DATA COLLECTION SURVEY ON PHNOM PENH – HO CHI MINH CITY EXPRESSWAY DEVELOPMENT PLAN IN THE KINGDOM OF CAMBODIA

FINAL REPORT

JUNE 2014

JAPAN INTERNATIONAL COOPERATION AGENCY

KATAHIRA & ENGINEERS INTERNATIONAL
CENTRAL NIPPON EXPRESSWAY CO. LTD.
METROPOLITAN EXPRESSWAY CO. LTD.

CM
CR (1)
14-002

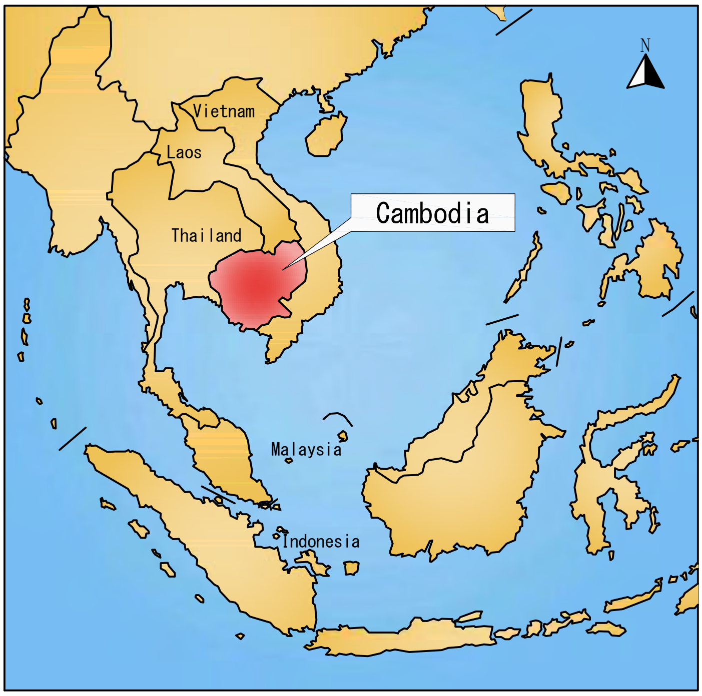
Exchange Rate

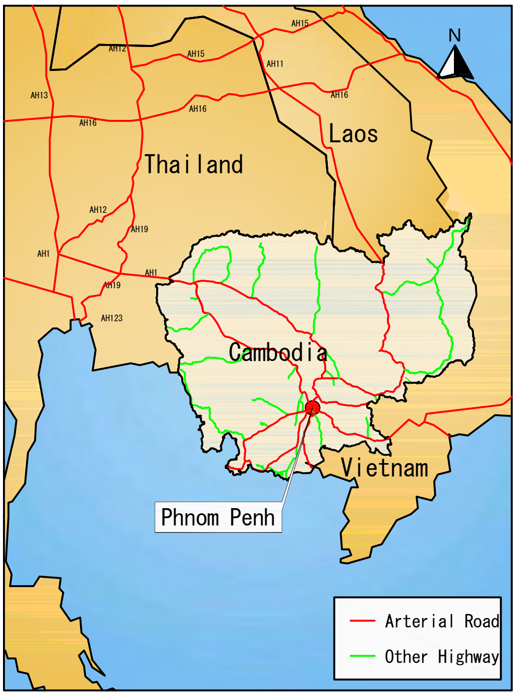
USD1.0＝JPY101.68

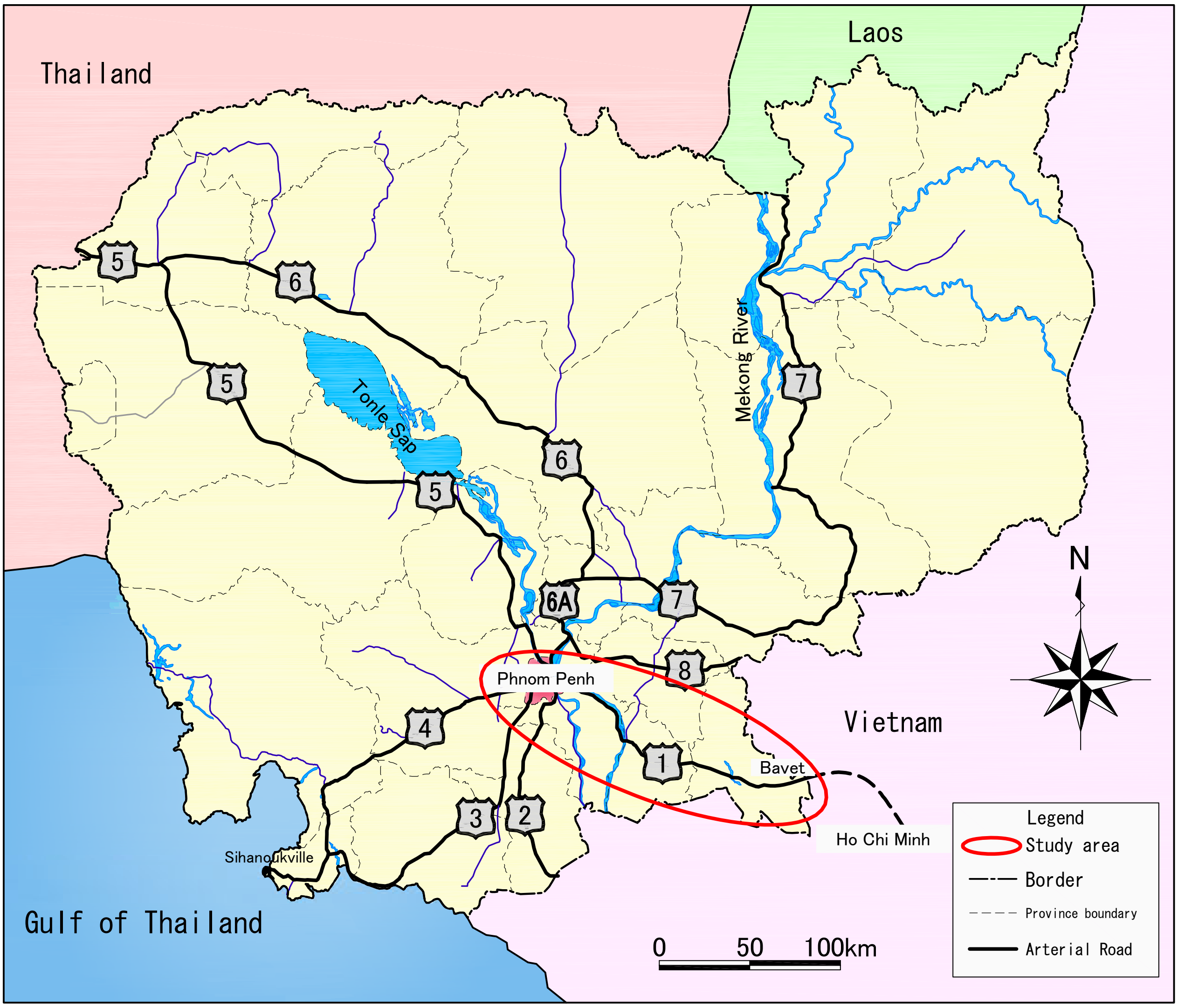
USD1.0＝KHR0.025

(KHR: Khmer Riel)

LOCATION MAP







SUMMARY

(1) The existing National Road No. 1 will be congested in the near future and a new road will become necessary between Phnom Penh – Svay Rieng (Bavet).

・ The cross-sectional composition of the existing National road No.1 (NR 1) is opposed 2 lanes plus motorcycle lanes on the both sides.

・ On the other hand, the traffic demand on NR 1 between Phnom Penh and Neak Loeung is forecasted to exceed 35,000 pcu/day by 2023 which cannot be accommodated by the existing road width of NR 1.

・ Widening of NR 1, especially between Phnom Penh and Neak Loeung is very difficult in view of the high density of houses on the roadside and large scale resettlement required for widening.

・ Thus, construction of a new road along a new alignment is the practical solution for the traffic congestion anticipated in the near future.

・ Considering the modernization of the economic/industrial structure of Cambodia, as well as the importance of Southern Economic Corridor of GMS, construction of an expressway between Phnom Penh and Ho Chi Minh City is the most suitable solution for traffic congestion on NR 1.

(2) Phnom Penh – Bavet (Ho Chi Minh City) Expressway will bring about various benefits.

・ Phnom Penh – Bavet Expressway (E1 Expressway) will bring about such benefits as listed below:

  ✓ Transition of industrial structure to modern one and contribute to the further economic growth of Cambodia

  ✓ Increase of tourists from Ho Chi Minh City

  ✓ Expansion of markets for agricultural products

  ✓ Increase of foreign investment and increase of job opportunities

  ✓ Enhancement of competitiveness of Cambodian export commodities

  ✓ Improvement of access to public services, such as high-level medical services

(3) It is time for Cambodia to start construction of expressway network.

・ Construction of expressway network needs to be started well before the economic growth.

・ With GDP per capita of USD 1,000, it is time for Cambodia to start construction of the expressway network.

(4) Improvement of the existing road network and construction of expressway network need to be implemented in parallel.

・ Improvement of the existing road network and construction of expressway network need to be implemented in parallel. This has been, and are being, done in many countries.

- Transport efficiency of expressway is more than 20 times of average road. Thus, larger construction cost per kilometer of expressway than that of ordinary road is justified.
- Amount of road investment should be increased so that implement improvement of the existing road network and construction of the expressway network can be implemented in parallel.
- Investment in road can be recovered with increase of government income in the future which accrues from the economic growth brought about by the improved road network including expressway network.
- Two percent (2%) of GDP can be the target for road investment.
- The GDP of Cambodia in 2013 was USD 15 billion. If 7% per annum of economic growth continues, GDP of Cambodia will exceed USD 22 billion before 2020. Thus, more than USD 400 million per year can be invested in road. Then, USD 250 million can be invested in expressway and 150 USD million can be invested in ordinary national highways.
- ODA should be positively introduced in development of the road network including expressway.
- In parallel to development of E1 Expressway, Neak Loeung – Bavet section of the existing National Road No.1 should be improved.

(5) Two alternative routes of E1 Expressway are proposed.

- Four alternative (A – D) routes of E1 Expressway were studied.
- Route B is recommended as the optimum route.
- Route C is also technically feasible and final selection of the route will be done after further evaluation of these two alternative routes by the Cambodian government.
- Ring Road No. 3 should be constructed simultaneously with E1 so that it can function as the feeder/collector of E1.

(6) Structure of E1 will be mixture of high embankment, low embankment and viaduct.

- Considering difficulty in obtaining large volume of soil, splitting of community, roadside land use, crossing of existing roads as well as flood, it is proposed that the structure of E1 Expressway be mixture of high (7.5 m) embankment, low (3 m) embankment and viaduct.
- Sufficient number of box culverts (in high embankment) or over-bridges (in low embankment) (at an interval of 1 km) shall be provided in order to secure the convenience of the traffic across the expressway.

(7) Cost of construction will be large but will be financially and economically viable.

- Construction cost of E1 is estimated to be approximately USD 2,230 million.
- Although the construction cost is huge, the benefit is also large, and EIRR is estimated to be more than 12%. Thus the project is evaluated be economically feasible.

- If an ODA loan with interest rate of 0.1% per annum[1] and grace period of 10 years is adopted as the fund source, the annual amount of redemption is calculated to be US$ 72 million which can be paid using the toll revenue every year, without introducing any supplementary fund, and the loan can be amortized in 35 years after opening to traffic.
- If the fund is obtained from commercial bank with an interest of 6% per annum, the toll revenue will not be sufficient to amortize the debt and the debt will increase in geometrical progression.
- In the most unfavorable scenario where the construction cost is increased by 10% while the toll revenue is reduced by 10%, the toll revenue is not sufficient to pay annual redemption and issuance of bond becomes necessary to fill the gap between the toll revenue and the redemption. Also, it will take 40 years after opening to traffic to amortize the ODA loan and the bond.
- In this case, it is proposed to construct Phnom Penh – Bavet Section in 3 phases to avoid concentration of investment and annual redemption and make amortization of loan easy.
- If constructed in 3 phases, all the debt (ODA loan and bond) of the most unfavorable case will be amortized in 34 years after opening to traffic of the expressway.

(8) PPP is not suitable for development of expressway network.

- PPP was first introduced in the developed countries where the basic road network has been already constructed.
- PPP is not suitable as the fund scheme for development of basic expressway network.
- Construction of expressway cannot be implemented as scheduled if PPP is adopted since the government has to wait until an interested investor appears.
- There are many countries who successfully constructed expressway network without using PPP and there are many countries who have problems in development of expressway network by adopting PPP as the main fund source.
- If there is a line or section where PPP is feasible, it means that there is sufficient profit to attract investors. Such section should be constructed by the government (Expressway Authority) and the profit should be used as the subsidy to non-profitable line/section.
- In the toll road system proposed by this survey, the fund for development of expressway is covered by the toll revenue and the government fund need not be injected. Thus, the proposed toll road system is very close to PPP in fund procurement.

(9) Toll revenue pool system should be introduced.

- Toll revenue pool system reduces the difficulty in financing of the construction of whole expressway network by taking the profit from profitable lines/sections and injecting it in non-profitable lines/ sections.

(10) If the feasibility is started by the beginning of year 2015, the opening of the 1st phase

[1] A STEP (Special Terms for Economic Partners) Loan of Japan is assumed here.

(Phnom Penh – Neak Loeung) is expected in year 2023.

- It is expected that it takes 9 years from the beginning of feasibility study to the opening to traffic of the 1st section. Thus, the first section is expected to be open in 2023 if the feasibility study starts from the beginning of 2015.
- The existing NR 1 accommodates the traffic between Phnom Penh and Bavet until E1 Expressway will be opened to traffic. It will also function as the alternative road for E1 Expressway. Thus improvement of this section should be implemented before the construction of E1 Expressway will be started.

(11) A new organization exclusively responsible for construction and operation of the national expressway network should be established.

- Implementation of expressway project requires high capacity of project administration, high level of engineering knowledge and skill, as well as high sense of commitment and incentive.
- Also, it requires fresh ideas not influenced by precedent cases and old ideas.
- Personnel involved in expressway projects need to be highly motivated and work efficiently. Thus, their working conditions, including salary, should be close to those of private firms.
- A new organization (Expressway Authority) should be newly established to be exclusively responsible for construction and operation of the expressway network, under the supervision of the Minister of Public Works and Transport.
- A preparatory office should be established in MPWT to start preparation of establishment of Expressway Authority.

(12) A few expressway-related laws need to be enacted and some revision should be made on Road Traffic Law

- Such legislations as Law for construction of expressway network, toll road law and decree/law for establishment of Expressway Authority need to be enacted for successful development of expressway network.
- Exiting Road Traffic Law need revision to be suitable for securing safe traffic on expressway. Several new stipulations, including the following, need to be added:
  - ✓ Minimum speed
  - ✓ Limitation of type of vehicles which are allowed to use expressway

(13) Feasibility study should be started in the beginning of year 2015.

- So that E1 Expressway will be open in early 2020s, the feasibility study should be started as soon as possible.
- The proposed route of E1 Expressway should be diligently evaluated by the Cambodian government and fixed before the feasibility study will be started.

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LIST OF ABBREVIATIONS

AC	: Asphalt Concrete
A/C	:ASEAN (Economic) Community
ADB	: Asia Development Bank
AH 1	: Asian Highway No. 1
ASEAN	: Association of South East Asian Nations
Bc	: Box Culvert
B/C	: Benefit Cost ratio
BOT	: Build, Operate and Transfer
Br	: Bridge
CDC	: Council for the Development of Cambodia
DBST	: Double Bituminous Surface Treatment
D/D	: Detailed Design
DPWT	: Department of Public Works and Transport
EFRP	: Emergency Flood Rehabilitation Project
EIRR	: Economic Internal Rate of Return
FS	: Feasibility Study
GDI	: Gender-related Development Index
GDP	: Gross Domestic Product
GMS	: Grater Mekong Sub region
IC	: Interchange (of expressway)
JICA	: Japan International Cooperation Agency
KP	: Kilometer Post
L	: Length
LA (L/A)	: Loan Agreement
LV	: Light Vehicle
MC	: Motorcycle
MEF	: Ministry of Economic and Finance
MOE	: Ministry of Environment
MOWRAM	: Ministry of Water Resource and Meteorology
M/P	: Master Plan
MPWT	: Ministry of Public Works and Transport
NASA	: National Aeronautics and Space Administration
NPV	: Net Present Value
NR	: National Road No. (ex: NR 1 = National Road No. 1)
OD	: Origin Destination

ODA	: Official Development Assistance
PC	: Pre-stressed Concrete
PCDG	: Pre-tensioned Precast Concrete Deck Girder
PCU	: Passenger Car Unit
PPP	: Public Private Partnership
P/S	: Preliminary Data Collection Survey for Expressway Development in the Kingdom of Cambodia
PSC	: Pre-tensioned Precast Plank hollow slab
RGC	: Royal Government of Cambodia
ROW	: Right of Way
RR 3	: Ring Road No. 3 (of Phnom Penh)
STEP	: Special Terms for Economic Partners
SEZ	: Special Economic Zone
SPT	: Standard Penetration Test
STRADA	: System for Traffic Demand Analysis
VCR	: Traffic Volume per Capacity Ratio
W	: Width

CHAPTER 1 INTRODUCTION

1.1 Background

The national road network of Cambodia was severely deteriorated during the civil war and there were many impassable sections. Many road rehabilitation projects were implemented in 1990s to early 2000s with financial assistance by Japan, USA, Australia, the Asian Development Bank (ADB), the World Bank and other development partners. As the result, urgent rehabilitation of the existing roads has been completed, and the main focus of road network development is now shifting to strengthening of the functions of existing road network to support the rapid economic growth of Cambodia, as well as to promote the regional cooperation among ASEAN and GMS countries.

One of the major issues for strengthening of the road network function is construction of the national expressway network. Because of much high efficiency, high travel speed and stable traffic condition, an expressway is a highway which enables drastically better transport services compared with the ordinary highways, and is considered to be essential for modern industrial and social activities.

Under such circumstances, Japan International Cooperation Agency (JICA) implemented "Preliminary Data Collection Survey for Expressway Development in the Kingdom of Cambodia" (herein after referred to as "the Preliminary Survey" or "P/S") in June to August 2013[1] to collect and compile the fundamental information/data which was used to discuss with the senior management of the Ministry of Public Works and Transport (MPWT) of the Royal Government of Cambodia (RGC) on the necessity of formulating a master plan for national expressway network of Cambodia.

[1] The report of P/S is attached as Annex-1.

The survey recommended that a national expressway network, with a total length of 2,200 km be planned and constructed.

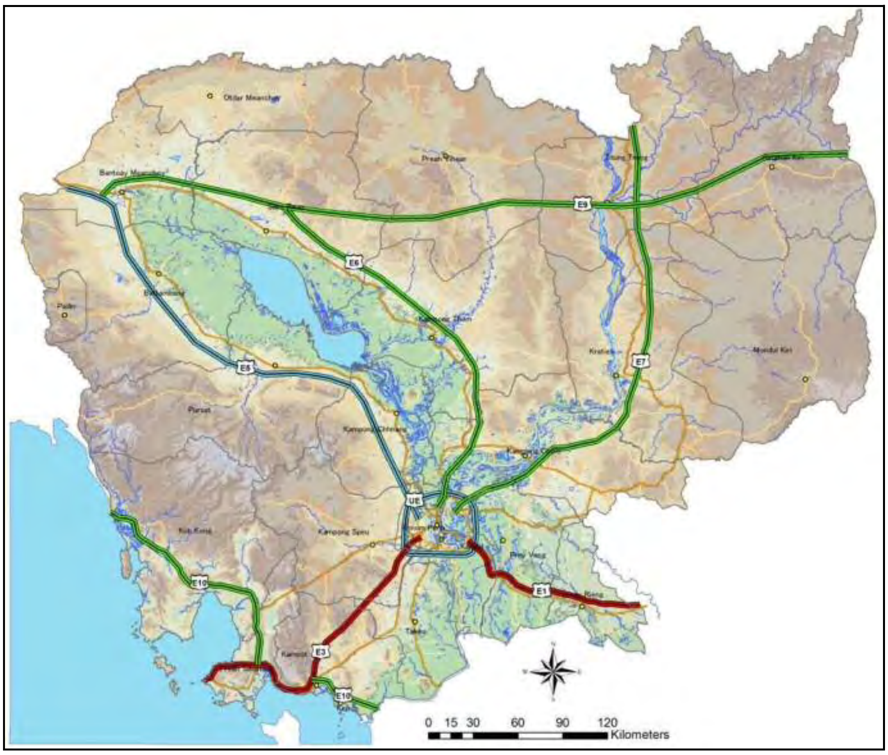


Figure 1.1-1 National Expressway Network Proposed by the Preliminary Survey

However, it turned out that a study on the expressway master plan had been started with a technical assistance of Henan Province, China.

After consultation between MPWT and JICA, it was agreed that JICA conduct data collection survey on development of Phnom Penh – Ho Chi Minh (Bavet) Expressway (E1 Expressway) which is of the highest priority among the many routes of the national expressway network of Cambodia.

1.2 Objective of the Survey

The objective of this survey is to examine the feasibility of the Phnom Penh – Bavet Section (hereinafter referred to as "E1 Expressway" in this report) of Phnom Penh – Ho Chi Minh City Expressway, including technical, economical and financial feasibility. The results of the survey, such as institutional plan, funding scheme and legal framework, are expected to be used as the pilot case for the whole national expressway network plan. **Thus, the discussions stated in this report can be applied to the whole expressway network of Cambodia.**

1.3 Scope of the Survey

To achieve these objectives, the scope of the survey is as listed below:

- Study of route of the E1 Expressway, including locations of interchanges and rest facilities
- Study of route of the section of Ring Road 3 which will not be included in the project of improvement of Ring Road 3 to be financed by ODA/PPP of Korea.
- Traffic demand forecast taking into account the "resistance" of toll
- Proposal of design criteria, typical cross section and preliminary cost estimate
- Economic/financial analysis, including estimation of toll revenue, cash flow analysis and funding plan
- Proposal for revision/adjustment in legal framework
- Proposal on the issues which are essential for actually implementing construction and operation of E1 Expressway, including institutional plan, operation and maintenance plan and implementation schedule.

The result of the survey will be used for preparing the scope of work (SOW) of the feasibility study of the E1 Expressway in the future.

1.4 Survey Area

The survey area is the area along supposed route of E1 Expressway and Ring Road 3.

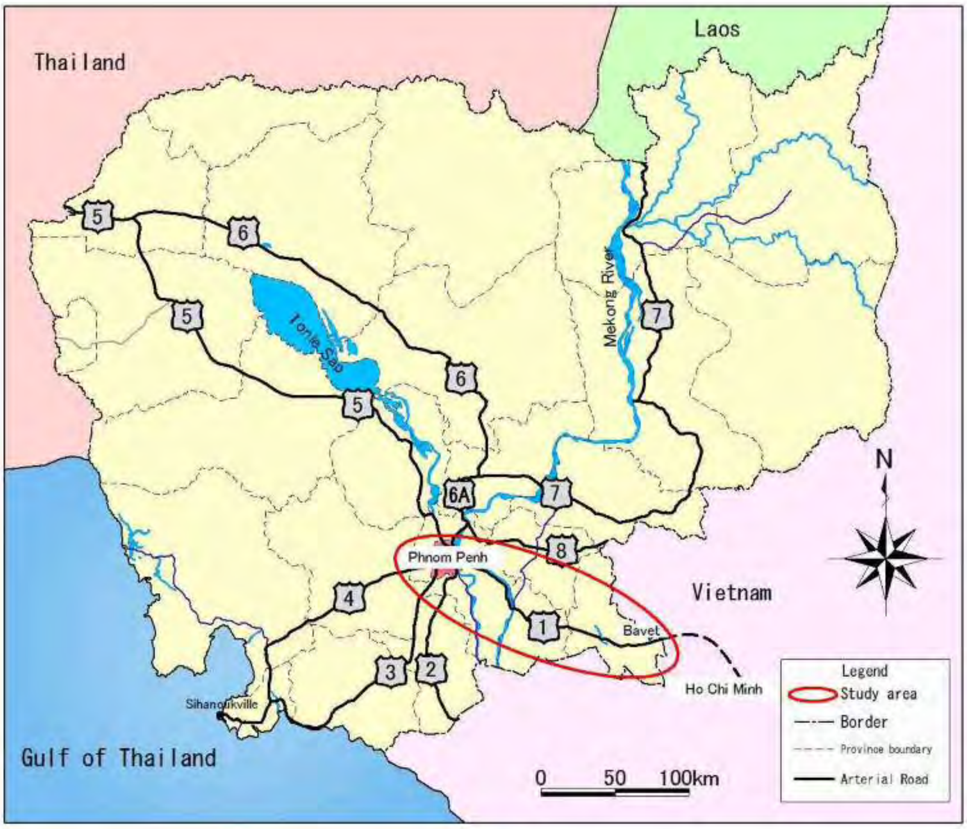
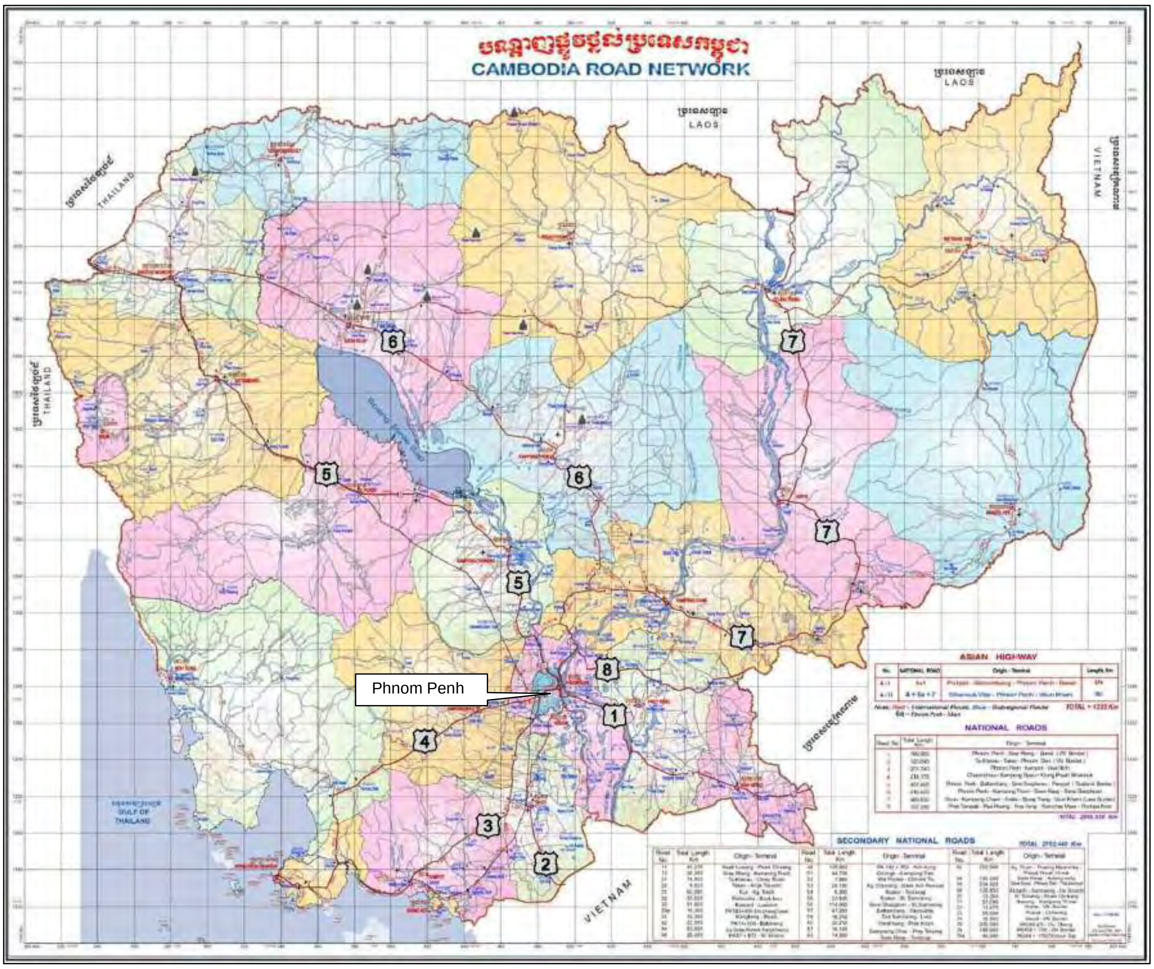


Figure 1.4-1 Survey Area

CHAPTER 2 ROAD NETWORK OF CAMBODIA AND NECESSITY OF EXPRESSWAY

2.1 National Road Network of Cambodia

National Road Network of Cambodia consists of arterial national roads with single digit numbers (1 to 8) and minor arterial roads with double digit numbers. The total length of National Roads is 5,224 km (as of year 2009). Out of this 5,224 km, 2,263 km are single digit national roads and 2,961 km are double digit national roads, respectively. Figure 2.1-1 shows the map of national road network of Cambodia. As can be seen in the figure, most of the arterial national roads of Cambodia extend in radial directions centered at Phnom Penh and reach to the border points with neighboring countries of Vietnam and Thailand. They are numbered, in principle, in crock-wise direction starting from No.1.



Source: MPWT

Figure 2.1-1 National Road Network of Cambodia

As stated in Chapter 1, almost all the sections of 1-digit roads have been urgently rehabilitated with double-layer bituminous surface treatment (DBST) or asphalt concrete (AC) surface and almost all the sections are now passable. Starting from early 2000s, the focus of the road network development of Cambodia has shifted from urgent rehabilitation of 1-digit roads to rehabilitation of 2-digit roads and strengthening of 1-digit roads, including widening to 4-lane and improvement of pavement from DBST to AC.

In view of the rapid economic growth in recent years and expected further development of economic and social activities, the road network of Cambodia needs to be strengthened in three fields.

(1) Widening and improvement of pavement into asphalt concrete to cope with the increase in traffic demand and increase in vehicle weight.

(2) Improvement of local roads in order to distribute the benefits of improvement of national roads to the local communities.

(3) Construction of expressways which are needed for modern industry/economy.

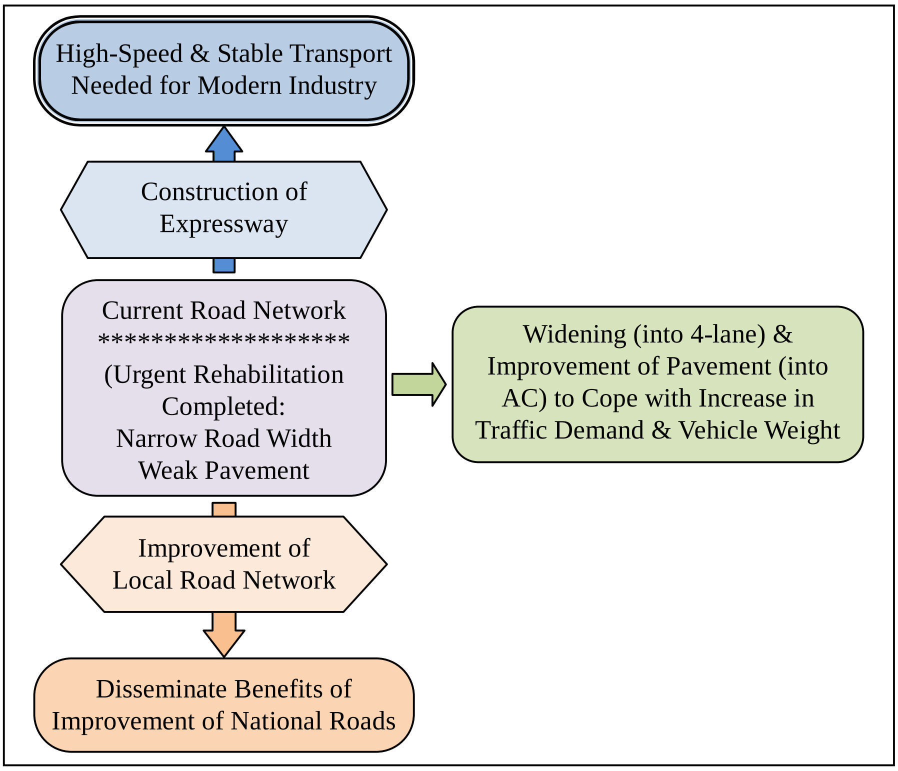


Figure 2.1-2 Three Fields for Strengthening of Road Network of Cambodia

2.2 Necessity of Expressway Development

2.2.1 Existing Condition of NR 1 and Traffic Congestion in the Near Future

Width of most part of the exiting NR 1 is 10 – 12 meters, except a 4km-long section between Monivong Bridge and KP 11. The section between KP 11 and the crossing point of Mekong

River (Neak Loeung Ferry) has been widened to 2 lanes with 2.5m-wide motorcycle lanes on both sides under Japanese grant aid. A cable-stayed bridge is currently being constructed across Mekong River at Neak Loeung and is expected to be completed in year 2015. The cross-sectional composition of this bridge is also 2 lanes plus motorcycle lanes.

On the other hand, the traffic demand on NR 1 is rapidly increasing due to the rapid economic growth of Cambodia and is anticipated to exceed 35,000 pcu/day by year 2023, or 10 years from today (see Section 6.2, Chapter 6). This traffic volume cannot be accommodated by the exiting road width of NR 1, and widening of NR 1 becomes necessary. However, the both sides of NR 1 is densely populated on the most of the sections between Phnom Penh and Neak Loeung, and thus, widening of NR 1 is very difficult from the viewpoint of land acquisition and resettlement.

Under such conditions, construction of a new road along a new alignment, away from NR 1 becomes the practical solution to the traffic congestion on NR 1 which is anticipated in the near future. If a new road is to be constructed, an expressway, rather than ordinary highway, is more suitable for the reasons as stated below.

2.2.2 Effect of Expressway on Economic Growth and Improvement of Social Welfare

Expressway network give various effects on the economic growth and improvement of social welfare through large scale improvement in transportation of goods and passengers. Governments of many countries consider expressway as an effective or indispensable tool for economic growth and creation of the society with much improved social welfare. Thus, many governments are, or have been, exerting strenuous effort to develop their expressway network. This section discusses effect of expressway network on economic growth and social welfare.

(1) Effect on Growth of National Economy

It is widely known that speedy and stable road transport is one of a few fundamental infrastructures to attract foreign investment[1], together with stable and sufficient power supply. This is because speedy and stable transport is indispensable for reducing transport cost and transportation time. Also, reduced transport cost and time result in increase in competitiveness of export products[2]. Both of these lead to growth of the national economy.

In addition, investment in expressway construction will stimulate the macro economy of Cambodia resulting in the economic growth. (Investment in fundamental infrastructure leads to economic growth. This is one of the major reasons that many government plans to invite international event such as the Olympic Games and the World Cup games of succor. For example, a trial calculation estimated that USD 600 million investment in expressway in Niigata, Japan would result in growth of the regional GDP worth nearly 3 times of it (USD 1,800 million). This is so-called “multiplier effect”.

1 Many Japanese businesses operating in Phnom Penh SEZ pointed out, in the interviews for the Willingness-to Pay survey conducted in this data collection survey, that high transportation cost is one of their major problems in Cambodia.

2 On-time delivery of parts is one of the major features of the modern industries such as automobile industry.

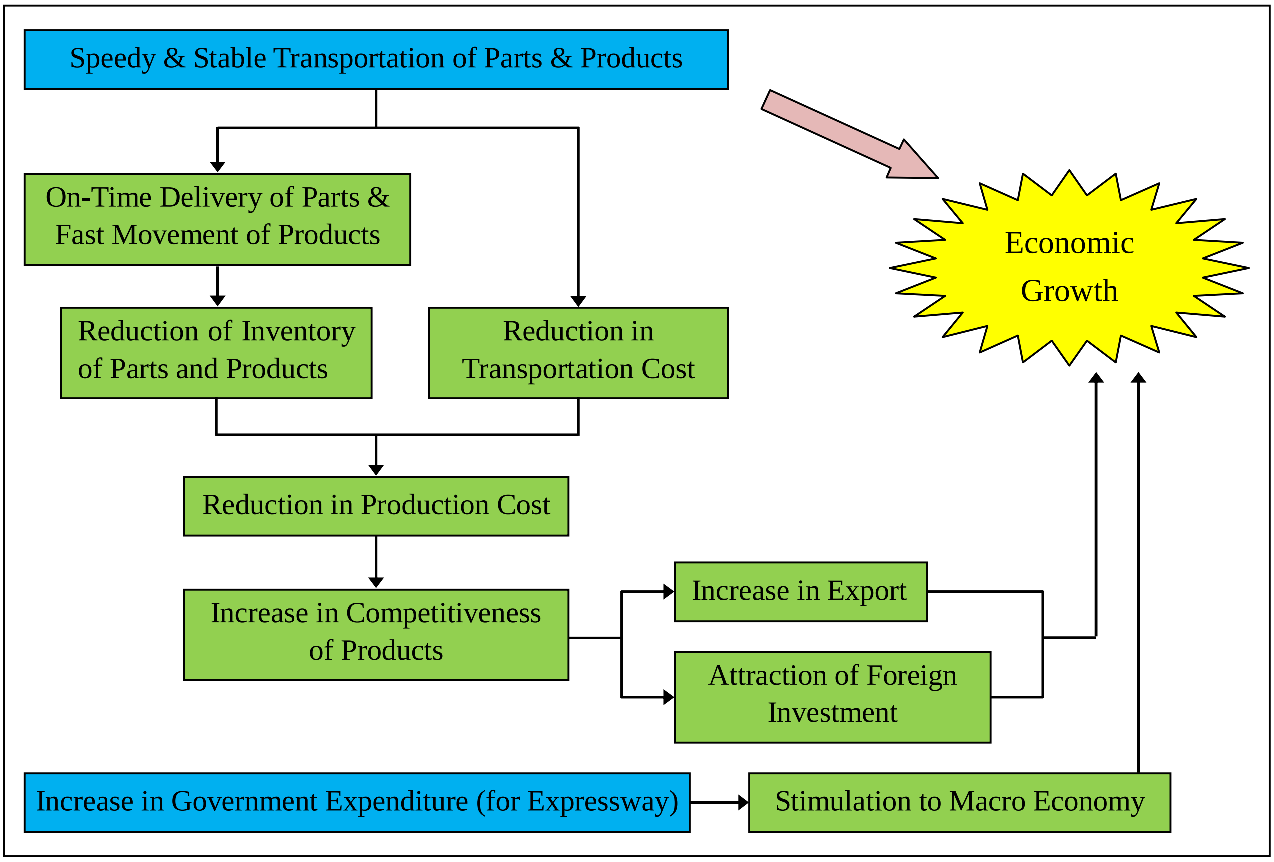


Figure 2.2-1 Effect on National Economy

As discussed in Chapter 3, the efficiency of expressway in Japan in transport of commodities is more than 20 times of that of ordinary road[3]. Therefore, contribution of the national expressway network is more than 20 times of that of ordinary roads in per km basis. Contrary, lack of the expressway network greatly reduces the efficiency of transport and hinders economic growth. This is the reason that many governments exert much effort, both financially and administratively, for development of expressway network.

(2) Effect on Promotion of Tourism

Phnom Penh is growing as the major tourist spot of Cambodia next to Siem Reap. Many of foreign tourists come to Phnom Penh from Ho Chi Minh City in Vietnam or vice versa. Many of such tourists travel by long-trip buses operating between Phnom Penh and Ho Chi Minh City. (Considerable number of tourists coming from Ho Chi Minh City and go to Siem Reap also take buses from Ho Chi Min City).

It is now taking 6 hours or more between Phnom Penh and Ho Chi Minh City, including 5 hours between Phnom Penh and Bavet (using the ferry at Neak Loeung). This will be shortened by 3 hours and become 3 hours when the expressway between Phnom Penh and Bavet will be

[3] The total length of expressway network (approximately 10,000 km) is 1% of that of all roads (more than 1,175,000 km) in Japan while the share of cargo transport on the expressway network (1.35 billion ton-km) is more than that of all roads (3 billion ton-km) or 43%. (See Table 3.1-1, Section 3.1).

completed. Currently, some portion of travelers between Ho Chi Minh City and Phnom Penh are using airplane. When the expressway will be completed, the bus services, with much shorter travel time and much more comfortableness than now, and with much lower fare than that of airplane, will have strong competitiveness against the air transport. This will lead to increase of tourists between these two cities, as a whole.

Figure 2.2-2 Foreign Tourists Arriving from Ho Chi Minh City by Bus

The above discussion is particularly true in case of E1 Expressway, and can be applied to other expressways in general. Currently, the tourist spots of Phnom Penh are represented by Wat Phnom. With construction of E1 Expressway, together with improvement of NR 5 will make the Oudongk heritage area (Phnom Oudongk and Longvaek) a part of the tourist spots of Phnom Penh.

(3) Effect on Agriculture

Agriculture also gets benefit from expressway. Reduction in transportation time will result in expansion of the market. Reduction in transportation time will bring about better freshness of the agricultural products as well as reduction of damage during haulage and reduction in the loss of the products. All these combined will result in increase of value of agricultural products at the market. In other words, if the market price is the same, vegetables produced at, and transported from, remote areas can be sold at the same market. Thus the sales of the agricultural products produced in the areas far from the market (big city) are expanded.

On the side of consumers, agricultural products of remote area transported via expressway will give wider variety of agricultural products enjoyed in the cities. Thus, the consumers can also enjoy the benefit of expressway.

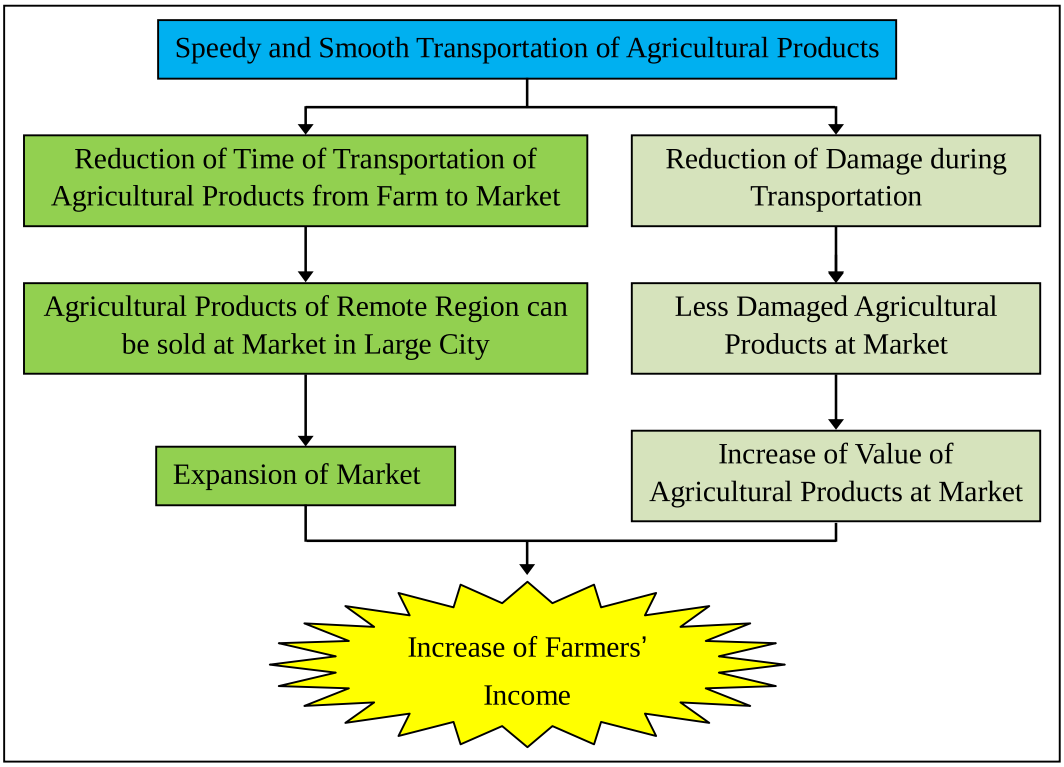


Figure 2.2-3 Effect on Agriculture

Likewise to the discussion of effect on promotion of tourism, the above discussion of the effect on agriculture can be applied to the expressway network of Cambodia in general, but particularly fits to the case of E1 Expressway since E1 is connected to Phnom Penh which is the largest market of Cambodia by far.

Figure 2.2-4 Agricultural Products Sold in One of the Major Food Market in Phnom Penh

The vegetables shown in the this photo were probably transported from the farms near Phnom Penh; More variety will be available when E1 Expressway will be open to traffic and various vegetables will be able to be transported from the farms in remote areas.

(4) Effect on Improvement of Social Welfare

The effect of expressway network development is not only on economic aspects. For example, owing to speedy and comfortable travel of people, the patients who are living in the remote area and need high-level medical care can access to large hospitals in large cities such as Phnom Penh.

Figure 2.2-5 Improvement of Access to High-Level Medical Services

(5) Regional Cooperation among ASEAN and GMS Countries

ASEAN countries including Cambodia are scheduled to agree on establishment of ASEAN Community (A/C), ASEAN version of EU, in 2015. A/C is expected to accelerate the regional cooperation and economic growth among the member countries. This will result in demand for speedy and stable transport of goods and people. The fact that strengthening of ASEAN Highway Network is listed among the components of the A/C Protocol is considered to indicate that the member countries of A/C well recognize the importance of strengthening its highway system.

Bangkok – Phnom Penh – Ho Chi Minh City route is one of the most important routes in ASEAN Highway Network, as can be easily understood from the fact that it is designated as Route No.1 of the ASEAN Highway Network (AH1) and also designated as Southern Corridor of GMS.

Source: Transport and Trade Facilities in General Mekong Subregion, ADB

Figure 2.2-6 Southern Corridor of GMS

Construction of the expressways between these cities, especially the expressway between Phnom Penh and Bavet is expected to contribute to the enhancement of connectivity between Bangkok, Phnom Penh and Ho Chi Minh City in view of the following facts:

- ✓ The distance between Phnom Penh and Ho Chi Minh City along the existing road is approximately 210 km. Connected by an expressway, it will take only 2 hours by a passenger car (3 hours by truck) to travel between the two cities. This will stimulate the communication between the two cities.
- ✓ Towards Bangkok, National Road No.5 (NR 5) from Prek Kdam to Poipet is to be widened to divided 4-lane and bypasses are to be constructed around the major cities such as Battambang and Kampong Chnang under Japanese ODA loan. (Phnom Penh – Prek Kdam section is currently being widened under financial assistance of Chinese government.) The distance between Phnom Penh and Poipet along the existing road is approximately 400 km and it takes around 10 hours by truck without taking rest. When the widening of NR 5 will be completed, travel time between Phnom Penh and Poipet will be reduced by more than 3 hours. Thus, connectivity between Phnom Penh and Bangkok will also be strengthened after completion of widening of NR 5.
- ✓ Construction of E1 Expressway, together with widening of NR 5 will greatly contribute to the strengthening of connectivity among Bangkok, Phnom Penh and Ho Chi Minh City.

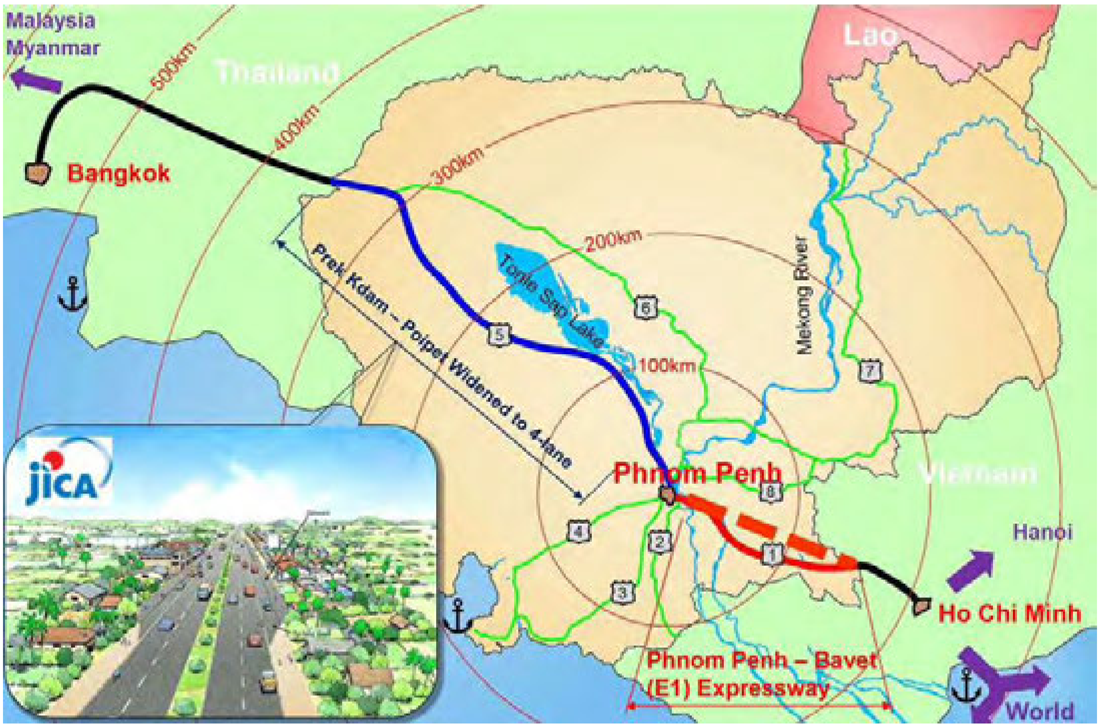
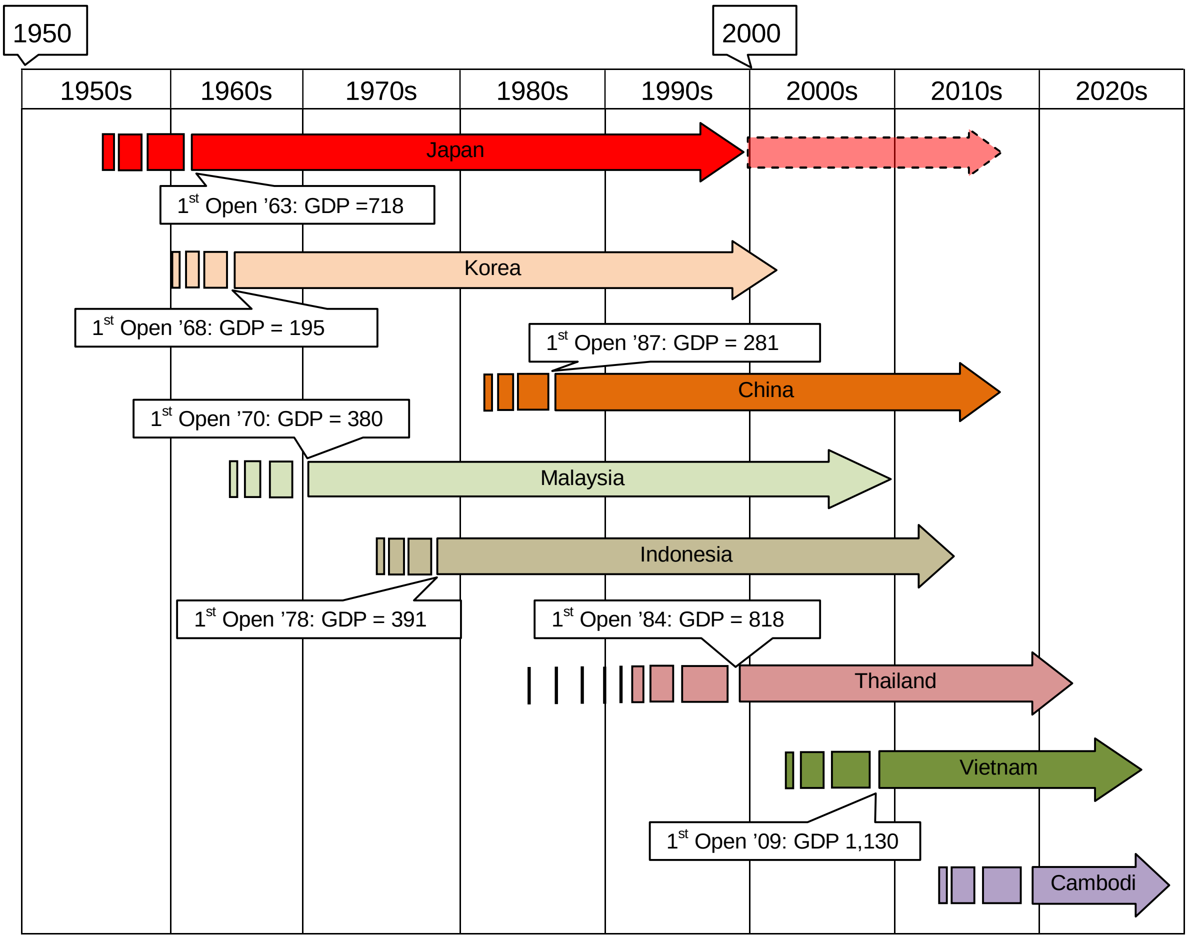


Figure 2.2-7 Connection between Bangkok – Phnom Penh – Ho Chi Minh City

2.2.3 Timing of Starting Construction of Expressway Network

Some people may ask whether or not it is too early for Cambodia to start constructing expressways when the national economy is still at its early stage of development and the ordinary national roads still needs many improvement works. The answer to this question is that development of the national expressway network is the investment to promote the economic growth and it needs to be started well before the rapid economic growth starts. Also, it should be noted that construction of expressway network needs long period, such as 30 years. Therefore, unless construction is started in well before the economic growth starts, the expressway network cannot be completed in time and cannot effectively support the economic growth.

The governments of many Asian countries are aware of the necessity for early start of expressway construction, and had started construction of expressway network well before the economic growth started when GDP per capita was much less than USD 1,000 (see Figure 2.2-8).



Note: "GDP" means GDP per capita

Figure 2.2-8 Timing of Expressway Construction in Asian Countries

The GDP per capita of Cambodia is now nearly USD 1,000. It is time for Cambodia to start construction of its national expressway network.

If the start of construction of the expressway network is delayed, it will hamper transition of industrial structure from low-tech and low-value-added industry to high-added-value and high-tech industry. It is often reported in the mass media that the foreign investors who are now operating in China and Vietnam are considering to move to other countries because the labor costs in these countries are rising in accordance with the economic growth. On the other hand, the labor cost of Myanmar is reported to be lower than that of Cambodia. If there is no particular advantage in Cambodia, those foreign investor may move to Myanmar, instead of Cambodia. If the expressway network is constructed, it will become a strong advantage to attract foreign investment.

In addition, if the construction of expressway network is delayed, the labor cost, material cost, land acquisition cost and other costs for expressway construction will become higher, due to economic growth, and the expressway projects will become financially difficult.

CHAPTER 3 FUNDAMENTAL POLICY ON EXPRESSWAY NETWORK DEVELOPMENT

Since development of expressway network is an important and large-scale national project, fundamental policy needs to be established and practiced after discussion among the stakeholders. This chapter discusses such fundamental issues. This chapter is to provide the political leaders as well as business leaders and the general public with the basis for discussion and consideration on the fundamental policy of expressway network development in Cambodia.

3.1 Justification and Possibility of Investment in Expressway Network Development

Development of a national expressway network requires huge amount of investment. This investment is justified in view of the huge and wide spectrum of benefits accruing from the expressway network as discussed in the previous chapter. However, someone may argue whether or not investment in expressway is justified in view of the scarcity in available fund as well as many problems of the existing road network which needs urgent measures. Thus, it needs to be well understood among the political leaders, government officials and general public that the investment in expressway network can be justified.

(1) Investment in Road Network as Preceding Investment for Future Economic Growth

Investment in road in general is regarded as the investment to support the economic growth. Economic growth is always accompanied by increase in movement of goods and people. If this increased movement of goods cannot be smoothly catered, the economic activities will be hampered. Thus, the government needs to complete improvement of the transport infrastructure, including road, by the time rapid economic growth starts. At this stage, the fund that the government can mobilize is not sufficient for implementing many projects of transport infrastructure. Therefore the government needs to borrow the fund to fill the fund shortage. With economic growth which occurs later, the government’s revenue increases. Thus, the fund invested on road network will be harvested in the future in the form of increased tax revenue or other form of government revenue. Therefore, it is justified that the government borrow money, strengthen the road network and harvest the increased tax revenue. This may be compared to the construction of a factory with fund borrowed from the bank and get profit when the factory produces the products. This profit is used to return the borrowed fund.

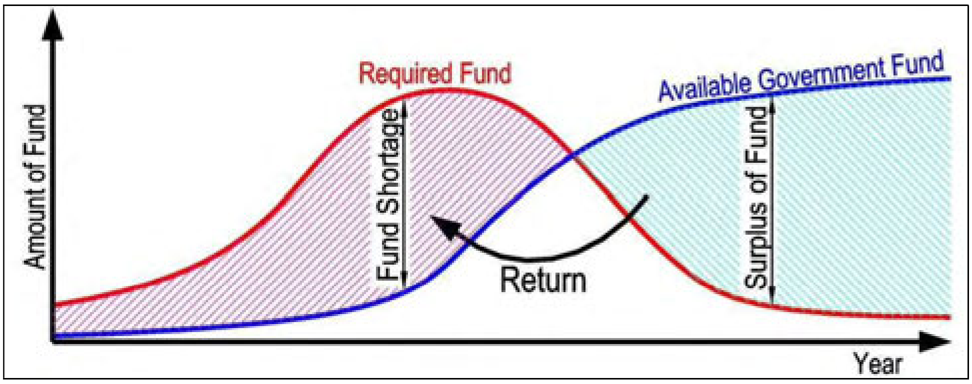


Figure 3.1-1 Concept of Preceding Investment and Future Return

(2) High Transport Efficiency of Expressway

Some people may argue that improvement of existing national roads is more urgent need and fund should be spent on the existing road network, rather than invested on expressway network. The answer to this question is high transport efficiency of expressway compared with the ordinary roads. As shown in Table 3.1-1, the total length of the expressway of Japan is 0.74% of the whole road network of Japan, while the volume of cargo transported via the expressway accounts for approximately 23%. This means that the volume of cargo that is transported via 1km of expressway is 31 times of that of 1km of ordinary roads.

Table 3.1-1 Comparison of Total Length and Ton-Kilometerage of Cargo Transport

(As of 2019)

Road	Total Length	Cargo Transport
Entire Road Network (Incld. National, Provincial & Municipal Rds.)	1,180,342 km	335.0 billion ton-km
	100%	100%
Expressway Network	8,730 km	76.8 billion ton-km
	0.74%	22.9%

On the other hand, the construction cost of expressway is assumed to be about 20 times of the cost of improvement of the existing national highways. Thus, in terms of USD 1 million of investment, expressway is 1.5 times efficient than that in the ordinary highway.

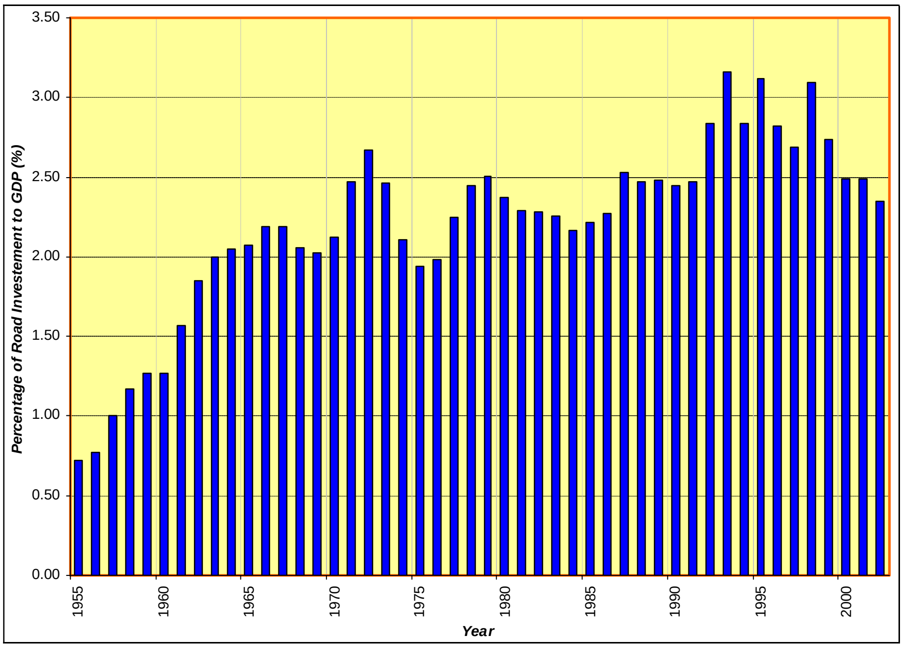
Table 3.1-2 Comparison of Construction Cost and Transport Efficiency

Typical Construction Cost [Expressway]:[Ordinary Road]	Transport Efficiency [Expressway]:[Ordinary Road]	Cost Performance Ratio
20:1	31:1	1.55:1

Of course, such comparison does not mean that all the road investment should be directed towards expressway. An expressway and ordinary highways are complementary with each other. An expressway serves the long-distance haulage and ordinary roads function as feeders of the expressway. Both are necessary and construction of expressway network and improvement of the existing road network needs to be implemented at the same time. Balanced investment in expressway and ordinary roads is important.

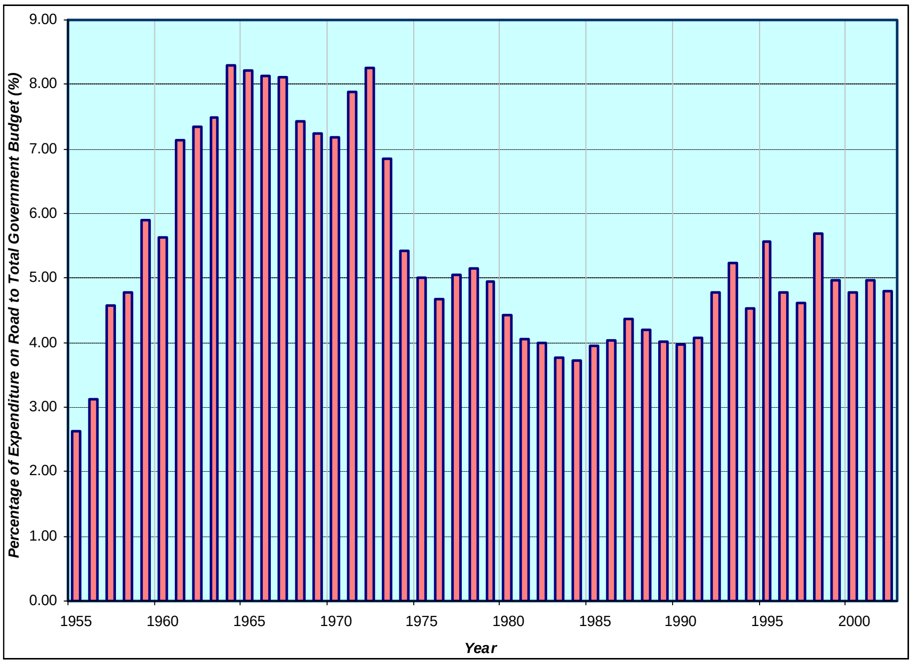
(3) Percentage of Road Investment against GDP and Total Government Expenditure

Many countries, especially developing countries, need to improve the road network which need considerable amount of investment every year. However, the fund which the government can invest on road is limited. Thus, the question here is how much investment should be spent on road network development.



Source: Road Administration (of Japan), National Road Users'Association of Japan, 2009 (in Japanese)

Figure 3.1-2 Percentage of Road Investment of Japan against its GDP



Source: Road Administration (of Japan), National Road Users'Association of Japan, 2009 (in Japanese)

Figure 3.1-3 Percentage of Road Expenditure of Japan against Government Budget

Figures 3.1-2 and 3.1-3 show the percentage of the road investment of Japan against its GDP and the percentage of the road expenditure against the government budget, respectively. In these figures the following can be observed:

✓ Japan has been spending 2% or more of GDP in road investment

✓ Expenditure on roads (including maintenance) has been 4% or more of the government budget.

In case of Cambodia, GDP in 2013 is approximately USD 15 billion. It is estimated to grow to USD 23 billion in 2020 (the middle point of expected construction period of E1 Expressway). The amount of annual disbursement for E1 Expressway at that time is estimated to be approximately USD 220 million. This corresponds to 1.0% of GDP. If 2% of GDP will spent on the entire road network, the investment on E1 Expressway will be about half of the total road investment. This means more than USD 200 million can be spent on ordinary road network.

Further, as GDP will grow, the amount of road investment will become larger. Thus, construction of expressway can be accelerated in the future.

(4) Road Investment as a Tool to Stimulate Economy

As briefly explained in Chapter 1, governments of many countries in the world use investments in infrastructure as a tool to stimulate the macro economy. A classical example of investment in public works as a tool to stimulate the economy is the development of Tennessee Valley, USA adopted by President Theodore Roosevelt in 1930s. Nowadays, some economists doubt this theory (Keynesian economics), but many government still use investment in public works, especially infrastructure, as a tool to stimulate macro economy of the country, and investment in expressway is often adopted as a typical measure for stimulating the economy.

(5) High Traffic Safety

An expressway is a very safe highway. The accident rate (injury and casualty) of expressway is approximately one tenth (1/10) of ordinary roads (see Table 3.1-3). This traffic safety can be attributed to the structure and facilities of expressway such as no entrance from roadside, no stop by signal, no crossing of pedestrians, separation of opposed traffic with median division, sufficiently wide lanes and shoulder, secured sight distance, generous curves, and guardrail to prevent vehicles from hitting roadside objects.

Table 3.1-3 Comparison of Accident Rate between Ordinary Roads and Expressway in Japan

Year		1990	2000	2009
Accident Rate (case/100 mil Vh-km)	Ordinary Road	102	120	99
	Expressway	11	11	8

For the government of Cambodia who is exerting effort to reduce traffic accident, construction of expressways will be a very effective measure.

3.2 Introduction of Toll Road System and Legal Authorization of Toll Collection

In many countries, expressways are constructed as toll roads. This is to recover the huge amount of fund spent on the construction of expressway network. In view of the huge construction cost, introduction of toll road system is practically the only solution for many governments to procure the fund for expressway network development. This is the case in almost all Asian countries which have constructed, or are constructing, expressway network, including Japan, Korea, China, Indonesia, Malaysia, Thailand and Vietnam. Thus, it is proposed that toll road system is introduced for development of the national expressway network in Cambodia.

3.2.1 Current Situation of Toll Road in Cambodia

Currently, several toll roads are operated in Cambodia. However most of them are relatively short in length and the amounts of tolls are small (less than USD 0.2 and further less than this for passenger car, except the toll road of Prek Pnov Bridge connecting NR 5 and NR 6). Table 3.2-1 shows examples of existing toll roads in Cambodia.

Table 3.2-1 Examples of Existing Toll Roads in Cambodia

Name	Length (km)	Toll (Heavy Truck: USD)	Toll Rate ($/km)
National Road No.4	214	14	0.067
Prek Pnov Bridge	9.5	4.3	0.45
Veng Sreng Road	8.5	1.5	0.18

In case of these toll roads, the toll level seems to be determined basically to cover the cost of maintenance. On the other hand, the toll road system to be introduced in the development of the expressway network is to cover the total of construction cost, maintenance and operation cost and the interest of the loan, which is much larger than the maintenance cost alone. Naturally, the toll level in such toll road system becomes much higher than those of the existing toll roads in Cambodia.

3.2.2 Introduction of Full-Scale Toll Road System

(1) Introduction of Full-Scale Toll Road System

In the toll road system used to develop a road network system, the cost of construction is procured in the form of loan (borrowing) from some source, including multi-lateral and bilateral aid agencies as well as bond issuance. This borrowed money (debt) is amortized (paid back) with the toll revenue accruing from the toll road. (See Figure 3.2-1.) This concept is considerably different from the existing toll roads in Cambodia. This concept needs to be properly understood by the road users in order that the toll expressway network is accepted.

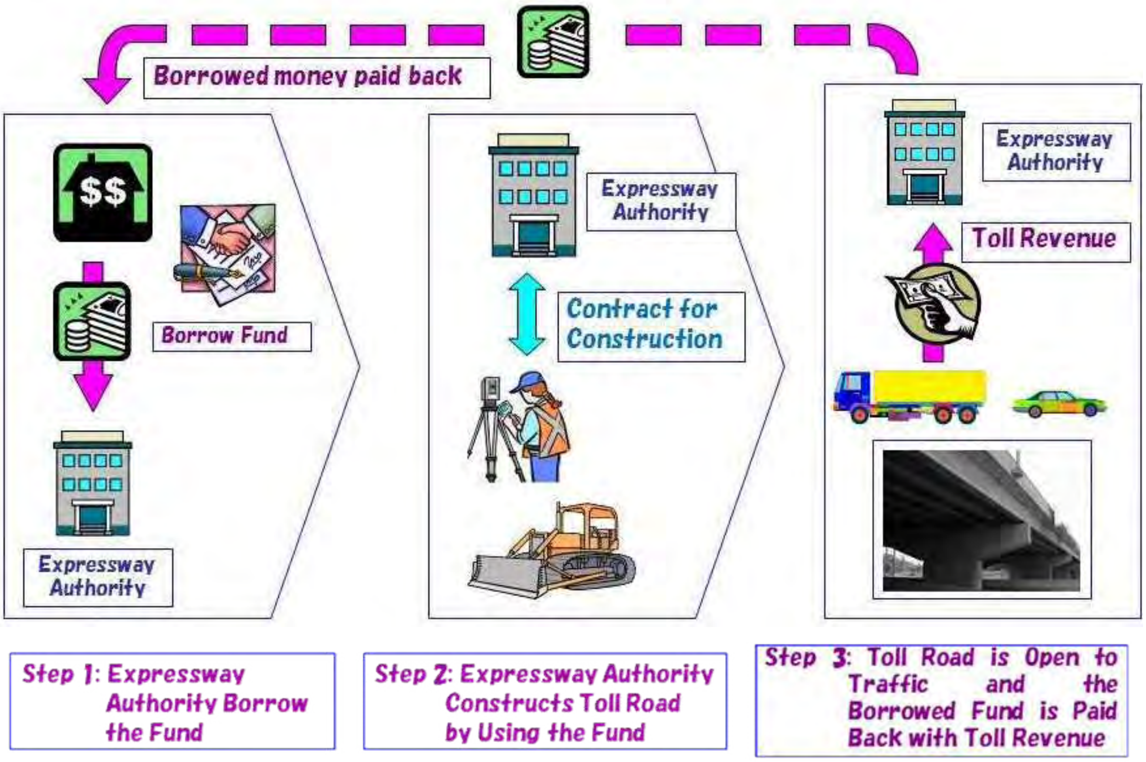


Figure 3.2-1 Basic Concept of Toll Road System

(2) Justification of Toll Collection: Scarcity in Government Fund, Pay-for-Better Service Concept

Some road user may argue that the roads are public facility and should be used free of charge. The government needs to give understandable answer to this question.

In many countries, toll roads are accepted by the road users for the following reasons:

(a) "Beneficiary-pay principle" or "fee-for-service concept": Those who get benefit or better service by using a good road should pay for the cost of construction and/or maintenance of the said road. In this case, the toll needs to be smaller than the benefit that the user of the toll road can get by using the said toll road.

(b) Scarcity of government's fund: The government needs some fund source(s), out of the existing sources of the government revenue to develop the planned network within the planned time framework. The planned road network development is essential for the socio-economic development of the nation which will give the benefit in the future.

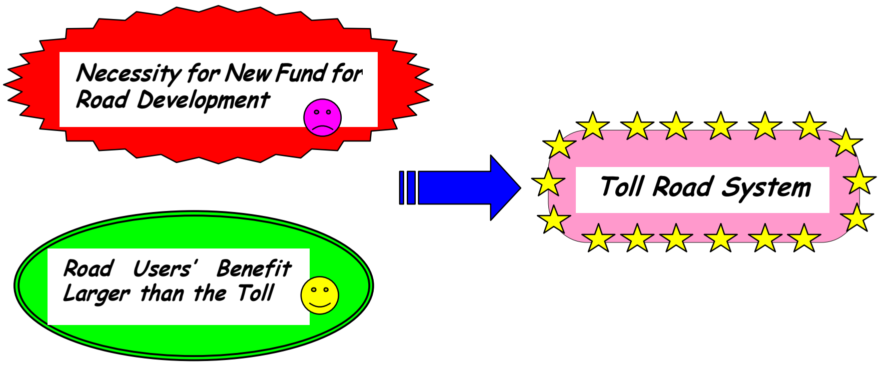


Figure 3.2-2 Justification of Toll Road System

(3) Requirement for Designating Toll Road

In many countries, there is a requirement when a toll road is designated, or toll is collected:

✓ There need to be an alternative road which is toll-free. This is to allow the road users who do not want to pay toll to travel without using the toll road.

This requirement is often stipulated in the relevant legislation (road law etc). It is recommended that this be clearly stipulated in the relevant legislation of Cambodia.

3.2.3 Toll Level Policy and Toll Setting

(1) Basic Principle for Toll Level

Toll level is usually set considering the following aspects:

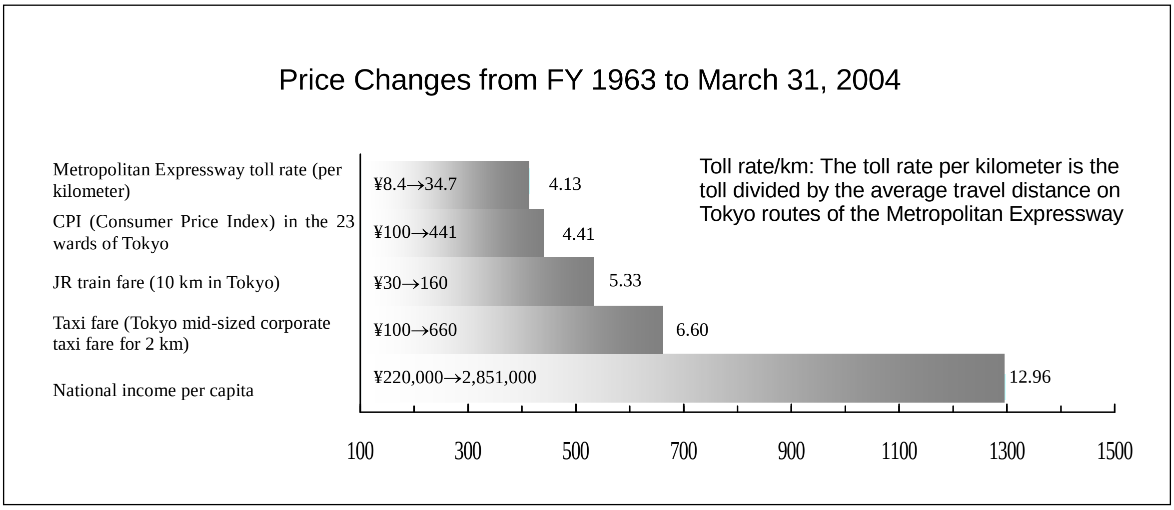
✓ Toll needs to be lower than the benefit that the user can get by using the toll road.

✓ Total toll revenue should be as large as possible to recover the construction cost.

A difficult problem is that the traffic volume on an expressway decrease as the toll becomes higher. Since the total toll revenue is the product of toll per vehicle multiplied by the traffic volume, it is often difficult to estimate the toll level which maximizes the total toll revenue.

It should be noted that a toll level can be adjusted (raised) as the general price level escalates. When the general price level is escalated as the economy grows, the sense of “burden” of the toll is weakened. Thus, toll level can be raised in the long period, making the amortization of debt of construction cost easier.

Figure 3.2-3 shows the change of toll level of the Metropolitan Expressway of Tokyo. In this figure, the ratio of escalation of toll level is close, but smaller than, the consumer price index (CPI) of Tokyo, while it is much smaller than the growth of GDP (national income) per capita.



Source: Guide to Metropolitan Expressway, Metropolitan Expressway Public Corporation, 2004

Figure 3.2-3 Price Escalation and Raising of Toll Level

(2) Ratio of Toll among Vehicle Types

The ratio among different types of vehicles, such as passenger car, small truck and heavy truck, is another important issue in setting toll level. In setting the ratio of toll among the vehicle types, the following are taken into consideration:

- ✓ Heavy vehicles give much larger damage to pavement than light vehicles. (Damage of pavement is proportional to the 4^{th} power of the axle load.) Thus, toll of heavy vehicles should be higher than light vehicles.
- ✓ Load of heavy vehicles necessitates the bridges, viaducts and other structure be stronger than if only small vehicles use the road. Thus, toll of heavy vehicles should be larger than that of light vehicles. However, the increase in construction cost of bridges and viaducts are not proportional to the weight of vehicles because substantial portion of the design load of a bridge or viaduct is the weight of bridge or viaduct itself (dead load).
- ✓ Large vehicles occupy larger area and give larger influence on traffic congestion. Passenger car unit (the coefficient to show the degree of influence of vehicles to congestion) of large vehicles (heavy truck and large bus) is in the rage of 3 – 5 times of that of passenger car. Thus, toll for heavy vehicle should be higher than that of small car.
- ✓ In many countries, expressway network is constructed to promote economic growth. Thus, toll policy which is advantageous to vehicles used in industrial activities (trucks) is adopted.

Considering the above matters, the ratio of toll between heavy truck and passenger car is set in the range of 1:1.5 – 1:5 in many countries. In Cambodia, the examples of ratio of toll among vehicle types are as summarized in Table 3.2-2. This table also shows the toll ratio of Japan.

Table 3.2-2 Ratio of Toll Level among Vehicle Type

Name of Toll Road	Passenger Car		Small Truck		Large Bus		Large Truck		Trailer	
	Toll*	Ratio	Toll*	Ratio	Toll*	Ratio	Toll*	Ratio	Toll*	Ratio
NR 4	0.006	1.0	0.02	3.33	0.026	4.33	0.067	11.1	0.088	14.67
Veng Sreng	-	-	0.069	1.0 (3.0)	0.1375	1.99 (5.97)	0.1875	2.72 (8.16)		
Expressway in Japan	0.246				0.406	1.65	0.6765	2.75	0.6765	2.75

Toll in USD/km

As can be seen in the above table, the ratios of toll for heavy vehicle are large in Cambodia. This is probably that the toll level is determined based on the cost for maintenance of pavement. On the other hand, the ratio of the toll for heavy vehicle in Japan is much smaller, but the amount of toll is much higher, than those in Cambodia. This is based on the consideration stated in the above.

It is proposed that the ratio of toll between passenger car and heavy vehicle be 1:3.0 in Cambodia.

3.2.4 Toll Revenue Pool System

It cannot be expected that all the sections/lines composing the nation-wide expressway network are financially feasible. The traffic volumes on the sections traversing the remote regions are not large and the toll revenues are not sufficient to cover the construction and operation costs. Still these sections need to be constructed and operated to promote the development of remote regions. These sections/lines of expressways need financial subsidy.

"Toll revenue pool system" is the system where the total toll revenue over the whole expressway network is used to amortize the total debt of the whole network. This means that profit from the line or section with large traffic volume is used to subsidize the deficit of the line or section where the traffic volume is not sufficient. In other words, the toll income from route A and route B are not marked and put into one basket and used to amortize the loan of route A and route be combined.

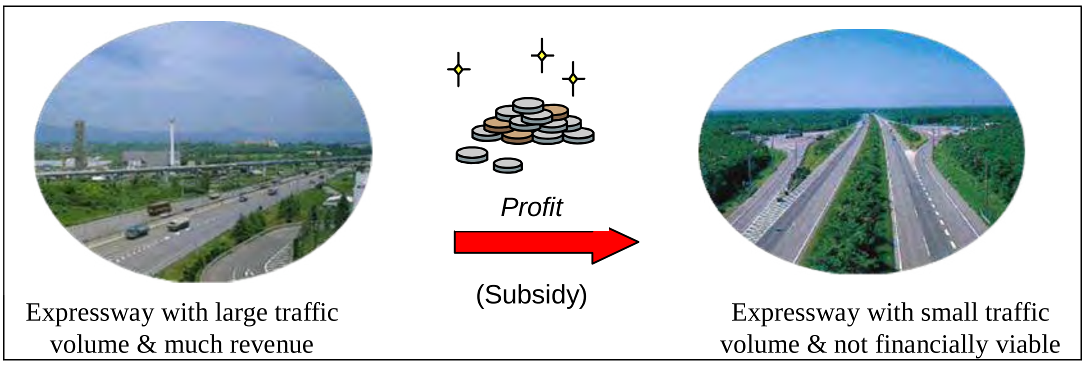


Figure 3.2-4 Concept of Toll Revenue Pool System

This system enables the government (the expressway authority) to construct the sections or lines where the toll revenue is not sufficient to amortize the loan for construction of the said section or line. In some countries, the toll revenue and repayment schedule of each expressway is planned independent from others. When independent financing scheme is adopted, construction of strategically important expressways is sometimes delayed due to difficulty in financing. Thus, toll revenue pool system is desirable to construct expressways as scheduled.

Unless substantial amount of subsidy from the general account of the government is input, toll revenue pool system is practically only method to complete the expressway network. One of the main objectives to develop the national expressway network is to promote equal regional development. From this viewpoint, it is necessary to construct whole network in accordance with the schedule. Therefore, it is recommended this system is adopted in the expressway network of Cambodia.

3.3 Balancing between Expressway Network Development and Improvement of Ordinary National Roads

There may be an opinion that improvement or rehabilitation of the existing roads are more urgent need for Cambodia or that expressway is too luxurious for Cambodia at present.

From viewpoint of national road network, both expressway and ordinary (trunk) national roads are necessary to let the road network fully function. Expressway and ordinary bear their own part of function in the hierarchy of road network:

- ✓ Expressways accommodate longest distance trip while ordinary trunk national highways accommodate long distance trip next to expressways.
- ✓ Ordinary national highways play a role of first feeder road to expressway
- ✓ Expressway and ordinary trunk national highway are complementary with each other. If expressway is closed for some reason, such as serious accident, the traffic on the expressway is diverted to the national highway, and vise versa.

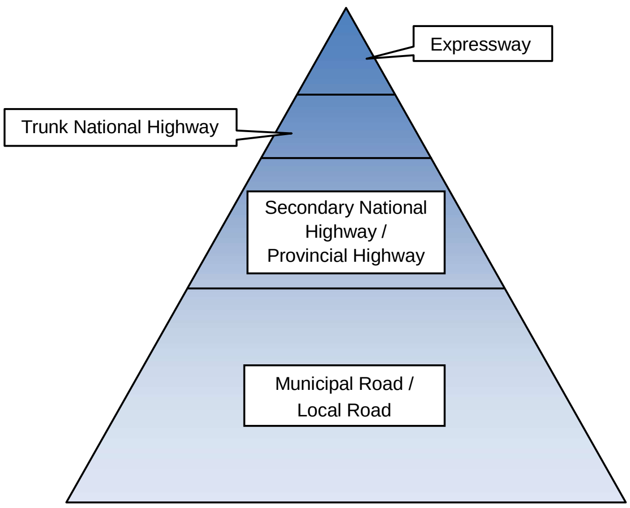


Figure 3.3-1 Hierarchy of Road Network

Moreover, in case that the expressway is a toll road, there need to be an alternative road which is free of toll. Thus, construction of expressway and improvement of existing national highway need to progress in parallel with each other. Actually, construction of expressway network was, and is being, implemented in parallel to the improvement/strengthening of the existing road network.

Then, there may be the problem of constraint of fund. Adoption of toll road system is the solution to solve this problem. This subject was discussed in Section 3.1 (1).

In case of E1 Expressway, the diligent plan of coordination with improvement of National Road No.1 (NR 1), which runs in parallel to E1, is necessary. This is discussed in Chapter 8.

3.4 Problem of PPP as the Fund Source for Expressway

PPP (public-private partnership), including BOT, BOO and other forms of participation of private fund, is often recommended as the fund source of road network development, especially toll roads. Seemingly PPP is the only solution for the government of developing countries who usually do not have sufficient fund for road network development.

Those who recommend PPP as the fund source for toll road development say that PPP is very useful tool for the governments for toll road development since the government does not need to prepare huge amount of fund. However, this is a view is based on the expectation that the toll roads yield sufficient profit to attract private investors.

Investors of PPP are not interested in unless substantial profit is expected. Quite often, construction of an expressway, or a section of expressway, which is very important from viewpoint of road network is delayed or cannot be implemented because of the small profit which cannot attract investors. In case of Cambodia, it is hardly conceivable that private investors are interested in expressway construction in view of the relatively low traffic demand. If there will be a PPP investor, it may demand substantial amount of subsidy from the government.

If there is a good profit from an expressway, this profit can be used as the fund source for constructing other expressways which may not be profitable. If an expressway which yields good profit is constructed and operated by PPP, this profit is absorbed by the concessionaire of the PPP and cannot be used by the government (Expressway Authority) to construct the deficit section/line and these sections/lines are left unconstructed for long period.

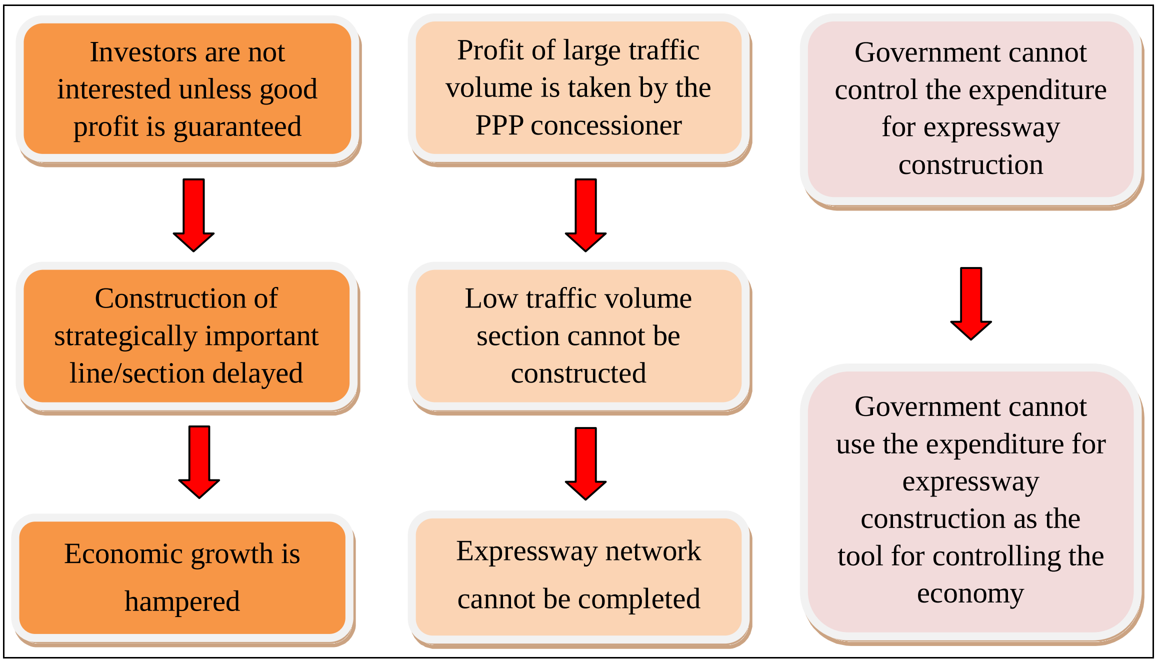


Figure 3.4-1 Problems of PPP

PPP in road was first adopted in rather developed countries such as UK and USA where fundamental road network had already been constructed and those constructed and operated under PPP were those which further strengthen the function of the road network. Thus such government could wait until appropriate proposal of PPP was submitted. In case of Cambodia and other developing countries, the fundamental road network is not yet completed and need to be developed in good accordance with the planned time schedule.

[Example: Case of expressway construction in Indonesia using BOT]

One of such examples is the case of Indonesia. Indonesian government decided in 1980s that ODA loans with low interest rates be used for improvement of ordinary (non-toll) roads and BOT (PPP) scheme be adopted for construction of expressways (toll roads) which yield cash revenue. In late 1980s and 1990s, several investors constructed expressways in and around the large cities, including Jakarta. However, very many lines/sections away from large cities where traffic volume (that is toll revenue) is not sufficient have been left unconstructed. Now, the government needs to offer some subsidies for such sections/lines to attract investors. Such subsidies could have been financed with the profit of the sections in or around the large cities if these sections had been constructed and operated by the government sector.

Another problem of PPP is that it is difficult for government to evaluate adequateness of PPP proposal in the early stage where there are not sufficient data/information on traffic volume and toll revenue, as well as the cost of operation and maintenance. As the result, the government tends to accept unreasonably advantageous condition, such as government subsidy, in the negotiation. Thus, PPP should not be adopted until the government accumulates sufficient experience in estimation of traffic volume and toll revenue, as well as the cost of operation and maintenance.

Still another drawback of PPP which is little noticed is that the Government cannot the investment on expressway even if the government wishes to use it as one of the tools to stimulate or cool down the national economy. Investment on infrastructure or other public works are often used as the tool to stimulate the economy, as suggested by the economist John M. Keynes. Although many governments do not use this method in a straightforward manner nowadays, still the basic principle can be applied: Government needs to reduce its expenditure when the economy is over-heating. However, the effect of such measure done by the government will become *dilute* if the investor of PPP continues to spend large amount of money for construction of expressway.

Governments of many Asian countries, including Japan, Korea, and China did not adopt PPP as the main fund source for constructing fundamental network of expressway.

Actually ADB recommended in 1990s PPP as a fund source to develop expressway network and other infrastructures. A seminar on introduction of PPP as the fund source of expressway construction was held in Beijing in 1996 where ADB and the World Bank recommended PPP. However Chinese government did not adopt PPP in expressway construction. (Instead, Chinese government adopted rather novel method; sell concession of toll collection and use the cash obtained through the concession as the fund for constructing a new expressway.

The main objective of adopting PPP is to reduce or eliminate the financial burden of the government. Establishment of expressway authority which procures the fund for construction of expressway by itself (autonomously)， through ODA loans and other method and amortize the debt using the toll revenue is very close to the idea of PPP.

CHAPTER 4 PLANNING OF PHNOM PENH – HO CHI MINH CITY EXPRESSWAY AND RING ROAD NO.3

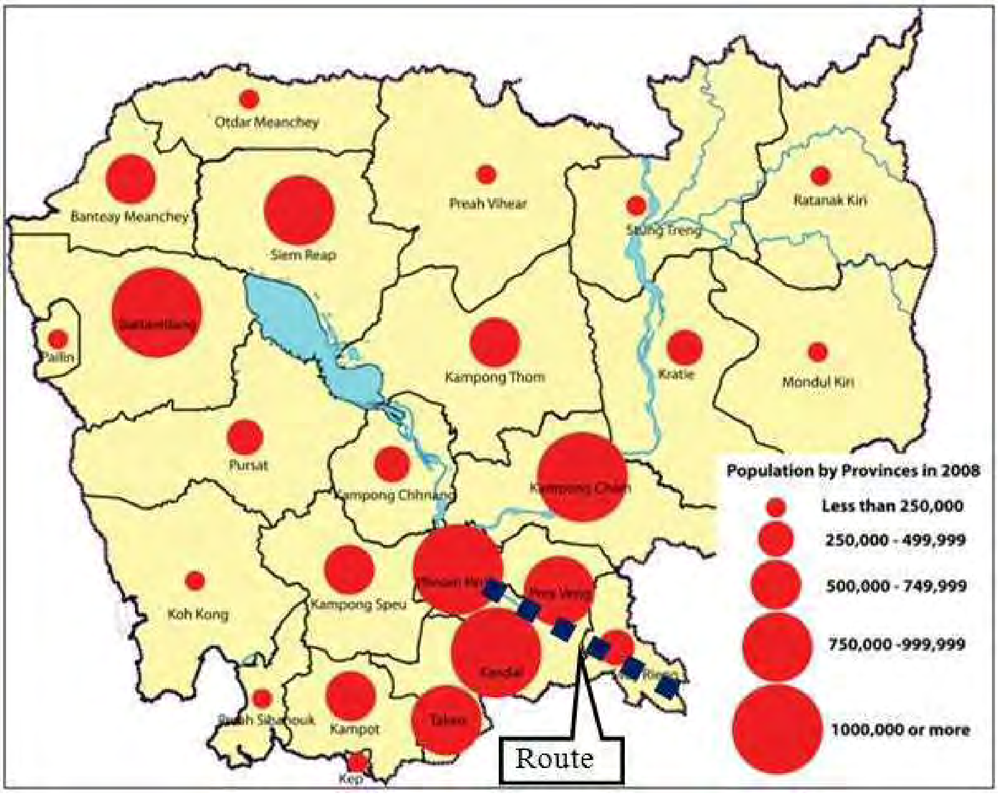
4.1 Role and Significance of Phnom Penh – Ho Chi Minh City Expressway

The route of Phnom Penh – Bavet Section (E1) of Phnom Penh – Ho Chi Minh City Expressway starts from Phnom Penh and pass through Kandal, Prey Veng and Svay Rieng provinces up to Bavet, the border point with Vietnam.

Moc Bai – Ho Chi Minh City Section of Phnom Penh – Ho Chi Minh City Expressway is planned by Vietnam side. The section is stipulated in the master plan of expressway network of Vietnam which was approved by the Prime Minister's Decision No. 1734/QD-TTg dated October 2008. This master plan defines 5,873 km expressway network in Vietnam.

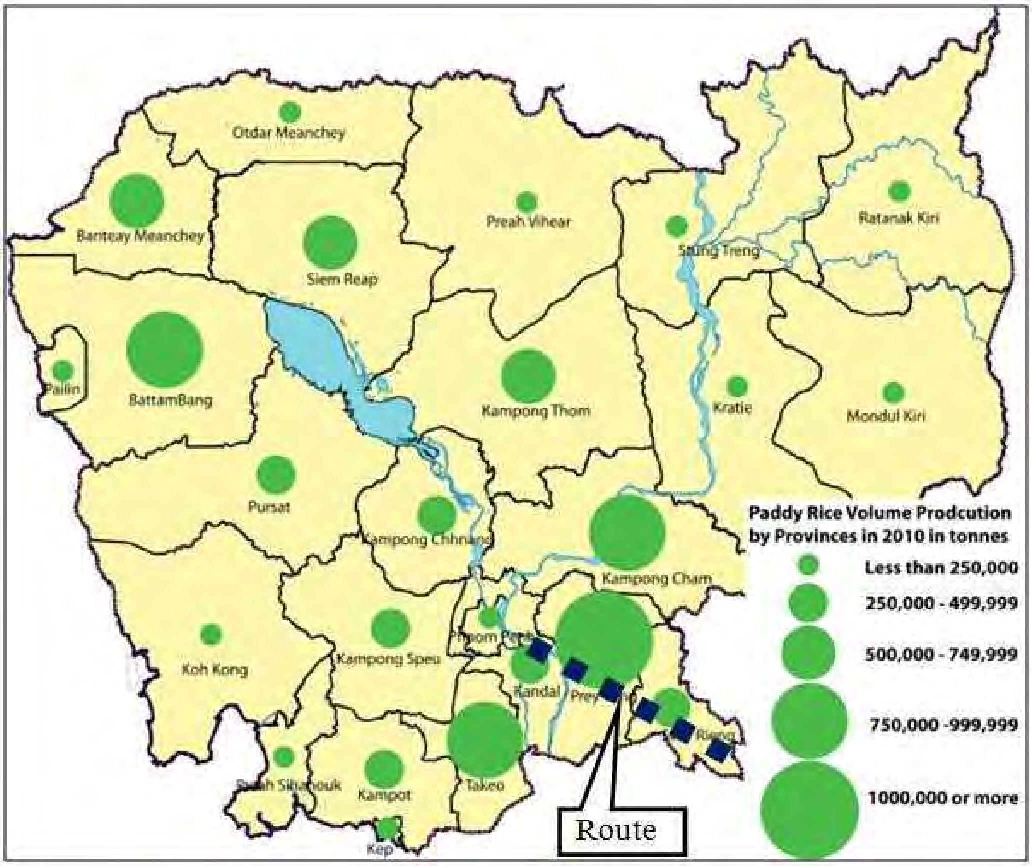
(1) Domestic Role

The route of E1 Expressway traverses the high population density area. Figure 4.1-1 shows population distribution by province in 2008. It covers the major production area of paddy rice and connects Special Economic Zones (SEZs). Figures 4.1-2 and 4.1-3 show paddy rice production by province in 2010 and location of SEZ, respectively. Thus, E1 is expected to contribute to the rapid economic growth in the high potential area along the route and is given high priority.



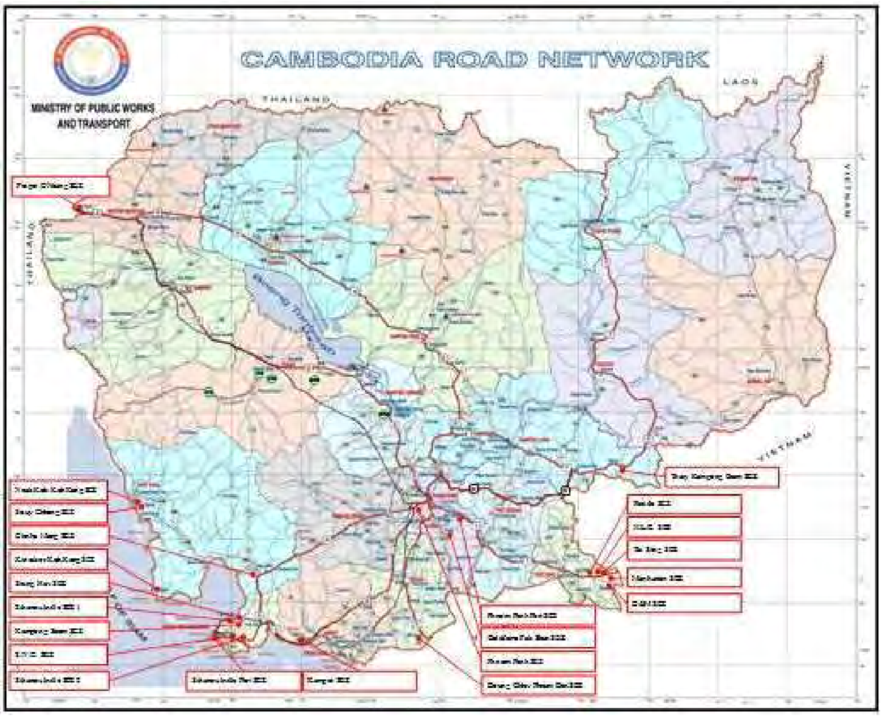
Source: Statistical Yearbook of Cambodia in 2011, NIS

Figure 4.1-1 Population Distributions in 2008



Source: Statistical Yearbook of Cambodia in 2011, NIS

Figure 4.1-2 Paddy Rice Production by Provinces in 2010



Source: Data Collection Survey JICA in 2013

Figure 4.1-3 Location of SEZ

(2) International Role

Phnom Penh – Ho Chi Minh City Expressway is to connect two major cities of Cambodia and Vietnam. It is connected, via Phnom Penh, to Expressway No.5 (E5) which is to be constructed along National Road No.5 and reaches to Poipet (the border with Thailand).

Phnom Penh – Ho Chi Minh City Expressway, together with E5, forms a route connecting Bangkok, Phnom Penh and Ho Chi Minh City. Thus, Phnom Penh – Ho Chi Minh City Expressway would be designated as ASEAN Highway No.1 and Asian Highway No.1 as shown in Figure 4.1-4.

Phnom Penh – Ho Chi Minh City Expressway, together with E5, constitutes major part of Southern Corridor of GMS as shown in Figure 4.1-5.

Source: Transport Infrastructure Survey in Cambodia 2010, JICA

Figure 4.1-4 Asian/ASEAN Highway Plan

Source: Transport and Trade Facilities in General Mekong Subregion, ADB

Figure 4.1-5 Major Economic Development Corridors in GMS

4.2 Route

4.2.1 Methodology of Expressway Route Selection

Procedures of expressway route selection are shown in Figure 4.2-1. After preliminary selection of the cities to be accessed by the expressway, 4 alternative routes were set and studied on the topographic map of 1:100,000 scale published by MPWT. The Google Earth satellite image was also used to obtain information about location of surface waters (lakes, rivers, streams, etc.), houses and other structures, and other information which are not seen on the topographic map. In addition to these, commercially purchased satellite photography was used in a complementally manner for the area where Google Earth satellite image is not clear enough to study the ground surface conditions.

Site survey was conducted to find obstacles on the alternative routes which cannot be found on the map. The results of the site survey were reflected in the evaluation of the alternative routes. Consideration was given to control points (important topography, buildings, etc. for adjusting the route of expressway) in the comparative evaluation of the alternative routes. Control points considered in evaluation of alternative routes are shown in Table 4.2-1.

After the site survey, alternative routes were compared by evaluating such items as flood area, access to major cities, alignment and phased construction. As a result, two alternative routes were selected for the further study on road structure.

The road structures such as high embankment, low embankment, and viaduct were compared by taking into consideration such items as splitting of community, magnitude of resettlement and construction cost. Finally, the best two routes with the optimum combination of road structure were proposed.

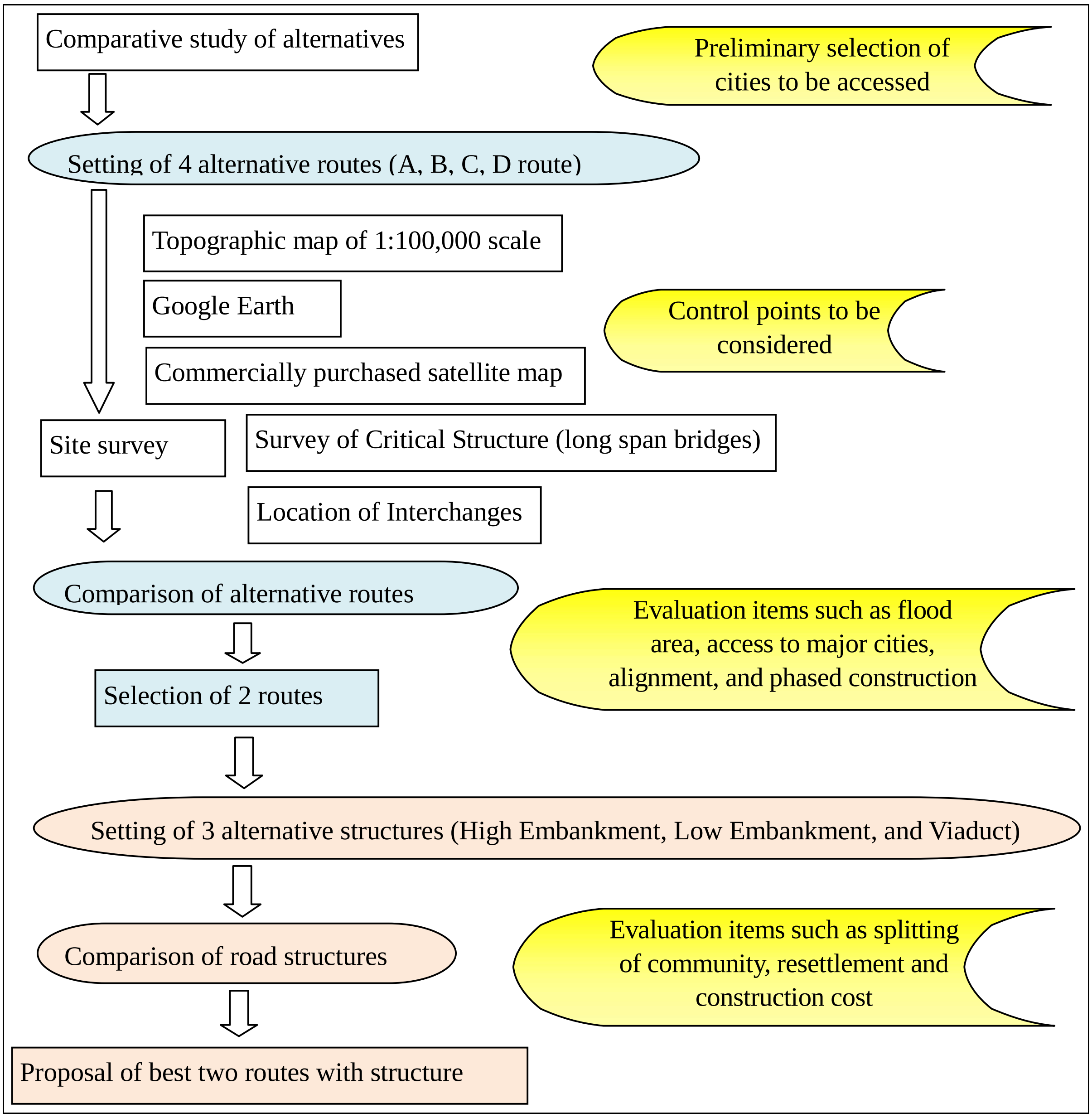


Figure 4.2-1 Flowchart of Expressway Route Selection

Table 4.2-1 Control Points to be Considered

1	Local condition	
1.1	Topography	River, lakes, marshes, roads
1.2	Geology	Soil, soft ground
1.3	Meteorology	Flood
2	Environmental conditions	
2.1	Living environment	Crowded residential housing areas, schools, temples, hospitals, factories
2.2	Large buildings	which requires large amount of compensation and long time for relocation
2.3	Natural environment	Special nature conservation areas if any
3	Cultural properties	If any
3.1	Historic spots	Historic spots, beauty spots, natural monument, buried cultural properties
4	Related public projects	
4.1	Interchange (IC)	Relationship between IC locations and access roads
4.2	Related projects	Municipal government planning projects, agricultural improvement projects
5	Public facilities	
5.1	Airports, river ports, power transmission tower	
5.2	Water reservoirs	
6	Others	
6.1	Areas designated for soil erosion	

4.2.2 Alternative Routes

Four alternative routes are set as shown in Figure 4.2-2. Routes A and B start from Phnom Penh and go along NR 1 up to Bavet passing through Neak Loeung and Svay Rieng City. Ring Road No.3 (RR3) from NR 21 to NR 1 will be constructed as the access road to Expressway. Routes A and B start from the west side of Mekong River on RR3 (RR3.Ex1 Interchange) and go along the west side of Mekong River up to the west side of Neak Loeung City. Route A crosses Mekong River 3 km south of Neak Loeung Bridge which is under construction and runs parallel to NR 1, 2 km away from NR 1 in south, up to Bavet. Route B crosses Mekong River 1 km north of Neak Loeung Bridge which is under construction and runs along NR1 in 2 km south of NR 1, and crosses NR 1 at the west edge of Bavet City.

Distance between the expressway route and NR 1 is set at 2 km. The reasons for this are as follows.

- ✓ Firstly, 2 km distance is considered to provide sufficient space for further development while houses are now located within 100 m from NR 1 on both sides of the road, except in the city centers.
- ✓ Secondly, 2 km is appropriate distance in consideration of the access road to Expressway from NR 1 and necessary space for interchange.

Routes C and D start from Phnom Penh and reach Bavet passing through Prey Veng City. RR3 from NR 21 to the starting point of Expressway will be constructed as the access road of expressway. Routes C and D start from the east side of Mekong River of RR3 (RR3.Ex2

Interchange). Route C joins Route B at Kraol Kau after passing Prey Veng City. Route D goes straight to Bavet after passing Prey Veng City. The profile of four alternative routes is shown in Table 4.2-2.

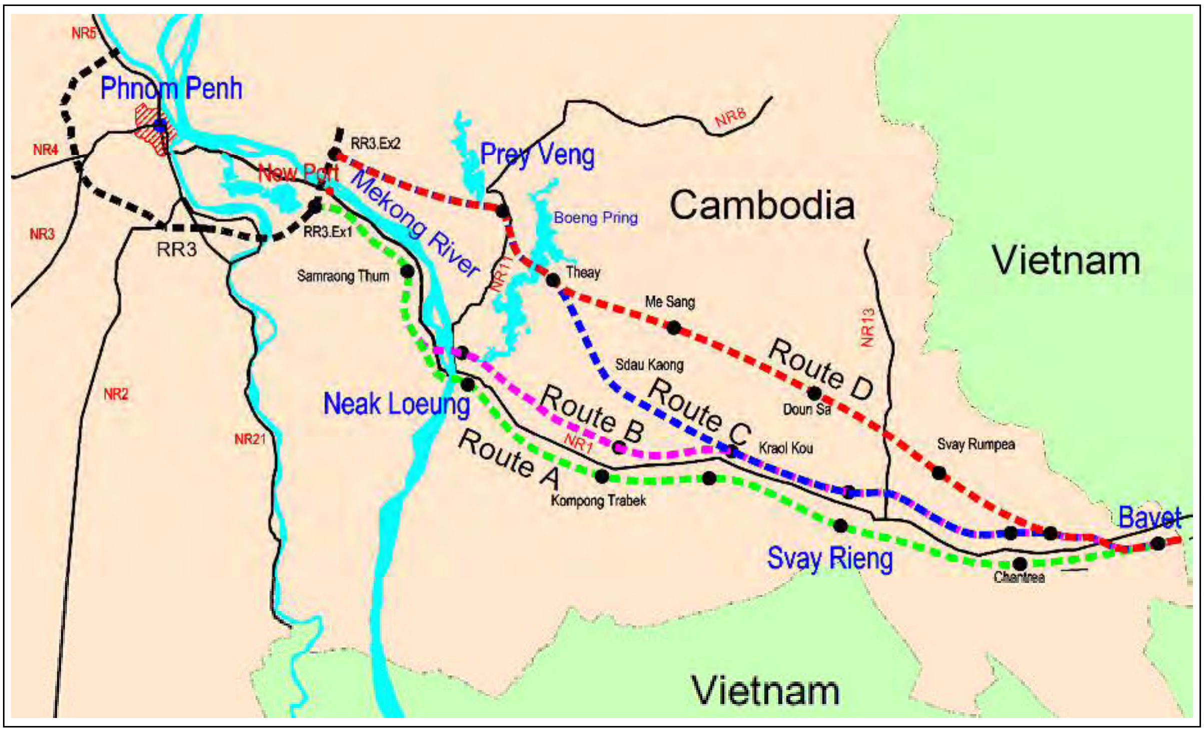


Figure 4.2-2 Map of Alternative Routes

Table 4.2-2 Profile of Four Alternative Routes

Item	Route A	Route B	Route C	Route D
Cities to be accessed	Neak Loeung Svay Rieng	Neak Loeung Svay Rieng	Prey Veng Svay Rieng	Prey Veng
Provinces to be traversed	Kandal, Prey Veng Svay Rieng	Kandal, Prey Veng Svay Rieng	Kandal, Prey Veng Svay Rieng	Kandal, Prey Veng Svay Rieng
Population (Y2008)	2,695,000	2,695,000	2,695,000	2,695,000
Target area for development	Area along NR1	Area along NR1	East side of Mekong River	East side of Mekong River
Route description	Go along 2 km south of NR1	Go along 2 km north of NR1	Section of 60 km from Prey Nhay to Bavet goes along NR1	Shortest route among 4 alternatives
Length of route From NR1	139 km+ 2 km (RR3) = 141 km	137 km+ 2 km (RR3) = 139 km	135 km+ 5 km (RR3) = 140 km	131 km + 5 km (RR3) = 136 km
Long span bridge	Cross Mekong River at Neak Loeung	Cross Mekong River at Neak Loeung	Cross Mekong River 2 km north of Phnom Penh New Port	Cross Mekong River 2 km north of Phnom Penh New Port

4.2.3 Control Points and Site Survey

Site survey was conducted to confirm the assumption and to find the obstacles on the alternative routes which cannot be found on the map. Locations of interchanges were confirmed after the site survey. The followings are control points and major findings of the site survey.

(1) Connecting Point with Ring Road 3

Ring Road 3 (RR3) is planned to pass 2 km north of the New Phnom Penh Port considering the future expansion of the port. The Connecting point of Routes A and B with RR3 (RR3.Ex1 Interchange) is set 2 km west of NR 1 to maintain proper distance from NR 1. Routes A and B traverse the area between NR 1 (Phnom Penh New Port) and the new SEZ as shown in Figure 4.2-3.

The Connecting point of Routes C and D with RR3 (RR3.Ex2 Interchange) is set 3 km east side of Mekong River considering proper distance from the river and local community.

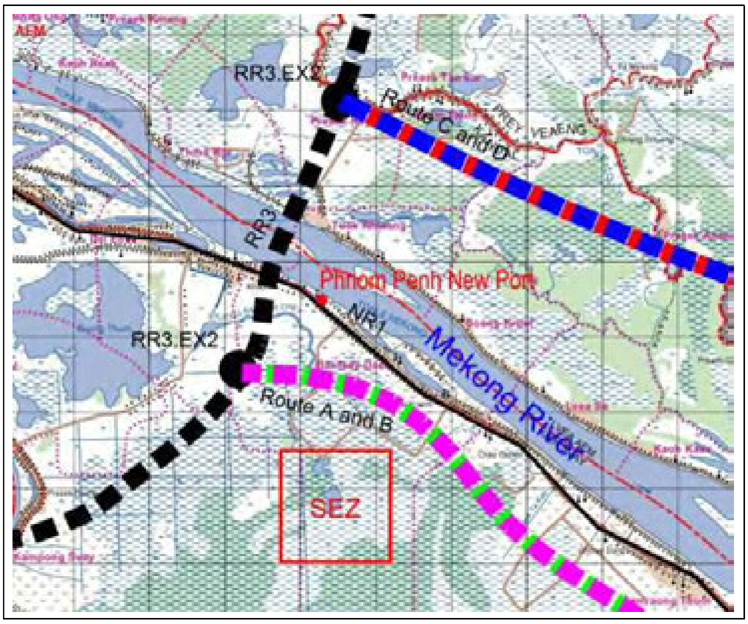


Figure 4.2-3 RR3, New Phnom Penh Port, New SEZ and Expressway

Figure 4.2-4 Connecting Point of Routes A and B with RR3 (RR3. Ex1)

Figure 4.2-5 Phnom Penh New Port

(2) Flood Area along NR 1 up to Neak Loeung

Lands in the area of South and West of Mekong River are used for rice production in the dry season. Farm access roads are passable in the dry season, but they are not passable in the rainy season because the land becomes 3-6 m under water. Route A and B start from Phnom Penh and go along 2 km west of NR 1 up to Neak Loeung. Distance of 2 km is considered to be enough to provide space for further development.

Figure 4.2-6 Flood Area along NR1 up to Neak Loeung

Figure 4.2-7 Flood Area along NR1 up to Neak Loeung

(3) Crossing point of Mekong River (Long Span Bridge)

Route A crosses the Mekong River 3 km south of Neak Loeung bridge which is under construction. In other words, Route A crosses the Mekong River 1 km south of the existing NR 1 (ferry route). This location is selected to make the crossing of Mekong River as short as possible, as well as to make the length of access road to NR 1 within acceptable range.

Route B crosses the Mekong River 1 km north of Neak Loeung Bridge under construction. In other words, Route B crosses the Mekong River 3 km north of the existing NR1 (ferry route). The length of Mekong River crossing and the length of access road to NR1 are also taken into account. The crossing points of Routes A and B over Mekong River are shown in Figure 4.2-8.

Ring Road 3 goes across the Mekong River 2 km north of Phnom Penh New Port as shown in Figure 4.2-9. The location of Mekong River crossing of RR3 is selected considering the length of river crossing and the distance to the connection point with Routes C and D.

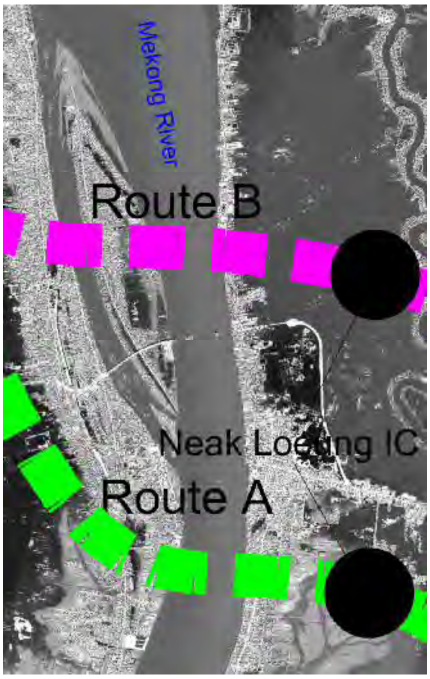


Figure 4.2-8 Crossing Point of Route A and B over Mekong River

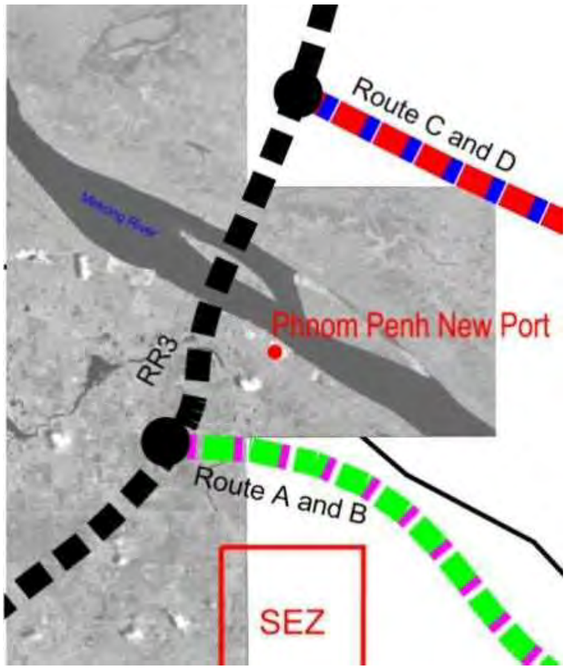


Figure 4.2-9 Crossing Point of Ring Road 3 over Mekong River

Figure 4.2-10 Crossing Point of Route A over Mekong River: Photo from West Side

Figure 4.2-11 Crossing Point of Route B over Mekong River: Photo from East Side

Figure 4.2-12 Crossing Point of RR3 over Mekong River: Photo from East Side

Figure 4.2-13 Crossing Point of RR3 over Mekong River: Photo from Ferry Boat

(4) Flood Area (Lake) around Prey Veng

The 6 km section of Routes C and D traverses the flood area (lake) of Prey Veng. This crossing of flood area is inevitable in order to take shorter route to the Bavet. Also the geographical spread of Prey Veng City, as well as the length of access road to Prey Veng City are another consideration for selecting this route. Figure 4.2-14 shows such conditions.

The 6 km-long section crosses the lake where water exists not only in the rainy season but also in the dry season. The depth of the lake water is 1 m to 2 m and there are some islands whose surface is only 1 m above the water level appear in dry season. Local people cultivate rice on such islands and do fishing at shallow water. They access to lowland by small boats.

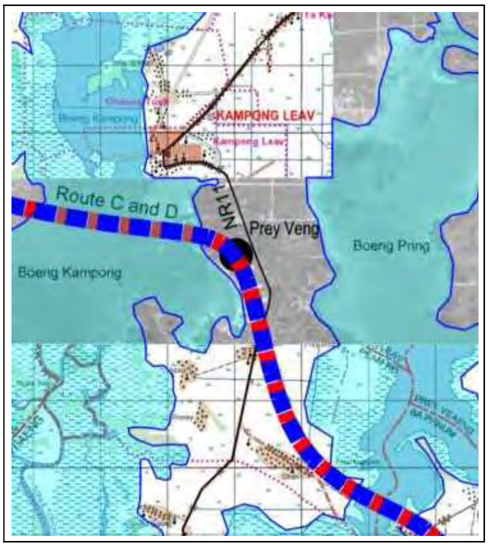


Figure 4.2-14 Flood Area (Lake) around Prey Veng

Figure 4.2-15 Flood Area (Lake) around Prey Veng

Figure 4.2-16 Flood Area (Lake) around Prey Veng

(5) Flood Area around Svay Rieng

The 8 km of Route A goes across the flood area of Svay Rieng where rice is cultivated in the dry season but entirely covered in water in the rainy season. However, Route B does not go across the flood area of Svay Rieng because the flood area is located at the south side of NR 1 as shown in Figure 4.2-17. Crossing point of the lake of Route B was decided with consideration of the shorter crossing distance.

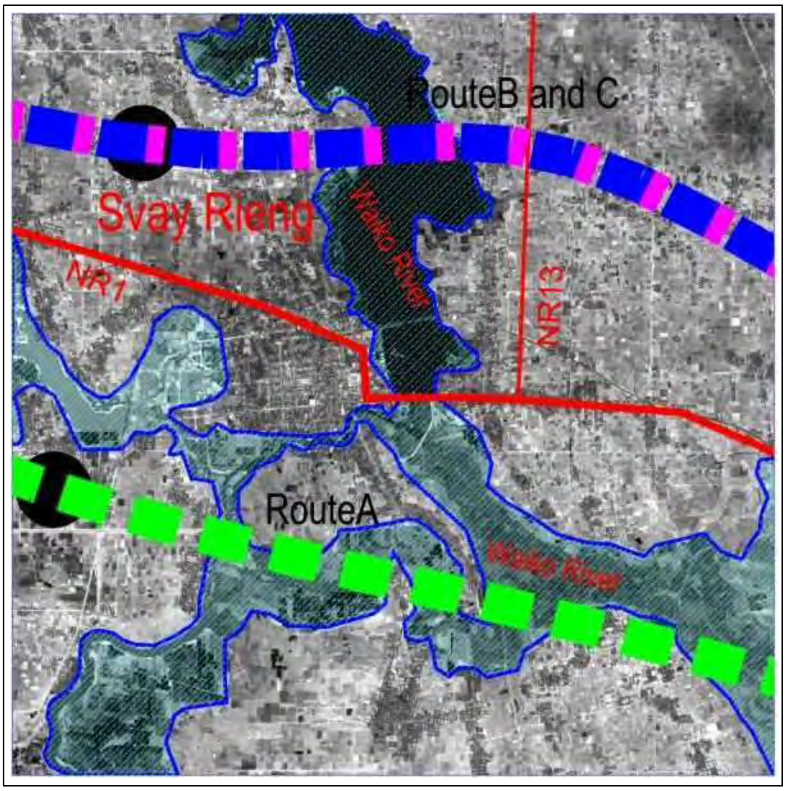


Figure 4.2-17 Flood Area around Svay Rieng

Figure 4.2-18 Lake along NR 1 at Svay Rieng

Figure 4.2-19 East Crossing Point of Lake at Svay Rieng

(6) A Series of SEZ Near Bavet and Border Control Facility

Figure 4.2-20 shows the location of a series of SEZ which were found during the study and confirmed on satellite image and through the site survey. The location of border facility was also confirmed.

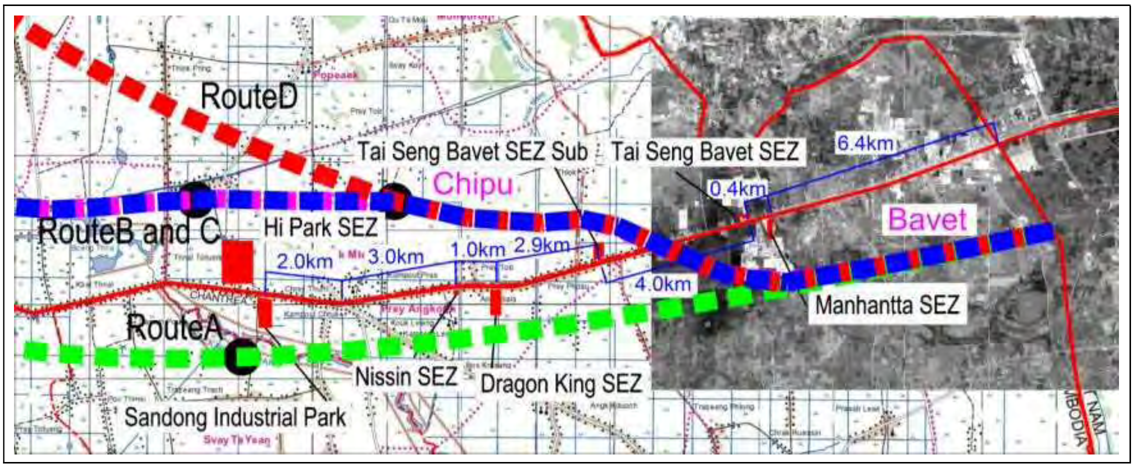


Figure 4.2-20 A Series of SEZ Near Bavet and Border Control Facility

Figure 4.2-21 Tai Seng Bavet SEZ

Figure 4.2-22 Shandog Sunshell SEZ

4.2.4 Location of Interchanges and Connection to Important Facilities

(1) Function of Interchange

Entrance to and exit from expressways are limited to interchanges. This is one of the most significant features of expressway. Thus an interchange is a connecting point of expressway and ordinary road. The arrangement of interchanges is very important for maximum utilization of expressway since location of interchange is crucial for drivers' convenience.

The function of an expressway is to provide fast, safe and uninterrupted travel, but if entrances and exits directly from/to roadside are allowed, traffic flow will be disturbed and the function of expressway will be impaired. For this reason it is not desirable to install interchanges too close each other. However, in or around urbanized area, traffic congestion occurs due to the vehicle concentration in one place, if the number of interchanges is insufficient. As a solution to this, shorter distance between interchanges is adopted to diversify the points of entrance and exit.

The standard distance between interchanges for each area is listed in Table 4.2-3.

Table 4.2-3 Standard Distance between Interchanges

Area	Standard Distance
Within Urbanized Area	5 km to 10 km
City Outskirts	15 km to 25 km
Between Cities	20 km to 30 km

Figure 4.2-23 Example of Interchange

(2) Location of Interchanges on E1 Expressway

The average distance between interchanges on E1 is proposed be around 20 km (15 to 25 km) considering the criteria stipulated in the expressway design manual of Japan. Locations of interchanges are selected based on the following considerations:

✓ Near the trunk road such as National Roads

✓ Near the city whose population is more than 30,000

✓ Near the economic area such as SEZ.

Figure 4.2-24 shows the locations of the interchanges of E1. Distance between the existing road and IC is planned about 2 km to minimize the construction cost of new access road. NR 1, NR 11 and NR 13 need minor improvements to be used as the access road, while other access roads such as NR 317, NR 319 and provincial roads need large-scale improved.

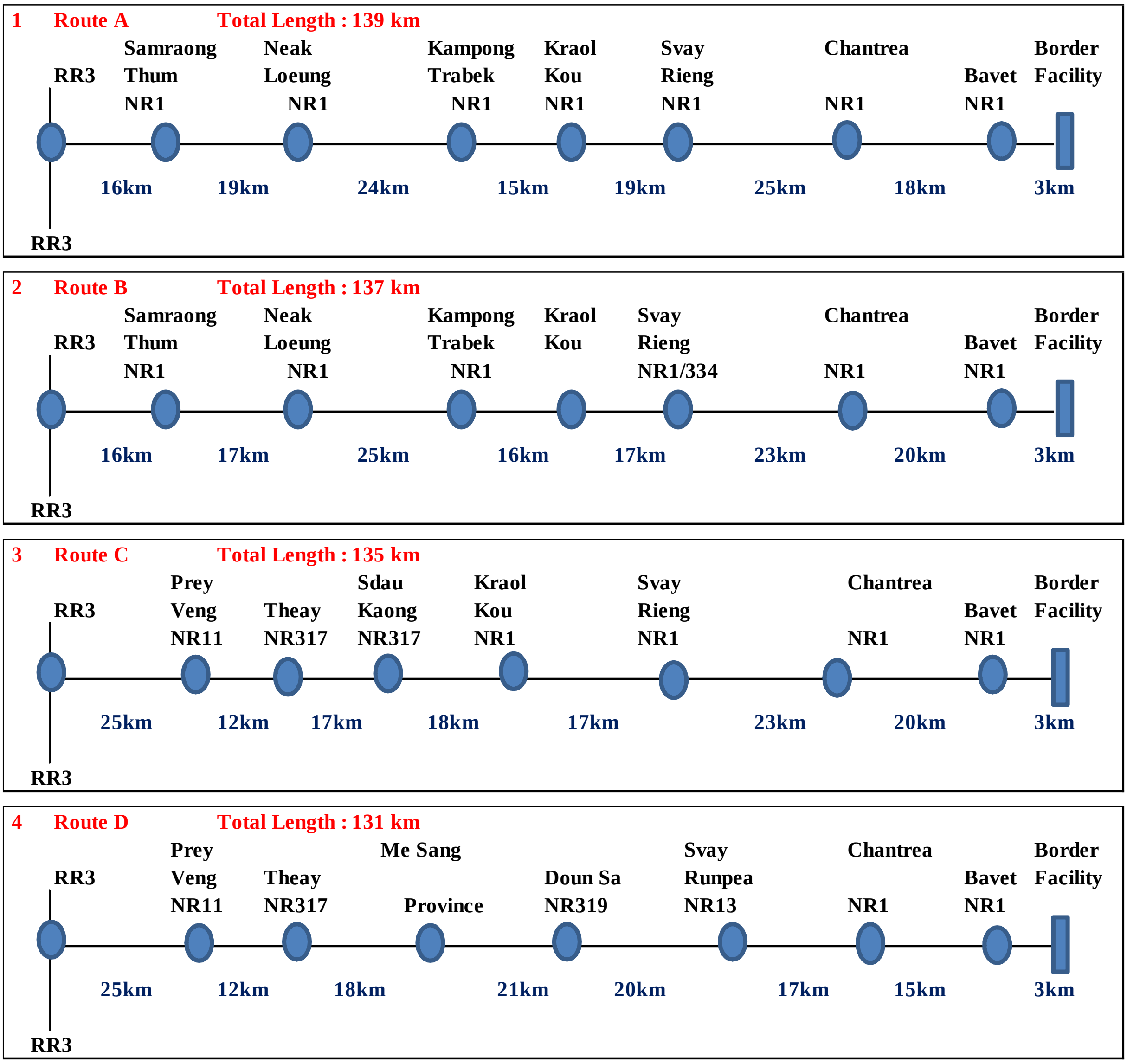


Figure 4.2-24 Location of Interchanges

(3) Connection to Important Facilities

Connection to important facilities such as city center, port and SEZ is as shown in Table 4.2-4.

Table 4.2-4 Important Facilities

Name	Description	Connection
City Center of Phnom Penh	Capital of Cambodia	Through NR1, RR3, NR3 and NR4
Phnom Penh SEZ		Through RR3 and NR4
Phnom Penh New Port	Under construction	4 km to RR3 IC
PP New Port SEZ		4 km to RR3 IC
City Center of Prey Veng		5 km to Prey Veng IC
City Center of Svey Rieng		2 km to Svey Rieng IC
City Center of Bavet		1 km to Bavet IC
A serious of SEZ at Bavet		2 km to 8 km to Chantrea or Bavet IC

4.2.5 Proposed Route

Four alternative routes were compared considering the following evaluation items.

- Population of provinces and districts along the route (Y2008)
- Access to major cities such as Prey Veng, Svay Rieng, Neak Loeung
- Economic activities: Access to SEZ and NR1
- Potential for new development
- Length of route
- Alignment of route
- Long span bridge
- Topography and Natural condition: Flood area
- Social environment: Resettlement
- Natural environment
- Phased construction

(1) Comparison of Route A and B

Firstly, Routes A and B are compared since both routes are similar in the feature of running along NR1. Route B is selected as the optimum proposed route after the comparison between Routes A and B. The reason for selecting of Route B is as follows:

✓ The 8 km of Route A crosses the flood area of Svay Rieng. On the other hand, Route B does not traverses the flood area of Svay Rieng because the flood area is located at the south side of NR 1.

(2) Comparison of Route C and D

Secondly, Route C and D are compared since both routes pass Svay Rieng and have the potential for the new development of the east side of Mekong River near Phnom Penh. Route C is selected as the proposed route for further study after the comparison between Route C and D because Route C connects to Svery Rieng City, the provincial capital. Route D is not suitable for phased construction as described in Chapter 8 because connection to NR 1 becomes too long, although it is the shortest route among 4 alternatives. Alternative routes on topographic map are shown in Figure 4.2-25. Table 4.2-5 shows the comparison of four alternative routes.

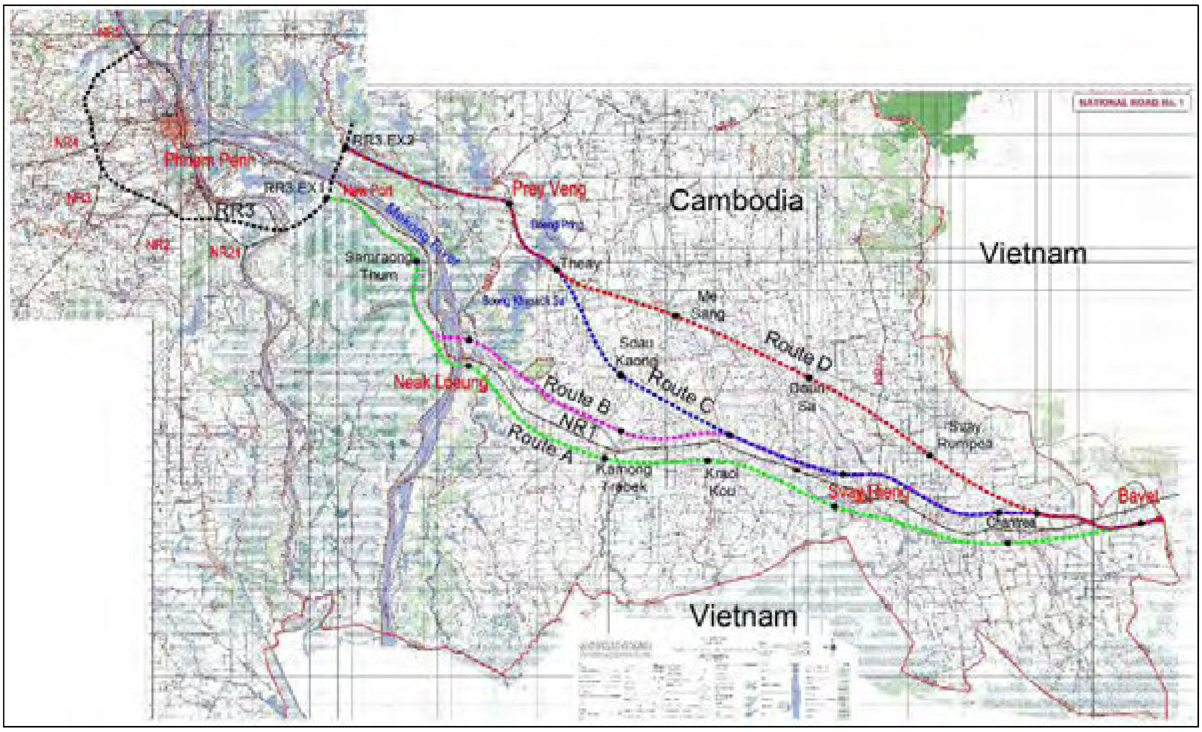


Figure 4.2-25 Alternative Routes on Topographic Map

(3) Comparison of Route B and Route C and recommended route

As described in the above, both Route B and Route C can be practically constructed. The Survey Team recommends Route B as the first priority based on the following reason:

- ✓ In case of Route C, diversion of the traffic to the existing NR 1 is difficult. Diversion of traffic to the existing NR 1 becomes necessary if a severe traffic accident occur on the expressway and the expressway is closed.

Table 4.2-5 Comparison of Four Alternative Routes

Evaluation Item	Route A	Route B	Route C	Route D
Population of provinces along the route (Y2008)	2,695,000	2,695,000	2,695,000	2,695,000
	○	○	○	○
Population of districts along the route (Y2008)	907,000	907,000	780,000	916,000
	○	○	△	○
Access to major Cities	Neak Loeung Svery Rieng	Neak Loeung Svay Rieng	Prey Veng Svay Rieng	Prey Veng
	○	○	◎	△
Economic activities Access to SEZ Access to NR1	Whole line goes along NR1	Whole line goes along NR1	60 km along NR1 from Kraol Kou	Shortest route
	◎	◎	○	△
Potential for new development	Area along NR1	Area along NR1	The east side of Mekong River	The east side of Mekong River
	○	○	◎	◎
Length of route	139 km+ 2 km (RR3) = 141 km	138 km+ 2 km (RR3) = 140 km	139 km+ 5 km (RR3) = 144 km	131 km+ 5 km (RR3) = 138 km
	○	○	○	◎
Alignment of route (Longitudinal and vertical)	good	good	good	good
	◎	◎	◎	◎
Long span bridge	Cross Mekong River at Neak Loeung	Cross Mekong River at Neak Loeung	Cross Mekong River 2 km north of Phnom Penh New Port	Cross Mekong River 2 km north of Phnom Penh New Port
	○	○	○	○
Topography and natural condition Flood area	West of Mekong Svay Rieng	West of Mekong	Prey Veng	Prey Veng
	△	○	○	○
Social environment Resettlement	Same as others	Same as others	Same as others	Same as others
	○	○	○	○
Natural environment	Rice field	Rice field	Rice field	Rice field
	○	○	○	○
Phased construction	Easy	Easy	Middle	Difficult
	◎	◎	○	△
Comprehensive Evaluation		B is Better than A	C is Better than D	
		◎	○	

Legend: ◎ Good ○ Fair △ Poor

4.3 Road Structure

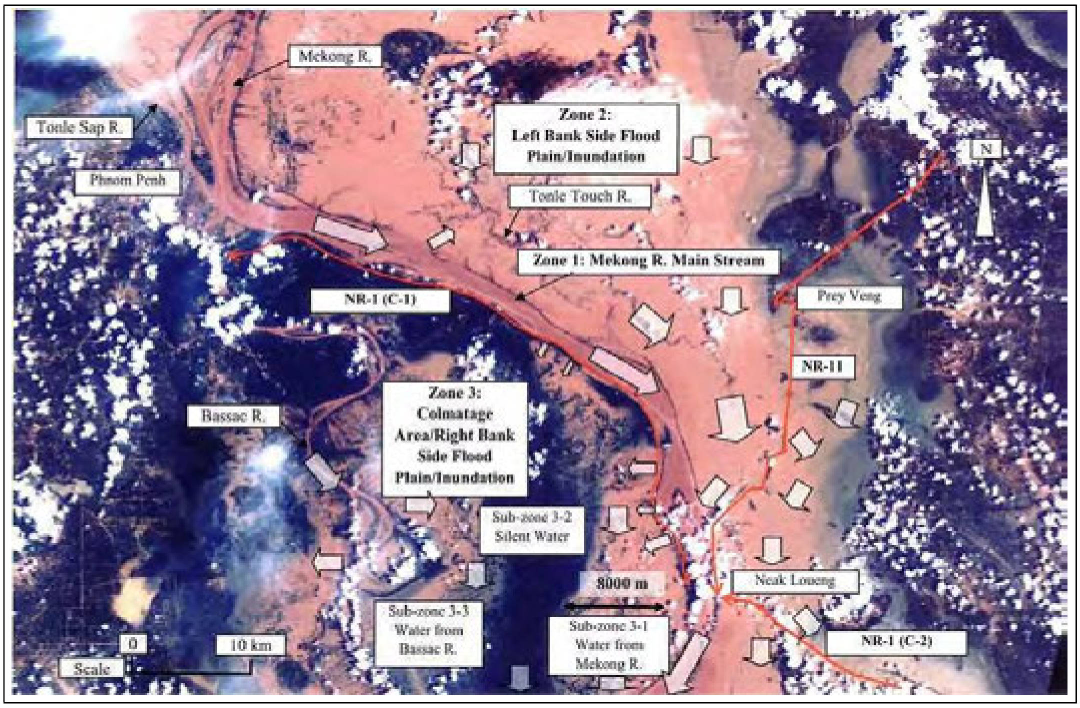
4.3.1 Height of Road Surface and Crossing of Other Road

(1) Flood Area

The 50 km-long section of Routes A and B, which is from Phnom Penh to Neak Loeung along NR 1, passes through the flood area. The 45 km-long section of Routes C and D, which is from Phnom Penh to Prey Veng crossing the Mekong River by RR3, also pass through the flood area. Figure 4.3-1 shows flood area of Cambodia. Figure 4.3-2 and 4.3-3 show the flooding condition and the location of overflow during the flood of 2000, respectively.

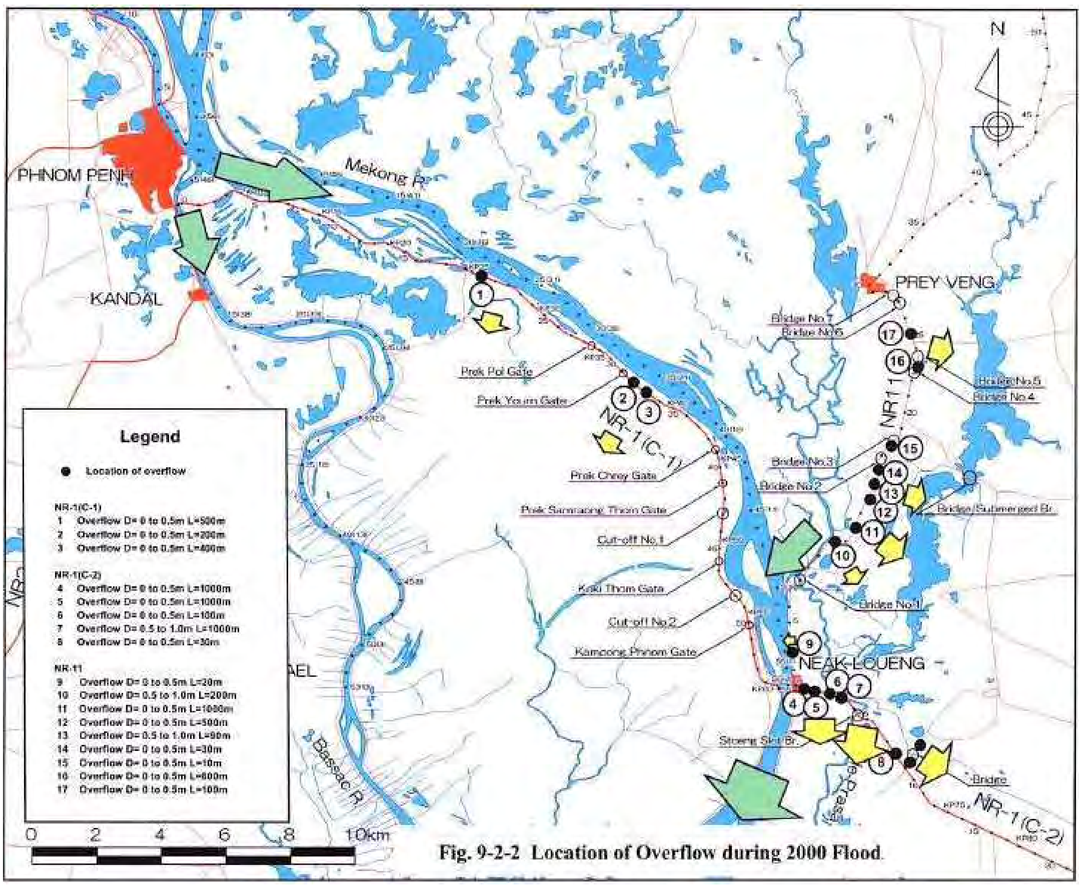
Source: The School Atlas of Cambodia

Figure 4.3-1 Flood Area



Source: The Feasibility Study on the Improvement of National Road No.1

Figure 4.3-2 Flooding Condition of 2000 Flood (Land Sat Image Sep. 26, Y2000)

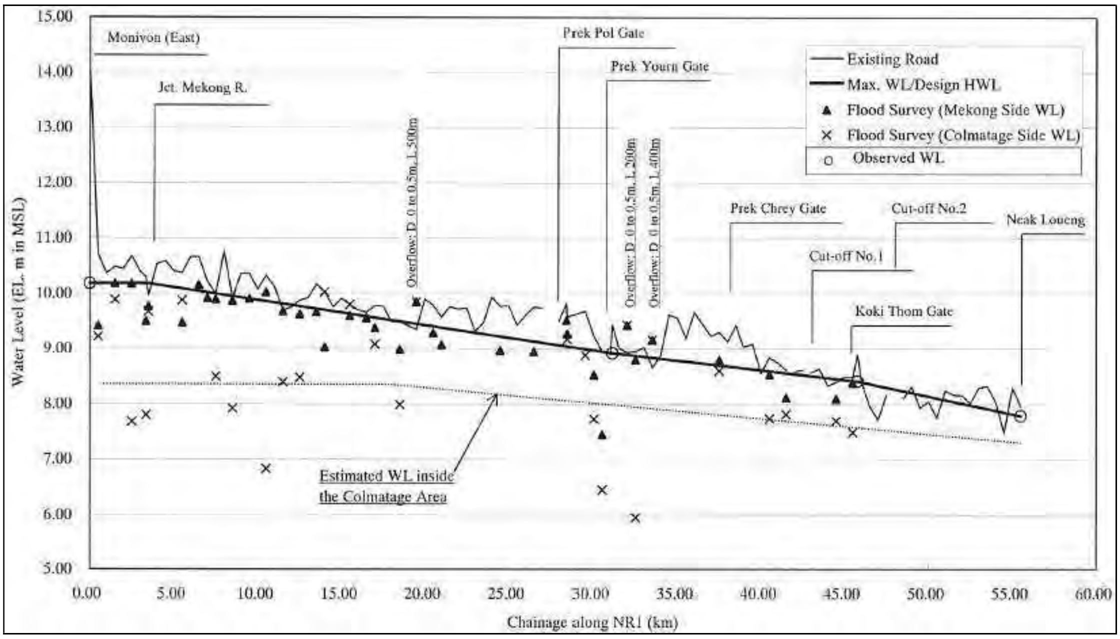


Source: The Feasibility Study on the Improvement of National Road No.1

Figure 4.3-3 Location of Overflow during 2000 Flood

(2) Height of Expressway Surface

The highest flood water levels along the NR1 in year 2000 have been estimated as shown in Figure 4.3-4. The maximum water level varies from 10 m above sea level (ASL) at Monivong Bridge to 8 m ASL at Neak Loeung. The maximum flood water level was almost the same as the road elevation of NR1. Another big flood occurred in 2010. The highest flood water level along the NR 1 in year 2000 is considered to be repeated in every 10 years. The height of expressway surface is set 1 m higher than the flood level in 2000 considering the importance of expressway transport.



Source: The Feasibility study on the Improvement of National Road No.1.

Figure 4.3-4 Flood Water Level

(3) Crossing of Other Roads

National roads are passable in the rainy season, which means that the height of National roads is above the flood water level. Therefore, clearance is needed in the rainy season at the crossing point of the expressway.

Lands in South and West of Mekong River are used for rice production in the dry season. Farm access roads are passable in the dry season but they are not passable in the rainy season while land is 3-6 m under water. Therefore, clearance of farm access is needed in the dry season but is not needed in the rainy season at the crossing point of the expressway. Farm access is planned at an interval of 1 km to secure the short access to rice field in the dry season.

Lands in north and east of Mekong River are also used for rice production in the dry season. Farm access roads are passable in both dry and rainy season except the time of severe flood like that occurred in year 2000. Farm roads are above flood water level while land is slightly under water. Therefore, clearance of farm access roads is needed in the rainy season at the crossing point of the expressway. Farm access roads is planned at an interval of 1 km.

Clearance during rainy/flood season is planned for small boats.

Table 4.3-1 Present Condition of Crossing Roads and Channels in the Rainy Season

Crossing	South and West of Mekong River	North and East of Mekong River
National roads	Passable above flood water level	Passable above flood water level
Farm access roads	Not passable under flood water level	Passable above flood water level
Channels	Passable by small boats at flood water level	Passable by small boats at flood water level

Table 4.3-2 Necessity of Clearance for Crossing Roads and Channels in the Rainy Season

Crossing	South and West of Mekong River	North and East of Mekong River	Number of crossing	Remarks
National roads	Need	Need	Around 10	Trunk roads
Farm access roads	No need. But need in dry season	Need	140	To be planned every 1 km
Channels	Need	Need	Around 10	

4.3.2 Alternative Road Structures

Three alternative road structures are considered for the expressway. They are high embankment, low embankment and viaduct, of which typical cross sections are as shown in Figures 4.3-5, 4.3-6 and 4.3-7, respectively.

Computer graphics of high embankment and water reservoir are shown in Figures 4.3-8 and 4.3-9, respectively. The Computer graphics of low embankment and viaduct are shown in Figures 4.3-10 and 4.3-11, respectively.

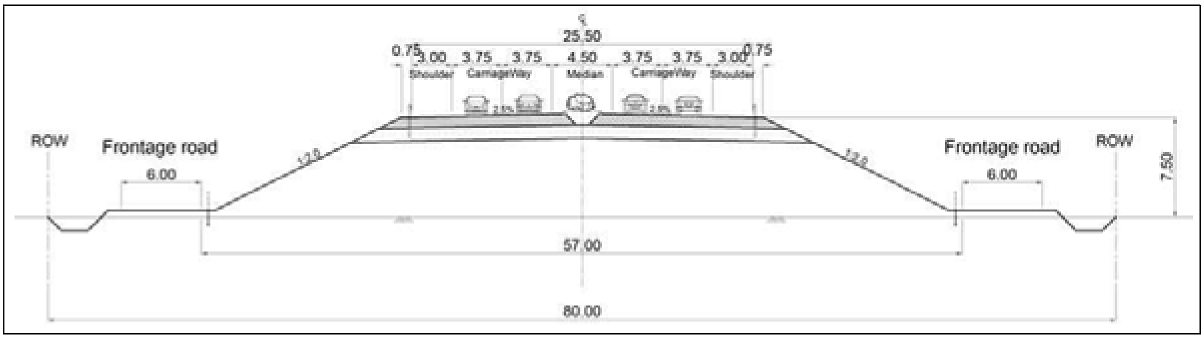


Figure 4.3-5 Typical Cross Section of High Embankment

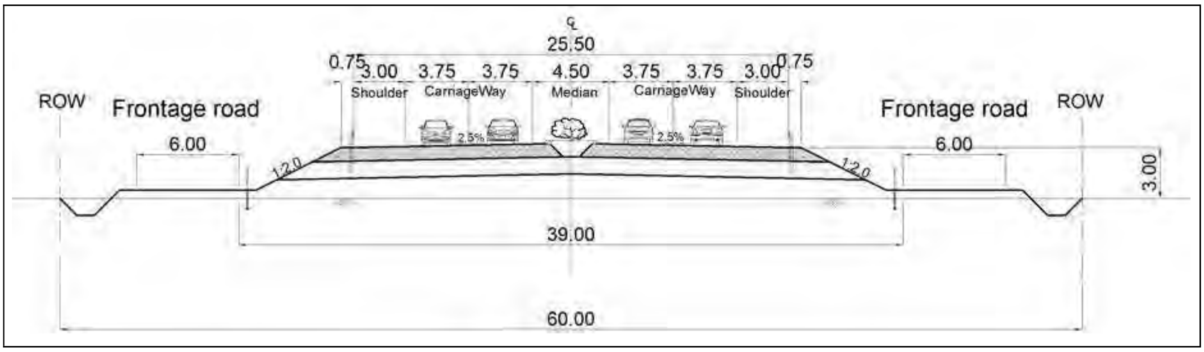


Figure 4.3-6 Typical Cross Section of Low Embankment

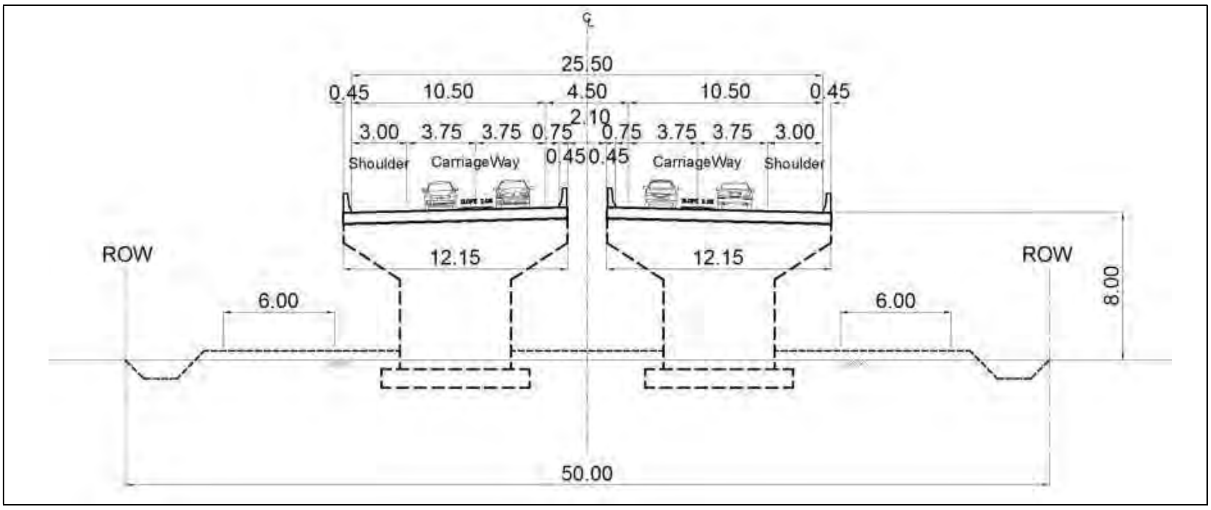


Figure 4.3-7 Typical Cross Section of Viaduct

Figure 4.3-8 Computer Graphics of High Embankment

Figure 4.3-9 Water Reservoir

Figure 4.3-10 Computer Graphics of Low Embankment

Figure 4.3-11 Computer Graphics of Viaduct

4.3.3 Items to be Considered for Road Structure

(1) Cost and Availability of Materials for Road Construction

Cost and availability of materials are evaluated in Table 4.3-3. The volume of each material below is required to construct 100 km-long section of expressway with high embankment structure. While the height of typical cross section of high embankment is 7.5 m at the point of crossing other roads, the height of the low embankment is 3.0 m. Thus, the average height of embankment could be 5.7 m after the adjustment of vertical alignment.

Transporting large volume of soil (16 million m^3) from mountain area 150 km away is not preferable considering insufficient number of trucks needed, and long construction period. Transporting large volume of dredged sand (16 million m^3) from Mekong River is also not easy, since it will cause serious bank erosion that may lead to environmental and social problems.

However, transporting soil from rice field 20 km away is considered to be feasible if the expressway project is simultaneously implemented with water reservoir project. Since gravel is essential material for cement concrete and asphalt concrete, it is inevitable and it is feasible to use 5 million m^3 of gravel transported from mountain area 150 km away.

Table 4.3-3 Evaluation of Four Materials for High Embankment

Material	Cost in USD/ m^3	Volume (m^3) L =100 km	Condition	Availability	Evaluation
Soil from Existing Borrow Pit	30	16 mil.	Transport distance of 150 km from mountain area	Too large volume, Expensive. No trucks, Long construction period Not favorable: (35 m+51 m) / 2 x 5.7 m -2.0 m = 159 m^2	△
Dredged sand	15	16 mil.	Transport distance of 50 km from Mekong River side	Too large volume No trucks, Long construction period Environmental problem of erosion Not Favorable	△
Soil from Nearby Borrow Pit	10	16 mil.	Soil is excavated from the borrow pits newly established along the expressway. Assumed transport distance of 20 km	16 big ne borrow pits to be planned 300 m x 800 m x 6 m depth x 0.8 = 1,000,000 m^3	○
Gravel	45	6 mil	Transport distance of 150 km from mountain area. Selected material	Necessary for cement concrete and asphalt concrete (27 m + 35 m) / 2 x 2 m = 62 m^2	○

Legend: ○ Favorable △ Unfavorable

(2) Use of Borrow Pit as Water Reservoir

Assuming that the distance between the borrow pit and the embankment site is 20 km, soil of rice field around the route can be used for embankment in view of its economical transportation cost. Such borrow pits can be utilized as reservoirs for irrigation of rice field and can promote increase of the rice production. Thus, the expressway project, if implemented in good coordination with water reservoir projects, can effectively facilitate increase of rice production. Ministry of Water Resource and Meteorology (MOWRAM) and local governments are in charge of water reservoir. Coordination among relevant ministries for using the borrow pits excavated for expressway construction as reservoirs for agriculture is highly desirable to efficient use of land and soil. If the scale of water reservoir is assumed 300 m x 800 m x 6 m depth, soil volume of one reservoir is calculated to be 1,000,000 m^3 (300 m x 800 m x 6 m x 0.8) and 16 reservoirs are needed for 16,000,000 m^3 of embankment. In terms of economical transportation cost and proper water reservoir arrangement, 20 km is assumed to be the probable hauling distance. Construction of a 10 km-long new road is assumed (or use of exiting road for 10 km is assumed) for hauling of soil from a borrow pit to the site of embankment.

(3) Road Structure of the Section Traversing the Wet Land Located in the West of Mekong River (RR3 – Neak Loeung)

It is supposed to be difficult to find suitable and sufficient sites of borrow pit because the area of rice field is limited. Furthermore, flood brings silty soil to the area every year and causes sedimentation, which would spoil the function of water reservoir. Therefore, viaduct is be adopted as the basic road structure here.

(4) Soft Ground

Countermeasures for soft ground such as vertical drain and stabilizing berm shall be used as necessary.

(5) Interval of Crossing Road

In case of low embankment, bridges need to be constructed to let the crossing roads pass over the expressway. On the other hand, box culverts are constructed to let the crossing roads pass under the expressway. The construction cost of over bridges is much higher than the box culverts. Thus it is more economical to adopt high embankment where the intervals of crossing roads are short and many over bridges need to be constructed.

(6) Blocking of Flood Water

Substantial portion of E1 Expressway traverses flood area of Mekong River. To minimize the natural impact caused by blocking the flood water and changing the hydrology of Mekong River, bridges and viaducts need to be adopted where necessary.

4.3.4 Comparison of Alternative Road Structures

Three alternative road structures are compared considering the following evaluation items. The result of comparison is shown in Table 4.2-5.

- ✓ Splitting of community: Crossing roads
- ✓ Blocking of flood water
- ✓ Social impact: Resettlement
- ✓ Countermeasure against soft ground
- ✓ Additional benefit and additional negative impact
- ✓ Construction cost

(1) Low Embankment (see Figure 4.3-6)

Since this structure requires ROW of 60 meter wide, number of necessary resettlement is the second smallest among three alternatives. Also, even this structure requires rather expensive construction cost of over-bridge, the total construction cost is only USD 5 million per kilometer, which is the lowest among three. Therefore, this structure is used for sparsely populated areas since adverse effect of community splitting is small. Low embankment consists of 1 m-high embankment, 1 m-thick subgrade and 1 m of pavement (subase course, base course and AC pavement). Hauling distance of the soil for 1 m embankment is assumed to be 5 km since the required volume of soil is not large and it is easy to find borrow pit near the route.

(2) High Embankment (see Figure 4.3-5)

This structure requires acquiring land in 80 meter width, and therefore it requires the largest scale of resettlement among three alternatives. The problem of splitting of the communities along the expressway can be substantially mitigated by providing culvert boxes for crossing at short intervals. The construction cost of culvert box is relatively low.

If the dimension of one borrow pit is assumed to be 300 m x 800 m x 6 m in length, width and depth, respectively, the volume of soil excavated from one borrow pit is calculated to be 1,000,000 m^3. In other words, one reservoir is needed for every 6 km of embankment.

The construction cost for this structure is USD 7 million per kilometer, because transportation cost of soil for embankment from nearby borrow pit is inexpensive. Therefore, this structure would be used for less populated area.

(3) Viaduct Structure (see Figure 4.3-7)

Although this structure requires the smallest scale of resettlement, the construction cost is the highest among three alternatives. ROW of 50 meter in width is required for this structure, and its construction cost is USD 24 million per kilometer.

Adoption of this structure will not only eliminate community splitting but also prevent from hindering of town/city expansion. Therefore, it is suitable for urbanized areas or densely populated areas. Also, it can be used in flood areas, since this structure will not block the flood water.

Table 4.3-4 Comparison of Road Structures

	High Embankment	Low Embankment	Viaduct
Embankment Material	From water reservoir 16,000,000 m^3	4,000,000 m^3 (35 m + 39 m) / 2 x 1 m = 37 m^2	0
Material	Transportation of embankment material: L = 150 km 6,000,000 m^3 (27 m + 35 m) / 2 x 2 m = 62 m^2	Transportation of embankment material: L = 150 m 6,000,000 m^3 (27 m + 35 m) / 2 x 2 m = 62 m^2	Transportation of aggregate to be used for cement concrete: 150 km 5,000,000 m^3
Community Split: Crossing roads	Box culverts installed at interval of 1 km 140 box culverts Increase access distance by 1 km at maximum	Over-bridge installed at interval of 1 km 140 over-bridges Increase access distance by 2 km at maximum	At-grade road can cross expressway at any location: will not hinder the expansion of town/city.
	○	△	◎
Blocking of flood water	Block flood water Open space required	Block flood water Open space required	Not block flood water
	○	△	◎
Social impact: Resettlement	W= 80 m	W= 60 m	W= 50 m
	△	○	◎
Countermeasure for soft ground	Many sand /cardboard drain	Little sand / cardboard drain	Foundation is long concrete piles
	△	○	◎
Other benefit	Water reservoirs contribute to increase in production of rice		Not hinder the expansion of town / city
	◎		○
Other negative impact	Resettlement caused by reservoir	None	None
	△		
Construction Cost	USD 7 mil/km	USD 5 mil/km	USD 24 mil/km
	○	◎	△

Legend: ◎ Good ○ Fair △ Poor

4.3.5 Proposed Road Structure

Figure 4.3-12 shows proposed routes and road structure.

(1) Route B

The 34 km-long section between the starting point of Route B (RR3, Ex1) and Neak Loeung, and the 15 km-long section from Neak Loeung heading to east are both located in flood-prone areas. Therefore, viaduct structure is adopted in these sections. On the other hand, low embankment structure is adopted at the 20 km-long section located around Kampong Trabek, since this section is in sparsely populated area. The next 21 km-long section located around Kraol Kou has less population, and high embankment structure is adopted. The 10 km-long section around Svay Rieng City adopts viaduct structure considering its large population of the city. The 27 km-long section between Svay Rieng City and Bavet Town adopts high embankment structure considering the population along the expressway. The viaduct structure is adopted for the 10 km-long section around Bavet town because of the large population. High embankment structure is adopted at the last 3 km section towards the national border, since border control facility need to be installed. The construction cost of Route B and RR3 is estimated at USD 2,226 million as shown in Table 4.3-5.

Table 4.3-5 Construction Cost of Route B

Route B	Length	Structure	Unit Cost USD/ km	Cost USD
RR3 (NR21 – NR1)	24 km	23 km Flat 1 km Viaduct	3 mil	66 mil
RR3. Ex1 IC – Neak Loeung Flood area	33 km	Viaduct Structure	24 mil	792 mil
Neak Loeung Bridge Over Mekong River	1 km	Long span Bridge.	92 mil	92 mil
Neak Loeung – 15 km to eastward Flood area	15 km	Viaduct Structure	24 mil	360 mil
Around Kampong Trabek sparsely populated area (1 mil.m^3)	20 km	Low Embankment	5 mil	100 mil
Around Kraol Kou Less populated area (3 reservoirs)	18 km	High Embankment	7 mil	126 mil
Around Svay Rieng City Densely populated area	10 km	Viaduct Structure	24 mil	240 mil
From Svay Rieng to Bavet Less populated area (5 reservoirs)	27 km	High Embankment	7 mil	189 mil
Around Bavet City Densely populated area	10 km	Viaduct Structure	24 mil	240 mil
Near Border Border facilities	3 km	High Embankment	7 mil	21 mil
Total of Route B	137 km		16 mil	2,160 mil
Ground Total Including RR3 and Route B	161 km		14 mil	2,226 mil

(2) Route C

The 25 km-long section between the starting point of Route C (RR3, Ex2) and Prey Veng, and the 20 km-long section from Prey Veng heading to east are both located in flood-prone areas. Therefore, viaduct structure is adopted in these sections. On the other hand, low embankment structure is adopted at the 20 km-long section located around Sdau Kaong, since this section is in sparsely populated area. The next 20 km-long section located around Kraol Kou has less population, and high embankment structure is adopted. The 10 km-long section around Svay Rieng City adopts viaduct structure considering the large population of the city. The 27 km-long section between Svay Rieng City and Bavet Town adopts high embankment structure considering the population along the expressway. The viaduct structure is adopted for the 10 km-long section around Bavet town because of the large population. High embankment structure is adopted at the last 3 km section towards the national border, since border control facility needs to be installed. The construction cost of Route C and RR3 is USD 2,182 million as shown in Table 4.3-6.

Table 4.3-6 Construction Cost of Route C

Route C	Length	Structure	Unit Cost USD/ km	Cost USD
RR3 (NR21 – NR1- RR3.Ex2)	29 km	26 km Flat 2 km Viaduct 1 km Long Br	6 mil	172 mil
RR3. Ex2 IC – Prey Veng Flood area	25 km	Bridge Structure	24 mil	600 mil
Prey Veng – 20 km to eastward Flood area	20 km	Viaduct Structure	24 mil	480 mil
West side of Prey Nhay sparsely populated area (1 mil.m^3)	20 km	Low Embankment	5 mil	100 mil
From Prey Nhay to Svay Rieng Less populated area (3 reservoirs)	20 km	High Embankment	7 mil	140 mil
Around Svay Rieng City Densely populated area	10 km	Viaduct Structure	24 mil	240 mil
From Svay Rieng to Bavet Less populated area (5 reservoirs)	27 km	High Embankment	7 mil	189 mil
Around Bavet City Densely populated area	10 km	Viaduct Structure	24 mil	240 mil
Near Border Border facilities	3 km	High Embankment	7 mil	21 mil
Total of Route C	135 km		15 mil	2,010 mil
Ground Total Including RR3 and Route C	164 km		13 mil	2,182 mil

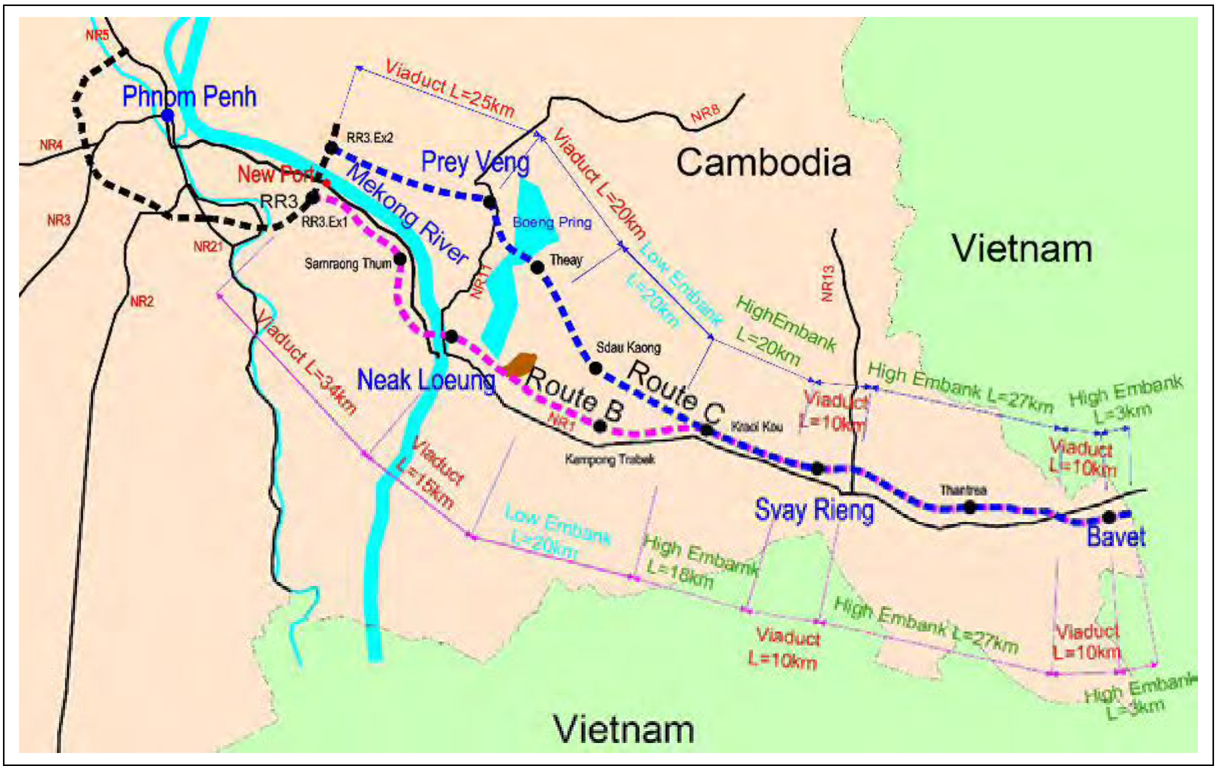


Figure 4.3-12 Proposed Routes and Road Structure

4.4 Location of Rest Facilities and Other Facilities

(1) Necessity of Rest Facilities

Drivers cannot freely get on and get off expressways. This means drivers must use designated entrances and exits in order to maintain rapid, constant, comfortable and safe driving, which is the basic purpose of expressways.

Expressway users cannot use rest areas which are located outside of the expressway without getting off at an interchange. Therefore, the provision of rest areas at proper intervals is indispensable for expressway users in comfortable and safety driving.

The rest facilities are classified into two categories depending on their functions (services). One is large scale rest area which has such facilities as restaurant, parking area, public lavatory, gas station, free rest space, route information, repair shop and garden. The other is small scale rest area which has only minimum facilities such as vending machine, parking area, public lavatory, and garden.

Intervals between rest areas are shown in Table 4.4-1.

Table 4.4-1 Intervals between Rest Areas

	Standard distance
Between Rest Areas	15 km to 25 km
Between Large scale rest areas	50 km to 100 km

Figure 4.4-1 Image of Rest Area

(2) Location of Rest Areas

Average distance between rest areas on E1 is proposed to be around 20 km (15 to 25 km) considering the criteria stipulated in Japanese design manual. Therefore, rest areas will be arranged between each interchanges which are planned as shown in Figure 4.2-23. Locations of rest areas are shown in Figure 4.4-2.

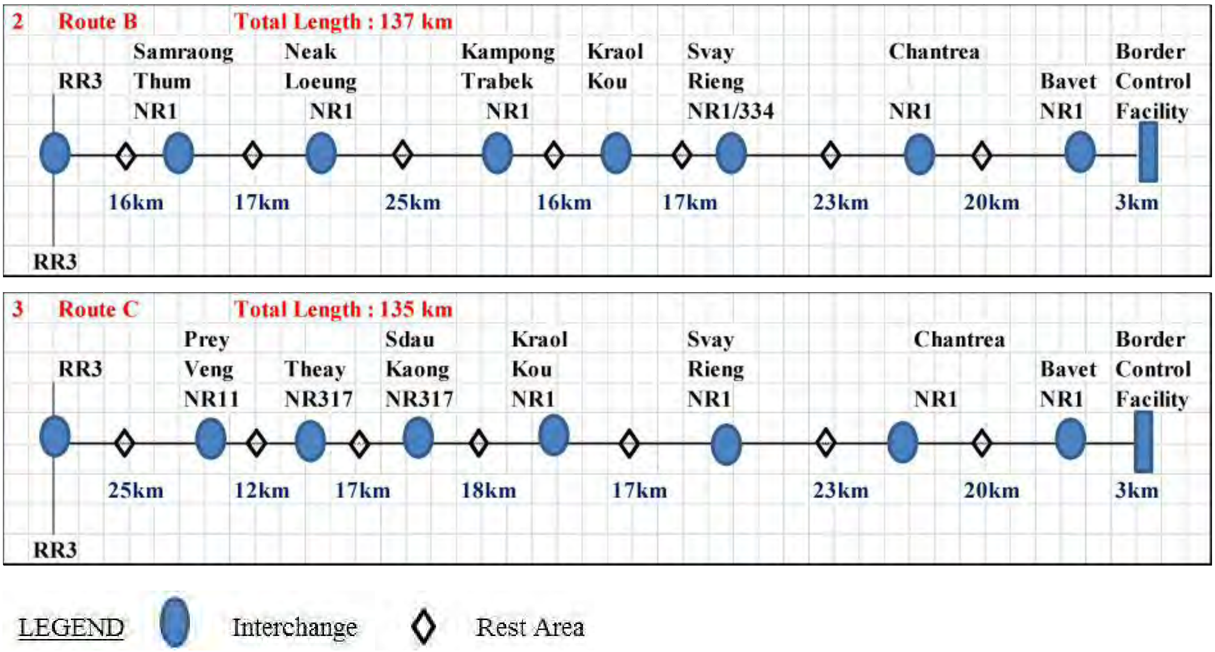


Figure 4.4-2 Locations of Rest Areas

(3) Bus Stop

In order to promote maximum utilization of expressways, bus stops for buses operating between cities are provided at interchanges. The bus stops provided on the expressways can offer a high speed transportation of passengers along the route by shortening the travelling time for the fixed route buses. Bus stops should be arranged after consultation with bus operating companies.

(4) Toll Gate

Since an expressway is a toll road, it is necessary to install a facility to collect tolls from expressway users.

(5) Border Control Facility

Border control facility should be planned after consultation with Vietnam side. Time required for immigration clearance should be short, in order not to discourage expressway users.

4.5 Ring Road No. 3

4.5.1 The Section from NR5 to NR21 Studied by Korea

(1) Brief History of the Study by Korea

Ring Road No. 3 (RR 3) has been studied by Korean Team in a form of PPP since 2009. They made three project presentations to Cambodian government including MPWT and MOEF in 2013. They almost finalized the proposal judging from the 3rd presentation materials. However, Phnom Penh Municipality started the improvement project of the section of RR 3 between NR 4 and NR 5, and a meeting was held between two parties to discuss who implement this project.

Brief history of the study is shown in the Table 4.5-1.

Table 4.5-1 Brief History of Project Proposed by Korea

Date	Item
May. 2009	Request of Korean ODA (EDCF) at ASEAN-Korea Summit Meeting
Sep. 2009	Submission of Pre-Feasibility Study
May.2010	Prime Minister's Approval on Project Scheme (PPP) and Alignment
Aug. 2012	Launching Feasibility Study
Jan. 2013	1st Project Presentation to Cambodian Government including MPWT and MEF
Apr. 2013	2nd Project Presentation to Cambodian Government including MPWT and MEF
June. 2013	3rd Project Presentation to Cambodian Government including MPWT and MEF
Mar, 2014	Conflict between PPP project and Project being implemented by Phnom Penh Municipality

Source: Presentation by Korea on June 2013 and meeting with Korea Expressway Corporation on February and March 2014

(2) Summary of Project Proposed by Korean Team

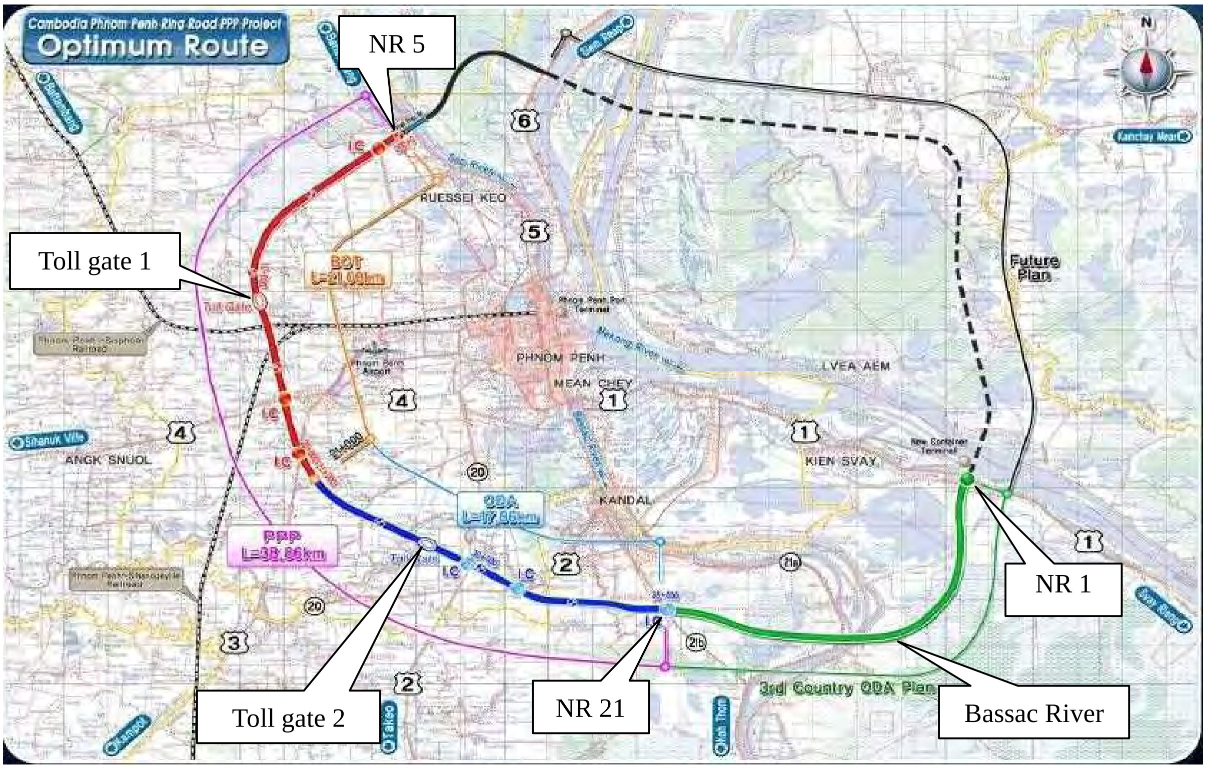
The length of PPP project, which is from NR 5 to NR 21, is 38.9 km and the cost is USD 90 mil. The 1st phase of the project consists of 21.0 km-long section financed by private fund

(USD 41 mil) and 17.9 km-long section financed by Korean ODA of EDCF (USD 49 mil). The unit cost of RR 3 proposed by Korean study team is USD 2.3 million/km (90 mil/ 38.9 km). Concession period of the project is 30 years. The summary of project proposed by Korea, route map of RR 3, future traffic volume and cross section are shown in Table 4.5-2, Table 4.5-3, and Figures 4.5-1 to 4.5-3.

Table 4.5-2 Summary of Project Proposed by Korea

Project Name	Phnom Penh Ring Road PPP Project
Location	Phnom Penh Prek Phnov - Kandal Tuol Krasang
Plan Length and Cost	Total 60.3 km (3 phased construction) Phase 1, L= 38.9 km, 2 lanes, USD 90 mil Phase 2, L= 38.9 km, 2 ⇒4 lanes, USD 51 mil Phase 3, L= 21.4 km, NR 21- NR 1, ODA project from other nation
Project Type	Build Operation Transfer (BOT) Phase 1 consists of 21.0 km of private fund (USD 41 mil) and 17.9 km of Korean ODA of EDCF (USD 49 mil)
Period (Phase 1)	Construction 3 years (2015 - 2017), Operation 30 years (2018 - 2047)
Summary of construction	Width:2 lanes (15.5 m) 2.5 m + 0.5 m + 3.5 m + 2.5 m + 3.5 m + 0.5 m + 2.5 m Interchanges : 6 units Toll gate: 2 units Pavement: Cement Concrete (main lane), Asphalt Concrete (shoulder)
Design	60-80 km/hr
Toll fee level	Similar to NR 4: Sedan USD 0.7 /toll gate (around 20 km) Heavy truck USD 3.00 /toll gate

Source: Presentation by Korea on June 2013: summarized by survey team



Source: Presentation by Korea on June 2013

Figure 4.5-1 Route Map of RR 3 Proposed by Korea

Table 4.5-3 Future Traffic Volume Estimated by Korea

Section		Toll gate 1			Toll gate 2		
Year		2018	2027	2037	2018	2027	2037
MC		14,840	24,420	41,069	11,845	15,896	29,460
LV		4,738	7,798	13,116	3,782	5,077	9,409
HV		1,205	1,984	3,336	962	1,291	2,391
Total	IN MC	20,783	34,202	57,521	16,589	22,264	41,260
		5,943	9,782	16,452	4,744	6,368	11,800

Source: Presentation by Korea on June 2013

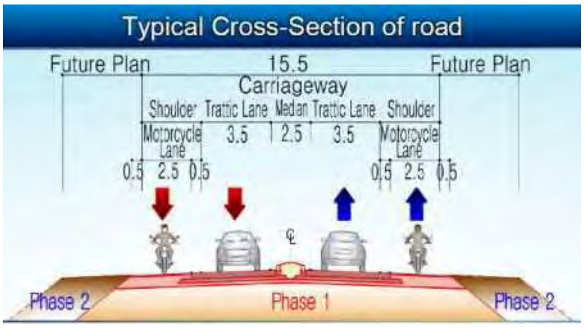


Figure 4.5-2 Typical Cross Section of Embankment of RR 3

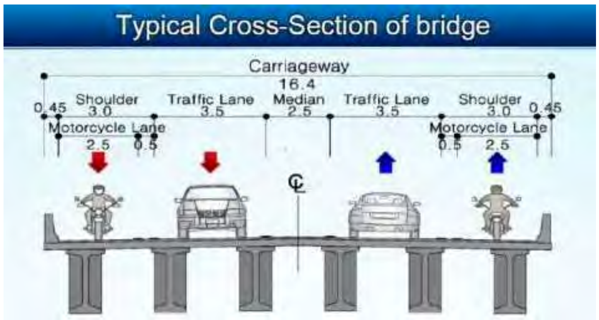


Figure 4.5-3 Typical Cross Section of Bridge of RR 3

Source: Presentation Material by Korean Team, June 2013

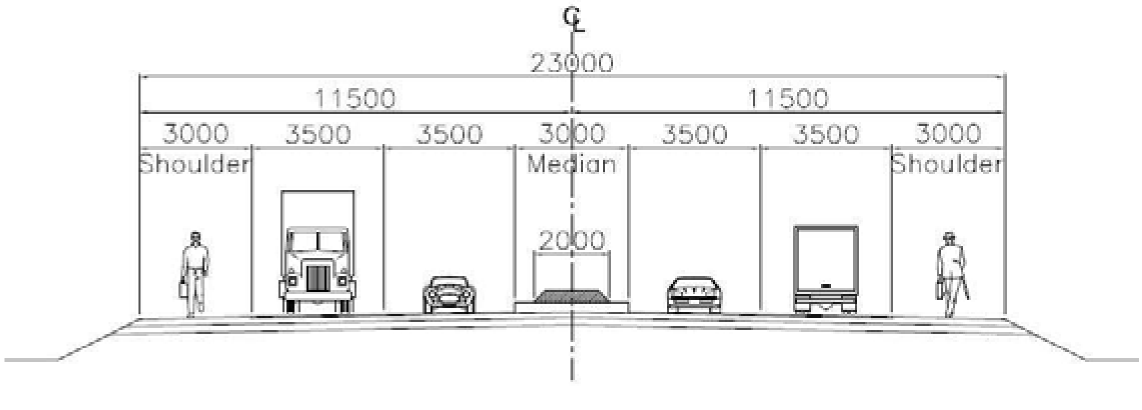
4.5.2 Ring Road 3 from NR 21 to NR 1 (Proposed Project)

(1) Route Planning

It is possible that the section of Ring Road 3 from NR 21 to Mekong River be considered as a candidate project for Japanese ODA. In case of Route B, total length is 24 km including a bridge on RR 3 over Bassac River. In case of Route C, total length is 29 km including a bridge over Bassac River and a long span bridge over Mekong River.

(2) Cross Section

Considering a rapid modal shift from motorcycle to car in many countries and small cost increase for upgrading from 2.5m-wide motorcycle lane to 3.5m-wide regular lane (for 4-wheel vehicle), the Study Team proposes @3.5 m x 4 lanes. Also, the 3.0 m pedestrian walkway on both sides is proposed in view of the importance of citizens' activities and safety of pedestrian traffic. The typical cross section of embankment is proposed based on the section of design standard.



Typical Cross Section of Embankment (Ring Road 3)

Figure 4.5-4 Typical Cross Section of Embankment for the Section from NR 21 to NR 1

(3) Construction cost

Construction cost of RR3 is as shown in Table 4.5-4.

In case of Route B, construction cost is estimated at USD 66 million. In case of Route C, construction cost is estimated at USD 172 million including the long span bridge over Mekong River.

Table 4.5-4 Construction Cost of RR3

	In case of Route B		In case of Route C	
	Length	Cost	Length	Cost
Embankment	23 km	USD 46 mil	26 km	USD 52 mil
Short span bridge	1 km	USD 20 mil	2 km	USD 40 mil
Long span bridge	0	0	1 km	USD 80 mil
Total	24 km	USD 66 mil	29 km	USD 172 mil

CHAPTER 5 PRELIMINARY HIGHWAY DESIGN AND PRELIMINARY COST ESTIMATE

5.1 Referred Design Standard

There are stipulations concerning expressway standards in Cambodian Road Design Standard. However, these stipulations were prepared in 1990's when construction of expressway in Cambodia was not realistic. Therefore, these stipulations need to be diligently examined to verify their practicability considering the current conditions of expressway in Cambodia. Also, it is necessary to refer the relevant standards of international highway network, such as ASIAN Highway and ASEAN Highway since E1 Expressway constitutes a part of these international highway networks. Further, the neighboring countries, namely Thailand and Vietnam have their own expressway standards, and these standards need to be carefully considered in selecting the design standards of expressways in Cambodia since these expressways will be connected to those of neighboring countries.

5.1.1 Design Standard of Cambodia

Design standard of Cambodia is as summarized in Table 5.1-1.

Table 5.1-1 Design Standard of Expressway Cambodia in 2003 (R6)

	Item		Remarks
	Road Class	R6	Expressway (Rural) (Access Control)
1	Design Speed	120 km/hr 100 km/hr 80 km/hr	Flat Terrain Rolling Terrain Mountainous Terrain
2	Lane Width	3.5 m	
3	Shoulder Width	3.0 m 2.5 m	Flat Terrain Rolling Terrain Mountainous Terrain
4	Median Width (Desirable)	6.0 - 18.0 m 5.0 - 12.5 m 4.0 - 8.0 m	Flat Terrain Rolling Terrain Mountainous Terrain
	Median Width (Minimum)	6.0 m 5.0 m 4.0 m	Flat Terrain Rolling Terrain Mountainous Terrain
5	General Maximum Grade (for Design Speed of 120 km/hr)	3-5% 4-6%	Flat Terrain Rolling Terrain

5.1.2 Design Standards of ASIAN Highway and ASEAN Highway

Design standards of ASIAN Highway and ASEAN Highway are as shown in Tables 5.1-2 and 5.1-3, respectively.

Table 5.1-2 Design Standards of ASIAN Highway (Primary)

	Item		Remarks
	Road Class	Primary	Expressway (4 or more lanes and access control)
1	Design Speed	120 km/hr 100 km/hr 80 km/hr 60 km/hr	Level (Flat Terrain) Rolling Terrain Mountainous Terrain Steep
2	Lane Width	3.5 m	
3	Shoulder Width	3.0 m 2.5 m	Flat Terrain and Rolling Terrain Mountainous Terrain and Steep
4	Median Width (Minimum)	4.0 m 3.0 m	Flat Terrain and Rolling Terrain Mountainous Terrain and Steep
5	Maximum Grade	4% 5% 6% 7%	Level (Flat Terrain) Rolling Terrain Mountainous Terrain Steep

Source: Annex II ASIAN HIGHWAY CLASSIFICATION AND DESIGN STANDARDS

Table 5.1-3 Design Standards of ASEAN Highway (Primary)

	Item		Remarks
	Road Class	Primary	Expressway (4 or more lanes and access control)
1	Design Speed	120 – 100 km/hr 100 - 80 km/hr 80 - 60 km/hr	Flat Terrain Rolling Terrain Mountainous Terrain
2	Lane Width	3.75 m	
3	Shoulder width	3.0 m 2.5 m	Flat Terrain Rolling Terrain Mountainous Terrain
4	Median Width (Minimum)	—	—
5	Maximum Grade	4% 5% 6%	Flat Terrain Rolling Terrain Mountainous Terrain

Source: Association of Southeast Asian Nation Annex B: ASEAN Highway Standards

5.1.3 Design Standards of Vietnam and Thailand

Design standard of Vietnam and Thailand are as shown in Tables 5.1-4 and 5.1-5, respectively.

Table 5.1-4 Design Standards of Vietnam

	Item		Remarks
	Road Class	Primary	Expressway (4 or mare lanes and access control)
1	Design Speed	120 - 100 km/hr 80 - 60 km/hr	Flat Terrain Mountainous Terrain
2	Lane Width	3.75 m	
3	Shoulder Width	3.0 m 2.5 m	Flat Terrain Rolling Terrain Mountainous Terrain
4	Median Width (Minimum)	4.5 m 3.0 m 2.5 m	without cover with cover and column with cover without column
5	Maximum Grade	4 - 5% 6%	Flat Terrain Mountainous Terrain

Source: TCVN 5729 2007 Expressway design standards

Table 5.1-5 Design Standards of Thailand

	Item		Remarks
	Road Class	Primary	Expressway (4 or mare lanes and access control)
1	Design Speed	120 - 100 km/hr 100 - 80 km/hr	Standard Absolute Lowest Standard
2	Lane Width	3.6 m	
3	Outer Shoulder Width Inter Shoulder Width	3.0 m 1.0 m	
4	Median Width (Minimum)	6.3 m	Standard
5	Maximum Grade	3%	Standard

Source: DETAILED ENGINEERING DESIGN OF MOTERWAYS IN THAILAND MOTERWAY DESIGN STANDARDS

5.1.4 Proposed Design Standard of E1 Expressway

Proposed design standard of E1 Expressway is as shown in Table 5.1-6. This standard follows mainly Cambodian standard. A major deviation of the proposed standard from the Cambodian standard is lane width of 3.75 m. The reason of this is explained in Subsection 5.2.1 below.

Table 5.1-6 Summary of Referred Design Standards and Proposed Design Standard of E1 Expressway

Items	Cambodia	Asian Highway	ASEAN Highway	Vietnam	Thailand	Japan	Proposed	Note
Road Class	**R6 (Rural)**	Primary	Primary	Class A	Moterway	Type-1	**R6**	
Terrain	**Flat**	Flat	Flat	Flat	Flat	Flat	**Flat**	
Design Speed (km/hr)	**120**	120	120	120	120	120	**120**	
Lane Width	**3.5**	3.5	3.75	3.75	3.6	3.5	**3.75**	3.5 ⇒ 3.75
Shoulder Width	**3.00**	3.00	3.00	3.00	3.00	2.50	**3.00**	
Median Strip	**4.0～12.0**	4	—	2.5～4.5	3.6～6.3	4.50	**4.50**	
Cross Slope	**2.5～3.0%**	2.0%	—	2.0%	2.0%	2.5%	**2.5%**	
Min. Radii of Horizontal Curve	**595**	520	390	650	720	570	**595**	
Maximum Vertical Grade	**3～5%**	4%	4%	4%	3%	2%	**4%**	
Vertical Clearance	**5.5**	4.5	4.5 (5.0)	5	5.25	4.5	**5.5**	

5.2 Cross Section

5.2.1 Cross Sectional Composition of E1 Expressway

The proposed cross sectional composition, adopting the design standards as discussed in the above, is shown in Figure 5.2-1.

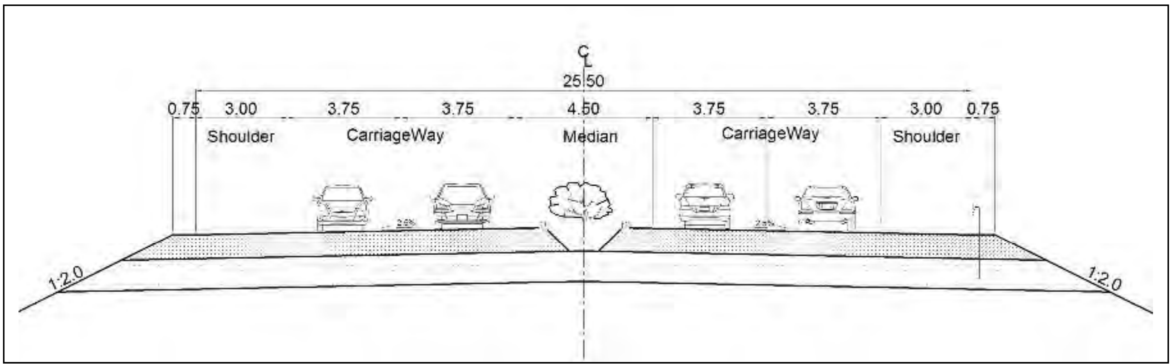


Figure 5.2-1 Proposed Cross Sectional Composition

(1) Lane width

Lane width of Cambodia standard is 3.5 m and those of Asian Highway, ASEAN highway, Vietnam, and Thailand are 3.5 m, 3.75 m, 3.75 m and 3.6 m, respectively. Lane width of 3.75 m is proposed so that it will be same with the standard of Vietnam, as well as those of Asian Highway and ASEAN Highway, since E1 expressway is to be connected the expressway of Vietnam.

(2) Median division

Width of median division stipulated in the design standard of Cambodia ranges 4.0 m to 12.0 m, and those of Asian Highway, Vietnam Standard, Thailand Standard are 4.0 m, 2.0 m, 4.5 m and 3.6 - 6.3 m, respectively. Wider median is desirable from the viewpoint of traffic safety (prevention of vehicles' crossing the centerline). However, wider median results in increase in construction cost and land acquisition cost. Median division of 4.5 m width conforms to the standards of Vietnam and Thailand. Experience in Japan shows that 4.5 m-wide median provides reasonable traffic safety. Therefore 4.5 m is proposed as the width of median division. It should be noted that this 4.5 m includes 0.75 m side strip on the both sides. Thus, the width of raised part of the median is 3.0 m.

(3) Shoulder

Main functions of shoulder are side clearance and emergency parking space of broken-down cars. Width of shoulder in Cambodian Standard is 3.0 m and those of Asian Highway, Vietnam, and Thailand are also 3.0 m. Therefore, 3.0 m is proposed as the width of shoulder.

5.2.2 Elevation of Road Surface

In Chapter 4, three types of road structure, high embankment, low embankment and viaduct, were proposed. The elevation of road surface of high embankment, low embankment and viaducts is proposed to be 7.5 m, 3.0 m and 8.0 m, respectively. The reasons for these elevations of road surface are explained below:

(1) High embankment

The elevation of road surface of high embankment section is planned to be 7.5 m. The reason for this height is as written below:

Vertical Clearance of Box Culvert	4.5 m
Thickness of Top Wall and Subgrade Cover	2.0 m
Pavement (AC + Base Course + Subbase Course)	1.0 m
Total	**7.5 m**

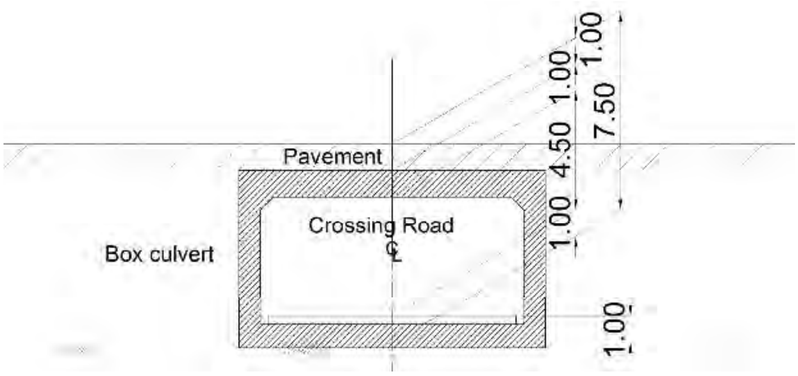


Figure 5.2-2 Conceptual Cross Section for High Embankment

(2) Low embankment

Pavement	1.0 m
Subgrade (1 m above Flood Water)	1.0 m
Embankment (Top of Embankment = Flood Water Level)	1.0 m
Total	**3.0 m**

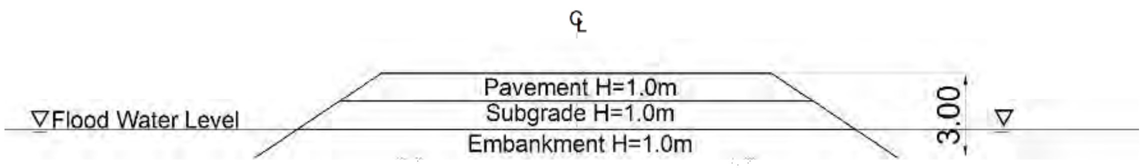


Figure 5.2-3 Conceptual Cross Section for Low Embankment

(3) Viaduct

Vertical Clearance for crossing Road	5.5 m
Height of Girder	1.5 m
Embankment	1.0 m
Total	**8.0 m**

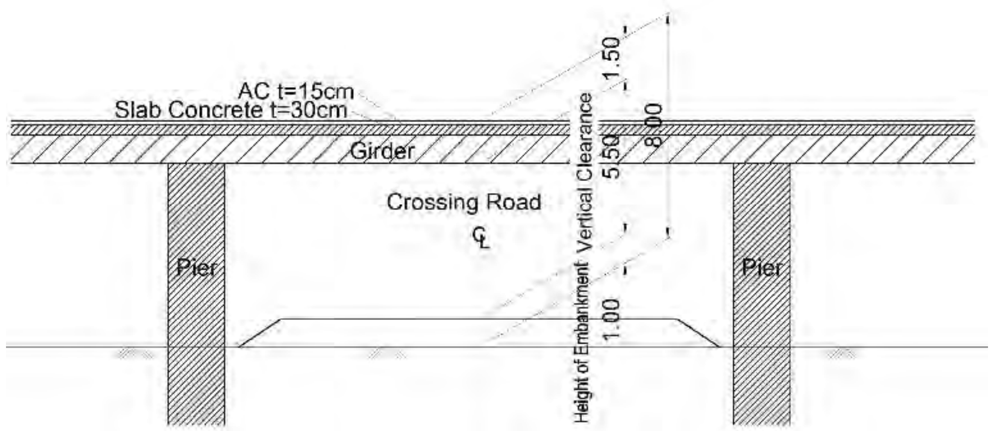


Figure 5.2-4 Conceptual Cross Section for Viaduct

5.2.3 Typical Cross Section

Considering the cross sectional composition as described in Subsection 5.2.1 and the height of roads surface as discussed in Subsection 5.2.2, three types of typical cross section as shown in Figures 5.2-5 to 5.2-7 are proposed.

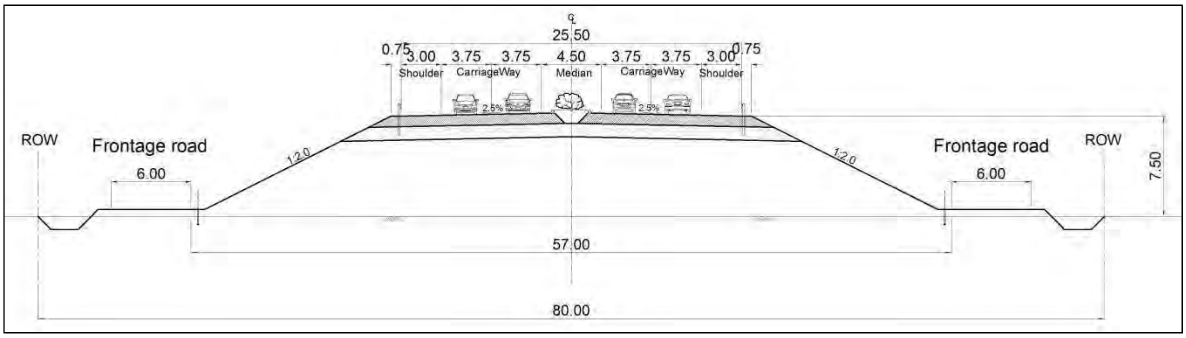


Figure 5.2-5 Typical Cross Section of High Embankment

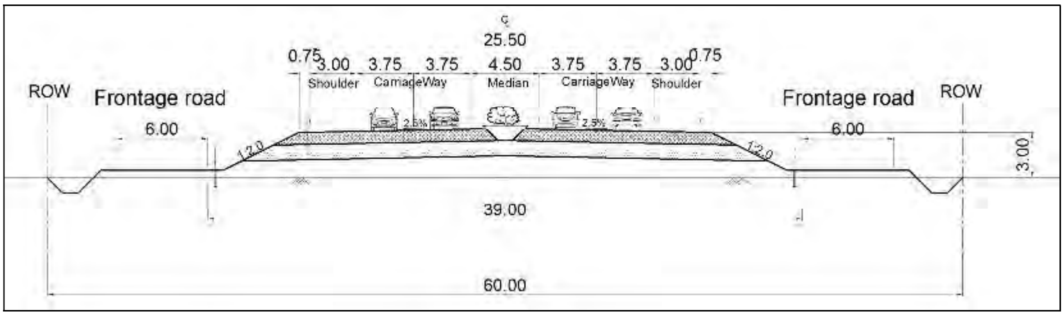


Figure 5.2-6 Typical Cross Section of Low Embankment

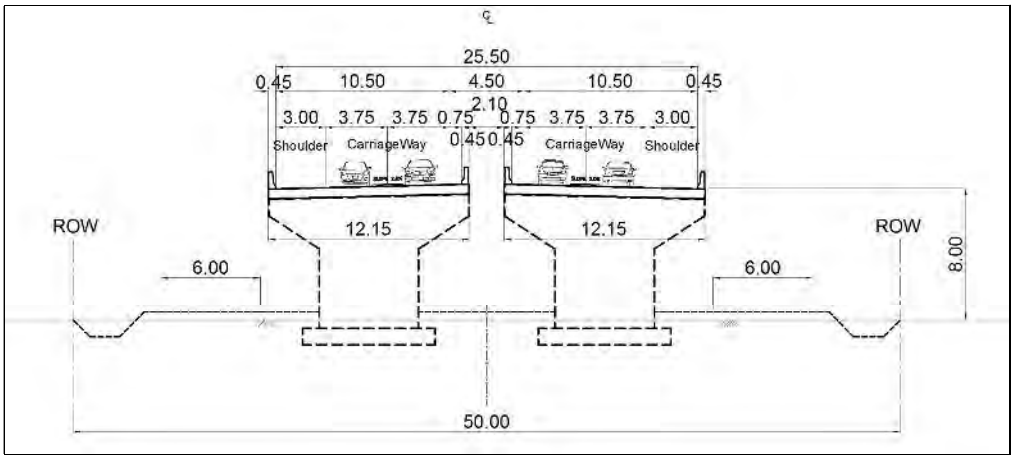


Figure 5.2-7 Typical Cross Section of Viaduct

5.2.4 Cross Section of Ring Road No.3

Ring Road No.3 (RR3) is an urban trunk road. This road is planned as a 4-lane highway. Planned typical cross section of RR 3 is shown below.

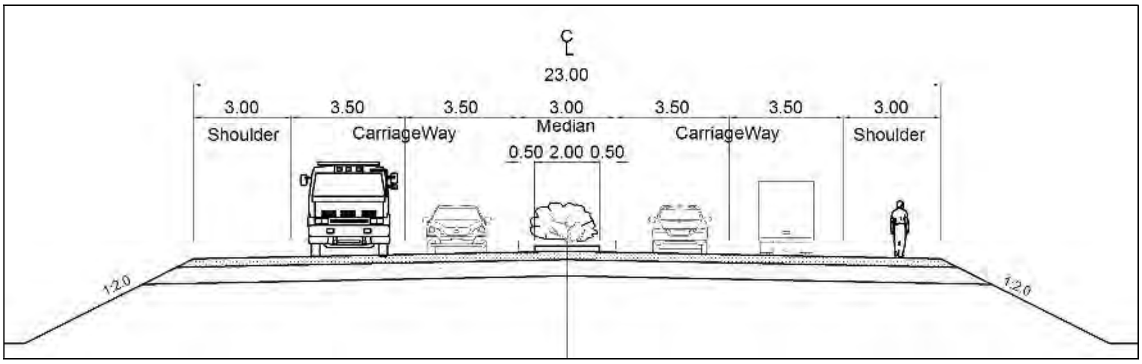


Figure 5.2-8 Typical Cross Section of Embankment of RR3

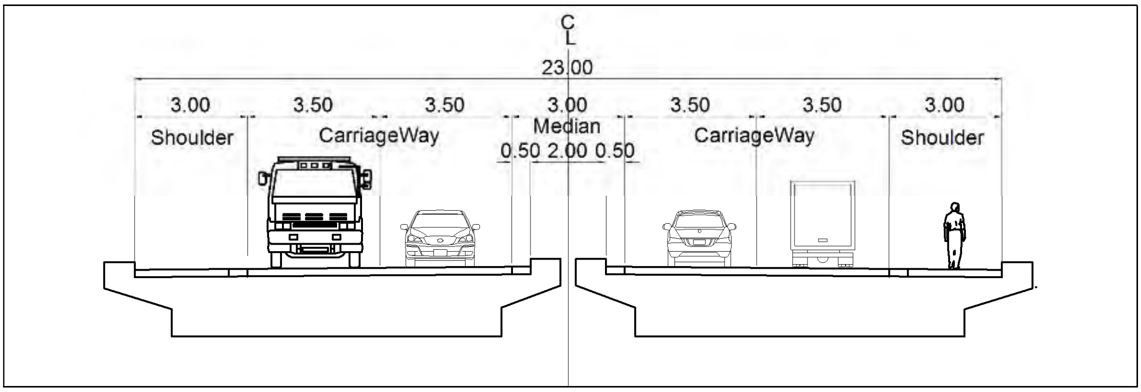


Figure 5.2-9 Typical Cross Section of Bridge of RR3

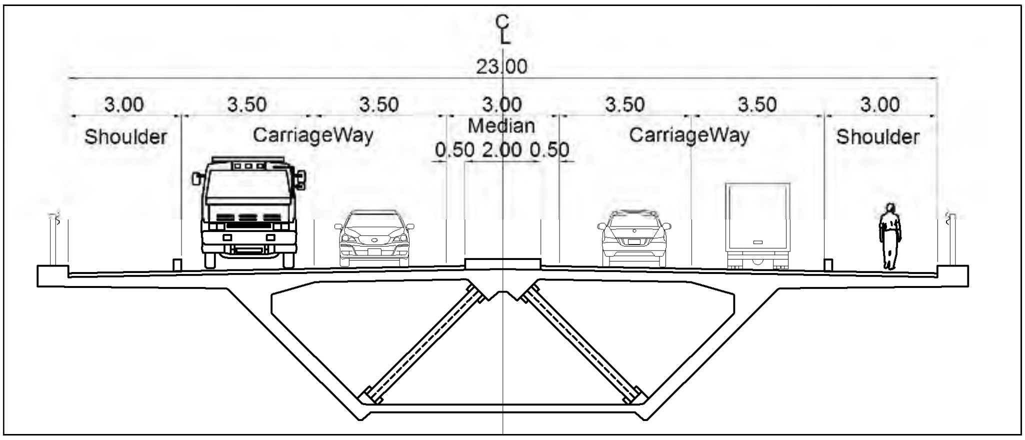


Figure 5.2-10 Typical Cross Section of Cable Stayed Bridge of RR3

(1) Lane width

Ring Road No.3 is classified as U5 class road in the Cambodia standard. Thus lane width is proposed to be 3.5 m.

(2) Median strip

Median strip 3.0 m was adopted referring National road No.5.

(3) Shoulder

Shoulder width is proposed to be 3.0 m, in accordance with Cambodian standard.

5.3 Horizontal Alignment of E1 Expressway

The area that E1 Expressway traverses is relatively flat and there are few topographical constraints except lakes and rivers. Main control points are towns and sparsely located houses. Thus, no serious problem in horizontal alignment is foreseen. More detailed study on horizontal alignment shall be conducted in the feasibility study and detailed design stages.

5.4 Profile of E1 Expressway

5.4.1 Ground Elevation

The topographical map which is readily available is the map of 1:100,000 scale published by MPWT. The data of ground surface elevation are sparse and are not sufficient for planning of height of highway. Thus, the numeric topography data provided through internet by NASA (National Aeronautics and Space Administration) were downloaded and used. These data show the ground height in 90 m interval. Figure 5.4-1 shows the data of ground height in gradation of color.

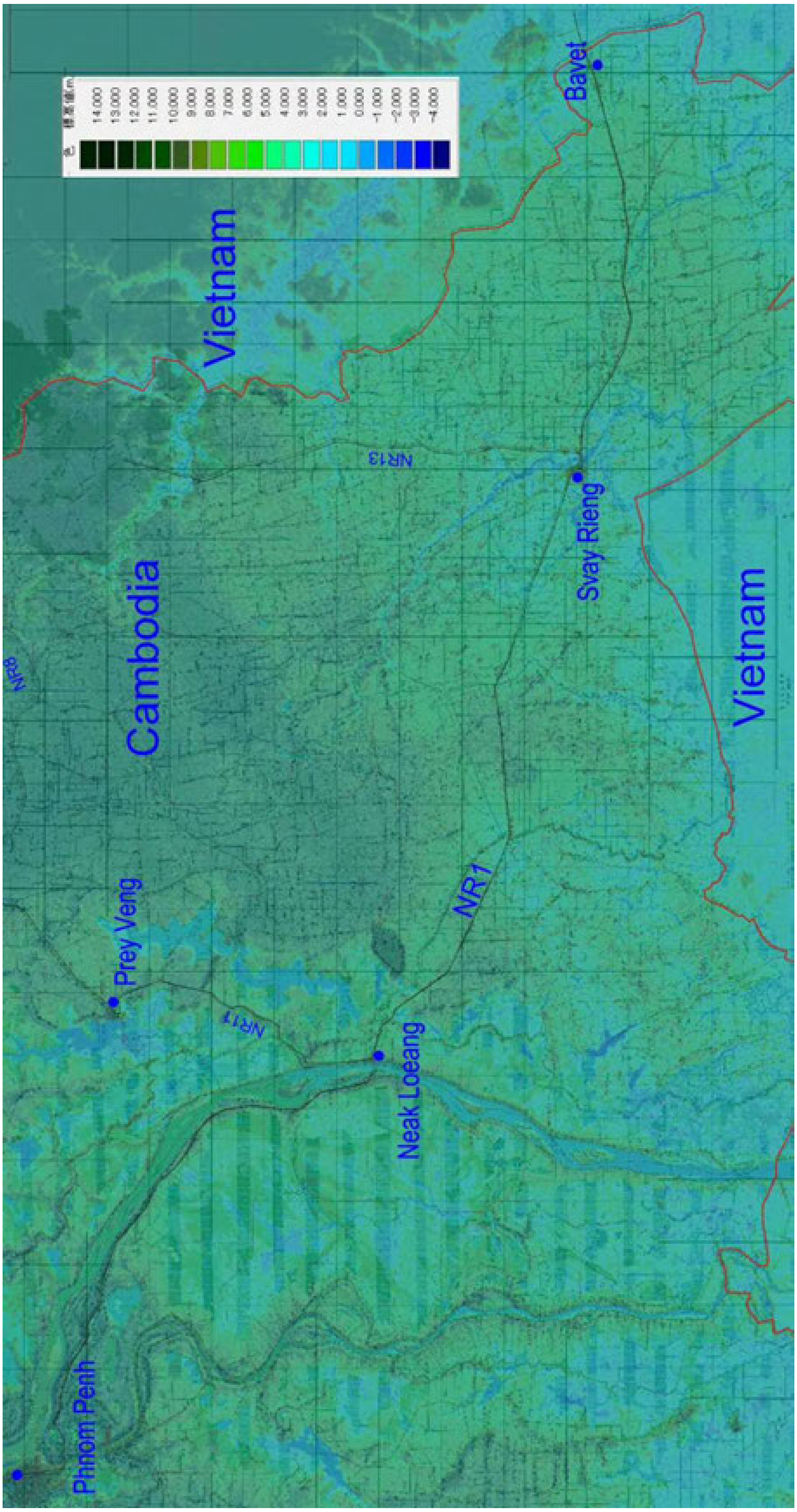


Figure 5.4-1 Graphical Presentation of Ground Height Data Provided by NASA

The ground height along the proposed routes were read from this map and used to draw profile (vertical alignment) of the expressway.

Three types of road structure, namely high embankment, low embankment and viaduct are to be adopted depending the site conditions, as discussed in Section 4.3. In selecting these road structures, elevation of ground surface relative to the level of flood water is considered. Low embankment is adopted where the elevation of the ground surface is relatively high, while high embankment is adopted where the elevation of ground surface is relatively low, as shown in Figure 5.4-2.

The height of embankment was calculated using the profile drawn using the ground elevation data as described above. The data of embankment height thus obtained were used to calculate the volume of earth work as described in Section 5.9. Figure 5.4-2 shows an example of profile.

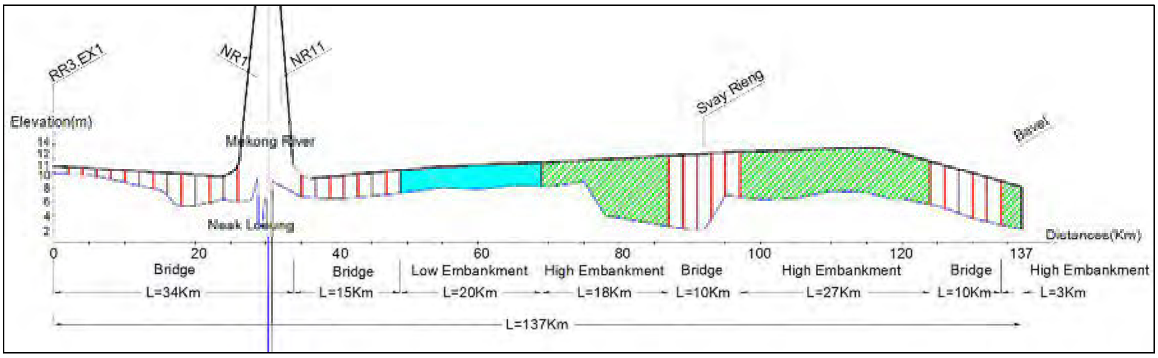


Figure 5.4-2 Example of Profile of Expressway

5.4.2 Adjustment of Profile in Order to Reduce Volume of Embankment

Considering the difficulty in obtaining soil material for embankment, it is preferable to reduce the height of embankment wherever possible. As explained in Subsection 5.2.1, the height of embankment is governed by the inner vertical clearance of the box culverts, and can be lowered between the culverts. Thus, possibility of lowering the embankment height between culverts, maintaining 7.5 m road surface height at culverts was studied.

Thus the reduction of embankment volume was estimated assuming the embankment height of 3 m between culverts with different maximum grade; 1% and 2%:

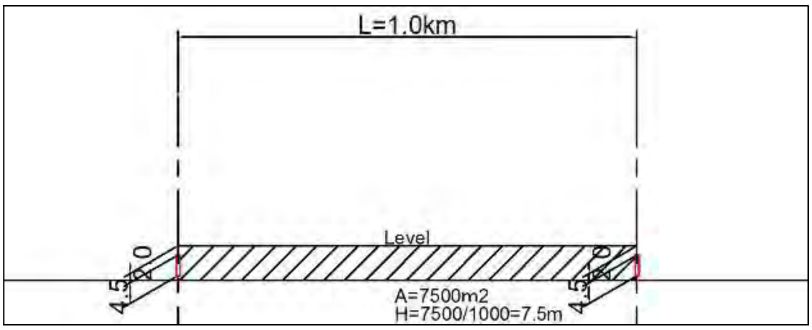


Figure 5.4-3 Profile of Case 1: H = 7.5 m (Constant)

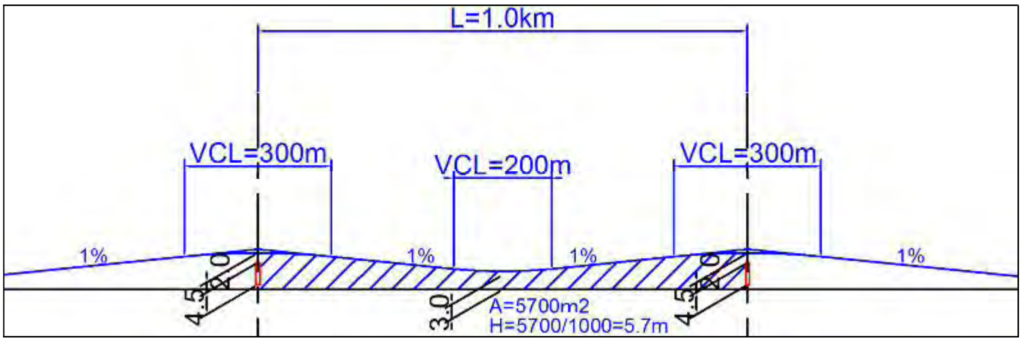


Figure 5.4-4 Profile of Case 2: Max. Gradient = 1%

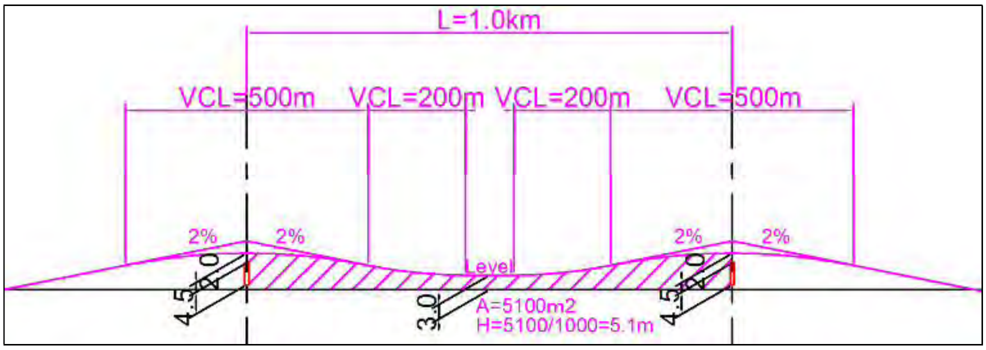


Figure 5.4-5 Profile of Case 3: Max. Gradient = 2%

Table 5.4-1 shows the result of such study. The volume of embankment can be reduced 68% of the Case 1 (7.5 m road surface height). However, occurrence of longitudinal gradient of 2% at interval of 500 m (2 times per 1 km) is considered to substantially spoil riding comfort. Thus, Case 3 is not recommended. As a conclusion, Case 2 is proposed as the method to reduce the volume of embankment.

Table 5.4-1 Result of Examination for Reducing the Volume of Embankment

Case	Max. Gradient	Crass Sectional Area of Embankment (m^2)	Ave. Height of Embank. (m)	Ratio of Ave. Height to Height of Case 1
1	Level (0%)	7500	7.5	100%
2	**1%**	**5700**	**5.7**	**72%**
3	2%	5100	5.1	68%

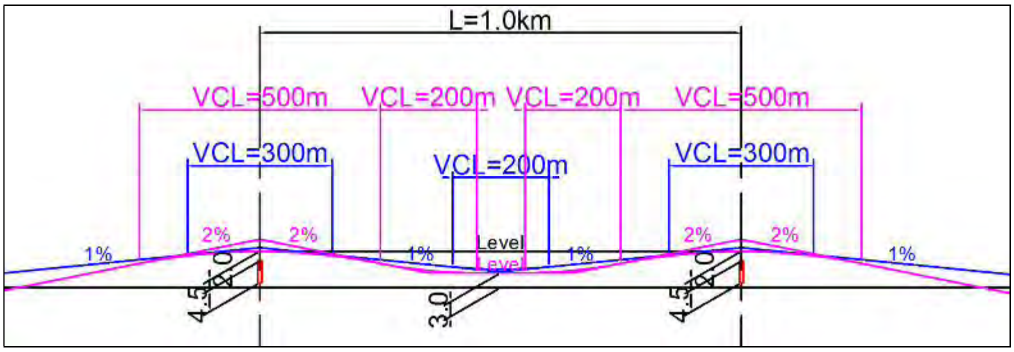


Figure 5.4-6 Profiles of Three Cases

5.5 Road Structure

5.5.1 Embankment

(1) Embankment Height

As discussed in Subsection 4.3.1, two types of embankment, 7.5 m and 3.0 m (height of road surface) are proposed depending on the roadside land use and other conditions. In case of high embankment, the height of embankment at sections between box culverts is proposed to be lowered to 3 m in order to reduce volume of embankment.

(2) Angle of Embankment Slope

From the viewpoint of traffic safety, mild slope of embankment is desirable. On the other hand, steep slope is desirable to reduce the volume of embankment. Angle of 1:2.0 is proposed for the embankment slope.

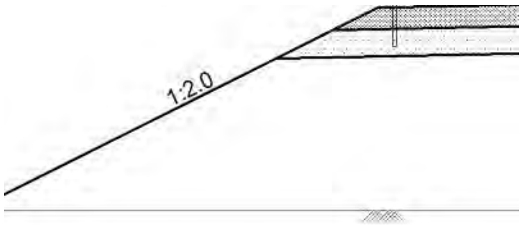


Figure 5.5-1 Slope Angle

5.5.2 Bridge and Box Culvert

(1) Long Span Bridge

In the case of B route, a long span bridge (tentatively called "New Neak Loeung Bridge") needs to be constructed to cross the Mekong River. In the case of C route, a long bridge on Ring Road No.3 becomes necessary to cross the Mekong River near the New Phnom Penh Port. General views of these bridges are shown in the figures below.

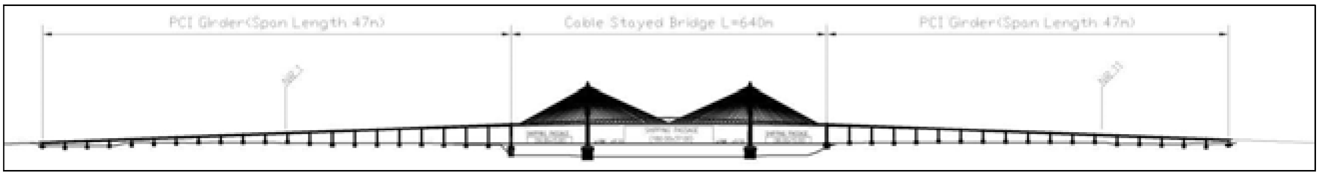


Figure 5.5-2 General View of New Neak Loeung Bridge

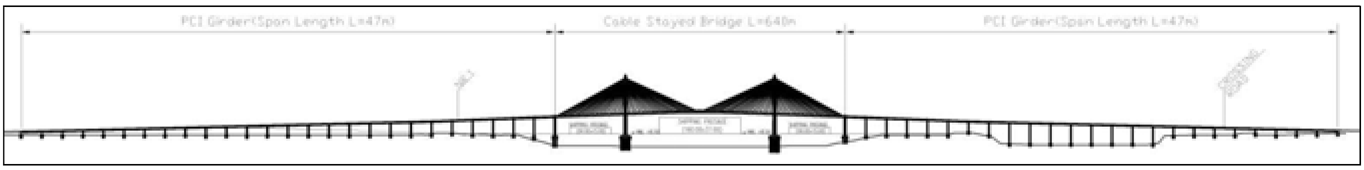


Figure 5.5-3 General View of Bridge for Ring Road 3

The typical cross section of the Neak Loeung Bridge as shown above is shown in Figure 5.5-4. The typical cross section of the bridge for RR 3 is shown in 5.2-10.

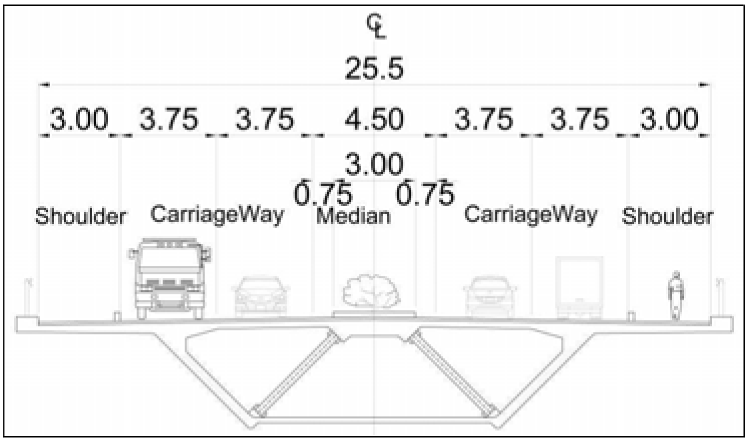


Figure 5.5-4 Typical Cross Section of Neak Loeung Bridge

(2) Viaduct (Short-Span Bridge)

Viaducts and short-span bridges are planned to traverse flooded area and lakes, respectively. Pre-tensioned, precast plank hollow slab (PSC) and post-tensioned, precast concrete deck girder (PCDG) are assumed to be adopted. The general characters of these bridge types are as summarized in Table 5.5-1.

Table 5.5-1 General Characters of Each Bridge Types

Bridge Type	Applicable Span Length (m)	Advantages	Disadvantages
PSC	5～25	・ Small girder height. ・ It is possible that planned elevation of road is lower than that of PCDG type. ・ Uniform quality of girder can be expected because fabricated in the shop. ・ Short production time.	・ Number of piers is more than that of PCDG . ・ Longer construction period of substructure than in PCDG. ・ Large number of girders. ・ Longer installation time of girder than in PCDG.
PCDG	25～47	・ Less number of piers is than in PSC. ・ Shorter construction time of substructure than in PSC type. ・ Less number of girders than PSC ・ Shorter installation time of girders than in PSC	・ Height of girder is large. ・ Planned road elevation becomes higher than that of PSC. ・ Difficult to secure uniform quality of girders because of site fabrication. ・ Casting yard is necessary. ・ Duration of construction of girder needs much time.

The ground of the area between Phnom Penh and Ho Chi Minh consists of soft soil layers, and the viaducts need to be supported by pile foundations. The location and thickness of soft layer is unknown at this moment and the types of foundation will be discussed considering the result of geotechnical surveys in the feasibility study.

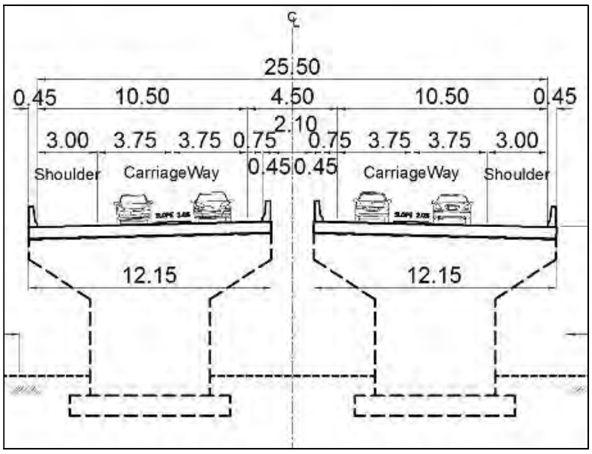


Figure 5.5-5   Typical Cross Section of Viaduct

5.5.3 Box Culvert

It is assumed that box culverts are installed at an interval of 1 km in the high embankment section in order to let the crossing roads pass under the expressway. Figure 5.5-6 shows an example of box culvert. Figure 5.5-7 shows an example of structure of box culvert.

Figure 5.5-6   Example of Box Culvert

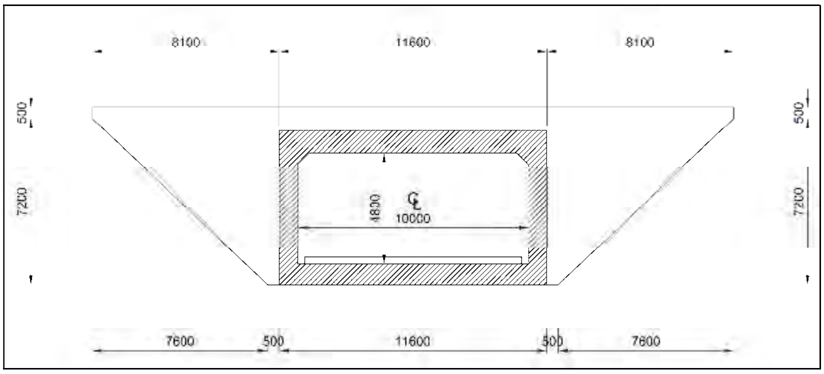


Figure 5.5-7   General View of Box Culvert

5.5.4 Over Bridge

On the low embankment section, over-bridges are assumed to be installed at an interval of 1 km to let the crossing road roads pass the expressway.

Figure 5.5-8 Computer Graphics of Flyover

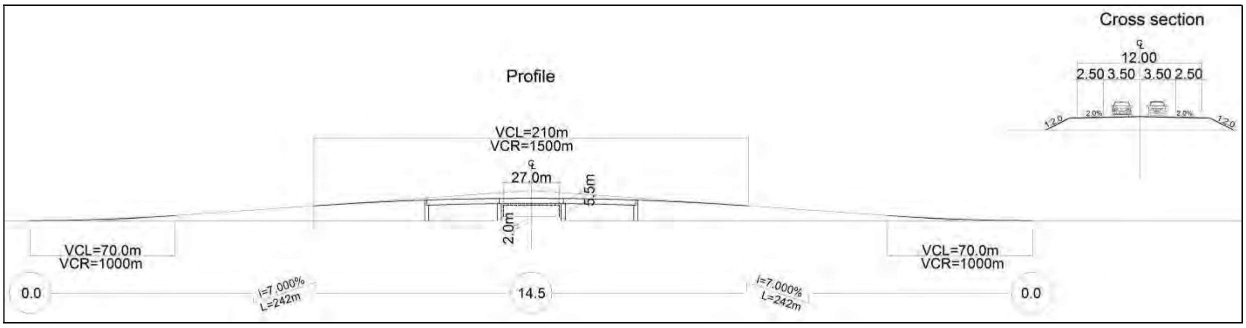


Figure 5.5-9 Profile of Flyover

5.5.5 Frontage Road

Frontage road is provided on the both side of the expressway to allow access to/from the crossing roads to/from lands along the expressway.

Width of frontage road is proposed to be 6.0 m in order to accommodate opposed 2-lane road.

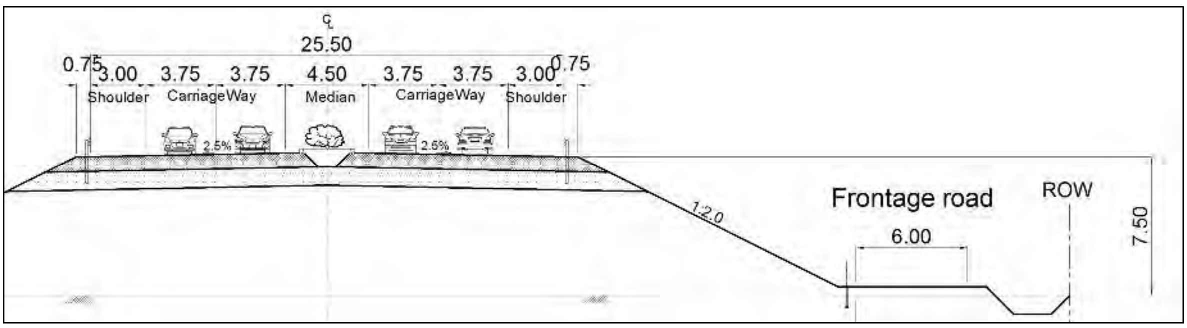


Figure 5.5-10 Typical Cross Section of High Embankment Section with Frontage Road

5.5.6 Pavement

(1) Minimum Thickness of AC Layer

"Road Design Standard of Cambodia; Part 2: Pavement" stipulates standard pavement structures taking into account traffic volume and type of subgrade. According to these standard pavement structures, the thickness of AC layer of a road with large volume of heavy traffic is 150 mm, while that of road with less traffic volume of heavy vehicles is 100 mm. Also, 150 mm-thick AC surface course is commonly adopted in many countries for highways where large volume of heavy vehicles is anticipated. Thus, 150 mm-thick AC layer is proposed.

(2) Pavement Structure

Table 5.5-2 shows the proposed pavement structure.

Table 5.5-2 Pavement Structure

Layer	Material	Thickness
Surface & Binder	AC	15 cm
Base	Stabilized gravel	25 cm
Sub base	Crusher run	40 cm
Total		**80 cm**

5.6 Facilities

5.6.1 Interchange and Toll Gate

(1) Interchange (IC)

One of the two most important features of an expressway is "access control". (The other most important feature is physical separation of two direction of traffic with median division.) The word "access control" means that entrance to, and exit from, the expressway is limited at interchanges (ICs).

There are several types of interchanges, such as trumpet type, diamond type and Y-shaped. In this survey, trumpet type is assumed for the purpose of cost estimation. Actual type of IC shall be studied in the future study (feasibility study). Figure 5.6-1 shows an example of aerial photo of trumpet type interchange. Figure 5.6-2 shows the plan view of a trumpet-type interchange.

Figure 5.6-1 Trumpet Type Interchange

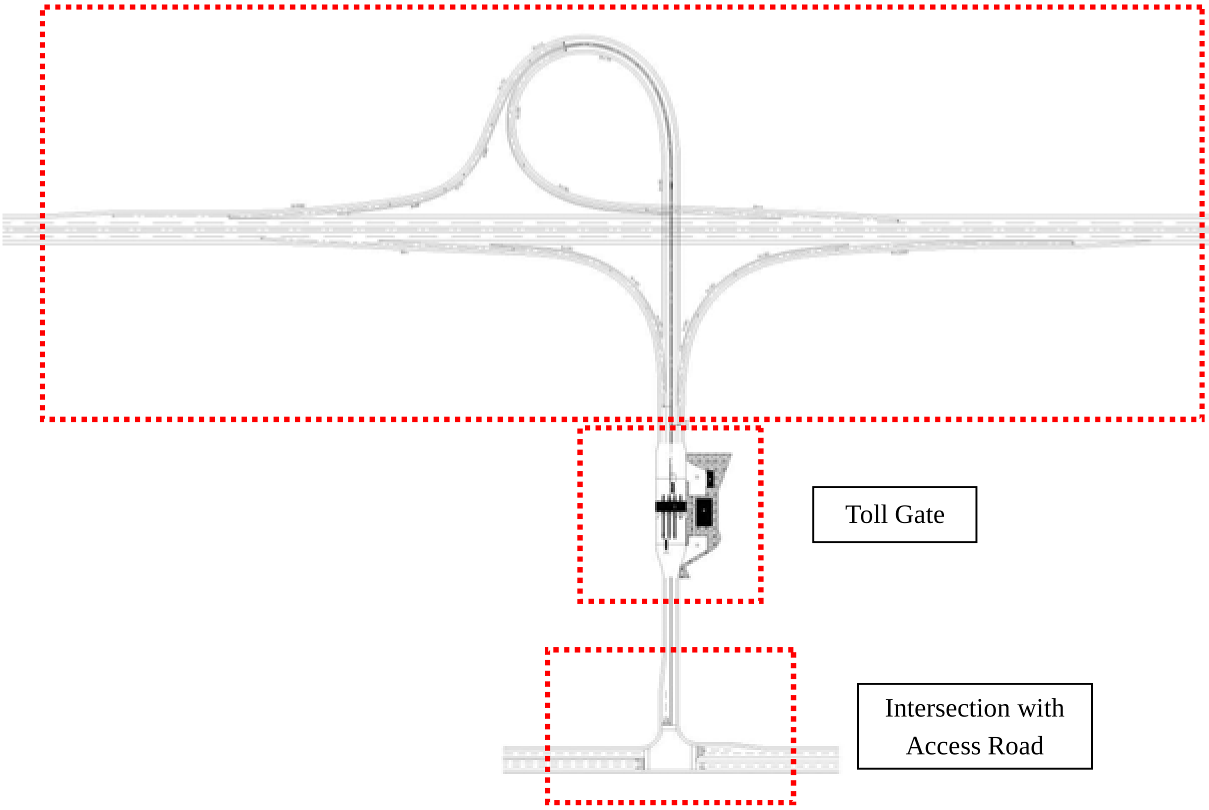


Figure 5.6-2　Plan View of Trumpet Type Interchange

(2) Toll Gate

A toll gate is a facility for collecting toll from the users of the expressway. Figure 5.6-3 shows a photo of an example of toll gate. Figure 5.6-4 shows an example of plan view of toll plaza (the area around toll gate).

Figure 5.6-3　Example of Toll Gate

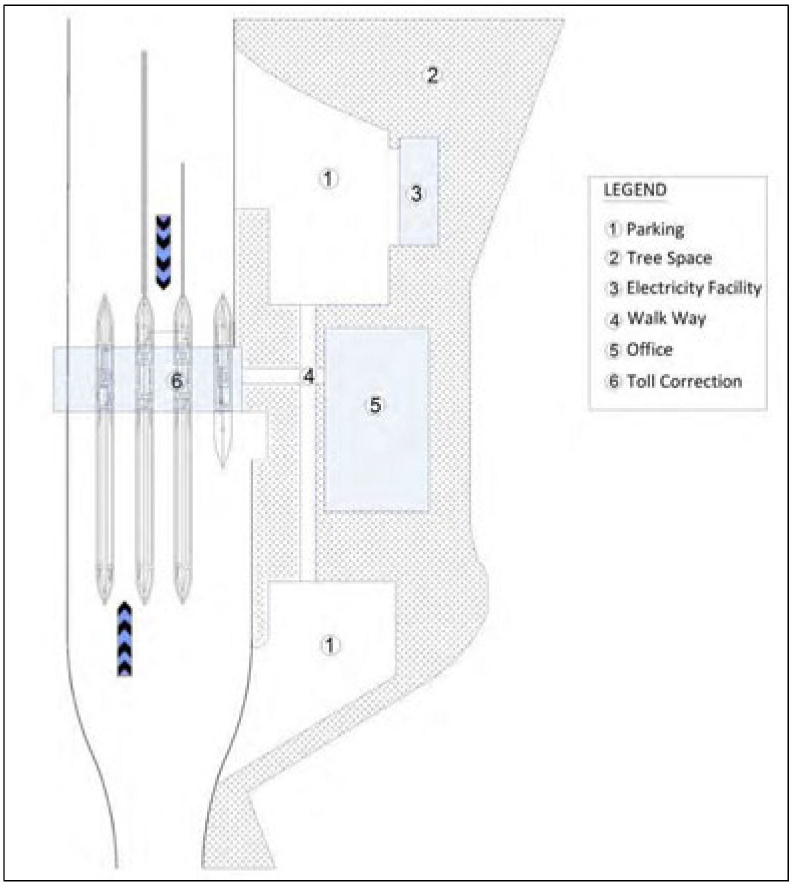


Figure 5.6-4 Examples of Toll Plaza

(3) Intersection with access road

At-grade intersection is assumed as the intersection with the access road. Traffic signal and exclusive right-turn and left-turn lanes are assumed to be provided.

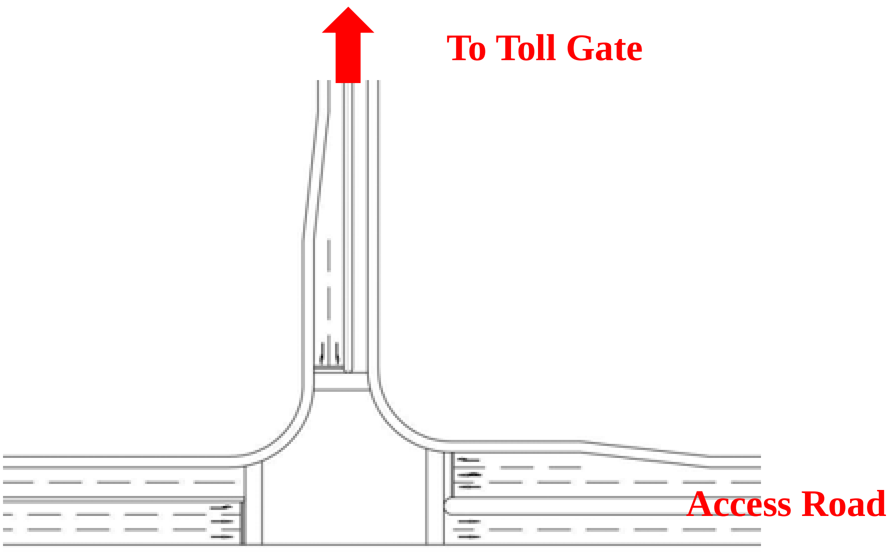


Figure 5.6-5 Examples of Intersection

5.6.2 Rest Area

A rest area or a service area is a public facility, located adjacent to an expressway where drivers and passengers can take rest, have meal, or refuel without exiting the expressways. Facilities in a large-scale rest area may include parking areas, fuel stations, restrooms and restaurants. The interval of rest areas is described in Chapter 4. Figure 5.6-6 shows an example of large-scale rest area. Figure 5.6-7 shows an example of layout of facilities of large-scale rest area.

Figure 5.6-6 Example of Rest Area

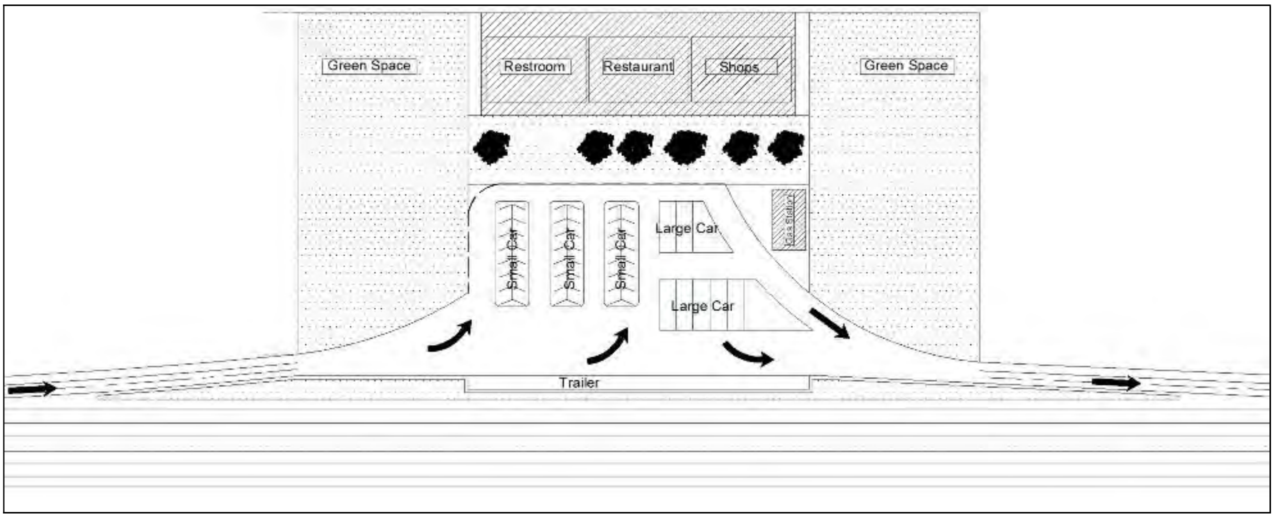


Figure 5.6-7 Example of Layout of Facilities of Rest Area

5.6.3 Border Control Facility

A border control facility is a place where procedures for travelers and/or goods crossing the border take place. A good example of such facility is the existing border control facility of NR 1 at Bavet. Figure 5.6-8 shows the assumed plan view of the border control facility.

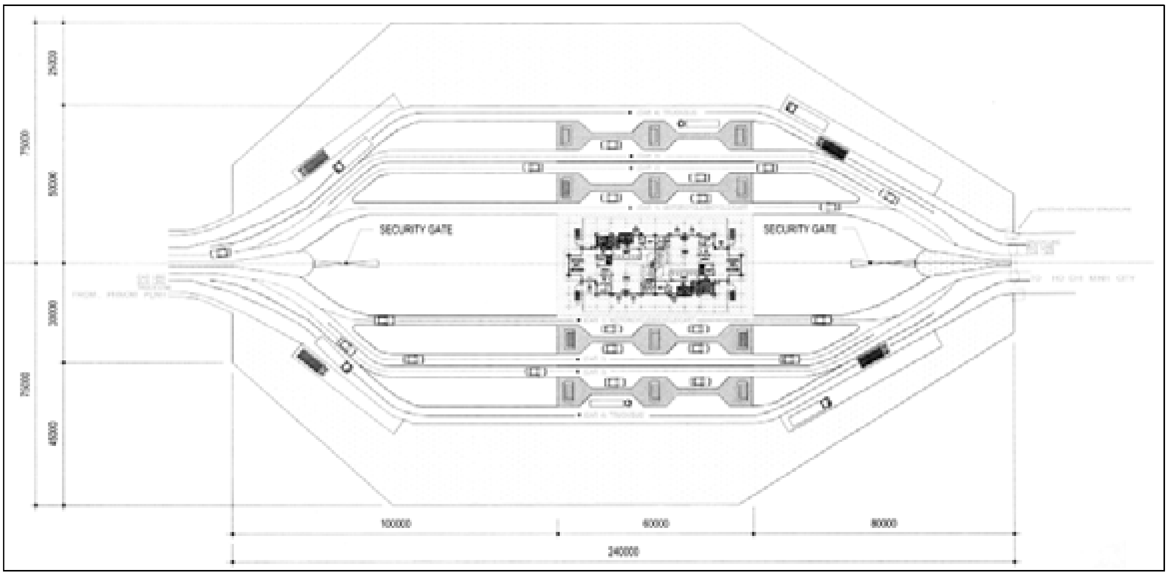


Figure 5.6-8 Example of Border Control Facility

5.6.4 Bus Stop

Bus stops are expected to increase the benefit of expressway by allowing passengers travel on long-distance bus. There are two types of bus stop constructed on expressway. One is installed adjacent to the carriageway and the other is installed on an interchange. Bus stops installed adjacent to the carriageway tends to be less frequently used because of scarcity in feeder transport service. Such bus stops are located along between the interchanges and often distant from urbanized area where public transport services are not available. On the other hand, bus stops located in interchanges are convenient because they are located in accessible distance from a town or city. Thus, bus stops constructed in interchanges are proposed. Figure 5.6-9 shows an example of bus stop installed in an interchange.

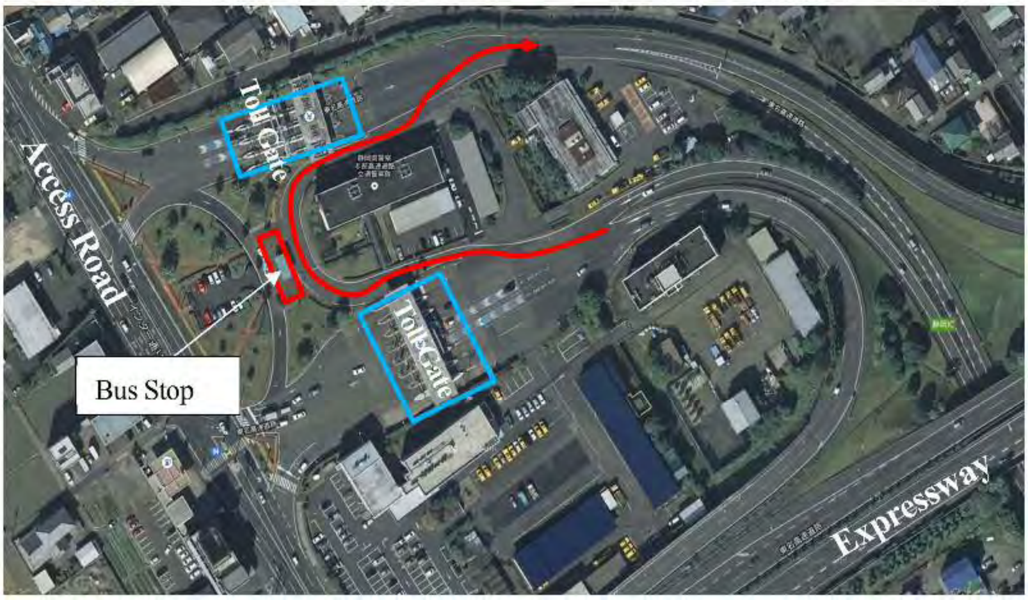


Figure 5.6-9 Example of Bus Stop

5.6.5 Other Facility

(1) Guardrail

Because of high travel speed on expressway, deviation of vehicles from the roadway can result in serious accidents, including fatal accidents. To prevent this, guardrails are installed on the both sides of the expressway.

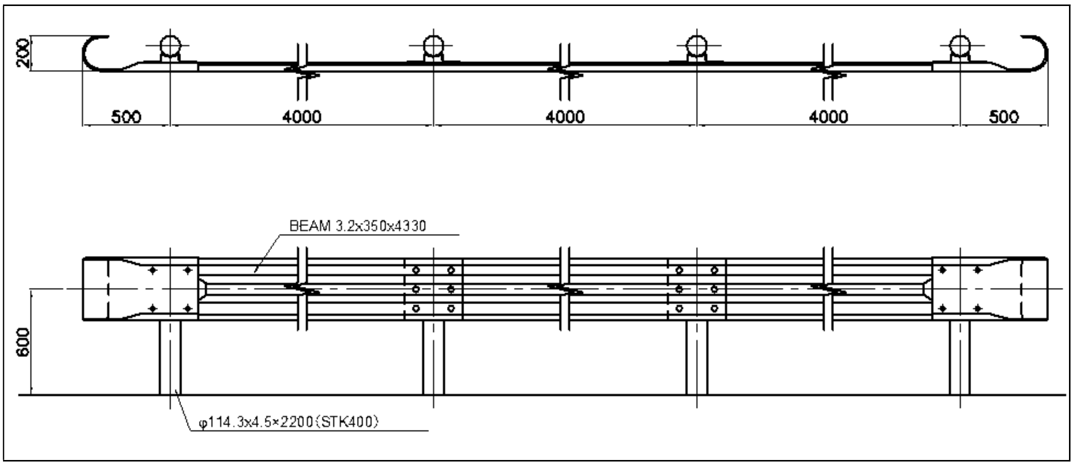


Figure 5.6-10 Example of Guardrail

Figure 5.6-11 Photo of Guardrail

(2) Lighting

Lighting is provided at hazardous locations. During night, hazardous locations need to be lighted to give good visibility to drivers. Lighting is planned at the following locations:

- Interchanges
- Bridges and viaducts

(3) Traffic Sign

Road sign and marking shall be provided. The regulatory sign such as "speed limit" and the guiding sign such as "interchange ahead" are considered. The marking on the pavement such as center line and driving lane are be necessary. Their detail locations will be studied in the detail design stage.

Figure 5.6-12 Examples of Guide Sign

(4) Fence

Fence is necessary to prevent people and livestock from entering or crossing expressway. Entrance of people and livestock may cause serious traffic accident. Fence is installed along the toe of slope. Figure 5.6-13 shows an example of fence.

Figure 5.6-13 Example of Fence

5.7 Preliminary Cost Estimate

5.7.1 Volume of Works

The volumes of works used in cost estimation are as follows.

(1) High Embankment (H = 7.5 m)

Cross-sectional Area: A = 165.88 m^2

Earth Work Volume (per km): V = 16,588 m^3

Earth Work Volume (per 100 km): V = 16,588,000 m^3

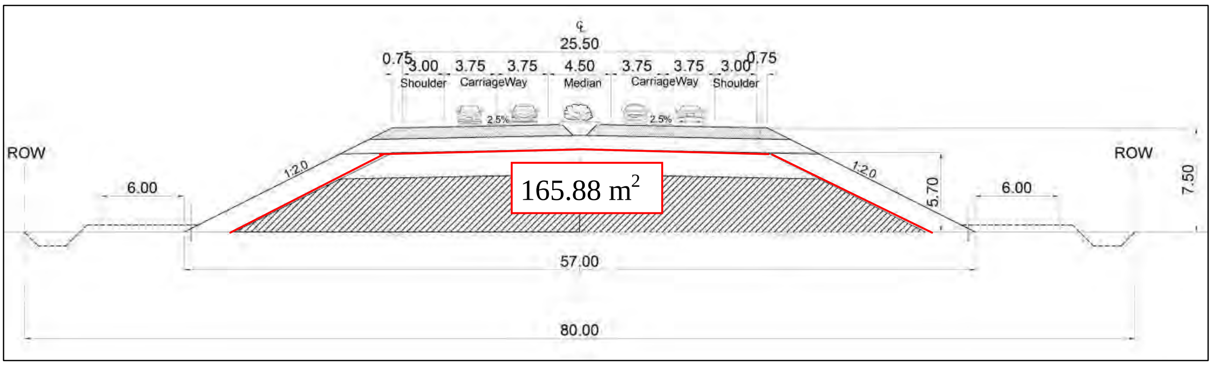


Figure 5.7-1 Cross Section of High Embankment

(2) Low Embankment (H = 3.0 m)

Cross-sectional Area: A = 48.76 m^2

Earth Work Volume (per km): V = 4,876 m^3

Earth Work Volume (per 100 km): V = 4,876,000 m^3

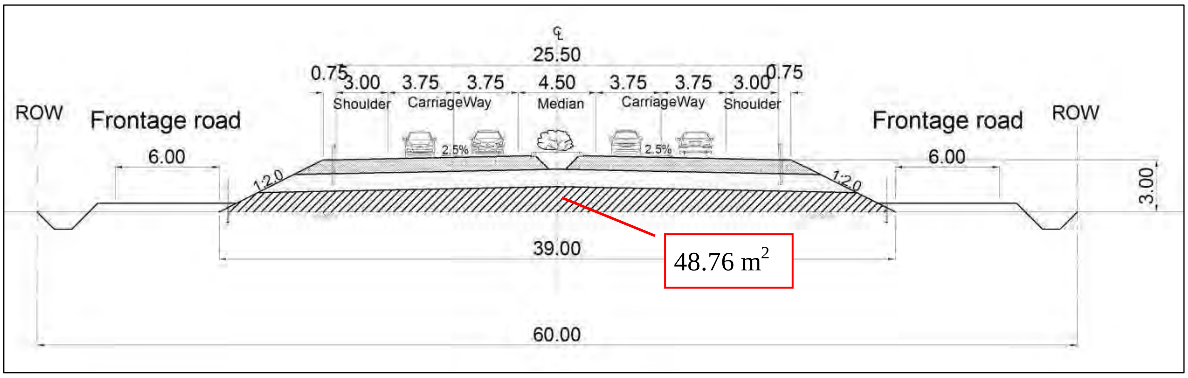


Figure 5.7-2 Cross Section of Low Embankment

(3) Pavement

Table 5.7-1 Volume of Pavement Works (1)

(Per linear m)

Item	Unit	Volume	Remark
Surface Course (t = 50 mm)	m^2	23	W = 23 m
Binder Course (t = 50 mm)	m^2	23	W = 23 m
Binder Course (t = 50 mm)	m^2	23	W = 23 m
Base Course (t = 250 mm)	m^3	6.75	V = 27×0.25
Sub base (t = 400 mm)	m^3	10.8	V = 27×0.40

Table 5.7-2 Volume of Pavement Works (2)

(Per linear km)

Item	Unit	Volume	Remark
Surface Course (t = 50 mm)	m^2	23,000	
Binder Course (t = 50 mm)	m^2	23,000	
Binder Course (t = 50 mm)	m^2	23,000	
Base Course (t = 250 mm)	m^3	6,750	
Sub base (t = 400 mm)	m^3	10,800	

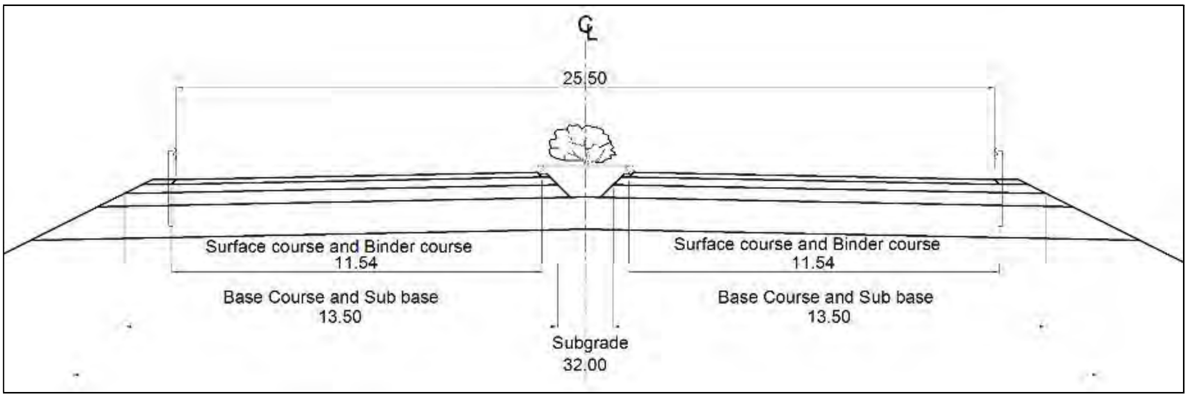


Figure 5.7-3 Cross Section for Pavement

(4) Subgrade

Table 5.7-3 Volume of Subgrade Works (1)

(Per linear m)

Item	Unit	Volume	Remark
Subgrade (t = 1000 mm)	m^2	32	V = 32×1

Table 5.7-4 Volume of Subgrade Works (2)

(Per linear km)

Item	Unit	Volume	Remark
Subgrade (t = 1000 mm)	m^2	32,000	

(5) Long Span Bridge (W = 23.0 m)

Area of Deck Slab (per m): A = 23.0 m^2

Area of Deck Slab (per km): A = 23,000 m^2

(6) Viaduct (W = 23.0 m)

Area of Deck Slab (per m): A = 23.0 m^2

Area of Deck Slab (per km): A = 23,000 m^2

(7) Over Bridge (W = 12 m, L = 90 m)

1 Unit/km (A = 1100 m^2)

100 Units/100 km

(8) Box culvert (12×5) L = 30 m

1 Unit/km

100 Units/100 km

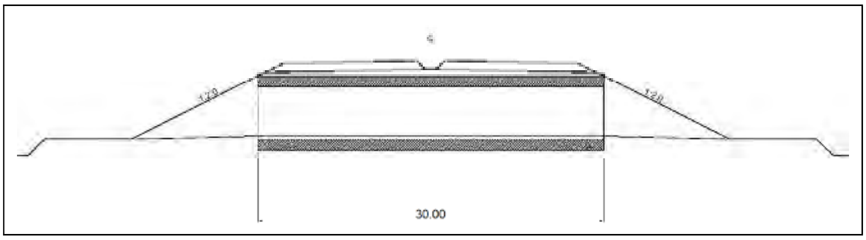


Figure 5.7-4 Cross Section at the Point Crossing Box Culvert

(9) Pipe Culvert (φ1.2) L = 50 m, L=35 m

10 Units/km

1000 Units/100 km

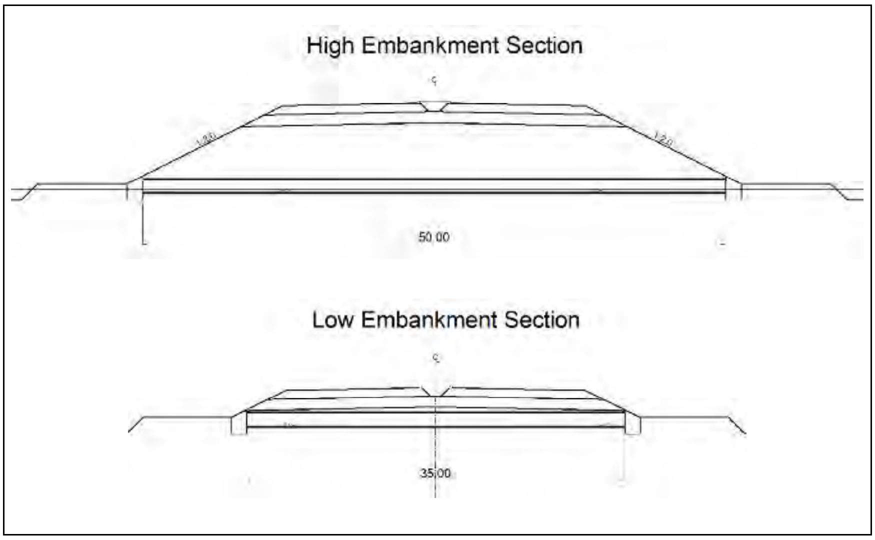


Figure 5.7-5 Cross Section at the Point Crossing Pipe Culvert

(10) Temporally Road (for Borrow Pit)

Dimension of Borrow Pit: W300×L800×D6 (V = 1,000,000 m^3)

1 Unit Temporally Road (W = 10 m, L = 10 km)/1 Borrow Pit

(11) Land Acquisition and Compensation

Table 5.7-5 Area of Land Acquisition and Compensation

(Volume/km)

Section	Width (m)	Land Acquisition (m^2)	Compensation (houses)
High Embankment	80	80,000	25
Low Embankment	60	60,000	18
Viaduct	50	50,000	15

5.7.2 Unit Cost

Unit costs are assumed by referring those of NR 1 Project, NR 5 Project and Neak Loeung Bridge Project and the unit costs used by NEXCO, Japan.

(1) Earth Works and Pavement

Table 5.7-6 Unit Cost for Earth Works and Pavement

Item	Unit	Unit Cost USD	Remark
Earth Works			
Embankment			
Transportation Cost	m3	3	0.15USD/m3/km Transportation Distance L=20km
Soil	m3	2	
Filling	m3	2	
Total	**m3**	**7**	
Subgrade			
Transportation Cost	m3	22.5	0.15USD/m3/km Transportation Distance L=150km
Selected material	m3	7	
Filling	m3	2	
Total	**m3**	**31.5**	
Sub base			
Transportation Cost	m3	22.5	0.15USD/m3/km Transportation Distance L=150km
Aggregate for sub base course	m3	15	
Filling	m3	2	
Total	**m3**	**39.5**	
Base Course			
Transportation Cost	m3	22.5	0.15USD/m3/km Transportation Distance L=150km
Aggregate for base course	m3	17	
Filling	m3	2	
Total	**m3**	**41.5**	

Table 5.7-7 Unit Cost for Asphalt Concrete

Item	Unit Cost	Volume	Unit	Cost	Remark
	USD			USD	
Binder Course (t=50mm)					
Asphalt concrete	90	0.12	m3	10.8	1m2x0.05mx2.3t/m3x1.05
AS-con spreading & compaction	0.45	1	m2	0.45	
Total			**m2**	**11.25**	
Surface Course (t=50mm)					
Asphalt concrete	90	0.12	m3	10.8	1m2x0.05mx2.3t/m3x1.05
AS-con spreading & compaction	0.45	1	m2	0.45	
Total			**m2**	**11.25**	

(2) Pavement and Subgrade

Table 5.7-8 Unit Cost of Pavement and Subgrade

Item	Unit Cost	Volume	Unit	Cost	Remark
	USD			USD	
Pavemant					
Surface Course (t=50mm)	11.25	23,000	m2	258,750	
Binder Course (t=50mm)	11.25	23,000	m2	258,750	
Binder Course (t=50mm)	11.25	23,000	m2	258,750	
Base Course (t=250mm)	41.5	6,750	m3	280,125	
Sub base (t=400mm)	39.5	10,800	m3	426,600	
Total				1,482,975	
Cost/Km				**1,482,975**	
Subgrade	31.5	32,000	m3	1,008,000	
Cost/Km				**1,008,000**	

(3) Bridge, Structure and Others

Table 5.7-9 Unit Cost of Bridge, Structure and Others

Item	Unit	Unit Cost	Remark
		USD	
Bridge			
Long span Bridge (Span length more than L= 50 m)			
Neak Loeung aproch	m2	5,000	
Baichai	m2	4,000	
Adopted Unit Cost	**m2**	**4,000**	
Viaduct (Short span Bridge) (Span length not more than L= 50 m)			
NR5 North Section	m2	1,550～1,700	
NR5South Section	m2	1,550～1,600	
Neak Loeung aproch	m2	1,250	
Neak Loeung aproch	m2	1,000	
Adopted Unit Cost	**m2**	**1,000**	
Box cluvert (12×5) L=30m	**Unit**	**300,000**	
Pipe Culvert φ1.2 L=35m			
NEXCO	m	1,000	
	Unit	35,000	
NR5	m	570	
	Unit	19,950	Ratio (NR5)/(NEXCO)=57%
Adopted Unit Cost	**Unit**	**20,000**	
Pipe Culvert φ1.2 L=50m			
NR5	m	570	
	Unit	28,500	
Adopted Unit Cost	**Unit**	**30,000**	
Over Bridge	**Unit**	**1,100,000**	W=12m, L=90m, A=1080m2
			1100×1000
Tempraly Road	**km**	**1,000,000**	W=10m
Land Acquisition	**m2**	**3**	
Compensation	**1house**	**1000**	

(4) Land Acquisition and Compensation

High Embankment (Cost/linear km)

Table 5.7-10 Unit Cost of Land Acquisition and Compensation (High Embankment)

Item	Unit	Unit Cost	Volume	Cost	Remark
		USD		USD	
Land Acquisition	m2	3	80,000	240,000	
Compensation	1house	1000	25	25,000	
Total				265,000	

Low Embankment (Cost/linear km)

Table 5.7-11 Unit Cost of Land Acquisition and Compensation (Low Embankment)

Item	Unit	Unit Cost	Volume	Cost	Remark
		USD		USD	
Land Acquisition	m2	3	60,000	180,000	
Compensation	1house	1000	18.75	18,750	
				198,750	

Viaduct (Cost/linear km)

Table 5.7-12 Unit Cost of Land Acquisition and Compensation (Viaduct)

Item	Unit	Unit Cost	Volume	Cost	Remark
		USD		USD	
Land Acquisition	m2	3	50,000	150,000	
Compensation	1house	1000	15.625	15,625	
				165,625	

(5) Ring Road No.3

Table 5.7-13 Unit Cost of Ring Road No.3

Item	Unit	Unit Cost	Remark
		USD	
Embankment	km	2,000,000	Considering No Interchanges and Overbridges, etc.
Long span bridge	m2	4,000	
Short span bridge	m2	1,000	

(6) Interchange (include SA and PA)

Construction cost for interchange including SA and PA is assumed 200 million USD/20 km (Unit) based on the experiences of NEXCO, Japan.

(7) Ovreall Unit Costs (Per linear km)

Unit Costs (/km) and break down of that are as follows.

Table 5.7-14 Breakdown of Unit Cost (/km)

Item	Unit Cost (/km)
Expressway	
Bridge	92 million USD
Viaduct	24 million USD
High Embankment	7 million USD
Low Embankment	5 million USD
Ring Road No.3	
Embankment	2 million USD
Bridge Long span	80 million USD
Bridge Short span	20 million USD

Table 5.7-15 Breakdown of Unit Cost (/km)

		Unit	Unit Cost (USD)	L(km)	W (m)	Volume	Cost	Cost/Km (million USD)
Expressway								
Bridge	**Long span**	m2	4,000	1	23	23,000	**92,000,000**	**92**
Viaduct		m2	1,000	1	23	23,000	23,000,000	
IC(Include PA・SA)		Unit	20,000,000			0.05	1,000,000	
Land Acquisition		km	150,000	1		1	150,000	
Compensation		house	1,000	1		15	15,000	
	Sub Total						**24,165,000**	**24**
High Embankment								
Embankment		m3	7	1		165,880	1,161,160	
Subgrade		km	900,000	1			900,000	
Pavement		km	1,500,000	1			1,500,000	
Box culvert (12×5) L=30m		Unit	300,000			1	300,000	
Pipe cluvert φ1.2 L=50m		Unit	30,000			10	300,000	
Construction Road		km	1,000,000			1.7	1,700,000	
IC(Include PA・SA)		Unit	20,000,000			0.05	1,000,000	
Land Acquisition		km	240,000	1		1	240,000	
Compensation		house	1,000	1		25	25,000	
	Sub Total						**7,126,160**	**7**
Low Embankment								
Embankment		m3	7	1		48,760	341,320	
Subgrade		km	900,000	1			900,000	
Pavement		km	1,500,000	1			1,500,000	
Bridge	Long span	m2	4,000					
	Short span	m2	1,000					
Pipe cluvert φ1.2 L=35m		Unit	20,000			10	200,000	
Over Bridge		Unit	1,100,000			1	1,100,000	
IC(Include PA・SA)		Unit	20,000,000			0.05	1,000,000	
Land Acquisition		km	180,000	1		1	180,000	
Compensation		house	1,000	1		18	18,000	
	Sub Total						**5,239,320**	**5**
Ring Road No.3								
Embankment		km	2,000,000	1		1	2,000,000	**2**
Bridge	**Long span**	m2	4,000	1	20	20,000	80,000,000	**80**
Bridge	**Short span**	m2	1,000	1	20	20,000	20,000,000	**20**

5.7.3 Total Cost and Breakdown

(1) Road Structure and Length

Proposed routes and types of road structures and their respective lengths are shown in Figure 5.7-6. Profiles of proposed routes are as shown in Figures 5.7-7 and 5.7-8.

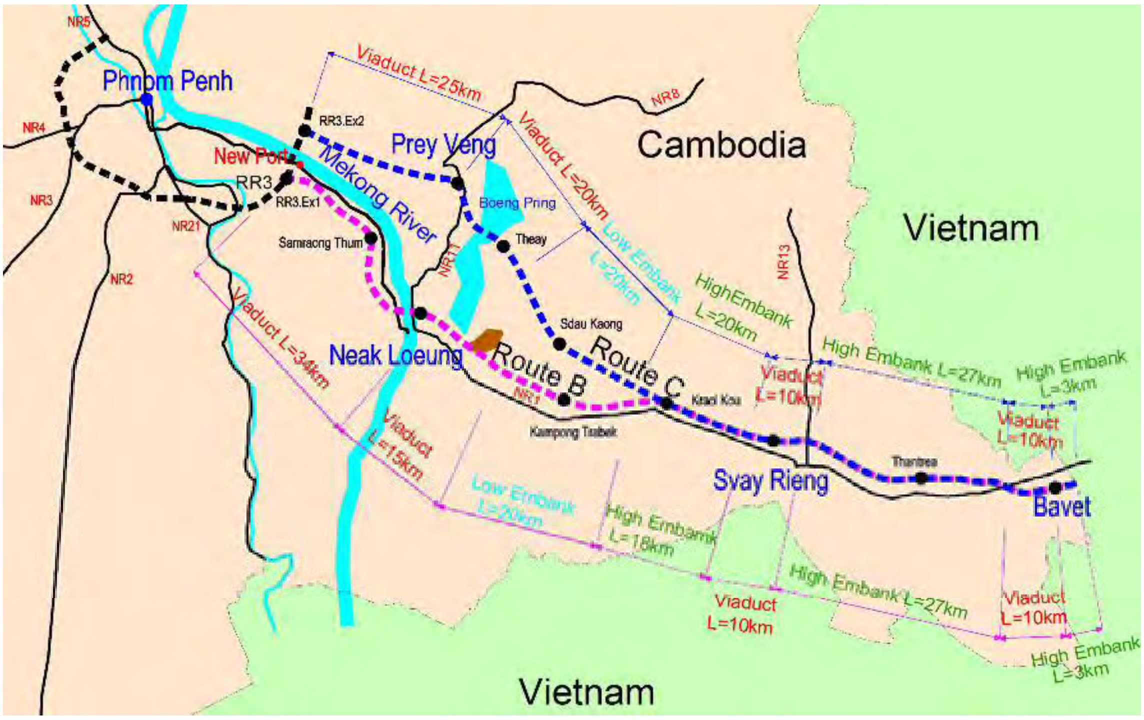


Figure 5.7-6 Proposed Routes and Type of Road Structure

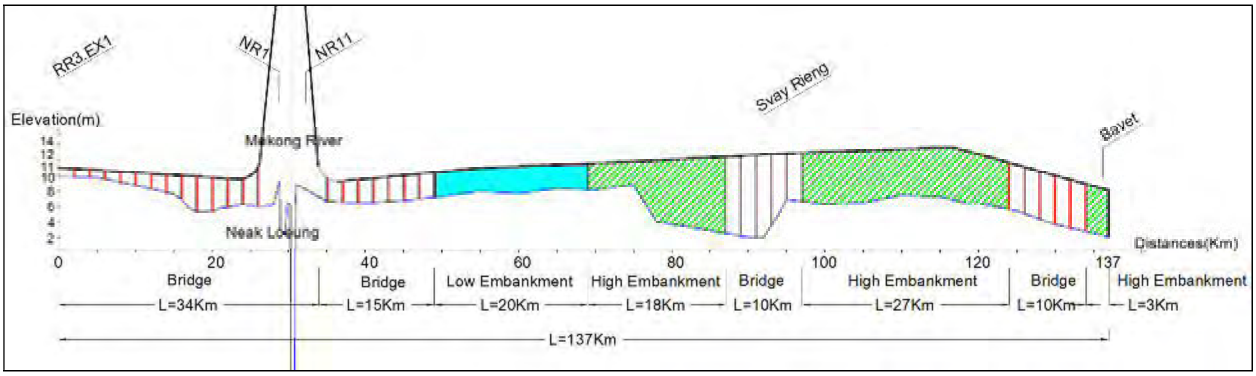


Figure 5.7-7 Simplified Profile of B Route

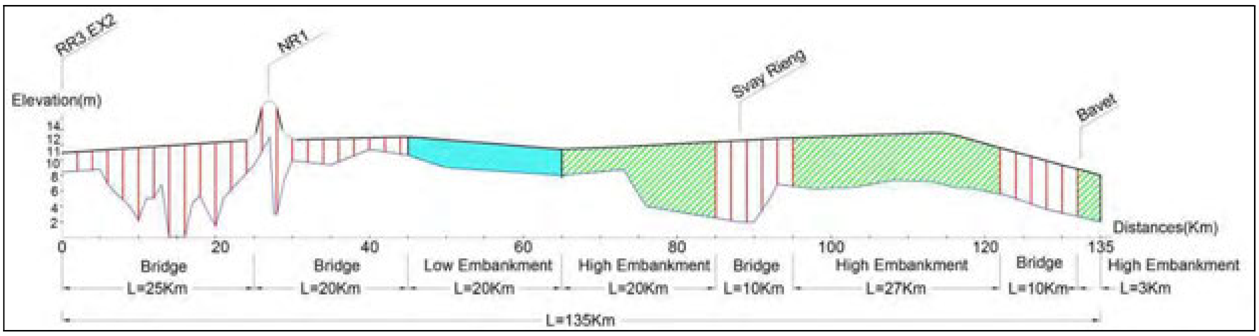


Figure 5.7-8 Simplified Profile of C Route

(2) Total Cost and Breakdown of Proposed Route

Total costs and breakdowns of the proposed routes are as follows.

The cost of the section from RR3.EX1 I.C. to Bavet I.C. of Route B is estimated at USD 2,160 million and the cost per linear km is USD 16 million. The cost of same section of Route B is estimated at USD 2,226 million and the cost per linear km is USD 14 million.

Table 5.7-16 Construction Cost of Route B

Item		L (km)	Unit Cost (million USD)	Construction Cost (million USD)
Expressway				
RR3 - Neak Loeung (L=34km)				
Bridge	Long span	1	92	92
Viaduct		33	24	792
Neak Loeung - Lvea (15km)				
Bridge	Long span	0	92	0
Viaduct		15	24	360
Lvea - Kraol Kou (Low Enbankment L=20km)				
Embankment		20	5	100
Kraol Kou - Svay Rien (High Enbankment L=18m)				
Embankment		18	7	126
Svay Rieng City (10km)				
Bridge	Long span	0	92	0
Viaduct		10	24	240
Svay Rien - Bavet (High Enbankment L=27m)				
Embankment		27	7	189
Bavet City (10km)				
Bridge	Long span	0	92	0
Viaduct		10	24	240
Bavet - Border (High Enbankment L=3km)				
Embankment		3	7	21
Expressway (RR3 - Bavet)				
Sub Total		**137**		**2,160**
Cost/km				**16**
Ring Road No.3				
RR3(NR21-NR1)				
Embankment		23	2	46
Bridge	Long span	0	80	0
Bridge	Short span	1	20	20
Sub Total		**24**		**66**
Cost/km				**3**
Grand Total		**161**		**2,226**
Cost/km				**14**

The cost of the section from RR3.EX2 I.C. to Bavet I.C of C Route is estimated at USD 2,010 million the cost per linear km is USD 15 million. The cost of the same section of B Route is estimated at USD 2,182 million and the cost per linear km is USD 13 million.

Table 5.7-17 Construction Cost of Route C

Item		L (km)	Unit Cost (million USD)	Construction Cost (million USD)
Expressway				
RR3.EX2 IC～Prey Venh (L=25km)				
Bridge	Long span	0	92	0
Viaduct		25	24	600
Prey Venh～20km (20km)				
Bridge	Long span	0	92	0
Viaduct		20	24	480
Low Enbankment (L=20km)				
Embankment		20	5	100
Kraol Kou - Svay Rien (High Enbankment L=20m)				
Embankment		20	7	140
Svay Rieng City (10km)				
Bridge	Long span	0	92	0
Viaduct		10	24	240
Svay Rien - Bavet (High Enbankment L=27m)				
Embankment		27	7	189
Bavet City (10km)				
Bridge	Long span	0	92	0
Viaduct		10	24	240
Bavet - Border (High Enbankment L=3km)				
Embankment		3	7	21
Expressway (RR3 - Bavet)				
Sub Total		**135**		**2,010**
Cost/km				**15**
Ring Road No.3				
RR3（NR21-NR1）				
Embankment		26	2	52
Bridge	Long span	1	80	80
Bridge	Short span	2	20	40
Sub Total		**29**		**172**
Cost/km				**6**
Grand Total		**164**		**2,182**
Cost/km				**13**

CHAPTER 6 TRAFFIC DEMAND FORECAST

6.1 Overview

E1 Expressway is planned as a toll road. Traffic demand forecast for a toll road needs to take into account the effect of the toll which works as a “resistance” to users of the toll road. Thus traffic forecast of expressway (toll road) follows the general flow as shown in Figure 6.1-1.

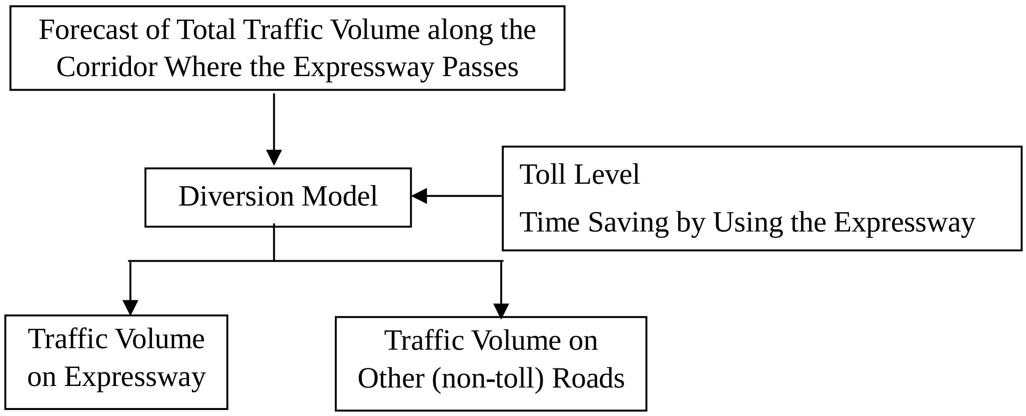


Figure 6.1-1 General Flow of Traffic Demand Forecast for Expressway

As conceptually shown in the above figure, certain portion of the total traffic flowing the corridor along the expressway is diverted to the expressway and the remainder uses non-toll ordinary roads. (In case of E1 Expressway, NR 1 is practically the only road from which the traffic will divert to the expressway.) The percentage of the traffic volume on the expressway against the total traffic volume along the corridor is called “diversion rate” and the formula for estimating diversion rate is called “diversion model”. Diversion model is usually a function of toll level and time saved by using the expressway.

6.2 Traffic Demand Forecast along the Corridor (E1 Expressway)

6.2.1 Overview of Traffic Demand Forecast

Figure 6.2-1 shows the general flow of traffic demand forecast along NR 1 from which the traffic will divert to E1 Expressway. Basic data including traffic survey data and zoning used in the final report of “Preparatory Survey for National Road No. 5 Improvement Project (Prek Kdam – Thlea Ma’am Section) in the Kingdom of Cambodia, JICA, December 2013” (hereinafter referred to as “FS of NR 5”) were used in this survey. These data were updated incorporating the most up-to-date information on the economic growth of Cambodia.

The data of traffic volume on NR 1 used in the FS of NR 5 were those counted in “the Data Collection Survey on the Trunk Road Network Planning for Strengthening of Connectivity through the Southern Economic Corridor" on 23 January 2013 and other studies conducted in 2011 and 2012.

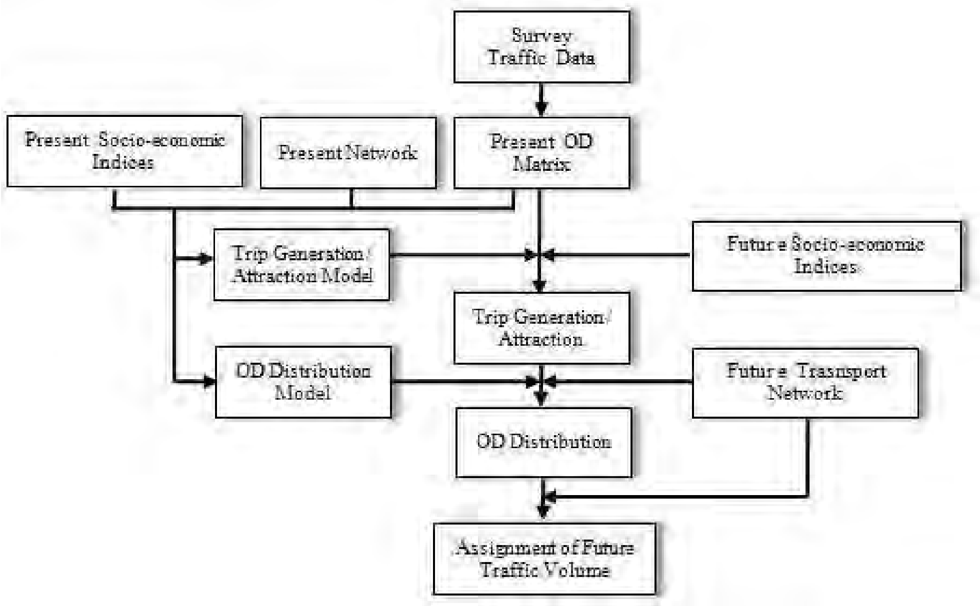


Figure 6.2-1 General Flow of Traffic Demand Forecast

6.2.2 Explanation of Elements of Traffic Forecast

Elements used in the traffic forecast are explained below:

(1) Vehicle Classification

Vehicles are classified as shown in Table 6.2-1.

Table 6.2-1 Vehicle Classification for Traffic Count

Group		Classification	
I	Motor Cycle (MC)	1	Motorbike and Motodop
		2	Tuk – tuk
		3	Motorumok
II	Light Vehicle (LV)	4	Sedan, Wagon, Van
		5	Taxi
		6	Mini Bus
		7	Light Truck / Pick Up
		8	Truck (2 axles)
III	Heavy Vehicle (HV)	9	Medium and Large Bus
		10	Truck (More than 3 axles)
		11	Semi & Full Trailer (with Container Load)
		12	Semi & Full Trailer (without Container Load)
		13	Tank lorry

Source: Preparatory Survey for National Road No. 5 Improvement Project (PrekKdam – Thlea Ma'am Section)

(2) Passenger Car Unit

Traffic volume is expressed in the form of Passenger Car Unit (pcu) and the number of vehicles. The pcu equivalents used in this survey are shown in Table 6.2-2.

Usually, pcu of sedan and pick-up truck is set at 1.0. In this survey, pcu of Light Vehicle (LV) is set at 1.25 considering that this category includes light truck, pick-up truck and 2 axle truck whose speeds are slower than passenger cars.

Table 6.2-2 PCU Factor

Categories	MC	LV	HV
PCU Equivalents	0.30	1.25	3.00

Source: Preparatory Survey for National Road No. 5 Improvement Project (PrekKdam – Thlea Ma'am Section)

(3) Future Network Scenario

Main assumptions on the truck roads in the future network are summarized in Table 6.2-3 and Figure 6.2-2.

Table 6.2-3 Main Assumptions of Future Road Network

Road Section		Future Project
NR 1	①	PK 30 – Neak Loeung: 2 lanes + MC lane
	②	1st Neak Loeung Br.: Completed
	③	2nd Neak Loeung Br.: Completed (E1 Expressway)
Ring Road	④	Ring Road 2 (Whole section): 4 lanes
	⑤	Ring Road 3 (NR 1 to NR 2): 4 lanes (NR 2 to NR 5) 4 lanes
NR 4	⑥	Whole Section: 4 lanes
NR 5	⑦	Whole Section: 4 lanes
	⑧	Kampong Chhnang Bypass, Battambang Bypass and Sri Soporn Bypass: Completed
NR6	⑨	Whole Section 4 lanes

Figure 6.2-2 Locations of Main Assumption of Future Road Network

(4) Future OD Table and Trip Production

The OD table used in the FS of NR 5 was used with the following adjustments to estimate traffic demand in the form of total trip production.

- Adjustment in the growth rate of GDP
- Adjustment in the total trip of Light Vehicle considering transition from Motor Cycle
- Consideration of the additional traffic demand induced by opening of expressway

(i) Growth rate of GDP

Table 6.2-4 shows the growth rate of GDP adopted in the FS of NR 5.

Table 6.2-4 GDP Growth Rate Used in FS of NR 5

Year	2012 - 2016	2016 - 2021	2021 - 2030
GDP Growth Rate (%/year)	6.6	6.2	5.6

These growth rates were assumed taking into consideration the growth rate predicted by various institutions as shown in Table 6.2-5. These data were the most up-to-date data as of early 2013.

Table 6.2-5 Annual Growth Rate of GDP Predicted by Various Institutions

Year	2012	2013	2014	2015	2016	2017	2021	2030
USDA	6.9	6.7	6.6	6.5	6.4	6.3	6.2	5.6
International Futures	6.5	6.3	6.5	6.4	6.1	6.2	6.7	7.1
IMF	6.2	6.4				7.7		-
MEF	6.5	6.5						-

Source: Economic Research Service, United states Department of Agriculture (USDA)
International Futures, University of Denver (International Futures)
World Economic Outlook, International Monetary Fund (IMF)
Cambodia Macroeconomic Framework 2010-2011, Ministry of Economic and Finance (MEF)

One of the most up-to-date data of GDP growth rates of Asian countries are found in the "Key Indicators of Asia and Pacific 2013" published by ADB. In this publication, GDP growth rate of Cambodia is 7.1% and 7.3% in 2011 and 2012, respectively. These growth rates are considerably higher than those predicted by the institutions as shown in Table 6.2-5. Considering these, the growth rate of 2013 – 2020 period is assumed to be 7.7% as predicted by IMF. The growth rate of 2020 – 2030 is assumed to be slightly lower than that of 2013 – 2020, as shown in Table 6.2-6.

Table 6.2-6 Assumed GDP Growth

Year	2013 - 2020	2020 -2030
GDP growth	7.70	7.09

(ii) Trip production

Incorporating the above-discussed growth rate of GDP, the future increase of trip production is estimated as shown in Figure 6.2-3.

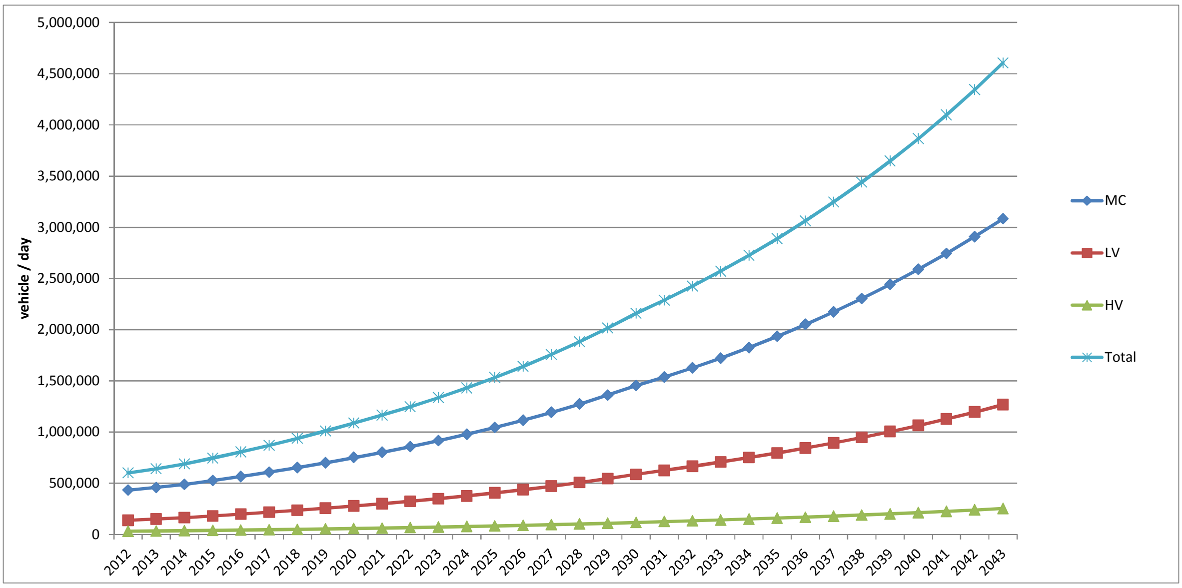


Figure 6.2-3 Estimated Future Trip Production

(iii) Shift from Motorcycle to Light Vehicle

In many countries, it is observed that users of motorcycle shift to passenger car or other type of 4-wheel vehicles as income increases. Thus, it may be reasonable to assume that the growth rate of motorcycles will be decreased and this decrease will result in increase of growth rate of Light Vehicles. Figure 6.2-4 shows such decrease in growth rate of motorcycles and increase of growth rate in Light Vehicles, assuming 4% of decrease in the growth rate of motorcycles.

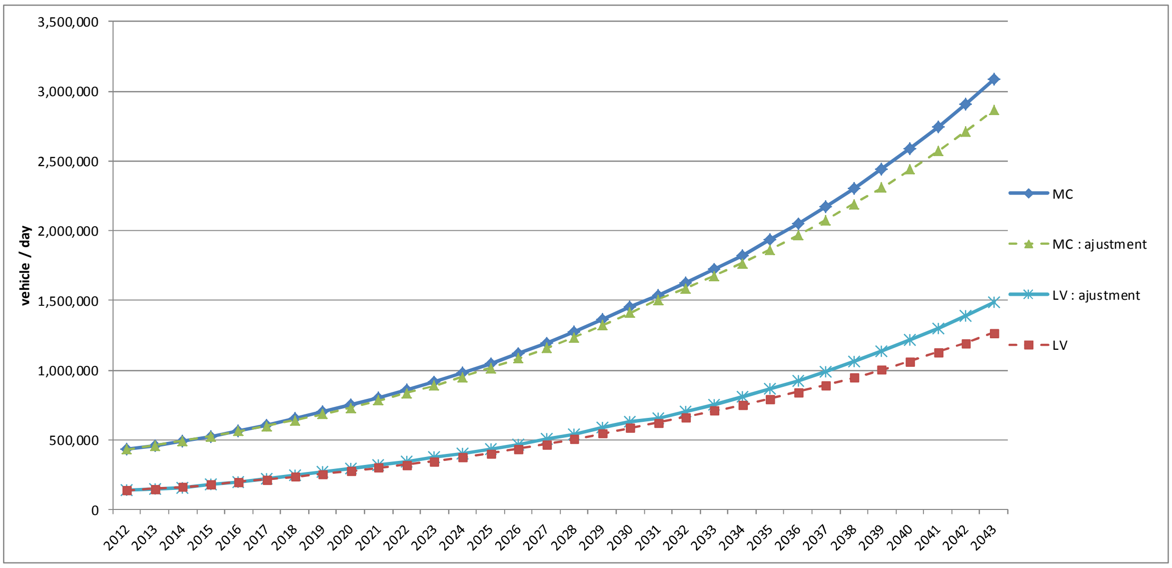


Figure 6.2-4 Traffic Volume Taking into Account the Shift from Motor Cycle to Light Vehicle

(iv) Additional traffic demand induced by opening of expressway

When an expressway becomes open to traffic and travel time becomes shorter than before, many enterprises plan to expand their business or start new businesses by using the expressway. As a result, a new traffic demand is created. This newly added traffic demand is called "induced traffic (demand)". Induced traffic demand is estimated by inputting the reduced travel time in the traffic forecast model (STRADA). Figure 6.2-5 compares the traffic volume (trip generation) with and without induced traffic. In general, induced traffic represents approximately 10% of the total traffic demand.

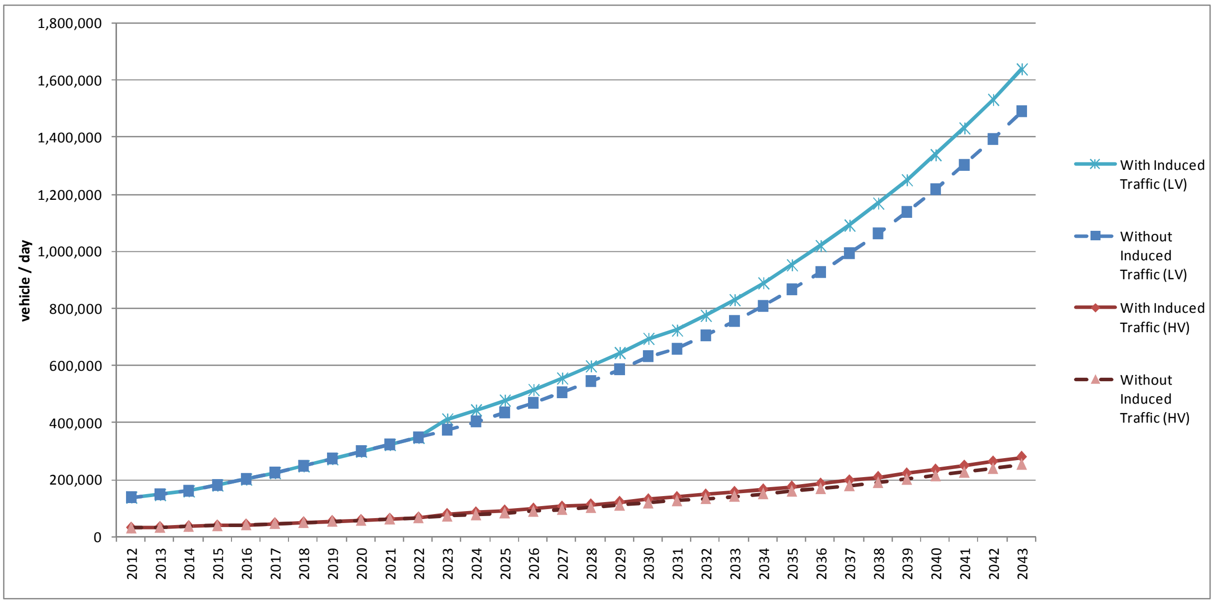


Figure 6.2-5 Comparison of Traffic Demand With and Without Induced Traffic

6.2.3 Traffic Demand between Phnom Penh and Bavet

The traffic demand on NR 1 between Phnom Penh and Bavet was forecasted employing the method as described above. The forecasted traffic demand between Phnom Penh and Bavet varies depending on the route of corridor where the expressway traverses as discussed in Section 4.2. This is due to the difference of traffic volume on the roads which run in parallel to the expressway. The roads parallel to Route C is complicated and discussion of traffic volume on the parallel roads is difficult. Therefore, the traffic demand on NR 1 is discussed here. NR 1 is mostly parallel to route B.

Tables 6.2-7 and 6.2-8 show the forecasted traffic demand on NR 1 in year 2023. Table 6.2-7 shows the traffic demand in terms of pcu while Table 6.2-8 shows that in terms of number of vehicles. Figure 6.2-6 shows the boundaries of sections used in these traffic demand forecasts.

Table 6.2-9 shows the traffic volume actually observed in various studies in the recent years, as reference. It is seen that the forecasted traffic demand in year 2023 is 2.5 times (near Bavet) to more than 4.5 times (near Phnom Penh) of the observed traffic volumes in year 2011 – 2013.

Table 6.2-7 Traffic Demand on NR 1 in PCU (Year 2023)

	Phnom Penh ~ Samraong Thum	Samraong Thum ~ Neak Loeung	Neak Loeung ~ Kampong Trabek	Kampong Trabek ~ Prey Nhay	Prey Nhay ~ Svay Rieng	Svay Rieng ~ Chipu	Chipu ~ Bavet
MC	13,274	7,049	7,114	4,429	4,429	3,298	3,926
LV	29,939	23,225	11,632	9,578	8,750	6,372	6,490
HV	10,707	6,987	5,739	4,286	3,912	2,103	2,103
2023Total	53,920	37,261	24,485	18,293	17,091	11,773	12,519

Table 6.2-8 Traffic Demand on NR 1 in Number of Vehicles (Year 2023)

	Phnom Penh ~ Samraong Thum	Samraong Thum ~ Neak Loeung	Neak Loeung ~ Kampong Trabek	Kampong Trabek ~ Prey Nhay	Prey Nhay ~ Svay Rieng	Svay Rieng ~ Chipu	Chipu ~ Bavet
MC	44,247	23,497	23,713	14,763	14,763	10,993	13,087
LV	23,951	18,580	9,306	7,662	7,000	5,098	5,192
HV	3,569	2,329	1,913	1,429	1,304	701	701
2023Total	71,767	44,406	34,932	23,854	23,067	16,792	18,980

Table 6.2-9 Observed Traffic Volume on NR 1 (in PCU)

	Phnom Penh ~ Samraong Thum	Samraong Thum ~ Neak Loeung	Neak Loeung ~ Kampong Trabek	Kampong Trabek ~ Prey Nhay	Prey Nhay ~ Svay Rieng	Svay Rieng ~ Chipu	Chipu ~ Bavet
MC	4,482	N.A.	2,573	786	2,305	N.A.	1,719
LV	5,745	N.A.	4,220	2,179	2,636	N.A.	2,447
HV	1,689	N.A.	1,239	1,416	726	N.A.	1,176
Total	11,916	N.A.	8,032	4,381	5,667	N.A.	5,342
Survey Yr.	2012		2011	2013	2011		2013

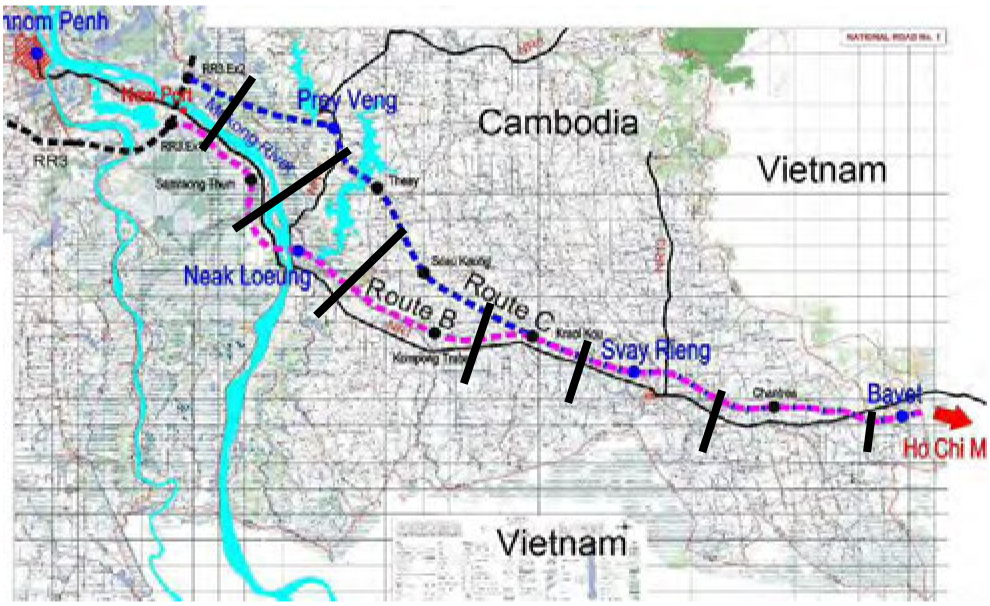


Figure 6.2-6 Boundaries of Sections for Traffic Demand Forecast

It is seen in Table 6.2-7 that the traffic volume between Phnom Penh and Neak Loeung exceed 37,000 pcu/day by 2023. The "basic capacity" [1] of a road with cross section of opposed 2-lane with motorcycle lanes has been estimated to be around 30,000 pcu/day in the FS of NR 5. The traffic demand between Phnom Penh and Neak Loeung is forecasted to exceed this capacity of NR 1 by far. This means that further widening of NR 1 or construction of a new road will become necessary in the near future.

Figure 6.2-7 graphically shows the traffic demand in pcu by section.

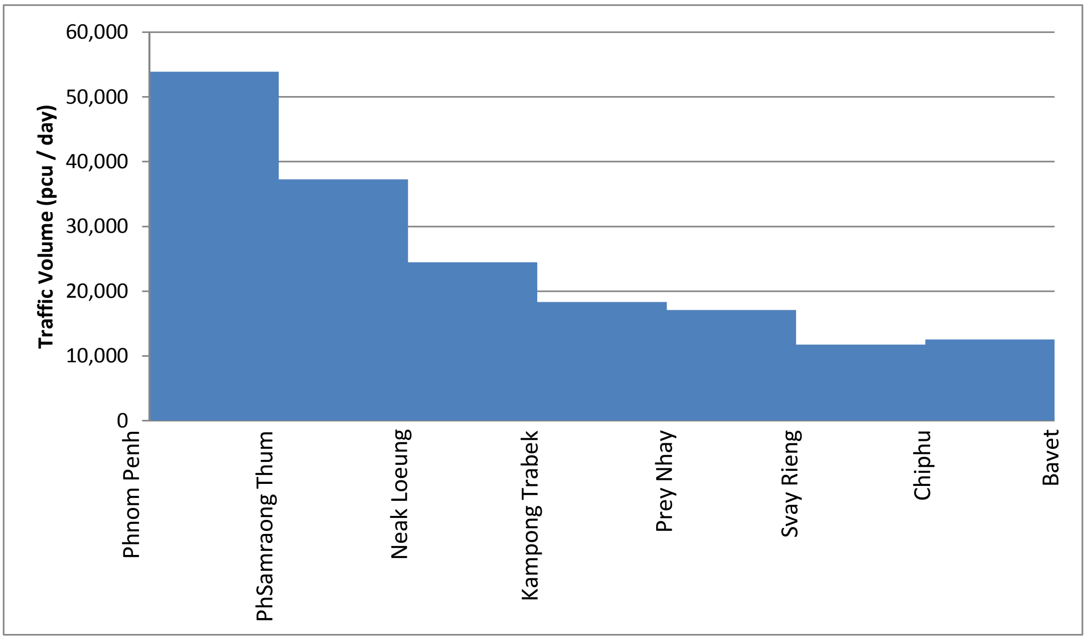


Figure 6.2-7 Traffic Demand on NR 1 by Section in Year 2023

Figure 6.2-7 indicates that the traffic demand drastically decrease after passing Neak Loeung and again decreases after passing Svay Rieng. The traffic demand on NR 1 between Neak Loueng and Svay Rieng is between 25,000 pcu/day and 17,000 pcu/day in 2023. The traffic demand of 25,000 pcu/day travelling the existing NR 1 between Neak Loeung and Kampong Trabek is evaluated at "Level of Service C" defined in Highway Capacity Manual (HCM) published by American Association of State Highway and Transport Officials (AASHTO). At Level of Service C, traffic congestion is anticipated in peak hours. However, such congestion is still regarded as acceptable one.

It is proposed later in this report (Chapter 7) that E1 Expressway be opened from Phnom Penh to

[1] The "basic capacity" refers to the maximum traffic volume which can flow the road. Any traffic volume larger cannot flow. There is no established estimation of basic capacity of "2-lane plus motorcycle lane" road. The estimation presented here was made based on the observation of the actual traffic condition on NR 1. (Please see pp 8-2 – 8-3, Chapter 8, the report of [Preparatory Survey for National Road No. 5 Improvement Project (Prek Kdam – Thlea Ma'am Section), JICA, 2013].)

Neak Loeung as the 1st phase and the traffic between Neak Loeung and Bavet use the existing NR 1 (please see Section 7.1 Implementation Schedule). Between the completion of the 1st phase and 2nd phase, considerable congestion is foreseen on the Neak Loeung – Kampong Trabek section of NR 1 but this congestion is considered to be acceptable for short period, such as 2 – 3 years.

6.3 Diversion Rate

The traffic volume on the expressway is estimated by multiplying the traffic demand on the along the corridor and diversion rate. Diversion rate is governed by the toll level and time saved by using the expressway. This section discusses how to estimate the diversion rate.

6.3.1 Model of Diversion Rate

Formula 6.1-1 is the model of diversion rate for inter-city expressway developed by the former Japan Highway Public Corporation.

$$P = \frac{1}{1 + \alpha (X/S)^{\beta} / T^{\gamma}} \qquad \text{Formula 6-1}$$

Where,

P: Diversion rate

X: Toll/Time difference

T: Time difference (difference of travel time between expressway and ordinary road)

S: shift rate (adjustment for effect of price escalation: assumed to be 1.0 here)

α, β, γ: parameters (empirically determined: see the table)

Parameter	Value
α	0.049
β	1.505
γ	0.542

In the above formula, the meanings of variants are as follows:

・X = C/T where C is the amount of toll and T is the difference of travel time between using the expressway and alternative (non-toll) road (in minutes). This shows the value of time (Yen/Min.) as evaluated by the users/non-users of the expressway.

・S: This variant is to adjust the increase of diversion rate over the time (such as 5 years) during which income level is upgraded and inflation in price level occurs and the value of time increases. In this survey S is assumed to be 1.0, implying no upgrading in income level and no inflation in price level.

6.3.2 Adjustment for Cambodia

The above diversion model was developed by the former Japan Highway Public Corporation, (current three NEXCOs) using the data of inter-city expressways in Japan. Thus, it needs to be adjusted so that it fits to the conditions of Cambodia. The most decisive variant of the diversion model is the value of time or how much the road users are willing to pay. In order to know the evaluation of time by the road users, Willingness-to-Pay (WTP) survey was conducted by interviewing trucking companies and bus companies operating between Phnom Penh and Ho Chi Minh City. These companies were selected because they are assumed to be sensitive to the value of time. Also, some Japanese firms operating in Phnom Penh Special Economic Zone (PPSEZ) were interviewed as the representatives of the users of international trucking services. The diversion model was modified by using the result of the WTP survey.

(1) WTP Survey (Please see Appendix 6-1 for details of WTP survey)

Five trucking companies, two bus companies and five Japanese industrial companies were interviewed. They were asked the amount of toll between Phnom Penh and Bavet which these companies are willing to pay. Practically usable data were obtained from eight companies, as shown in Table 6.3-1 and Figure 6.3-1.

Table 6.3-1 Payable Toll Amount (for Heavy Truck and Large Buses)

Company	Payable Toll (US$)
A	30
B	50
C	50
D	20
E	15
F	50
G	50
H	100
Average[1)]	39.375

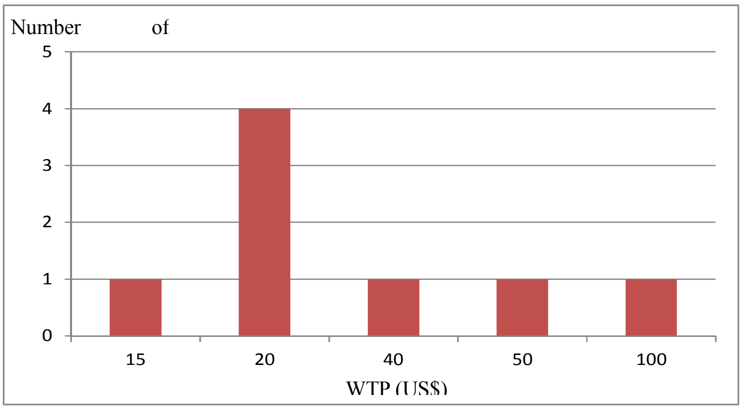


Figure 6.3-1 Distribution of Payable Toll Amount

In order to adjust a diversion model, the average of the payable toll was calculated after discarding the maximum value (US$100) and the minimum value (US$15). The average of the payable toll for traveling Phnom Penh – Bavet 140 km thus obtained was US$41.7, or US$ 0.3/km for a heavy truck or a large bus.

(2) Adjustment of Diversion Model to Fit to the Conditions of Cambodia

Based on the above results of the WTP survey, diversion model of Formula 6-1 was modified as explained below:

- The time difference between the expressway and NR 1 for traveling Phnom Penh – Bavet (140 km) is assumed to be 120 minutes.
- The average value of time saved by using expressway is US$ 41.7, from the result of WTP survey.
- Thus, the value of time per minute is calculated as;

  [US$41.7] / [120 minutes] = Approx. US$0.35/min.
- Since this value (US$0.35/min.) represents the average of the reply of the road users, this time value corresponds the diversion rate of 50% on the diversion curve.
- In Japan, the time value at 50% of diversion rate is approximately 41 Yen/min (approximately US$0.4/min.)
- Therefore, the curve of diversion is shifted to leftwards so that diversion rate of 50% becomes US$ 0.35/min.

Figure 6.3-2 shows this process of adjustment.

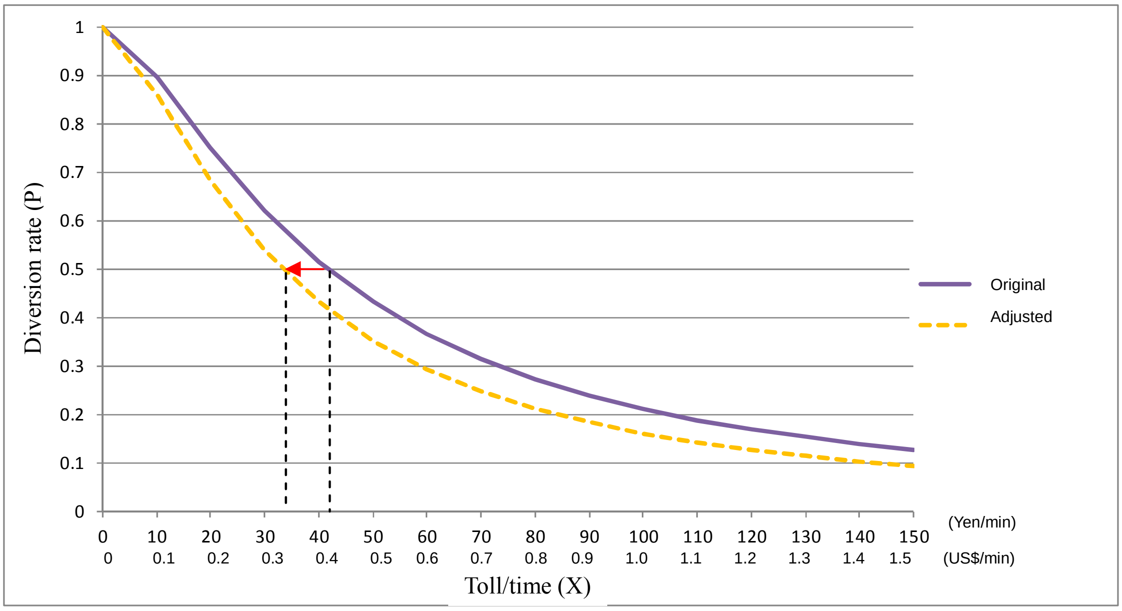


Figure 6.3-2 Adjustment of Diversion Curve for Cambodia (Heavy Vehicles)

To shift the diversion curve, the parameter α in Formula 6-1 is changed as shown in the table below:

Table 6.3-2 Adjustment of Parameters of Diversion Model

Parameter	Japan	Adjusted for Cambodia
α	0.049	0.0686
β	1.505	⇦
γ	0.542	⇦

(3) Diversion rate for Light Vehicles

The diversion rate as presented above is applied on heavy vehicles (heavy trucks and large buses). Strictly speaking, the shape of diversion curve for light vehicles (passenger car and light trucks) is not same with that for heavy vehicles. However, there are no reliable data for light vehicles, the diversion curve for heavy vehicles is used by assuming the average time value of 1/3 of that of heavy vehicles (US$ 0.12/min). This assumption is based on the fact that the ratio of toll level between heavy vehicles and light vehicles are around 3:1 in many countries.

6.4 Traffic Demand Forecast of Phnom Penh – Ho Chi Minh City Expressway

Traffic demand on the expressway is obtained by multiplying the traffic demand on NR 1 and the diversion rate. This calculation was made on Route B and Route C as discussed in Chapter 5.

(1) Traffic Volume in Year 2023

Tables 6.4-1 and 6.4-2 show the traffic demand on the expressway for Route B in pcu and number of vehicles, respectively. It is assumed in the estimation of traffic volume on expressway that motorcycles do not travel the expressway. This is due to the fact that small motorcycles (usually those with engine capacity of 125 cc or less) are not allowed to use expressway in many countries, while majority of the motorcycles in Cambodia have engines smaller than 125 cc. Figure 6.4-1 graphically shows the traffic demand on the expressway by section. It is observed that the traffic demand on the expressway drastically decreases after passing Neak Loeung and decreases again after passing Svay Rieng. These decreases of traffic demand leads to the proposal of phased construction of E1 Expressway as presented in Section 7.1.

Table 6.4-1 Traffic Volume on Expressway in Year 2023 (Route B; PCU)

	Phnom Penh ~ Samraong Thum	Samraong Thum ~ Neak Loeung	Neak Loeung ~ Kampong Trabek	Kampong Trabek ~ Prey Nhay	Prey Nhay ~ Svay Rieng	Svay Rieng ~ Chipu	Chipu ~ Bavet
km	16.0	17.0	25.0	16.0	17.0	23.0	20.0
LV	21,608	20,816	11,714	11,503	10,956	4,839	4,880
HV	5,468	5,082	3,373	3,301	3,014	1,088	1,088
2023Total	27,076	25,898	15,087	14,804	13,970	5,927	5,968

Table 6.4-2 Traffic Volume on Expressway in Number of Vehicles in Year 2023 (Route B; Nmber of Veh.)

	Phnom Penh ~ Samraong Thum	Samraong Thum ~ Neak Loeung	Neak Loeung ~ Kampong Trabek	Kampong Trabek ~ Prey Nhay	Prey Nhay ~ Svay Rieng	Svay Rieng ~ Chipu	Chipu ~ Bavet
km	16.0	17.0	25.0	16.0	17.0	23.0	20.0
LV	17,286	16,653	9,371	9,202	8,765	3,871	3,904
HV	1,823	1,694	1,124	1,100	1,005	363	363
2023Total	19,109	18,347	10,496	10,303	9,769	4,234	4,267

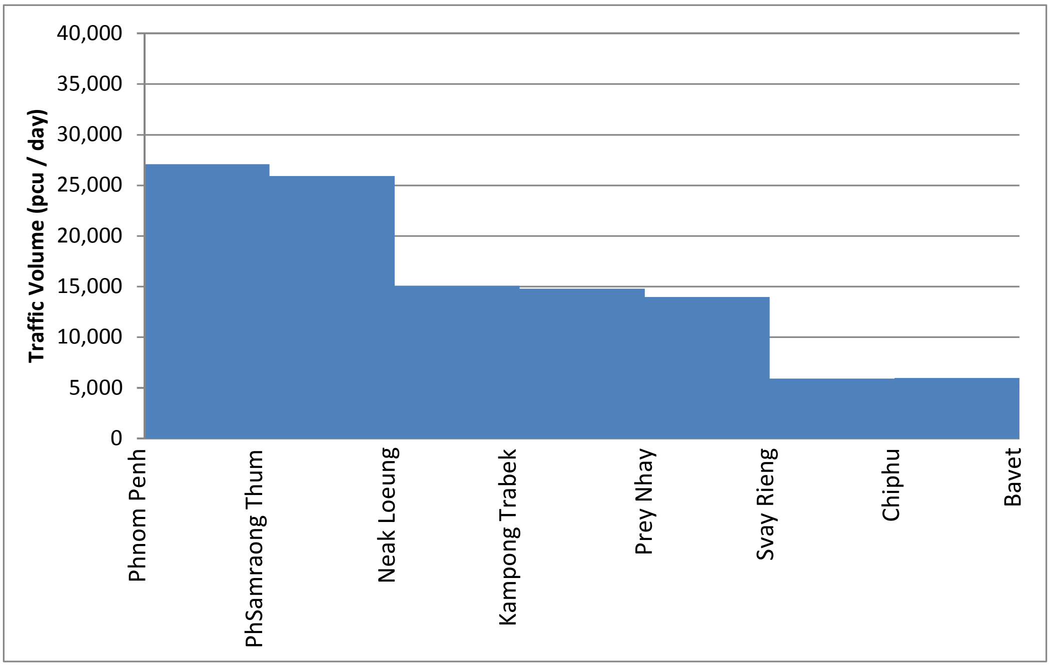


Figure 6.4-1 Traffic Volume on Expressway by Section in Year 2023 (Route B)

Table 6.4-3, Table 6.4-4 and Figure 6.4-2 show the traffic demand on the expressway for Route C.

Table 6.4-3 Traffic Volume on Expressway for Route C (Year 2023; PCU)

	Phnom Penh ~ Samraong Thum	Samraong Thum ~ Neak Loeung	Neak Loeung ~ Kampong Trabek	Kampong Trabek ~ Prey Nhay	Prey Nhay ~ Svay Rieng	Svay Rieng ~ Chipu	Chipu ~ Bavet
km	25.0	12.0	17.0	18.0	17.0	23.0	20.0
LV	24,824	9,438	8,490	8,408	8,807	4,719	4,749
HV	8,165	3,758	3,239	3,070	2,833	1,081	1,081
2023Total	32,989	13,196	11,729	11,478	11,640	5,800	5,830

Table 6.4-4 Traffic Volume on Expressway for Route C (Year 2023; Number of Veh.)

	Phnom Penh ~ Samraong Thum	Samraong Thum ~ Neak Loeung	Neak Loeung ~ Kampong Trabek	Kampong Trabek ~ Prey Nhay	Prey Nhay ~ Svay Rieng	Svay Rieng ~ Chipu	Chipu ~ Bavet
km	25.0	12.0	17.0	18.0	17.0	23.0	20.0
LV	19,859	7,550	6,792	6,726	7,046	3,775	3,799
HV	2,722	1,253	1,080	1,023	944	360	360
2023Total	22,581	8,803	7,872	7,750	7,990	4,136	4,160

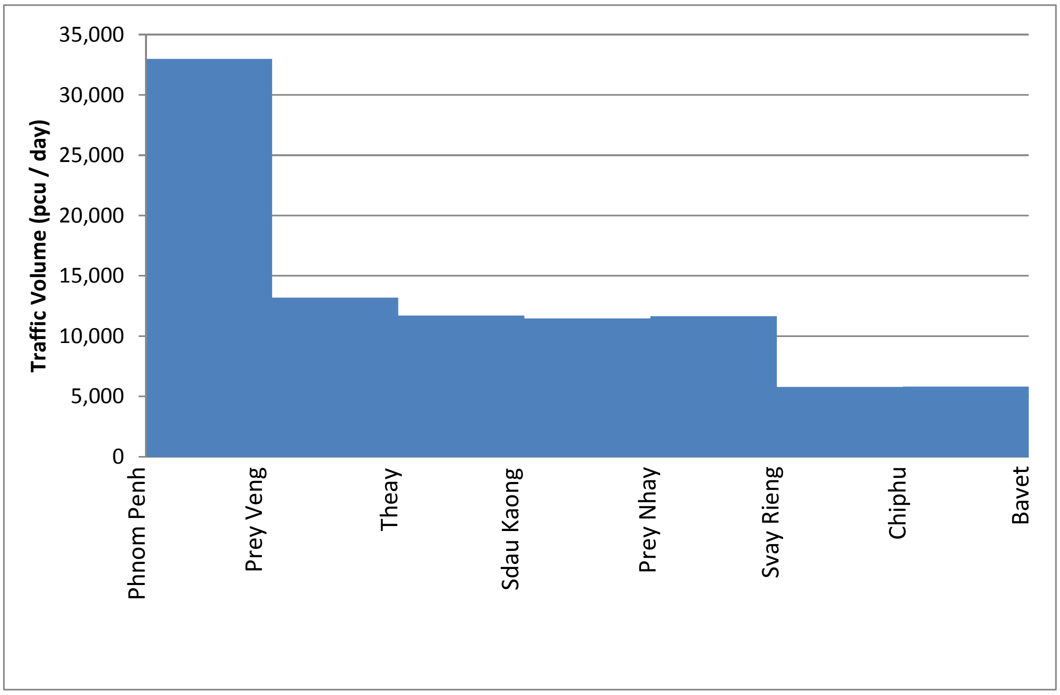


Figure 6.4-2 Traffic Volume on Expressway by Section in Year 2023 (Route C)

(2) Traffic Volume in Year 2033

Traffic volume on the expressway in year 2033 for Route B is shown in Tables 6.4-5 and 6.4-6 as well as in Figure 6.4-3. It is noted that the traffic demand on Phnom Penh – Neak Loeung section grows to approximately 50,000 pcu/day by year 2033. With this traffic demand, traffic becomes considerably congested. At this stage it may be necessary to plan construction of another expressway between Phnom Penh and Neak Loeung. One of the measures to this is to construct another expressway along Route C (if Rout B is to be constructed first).

Table 6.4-5 Traffic Volume in Year 2033 (Route B; PCU)

	Phnom Penh ~ Samraong Thum	Samraong Thum ~ Neak Loeung	Neak Loeung ~ Kampong Trabek	Kampong Trabek ~ Prey Nhay	Prey Nhay ~ Svay Rieng	Svay Rieng ~ Chipu	Chipu ~ Bavet
km	16.0	17.0	25.0	16.0	17.0	23.0	20.0
LV	41,917	38,937	29,517	28,421	30,013	10,123	10,206
HV	11,485	9,966	10,272	9,534	9,495	2,511	2,511
2033Total	53,402	48,903	39,789	37,955	39,508	12,634	12,717

Table 6.4-6 Traffic Volume on Expressway in Year 2033 (Route B; Number of Veh.)

	Phnom Penh ~ Samraong Thum	Samraong Thum ~ Neak Loeung	Neak Loeung ~ Kampong Trabek	Kampong Trabek ~ Prey Nhay	Prey Nhay ~ Svay Rieng	Svay Rieng ~ Chipu	Chipu ~ Bavet
km	16.0	17.0	25.0	16.0	17.0	23.0	20.0
LV	33,534	31,150	23,614	22,737	24,010	8,098	8,165
HV	3,828	3,322	3,424	3,178	3,165	837	837
2033Total	37,362	34,472	27,038	25,915	27,175	8,935	9,002

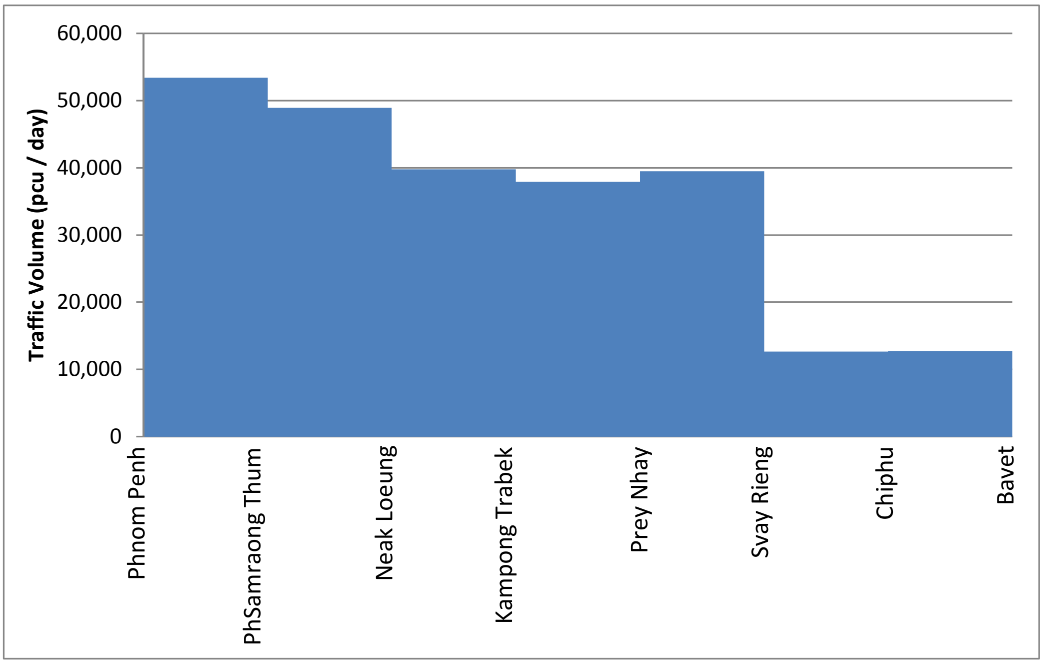


Figure 6.4-3 Traffic Volume on Expressway in Year 2033 (Route B)

Table 6.4-7, Table 6.4-8 and Figure 6.4-4 show the traffic demand on the expressway for Route C in year 2033.

Table 6.4-7 Traffic Volume in Year 2033 (Route C; PCU)

	Phnom Penh ~ Samraong Thum	Samraong Thum ~ Neak Loeung	Neak Loeung ~ Kampong Trabek	Kampong Trabek ~ Prey Nhay	Prey Nhay ~ Svay Rieng	Svay Rieng ~ Chipu	Chipu ~ Bavet
km	25.0	12.0	17.0	18.0	17.0	23.0	20.0
LV	45,503	24,241	21,621	21,245	21,083	10,185	10,248
HV	16,847	10,353	8,993	8,394	7,485	2,708	2,708
2033Total	62,350	34,594	30,614	29,639	28,568	12,893	12,956

Table 6.4-8 Traffic Volume on Expressway in Year 2033 (Route C; Number of Veh.)

	Phnom Penh ~ Samraong Thum	Samraong Thum ~ Neak Loeung	Neak Loeung ~ Kampong Trabek	Kampong Trabek ~ Prey Nhay	Prey Nhay ~ Svay Rieng	Svay Rieng ~ Chipu	Chipu ~ Bavet
km	25.0	12.0	17.0	18.0	17.0	23.0	20.0
LV	36,402	19,393	17,297	16,996	16,866	8,148	8,198
HV	5,616	3,451	2,998	2,798	2,495	903	903
2033Total	42,018	22,844	20,294	19,794	19,361	9,051	9,101

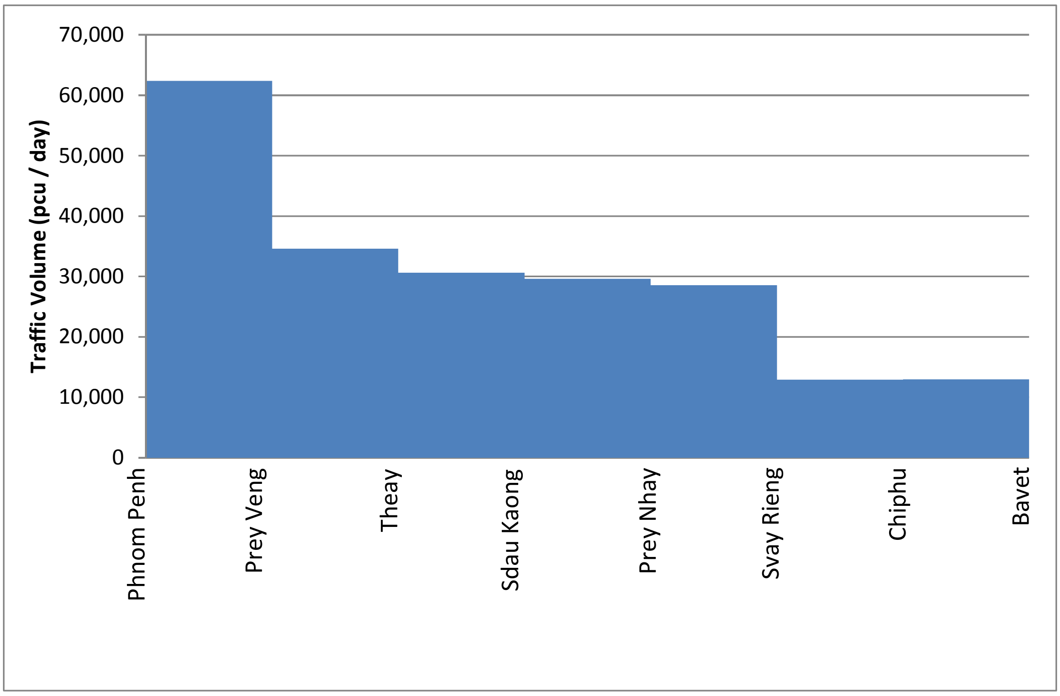


Figure 6.4-4 Traffic Volume on Expressway in Year 2033 (Route C)

In general, the traffic volume for Route C is less than that for Route B.

(3) Traffic Volume on NR 1

To see that the existing NR 1 can accommodate the traffic not using the expressway, the traffic volume on NR 1 was estimated by subtracting the traffic volume on the expressway from the traffic volume on NR 1 without expressway (Table 6.4-9).

Table 6.4-9 and Figure 6.4-5 show the traffic volume remaining on NR 1 in year 2023 after opening of the expressway, while Table 6.4-10 and Figure 6.4-6 show traffic volume on NR 1 in 2033. From these tables, it is known that the traffic volume remaining on NR 1 can be accommodated by the existing road width up to year 2023, while the traffic volume between Phnom Penh and Neak Loeung exceed the capacity of the existing NR 1 by year 2033 and widening of NR 1 or construction of another new road becomes necessary.

Table 6.4-9 Traffic Volume on NR 1 after Opening of Expressway in 2023

	Phnom Penh ~ Samraong Thum	Samraong Thum ~ Neak Loeung	Neak Loeung ~ Kampong Trabek	Kampong Trabek ~ Prey Nhay	Prey Nhay ~ Svay Rieng	Svay Rieng ~ Chipu	Chipu ~ Bavet
MC	15,871	9,648	8,205	5,480	5,480	3,298	3,926
LV	17,300	11,380	4,036	2,153	1,939	1,533	1,610
HV	8,476	5,146	3,740	2,313	2,223	1,015	1,015
2023Total	41,647	26,174	15,981	9,946	9,642	5,846	6,551

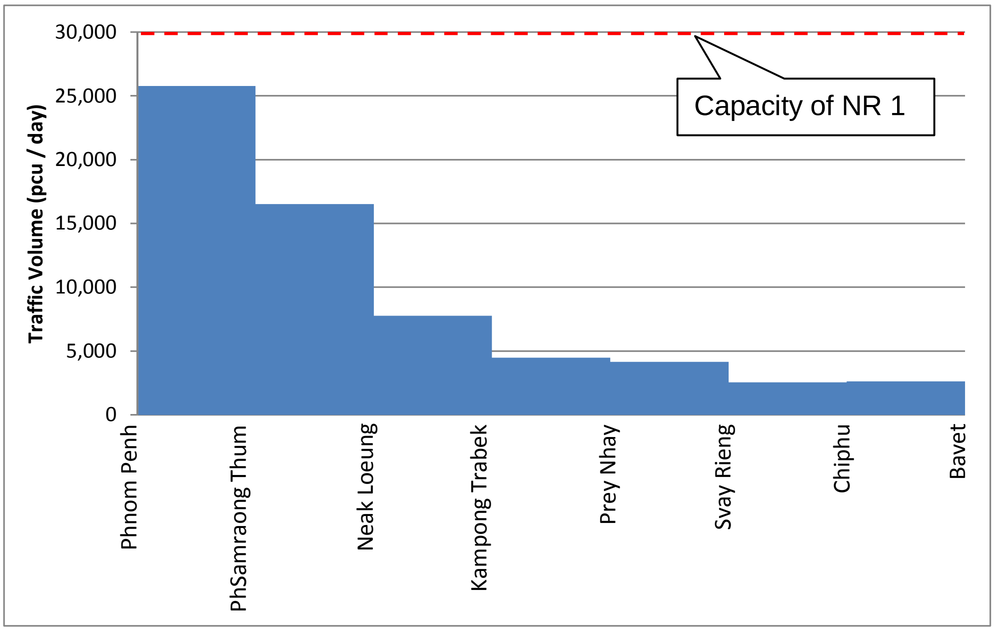


Figure 6.4-5 Traffic Volume on NR 1 after Opening of Expressway in 2023

Table 6.4-10 Traffic Volume on NR1 after 2033

	Phnom Penh ~ Samraong Thum	Samraong Thum ~ Neak Loeung	Neak Loeung ~ Kampong Trabek	Kampong Trabek ~ Prey Nhay	Prey Nhay ~ Svay Rieng	Svay Rieng ~ Chipu	Chipu ~ Bavet
MC	31,629	19,638	14,732	9,834	9,834	6,452	7,663
LV	37,062	27,236	5,170	2,770	6,067	2,419	2,562
HV	16,921	11,184	5,066	3,116	4,374	1,680	1,680
2033Total	85,612	58,058	24,968	15,720	20,275	10,551	11,905

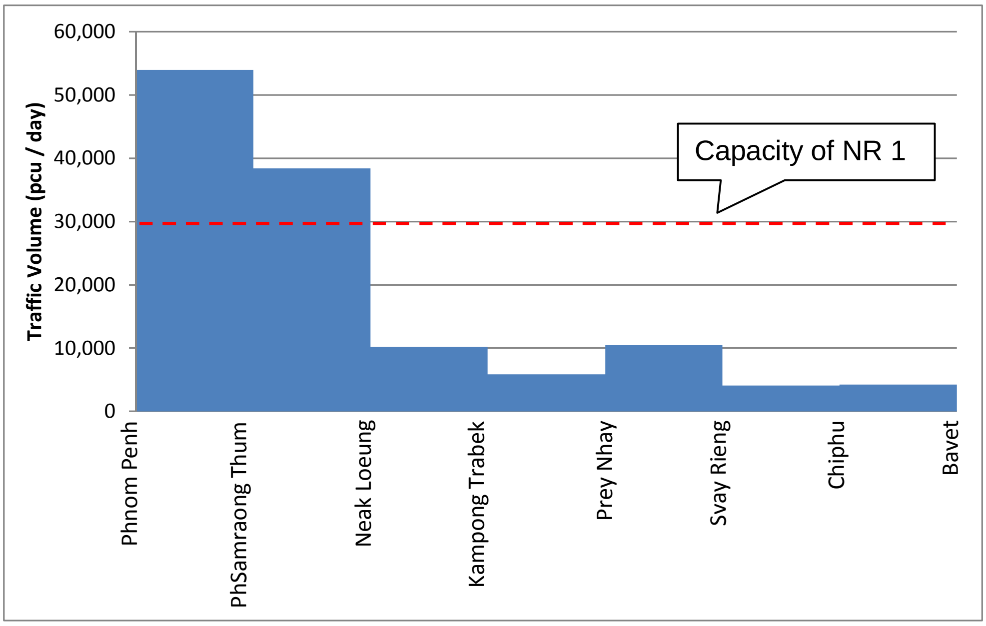


Figure 6.4-6 Traffic Volume on NR 1 in 2033

CHAPTER 7 IMPLEMENTATION PLAN

7.1 Implementation Schedule

7.1.1 Overall Time Schedule

Figure 7.1-1 shows the Implementation schedule. In the implementation schedule, the year of starting the full feasibility study is designated as the 1st year. This figure also shows the desirable improvement schedule of the existing NR 1, which is further discussed in Section 7.4 below.

The construction works are proposed to be implemented in 3 phases as shown below:

Phase 1: Phnom Penh (Ring Road 3) – Neak Loeung (35 km); Begininng of 6th year

Phase 2: Neak Loeung – Svay Rieg (58 km); Middle of 8th year

Phase 3: Svay Rieng – Bavet (46 km); Beginning of 11th year

This phasing is proposed to reduce the annual amount to be paid at the amortization stage of the loan. By splitting the construction into 3 phases, the expense for construction is spread over longer period than that in the construction of whole section implemented in short period such as 4 years. Thus, borrowing of the loan can be split into 3 times and amortization period becomes longer. As the result, the amount to be paid every year at the amortization stage becomes smaller. (Please see Subsection 8.2.6 for cash flow analysis of the phased construction.)

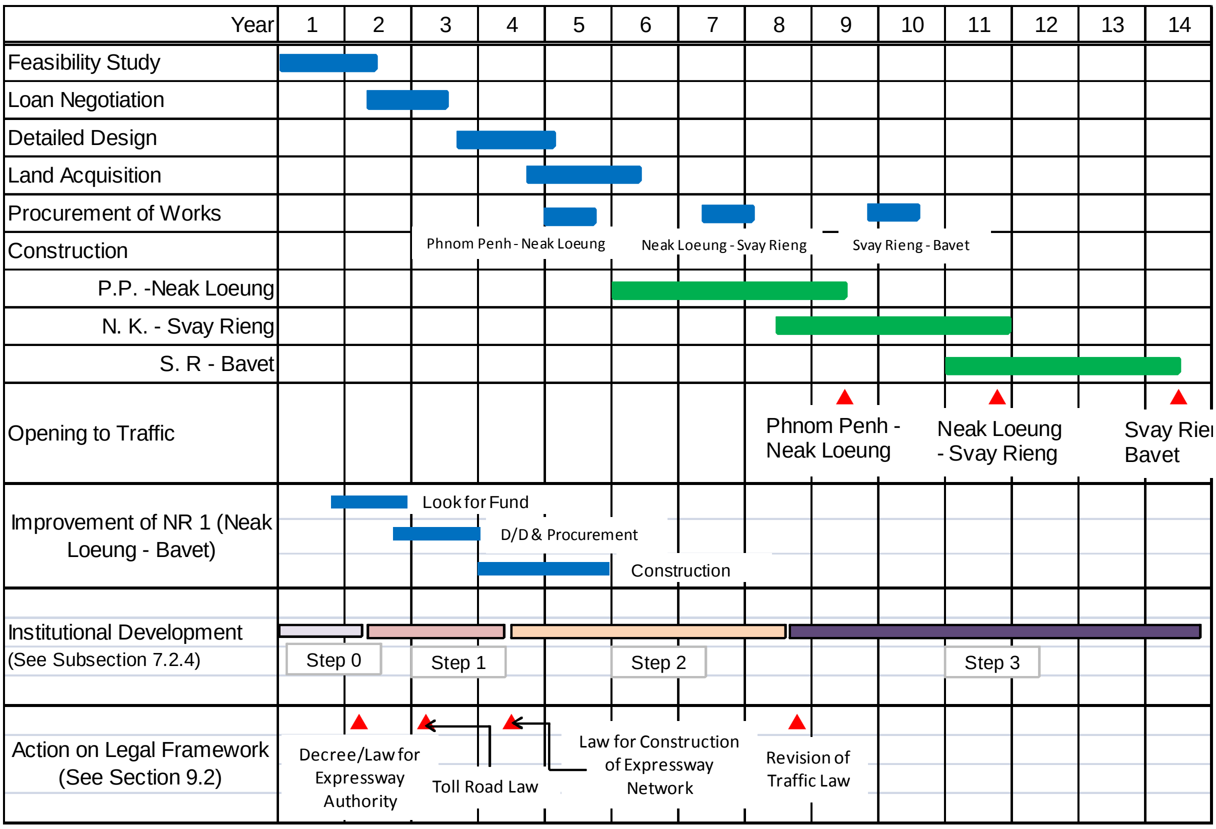


Figure 7.1-1 Implementation Schedule

The forecasted traffic demand on the expressway decreases after passing Neak Loeung and decrease again after passing Svay Rieng (please see 6.4). This is also the reason that the phased construction is proposed.

If the feasibility study (F/S) is started between late 2014 and the beginning of 2015, the opening of Phnom Penh – Neak Loeung section is expected to be sometime in 2023. The opening of the last section, Svay Rieng – Bavet is expected in 14th year, or year 2028.

It is assumed here that the pavement of Neak Loeung – Bavet section of the existing national road No.1 (NR 1) will be improved and used as the main road until the E1 expressway will be constructed. (This issue will be discussed in Section 7.4.) If NR 1 is improved, the phasing in the construction of the E1 Expressway will not cause serious problems in traffic or transport. This can be said considering that the traffic volume on NR 1 in year 2023 is estimated at 18,000 - 25,000 pcu between Neak Loeung and Svay Rieng. This traffic volume can be catered by the existing NR 1 which has 10 m-side carriageway, as discussed in Section 7.4.

7.1.2 Time Schedule of Task Items

In planning the overall time schedule as cited above, the following time schedules are assumed for respective task items:

(1) Feasibility Study

Feasibility study is estimated to take 18 months, considering such factors as; the total length of expressway (approximately 140 km), difficulty in visiting the site and checking the site conditions due to scarcity of roads along the expressway road, and complexity of EIA and study on social impacts.

(2) Loan Negotiation

Loan negotiation is estimated to take approximately 10 months. This is estimated based on the experience of the loan negotiation of NR 5.

(3) Detail Design (D/D)

To prepare the detail design, the expressway authority needs to employ a consultant team. Procurement of consultant services can be started before the singing of L/A by obtaining the concurrence on the advanced action. However, the past experience shows that the procurement process of the consultant services, including various approvals by the relevant authorities of Cambodia, takes approximately 10 months or more. Thus detail design is expected to start a few months after the signing of L/A.

(4) Land Acquisition

Land acquisition for whole section of Phnom Penh – Bavet is estimated to take nearly 3 years considering the length of the expressway. However, it is assumed that the effort of land acquisition is concentrated in Phnom Penh – Neak Loeung section and that it takes 1.5 years to acquire approximately 90% of the required land, which is considered to be the minimum percentage of land acquisition for starting the civil works. The remaining portion may be acquired after the civil works start.

Land acquisition can be started a few months before the completion of D/D, as soon as the outer edge of the required land (line of toe of embankment slope or the outer line of the frontage road, in case of embankment section) is determined.

(5) Procurement of Civil Works

Procurement of the civil works shall be started as soon as D/D is completed and the bill of quantity and other documents will be available. Actually, announcement of commencement of procurement can be issued a few months before D/D is completed. This process, including bid evaluation, approval of bid evaluation and contract negotiation is estimated to takes minimum 10 months.

(6) Construction

It is assumed that the construction works start 2 months after completion of contract negotiation and takes 42 months (3.5 years) for one phase such as Phnom Penh – Neak Loeung section. Two years and half (2.5 years) are assumed as the time interval between the start of Phase 1 and Phase 2, and interval between Phase 2 and Phase 3.

(7) Institutional Development

Establishment and development of the Expressway Authority is indispensable for successful implementation of expressway projects. This subject is further discussed in Section 7.3.

(8) Action on Legal Framework

A few laws and decrees need to be enacted or revised as discussed in Chapter 9. Figure 7.1-1 shows the benchmarks for timing of enactment or revision of law or decrees. Actual timing of enactment of some laws, such as the Law for Construction of Expressway Network can be affected by political decision since it is highly political matter.

(9) Improvement of NR 1

This subject is discussed in Section 7.4.

(10) Coordination with Vietnamese Government

Although it is not shown in Figure 7.1-1, coordination with Vietnamese Government is necessary from the stage of Feasibility Study through operation of the expressway. The subjects to be coordinated include the following:

✓Route and design standard of expressway
✓Location, capacity and structure of border facility
✓Location and capacity of rest facilities
✓Expected time of completion of expressways in the both countries
✓Method of toll collection, such as ETC

7.2 Maintenance and Operation

After completion, an expressway needs to be maintained and operated. In case of a toll expressway, diligent maintenance and operation is required for the following reasons:

- ✓ The road users expect high level of service since they pay money
- ✓ Even a small defect may result in serious accidents because of high travel speed of vehicles.
- ✓ Cash is collected at toll gates: Handling of cash needs attention.

Contents of the required maintenance and operation works are quite different from the road maintenance works currently practiced in Cambodia. Figure 7.2-1 shows the main contents of operation and maintenance works of expressway. The following subsections give brief explanations of these work contents.

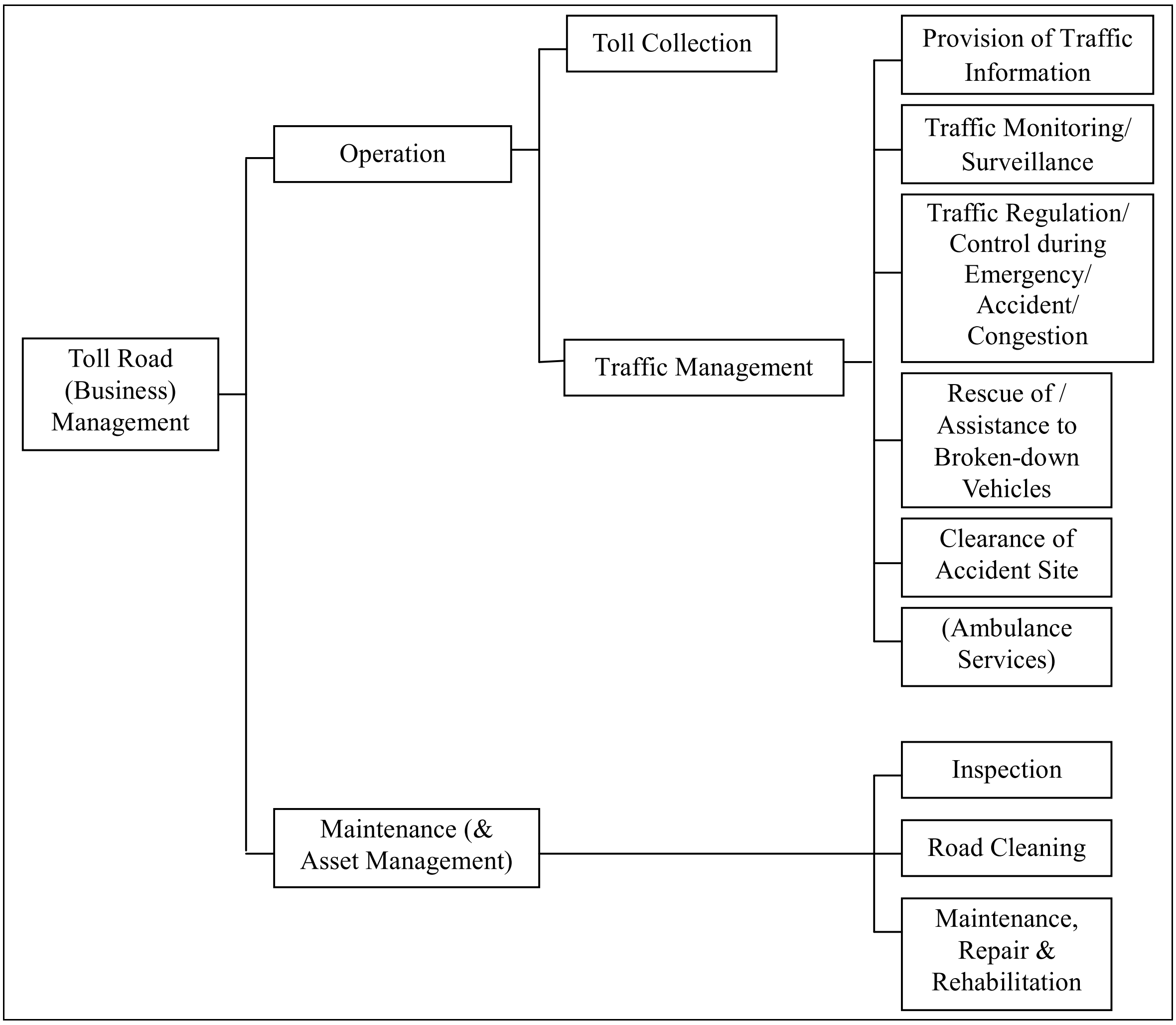


Figure 7.2-1 Contents of Operation and Maintenance Works

7.2.1 Toll Collection

Toll collection is literally the task to collect the toll. Toll collection nowadays is done electronically (electronic toll collection: ETC) and the portion of toll collected in the form of cash is minor. Still, considerable amount of cash needs to be handled. Thus, due attention needs to be paid to prevent robbery and embezzlement.

Figure 7.2-2 ETC Toll Gate

7.2.2 Traffic Management

This word “traffic management” is distinguished from the word “traffic control”. “Traffic control” in this chapter means regulation or control of traffic by police officers (or law enforcer), while “traffic management” means the works implemented by the road administrator as listed below:

(i) Provision of traffic information

(ii) Traffic monitoring/surveillance

(iii) Traffic regulation/control during emergency/ accident/ congestion

(iv) Rescue of / assistance to broken-down vehicles

(v) Clearance of accident site

In addition to the above, ambulance service may be provided by the operator of the expressway (expressway authority).

Figure 7.2-3 Traffic Control Room and Traffic Information

7.2.3 Maintenance

Maintenance includes works such as inspection of the conditions, maintenance, repair and rehabilitation of the road and relevant facilities. Maintenance usually include road surface cleaning also.

Usually, road maintenance works are categorized into the following three types.

(i) Routine maintenance,

(ii) Periodic maintenance, and

(iii) Emergency maintenance.

“Routine maintenance” refers to works with features as listed below.

- ✓ Need to be implemented more frequently than “periodic maintenance”. Time interval or frequency may vary from more than once a day to once a year.
- ✓ Relatively simple or small in scale.
- ✓ Often interval of implementation is less dependent on the traffic volume than in case of periodic maintenance and is relatively regular compared with that of periodical maintenance.

In contrast to routine maintenance, “periodic maintenance” has the following features:

- ✓ Longer interval of implementation (once a year to once per 10 years),
- ✓ Relatively large in scale: Often requires closure of lane(s) or even several sections of the expressway, and
- ✓ Often, the interval of implementation is influenced by traffic volume, especially that of heavy vehicles.

“Emergency maintenance” mainly refers to repair works for damages caused by natural disasters or large-scale accidents.

These works are essentially similar to the maintenance of ordinary national highways. However, much higher level of service is required for expressway because of the high travel speed. Also, the road users tend to require high level of service because they pay money for using the expressway.

7.3 Institutional Plan

7.3.1 Existing Organization

The Road Infrastructure Department (RID) of the Ministry of Public Works and Transport (MPWT) is responsible for road national road projects. Figure 7.3-1 shows present structure of MPWT as of 2014.

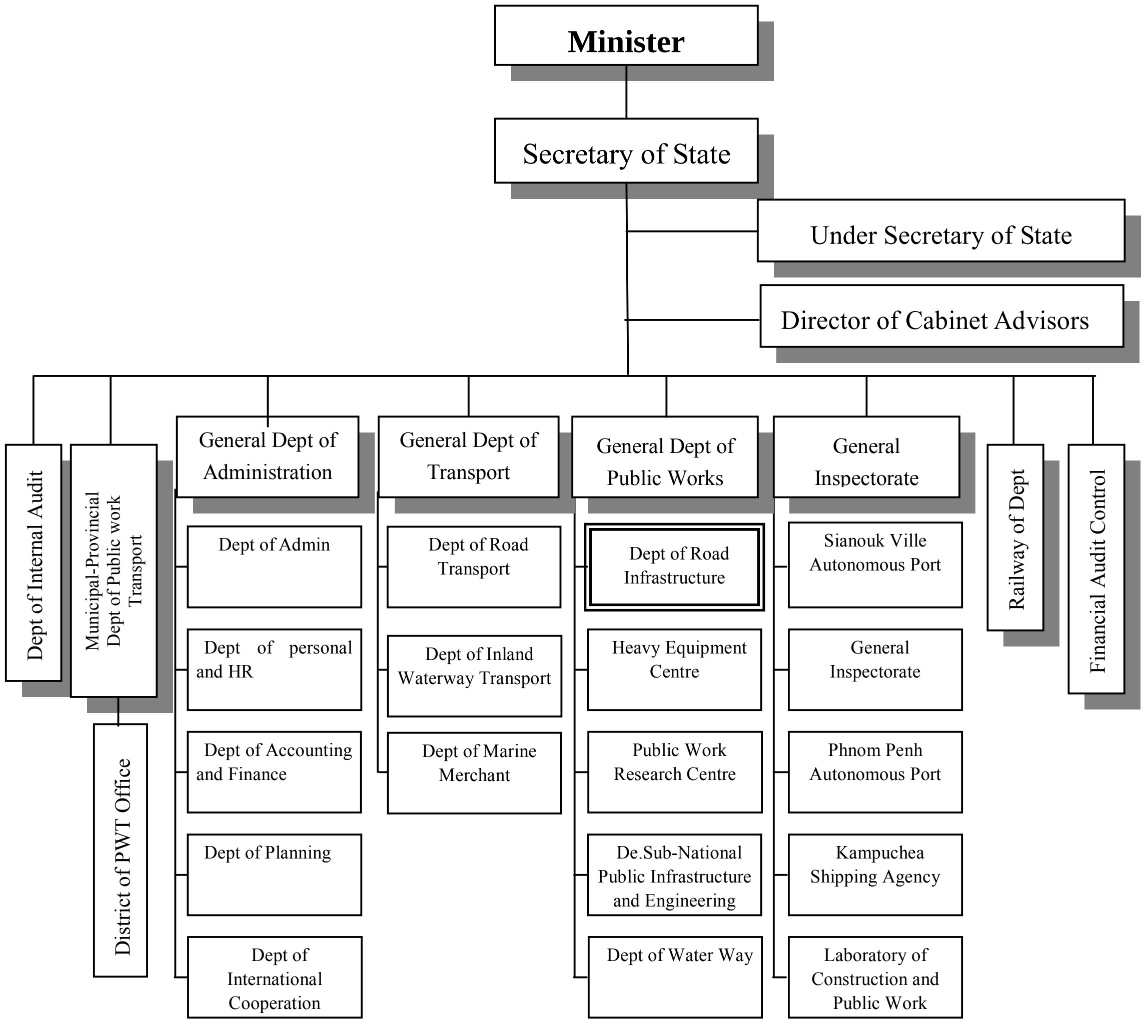


Figure 7.3-1 Structure of MPWT (2014)

Currently, the main tasks of RID is improvement, rehabilitation and maintenance of the national roads, and there are rather limited number of new construction projects. Thus, majority of the road projects handled by RID are of relatively small in scale. Large-scale projects are often financed by donors including ADB and Japan. Project Management Units are established to implement these large-scale projects. Thus the opportunities where RID accumulate experiences of implementing/administering large-scale project as organization is limited.

7.3.2 Necessity of New Organization

Development of a national expressway network is an important national project. It requires large amount of fund and high capacity of project implementation. Its effect is large and occurs in wide spectrum. Thus, the implementing agency of expressway projects is required to possess high level of engineering knowledge and skill, high commitment and motivation, as well as fresh and flexible mind to solve novel problems which have not been experienced in the past road projects.

It is, thereby, impossible for only one unit under the government to handle this large-scale task. The organization dedicated for expressway construction and operation is indispensable with approval of proper legislation. Our recommendation is that this special corporation should be established as soon as possible in order to steadily establish expressway network in the whole country of Cambodia. This section discusses such an institutional setup.

7.3.3 Practices of Foreign Countries

Many countries including developing countries have established organization specialized for expressway construction and management in their own countries. Table 7.3-1 shows some examples of such organizations in the world. As seen in the table, most of the organizations are public corporations 100% owned by the government. This fact testifies that state-owned corporation is the most suitable form of organization for development of national expressway network.

Table 7.3-1 Toll Road Organizations of Various Countries (1/2)

Country	Name of Organization	Legal Status and Function	Remarks
Asia			
Japan	1. Japan Highway Public Corporation 2. Metropolitan Expressway Public Corporation 3. Hanshin Expressway Public Corporation 4. Honshu – Shikoku Bridge Authority 5. Toll Road Authorities owned by the local governments	1 & 4: 100% owned and supervised by the central government. 2 & 3: Owned jointly by the central government and the relevant local governments. Mainly supervised by the Minister of Land, Infrastructure and Transport, but basic policy needs to be agreed by the Council where the governors of the local governments are the members. 1: Responsible for the construction & operation of the national expressway network system. 2 & 3: Responsible for the construction & operation of the urban expressway network in and around Tokyo and Osaka – Kyoto – Kobe Area, respectively. 4. Responsible for the construction and operation of bridges and highways connecting Honshu (the main island) and Shikoku Island.	Before privatization in 2006
China	Provincial Expressway Corporations or newly established Expressway Construction Headquarters in the Provincial Government	• 100% owned by the Provincial Government or a part of the Provincial Government • Responsible for construction and operation of the part of the National Trunk Highway System (NTHS) in the Province	Central Govt. is responsible for NTHS planning
Korea	Korean Highway Corporation	• 100% owned by the central government. • Responsible for inter-urban expressways	
Indonesia	Indonesian Highway Corporation (PT Jasa Marga)	• 100% owned by the central government. The Ministry of Finance act as the shareholder. • Supervised by the Board of Commissioners, comprising Director General of Roads, Representative of the Ministry of Finance, Representative of National Traffic Police Dept. and others. • Operating large portion of the toll roads in the country • There are several toll roads constructed and operated by private investors.	Jasa Marga was the sole organization for expressway when it was established.
Malaysia	Malaysia Highway Authority (Lembaga Lebuhraya Malaysia)	• 100% owned by the central government. • Supervised by the Minister of Public Works • Responsible for construction/operation of toll expressways	
Thailand	Expressway Authority of Thailand (EXAT)	• Responsible for construction/operation of urban expressways network. • Originally established as Expressway and Rapid Transit Authority (ETA) under the Ministry of Interior and has been reorganized as EXAT under the Ministry of Transport and Communication in 2007.	Interurban expressways are under DOH
Vietnam	Vietnam Expressway Corporation (VEC)	• Established in year 2005 to be responsible for construction/operation of the national expressway network.	

Table 7.3-1 Toll Road Organizations of Various Countries (2/2)

Country	Name of Organization	Legal Status and Function	Remarks
Europe*			
Italy	1. ANAS 2. Autostrade S.p.A 3. Concessionaires invested mainly by the local governments	1: 100% owned by the central government and is responsible for construction/operation of expressways (autostrade). 2 & 3: Implement construction/operation of expressways under the contracts with ANAS • ANAS started construction of the expressways after the World War II	
France	1. SEM: Societes d'Economie Mixte Concessionnaires d'Autoroutes 2. Cofiroute (Private Company) 3. Others	1: Owned either (i) by a single local government, or (ii) jointly by multiple number of local governments, or (iii) jointly by local government and chamber of commerce. There are various SEMs which construct and operate expressways (autoroutes) by the concession with the central government. 2: 100% private company. Function is same to SEMs. 3: Special companies established to be responsible for operation of particular facilities such as Mont Blanc Tunnel.	
Austria	AFINAG: Autobahnen und Schnellstrassen Finanzierung Aktiengesellschft	• AFINAG was established in 1982 to finance expressway projects and remodeled in 1997 to be responsible for toll collection of expressways.	

**Source: Express Highway Research Foundation of Japan, "Situation of Expressways in Foreign Countries", May 2005 (in Japanese language)*

7.3.4 Development of Organization

The proposed expressway authority does not need be established in “full size” from the beginning. Rather it is easier and more practical to start as small organization and develop gradually so that it can handle the task required at each development stage of the national expressway network.

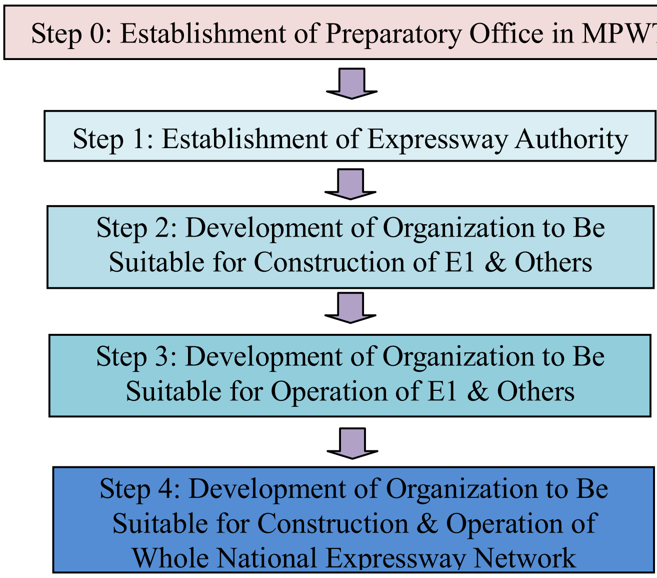


Figure 7.3-2 Steps of Development of Organization

(1) Step 0: Establishment of Preparatory Office in MPWT Proper

A small office or division is established in MPWT. The function of this office is to prepare establishment of the expressway authority. This office should have 2 sections under the director; one section which deals with administration and legal matters and another section which deals with engineering planning. It is proposed that the preparatory office be established under the Director General of Public Works. Figure 7.3-3 shows the position of the preparatory office in MPWT. Figure 7.3-4 shows an example of organization of the preparatory office.

(2) Step 1: Establishment of Expressway Authority (Tentative Name)

An independent organization (tentatively called “Expressway Authority”) is established under, but outside of, MPWT. The main function of Expressway Authority at this stage is to administer feasibility studies and detail design. Also, assistance to MPWT in revision of relevant legislations is the function of the Expressway Authority at this stage. Thus, the Expressway Authority should have 4 divisions; administration, legal, planning (in charge of feasibility study) and engineering (in charge of design).

The chief executive officer (managing director or president or other name) need to possess strong political power because introduction of many new rules, such as high salary level close to those of private sector, rule for travelling expressway at high speed, and traffic enforcement and ambulance services on expressway, needs to be consulted agreed between the relevant ministries including MEF and Traffic Police Department.

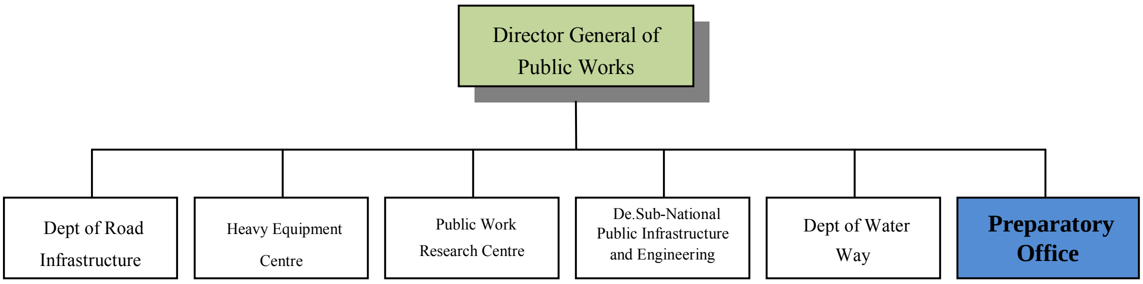


Figure 7.3-3 Placement of Preparatory Office in MPWT

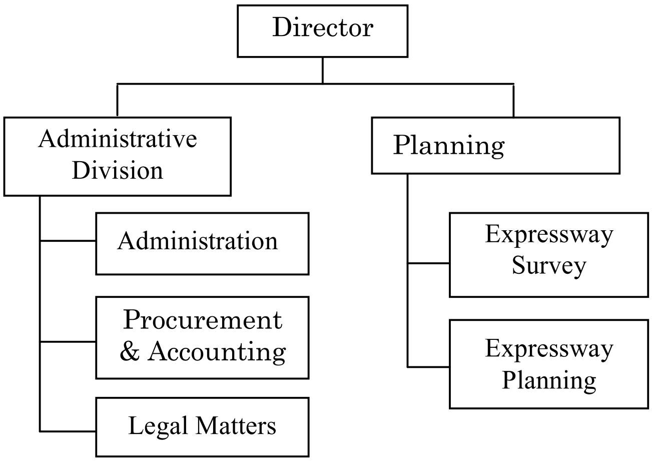


Figure 7.3-4 Example of Organization of Preparatory Office.

(3) Step 2: Development of Organization to be Suitable for Construction of E1 and Other Expressways

Shortly before the procurement of civil work of E1 starts, the organization of the Expressway Authority needs to be developed so that it can administer the procurement and construction. Thus, a new unit for project management needs to be added to the organization of Step 2. Figure 7.3-5 shows an example of organization of the Expressway Authority at Step-3

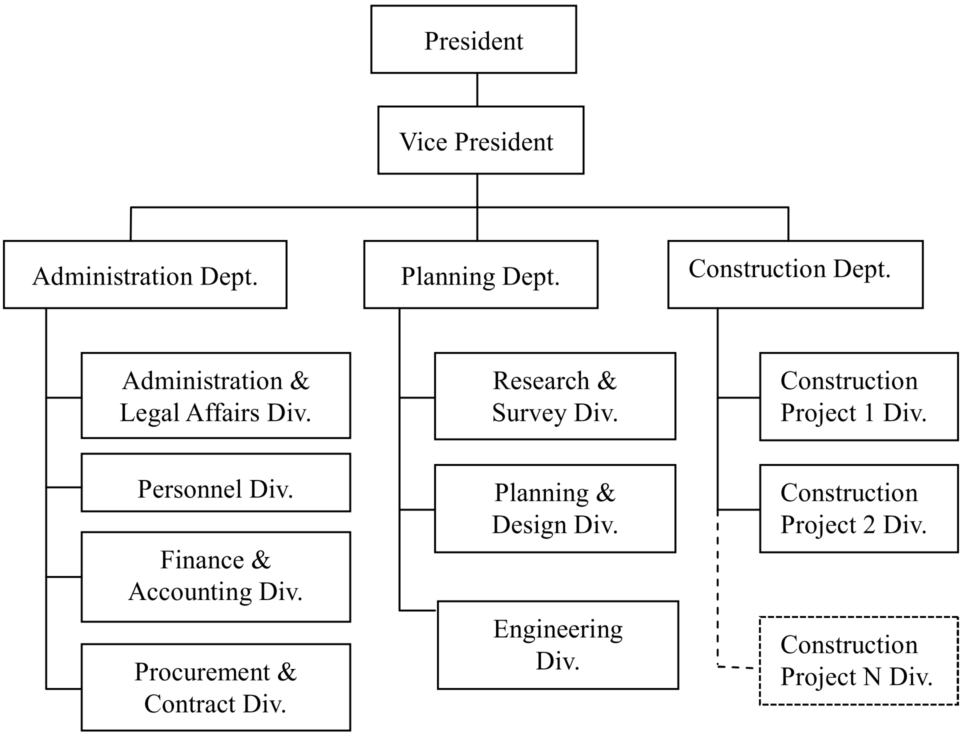


Figure 7.3-5 Organizational Structure of Step 3

(4) Step 3: Development of Organization to be Suitable for Operation of E1 and Other Expressway

Approximately 1 year before the opening of E1 Expressway, the Expressway Authority needs to start preparation for operation of the expressway. The tasks in the operation stage are as described in Section 8.2 above. They are toll collection, traffic management and maintenance. The departments and/or divisions added at this stage are, toll collection division/financial department, maintenance and traffic engineering department, traffic operation division. Figure 7.3-6 shows an example of organizational structure at Step 4.

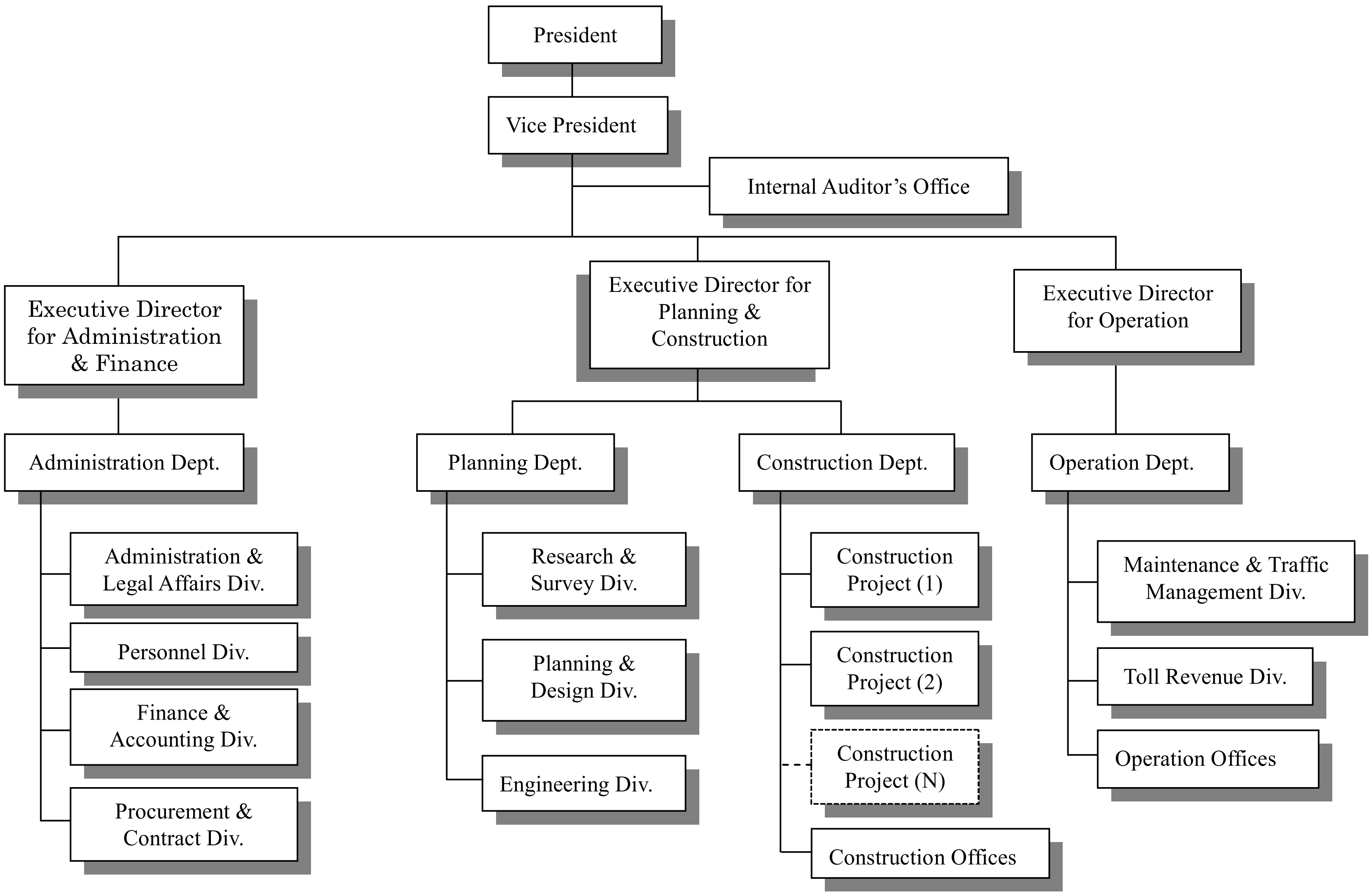


Figure 7.3-6 Organizational Structure at Step 4

The staff of these departments/divisions need to undergo training to acquire sufficient knowledge and skill prior to the opening of the expressway so that the newly opened expressway can be operated smoothly. It should be noted that the drivers are not accustomed to travelling on expressway and diligent management of traffic is required in the early stage of opening of expressway. Further, it should be kept in mind that the capacity development is required also for the personnel of the entities outside of the Expressway Authority who undertake the actual works of toll collection and other tasks by contract.

(5) Step 4: Development of Organization to be Suitable for Construction and Operation of Whole Expressway Network

This is the final stage of the development of organization. After opening of E1, other lines of the national expressway network will be constructed and operated. As the construction and operation is expanded, the number of staff needs to be increased to cope with the increased work volume.

7.4 Coordination with Improvement of National Road No.1

National Road No. 1 (NR 1) plays an important role in enhancing the function of E1 Expressway:

✓ Non-toll alternative road for E1

✓ Feeder road of E1

✓ Alternative road in case of closure of E1

✓ Road for shorter trip

✓ Road for daily citizen life

Currently, the section between Phnom Penh and Neak Loeung is being improved under grant aid of Japanese government and a cable-stayed bridge is being constructed across the Mekong River near the location where ferry service is provided. Thus, the traffic environment on this section will be greatly improved in one or two years from now when these improvement and construction will be completed.

On the other hand, there is no concrete plan for improvement of the Neak Loeung – Bavet section of NR 1. The improvement of this section was completed in year 2006 under the financial assistance of ADB. The existing pavement is DBST with width of 10 m. The main improvement work to be urgently done is improvement of pavement from DBST to AC pavement.

There will be very little necessity for widening since the estimated traffic volume in year 2033 is 25,000 pcu or less which can be accommodated with the existing carriage width. The cost of such improvement of pavement for approximately 100 km-long section is estimated at USD 50 million or less.

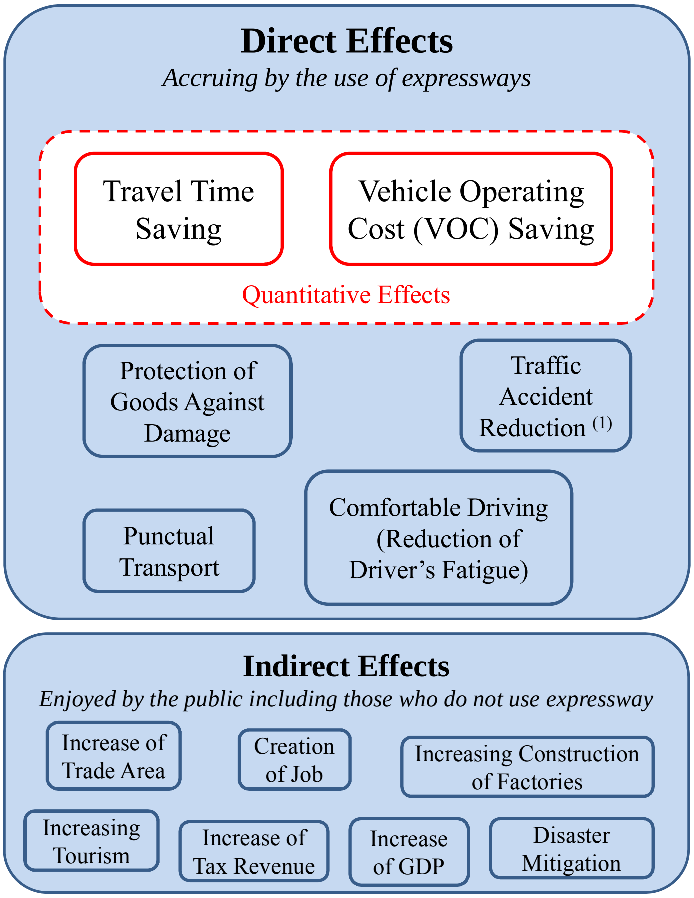
If appropriate fund source is found in 1 to 2 years from now and the construction works is started in 3 years from now, this improvement can be completed before the opening of the Phase 1 of E1 (Phnom Penh – Neak Loeung), as shown in Figure 7.1-1. Then, the traffic using the Phase 1 section of E1 can smoothly travel between Neak Loeung and Bavet via the improved NR 1 until the Phase 2 and Phase 3 sections of E1 will be completed and be open to traffic.

Justification for investing in the expressways and the ordinary national roads is explained in Section 3.3.

CHAPTER 8 ECONOMIC AND FINANCIAL ANALYSIS

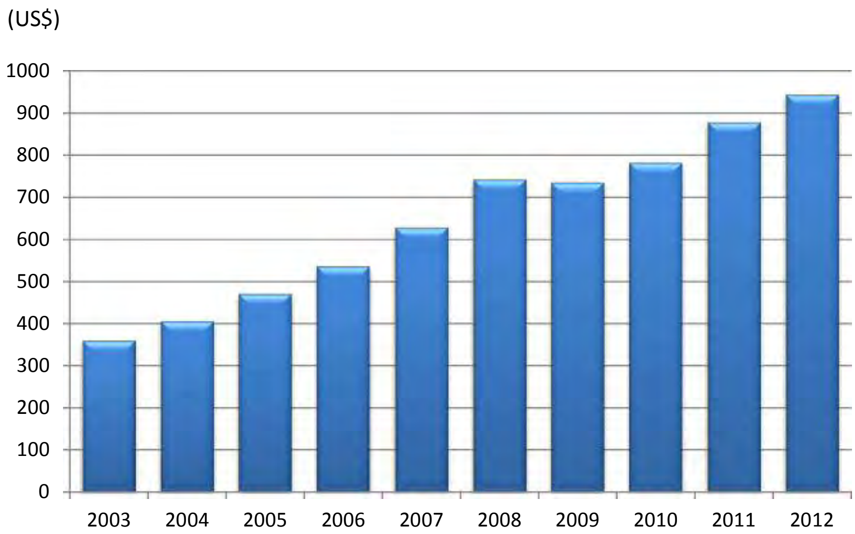
8.1 Economic Analysis

The focus of this chapter is to analyze the economic effects of the development of Phnom Penh – Ho Chi Minh City Expressway. There are various effects, both quantitative and qualitative, are produced by expressway developments. Qualitative effects are the effects which are difficult or impossible to be quantified. Examples of expected effects of expressway development are shown in Figure 8.1-1. These effects are generally classified into "direct effects" which are generated by the use of expressways and "indirect effects" which are enjoyed by the public including those who do not use expressway directly. Two of direct effects; travel time saving effect and vehicle operating cost saving effect, can be quantified by converting into monetary value (generalized cost) and cost benefit analysis of project is implemented to evaluate the economic viability. There are many other direct effects such as traffic accident reduction, improvement of punctuality, comfortable driving, etc. Although those direct effects are not calculated in this survey, these effects are explained in this chapter as well as indirect effects of expressway development.



(1) *Although effect of traffic accident reduction is regarded as quantitative effects in most of developed countries, due to lack of data, it is classified in qualitative effect in this survey.*

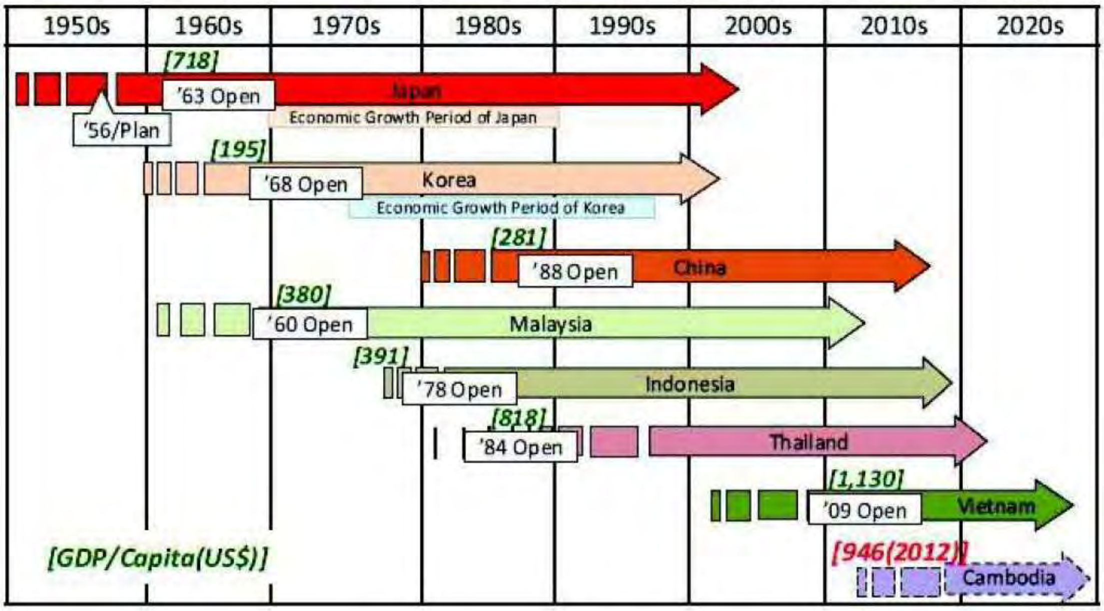
Figure 8.1-1 Expected Effects of Expressway Development



Source: http://data.worldbank.org/indicator/NY.GDP.PCAP.CD (compiled by the author)

Figure 8.1-2 Growth of GDP Per Capita in Cambodia

Figure 8.1-2 shows the growth of GDP per capita in Cambodia for recent 10 years. It reached approximately USD 1,000 in 2012. Figure 8.1-3 shows the time of starting expressway construction in Asian countries and period of high economic growth was achieved in each country. In this figure, numbers in the brackets denote the GDP per capita when first expressway opened. It is seen in the figure that GDP per capita of these countries were USD 1,000 or less when construction of expressway was started. It is also observed in the figure that there is strong relationship between expressway development and economic growth. From this figure, it can be considered that expressway conduces constant high economic growth. In this chapter, the effect of introducing expressway will be discussed specifically.



Source: Leaflet of Preliminary Data Collection Survey for Expressway Development

Figure 8.1-3 Time of Start of Expressway Construction in Asian Countries

8.1.1 Quantitative Analysis

The main purpose of quantitative economic analysis is to show the effects of expressway development from the viewpoint of national economy and it aims at evaluating the economic viability of the project implementation. Economic analysis estimates whether the project yields sufficient benefit compared to the economic resources required.

(1) Methodology

Quantitative economic evaluation is conducted in terms of comparative analysis between benefits and costs. Benefits contain (i) time saving benefit and (ii) vehicle operation cost (VOC) saving benefit, while costs consist of construction cost and operation/maintenance cost. Indicators adopted here for quantitative economic analysis are the conventional "economic internal rate of return (EIRR)", "benefit-cost ratio (B/C ratio)" and "net present value (NPV) of the benefit". Evaluation was conducted on the basis of transport demand forecast.

The benefit is regarded as various desirable effects given to the national economy when the project is implemented, and the cost is regarded as all national economical expenditure required for the project implementation concerned.

In order to evaluate the projects from an economic view point, the following economic indicator were considered:

- NPV of a given project is obtained by subtracting the present value of the costs from the present value of the future benefits. The benefits as well as the costs are discounted at the rate of opportunity cost of capital (discount rate). The investment is viable if the NPV is positive.
- EIRR of a given project is defined as the discount rate at which the present value of benefits and the present value of costs are equal. It is a measure of the marginal efficiency of capital. For a project to be viable, the EIRR has to be greater than the Opportunity Cost of capital rate. Normally the NPV and EIRR will give the same indications of viability and priority ranking between projects.
- B/C ratio refers to the ratio of the present value of the economic benefits stream to the present value of the economic cost stream. The investment is viable for the project if the B/C ratio is greater than 1.

(2) Implementation Plan of the Project and Evaluation Period

The economic analysis is based on the Project implementation schedule proposed in Chapter 8 as shown in Table 8.1-1. The evaluation period is assumed to be 30 years from 2023 to 2052 taking the service life of the Project into account.

Table 8.1-1 Project Implementation Schedule for Economic Analysis

Year	2018 2022	2023
Infrastructure Design & Construction	→	
Operation & Maintenance		→

(3) Evaluation Period and Daily Factor

Evaluation period is set as 30 years after opening to traffic. The annualizing factor of the daily benefits is assumed to be 340 days per year taking into consideration the weekly variation in the volume of traffic on the roads.

(4) Discount Rate

A discount rate of 12% is adopted, taking into account the opportunity cost of capital in Cambodia.

(5) "With Project" and "Without Project"

"With Project" covers the situation where the proposed expressway project is implemented, and "Without Project" covers the situation where no such investment takes place. The quantified economic benefits, which would be realized from the implementation of the project, are defined as savings in vehicle travel time costs and vehicle operating costs derived from the difference between "With Project" and "Without Project".

The economic analysis procedure as illustrated in Figure 8.1-4 is employed in this survey. In order to estimate the benefit, traffic assignment to the road networks with and without the Project is considered.

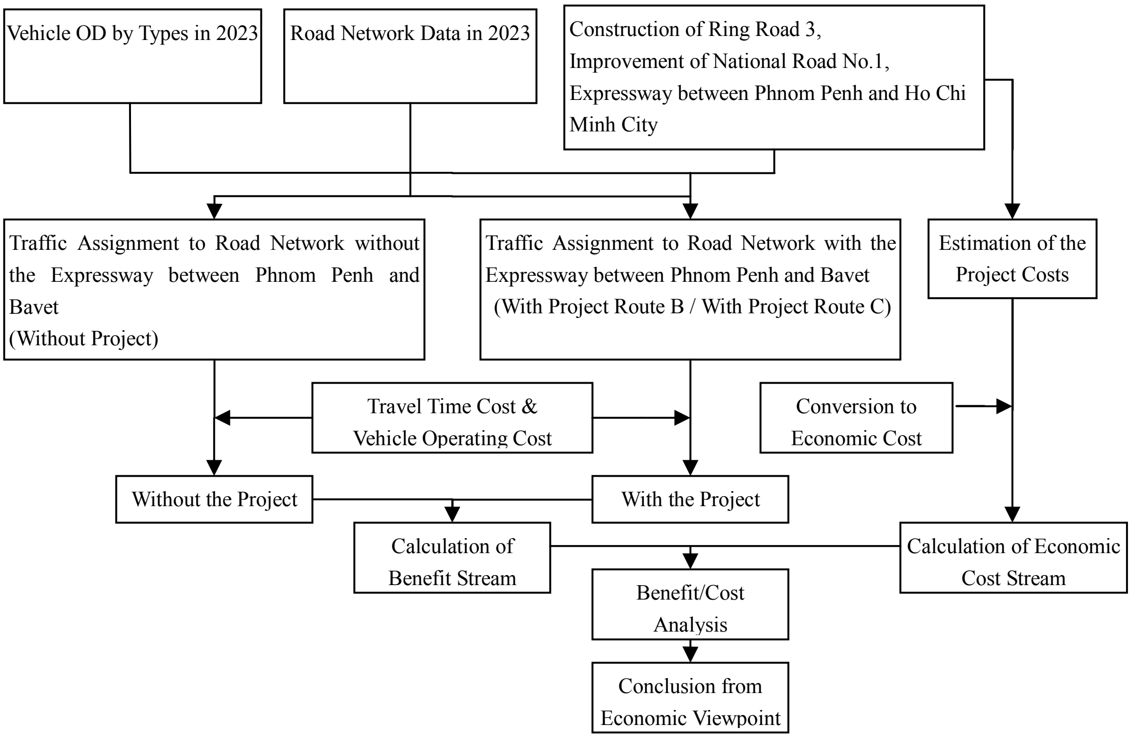


Figure 8.1-4 Procedure of Economic Analysis

(6) Estimation of Travel Time Cost and Vehicle Operation Cost

Travel time costs (TTC) is the value of time spent in traveling that could be used in the other activities. Vehicle operating costs (VOC) is the physical costs of operating a vehicle such as consumption of fuel, lubricants, spare parts, deprecation, crew costs, and others. The benefit of the project is calculated as the total of differences of TTC and VOC between the cases where the expressway is constructed and not constructed.

(a) Travel time cost (TTC)

As for motorcycles and light vehicles, TTC used in “the Preparatory Survey for National Road No. 5 Rehabilitation Project (Middle Section: Thlea Ma’am – Battambang) in the Kingdom of Cambodia”, JICA, 2014 is used. As for heavy vehicles (large bus and heavy truck), the TTC is determined based on the result of the Willingness-to-Pay (WTP) survey. Table 8.1-2 shows the TTC of these vehicle types.

Table 8.1-2 Adopted Travel Time Cost Per Vehicle

(Unit: US$/ hour)

Year	Motorcycle	Light Vehicle	Heavy Vehicle
2014	0.68	7.07	20.85

(b) Vehicle Operating Cost (VOC)

The VOC used in “the Preparatory Survey for National Road No. 5 Rehabilitation Project (Middle Section: Thlea Ma’am – Battambang) in the Kingdom of Cambodia” is also used as the VOC in this Survey, considering consumer price in 2014. Table 8.1-3.shows the VOC.

Table 8.1-3 Vehicle Operating Cost by Vehicle Type

(Unit US$/ 1,000 km)

Type	Item	Motor Cycle	Sedan Car	Pick-up	Mini Bus	Large Bus	Light Truck	Medium Truck	Heavy Truck
Distance related VOC	Fuel cost	311.7	3,116.7	3,116.7	4,051.7	13,974.1	10,181.1	19,963.0	32,938.9
	Lubricant cost	5.9	73.3	91.7	122.2	1604.2	366.7	1833.3	1833.3
	Tire cost	17.9	112.0	112.0	146.0	2128.0	560.0	2360.0	5066.7
	Maintenance cost	9.4	232.5	213.6	334.3	584.2	225.3	598.1	759.9
	Depreciation cost	0.6	14.4	13.2	20.6	36.1	13.9	30.8	39.1
	Sub total	345.4	3,548.9	3,547.1	4,674.8	18,326.5	11,347.0	24,785.2	40,637.9
	Overhead cost	0.0	0.0	354.7	467.5	1,832.7	1,134.7	2,478.5	4,063.8
	Total	345.4	3,548.9	3,901.8	5,142.3	20,159.2	12,481.7	27,263.7	44,701.7
Time related VOC	Crew cost	4.5	75.0	75.0	2,250.0	3,375.0	2,500.0	3,750.0	4,500.0
	Maintenance cost	36.0	105.0	105.0	375.0	675.0	375.0	675.0	787.5
	Insurance cost	28.1	697.5	640.8	334.3	584.2	225.3	598.1	759.9
	Depreciation cost	0.3	7.7	7.1	11.1	19.4	7.5	16.6	21.1
	Sub total	68.9	885.2	827.9	2,970.4	4,653.6	3,107.8	5,039.7	6,068.4
	Overhead cost	0.0	0.0	82.8	297.0	465.4	310.8	504.0	606.8
	Total	68.9	885.2	910.7	3,267.4	5,119.0	3,418.6	5,543.6	6,675.3
Total		414.3	4,434.1	4,812.5	8,409.7	25,278.1	15,900.4	32,807.3	51,376.9
VOC /1000 km		41.4	147.8	160.4	280.3	361.1	265.0	328.1	513.8

(7) Construction Cost and Operation and Maintenance (O/M) Cost

The costs of construction presented in Chapter 5 (US$ 2,226 million for Route B and US$ 2,182 million for Route C) are used in the economic evaluation. The cost of maintenance is assumed as shown in Table 8.1-4.

Table 8.1-4 Annual Operation and Maintenance Cost

Items	Cost (US$ million)	Remarks
Maintenance	5	Maintenance Cost for the Road Facilities, etc.
Operation	5	Operation Cost for the Toll Plaza, etc.
Overhead	2	Labor Cost, Office Management, etc.
Total Annual Cost	12[1)]	

1) Total annual O/M cost is assumed to be 5% of the total construction cost. Unit cost of O/M per kim is 12 million/135 km = US$ 0.9 mil./km. This is about 1/10 of O/M cost in Japanese expressway. (In NEXCO-Central Co., O/M cost is about $0.9 million/km in 2012.)

Some basic presumptions assumed in the economic analysis are as follows:

- Escalation factor : Price escalation is not taken into account for construction cost, maintenance cost.
- Tax and import duty : Value added tax and import duty are excluded from cost.
- Land acquisition cost : Land acquisition cost is included.

(8) Cost Benefit Analysis

The result of the economic analysis is shown in Table 8.1-5. The economic analysis of Route B and Route C are based on the annual user's benefit and cost estimate shown in Tables 8.1-6, and 8.1-7, respectively. It should be noted that the construction cost of Ring Road 3 is not included since this analysis focuses on E1 Expressway.

EIRR and other economic indicators of Route C is better than those of Route B. This is due to lower construction cost of Route C. As stated in Chapter 4, Route B is recommended considering its advantages although the economic indicators of Route B is less preferable than those of Route C.

Usually, EIRR of 10% is regarded as sufficient for a road project to be regarded as economically feasible. Thus, it can be said that EIRR of E1 Expressway project is at feasible level.

Table 8.1-5 Result of Economic Analysis

Indicator	Result	
	Route-B	Route-C
EIRR	12.6%	15.9%
B/C	1.06	1.49
NPV（US$ million）	73.6	515.6

The cost-benefit analysis stream are the 30 year project life is shown in Table 8.1-6, Table 8.1-7.

Table 8.1-6 Cost Benefit Stream of the Project (Route B)

(Unit: million US$)

	Year	Construction Cost	Maintenance Cost	Total Cost	Value of Saving Time	Saving VOC	Total Benefit	Net Benefit	Discount Cash Flow 12.0%		
									Cost	Benefit	Net Benefit
	2014			0.0			0.0	0.0	0.0	0.0	0.0
	2015			0.0			0.0	0.0	0.0	0.0	0.0
	2016			0.0			0.0	0.0	0.0	0.0	0.0
	2017			0.0			0.0	0.0	0.0	0.0	0.0
	2018			0.0			0.0	0.0	0.0	0.0	0.0
	2019			0.0			0.0	0.0	0.0	0.0	0.0
	2020	2,160.0		2,160.0			0.0	-2,160.0	1,094.3	0.0	-1,094.3
	2021			0.0			0.0	0.0	0.0	0.0	0.0
0	2022			0.0			0.0	0.0	0.0	0.0	0.0
1	2023		12.0	12.0	207.3	24.4	231.6	219.6	4.3	83.5	79.2
2	2024		12.0	12.0	221.8	26.1	247.9	235.9	3.9	79.8	75.9
3	2025		12.0	12.0	237.3	27.9	265.2	253.2	3.4	76.2	72.8
4	2026		12.0	12.0	253.9	29.9	283.8	271.8	3.1	72.8	69.8
5	2027		12.0	12.0	271.7	32.0	303.6	291.6	2.8	69.6	66.8
6	2028		12.0	12.0	290.7	34.2	324.9	312.9	2.5	66.5	64.0
7	2029		12.0	12.0	311.0	36.6	347.6	335.6	2.2	63.5	61.3
8	2030		12.0	12.0	332.8	39.2	372.0	360.0	2.0	60.7	58.7
9	2031		12.0	12.0	346.1	40.7	386.9	374.9	1.7	56.3	54.6
10	2032		12.0	12.0	360.0	42.4	402.3	390.3	1.6	52.3	50.8
11	2033		12.0	12.0	374.4	44.1	418.4	406.4	1.4	48.6	47.2
12	2034		12.0	12.0	389.3	45.8	435.2	423.2	1.2	45.1	43.9
13	2035		12.0	12.0	404.9	47.6	452.6	440.6	1.1	41.9	40.8
14	2036		12.0	12.0	421.1	49.6	470.7	458.7	1.0	38.9	37.9
15	2037		12.0	12.0	438.0	51.5	489.5	477.5	0.9	36.1	35.2
16	2038		12.0	12.0	455.5	53.6	509.1	497.1	0.8	33.5	32.7
17	2039		12.0	12.0	473.7	55.7	529.4	517.4	0.7	31.1	30.4
18	2040		12.0	12.0	492.6	58.0	550.6	538.6	0.6	28.9	28.3
19	2041		12.0	12.0	512.4	60.3	572.6	560.6	0.6	26.9	26.3
20	2042		12.0	12.0	532.8	62.7	595.5	583.5	0.5	24.9	24.4
21	2043		12.0	12.0	554.2	65.2	619.4	607.4	0.4	23.2	22.7
22	2044		12.0	12.0	576.3	67.8	644.1	632.1	0.4	21.5	21.1
23	2045		12.0	12.0	599.4	70.5	669.9	657.9	0.4	20.0	19.6
24	2046		12.0	12.0	623.4	73.4	696.7	684.7	0.3	18.5	18.2
25	2047		12.0	12.0	648.3	76.3	724.6	712.6	0.3	17.2	16.9
26	2048		12.0	12.0	674.2	79.3	753.6	741.6	0.3	16.0	15.7
27	2049		12.0	12.0	701.2	82.5	783.7	771.7	0.2	14.8	14.6
28	2050		12.0	12.0	729.2	85.8	815.1	803.1	0.2	13.8	13.6
29	2051		12.0	12.0	758.4	89.2	847.7	835.7	0.2	12.8	12.6
30	2052		12.0	12.0	788.7	92.8	881.6	869.6	0.2	11.9	11.7
	Total	2,160.0	360.0	2,520.0	13,980.6	1,645.2	15,625.8	13,105.8	1,133.4	1,207.0	73.6

Table 8.1-7 Cost Benefit Stream of the Project (Route C)

(Unit: million US$)

	Year								Discount Cash Flow 12.0%		
		Construction Cost	Maintenance Cost	Total Cost	Value of Saving Time	Saving VOC	Total Benefit	Net Benefit	Cost	Benefit	Net Benefit
	2014			0.0			0.0	0.0	0.0	0.0	0.0
	2015			0.0			0.0	0.0	0.0	0.0	0.0
	2016			0.0			0.0	0.0	0.0	0.0	0.0
	2017			0.0			0.0	0.0	0.0	0.0	0.0
	2018			0.0			0.0	0.0	0.0	0.0	0.0
	2019			0.0			0.0	0.0	0.0	0.0	0.0
	2020	2,010.0		2,010.0			0.0	-2,010.0	1,018.3	0.0	-1,018.3
	2021			0.0			0.0	0.0	0.0	0.0	0.0
0	2022			0.0			0.0	0.0	0.0	0.0	0.0
1	2023		12.0	12.0	244.8	57.1	301.9	289.9	4.3	108.9	104.5
2	2024		12.0	12.0	262.0	61.1	323.0	311.0	3.9	104.0	100.1
3	2025		12.0	12.0	280.3	65.3	345.6	333.6	3.4	99.4	95.9
4	2026		12.0	12.0	299.9	69.9	369.8	357.8	3.1	94.9	91.8
5	2027		12.0	12.0	320.9	74.8	395.7	383.7	2.8	90.7	87.9
6	2028		12.0	12.0	343.4	80.0	423.4	411.4	2.5	86.6	84.2
7	2029		12.0	12.0	367.4	85.6	453.0	441.0	2.2	82.8	80.6
8	2030		12.0	12.0	393.1	91.6	484.8	472.8	2.0	79.1	77.1
9	2031		12.0	12.0	408.9	95.3	504.2	492.2	1.7	73.4	71.7
10	2032		12.0	12.0	425.2	99.1	524.3	512.3	1.6	68.2	66.6
11	2033		12.0	12.0	442.2	103.1	545.3	533.3	1.4	63.3	61.9
12	2034		12.0	12.0	459.9	107.2	567.1	555.1	1.2	58.8	57.5
13	2035		12.0	12.0	478.3	111.5	589.8	577.8	1.1	54.6	53.5
14	2036		12.0	12.0	497.4	115.9	613.4	601.4	1.0	50.7	49.7
15	2037		12.0	12.0	517.3	120.6	637.9	625.9	0.9	47.1	46.2
16	2038		12.0	12.0	538.0	125.4	663.4	651.4	0.8	43.7	42.9
17	2039		12.0	12.0	559.6	130.4	690.0	678.0	0.7	40.6	39.9
18	2040		12.0	12.0	581.9	135.6	717.6	705.6	0.6	37.7	37.1
19	2041		12.0	12.0	605.2	141.0	746.3	734.3	0.6	35.0	34.4
20	2042		12.0	12.0	629.4	146.7	776.1	764.1	0.5	32.5	32.0
21	2043		12.0	12.0	654.6	152.6	807.2	795.2	0.4	30.2	29.7
22	2044		12.0	12.0	680.8	158.7	839.4	827.4	0.4	28.0	27.6
23	2045		12.0	12.0	708.0	165.0	873.0	861.0	0.4	26.0	25.7
24	2046		12.0	12.0	736.3	171.6	907.9	895.9	0.3	24.2	23.8
25	2047		12.0	12.0	765.8	178.5	944.3	932.3	0.3	22.4	22.1
26	2048		12.0	12.0	796.4	185.6	982.0	970.0	0.3	20.8	20.6
27	2049		12.0	12.0	828.3	193.0	1,021.3	1,009.3	0.2	19.3	19.1
28	2050		12.0	12.0	861.4	200.8	1,062.2	1,050.2	0.2	18.0	17.8
29	2051		12.0	12.0	895.9	208.8	1,104.7	1,092.7	0.2	16.7	16.5
30	2052		12.0	12.0	931.7	217.1	1,148.8	1,136.8	0.2	15.5	15.3
	Total	2,010.0	360.0	2,370.0	16,514.7	3,848.7	20,363.4	17,993.4	1,057.4	1,573.0	515.6

(9) Sensitivity Analysis

A sensitivity analysis is conducted to see the influence of fluctuation of benefit and construction cost. Sensitivity analysis is made on the cases with ±10% in the cost and ±10% in the benefit. The case with "+ 10%" in cost and "- 10%" in benefit is supposed to represent unfavorable scenarios. The results of the sensitivity analysis of Route-B and Route-C are shown in Tables 8.1-8, and 8.1-9, respectively.

The EIRR of the worst case (+ 10 5 in const and – 10% in benefit) of Route B is more than 10%, implying that the project is economically feasible even under the worst scenario.

Table 8.1-8 Results of the Sensitivity Analysis (Route B)

Case		Economic Indicator	Benefits		
			-10%	Base Case	10%
Costs	-10%	NPV (US$ million)	62.4	183.1	303.8
		B/C	1.06	1.18	1.30
		EIRR (%)	12.5%	13.5%	14.5%
	Base Case	NPV (US$ million)	-47.1	73.6	194.3
		B/C	0.94	1.06	1.17
		EIRR (%)	11.6%	12.6%	13.5%
	10%	NPV (US$ million)	-156.5	-35.8	84.9
		B/C	0.87	0.97	1.07
		EIRR (%)	10.8%	11.7%	12.6%

Table 8.1-9 Results of the Sensitivity Analysis (Route C)

Case		Economic Indicator	Benefits		
			-10%	Base Case	10%
Costs	-10%	NPV (US$ million)	460.1	617.4	774.7
		B/C	1.48	1.65	1.81
		EIRR (%)	15.9%	17.1%	18.2%
	Base Case	NPV (US$ million)	358.3	515.6	672.9
		B/C	1.34	1.49	1.64
		EIRR (%)	14.8%	15.9%	17.0%
	10%	NPV (US$ million)	256.5	413.8	571.1
		B/C	1.22	1.36	1.49
		EIRR (%)	13.9%	15.0%	16.0%

8.1.2 Indirect Effect

As mentioned above, economic effects of expressway development pervades in wide range of socio-economic activities. The general idea of expected effects of expressways development is explained in this section with introduction of case study in Japan.

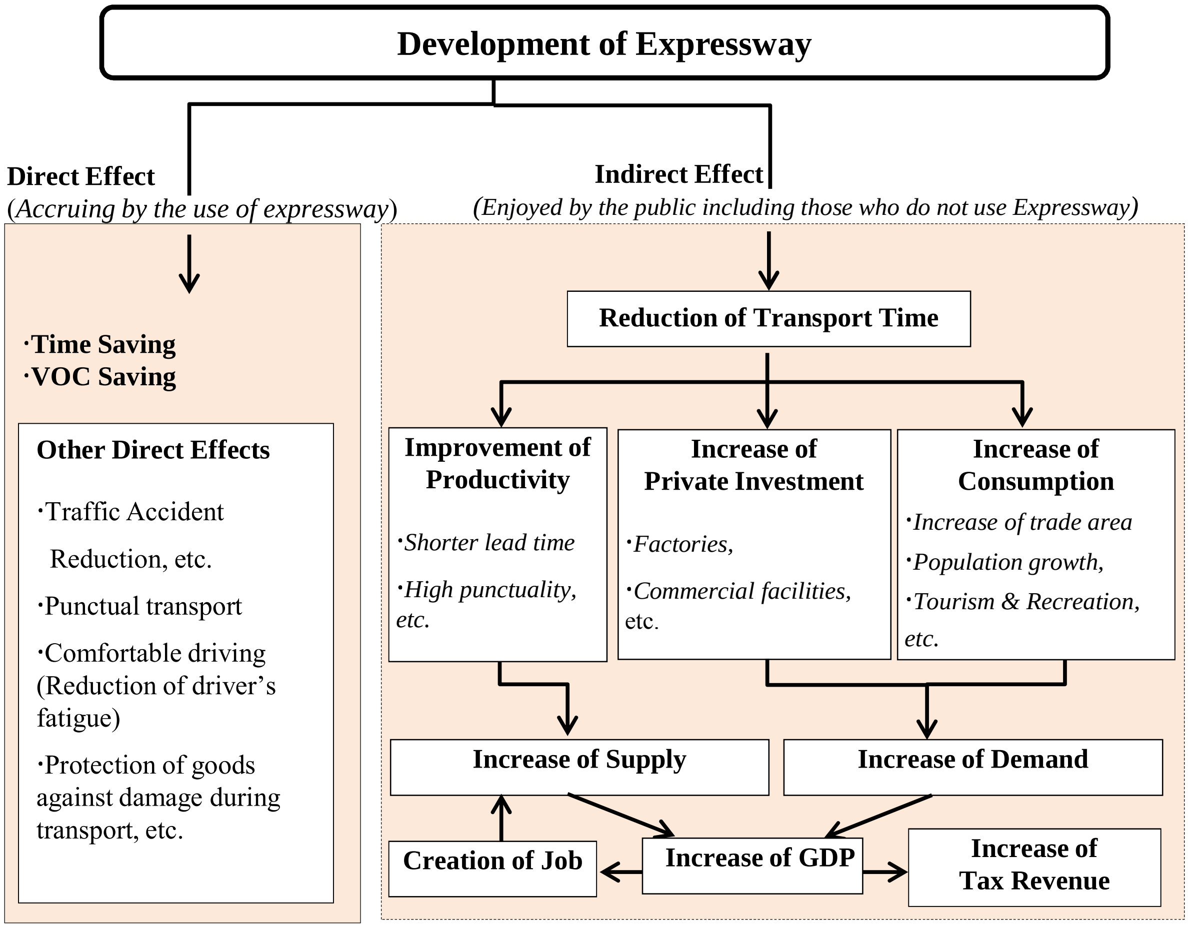


Figure 8.1-5 Effects of Expressway Development

Figure 8.1-5 shows the expected direct effects and indirect effects of expressway development. On the right side of the figure, the flow of how indirect pervade is shown.

While direct effects can be quantifiable, it is often difficult to quantify indirect effects. However indirect effects are those seen in such form as growth in GDP, regional development and increase of job opportunities, they are more sensible to the people and more important from the viewpoint of national economy.

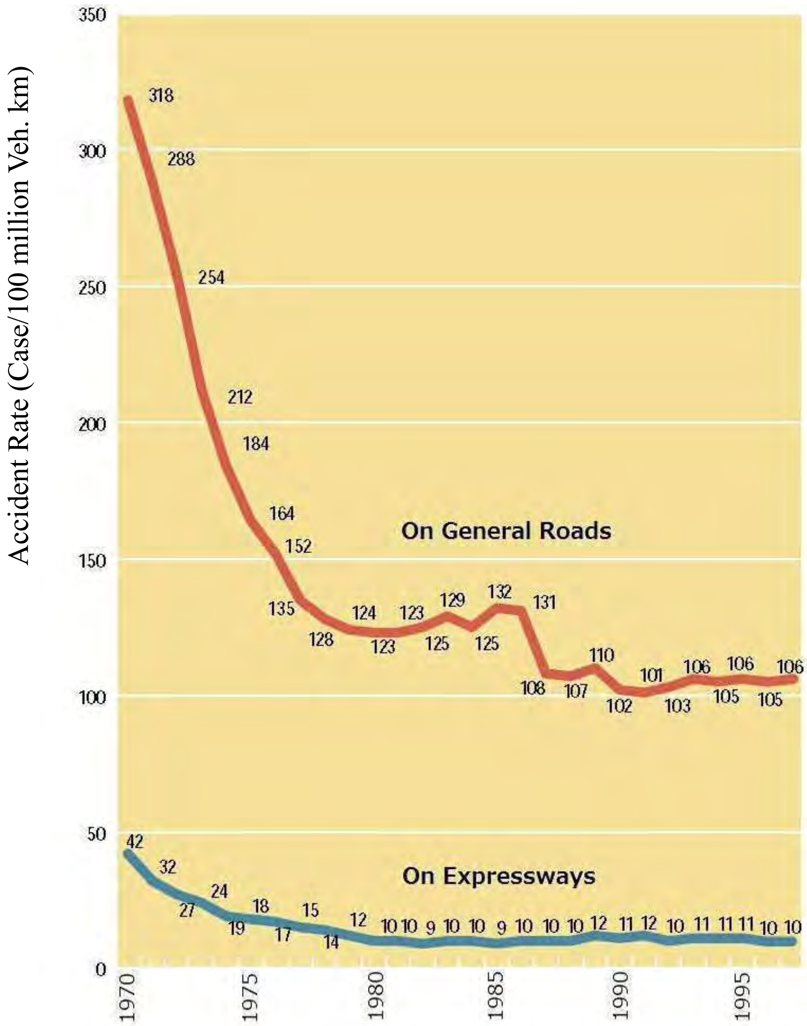
After the opening of expressway, transport or travel time becomes shorter and transportation cost of products is reduced, resulting in better competitiveness of products in the market. Travel of transport using expressway also provides punctuality. These advantages encourage establishment of new businesses and expansion of the existing commercial and industrial activities. This, in turn, will result in increase in GDP and job opportunities.

On the demand side, market area of goods and services is expanded and the number of target consumer becomes large. This results in growth of GDP.

(1) Traffic Safety

Before moving on to the case study of indirect effects, reduction of traffic accidents which is one of the direct effects of expressway is demonstrated.

Figure 8.1-6 shows the decrease of the accident rates on general roads and expressway in Japan respectively. Owing to the various countermeasures against traffic accidents, the number of accidents decreased year by year. Even after the significant decrease of accidents on the general roads, the ratio of accident on expressway is only about 10% of that of general road. It means that driving on expressway is 10 times safer than on general roads.



Source: NEAR: New Expressway and Region,Japan Highway Public Corporation (in Japanese)

Figure 8.1-6 Comparison of Accident Rates between General Road and Expressways

(2) Opening of New Factories

Figure 8.1-7 shows the percentages of newly located factories by distance from ICs of expressways in Japan. It is seen that the percentage of factories built near area from IC has been steadily increasing. As a result, the job opportunities in the area near the expressways increased at larger rate than in the area away from the expressways.

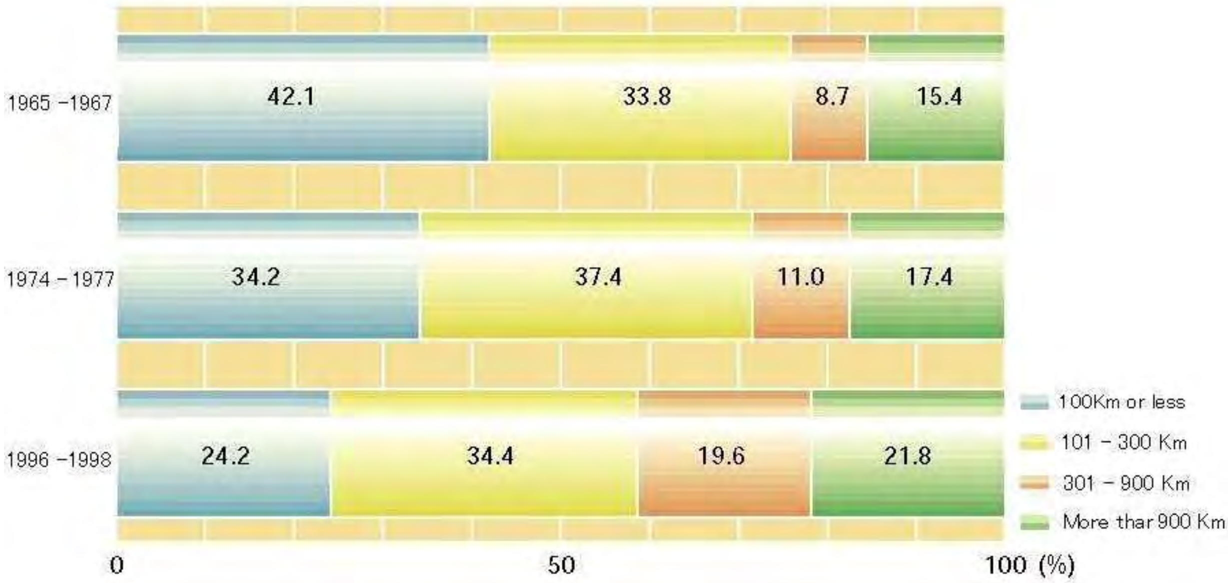
Source: NEAR: New Expressway and Region, Japan Highway Public Corporation (in Japanese)

Figure 8.1-7 Percentage of Newly Opened Factories by Distance from IC (Japan)

(3) Expansion of Market for Agricultural Products

Figure 8.1-8 shows change of distance between Tokyo Central Wholesale Market (TCWM) and the place of production of agricultural products sold at TCWM. These agricultural products are transported to Tokyo via expressway. As the expressway network is extended towards remote areas, the percentage of agricultural products coming from remote areas increased. The reasons for this are two folds:

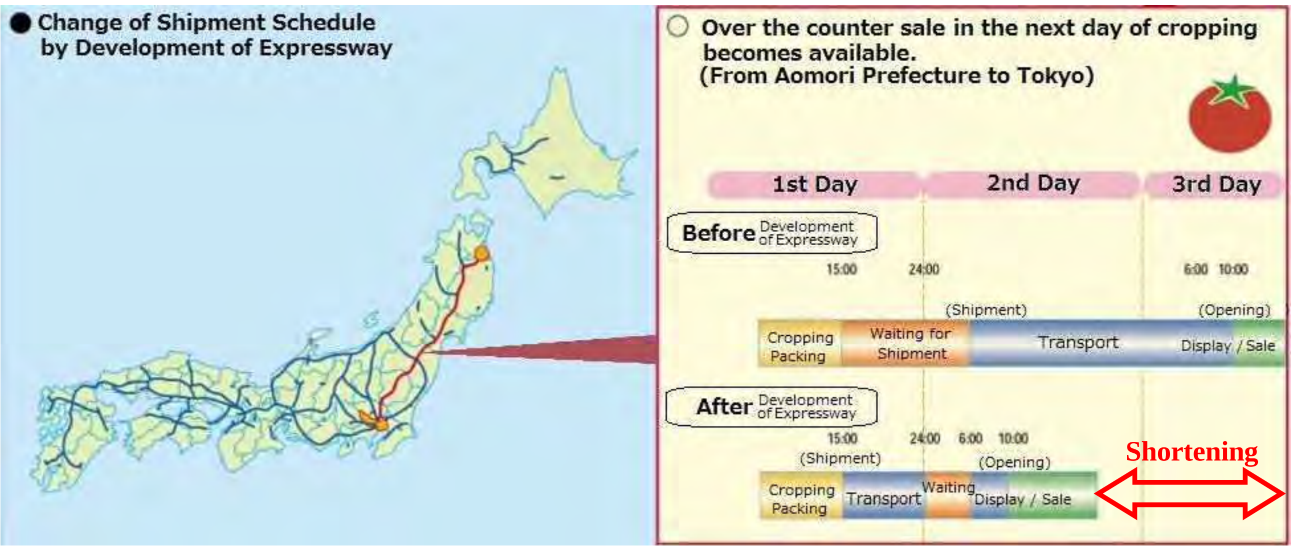
With shorter time required for transporting from the farm to the market and less damage of products owing to smooth road surface, vegetables, fruits and other agricultural products can be transported longer distance, and the market of these agricultural products is expanded.



Source: NEAR: New Expressway and Region, Japan Highway Public Corporation (in Japanese)

Figure 8.1-8 Change of Hauling Distance of Agricultural Products Sold at Tokyo Central Wholesale Market

Figure 8.1-9 shows an example of shortening of transport time of agricultural products (tomato) produced in Aomori Prefecture which is 900 km away from Tokyo. After the opening of Tohoku Expressway, transport time from production area to Tokyo was shortened by one day. This reduction in transportation time enabled the vegetables produced in Aomori be sold in the market in Tokyo.



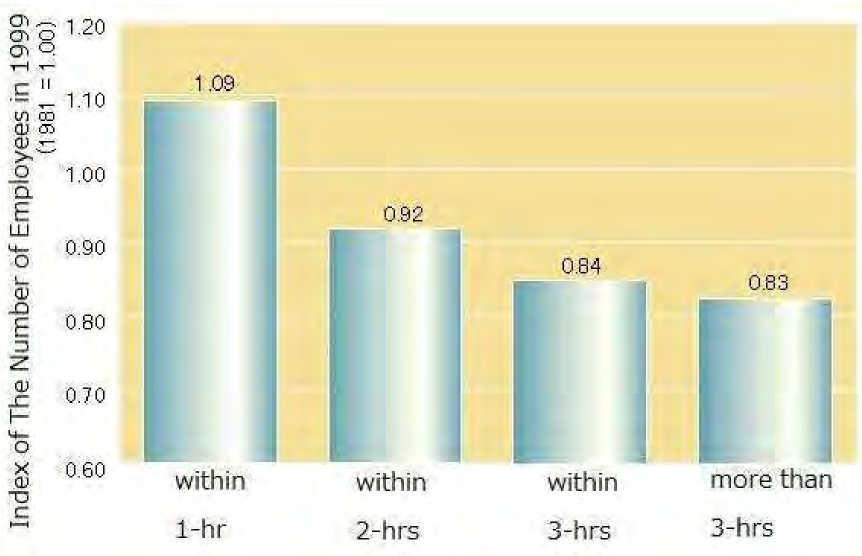
Source: <u>http://www.mlit.go.jp/road/koka4/1/1-22.html</u>

Figure 8.1-9 Example of the Changed Transport Time of Tomato (Japan)

In case of E1 Expressway, the distance between Phnom Penh and Ho Chi Minh city is about 250 km, much shorter than the above example of Aomori in Japan. Thus, it is possible that the agricultural products of Cambodia be exported to Ho Chi Minh City if the conditions becomes favorable.

(4) Increase of Employment

Factories are constructed at locations near to ICs so that time of access to the expressway becomes short. Thus, the increase of employments becomes larger in the areas near ICs than in the areas away from ICS. Figure 8.1-10 shows the difference of growth in the number of employees from 1981 to 1999 in areas with various time of access to IC. It is seen that the growth rate of employment becomes larger as the time of access to IC becomes shorter.



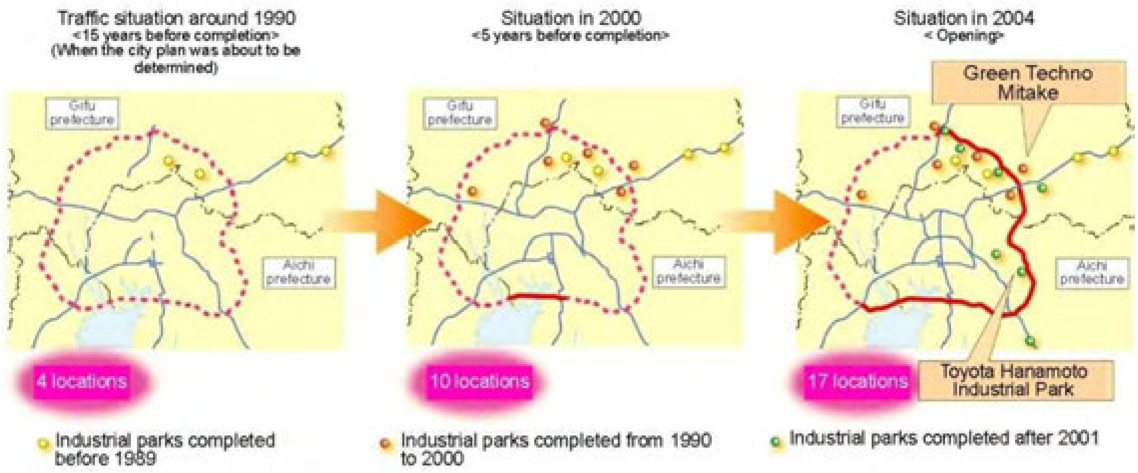
Source: NEAR: New Expressway and Region, Japan Highway Public Corporation (in Japanese)

Figure 8.1-10 Growth of Employment by Time of Access to IC (from Year 1981 to Year 1999)

(5) Effect of Development of Ring Road around a Large City

Construction of RR 3 is proposed so that it functions as the collector/distributor road for E1 Expressway. At the same time, RR 3 is necessary as one of the arterial ring roads of Phnom Penh as (i) the detour route for the traffic which bypasses Phnom Penh and (ii) collector/distributor road for the existing arterial national roads centered at Phnom Penh, such as NR 5, NR 2, NR 4 and NR 3. When a ring road is completed, many centers of logistic activities, such as container yards are constructed along the ring road. Figure 8.1-11 shows that development of logistic centers along a ring road around Tokyo.

In Phnom Penh, the effect of constructing RR3 can be seen even today. Many container depots (dry ports) have been constructed and are operating along the existing section of RR3 from NR 4 to NR 5.



Source: http://www.mlit.go.jp/road/road e/03key challenges/4-1.pdf

Figure 8.1-11 Transition of Located Industrial Park besides Ring Road (Japan)

(6) Indirect Effect Specific to Development of E1 Expressway

Analysis of effect of E1 Expressway development requires detailed data of movement of people and cargo along NR 1. Possible effect of development of E1 Expressway is discussed here based on the general experiences in Japan and other countries.

It can be said that the shortening of travel time between two large cities to about 3 hours, from current 6 hours or more can drastically change the sentiment of people on the easiness /difficulty of traveling between the two cities and condition of business and industry.

Experts of transport plan and transport economics of Japan have adopted the concept of “conscious distance” which is contrasted to “physical distance”. Conscious distance refers to the “feeling” or “sentimental evaluation” of distance between two locations. Sensible shortening of conscious distance can lead to drastic increase of travel of people between the two locations, which in turn, can result in drastic change in business and other fields.

(a) Effect on connectivity with the member countries of ASEAN Community and development of new industries

After signing of ASEAN Community scheduled in 2015, flow of goods, services, and people will increase. The regional cooperation among Thailand, Cambodia and Vietnam will be accelerated. As stated in Chapter 2, Bangkok – Phnom Penh – Ho Chi Minh City route is one of the most important transport corridors of ASEAN. This means that many factories will be newly constructed along this corridor. As explained in the above, E1 Expressway is expected to greatly improve the connectivity between Phnom Penh and Ho Chi Minh City.

One of the Japanese firms interviewed in the Willingness-to-Pay survey stated the following:

“This firm (manufacturer of electric appliances) is operating factories in Thailand and Vietnam. These factories are producing different kinds of parts. Currently two factories are

exchanging the necessary parts and constructing the products. If an expressway is constructed between Phnom Penh and Ho Chi Minh City and NR 5 is improved, it will be possible to open a new factory in Cambodia and assemble some products by transporting parts from the factories in Thailand and Vietnam."

As can be seen in this example, there is a good possibility that new industries will start operation taking advantage of geographical location of Cambodia *i.e.* middle point between Thailand and Vietnam.

(b) Increase of export through Ho Chi Minh City (Cai Mep) port

Currently, products of Japanese industries operating in Phnom Penh SEZ are exported mainly through Sihanoukville port. Some of these Japanese firms stated that substantial portion of their products are currently exported to China and Japan either via Sihanoukville port or via Phnom Penh New Port and transshipped at Ho Chi Minh City (Cai Mep) port. These firms also stated that the products exported to China and Japan may be exported directly through Ho Chi Minh City port after completion of E1 Expressway and the products to other areas (Singapore and Europe) will be exported through Sihanoukville port. On the other hand, some other firms stated that they will continue to use Sihanoukville port even after completion of E1 Expressway since speedy transport is not important for their products and they prefer lower transport cost of using Sihanoukville port.

Exporting products which have high time value and require speedy transport through Ho Chi Min City port will contribute to reduction in transportation cost and improvement of competitiveness of such products produced in Phnom Penh SEZ and may lead to attraction of more foreign investment in Phnom Penh SEZ or similar SEZs.

(c) Enhancement of business communication between Phnom Penh and Ho Chi Minh City

It is expected that the drastic shortening of travel time between Phnom Penh and Ho Chi Minh City completely change the manner of travel of people between the two cities. Currently, a business traveler departing Phnom Penh in the morning by car arrives in Ho Chi Minh City in the afternoon of the same day. He or she may have meeting with his/her business partner in the late afternoon of the same day or in the morning of the next day. Even if the business meeting is finished within the same day, it is difficult to come back to Phnom Penh in a same day. Thus, such business trip needs two days.

After completion of E1 Expressway, he/she can arrive in Ho Chi Minh City before noon if he/she departs Phnom Penh around 8:00 AM. If the business meeting can be finished in the early afternoon of the same day, he/she can come back to Phnom Penh in the same day. Thus it will not be necessary to stay one night in Ho Chi Minh City. This will let such business traveler feel that it is very easy to travel between the two cities, and the business communication which require face-to-face talk will be very much enhanced, leading to increased business opportunities.

Example of such change of business environment was seen when the Shinkansen started operation between Tokyo and Osaka in Japan in 1964. Before the service of Shinkansen was available, it used to take more than 8 hours to travel between Tokyo and Osaka. The business travelers at that time used to stay one night in Osaka or Tokyo when they travel between the two cities. After start of operation of Shinkansen, it became possible to go and come back in a same day, resulting in much more close business communication between the two city.

(d) Increase of tourists

As discussed in Section 2.2, many of the tourists travelling between Ho Chi Minh City and Phnom Penh are using buses. Currently it takes around 7 hours between the two cities, including the time for border-crossing process and crossing of Mekong River by the ferry. When this travel time will be shortened to 3 hours, or a half day, it will generate a new demand of tourists.

8.2 Financial Analysis and Financing Plan

The purpose of the financial analysis in this chapter is to evaluate the financial viability of Phnom Penh – Bavet Section (E1) of Phnom Penh – Ho Chi Minh City Expressway project by comparing the term for completion of loan repayment by each case.

8.2.1 Fund Source and Financing Plan

As discussed in the above, construction of an expressway needs huge amount of fund, much larger than in ordinary road projects. Several fund sources can be assumed; budget of general account of the government (tax), ODA loans, bond, loan from private banks, and PPP. The "pros and cons" of these fund sources are compared in Table 8.2-1. In comparing these fund sources, it is assumed that a new institution responsible for expressway network be established under MPWT and toll be collected on the expressways.

Table 8.2-1 Comparison of Fund Sources

Fund Source	Description	Advantage	Disadvantage	Evaluation
General Account	A part of the budget in the general account of the government	Free of interest	Shortage of fund	Not suitable
ODA Loan	Loan from multilateral and bilateral aid institution	Low interest rate Long grace period and long amortization period	There is a limit for the total amount including those for other ministries.	Most suitable
Bond	Fund raised by issuing bond (domestically or internationally)	Express Authority can issue and the government needs only guarantee.	Higher interest rate and shorter amortization period than ODA loan.	Can be used as supplementary fund source
Loan from Commercial Bank	Borrowing of mainly short-term loan from commercial banks to obtain cash needed for day-to-day operation	Cash can be obtained relatively flexibly.	High interest rate	Limited to relatively small amount of cash for day-to-day operation
PPP	Private (domestic & foreign) investors provide substantial portion of fund	Amount of fund that government needs to prepare is substantially reduced	Expressway projects tend to delayed from plan Difficult to construct low-volume sections/lines	See Section 3.4 for explanation on problems of PPP

It is recommended that ODA loans be used the main fund source for construction. It is also proposed to issue bond at the stage of amortization of the loan (debt), if the toll revenue will not be sufficient to pay the required amount of annual repayment. This is discussed in Subsection 8.2.6 below.

8.2.2 Project Schedule

For the purpose of financial analysis, overall schedule of the project is assumed as shown in Table 8.2-2, considering the project implementation schedule as described in Chapter 9.

Table 8.2-2 Project Schedule

Project Phase	Year (Period)
Construction period	2018-2022 (5 years)
Start year of operation	2023

8.2.3 Revenue Estimation

Income for this project is the toll revenue accruing from the Phnom Penh –Bavet Expressway. Based on the traffic demand forecast on the expressway as described in Chapter 6, the annual toll revenue of expressway is calculated.

8.2.4 Loan Conditions

Because the E1 Expressway project requires a large amount of initial construction cost, ODA loan, with conditions as shown in Table 8.2-3[1], is assumed to be used as the funds for construction.

Table 8.2-3 Loan Condition

Interest Rate	0.1% per annum
Amortization Period	30 years
Grace Period	10 years

In case that the toll revenue is not sufficient for annual repayment of ODA loan, refinancing will be needed. It is assumed to issue bonds to fill the gap between repayment and revenue. The interest rate of bond is set as 10% based on the hearing survey to the Association of Banks in Cambodia (see the minutes of interview to the Association of Banks in Cambodia).

Table 8.2-4 Condition of Bond

Interest Rate	10% per annum
Amortization Period	5 years

[1] A STEP (Special Terms for Economic Partners) Loan of Japan is assumed here.

Minutes of Hearing to the Association of Banks in Cambodia

Date & Time: Mon, 17 March, 2014; 9:00 - 9:30AM

Venue: Meeting room of CANADIA BANK

Attendants:

・ Association of Banks in Cambodia (ABC):
Mr. Charles Vann, President of the ABC / Executive Vice President of CANADIA BANK

・ Survey Team: Sakurai, Nakamura

Summary of Hearing:

Whether Cambodian government can issue bonds for development of the new Expressway was discussed under the following conditions:

・ For the initial construction cost, ODA loan can be used.
・ ODA loan adds almost no-interest and its grace period will be 10 year.
・ When its repayment begins, if toll revenue is still not enough, refinancing by Cambodian government such as bond issuing will be required.

(Opinions by Mr. Charles Vann)

・ If the interest rate is 10%, there will be a demand for the bonds in Cambodian finance market.
・ Because 10% seems to be too high for the government, interest rate will need to be low as much as possible with the circumstance in finance market.
・ If the condition is good enough to deal with for private sectors, they will buy.
・ We have influence in the Cambodian politics and ministries, and fully support anything about economic development including development of new Expressways.

8.2.5 Project Cost

The Project costs for this financial analysis includes the construction cost as discussed in Chapter 5 (US$ 2,226 million for Route B) and operation and maintenance cost. The operation and maintenance cost is assumed as shown in Table 8.2-5.

Table 8.2-5 Annual Operation and Maintenance Cost

Items	Cost (US$ million/year)	Remarks
Maintenance	5	Maintenance Cost for the Road Facilities, etc.
Operation	5	Operation Cost for the Toll Plaza, etc.
Overhead	2	Labor Cost, Office Management, etc.
Total Annual Cost	12	

8.2.6 Cash Flow Analysis

(1) Case- I; Base Case

Figure 8.2-1 and Table 8.2-6 show the result of cash flow projection of Route B with the assumptions shown above. In this case; ODA Loan is steadily repaid by toll revenue every year. The total debt of the loan will be amortized 35 years after opening to traffic. It should be noted that the annual toll revenues from 14th year to 21st year, after subtracting maintenance and operation costs are less than the annual amount of repayment (US$72 million). However this gap can be filled by using the accumulated revenue before the repayment starts (from 9th year to 13th year).

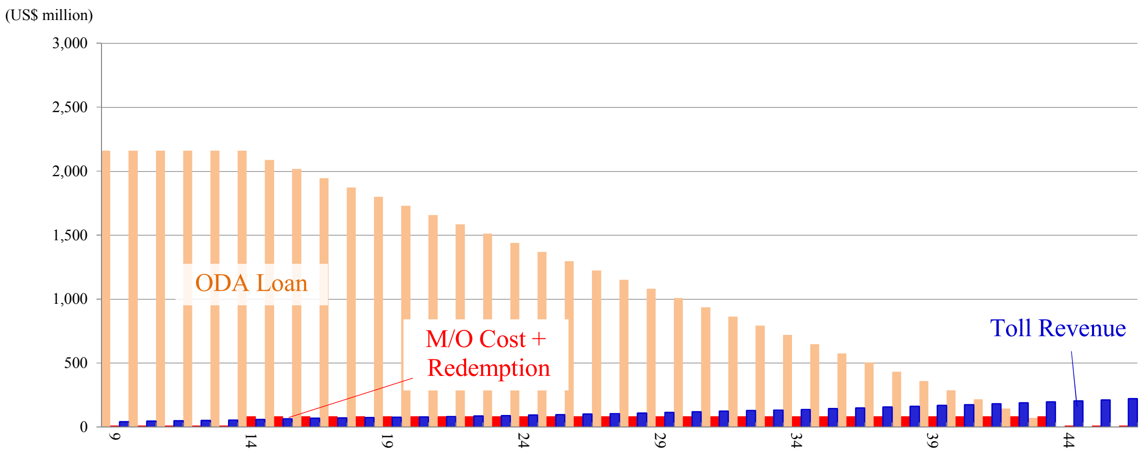


Figure 8.2-1 Cash Flow of Case-I "Base Case"

Table 8.2-6 Cash Flow of Case I

[Million-US Dollar]

Year	(−) A	(−) B	(−) C [A+B]	(+) D	(+) E	(−) F	(+) G [E−F]	(−) H	(−) I	(−) J	(−) K	(+) L
	Debt Outstanding (BOY)			Cumulative Surplus			Balance of Payment	ODA	Other Payments		New Borrowing	Net Surplus
	ODA Loan	Refinanced Loan			Toll Revenue	M/O cost		Repayment	Principal	Interest		
2022	**2,160**										0.0	
2023	2,160	0	2,160	0	43	**12**	31	0	0	0	0	31
2024	2,160	0	2,160	31	46	12	34	0	0	0	0	34
2025	2,160	0	2,160	64	49	12	37	0	0	0	0	37
2026	2,160	0	2,160	101	52	12	40	0	0	0	0	40
2027	2,160	0	2,160	141	56	12	44	0	0	0	0	44
2028	2,160	0	2,160	185	60	12	48	72	0	0	0	-24
2029	2,088	0	2,088	161	64	12	52	72	0	0	0	-20
2030	2,016	0	2,016	141	68	12	56	72	0	0	0	-16
2031	1,944	0	1,944	125	71	12	59	72	0	0	0	-13
2032	1,872	0	1,872	112	74	12	62	72	0	0	0	-10
2033	1,800	0	1,800	102	77	12	65	72	0	0	0	-7
2034	1,728	0	1,728	95	80	12	68	72	0	0	0	-4
2035	1,656	0	1,656	91	83	12	71	72	0	0	0	-1
2036	1,584	0	1,584	90	87	12	75	72	0	0	0	3
2037	1,512	0	1,512	93	90	12	78	72	0	0	0	6
2038	1,440	0	1,440	99	94	12	82	72	0	0	0	10
2039	1,368	0	1,368	109	97	12	85	72	0	0	0	13
2040	1,296	0	1,296	122	101	12	89	72	0	0	0	17
2041	1,224	0	1,224	139	105	12	93	72	0	0	0	21
2042	1,152	0	1,152	161	110	12	98	72	0	0	0	26
2043	1,080	0	1,080	186	114	12	102	72	0	0	0	30
2044	1,008	0	1,008	216	118	12	106	72	0	0	0	34
2045	936	0	936	250	123	12	111	72	0	0	0	39
2046	864	0	864	290	128	12	116	72	0	0	0	44
2047	792	0	792	334	133	12	121	72	0	0	0	49
2048	720	0	720	383	139	12	127	72	0	0	0	55
2049	648	0	648	438	144	12	132	72	0	0	0	60
2050	576	0	576	498	150	12	138	72	0	0	0	66
2051	504	0	504	564	156	12	144	72	0	0	0	72
2052	432	0	432	635	162	12	150	72	0	0	0	78
2053	360	0	360	714	169	12	157	72	0	0	0	85
2054	288	0	288	798	175	12	163	72	0	0	0	91
2055	216	0	216	890	182	12	170	72	0	0	0	98
2056	144	0	144	988	190	12	178	72	0	0	0	106
2057	72	0	72	1,094	197	12	185	72	0	0	0	113
2058	0	0	0	1,207	205	12	193	0	0	0	0	193
2059	0	0	0	1,400	213	12	201	0	0	0	0	201
2060	0	0	0	1,601	222	12	210	0	0	0	0	210
2061	0	0	0	1,811	231	12	219	0	0	0	0	219
2062	0	0	0	2,030	240	12	228	0	0	0	0	228
2063	0	0	0	2,258	250	12	238	0	0	0	0	238
2064	0	0	0	2,495	260	12	248	0	0	0	0	248
2065	0	0	0	2,743	270	12	258	0	0	0	0	258
2066	0	0	0	3,001	281	12	269	0	0	0	0	269
2067	0	0	0	3,270	292	12	280	0	0	0	0	280
2068	0	0	0	3,550	304	12	292	0	0	0	0	292
2069	0	0	0	3,841	316	12	304	0	0	0	0	304
2070	0	0	0	4,145	328	12	316	0	0	0	0	316
2071	0	0	0	4,461	342	12	330	0	0	0	0	330
2072	0	0	0	4,791	355	12	343	0	0	0	0	343
EOY	0	0	0	5,134								

As demonstrated in the above, the project of E1 Expressway becomes financially viable, or the debt can be amortized if ODA loan used as the fund source. On the other hand, the debt will continuously increase if a loan from private loan whose interest rate is much higher and the grace period is mach shorter than those of ODA loan. Figure 8.2-2 shows an example of such case. In this example, interest rate of the loan is assumed to be 6% per annum (much smaller than what is practically anticipated). Grace period is assumed to not be applied. (The loan needs borrowed in a year needs to be redeemed next year.)

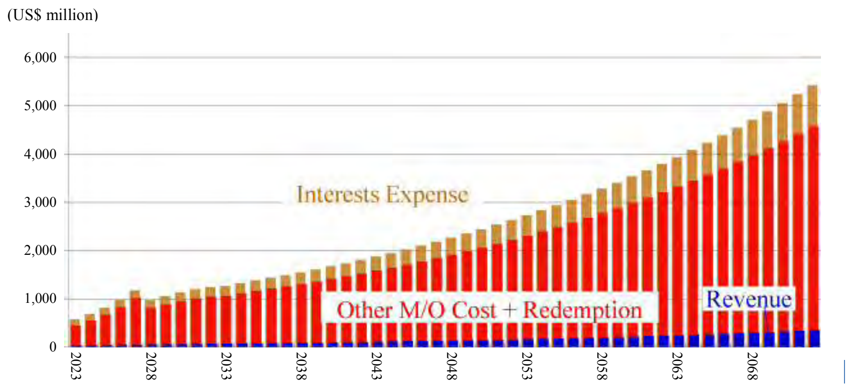


Figure 8.2-2 Debt Outstanding by Year, in Case of Private Fund is Used

Without grace period, the expressway authority needs to borrow a new loan every year to redeem the loan of the previous year plus the interest for the loan. Since the amount of the initial debt (the construction cost of the expressway) is huge, the amount interest is also huge, exceeding the annual amount of toll revenue by far. Therefore, the total amount of loan to be borrowed in a given year becomes larger than that of previous year. This is repeated every year, and the total amount of the principal and the interest will increase in geometric progression.

This example shows it is very difficult to make an expressway project financially without introducing ODA loan with generous condition.

(2) Case- II; Cost:+10%, Revenue:-10%

Major risk factors of expressway project include increase in construction cost, decrease in traffic volume which leads to toll revenue and increase in interest rate. As an unfavorable case (Case-II), increase in the construction cost by 10% and decrease in the traffic volume by 10% is calculated. Figure 8.2-3 shows the cash flow projection of Case- II.

As the result of calculation, refinanced loan (issuance of bonds) becomes necessary 11 years after the start of service of the expressway.

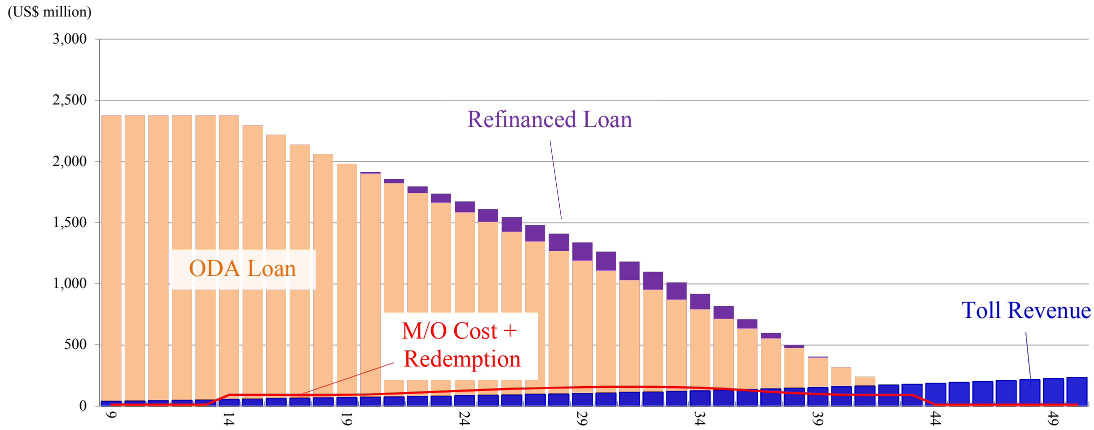


Figure 8.2-3 Cash Flow of Case-II "Cost:+10%, Revenue:-10%"

(3) Case-III; Cost:+10%, Revenue:-10% with Open in 3-Phases

In Case II, issuance of bond becomes necessary to supplement the insufficiency in the toll revenue which is not large enough to pay annual redemption. One of the measures to avoid this situation is to reduce the amount of annual redemption. This becomes possible by dividing the expressway into several sections and differentiating the construction of these sections or adoption of phased construction. By doing this, borrowing of the loan is spread over longer period resulting in distribution of repayment over longer period and reduction in annual amount of redemption.

Here it is assumed that Phnom Penh – Bavet section is divided into 3 sub-sections and Phnom Penh – Neak Loeung Sub-section is constructed first, followed by Neak Loeung – Svay Rieng Sub-section start to be constructed 2.5 years after the start of construction of Phnom Penh – Neak Loeung Sub-section. Table 8.2-7 shows the opening year, and increase of toll revenue due to opening of new section and construction cost of each section.

Table 8.2-7 Annual Toll Revenue & Construction Cost of Each Section

Section	Annual Toll Revenue (in 2023)	Construction Cost	Opening Year
Phnom Penh - Neak Loeung	US$ 19 million	US$ 911 million	2023
Neak Loeung - Svay Rieng	US$ +18 million	US$ 828 million	2025
Svay Rieng - Bavet	US$ +6 million	US$ 491 million	2028

Cash flow projection of this case is shown in Figure 8.2-4. With the phased construction, toll annual redemption is reduced and can by paid with the toll revenue without issuing bond. The amortization period remains same to that of Case I.

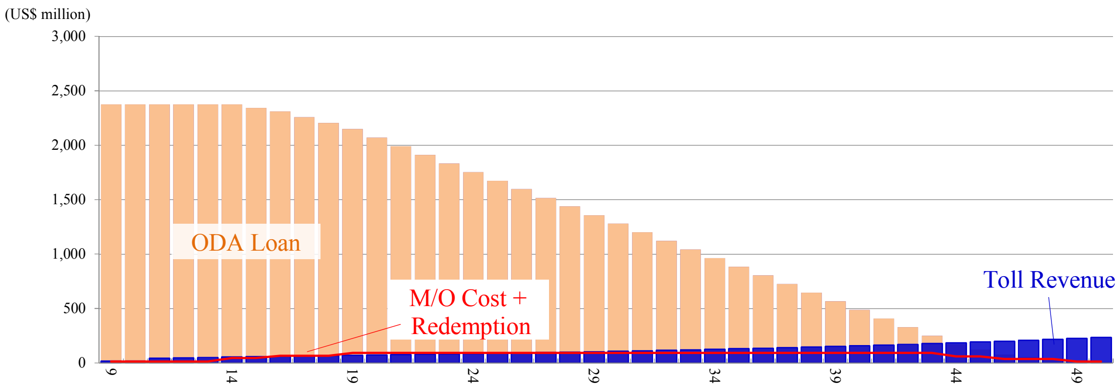


Figure 8.2-4 Cash Flow of Case-III "Cost:+10%, Revenue:-10%, 3-Phases Open"

(4) Cash Flow Analysis for Route C

Similar analysis were made for Route C. The results are shown in Appendix 8-1.

CHAPTER 9 LEGISLATIVE SYSTEM

9.1 Existing Relevant Legislations

9.1.1 Existing Laws

There are two important laws relevant to road construction and management in the Kingdom of Cambodia:

✓ Law on Land Road (Approved by the National Assembly in April 2014)

✓ Law on Road Traffic (Issued January, 2007)

Contents of these laws are summarized in the Tables 9.1-1 and 9.1-2.

Table 9.1-1 Law on Land Road

Chap. No.	Subject	Contents
1	General Provision	Definition, purposes, and scope of law
2	Road Management Authority	Ministry of Public Works and Transport (hereinafter referred to as MPWT), Ministry of Rural Government, and Sub-national Administration Entities are authorities in charge of roads in Cambodia
3	Type Name and Classification of the Road	Definition of classification of all roads in Cambodia and how to name roads are stipulated.
4	Development and Maintenance of Roads	Regulations regarding procedures of developing and maintaining roads, utilization of roadside, compliance with technical standard, and rules for private entities' attendance to road projects
5	Technical Entity and Road Infrastructure Technical Regulation	Establishment of National Institute of Road Infrastructure Development and National Department for experimentation of road sector and enactment of infrastructural technical regulations by MPWT
6	Utilization of Roads	The maximum limit of weight for transportation, utilization for cultural activities on the roads, offset distance from roadside for structures, procedures of the case of damaging roads for some business, etc.
7	Protection of Road Infrastructure	Regulations of prohibiting all activities causing damages to road infrastructure and causing obstacles to traffic safety on the roads
8	License of Road	License is necessary for doing business on road infrastructure and installing a laboratory in road sector.
9	Road Maintenance Fund	Road maintenance fund should be established for maintaining and repairing roads and its organization and function are determined by sub-decree.
10	Road Inspector	Road inspector appointed by Ministries in charge of road sector has the right to investigate research, control and enforce the implementation of law.
11	Penalty	Prescribed penalties are incurred to the persons convinced of offences under this law. Penalties such as written warning, fine, and imprisonment are regulated against various offences regarding road infrastructures.
12	Inter Provision	All regal text shall be remaining force until new law modifies it.
13	Final Provision	All other provisions which are in conflict with the provisions of this law shall be abrogated.

Table 9.1-2 Law on Road Traffic

Chap. No.	Item	Contents
1	General Provision	Application, purposes, and definition of terminology
2	Traffic Signs	Functions of various traffic signs including traffic lights and direction signs of traffic police.
3	Drivers	What the driver must comply when driving on general roads is regulated.
4	Use of Vehicle Light and Horn	Regulations regarding use of vehicle lights and horn.
5	Pedestrians and Animal Riders/Herders	What the pedestrians and animal riders/herders must comply when using roads is regulated.
6	In Case Having Traffic Accident	What all stakeholders including police of the accident site must implement at the time of the accident is speculated.
7	Vehicles Management and Transportation	Regulations relevant to all driving licenses with score card, driving school, vehicle registration, transportation business, limitation of permitted maximum weight of automobile and so forth.
8	National Committee of Road Traffic Safety	Role and budget of National Committee of Road Traffic Safety.
9	Competence of Officers Implementing the Traffic Law	Regulations of competence of officers such as removing driving license at traffic offences, filing the lawsuit to the court against driver who breaks traffic law, and examining suspicious drunk drivers.
10	The Penalty	Regulated fine and penalties against various traffic law offences including traffic police officers.
11	Inter-provision	Supplement explanations on this law
12	Final Provision	This law was adopted by National Assembly of the Kingdom of Cambodia on 20th December 2006.

Main points of these laws, in connection to this survey on expressway, are as listed below:

✓ MPWT is given authority of developing national roads including expressway with agreement of the Royal Government of Cambodia.

✓ Roads in Kingdom of Cambodia are categorized in following 6 types.

(i) Expressways

(ii) National-roads

(iii) Provincial-roads

(iv) Country side-roads

(v) Municipal-roads, city-roads, and provincial roads

(vi) Other types of roads defined by the Government

✓ The road development and maintenance funds are from following sources;

(i) National budget

(ii) International development fund (grant, loan)

(iii) Funding from private sectors

(iv) Donation

(v) Profits from investment (BOT system) and legal business on road sector (Charge for loading on large vehicle)

(vi) Fines such as traffic law violation

✓ There is no definition of motorway or expressway in the Law on Road Traffic: Therefore, there are no rules on the types of vehicles such as motorcycles and bicycles which are not allowed entering expressway.

9.1.2 Necessity of Law for Toll Road

Although there are several toll roads in Cambodia, there is no law for toll road and each toll road system and each toll road is operated with conditions stipulated in the concession contract given to each toll road. Accordingly, there is very little uniformity in such areas as toll level, level of maintenance and level of traffic condition (congestion). The following subjects need to be stipulated in the law to clarify the necessity and conditions for toll road operation.

✓ Definition of toll road and toll

✓ Conditions for allowing toll collection and toll road operation, including mandate for toll- free alternative road and toll collection period

✓ Basic principles for toll level

✓ Responsibility and authority of government on toll road

✓ Responsibility and rights of toll road operator

Expressways in Cambodia are proposed to be constructed and operated as toll roads. The toll level is anticipated to be much higher than those of the existing toll roads. Thus, clear policy and justification need to be shown in the toll road low so that toll road system is supported by the political leaders and the people of Cambodia.

9.2 Legislation Necessary for Planning, Construction and Operation of Expressway Network

9.2.1 Basic Legislations Necessary for Development of National Expressway Network

In addition to the law for toll road, the lows or other legislations as listed in Table 9.2-1 are necessary to successfully develop the national expressway network. The legislations relevant to expressway development in Japan and Vietnam are presented, as reference, in Subsections 9.2.2

and 9.2.3, respectively. In case of Vietnam, legislations similar to those listed in Table9.2-1 have been issued.

Table 9.2-1 Laws or Legislations Necessary for Development of National Expressway Network

Legislation	Main Provisions
National Expressway Law	・ Definition of National Expressway and National Expressway Network, including the planned routes. ・ Overall time schedule of implementation. ・ Responsibility and power of Government on development of national expressway network. ・ Establishment of Expressway Council, consisting of the representatives of politicians, experts, and road users etc., including its power and responsibility on planning and implementation of national expressway network. ・ Establishment of the Expressway Authority as the implementation agency.
Toll Road Law	・ Principles for setting toll level ・ Fund for construction and use of toll revenue for recovery of the construction and operation costs. ・ Introduction of toll revenue pool system (See Subsection 3.2.4)
Law for Establishment of Expressway Authority	・ Definition of Cambodian Expressway Authority. ・ Responsibility and power of Expressway Authority ・ Supervision of Expressway Authority by the government (Minster of MPWT) ・ Capital is invested from the government. ・ Capacity for procuring necessary funds, including issuing of bond, and responsibility of amortization of debt.
Revision in Road Traffic Law	・ Minimum speed on expressway. ・ Left lane is used only for overtaking. ・ Types of vehicles which are allowed to use expressway.

(1) National Expressway Law

The most important role of this law is to show the determination of the government for constructing the expressway network. By showing the strong will of the government for national expressway, the general public including the road users will make plan on how to utilize it effectively. Therefore, this law should clearly indicate the overall figure of the plan of national expressway network, including route of each line, overall schedule, responsibility of government and establishment of implementing agency.

(2) Additional Provisions for Expressway in the Toll Road Law

Toll road law is applied not only on the national expressways but also on ordinary toll roads (similar to the existing toll roads). Thus, the toll road law cannot stipulate what cannot be applied to the ordinary toll roads. Since the national expressway network is constructed and operated by the governmental organization (Expressway Authority), the procedures of setting toll level and adoption of toll revenue pool system should be stated.

(3) Law for Establishment of Expressway Authority

According to the legislative system of Cambodia, the Expressway Authority can be established with issuance of Ministerial Decree. However, promulgation of a law is preferable so that establishment of Expressway Authority (and development of the expressway network) is discussed among the ministries and in the National Assembly.

9.2.2 Legislations Relevant to Expressway in Japan as Reference

As reference, the expressway-related laws of Japan are listed below:

(1) Act on Special Measures for Road Network Development

・Promulgation ; March, 1956, Law No.7

・This law has established toll road system.

(2) Laws on Construction of Trunk Motorways for Development of Nation

・Promulgation ; April, 1966, Law No.68

・First Act was promulgated in 1957 and almost entirely amended in 1966.

・The purpose of this law: to develop arterial expressways traversing in longitudinal and crossing manner on Japanese archipelago for establishment of expressway network so that the promotion of an innovative industry and the expansion of people's living area can be promoted as universal development of the whole country.

・Main contents of this Act are as follows.

✓ Planned routes of national development arterial expressways

✓ Master plan of expressway construction routes

✓ Establishment of the expressway council

(3) National Expressway Law

・Promulgation ; April, 1957, Law No.79

・The purpose of this law: To stipulate the procedures of national expressway network

・Main contents of this law are as follows.

✓ Planned routes of national expressways

✓ Significance of national expressway and procedures of development

✓ Master plan of national expressway

✓ Management of expressway construction, maintenance and repair

(4) Japan Highway Public Corporation Law

・Promulgation ; March, 1956, Law No.6

- The purpose of this law: Japan Highway Public Corporation implements construction, reconstruction, maintenance, repair and other managements of expressways that can obtain tolls on pass and use of them and then contributes to promotion of expressway development nationwide and efficient traffic.
- JHPC is set up as a sole public corporation which can deal with construction, reconstruction, maintenance, repair and other managements of national expressway which can collect toll.
- Bond of JHPC is guaranteed by Japanese government.
- JHPC can issue road bond for new expressway construction and government accepts it.
- JHPC has to redeem all bonds based on plan of repayment approved by government.

It should be noted that all of above legislations are in conformity with each other by placing JHPC as sole governmental organization for development of the national expressway network. The law for Construction of Trunk Motorway clearly stipulates that JHPC is the implementing agency for expressway and this is supported by the law for JHPC. The "Act for Special Measures" also stipulates the principles of toll collection and toll level setting, assuming that JHPC be established and be in charge of construction, toll collection and redemption of the construction cost. This mechanism of expressway network development is schematically presented in Figure 9.2-1.

Figure 9.2-1 Relation between Expressway-Related Legislations

9.2.3 Legislations Relevant to Expressway in Vietnam as Reference

As another reference, the expressway-related laws of Vietnam are listed below:

(1) Prime Minister's Decision on Expressway Master Plan (Decision 1734/QD-TTg), 2008

Expressway Master Plan was prepared in 2007 by the Ministry of Transport (MOT) and approved by the Prime Minister in 2008. This decision defines 5,873km-long expressway network in Vietnam. The total investment for the construction of expressway network is approximately VND 766,220 million (approximately USD 50 billion).

(2) Prime Minister's Decision on Establishment of Vietnam Expressway Corporation (Decision 3003/ QD-BVGT), 2004

This decision stipulates establishment of Vietnam Expressway Corporation as a state-owned company under the Minister of Transport.

(3) Regulation on Toll Level of Improved National Highway (Minister of Finance's Decision 90/TT- BTC), 2004

This decision is to stipulate the policy on setting toll level of national highway. However, the road project under discussion of this decision is improvement, and toll level for newly constructed road is not included.

(4) Draft Regulation on Management & Operation HCM- Trung Luong (Minister's Decision 195/QD-BGTVT), 2010

Since the above regulation was not suitable for setting toll level for a newly constructed expressway, another regulation was issued in a form of "draft" so that toll of HCM – Trung .Luong Expressway. This decision was issued just before the opening of HCM – Trung .Luong Expressway in year 2010 (the first opening of expressway in Vietnam). However, the toll of this expressway had not been collected for two years. The delay in toll collection is attributed to such facts as the delay in finishing some of construction works such as fence and frontage road, delay in introduction of the toll collection facilities and equipment and delay in the setting of toll level.

Issuance of this regulation implies that there is no legislation universally applied to toll collection on roads in Vietnam.

(5) New Decree on BOT, BTO, BT Regulation including PPP scheme (Decree 108), 2010 (Issued by Prime Minister)

Old decree on BOT was promulgated in 2007. This decree did not include maintenance of facilities. Thus this new decree was issued. However, many BOT/PPP projects are delayed or facing difficulty due to lack of fund.

(6) Revision of Road Traffic Law (Law 23/2008/QH12), 2008

The old traffic law (Law 23/QH) was revised in 2008 incorporating new stipulations on the rules of traffic on expressway. It is noted that this revision was issued 2 years before the opening of the first expressway in Vietnam.

9.2.4 Legislations Relevant to Expressway in Thailand as Reference

As still another reference, the expressway-related laws of Thailand are listed below:

(i) Concession Highway Act: Law for concession of toll road

(ii) Motor Vehicle Use on Highway and Bridge Fee Specification Act: Rule for toll collection

(iii) Expressway Authority of Thailand Act: Law for establishing Expressway Authority of Thailand)

(iv) Highway Act: General policy on highway administration including expressway

(v) Land Traffic Act: Law on the rule for road traffic, including traffic on expressway

Details of these acts (laws) are not known. However, it can be assumed that these laws stipulates the necessary subjects as proposed in Subsection 9.2.1, except the expressway network plan.

CHAPTER 10 APPLICATION OF UP-TO-DATE TECHNOLOGIES

Since expressway is modern and very important infrastructure used by many people, various up-to-date technologies have recently been, and are being, introduced. Good example of such up-to-date is electronic toll collection (ETC). Some other types of information technologies are also practically used on expressway. These technologies can greatly improve the efficiency, security and dependability of toll expressway operation.

10.1 ETC

ETC is a method for collecting the toll through electronic device. The main advantages of ETC are as follows:

- ✓ It is not necessary to handle cash. Thus, possibility of accident or crime is greatly reduced.
- ✓ Time for collecting toll is greatly shortened. Thus, congestion at toll gate can be eliminated or greatly mitigated.
- ✓ Efficiency of toll collection as a whole (calculation of amount of toll to be collected, toll collection at toll gate, transferring the toll revenue to the bank, recording of toll revenue etc) is greatly improved and the cost for toll collection is reduced.

Figure 10.1-1 shows an example of ETC toll gate.

Figure 10.1-1 ETC Toll Gate

There are several types of ETC. They are divided into two large groups depending of the whether or not the toll be collected by transferring the money from the bank account of the user or once electronically transferred (charged) on a card with IC chip or magnetic memory. Further study is needed to find out which type is most suitable for the situation of Cambodia.

10.2 Information Technology (IT)

Although ETC is regarded as one of the ITs, in the sense that it uses various up-to-date technologies of data communication and data transmission, it is often discussed independently from other IT technologies used in expressway. Thus, IT, as used here, refers to technologies other than ETC. ITs used in most often in traffic management in expressway. The tasks of traffic management where IT is used are as listed below:

Table 10.2-1 Examples of IT Used in Expressway

Task	Manner of Use of IT
Traffic Surveillance	・ Closed circuit TV is used to monitor traffic condition and accident. ・ Various detectors of traffic volume and travel speed of vehicles are used to know the degree of traffic congestion.
Monitoring of Weather Condition	Weather condition is monitored to know hazardous condition.
Provision of Traffic Information	Various information of road condition, traffic condition including accident and traffic jam, and weather condition are provided to road users through various devices including traffic information boards and signs on the expressway, traffic information board installed in rest areas and highway radio.
Traffic Control	・ Data/information obtained through traffic surveillance system and weather monitoring system are sent to the traffic control room and used for actions to secure traffic safety. ・ Such actions include lowering of speed limit, warning to drivers through traffic information board and closure of expressway.

CHAPTER 11 PROPOSAL FOR FURTHER STUDY

To seek for ODA loan, more detailed study than this survey (herein after referred to as "feasibility study" or F/S) will be necessary. This chapter proposes the scope of work of such F/S. Naturally, the scope of work of the F/S will be determined after discussion between the donor and Cambodian government.

11.1 Scope of Work

The scope of work of the feasibility study is as outlined below:

(i) Selection of the route (alignment) of the expressway to be constructed

(ii) Topology survey, geotechnical survey, traffic survey and other surveys needed for design and estimation of traffic volume

(iii) Coordination with Vietnamese government on the route near the border, time schedule of construction border crossing and relevant other matters (with necessary assistance by the Cambodian side)

(iv) Preliminary design for cost estimation, including design of expressway itself, interchanges, rest areas and other appurtenant facilities

(v) Estimation of the construction cost

(vi) Estimation of traffic volume on the expressway and toll revenue

(vii) Financial analysis including proposal of toll level, cash flow analysis and proposal on funding plan

(viii) Estimation of effects of the E1 Expressway Project on socio-economic activities and macro economy

(ix) Proposals of implementation plan, including implementing schedule, maintenance operation plan, institutional plan and actions for legal framework.

(x) Survey for environmental and social consideration

11.2 Outline Terms of Reference

The main points of the terms of reference of F/S are listed below:

(1) Consultation with the Royal Government of Cambodia (RGC) on the decision of the route of E1 Expressway

The route of E1 Expressway needs to be finalized based on the consultation between the study team and RGC. In this case, RGC is represented by MPWT. MPWT is requested to have diligent consultation with the relevant political leaders and governmental institutions, including MEF and CDC, and be ready to discuss with the JICA Study Team on the selection of route of E1 Expressway in the beginning of the feasibility study.

(2) Site survey

Site conditions including locations of houses, unfavorable natural conditions such as swamp and soft ground, and existing roads along the decided route are surveyed in order to make it sure that there are not serious problems on the planned route. The route may be adjusted after topographical survey along the planned center line of the expressway if any serious problem is found on the route during the topographical survey.

(3) Temporary determination of center line

The center line of the expressway is temporarily fixed on the satellite photo and coordinates of the important points on the center line are read on the satellite photo. For this purpose, commercially sold satellite photo is purchased and used.

(4) Aerial photo

Aerial photo using para-glider (employed in the Preparatory Surveys for National Road No. 5 Improvement Project) is taken covering minimum 100m from the center line on both sides of the center line. Orthographic photo is compiled. The design of the expressway is made on this orthographic photo.

(5) Topographical survey

Topography along the center lines of the expressway and RR 3 is surveyed:

- ✓ Setting center line stakes and survey of ground height at interval of 200m
- ✓ Cross-sectional survey at interval of 1km and width of 100m on both sides from the center line
- ✓ Cross sectional survey of river bed and lake bed across Mekong River and the lake near the city of Svay Rieng; along the center line of the expressway and along the lines parallel to the centerline 50m away on the both sides of the centerline.

(6) Natural condition surveys

(a) Geotechnical survey

- ✓ Boring, sampling, standard penetration test and laboratory soil tests; for the bridge for crossing Mekong River, other bridges and viaducts
- ✓ Geotechnical survey for analysis of stability and settlement of embankment on soft ground
- ✓ The quantities of geotechnical survey items are as shown in the table below:

Table 11.2-1 Quantities of Geotechnical Survey Items

Objective	Item	Quantity	Remarks
Mekong River Bridge	Boring	70m x 5 locations = 350m	River center, both river banks, 200m from river banks
	Standard Penetration Test	1 set/meter x 350m = 350 sets	
	Physical property test	1 set/meter x 350 = 350 sets	Water content, grain size, Atterberg limits
Bridge & Viaduct	Boring	40m x 35 locations = 1,400m	1 location/2km x 69km = 35 locations
	Standard Penetration Test	1 set/meter x 1,400m = 1,380 sets	
	Physical property test	1 set/meter x 1,400 = 1,400 sets	Water content, grain size, Atterberg limits
Embankment on Soft Ground	Boring	30m x 45 locations = 1,350m	1 location/2km x 90km = 45 locations
	Standard Penetration Test	1 set/meter x 1,350m = 1.350 sets	
	Physical property test	1 set/meter x 1,350 = 1,350 sets	Water content, grain size, Atterberg limits
	Undisturbed Sampling	30 samples	6 samples x 5 locations = 30 samples
	Consolidation Test & Unconfined Compression Test	30 sets	
Total	Boring	3,100m	
	Standard Penetration Test	3,100 sets	
	Physical Property Test	3,100 sets	
	Undisturbed Sampling	30 samples	
	Consolidation Test & Unconfined Compression Test	30 sets	

(b) Hydrological survey

Impact to hydrology (flood) of Mekong River shall be analyzed.

(7) Traffic survey and traffic demand forecast

- ✓ Traffic count on NR 1 (6 locations; 24hr. = 3 locations, 16hr. = 3 locations)
- ✓ OD survey by roadside interview (3 locations; target sampling rate = 10%)
- ✓ Traffic forecast using the socio-economic framework predicted by the analysis described in (12) below. In forecasting the traffic demand on the expressway, a proper diversion model considering the resistance of the toll should be employed.

(8) Design of expressway and RR3

- ✓ Design of main body of expressway and RR3 (cross section, embankment, viaduct & bridge, culvert, over-bridge, pavement): Plan view on orthographic photo with a scale of 1:2,0000, cross section at an interval of 200m and profile with a scale of 1: 500 (vertical) and 1:5,000 (horizontal)
- ✓ Design of interchange, rest facility and border facility; design of interchanges shall consider phased construction (and opening to traffic by short section).

(9) Cost estimate

Construction cost, cost for consultant services, land acquisition cost and other costs shall be estimated based on the preliminary design as described in (8) above.

(10) Implementation plan

Execution plan of E1 Expressway and RR 3, including time schedule considering phased construction shall be prepared. Maintenance and operation plan shall also be prepared.

(11) Financial analysis and fund plan

Cash flow analysis and funding plans for various possible scenarios shall be done and optimum plan shall be recommended. This includes proposal of toll level and estimation of toll revenue.

(12) Economic analysis, prediction of future socio-economic framework and evaluation of impact on macro economy and project evaluation

In addition to the usual economic analysis for road projects (estimation of EIRR, NPV and B/C ratio), future socio-economic framework is predicted and the impact of E1 Expressway to the macro-economy of Cambodia and GMS shall be studied. The predicted future socio-economic framework shall be used in traffic forecast.

(13) Institutional plan

Plan for establishing and developing the Expressway Authority is prepared. Plan of capacity development for various functions of the Expressway Authority shall be proposed.

(14) Legal framework

Necessary legislations shall be studied and necessary actions with time schedule shall be proposed.

(15) Study for Environmental and Social Consideration

The project of E1 Expressway is supposed to be classified “Category A” stipulated in “the Guideline for Environmental and Social Considerations” of JICA. Thus, surveys for EIA and resettlement, including assistance to Cambodian government in preparing EIA report and Resettlement Action Plan (RAP) shall be provided.

11.3 Time Framework and Reports

It is anticipated to take approximately16 months from commencement to completion of F/S. The following reports shall be submitted to the steering committee and discussed:

Table 11.3-1 List of Reports

Report	Approximate Time of Submission *	Main Contents
Inception Report	1 month	Study plan and schedule, discussion on the route of the expressway
Progress Report	6 months	Route of the expressway, result of site survey, traffic survey, traffic demand forecast
Interim Report	11 months	Preliminary design of E1 Expressway and Ring Road 3
Draft Final Report	14 months	Cost estimate, financial and economic analysis, implementation plan, institution plan, legal framework, environmental and social consideration
Final Report	16 months	The results of the study, incorporating the comments to the Draft Final Reports

**Number of month from the start of the Study*

11.4 Proposed Composition of Study Team

The proposed composition of the study team is as follows:

- Team Leader/Expressway Policy
- Expressway Plan
- Traffic Survey and Traffic Demand Forecast
- Highway Design
- Bridge Plan
- Natural Condition Survey
- Hydrological Analysis
- Execution Plan and Cost Estimate
- Financial Analysis and Fund Plan
- Socio-Economic Framework and Socio-Economic Impact Analysis
- Environmental Impact Study
- Social Impact Study and Resettlement Plan

11.5 Undertaking by Cambodian Government

The Royal Government of Cambodia, represented by MPWT shall take the following actions:

- Establish a steering committee participated by the representatives of the relevant ministries including MEF, CDC, as well as JICA and the study team.
- Provision of office space for the study team

- Assistance to the study team in collecting information and conducting the various surveys
- Assistance to the study team in visiting the relevant institutions and discuss the matters relevant to the study.
- Assistance to the study team for coordinating with Vietnamese government.

CHAPTER 12 RECORD OF SEMINAR

A seminar was held on 28 April 2014 to disseminate the result of this survey and raise the awareness of the stakeholders on the necessity of expressway network in Cambodia. The seminar was co-hosted by JICA Cambodia Office and MPWT. The seminar was planned and prepared with Mr Takashi Shimada, JICA Transport Policy Advisor for MPWT as the central figure.

12.1 Outline of the Seminar

(i) Date and Time: 9:00 – 16:30, Monday, 28 April 2014

(ii) Venue: Raffles Hotel Le Royal, Phnom Penh

(iii) Agenda: As shown in the table below:

Time	Agenda	Person	Position
08:30 – 09:00	Registration		
09:00 – 09:30	Opening Session		
	Opening Remarks	Mr. Hiroshi Izaki	Chief Representative, JICA Cambodia Office
	Opening Remarks	H.E. Tram Iv Tek	Minister of MPWT
	Photo Session		
09:30 – 10:00	Coffee Break		
10:00 – 11:30	Key Note Presentation		
	Background of Expressway Study	Mr. Takashi Shimada	JICA Transport Policy Advisor for MPWT
	Financial Support of Cambodian Banks and Expressway Development	Mr. Charles Vann	Vice Chairman of Association of Bank in Cambodia
	Expressway Network Development in Vietnam	Mr. Nguyen Ngoc Thuyen	Deputy Director General, ICD, MOT, Vietnam
	Current Situation of Expressway and Logistics Infrastructure in HCMC	Mr. Masatomo Toyoda	Senior Project Formation Advisor, JICA Liaison Office in HCMC
	Ground Design of Expressway in Cambodia and Priority Project	Mr. Shunji Hata	JICA Expressway Study Team
	Financial, Institutional and Leagal Issues for Expressway Development	Mr. Tatsuyuki Sakurai	Leader of JICA Expressway Study Team
11:30– 12:00	Presentation of Stakeholders		
	Long Distance Track Transportation and Expressway Development	Mr. Sok Chhenang	Executive Director of CAMTA
12:00 – 13:30	Lunch Break		
13:30 – 15:30	Q & A Session and Open Panel	Panel Member H.E Tauch Chankosal, Secretary of State, MPWT	

Time	Agenda	Person	Position
		Mr. Nguyen Ngoc Thuyen, Deputy Director General, ICD, MOT, Vietnam Mr. Sok Chhenang, Executive Director of CAMTA Mr. Tatsuyuki Sakurai, Leader of JICA Expressway Study Team Mr. Shunji Hata, JICA Expressway Study Team	
15:30 – 16:00	Coffee Break		
16:00 – 16:30	Closing Session		
	Wrap Up	Mr. Masahiko Egami	Representative, JICA Cambodia Office
	Closing Remarks	H.E Tauch Chankosal	Secretary of State, MPWT

A leaflet explaining the importance of E1 Expressway project was prepared and distributed as the basic material of the seminar. This leaflet is shown in Appendix 12-1. The contents of presentations (Powerpoint) are attached as Appendix 12-2 to Appendix 12-5.

12.2 Record of Discussion

Record of Discussion is attached in the following pages:

12.3 Photos

Photos of the seminar are shown below:

Opening Remarks by H.E. Minister of MPWT

Panel Session

Record of Discussion

1. **Opening Remarks by Mr. Izaki, Chief Representative, JICA Cambodia Office**
   - JICA has been supporting development of the Southern Economic Corridor.
   - Neak Loeung Bridge on National Road No. 1 will open next year.
   - National Road No. 5 will be widened to 4 lanes by 2020.
   - Timely completion of those projects strengthen connectivity with neighboring countries.
   - However, development of expressway network is one of the most important issues for Cambodia to maintain competitiveness and sustain economic growth.
   - JICA has been focusing on Phnom Penh – Ho Chi Minh City expressway.
   - JICA and Japan are the best partners to realize this pfoject.

2. **Opening Remarks by H. E. Tram Iv Tek, the Minister of MPWT**
   - Road network of Cambodia has been very much improved in the last 15 years.
   - Still there are many sections to be improved.
   - On the other hand, we have to start construction of expressway network to support the economic growth of Cambodia since GDP per capita of Cambodia is now USD 1,000.
   - Expressway network will enhance the cooperation with the ASEAN countries, especially Thailand and Vietnam.
   - The Southern Corridor is the most important corridor of GMS.
   - Phnom Penh to Ho Chi Minh City is 250km and it will take only 2hours and half if connected by an expressway.
   - Expressway network is important not only for industry and economic growth.
   - Market of agricultural products will be expanded.
   - Expressway is more efficient and safe than ordinary roads.
   - I have submitted a letter to the Prime Minister to approve that MPWT further proceed this project with assistance of Japan.

3. **Presentation by Mr. Shimada, JICA Transport Policy Advisor for MPWT**
   - Importance of geographical consideration in transport planning
   - Overview of logistics movement in ASEAN
   - Cambodia is situated at the center of Thailand and Vietnam.
   - Assistance by JICA in transport sector of Cambodia
   - Necessity of expressway in Cambodia and E1 Expressway to accelerate the economic growth.
   - Travel time between PP and HCM will be 2.5 hours when expressway will be completed.
   - Expressway will push up economic growth and satisfies people's new requirements

4. **Presentation by Mr. Charles Van, Vice Chairman of Association of Bank in**

Cambodia

- Connectivity among ASEAN countries need to be strengthened.
- Importance of expressway in attracting foreign investment and economic growth of Cambodia
- Role of commercial banks in development of expressway network: buying the bonds issued by the expressway authority, supply funds for private firms who will open expressway-related businesses (restaurant and gas station), supplying fund to truck and bus companies for purchasing new vehicles

5. **Presentation by Mr. Sok Chheang**, Executive Director of **Cambodia Trucking Association**

[Explanation on Cambodia Trucking Association (CAMTA)]

- Number of member = 20, Vessel owned by the members = 1,500 units, 9 dry ports, 10ncontainer depots etc
- Services provided by the members are trucking services, truck rental, dry port, cargo consolidation, container yard etc.

[Truck service between PNH and HCMC]

- Export cargo (garment), few import cargo (raw material, fruits etc), return with empty container, custom clearance service
- PP – SHV takes 4 – 6 hours; $ 180 for export and $ 230 for import (include toll)
- PP – Bavet takes 3 – 4 hours; $ 200 (include toll and others)
- PP –Bavet –HCMC takes 6 – 8 hours; $520 (include ferry charge and others)

[Problems]

- Problems are; narrow roads, poor condition (pavement), waiting time at Neak Loeung Ferry, scan of imported cargo container at border point
- Traffic congestion in Vietnam
- Ban of day time travel of trucks through Phnom Penh.

[Contribution of expressway to international truck services]

- Time saving, fuel saving, stable speed, lower truck fare and better connection with international truck

[Challenging Issues]

- Narrow road and traffic congestion, undisciplined driving behavior
- Ban of truck traffic through PP city during day time.
- Unofficial/unregistered transportation business

6. **Presentation by Mr. Nguyen Ngoc Thuyen**, Deputy Director General, International Cooperation Department, **MOT of Vietnam**

[Necessity of expressway plan]

- Promote socio-economic growth, improve people’s life, strengthen friendship between

neighboring countries
- Facilitate regional integration
- Improve production efficiency

[Vietnam – Cambodia border gates]
- 10 international border gates

[Expressway projects around Ho Chi Minh City]
- Ben Luc – Long Thanh Expressway: 57.8km, $1,607 mil., co-financed by ADB, JICA and VET Gvt.
- Ho Chi Minh – Long Thanh –Dau Giay Expressway: 55km, $997.66 mil., co-financed by ADB, JICA and VET Gvt.
- Bien Hoa – Vung Tau Expressway: 77.8km, $1.3 bil. BOT scheme
- Da Nang – Quang Ngai Expressway: 139.5km, $1,472 mil., co-financed by WB, JICA and VET Gvt.

[Coordination of expressway in Cambodia and expressway in Vietnam]
- Vietnam started construction of expressway when GDP/capita was USD 1,000.
- Improvement of connectivity between PP and HCM is important.
- If PP is connected to HCM by expressway, Cambodia can export the products through the port of HCM City
- Vietnam will start construction of expressway from HCM to Bavet to be in time for completion of PP – Bavet expressway.

7. **Presentation by Mr. Toyoda**, Senior Project Formation Advisor, **JICA Liaison Office in Ho Chi Minh City**
- Road network around Ho Chi Minh City: Ring Road No. 3, Ben Luc Long – Thanh etc
- Toll = USD 2 / 20km
- Grand vision is necessary for effective implementation.
- JICA provides various technical support such as IT.
- Regional transport master plan is necessary.
- Combination of the expressway in Cambodian side and NH22 and RR3 in Vietnam is important.
- Organization and financial plan is indispensable for proper development of expressway network.
- Logistic issues (transportation cost, port management etc) need to be addressed.

8. **Presentation by Mr. Hata, Expressway Survey Team**

[Ground design of expressway in Cambodia Plan]
- Explanation of the brief history of the survey conducted by JICA in 2013 and 2014
- Proposed expressway network in Cambodia

- Evaluation of priority of each line of expressway network
- Proposed priority project of E1 expressway

[Plan of E1 Expressway]

- Explanation of flow chart of expressway route selection
- Comparison of 4 alternative routes and proposal of 2 candidate routes of E1
- Evaluation of 3 materials for high embankment
- Comparison of three alternative structures : high embankment, low embankment and viaduct
- Layout of interchanges and rest areas, Explanation of flood in 2000
- Proposed 2 routes with suitable structures
- Cost estimation

9. Presentation by Mr. Sakurai, Expressway Survey Team

[Financial analysis]

- “Full-scale toll road system” where the construction cost is covered with the toll revenue should be introduced.
- ODA loan with grace period of 10 years and amortization period of 20 years is assumed.
- Construction cost is estimated at USD 2,230 million.
- Annual toll revenue is estimated to be USD 40 million in the year of opening and will grow to USD 100 million.
- Annual amount of redemption is estimated at USD 75 million which starts to be paid 5 years after opening.
- The loan is calculated to be amortized 35 years after opening to traffic.
- PPP is not suitable for construction of expressway network because the government has to wait until the investor is interested and decide investment.
- Thus, construction of important section is often delayed.
- The government should construct the sections which yield profit and use this profit for constructing non-profitable sections.

[Organization for expressway]

- Expressway projects need high level of engineering, high capacity for project implementation, new idea and high commitment.
- Thus, a new institution exclusively responsible for construction and maintenance of expressway network should be established.

[Implementation schedule]

- If the feasibility will be started late 2014 – early 2015, start of construction works will be 2020.
- It is proposed to construct Phnom Penh – Bavet section in 3 phases; PP – Neak Loeung, Neak Loeung – Svay Rieng, Svay Rieng – Bavet.

- This will reduce the annual amount of redemption.
- The opening of PP – Neak Loeung Section will be year 2023 and opening of the whole section will be 2028.
- Traffic volume between Neak Loeung and Bavet in 2023 is estimated at 25,000 pcu which can be accommodated by the existing NR 1.
- It is assumed that Neak Loeung – Bavet section will be improved with financial assistance of some donor before start of construction of E1 Expressway.

[Legal framework]

- The following legislations need to be promulgated
  - ✓ Law for construction of expressway network
  - ✓ Law for toll road
  - ✓ Law/decree for establishing expressway authority
  - ✓ Revision of Road Traffic Law (minimum speed on expressway, regulation on type of vehicles which can travel expressway, etc)

10. **Question & Answer, and Discussion**

✧ (Name & position of questioner unknown)

- ✓ (To Mr. Thuyen) Please explain the experience of Vietnam in Expressway.

✧ Mr. Thuyen

- ✓ Construction cost of expressway is huge. For example, it was shocking to know the construction cost of Lao Cai – Hanoi was USD 1.2 billion. Constructing section by section is important.
- ✓ Expressway construction and operation need training in various areas.
- ✓ Traffic grows much faster than expected. So, construction of expressway needs to be started early enough.

✧ Mr. Choy of Korean Expressway Corporation

- ✓ The cost of E1 Expressway is huge (USD 2.2 billion). Repayment of the loan by the government may be difficult. What is your proposal on this aspect.
- ✓ It is proposed to issue bond. How is the bond used?

✧ Sakurai

- ✓ The loan will be repaid by the expressway authority using the toll revenue. The government will not repay the loan.
- ✓ If the toll revenue is not sufficient to repay the loan, bond will be issued to supplement the shortfall of the revenue. Thus, the government is basically not responsible for repayment of the loan.

✧ Mr. Yu Darah, Road Infrastructure Department, MPWT

- ✓ How much will be the operation cost?

- ✓ Overloading and pollution are big problems. What is the policy of CAMTA on this issue?

✧ Mr. Chhean, CAMTA

- ✓ Rule of CAMTA is that the member companies comply the law and the member companies observe the rule. But this result in increase in transport cost.
- ✓ Exhaust gas of old trucks is the problem. The government should encourage trucking companies to use new trucks.

✧ Mr. Choy, Korean Expressway Corporation

- ✓ There are two types of toll collection; open system and closed system. Which one do you propose?
- ✓ Considering huge amount of investment (USD 2.2 billion) and traffic volume (25,000 pcu/day) which can be accommodated by 2-lane highway, is it not possible to initially construct 2-lane and widen to 4-laen later as the traffic volume increase in future?

✧ Mr. Sakurai

- ✓ Closed toll collection system is suitable for inter-city toll road while open system is used in urban toll road. E1 Expressway is inter-city expressway and closed system is proposed.
- ✓ The largest disadvantage of 2-lane expressway is that overtaking is not possible. This causes many problems. In addition, the traffic volume on E1 Expressway is estimated to increase rapidly. Thus, construction of 4-lane from the beginning is recommended.

✧ Mr Kay, Ministry of Water Resources

- ✓ Extensive resettlement will be necessary. How is the magnitude of resettlement?

✧ Mr. Hata

- ✓ According to the survey on the satellite map, number of houses to be relocated is 25 per km.

✧ Official of Directorate General of Transport, MPWT (Name unknown)

- ✓ Will there be no competition between land (road) transport and inland waterway transport?

✧ Sakurai

- ✓ Type of cargo to be transported by expressway and inland waterway is different. High added value commodities such as IT parts will be transported through expressway while bulk low-value commodities such as rice will be transported by inland waterways. Thus, there will be little completion between the two.

11. Wrap up by Mr. Egami, Representative, JICA Cambodia Office

- Mr. Izaki, Chief Representative of JICA Cambodia office stated that JICA has been working with MPWT to improve the Southern Economic Corridor and is ready for considering implementation of full-scale feasibility study of E1 Expressway, if Cambodian government requests.

- HE Minister of MPWT stated that MPWT understands the necessity of expressway network and he has sent a letter to the Prime Minister seeking approval to move this project forward.
- Mr. Charles Van, Association of Bank in Cambodia drew attention to preparedness for ASEAN integration and importance of reliable transportation infrastructure to compete n ASEAN Community. He gave positive comments of on the expressway plan which will attract foreign direct investment.
- Mr. Shimada, JICA Transport Policy Advisor for MPWT explained the importance of geographical thinking considering the ASEAN integration. He emphasized that strengthening connectivity with neighboring countries by high quality infrastructure is essential. He stated that Phnom Penh – Ho Chi Minh City Expressway is will promote the growth of Cambodian economy.
- Mr. Sok of CAMTA described the current situation of truck operation between Phnom Penh and Ho Chi Minh City. He stated strong expectation for the expressway development.
- Mr. Thuyen, Deputy Director General, ICD, MOT, Vietnam presented practices of expressway development in Vietnam. He explained that development of expressway network in Vietnam started 12 years ago when GDP/capita was USD 1,000. He explained that he observed rapid increase of traffic volume after opening of expressway. He emphasized importance of expressway between Phnom Penh and Ho Chi Minh City, and explained that the governments of Cambodia and Vietnam will continue cooperation to strengthen the communication between the two countries.
- Mr. Toyoda of JICA Office in HCMC illustrated the current road network development in and around HCMC with huge financial assistance from JICA, ADB and the World Bank and expressed his expectation on the similarly dynamic road network in Phnom Penh and Cambodia.
- Mr. Hata, JICA Expressway Study Team showed the comparison of alternative routes of E1 Expressway. He explained that selection of the route needs to take into consideration political viewpoints and social development strategy, and thus, there is room for decision of route by further comprehensive discussions by Cambodian side.
- Mr. Sakurai, Team Leader, JICA Study Team explained how to realize the project from the viewpoint of funding issue, institutional establishment and enactment of relevant laws. Given the estimated huge investment cost, he focused on the financial analysis. The keys are; (i) full-scale toll road system, (ii) Yen loan with very low interest rate and long grace period, and (iii) phased construction plan to avoid concentration of investment in a short period. He also explained that PPP scheme is not recommended.
- In the Q & A Session and Open Panel chaired by HE Tauch Chankosal, Secretary of

State, MPWT, most of the questions were about funding issue. Technical topics varied from toll collection, overload control, number of lanes, traffic volume prediction and necessity of reliable vehicle registration system. Expressway is a good project for Cambodia, not only because of its big impact on the economy of Cambodia but also it provides good opportunity for the government officials to learn lot of new things. It is expected that the expressway project can be a trigger to upgrade the hardware but also upgrade the social system and engineering level.

- As a conclusion, JICA is ready for considering implementation of full-scale feasibility study as the next step, as Mr. Izaki mentioned. JICA is the best partner to work on this project.

12. Closing remarks by HE Tauch Chankosal, Secretary of State, MPWT

- The corridor connecting Bangkok – Phnom Penh – Ho Chi Minh City is the most important corridor of ASEAN.
- National Road No. 5 connecting Phnom Penh and Poipet will be widened to 4-lane by 2020.
- On the other hand, the width of National Road No. 1 is 10m and it is difficult to widen NR 1 because the roadside land is highly developed. Therefore, construction of a new road between Phnom Penh and Bavet is necessary.
- Cambodia needs to start construction of the expressway network to support the development of economic and social activities of Cambodia.
- E1 Expressway is the most important expressway in the expressway network of Cambodia.
- There are many problems to be overcome in order to realize E1 Expressway.
- Today's seminar showed the road map to realize E1 expressway.
- I would like to thank JICA to hold this seminar and request continuous support for realizing E1 Expressway.