TCVN 4054-2005**
2	Highway Design Standard	22TCN 273-01
3	Standard for design of rural roads	22 TCN 210-92
4	Standard for design of urban roads and streets	20TCN 104-1983
5	Standard for design of soft pavement	22TCN 211 -2006
6	Standard for design of hard pavement	22TCN 223 -95
7	Standard for soft soil treatment design with PVD	22TCN 244 -98
8	Geo-textiles in construction of embankment on soft soil	22TCN 248 -98
9	Steel bridges and steel structures	TCXDVN 338-2005
10	Transport projects in areas with earthquakes – Design Standard	22TCN 221 -95
11	Load and effect	TCVN 2737 -95
12	Piles foundation – Design Standard	20TCN 21-86
13	Pre-stressed concrète anchors T13, T15, & D13, D15	22TCN 267 -2000
14	Standard for tunnel design	11TCN 19 -84
15	Standard for Environmental Impact Assessment in F/S and Design of transport projects	22TCN 242 -98
16	Standard for lighting design for highways, urban roads and streets	TCXDVN 259:2001
17	Design of drainage network outside the project site	22TCN 51-84
18	Regulations of highways signs	22TCN 237 -01
19	Technical grading of inland river waterway	TCVN 5664-92
	d. Reference standards/ Specifications	
1	Guidelines for geometric design – Highways	AASHTO
2	Guidelines for geometric design – Bridges	AASHTO
3	Standard for piles foundation design (Russian)	SNIP 2.02.03-85
4	(Recommendation for cable stay Design, Testing and Installation)	(PTI Guide Specification)
	Standards/ Specifications for materials, testing, construction and acceptance	
	a. Specifications for construction and acceptance	
1	Standard for construction and acceptance of aggregate bases/ sub-bases in highway pavement structure	**22TCN 334-2006**
2	Standard for construction and acceptance of asphalt pavement	22 TCN 271-2001
3	Standard for construction and acceptance of cement consolidated stones subgrade in highway pavement structure	22 TCN 245-98
4	Standard of lab CBR test of soil and stones	22TCN 332-2006
5	Standard for lab compaction test of soil and stones	22TCN 333-2006
6	Standard for construction and acceptance of bridges and culverts	22TCN 266 -2000
7	Standard for construction and acceptance of asphalt concrete pavement	22TCN 249 -98
8	Standard bored piles	22TCN 257 -2000
9	Standard for construction and acceptance of precast round culverts	22TCN 159 -86
10	Specifications for checking and evaluating pavement roughness (IRI)	22 TCN 277-01
11	Standard for pavement roughness with 3m-long tape	22 TCN 16-79
	b. Standards/ Specifications for materials	
1	Steel slab bridge bearings	AASHTO M251-92
2	Expansion joints	AASHTO M297-96, AASHTO M183-96
3	Technical specifications and method for testing Polime bitumen	22TCN 319-04

No.	STANDARDS/ SPECIFICATIONS	Ref No.
4	Specifications for classification of dense bitumen for highways	22TCN 227 -95
5	Standard for taking bitumen samples used for highways, airports and yards	22TCN 231 -96
6	Standard for asphalt concrete testing	22TCN 62 -84
7	Standard for bitumen testing	22TCN 65 -84
8	Specifications for dense bitumen – Technical specifications and method for testing	22TCN 279-01
9	Standard for physio-mechanical properties testing of rock samples	22TCN 57 -84
10	Standard for testing mineral powder used for asphalt concrete	22TCN 58 -84
11	Cement – Classification	TCVN 5439:1991
12	Portland cement – technical specifications	TCVN 2682:1989
13	Mixed Portland cement – technical specifications	TCVN 6260:1997
14	Construction sand – technical specifications (used as reinforcement for embankment concrete and filling sand)	TCVN 1770:1986
15	Construction sand – Testing method (sampling and testing)	TCVN 337-1986 ñeán TCVN 346-1986
16	Construction sand – Method of defining Mica content	TCVN 4376-1986
17	Sand, stones and gravels used in construction	TCVN 1770-1986 ñeán TCVN 1772-1986
18	Fine sand for concrete and mortar – Guidelines for use (Technical specifications of fine sand for concrete and mortar, using fine sand for concrete)	TCXD 127-1985
19	Mortar – Technical specifications	TCVN 4314:1986
20	Water for concrete and mortar – technical specifications	TCVN 4506:1987
21	Cement concrete	22TCN 60-84
22	Concrete – checking and evaluating durability – General regulations	TCVN 5440:1991
23	Heavy concrete – natural moisture maintenance is required	TCVN 5592:1991
24	Concrete – grading according compression strength	TCVN 6025:1995
25	Heavy concrete –with ultra sonar and to define compression strength	TCXD 171:1989
26	Heavy concrete – method for defining prism strength and elastic modules in static compression	TCVN 5726:1993
27	Method for testing concrete depression	TCVN 3106-993
28	Method for checking concrete strength development	TCVN 3118-993
29	Admixtures KDT2 for mortar and concrete	TCXD 173:1989
30	Cooling low carbon steel-wire used as concrete reinforcement	TCVN 3101:1979
31	Hot-milled concrete steel	TCVN 1651:1985
32	Hot-mill carbon steel used for construction – technical specifications	TCVN 5709:1993
33	Steel scaffold	TCVN 6052:1995
34	Standard for electric equipment	19TCN 19:11TCN 20 vaø TCVN 4756-89
35	International Standards for materials and tests	AASHTO-T; AASHTO-M; ASTM vaø JIS G3112

IV. TRANSPORT ECONOMICS

A. Economic Forecasts for the Project Area

412. Ho Chi Minh City is said to be the most important economic centre in Vietnam, since it accounts for a high proportion of Vietnam's economy. Ho Chi Minh City plays an important driving impetus for the economy of Vietnam. Although it only has 0.6% of the land area and 7.5% of the population, it normally accounts for 20-25% of the national GDP and 35% of the FDI (Foreign Direct Investment) projects. In 2007 the GDP per capita reached US$ 2,100, compared to the country's average level of US$ 730. The intended target of US$ 2,500 per capita was reached 2008.

413. The economy of Ho Chi Minh City covers different fields from mining, seafood processing, agriculture and construction; to tourism, finance, industry and trading. In June 2007 the City was home to three Export Processing Zones and 12 Industrial Parks.

414. Ho Chi Minh City is the leading FDI absorber of Vietnam. In 2007 the FDI projects resulted in $US 3 billion, and in early 2008 this had increased to $US 8.5 billion. Some 300,000 businesses, including many large enterprises, are involved in high-tech, electronic, processing and light industries, also in construction, building materials and agro-products. The city's Export-Import Turnover through HCMC ports accounted for US$36 billion, or 40 percent of the national total.

415. However, the economic recession since mid-2008 affects both Ho Chi Minh City and Vietnam as a whole, hopefully only temporarily. The City's gross domestic product in 2008 was US$17.33 billion, an increase by only 10.7% against 2007 and the lowest growth since 2003. The proportion of city households living under the poverty line was, according to the Statistics Office, nevertheless reduced to only 0.34%, and there were no households with an income lower than US$359 per year.

416. From January to June 2009 the GDP only increased by 4.1% as compared to the same period 2008. Most exports went down: shoes 10.8%, sea-food 10.4%, electronics 12.8%, etc. The imports were also reduced. The number of tourists to HCM City was reduced by 19%, and the total number of foreign visitors by 16%.

417. In such a situation it is difficult to estimate when and how the economy will grow upwards again. There are many plans for the development of the transport system as well as for industries, services and construction, and there are also many previous estimates by different consultants for HCM City's future economy. Since the traffic demand is normally estimated through a correlation with GDP, the same uncertainty will apply to the assessed traffic volumes.

418. This Consultant prefers the thorough, long term economic estimates prepared in the so called "N-11" report by Goldman Sachs Economic Research Group 2007. The purpose of "N-11" was (and still is) to assess which development countries that will be the first to catch up with the "upper middle income countries", including (for example) Indonesia, Philippines, Iran, Pakistan and Egypt. The report analyses a large number of different factors and calculates that Vietnam could well bypass most of those countries in 2025. Vietnam's income per capita would then be US$ 4,583, according to the report.

B. The Function of the Expressway

419. The Expressway is evaluated as becoming a link in the road network of HCM City and the adjacent provinces. Connecting to the future parts of Ring Road 3 and a number of radial roads, the expressway will interact with the existing road network, as well as with a number of socio-economic development opportunities causing indirect benefits.

420. The route will be approximately 58 km long, starting from the Trung Luong expressway where it connects to a (still to be developed) section of Ring Road 3. Continuing in an East-West direction along the southern edge of Ho Chi Minh City, it will connect to a number of arterial highways or provincial roads in different interchanges, before it ends in the junction with the Bien Hoa – Vung Tao expressway.

421. The proposed Ben Luc – Long Thanh route is one of six expressways planned for the HCM City and its surroundings, proposed in the Development Master Plan to 2020 and approved by government in Decision No. 589/2008/QT-TTg dated 20 May 2008.

422. Along that route, it will pass a number of industrial and municipal residential zones, including Long Kim in the Can Giuoc district of Long An province, the Da Phuoc waste processing zone in Binh Chanh District, the Hiep Phuoc industrial park in HCM City and the Thi Vai river in Dong Nai, both of which are domestic water traffic routes. It will also serve a number of important roles, such as:

423. The route will be an important part of the expressway network in the southern region, bypassing central HCM City to link Dong Nai with Long An on HW 1, and also provide high-speed access towards the City centre.

424. The route will serve as a ring road (Ring Road 3), circulating the whole of central HCM City. Together with the proposed Highway No. 52, the route would provide high-speed access from the western and southern parts of the region to the proposed Long Thanh International Airport.

425. Much improved access will be provided towards the outlying ports to which Saigon Port is being relocated and expanded, to the east and west of the Hiep Phuoc and Nha Be ports, and to the proposed Cai Mep and Thi Vai deep sea ports. It would help support the development and attraction of tourism in for example Ba Ria – Vung Tao. Good access will be provided to some existing and many of the planned, new industrial parks and export processing zones. The Nhon Trach industrial park, for example, will get a strong development potential in close proximity to central HMC City, the airport, and the port facilities.

426. The development of the expressway will ease traffic congestion and enable traffic that must otherwise divert between Ban Luc and Nhon Trach to travel short distances. By improving congestions and easing access, the expressway would also help to reduce traffic accidents and CO_2 emissions.

C. Methodology

427. The purpose of this economic analysis is to investigate the socio-economic effects of the expressway project and assess its economic relevance. The indicators used will be the Economic Internal Rate of Return (EIRR) and the Net Present Value (NPV).

428. The expressway is evaluated as being a link in the road network of HCM City and its adjacent provinces[1], connecting a number of industrial and residential zones, tourist areas, existing ports and proposed new ports, the planned Long Thanh International Airport, etc. Connecting to the already existing parts of Ring Road 3 and a number of radial roads, the expressway will interact with the existing road network, as well as with a number of socio-economic development opportunities causing indirect benefits.

429. The evaluation will be undertaken through Cost-Benefit Analysis with the following steps:

- Estimate the costs of the civil works with the proposed design; including all necessary work for the road and the bridges, land acquisition and resettlement, supervision costs, and contingencies..
- Add estimated costs for maintenance with suitable intervals; after the expressway has been opened for traffic.
- Calibrate the Vehicle Operating Costs for different vehicle types, and the time costs for goods and passengers, to 2009 values.
- Estimate the future traffic volumes on the expressway, the expected future traffic demand in the whole road network, and use the HOUTRANS model to estimate the likely changes by time, first without and then with the expressway. See Appendix B.
- Estimate the possible indirect benefits of the expressway (if constructed), considering (a) its effects for existing and planned investments in industrial parks, port and airport projects, tourism, etc., and (b) its effects for traffic in the existing road network in HCM City with surroundings (such as reduced congestions), and (c) the benefits for the traffic along the expressway.
- Undertake the Cost-Benefit evaluation for the different costs and benefits as described above, and also Risk Analysis as may be needed.

430. The following general assumptions and conventions are used throughout this appendix:

- All costs and benefits are in US$, assuming an exchange rate of VND 17,800 per US$ and fixed values as per December 2009.
- The opportunity cost of capital is 12%.
- The total costs of all road works, including resettlements, supervision, contingencies, etc. is assumed to be distributed between the six years 2011 – 2016, partly differently between different years due to the different types of work.
- The first section of the road will be open by the end of 2015 and whole expressway by mid 2016. The benefits to be evaluated will cover the 20 years 2016-2035.

431. Financial evaluations and other financial issues are included in the following Section.

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[1] Long An, Dong Nai, Tay Ninh, Binh Duong and Baria-Vung Tau

432. The following headings describe the benefits for issues regarding the road network more approximately.

a. Tourism

433. Ho Chi Minh City is located at the heart of southern part of Viet Nam between the northern edge of the Mekong Delta and the Southern Eastern region of volcanic red lateritic soils. Being a transformation between the two terrains, Ho Chi Minh City area is intertwined with natural forest, vast plains, long coast and hundreds of rivers and canals. The Saigon River winds around the city and connects it with the East Sea.

434. Over the past three centuries Saigon, once praised as the “Pearl of the Orient”, was known as an important trade center for Vietnamese, Chinese, Japanese and Western merchants. It had also been christened the “Paris of Asia” for its wide boulevards lined with stately trees and magnificent villas.

435. Due to the current economic climate the number of foreign tourists has been reduced. During the first nine months of 2009, the number of foreign arrivals dropped by 16% from the same period in 2008. However the Department of Tourism is convinced that this is a temporary problem and has a program to recover tourism during 2010 with construction of hotels and improving the forests, coats and rivers in the area.

b. Industrial Parks and Export Processing Zones

436. This subject is described with more details in APPENDIX D.4

437. Until June 2008, three export processing zones and twelve industrial parks in Ho Chi Minh City attracted 1,156 investment projects, including 472 foreign investments with a total capital of 2,57 billion US$. The products were valued at about 16 billion US$ and exported to more than 50 countries. About 300,000 workers are working in the export zones.

438. The number of industrial parks in HCMC has now increased to 22. According to the Master Plan it will increase further with seven new parks and two expanded before 2020 – all within the City, and with a total area of about 5,800 ha.

439. The ambitions are similar in the Provinces surrounding Ho Chi Minh City. As per 2008:

- Dong Nai Province, just South-East of HCMC: Already 29 Industrial Parks with over 787 foreign direct investment (FDI) projects from 31 countries and territories. The investment capital is US$ 8.4 billion, ranking third after Ho Chi Minh City and Ha Nai. Eight additional parks, including Nhon Trach H-III, will be developed on or before 2015.
- Long An Province, South-West of HCMC. Fourteen Industrial Parks have been established, mostly between the Trung Luong Expressway and NH-1,just South of the proposed Expressway. Another eight Industrial Parks are planned on or before 2015.
- Bin Duong Province, North of HCMC: 27 Industrial Parks are established on a total area of 8,877 ha and distributed in four districts: Ben Cat (9), Did An

(6), Than An (3), and Tan Yuen (3). The remaining six are located in an urban area.

440. Additional data on the Export Processing Zones and Industrial Parks in or near Ho Chi Minh City, particularly those that could be of interest for the proposed Expressway, are included in the Appendix "Export Processing Zones and Industrial Parks in Ho Chi Minh City and its Surroundings".

c. Ports

441. The Saigon Port, established 1860 during the French colonial period, is located in the heart of HCM City. After many phases of development Saigon Port is now the main international port in southern Vietnam, with a land area of 570,000 m^2 and five terminals, wharves, open yards, and warehouses. Since the 2005-2010 development plan, the port is now also providing services for container trans-shipments.

442. Saigon New Port ("Tan Cang") was set up by the Americans as a military port in the 1960's. Since 1989 it is under the state owned Saigon New Port Company (SNP), the leading container terminal operator and developer in Vietnam. The Saigon New Port now has four facilities, connected to different regions in southern Vietnam by roads and waterways: the Tan Cang terminal, the Tan Cang Cat Lai port, the Tan Cang - Song Than ICD, and the Tan Cang Nhon Trach Container Depot.

443. The container cargo in Tan Cang increased by more than 30% per year 2002-2005, and the total handling volume by about 40% per year. Since the container cargo in Saigon Port can hardly increase further, it has been suggested that Tan Cang moved to the Cat Lai area where there is less traffic congestion.

444. The port development plans also include the Cai Mep International Container Terminals and the Thi Vai Multi-purpose Terminals, which have already started partial operation.

445. HOUTRANS, the 2003-04 JICA study, the 2007-08 JETRO study, and this study 2009, all estimated forecasts of transport demands. The planned moving of port functions further south are expected to significantly increase the traffic along parts of the Expressway. From the proposed customs terminal for Thi Vai – Cai Mep, the JETRO study for the Cai Mep / Thi Cai ports also considers a northbound railway parallel to Road 51, as an alternative for perhaps 20-30% of the cargo.

d. The Long Thanh International Airport

446. Long Thanh International Airport is planned for construction in Long Thanh, Dong Nai Province, approximately 40 km northeast of Ho Chi Minh City and 70 km South-West petroleum city of Vung Tau, by the Highway 51A. The Master Plan for this new airport was approved by the Prime Minister in July 2005, to replace Tan Son Nha International Airport as the country's leading international airport

447. After some delay, the first phase is now planned to begin in 2010 and finish in 2015. Upon completion of this phase, the airport will have a capacity of 20 million passengers per year, one passenger terminal, and two parallel runways capable of receiving airplanes like the large Airbus A380 super-jumbo. The estimated capital for this first phase is US$ 3-billion. Along with the existing Highway 51A, two new government planned expressways are proposed to be

built in order to facilitate transportation to and from the new airport: the Ho Chi Minh - Long Thanh - Dau Day expressway, connecting the airport to Ho Chi Minh City; and the Bien Hoa - Vung Tau expressway, linking Bien Hoa city and Vung Tau city.

448. Phase 2 will begin after 2015. After completion of Phase 2, the airport will be extended further to its full design capacity. It should then have three passenger terminals designed for 80 to 100 million passengers per year, and a cargo terminal for up to five million metric tons of cargo per year. The total invested capital is then estimated to reach about US$8 billion.

449. Considering the passenger estimates for the period 2015-2030, the Consultant made the following assumptions for the HOUTRANS calculations:

- About 80% of the air passengers will travel to and from HCM City and its neighbouring Provinces, while 20% will travel on shorter distances.
- Of the above 80%, 80% (i.e. 64% of the total) will use public transport such as bus, while 20% (i.e. 16% of the total) will use taxis or private cars.
- The average capacity of cargo trucks will be about 10 tonnes.

450. These assumptions will result in the following traffic volumes in PCU/day.

Table 111: Traffic volumes in PCU/day

	2016	**2026**	**2036**
Total PCU	11,863	19,288	62,180

451. Without access to the airport from the Long Thanh–Dau Giaỷ Expressway, as has been proposed, much of this traffic would probably instead use the project road and Highway NH. 51.

D. Cost estimates for the construction of the Expressway

452. As described previously, the Consultants' engineers have spent much time to design the Expressway to (a) maximize its socio-economic benefits for the surrounding area and the planned improvements to industrial parks, residential areas, ports, tourist areas, etc; (b) help improve the traffic problems by attracting traffic from a more congested road network of Ho Chi Minh City and surroundings; (c) minimize the negative environmental effects of the Expressway, not the least concerning land acquisition and resettlement; and (d) avoid higher costs than necessary to accomplish all these objectives.

1. Economic Costs of the Expressway

453. The Cost Estimate Section lists the Financial Cost details in Table 106 of the proposed construction of four lanes. This cost must be converted into the Economic Cost. The financial cost is split into foreign currency (which is a tradable cost) and local currency (which is non-tradable cost) by the categories. These assume splits are shown in Table 112.

Table 112: Foreign Currency and Local Currency % by Category

Description	Total %	Foreign Currency (Tradable) %	Local Currency (non-tradable) %
Civil Works	100%	55%	45%
Land Acquisition	100%	0%	100%
VEC Laboratory Equipment	100%	70%	30%
Unexploded Ordnance Clearance	100%	0%	100%
Consulting Services (SPV)	100%	55%	45%
Expressway facilities	100%	70%	30%
VEC Project Administration Cost	105%	0%	105%

454. Next to obtain the economic cost the price contingency and taxes are removed from the tradable and non-tradable costs. The shadow exchange rate factor has been determined to be 1.04. The tradable costs are divided by shadow exchange rate factor.

Table 113: Economic Costs of the Expressway

Description	Financial Costs			Economic Costs		
	Total (US$ Million)	Foreign Currency (Tradable)	Local Currency (non-tradable)	Foreign Currency (SERF)	Local Currency (non-tradable)	Total Economic (US$ Million)
A. Base Costs						
Civil Works A-1 Package A (ADB)	$75.959	$41.777	$34.181	$40.170	$34.181	$74.352
Civil Works A-2 Package B (ADB)	$91.902	$50.546	$41.356	$48.602	$41.356	$89.958
Civil Works A-3 Package C (ADB)	$86.857	$47.771	$39.086	$45.934	$39.086	$85.020
Civil Works A-4 Package D (CoF)	$29.952	$16.473	$13.478	$15.840	$13.478	$29.318
Civil Works A-5 Package E (CoF)	$425.152	$233.833	$191.318	$224.840	$191.318	$416.158
Civil Works A-6 Package F (ADB)	$60.185	$33.102	$27.083	$31.828	$27.083	$58.911
Civil Works A-7 Package G (ADB)	$61.001	$33.550	$27.450	$32.260	$27.450	$59.710
Civil Works A-8 Package H (ADB)	$88.532	$48.693	$39.840	$46.820	$39.840	$86.660
Civil Works	**$919.539**	**$505.747**	**$413.793**	**$486.295**	**$413.793**	**$900.087**
Land Acquisition	$215.700	$0.000	$215.700	$0.000	$215.700	$215.700
VEC Laboratory Equipment	$1.100	$0.770	$0.330	$0.740	$0.330	$1.070
Unexploded Ordnance Clearance	$4.000	$0.000	$4.000	$0.000	$4.000	$4.000
Consulting Services (SPV)	$35.000	$19.250	$15.750	$18.510	$15.750	$34.260
of which: ADB Section	$18.500	$10.175	$8.325	$9.784	$8.325	$18.109
of which: Co-financer Section	$16.500	$9.075	$7.425	$8.726	$7.425	$16.151
Expressway facilities	$60.184	$42.129	$18.055	$40.509	$18.055	$58.564
(Subtotal)	**$1,235.524**	**$567.896**	**$667.628**	**$546.053**	**$667.628**	**$1,213.681**
VEC Project Administration Cost	$12.400	$0.000	$12.400	$0.000	$12.400	$12.400
(Base Cost)	**$1,247.924**	**$567.896**	**$680.028**	**$546.053**	**$680.028**	**$1,226.081**
Physical Contingency	$66.900	$28.800	$38.100	$27.303	$34.001	$61.304
Price Contingency	$202.900	$13.700	$189.200			
Total Base Cost & Contingencies	**$1,517.724**	**$610.396**	**$907.328**	**$573.356**	**$714.029**	**$1,287.386**

455. These costs are in Table 113 are brought forward into the economic evaluation but first have to be phased. The implementation schedule calls for costs to be distributed over six years from 2011 to 2016.

Table 114: Percent Costs by Category by Year

Year	2011	2012	2013	2014	2015	2016	Total
A. Base Costs							
Civil Works A-1 Package A (ADB)	0.0%	20.0%	20.0%	30.0%	30.0%	0.0%	100.0%
Civil Works A-2 Package B (ADB)	0.0%	20.0%	20.0%	30.0%	30.0%	0.0%	100.0%
Civil Works A-3 Package C (ADB)	0.0%	20.0%	20.0%	30.0%	30.0%	0.0%	100.0%
Civil Works A-4 Package D (CoF)	0.0%	0.0%	20.0%	40.0%	40.0%	0.0%	100.0%
Civil Works A-5 Package E (CoF)	0.0%	0.0%	20.0%	30.0%	40.0%	10.0%	100.0%
Civil Works A-6 Package F (ADB)	0.0%	0.0%	20.0%	40.0%	40.0%	0.0%	100.0%
Civil Works A-7 Package G (ADB)	0.0%	0.0%	20.0%	40.0%	40.0%	0.0%	100.0%
Civil Works A-8 Package H (ADB)	0.0%	0.0%	20.0%	40.0%	40.0%	0.0%	100.0%
Civil Works	**0.0%**	**5.5%**	**20.0%**	**32.6%**	**37.2%**	**4.6%**	**100.0%**
Land Acquisition	50.0%	50.0%	0.0%	0.0%	0.0%	0.0%	100.0%
VEC Laboratory Equipment	50.0%	50.0%	0.0%	0.0%	0.0%	0.0%	100.0%
Unexploded Ordnance Clearance	50.0%	50.0%	0.0%	0.0%	0.0%	0.0%	100.0%
Consulting Services (SPV)	**5.3%**	**12.9%**	**22.4%**	**22.4%**	**22.4%**	**14.7%**	**100.0%**
of which: ADB Section	10.0%	20.0%	20.0%	20.0%	20.0%	10.0%	100.0%
of which: Co-financer Section	0.0%	5.0%	25.0%	25.0%	25.0%	20.0%	100.0%
Expressway facilities	0.0%	0.0%	0.0%	0.0%	30.0%	70.0%	100.0%
(Subtotal)	**9.2%**	**13.6%**	**15.5%**	**24.8%**	**29.7%**	**7.2%**	**100.0%**
VEC Project Administration Cost	20.0%	20.0%	20.0%	20.0%	10.0%	10.0%	100.0%
(Base Cost)	**9.4%**	**13.6%**	**15.5%**	**24.8%**	**29.5%**	**7.3%**	**100.0%**
Physical Contingency	9.4%	13.6%	15.5%	24.8%	29.5%	7.3%	100.0%
Price Contingency							
Base Cost + Contingencies	**9.4%**	**13.6%**	**15.5%**	**24.8%**	**29.5%**	**7.3%**	**100.0%**

Table 115: Phasing of the Economic Costs

Description	2011	2012	2013	2014	2015	2016	Total
Civil Works	**$0.000**	**$49.866**	**$180.017**	**$293.486**	**$335.102**	**$41.616**	**$900.087**
Land Acquisition	$107.850	$107.850	$0.000	$0.000	$0.000	$0.000	$215.700
VEC Laboratory Equipment	$0.535	$0.535	$0.000	$0.000	$0.000	$0.000	$1.070
Unexploded Ordnance Clearance	$2.000	$2.000	$0.000	$0.000	$0.000	$0.000	$4.000
Consulting Services (SPV)	$1.811	$4.429	$7.659	$7.659	$7.659	$5.041	$34.260
of which: ADB Section	$1.811	$3.622	$3.622	$3.622	$3.622	$1.811	$18.109
of which: Co-financer Section	$0.000	$0.808	$4.038	$4.038	$4.038	$3.230	$16.151
Expressway facilities	$0.000	$0.000	$0.000	$0.000	$17.569	$40.995	$58.564
(Subtotal)	**$112.196**	**$164.680**	**$187.677**	**$301.146**	**$360.331**	**$87.652**	**$1,213.681**
VEC Project Administration Cost	$2.480	$2.480	$2.480	$2.480	$1.240	$1.240	$12.400
(Base Cost)	**$114.676**	**$167.160**	**$190.157**	**$303.626**	**$361.571**	**$88.892**	**$1,226.081**
Physical Contingency	$5.734	$8.358	$9.508	$15.181	$18.079	$4.445	$61.304
Price Contingency							
Base Cost + Contingencies	**$120.410**	**$175.518**	**$199.665**	**$318.807**	**$379.649**	**$93.336**	**$1,287.386**

2. Maintenance costs

456. Based on international and domestic experience, the Consultant assumes the following maintenance costs for the expressway, including the bridges.

- Routine maintenance: US$ 14,284 per km.
- Periodic maintenance, on average, US$ 59,052 per km and year.

457. To minimize congestion on the expressway, it is proposed that the periodic maintenance shall be undertaken frequently but over relative short distances at a time.

Other operating costs, like street lights or salaries for the road toll staff are normally not included in economic evolutions. The costs are detailed in Table 106.

E. Vehicle operating costs and Time savings costs

458. The road users' savings in vehicle operating costs (VOC) and travel time costs (TTC) are direct economic benefits of a new road and the Ho Chi Minh City road network as outlined earlier. The project road which will provide a significant share of the transport requirement within the project area: industrial parks and export processing zones, connections between HCM city and adjacent provinces, ports and the new International Airport at Long Thanh.

459. The methodology and results for estimating VOC for different vehicle types is shown in Table 116 below is a brief summary for approximate calculations, including the most important factors.

Table 116: Vehicle operating costs for each vehicle type

	Motor cycle	Passenger Car	Minibus	Standard Bus	Small Truck	Big Truck	Container Truck
Financial cost 2009 US$	$883	$30,000	$32,000	$95,000	$28,750	$51,090	$70,000
Import Duty		83%	30%	30%	70%	20%	18%
Excise Duty		45%	15%	15%	15%	15%	15%
VAT	5%	5%	5%	5%	5%	5%	5%
Economic Cost	$550	$12,876	$15,102	$12,750	$15,264	$36,493	$50,725
Assumed average value	$330	$7,082	$11,773	$34,833	$8,396	$20,071	$27,899
Assumed average age	10 yrs	15 yrs	15 yrs	15 yrs	15 yrs	15 yrs	15 yrs
Gross vehicle weight kgs	100	1,630	11,500	14,500	7,925	25,000	25,480
Capacity-passengers	2	5	16	34	3	3	3
Capacity-goods kgs	0	0	0	0	3,750	12,000	16,500
Average no. of crew	0	0	2	2	2	2	2
Passenger Occupancy	1.5	2.4	12.0	28.0	0.0	0.0	0.0
Average load (tonnes)					2.5	7.0	11.0
Type of Fuel (P or D)	Petrol	Petrol	Diesel	Diesel	Diesel	Diesel	Diesel
Fuel Price (US$/L) Fin.	$0.79	$0.79	$0.67	$0.67	$0.67	$0.67	$0.67
Fuel Price (US$/L) Econ.	$0.59	$0.79	$0.50	$0.50	$0.50	$0.50	$0.50
Oil Price (US$/L) Fin.	$3.32	$3.32	$3.32	$3.32	$3.32	$3.32	$3.32
Oil Price (US$/L) Econ.	$3.02	$3.02	$3.02	$3.02	$3.02	$3.02	$3.02
Fuel Consumption (L/100 km)	2.2	10.0	20.0	30.0	26.0	38.0	60.0
Oil Consumption (L/1000 km)	0.3	2.5	8.0	12.0	12.0	17.0	25.0
No. of Axles	2	2	2	2	2	3	5
No. of Tyres	2	4	6	6	6	10	18
Typical Tyre Size	250x17	195x15	195x15	825x16	825x16	1100x20	1100x20
Price per Tyre (US$) Fin.	$10	$56	$256	$400	$182	$400	$403
Price per Tyre (US$) Econ.	$9	$48	$222	$348	$158	$348	$350
Maintenance hours/year	5	20	100	150	100	120	150
Maintenance labour cost (US$/hr)	$1	$3	$3	$3	$3	$3	$3

	Motor cycle	Passenger Car	Minibus	Standard Bus	Small Truck	Big Truck	Container Truck
Spare parts consumption US$/yr	$26	$900	$960	$2,850	$960	$1,533	$2,100
Insurance (US$/yr)	$3	$19	$185	$212	$71	$98	$125
Crew Wages (US$/month/person)			$215	$300	$240	$325	$400
Hourly Utilization Ratio	30%	40%	60%	60%	50%	45%	60%
Productive time (hrs driven/yr)	450	500	1,000	1,200	1,200	1,200	1,600
Average Mileage (km/year)	10,000	15,000	40,000	60,000	30,000	40,000	45,000
Overhead costs (% of fixed cost)			15%	15%	10%	10%	12%
Annual Vehicle Tax (US$/year)	$0	$4	$4	$6	$6	$9	$9
Vehicle use US$/km	$0.010	$0.032	$0.020	$0.039	$0.016	$0.033	$0.041
Fuel cost US$/km	$0.022	$0.059	$0.101	$0.151	$0.101	$0.192	$0.303
Oil cost US$/km	$0.002	$0.008	$0.023	$0.036	$0.024	$0.052	$0.076
Tyre cost US$/km	$0.003	$0.006	$0.030	$0.047	$0.021	$0.046	$0.035
Crew cost US$/km	$0.000	$0.000	$0.118	$0.110	$0.072	$0.179	$0.195
Maintenance cost US$/km	$0.022	$0.064	$0.032	$0.055	$0.034	$0.047	$0.057
Vehicle Operating cost US$/km	**$0.059**	**$0.169**	**$0.324**	**$0.438**	**$0.268**	**$0.549**	**$0.707**

1. Time Saving Costs

460. The value ('cost') of lost time while travelling obviously depends on the distance and the vehicle speed, but for the national economy also on the value of the work that the traveler could otherwise have done in the meantime. That value is related to the person's income, which is the main factor in assessing the value of time for passenger travel. Table 117 is estimated for year 2016, but due to the economic growth rate and increased salaries, the time values will most likely increase further for the years thereafter.

461. For goods transport, the value of lost time is often less than for passenger transport along the same route, at least unless the route is long or the goods sensitive to damages. Otherwise, the time value will be limited to the (theoretical) loss in interest rate for the goods during the transport time.

Table 117: Time costs per hour for passengers and goods in different vehicle types

Vehicle Type	Motorcycle	Passenger Car	Mini Bus	Standard Bus	Small Truck	Big Truck	Container Truck
Passenger monthly wage rates	3,000,000	6,000,000	3,000,000	3,000,000			
Hourly wage rate in $	$0.97	$1.94	$0.97	$0.97			
Driver monthly wage rate		3,500,000	3,500,000	3,500,000	3,500,000	4,000,000	5,000,000
Assistants			2,500,000	2,500,000	1,750,000	3,000,000	3,000,000
Driver +Assistant hourly rate $	$0.00	$1.13	$1.94	$1.94	$1.70	$2.26	$2.58
Percentage work time passengers	40%	40%	40%	40%			
Passenger Time Cost $	$0.39	$0.77	$0.39	$0.39			
Vehicle Occupancy & Freight Tons	1.5	2.5	10	28	3	10	20
Freight Value per ton hour $					$0.17	$0.17	$0.22
Time Cost per hour by vehicle type $	**$0.58**	**$3.07**	**$5.81**	**$12.79**	**$2.12**	**$3.96**	**$6.98**

Note: The vehicle occupancy rates from HOUTRANS Study

F. Benefits for the HCMC Traffic Network

462. Appendix B describes in some detail the expected future traffic volumes on the Expressway, and the future traffic demand in the HCMC road network as a whole. Based on results from some previous studies, the Consultant investigated the more recent developments and plans, and used the results to update the HOUTRANS model.

463. The Expressway was divided into sections, separated by an interchange and cross road in both ends. During 2016, the expected average daily traffic varied from about 3,800 PCU in

the Eastern end (between NH-51 and the Ben Hoa – Vung Tao expressway), and about 20,800 PCU on the middle section between the provincial Bac Nam road.

464. The HOUTRANS model as described in the Traffic section was used to produce the traffic forecast and to calculate the network benefits of the expressway. The model was first run "With Project" as the Base Case in which the expressway is built. The model was run then again "Without Project" which removed the expressway from the model. The results of the benefits for the HCMC Traffic Network from 2016 onwards are calculated as the vehicle operating costs savings and time costs savings for different vehicle types along the road, multiplied by the number of days per year.

465. As described in the Traffic Section the Benefits of the project expressway were calculated using the HOUTRANS traffic model. The results of the calculation are shown in Table 21 and Table 22 where the Appendix B the traffic demand and Generation-Attraction data was assigned in the road network for HCM City and surrounding provinces, using HOUTRANS. This was done both with and without the Expressway, and in each case for each of the years 2016, 2026, and 2036. Both the number of PCU km and PCU hours in the network were included in the output from HOUTRANS.

1. Generated Traffic Benefits

466. The total traffic forecast, the kilometres saved and the hours saved produced by the HOUTRANS model include both normal and generated traffic. Generated traffic is the additional vehicle travel that results from a transportation improvement. Traffic congestion causes people to defer trips that are not urgent, choose alternative destinations and modes if possible, and forego avoidable trips. Conversely, road system changes that reduce congestion increase peak-period vehicle travel. Using the "rule of half" the benefits of the generate traffic should be reduced by 50%.

467. To obtain the amount of generated traffic on the project expressway it has been assumed that 20% of the benefits are generated benefits and therefore these will be reduced by half. The VOC savings benefits are calculated by multiplying the kilometres saved as shown in Table 21 by the operating costs for each vehicle as shown in Table 116.

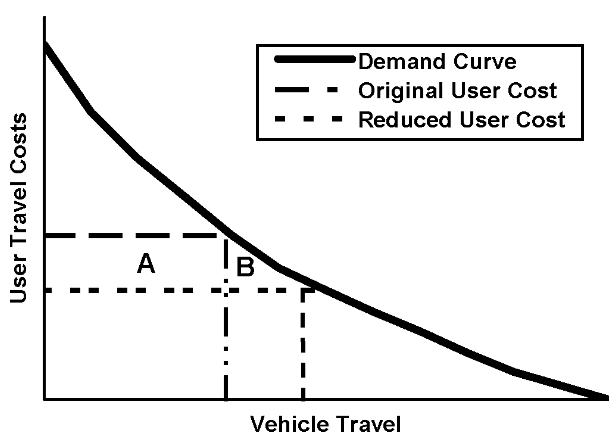

Figure 57: Vehicle Travel Demand Curve

Note: From Generated Traffic and Induced Travel, by Todd Litman

468. The normal benefits are the area of rectangle A as shown in Figure 57 while the generated traffic is the triangle B.

Table 118: Normal and Generated Benefits for VOC and Time Savings

Year	Total VOC Savings	Normal VOC Savings	Generated VOC Savings	Accrued VOC Savings	Total Time Savings	Normal Time Savings	Generated Time Savings	Accrued Time Savings
2016	119,230,160	95,384,128	11,923,016	107,307,144	46,906,636	37,525,309	4,690,664	42,215,972
2017	166,236,471	132,989,177	16,623,647	149,612,824	91,479,865	73,183,892	9,147,987	82,331,879
2018	213,242,781	170,594,225	21,324,278	191,918,503	136,053,095	108,842,476	13,605,309	122,447,785
2019	260,249,091	208,199,273	26,024,909	234,224,182	180,626,324	144,501,059	18,062,632	162,563,692
2020	307,255,401	245,804,321	30,725,540	276,529,861	225,199,553	180,159,643	22,519,955	202,679,598
2021	354,261,711	283,409,369	35,426,171	318,835,540	269,772,783	215,818,226	26,977,278	242,795,504
2022	401,268,022	321,014,417	40,126,802	361,141,219	314,346,012	251,476,810	31,434,601	282,911,411
2023	448,274,332	358,619,465	44,827,433	403,446,899	358,919,241	287,135,393	35,891,924	323,027,317
2024	495,280,642	396,224,514	49,528,064	445,752,578	403,492,471	322,793,977	40,349,247	363,143,224
2025	542,286,952	433,829,562	54,228,695	488,058,257	448,065,700	358,452,560	44,806,570	403,259,130
2026	589,293,262	471,434,610	58,929,326	530,363,936	492,638,929	394,111,144	49,263,893	443,375,037
2027	651,767,320	521,413,856	65,176,732	586,590,588	617,807,006	494,245,605	61,780,701	556,026,305
2028	713,586,428	570,869,142	71,358,643	642,227,785	742,293,783	593,835,026	74,229,378	668,064,405
2029	764,121,764	611,297,411	76,412,176	687,709,588	854,067,076	683,253,661	85,406,708	768,660,369
2030	805,491,714	644,393,371	80,549,171	724,942,543	953,424,673	762,739,738	95,342,467	858,082,205
2031	840,305,704	672,244,563	84,030,570	756,275,134	1,042,367,236	833,893,789	104,236,724	938,130,512
2032	869,349,651	695,479,721	86,934,965	782,414,686	1,121,379,781	897,103,825	112,137,978	1,009,241,803
2033	887,701,530	710,161,224	88,770,153	798,931,377	1,183,601,959	946,881,567	118,360,196	1,065,241,763
2034	889,707,602	711,766,082	88,970,760	800,736,842	1,220,481,070	976,384,856	122,048,107	1,098,432,963
2035	889,907,691	711,926,153	88,990,769	800,916,922	1,251,255,467	1,001,004,374	125,125,547	1,126,129,921

G. Cost-Benefit Evaluation

Table 119 on the next page includes the costs and benefits as described above, one in each column. The evaluation assumes a four-lane Expressway, which might need to be widened to eight lanes some time 2027-2035.

- The “Construction Costs” for each of the six years 2011-2016 are shares of the total construction costs for a four lane road.
- The “Maintenance Costs” include the routine maintenance at the cost of US$ 827, 739 per year, and the periodic maintenance at the cost of US$ 23,975,000 every seven years.
- The “Normal Network Benefits” refer to the vehicle operating costs savings and time costs savings for the normal traffic in the HCMC network.
- The “Generated Network Benefits” refer to the effects of the generated traffic for the overall Road Network in HCM City.
- The “Sum” adds up with the six columns to the left of this column, for each year.

- As in a standard Cost-Benefit evaluation, the "Present Value" is the product of (a) the "Sum" column and (b) the Opportunity Cost of Capital, which decreases by 12% for each year and therefore also reduces the "Sum".

Table 119: Calculation of Net Present Value and EIRR

Year	Costs		Normal Network Benefits		Generated Benefits		Sum
	Expressway Capital Costs	Routine & Periodic Maintenance	VOC Saving	Time Saving	VOC Saving	Time Saving	
2009							
2010							
2011	$120,409,861						($120,409,861)
2012	$175,518,445						($175,518,445)
2013	$199,664,819						($199,664,819)
2014	$318,806,961						($318,806,961)
2015	$379,649,213						($379,649,213)
2016	$93,336,224	$827,739	$95,384,128	$37,525,309	$11,923,016	$4,690,664	$55,359,154
2017		$827,739	$132,989,177	$73,183,892	$16,623,647	$9,147,987	$231,116,963
2018		$827,739	$170,594,225	$108,842,476	$21,324,278	$13,605,309	$313,538,549
2019		$827,739	$208,199,273	$144,501,059	$26,024,909	$18,062,632	$395,960,134
2020		$827,739	$245,804,321	$180,159,643	$30,725,540	$22,519,955	$478,381,720
2021		$827,739	$283,409,369	$215,818,226	$35,426,171	$26,977,278	$560,803,306
2022		$827,739	$321,014,417	$251,476,810	$40,126,802	$31,434,601	$643,224,891
2023		$23,975,000	$358,619,465	$287,135,393	$44,827,433	$35,891,924	$702,499,216
2024		$827,739	$396,224,514	$322,793,977	$49,528,064	$40,349,247	$808,068,062
2025		$827,739	$433,829,562	$358,452,560	$54,228,695	$44,806,570	$890,489,648
2026		$827,739	$471,434,610	$394,111,144	$58,929,326	$49,263,893	$972,911,234
2027		$827,739	$521,413,856	$494,245,605	$65,176,732	$61,780,701	$1,141,789,154
2028		$827,739	$570,869,142	$593,835,026	$71,358,643	$74,229,378	$1,309,464,450
2029		$827,739	$611,297,411	$683,253,661	$76,412,176	$85,406,708	$1,455,542,218
2030		$23,975,000	$644,393,371	$762,739,738	$80,549,171	$95,342,467	$1,559,049,748
2031		$827,739	$672,244,563	$833,893,789	$84,030,570	$104,236,724	$1,693,577,907
2032		$827,739	$695,479,721	$897,103,825	$86,934,965	$112,137,978	$1,790,828,750
2033		$827,739	$710,161,224	$946,881,567	$88,770,153	$118,360,196	$1,863,345,401
2034		$827,739	$711,766,082	$976,384,856	$88,970,760	$122,048,107	$1,898,342,066
2035		$827,739	$711,926,153	$1,001,004,374	$88,990,769	$125,125,547	$1,926,219,104
						NPV	$2,070,328,667
						EIRR	25.52%

F. Sensitivity and Risk Analysis

The main risk from an economic and financial point of view would probably be a significantly less traffic demand along the Expressway than expected, due to delays in the completion of connecting roads, or in the work on the planned container ports, industrial parks, or the new international airport.

Other risks could be related to the construction. Delays could be caused by problems with (for example) the land acquisition / resettlement, other environmental concerns, difficult bridge

constructions, unexpected problems with surface water or flooding, or administrative problems. For these reasons, contingencies have been allocated in the prepared construction cost.

Uncertainties in vehicle operating costs, time costs, or in the relative frequencies of different vehicle types, are likely to be within +/- 10-15%. This would not cause any significant differences to either the NPV or the EIRR.

Table 120: Sensitivity and Switching Values

Item	Change (%)	NPV	EIRR (%)	Sensitivity Indicator	Switching Value (%)
Base Case		$2,070.33	25.52%		
Costs					
Investment Costs increase	20.00%	$1,899.36	23.17%	0.41	242.18%
Benefits					
Network Benefits decrease	-20.00%	$1,483.05	22.65%	1.42	70.51%
Costs & Benefits					
Investment Costs increase Benefits Decrease	20.00% -20.00%	$1,312.07	20.47%	1.83	54.61%
Delay in Project Start					
One year		$2,336.98	27.85%	NPV increases	by 13%

A reduction to half of the traffic volume assumed by the Consultant could also reduce the EIRR to about 17.2% only. The construction of the Expressway would still be valid.

V. FINANCIAL ANALYSIS AND EXPRESSWAY OPERATIONS

A. Project Financial Analysis

1. Project Cost

a. Construction Cost

469. Co-financing of the Project between the ADB and the Co-financier has been assumed by the Technical Assistance (TA) Consultants. The first draft proposed demarcation for each of the possible co-financiers is the followings:

- ADB financing: Km 00+000 to Km 20+395
- Co-financier financing: Km 20+395 to Km 31+371
- ADB financing: Km 31+371 to Km 57+500

470. Based on the cost estimates, the Project construction cost after contingencies and before financial charges during development (FCDD) was shown as in the Table 121 below:

Table 121: Estimated Project Construction Cost after Contingencies

	Foreign Currency	Local Currency	Total (US$ Million)
Civil Works	505.7	413.8	919.5
of which: ADB Section	-255.4	-209.0	-464.4
of which: Co-financer Section	-250.3	-204.8	-455.1
Land Acquisition	0.0	215.7	215.7
VEC Laboratory Equipment	0.8	0.3	1.1
Unexploded Ordnance Clearance	0.0	4.0	4.0
Consulting Services (SPV)	19.3	15.7	35.0
of which: ADB Section	-10.2	-8.3	-18.5
of which: Co-financer Section	-9.1	-7.4	-16.5
Expressway facilities	42.1	18.1	60.2
(Subtotal)	567.9	667.6	1,235.5
VEC Project Administration Cost	0.0	12.4	12.4
(Base Cost)	567.9	680.0	1,247.9
Physical Contingency	28.8	38.1	66.9
Price Contingency	13.7	189.2	202.9
Base Cost + Physical + Price Contingencies	610.4	907.3	1,517.7

Note: For the cost item of civil works and supervision of Co-financier section the calculation of the price contingency before the physical contingency. For the other cost items, the calculation of the physical contingency is before the price contingency.

471. The rate of physical contingency is assumed to be 5% for all cost items. The rates of price contingency are set up for foreign currency portion and local currency portion on a basis of the information obtained from ADB as shown in Table below:

Table 122: Assumed Rate of Price Contingency

Annual Rate	2010	2011	2012	2013	2014	2015	2016
Foreign Currency Portion	1.0%	0.0%	0.3%	0.5%	0.5%	0.5%	0.5%
Local Currency Portion	5.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%

Source: Estimated by Consultants

472. For the cost items of civil works and supervision for the Co-financier section, the calculation of the price contingency was done before the physical contingency. For the other cost items, calculation of the physical contingency was done before the price contingency.

473. Apart from the costs of land acquisition, compensation & resettlement, VEC Project administration cost, environmental monitoring plan, and unexploded ordinance clearance, the costs are assumed to include the tax component of 10% VAT.

b. Operation and Maintenance Costs

474. The operation and maintenance (O/M) costs comprising of two components of the routine O/M costs and the periodic maintenance costs are based on the results of the engineering study. The routine O/M costs at 2009 prices are approximately US$ 5.909 million per annum, which is the operation costs of US$ 4.532 million and the maintenance cost of US$ 0.829 million, and the electricity cost for highway lighting of US$ 0.548 million. The periodic maintenance including overlay is assumed to be US$ 23.975 million every 7 years. The actual disbursement of periodic maintenance costs are assumed to be done partially in an annual average basis from year 2021 (annual amount of US$ 3.425 million). The O/M costs are assumed to increase in accordance with the inflation rate of 6% per annum.

2. Assumptions

a. Current Price Basis

475. The financial projections are presented in current price terms, which are taking the potential impact of domestic and foreign inflation into account, assuming domestic and international inflation rates of 6% and 0.5% per annum, respectively, over the analysis period.

b. Depreciation

476. The life expectancy of fixed assets is assumed to be 40 years without any residual value, taking regulations, the actual physical duration, and sample cases in other countries into account. This is based on the depreciation regulation of MOF (The Finance Minister's Decision No. 206/2003/QD-BTC of December 12, 2003 *"Regulation of Management, Use and Depreciation of Fixed Assets"*. The life expectancy of fixed assets for a highway is stipulated to be 20 years. According to the financial regulations of VEC, the depreciation period for fixed assets such as an expressway has minimum depreciation duration equivalent to the payback period of the project and the current regulations on depreciation. When considering the payback period of the OCR loan, this would give a minimum period of 25 to 30 years. On the other hand, the actual physical life expectancy of assets is considered to be much longer. The life expectancy of highway structure in tax law is 30 to 60 years in Japan, and 39 years in USA.

477. The cost item of expressway facilities (ITS system & facilities, etc.), a life expectancy of 10 years are assumed. Those assets are scheduled to be repurchased every 10 years.

c. VEC's Corporate Tax

478. The corporate tax was calculated using the rate of 25% as specified in the latest Vietnam Law on Corporate Income Tax (No. 14-2008-QH12) dated May 2008. Taxable income is defined as equal to the revenue less deductible expenses. These deductable expenses include operating costs and allowable deprecation of assets. Net operating losses may be carried forward for a period of consecutive five years.

d. Exchange Rate

479. The assumed exchange rate is: VND 17,800 per US$ as of December 2009.

e. Start Year of Expressway Operations

480. The assumed year of start of full operation of expressway is 2017. In 2016, a partial operation is assumed.

3. Toll Rates

a. Existing Toll Roads

481. In Vietnam there are not yet any comparable expressways to analyze a comparable level of tolls. Some sections of national highways are tolled. The tolls for the national highways are set according to the decree of Ministry of Finance, as shown in the following table:

Table 123: The Existing Tolls for National Highways

		VND per One Time
1	Two, three wheel motorcycles and equivalent	1,000
2	Tractors and equivalent	4,000
3	Passenger vehicles with less than 12 seats, freight vehicles with loading capacity under 2 tonnes and public buses	10,000
4	Passenger vehicles with less than 12 to 30 seats, freight vehicles with loading capacity 2 to 4 tonnes	15,000
5	Passenger vehicles with over 31 seats, freight vehicles with loading capacity 4 to 10 tonnes	22,000
6	Freight vehicles with loading capacity 10 to 18 tonnes and 20 ft container trucks	40,000
7	Freight vehicles with loading capacity over 18 tonnes and 40 ft. container trucks	80,000

Source: Circular 90/2004/TT-BTC, as of September 7 2004, Guiding the Regime of Road Toll Collection, Payment, Management and Use, MOF

b. Other Studies

482. There are recent study reports regarding national expressway projects. The assumed tolls in each of these study reports are shown as follows:

Table 124: Assumed Tolls per Km for Passenger Car for each Study Reports

Study	Assumed Toll per Km (Passenger Car) (VND per Km)
Expressway Network Development Plan Project (FINNROAD) (March 2007)	400
Noi Bai – Lao Cai Expressway Project (ADB) (September 2007)	600, 700, 800, 1000 in line with financing plan
HCMC – Long Thanh – Dau Giay Expressway Project (ADB) (September 2008)	900

Source: Each Study Report

c. Regulations of Tolls

483. According to the Circular 90/2004/TT-BTC, as of September 7 2004, Guiding the Regime of Road Toll Collection, Payment, Management and Use, MOF, the level of toll rates applicable to roads invested by the state with loan capital and subject to toll collection for capital recovery, shall not exceed twice the toll rates applicable to roads with tolls for operation and maintenance revenue only.

484. Recently, *"Decision of Prime Minister on Piloting Some Mechanism, Policies Applied to Expressway Investment Operation Project of the Employer – Vietnam Expressway Corporation"* (VEC), 1202/QD-TTg dated September 10, 2007 has been issued. This Decision allows VEC to decide the appropriate toll level to ensure repayment requirement of the project (except for a project, requested by the authorized state-owned agency to apply the toll level regulated by the Government).

4. Revenues

485. The revenues applied in this financial analysis have been based on the results of the traffic forecast models with planning years 2016, 2026 and 2036. The traffic forecast model had been run under various toll rate regimes in which the six categories of vehicle types of passenger car, minibus, standard bus, small truck, big truck, and container truck had been set up and assignment results had been re-estimated. As a result of the traffic forecast model runs, toll rate regime in the case of passenger car with VND 1,000 per km had been recommended. Please note the recommended Project Toll Rates are given in Table 125. The maximum total revenue amount had actually produced by other toll regime than the recommended one. While the recommended one has produced a similar total amount to the other one, the recommended one has produced more revenues in the critical early years. (Regarding the details, refer to the section of Traffic Forecast Model Rerun.)

Table 125: Recommended Project Toll Rates

Toll Rate Regime	Passenger Car	Minibus	Standard Bus	Small Truck	Big Truck	Container Truck
Current one time pay	10,000 VND	15,000 VND	22,000 VND	22,000 VND	40,000 VND	80,000 VND
Toll Index	1.00	1.50	2.20	2.20	4.00	8.00
Project Rate	1,000 VND/km	1,500 VND/km	2,200 VND/km	2,200 VND/km	4,000 VND/km	8,000 VND/km

486. The toll revenues are assumed to be increased every five years in accordance with the inflation rate of 6% per annum. VAT (10%) is assumed to be charged to the toll revenues.

487. Regarding projected traffic volumes, the capacity saturation for highway is considered, and the traffic volume is capped once capacity is reached.

5. Financing Plan

a. Co-financing Scheme

488. It is assumed that the Project cost will be funded by the basic scheme of co-financing between the ADB and the Co-financier. The assumed financing sources are the ADB's OCR, the Co-financier's Loans (for civil work component and for consultancy component), and the government counterpart funds. The counterpart funds are assumed to be a subsidy. It is assumed that regarding the ADB's Loan and the Co-financier's Loans, the VEC will borrow the funds from Ministry of Finance on a re-lending basis, with the assumed re-lending premium of 0.2% per annum additional to each loan.

b. OCR

489. Regarding OCR, the loan amount is sub-divided into two components of OCR (Tranche-1) and OCR (TYranche-2). The loan amounts of Tranche-1 and Tranche-2 are set up based on the following financing plan demarcation:

Table 126: OCR Financing Plan Demarcation (Tranche-1 and Tranche-2)

	Tranche-1	Tranche-2	Total (US$ Million)
Civil Work (ADB)	254.7	209.7	464.4
VEC Laboratory Equipment	1.1	0.0	1.1
Consulting Services (ADB)	9.6	8.9	18.5
VEC Administration	9.2	3.2	12.4
Total	274.6	221.8	496.4

Note: Amounts include taxes, and excludes contingencies.

c. Assumed Loan Conditions

490. The loan conditions for each funding source are assumed to be as shown in the following Table 127:

Table 127: Assumed Loan Conditions

Loan	Assumed Condition
OCR (Tranche-1) Loan Approval: Year 2010 Start Year of Loan Disbursed: Year 2011	Interest rate: 2.04% (5 Years Libor 1.74% plus Spread 0.3%) Re-Lending interest rate (0.2%) After Re-Lending interest rate : 2.24% Total Repayment 27 years (Grace period (for principal repayment): 7 years and net repayment of 20 years). (FCDD: Capitalized during 6 years (2011 to 2016). Interest payment from 7th year (2017). Principal repayment from 8th year (2018).) Commitment charge: 0.15% on un-disbursed balance Amortization schedule: Installment schedule is determined using annuity basis with 10% discount rate.
OCR (Tranche-2) Loan Approval: year 2012 Start year of Loan Disbursed: Year 2013	Interest rate: 2.14% (5 Years Libor 1.74% plus Spread 0.4%) Re-Lending interest rate (0.2%) After Re-Lending interest rate : 2.34% Total Repayment 27 years (Grace period (for principal repayment): 7 years and net repayment of 20 years). (FCDD: Capitalized during 6 years (2011 to 2016). Interest payment from 5th year (2017). Principal repayment from 8th year (2020).) Commitment charge: 0.15% on un-disbursed balance Amortization schedule: Installment schedule is determined using annuity basis with 10% discount rate.
Co-financier Loan (Civil Work)	Interest rate: 1.2% Re-Lending interest rate (0.2%) After Re-Lending interest rate : 1.4% Total Repayment 30 years (Grace period: 10 years and net repayment of 20 years) Amortization schedule: Equal amortization
Co-financier Loan (Consultancy)	Interest rate: 0.01% Re-Lending interest rate (0.2%) After Re-lending interest rate : 0.21% Total Repayment 30 years (Grace period: 10 years and net repayment of 20 years) Amortization schedule: Equal amortization

Source: Assumed by Consultants.

d. Assumed Financing Plan by Cost Item and by Funding Source

491. The financing plan by cost item and by funding source is assumed as follows:

- The Co-financier's Loan (Civil Work) is assumed to be applied for the portion of civil work for the Co-financier's section.
- The Co-financier's Loan (Consultancy) is assumed to be applied for the portion of supervision work for the Co-financier's section.
- The subsidy as a counterpart fund will be used for the cost items of unexploded ordinance clearance, tax portion related to cost item for the Co-financier's section, and land acquisition & resettlement.

- The OCR of the ADB is assumed to be used for the cost items of civil works for the ADB section, supervision of the ADB's section, environmental monitoring plan, VEC Project Administration cost, and tax portion related to other cost items than those for the Co-financier's section.

492. The assumed financing plan by cost item and funding source is shown in the following Table. It is to be noted that the assumed financing plan including loan conditions should be confirmed among the financing stakeholders of the ADB, the Co-financier, and Vietnamese Government (MOF, MOT, and VEC).

Table 128: Assumed Financing Plan by Cost Item and Funding Source

	Co-financier Loan (Civil Work)	Co-financier Loan (Consultancy)	ADB OCR (Tr-1)	ADB OCR (Tr-2)	ADB OCR	Subsidy	Total
Civil Work (ADB Section)			(279.4)	(233.7)	513,1		513.1
Civil Work (Co-financier Section)	510.6						510.6
Land / Resettlement						259.6	259.6
VEC Laboratory Equipment			(1.1)	(0.0)	1.1		1.1
Unexploded Ordinance Clearance						4.8	4.8
Supervision (ADB Section)			(9.2)	(8.5)	17.7		17.7
Supervision (Co-financier Section)		15.8					15.8
VEC Project Administration			(11.5)	(4.7)	16.2		16.2
Expressway Facilities	66.4						66.4
(Subtotal)	577.0	15.8			548.1	264.4	1,405.3
Tax Portion (Other Than COF)			(29.0)	(24.2)	53.2		53.2
Tax Portion (Co-financier)						59.3	59.3
(Total)	577.0	15.8	(330.2)	(271.1)	601.2	323.7	1,517.7

Source: Assumed by Consultants.
Note: includes contingencies.
Unit: US$ Millions.

493. Based on the above assumptions of financing plans, the total project cost including FCDD by funding source is estimated as shown in the following Table:

Table 129: Estimated Project Cost by Funding Source including FCDD

Case-1	Co-financier Loan (Civil Work)	Co-financier Loan (Consultancy)	ADB OCR (Tr-1)	ADB OCR (Tr-2)	OCR	Subsidy	Total
Financing	577.0	15.8	(330.2)	(271.1)	601.2	323.7	1.517.7
FCDD (Without Re-Lending Fee)	42.5	0.0	(21.4)	(14.0)	35.4	0.0	77.9
Total	619.5	15.8	(351.6)	(285.1)	636.6	323.7	1.595.6
Financing	577.0	15.8	(330.2)	(271.1)	601.2	323.7	1.517.7
FCDD (With Re-Lending Fee)	49.8	0.2	(23.4)	(15.3)	38.6	0.0	88.7
Total	626.8	16.0	(353.6)	(286.3)	639.9	323.7	1,606.4

Source: Estimated by Consultants.
Note: Unit: US$ Millions

6. Results of Project Financial Analysis

494. Revenues, the following two cases are assumed:

- Case-1: Toll rate of VND 1,000 per km for passenger car

- Case-2: Toll rate of VND 800 per km for passenger car

495. The results of the Project financial analysis are summarized in the following table and shown in detail overleaf:

Table 130: Project Financial Analysis Results

Case	Toll rate: VND per km for passenger car	Amount of Subsidy (US$ Million)	Accumulated Net Cash Flow (Positive or Negative)	Equity (Positive or Negative)	FIRR	WACC	Minimum DSCR	Average DSCR
Case-1	1,000	324	Positive	Positive	2.7%	0.7%	0.44 (year 2027)	1.89
Case-2	800	324	Negative (year 2022 to 2025)	Positive	1.8%	0.7%	0.20 (year 2027)	1.50

Source: Estimated by Consultants.

Note: Accumulated net cashflow: Positive or Negative: Positive stands for "No further government subsidy will be required". Negative stands for "Further government subsidy will be required".

Negative Equity in balance Sheet: Positive or Negative: Positive stands for "Equity will remain positive". Negative stands for "Equity will show negative even once"

FIRR: Financial internal rate of return, WACC: Weighted average cost of capital.

DSCR: Debt service coverage ratio.

a. (Case-1)

496. In Case-1, FIRR value shows 2.7% exceeding the value (0.7%) of WACC (weighted average cost of capital).

- The indicator of accumulated net cash flow (positive or negative) in which "positive" stands for "no further government subsidy will be required" or "negative" stands for "further government subsidy will be required", shows positive.
- The indicator of negative equity (positive or negative), in which "positive" stands for "equity will remain positive", or "negative" stands for "equity will show negative even once", shows positive.
- DSCR (debt service coverage ratio), minimum DSCR shows 0.44 in year 2027, followed by 0.88 in year 2021 and 0.98 in year 2022. These are considered mainly due to; the cash outflow for "reinvestment of expressway facilities" in year 2027, and the start of principal repayment and interest payment of Co-financier loan from year 2021. However, except these years, DSCR show generally over 1.0 for other years.
- The average DSCR shows 1.89. The value of 1.2 is conceived as a criteria regarding minimum DSCR in the financial evaluation of ADB.

497. In general, FIRR value shows well, and the indicators related to cash flow situation (DSCR) seem less sound.

b. (Case-2)

498. In general, Case-2 shows less sound financial situations compared to Case-1, reflecting less amount of revenue.

- FIRR value shows 1.8% exceeding the value (0.7%) of WACC. The cash flow situations are worse compared to Case-1.
- The indicator of accumulated net cash flow shows negative during 2022 to 2025.
- The indicator of negative equity (positive or negative) is positive.
- Regarding DSCR, minimum DSCR is 0.20 in year 2027, followed by 0.73 in year 2021 and 0.78 in 2037, representing value less than 1.0 for the years of 2022 to 2024.
- These are considered mainly due to; the cash outflow for “reinvestment of expressway facilities” in year 2027 and 2037, and the start of principal repayment and interest payment of Co-financier loan from year 2021, as well as lower revenues.
- The average DSCR is 1.50, representing the worse values of indicators related to DSCR compared to Case-1.

c. Observation

499. As shown above, both for Case-1 and Case-2, the financial analysis indicators such as FIRR are acceptable. Regarding the cash flow projections, while Case-1 is sound, Case-2 is less sound.

500. In Case-1, in general, the values of DSCR are over 1.0 with the exception (0.44 in year 2027, 0.88 in year 2021, and 0.98 in year 2022). While the value in year 2027 is due to “reinvestment cost for expressway facilities”, the values in 2021 and 2022 are mainly due to the starting of loan repayment with the termination of grace period. And the value of average DSCR is over 1.8.

d. Conclusion

501. In Case-1, while the cash flow situations are considered sound in general, the value of the minimum DSCR shows less than 1.2.

502. However, considering the above observation, the Project for Case-1 can’t be said to be financially unviable, if allowances can be given to judgment of cash flow situations and DSCR criteria.

7. FIRR

a. Estimation of FIRR

503. The financial internal rate of return (FIRR) for the Project is calculated based on similar assumptions to the financial performance analysis shown above. There are, however, several distinctive assumptions:

- The FIRR calculation is made on the basis of constant 2009 prices unlike the Cash-Flow and other financial calculations where inflation and depreciation are fully taken into account.
- The calculation period is from 2011 to 2044.
- The project cost excluding price contingency is applied.
- The revenues are not adjusted for inflation and currency depreciation.
- The operation and maintenance costs are not adjusted for inflation.
- The residual value in the final year of calculation period is considered.

Table 131: Estimated Financial Internal Rate of Return (FIRR) (For Case-1)

Year	Costs					Revenue	Cash Flow (After Corporate Tax
	Capital Investment	O/M	VAT	Corporate Tax	Total		
2011	120.2				120.2		(120.2)
2012	172.3				172.3		(172.3)
2013	187.5				187.5		(187.5)
2014	293.0				293.0		(293.0)
2015	366.0				366.0		(366.0)
2016	78.4	1.5	0.6	0.0	80.5	6.6	(73.9)
2017		5.9	2.6	0.0	8.5	28.4	19.9
2018		5.9	3.0	0.0	8.9	33.4	24.5
2019		5.9	3.5	0.0	9.4	38.7	29.3
2020		5.9	4.1	0.0	10.0	44.6	34.6
2021		9.3	4.6	0.0	13.9	50.5	36.6
2022		9.3	5.1	0.0	14.4	56.6	42.2
2023		9.3	5.7	0.0	15.0	63.1	48.1
2024		9.3	6.3	0.0	15.6	69.8	54.2
2025		9.3	7.0	3.2	19.5	76.8	57.3
2026		9.3	7.6	9.1	26.0	84.0	58.0
2027	63.7	9.3	8.3	9.6	90.9	91.5	0.6
2028		9.3	9.0	10.3	28.6	99.2	70.6
2029		9.3	9.6	10.6	29.5	105.2	75.7
2030		9.3	10.0	10.7	30.0	110.5	80.5
2031		9.3	10.4	16.6	36.3	114.2	77.9
2032		9.3	10.7	16.0	36.0	117.4	81.4
2033		9.3	10.8	15.3	35.4	119.2	83.8
2034		9.3	10.8	14.2	34.3	119.2	84.9
2035		9.3	10.8	13.2	33.3	119.3	86.0
2036		9.3	10.9	18.6	38.8	119.4	80.6
2037	63.7	9.3	10.9	17.2	101.1	119.4	18.3
2038		9.3	10.9	16.0	36.2	119.4	83.2
2039		9.3	10.9	14.9	35.1	119.4	84.3
2040		9.3	10.9	13.8	34.0	119.4	85.4
2041		9.3	10.9	18.9	39.1	119.4	80.3
2042		9.3	10.9	17.5	37.7	119.4	81.7
2043		9.3	10.9	16.2	36.4	119.4	83.0
2044	(365.2)	9.3	10.9	15.0	(330.0)	119.4	449.4
				FIRR before Corporate Tax			3.36%
				FIRR after Corporate Tax			2.72%
				WACC			0.69%

Source: Estimated by Consultants
Note: ( ) = negative, FIRR = Financial Internal Rate of Return, O/M = Operation & Maintenance
VAT = Value Added Tax,

504. Based on the above mentioned assumptions, FIRR in Case-1 is estimated to be 2.7%.

Table 132: Projected Financial Statements (For Case-1) (Unit: US$ Million)

Item	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
A. Income Statement																		
Gross Revenue	0.0	0.0	0.0	0.0	0.0	9.0	38.5	44.7	51.2	58.1	87.0	96.3	105.9	115.7	125.6	181.6	195.3	208.9
VAT to Revenue	0.0	0.0	0.0	0.0	0.0	0.8	3.5	4.1	4.7	5.3	7.9	8.8	9.6	10.5	11.4	16.5	17.8	19.0
O/M Costs	0.0	0.0	0.0	0.0	0.0	2.2	9.4	10.0	10.6	11.2	11.9	12.6	13.4	14.2	15.0	15.9	16.9	17.9
Periodical Maint. C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.9	7.3	7.7	8.2	8.7	9.2	9.8	10.4
Operating Profit	0.0	0.0	0.0	0.0	0.0	6.0	25.5	30.7	35.9	41.6	60.3	67.7	75.2	82.8	90.5	140.0	150.9	161.7
Depreciation	0.0	0.0	0.0	0.0	0.0	10.7	38.6	38.6	38.6	38.6	38.6	38.6	38.6	38.6	38.6	38.6	41.5	41.5
Interest (ADF)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Interest (OCR)	0.0	0.0	0.0	0.0	0.0	0.0	14.6	14.6	14.4	14.2	13.9	13.6	13.2	12.8	12.4	11.9	11.4	10.8
Interest (Cofinancier: Civil Work)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.6	8.1	7.7	7.2	6.8	6.4	5.9	5.5
Interest (Cofinancier: Consultancy)	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02
Interest (Bond)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Profit before Tax	0.0	0.0	0.0	0.0	0.0	(4.7)	(27.7)	(22.5)	(17.1)	(11.2)	(0.9)	7.3	15.6	24.1	32.7	83.0	92.1	103.9
Corporate Tax	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.9	20.8	23.0	26.0
Net Operating Profit / (Loss)	0.0	0.0	0.0	0.0	0.0	(4.7)	(27.7)	(22.5)	(17.1)	(11.2)	(0.9)	7.3	15.6	24.1	25.8	62.3	69.1	77.9
Accumulated		0.0	0.0	0.0	0.0	(4.7)	(32.4)	(55.0)	(72.1)	(83.3)	(84.2)	(76.9)	(61.2)	(37.1)	(11.4)	50.9	120.0	197.9
B. Cashflow Statement																		
Operating Income	0.0	0.0	0.0	0.0	0.0	(4.7)	(27.7)	(22.5)	(17.1)	(11.2)	(0.9)	7.3	15.6	24.1	25.8	62.3	69.1	77.9
Depreciation	0.0	0.0	0.0	0.0	0.0	10.7	38.6	38.6	38.6	38.6	38.6	38.6	38.6	38.6	38.6	38.6	41.5	41.5
Net CF from Operation	0.0	0.0	0.0	0.0	0.0	6.0	10.9	16.1	21.5	27.4	37.8	46.0	54.3	62.7	64.4	100.9	110.6	119.4
Equity	128.4	136.2	10.1	15.5	24.5	9.1	0.0	0.0	0.0									
Loan	5.4	67.6	219.8	355.6	452.1	93.5	0.0	0.0	0.0									
Investment Cost	133.7	203.7	230.0	371.2	476.6	102.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	95.4	0.0
Debt Repayment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.2	6.8	12.5	45.9	47.2	48.7	50.4	52.2	54.2	56.4	58.9
Net Cashflow	0.0	0.0	0.0	0.0	0.0	6.0	10.9	9.9	14.7	15.0	(8.1)	(1.3)	5.6	12.3	12.2	46.7	(41.2)	60.6
Accumulated Cashflow	0.0	0.0	0.0	0.0	0.0	6.0	16.9	26.8	41.6	56.5	48.5	47.2	52.8	65.1	77.3	124.0	82.8	143.4
C. Balance Sheet																		
Current asset	0.0	0.0	0.0	0.0	0.0	6.0	16.9	26.8	41.6	56.5	48.5	47.2	52.8	65.1	77.3	124.0	82.8	143.4
Fixed asset	134.3	339.3	573.7	954.5	1,448.0	1,572.3	1,580.7	1,589.1	1,597.7	1,606.4	1,606.4	1,606.4	1,606.4	1,606.4	1,606.4	1,606.4	1,701.7	1,701.7
Accumulated Depreciation	0.0	0.0	0.0	0.0	0.0	10.7	49.3	88.0	126.6	165.3	203.9	242.6	281.2	319.9	358.5	397.2	438.7	480.3
Net Fixed asset	134.3	339.3	573.7	954.5	1,448.0	1,561.7	1,531.4	1,501.2	1,471.1	1,441.1	1,402.5	1,363.8	1,325.2	1,286.5	1,247.9	1,209.2	1,263.0	1,221.5
Total Asset	134.3	339.3	573.7	954.5	1,448.0	1,567.6	1,548.2	1,528.0	1,512.6	1,497.6	1,450.9	1,411.0	1,377.9	1,351.6	1,325.2	1,333.2	1,345.8	1,364.9
Equity	128.4	264.5	274.7	290.2	314.7	319.0	291.3	268.8	251.6	240.4	239.6	246.9	262.5	286.6	312.4	374.7	443.7	521.6
Loan	5.9	74.8	299.0	664.3	1,133.3	1,248.6	1,256.9	1,259.2	1,261.0	1,257.2	1,211.4	1,164.1	1,115.4	1,065.0	1,012.8	958.6	902.1	843.3
Total Liability and Equity	134.3	339.3	573.7	954.5	1,448.0	1,567.6	1,548.2	1,528.0	1,512.6	1,497.6	1,450.9	1,411.0	1,377.9	1,351.6	1,325.2	1,333.2	1,345.8	1,364.9
DSCR (Debt Service Coverage Ratio)							1.75	1.48	1.69	1.56	0.88	0.98	1.08	1.18	1.17	1.64	0.44	1.81
Debt to Total Assets						0.796	0.812	0.824	0.834	0.839	0.835	0.825	0.809	0.788	0.764	0.719	0.670	0.618

Note (Toll Rate: VND 1,000 per km for Passenger Car)

Table 133: Projected Financial Statements (For Case-2) (Unit: US$ Million)

Item	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
A. Income Statement																		
Gross Revenue	0.0	0.0	0.0	0.0	0.0	7.8	33.2	38.7	44.2	50.3	75.2	83.3	91.6	100.0	108.6	157.0	168.7	177.0
VAT to Revenue	0.0	0.0	0.0	0.0	0.0	0.7	3.0	3.5	4.0	4.6	6.8	7.6	8.3	9.1	9.9	14.3	15.3	16.1
O/M Costs	0.0	0.0	0.0	0.0	0.0	2.2	9.4	10.0	10.6	11.2	11.9	12.6	13.4	14.2	15.0	15.9	16.9	17.9
Periodical Maint. C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.9	7.3	7.7	8.2	8.7	9.2	9.8	10.4
Operating Profit	0.0	0.0	0.0	0.0	0.0	4.9	20.8	25.2	29.6	34.5	49.6	55.8	62.2	68.6	75.0	117.6	126.8	132.7
Depreciation	0.0	0.0	0.0	0.0	0.0	10.7	38.6	38.6	38.6	38.6	38.6	38.6	38.6	38.6	38.6	38.6	41.5	41.5
Interest (ADF)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Interest (OCR)	0.0	0.0	0.0	0.0	0.0	0.0	14.6	14.6	14.4	14.2	13.9	13.6	13.2	12.8	12.4	11.9	11.4	10.8
Interest (Cofinancier: Civil Work)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.6	8.1	7.7	7.2	6.8	6.4	5.9	5.5
Interest (Cofinancier: Consultancy)	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02
Interest (Bond)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Profit before Tax	0.0	0.0	0.0	0.0	0.0	(5.8)	(32.5)	(28.0)	(23.4)	(18.4)	(11.6)	(4.5)	2.6	9.9	17.2	60.7	67.9	74.8
Corporate Tax	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.2	17.0	18.7
Net Operating Profit / (Loss)	0.0	0.0	0.0	0.0	0.0	(5.8)	(32.5)	(28.0)	(23.4)	(18.4)	(11.6)	(4.5)	2.6	9.9	17.2	49.6	50.9	56.1
Accumulated		0.0	0.0	0.0	0.0	(5.8)	(38.3)	(66.3)	(89.8)	(108.1)	(119.7)	(124.2)	(121.6)	(111.7)	(94.5)	(45.0)	5.9	62.1
B. Cashflow Statement																		
Operating Income	0.0	0.0	0.0	0.0	0.0	(5.8)	(32.5)	(28.0)	(23.4)	(18.4)	(11.6)	(4.5)	2.6	9.9	17.2	49.6	50.9	56.1
Depreciation	0.0	0.0	0.0	0.0	0.0	10.7	38.6	38.6	38.6	38.6	38.6	38.6	38.6	38.6	38.6	38.6	41.5	41.5
Net CF from Operation	0.0	0.0	0.0	0.0	0.0	4.9	6.2	10.6	15.2	20.3	27.1	34.1	41.3	48.5	55.8	88.2	92.5	97.7
Equity	128.4	136.2	10.1	15.5	24.5	9.1	0.0	0.0	0.0									
Loan	5.4	67.6	219.8	355.6	452.1	93.5	0.0	0.0	0.0									
Investment Cost	133.7	203.7	230.0	371.2	476.6	102.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	95.4	0.0
Debt Repayment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.2	6.8	12.5	45.9	47.2	48.7	50.4	52.2	54.2	56.4	58.9
Net Cashflow	0.0	0.0	0.0	0.0	0.0	4.9	6.2	4.4	8.4	7.8	(18.8)	(13.1)	(7.5)	(1.9)	3.6	34.0	(59.3)	38.8
Accumulated Cashflow	0.0	0.0	0.0	0.0	0.0	4.9	11.0	15.5	23.9	31.7	13.0	(0.2)	(7.6)	(9.5)	(5.9)	28.1	(31.2)	7.6
C. Balance Sheet																		
Current asset	0.0	0.0	0.0	0.0	0.0	4.9	11.0	15.5	23.9	31.7	13.0	(0.2)	(7.6)	(9.5)	(5.9)	28.1	(31.2)	7.6
Fixed asset	134.3	339.3	573.7	954.5	1,448.0	1,572.3	1,580.7	1,589.1	1,597.7	1,606.4	1,606.4	1,606.4	1,606.4	1,606.4	1,606.4	1,606.4	1,701.7	1,701.7
Accumulated Depreciation	0.0	0.0	0.0	0.0	0.0	10.7	49.3	88.0	126.6	165.3	203.9	242.6	281.2	319.9	358.5	397.2	438.7	480.3
Net Fixed asset	134.3	339.3	573.7	954.5	1,448.0	1,561.7	1,531.4	1,501.2	1,471.1	1,441.1	1,402.5	1,363.8	1,325.2	1,286.5	1,247.9	1,209.2	1,263.0	1,221.5
Total Asset	134.3	339.3	573.7	954.5	1,448.0	1,566.5	1,542.4	1,516.6	1,495.0	1,472.8	1,415.4	1,363.7	1,317.5	1,277.0	1,242.0	1,237.3	1,231.8	1,229.1
Equity	128.4	264.5	274.7	290.2	314.7	317.9	285.4	257.4	234.0	215.6	204.1	199.5	202.1	212.0	229.2	278.7	329.7	385.8
Loan	5.9	74.8	299.0	664.3	1,133.3	1,248.6	1,256.9	1,259.2	1,261.0	1,257.2	1,211.4	1,164.1	1,115.4	1,065.0	1,012.8	958.6	902.1	843.3
Total Liability and Equity	134.3	339.3	573.7	954.5	1,448.0	1,566.5	1,542.4	1,516.6	1,495.0	1,472.8	1,415.4	1,363.7	1,317.5	1,277.0	1,242.0	1,237.3	1,231.8	1,229.1
DSCR (Debt Service Coverage Ratio)							1.42	1.21	1.40	1.29	0.73	0.81	0.89	0.97	1.05	1.47	0.20	1.52
Debt to Total Assets						0.797	0.815	0.830	0.843	0.854	0.856	0.854	0.847	0.834	0.815	0.775	0.732	0.686

Note (Toll Rate: VND 800 per km for Passenger Car)

b. Estimation of WACC (Weighted Average Capital Cost)

505. The weighted average cost of capital (WACC) is calculated for comparison with the FIRR value. Inflation rates are assumed to be 0.5% and 6.0% for foreign and domestic inflation rates, respectively. As a result, WACC is estimated to be 0.7%.

Table 134: Estimated Weighted average Cost of Capital (WACC)

	Co-financier Loan (Civil Work)	Co-financier Loan (Consultancy)	OCR (Tranche-1)	OCR (Tranche-2)	Subsidy	Total
Amount (US$ million)	577.0	15.8	330.2	271.1	323.7	1,517.7
Weighting	38.0%	1.0%	21.8%	17.9%	21.3%	100.0%
Nominal Cost	1.4%	0.21%	2.24%	2.34%	0.00%	
Tax Rate	25%	25%	25%	25%		
Tax-adjusted Nominal Cost	1.05%	0.16%	1.68%	1.76%	0.00%	
Inflation Rate	0.50%	0.50%	0.50%	0.50%	6.00%	
Real Cost	0.55%	0.00%	1.17%	1.25%	0.00%	
Weighted Component of WACC	0.21%	0.00%	0.26%	0.22%	0.00%	0.69%

Source: Estimated by Consultants

a. Sensitivity Test

506. Sensitivity test for FIRR is made for the case of Case-1 by altering the construction costs (cost over-run of +10%), O/M costs (cost over-run of +10%), or the decrease of traffic volume (-10%).

Table 135: Sensitivity Test for FIRR (For Case-1)

	FIRR (%)	WACC (%)
1. Base Case	2.72%	0.69%
2. Traffic volume decrease by 10%	2.19%	0.69%
3. Construction cost increased by 10%	2.29%	0.74%
4. O/M costs increased by 10%	2.67%	0.69%
5. Combination of above 2, 3 and 4	1.72%	0.74%

Source: Estimated by Consultants

B. The Vietnam Expressway Corporation (VEC)

1. Legal and Institutional Development Background of VEC

507. The Vietnam Expressway Corporation (VEC) was established in October 2004 as a state-owned enterprise (SOE) under the direct control and supervision of the Ministry of Transport (MOT). VEC is the designated entity to become the eventual owner and perhaps also operator[2] of selected[3] expressway assets in Viet Nam. Hence, VEC is apparently not the only "player" in the development of expressways in Viet Nam.

508. VEC's current core activities consist of the promotion of the expressway "Master Plan" and the development of three out of six (6) active expressway projects, out of which the "Cau Gie – Ninh Binh, Noi bai – Lao cai and Ho Chi Minh – Long Thanh – Dau Giay expressways are under construction with the supervision of VEC.

509. To date as of 31st December 2008 charter capital of the Company is US dollar 56.27 million. VEC has issued some government backed-bond for financing the construction of the Cau Gie – Ninh Binh and Noi Bai – Lao Cai Expressways.

510. VEC in its current start-up phase is provisionally organized in accordance with the provisions of the "Law on State Enterprises"[4] along three (3) hierarchical levels, seven (7) divisions with functional responsibilities. In addition, there are two (3) project implementing units (PIUs) for the Cau Gie - Ninh Binh, Noi Bai - Lao Cai projects and Southern projects and two (02) subsidiaries including the Expressway Consulting Joint Stock Company and the Expressway Servicing Joint Stock Company . Total staff on VEC's payroll was 243 people in June 2009.

511. Major issues faced by VEC presently include:

- The almost total absence of in-house demand modeling expertise which results in having to rely on other entities
- VEC's lack of practical experience as an expressway owner and operator, and
- VEC's lack of practical experience in asset management and full commercial orientation of its activities.

2. Summary of Expressway Investment Plan 2008 to 2025

512. Recently, MOT has submitted the expressway master plan on November 2007, (No. 7056/TTg-BGTVT) and the approval by Prime Minister has been given on December 2008 (No.

[2] The discussion as to whether O&M of the expressways should be outsourced under concessionaire contracts is on-going and no final decision seems to have been taken yet.

[3] See Section 7.3 for details. According to information received from VEC, not all expressways identified presently in the Prime Minister's approval list will be constructed and operated by VEC.

[4] Details of the current organization structure are presented and discussed in the FINNROAD-Study; Vol. 2; Chapter 2.4, pp. 13 ff.

1734/QD-TTg). The outline is that the total length is 5,873 km (including 120 km on operation), of which 2,512 km up to year 2020, and 3,241 km after year 2020. The expressways of Cau Gie – Ninh Binh, Noi Bai – Lao Cai, Long Thanh – Dau Giay, and Ben Luc – Long Thanh are included into the category of planned section up to 2020.

513. VEC is mandated with the implementation of selected expressway priority projects that form part of the recent expressway master plan (MP) attached to the Decision 1734/QD-TTg dated 01 December 2008 signed by the Prime Minister. The master plan comprises thirty-nine (39) expressway investment projects that are prioritized by the period before 2020 and afterwards as summarized in Table 136.

Table 136: Viet Nam Proposed Expressway Network Development Plan

Before 2020	Beyond 2020
22 projects	17 projects
Total length: 2,512 km	Total length: 3,241 km
Total cost: US $ 18,890 m	Total cost: US $ 24,156 m

Source: Decision 1734/2008/QD-TTg dated 01 December 2008

Note: Total cost is defined as cost before financing and expressed in 2009 US dollar constant price base (1US$ = VND 17,800).

514. Out of the twenty-two expressway projects listed in the expressway master plan for implementation before 2020, six projects are approved for VEC management. Out of the six projects, only four, namely:

- Cau Gie – Ninh Binh (presently under construction)
- Noi Bai - Lao Cai (presently under construction and tender stage),
- Ho Chi Minh - Long Thanh – Dau Giay (presently under construction and tender stage)
- Ben Luc - Long Thanh (presently in its FS)

515. The above four are covered by the present financial viability consideration of VEC. The other three are the Da Nang – Quang Ngai, the Ha Noi – Lang Son and the Ha Long – Mong Cai expressways. The Da Nang – Quang Ngai is designed with a feasibility study conducted in 2007 which is required to be reviewed by one of the sponsors (WB). The feasibility study of the Ha Noi – Lang Son and the Ha Long – Mong Cai expressways has been started since November 2009. The management of the Da Nang – Quang Ngai project is assigned to the PIU3 of VEC while that of the Ha Noi – Lang Son and Ha Long – Mong Cai roads is expected to be outsourced to consulting firms. The seven projects under VEC management are summarized in Table 137.

Table 137: Expressway Projects Approved for VEC management

Expressway Name	Status			Tentative Sources of Funds (US$ millions)			
	Start constr	Start operat	Length (km)	Gvt.	Gvt. bonds	ODA	Invt. Cost
Cau Gie - Ninh Binh	on-going	2013	50	x	x		482.17
Noi Bai - Lao Cai	on-going	2013	244	x		ADB	1,216.05
HCM - Long Thanh - Dau Giay	on-going	2013	55	x		ADB, JBIC	932.40
Ben Luc - Long Thanh	2012	2016	58	x		ADB, JICA	1,616.50
Ha Noi - Lang Son	2013*	tbd	130	x		Chinese ODA/ BOT	740.00
Ha Long - Mong Cai	2013*	tbd	128	x		Chinese ODA/ BOT	837.60
Da Nang – Quang Ngai	2010	2013	130	x		WB/JICA	2,480.00
Total			795				8,304.72

Sources: Decision 1734/2008/QD-TTg dated 01 December 2008

Decision 412/2007/QD-TTg dated 11 April 2007

Note: * Oriental Consultants Co. Lmt. started a TA on Nov 2, 2009 and but construction date has not been decided

tbd = to be determined; Investment cost of HN-LS and HL-MC is without FCDD.

Table 138: VEC Tentative Expressway Draw-Down Schedule & Related Investment Cost

Expressway Project	Cau Gie - Ninh Binh	Noi Bai - Lao Cai	HCMC- Long Thanh- Dau Giay	Ben Luc - Long Thanh	TOTAL
Length Kms	**50 km**	**244 km**	**55 km**	**58 km**	**407 km**
Year 2008	131.56	0.00	66.92		198.48
Year 2009	38.37	1.18	294.88		334.43
Year 2010	100.29	298.54	161.41		560.24
Year 2011	105.22	316.49	171.85	144.60	738.16
Year 2012	106.73	374.18	183.32	514.93	1,179.16
Year 2013		165.49	26.78	289.49	481.76
Year 2014		28.47	6.67	304.65	339.79
Year 2015		29.31	6.76	320.70	356.77
Year 2016		2.40	6.86	8.19	17.45
Year 2017			6.95	8.30	15.25
Year 2018				8.42	8.42
Year 2019				8.53	8.53
Year 2020				8.65	8.65
TOTAL	**482.17**	**1,216.06**	**932.40**	**1,616.46**	**4,247.09**

Notes: Unit = US$-millions

[1] So far, 131.56mil was disbursed for the construction of CG-NB expressway. Although the construction has started since 2006, this amount was assumed to be spent in 2008. The

drawdown schedule for the rest of expected investment cost in the next 4 years (2009 - 2012) is assumed at: 2009 = 10%; 2010 = 30%, 2011 = 30% and 2012 = 30% for remaining construction cost. The disbursement of other three projects is taken from respective FSs.

[2] A review of the Noi bai – Lao cai feasibility study has been taken since September 2009 and data is taken from tentative estimations of consultants.

[3] The Ho chi minh – Long thanh – Dau giay (HLD) expressway data is collected from the local financial consultant of the Ho chi minh – Long thanh – Dau giay Technical Assistance Project and ADB's Project Administration Memorandum in June 2009.

[4] It is assumed that the FC is 46% of the engineering base cost and the LC the balance of 54%.

[5] During construction period, bond interest is treated as FCDD, capitalized into investment cost and financed by extra bond issuance.

3. VEC`S Financial Position 2006 - 2008

516. The financial management system in VEC is in its early stage of development, due to VEC`s short life in existence (starting from October 2004). Most of the financial activities are performed by the Accounting and Financial Department, which has 11 staff including 1 chief accountant, 2 deputy chiefs and other 08 accountants whose work load is related to cash payment and infrastructure accounting. The code of conduct or job description for each position have not been clearly stated.

517. Over the last three years, VEC totally depends on deposit interest to spend on their administrative costs. This source of income, although fluctuates through years, is unsustainable. The rise in 2008 came from higher interest rate (doubled the rate in 2007) and undisbursed amount of issued bonds. In the future, when borrowing by issuing long-term bond (normally 1- to 15 years), VEC has to pay higher interest rate despite of the Government guarantee, that may exceed demand interest rate earned from banks. Similarly, disbursement rate will be higher in coming years when expressway plans are implemented leading to lower unused cash and interest earnings.

518. Assets of the company have increased over time, partially from higher equity gained from road fee collection at Cau Gie Southern Station and mostly from long-term bonds. In 2007, VEC issued US $ 22.47mil 15-year bond with 9% interest rate. In 2008, another US $ 39.33mil 5-year bond was issued with the same rate. In-mid 2008, due to high inflation, the company had to pay 16% interest rate for US $ 28.09 mil bond with maturity ranging from 3 to 24 months. Although the short maturity put the company in liquidity risk, VEC can refinance that with cheaper funding when the high inflation is over. Currently, annual market rate decreased to 10-11% for long-term bond.

519. In contrast of the increase in assets, equity share decreases sharply (from 63% in 2007 to 36% in 2008) and the trend will continue resulting from huge borrowing on expressway construction. Loan, especially with long-term maturity, has risen from 0.01% in 2006 to 33% in 2007 and 58% in 2008. Currently, VEC's ability to pay is moderate with the current ratio and quick ratio standing at 11.28 and 3.18, respectively (in 2008). Cash closing balance is positive and increasing in the last three years which is strongly attributed to borrowing inflow. Net cash flow from business and investment activities is negative in all three years. In the coming years, when payments are made to contractors for completed works, the company may have less cash in hand and face a severe liability risk. Given this situation, lenders may be reluctant to provide more loans without government guarantee.

520. To ensure its financial viability in the future, VEC is to diversify services. One of the main revenue sources is toll collection, which is currently regulated to be decided at VEC discretion in expressways under their management (see Appendix E1). However, due to expressways' funding sources mainly from borrowings, the rate is expected to raise two or threefold to make them financially attractive to investors and lenders. Moreover, other activities like motels, restaurants, petrol station, and so on for road users are to be invested synchronously along with the road construction to generate extra income to the company when roads are put into use.

4. VEC Financial Viability Analysis 2008 to 2033

521. The following step-by-step methodology is employed to assess the institutional financial viability of VEC under the given master plan investment scenario for the four expressway projects with financial drawdown given in Table 138 and the toll rate level applied to each project.

522. **Step 1:** Based on FS of each project, the financial drawdown schedule with FCDD is extracted. Total investment cost into the proposed four expressways over the period 2008 to 2020 are estimated at US dollar 4,247.06 million (including FCDD). Details of financing amount and sources of each project as well borrowing/equity share are shown in Table 139.

Table 139: Financing amount, sources, borrowing & equity share of each project

Project	ADB (OCR)	ADB (ADF)	JBIC	Co-financier	Bond	Total loan	Equity	Total	Loan share	Equity share
CG-NB					426.17	426.17	56.00	482.17	88.39%	11.61%
NB-LC	894.02	202.04				1,096.05	120.00	1,216.02	90.13%	9.97%
HCM-LT-DG	410.20		516.50			926.70	5.70	932.40	99.39%	0.61%
BL-LT	638.35			641.39		1,279.75	336.72	1,616.47	79.17%	20.83%
Total	1,942.57	202.04	516.50	641.39	426.17	3,728.67	518.42	4,247.06	87.79%	12.21%

523. **Step 2:** O&M estimations comprise (i) cost for the main maintenance office and sub-maintenance offices, (ii) cost for toll collection, (iii) cost for maintenance of electric facilities, (iv) routine maintenance cost and periodic maintenance cost. O&M cost are also inflation adjusted over the life span of the projects.

524. **Step 3:** Consolidated gross revenues are estimated after physical demand measured in PCU and/or PCU/km/year is adjusted for different toll rate assumption. It is assumed that VEC will obtain the toll collection rights for the Cau Gie – Ninh Binh expressway that is under construction. Toll collection on that expressway is assumed to commence in 2013 in the first three projects and in 2016 in Ben Luc – Long Thanh expressway. Gross revenue streams are capped when physical demand reaches design capacity. Appendix E1 identifies gross revenue streams by expressway and consolidated revenue of VEC.

525. **Step 4:** Based on loan repayment schedule, consolidated loan repayment schedule for the four expressway projects is developed.

526. **Step 5:** In the initial analytical step the following performance indicators are assessed:

- Is the net revenue stream sufficient to cover O&M expenditures, and
- Is the cash flow after O/M cost and tax sufficient to cover debt service?

527. The following preliminary findings can be drawn from the picture that emerges, if all four expressway projects are implemented in accordance with the investment schedule, if all financing plan assumptions are kept as assumed in the analysis and if the time horizon for calculations is 27 years since the first year of construction (2008-2035).

528. **Finding 1**: **Toll rate assumptions:** Physical demand in PCU and/or PCU/km/year is a dependent variable of (i) toll rate assumptions and (ii) expressway influence area and network demand. Due to interest conflict, the stand alone viability considerations by TEDI and VEC are based on different toll rates with a view to ascertain that individual expressways are “viable” from a debt service point of view only, i.e. they must be able to pay back debts from the first operational year onwards. The relationship between toll rate and traffic demand should be modeled using proven software.

529. **Finding 2:** **Toll rate determination:** Toll rate determination is at present based on tolls levied on national highways under the prevailing toll regulation and consultants’ selection from various levels varying from VND 500/km to VND 1,500/km. It is unclear whether the toll rate is or is not within the limits of user benefits. Even though, according to Government decision VEC is able to select a rate at their discretion for expressways under their management (see Appendix E1), a realistic toll rate should be based on user benefits and willingness-to pay, which can only be measured by a carefully taken survey and reliable model.

530. **Finding 3**: **Toll rate increases:** Viet Nam has at present no law/decree that would allow for transparent toll rate increases. However, the above financial considerations increase net revenue streams every five years by the assumed inflationary factor, thereby expressing gross revenues in nominal terms. Such assumption is theoretically correct and allowed under viability considerations. However, in reality and as the example in other countries shows, increasing nominal toll rates can be a troublesome exercise, since the public does not easily understand that the nominal price of tolls should keep pace with general inflation in the economy. Hence, gross revenue and therefore net revenue streams are overestimated in the above base case.

531. **Finding 4**: **Demand estimations:** As was observed above, Viet Nam has presently only limited capability to undertake network-wide demand estimations for the proposed network configuration. That leaves demand estimations undertaken on a “stand alone” basis highly vulnerable to unacceptable error margins. Physical demand, assumed toll rates and therefore estimated gross/net revenue streams are the “lifeline” when it comes to financial viability, either on a “case-by-case” basis and/or on a consolidated basis.

532. **Finding 5**: **Financing plan:** The Cau Gie – Ninh Binh expressway was decided to be constructed by sharing funding between VEC equity and domestically issued bonds with Government’s guarantee. ADB also pledged to support the construction of the Noi Bai – Lao Cai by a combination of ADF and OCR sources additional to a government subsidy (US$120mil). Financing plans of these roads are basically determined[5]. Financial plan of the Ho chi minh-

[5] The Noi bai – Lao cai FS is under a review with a TA funded by ADB due to out-of-date construction costs using 2007 price. According to tentative result of the review, in order to improve the project’s financial viability, US$ 120million (previously assumed to be financed by Government-backed VEC-bond) should be funded in form of a subsidy from the Government of Vietnam with no requirement of interest and principal payment. Results of this review are applied to this analysis.

Long Thanh-Dau Giay expressway is discussed in Finding 9 below with terms and conditions shown in Appendix E1. Final decisions on fund sharing have not been made in the Ben Luc-Long Thanh project (though basically agreed between the ADB and Vietnamese governmental agencies by end of January 2010). The financing plan should be based on (i) a viable business development plan of the implementing entity; (ii) the financial capacities of the implementing entity and (iii) the "merits" in economic and financial terms of each individual investment project.

533. **Finding 6**: **Revenue and profits:** VEC's annual net revenue streams are either insufficient to cover O&M expenditures, interest and depreciation or slightly above costs over the first 05 years after putting the first three expressways (CG-NB, NB-LC and HCM-LT-DG) into operation. Profit after tax only climbs to a comfortable level from 2019 onwards.

534. **Finding 7:** **Cash flow:** Annual net cash flow is positive since the first year of operation (2013), except for 2011 when the BL-LT project has to start returning principal to the Co-financier and first periodical maintenance is made in all projects. This encouraging result might come from the assumption of a substantial free money from the Government in both the Noi Bai-Lao Cai and Ben Luc-Long Thanh expressways.

535. **Finding 8:** **DSCR:** Together with increasing annual net revenues streams over years, debt service coverage ratio satisfies ADB requirement (1.2) in all years under consideration.

536. **Finding 9:** **Financial leverage:** After putting these expressways into operation, VEC debt ratio is considerably high (around 94% in the 2013 – 2018 period). The ratio remains at the high level above 80% till 2022 when VEC start paying back JBIC and other lenders (e.g. the co-financiers in the BL-LT project). From 2022 onwards, the debt ratio decreases steadily and continuously to 39.3% in 2035. However, this picture may change if VEC continues borrowing to finance other expressways in the future such as the Hanoi – Lang Son or Ha Long – Mong Cai.

537. **Finding 10:** **Domestic debt burden:** In early 2009, due to the economic recession occurring worldwide and in Vietnam, the Government introduced an interest rate support program with a 4% interest rate reduction for borrowing in working capital. VEC was eligible to borrow VND 1,000 billion (equivalent to US dollar 56.18 million) from a commercial bank paying 6% after-reduction interest rate. Besides, because of the high inflation rate, VEC had to issue VND 500 billion (equivalent to US dollar 28.09 million) bond with maturity ranging from 3 to 24 months in 2008, paying 16% yearly interest rate. These borrowings are to be matured very soon which will require VEC to continue issuing more bonds which are used to repay matured debts and finance new construction. If the amount, which is now assumed to be funded by a government subsidy in the Noi Bai – Lao Cai projects as agreed between ADB and governmental agencies last month (January 2010), comes from government-back VEC bonds as initially assumed, the financial situation of VEC will be much worse due to difficulties in issuing bonds and repayment burden.

538. **Finding 11:** **Domestic borrowing difficulties:** The current economic situation in Vietnam is unstable and difficult to forecast. Due to the global economic crisis which negatively affected Vietnam socio-economic situation, the Government has to apply expansionary fiscal and monetary policies to stimulate domestic demand supporting business and rural/disadvantaged areas. The consequence of such policies might be a pressure on inflation and exchange rate. The gold price in both international and domestic markets is another issue causing distortion and difficulties to the economy. Both institutional and individual investors tend

to select more safety investment options in real estate, gold, etc. and require higher interest rate for bonds, especially bonds with high maturity. Since the beginning of 2009, VEC has failed many times while trying to sell 3-year and 5-year maturity Government-guaranteed bonds in the capital market. Their bond interest rate which is capped by the Ministry of Finance (MOF) is usually lower than market requirement.

539. Given the current situation and macro-economic concerns in Vietnam, it will be very difficult to borrow by bonds, especially with long maturity or VEC has to pay higher rate as they did in 2008. This is not a easy solution to VEC because the rate is control by MOF, who is reluctant to increase interest to avoid creating pressures to the raise domestic interest rate. Moreover, high rate will erode VEC profit and harm its ability to pay which is very important to a company carrying high debt ratio like VEC.

540. **Finding 12: Financial management system:** Under the Ho Chi Minh-Long Thanh-Dau Giay TA from ADB, a financial information system (FIS) is developed to help VEC in making a financially sustainable expressway investment plan that takes into account monitoring and planning cost-recovery tariff levels, forecasting traffic levels, making projected financial statements, and developing a debt-management strategy. The FIS setup is necessary and helpful to VEC in projecting and monitoring expressway plans. Currently, FIS is in the progress of transferring from the software developer.

541. **Finding 13:** In the present VEC organization, there is an internal audit/inspection committee reporting to the Management Board, which is directed by a graduate in finance. There is also a Finance and Accounting Department with the majority work load relating to accounting. The company lack a division specialized in financial management. The current Finance and Accounting Department is doing well in accounting and forming financial reports, collecting accounts receivable, formulating annual budget. However, they lack necessary skills in long-term budgeting and risk management which are essential for large company involving in infrastructure investment as VEC.

542. **Finding 14:** In summary, VEC under the given basket of assumptions with considerable government subsidy in the Noi Bai-Lao Cai (US$ 120mil) and the Ben Luc-Long Thanh (US$ 336mil) expressways will be financial unstable and unprofitable over the period 2013 to 2017, and then enter a period of relatively high profitability. Its ability to pay is also positive with high DSCR since the first year of expressway operation. However, there is no firm confirmation of the Government regarding the mentioned subsidy, and data is unreliable far in the future.

5. Assessment of VEC`s Prevailing Financial Management System

a. VEC Background as Implementing Agency (IA)

543. VEC is already the designated operating entity with toll collection rights for the Cau Gie – Ninh Binh expressway project that is under construction and for which VEC will be granted toll collecting rights for at least ten years. VEC is at present a SOE that needs in accordance with prevailing law to be converted before mid-2010 into either a limited liability or shareholding company. That conversion requirement falls into a high investment period for VEC and the actual legal and operational consequences have so far not been investigated in detail.

544. VEC was in the past the implementing agency for TA 4695-VIE and has therefore practical experience with externally/ADB funded projects.

b. Organizational Structure

545. For the time being, VEC's provisional organization structure is sufficient for the tasks at-hand. However, it is apparent that once VEC assumes full responsibility for its commercial success and VEC gets deeper involved with financial transactions that additional in-house capacity needs to be established and nourished through targeted capacity building measures.

c. Future Staffing of Financial Management System

546. VEC has at present 11 staff members in the accounting and finance department. Five people have over 15 years professional experience and six have professional experience of less than ten years. In general and at present levels of activity (i.e. mainly master plan promotion, supervision of detailed designs, tendering for construction and supervision of construction supervision consultants) it is fair to observe that the present quantity and quality of VEC's accounting and finance department is at a sufficient level. In addition, five of the eleven staff members have received training in ADB procedures.

547. However, once the tasks of the finance department become more complex with an increasing number of investment projects and financial planning, evaluation and monitoring needs, it is reasonable to assume that additional personnel will be needed in particular for the areas of financial planning, evaluation, monitoring and risk assessment. It is essential that VEC establishes core expertise in the formulation of financing plans, including more sophisticated financing tools, such as bonds. These activities must be supported by a strong management information system (MIS), of which financial management is only one element.

d. Accounting Policies & Procedures

548. VEC has presently a computerized finance system that records all transaction to an on-line general ledger. All cost allocations are examined and made in accordance with established rules and procedures.

e. Budgeting System

549. VEC's budget is prepared by the Finance and Accounting Department and approved by the Director General. The procedures are in accordance with Vietnamese accounting standards and comply with ISO 9001-2000 provisions. VEC's budget includes physical and financial targets. Parts of the budget are targeted to invest into fixed assets and retained earnings are used to earn interest through other financial activities, such as short-term money deposits. The budgets are prepared in detail to allow for an assessment of planned versus actual performance. Actual expenditures are monitored on a monthly basis against actual budgets. Should there be any deviation of actual expenditures over budget, prior approval for "overspending" must be obtained.

f. Safeguards over Assets

550. VEC has a system in place that protects its present assets against fraud, waste and abuse. Subsidiary records of fixed assets are kept, stock is taken and checked and kept up-to-date and the data are reconciled with control accounts. Assets are covered in a sufficient manner by insurance policies.

g. Internal Audit

551. VEC has an internal audit department that is called “Control Board”. The Control Board is staffed by three members and headed by a person with over twenty years experience in internal audit. The control Board reports directly to VEC’s Management Board. It is the intention of VEC that all expressway projects will also fall under the internal jurisdiction of the Control Board. In case of need, the Management Board takes swift action upon recommendations of the Control Board.

h. External Audit

552. VEC’s financial statements are audit regularly by hired outside independent auditors. Audit reports are issued annually. External audits comply with the requirements of the “International Standards on Auditing”. During the five-year existence of VEC, no major accountability issues were identified in the external audit reports.

6. Conclusions & Recommendations

553. The present institutional viability analysis undertaken for VEC had to make fundamental assumptions as regards project cost, traffic demand, toll rates, draw down schedule and financing plans, operational and maintenance cost. Hence, while the emerging picture is quite positive, the following “caveats” should be taken into account in an assessment of the institutional viability that should be undertaken in more detail in the near future:

554. **Realistic revenue projections:** VEC should establish an in-house capability and capacity to model demand on the road/expressway network, in order to achieve its own and independent estimations on “most likely revenue” scenarios. Revenues from tolls and retained earnings derived from such revenues[6] are the long-term life-line of VEC’s financial viability. Project-wise and/or institution-wise financial viability is typically very sensitive to demand or revenue overestimations. There is out-house expertise that is currently charged by the GoV with undertaking pre-feasibility and/or feasibility studies for the proposed expressway projects. However, the data and recommendations of these studies are not critically checked and it appears to be unclear to what extent they comply with standard error margins allowable: pre-feasibility study error margin equal or < 25%; F/S error margin equal or < 10% and bankable F/S error margin equal or < 3%.

555. **Toll rate setting:** As the case under consideration shows, the individual expressways are investigated under different toll rate assumptions. This is unsatisfactory from a policy point of view, since its implies that “in reality” toll expressway users are charged differently for expressways of the same technical design standards. Toll rates should be determined based on realistically estimated user benefits. Also, while an attempt has been made to adjust the physical demand in this investigation to the assumed toll rate ranging from VND 800/km to VND 1,000/km, this can be hardly more than a very rough proxy.

556. Moreover, in all projects, traffic demand is converted from projected number of vehicles by vehicle type to PCU (passenger carrying unit) per kilometer per day before multiplying with

[6] Revenues from other infrastructure facilities, such as for example gasoline stations and rest areas, are typically a very small fraction of the toll revenues only. They are therefore not considered here.

the assumed toll rate to estimate revenue. However, in practice vehicles are to pay different toll rate levels depending on their types (e.g. car <8 seats, bus 8-15 seats, bus 16+ seats, truck <2.5t, truck 2 axles, truck 3 axles, truck 4+ axles, motorcycle, etc.). VEC should establish an in-house capability and capacity to project toll rate level by vehicle type making each project sufficiently viable in terms of finance.

557. **Equity contributions:** Currently, out of the three expressways under construction including Cau Gie – Ninh Binh, Noi Bai – Lao Cai and, the Government contributed only US dollar 56 million to the Cau Gie – Ninh Binh project in forms of VEC equity accounting for 11.62% project costs. Share of assumed Government contribution in the Ho Chi Minh – Long Thanh – Dau Giay projects is marginal with 0.54%. The equity share in the Noi Bai-Lao Cai and Ben Luc – Long Thanh is an assumption without firm commitment from the Government. The GoV through MOF considers an equity contribution as “sunk cost”, i.e. no return-on-equity (ROE) is expected. Hence, from a VEC point-of view the equity contribution is actually a subsidy and it improves therefore VEC’s overall financial picture by reducing initial investment cost (with lower FCDD) and financial performance criteria. It should be investigated from a “project-stand-alone” and then “institutional point-of-view” what happens if (i) the equity portion is increased and treated as a subsidy (as is the case), or (ii) the equity portion is kept and/or increased and treated as equity that needs to generate a certain percentage in ROE.

558. Expressways are critical infrastructure to economic development as a basis for investment from both state and private sources. Investment in expressways themselves, nonetheless, is substantially high. The costs to construct all projects assigned to VEC (see Table 3) are about US dollar 8 billion[7]. Carrying investment in all these expressways by a high portion of borrowings creates a burden of interest and principal payment liability to VEC and reduces projects’ financial feasibility and sustainability. High debt ratio also worries donors who provides not only concessional loans but also requires commercial terms in some loans. Although all loans are backed by the Government, VEC financial sustainability and ability-to-pay are important criteria for project selection by lenders.

559. Given the advantages of Government subsidy and the importance of investment in expressways, it is essential for governmental financial and state management agencies (MOF and MOT) to consider contributing higher government share in expressways investments as well as to increase VEC’s equity, as expressway management companies in some countries[8]. This will help to improve project financial viability, VEC profitability and financial sustainability as well as lenders’ confidence in the Government’s commitment as regards expressway development support.

560. **Institutional privilege requirements:** Some preferential policies has been issued to support VEC’s operation such as corporate income tax exemption and reduction, right to decide

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[7] Investment costs of the Hanoi – Lang Son and Ha Long Mong Cai expressways shown in Table 137 are roughly estimated without FCDD. If FS for these projects are developed with more precise data and methodology, investment cost of each project may exceed US dollar 1 billion

[8] The Korean Expressway Company (KEC), established in 1969 and owed by the Korean Government, plays the role as investment owner and manager of the whole expressway network in Korea (3,113 km in operation). The current register capital of KEC is valued at US dollar 25 billion in addition to US dollar 20 billion accumulated surplus. KEC’s main shareholder is the Koran Government (holding 86.95% of capital together with other three Korean banks.

toll rate in expressways under their management, on-lending borrowing through MOF from international donors, etc (see Decision 1202/QD-TTg dated September 2007). However, further review of these privileges needs to be made to evaluate their sufficiency. The model applied in VEC currently is unique and newly introduced in Vietnam without prior domestic experience.

561. **Financial management system:** The current FM system in VEC is doing well in accounting daily transactions and developing annual plan, but lack expertise in long-term budgeting and risk management. In order to fully develop the system in financial management, there should be an manager (e.g. deputy general director) holding the responsibility of a Chief Financial Manager (CFO) as well as a strengthened financial department with more staff engaging in budgeting and risk management.

562. **Loan considerations:** Under the given terms & conditions the OCR loan is relatively "cheap money" when compared with market rates. The annual borrowing rate is also diminished from 5.63% (without on-lending fee charged by MOF) in 2007 when loan agreement for the Noi Bai – Lao Cai project was signed to 2.92%% (without on-lending charge) currently required by ADB due to the global economic crisis. However, as the investigation shows, the amount borrowed should be "minimized", in order to minimize the considerable debt service burden that occurs when toll revenue generating capacity is still at lower levels, due to low traffic demand.

563. **Other financing tools:** It should be investigated whether the issuing of bonds could considerably increase project and/or institutional financial performance. As other participants in the bond market, VEC has to pay market rate as to be successful in mobilizing money by bonds, which trends to increase above the assumed 11% in this analysis. However, VEC's offered rate should be lower than a cap regulated by MOF. As such, bond is considered as the most expensive funding source. This source is also unreliable due to lack of commitment to lend since the starting point of project's construction as other borrowings from institutional donors like ADB or JBIC. This unreliability may delay project progress or force VEC to either issue more expensive bonds or temporally borrow with high interest rate from commercial banks to redeem their financial obligation to contractors.

564. Also, investment cost contains a sizeable share in taxes (about 10% for VAT) and in land acquisition/compensation that is not returned by depreciation. MOF together with VEC should investigate the financial performance benefits that can be obtained by granting, for example, VAT waivers or government subsidy to be spent on land acquisition/compensation as the hypothesis given in the Ben Luc – Long Thanh project. The tradeoff between equity contributions and tax waivers may result in better project and/or institutional financial performance.

565. Beside asking for lending from financial institutions or using state budget to finance road construction, the Government and VEC can think of other financing options such as build-operate-transfer (BOT), build-transfer (BT), build-operate-own (BOO) and public-private partnership (PPP). These investment tools has been applied in road development in many countries including Vietnam's neighbors as China, Singapore, Indonesia, South Korea, etc. Funds mobilized from non-state sources will help to reduce the government's and VEC's financial burden in financing expressway projects.

566. Presently, the Binh Minh Import Export Production and Trading Company (Bitexco) was approved by the Government to develop the Dau Giay- Phan Thiet road (128km) under the BOT

form. BEDC (BIDV Expressway Development Company), a consortium established by large corporations and economic groups, including Vinashin, PetroVietnam, Bitexco, VNPT, and Song Da Corporation, was allowed by the Government to construct the Trung Luong – My Thuan – Can Tho expressways (82km). The BEDC also waiting for the Government to approve their proposal to acquire the right of toll collection on the near-completion HCMC-Trung Luong Expressway (62 km) over 40 years. In return, the consortium will refund the investment (US dollar 581 million) to the Government in four years after the handover of the commercial right over the expressway linking HCMC with Mekong Delta' Tien Giang Province.

567. Given these examples, the financial contribution of private investment in expressways is insubstantial with several pilot forms. The role of private participation in expressway development in Vietnam has not been emphasized. Some main causes are raised to explain the situation, which are the unattractiveness of transportation projects, large capital requirement, long payback period and high risk involved.

In order to promote further this model, a more detail study is needed, which is beyond the scope of this report. In general, because of the challenges faced by private investors, the Government should introduce preferable incentives such as high state capital share (that may probably decrease over time with more confidence built from private parties), tax waivers/reduction, more transparent legal framework, etc.

568. **VEC investment and business plan:** VEC needs to prepare a business plan that is based on realistic appraisals of traffic demand and the economic and financial viability of the individual expressway projects. Based on such a plan, a phasing of expressway implementation could be undertaken from the view-point of financial viability and sustainability of VEC.

C. Private Sector Participation for Expressway Operation

569. Recently, the scheme of PPP (Pubic Private Partnership) has been prevailing in the field of development and operation and maintenance of infrastructure. As for PPP scheme for development and operation/maintenance of expressway in Vietnam, the study of FINNROAD has been already discussed broadly. (Expressway Network Development Plan Project, Final Report, FINNROAD, April 2007)

570. In this text, the focusing point of discussion about PPP will be on the operation and maintenance of expressway which is to be constructed in terms of publicly-financed scheme. The possibility of PPP for the operation and maintenance of expressway will be sought.

1. Overview of Expressway Projects Related to PPP in Vietnam

571. Table 140 shows the overview of several samples of major expressway projects related to PPP mainly focusing on Ho Chi Minh City area and Southern area in Vietnam.

Table 140: Major Expressway Projects Related to PPP Focusing on HCMC and Southern Area

Outline of Expressway				Form of Private Participation	Management Body (Investor)	Project Cost (Approximate)
Name of Expressway	Section	Km in Length (Approx.)	On Operation/ /Under Construction/ Planned			
1. Trung Luong - My Thuan -Can Tho	Tien Giang, Đong Thap, Vinh Long va Can Tho (Parallel to NH1)	92 km	Planned	BOT	BIDV	26,250 billion VND (1.53 billion US$)
2. My Phuoc – Tan Van	Thu Dau 1- Thuan An – Di An (Parallel to NH 13)	30 km	Planned	BOT	BECAMEX IDC	1,277 billion VND
3. Dau Giay - Phan Thiet	Đong Nai - Binh Thuan(Parallel to NH1)	120 km	Planned	BOT	BITEXCO	1.2 billion USD
4. Bien Hoa - Vung Tau	Bien Hoa (Đong Nai) - Vung Tau (Parallel to NH51)	76 km	Planned	BOT	Dasan, IDICO, BIDV	12,000 billion VND
5. Dau Giay - Lien Khuong	Dong Nai – Da Lat	200 km	Planned	BOT	IUDC	More than 1 billion USD
6. Binh Duong Boulevard, HCMC, Binh Duong	HCMC – My Phuoc – Bordering Binh Phuoc Province (Widening of NH13)	62 Km	Open in 2000	BOT	BECAMEX IDC	683 billion VND
7. Rach Mieu Bridge	Ben Tre Province (Crossing My Tho River)	2.9 km	Open in 2009	BOT	CIENCO1,5 and 6	1,400 billion VND
8. An Suaong – An Lac, HCMC	An Suong – An Lac (Widening of NH1)	14 km	Open in 2005	BOT	IDICO-IDI	832 billion VND
9. Binh Trieu 2 Bridge, HCMC	(Crossing Saigon River)	0.6 km	Open in 2006	BOT	CII	450 billion VND
10. NH 1K	Hoa An Bridge - NH 1A	10 km	Open in 2007	BOT	194 Co.,Phu Tho Co. Rang Dong Co.	250 billion VND
11. Hanoi Highway	Saigon Bridge – Dongnai Bridge	15 km	2009 - 2012	BOT	CII	2,000 billion VND (= 125 million US$)
12. NH 51	NH 1A – Vung Tau T-junction (Widening of NH 51)	73 km	Under Construction	BOT	BVEC (IDICO Group)	2,073 billion VND
13. Nguyen van Linh Expressway	NH 1A – Huynh Tan Phat	18 km	Open in 2007	BOT	Phu My Hung Joint Stock Company	100 million US$
14. Phu My Bridge	District 7 – District 2, HCMC (Crossing Saigon River)	2 km	Under Construction (- 2009)	BOT	Phu My BOT Joint Stock Company	2,077 billion VND
15. Dongnai No. 2 Bridge (Northern Area)	HCMC – Dong Nai	0.5 km	Under Construction	BOT	CC1	1,877 billion VND
16. Ninh Binh – Thanh Hoa	Ninh Bình - Thanh Hoa	75 km	Planned	BOT	VICEM	12,800 billion VND
17. Ha Noi - Hai Phong	Hưng Yen, Hai Duong va Hai Phong.	106 km	Under Construction	BOT	VIDIFI	21,900 billion VND (about 1.3 billion USD)
18. Hai Hung, Yen Lenh Bridge	Ha Nam – Hung Yen	2.2 km	Open in 2004	BOT	Thang Long Construction Corporation	340 billion VND
19. Noi Bai – Vinh Yen	Noi Bai – Vinh Yen (Widening of NH 2)	22 km	Open in 2008	BOT	National Highway 2 BOT Joint Stock Company	123 billion VND

(Source) Consultants, compiled based on:
Expressway Network Development Plan Project (Final Report, FINNROAD, April 2007)
Information from Web-sites.

Notes: PPP: Public Private Partnership
BIDV: Bank for Investment and Development of Viet Nam

BECAMEX IDC: BECAMEX Investment and Industrial Development Construction Corporation (Binh Duong Province)
BITEXCO: Binh Minh Import-Export Production and Trade Company
Dasan: Consulting Company
IDICO: Vietnam Urban and Industrial Zone Development Investment Corporation (State Corporation under MOC)
IUDC: Incheon Urban Development Company (Korean company)
IDICO-IDI: Member of IDICO (IDICO Infrastructure Development Investment Company)
CII: Ho Chi Minh City Infrastructure Investment Joint Stock Company
CIENCO1: Civil Engineering Construction Corporation No.1 (State Corporatio under MOT)
194 Co., Phu Tho Co. Rang Dong Co.: Vietnamese private construction company
Phu My Hung Joint Stock Company: Taiwanese Company
Phu My BOT Joint Stock Company:
CC1: Construction Company No.1 (State Corporation under MOC)
VICEM: Viet Nam Cement Industry Corporation
VIDIFI: Vietnam Development Infrastructure and Financial Investment
Thang Long Construction Corporation: State Corporation under MOT
National Highway 2 BOT Joint Stock Company: Joint venture by five companies (State Corporation under MOC) including IDICO

572. Table 140 has some findings below:

- While there are expressway project with new alignment parallel to existing national highway, there are widening projects of the existing national highways.

- Majority scheme of PPP is BOT scheme.

- While majority of investors of BOT projects is Vietnamese entity, particularly State Corporation or local government basis corporation, Vietnamese private investor or foreign investor are minor.

- For example, IDICO group is the State Corporation under the MOC (Ministry of Construction), with activities of development/investment of industrial zones, urban/residential areas development, hydro power, BOT transport, etc.

- And, Construction Company No.1 is also the State Corporation under MOC.

- CIENCO1 (CIENCO comprising 1 to 8) is the State Corporation under the MOT (Ministry of Transport), with activities of civil engineering, power plant, consultants, investment, financing, etc.

- BECAMEX IDC Corporation is State Corporation with relationship to local government (Binh Duong Province), with activities of infrastructure development / investment, project investment in the form of BOT, etc., financing, civil construction, industry and transportation.

- CII (Ho Chi Minh City Infrastructure Investment Joint Stock Company) has been established for the urban infrastructure development on the basis of authority of Ho Chi Minh municipality.

2. Overview of World Bank Report on Road Sector PPP in Vietnam

573. The followings are the overview of the World Bank study report regarding Vietnam Road Sector PPP Project. ("Road Network Improvement Project: Public Private Partnership (PPP) in the Road Sector, Draft Final Report, September 2008, World Bank".)

a. Vietnamese Experience with PPPs

574. Since 1994, PPP infrastructure projects in Vietnam have been concentrated in the field of energy and telecommunications sector. According to the PPP Database of World Bank, the share percentage of investment in transport sector is estimated 3% of the total amount of PPP investment up to end of 2006.

Table 141: Vietnamese Experience with PPPs

(Sector)	(Billion US$)	(Share Percentage)
Energy	$2.72 billon	68.0%
Telecommunications	$0.95 billon	24.0%
Water/Sewage	$0.21 billon	5.0%
Transport	$0.12 billon	3.0%
Total	$4.00 billon	100.0%

Source: PPI Database, World Bank 2007

575. PPP transport projects comprise the sector of seaport and airport terminals. No road sector projects were included in the database. At the time of the said report of World Bank study, thirteen road sector BOT projects have been found. Regarding these road sector BOT projects in Vietnam, World Bank report has evaluated that:

576. In the most cases, the investors of road sector BOT projects have been not a true private sector party, but an SOE (State-owned enterprise) or a joint stock company with majority shareholding by SOEs. These projects can therefore not be called as PPPs. However, the shareholders of the project company do operate on a commercial, "for profit", basis, then they can be considered as part of the "business" sector although not the "private sector". For this reason the term of Public-Business-Partnership (PBP) has been represented to describe the contract form of a "BOT" type contract between an authorized sate body and a public owned company as the investor.

577. The review of Vietnamese experience has shown that the usage of scheme of PBP has been successful in speeding up development of Vietnamese road infrastructure by mobilizing additional capital resources.

b. Financial Sector Review

578. The national commercial banking sector is, basically, not capable to participate substantially in the provision of the total amount necessary, on the terms and conditions required for the projected future financing road infrastructure projects in Vietnam.

579. On the international market the Vietnamese country rating by the rating agency (Standard & Poor) has indicated that the country is not investment grade, meaning that the country is not acceptable for the mainstream international investors in terms of requirement of

minimum rating level. Therefore, at this stage there is no immediate availability of substantial long term funding for road infrastructure projects in the international bond and bank market.

c. Proposed Framework for Government Support

580. Creating an enabling environment for the development PPP's in the Vietnamese road sector requires a Government strategy for mobilization of public participation, the design of an accurate risks assessment and the establishment of appropriate risk allocation and (financial) support mechanism.

581. An appropriate toll tariff is the main instruments for allocating risks between road users and the operators during the concession period.

582. In general, the Government can offer a wide range of incentives and take various other measures in order to reduce the risks and uncertainties that may be associated with a PPP project. The instruments and level of support provided depend on the risks involved for transfer to the private sector and the financing requirements of the project once a risk allocation structure has been established. The incentives are offered in a way that can significantly improve the financial viability of projects and reduce their implementation risks to make them attractive for the private sector.

583. The proposed potential support measures are, for example:

- Grants
- Operating subsidy (for O&M Contracts)
- Tax incentives

d. Legal and Regulatory Framework

584. Vietnam's current legal and regulatory framework is broadly enabling of PPPs in the road sector. However, significant improvements are still required, especially if the Government is interested in moving beyond existing "PPP type" arrangement with domestic SOEs towards attracting more foreign private investment to the roads sector.

585. The BOT Decree (78/2007) is a generic PPP law which is not tailored to the specific requirement of roads sector PPPs. Nor do existing road sector laws provide a comprehensive framework for PPPs. The adoption of a specific road sector PPP legal instrument is proposed to ensure that a flexible, enabling framework is in place. A draft version of a road sector PPP Decree has been prepared under these services.

586. Other key legislative and regulatory proposals are:

- Removal of the constrains on toll tariffs defined in Circular 90/2004, to allow toll tariffs to be varied in accordance with the specific characteristics of each project.
- Amendment to the law on investment to give road sector PPP projects the same special treatment as construction and development of infrastructure

foundation of industrial parks, export processing zones, high tech parks and economic zones.

- Clarification on the extent to which PPP projects are exempt from the Law on Tendering and associated by-laws.

3. Private Sector Participation PPP for O/M of Expressways

587. In this section, the focusing point of discussion about the private sector participation will be on the operation and maintenance of expressway which is to be constructed in terms of publicly-financed scheme. The possibility of the private sector participation for the operation and maintenance of expressway will be sought.

588. Not only in developed countries but also in developing countries, the conventional scheme of O/M by facility owner for publicly-built infrastructure has been main stream for a long term. In this scheme, O/M services are carried out directly by facility owner, in which responsibility for O/M and O/M cost burden are shouldered by facility owner.

589. Recently, mainly under the following background, PPP for infrastructure development has been introduced:

- Budgetary constrains in public sector
- Consideration for method to import private sector efficiencies and technical know-how

590. Also for the field of O/M for existing public facilities, there is no exception.

591. Participation of private sector into the field of services of operation and maintenance for existing public facilities has been prevailing. Out-sourcing of O/M services to private sector is initial stage of PPP in existing public facilities.

592. The following four options are assumed:

- Service contract
- Management contract
- Lease contract
- O/M Concession

593. The main features of these options of PPP (Public-Private Partnership) scheme for operation and maintenance of existing facilities are referred to Table 142.

Table 142: PPP Scheme of Operation and Maintenance (O/M) for Existing Facilities

	(1) Service Contract	(2) Management Contract	(3) Lease Contract	(4) O/M Concession
Main Feature	O/M services are out-sourced (only portions of services) to private company. Public remains the primary service provider. Private performs O/M services at the agreed cost. Public pay a fee for services to private. Public is responsible for funding capital investments required to facility expansion or improvement. Public remains in charge of tariff setting and assets.	Similar to Service Contract, but expanded the services to be contracted out, including some or all of the management and O/M of services. While public has ultimate obligation for service provision, daily management control is assigned to private. Private provides working capital, but no financing for investment for expansion or improvement. Private is paid by predetermined fee. Private interacts with customers, and public is responsible for setting tariffs. Useful in encouraging enhanced efficiencies and technology sophistication.	Private is responsible for services in its entirety. Except for new and replacement investments, which remain public responsibility, private provides services at his expense and risk. Responsibility for service provision is transferred from public to private. Private retains revenue collected from customers, and makes a specified lease payment to public. Private's profits depend on utility's sales and costs. This will provide incentive for private to achieve higher level of efficiency and higher sales. Useful in encouraging enhanced efficiencies and technology sophistication.	Private is responsible for the full delivery of services including O/M, collection, management, and rehabilitation. Private is responsible for all capital investment as well as for working capital. (Public may contribute to the capital investment cost (investment subsidy), if necessary.) Public is responsible for establishing performance standard, and monitoring. Public's role shifts from service provider to service regulator on tariff and quality of services. Private collect tariff directly from customers. The tariff is established by the concession contract. Useful in encouraging enhanced efficiencies and technology sophistication. Providing incentive to private to achieve improved level of efficiency. Including complexity of contract. Public needs to upgrade his regulatory capacity related to tariffs and performance monitoring.
Ownership of Existing Facility	Public	Public	Public	Public
Responsibility for O/M	Public	Private (Ultimate obligation for service provision remains in public.)	Private by Lease Contract	Private by Concession Contract
Revenue Risk	Public	Public	Private	Private
Risk for Private	Service contract provides a relatively low-risk option for expanding the role of private sector.	No risk of capital investment borne by private sector.	Financial risk for O/M is born by private. Private's profits depend on utility's sales and costs. Private's revenues are derived from customers, hence, the question of tariff level become increasingly sensitive.	Similar to (3) Lease Contract

Source: Compiled by Consultants based on:

Public-Private Partnership Handbook, ADB

Expressway Network Development Plan Project No. TA 4695-VIE, Final Report, FINNROAD, April 2007

Road Network Improvement Project: PPP in Road Sector, Vietnam, Draft Final Report, World Bank, September 2008

Web-site of FHWA (United States Department of Transport – Federal Highway Administration)

4. Recent Topics on PPP Scheme of Expressway O/M in Vietnam

a. HCMC – Trung Luong Expressway Project

594. HCMC – Trung Luong Expressway has been already invested by the Vietnamese Government from national budget funding. After completion of civil engineering works, BIDV (Bank of Investment Development of Vietnam) Expressway Development Company (BEDC) will be the unit who applies for buying the toll fee collection right over the above section.

595. Transferring model is: After having been supported by the Government with compensation for land acquisition cost, BEDC will have its responsibility to refund all remaining amount to the Government. Time for refunding to the Government is 17 years.

596. This can be considered as one model of PPP (O/M Concession).

b. Plan of Study for Evaluation of PPP Pilot Projects in Vietnam

597. Currently, the Ministry of Planning and Investment of Vietnam (MPI) has a plan to execute a study for evaluation of PPP Pilot Projects in Vietnam for the field of thermal power, hydro power, water supply and expressway maintenance.

5. PPP Scheme of O/M Services for VEC

598. Table 143 shows the comparison of PPP scheme of O/M services for VEC in accordance with the Table previously shown.

599. Regarding the contract scheme in terms of legal stipulation, the contents of contract in the case of Lease Contract or O/M Concession will require rather strict than others. And also for the O/M service standard, the regulation in the case of Lease Contract or O/M Concession will require rather comprehensive than others.

600. Regarding O/M service standard, for example in Indonesia, Ministry of Public Works, Indonesia has issued a “Minimal Service Standard for Toll Road”, comprising service substances covering toll road condition, average covering speed, accessibility, mobility, safety, rescue/safety unit and service aid.

601. Especially, in the case of O/M service performed not by only one company but by several companies for each toll road section, united O/M service standard is required.

Table 143: Comparison of PPP Scheme of O/M Services for VEC

	(1) Service Contract	(2) Management Contract	(3) Lease Contract	(4) O/M Concession
Contract Scheme for VEC	Out-source Contract (only portion of services) of O/M services to Private Company under the prepared O/M Service Standard	Similar to Service Contract. (expanded the scope of services to be contracted out)	O/M Lease Contract between VEC and Private Company under the prepared O/M Service Standard (rather strict)	O/M Concession Contract between VEC and Private Company under the prepared O/M Service Standard (rather strict)
Accumulation of Business Experience / Know-how of O/M Services for VEC	VEC can accumulate business experience / know-how of O/M services although less degree compared to Direct O/M	Similar to Service Contract.	Degree of accumulation of business experience / know-how of O/M services are less than Direct O/M, Service Contract, or Management Contract	Similar to Lease Contract

Source: Compiled by Consultants

6. Recommended PPP Scheme for VEC

602. According to the information obtained from VEC, VEC has a mind to be reluctant for O/M Lease or O/M Concession scheme, conceiving that the price of concession would be too high to be afforded by private company, and VEC have a mind to perform toll collection by himself.

603. In the experience in developed countries, for example in Japan, the Japan Highway Public Corporation has initially performed “service contract” since initial operation stage.

604. While as a “direct O/M”, service field of “toll collection” and “highway patrol” for partial road section have been performed, as a “service contract, service field of “toll collection” and “highway patrol” as well as other service fields have been done broadly. And step by step, the share portion of “service contract” in service fields has been increased compared to “direct O/M”.

605. It is considered that even there will be an introduction of O/M Concession in future, the scheme of “service contract” or “management contract” as a PPP scheme is reasonable to be introduced as a first step. Through an accumulation of business experience / know-how of O/M services in the scheme of “service contract” or “management contract” as a PPP scheme, VEC will proceed to the next stage to make a decision regarding, for example, “O/M concession”.

VI. ENVIRONMENTAL ASSESSMENT

606. The Environmental Assessment can be found in Volume III of the Final Report.

VII. RESETTLEMENT

607. The Resettlement Section can be found in Volume IV of the Final Report.

VIII. POVERTY AND SOCIAL IMPACT ASSESSMENT

608. The Poverty and Social Impact Assessment Section can be found in Volume IV of the Final Report.

IX. ETHNIC MINORITIES

609. The Ethnic Minorities Section can be found in Volume IV of the Final Report.

X. SOCIAL DEVELOPMENT AND GENDER ACTION PLAN

610. The Social Development and Gender Action Plan Section can be found in Volume IV of the Final Report.

XI. PREVENTION OF HIV/AIDS AND HUMAN TRAFFICKING

611. The Prevention of HIV/AIDS and Human Trafficking Section can be found in Volume IV of the Final Report.

XII. PUBLIC CONSULTATION

612. The Public Consultation Section can be found in Volume IV of the Final Report.