SOCIALIST REPUBLIC OF VIETNAM
PEOPLE'S COMMITTEE OF HAI PHONG CITY

SOCIALIST REPUBLIC OF VIETNAM PREPARATORY SURVEY ON HAI PHONG ARTERIAL ROAD CONSTRUCTION PROJECT

FINAL REPORT

December 2016

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

CHODAI CO., LTD.
ORIENTAL CONSULTANTS GLOBAL CO., LTD.
ALMEC VPI CO., LTD.

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Summary

1. Background of the Survey

The Vietnamese government (GOV) has prepared the "Socio-Economic Development Plan: SEDP 2011-2015" for rapid and sustainable development of the country. According to the plan, GOV has put high priority on the development of Hai Phong City. Hai Phong City also has a development plan for Lach Huyen port which is an international port on the growth axis in northern Vietnam expected to be opened in 2017.

Based on the "Amendment of Hai Phong Construction Master Plan to 2025 and Vision to 2050, September 2009", Hai Phong City plans to redevelop the existing city area and develop new residential areas and industrial complexes on the north side of the Cam River. Due to the large scale of the development plans, severe traffic congestion in the city is expected to increase in the near future. There are currently two bridges crossing the Cam River, however it is predicted that the bridges do not have enough capacity to cope with increasing future traffic. Improvement of the ring road and construction of new facilities to cross Cam River are possible solutions to this issue.

The Ministry of Economy, Trade and Industry of Japan carried out the Preliminary Feasibility Study on the Hai Phong Arterial Road Construction Project in Hai Phong City, Vietnam (hereinafter referred to as "the Project"), and submitted the report to the Hai Phong People's Committee (HPPC) in February 2014. HPPC examined the report and consulted with Vietnamese ODA agencies to apply for Preparatory Survey assistance to Japan International Cooperation Agency (JICA) to be loaned to the Project. Based on discussions between the JICA mission and HPPC, JICA decided to dispatch a Preparatory Survey Team to carry out a survey for the Hai Phong Arterial Road Construction Project with Japanese ODA funds.

2. Summary of the Survey and Contents of the Project

The project includes the study of structural design, economic analysis of the Project, study of a management body for the maintenance of the project, Environmental Impact Assessment (EIA) and a Resettlement Action Plan (RAP). The Study Team commenced the Survey in March 2015 and completed it in February 2016. Furthermore, the final report which is adjusted for preceding Nguyen Trai bridge construction project, independently of Vu Yen Bridge and Ring Road 3 was completed in December 2016.

(1) Selection of Route

The three projects shall be coordinated with the Master Plan for the Urban Development of Hai Phong City. The alignment of the bridge approach roads and Ring Road 3 is planned to minimize the number of houses to be resettled along the road.

Vietnamese design standards and highway design standards are adopted in this project, and a 4-lane carriageway and two motorbike lanes with an 80km design speed is recommended for both crossings.

(2) Relative project

Several other projects are in progress that influence the projects in this study. The connection and impact on the project is considered in the project and shall be planned in detail at the detailed design stage.

- Road Transport Master Plan for Hai Phong City up to 2020, Vision for 2030
- Hanoi-Hai Phong Expressway (under construction)
- Ninh Binh-Hai Phong-Quang Nihn Expressway (under construction as a BOT scheme)
- Dinh Vu-Cat Hai Economic Zone Road Master Plan (under construction)
- Vietnam Singapore Township Industrial and Service Park (VSIP) Hai Phong (under construction)
- Vu Yen Island Development Project (under construction)
- New Urban Area Development Project, Hoang Van Thu Project (planned)

(3) Objectives of the Project

Based on the development plan for Hai Phong Port and recommendation from the maritime administration of Hai Phong, the navigation clearance is 25m for Nguyen Trai Bridge and 47.77m for Vu Yen Bridge. An arch bridge is recommended for Nguyen Trai Bridge and a cable-stayed bridge for Vu Yen Bridge. The Project comprises of the following components:

(1) Nguyen Trai Bridge Construction

Nguyen Trai Bridge, a balanced arch bridge, which connects the current administrative center on the south side of the Cam River and the planned administrative center on the northern side of the river in Hai Phong City.

- Number of lane: 4 lanes, each 3.75m wide.
- Span arrangement: Arch bridge, L = 92 + 280 + 92 = 464 m.
- Approach bridge (north and south): Super T girder, Steel Box Girder
- Nguyen Trai South Interchange (ramp bridge) : Hollow slab girder

(2) Vu Yen Bridge Construction

Vu Yen Bridge, a cable-stayed bridge, which connects connect Vu Yen Island and the Dinh Vu - Cat Hai Economic Zone.

- Number of lane: 4 lanes, each 3.75m wide.
- Span arrangement: Cable stayed bridge, L = 40 + 159 + 340 + 159 + 40 = 738 m.
- Approach bridge (north and south): Super T girder
- Vu Yen South Interchange (ramp bridge): Hollow slab girder

(3) Ring Road Construction

Hai Phong Ring Road No. 3 consisting of four overpass bridges and five interchanges is to connect Vu Yen Bridge to National Highway No. 10.

- Overpass bridge No.1, 2 and 3: Super T girder
- Ruot Lon Bridge: PC Box girder

- No. 1, 2, and 3 Interchanges, and Vu Yen Island Interchange

Executing Agency: Management Unit of Urban Development Construction (MU of UDC)

(4) Social Impact

It is estimated that total number of 291 house structures and/or other properties such as gate and fence, are to be affected (among them 258 may be physically relocated) and land area of 1,102,043 m^2 (approximately 110 ha) are to be acquired by the Project. The number of affected houses and the area of acquired land are likely to change due to further design of civil works.

A total number of 1,862 households and 7 organizations with 6,184 people could be affected in any way by the project. Among the number, it is estimated that 779 households (HHs) will be affected by the project with their loss of more than 30% of agricultural land under the impact of land acquisition.

3 Implementation Period and Cost Estimation

The total cost for construction is estimated at 11,026 billion Vietnamese dong (VND), with a breakdown of 3,243 billion VND for Nguyen Trai Bridge, 4,836 billion VND for Vu Yen Bridge and 2,947 billion VND for Ring Road 3. The compensation and resettlement implementation cost of the project is estimated at 1,896 billion VND. This cost does not include the relocation cost of Hai Phong Port and Hai An Port.

The preparatory period including the approval of the EIA, detailed design of the project, tender preparation, and selection of the contractor is expected to be 42 months. The construction periods for Nguyen Trai Bridge, Vu Yen Bridge and Ring Road 3 are expected to be 34 months, 42 months and 42 months, respectively.

4 Economic Evaluation

The results of the economic evaluation are summarized in the table below. The proposed projects are highly feasible economically. Particularly, the Nguyen Trai Bridge project shows remarkably high economic performance.

Vu Yen Bridge and Ring Road 3 are considered as one project for the financial analysis because the projects are indivisible. The EIRR of the project is 20.5% and the sensitivity analysis is 14.2% on the same assumption as for Nguyen Trai Bridge. Although this value is not high compared to Nguyen Trai Bridge, it is still high enough for implementing the project for the development of Hai Phong City.

Table 4-1 Results of the Economic Evaluation

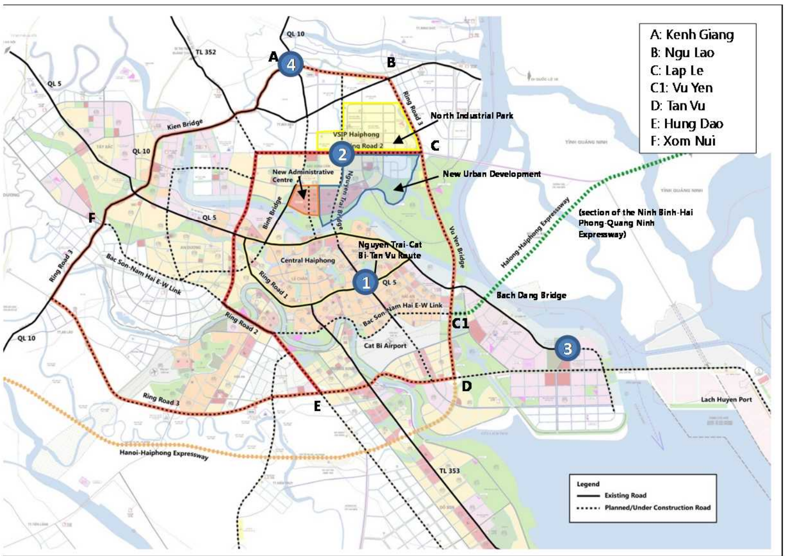
Project	EIRR (%)	BCR (at 12% p.a.)	NPV (JPY million at 12% p.a.)
Nguyen Trai Bridge	34.6	5.1	52.9
Vu Yen Bridge + Ring Road 3	20.5	2.1	31.7
Nguyen Trai Bridge + Vu Yen Bridge + Ring Road 3	17.0	1.6	24.8

5 Quantitative Indicators of Effectiveness

Quantitative indicators of effectiveness are shown in Table 5-1. Travel time between center of Hai Phong and VSIP is expected to reduce from 25.7 minutes in 2015 to 13.7 minutes in 2025 by Nguyen Trai Bridge, and travel time between Dinh Vu Industrial estate and Kenh Giang is expected to reduce from 40.9 minutes in 2015 to 32.8 minutes in 2025 by Vu Yen Bridge.

Table 5-1 Quantitative Indicators (operation and effectiveness)

	Indicator	Target	Base Year (2015, actual)	Target (tentative 2025 – after two years of completion)
1	Average Annual daily Traffic (PCUs/day)	Nguyen Trai Bridge	N.A. (not existing)	26,219
		Vu Yen Bridge		25,690
		North section of RR3		9,896
2	Travel Time (minutes) – Nguyen Trai Bridge	Between Center of Hai Phong (Intersection of NH5 and Le Phong Hong) and VSIP * see Map below (①～②)	25.7 (via Bing Bridge)	13.7
	Travel Time (minutes) – Vu Yen Bridge and RR3	Between Dinh Vu Industrial Estate and Kenh Giang (Intersection of NH10 and Provincial Road 359C) *see Map below (③～④)	40.9 (via Bing Bridge)	32.8
3	VOC Saving (000VND/day, economic)	Entire Hai phong Metropolis	N.A. (not existing)	75,885
4	Promotion of Urban Development in the Vicinity	Population of Thuy Nguyen District	318,387 (2013)	456,000 (2020)
		Population of New Urbanized Area	16,298 (2013)	150,000 (2020)
		No. of Workers of the New Administration Center	N.A. (not existing)	5,000 (2020)



6 Recommendations

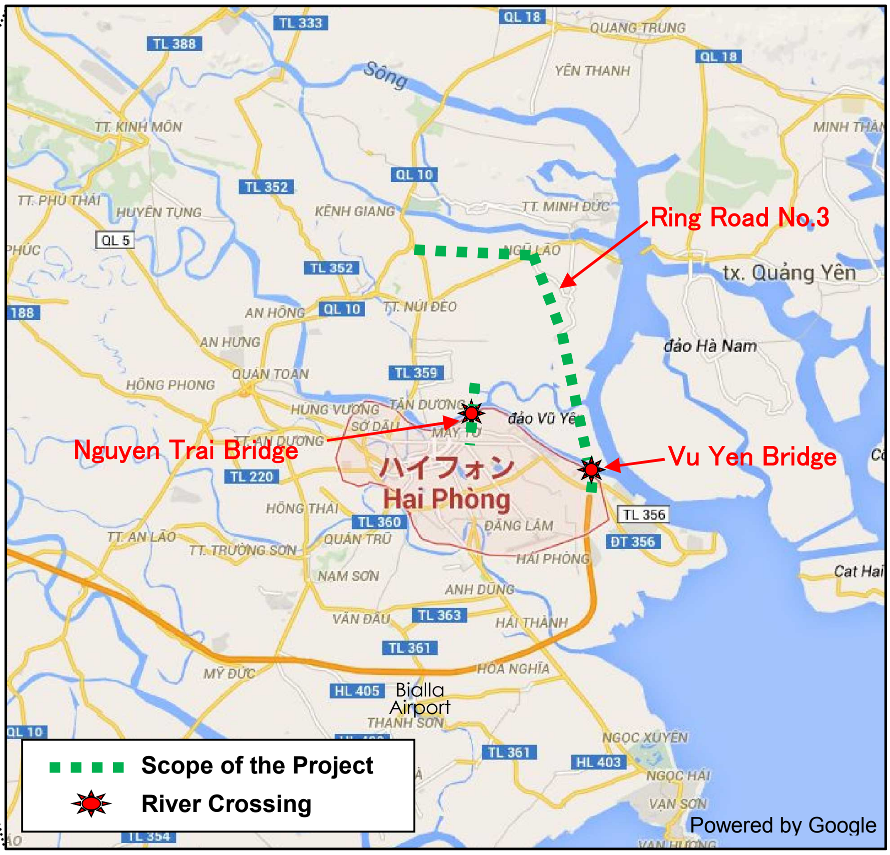
1) Traffic on Kien Bridge has already reached the capacity of the bridge and Binh Bridge is also expected to reach full capacity in 2018. Therefore, it is recommended that Nguyen Trai Bridge should be opened for traffic in 2022. Considering the time schedule for bridge construction, the project shall be started as soon as possible.

2) Construction of Vu Yen Bridge and Ring Road 3 is also recommended to be started almost with the same timing as Nguyen Trai Bridge, because even if Nguyen Trai Bridge is constructed on schedule, the traffic on the bridge will exceed capacity soon after opening.

3) Development plans for a resort area on Vu Yen Island are in progress by the VIN group. The interchange connecting Vu Yen Bridge and the road planned by the VIN group shall be planned in detail at the detailed design stage.

4) Mangrove forests are one of the most precious environmental assets of Hai Phong City that need to be conserved. Reforestation of a mangrove forest area of about 18,000m^2 should be planned in detail in the next stages of the Project as the compensated forest for the mangrove forest lost by the Project.

PROJECT LOCATION MAP



Basic data of

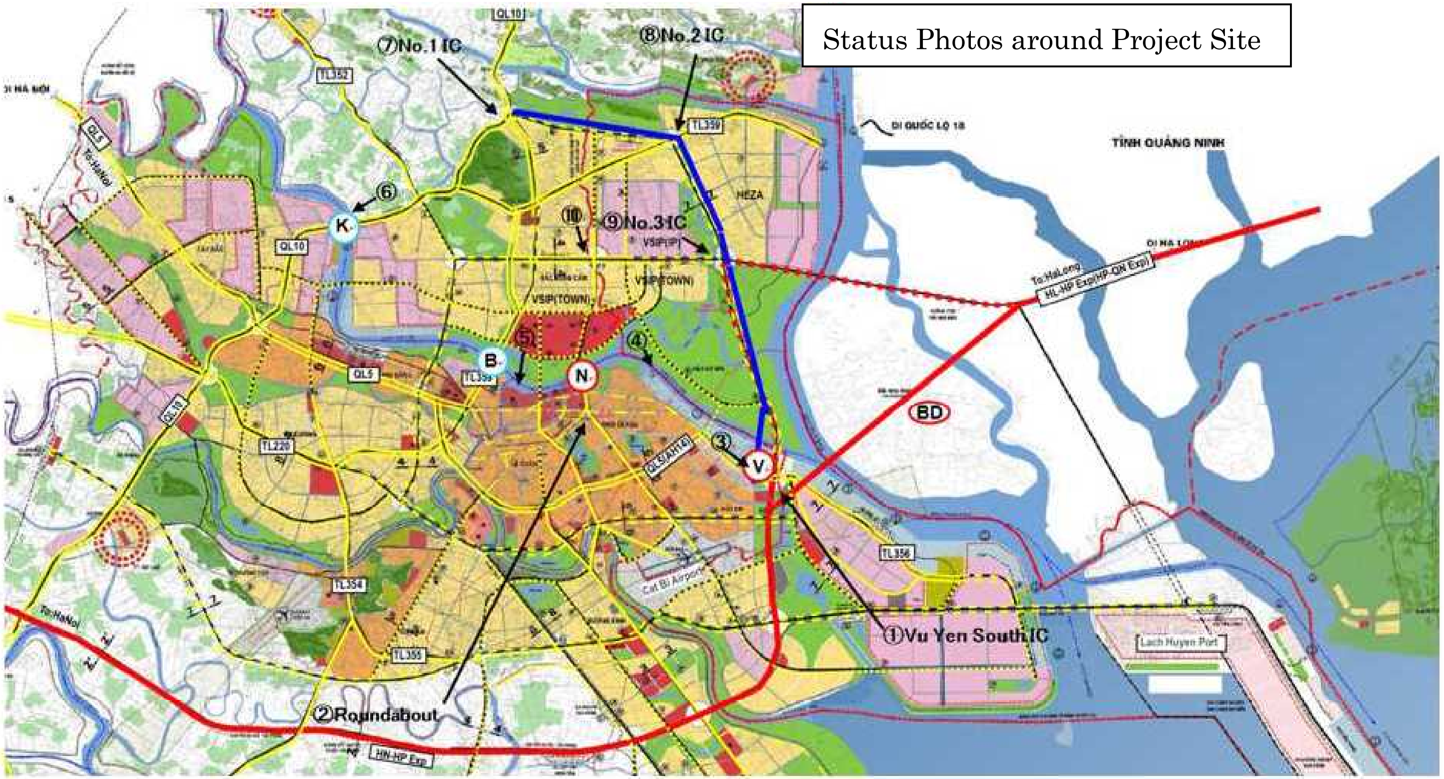
(November, 2015 Source; Home page of Ministry of Foreign Affairs)

■Area	329,241km²
■Population	92.5 million (2013: The United Nation Estimates)
■Capital	Hanoi
■People	Kinh people (Vietnamese people) about 86% and 53 minority group
■Language	Vietnamese
■Religion	Buddhism, Catholic, Caodaism, others.
■Major Industry	Agriculture, forestry and fisheries, mining, light industry
■GDP	188 billion USD (2014, IMF)
■Economic Grows	6.0% (2014)
■Inflation Rate	4.0% (2014, annual average)
■Currency	1VND=0.0055JPY (Nov.2015)

■ODA Performance of GOJ (2013, ODA)

(1) Loaned fund cooperation	201.985	Billion JPY
(2) Grant aid	0.824	Billion JPY
(3) Technical cooperation	8.271	Billion JPY

Status Photos around Project Site



- National highway class(in service)
- Main road class(in service)
- Urban road class
- Highway
- Ring road No.2
- Ring road No.3

※Dashed line is not -service section

- K Kien Bridge (Existing)
- B Binh Bridge (Existing)
- N Nguyen Trai Bridge (Planning)
- V Vu Yen Bridge (Planning)
- BD Bach Dang Bridge (Planning)

①Vu Yen South IC

Road to Lach Huyen is crowded by large trucks

③Oil Facilities

Road alignment have to keep safe distance300m from oil facilities .

⑤Bach Dang Shipyard & Hai Phong Port

Bach Dang Shipyard & Hai Phong Port will be relocate by 2021.

②Nguyen Trai Street & Roundabout

④Stream Regime at Cam River

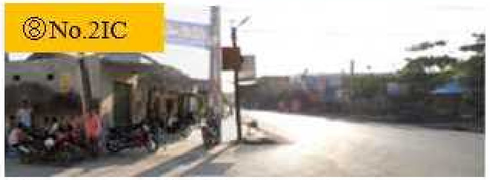
Left bank: remaining nature like mangrove
Right bank: port facilities are lined
･All size vessels is crossing
･High-voltage line is lined up NS direction near by Vu Yen Br.

⑥Pavement Condition at Kien Bridge

Pavement was damaged

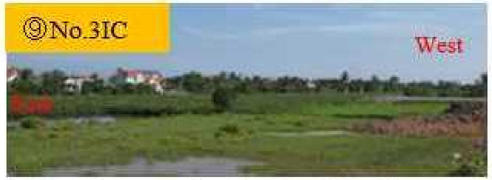
⑦No.1IC

⑧No.2IC



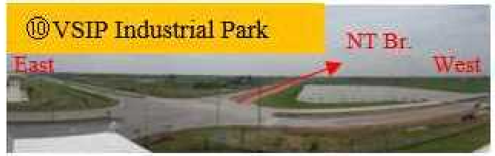
Alignment pass though residential area.

⑨No.3IC



No.3IC is connected No.1& No.2IC and will stretch from VSIP side.

⑩VSIP Industrial Park



11 Japanese companies dwell in VSIP Park.
(as of Oct,2014)

Nguyen Trai Bridge from Nguyen Trai South IC, CG Image

Vu Yen Bridge and Vu Yen South IC, CG Image

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Chapter 4 TRAFFIC SURVEYS AND TRAFFIC DEMAND FORECAST

Chapter5 EXAMINATION OF ALIGNMENT AND SUITABLE CROSSING ALTERNATIVES FOR THE CAM RIVER

Chapter 6 DESIGN

- Abbreviation -

Abbreviation	Formal name	Japanese
AADT	Annual Average Daily Traffic	年平均日交通量
AASHTO	American Association of State Highway and Transportation Official	米国全州道路交通運輸行政官協会
ADB	Asian Development Bank	アジア開発銀行
AHP	Analytic Hierarchy Process	階層分析法
APs	Affected Persons	影響される人
ASTM	American Society for Testing and Materials	米国試験材料協会
B/C	Benefit per Cost ratio	費用便益比
BOD	Biochemical Oxygen Demand	生物化学的酸素要求量
BOD	Biochemical Oxygen Demand	生物化学的酸素要求量
BOT	Built Operation Transfer	BOT 方式（PFI の事業方式の一つ）
BQ	Bill of Quantities	数量計算書
BRT	Bus Rapid Transit	バス高速輸送システム
BT	build-transfer	BT 方式(建設-移転)
CBA	Cost Benefit Analysis	費用便益分析
CBR	California Bearing Ratio	シービーアール試験
CCTV	Closed-Circuit Television Systems	閉鎖回路テレビシステム
CIF, C.I.F	Cost, Insurance and Freight	運賃保険料込み条件
CIP	Cast-In-Place	現場打ち
COD	Chemical Oxygen Demand	化学的酸素要求量
CPC	Commune People's Committee	最小行政区の人民委員会
CPI	Consumers Price Index	消費者物価指数
DAC	Development Assistance Committee	開発援助委員会
DARD	Department of Agriculture and Rural Development	農業・農村開発部
DCP	Dynamic Cone Penetration Test	動的コーン貫入試験
DD, D/D	Detailed Design	詳細設計
DMS	Detailed Measurement Survey	細資産調査
DOC	Department of Construction	建設部
DOF	Department of Finance	財務部
DONRE	Department of Natural Resources and Environment	天然資源環境部
DOT	Department of Transportation	運輸省
DWT	Dead Weight Tonnage	載貨重量トン
EIA	Environmental Impact Assessment	環境影響評価

EIRR	Economic Internal Rate of Return	経済的内部収益率
EL	Elevation Level	標高
EMP	Environmental Management Plan	環境管理計画
FIRR	Financial Internal Rate of Return	財務的内部収益率
FOB, F.O.B	Free On Board	本船甲板渡し条件
FS, F/S	Feasibility Study	実施可能性調査
FY	Fiscal Year	会計年度
GDP	Gross Domestic Product	国内総生産
GHG	Greenhouse Gas	温室効果ガス
GNI	Gross National Income	国民総所得
GNP	Gross National Product	国民総生産
GRDP	Gross Regional Domestic Product	地域内総生産
GSO	General Statistics Office	統計局
HPPC	Hai Phong People's Committee	ハイフォン市人民委員会
HWL	Hight Water Level	朔望平均満潮面
IMF	International Monetary Fund	国際通貨基金
IT/R	Interim Report	中間報告書
JBIC	Japan Bank for International Cooperation	国際協力銀行
JETRO	Japan External Trade Organization	独立行政法人日本貿易振興機構
JICA	Japan International Cooperation Agency	独立行政法人国際協力機構
JPY	Japanese Yen	日本円
LEP	the Law on Environmental Protection	環境保護法
LWL	Low Water Level	朔望平均干潮面
LUR	Land-use Rights	土地使用権
MAC	Maximum Acceptable Concentration	最大許容濃度
MARD	Ministry of Agriculture and Rural Development	農業・農村開発省
MOC	Ministry of Construction	建設省
MOF	Ministry of Finance	財務省
MONRE	Ministry of Natural Resources and Environment	ベトナム天然資源環境省
MPI	Ministry of Planning and Investment	計画・投資省
MSL	Mean Sea Level	平均海面
NPV	Net Present Value	正味現在価値
NH	National Highway	国道
O&M	Operation and Maintenance	運営維持管理
OD	Origin and Destination	起終点

ODA	Official Development Assistance	政府開発援助
OECD	Organization for Economic Co-operation and Development	経済協力開発機構
PAP	Project Affected People	プロジェクトの影響を受ける住民
PC	Pre-stressed Concrete	プレストレストコンクリート
PCU	Passenger Car Unit	乗用車換算台数
PFI	Private Finance Initiative	PFI
PMU	Project Management Unit	事業実施組織
PPP	Public Private Partnership	PPP
PR	Province road	県道
RAP	Resettlement Action Plan	住民移転計画
RC	Reinforced-Concrete	鉄筋コンクリート
ROW	Right of Way	道路用地
RCS	Replacement Cost Study	住民移転費用の調査
SCF	Standard Conversion Factor	標準変換係数
SEDP	Socio-Economic Development Plan	社会経済開発計画
SEDS	Social Economic Development Strategy	社会経済開発戦略
SHMs	stakeholder consultation meetings	-
SLSC	Standard Least Squares Criterion	水文確率分析における分布形の適合度を表す評価指標
SPC	Special Purpose Company	特定目的会社
SPSP	Steel Pipe Sheet pile.	鋼管矢板
SPT	Standard Penetration Test	標準貫入試験
TA	Technical Assistance	技術支援
TDSI	Transport Development and Strategy Institute	ベトナム交通開発戦略研究所
TEDI	Transport Engineering Design Inc.	交通コンサルタント会社
TTC	Travel Time Cost	旅行時間費用
UD	Undisturbed Soil	原状土
UN	United Nations	国際連合
UNEP	United Nations Environment Program	国際連合環境計画
UNESCO	United Nations Educational, Scientific and Cultural Organization	国際連合教育科学文化機関
USD, US$	United States Dollar	アメリカドル
VAT	Value Added Tax	付加価値税
VND	Vietnam Dong	ベトナムドン
VOC	Vehicle Operation Cost	走行費用

VSIP	Vietnam Singapore Industrial Park	ベトナム・シンガポール工業団地
WB	World Bank	世界銀行
WTO	World Trade Organization	世界貿易機関

Chapter 1 INTRODUCTION

1.1 Background of the Survey

The Vietnamese government (GOV) has prepared the “Socio-Economic Development Plan: SEDP 2011-2015” for rapid and sustainable development of the country. According to the plan, GOV has put high priority on the development of Hai Phong City. Hai Phong City also has a development plan for Lach Huyen port which is an international port on the growth axis in northern Vietnam expected to be opened in 2017.

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1.2 Scope of the Project

The scope of the Project is as follows.

1.2.1 Nguyen Trai Bridge

Nguyen Trai Bridge would connect the current administrative center on the south side of the Cam River and the planned administrative center on the north side of the river in Hai Phong City. HPPC regards the bridge as one of the most important bridges for the development of the north area as the new administrative center of Hai Phong City.

1.2.2 Vu Yen Bridge

Vu Yen Bridge would connect Vu Yen Island and the Dinh Vu - Cat Hai Economic Zone. HPPC regards the bridge as one of the most important bridges for the development of the north industrial zones in Hai Phong City.

1.2.3 Hai Phong Ring Road No. 3

Hai Phong Ring Road No. 3 would connect Vu Yen Bridge to National Highway No. 10. HPPC regards the road as indispensable for the effectiveness of Vu Yen Bridge and the development of the north industrial zones in Hai Phong City.

1.3 Technical Issues of the Project

The feasibility of Nguyen Trai Bridge, Vu Yen Bridge and Ring Road No. 3 was evaluated by taking into consideration the qualitative effect of traffic volume of the trunk roads in the project area and the benefits due to the Project.

1) The order of priority is "Nguyen Trai Bridge, Vu Yen Bridge and Ring Road No. 3" in the upper level plan (SEDS2011-2020, SEDP2011-2015, Hai Phong Construction Master Plan).
2) Future traffic demand on the roads in the Project area and necessary road width.
3) Suitable measures to cross the Cam River.
4) Examination of soft soil and treatment.
5) Study of an appropriate construction management body for the Hai Phong Arterial Road Construction Project and maintenance management of the constructed structures as Japanese ODA funded undertakings.

1.4 Location of the project

The project area covers mainly Hai Phong City in Vietnam, where the two planned main bridges of the Project are located, and also the north area including the Vietnamese capital Hanoi as needed. In addition, other areas in Vietnam are also researched for procurement conditions (construction materials and equipment, construction companies, etc.) as needed.

The location of the Project and Main bridges are shown in Figure 1.4-1 and Figure 1.4-2.

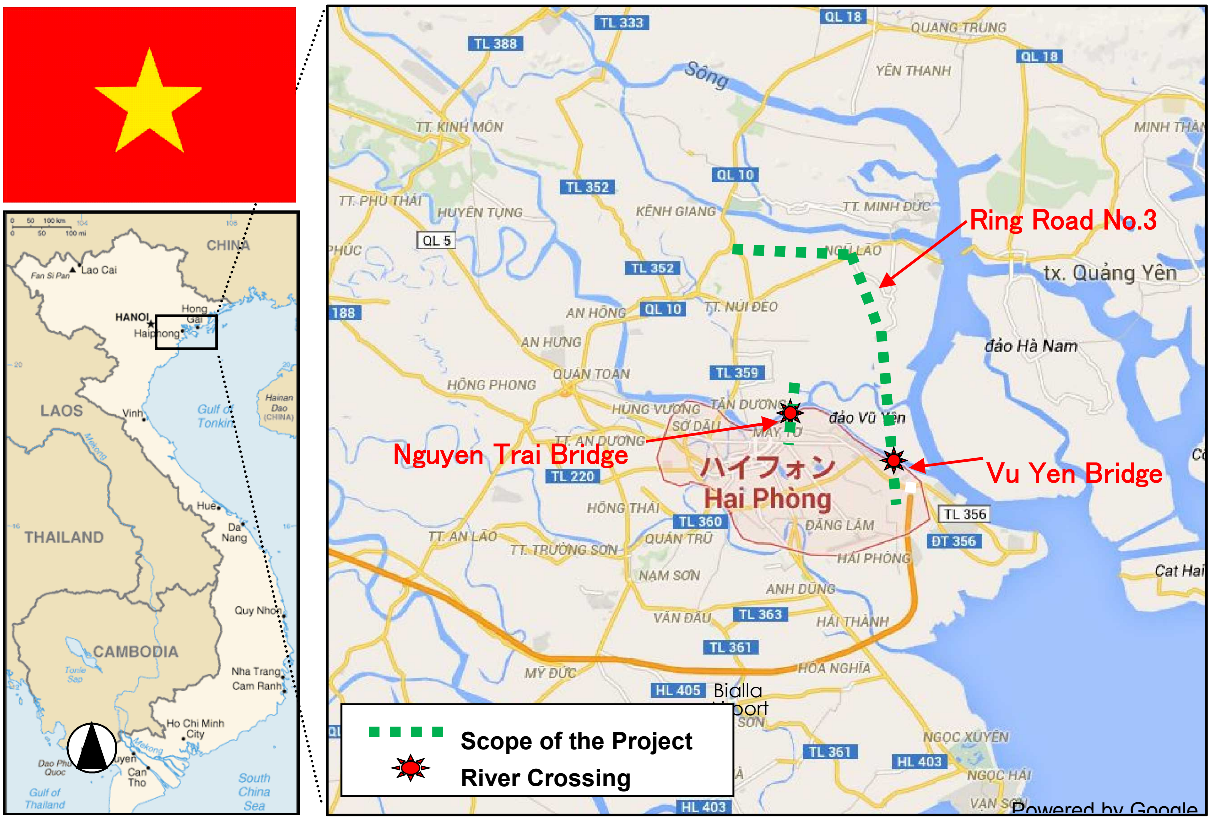
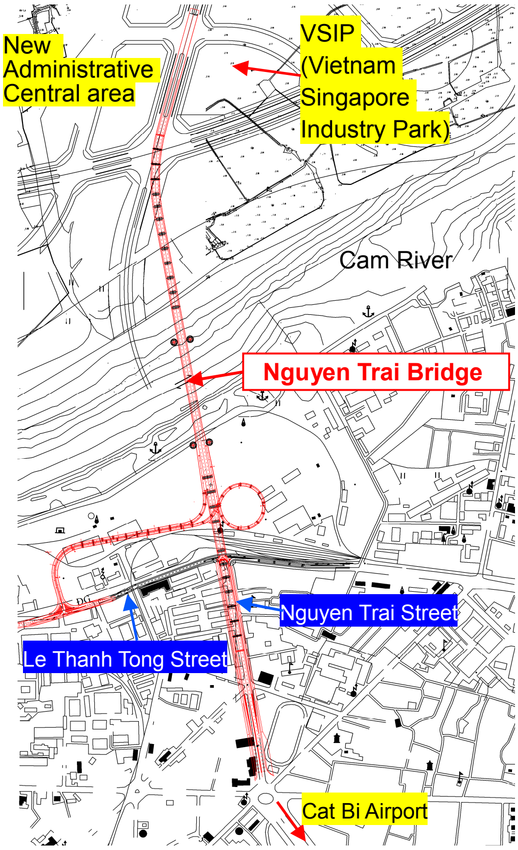
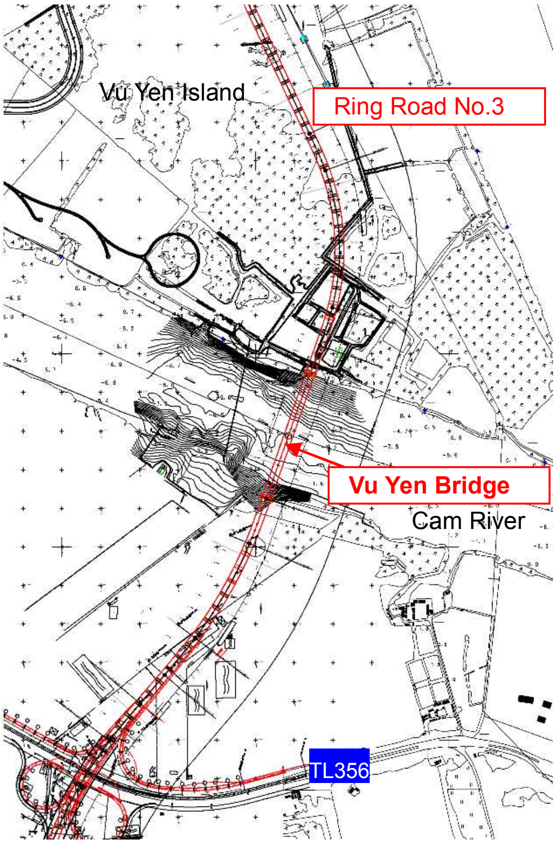


Figure 1.4-1 Location of the Project





Nguyen Trai Bridge **Vu Yen Bridge**

Figure 1.4-2 Location of crossing of Cam River

Concept of the Feasibility Study of the Project

<table>
<tr><td>1.Project Location</td><td>Hai Phong City
Nguyen Trai Bridge; Thuy Nguyen District – Ngo Quyen District
Ring Road No.3, Vu Yen Bridge; Thuy Nguyen District – Hai An District</td></tr>
<tr><td>2.Forcasted year</td><td>2020, 2030</td></tr>
<tr><td colspan="2">3.Socio-economic Framework</td></tr>
<tr><td colspan="2">GDP growth rate of Hai Phong City 10.1% in 2015, 9.1% in 2020, 7.6% in 2030 and Population of Hai Phong City 2,257,000 in 2020 and 2,428,000 in 2030 were applied as condition of the socio-economic framework.</td></tr>
<tr><td colspan="2">4.Traffic Demand Forecast</td></tr>
<tr><td colspan="2">The incremental traffic generated from the following development program was taken into consideration in estimating the traffic demand.
A) Traffic generated by Lach Huyen Port (to be executed from 2015)
B) Traffic generated by VSIP and New Administrative Center (to be executed from 2011).
C) Passenger generated by Internationalization of Cat Bi Airport
Study cases are following 5 case include Case-1 of “Do nothing”.
Case-2 Nguyen Trai Bridge and Vu Yen bridge
Case-3 Nguyen Trai Bridge
Case-4 Vu Yen Bridge
Case-5 Nguyen Trai Bridge without JCT to Le Thanh Tong St. and Vu Yen Bridge
In the case that is both bridge construction (Case-2), forecasted traffic volume in 2030 are 41,600PCU/day for Kien Bridge, 69,700 for Binh Bridge, 75,300 for Nguyen Trai Bridge, 55,000 for Vu Yen Bridge.</td></tr>
<tr><td colspan="2">5. Outline of Preliminary Engineering Design</td></tr>
<tr><td colspan="2"><u>Highway Design</u>
Vietnamese road standard TCXDVN 104-2007 and TCVN4054-2005 are adopted and the Highway with 4 lanes of the carriageway with design speed of 80 km/h is recommended.
<u>Bridge Design</u>
The horizontal clearance 80m and the vertical clearance 25m for Nguyen Trai Bridge and 47.77m for Vu Yen Bridge from 5% HWL are recommended as main navigation route.
Navigation clearance applied for Ruot Long Bridge was recommended 50m width and 9.5m height as Class II river.
<u>Profile of the Project</u>
(A) <u>Nguyen Trai Bridge</u>
The total length of the Project: 1,810 m
Main bridge length: 1,404 m (464m-long main bridge, 468 m and 472 m approach bridge)
(B) <u>Ring Road No.3, Vu Yen Bridge</u>
The total length of the Project: 17,780 m
Main bridge length: 3,148 m (728 m-long main bridge, 1,200 m and 1,220 m approach bridge)</td></tr>
<tr><td colspan="2">6.Project Cost and Implementation Plan</td></tr>
<tr><td colspan="2">Total project cost is estimated 21,056 billion VND, including the construction cost, land acquisition and compensation costs, using the price level in November 2015. The total construction period, including the mobilization period is estimated at 42 months, and the overall project implementation period is to be about 6.4 years.</td></tr>
</table>

Chapter 2 COMPREHENSION OF THE BACKGROUND OF THE PROJECT

2.1 Economic and Social Background of Vietnam

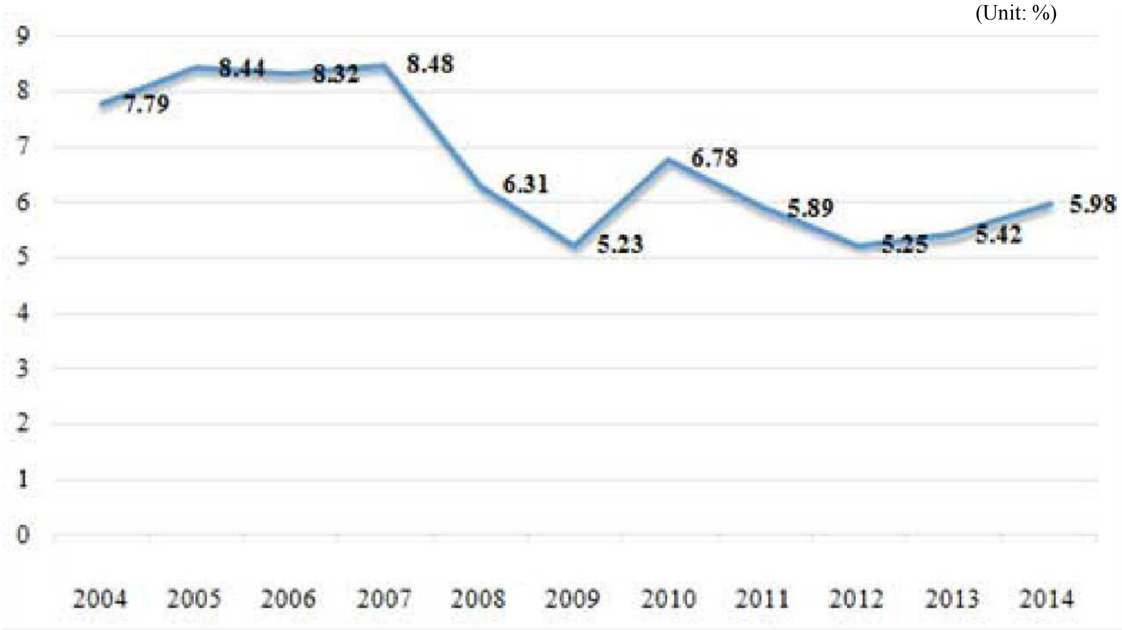
2.1.1 Economic Background

(1) Macroeconomic Background

The Socialist Republic of Viet Nam (hereinafter referred to as "Vietnam") enacted the Doi Moi Renovation Policy in 1986 and began obtaining its effects around 1989. After that, economic growth in Vietnam continued and reached a high of 9% in 1995 and 1996. In 1997, however, tendencies such as a slow-down of the growth rate surfaced and foreign direct investment abruptly decreased due to the impact of the Asian financial crisis, with the growth of rate dropping to 4.8% in 1999.

After that, the growth rate continued to recover and reached 6.7% in 2000, 7.2% in 2003, 8.4% in 2005 and 8.48% in 2007. The Corporation Law enacted in 2000 (the revised Law was enacted in November 2005) simplified the procedure of establishing private companies and accelerated the establishment of corporations, resulting in a recovery of the national economy. In recent years, Vietnam has promoted market economy reforms and integration with the international economy, and it became an official WTO member in January 2007. However, causes of concern still remain such as the chronic foreign trade deficit and the immature investment environment. The economic growth rate in 2008 decelerated to 6.31% following the effect of events such as the high inflation rate of 19.9% over the previous year and the global economic crisis. In 2009, the growth rate further slowed down to 5.23%. In 2010, the growth rate recovered to 6.78%, the level before the crisis, because the governmental policies of economic stimulus and monetary easing (4% interest rate) which came into effect in 2009 worked well. However, due to monetary restraint by the Vietnamese government for inflation control, the growth rate then slowed down to 5.89%. The economic growth rate of Vietnam in 2012 was 5.25%, which was below the government's original goal of 6.0%. This value is the second lowest in the past 20 years, next to the value in 1999 (4.8%) which was due to the impact of the Asian financial crisis in 1997. The economic growth rate in 2014 was 5.98%, higher than the government's original goal of 5.8%. On the other hand, the rise of the Consumer Price Index remained at a yearly average of 9.2%, lower than the government's goal of 10.0%. The exchange rate against the US dollar is maintained at 20,800 VND (Vietnam Dong) / USD (US Dollar). These data infer that the macroeconomic conditions in Vietnam remain stable. The trade balance also finally showed a surplus after 19 years.

(Unit: %)



(Source: GSO of Vietnam website)

Figure 2.1-1 Economic Growth Rate of Vietnam

Table 2.1-1 Macroeconomic Indexes in Vietnam

As of November 2013 (Units: Local currency = VND; Rate = %)

Year	2003	2004	2005	2006	2007	2008
Real GDP Growth Rate	7.3	7.8	8.4	8.2	8.5	6.2
Total nominal GDP (trillion VND)	613.443	715.307	914.0	1061.6	1246.8	1616.0
Total nominal GDP (billion USD)	39.552	45.428	57.633	66.375	77.417	99.13
Total nominal GDP – Remarks						
GDP per capita (nominal, USD)	489	554	700	796	919	1,145
Consumer price increase rate	3.1	7.7	8.3	7.5	8.3	23.0
Consumer price increase rate – Remarks	Previous year = 100	Previous year = 100	Previous year = 100	Previous year = 100	Previous year = 100	Previous y ear = 100
Unemployment rate	5.8	5.6	5.3	4.8	4.6	4.7
Unemployment rate – Remarks	Urban areas	Urban areas	Urban areas	Urban areas	Urban areas	Urban area s
Current balance (international basis, USD)	-1,931	-1,564	-560	-163	-7,000	-10,800
Trade balance (USD)	-5,107	-5,484	-4,314	-5,065	-14,204	-18,029
Foreign exchange reserves (USD)	6,224	7,041	9,051	13,384	23,479	23,890
Foreign debt balance (USD)	14,100	15,266	17,200	19,100	23,000	30,200
Exchange rate (against USD) – Interim mean value	15,509.6	15,746	15,858.9	15,994.3	16,105.1	16,302.3
Exchange rate (against USD) – Term-end value	15,646	15,777	15,916	16,054	16,114	16,977
Money supply growth rate	33.1	31.0	30.9	29.7	49.1	20.7
Exports (USD)	20,149	26,485	32,447	39,826	48,561	62,685
Exports (USD) – Remarks						
Exports to Japan (USD)	2,909	3,542	4,340	5,240	6,090	8,468
Exports to Japan (USD) – Remarks						
Imports (USD)	25,256	31,969	36,761	44,891	62,765	80,714
Imports (USD) – Remarks						
Imports from Japan (USD)	2,982	3,553	4,074	4,702	6,189	8,240
Imports from Japan (USD) – Remarks						
Direct investment received (million USD)	3,191	4,548	6,840	12,004	21,348	71,726
Direct investment received (USD) – Remarks	Incl. new expansion on registered captal base	Incl. new expansion on registered captal base	Incl. new expansion on registered captal base	Incl. new expansion on registered captal base	Incl. new expansion on registered captal base	Incl. new expansion on registered captal base

Year	2009	2010	2011	2012	2013	2014
Real GDP Growth Rate	5.3	6.8	5.9	5.0	5.42	5.98
Total nominal GDP (trillion VND)	1809.1	2157.8	2779.9	3245.4	3584.3	3937.9
Total nominal GDP (billion USD)	106.01	115.93	135.54	155.99.	171.10	187.87
Total nominal GDP – Remarks						
GDP per capita (nominal, USD)	1,160	1,273	1,517	1,749	1,908	2,052
Consumer price increase rate	6.9	9.2	18.6	9.2	6.6	4.1
Consumer price increase rate – Remarks	Previous year = 100	Previous year = 100	Previous year = 100	Previous year = 100	Previous year = 100	Previous y ear = 100
Unemployment rate	4.6	4.3	3.6	3.3	3.59	3.4
Unemployment rate – Remarks	Urban areas	Urban areas	Urban areas	Urban areas	Urban areas	Urban area s
Current balance (international basis, USD)	-6,100	-4,300	-600	n.a.		
Trade balance (USD)	-12,853	-12,610	-9,844	284		
Foreign exchange reserves (USD)	16,447	12,467	13,539	n.a.		
Foreign debt balance (USD)	38,700	45,400	50,300	n.a.	.	
Exchange rate (against USD) – Interim mean value	17,065.1	18,612.9	20,509.8	20,805	20,948	20,960
Exchange rate (against USD) – Term-end value	17,941	18,932	20,828	20,865	21,0020	21,056
Money supply growth rate	26.2	29.7	11.9	n.a.	.	
Exports (million USD)	57,096	72,191	96,906	114,631	132,033	150,186
Exports (USD) – Remarks						
Exports to Japan (USD)	6,335	7,727	10,781	13,510	13,630	
Exports to Japan (USD) – Remarks						
Imports (USD)	69,949	84,801	106,750	114,347	132,032.6	148,048
Imports (USD) – Remarks						
Imports from Japan (USD)	6,836	9,016	10,400	11,603	11,614	
Imports from Japan (USD) – Remarks						
Direct investment received (million USD)	22,626	19,764	14,696	13,013	22,352	21,921
Direct investment received (USD) – Remarks	Incl. new expansion on registered captal base	Incl. new expansion on registered captal base	Incl. new expansion on registered captal base	Incl. new expansion on registered captal base	Incl. new expansion on registered captal base	Incl. new expansion on registered captal base

Real GDP growth rate, real nominal GDP, consumer price increase rate, unemployment rate, trade balance, export/import amount, export/import to/from Japan, direct investment received, GDP structure by industry, and total domestic expenditure breakdown: Statistical yearbook 2014, Statistical yearbook 2013, General Statistics Office of Vietnam website, http://www.gso.gov.vn/default_en.aspx?tabid=491

Current balance and foreign debt balance: World Bank "A World Bank Economic Update for the East Asia and Pacific Region"

GDP per capita: IMF "World Economic Outlook Database"

Foreign exchange reserves and exchange rate: IMF "IFS" CD-ROM

Money supply growth rate: IMF "International Financial Statistics Yearbook"

[Note] Money supply growth rate: "Broad Money" in IMF "International Financial Statistics Yearbook 2010" was stated as money supply growth rate.

Source: JETRO website

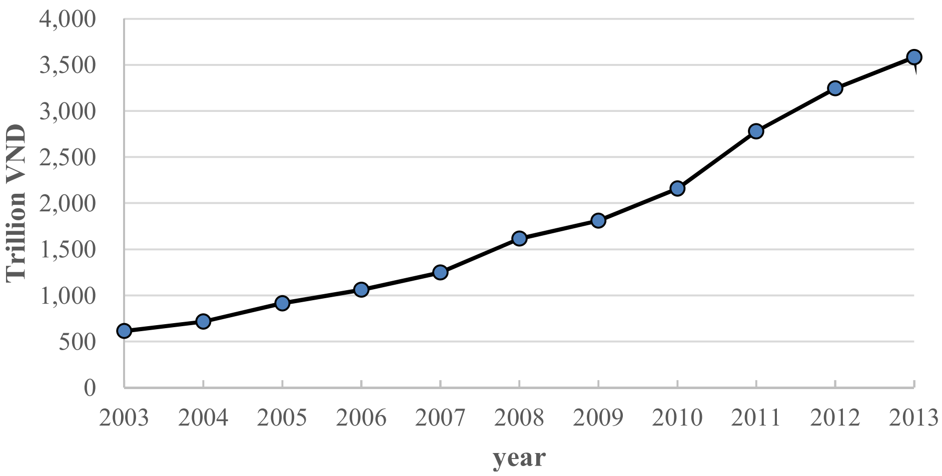
2.1.2 Outline of Industry

According to statistics for the past 9 years on the structure of gross domestic product (GDP) by industry in Vietnam, the total GDP amount grew approximately 1.6 times over 9 years (from VND 1,588,646 billion (2005) to VND 2,543,596 billion (2013)). The annual average growth rate used to be almost 8%, but has slowed down after 2008 and is currently around 5% ~ 6%. The GDP values by industry have been increasing. In their composition, the primary industry (agriculture and fisheries) has decreased from 21% to 15%. On the other hand, the secondary industry (mining and manufacturing) has increased from 39% to 42%. Regarding the tertiary industry (service and transportation), the ratio has been almost flat (27% ~ 29%). Figure 2.1-2 ~ Figure 2.1-4 show the GDP structure by industry.

Table 2.1-2 GDP at Constant 2010 Prices by Type of Economic Activity, Items and Year

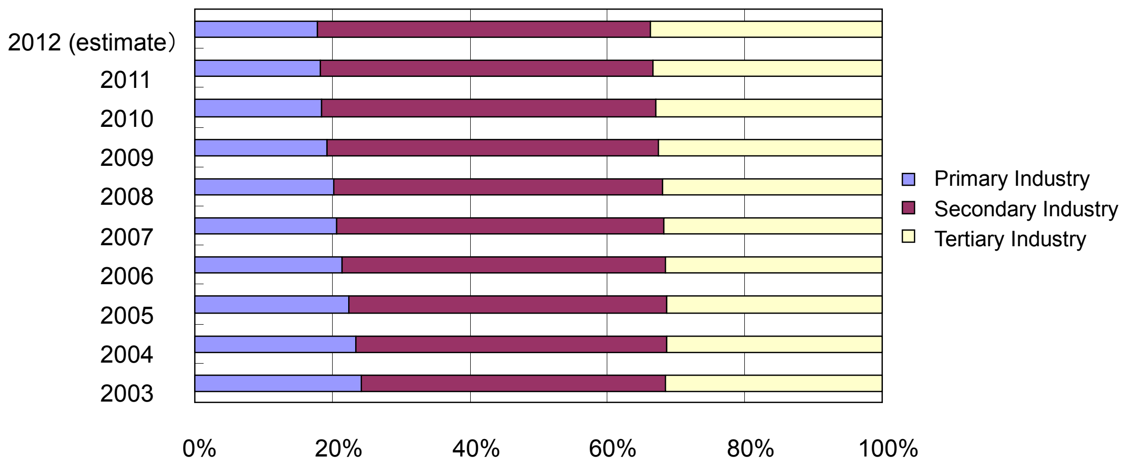
(Unit: billion VND)

	2005	2006	2007	2008	2009	2010	2011	2012	Prel. 2013
Agriculture, forestry and fishing	342,811	355,831	369,905	387,262	394,658	407,647	424,047	435,414	446,905
Mining and quarrying	212,381	208,134	203,555	195,756	210,666	215,090	220,518	230,883	230,421
Manufacturing	248,709	281,925	316,812	347,808	357,415	387,382	429,994	454,933	488,780
Electricity, gas, stream and air conditioning supply	44,794	49,232	53,707	59,112	64,446	71,709	78,529	88,266	95,804
Water supply, sewerage, waste management and remediation activities	8,108	8,736	9,446	10,108	10,765	11,561	12,648	13,710	14,958
Construction	91,523	101,632	113,979	113,546	126,441	139,162	138,305	142,800	151,182
Wholesale and retail trade; repair of motor vehicles and motorcycles	193,430	209,969	228,477	243,955	262,686	283,947	306,161	327,348	348,704
Transportation and storage	40,322	44,406	49,468	55,360	60,056	65,305	69,993	73,997	78,134
Accommodation and food service activities	52,688	59,231	66,822	72,661	74,328	80,788	86,858	92,929	102,138
Information and communication	14,624	16,039	17,745	19,608	21,014	22,732	24,373	26,559	28,902
Financial, banking and insurance activities	77,704	84,058	91,490	100,780	109,545	118,688	127,356	134,259	143,505
Real estate activities	105,410	112,776	118,561	124,925	130,333	134,774	139,545	141,062	144,122
Professional, scientific and technical activities	22,630	23,725	25,061	26,096	27,217	28,453	30,240	32,412	34,804
Administrative and support service activities	6,480	6,816	7,256	7,670	8,031	8,425	9,019	9,613	10,352
Activities of Communist Party, socio-political organizations; public administration and defence; compulsory security	38,666	41,593	44,973	47,883	51,365	55,200	59,131	63,471	68,383
Education and training	34,805	37,735	41,037	44,306	47,215	50,495	54,149	58,135	62,818
Human health and social work activities	16,422	17,709	19,135	20,620	22,008	23,544	25,256	27,118	29,261
Arts, entertainment and recreation	10,169	10,972	11,898	12,907	13,925	15,052	16,094	17,211	18,504
Other service activities	24,597	26,436	28,573	30,408	32,312	34,493	36,672	38,829	41,830
Activities of households as employers; undifferentiated goods and services producing activities of households for own use	2,374	2,549	2,765	2,977	3,164	3,380	3,593	3,829	4,087
TOTAL	1,588,646	1,699,501	1,820,667	1,923,749	2,027,591	2,157,828	2,292,483	2,412,778	2,543,596



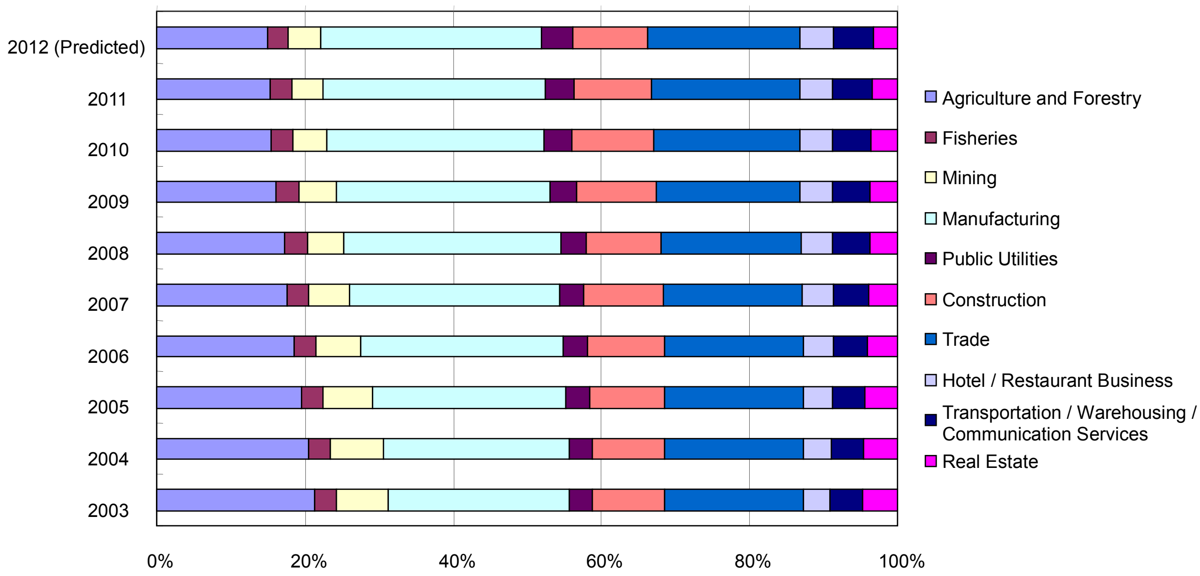
Source: Study Team

Figure 2.1-2 Change of GDP in the Past 10 Years



Source: Study Team

Figure 2.1-3 Change of Structural Ratio by Industry

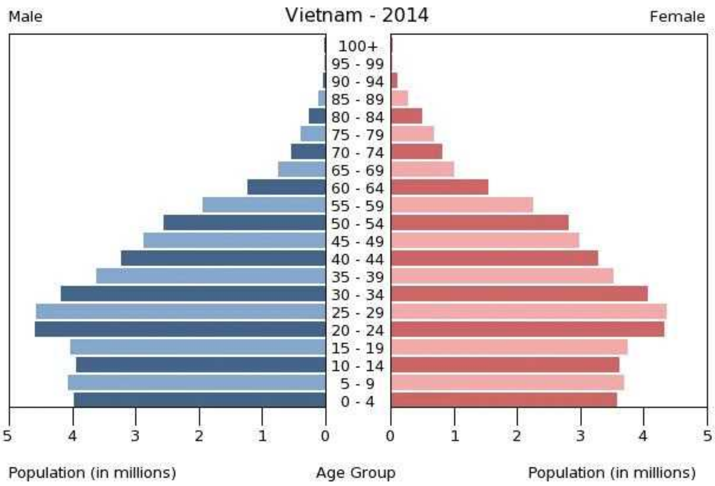


Source: Study Team

Figure 2.1-4 Change of Structural Ratio by Industry Category

2.1.3 Population in Vietnam

The population in Vietnam is approximately 90.728 million (2014). The yearly rate of increase of the population is 1.07% (average for the past 5 years). The population ratio forms a pyramid structure, with most people younger than in their thirties and forties. This means that Vietnam has a plentiful work force and a high-consuming population, and the basic conditions are satisfied for future economic growth.



Source: General Statistics Office of Vietnam website (http://www.gso.gov.vn/default_en.aspx?tabid=491).

Figure 2.1-5 Population Ratios in Vietnam

2.1.4 Foreign Direct Investment

According to the Foreign Investment Agency (FIA), the total number of approved direct inward investments (new / expansion) numbered 1,535 in 2012, a 4.8% decrease from the previous year, and amounted to USD 13.01 billion (11.5% decrease). In 2014, the corresponding figures were 1,843 numbers (compared with 1,530 numbers and a 20% increase in 2013) and USD 21.92 billion (1.9% decrease). According to the Ministry of Planning and Investment (MPI), the number of approved new investments was 1,100 (0.8% increase) and amounted to USD 7.854 billion (32.0% decrease). From a statistical viewpoint, although the approved amount has largely decreased due to the decline in the number of large investment plans, expansion investment by companies entering the Vietnamese market has significantly increased, and numbered 435 numbers (16.3% increase) worth a total of USD 5.151 billion (64.4% increase).

According to new direct inward investment by country / region (see Table 2.1-3), Japan was at the top both in the number of cases and amount in 2012 and 2013. However in 2014, the amount invested by Japan decreased drastically from the previous year (growth rate: -60.9%).

According to JETRO, The main cause of the direct equity investment decrease is because a major company of the same country reduced foreign direct investment by Japanese depression and slumped yen.

According to the investment amount by industry (see Table 2.1-4), the approved amount for processing / manufacturing was at the top (USD 4.796 billion), and accounted for 78.4% of the total amount when combined with real estate investment which had large investment plans. On the contrary, investment for construction accounted for only 8.9% in 2011 and 2.3% in 2012.

According to VnExpress (2015/2/23), Korea is that the approval price (It was new and increased the capital additionally.) and the number of investment items occupied 36% of the whole and 31% respectively at the country and in the area invested in Vietnam, and the top is maintained.

Table 2.1-3 Direct Inward Investment by Country / Region (New, Approval Basis)

Unit: million USD, % and case

	2011		2012		2013		2014			2014/2013
	Invested Amount	%	Invested Amount	%	Invested Amount	%	Invested Amount	%	Number of Cases	Growth Rate
Japan	1,849	12	4,007	30.8	5,875	26.8	2,299	10.5	342	△60.9.
Korea	873	6	757	5.8	4466	20	7705	35	588	72.5
Hong Kong	2,948	20	549	4.2	730	3.2	3036	13.8	112	315.9
Singapore	2,005	13	488	3.7	4,769	21	2892	13.2	119	△39.3
Cyprus	143	1	376	2.9	0	0	0	0	0	0
China	600	4	302	2.3	2338	10.4	497	2.3	112	△78.7
Taiwan	372	2.5	192	1.4	673	3	1228	5.6	101	82.5
Germany	52	0.3	186	1.4	122	0.5	173.8	0.8	28	41.8
Malaysia	360	2.4	116	0.9	147	0.6	388.4	1.8	36	163.9
U.K.	802	5.4	110	0.8	309	1.4	790.4	3.6	29	155.6
Finland	302	2	1	0.007	0	0	0	0	0	0
Total (incl. others)	14,696	100	13,013	100	22,352	100	21,921	100	1843	△1.9

Note: New investments on approval basis, excluding expansion investments. U.K. includes Virgin Islands and Cayman Islands. The figures shown are preliminary values (statistical figures until the middle of December each year).

Source: JETRO website: Prepared based on material from the Ministry of Planning and Investment (MPI), Statistical yearbook 2014 (summary), Statistical yearbook 2013.

Table 2.1-4 Direct Inward Investment by Industry (New, Approval Basis)

Unit: million USD, % and case

	2011		2012			
	Amount	Percentage	Cases	Amount	Percentage	Growth rate
Processing / Manufacturing	5,221	45.2	498	4,796	61.1	△8.1
Real estate	742	6.4	10	1,356	17.3	82.9
Retail Distribution / Repair	414	3.6	175	431	5.5	4.1
Information / Communications	496	4.3	79	395	5.0	△20.2
Transportation / Warehousing	49	0.4	28	209	2.7	326.5
Construction	1,033	8.9	81	182	2.3	△82.4
Health Care / Social Support	22	0.2	5	137	1.7	521.9
Public Utilities	2,526	21.9	13	89	1.1	△96.5
Professional Services	248	2.1	146	63	0.8	△74.7
Mining	98	0.9	6	62	0.8	△37.1
Art / Entertainment	15	0.1	5	44	0.6	105.7
Hotel / Restaurant Business	253	2.2	15	34	0.4	△86.7
Total (incl. others)	11,559	100.0	1,100	7,854	100.0	△32.0

Note: New investments on approval basis, excluding expansion investments.

Source: JETRO website: Prepared based on material from the Ministry of Planning and Investment (MPI).

2.2 Economic and Social Background of Hai Phong City

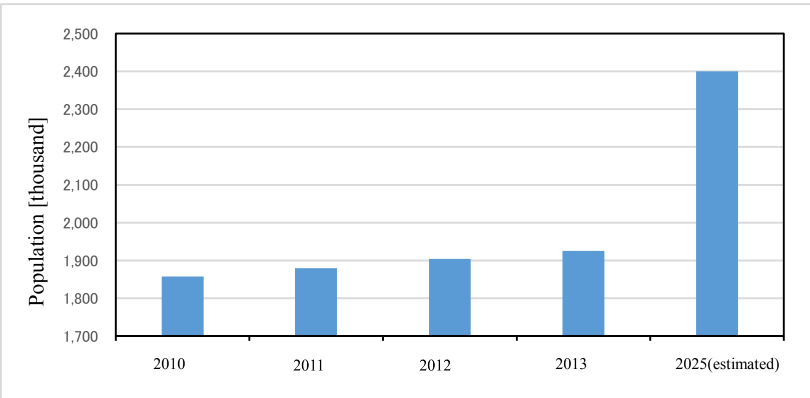
2.2.1 Outline of Hai Phong City

Hai Phong City is the third largest city in Vietnam, located in the northern part of the country approximately 100km east of Ha Noi. Hai Phong City has an area of 1,524km^2 (52nd largest out of 60 cities / districts), and a population of 1.904 million (in 2012, 7th largest in the country), with a population density of 1,250 persons per km^2 (4th largest in the country). The population growth rate has remained around 10% for more than 20 years. As Hai Phong City is located in the coastal zone, ports and harbors have been developed from ancient times. Although it was largely damaged by air raids and blockades by mines etc., it was reconstructed as an industrial city, and it is expected to develop into one of the largest port cities in Vietnam. It has an over 125km long coastal line with unique topographic features and natural landscapes, and infers a potential for further economic development.

At present, the urban areas of Hai Phong City are located on the south side of the Cam River. On the other hand, industrial parks and a new urban center are planned to be located on the north side of the river, and are expected to contribute to the development of the city. In order to develop the north area, facilities such as bridges for the crossing of the Cam River are indispensable. These facilities are eagerly anticipated, and would act as a connection to Lach Huyen port, a base for the development of industrial parks, a connection to the Ha Noi - Hai Phong Expressway, and also a connection to Cat Bi Airport which is to become an international airport.

2.2.2 Population of Hai Phong City

The population of Hai Phong City was 1,946,000 in 2014 and has increased by about 310,000 from 1,610,000 (approximately 20%) at a yearly rate of 1% in the 18 years since 1995. It is expected in the urban development master plan (UD-MP) of Hai Phong City that the population will reach 2,400,000 in 2025 (25% increase from 2013) due to economic development resulting from the development of projects such as Lach Huyen port, the north area of the Cam River, etc.



Source: Made by the Study Team based on data from the Statistical Department and UD-MP of Hai Phong City

Figure 2.2-1 Population of Hai Phong City

The main industry of Hai Phong City and the Red River delta area including Hanoi City is the manufacturing field (11 billion USD, 86% of total annual revenue). Coal production in the area is high with reserves of about 150 million ton. The annual revenue from the agriculture field, mainly from rice production, is also high and amounts to 12% (3 billion USD) of the total. While Hai Phong City is the second most important industrial area, it also has significant rice production and one of the largest fisheries in Vietnam. Hai Phong City plays an important role as the outport of Hanoi City with trade amounting to 3,023.7 million USD in exports and 3,058.9 million USD in imports, and the export and import amount has been increasing at a rate of more than 10% year-on-year (source: Vietnam Register 2013 and Road & Railway Police Department 2013).

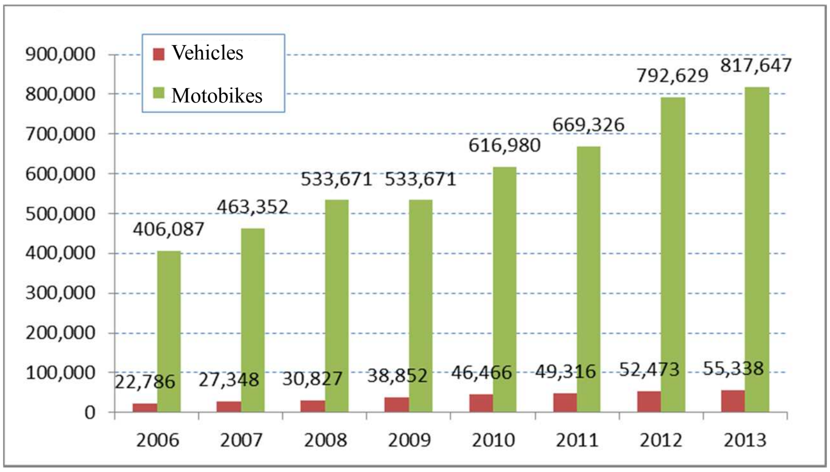
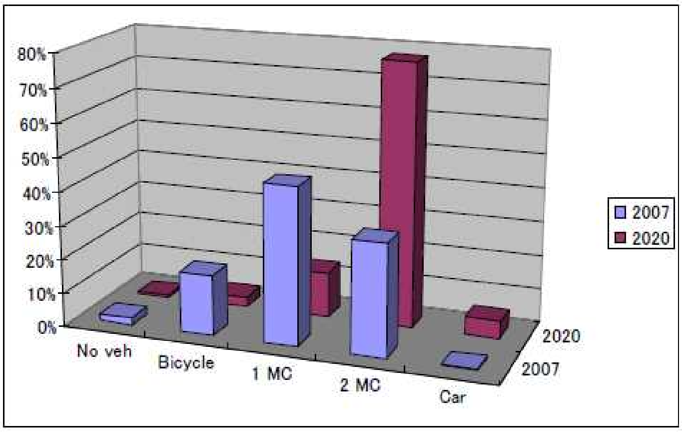


Figure 2.2-2 Number of Registered Vehicles and Motorbikes



Source: Urban Transport in Vietnam's Medium-Sized Cities, World Bank December 2007
* 1 MC: Households owning 1 motorcycle, 2 MC: Households owning more than 2 motorcycles

Figure 2.2-3 Household Vehicle Ownership Pattern, 2007 and 2020

(1) Modes of transportation and actual conditions

1) Development of motorization

Transportation in the urban area of Hai Phong City is rapidly increasing with economic development and the registered number of vehicles and motorbikes has doubled between 2006 and 2013 as shown in Figure 2.2-2. The portion of the motor bikes of the registered number (about 0.9 million) is 93.7%.

2) Vehicle Ownership

According to "Urban Transport in Vietnam's Medium-Sized Cities", World Bank December 2007, the vehicle ownership will change in Hai Phong City as shown in Figure 2.2-3. While car ownership will spread to 5% of households by 2020, motorcycle ownership will remain high, with a sharp increase in the share of households owning more than 2 units.

Therefore, the traffic congestion is expected to be escalated with the increase of the vehicle owners in the future.

(2) Freight and Passenger Transportation

1) Change in Freight Transportation

According to the "Hai Phong City Traffic Development Master Plan (TD-MP)", the increase in the traffic volume in annual average was 17.5% from 2014 to 2013, while the freight transportation amounted to 6.950 ton in 2013.

2) Change in Passenger Transportation

Road transportation of passengers in Hai Phong City occupies 87% of the total transportation mode and the annual increase is 10.1%. It reached 31,590,000 in 2013. It is a most urgent task to develop the road infrastructure for the increasing freight and passenger transportation volume.

Table 2.2-1 Passenger transportation by transportation mode

(Unit: 1 million people)

	Transportation mode	2008	2009	2010	2011	2012	2013
1	Road transportation	26.18	25.5	25.3	31.12	31.51	31.59
2	Water transportation (incl. tourist boats)	2.82	2.22	3.53	3.11	2.54	2.95
3	Air transportation	0.29	0.38	0.48	0.63	0.63	0.61
4	Railway transportation	0.63	0.7	0.9	1.05	1.15	1.23
Total		**29.92**	**28.85**	**30.21**	**35.28**	**34.94**	**36.38**

Source: Hai Phong Statistical Handbook - 2013

3) Condition of Existing Bridges

Kien Bridge (Yen loan: Completed in 2004, PC Cable-Stayed Bridge)

Kien Bridge is part of National Highway No. 10 and the "3rd Ring Road" defined in the TD-MP and crosses the Cam River. The bridge has only 2 road lanes (1 in each direction) and the pavement has deteriorated so that driving speed is low and the road is crowded.

Binh Bridge（Special Yen loan: Completed in 2005, Composite Cable-Stayed Bridge）

Binh Bridge crosses the Cam River from south to north on the west side of the old city area and has a total of 4 lanes (2 lanes + 1 motor bike lane in each direction). In July 2010, a typhoon caused 3 cargo vessels to collide with the bridge so that part of the main girders and stay cables were damaged. Design and construction for repairs were carried out and the bridge was again opened for regular traffic in November 2012. Current traffic conditions on the bridge remain favorable.

2.3 Review of Transport Infrastructure

2.3.1 Regional Road Plan and Projects

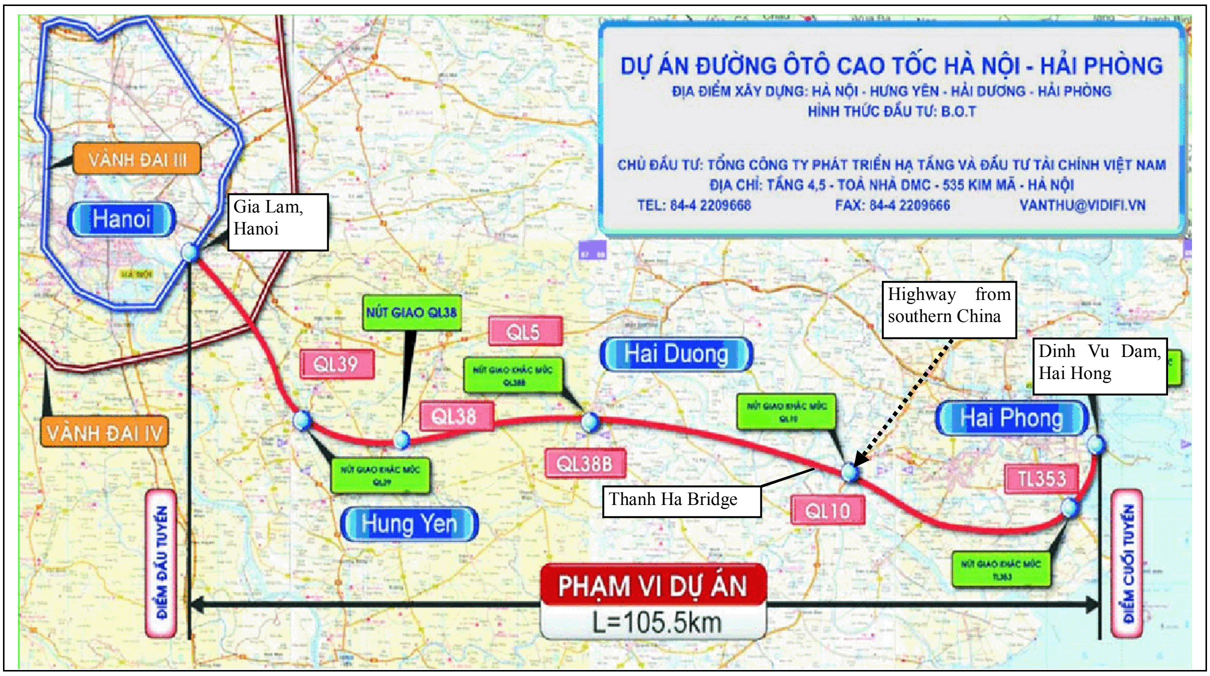
(1) Hanoi-Hai Phong Expressway

The 105.5km long and 33m wide Ha Noi-Hai Phong Expressway[1] will link Ha Noi's Gia Lam district to the Dinh Vu dam in Hai Phong City. It will be Vietnam's first intercity highway built to international standards after it opens and will have a design speed of 120 km/h. In Hai Phong City, the expressway covers the 33.5km distance from Thanh Ha Bridge to Dinh Vu dam.

The route will pass through 4 cities in the provinces of Ha Noi, Hung Yen, Hai Duong and Hai Phong and will connect the port in Hai Phong to the main economic zone of north Vietnam and highway from southern China. The route is expected to increase traffic capacity in the corridor between Ha Noi and Hai Phong as well as reduce traffic congestion on the existing National Highway 5 (QL 5) which is currently the main road connection between Ha Noi and Hai Phong City.

The average cross section of the expressway is 100m with 6 lanes where each lane is 3.75m wide. The road will also have 2 emergency stopping lanes, a median strip, as well as greenery strips and frontage roads on each side. There will be 7 interchanges with national highways, 17 large bridges, 24 medium length bridges and 22 flyovers. In addition, the expressway will have a closed toll collection system.

[1] "Hanoi - Hai Phong Expressway Project," *Vietnam Infrastructure Development and Finance Investment Joint Stock Company*, http://www.vidifi.vn/english/index.php?option=com_content&view=article&id=4:hanoi-%E2%80%93-Hai Phong-expressway-project&catid=3&Itemid=65; accessed on 30 March 2015



Source: Vietnam Infrastructure Development and Finance Investment Joint Stock Company

Figure 2.3-1 Route of the Hanoi - Hai Phong Expressway

The total cost of the project is around 35 trillion VND (US$1.6 billion, US$1.00=21,545 VND). The project is funded by funds from the Vietnam Infrastructure Development and Finance Investment Joint Stock Company, loans from the Vietnam Development Bank, Joint Stock Commercial Bank for Foreign Trade of Vietnam and other sources.

The project is being implemented in 10 packages under a build-operate-transfer (BOT) scheme.

During Vietnamese Prime Minister Nguyen Tan Dung's visit to India between 27 and 28 October 2014, an agreement was made to sell the toll rights to Indian Infrastructure Company Infrastructure Leasing and Financial Services Limited (IL&FS). Under the contract, IL&FS will buy a 49% stake in the project while the remaining 51% will be retained by the Vietnam Infrastructure Development and Finance Investment Joint Stock Company[2].

The expressway is scheduled to be completed at the end of 2015.

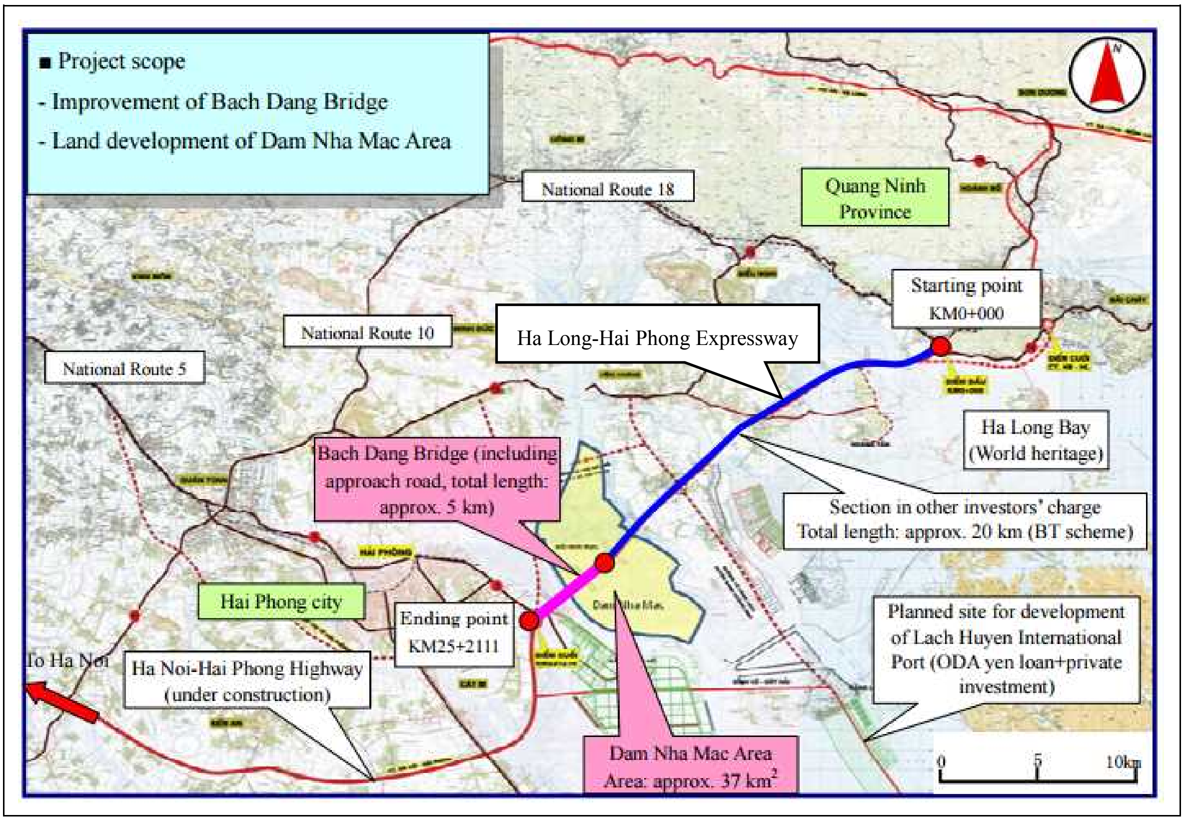
(2) Ninh Binh-Hai Phong-Quang Ninh Expressway

1) Quang Ninh - Hai Phong Section

Currently, the Vietnamese government and the Ministry of Transport have agreed for Quang Ninh Province to implement the Ha Long - Hai Phong Expressway (also called the Quang Ninh - Hai Phong section) from Ha Long City to the end of the Ha Noi - Hai Phong Expressway with the same alignment as the planned Ninh Binh - Hai Phong - Quang Ninh Expressway.

This section is being built under a build-operate-transfer (BOT) scheme.

[2] "Road Transport Plan for Hai Phong City up to 2020, Vision for 2030," Transport Development and Strategy Institute (TDSI), December 2014



Source: Study on the Development of Bach Dang Bridge on Ha Long - Hai Phong Highway in the Socialist Republic of Vietnam, Japan External Trade Organization (JETRO), February 2013

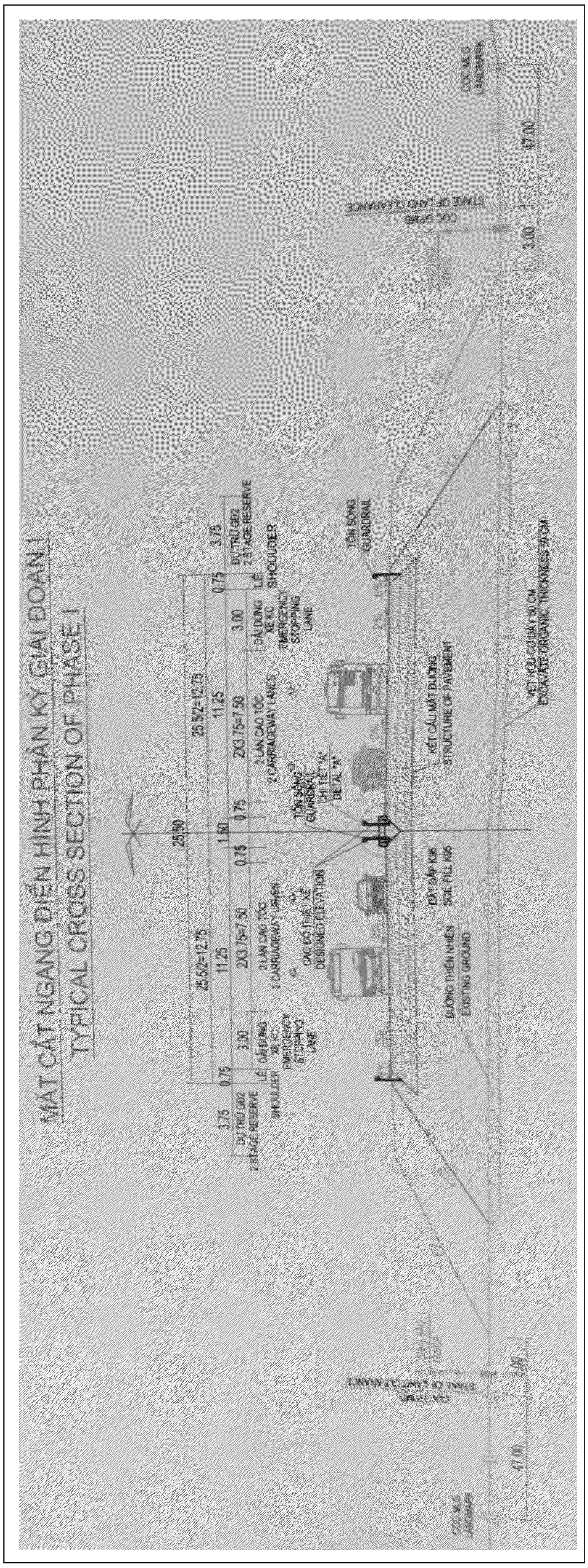
Figure 2.3-2 Ha Long - Hai Phong Expressway Route Alignment

The Ha Long - Hai Phong Expressway has 2 main components, the 19.5km expressway and the 5.45km long Bach Dang Bridge over the Bach Dach River. The cost of the highway is 6.4 trillion VND (US$297 million, US$1.00=21,545 VND) while the Bach Dang Bridge will cost 7.2 trillion VND[3] (US$334 million, US$1.00=21,545 VND).

Bach Dang Bridge

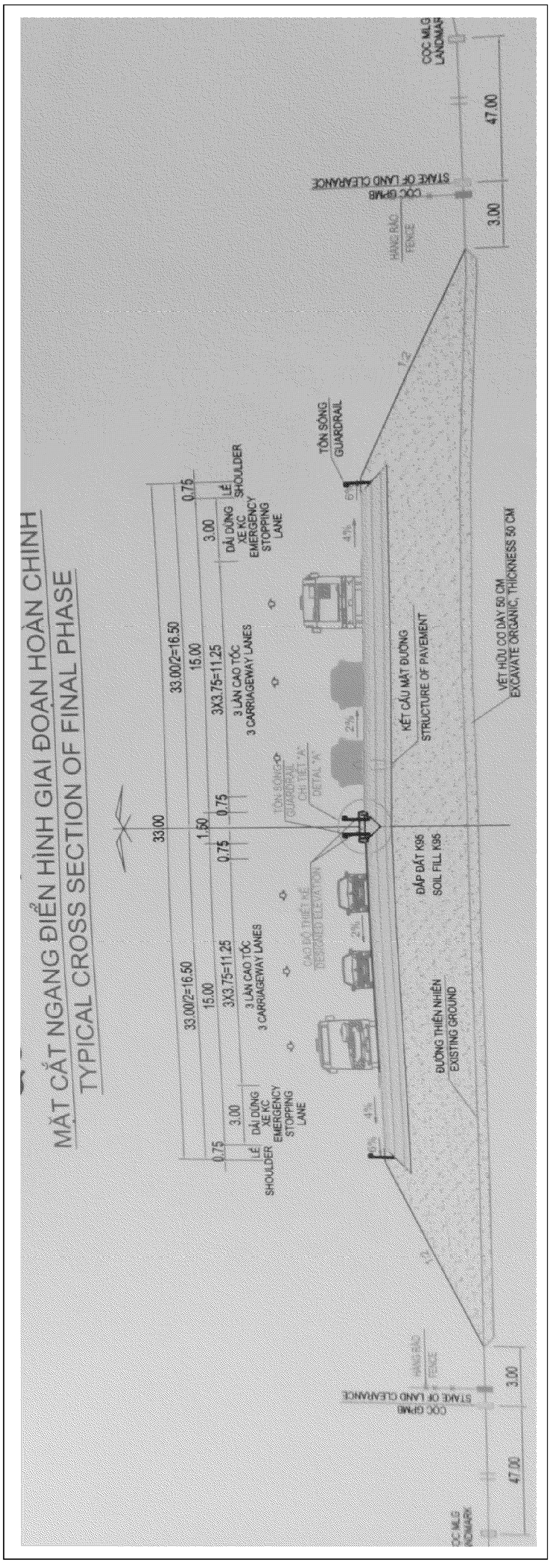
Initially, Bach Dang Bridge will have a width of 25m and will accommodate 4 lanes which can be widened to 6 lanes in the future (see the following figures).

[3] "Ha Long-Hai Phong highway construction launched," Nhan Dan Online, http://en.nhandan.org.vn/business/item/2792402-ha-long-Hai Phong-highway-construction-launched.html; accessed 30 March 2015



Source: Quang Ninh Province Department of Transport

Figure 2.3-3 Cross Section of Bach Dang Bridge During Phase 1



Source: Quang Ninh Province Department of Transport

Figure 2.3-4 Cross Section of Bach Dang Bridge During the Final Phase

Bach Dang Bridge will have a 24-month construction schedule. Construction started on 25 January 2015 and is scheduled to be finished in early 2017[4]. Since 8 investors are taking part in the project, the construction schedule can be shortened according to the Quang Ninh Province Department of Transport. The 8 investors are CIENCO, Phuc Loc, Cuong Thi, Cong Thanh, Phuong Thanh, Trung Nam and SE of Japan.

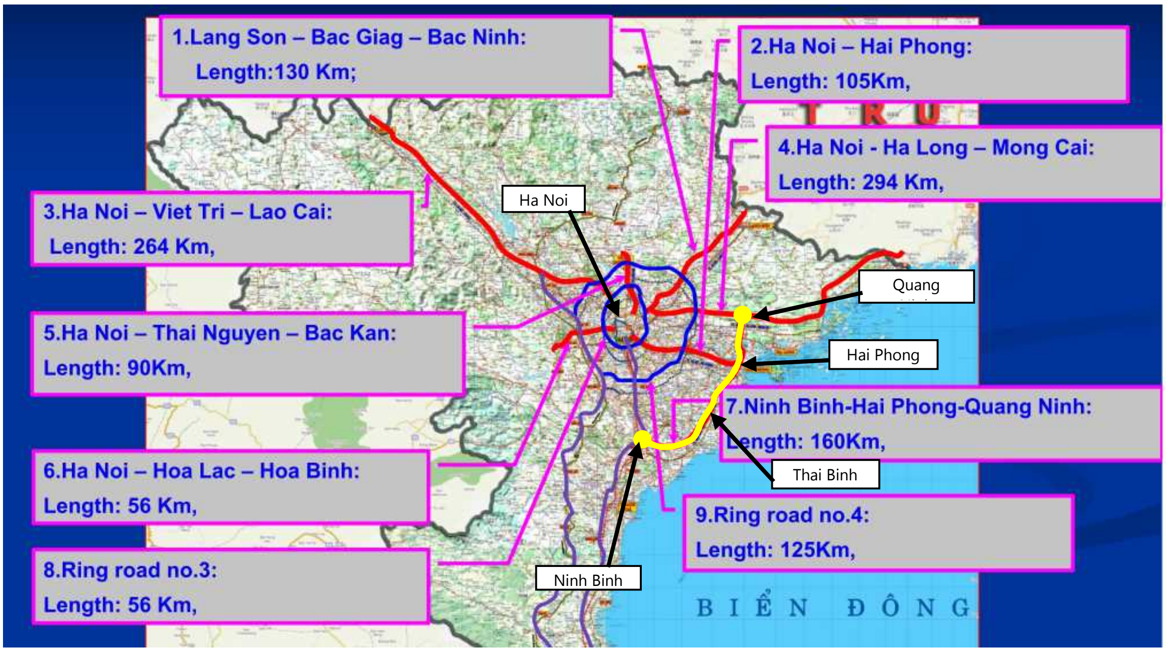
Expressway Section

The expressway will have 4 lanes in the beginning but this can be expanded to 6 lanes in the future.

The expressway portion broke ground on 13 September 2014 and also has a 24-month construction schedule. Work on the last package of the expressway section just started (in March 2015) and completion is scheduled for early 2017. In 2017, Quang Ninh Province will complete the entire project including the connecting section to the Ha Noi - Hai Phong Expressway.

When fully opened, the travel distance between Ha Long and Hai Phong will be shortened from 70km to 25km.

[4] "Bridge project to connect northern economic triangle," *Vietnam Investment Review*, http://www.vir.com.vn/bridge-project-to-connect-northern-economic-triangle.html; accessed 30 March 2015



Source: Report on Viet Nam Expressway Development Plan, Bui Dinh Tuan, Director of Viet Nam Expressway Operation and Maintenance Limited Liability Company, Sept. 2013

Figure 2.3-5 Route Alignment of the Ninh Binh-Hai Phong-Quang Ninh Expressway

(3) Hai Phong - Thai Binh Section

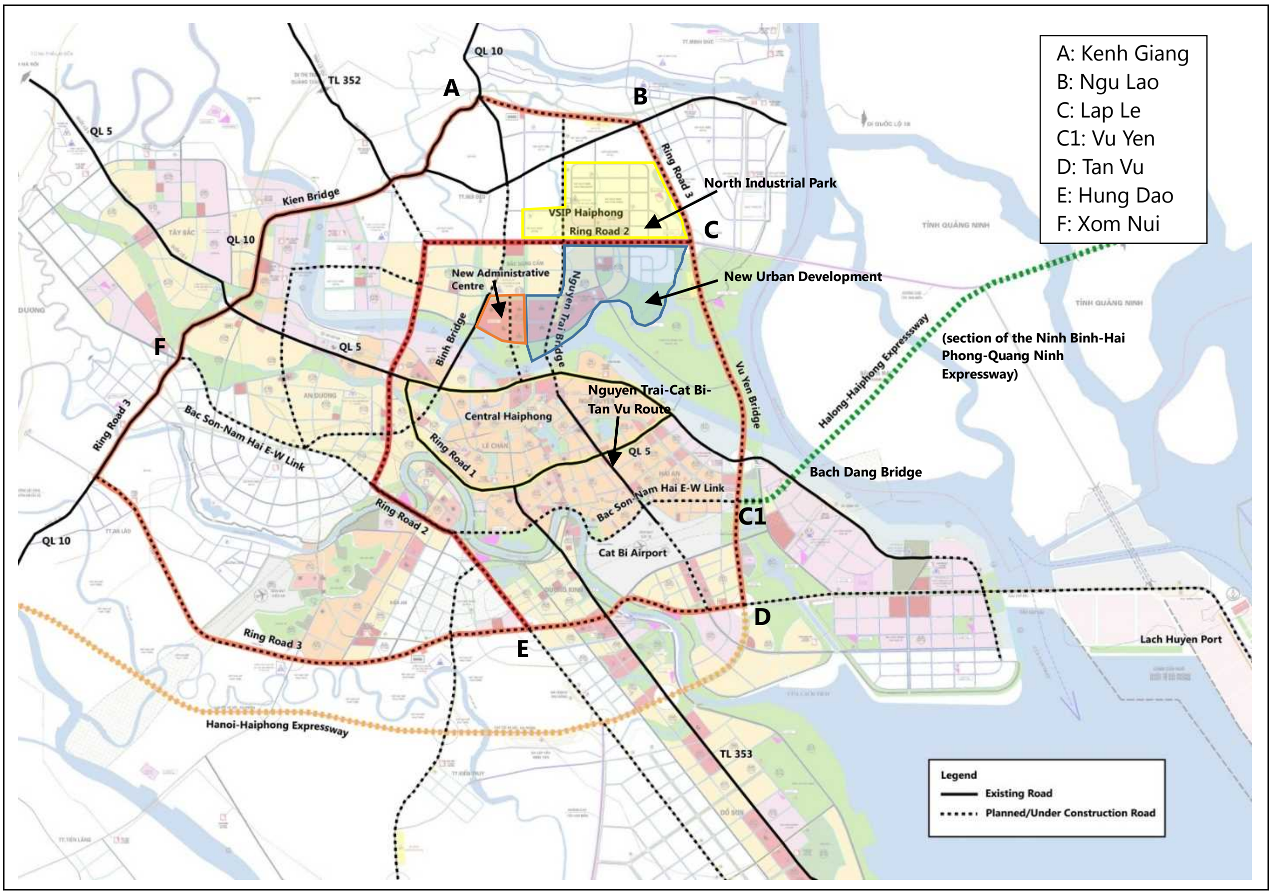
This section of the expressway will also be implemented under a BOT funding scheme and construction is scheduled to start in 2017.

2.3.2 Hai Phong Road Plan and Projects

(1) Summary of the Road Transport Master Plan, December 2014

In addition to the 3 intercity expressways mentioned previously, the "Road Transport Plan for Hai Phong City up to 2020, Vision for 2030" developed by the Vietnamese Ministry of Transport Development and Strategy Institute (TDSI) in December 2014 for Hai Phong's Department of Transport outlines the planning of major urban arterial roads and intercity national roads which are to cross Hai Phong in 2020 and 2030.

A snapshot of the Road Transport Master Plan (RT-MP) of Hai Phong by 2030 can be seen in the following figure.



Source: Study Team

Figure 2.3-6 Hai Phong Road Network Plan by 2030

1) Ring Roads

There are 3 major ring roads planned and designated for Hai Phong. The planning/construction status of these ring roads is shown in Figure 2.3-6.

Ring Road 1 is designed as a loop road surrounding the old central city of Hai Phong and the alignment utilizes existing city streets. See the general alignment of Ring Road 1 in Figure 2.3-6.

Ring Road 2 will be a new road forming a half circle from the Lap Le interchange with Ring Road 3 (Point C in Figure 2.3-6) in the VSIP Hai Phong area in the northeast of Hai Phong and will end at the Hung Dao interchange with Ring Road 3 (Point E in Figure 2.3-6). Ring Road 2 will be constructed in sections between now and 2030. The section of Ring Road 2 south of the Cam River is scheduled to be constructed by 2020 while the section crossing the Cam River and connecting with VSIP Hai Phong is scheduled to be constructed by 2030.

Ring Road 3 is the longest of the ring roads planned for Hai Phong. The section from Point A to Point F in Figure 2.3-6 already exists as National Road 10 (QL 10). The other sections will need to be newly constructed. The section from Point F to D have yet to be studied while the section from Point A to C1 is the target of this study.

2) Urban Arterial Roads

Figure 2.3-6 also shows the approximate alignment of the urban arterial roads which are being planned for Hai Phong. Although some sections of the urban arterial roads have already been constructed mainly near and south of the central area of Hai Phong, most are yet to be built. Two of the most important urban arterial roads are the Nguyen Trai Bridge - Cat Bi Airport - Tan Vu route and the Bac Son - Nam Hai East-West Link.

The Nguyen Trai Bridge - Cat Bi Airport - Tan Vu route is an arterial road that would connect the VSIP Hai Phong area north of the Cam River to Cat Bi Airport and Tan Vu while going through central Hai Phong. A portion of this road is already complete between central Hai Phong and Cat Bi Airport (see Figure 2.3-6) while the northern section which crosses the Cam River, the Nguyen Trai Bridge, is one of the targets of this study. The southbound section from Cat Bi Airport to Tan Vu is planned to be constructed underground. For both these sections, construction is scheduled between 2020 and 2030.

The Bac Son - Nam Hai East-West Link is part of a World Bank funded project and is described in greater detail in the following section.

3) Crossings over the Cam River

In RT-MP, 5 bridges and 1 tunnel excluding the existing Kien Bridge and Binh Bridge are planned as facilities to cross the Cam River. The locations of the crossings are shown in Figure 2.3-7. According to the DOC Planning Institute, which prepared RT-MP, and DOT, it has been decided to prioritize the construction of the two bridges which are objects of this survey among the 6 planned crossings included in RT-MP.

It has been decided to prioritize the construction of Vu Yen Bridge since it is required as part of Ring Road No. 2 and Ring Road No. 3.

HPPC is planning to construct the following three north-south routes in the Hai Phong City area as main roads: (1) Cat Bi Airport – Lach Tray Street – Nguyen Trai Bridge – New Administrative Center, (2) Vo Nguyen Giap Street – Hoang Van Thu Bridge – New Administrative Center, (3) a new north-south road located east of Vo Nguyen Giap Street and west of Lach Tray Street – Hoang Van Thu Bridge – New Administrative Center. Out of these, HPPC has decided to prioritize route (1) which connects Cat Bi Airport with the New Administrative Center and VSIP. Because of this, Nguyen Trai Bridge which is part of this route will be constructed before the other bridges. A 50.5m wide road has already been completed in accordance with RT-MP until a location about 400m from Nguyen Trai Bridge on the south side of the route.

According to the Urban Construction and Development PMU which is responsible for the planning of the Hoang Van Thu Bridge located 1km upstream from Nguyen Trai Bridge, it has not yet been decided what year construction of the bridge will start. Since construction is not progressing on the roads connected to the south of Hoang Van Thu Bridge and there are no other connections to main roads, the benefits of constructing the bridge are considered to be low at present.

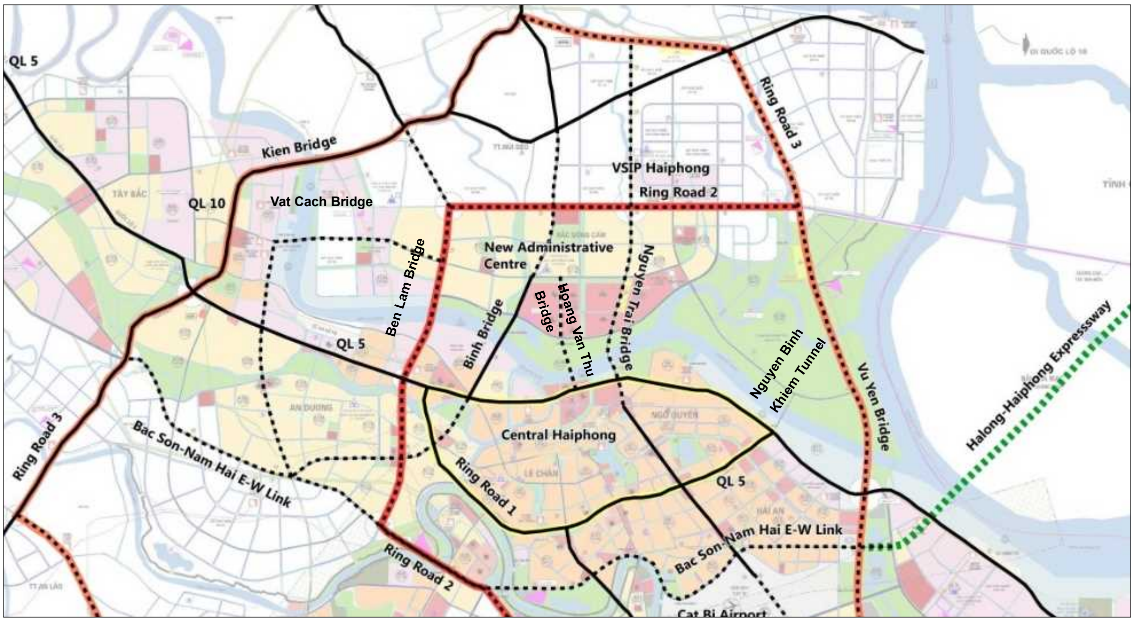


Figure 2.3-7 Planned Bridge and Tunnel Crossings over the Cam River

(2) Bac Son - Nam Hai East-West Link World Bank Project

The "Hai Phong Transport Development Project" is currently being conducted with funding from the World Bank.

The project has 3 main components: Component A focuses on road development, Component B on improving public transport, and Component C on human resource development for public transport. The project has 2 overall objectives, the development of an arterial road to support future urban development and improve public transport by conducting a pilot project for buses and helping to support the development of public transport professionals.

Of the US$277 million total project cost, US$175 million was loaned by the World Bank and a large majority of the funds were spent on Component A, the arterial road project. The breakdown of the project budget is as follows.

Table 2.3-1 Budget of the World Bank Project

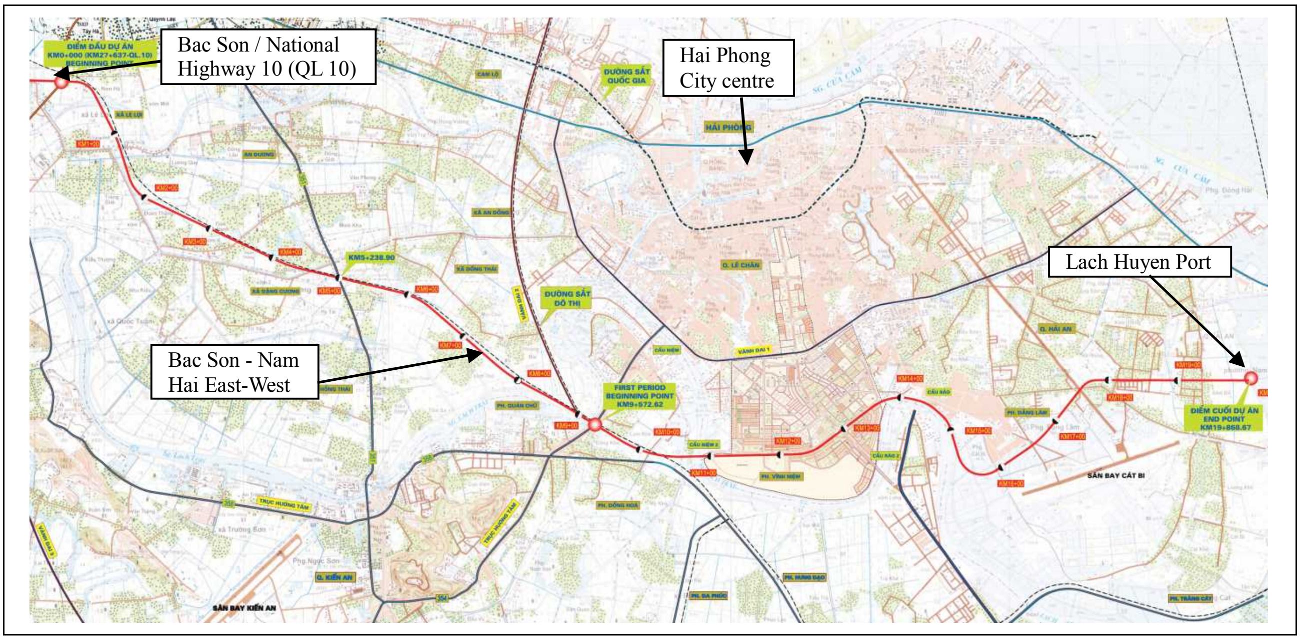
(Unit: US$ million)

	Estimated Cost	World Bank Loan
Component A - Arterial Road Development	263.58	163.93
Component B - Improvement of Public Transport	8.04	6.24
Component C - Development of Public Transport	4.99	4.82
Total	276.61	174.99

Source: Report No. 57809-VN, World Bank (2011)

Component A is a project to develop an arterial road that cuts across the southern portion of Hai Phong called the Bac Son - Nam Hai East-West Link. The purpose of this arterial road is to secure traffic capacity for commercial vehicles coming from the Hanoi direction to access Lach Huyen port in Hai Phong. In addition, the development of this road has a high priority in the infrastructure plans of Vietnam as it was included in TD-MP approved by the Vietnamese Prime Minister.

This road starts from the western part of Hai Phong at the intersection of Bac Son and National Highway 10 (QL 10) and goes in an east-west direction until it reaches the Lach Huyen port. The width of the road is 50.5 m which can be expanded to 6 lanes in the future, however, at the time of opening, the road will be built to 4 lanes as per the traffic demand forecast. The road is scheduled to open by 2016.



Source: Report No. 57809-VN, World Bank (2011)

Figure 2.3-8 Alignment of the Bac Son - Nam Hai East-West Link

(3) Dinh Vu - Cat Hai Economic Zone Road Master Plan

As part of the Dinh Vu - Cat Hai Economic Zone Master Plan, a road infrastructure master plan was developed by the consultant, Nikken Sekkei Civil Engineering of Japan.

With regards to transport infrastructure in the Dinh Vu - Cat Hai Economic Zone, urban expressways, main urban roads, secondary urban roads and frontage roads were laid out in the target area and cross-sections for each type of road were developed. This is shown in the following figure.

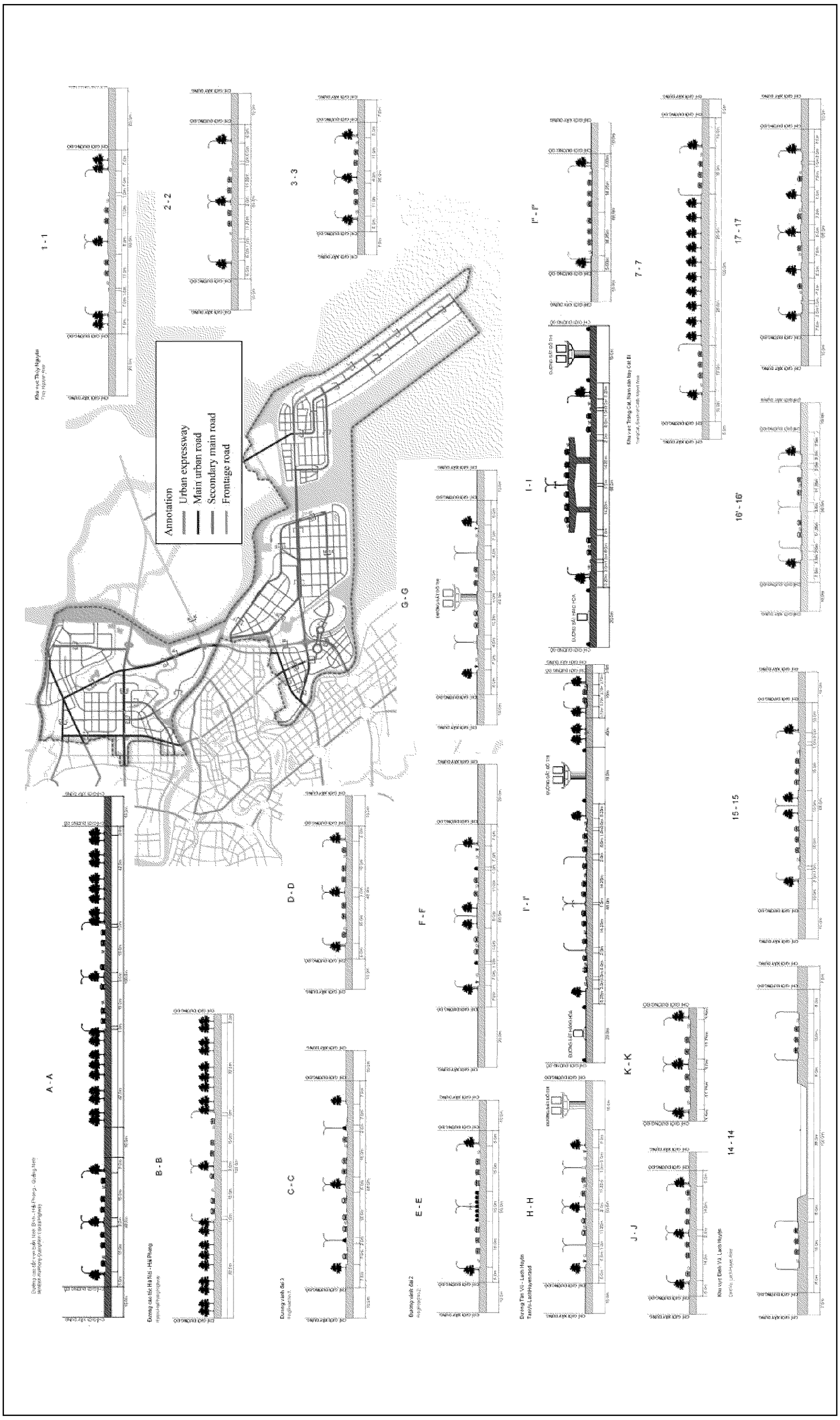


Figure 2.3-9 Transport Infrastructure Plan in the Dinh Vu - Cat Hai Economic Zone

2.3.3 Public Transport Plans

(1) Public Transport Plans in the Transport Development Master Plan

Public transport infrastructure was also incorporated into the transport infrastructure planning, and 3 potential urban railway alignments were identified and physical space was allocated to them in TD-MP. In regard to public bus transport, bus routes going to the city center of Hai Phong, those serving employees in the industrial park and port area, as well as loop bus routes serving the urban areas in the planning area were also identified.

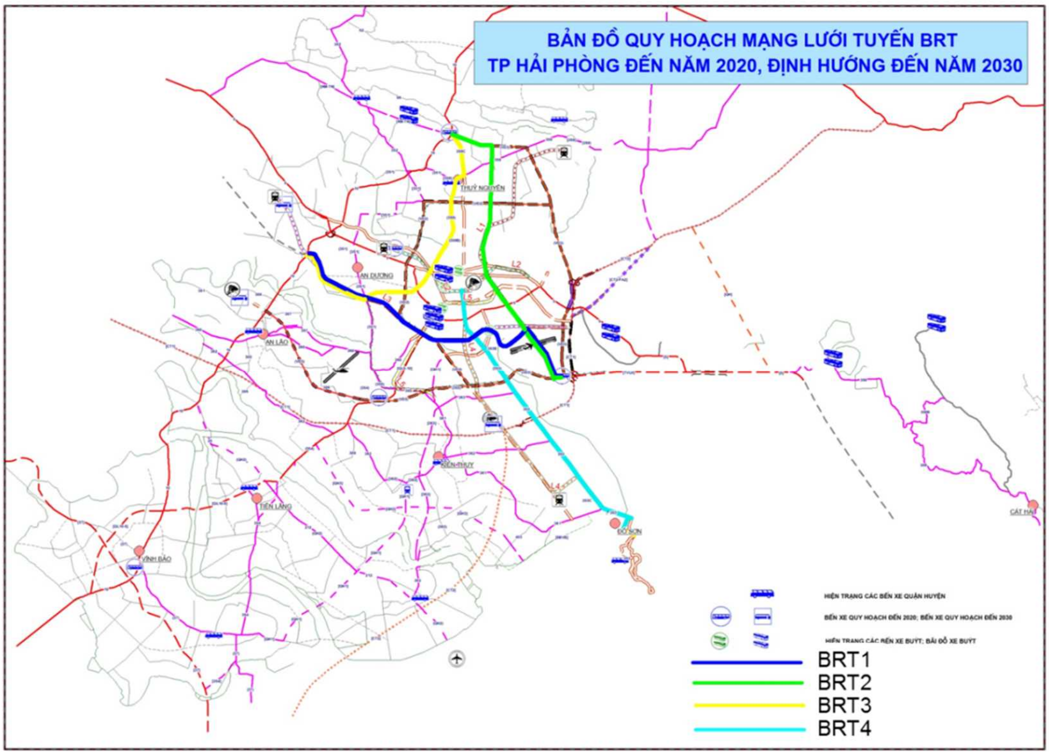
(2) BRT Plan

In the Hai Phong Public Transport Master Plan (PT-MP) produced by the Department of Transport of Hai Phong, 4 Bus Rapid Transit (BRT) routes are planned.

In Vietnam, the World Bank is supporting the planning and construction of BRT lines in Ha Noi, Da Nang and Ho Chi Minh City, but in the case of Hai Phong, there had not been any concrete discussions on support from the World Bank or from other international aid agencies regarding the planning and construction of BRT lines as of March 2015.

Of the 4 BRT lines, the route for BRT2 is planned to go over Nguyen Trai Bridge which is one of the bridges targeted in this study.

A map of the planned BRT lines and a summary of the planned routes are shown below.



Source: Hai Phong Department of Transport

Figure 2.3-10 Hai Phong BRT Plan

Table 2.3-2 Outline of BRT Plan in Hai Phong

	Route	Major Stations	Length (km)	Targeted Opening	
				Before 2020	After 2021
BRT1	Bac Son - East Bus Terminal	Bac Son - Le Hong - Cat Bi Airport - East Bus Terminal	22	○	
BRT2	North Bus Terminal - East Bus Terminal	North Bus Terminal - Ring Road 3 - Nguyen Trai Bridge - Le Hong Phong - Cat Bi Airport - East Bus Terminal	20		○
BRT3	Bac Son - North Bus Terminal	Bac Son - Dang Cuong - Thuong Ly - TL 359 - North Bus Terminal	21		○
BRT4	Hai Phong Central Area - Do Son	Ho Sen - Cau Rao - Pham Van Dong - Do Son	22	○	

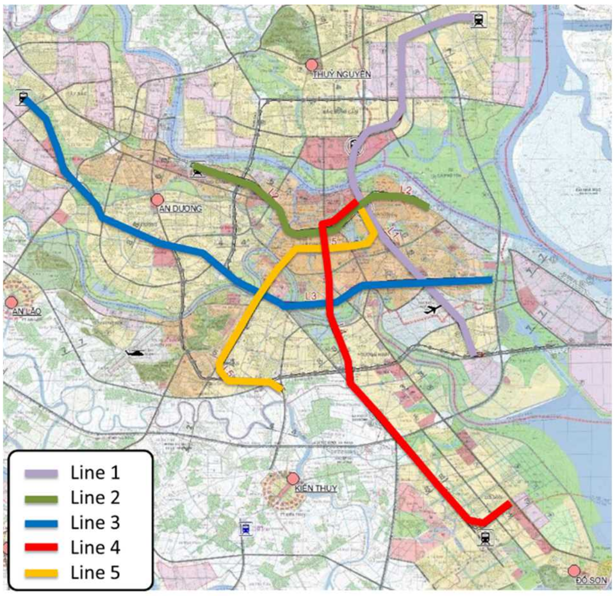
Source: Hai Phong Department of Transport

(3) Proposed Future Urban Railway Plan

For the period between 2020 and 2030, 5 urban railway lines have been proposed for Hai Phong, but as of March 2015, these 5 lines had yet to be studied in detail.

Currently, the Department of Transport of Hai Phong is revising the Transport Master Plan and only the road infrastructure development portion has been completed. The proposed future urban railway plan in Hai Phong will most likely be revised from the current proposal as shown below once the public transport portion of the Transport Master Plan has been updated.

Table 2.3-3 Proposed Future Urban Railway Plan in Hai Phong

	Route	Length (km)	Construction Period	Route Map
Line 1	Cam River North Side - Cat Bi - Tan Vu	20.8	2020 - 2025	
Line 2	Cam Lo - Hai Phong - Chua Ve	12.0	2030	
Line 3	Bac Son - Nam Hai	24.1	2030	
Line 4	Lac Vien - Ho Sen - Cau Rao 3 - Do Son	20.2	2020 - 2025	
Line 5	Lac Vien - Ho An Bien - Cau Niem - Da Phuc	14.2	2030	
	Total Length:	91.3		

Source: Hai Phong Department of Transport

2.3.4 Airport and Seaport Projects

(1) Lach Huyen Port

The Vietnamese Ministry of Transport has planned the development of an international gateway port in the coastal area of Hai Phong on the Dinh Vu peninsula and on Cat Hai Island.

The entire area will be connected to the existing and future road network of Hai Phong including the Ha Noi - Hai Phong Expressway which is due to open by the end of 2015.

The development of Lach Huyen Port is also part of the Dinh Vu - Cat Hai Economic Zone designed by the Vietnamese government.

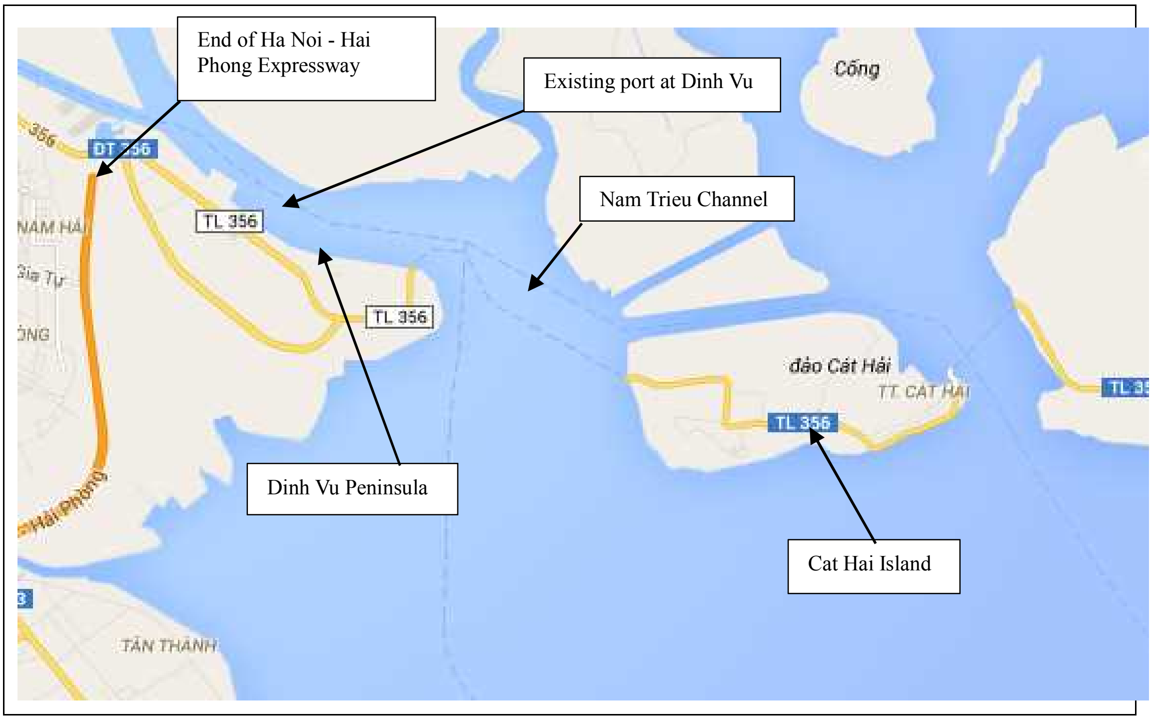
According to the "Master Plan of Viet Nam Seaport System to 2020" approved by the Prime Minister in Decision No. 2190/QD-TTG, seaports are classified into 6 groups for each geographic area of Vietnam: Group 1 (Northern Seaports), Group 2 (Northern Central Seaports), Group 3 (Mid-Central Seaports), Group 4 (Southern Central Seaports), Group 5 (Ho Chi Minh City area seaports) and Group 6 (Mekong Delta Seaports)[5].

The Lach Huyen Port project consists of 2 sections, the Dinh Vu port development for the near term and the Lach Huyen deep sea port development for the long term. The port belongs to the Group 1 port system which was included by the Prime Minister in the "North Seaport Group

[5] Development of Container Ports Vietnam, Ministry of Transport, Vietnam Maritime Administration, UNESCAP Presentation, Bangkok, Nov. 21, 2012

Schemes for 2010 and 2020." [6]

Currently, the Dinh Vu peninsula is a developing industrial and trade zone that is separated by the Nam Trieu Channel from Cat Hai Island. Cat Hai Island is mostly undeveloped land where the new deep sea port, Lach Huyen Port will be built.



Source: Based Image from Google Maps, 2015

Figure 2.3-11 Current Conditions of Lach Huyen Port (2015)

There is an existing port on the Dinh Vu peninsula and it is planned for the port to be upgraded from 2 berths to 5 berths by 2020, increasing capacity to 6 million tons per year. The Dinh Vu Port development has 2 phases: Phase 1 (2001-2005) consisted of the construction of 2 harbors with 20,000 tonnage throughput per harbor while Phase 2 consists of the construction of 4 additional harbors with 20,000 tonnage throughput per harbor.

It was estimated that Dinh Vu Port will handle 4.5 million tons/year in 2015 so it may be necessary to expand the port towards the lower section of Dinh Vu peninsula to meet this demand. The ultimate capacity of Dinh Vu Port was assumed to be 10 million tons/year.

The following figure shows the expanded Dinh Vu Port by 2020 and the associated new road network.

[6] Consulting Services for Planning Construction Investment Project, Tan Vu-Lach Huyen Highway Project in Hai Phong City, Traffic Forecast Demand (Adjusted Hanoi-Hai Phong Expressway), Mar. 6, 2009, Revision 2, Japan Bridge & Structure Institute, Inc., Hyder Consulting Ltd., Highway Engineering Consultants Joint Stock Company

Source: Consulting Services for Planning Construction Investment Project Tan Vu - Lach Huyen Highway Project in Hai Phong City (2009)

Figure 2.3-12 Upgraded Dinh Vu Port

Cat Hai Island is located east of the Dinh Vu peninsula and separated from the mainland by the Nam Trieu Channel. There are approximately 27,390 people living on the island with 2 townships and 10 communities.

The new deep sea Lach Huyen Port is to be developed at Cat Hai Island and will be able to serve 45,000-50,000 ton capacity ships. In planning documents completion is targeted for 2030. The following figure shows the ultimate plan and build-out of Dinh Vu Port and Lach Huyen deep sea port. It is estimated that Lach Huyen Port will handle 5.1 million tons/year in 2015 and 29.1 million tons/year in 2020.

Source: SEDS 2011-2020, SEDP 2011-2015, Hai Phong Construction Master Plan

Figure 2.3-13 Ultimate Build-Out of Dinh Vu Port and Lach Huyen Deep Sea Port

(2) Cat Bi International Airport

According to the People's Committee of Hai Phong and the Airports Corporation of Vietnam, a new passenger terminal is currently being constructed at Cat Bi International Airport, the main airport in Hai Phong.

The investment amount for the new passenger terminal is about 1.5 trillion VND (US$70 million, US$1.00=21,545 VND) and is funded using a build-transfer (BT) scheme.

The new passenger terminal is being constructed 150m away from the existing passenger terminal. It will be a 2-story structure with a gross floor area of about 15,000 m^2. Also, a 6,000m^2 parking garage will be constructed. The new terminal will be used for both international and domestic flights, with the first floor for arrivals and the second floor for departures.

The new terminal is scheduled for completion on 13 May 2016. Once completed and in operation, it is estimated that the annual passenger handling capacity of the airport will increase by 5 times to 4,000,000. The People's Committee of Hai Phong expects that the upgrading of Cat Bi International Airport will accelerate economic development in Hai Phong.

The estimated passenger and freight capacity of the new terminal is summarized below.

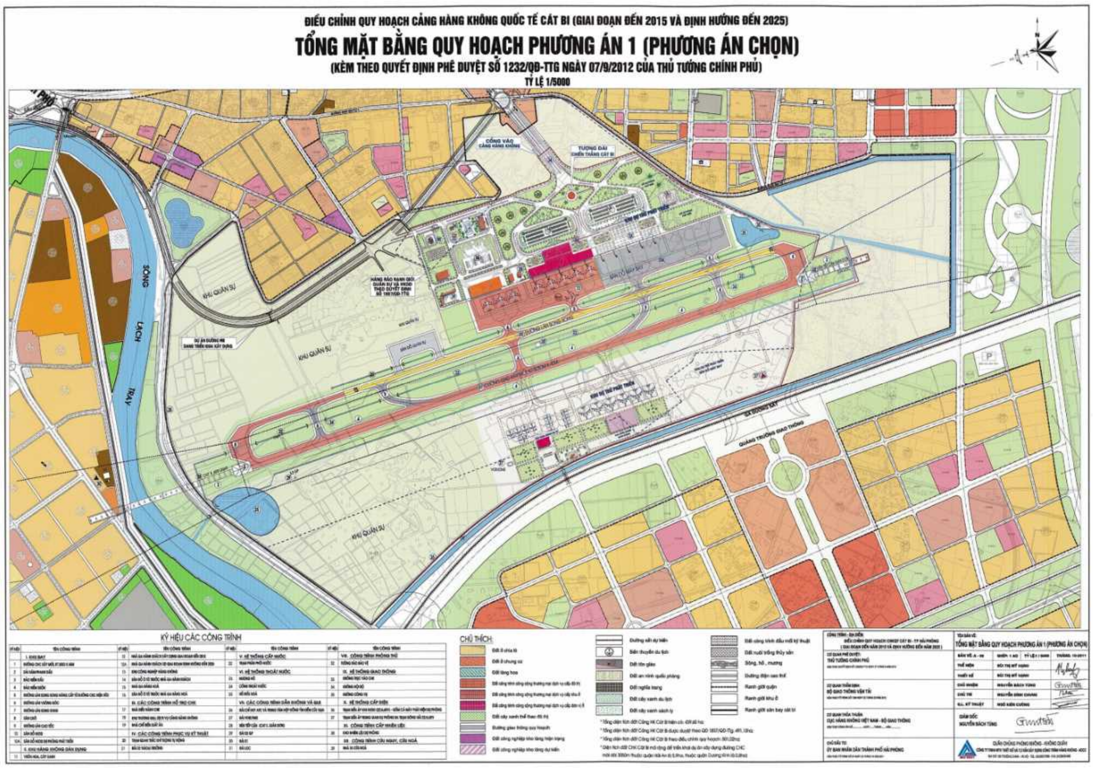
- In 2015 (existing passenger terminal):
  - 2,000,000 passengers/year
  - 17,000 tons of freight/year

- In 2025 (with new passenger terminal):
  - 4,000,000 passengers/year
  - 82,000 tons of freight/year

Table 2.3-4 Statistical Data of Cat Bi Airport

Item	Unit	2013	2014 (estimate)	2014/2013
Take-Off and Landing	Times	6,236.0	6,750.0	+8.2%
Passenger Transportation	1,000 persons	834.5	850.5	+1.9%
Freight	Tons	5,505.0	5,862.0	+6.5%
Revenue	Billion VND	49.7	54.6	+9.8%

Source: Hai Phong Statistical Book 2014 (updated on 28 January 2015)



Source: Hai Phong Department of Transport

Figure 2.3-14 Cat Bi International Airport Plan

2.4 Scale and Results of Japanese ODA

Economic cooperation with Japan restarted in November 1992, and Japan is currently the largest provider of assistance to Vietnam in the world, with ODA loans in 2012 amounting to 200 billion yen (Exchange of Notes basis).

Table 2.4-1 Scale and Results of Japanese ODA to Vietnam

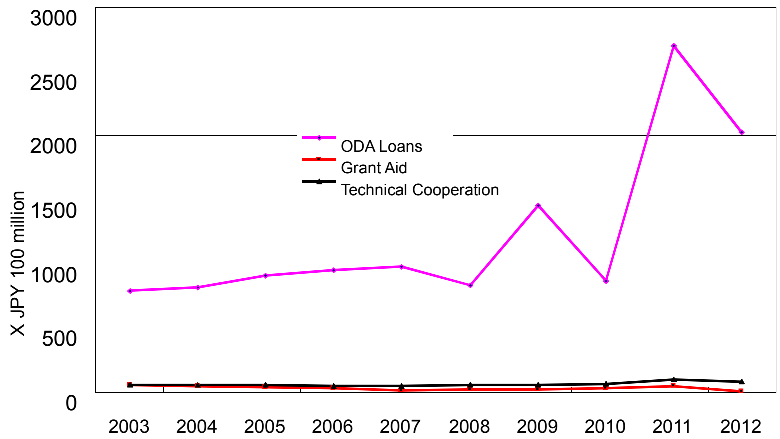
Unit: JPY 100 million

	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
ODA Loans	793.30	820.00	908.20	950.78	978.53	832.01	1,456.00	865.68	2,700.38	2,029.26	1,177.61
Grant Aid	56.50	49.14	44.65	30.97	21.18	26.63	28.26	35.46	52.77	12.23	23.98
Technical Cooperation	55.77	57.11	56.51	52.75	51.98	59.65	61.42	71.52	104.86	85.15	107.12

Source: Ministry of Foreign Affairs website, http://www.mofa.go.jp/mofaj/area/vietnam/data.html

JICA website, http://www.jica.go.jp/about/report/2014/ku57pq00001nol70-att/s02.pdf

Note: "Fiscal Year" (FY) is based on the signatory date of the Exchange of Notes for loans (ODA loans) and the budgetary year for grant aid and technical cooperation. The amount is on an Exchange of Notes basis for loans and grant aid, and on an actual expense basis for technical cooperation.



Source: Study Team

Figure 2.4-1 Scale and Results of Japanese ODA to Vietnam

Table 2.4-2 ODA Project List in Hai Phong

No	Source	Project Name	Year	Type
1	Finland ODA	Rao II Bridge construction project	2009	Loan
2		Water supply and drainage in Hai Phong	Unknown	Loan
3		Viet Tiep hospital upgrade and rehabilitation	Ongoing	Loan
4	WB	Hai Phong urban transportation development project	2011 (Ongoing)	Loan
5	Japan ODA	Hai Phong Port Rehabilitation Project	1994, 2000	Loan
6		National Highway No.10 Improvement Project (I)	2000	Loan
7		Binh Bridge construction project	2000	Loan
8		Binh Bridge repair and rehabilitation project	2012	Loan
9		Lach Huyen Port Infrastructure Construction Project (Road and Bridge)	2011, 2014 (Ongoing)	Loan
10		Lach Huyen Port Infrastructure Construction Project(Prot)	2011, 2014 (Ongoing)	Loan
11		Hai Phong City Environmental Improvement Project	2005, 2009 (Ongoing)	Loan
12	JICA Partnership Program	Technical transfer for improvement of technical and management ability of Hai Phong fabrication industry	Unknown	
13		Support for human resource training to improve the efficiency of goods flow in Hai Phong Port	Unknown	
14		Support for improving of management ability of water supply & drainage for Hai Phong Water Supply Co.	Unknown	
15		Improve public awareness, education and media of waste water, stormwater drainage and solid waste management	Unknown	
16		Improve management ability on factory of producing companies	Unknown	
17		Support for training of medical human resources (with Kagawa province)	Unknown	
18		Support for training of human resource for improvement of the operation for water drainage system	Unknown	
19	ADB	Hai Phong water supply project	Unknown	TA
20		Water sector investment program - Tranche 2	Unknown	Loan

Chapter 3 NATURAL CONDITIONS

This chapter presents all the results of natural condition survey. In order to secure the necessary accuracy of the preparatory study, the survey was implemented along the proposed routes of the Nguyen Trai Bridge, Vu Yen Bridge and Ring Road 3. The survey was consigned to local contractors and was performed under supervision of the JICA study team.

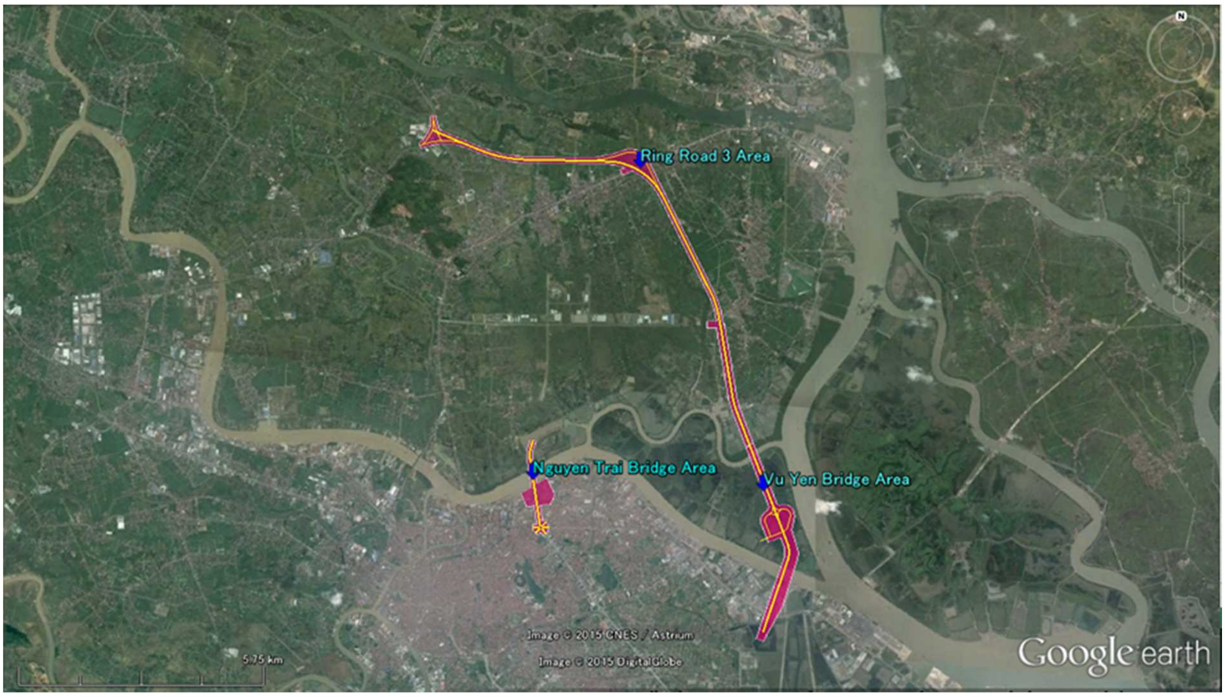
The survey includes topographic and geological survey. The site survey was started on 1st April and completed on 14th August. Progress chart of the survey is shown in Figure 3.1.

		2015						Date Started	Date Completed
		March	April	May	Jun	July	Aug		
Topographic Survey	Site Work							3rd April	10th July
	Report							11th May	11th August
Obstacle Survey	Site Work							4th April	1st June
	Report							2nd June	13th July
Geological Survey	Site Work							1st April	11th July
	Laboratory Test							1st May	29th July
	Report							11th May	14th August

Figure 3.1 Progress Chart for Natural Condition Survey

3.1 Topographic Survey

Topographic survey includes land topographic survey and echo sounding on water was implemented to acquire the information for planning and designing of target facilities. Figure 3.1-1 show maps of the surveyed area include Nguyen Trai Bridge Site (NT site), Vu Yen Bridge Site (VY site) and Ring Road 3 Site (RR site). As built coordinates and elevation of exploratory drilling points were also determined by the survey (SI point positioning). Table 3.1-1 shows quantities of the topographic survey work. Results of the survey were compiled in each topographic map and sections and submitted separately. They were utilized to realize topographic conditions at the project sites for determining type and scale of the target facilities.



Base image from Google Earth, 2015

Figure 3.1-1 Range of Topographic Survey Area

Table 3.1-1 Quantities of Topographic Survey Work

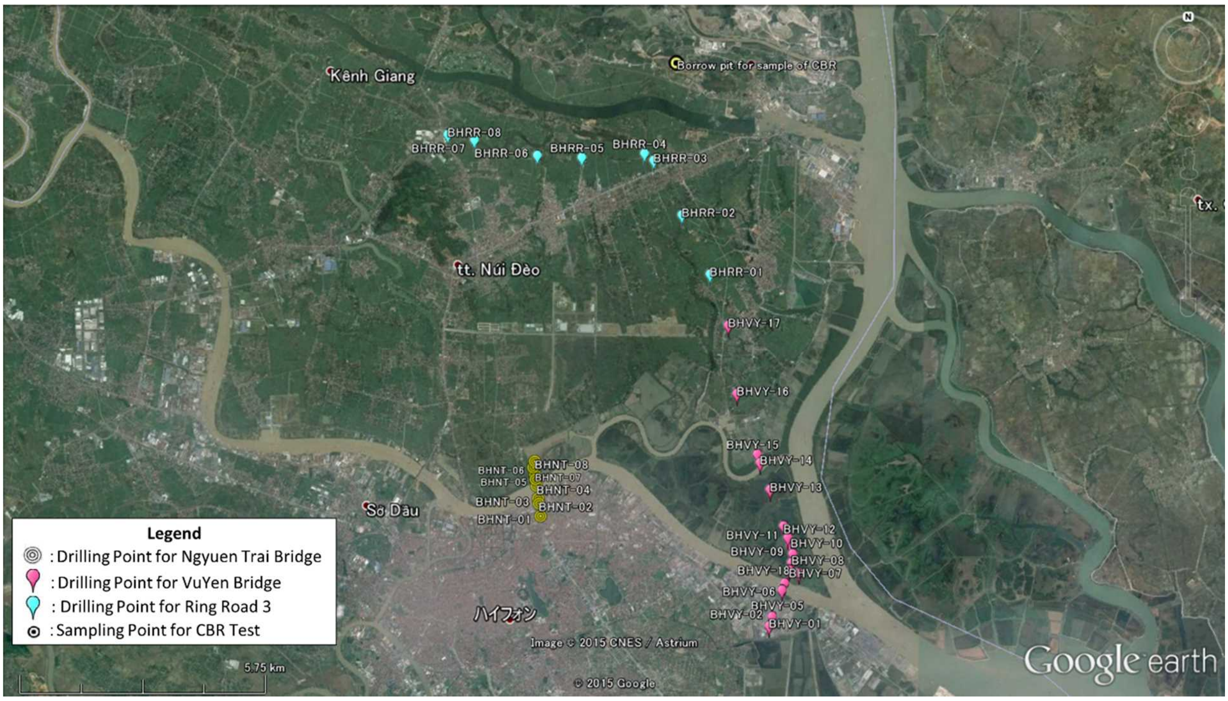
Item	Unit	Quantities	Remarks
Horizontal and Vertical control net work			
Primary control points	Points	10	
Leveling control network	km	43.261	
Secondary control point	Points	81	
Technical leveling network	km	26.809	
Topographic Survey			
Topographic map, scale of 1/1000 on land	ha	583.52	
Topographic map, scale of 1/1000 in river	ha	45.439	
Profile at scale for V=1/100, H=1/1000	km	19.862	
Cross section at scale for V=1/200, 1/200	km	73.15	
SI positioning	Points	32	

3.2 Geological Survey

Geological survey includes exploratory drillings and laboratory soil tests to acquire the information for planning and designing of target facilities.

3.2.1 Contents and Results of the Geological Survey

In the geological survey, exploratory drillings were carried out at selected locations of proposed abutments and piers of the bridges and at some embankments. One bulk sample for CBR tests was also collected from a proposed borrow pit. Locations of the drilling and the bulk sample sampling were shown in Figure 3.2-1.



Base image from Google Earth, 2015

Figure 3.2-1 Location of Geological Survey

Standard Penetration Test (SPT), Undisturbed soil Sampling (UD Sampling) and rock coring were included in the exploratory drillings. Ground water levels of the drilling holes were also measured.

SPTs were performed at each 1 meter depth except for the depths of UD Sampling. The tests were continued until detecting 3 meter with “N value equal to or more than 50” (continuously 4 times) or 5 meter with “N value equal to or more than 30” (continuously 6 times) thick consecutive hard soil layer or rock layer. UD Samplings were performed at selected depths in very soft to soft soil layers of “N value equal to or less than 4” by using hydraulic piston samplers.

Results of the exploratory drillings are compiled in each drilling log and presented in an Appendix A. Photographs of SPT sample for each drilling location are compiled and presented in an Appendix B.

Quantities of the exploratory drilling work were shown in Table 3.2-1.

Table 3.2-1 Quantities of Exploratory Drilling Work

Location		HP (nos)	SPT (nos)	Rock Coring (nos)	Final Depth (m)
Nguyen Trai Bridge Area	BHNT-01	3	44	0	47.45
	BHNT-02	2	47	3	50.00
	BHNT-03	1	48	3	49.08
	BHNT-04	2	41	3	44.24
	BHNT-05	2	37	0	39.45
	BHNT-06	2	43	3	45.27
	BHNT-07	2	40	0	42.45
	BHNT-08	2	46	3	48.03
Subtotal		16	346	15	365.97
Vu Yen Bridge Area	BHVY-01	2	40	3	43.37
	BHVY-02	3	42	3	45.12
	BHVY-05	2	43	3	45.07
	BHVY-06	2	42	3	44.06
	BHVY-07	1	39	2	40.10
	BHVY-08	2	39	3	41.06
	BHVY-09	1	39	3	40.29
	BHVY-10	2	37	3	39.06
	BHVY-11	2	37	3	39.49
	BHVY-12	3	38	3	41.09
	BHVY-13	2	41	3	41.91
	BHVY-14	2	37	3	39.07
	BHVY-15	2	39	3	41.07
	BHVY-16	1	39	3	40.05
	BHVY-17	2	32	3	33.79
	BHVY-18	1	44	3	44.65
Subtotal		30	628	47	659.25
Ring Road 3 Area	BHRR-01	1	22	3	23.12
	BHRR-02	0	20	3	20.07
	BHRR-03	1	17	3	18.03
	BHRR-04	1	19	3	19.96
	BHRR-05	1	21	3	22.09
	BHRR-06	2	19	3	20.07
	BHRR-07	1	17	3	19.02
	BHRR-08	2	28	3	30.07
Subtotal		9	163	24	172.43
Total		55	1137	86	1197.65

HP: Undisturbed soil sampling using Hydrolic Piston sampler
SPT: Standard Penetration Test

Laboratory soil tests were carried out in a contractor's laboratory in Hanoi under supervision of an engineer of JICA study team. All the UD Samples, some SPT samples and a bulk sample from the borrow pit were subjected to test program. Physical property tests were carried out on all the selected samples. Mechanical property tests were carried out on UD samples and CBR tests were carried out on the bulk sample. Tests were performed in accordance with ASTM standards.

Quantities of the laboratory soil tests were shown in Table 3.2-2. All test results were summarized in Table 3.2-3 and Appendix A3. All raw data were submitted separately as the contractor's factual report. The test results were utilized to evaluate each soil layer and were used for designing.

Table 3.2-2 Quantities of Laboratory Soil Test

Location		Physical Property Tests					Mechanical Property Tests		CBR
		Wn	Gs	Sieve	LL & PL	γt	qu	Consolidation	
Nguyen Trai Bridge Area	BHNT-01	4	5	5	5	3	3	3	-
	BHNT-02	4	4	4	3	2	2	2	-
	BHNT-03	3	3	3	3	1	1	1	-
	BHNT-04	3	4	4	4	2	2	2	-
	BHNT-05	4	4	4	4	2	2	2	-
	BHNT-06	4	4	4	4	2	2	2	-
	BHNT-07	4	4	4	4	2	2	2	-
	BHNT-08	4	4	4	4	2	2	2	-
Subtotal		30	32	32	31	16	16	16	0
Vu Yen Bridge Area	BHVY-01	4	4	4	4	2	2	2	-
	BHVY-02	5	5	5	4	3	3	3	-
	BHVY-05	4	4	4	4	2	1	2	-
	BHVY-06	4	4	4	4	2	2	2	-
	BHVY-07	3	3	3	3	1	1	1	-
	BHVY-08	4	4	4	4	2	2	2	-
	BHVY-09	2	3	3	3	1	1	1	-
	BHVY-10	4	4	4	4	2	2	2	-
	BHVY-11	3	4	4	4	2	2	2	-
	BHVY-12	5	5	5	5	3	3	3	-
	BHVY-13	3	4	4	4	2	2	2	-
	BHVY-14	4	4	4	4	2	2	2	-
	BHVY-15	3	4	4	4	2	2	2	-
	BHVY-16	3	3	3	3	1	1	1	-
	BHVY-17	4	4	4	4	2	2	2	-
	BHVY-18	3	3	3	3	1	1	1	-
Subtotal		58	62	62	61	30	29	30	0
Ring Road 3 Area	BHRR-01	3	3	3	3	1	1	1	-
	BHRR-02	2	4	4	4	-	-	-	-
	BHRR-03	3	3	3	3	1	1	1	-
	BHRR-04	3	3	3	3	1	1	1	-
	BHRR-05	3	3	3	3	1	1	1	-
	BHRR-06	3	4	4	3	2	2	2	-
	BHRR-07	3	3	3	3	1	1	1	-
	BHRR-08	3	4	4	4	2	2	2	-
Subtotal		23	27	27	26	9	9	9	0
Borrow Pit	Borrow Pit	-	-	-	-	-	-	-	1
Subtotal		0	0	0	0	0	0	0	1
Total		111	121	121	118	55	54	55	1

Wn: Water Content **Gs**: Specific Gravity **Seive**: Grain Size Analysis **LL&PL**: Atterberg Limit
γt: Unit Weight **qu**: Uncomfined compression Test

Table 3.2-3 Summary of Soil Test Results

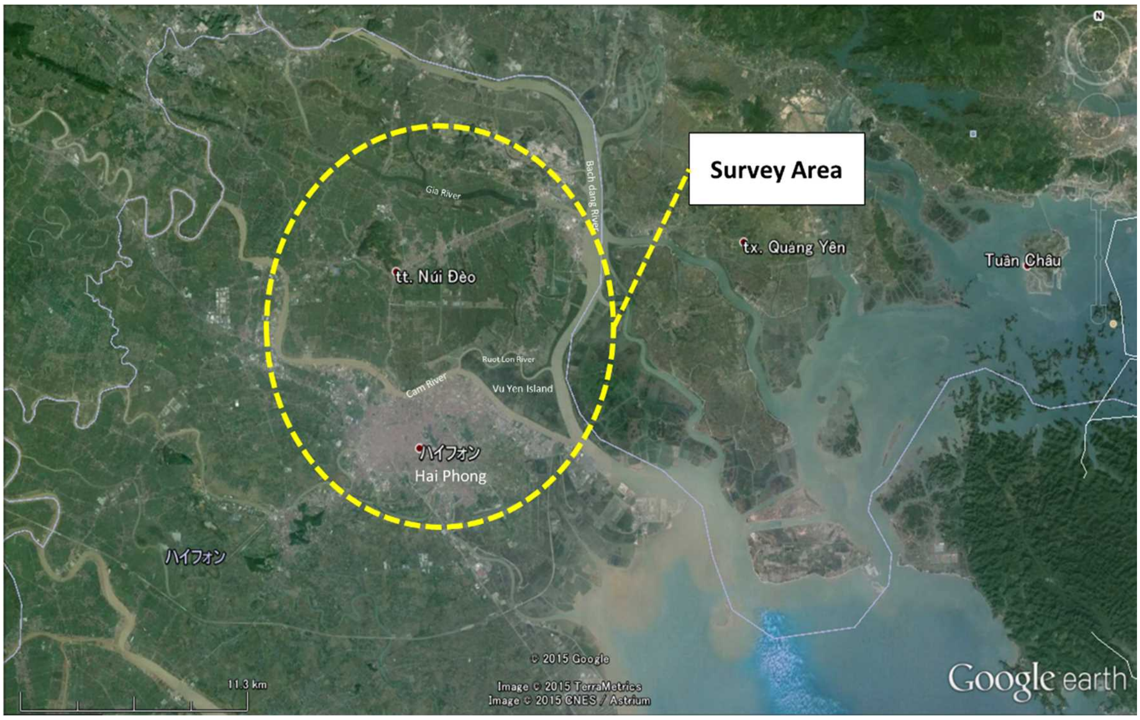
Area	BH No.	Sample No.	Sample depth (Top)	Sample depth (Bottom)	Depth AV (m)	Elevation (m)	Wn	Gs	γt (kN/m^3)	Dry density	e	Sr	LL	PL	PI	Gravel	Sand	Silt	Clay&colloid	D60	D10	Soil description by Laboratory of TEC	ASTM classification	Pc (kPa)	Cc	Cr	Unconfined Compression Strength qu (kPa)	qu/2 (kPa)	Strain at failure (%)	CBR (%)	Remarks
NGUYEN TRAI BRIDGE	BHNT-01	HP-1	4.00	5.00	4.50	-2.20	55.75	2.74	16.3	1.07	1.561	97.86	50.27	33.26	17.01	0	1.76	72.47	25.77			Darkish grey Elastic silt	MH	80	0.538	0.079	37.79	18.89	15.00		
		HP-2	15.00	16.00	15.50	-13.20	37.59	2.69	17.8	1.32	1.038	97.42	38.48	25.03	13.45	0	3.42	80.78	15.80			Brownish grey Silt	ML	135	0.37	0.05	35.62	17.81	15.00		
		HP-3	23.00	24.00	23.50	-21.20	51.55	2.73	16.9	1.13	1.416	99.39	56	34.38	21.62	0	3.14	69.12	27.74			Brownish grey Elastic silt	MH	152	0.563	0.071	41.39	20.69	6.09		
		SPT-10	11.00	11.45	11.23	-8.93	27.45	2.71	-	-	-	-	32.78	21.15	11.63	0	11.36	67.84	20.80			Yellowish grey Lean clay	CL								
		SPT-35	38.00	38.45	38.23	-35.93	-	2.65	-	-	-	-	14.25	10.37	3.88	0	91.26	8.74	0.00	0.2099	0.0769	Yellowish grey Poorly - graded sand with silt	SP-SM								
	BHNT-02	HP-1	4.00	5.00	4.50	-1.77	45.28	2.71	17.2	1.21	1.24	98.96	50.31	33.21	17.1	0	1.16	71.41	27.43			Brownish grey Elastic silt	MH	101	0.45	0.05	46.06	23.03	15.00		
		HP-2	19.00	20.00	19.50	-16.77	42.09	2.75	17.2	1.23	1.236	93.65	41.26	31.28	9.98	0	3.80	85.18	11.02			Brownish grey Silt	ML	188	0.62	0.083	81.01	40.51	4.27		
		SPT-30	32.00	32.45	32.23	-29.50	18.65	2.65	-	-	-	-	-	-	-	1.39	88.75	4.86	5.00	0.463	0.089	Grey Poorly - graded sand	SP								
		SPT-36	38.00	38.45	38.23	-35.50	11.47	2.65	-	-	-	-	13.98	10.25	3.73	11.00	53.30	13.70	22.00	1.307	0.060	Grey Silty sand	SM								
	BHNT-03	HP-1	16.00	17.00	16.50	-14.23	47.49	2.72	17.1	1.18	1.305	98.98	50.01	32.55	17.46	0	1.94	72.29	25.77			Brownish grey Elastic silt	MH	148	0.42	0.063	23.85	11.92	14.43		
		SPT-22	23.00	23.45	23.23	-20.96	51.28	2.67	-	-	-	-	59.24	32.07	27.17	0	2.41	77.79	19.80			Grey Elastic silt	MH								
		SPT-33	34.00	34.45	34.23	-31.96	22.89	2.65	-	-	-	-	14.01	10.36	3.65	0	83.91	16.09	0.00	0.186	0.066	Grey Silty sand	SM								
	BHNT-04	HP-1	4.00	5.00	4.50	-8.83	51.76	2.74	16.9	1.13	1.425	99.52	36.88	27.25	9.63	0	63.80	33.68	2.52			Brown Silty sand	SM	53	0.477	0.055	28.29	14.14	6.50		
		HP-2	15.00	16.00	15.50	-19.83	47.39	2.78	17.2	1.19	1.336	98.61	55.48	32.44	23.04	0	2.90	71.33	25.77			Bluish grey Elastic silt	MH	233	0.829	0.109	119.10	59.55	3.27		
		SPT-4	6.00	6.45	6.23	-10.56	-	2.65	-	-	-	-	13.21	10.06	3.15	0	92.00	8.00	0.00	0.201	0.078	Poorly - graded sand with silt	SP-SM								
		SPT-24	27.00	27.45	27.23	-31.56	27.09	2.68	-	-	-	-	32.87	21.55	11.32	0	2.42	73.48	24.10			Lean clay	CL								
	BHNT-05	HP-1	4.00	5.00	4.50	-4.30	44.55	2.75	17.3	1.22	1.254	97.7	51.55	33.97	17.58	0	3.62	69.31	27.07			Brownish grey Elastic silt	MH	89	0.30	0.025	18.29	9.15	11.05		
		HP-2	19.00	20.00	19.50	-19.30	36.96	2.71	18.0	1.34	1.022	98.01	41.69	29.34	12.35	0	42.36	51.82	5.82			Darkish grey Sandy silt	ML	162	0.269	0.019	21.76	10.88	10.41		
		SPT-10	11.00	11.45	11.23	-11.03	29.93	2.74	-	-	-	-	29.12	19.18	9.94	0	32.04	60.60	7.36			Darkish grey Sandy lean clay	CL								
		SPT-25	27.00	27.45	27.23	-27.03	35.60	2.75	-	-	-	-	38.05	23.38	14.67	0	3.52	70.71	25.77			Grey Lean clay	CL								
	BHNT-06	HP-1	2.00	3.00	2.50	0.38	52.72	2.71	16.7	1.11	1.441	99.15	50.21	35.56	14.65	0	4.08	78.42	17.50			Brownish grey Elastic silt	MH	54	0.391	0.045	21.83	10.92	15.00		
		HP-2	6.00	7.00	6.50	-3.62	54.74	2.68	16.4	1.08	1.481	99.06	54.99	36.76	18.23	0	11.98	68.75	19.27			Brownish grey Elastic silt	MH	67	0.479	0.054	19.69	9.84	12.96		
		SPT-11	13.00	13.45	13.23	-10.35	54.14	2.67	-	-	-	-	34.13	27.48	6.65	0	31.96	60.65	7.39			Darkish grey Sandy silt	ML								
		SPT-34	36.00	36.45	36.23	-33.35	28.27	2.79	-	-	-	-	50.71	28.57	22.14	0	3.04	67.50	29.46			Yellowish grey Elastic silt	MH								
	BHNT-07	HP-1	3.00	4.00	3.50	-1.40	40.73	2.74	17.5	1.27	1.157	96.46	48.26	29.79	18.47	0	1.80	69.14	29.06			Brownish grey Silt	ML	74	0.386	0.045	32.11	16.06	12.56		
		HP-2	10.00	11.00	10.50	-8.40	51.56	2.69	16.5	1.11	1.423	97.47	54.82	33.99	20.83	0	9.60	64.13	26.27			Brownish grey Elastic silt	MH	85	0.565	0.084	42.73	21.36	9.05		
		SPT-25	27.00	27.45	27.23	-25.13	39.02	2.77	-	-	-	-	43.41	25.93	17.48	0	6.04	67.83	26.13			Grey Lean clay	CL								
		SPT-34	36.00	36.45	36.23	-34.13	24.94	2.65	-	-	-	-	13.57	10.42	3.15	0	81.50	18.50	0.00	0.181	0.063	Grey Silty sand	SM								
	BHNT-08	HP-1	8.00	9.00	8.50	-6.77	59.85	2.7	16.1	1.03	1.621	99.69	58.73	35.62	23.11	0	1.68	72.29	26.03			Brownish grey Elastic silt	MH	49	0.49	0.076	21.52	10.76	11.26		
		HP-2	13.00	14.00	13.50	-11.77	46.48	2.71	17.2	1.19	1.277	98.64	41.33	27.94	13.39	0	1.50	79.35	19.15			Brownish grey Silt	ML	95	0.49	0.076	61.09	30.54	12.80		
		SPT-28	30.00	30.45	30.23	-28.50	27.62	2.78	-	-	-	-	36.7	21.3	15.4	0	3.02	67.53	29.45			Grey Lean clay	CL								
		SPT-39	41.00	41.45	41.23	-39.50	20.1	2.68	-	-	-	-	19.77	16.77	3	0	35.22	57.35	7.43			Darkish grey Sandy silt	ML								
VU YEN BRIDGE	BHVY-01	HP-1	6.00	7.00	6.50	-4.12	54.46	2.7	15.6	1.03	1.621	90.71	50.04	31.91	18.13	0	10.02	76.07	13.91			Brownhish grey Elastic silt	MH	60	0.501	0.069	28.86	14.43	7.53		
		HP-2	8.00	9.00	8.50	-6.12	49.09	2.71	16.4	1.12	1.42	93.69	49.35	28.17	21.18	0	6.40	81.31	12.29			Brownhish grey Silt	ML	89	0.542	0.09	37.89	18.95	9.81		
		SPT-15	18.00	18.45	18.23	-15.85	28.68	2.72	-	-	-	-	39.93	22.52	17.41	0	2.84	68.08	29.08			Brown Lean clay	CL								
		SPT-26	29.00	29.45	29.23	-26.85	31.54	2.7	-	-	-	-	31.44	20.25	11.19	0	49.22	48.20	2.58			Yellowwish grey Sandy lean clay	CL								
	BHVY-02	HP-1	4.00	5.00	4.50	-2.48	42.73	2.72	17.3	1.24	1.194	97.34	38.74	23.07	15.67	0	4.62	76.21	19.17			Bluish grey Lean clay	CL	81	0.388	0.043	43.77	21.89	9.16		
		HP-2	7.00	8.00	7.50	-5.48	46.77	2.7	16.1	1.12	1.411	89.5	39.86	24.97	14.89	0	11.60	77.54	10.86			Bluish grey Lean clay	CL	97	0.53	0.064	42.56	21.28	8.86		
		HP-3	12.00	13.00	12.50	-10.48	55.82	2.67	16.0	1.05	1.543	96.59	51.82	28.2	23.62	0	21.52	67.74	10.74			Brownish grey Fat clay with sand	CH	108	0.629	0.088	38.22	19.11	9.91		
		SPT-12	15.00	15.45	15.23	-13.21	34.07	2.65	-	-	-	-	30.28	23.38	6.90	0	69.24	28.19	2.57			Grey Silty sand	SM								
		SPT-31	34.00	34.45	34.23	-32.21	18.88	2.65	-	-	-	-	20.15	14.25	5.90	0	62.56	34.87	2.57			Yellowish grey Silty clayey sand	SC-SM								
	BHVY-05	HP-1	4.00	5.00	4.50	-2.10	44.16	2.74	16.8	1.19	1.303	92.86	45.2	27.00	18.20	0	5.22	69.01	25.77			Brownhish grey Silt	ML	93	0.474	0.068	40.74	20.37	7.6		
		HP-2	8.00	9.00	8.50	-6.10	32.39	2.75	17.4	1.34	1.052	84.67	33.55	25.56	7.99	0	28.82	68.51	2.67			Bubble grey Silt with sand	ML	137	0.39	0.047					
		SPT-13	15.00	15.45	15.23	-12.83	26.27	2.75	-	-	-	-	35.06	20.84	14.22	0	0.90	69.67	29.43			Yellowwish brown Lean clay	CL								
		SPT-38	40.00	40.45	40.23	-37.83	23.87	2.61	-	-	-	-	23.32	18.80	4.52	0	39.50	58.14	2.36			Grey Sandy silty clay	CL-ML								
	BHVY-06	HP-1	3.00	4.00	3.50	-4.95	48.1	2.74	16.2	1.11	1.468	89.78	43.18	25.86	17.32	0	4.04	80.26	15.70			Grey Lean clay	CL	44	0.475	0.067	22.12	11.06	9.29		
		HP-2	5.00	6.00	5.50	-6.95	47.53	2.77	17.0	1.17	1.368	96.24	45.73	27.47	18.26	0	4.00	77.04	18.96			Brownhish grey Silt	ML	58	0.479	0.051	28.13	14.06	8.81		
		SPT-22	24.00	24.45	24.23	-25.68	44.50	2.75	-	-	-	-	49.86	28.73	21.13	0	1.00	79.79	19.21			Grey Silt	ML								
		SPT-32	34.00	34.45	34.23	-35.68	20.38	2.62	-	-	-	-	25.93	15.33	10.6	0	32.22	62.10	5.68			Grey Sandy lean clay	CL								
	BHVY-07	HP-1	6.00	7.00	6.50	-6.12	62.67	2.68	15.8	0.99	1.707	98.39	63.91	35.37	28.54	0	2.96	74.41	22.63			Bluish grey Elastic silt	MH	77	0.818	0.132	51.91	25.95	4.36		
		SPT-17	18.00	18.45	18.23	-17.85	40.78	2.7	-	-	-	-	46.25	30.81	15.44	0	6.38	72.62	21.00			Grey Silt	ML								
		SPT-30	31.00	31.45	31.23	-30.85	23.34	2.69	-	-	-	-	36.43	20.95	15.48	0	5.80	70.09	24.11			Brownish yellow Lean clay	CL								
	BHVY-08	HP-1	3.00	4.00	3.50	-2.27	29.18	2.69	18.8	1.49	0.805	97.51	26.42	21.59	4.83	0	58.78	38.67	2.55			Grey Silty clayey sand	SC-SM	138	0.193	0.011	58.24	29.12	5.51		
		HP-2	9.00	10.00	9.50	-8.27	27.86	2.79	19.2	1.53	0.824	94.33	35.61	23.73	11.88	0	6.02	73.41	20.57			Reddish brown Lean clay	CL	127	0.253	0.032	41.36	20.68	7.00		
		SPT-19	21.00	21.45	21.23	-20.00	42.47	2.73	-	-	-	-	48.02	28.14	19.88	0	7.82	81.37	10.81			Bluish grey Silt	ML								
		SPT-33	35.00	35.45	35.23	-34.00	20.38	2.68	-	-	-	-	19.75	14.83	4.92	0	52.92	44.59	2.49			Bluish grey Silty clayey sand	SC-SM								
	BHVY-09	HP-1	5.00	6.00	5.50	-4.57	46.05	2.68	17.1	1.19	1.252	98.57	49.51	31.09	18.42	0	9.78	67.78	22.44			Brownish grey Silt	ML	125	0.544	0.066	61.84	30.92	5.76		
		SPT-16	17.00	17.45	17.23	-16.30	48.69	2.72	-	-	-	-	55.92	33.00	22.92	0	1.70	72.81	25.49			Brown Elastic silt	MH								
		SPT-33	34.00	34.45	34.23	-33.30	-	2.65	-	-	-	-	14.25	10.63	3.62	0	85.87	14.13	0.00	0.227	0.068	Light grey Silty sand	SM								

Area	BH No.	Sample No.	Sample depth (Top)	Sample depth (Bottom)	Depth AV (m)	Elevation (m)	Wn	Gs	γ_t (kN/m^3)	Dry density	e	Sr	LL	PL	PI	Gravel	Sand	Silt	Clay&colloid	D60	D10	Soil description by Laboratory of TEC	ASTM classification	Pc (kPa)	Cc	Cr	Unconfined Compression Strength qu (kPa)	qu/2 (kPa)	Strain at failure (%)	CBR (%)	Remarks
VU YEN BRIDGE	BHVY-10	HP-1	6.00	7.00	6.50	-5.49	55.4	2.78	16.4	1.07	1.598	96.38	48.17	33.63	14.54	0	7.64	64.95	27.41			Bluish grey Silt	ML	75	0.661	0.078	37.76	18.88	6.49		
		HP-2	16.00	17.00	16.50	-15.49	47.46	2.79	17.3	1.2	1.325	99.93	51.75	31.99	19.76	0	2.52	68.45	29.03			Bluish grey Elastic silt	MH	265	0.785	0.100	139.98	69.99	6.56		
		SPT-12	13.00	13.45	13.23	-12.22	27.21	2.75	-	-	-	-	42.40	25.45	16.95	0	7.86	63.08	29.06			Brownish yellow Lean clay	CL								
		SPT-26	28.00	28.45	28.23	-27.22	15.75	2.67	-	-	-	-	21.33	13.78	7.55	0	42.62	49.99	7.39			Bluish grey Sandy lean clay	CL								
	BHVY-11	HP-1	5.00	6.00	5.50	-5.03	39.00	2.71	17.4	1.28	1.117	94.62	43.04	28.84	14.2	0	18.36	67.45	14.19			Bluish grey Silt with sand	ML	151	0.403	0.045	45.86	22.93	6.5		
		HP-2	10.00	11.00	10.50	-10.03	36.18	2.82	17.9	1.34	1.104	92.42	31.72	19.3	12.42	0	11.50	67.94	20.56			Bluish grey Lean clay	CL	111	0.372	0.038	69.81	34.90	4.94		
		SPT-30	32.00	32.45	32.23	-31.76	-	2.65	-	-	-	-	13.76	10.52	3.24	0	90.80	9.20	0.00	0.224	0.076	Yellow Poorly - graded sand with silt	SP-SM								
		SPT-33	35.00	35.45	35.23	-34.76	21.59	2.7	-	-	-	-	28.04	19.63	8.41	0	8.70	83.75	7.55			Grey Lean clay	CL								
	BHVY-12	HP-1	3.00	4.00	3.50	-2.97	30.25	2.72	18.0	1.41	0.929	88.57	26.49	20.02	6.47	0	37.06	55.49	7.45			Brownish grey, bluish grey Sandy silty clay	CL-ML	137	0.252	0.02	36.33	18.16	6.99		
		HP-2	8.00	9.00	8.50	-7.97	38.49	2.74	17.2	1.26	1.175	89.76	35.44	21.04	14.4	0	51.08	39.71	9.21			Bluish grey Clayey sand	SC	101	0.487	0.075	54.39	27.20	5.78		
		HP-3	12.00	13.00	12.50	-11.97	43.83	2.72	16.6	1.17	1.325	89.98	43.32	27.71	15.61	0	1.70	75.58	22.72			Brownish grey Silt	ML	225	0.634	0.085	129.26	64.63	6.73		
		SPT-21	24.00	24.45	24.23	-23.70	31.99	2.7	-	-	-	-	34.19	22.34	11.85	0	2.40	69.89	27.71			Bluish grey Lean clay	CL								
		SPT-31	34.00	34.45	34.23	-33.70	17.23	2.67	-	-	-	-	18.08	12.17	5.91	0	60.04	37.40	2.56			Grey Silty clayey sand	SC-SM								
	BHVY-13	HP-1	4.00	5.00	4.50	-2.62	44.72	2.73	17.1	1.2	1.275	95.75	37.62	24.47	13.15	0	37.28	48.48	14.24			Brownish grey Sandy lean clay	CL	104	0.407	0.048	34.95	17.48	6.29		
		HP-2	12.00	13.00	12.50	-10.62	42.33	2.74	17.2	1.24	1.21	95.85	41.17	26.15	15.02	0	2.42	71.49	26.09			Bluish grey Silt	ML	245	0.581	0.072	133.54	66.77	7.00		
		SPT-19	21.00	21.45	21.23	-19.35	28.66	2.7	-	-	-	-	40.92	24.21	16.71	0	2.10	73.55	24.35			Yellowish grey Lean clay	CL								
		SPT-26	28.00	28.45	28.23	-26.35	-	2.65	-	-	-	-	13.96	10.45	3.51	0	88.05	11.95	0.00	0.201	0.072	Grey Poorly - graded sand with silt	SP-SM								
	BHVY-14	HP-1	5.00	6.00	5.50	-5.17	27.41	2.74	18.8	1.51	0.815	92.15	24.48	19.55	4.93	0	58.14	36.00	5.86			Brownish grey Silty clayey sand	SC-SM	165	0.203	0.012	36.91	18.46	3.97		
		HP-2	11.00	12.00	11.50	-11.17	54.87	2.73	16.0	1.05	1.6	93.62	50.15	31.63	18.52	0	2.22	61.68	36.10			Brownish grey Elastic silt	MH	174	0.753	0.099	93.72	46.86	6.43		
		SPT-6	7.00	7.45	7.23	-6.90	25.7	2.73		-	-	-	36.5	21.79	14.71	0	4.40	72.86	22.74			Yellowwish grey Lean clay	CL								
		SPT-22	24.00	24.45	24.23	-23.90	38.79	2.74		-	-	-	39.35	23.17	16.18	0	2.12	78.44	19.44			Grey Lean clay	CL								
	BHVY-15	HP-1	4.00	5.00	4.50	-5.05	39.34	2.68	17.7	1.3	1.062	99.28	37.81	24.71	13.1	0	25.58	58.76	15.66			Brownish grey, bluish grey Lean clay with sand	CL	136	0.3	0.028	28.16	14.08	7.81		
		HP-2	10.00	11.00	10.50	-11.05	45.34	2.77	16.9	1.18	1.347	93.24	44.00	26.66	17.34	0	2.30	69.91	27.79			Bluish grey Silt	ML	186	0.621	0.079	102.41	51.21	5.71		
		SPT-16	18.00	18.45	18.23	-18.78	50.44	2.66	-	-	-	-	53.17	28.92	24.25	0	1.50	86.05	12.45			Grey Fat clay	CH								
		SPT-23	25.00	25.45	25.23	-25.78	-	2.6	-	-	-	-	14.25	10.75	3.5	0	82.92	17.08	0.00	0.203	0.064	Yellowwish grey Silty sand	SM								
	BHVY-16	HP-1	3.00	4.00	3.50	-2.38	60.62	2.68	15.6	0.99	1.707	95.17	52.14	34.09	18.05	0	7.88	69.49	22.63			Darkish grey Elastic silt	MH	63	0.549	0.071	13.07	6.53	10.98		
		SPT-19	20.00	20.45	20.23	-19.11	51.21	2.76	-	-	-	-	57.91	33.05	24.86	0	6.51	73.04	20.45			Grey Elastic silt	MH								
		SPT-31	32.00	32.45	32.23	-31.11	20.15	2.63	-	-	-	-	13.25	10.17	3.08	6.76	85.95	7.29	0.00	0.976	0.094	Yellowish grey Well - graded sand with silt	SW-SM								
	BHVY-17	HP-1	3.00	4.00	3.50	-2.59	51.34	2.67	16.7	1.12	1.384	99.04	40.92	27.3	13.62	0	27.20	62.04	10.76			Darkish grey Silt with sand	ML	54	0.396	0.06	26.07	13.03	10.51		
		HP-2	6.00	7.00	6.50	-5.59	50.51	2.73	16.6	1.12	1.438	95.89	48.49	33.52	14.97	0	1.96	72.27	25.77			Yellowish grey Silt	ML	109	0.523	0.088	38.57	19.28	15.00		
		SPT-10	12.00	12.45	12.23	-11.32	48.49	2.72	-	-	-	-	51.33	30.09	21.24	0	3.70	78.59	17.71			Grey Elastic silt	MH								
		SPT-19	21.00	21.45	21.23	-20.32	18.06	2.68	-	-	-	-	17.20	13.26	3.94	0	31.30	66.20	2.50			Yellowish grey Sandy silt	ML								
	BHVY-18	HP-1	4.00	5.00	4.50	-1.61	33.03	2.72	18.2	1.4	0.943	95.27	35.36	28.61	6.75	0	41.12	56.27	2.61			Grey Sandy silt	ML	142	0.258	0.013	42.76	21.38	6.1		
		SPT-25	26.00	26.45	26.23	-23.34	44.92	2.7	-	-	-	-	48.4	27.73	20.67	0	1.02	78.19	20.79			Grey Silt	ML								
		SPT-38	39.00	39.45	39.23	-36.34	25.78	2.7	-	-	-	-	21.78	16.42	5.36	0	39.98	54.22	5.80			Darkish grey Sandy silty clay	CL-ML								
RING ROAD 3	BHRR-01	HP-1	3.00	4.00	3.50	-2.04	47.65	2.67	16.6	1.14	1.342	94.8	48.78	32.28	16.5	0	11.68	77.56	10.76			Yellowish grey Silt	ML	50	0.364	0.046	15.45	7.73	15.00		
		SPT-9	10.00	10.45	10.23	-8.77	44.88	2.67	-	-	-	-	45.69	27.27	18.42	0	6.65	73.95	19.40			Grey Silt	ML								
		SPT-16	17.00	17.45	17.23	-15.77	23.1	2.67	-	-	-	-	27.27	16.69	10.58	0	33.91	54.47	11.62			Yellowish grey Sandy lean clay	CL								
	BHRR-02	SPT-1	1.00	1.45	1.23	-0.41	45.5	2.7	-	-	-	-	43.57	26.97	16.6	0	7.16	68.73	24.11			Brownish grey Silt	ML								
		SPT-6	6.00	6.45	6.23	-5.41	51.18	2.67	-	-	-	-	46.37	29.05	17.32	0	5.24	68.77	25.99			Grey Silt	ML								
		SPT-12	12.00	12.45	12.23	-11.41	-	2.62	-	-	-	-	13.98	10.52	3.46	0	94.45	5.55	0.00	0.222	0.082	Yellowish grey Poorly - graded sand with silt	SP-SM								
		SPT-15	15.00	15.45	15.23	-14.41	-	2.63	-	-	-	-	-	-	-	27.27	53.64	4.54	14.55	2.229	0.101	Whitish grey Poorly - graded sand with gravel	SP								
	BHRR-03	HP-1	6.00	7.00	6.50	-3.85	43.29	2.72	17.2	1.22	1.23	95.73	47.85	30.47	17.38	0	2.04	70.23	27.73			Brownish grey, darkish grey Silt	ML	114	0.445	0.056	35.05	17.52	10.96		
		SPT-7	8.00	8.45	8.23	-5.58	55.51	2.67	-	-	-	-	53.99	28.08	25.91	0	4.78	81.01	14.21			Grey Fat clay	CH								
		SPT-11	12.00	12.45	12.23	-9.58	21.94	2.67	-	-	-	-	30.49	20.61	9.88	0	20.17	65.65	14.18			Yellowish grey Lean clay with sand	CL								
	BHRR-04	HP-1	5.00	6.00	5.50	-2.89	41.46	2.67	17.4	1.26	1.119	98.93	46.25	29.36	16.89	0	6.84	79.16	14.00			Brownish grey, darkish grey Silt	ML	111	0.388	0.058	49.80	24.90	13.22		
		SPT-2	2.00	2.45	2.23	0.39	19.11	2.67	-	-	-	-	25.38	16.35	9.03	0	34.98	57.32	7.70			Yellowish grey Sandy lean clay	CL								
		SPT-12	13.00	13.45	13.23	-10.62	19.77	2.68	-	-	-	-	24.74	15.54	9.2	0	15.22	65.51	19.27			Grey Lean clay with sand	CL								
	BHRR-05	HP-1	6.00	7.00	6.50	-3.98	51.34	2.71	16.8	1.13	1.398	99.52	44.62	28.62	16	0	21.64	59.21	19.15			Brownish grey Silt with sand	ML	91	0.525	0.084	24.48	12.24	10.13		
		SPT-7	8.00	8.45	8.23	-5.71	21.83	2.67	-	-	-	-	23.53	16.47	7.06	0	61.77	35.60	2.63			Yellowish grey Clayey sand	SC								
		SPT-10	11.00	11.45	11.23	-8.71	25.25	2.7	-	-	-	-	32.68	21.54	11.14	0	10.08	63.76	26.16			Grey Lean clay	CL								
	BHRR-06	HP-1	1.00	2.00	1.50	0.35	43.28	2.71	16.9	1.2	1.258	93.23	43.31	27.97	15.34	0	4.66	74.31	21.03			Grey Silt	ML	109	0.449	0.069	28.26	14.13	14.57		
		HP-2	6.00	7.00	6.50	-4.65	31.15	2.72	18.9	1.47	0.85	99.68	32.95	21.79	11.16	0	11.30	77.78	10.92			Grey, yellowish grey Lean clay	CL	143	0.267	0.033	90.78	45.39	13.65		
		SPT-8	9.00	9.45	9.23	-7.38	42.27	2.67	-	-	-	-	36.18	20.78	15.4	0	15.67	67.66	16.67			Grey Lean clay with sand	CL								
		SPT-12	13.00	13.45	13.23	-11.38	-	2.65	-	-	-	-	-	-	-	0	95.35	4.65	0.00	0.203	0.077	Grey Poorly - graded sand	SP								
	BHRR-07	HP-1	5.00	6.00	5.50	-4.29	50.37	2.68	16.8	1.14	1.351	99.92	48.96	37.02	11.94	0	9.92	77.54	12.54			Darkish grey Silt	ML	105	0.475	0.062	56.65	28.33	13.37		
		SPT-9	11.00	11.45	11.23	-10.02	26.02	2.79	-	-	-	-	37.3	23.62	13.68	0	5.20	60.87	33.93			Yellowish grey Lean clay	CL								
		SPT-13	15.00	15.45	15.23	-14.02	26.44	2.7	-	-	-	-	39.4	25.08	14.32	0	3.91	67.79	28.30			Grey Lean clay	CL								
	BHRR-08	HP-1	7.00	8.00	7.50	-5.46	43.17	2.71	16.5	1.17	1.316	88.9	45.29	30.71	14.58	0	13.56	70.76	15.68			Brownish grey Silt	ML	85	0.496	0.078	33.40	16.70	12.42		
		HP-2	9.00	10.00	9.50	-7.46	51.97	2.72	16.7	1.12	1.429	98.92	49.15	34.25	14.9	0	2.5	68.4	29.10			Brownish grey Silt	ML	113	0.511	0.088	38.22	19.11	15.00		
		SPT-12	14.00	14.45	14.23	-12.19	-	2.65	-	-	-	-	14.58	11.03	3.55	0	94.66	5.34	0.00	0.256	0.083	Yellowish grey Poorly - graded sand with silt	SP-SM								
		SPT-19	21.00	21.45	21.23	-19.19	36.29	2.79	-	-	-	-	40.62	24.78	15.84	0	6.54	64.00	29.46			Brownish grey Lean clay	CL								
	Borrow Pit		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.08	

3.2.2 Evaluation of Geology

(1) General Topography and Geology

The site is located on North Vietnam, eastward about 100 km from Hanoi city. Figure 3.2-2 shows the location of the site area. The area is in the Red River delta where a large low land or wet land is developed. Some tributaries are meandering and forming complex channels in the area. The area is spread west side of Bach Dang River between 6 km and 18 km from the river mouth. The Cam River cuts through the area from west to east at its southern part. Vu Yen Island occupies southeast part in the area. It is faced to Cam River at its south and to Bach Dang River at its east. Mangrove swamps and tidal flats spread along those riversides.



Base image from Google Earth, 2015

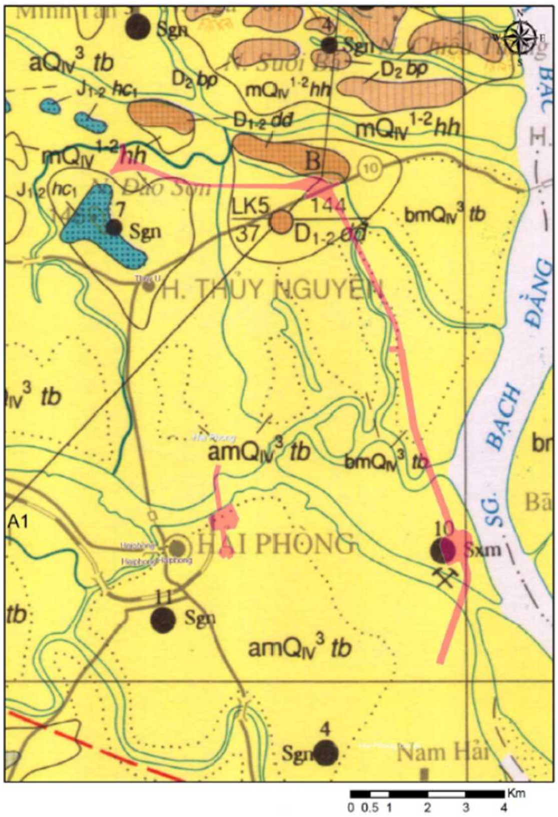
Figure 3.2-2 Location of the Site Area

Considering from the general topography and the river flow, general trend of elevation of the area is estimated higher at north-west and lower at south-east. The elevation of the site is roughly MSL -1.5 m to +3.0m at drilling locations except at BHNT-04. BHNT-04 is located in the Cam River at which elevation is MSL-4.33m.

Figure 3.2-3 shows a general geology around the site. Young deposits are the main geology of this area, which are named “Than Binh Formation”, “Hai Hung formation”, “Vinh Phuc Formation” and “Ha Noi Formation”. These were deposited in Quaternary. Un-cemented sand, silt and clay form these deposits.

Under the Quaternary deposits, some older deposits were reported. These are Jurassic and

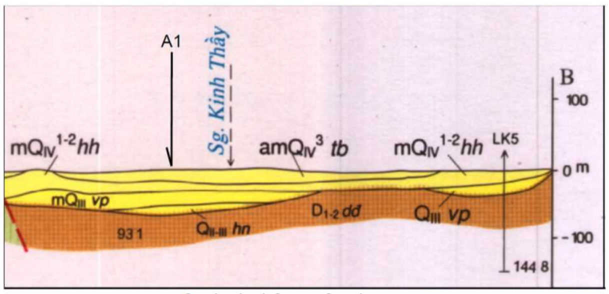
Devonian deposits. The Jurassic deposits found this area were named “Ha Coi Formation”. These were deposited in Jurassic. The Devonian deposits were named “Ban Pap Formation” and “Duong Dong Formation”. These older deposits are mainly of sandstone and mudstone. The sandstone and the mudstone including shale were found shallower depth near to the hills and some outcrops were found at the hills near the site. Some limestones are also reported from the Ban Pap Formation.



Legend

Geological Age	Marks	Formation Name and the Description
Quaternary, from about 2.6 Ma (million years ago) to present. These parts are rather young deposits	Q_{IV}^{3} *tb*	Thai Binh Formation (am): clay, silt, greyish-brown sand; (bm): sand, silt, dark-grey clay; (a): quartz sand; (ab): brown clay, interbedded with black clay, remains of plant; (m): fine- middle-grained grey sand; (mv): fine-grained sand. 1-5m thick.
	Q_{IV}^{1-2} *hh*	Hai Hung Formation (am): sand, silt, greyish-yellow clay; (mb): silt, clay, sand, peat; (m)·silt, greyish-yellow clay; (lb): dark grey silt, sand, grit, black and green clay, kaolin mixed with remain of plant . 2-10m thick.
	Q_{III} *vp*	Vinh Phuc Formation (am): sand, a little grit and granule, motley-coloured silt and clay; (m): grey si1ty clay. 5-20m thick. Bearing micro fossils of foraminiferas and diatoms.
	Q_{II-III} *hn*	Ha Noi Formation (a): pebble, grit, granule interbedded with yellow silty sand; (ap): peblbe, granule, breccia, quartz grit. 2-20m thick.
Jurassic, from about 201 Ma to 145 Ma (million years ago)	J_{1-2} *hc*$_2$	Ha Coi Formation Upper Subformation: siltstone, silty sandstone, thin layers of coaly shale. 300-350m thick.
	J_{1-2} *hc*$_1$	Ha Coi Formation Lower Subformation: conglomerate, gritstone, sandstone, interbedded with thin layers of siltstone. 200-300m thick.
Devonian, from about 419 Ma to 359 Ma (million years ago)	D_2 *bp*	Ban Pap Formation: grey, dark grey, thin- to thick-bedded limestone, interbedded with chert, cherty limestone, clayish limestone. 420m thick. Bearing fossils of corals, sponges, stromatopora.
	D_{1-2} *dd*	Duong Dong Formation: quartz sandstone, quartzitic sandstone, siltstone, clay shale, cherty shale, marl. 450-550m thick. Bearing fossils of brachiopods (lamp shells).

Modified from “Geology and Mineral Resources of Hai Phong, Sheet (F-48-XXIX)“, Department of Geology and Minerals of Viet Nam, Hanoi 1999



Geological Cross Section

Figure 3.2-3 Geological Map around the Site

(2) Evaluation of Geology for Each Site

1) Evaluation of Geology for the Nguyen Trai Bridge Site

A soil profile along Nguyen Trai Bridge is prepared and shown in Figure 3.2-4 and the enlarged figure is compiled in Appendix A3. Geological material distributed in this site is subdivided into Fill Layer, Quaternary Deposits and Older Deposits.

<Fill Layer>

The top layer at this site is Fill layer which is a manmade layer distributed on southern area of the Cam River and at BHNT-06. Thickness of the layer ranges from 1.00m to 11.50m. The layer is brownish grey in color and is consisted of sandy soil and rock fragments.

<Quaternary Deposits>

Major soil materials distributed under the Fill layer in this site are Quaternary deposits which are tentatively subdivided into Holocene deposits and Pleistocene deposits.

Holocene deposits, probably are composed with very soft to soft cohesive soil and very loose to medium dense sandy soil. The cohesive soil layer is named Ac layer and the sandy soil layer is named As layer. Pleistocene deposits, probably are found under the Holocene deposits, which are medium dense to very dense sandy soil named Ds layer.

Thickness of the Ac layer ranges from 20.00m to 38.20m. The layer is light grey, blackish grey, brownish grey and yellowish grey in color.

The As layer is encountered below Ac layer. Sandy soil layer in the upper part of the Ac layer found at BHNT-04 and BHNT-05 is also classified into As layer. Thickness of the upper As layer is 6.80m at BHNT-04 and 4.70m at BHNT-05. The layer is blackish grey in color. Thickness of lower As layer ranges from 2.00m to 12.80m. The layer is gray, light grey and blackish grey in color.

The Ds layer is encountered below lower As layer or Ac layer. Thickness of the Ds layer ranges from 1.60m to 6.25m. The layer is grey, whitish grey, light grey and blackish grey in color. This layer may be a candidate of bearing layer for deep foundation.

<Older Deposits>

Older deposits are encountered under the Quaternary deposits, which are the bedrock formation at the site. Medium strong sandstone and mudstone are the main material which will be a candidate of bearing layer of deep foundation at the site. Depth to the top of the deposits differs from MSL-39.12m to MSL-45.03m.

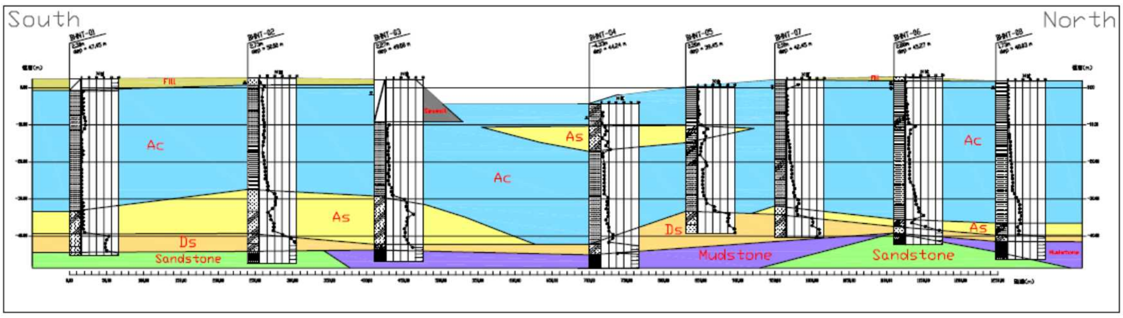


Figure 3.2-4 Soil Profile for Nguyen Trai Bridge Site

2) Evaluation of Geology for the Vu Yen Bridge Site

Soil profiles along Vu Yen Bridge are prepared and shown in Figure 3.2-5 and Figure 3.2-6 and the enlarged figures are compiled in Appendix A3. Geological material distributed in this site is subdivided into Fill, Quaternary Deposits and Older Deposits.

<Fill Layer>

The top layer at this site is Fill layer except at Vu Yen Island. Thickness of the Fill layer ranges from 0.80m to 2.60m. The layer is blackish grey, dark grey and yellowish grey in color and is consisted of cohesive soil, sandy soil and rock fragments.

<Quaternary Deposits>

Categorization of major soil materials is same as Nguyen Trai Bridge site.

Holocene deposits, probably are composed with very soft to soft cohesive soil and stiff cohesive soil. The very soft to soft cohesive soil layer is named Ac layer and the stiff cohesive soil layer is named Al layer. The Al layer is the extension of the alternation layer distributing at RR site where the layer is consisted of alternation of loose to medium dense sandy soil includes occasional gravelly soil and soft to very stiff cohesive soil.

Pleistocene deposits, probably are found under the Holocene deposits, which are medium dense to very dense sandy soil named Ds layer.

Thickness of Ac layer ranges from 21.00m to 39.90m with a general trend of the thinner to the North. The layer is grey, light grey, dark grey, bluish grey and yellowish grey in color.

Al layer is encountered below Ac layer at BHVY-17 with thickness of 4.10m. The layer is yellowish grey in color.

Ds layer is encountered below Holocene deposits. Thickness of Ds layer ranges from 1.00m to 16.45m. The layer is grey, light grey, dark grey and brownish grey in color. This layer may be a candidate of bearing layer for deep foundation.

<Older Deposits>

Older deposits are encountered under the Quaternary deposits, which are the bedrock formation at the site. Medium strong sandstone and mudstone are the main material which will be a candidate of bearing layer of deep foundation at the site. Depth to the top of the deposits differs from MSL-32.88m to MSL-42.45m with a general trend of the shallower to the North.

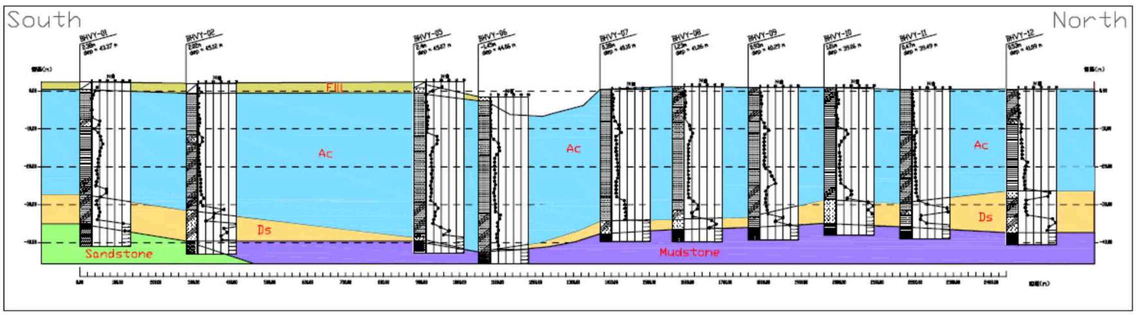


Figure 3.2-5 Soil Profile for Vu Yen Bridge Site (from VY-01 to VY-12)

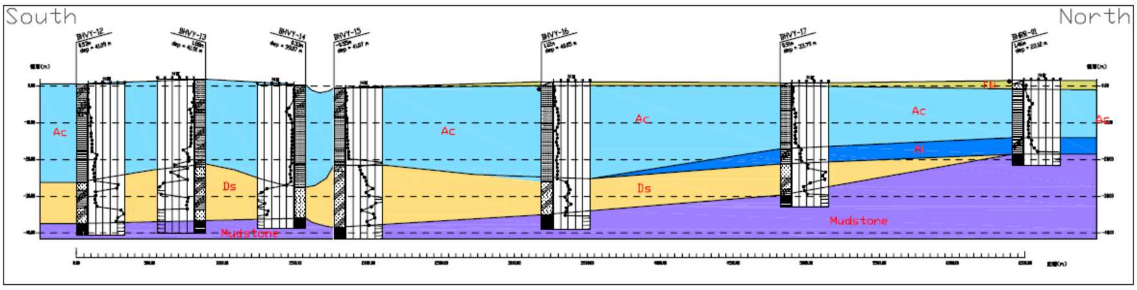


Figure 3.2-6 Soil Profile for Vu Yen Bridge Site (from VY-12 to VY-17)

3) Evaluation of Geology for the Ring Road 3

Soil profiles along Ring Road 3 are prepared and shown in Figure 3.2-7 and Figure 3.2-8 and the enlarged figures are compiled in Appendix A3. Geological material distributed in this site is also subdivided into Fill, Quaternary Deposits and Older Deposits.

<Fill Layer>

The top layer of this site is the Fill found at BHRR-01 with thickness of 2.30m. The layer is grey in color and is consisted of cohesive soil, sandy soil and rock fragments.

<Quaternary Deposits>

Major soil materials distributed in this site are probable Holocene deposits of Quaternary. The deposits are composed with very soft to soft cohesive soil and alternation of loose to medium dense sandy soil includes occasional gravelly soil and soft to very stiff cohesive soil. The cohesive soil layer is named Ac layer and the alternation layer is named Al layer.

Ac layer is top layer except at BHRR-01. Thickness of the Ac layer ranges from 8.70m to 13.20m. The layer is grey, whitish grey, blackish grey and brownish grey in color.

Al layer is encountered below Ac layer at all the drill holes. Thickness of Al layer ranges from 4.50m to 17.10m. The layer is blackish grey, yellowish grey and reddish brown in color.

<Older Deposits>

The Older Deposits were found at shallower depth at this site than other sites. This is predicted by studying general geology and the result is corresponded. Material of the deposits at this site is mostly medium strong mudstone. They will be a candidate of bearing stratum at this site. Depth to the top of the deposits differs from MSL-11.55m to MSL-24.76m.

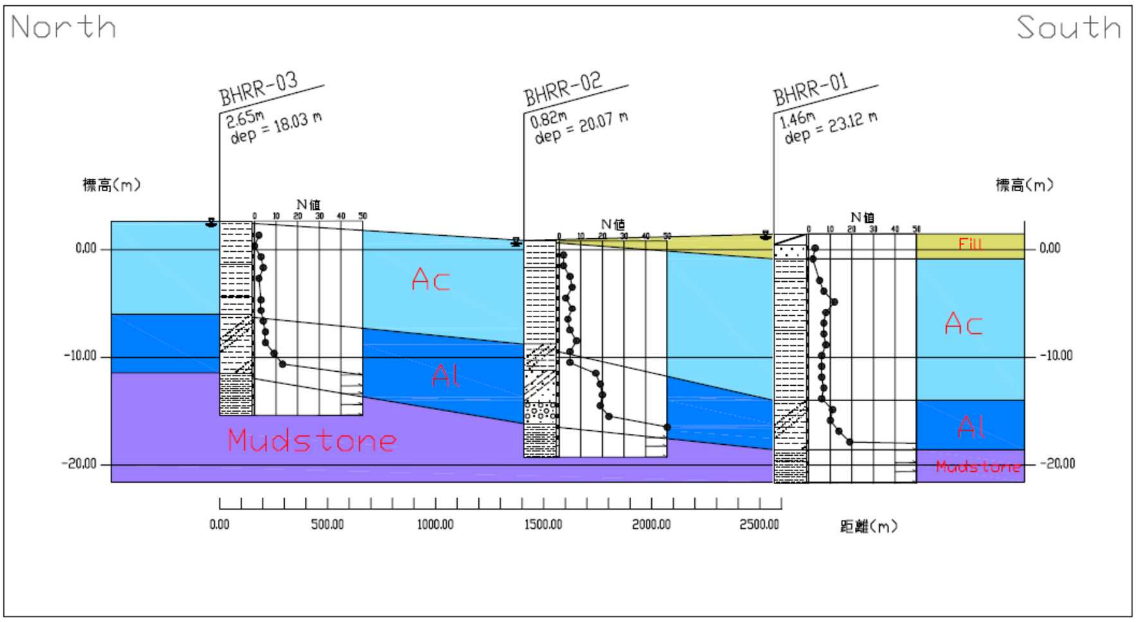


Figure 3.2-7 Soil Profile for Ring Road 3 Route (from RR-01 to RR-03)

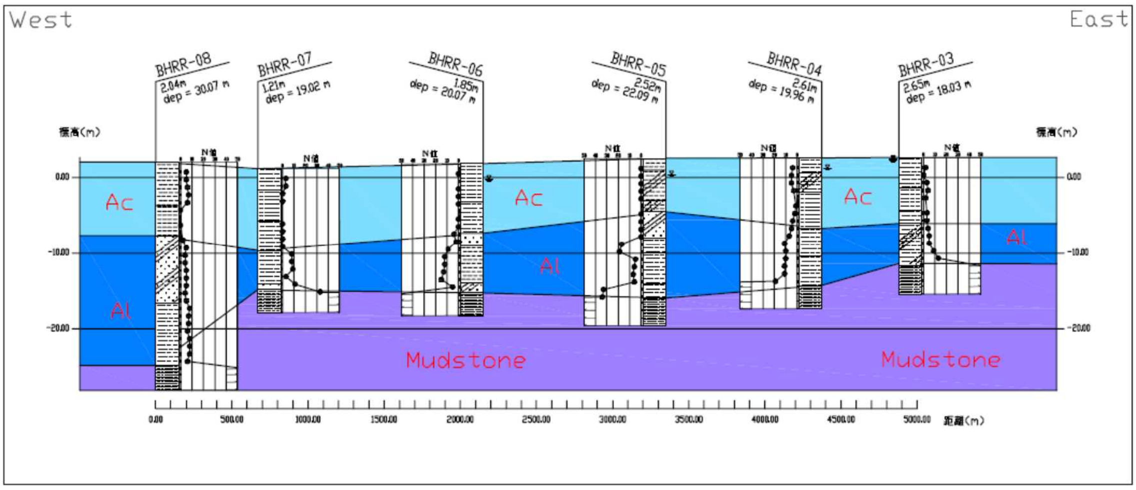


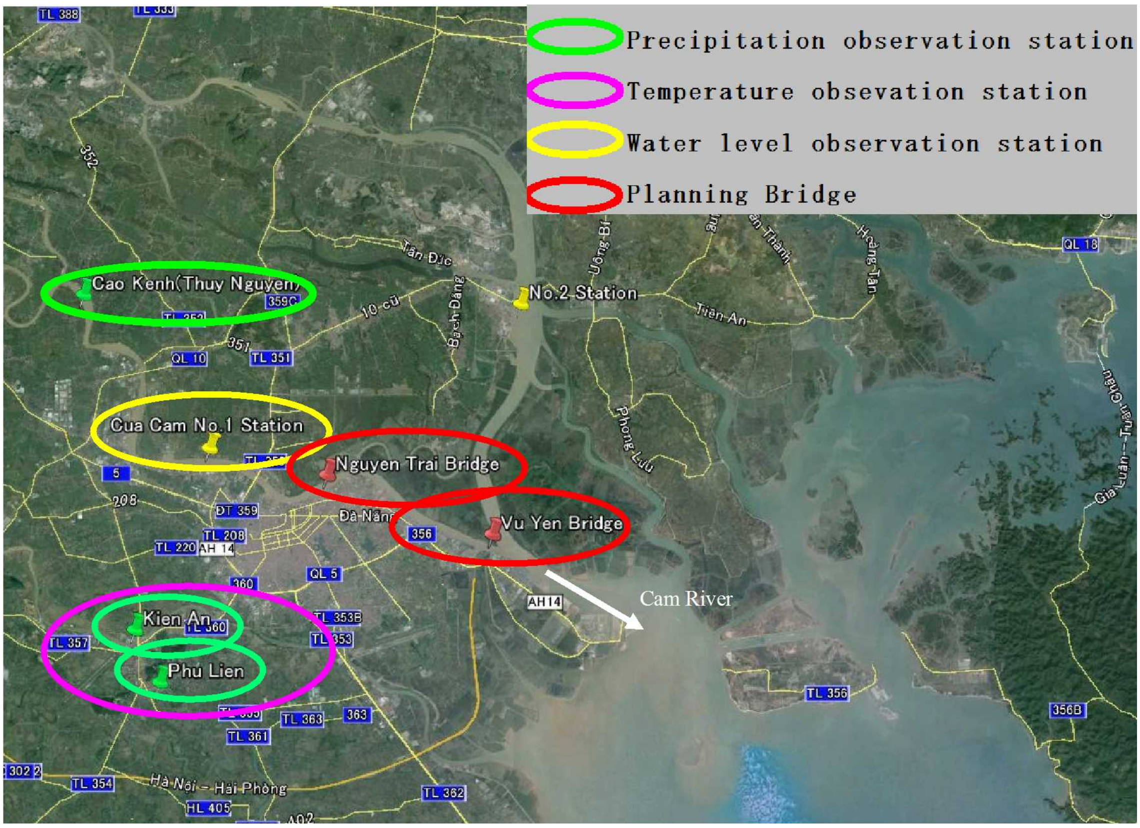
Figure 3.2-8 Soil Profile for Ring Road 3 Route (from RR-03 to RR-08)

3.3 Meteorological Conditions around the Project Site

3.3.1 Location of Observation Stations

Figure 3.3-1 shows the location of the observation stations, and the data is composed of the following components:

- Temperature data : Phu Lien-Kien An (1995-2014)
- Rainfall data : Thuy Nguyen (1972-2014)
  Kien An (1992-2014)
  Phu Lien (1970-2014)
- Water level in Cam River : Cua Cam (2000-2014)



Base Image from Google Earth, 2015

Figure 3.3-1 Location of Observation Stations

3.3.2 Temperature

The annual average temperature in the Hai Phong area ranges between 20-23 degrees Celsius. Figure 3.3-2 shows a record of the highest and lowest temperatures in Phu Lien - Kien An over the past 20 years, and the highest recorded temperatures have been about 35-38 degrees Celsius in June or July. Correspondingly, the lowest recorded temperatures have been about 5-10 degrees Celsius in December, except in 2002 when the temperature was exceptionally low.

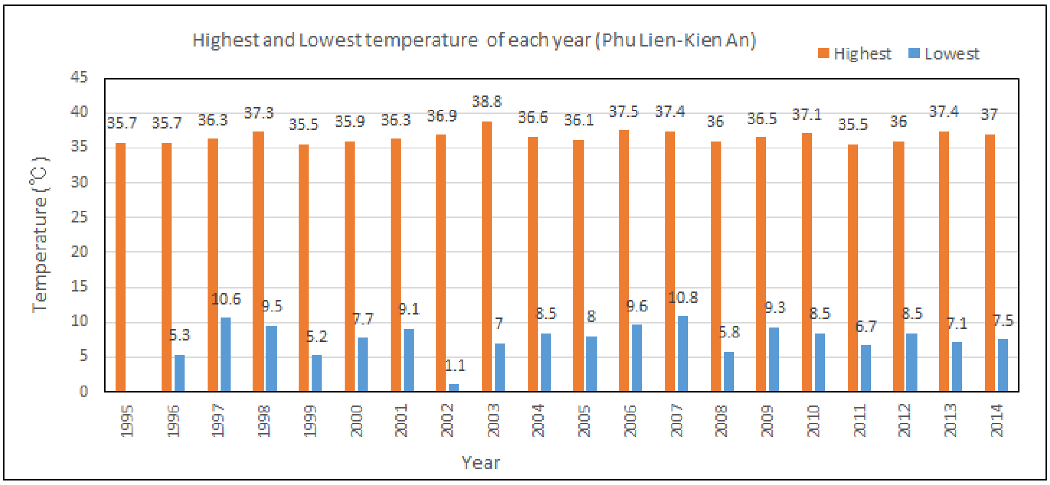


Figure 3.3-2 Highest and Lowest Yearly Temperature (1995-2014)

3.3.3 Precipitation

The precipitation conditions in Thuy Nguyen, Kien An and Phu Lien are shown in Figure 3.3-3 to Figure 3.3-6. As shown in these figures, the precipitation conditions in Hai Phong can be summarized as follows:

- Annual precipitation is between 1,530-1,650mm.
- There are between 50 and 150 annual rain days depending on the station
- Maximum annual precipitation reaches 350mm in August
- Based on the monthly precipitation data, the rainy season in Hai Phong is between May and September (max: August 300-350mm), and the dry season is between October and April
- August has the maximum number of monthly rain days with about 15 days

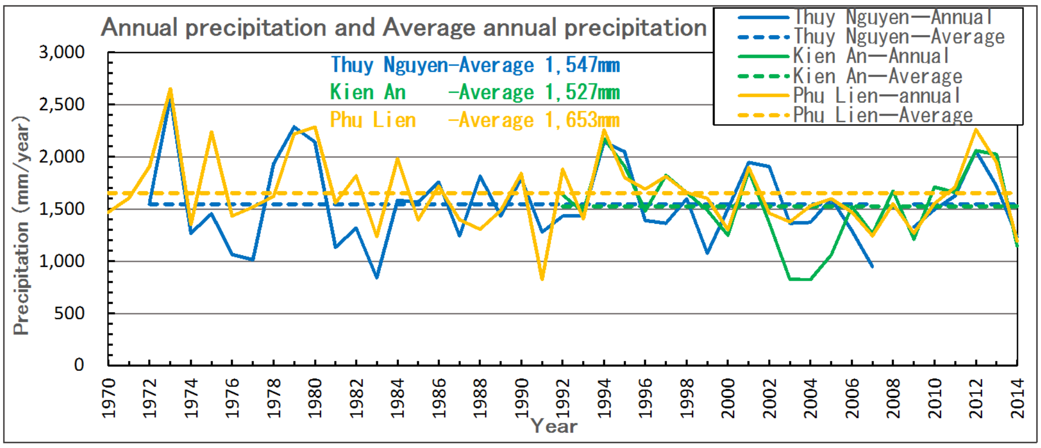


Figure 3.3-3 Annual Precipitation and Average Annual Precipitation (1970-2014)

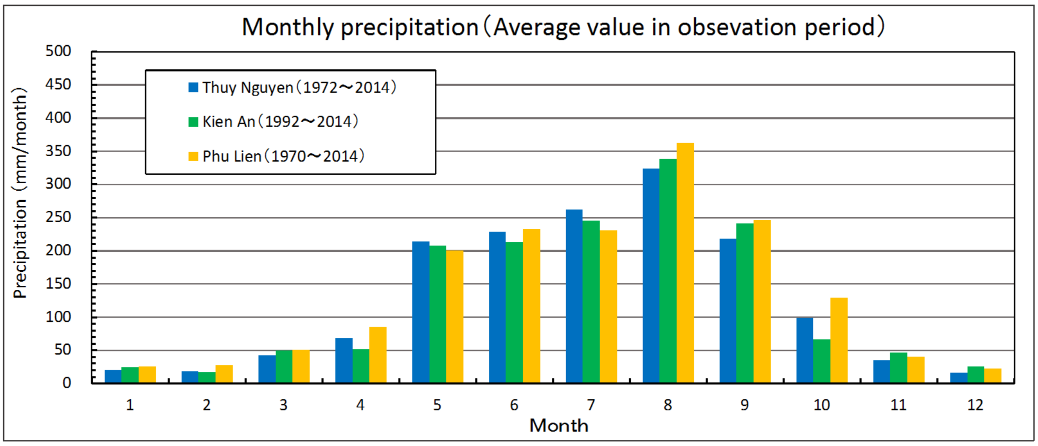


Figure 3.3-4 Monthly Precipitation (Average Value in Observation Period)

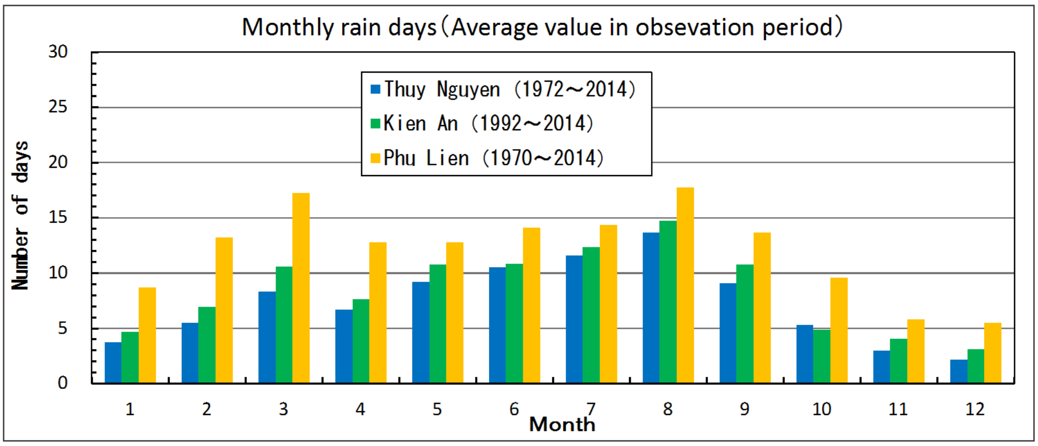


Figure 3.3-5 Monthly Rain Days (Average Value in Observation Period)

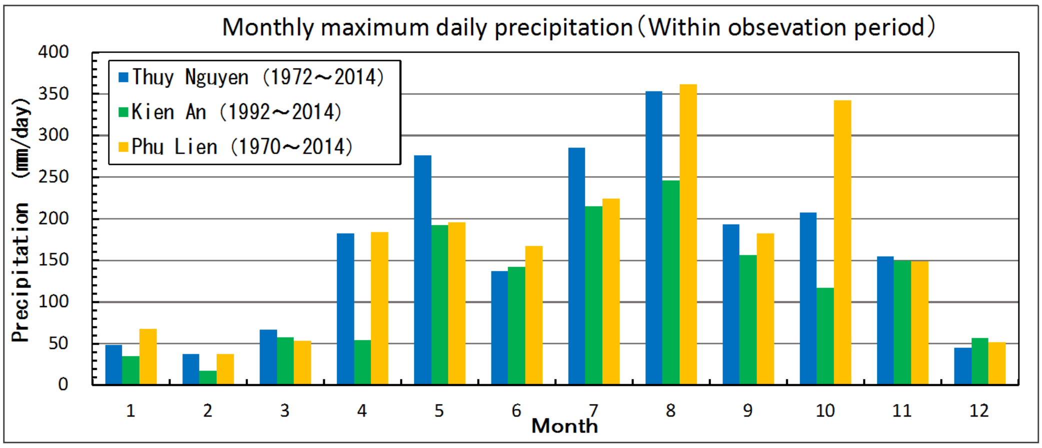


Figure 3.3-6 Monthly Maximum Daily Precipitation (Within Observation Period)

3.3.4 Flow Characteristics

(1) Probability Analysis of the Cam River Water Level

Table 3.3-1 shows a record of the monthly highest and lowest high water level (H.W.L.) at Cua Cam station on the Cam River from 2000 to 2014.

The Study Team calculated a probability distribution of the water level at Cua Cam station based on records of the highest water level each year (see Table3.3-2). Among the wide variety of probability distribution models, the following turned out to be a good fit:

1. Gumbel distribution
2. Generalized Extreme Value distribution (GEV I)
3. Log Pearson type III distribution (LOGP3)
4. SQRT-exponential type maximum distribution (SQRT-ET)

In this distribution, the value of SLSC to evaluate fitness less than 0.04 is only 2 (GEV I).

Table 3.3-3 shows the results of the water level probability analysis at Cua Cam.

Table 3.3-1 Highest Water Level per year at Cua Cam

year	HWL(cm)	year	HWL(cm)	year	HWL(cm)	year	HWL(cm)
2000	194 (04.JUL)	2004	214 (01.AUG)	2008	221 (16.NOV)	2012	211 (29.OCT)
2001	203 (22.JUL)	2005	237 (31.JUL)	2009	212 (22.JUL)	2013	232 (23.JUL)
2002	190 (12.JUL)	2006	205 (09.AUG)	2010	187 (17.JUL)	2014	191 (17.OCT)
2003	190 (14.JUL)	2007	191 (14.JUL)	2011	209 (30.JUL)		

Table 3.3-2 Results of Water Level Probability Analysis at Cua Cam

Cam River-Cua Cam

Conformity degree evaluation calculation list

Exceedence probability;Water Level(cm)

Item \ Method		GUMBEL	GEV*I	LOGP3	SQRT-ET	
Return・Period	2-Year	203. 62	202. 84	203. 42	202. 81	
	5-year	220. 52	217. 66	217. 75	216. 49	
	10-year	231. 70	227. 68	226. 88	225. 78	
	20-year	242. 42	237. 44	235. 42	234. 87	
	25-year	245. 82	240. 57	238. 09	237. 79	
	30-year	248. 61	243. 12	240. 26	240. 18	
	50-year	256. 33	250. 30	246. 26	246. 90	
	100-year	266. 73	260. 10	254. 28	256. 10	
	200-Year	277. 11	270. 02	262. 25	265. 44	
	300-Year	283. 16	275. 88	266. 91	270. 97	
	500-Year	290. 79	283. 33	272. 79	278. 00	
SLSC		0. 0412	0. 0385	0. 0422	0. 0445	
Correlation Coefficient		0. 9803	0. 9800	0. 9811	0. 9799	
Estimate value		259. 03	258. 49	252. 40	257. 63	
Estimate error		13. 1	19. 3	12. 3	13. 6	
Candidate for adoption			○			

Number of sample N=15 Maximum value=237cm
Note1 :SLSC is Standard least-squares criterion regarding 100-Year Probability.
Note2 :Estimate value and error is a value by Jackknife Method regarding 100-year.
⇒ Method for evaluating the stability of probability model.
Note3 :○- Shall meet the SLSC≦0.04.

(2) Relationship between Water Level, Flow Rate and Flow Velocity

1) Observation Period

The relationship between the water level, flow rate and flow velocity of the Cam River is analyzed based on the following data table. The data can be regarded as containing the maximum flow velocity because the maximum high water level is 2.34m, which is almost equivalent to that of a 20-year return period.

Table 3.3-3 Observation Period of Hourly Water Level and Flow Velocity at Cam River

year	date	year	date	year	date	year	date
2001	7/20-7/24	2005	7/28-8/1	2009	7/21-7/24	2013	6/22-6/24
2002	7/10-7/14	2006	8/8-8/12	2010	7/16-7/18	2014	9/15-9/19
2003	11/26-11/30	2007	7/12-7/16	2011	7/29-7/31		
2004	7/31-8/3	2008	6/14-6/17	2012	10/27-10/30		

Source: Dr. Bui Cong Quang, Water Resource University, Vietnum

2) Results of Case Studies

Figure 3.3-7 shows the hourly water level, flow rate and flow velocity for the maximum water level during the observation periods in Table 3.3-4. Among these, the flow velocity around Nguyen Trai Bridge and Vu Yen Bridge are calculated from the observed water levels and flow quantities based on the cross-section of each river site.

The maximum reverse flow rate from downstream to upstream occurs at the same time, and these values are also shown in Figure 3.3-7.

Conversely, Figure 3.3-8 shows the case with maximum flow rate from upstream to downstream. Furthermore, Figure 3.3-9 shows the case with maximum flow velocity at Nguyen Trai Bridge and Vu Yen Bridge simultaneously.

Therefore, the maximum flow velocity is 0.95 m/s at Nguyen Trai Bridge and 0.91 m/s at Vu Yen Bridge. Table 3.3-4 shows a summary of the study.

Table 3.3-4 Summary Study of Maximum Water Level, Flow Rate and Flow Velocity

	Maximum flow rate [m3/s]	Maximum water level [m]	Flow velocity at Nguyen Trai Br. [m/s]	Flow velocity at Vu Yen Br. [m/s]
Case 1 (Figure 3.3-7)	-1,260	2.34	-0.39	-0.38
Case 2 (Figure 3.3-8)	2,130 (up to down)	0.57	0.84	0.80
Case 3 (Figure 3.3-7)	-2,280 (down to up)	2.16	-0.73	-0.70
Case 4 (Figure 3.3-9)	2160	-0.36	0.95	0.91

Note: The gray cells are master factors in each case.

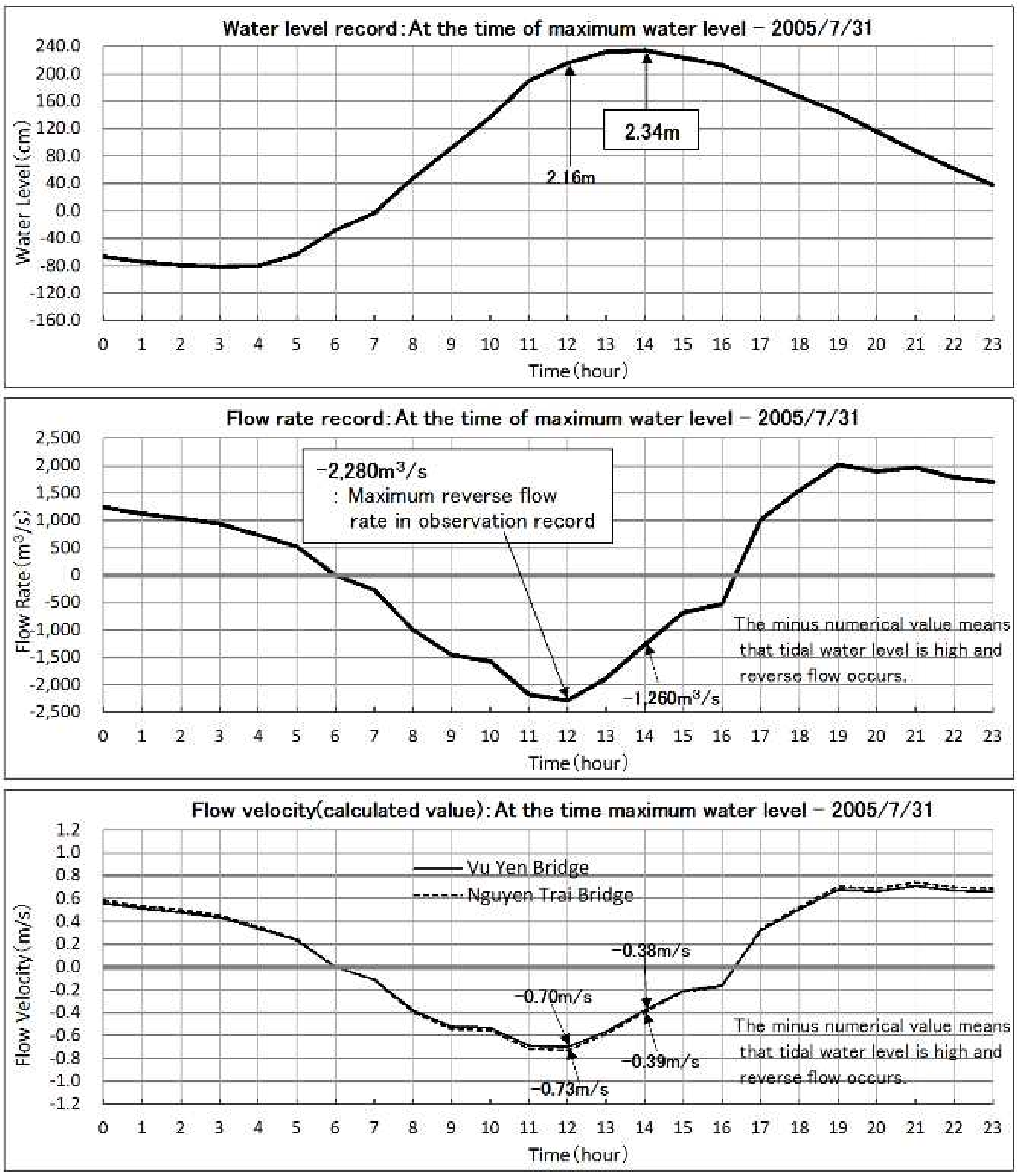


Figure 3.3-7 Hmax-Q-V and【H-(-Qmax)-V】Record：2005/7/31

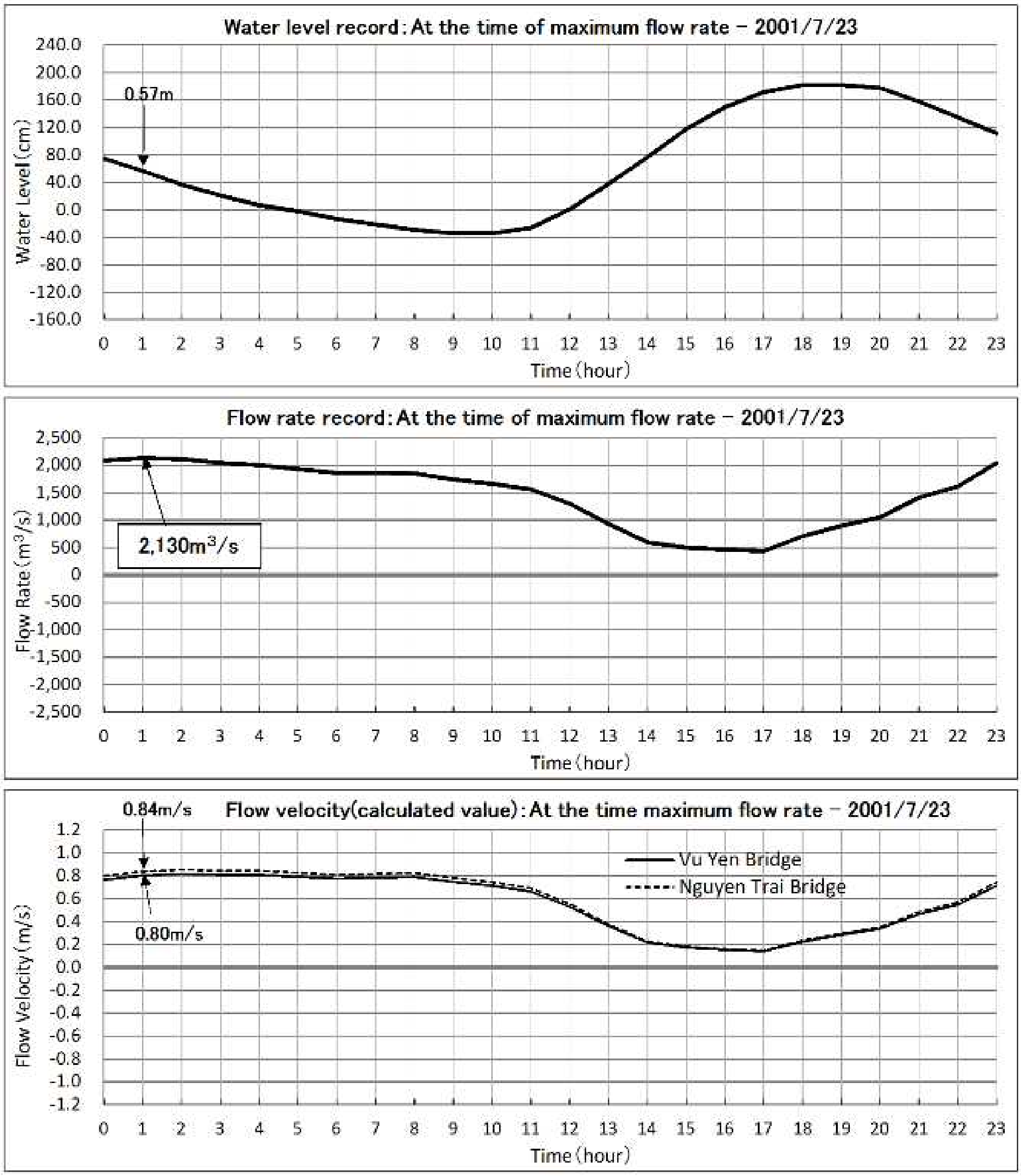


Figure 3.3-8　H-Qmax-V Record：2001/7/23

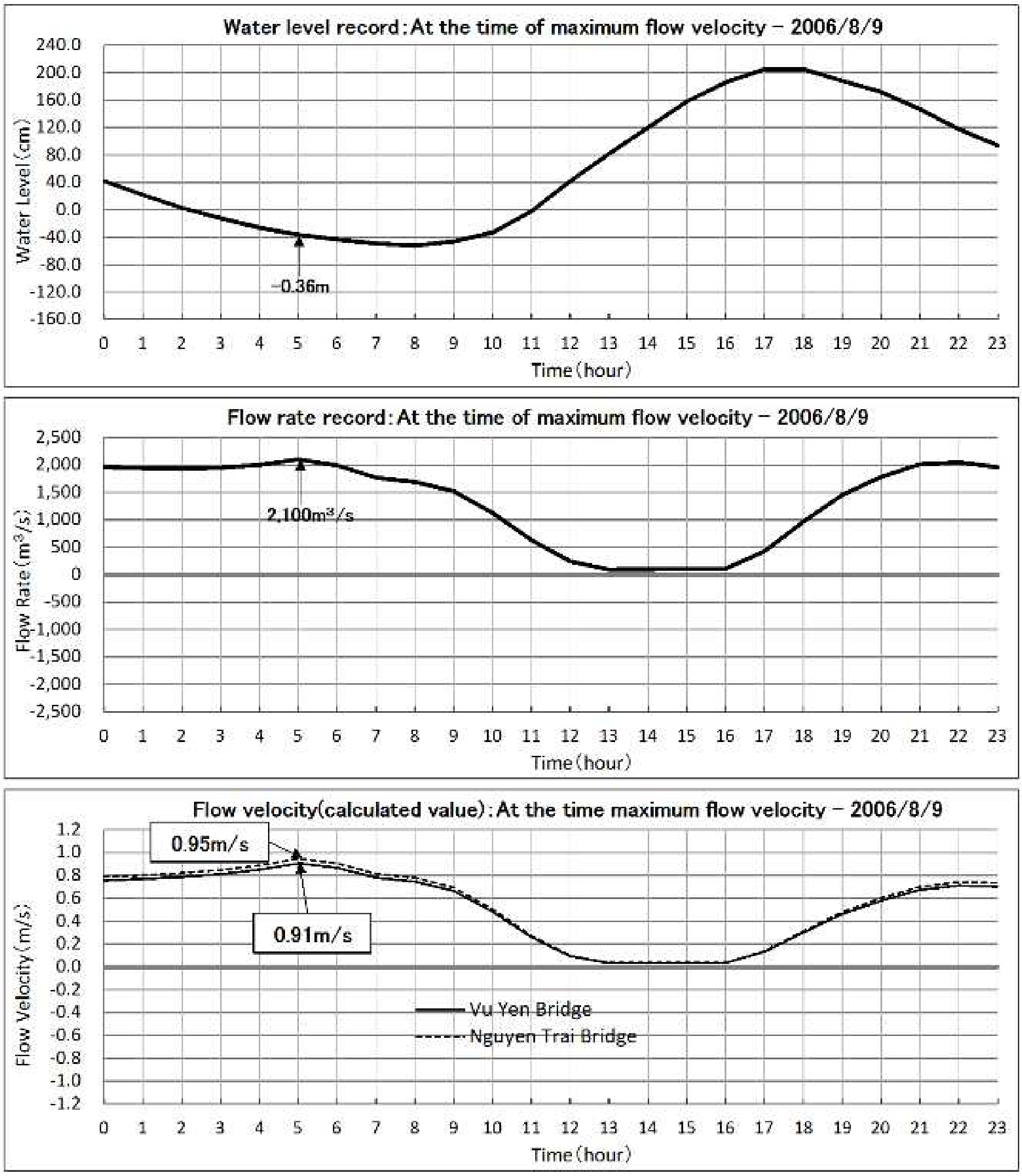


Figure 3.3-9 H-Q-Vmax Record：2006/8/9

(3) Scour

1) Scour Depth Equations

Scour depth is calculated by Method 1(Farraday and Charlton Equation) and Method 2 (Blench Equation) and the larger value is then selected. Both calculated values are considered global scour and consist of general riverbed degradation and local scour. Explanation of Method1 and Method2 are described in appendix.

2) Case Studies and Results of Scour Depth

Scour depth is calculated based on the conditions of Case 1 to Case 4 below, which correspond to the observation periods listed in Section (2) above.

Case 1: Record of maximum water level

Case 2: Record of maximum flow rate

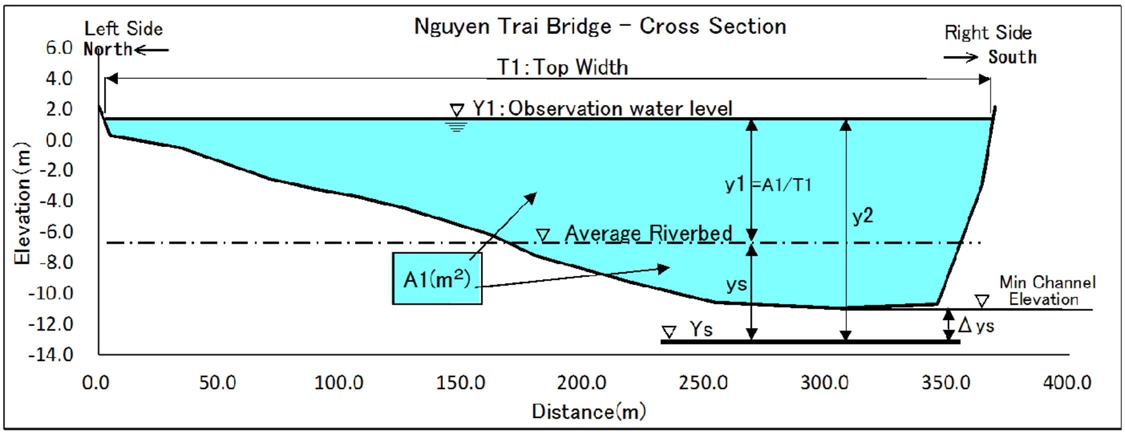
Case 3: Record of maximum reverse flow rate

Case 4: Record of maximum flow velocity

Table 3.3-5and Table 3.3-6 show the scour value results at each bridge site. The maximum scour value Δy_s at the time of maximum flow velocity occurs in Case 4 at both sites and Δy_s is estimated as 1.0m at Nguyen Trai Bridge and 1.1m at Vu Yen Bridge.

Table 3.3-5 Result of Scour Depth at Nguyen Trai Bridge Site

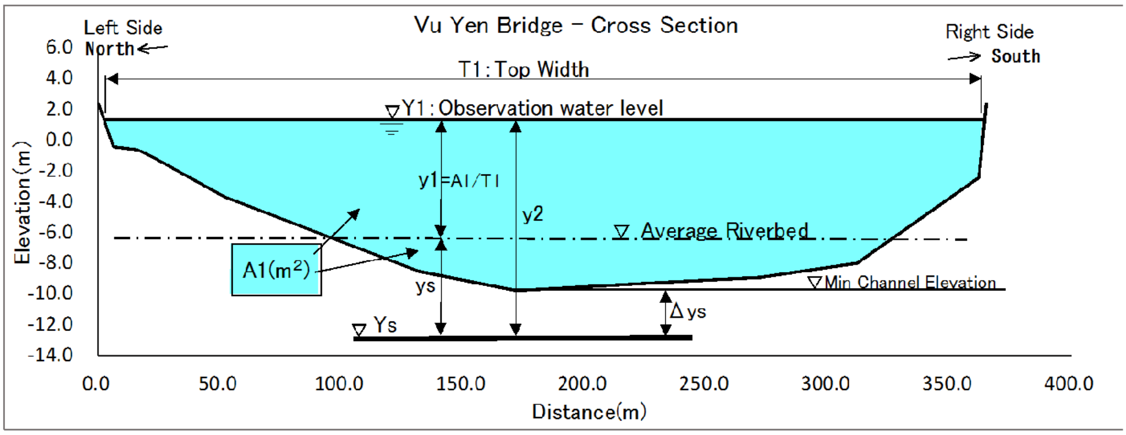
Item	Case1 (Hmax)	Case2 (Qmax)	Case3 (−Qmax)	Case4 (Vmax)
Design Discharge Q (m^3/s)	1,260.0	2,130.0	−2,280.0	2,100.0
Estimated water surface elevation Y1(m)	2.34	0.57	2.16	−0.36
Manning's roughness coefficient n	0.030			
Cross Sectional Area − A1 (m^2)	3,203.2	2,540.3	3,132.5	2,220.6
Top Width−T1(m)	370.9	355.3	370.3	339.7
Min Channnel Elevation	−10.96			
Average Flow Depth − y1 (m)	8.64	7.15	8.46	6.54
Average Flow Velocity − v1 (m/s)	0.39	0.84	0.73	0.95
Average Design Unit Discharge q (m^3/s)	3.40	6.00	6.16	6.18
Bed Materials	Silt−Cohesive			
Size of the bed material D_{50} (mm)	0.150			
Size of the bed material D_{90} (mm)	0.400			
Nature of Location	Parallel to bank			
Design multipliers for Estimation Total Scour	1.5			
Method 1:by Farraday and Charlton、1983				
Voids Ratio	1.200			
Critical Tractive Stress τC (N/m^2)	2.80			
Average Depth of General Scour y2 (m)	4.63	7.55	7.72	7.75
Design Depth of Total Scour y2(m)	6.95	11.32	11.59	11.63
Design Depth of Total Scour ys(m)	−1.69	4.17	3.13	5.09
Method 2:by Blench、1969				
Blench's "Zero Bed Factor" Fb (m/s^2)	0.23			
Average Depth of General Scour y2 (m)	3.64	5.30	5.39	5.41
Design Depth of Total Scour y2(m)	5.46	7.95	8.09	8.11
Design Depth of Total Scour ys(m)	−3.18	0.80	−0.37	1.57
Adopted Total Scour Value ys(m)	−1.69	4.17	3.13	5.09
Design bed elevation after scour Ys(m)	−10.96	−10.96	−10.96	−11.99
Design scour depth from Min Chl Elev ⊿ys (m)	0.00	0.00	0.00	1.03



Note: This cross-section is seen from upstream to downstream

Table 3.3-6 Result of Scour Depth at Vu Yen Bridge Site

Item	Case1 (Hmax)	Case2 (Qmax)	Case3 (−Qmax)	Case4 (Vmax)
Design Discharge Q (m^3/s)	1,260.0	2,130.0	−2,280.0	2,100.0
Estimated water surface elevation Y1(m)	2.34	0.57	2.16	−0.36
Manning's roughness coefficient n	0.030			
Cross Sectional Area − A1 (m^2)	3,327.3	2,650.1	3,255.8	2,317.9
Top Width−T1(m)	364.2	359.4	364.2	352.2
Min Channnel Elevation	−9.78			
Average Flow Depth − y1 (m)	9.14	7.37	8.94	6.58
Average Flow Velocity − v1 (m/s)	0.38	0.80	0.70	0.91
Average Design Unit Discharge q (m^3/s)	3.46	5.93	6.26	5.96
Bed Materials	Silt and Clay−Cohesive			
Size of the bed material D_{50} (mm)	0.015			
Size of the bed material D_{90} (mm)	0.060			
Nature of Location	Parallel to bank			
Design multipliers for Estimation Total Scour	1.5			
Method 1:by Farraday and Charlton、1983				
Voids Ratio	1.200			
Critical Tractive Stress τ C (N/m^2)	3.300			
Average Depth of General Scour y2 (m)	4.38	6.97	7.30	7.00
Design Depth of Total Scour y2(m)	6.58	10.45	10.95	10.50
Design Depth of Total Scour ys(m)	−2.56	3.07	2.01	3.92
Method 2:by Blench、1969				
Blench's "Zero Bed Factor" Fb (m/s^2)	0.15			
Average Depth of General Scour y2 (m)	4.24	6.05	6.28	6.08
Design Depth of Total Scour y2(m)	6.36	9.08	9.41	9.12
Design Depth of Total Scour ys(m)	−2.77	1.71	0.47	2.53
Adopted Total Scour Value ys(m)	−2.56	3.07	2.01	3.92
Design bed elevation after scour Ys(m)	−9.78	−9.88	−10.71	−10.86
Design scour depth from Min Chl Elev ⊿ys (m)	0.00	0.10	0.93	1.08



Note: This cross-section is seen from upstream to downstream

3) Estimation of Scour Depth Caused by the Pier of Nguyen Trai Bridge

The pier of Nguyen Trai Bridge will be constructed 90m from the left bank. The scour depth caused by this pier in case of maximum flow velocity is estimated based on Japanese technical standards. The parameters and values are as shown below:

(a) Froude number, $F_r = V_1/\sqrt{g \times y_1} = 0.95[m/s]/\sqrt{9.8[m/s^2] \times 6.54[m]} = 0.12$ (refer to Table 3.3-5)
(b) Water depth at pier, $h_0 = -0.36[\mathrm{m}] - (-3.0[\mathrm{m}]) = 2.64[\mathrm{m}]$(refer to Figure 3.3-11)
(c) Width of pier, $D = 18.49[\mathrm{m}]$
(d) Depth/ Grain size, $h_0/D_{50} = 2.64[m]/0.15 \times 10^{-3}[m] = 17{,}600$
(e) Maximum scour depth at pier / Width of pier, Z/D=0.3 (refer to Figure 3.3-10)

$$\therefore \mathrm{Z} = \mathrm{D} \times 0.3 = 18.49[\mathrm{m}] \times 0.3 \fallingdotseq 5.5[\mathrm{m}]$$

(f) Deepest riverbed height after scouring, $H_{min} = -3.0[\mathrm{m}] - 5.5[\mathrm{m}] = -8.5[\mathrm{m}]$

According to the results in (a) to (f), the scour depth and shape at Nguyen Trai Bridge is estimated as shown in Figure 3.3-11.

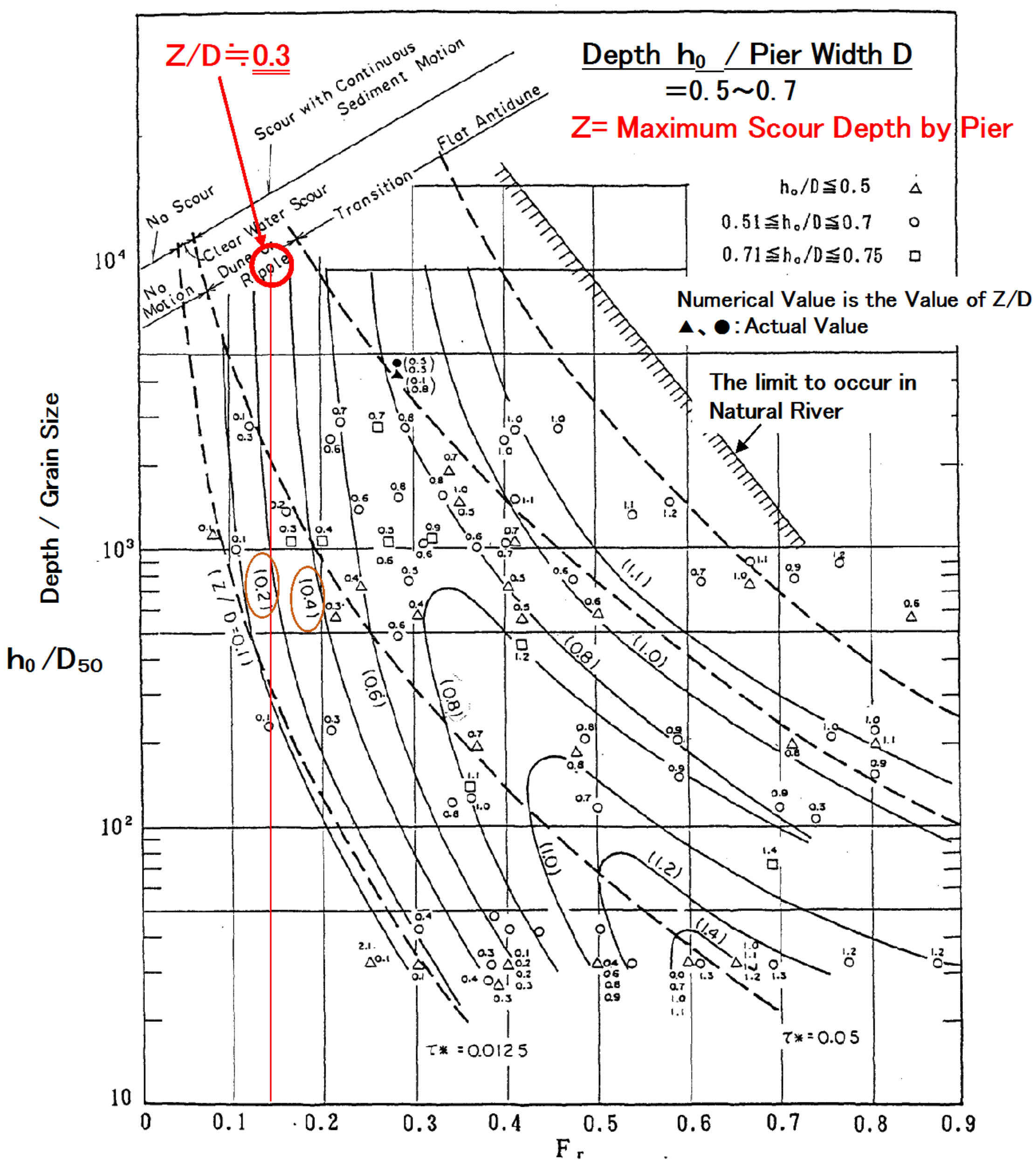
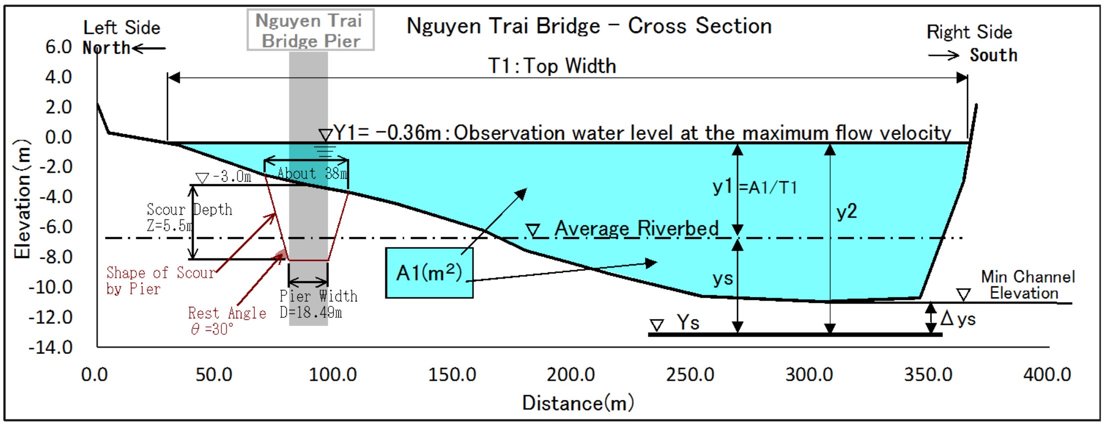


Figure 3.3-10 Estimated Graph of Scour Depth based on Japanese Technical Standards



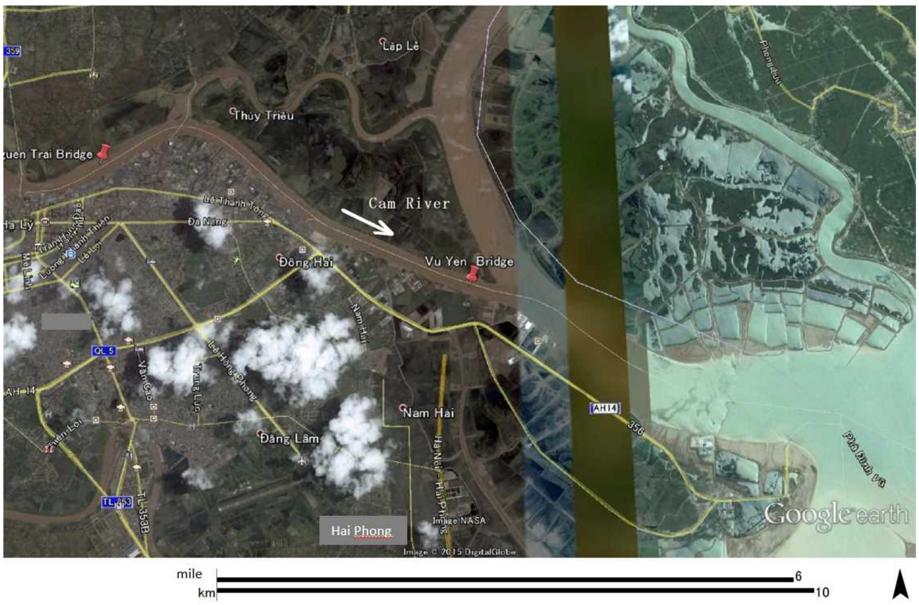
Note: This cross-section is seen from upstream to downstream

Figure 3.3-11 Estimated Scour Depth and Shape by Pier of Nguyen Trai Bridge

(4) Stability of River Channel

Figure 3.3-12 shows 2 satellite images of the Cam River around the project site taken in August 2005 and August 2015. A comparison of both images show no difference around the project sites around Vu Yen Bridge and Nguyen Trai Bridge. Although there is a slight difference in the coastline shape between the 2 photos, this seems to be the result of differences in tide level and is thus not significant.

The river channel around the project site can therefore be said to have been stable at least during the past 10 years.



(a) August 7th, 2005

Base image from Google Earth, 2015

(b) August 18th, 2015

Figure 3.3-12 Satellite Images at of Cam River

3.3.5 Wind

1) Observation Data and Analysis of Wind Velocity

For wind direction and velocity, data from 1995 to 2014 at Phu Lien/Kien An is used for analysis. Table 3.3-7 shows records of the monthly wind velocity. Observed data and characteristic of wind record is shown in Appendix A3.

Table 3.3-7 List of Maximum Wind Velocity Phu Lien/Kien An (1995-2014)

Phu Lien/Kien An-Hai Phong — Maximum wind velocity (m/s)

Year \ Month	1	2	3	4	5	6	7	8	9	10	11	12
1995	7	7	8	9	8	8	8	**25**	12	15	12	8
1996	7	7	11	10	10	10	**38**	35	12	8	10	7
1997	7	6	8	24	9	18	9	**33**	10	7	10	10
1998	8	9	8	20	18	21	10	10	**30**	8	8	10
1999	7	6	7	8	9	10	**23**	17	14	17	15	13
2000	12	10	10	14	13	15	19	**24**	14	18	13	11
2001	13	10	12	23	**28**	18	20	17	15	18	15	11
2002	10	11	12	14	**19**	16	16	14	16	13	10	16
2003	14	11	14	15	18	**22**	**22**	**22**	13	11	11	12
2004	12	7	7	10	10	14	14	11	10	12	8	**16**
2005	8	8	8	8	12	14	**28**	18	18	7	7	12
2006	10	8	8	**16**	11	13	**16**	10	10	9	13	6
2007	7	7	7	10	**13**	10	12	**13**	11	12	8	8
2008	6	6	6	7	11	**16**	12	18	14	9	7	7
2009	6	7	12	10	8	10	8	**13**	9	10	8	8
2010	5	8	12	8	16	10	**22**	14	14	7	7	7
2011	5	5	10	5	6	10	16	14	**17**	8	6	6
2012	5	5	7	13	10	10	12	12	8	**20**	8	7
2013	6	10	11	9	12	10	10	15	10	7	**18**	7
2014	7	7	8	9	9	9	8	10	**18**	9	7	17

2) Probability Analysis for Wind Velocity

The maximum wind velocity for each year at Phu Lien/ Kien An, Hai Phong, and probabilities have been calculated using these values.

Among the different probability distribution models, the following turned out to be a good fit:

1. Gumbel distribution(Gumbel)
2. Generalized Extreme Value distribution (GEV I)
3. Log Pearson type III distribution (LOGP3)
4. SQRT-exponential type maximum distribution (SQRT-ET)

In this distribution, the value of SLSC to evaluate fitness less than 0.04 are all models. Table 3.3-8 shows the results of the wind velocity probability analysis, and Gumbel best matches the probabilities for the wind velocity and is therefore selected.

Table 3.3-8 Results of Wind Velocity Probability Analysis

Hai Phong - Wind Velocity

Conformity degree evaluation calculation list

Exceedence probability;Wind Velocity(m/s)

Item \ Method		GUMBEL	GEV*I	LOGP3	SQRT-ET	
Return・Period	2-Year	20.98	20.66	20.74	20.46	
	3-year	24.30	23.61	23.64	23.31	
	5-year	28.00	26.95	26.91	26.68	
	10-year	32.65	31.24	31.07	31.22	
	20-year	37.10	35.44	35.13	35.87	
	30-year	39.67	37.90	37.51	38.68	
	50-year	42.88	41.02	40.53	42.33	
	100-year	47.20	45.30	44.71	47.49	
	200-Year	51.51	49.66	49.00	52.91	
	300-Year	54.03	52.25	51.58	56.21	
	500-Year	57.20	55.55	54.89	60.48	
SLSC		0.0264	0.0206	0.0257	0.0248	
Correlation Coefficient		0.9948	0.9947	0.9950	0.9925	
Estimate value		44.83	44.84	44.03	48.38	
Estimate error		5.4	7.5	6.8	6.1	
Candidate for adoption		◎	○	○	○	

Number of sample N=20 **Maximum value=38m/s** Phu Lien/Kien An:1995-2014
Note1 :SLSC is Standard least-squares criterion regarding 100-Year Probability.
Note2 :Estimate value and error is a value by Jackknife Method regarding 100-year.
⇒ Method for evaluating the stability of probability model.
Note3 :○- Shall meet the SLSC≦0.04.
Note4 :◎- Distribuntion form to adopt:Estimate Error is minimum in SLSC≦0.04.

Based on the observed data, the maximum design speed at the bridge site with a 100-year return period is 47.2m/s (2min average wind speed, H=12m from land, land height 115m), and this is thus also used as the design wind speed in Chapter 6.

Chapter 4 TRAFFIC SURVEYS AND TRAFFIC DEMAND FORECAST

4.1 Traffic Surveys for Assessing Traffic Demand

In order to update and calibrate the existing travel demand forecast model for use in this study to forecast the future traffic demand, a traffic count, vehicle occupancy and roadside OD interview survey were conducted by contracting out the work to a local contractor, Vietbuild Joint Stock Company (Vietbuild). Vietbuild conducted the surveys under the supervision of the JICA Study Team from the second half of March 2015 to the first half of April 2015.

4.1.1 Setup for the Traffic Count and Vehicle Occupancy Surveys

The traffic count and vehicle occupancy surveys were carried out at 11 locations. Of the 11 locations, for 4 locations, the surveys were conducted for 7 consecutive days (Monday to Sunday), and for seven 7 locations, the surveys were conducted for 4 consecutive days, 3 weekdays and 1 weekend for 9 predetermined vehicle types as shown below.

Table 4.1-1 Vehicle Types for the Traffic Count and Vehicle Occupancy Surveys

No.	Vehicle Type
1	Bicycle
2	Motorcycle
3	Car
4	Taxi
5	Cyclo
6	Minibus (Public/Private)
7	Medium and large buses (Public/Private)
8	Truck
9	Others
Note: Vehicle types chosen to match vehicle types from the 2007 World Bank Study on existing traffic demand forecast database/model	

Source: Study Team

Regarding the 4 locations where the surveys were conducted for 7 consecutive days, these survey stations were located on roads where heavy commercial (truck) traffic volume was identified. The 4 locations were: (1) QL5, Nomura Industrial Park, (2) QL10 Kien Bridge, (3) TL359 Binh Bridge and (4) AH14, Dong Hai Bridge. In addition, in order to obtain more detailed information regarding the composition of the types of commercial vehicles that passed by these survey stations, a more detailed traffic count for 4 types of commercial vehicles (pickup truck, rigid-chassis truck (2 axles), rigid-chassis truck (3 or more axles) and truck/tractor-trailer) was also conducted for an additional 4 days (2 weekdays and 2 weekend days). Details regarding this additional traffic count are shown in Section 4.1.2(2)4).

For the traffic count and vehicle occupancy surveys, due to safety concerns about surveying on the roadside, the local contractor set up video cameras to record the traffic conditions at the 11 locations for 24 hours and then staff from the local contractor counted the vehicles and vehicle occupancy by replaying the recorded video at their office. A summary of the survey stations and a map of the survey locations are shown as follows.

Table 4.1-2 Summary of the Traffic Count and Vehicle Occupancy Survey Stations

No.	Survey Station	Survey Hours	Survey Days (Weekday)	Survey Days (Weekends)	Total Survey Days
1	QL5, Nomura Industrial Park	24	5	2	7
2	QL10, Kien Bridge	24	5	2	7
3	TL359, Binh Bridge	24	5	2	7
4	AH14, Dong Hai Bridge	24	5	2	7
5	TL 352, Si Bridge	24	3	1	4
6	QL10, Gia Bridge	24	3	1	4
7	TL359, Thuy Trieu/Ngu Lao	24	3	1	4
8	QL10, Tram Bac Bridge	24	3	1	4
9	Phan Dang Luu St., Kien An Bridge	24	3	1	4
10	Truong Chinh Street, Niem Bridge	24	3	1	4
11	Pham Van Dong St.	24	3	1	4

Source: Study Team

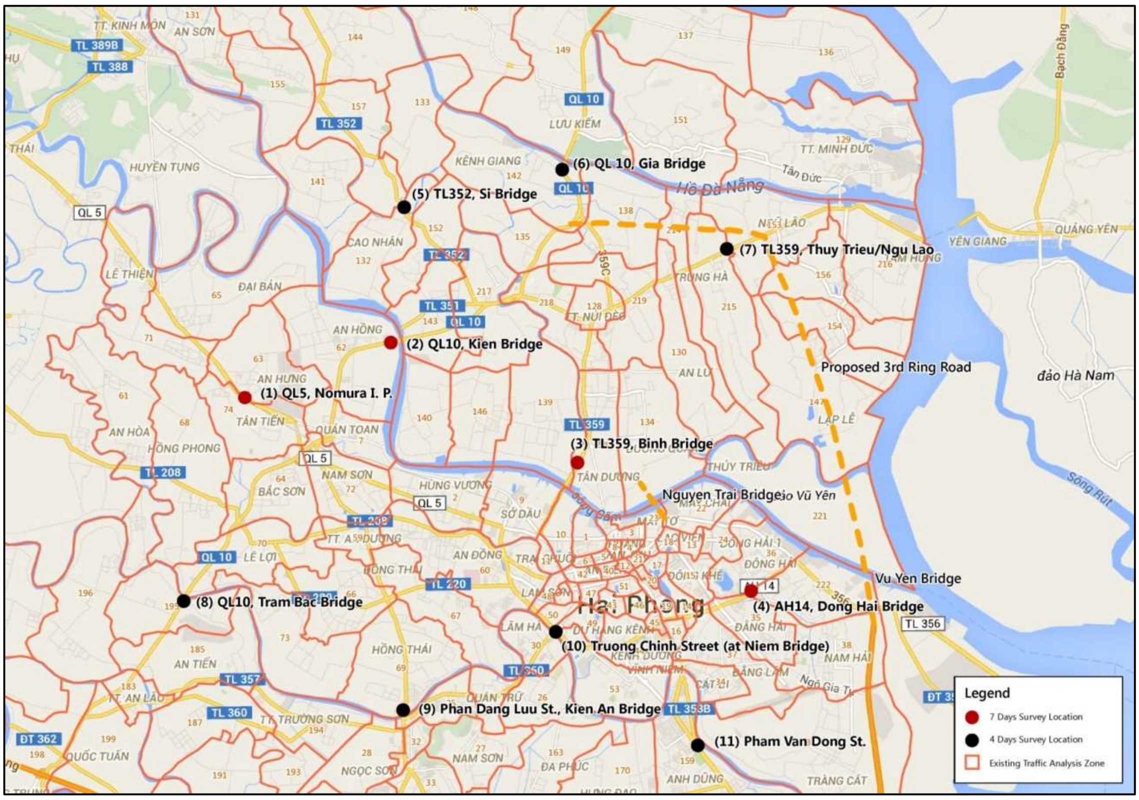


Figure 4.1-1 Traffic Count and Road Side OD Interview Survey Locations

4.1.2 Results from the Traffic Count Survey

(1) Passenger Car Unit Factors Used

The official passenger car unit (PCU) factors for Vietnam are shown in the following table and come from the Vietnamese standard TCXDVN 104:2007 - Urban road - Design specification (TCXDVN 104:2007 - Đường đô thị - yêu cầu thiết kế).

Table 4.1-3 Vietnam Official Passenger Car Unit Factors

Vehicle	Design Speed (km/h)		
	≥ 60	30, 40, 50	≤ 20
Bicycle	0.50	0.30	0.20
Motorcycle	0.50	0.25	0.15
Car	1.00	1.00	1.00
2-axle trucks and buses with less than 25 seats	2.00	2.50	2.50
3-axle trucks and buses with more than 25 seats	2.50	3.00	3.50
Trailers trucks and articulated buses	3.00	4.00	4.50

Source: TCXDVN 104:2007 - Đường đô thị - yêu cầu thiết kế (Urban road - Design specification)

Because the speed of vehicles on Vietnamese roads is usually quite slow, the PCU factors used in this study for motorcycles, cars, taxis, minibuses and medium and large buses came from the 30, 40 and 50 km/h design speed column.

For the bicycle mode, because the speed of this mode is usually slow, the PCU factor used came from the 20 km/h design speed column.

For the PCU factor used for trucks, detailed truck traffic counts were taken at Survey Stations (1), (2), (3) and (4) which were also the site of the axle load survey stations and the PCU factor for trucks was calculated using a weighted average of the truck traffic counts for the 4 main truck types: pickup trucks, rigid-chassis truck (2 axles), rigid-chassis truck (3 or more axles), truck/tractor-trailer. For these different truck types, the official PCU values for Vietnam for the design speed of 30, 40, 50 km/h were used in the weighted average calculation. This is shown in the following table.

Table 4.1-4 Calculating the Overall PCU Value for Trucks

	Pickup Truck	Rigid-Chassis Truck (2 axles)	Rigid-Chassis Truck (3 or more axles)	Truck/Tractor-trailer	Total of Surveyed Trucks	Truck PCU Factor Weighted Average
Number of Surveyed Trucks	11,634	26,646	8,548	80,980	127,808	-
Weights for Weighted Avg.	9.1%	20.8%	6.7%	63.4%	100%	-
PCU Value	2.50	2.50	3.00	4.00	-	3.48

Note: The different types of trucks were only surveyed at Survey Stations (1), (2), (3) and (4) for 2 weekdays and 2 weekends. For more details see 4.1.2(2)4) Detailed Truck Traffic Counts at the Axle Load Survey Stations

Source: Study Team

The vehicle category of "Others" consisted of other small non-motorized vehicles (i.e. carts pulled by animals, carts pulled by people, etc.) so the PCU factor for non-motorized vehicles of 0.20 was set for the "Others" vehicle category as well. This PCU factor was also based on previous experience from transport studies in Southeast Asia.

The PCU factors, shown below, were then used to calculate the PCU equivalent traffic volume for both directions and the modal share at each survey station.

Table 4.1-5 Passenger Car Unit Factors Used

	Bicycle	Cyclo	Motorcycle	Car	Taxi	Minibus (<25 pax)	Medium and Large Bus (>25 pax)	Truck[2]	Others
PCU Factor	0.20	2.00[1]	0.25	1.00	1.00	2.50	3.00	3.48	0.20

Note:
1. Based on previous experience from transport studies in Southeast Asia (i.e. Metro Manila Urban Transportation Integration Study (JICA, 1999))
2. Calculated based on a weighted average of surveyed truck types. See Table 4.1-4 for more details.

Source: Study Team

(2) Summary of the Traffic Situation

1) Current Traffic Situation in the Study Area

The current traffic situation showing the current road capacity at the cross sections of the 11 survey stations as well as the traffic volume of the motorcycle and truck modes, total traffic (inbound and outbound) and the individual inbound and outbound traffic in PCU are shown in the following table.

Table 4.1-6 Current Traffic Situation in the Study Area

Unit: Average Daily Traffic Volume (PCU)

No.	Survey Station	Current Road Capacity at Survey Station Cross Section	Motorcycle Traffic Volume	Truck Traffic Volume	Total Traffic (Inbound and Outbound)	Inbound Traffic	Outbound Traffic
1	QL5, Nomura Industrial Park	90,000	8,820	48,241	70,602	35,545	35,057
2	QL10, Kien Bridge	30,000	4,157	15,686	26,196	12,834	13,362
3	TL359, Binh Bridge	22,000	11,293	6,292	27,591	13,734	13,856
4	AH14, Dong Hai Bridge	63,960	6,259	45,888	58,414	28,565	29,849
5	TL 352, Si Bridge	20,000	4,902	3,418	10,366	5,295	5,070
6	QL10, Gia Bridge	30,000	6,259	13,597	29,151	14,405	14,745
7	TL359, Thuy Trieu/Ngu Lao	30,000	5,672	6,394	15,874	7,893	7,982
8	QL10, Tram Bac Bridge	30,000	5,008	13,409	24,794	12,603	12,191
9	Phan Dang Luu St., Kien An Bridge	70,000	6,426	8,682	19,111	9,410	9,701
10	Truong Chinh Street, Niem Bridge	63,960	30,964	10,604	57,834	29,201	28,633
11	Pham Van Dong St.	63,960	7,284	6,775	23,032	11,622	11,410

Source: Study Team

The daily traffic variation, night/day ratio, peak ratio, weekday vs. weekend traffic and the proportion of traffic volume by survey station are shown in the following sections.

2) Daily Traffic Variation

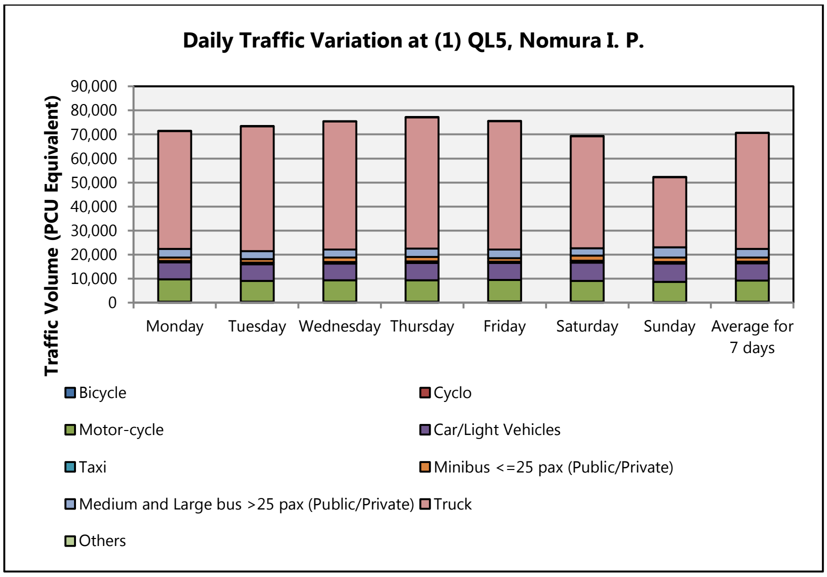
The daily traffic variation by survey station for both the inbound and outbound directions is shown in Figure 4.1-2, Figure 4.1-3, Figure 4.1-4, Figure 4.1-5, Figure 4.1-6, Figure 4.1-7, Figure 4.1-8, Figure 4.1-9, Figure 4.1-10, Figure 4.1-11 and Figure 4.1-12.

For survey stations 1 to 4, traffic data was collected for 7 days while for survey stations 5 to 11, traffic data was only collected for 4 days in total, 3 weekdays and 1 weekend day. In order to compare the daily traffic variation using the same baseline, the 4 day traffic data from survey stations 5 to 11 was extrapolated to 7 days. The methodology and calculations for the extrapolation is shown in Appendix A4.

For the 7 day survey stations (Survey Stations 1-4), traffic volume was fairly consistent for each day with the exception of the survey stations on the major trucking routes, that is (1) QL5, Nomura Industrial Park and (4) AH14, Dong Hai Bridge. It can be seen that on Sundays there is a sizable decrease in traffic volume.

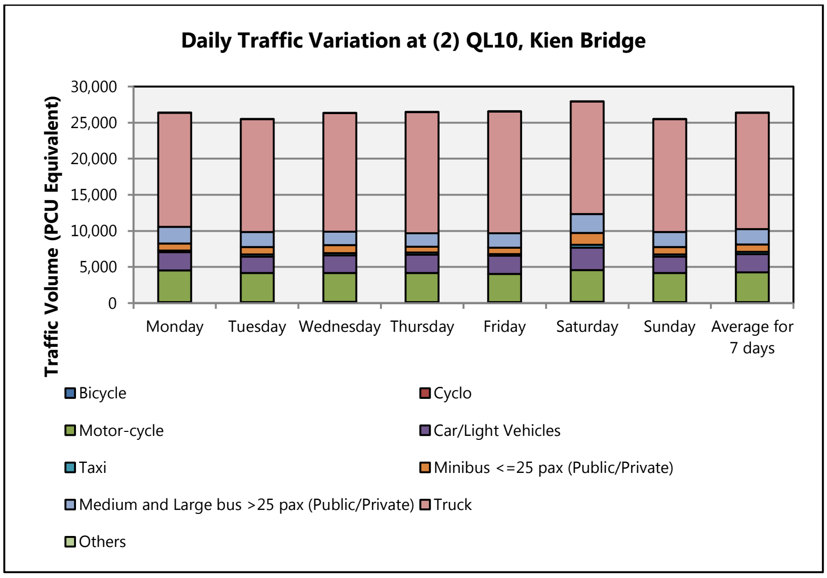
At (1) as shown in Figure 4.1-2, the Monday to Saturday average total traffic volume was 73,670 and the Sunday total traffic volume was 52,193. The Sunday total traffic volume decreased by 29.2% compared to the Monday to Saturday average total traffic volume.

At (4) as shown in Figure 4.1-5, the Monday to Saturday average total traffic volume was 61,996 and the Sunday total traffic volume was 36,922. Compared to the Monday to Saturday average total traffic volume, the traffic volume on Sunday decreased by 40.4%.



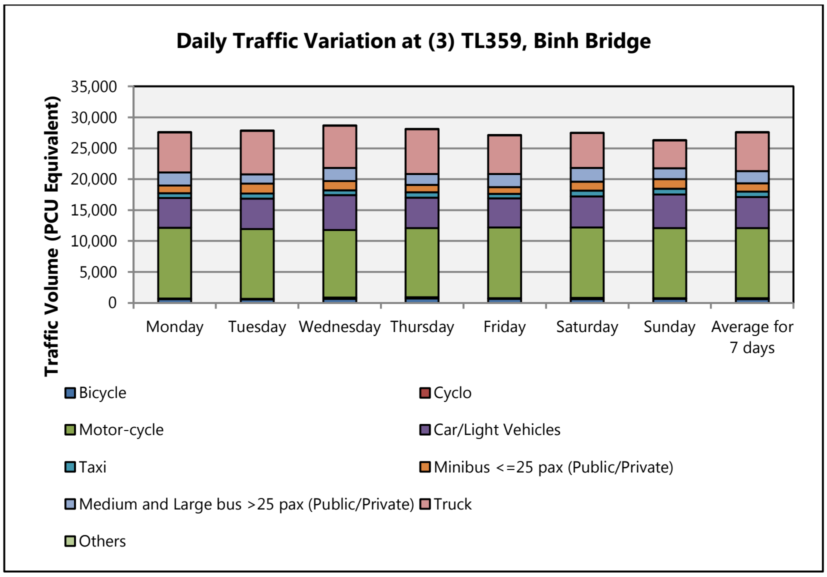
Source: Study Team

Figure 4.1-2 Daily Traffic Variation at Survey Station 1



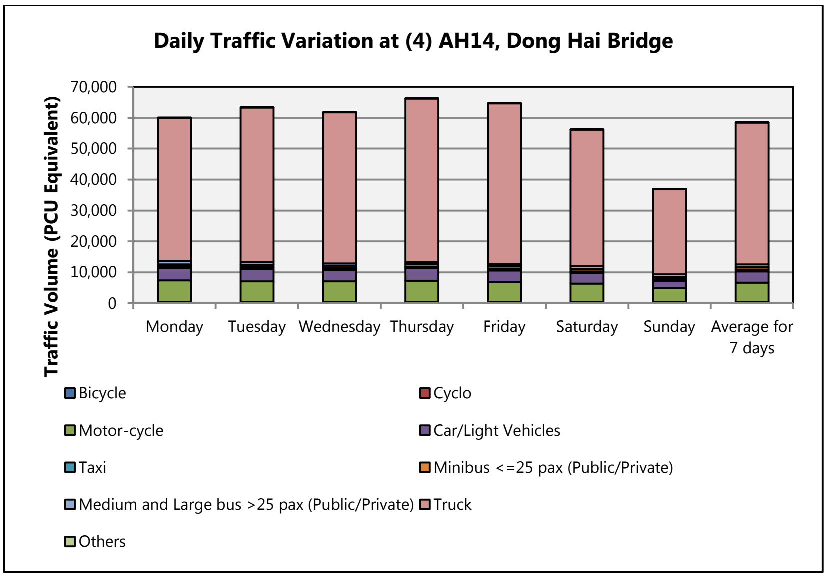
Source: Study Team

Figure 4.1-3 Daily Traffic Variation at Survey Station 2



Source: Study Team

Figure 4.1-4 Daily Traffic Variation at Survey Station 3



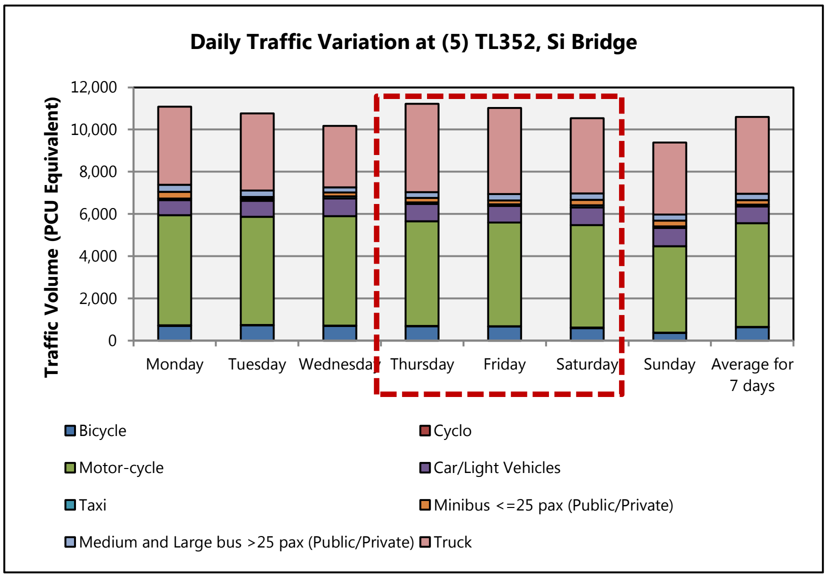
Source: Study Team

Figure 4.1-5 Daily Traffic Variation at Survey Station 4

The daily traffic variation for the 4 day survey stations are shown in the following figures.

Except (8) QL10, Tram Bac Bridge, and (11) Pham Van Dong St., where it was observed that the total traffic volume was pretty consistent every day, for the other 4 day survey stations, differences between the Sunday and/or weekend traffic volume compared to the Monday to Saturday and/or the weekday traffic volume differed between 8-23%.

At (5) TL352, Si Bridge, as shown in Figure 4.1-6, the average weekday total traffic volume was 10,865 while the average weekend total traffic volume was 9,981. There was only a decrease of 8.1% in the total traffic volume on the weekends compared to the weekdays.

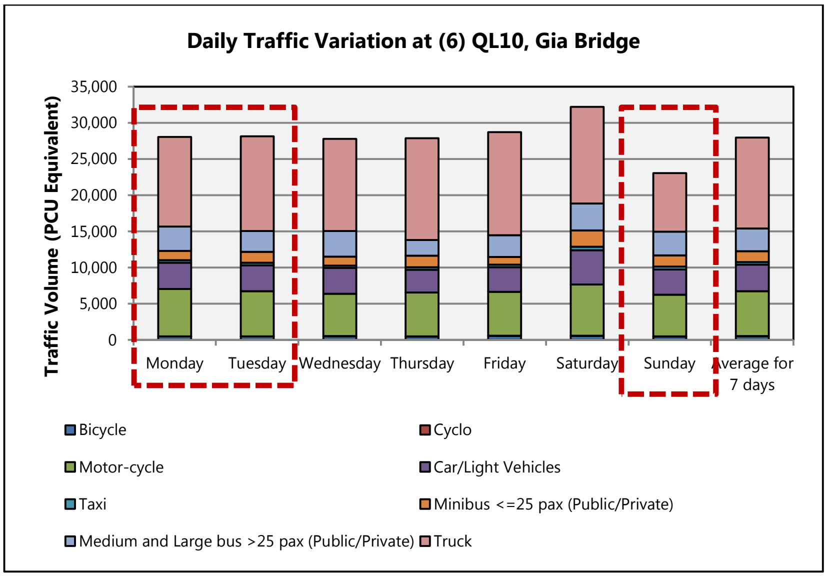


Note: Dashed box indicates the estimated traffic volume from the non-surveyed days (3 days)

Source: Study Team

Figure 4.1-6 Daily Traffic Variation at Survey Station 5

At (6) QL10, Gia Bridge, as shown in Figure 4.1-7, the average Monday to Saturday total traffic volume was 28,795 while the Sunday total traffic volume was 23,052. There was a decrease of 19.9% in the total traffic volume on Sunday compared to the average from Monday to Saturday.

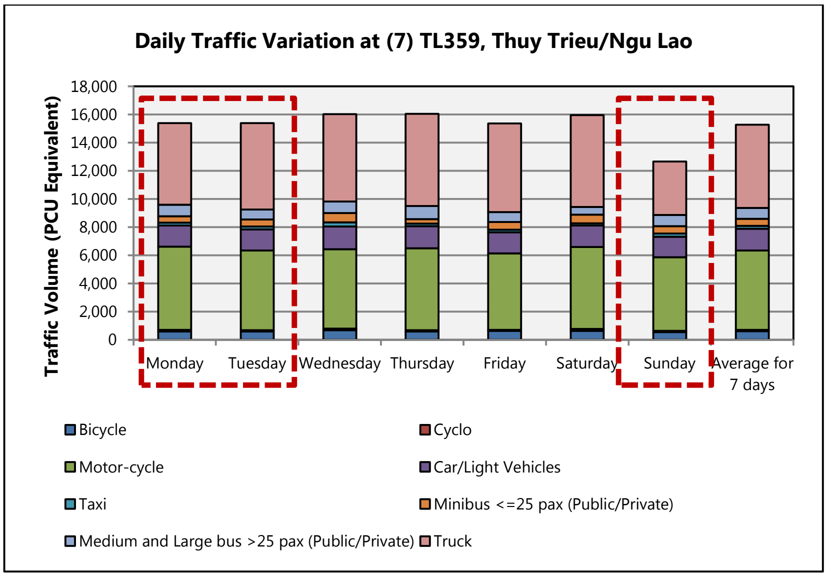


Note: Dashed box indicates the estimated traffic volume from the non-surveyed days (3 days)

Source: Study Team

Figure 4.1-7 Daily Traffic Variation at Survey Station 6

At (7) TL359, Thuy Trieu/Ngu Lao, as shown in Figure 4.1-8, the average Monday to Saturday total traffic volume was 15,721 while the Sunday total traffic volume was 12,691. There was a decrease of 19.3% in the total traffic volume on Sunday compared to the average from Monday to Saturday.

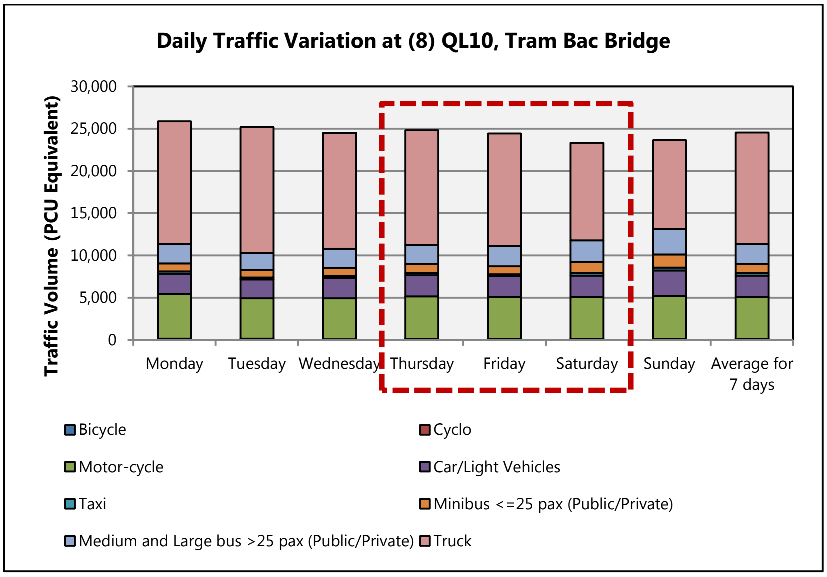


Note: Dashed box indicates the estimated traffic volume from the non-surveyed days (3 days)

Source: Study Team

Figure 4.1-8 Daily Traffic Variation at Survey Station 7

At (8) QL10, Tram Bac Bridge, as shown in Figure 4.1-9, the average weekday total traffic volume was 24,949 while the average weekend total traffic volume was 23,486. There was only a decrease of 5.9% in the total traffic volume on the weekends compared to the weekdays.

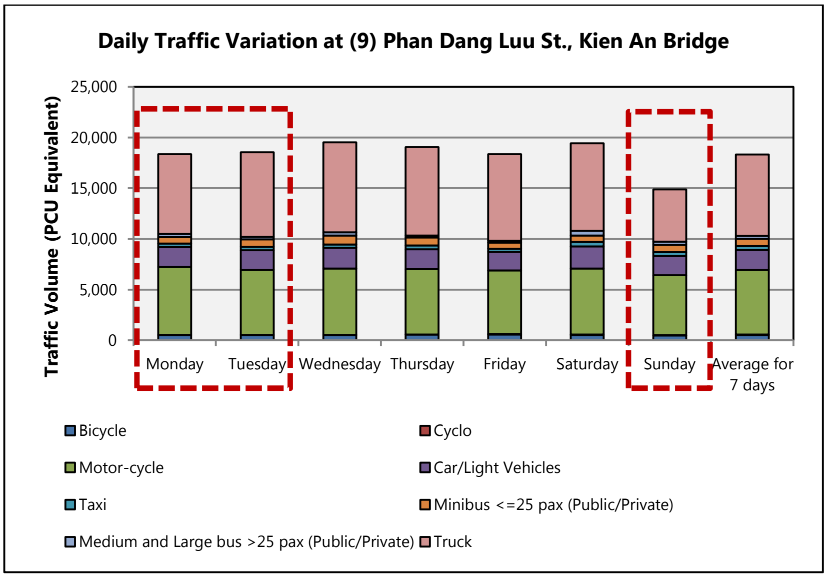


Note: Dashed box indicates the estimated traffic volume from the non-surveyed days (3 days)

Source: Study Team

Figure 4.1-9 Daily Traffic Variation at Survey Station 8

At (9) Phan Dang Luu St., Kien An Bridge, as shown in Figure 4.1-10, the average Monday to Saturday total traffic volume was 18,901 while the Sunday total traffic volume was 14,913. There was a decrease of 21.1% in the total traffic volume on Sunday compared to the average from Monday to Saturday.

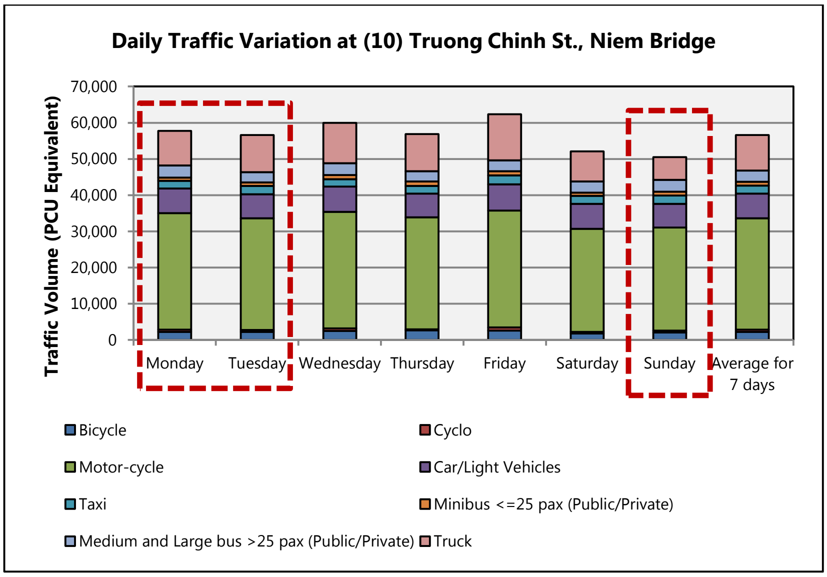


Note: Dashed box indicates the estimated traffic volume from the non-surveyed days (3 days)

Source: Study Team

Figure 4.1-10 Daily Traffic Variation at Survey Station 9

At (10) Truong Chinh St., Niem Bridge, as shown in Figure 4.1-11, the average weekday total traffic volume was 58,721 while the average weekend total traffic volume was 51,321. There was only a decrease of 12.6% in the total traffic volume on the weekends compared to the weekdays.

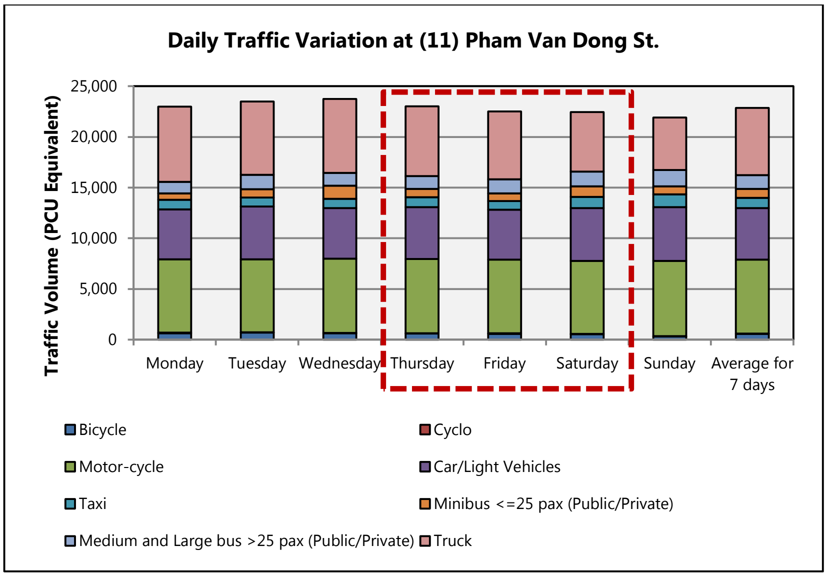


Note: Dashed box indicates the estimated traffic volume from the non-surveyed days (3 days)

Source: Study Team

Figure 4.1-11 Daily Traffic Variation at Survey Station 10

At (11) Pham Van Dong St., as shown in Figure 4.1-12, the average weekday total traffic volume was 23,150 while the average weekend total traffic volume was 22,183. There was only a decrease of 4.2% in the total traffic volume on the weekends compared to the weekdays.



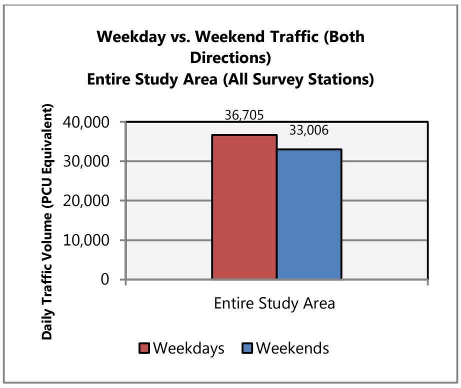
Note: Dashed box indicates the estimated traffic volume from the non-surveyed days (3 days)

Source: Study Team

Figure 4.1-12 Daily Traffic Variation at Survey Station 11

3) Weekday vs Weekend Traffic

The weekday and weekend traffic for both directions for the entire study area is shown in the following figure. The weighted mean, using the number of surveyed days as weights, was used to calculate the average traffic for weekdays and weekends. On average, in the entire study area, the weekday traffic volume was 36,705 PCUs while the weekend traffic volume was 33,006 PCUs.



Note: Weighted mean used to calculate the average where the weights used were the number of surveyed days

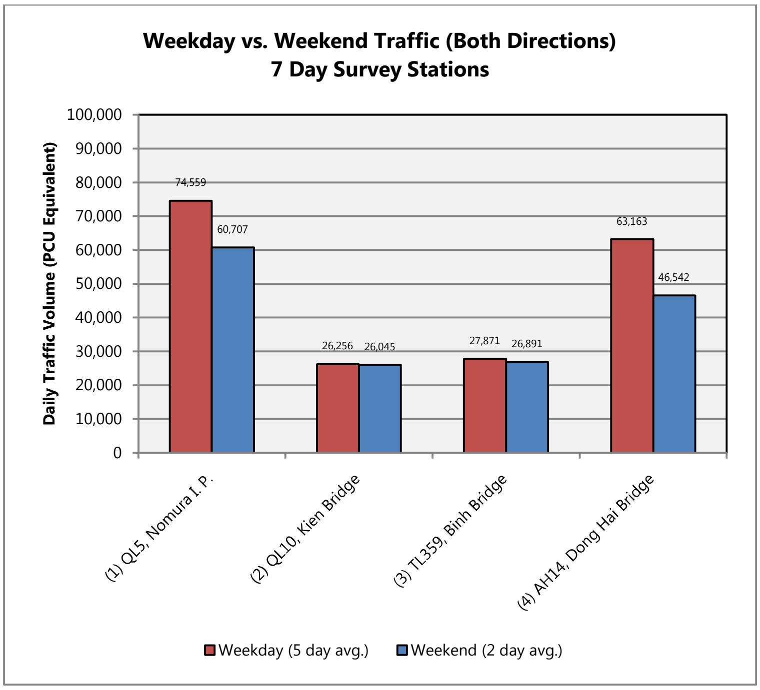
Source: Study Team

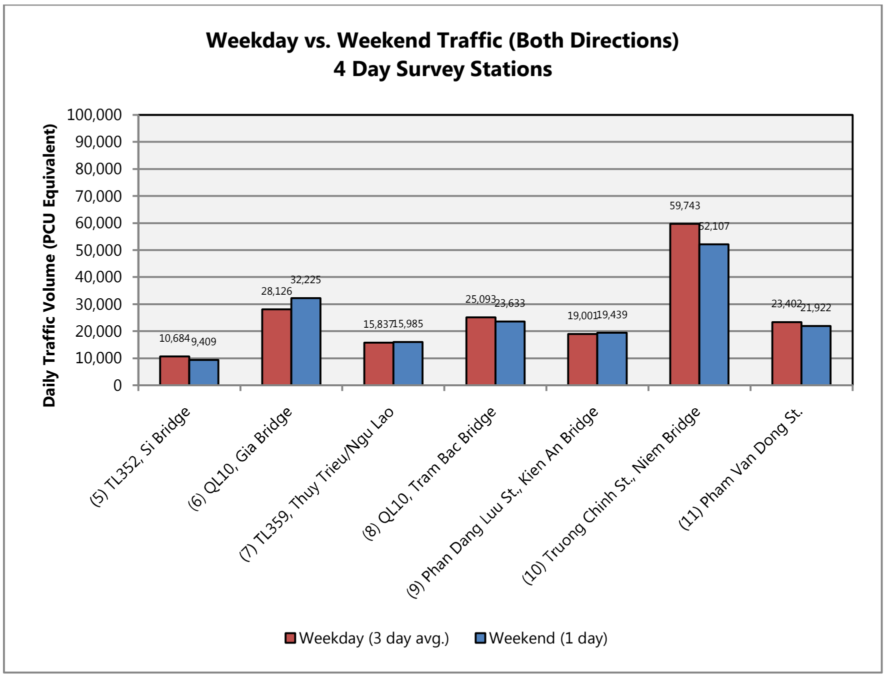
Figure 4.1-13 Weekday vs. Weekend Traffic for Both Directions for the Entire Study Area

In terms of the weekday vs. weekend traffic for each survey station, the traffic volumes are shown in the following figure.

For the survey stations located on the major truck routes (1) and (4) it can be seen that the average weekday traffic differs significantly from the average weekend traffic: 74,559 on the weekdays compared to 60,707 on the weekends at (1) and 63,163 on the weekdays compared to 46,542 on the weekends at (4). At (1) there is a decrease of 19% in the traffic volume on the weekends compared to the weekdays and at (4), there is a decrease of 26% in the traffic volume on the weekends compared to the weekdays.

For the 4 day survey stations, with the exception of survey stations (6) and (10), the average weekday traffic does not differ significantly from the weekend traffic. At (6), it was observed that there was more traffic on the weekend survey day compared to the average weekday (32,225 versus 28,126, a 15% increase) and at (10), the weekend survey day traffic was 52,107 compared to 59,743 for the average weekday traffic, a 13% decrease.





Source: Study Team

Figure 4.1-14 Weekday vs. Weekend Traffic for Both Directions by Survey Station

4) Detailed Truck Traffic Counts at the Axle Load Survey Stations

An additional traffic count was conducted for the 4 truck vehicle types (pickup truck, rigid-chassis truck (2 axles), rigid-chassis truck (3 or more axles) and truck/tractor-trailers) for 4 days (2 weekdays and 2 weekends)) at the 4 locations where the axle load survey was also conducted (see Section 4.3) in order to get details of the composition of the truck traffic volume. The 4 locations were the axle load surveys were also conducted were:

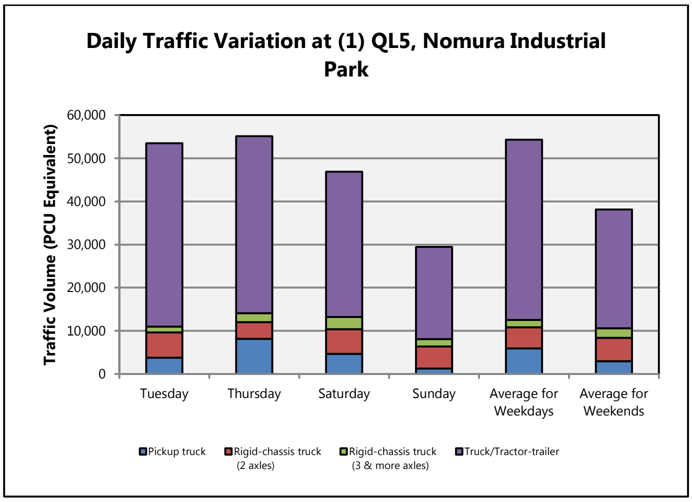
- (1) QL5, Nomura Industrial Park
- (2) QL10, Kien Bridge
- (3) TL359, Binh Bridge
- (4) AH14, Dong Hai Bridge

a) *Detailed Daily Truck Traffic Variation at the Axle Load Survey Stations*

Looking at the daily truck traffic variation from the 4 survey stations, Sunday has the lowest truck traffic volume as this is probably the main day of rest for commercial vehicle drivers. Survey stations (1) and (4) have the highest truck traffic volumes overall because (1) is located on the QL5 road linking Hai Phong to Hanoi and (4) is on the main road linking QL5 to the port in Hai Phong.

Among the 2 bridges which cross the Cam River, Kien Bridge has a significantly larger truck traffic volume than Binh Bridge, around a 2-time difference and Kien Bridge has a larger proportion of large/heavy truck vehicles whereas lighter truck vehicles were observed to use Binh Bridge more. The following figures show the daily truck traffic volume for the 4 survey stations.

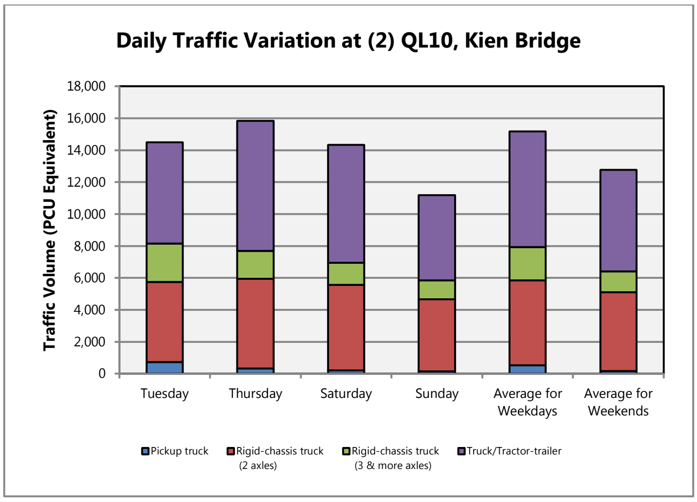
At (1) QL5, Nomura Industrial Park, the truck traffic for the 2 surveyed weekdays was roughly the same at around 53,000-56,000 PCU while for weekend days, it was observed that there was a large reduction in truck traffic between Saturday and Sunday, around 47,000 PCU versus around 30,000 PCU, respectively.



Source: Study Team

Figure 4.1-15 Daily Truck Traffic Variation at (1) QL5, Nomura Industrial Park

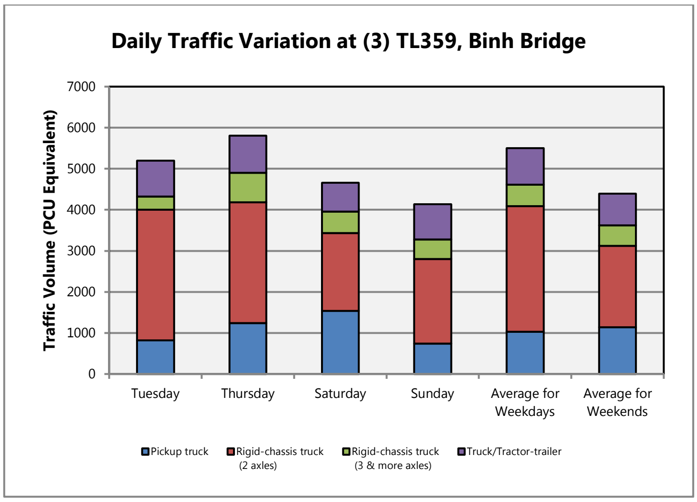
At (2) QL10, Kien Bridge, the truck traffic on the weekdays was roughly the same for the 2 surveyed days at around 14,500-16,000 PCU while on the weekends, there was a slight decrease in the truck traffic volume on Sunday compared to Saturday (around 11,200 PCU on Sunday vs. around 14,300 PCU on Saturday).



Source: Study Team

Figure 4.1-16 Daily Truck Traffic Variation at (2) QL10, Kien Bridge

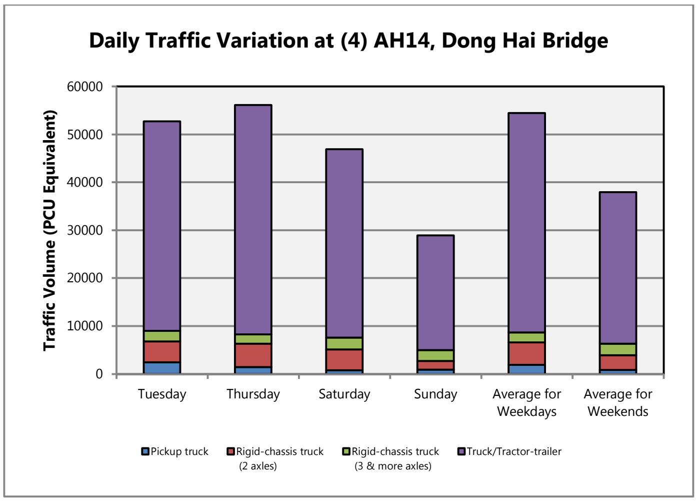
At (3) TL359, Binh Bridge, the truck traffic on the 2 surveyed weekdays ranged from 5,200-5,800 PCU while the truck traffic on the 2 surveyed weekend days ranged from around 4,700 PCU on Saturday compared to 4,100 PCU on Sunday.



Source: Study Team

Figure 4.1-17 Daily Truck Traffic Variation at (3) TL359, Binh Bridge

At (4) AH14, Dong Hai Bridge, the truck traffic on the 2 surveyed weekdays ranged from between around 53,000-56,000 PCU while the truck traffic on the 2 surveyed weekend days ranged from around 47,000 PCU on Saturday to around 29,000 PCU on Sunday.



Source: Study Team

Figure 4.1-18 Daily Truck Traffic Variation at (4) AH14, Dong Hai Bridge

5) Ratio of Daily Traffic to Daytime Traffic

The ratio of daily traffic to daytime traffic is the proportion between the 24 hour traffic volume and the 12 hour traffic volume and the calculations are shown in Appendix A4.

For the entire study area, the daily traffic to daytime traffic ratio for motorcycles, cars, buses and trucks were 1.32, 1.35, 1.36 and 1.61 respectively. This is shown in the following table.

Table 4.1-7 Ratio of Daily Traffic to Daytime Traffic for the Entire Study Area

All Survey Stations – Ratio of Daily Traffic to Daytime Traffic (Unit: Daily Average)				
Survey Station	**Motorcycles**	**Cars**	**Buses**	**Trucks**
Entire Study Area (All 11 Survey Stations)	1.32	1.35	1.36	1.61

Note: Weighted mean used to calculate the average where the weights used were the bidirectional traffic count data from each survey stations

Source: Study Team

For the motorcycle, car and bus modes, for the 7 day survey stations (1-4) and the 4 day survey stations (5-11), the daily traffic to daytime traffic ratio was around the range of 1.30 to 1.40 and was fairly consistent between survey stations which means that the time variation in traffic volume for these modes are similar for each of the survey stations.

On the other hand, for the truck mode, the ratio of daily traffic to daytime traffic fluctuated between a low of 1.16 to a high of 1.75. High values were calculated at survey stations (1), (2), (4), (6) and (8) as these survey stations had values above 1.50. This means that at these survey stations, there were high traffic volumes of trucks during the nighttime.

The 7 day average values for the ratio of daily traffic to daytime traffic are shown in the following tables. The values for each surveyed day are shown in the tables in Appendix A4.

Table 4.1-8 Ratio of Daily Traffic to Daytime Traffic for the 7 Day Survey Stations (7 Day Average)

7 Day Survey Stations – Ratio of Daily Traffic to Daytime Traffic (Unit: 7 Day Average)				
Survey Station	**Motorcycles**	**Cars**	**Buses**	**Trucks**
(1) QL5, Nomura Industrial Park	1.38	1.37	1.32	1.69
(2) QL10, Kien Bridge	1.31	1.36	1.36	1.54
(3) TL359, Binh Bridge	1.31	1.32	1.39	1.30
(4) AH14, Dong Hai Bridge	1.29	1.30	1.35	1.75

Note: Arithmetic mean used to calculate the average

Source: Study Team

Table 4.1-9 Ratio of Daily Traffic to Daytime Traffic for the 4 Day Survey Stations (4 Day Average)

4 Day Survey Stations – Ratio of Daily Traffic to Daytime Traffic (Unit: 4 Day Average)				
Survey Station	**Motorcycles**	**Cars**	**Buses**	**Trucks**
(5) TL 352, Si Bridge	1.40	1.29	1.41	1.16
(6) QL10, Gia Bridge	1.35	1.35	1.35	1.55
(7) TL359, Thuy Trieu/Ngu Lao	1.33	1.29	1.42	1.37
(8) QL10, Tram Bac Bridge	1.33	1.32	1.40	1.54
(9) Phan Dang Luu St., Kien An Bridge	1.32	1.32	1.45	1.26
(10) Truong Chinh Street, Niem Bridge	1.32	1.38	1.38	1.46
(11) Pham Van Dong St.	1.27	1.39	1.27	1.19

Note: Arithmetic mean used to calculate the average

Source: Study Team

6) Peak Ratio

The peak ratio was calculated by taking the proportion between the peak hour and the 12 hour traffic volume (7:00 – 19:00) by direction and for each vehicle group. The vehicle groups used were the same as the ones used in the calculation of the ratio of daily traffic to daytime traffic. The weekday and weekend average peak ratios for the entire study area for the inbound and outbound directions are shown in the following tables. Inbound refers to traffic coming into Hai Phong while outbound refers to traffic leaving Hai Phong.

Table 4.1-10 Entire Study Area Weekday Average Peak Ratio

Peak Ratio – Weekday Average				
Entire Study Area (All 11 Survey Stations)				
Direction	Motorcycles	Cars	Buses	Trucks
Inbound	0.21	0.12	0.15	0.12
Outbound	0.18	0.11	0.15	0.11

Note: Weighted mean used to calculate the average where the weights used were the bidirectional traffic count data from each survey station

Source: Study Team

Table 4.1-11 Entire Study Area Weekend Average Peak Ratio

Peak Ratio – Weekend Average				
Entire Study Area (All 11 Survey Stations)				
Direction	Motorcycles	Cars	Buses	Trucks
Inbound	0.14	0.12	0.14	0.12
Outbound	0.14	0.12	0.17	0.11

Note: Weighted mean used to calculate the average where the weights used were the bidirectional traffic count data from each survey station

Source: Study Team

For the truck mode, for all of the survey stations and both directions, there was almost no variation between the peak ratio for the weekdays and the weekends. For trucks, the peak hour traffic made up between 10-15% of the 12 hour traffic volume.

On the other hand, for motorcycles, for some survey stations such as (1), (4), (5), (8), there was a large variation between the peak ratio for the weekdays and weekends.

The weekday and weekend average peak ratio values for both the inbound and outbound directions are shown in the following tables. Detailed peak ratio values by day of the week for all survey stations are shown in Appendix A4.

Table 4.1-12 Weekday Average Peak Ratio, Inbound Direction

Peak Ratio – Weekday Average				
Inbound Direction				
Survey Station	Motorcycles	Cars	Buses	Trucks
(1) QL5, Nomura Industrial Park	0.29	0.11	0.13	0.12
(2) QL10, Kien Bridge	0.18	0.12	0.14	0.12
(3) TL359, Binh Bridge	0.17	0.12	0.17	0.12
(4) AH14, Dong Hai Bridge	0.17	0.13	0.19	0.12
(5) TL 352, Si Bridge	0.42	0.13	0.21	0.13
(6) QL10, Gia Bridge	0.21	0.13	0.14	0.11
(7) TL359, Thuy Trieu/Ngu Lao	0.16	0.14	0.15	0.12
(8) QL10, Tram Bac Bridge	0.40	0.13	0.13	0.13
(9) Phan Dang Luu St., Kien An Bridge	0.19	0.11	0.20	0.11
(10) Truong Chinh Street, Niem Bridge	0.18	0.11	0.12	0.13
(11) Pham Van Dong St.	0.19	0.13	0.17	0.12

Note: Arithmetic mean used to calculate the average

Source: Study Team

Table 4.1-13 Weekday Average Peak Ratio, Outbound Direction

Peak Ratio – Weekday Average				
Outbound Direction				
Survey Station	Motorcycles	Cars	Buses	Trucks
(1) QL5, Nomura Industrial Park	0.21	0.10	0.13	0.11
(2) QL10, Kien Bridge	0.17	0.11	0.14	0.11
(3) TL359, Binh Bridge	0.14	0.11	0.16	0.13
(4) AH14, Dong Hai Bridge	0.24	0.15	0.23	0.11
(5) TL 352, Si Bridge	0.21	0.12	0.19	0.13
(6) QL10, Gia Bridge	0.17	0.12	0.13	0.14
(7) TL359, Thuy Trieu/Ngu Lao	0.15	0.12	0.25	0.11
(8) QL10, Tram Bac Bridge	0.27	0.12	0.13	0.11
(9) Phan Dang Luu St., Kien An Bridge	0.21	0.11	0.18	0.11
(10) Truong Chinh Street, Niem Bridge	0.16	0.10	0.11	0.14
(11) Pham Van Dong St.	0.16	0.11	0.11	0.12

Note: Arithmetic mean used to calculate the average

Source: Study Team

Table 4.1-14 Weekend Average Peak Ratio, Inbound Direction

Peak Ratio – Weekend Average				
Inbound Direction				
Survey Station	Motorcycles	Cars	Buses	Trucks
(1) QL5, Nomura Industrial Park	0.17	0.11	0.13	0.12
(2) QL10, Kien Bridge	0.14	0.16	0.14	0.12
(3) TL359, Binh Bridge	0.14	0.12	0.14	0.12
(4) AH14, Dong Hai Bridge	0.13	0.11	0.17	0.11
(5) TL 352, Si Bridge	0.15	0.13	0.25	0.13
(6) QL10, Gia Bridge	0.16	0.14	0.14	0.11
(7) TL359, Thuy Trieu/Ngu Lao	0.13	0.13	0.20	0.13
(8) QL10, Tram Bac Bridge	0.14	0.15	0.18	0.11
(9) Phan Dang Luu St., Kien An Bridge	0.18	0.12	0.13	0.11
(10) Truong Chinh Street, Niem Bridge	0.13	0.11	0.14	0.13
(11) Pham Van Dong St.	0.11	0.12	0.11	0.11

Note: For survey stations 5 to 11, data was only collected on one weekend day, either Sat. or Sun.

Source: Study Team

Table 4.1-15 Weekend Average Peak Ratio, Outbound Direction

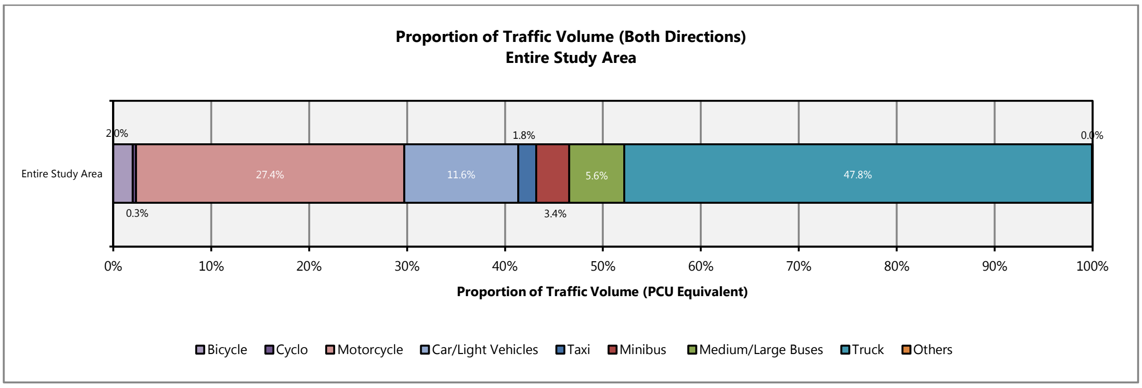
Peak Ratio – Weekend Average				
Outbound Direction				
Survey Station	Motorcycles	Cars	Buses	Trucks
(1) QL5, Nomura Industrial Park	0.16	0.11	0.15	0.11
(2) QL10, Kien Bridge	0.14	0.12	0.19	0.11
(3) TL359, Binh Bridge	0.13	0.12	0.20	0.12
(4) AH14, Dong Hai Bridge	0.18	0.13	0.23	0.11
(5) TL 352, Si Bridge	0.12	0.18	0.18	0.14
(6) QL10, Gia Bridge	0.14	0.12	0.17	0.10
(7) TL359, Thuy Trieu/Ngu Lao	0.13	0.12	0.13	0.13
(8) QL10, Tram Bac Bridge	0.14	0.15	0.18	0.11
(9) Phan Dang Luu St., Kien An Bridge	0.20	0.11	0.23	0.11
(10) Truong Chinh Street, Niem Bridge	0.13	0.11	0.11	0.11
(11) Pham Van Dong St.	0.10	0.11	0.12	0.12

Note: For survey stations 5 to 11, data was only collected on one weekend day, either Sat. or Sun.

Source: Study Team

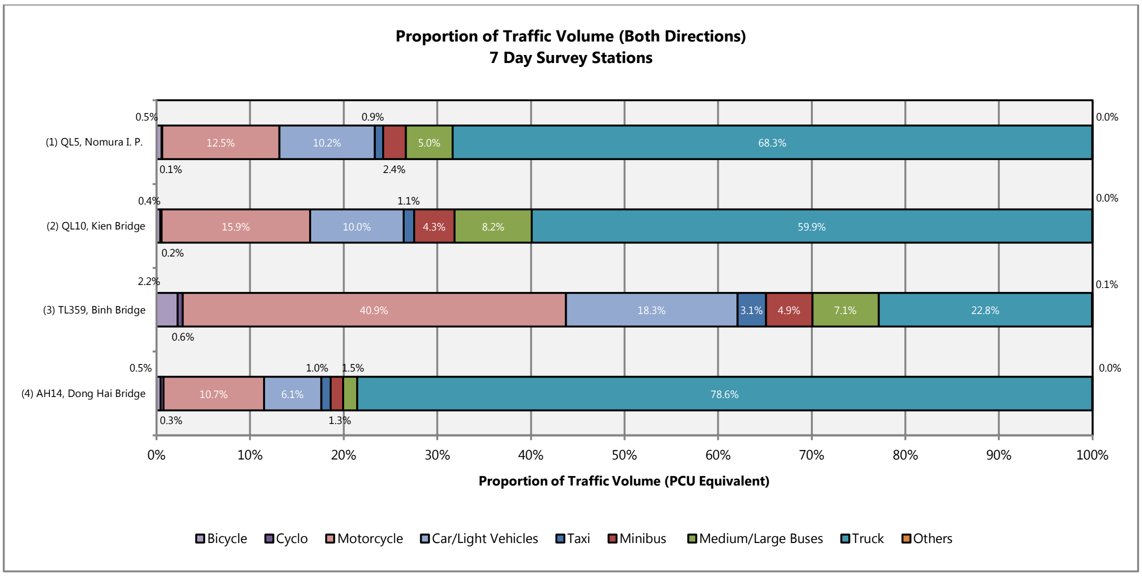
7) Proportion of Traffic Volume by Survey Stations

The mode shares for each surveyed vehicle type for each survey station are shown in the following figures. For the entire study area, there were 2 dominant modes: motorcycles which made up 27.4% of the total surveyed traffic and trucks which made up 47.8% of the total surveyed traffic.



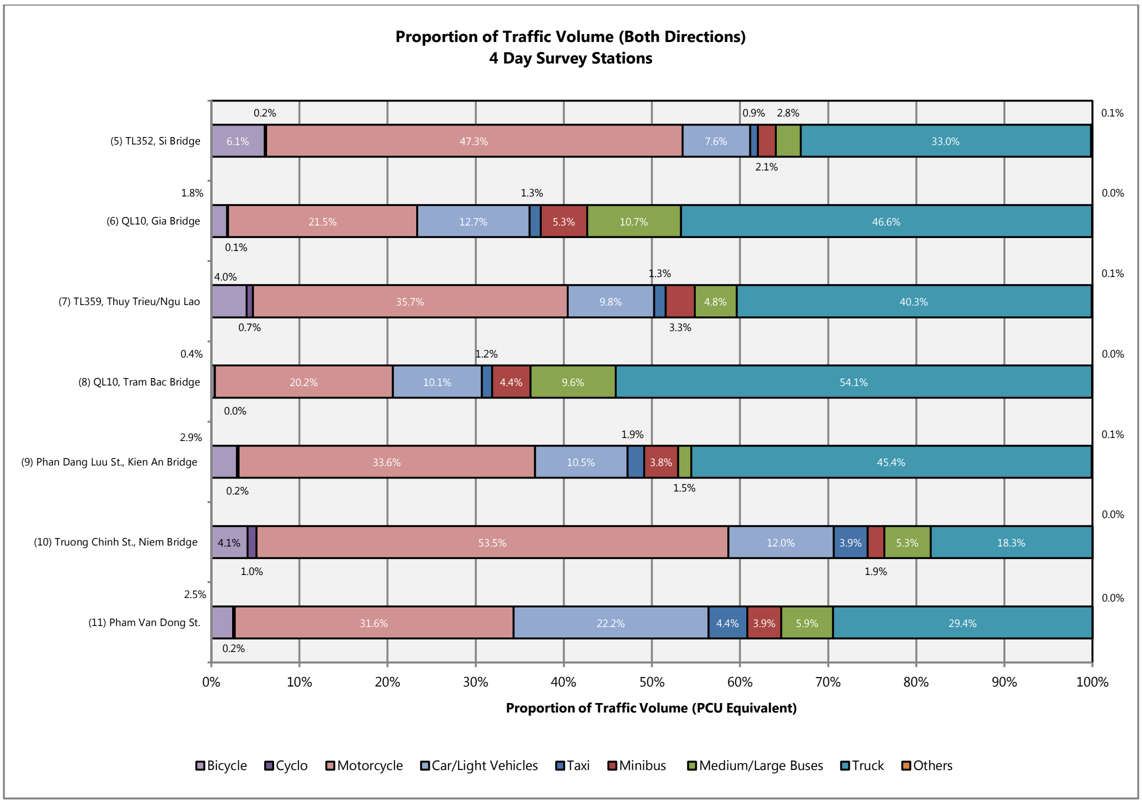
Source: Study Team

Figure 4.1-19 Proportion of Traffic Volume for Both Directions for the Entire Study Area



Source: Study Team

Figure 4.1-20 Proportion of Traffic Volume for Both Directions for the 7 Day Survey Stations

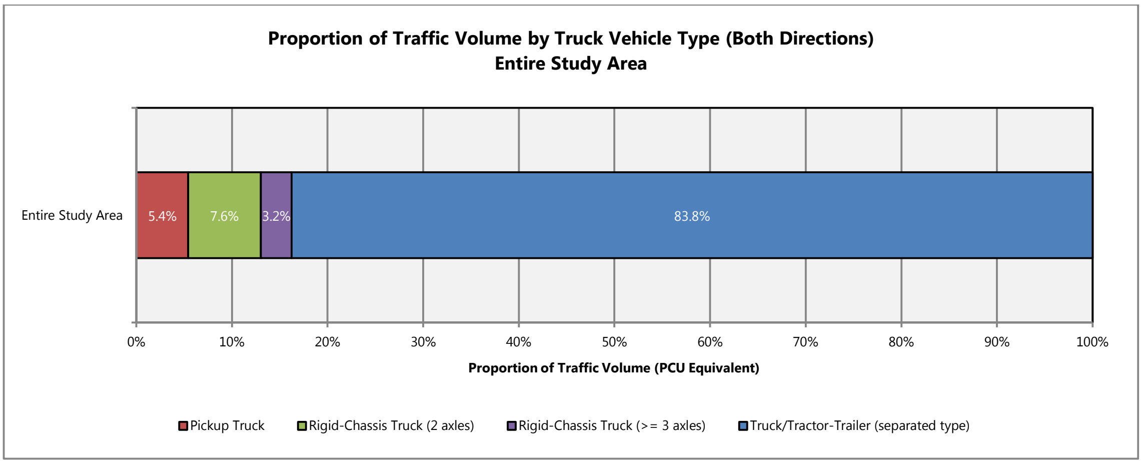


Source: Study Team

Figure 4.1-21 Proportion of Traffic Volume for Both Directions for the 4 Day Survey Stations

8) Proportion of Truck Vehicles at the Axle Load Survey Stations

The proportion of truck vehicles for all survey stations were calculated using the weighted mean and are shown in the following figure. For all survey stations, the truck/tractor-trailer vehicle type represented a large majority of all truck vehicles surveyed (83.8%). The proportions for other truck vehicle types are shown in the following figure.

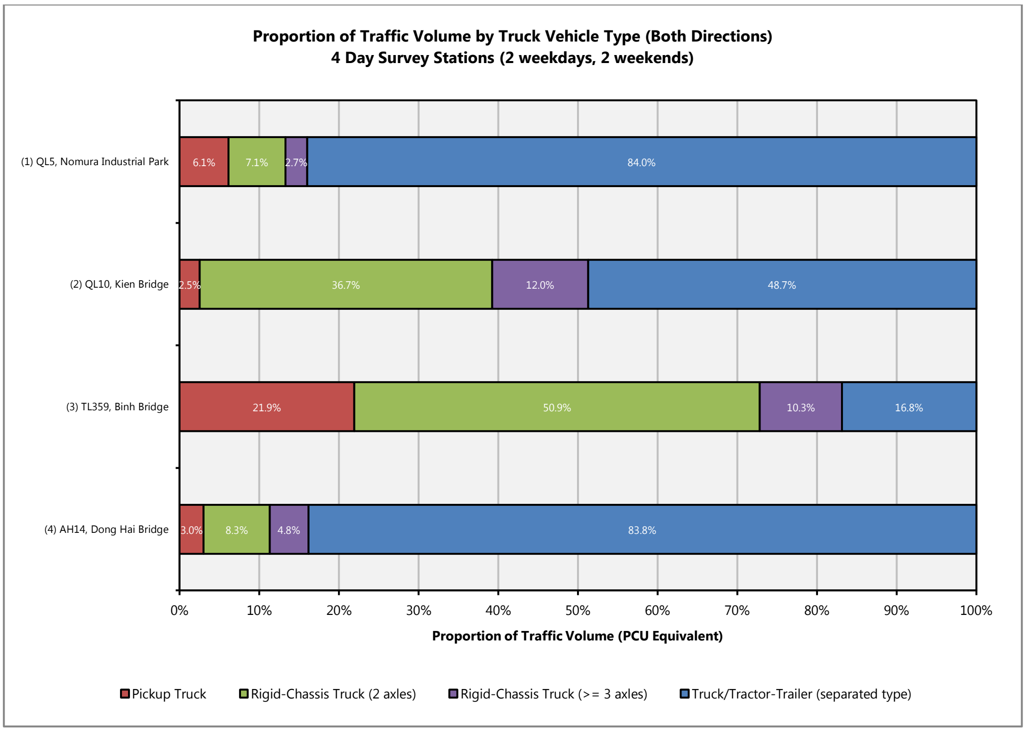


Source: Study Team

Figure 4.1-22 Proportion of Truck Traffic Volume for Both Directions for All Axle Load Survey Stations

The proportion of the different types of truck vehicles for the survey stations (stations 1 to 4) that were also used for the axle load survey is shown in the following figure.

For survey stations (1) and (4), 80% or more of the trucks were truck/tractor-trailer vehicles while for survey station (2), Kien Bridge, more than 35% of the truck vehicles were 2 axle rigid-chassis trucks and 48% where truck/tractor-trailer vehicles. For (3) Binh Bridge, half of all trucks that were surveyed were 2 axle rigid chassis trucks and there was a large percentage of pickup trucks (21.9%) compared to the other survey stations.



Source: Study Team

Figure 4.1-23 Proportion of Truck Traffic Volume for Both Directions for Survey Stations 1-4

(3) Survey Stations with the Highest Traffic Volumes

The survey station with the highest traffic volume overall for average daily weekdays in terms of PCU was (1) QL5, Nomura Industrial Park on the major artery of QL5 that connects Hai Phong with Hanoi and other cities to the east. The PCU volume was 74,559 and 68.3% of traffic in terms of PCU were from trucks (see Figure 4.1-14 and Figure 4.1-20).

The survey stations with the next highest traffic volumes for weekdays were (4) AH14, Dong Hai Bridge which is located on the road that connects QL5 with the port of Hai Phong and the Dinh Vu industrial zone with a PCU volume of 63,163 and a modal share of trucks of 78.6% (see Figure 4.1-14 and Figure 4.1-20).

The other survey station which had a PCU volume exceeding 50,000 was (10) Truong Chinh St., Niem Bridge in the heart of the city with a PCU volume of 59,743 (see Figure 4.1-14). Because it is located in the heart of the city, there is a large proportion of motorcycles (53.5%) compared to all other modes.

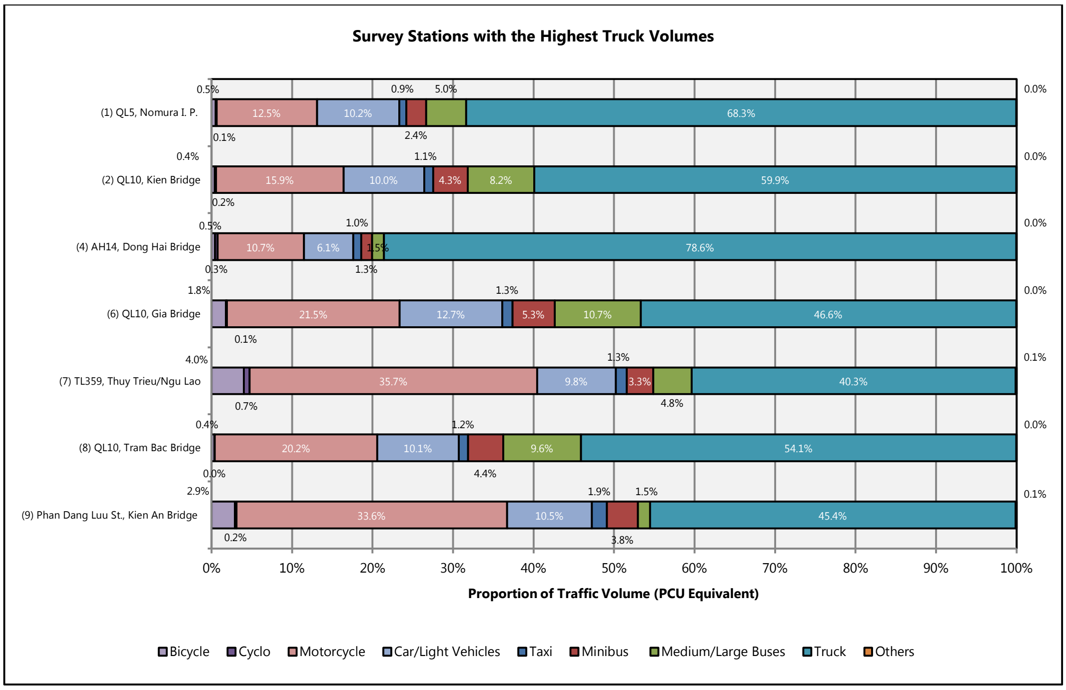
(4) Traffic Volume at the Two Major Cam River Crossings

Currently, there are only 2 bridges that cross the Cam River: Kien Bridge and Binh Bridge. From the traffic survey results, it can be observed that there is more traffic at Binh Bridge compared to Kien Bridge. At (3) TL359, Binh Bridge, the observed average daily traffic volume was around 27,000 PCUs while at (2) QL10, Kien Bridge, the observed average daily traffic volume was around 26,000 PCUs (see Figure 4.1-14). It was observed that there were more trucks that used Kien Bridge to cross the Cam River than Binh Bridge as trucks made up 59.9% of the traffic volume at (2) QL10, Kien Bridge compared to 22.8% at (3) TL359, Binh Bridge (see Figure 4.1-20).

(5) Survey Stations with the Highest Truck Volumes

On roads near industrial areas or on intercity arterial roads, the dominant traffic mode was trucks and they comprised at least 38% of all PCU equivalent vehicle traffic as shown in Figure 4.1-24. The survey stations where this was observed include:

1) QL5, Nomura Industrial Park
2) QL10, Kien Bridge
4) AH14, Dong Hai Bridge
6) QL10, Gia Bridge
7) TL359, Thuy Trieu/Ngu Lao
8) QL10 Tam Bac Bridge
9) Phan Dang Luu St., Kien An Bridge



Source: Study Team

Figure 4.1-24 Survey Stations with the Highest Truck Volumes

(6) Survey Station near the Proposed Section of the 3rd Ring Road

The survey station closest to the proposed section of the 3rd ring road is (7) TL359, Thuy Trieu/Ngu Lao. An average daily traffic volume of around 16,000 PCUs (see Figure 4.1-14) was observed for both weekdays and weekends. Compared to other survey stations, the number of vehicles observed was in the lower end.

Also, regarding the proportion of vehicles, the share of trucks and motorcycles were approximately the same with trucks taking a slightly greater share at 38.3% versus 36.9% (see Figure 4.1-24). The presence of almost equal shares for trucks and motorcycles indicates that this road is used both as a local road and as a minor route for trucks and commercial vehicles.

4.1.3 Results of the Vehicle Occupancy Survey

The average vehicle occupancy results are shown in Table 4.1-16. The calculations for the average values are shown in Appendix A4.

Table 4.1-16 Average Vehicle Occupancy for Both Directions by Survey Station

No.	Survey Station	Both Directions								
		Bicycle	Cyclo	Motor cycle	Car/Light Vehicles	Taxi	Minibus (<=25 pax) (Public/Private)	Medium and Large bus (>25 pax) (Public/Private)	Truck	Others
1	QL5, Nomura Industrial Park	1.09	1.05	1.43	2.37	2.23	16.72	30.29	1.64	1.00
2	QL10, Kien Bridge	1.08	1.00	1.44	2.37	2.16	13.63	29.80	1.65	1.00
3	TL359, Binh Bridge	1.11	1.02	1.46	2.25	2.11	12.92	27.56	1.62	1.00
4	AH14, Dong Hai Bridge	1.09	1.07	1.49	2.29	2.15	14.13	24.76	1.67	1.00
5	TL352, Si Bridge	1.19	1.00	1.30	2.25	1.98	14.26	18.81	1.66	1.00
6	QL10, Gia Bridge	1.15	1.10	1.33	2.26	2.14	14.17	23.43	1.62	1.00
7	TL359, Thuy Trieu/Ngu Lao	1.19	1.04	1.35	2.24	1.90	13.05	18.97	1.63	1.00
8	QL10, Tram Bac Bridge	1.05	1.00	1.32	2.19	2.09	15.09	25.21	1.62	1.00
9	Phan Dang Luu St., Kien An Bridge	1.14	1.06	1.30	2.18	2.21	12.03	22.25	1.65	1.00
10	Truong Chinh Street (at Niem Bridge)	1.14	1.11	1.42	2.31	2.15	13.66	21.67	1.51	1.00
11	Pham Van Dong St.	1.13	1.00	1.41	2.30	2.17	14.82	25.26	1.55	1.00
All Survey Stations		1.13	1.07	1.41	2.30	2.15	14.34	26.46	1.64	1.00

Note: Weighted mean used for all vehicle types

Source: Study Team

4.1.4 Results of the Roadside Origin-Destination Interview Survey

The roadside origin-destination (OD) interview survey was conducted for the purpose of obtaining the OD table for the current situation. The data obtained to create the OD table for the current situation was then used to calibrate the existing traffic demand model to reflect the current situation.

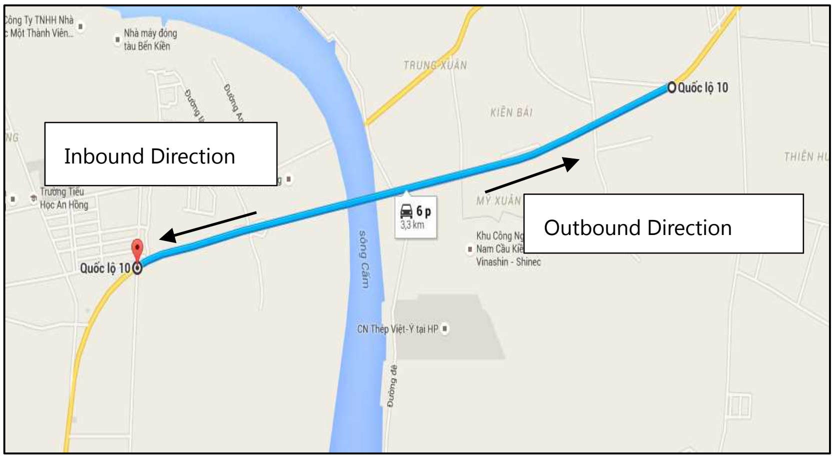
Details regarding the setup and results from the roadside origin-destination survey for surveyed private mode drivers, public mode drivers and freight mode drivers are shown in Appendix A4.

4.2 Travel Speed Survey on Kien Bridge

4.2.1 Background

A travel speed survey was conducted on a 3.3 km stretch of the existing Kien Bridge to determine the speed to set in the approach for the proposed Nguyen Trai Bridge (1.5 km approach, 4% grade) and Vu Yen Bridge (2.5 km approach, 4% grade) in the traffic assignment stage of the transport demand modeling.

The travel speed survey was conducted on 16 July 2015 for the 4 commercial vehicle types (pickup truck, rigid-chassis truck, tractor-trailer and bus) and on 20 July 2015 for cars using the M-241 GPS logger. For both days, the survey was conducting during the morning peak (06:00-10:00), off-peak (12:00-15:00) and evening peak (16:00-20:00) time periods in both directions (inbound and outbound).



Source: Study Team

Figure 4.2-1 Travel Speed Survey Location – Kien Bridge

4.2.2 Results

The number of surveyed vehicles is shown in the following table. In total 66 vehicles were surveyed.

Table 4.2-1 Number of Surveyed Vehicles for the Travel Speed Survey

Number of Surveyed Vehicles - Kien Bridge			
	Inbound	Outbound	Total by Vehicle Type
Car	12	12	24
Bus	7	8	15
Rigid-Chassis	5	6	11
Tractor-Trailer	7	5	12
Pickup Truck	2	2	4
Total Vehicles			66

Source: Study Team

For the inbound direction (to Hai Phong), for commercial vehicles (bus and trucks), the speed of vehicles on the sloped approach to the bridge was roughly between 84% and 88% (refer to the speed reduction rate) of the speed of vehicles on the flat section. In comparison, for cars, the speed on the sloped approach was 114% of the speed of vehicles on the flat section.

Table 4.2-2 Commercial Vehicle Speeds on the Inbound Direction of Kien Bridge

Kien Bridge - Inbound (To QL5)				
	Entire Section Speed (km/h)	**Flat Section Speed (km/h)**	**Slope Speed (km/h)**	**Speed Reduction Rate (Slope Speed/Flat Section Speed)**
Car	40.93	45.54	51.94	1.14
Bus	38.32	42.33	37.15	0.88
Rigid-Chassis	39.31	45.03	38.94	0.87
Tractor-Trailer	37.76	43.54	37.64	0.87
Pickup Truck	35.78	42.00	35.19	0.84

Note: Arithmetic mean used to calculate the average

Source: Study Team

For the outbound direction (away from Hai Phong), for commercial vehicles, the speed of vehicles on the sloped approach to the bridge was roughly between 80% and 91% of the speed of vehicles on the flat section. For cars, the speed of vehicles on the sloped section and the flat section was roughly the same.

Table 4.2-3 Commercial Vehicle Speeds on the Outbound Direction of Kien Bridge

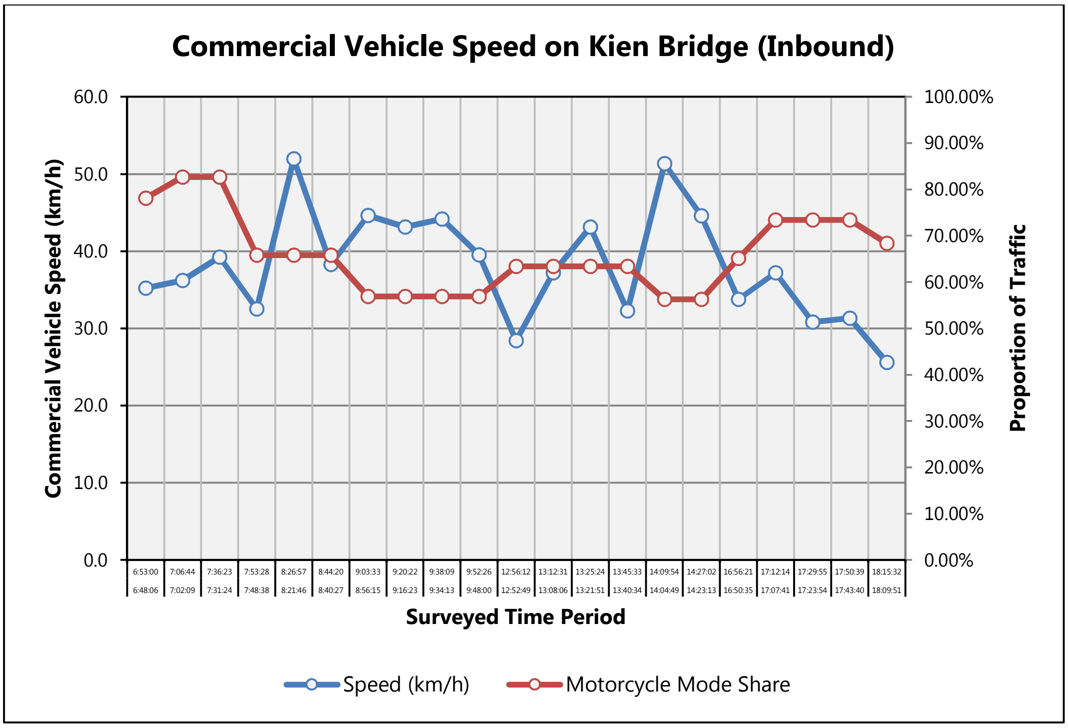
Average Travel Speeds - Kien Bridge - Outbound (North)				
	Entire Section Speed (km/h)	**Flat Section Speed (km/h)**	**Slope Speed (km/h)**	**Reduction Speed Rate (Slope Speed/Flat Section Speed)**
Car	47.09	48.24	47.39	0.99
Bus	42.18	49.74	43.45	0.88
Rigid-Chassis	37.89	45.04	36.83	0.80
Tractor-Trailer	37.97	42.36	38.18	0.91
Pickup Truck	38.02	48.59	38.40	0.80

Note: Arithmetic mean used to calculate the average

Source: Study Team

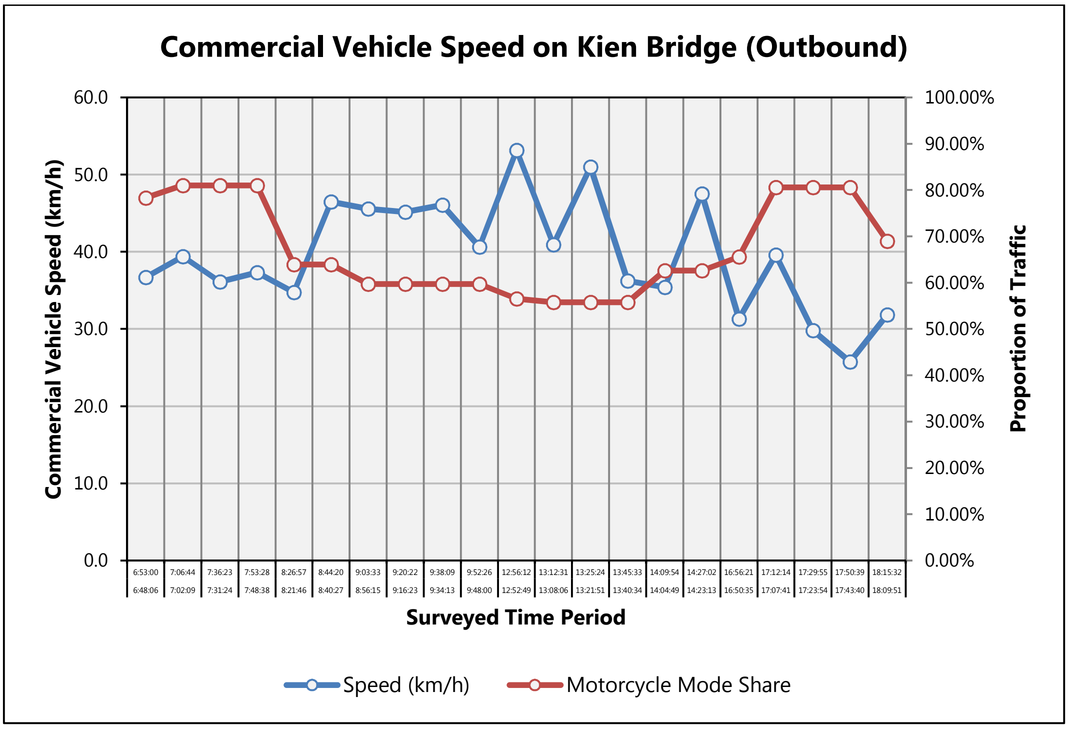
The speed of commercial vehicles was also compared to the proportion of motorcycle vehicles on the bridge. Motorcycles generally have a much slower traveling speed than cars and trucks and if there is a large proportion of motorcycle traffic on the bridge, then the speed of commercial vehicles would similarly decrease.

The following figures show the speed of commercial vehicles by surveyed time period along with the proportion of motorcycle traffic on the same section of road for both the inbound and outbound directions. It can generally be observed that if the proportion of motorcycles is 70% or more, the average overall speed of commercial vehicles falls below 40 km/h.



Source: Study Team

Figure 4.2-2 Commercial Vehicle Speeds Compared to Motorcycle Mode Share in the Inbound Direction



Source: Study Team

Figure 4.2-3 Commercial Vehicle Speeds Compared to Motorcycle Mode Share in the Outbound Direction

4.3 Axle Load Survey for Civil Works Design

An axle load survey was conducted to determine the vehicle loading characteristics for road pavement and bridge design and maintenance. Pavement design and performance are influenced by the traffic loading on the pavement and the most significant parameter to assess the influence of traffic load on pavement is axle load.

In this project, in addition to the design of the Ring Road 3 section, Nguyen Trai and Vu Yen Bridges also need to be designed. For bridges, the impact and effect of overloaded vehicles to damage on bridges differs from that of road pavements. Bridges have to carry the combined load of many or all of the axles of a vehicle simultaneously so not only gross vehicle mass needs to be considered, but the axle weight and inter-axle spacing and influence on bridge damage. Increased vehicle loads impose additional stress on the load carrying capacity of bridge structures and reduces the maintainability of the bridge structure by accelerating deterioration[1].

4.3.1 Setup for the Axle Load Survey

The axle load survey was conducted by the same local contractor, Vietbuild, as the traffic surveys for assessing traffic demand in cooperation with the Hai Phong Department of Transport and the Hai Phong Traffic Police using their mobile weigh bridges. The axle load surveys were conducted at 4 locations for 2 weekdays and 1 weekend day.

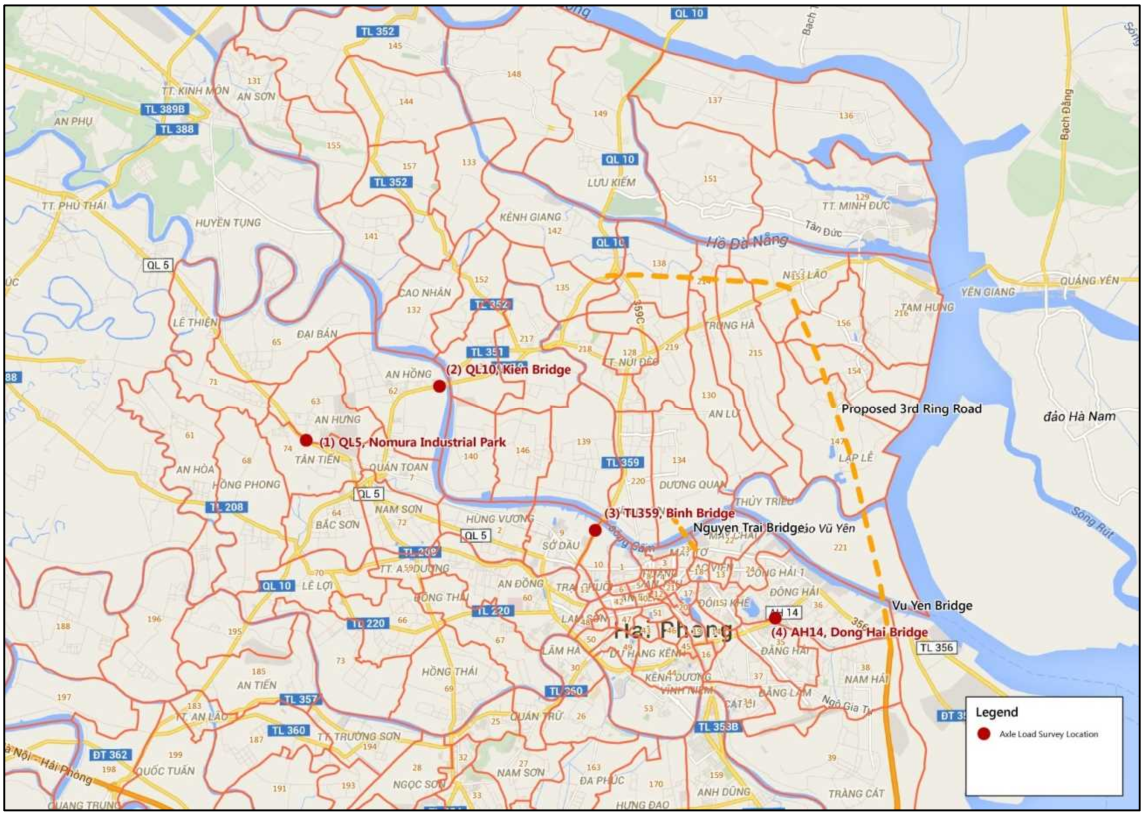
The detailed survey locations and times are shown in the following table and figure.

Table 4.3-1 Summary of the Axle Load Survey

No.	Survey Station	Survey Hours	Survey Days (weekday)	Survey Days (weekend)	Total Survey Days
1	QL5, Nomura Industrial Park	12	2	1	3
2	QL10, Kien Bridge	12	2	1	3
3	TL359, Binh Bridge	12	2	1	3
4	AH14, Dong Hai Bridge	12	2	1	3

Source: Study Team

1 Guideline No. 4 - Axle Load Surveys, Roads Department, Botswana/Norwegian Public Roads Administration, December (2000)



Source: Study Team

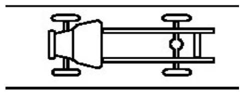
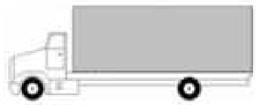
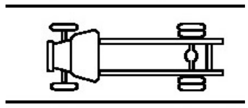
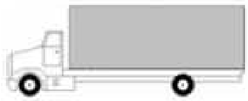
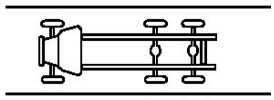
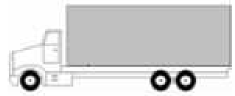
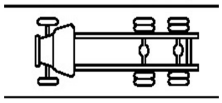
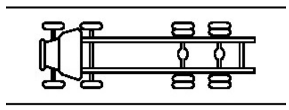
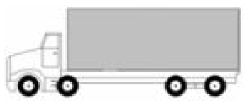
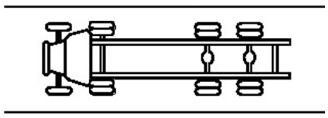
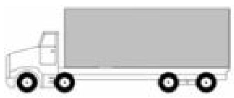
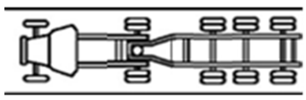
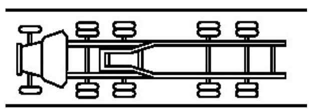
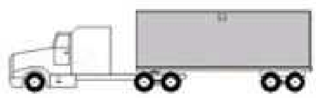
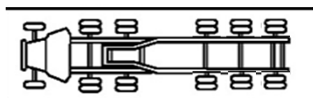
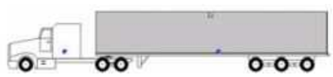
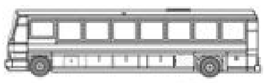
Figure 4.3-1 Axle Load Survey Locations

The axle configuration of surveyed commercial vehicles was classified based on observing the existing situation in Hai Phong. The axle configuration classification was done following international convention.

Each axle is represented by a "1" or "2" depending on the number of wheels at each end of the axle. To separate the front axle from the rear axles, a "." is placed between the numbers. A truck towing a trailer is denoted by a "+" sign and tractor-trailers or articulated vehicles are denoted by the "-" sign.

The observed axle configurations are shown in the following table.

Table 4.3-2 Classification of Typical Axle Load Configurations in Vietnam

No.	No. of Axles	Axle Config. Code	Type	Description	Layout of Axle	Appearance
1	2 axles	1.1	Rigid-Chassis Commercial Vehicles	Single tires on front and rear axles		
2	2 axles	1.2	Rigid-Chassis Commercial Vehicles	Single tires on front axle Twin tires on rear axles		
3	3 axles	1.11	Rigid-Chassis Commercial Vehicles	Single tires on front axle Single tires on rear two axles		
4	3 axles	1.22	Rigid-Chassis Commercial Vehicle	Single tires on front axle Twin tires on rear axles and two rear axles		
5	4 axles	11.22	Rigid-Chassis Commercial Vehicles	Single tires on front two axles Twin tires on rear two axles		
6	4 axles	12.22	Rigid-Chassis Commercial Vehicles	Single tires on first front axle, twin tires on second front axle Twin tires on rear two axles		
7	5 axles	1.2+222	Truck-Trailer (Full-trailer)	Single tires on front axle of the truck, twin tires on the rear axle of the truck Twin tires on the 3 axles of the trailer		
8	5 axles	1.22-22	Tractor-Trailer	Single tires on the front axle of the tractor, twin tires on both rear axles of the tractor Twin tires on the two axles of the trailer		
9	6 axles	1.22-222	Tractor-Trailer (Semi-trailer)	Single tire on front axle of tractor, twin tires on both rear axles of tractor Twin tires on the three axles of the trailer		
10		Bus		Single tire on front axle Single tire on rear axle		

Source: Study Team

4.3.2 Results of the Axle Load Surveys

At survey station (1) QL5, Nomura Industrial Park, 650 trucks and 68 buses were surveyed and this accounted for 2.20% of the truck volume. At (2) QL10, Kien Bridge, 299 trucks and 48 buses were surveyed and this accounted for 4.48% of the truck volume. At (3) TL359, Binh Bridge, 119 trucks and 35 buses were surveyed amounting to 4.36% of the truck volume.

At (4) AH14, Dong Hai Bridge, there is only one way out from the Dinh Vu Industrial Park and Port and there were almost no buses that passed through. At this survey station, 377 trucks were surveyed out of 18,774 trucks that passed through for a 3 day, 12 hour period and this was equal to 2.01% of all trucks. The values are shown in the following table.

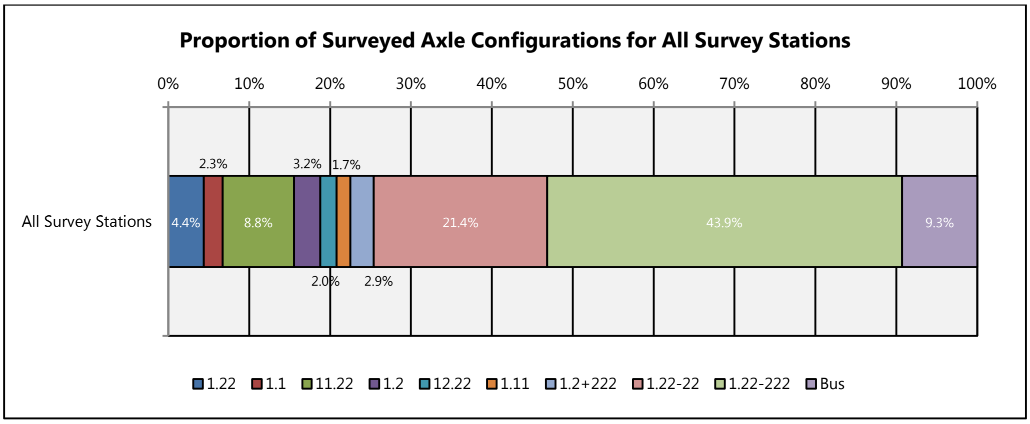
Table 4.3-3 Summary of the Axle Load Survey

No.	Axles	Axle Configuration	Station 1	Station 2	Station 3	Station 4	All Stations
1	2 axles	1.1	13	18	9	3	43
2	2 axles	1.2	25	14	16	3	58
3	3 axles	1.11	4	1	5	14	24
4	3 axles	1.22	28	29	15	1	73
5	4 axles	11.22	61	28	19	62	170
6	4 axles	12.22	15	3	1	1	20
7	5 axles	1.2+222	20	1	0	4	25
8	5 axles	1.22-22	122	59	23	164	368
9	6 axles	1.22-222	362	146	31	125	664
Total Number of Surveyed Trucks (3 days, 12 hours)			**650**	**299**	**119**	**377**	**1445**
Total Number of Counted Trucks (3 days, 12 hours)			**29,551**	**6,679**	**2,730**	**18,774**	**57,734**
Sample Size of Trucks (%)			**2.20%**	**4.48%**	**4.36%**	**2.01%**	**2.50%**
10		Bus	68	48	35	0	151
Total Number of Surveyed Buses (3 days, 12 hours)			**2,798**	**1,760**	**1,794**	**900**	**7,252**
Sample Size of Buses (%)			**2.43%**	**2.73%**	**1.95%**	**0.00%**	**2.08%**
Total Number of Surveyed Trucks and Buses							**1,596**

Note:
Axle load survey conducted over a period of 3 days and 12 hours

Source: Study Team

The following figure shows the proportion of surveyed axle configurations for the entire study area (all 4 survey stations) calculated using the weighted mean. The axle configurations surveyed with the largest proportions were the 1.22-222 tractor-trailer configuration at 43.9% and the 1.22-22 tractor-trailer configuration at 21.4%.



Source: Study Team

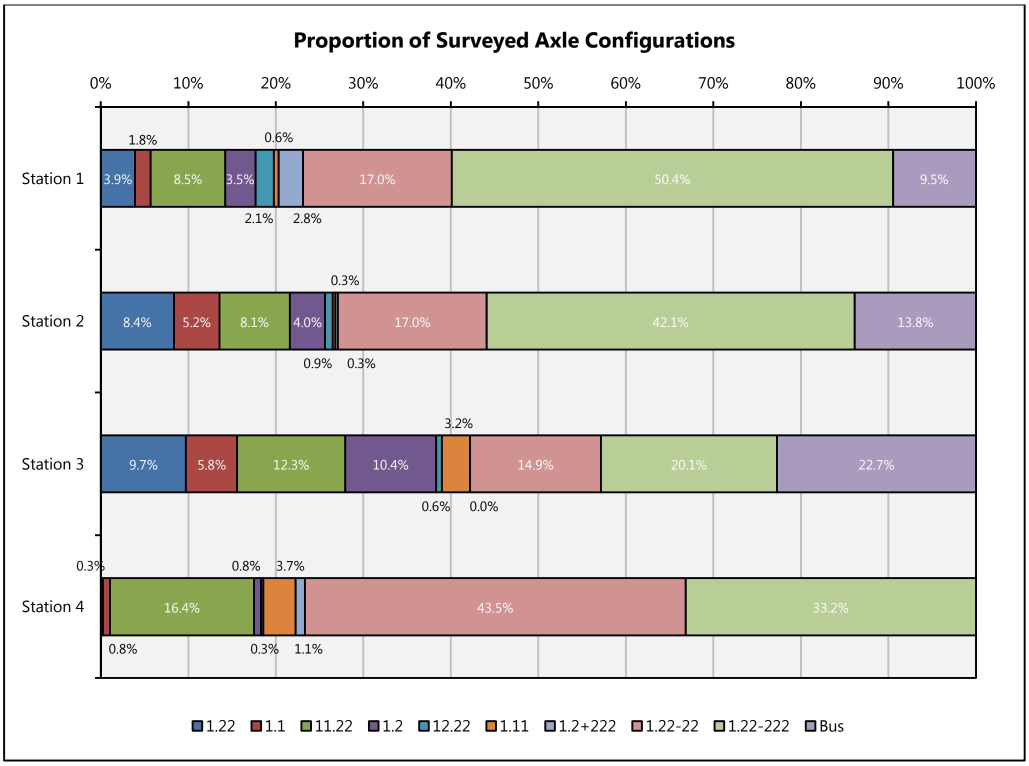
Figure 4.3-2 Proportion of Surveyed Axle Configurations and Buses for All Survey Stations

The following figure shows the proportion of surveyed axle configurations by survey station.

At survey stations (1) and (2), tractor-trailers made up a majority of all vehicles surveyed. At survey station (1) QL5, Nomura Industrial Park, tractor-trailers with an axle configuration of 1.22-222 made up 50.4% of all vehicles surveyed. At (2) QL10, Kien Bridge, the same axle configuration and vehicle type as in (1) made up 42.1% of all vehicles surveyed.

At (3) TL359, Binh Bridge, there was a greater diversity in the types of vehicles surveyed. There was no outright majority between the different axle configurations but among truck vehicles, 1.22-222 tractor-trailers had the largest share (20.1%). Surprisingly, buses had the largest share at this survey station at 22.7%.

At (4) AH14, Dong Hai Bridge, tractor-trailers again made up a majority of vehicles surveyed, however, at this survey station, vehicles with the 1.22-22 axle configuration had the largest share at 43.5%.



Source: Study Team

Figure 4.3-3 Proportion of Surveyed Axle Configurations and Buses by Survey Station

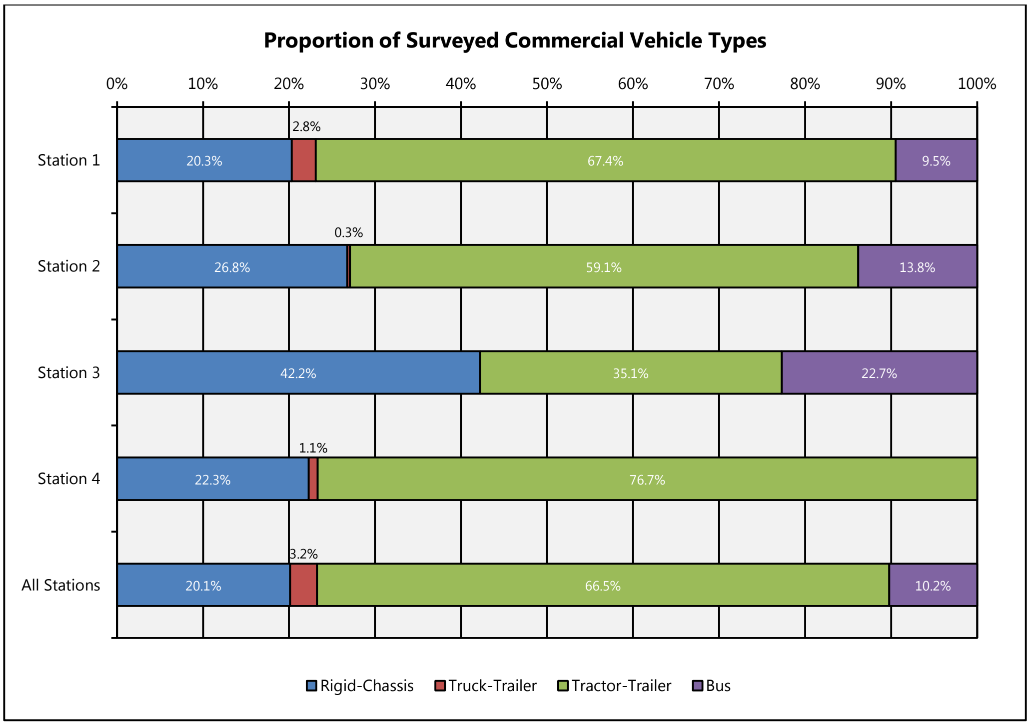
The following table and figures show the number and proportion of vehicles surveyed by type of commercial vehicle. Tractor-trailers formed a majority of the share of vehicles surveyed at survey stations (1), (2) and (4) while at survey station (3) TL359, Binh Bridge, rigid-chassis trucks formed the majority of the vehicles surveyed at 42.2%.

For all survey stations, tractor-trailers made up the majority of vehicles surveyed at 64.7% followed by rigid-chassis trucks at 24.3%, buses at 9.5% and truck-trailers at 1.6%

Table 4.3-4 Number of Survey Vehicles by Commercial Vehicle Type for Each Survey Station

Vehicle Type	Station 1	Station 2	Station 3	Station 4	All Stations
Rigid-Chassis	146	93	65	84	388
Truck-Trailer	20	1	0	4	25
Tractor-Trailer	484	205	54	289	1032
Bus	68	48	35	0	151
Total:	718	347	154	377	1596

Source: Study Team



Note: Proportion for all stations calculated using the weighted mean

Source: Study Team

Figure 4.3-4 Proportion of Surveyed Vehicles by Commercial Vehicle Types for Each Survey Station

(1) Analysis Methodology

In order to assess the damage heavy commercial vehicles put on pavement, the raw measured data in metric tons for each axle needed to be processed into an average equivalency factor (EF) for each type of vehicle. The average EF for each type of vehicle represents the average damaging effect of a vehicle in each class, not the damaging effect for the average vehicle.

The EF is expressed as the number of standard (80 kN) axles that would cause the same amount of damage. The relationship between the axle load and damage is a power relationship. For example, a standard axle load of 8.16 metric tons will have an EF = 1, while doubling the axle load to 16.32 metric tons will have an EF = 22.6, in other words, a damaging effect will be 22 times bigger than that of standard 8.16 metric tons trucks, instead of only a double (2 times) damaging effect.

The overall purpose of the analysis was to calculate the average EF value for each commercial vehicle type[2], therefore the average EF was calculated based on the 4 major commercial vehicle types: rigid-chassis, truck-trailer, tractor-trailer and bus.

[2] Overseas Road Note 40, A guide to axle load surveys and traffic counts for determining traffic loading on pavements. TRL Limited for Department for International Development, UK Government. p. 41

Table 4.3-5 Commercial Vehicle Types for the Average EF Analysis

Commercial Vehicle Type	Axles	Axle Configuration
Rigid-Chassis	2 axles	1.1
	2 axles	1.2
	3 axles	1.11
	3 axles	1.22
	4 axles	11.22
	4 axles	12.22
Truck-Trailer	5 axles	1.2+222
Tractor-Trailer	5 axles	1.22-22
	6 axles	1.22-222
Bus		-

Source: Study Team

Details regarding the calculation method of the EF are shown in Appendix A4.

The analysis of the axle load data for each commercial vehicle type is shown by survey station in the following sections.

(2) Survey Station 1 - QL5, Nomura Industrial Park

The average EF values as well as the lower and upper confidence interval values for rigid-chassis trucks, truck-trailers, tractor-trailers and buses for survey station (1) are shown as follows. For truck vehicles, tractor-trailers had the highest average EF value followed by truck-trailers and rigid-chassis trucks. Histograms and descriptive statistics are shown in Appendix A4.

Table 4.3-6 Summary of the Average EF Values at Survey Station 1

Unit: Equivalency Factor (EF)

Survey Station 1 – QL5, Nomura Industrial Park				
	Rigid-Chassis	Truck-Trailers	Tractor-Trailers	Buses
Average	2.77	5.20	5.92	0.71
Lower Confidence Level (95%)	2.25	3.71	5.58	0.53
Upper Confidence Level (95%)	3.38	7.15	6.27	0.91
Sample Size	146	20	484	68
Note: Refer to Appendix A4 for the calculation method for the average				

Source: Study Team

(3) Survey Station 2, QL10 - Kien Bridge

A summary of the average EF values and lower and upper confidence interval values for all the commercial vehicle types for survey station (2) is shown in the following table. For truck vehicles, tractor-trailers had the highest average EF value followed by rigid-chassis trucks. There were not enough truck-trailers surveyed to calculate a meaningful average EF value.

Table 4.3-7 Summary of the Average EF Values for Survey Station 2

Unit: Equivalency Factor (EF)

Survey Station 2 – QL10, Kien Bridge				
	Rigid-Chassis	**Truck-Trailers***	**Tractor-Trailers**	**Buses**
Average	1.78	-	5.94	0.48
Lower Confidence Level (95%)	1.42	-	5.53	0.29
Upper Confidence Level (95%)	2.20	-	6.36	0.69
Sample Size	93	1	205	48
Note: Refer to Appendix A4 for the calculation method for the average, *Not enough samples to compute the average				

Source: Study Team

(4) Survey Station 3 - TL359, Binh Bridge

A summary of the average EF values and lower and upper confidence level values for all the commercial vehicle types for survey station (3) is shown in the following table. For truck vehicles, tractor-trailers had the highest average EF value followed by rigid-chassis trucks. No truck-trailer vehicles were surveyed at this survey station.

Table 4.3-8 Summary of the Average EF Values for Survey Station 3

Unit: Equivalency Factor (EF)

Survey Station 3 – TL359, Binh Bridge				
	Rigid-Chassis	**Truck-Trailers***	**Tractor-Trailers**	**Buses**
Average	1.62	-	5.43	0.31
Lower Confidence Level (95%)	1.21	-	4.41	0.16
Upper Confidence Level (95%)	2.10	-	6.63	0.48
Sample Size	65	0	54	35
Note: Refer to Appendix A4 for the calculation method for the average, *No vehicles surveyed for this truck type				

Source: Study Team

(5) Survey Station 4 - AH14, Dong Hai Bridge

A summary of the average EF values and lower and upper confidence level values for all the commercial vehicle types for survey station (4) is shown in the following table. For truck vehicles, tractor-trailers had the highest average EF value followed by rigid-chassis trucks. There were not enough truck-trailer vehicle samples to calculate a meaningful average EF value for that vehicle type and no buses were surveyed.

Table 4.3-9 Summary of the Average EF Values for Survey Station 4

Unit: Equivalency Factor (EF)

Survey Station 4 – AH14, Dong Hai Bridge				
	Rigid-Chassis	Truck-Trailers[1]	Tractor-Trailers	Buses[2]
Average	3.00	-	4.67	-
Lower Confidence Level (95%)	2.45	-	4.20	-
Upper Confidence Level (95%)	3.63	-	5.19	-
Sample Size	84	4	289	0
Note: Refer to Appendix A4 for the calculation method for the average, 1) Not enough samples to calculate the average, 2) No vehicles surveyed				

Source: Study Team

(6) All Survey Stations

A summary of the average EF values and lower and upper confidence level values for all the commercial vehicle types for all of the survey stations is shown in the following table. For truck vehicles, tractor-trailers had the highest average EF value followed by truck-trailers and rigid-chassis trucks. As expected, buses had the lowest average EF value.

Table 4.3-10 Summary of the Average EF Values for All Survey Stations

Unit: Equivalency Factor (EF)

All Survey Stations				
	Rigid-Chassis	Truck-Trailers	Tractor-Trailers	Buses
Average	2.34	4.50	5.37	0.53
Lower Confidence Level (95%)	2.09	3.27	5.14	0.43
Upper Confidence Level (95%)	2.62	6.09	5.62	0.65
Sample Size	388	25	1032	151
Note: Refer to Appendix A4 for the calculation method for the average				

Source: Study Team

(7) Comparison of the Average EF Values by Each Survey Station and All Survey Stations

The following table shows a comparison of the average EF values by survey station.

For the rigid-chassis truck type, survey stations (1) and (4) seem to have a larger average EF value compared to survey stations (2) and (3). This is probably due to the presence of the Nomura Industrial Park at survey station (1) and survey station (4) being situated on the main route to the Dinh Vu Industrial Zone and port.

For the truck-trailer truck type for stations (2) and (3), there were either not enough samples to calculate an average EF value or there were no samples at all but for stations (1) and (4), the average EF value didn't seem to differ by that much.

For the tractor-trailer truck type, the average EF values were fairly constant between each of the survey stations and this could be because their main cargo is containers which are usually allowed a certain maximum weight in order for them to be loaded onto freight ships.

For buses, compared to the other survey stations, survey station (1) had a higher average EF value than the others. This may be because survey station 1 is located on the main intercity road between Hai Phong and the cities to the west of Hai Phong such as the capital Hanoi and therefore the buses that were surveyed on this road may have had more passengers and cargo on the vehicles.

Table 4.3-11 Comparison of Average EF Values by Survey Station

Comparison of Average EF Values				
Unit: Average EF Value	**Rigid-Chassis**	**Truck-Trailer**	**Tractor-Trailer**	**Bus**
Station 1	2.77	5.20	5.92	0.71
Station 2	1.78	-	5.94	0.48
Station 3	1.62	-	5.43	0.31
Station 4	3.00	-	4.67	-
All Survey Stations	2.34	4.50*	5.37	0.53

Note: EF = Equivalency Factor, *The value is not the same as Station 1 because there were a couple of samples for Stations 2 and 4, but not enough to calculate an average value for Stations 2 and 4

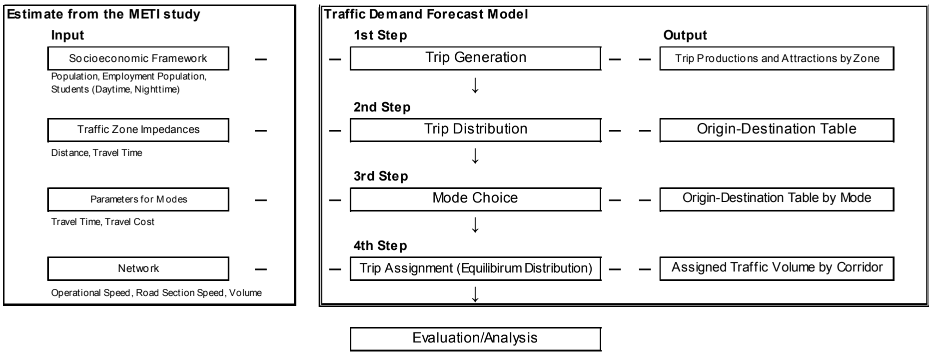
Source: Study Team

4.4 Traffic Demand Forecast

4.4.1 Forecast Methodology

(1) Summary of the Estimation Method

For the traffic demand forecast, the traditional four step traffic demand forecast model that was used is shown in Figure 4.4-1.



Source: Study Team

Figure 4.4-1 Four Step Traffic Demand Forecast Model

(2) Methodology for Estimating the Truck Traffic Volume

On Vu Yen Bridge, the design calls for a 1.5 km ascending approach with a grade of 4%. Thus, there are concerns that the traffic capacity will decrease due to a decrease in the travel speed of large-sized trucks and tractor-trailers as these vehicles move through the approach.

Therefore, the traffic network conditions for Vu Yen Bridge which is expected to carry many large sized vehicles is shown in Table 4.4-1. On the other hand, because it is assumed that the number of large sized vehicles passing through Nguyen Trai Bridge will be small[3], the settings as shown below will not be applied to Nguyen Trai Bridge.

Table 4.4-1 Method for Setting the Entry Data for Vu Yen Bridge

Input Data	Setting of Entry Data for Vu Yen Bridge
Maximum Speed	Based on the travel speed survey, the travel speed on the ascending approach of a bridge is 85% of the flat ground travel speed. From the decrease in the travel speed of large sized vehicles on one traffic lane, if it is assumed that a regular vehicle travels on the other traffic lane, then the overall maximum speed is set at 92.5% of the flat ground travel speed (65 km/h). The large vehicle ratio was set at roughly 16% for the traffic demand forecast.
Highway Capacity	According to the Highway Capacity Manual, the traffic volume is different based on the slope and proportion of large sized vehicles. Because it is not possible in the traffic distribution system to change the PCU value for large sized vehicles for specific sections of roads, a gradual decrease in the traffic volume was considered instead. According to the Highway Capacity Manual, if the proportion of large sized vehicles is 15%, the large sized vehicle PCU should be set as 2.75. At 0%, the PCU for large sized vehicles should be set at 1.5. As a result, the traffic capacity is set at 70,000 PCU as this is 93.2% of the normal traffic capacity: (1 PCU/2.75 PCU)/(1 PCU/1.5 PCU) * 15% + 1 PCU * 85%.

Source: Study Team

[3] In the traffic demand forecast, it was estimated that the proportion of trucks at Nguyen Trai Bridge would be 6% in 2030

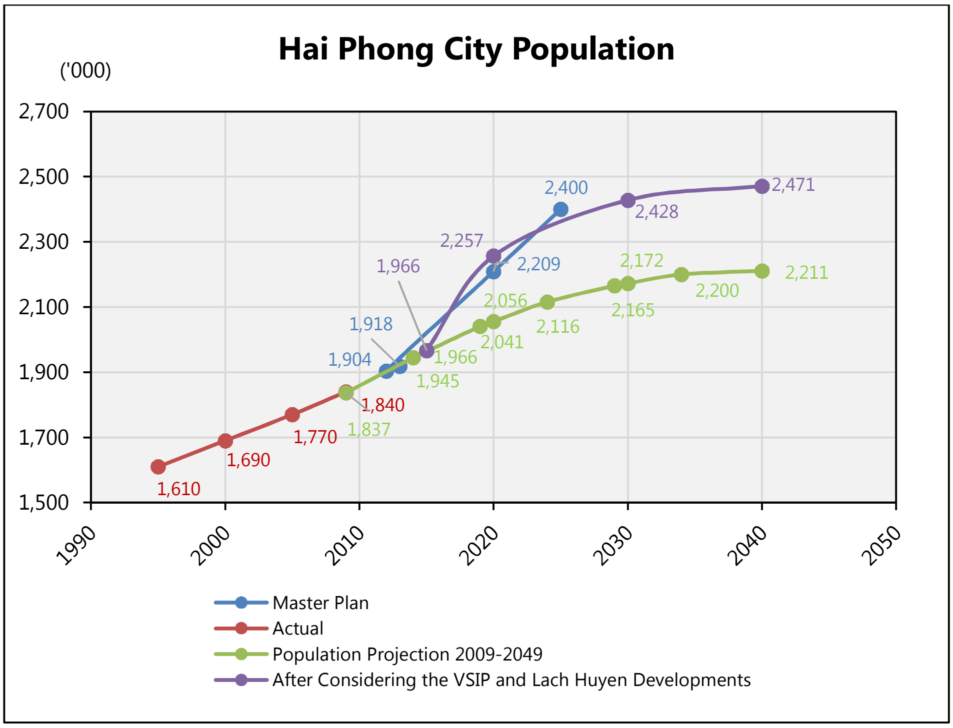
4.4.2 Confirmation of the Socioeconomic Framework

(1) Assumptions about the Future Population

The socioeconomic framework was updated based on the population projection from 2009-2049 (by gender, age group[4]) that the Vietnamese government conducted for the entire country.

Based on the estimated future population value and considering the development plan of the Vietnam-Singapore Industrial Park (VSIP) Hai Phong and the urban development population around Lach Huyen port, the future population value was set.

As a result, it was confirmed that if the VSIP and urban development around Lach Huyen port was carried out as per the plans, the estimated population in 2020 and 2030 would be around the same as the estimated population as specified in the master plan.



Source: Study Team

Figure 4.4-2 Assumptions Regarding the Population of Hai Phong[5]

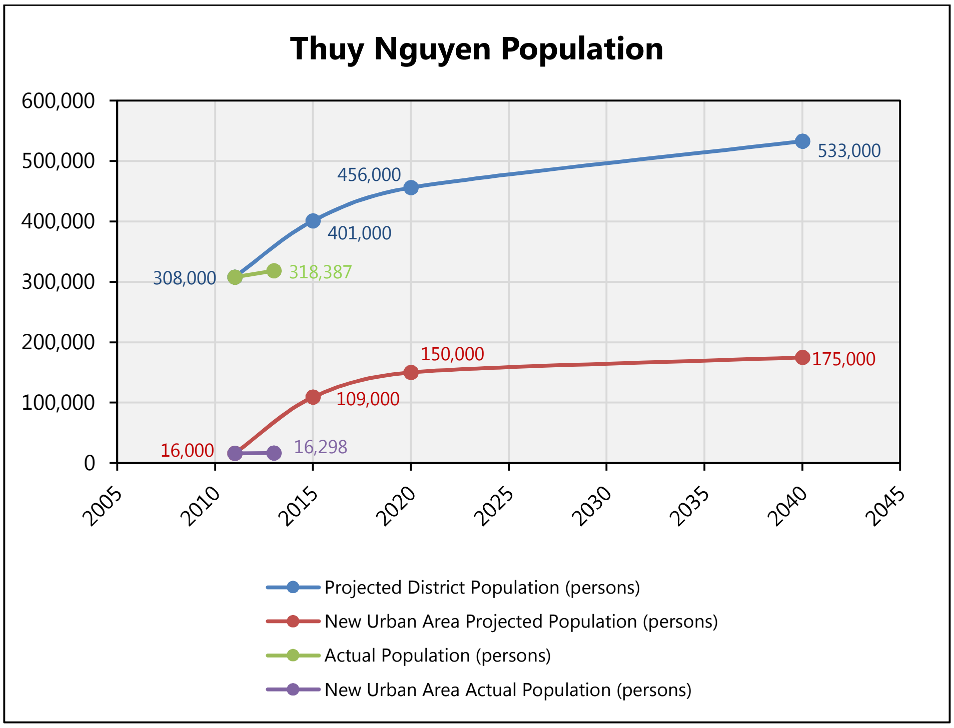
[4] Compared to a typical traffic demand forecast that uses average growth rates, because the population projection was estimated by gender and age groups, the model accuracy of the traffic demand forecast model is high.

5 The population projection from 2009-2049 and the trend lines for 2020, 2030 and 2040.

(2) Population of Thuy Nguyen District

VSIP Hai Phong is planned in the Thuy Nguyen district. In the future, there is a possibility that the traffic volume that will cross the Cam River will increase as a result of the estimated increase in the population of this area. For this reason, as per the following, the population of Thuy Nguyen was set by adding the estimated population of the VSIP Hai Phong development on top of the actual population figures from the district.

As a result, Thuy Nguyen in 2013 had a population of around 318,000 and it was estimated that by 2020, the population would increase to 456,000. Of the increase in population from 318,000 to 456,000, 150,000 comes from the planned development population of VSIP Hai Phong. Therefore, it was assumed that the future population increase in Thuy Nguyen comes almost entirely from the VSIP Hai Phong development.



Notes:
1) The figures for the projected district and new urban area populations come from the "Pre-Feasibility Study for the Nguyen Trai Bridge Project at Thuy Nguyen District in Hai Phong, Vietnam, Final Report, AECOM"
2) The actual population figures for Thuy Nguyen come from the city of Hai Phong and the actual population figures for the new urban area were estimated based on the growth rate of the zones around VSIP.

Source: Study Team

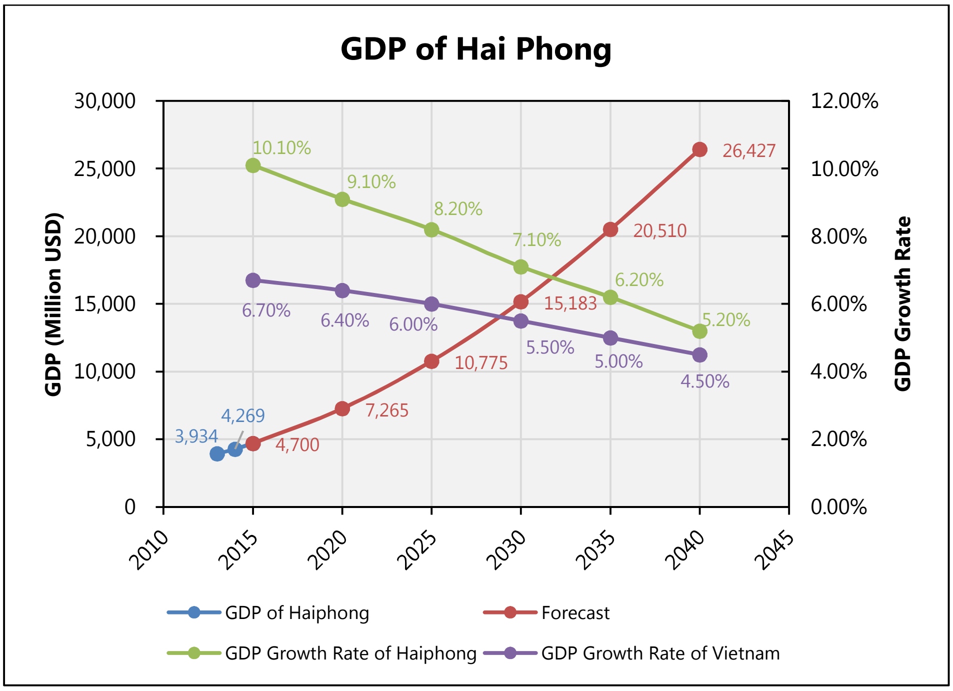
Figure 4.4-3 Thuy Nguyen District Population Assumptions

(3) The GDP of Hai Phong

Using the GDP growth rate from 2015 onwards from the Pre-Feasibility Study for the Nguyen Trai Bridge Project at Thuy Nguyen District in Hai Phong, Vietnam, Final Report by AECOM and the 2013 and 2013 GDP figures provided by the city of Hai Phong, the future GDP of Hai Phong was estimated.

As of 2015, the GDP figure was US$4,269 million but by 2020, the GDP is estimated at US$7,265 million, an increase of 1.7 times compared to the figure in 2015. In addition, by 2030, the GDP is estimated to reach US$15,183 million which is an increase of around 3.5 times the figure in 2015.

As a result, from the development of Hai Phong in addition to the good economic conditions in Vietnam, the GDP was estimated to dramatically increase.



Note: The VND-USD conversion rate used was the average value from the first and second half of 2010 (US$1.00 = 18,243 VND)

Source: Study Team

Figure 4.4-4 Hai Phong GDP Assumptions

4.4.3 Confirmation of Road and Urban Development Plans

(1) Road Plans

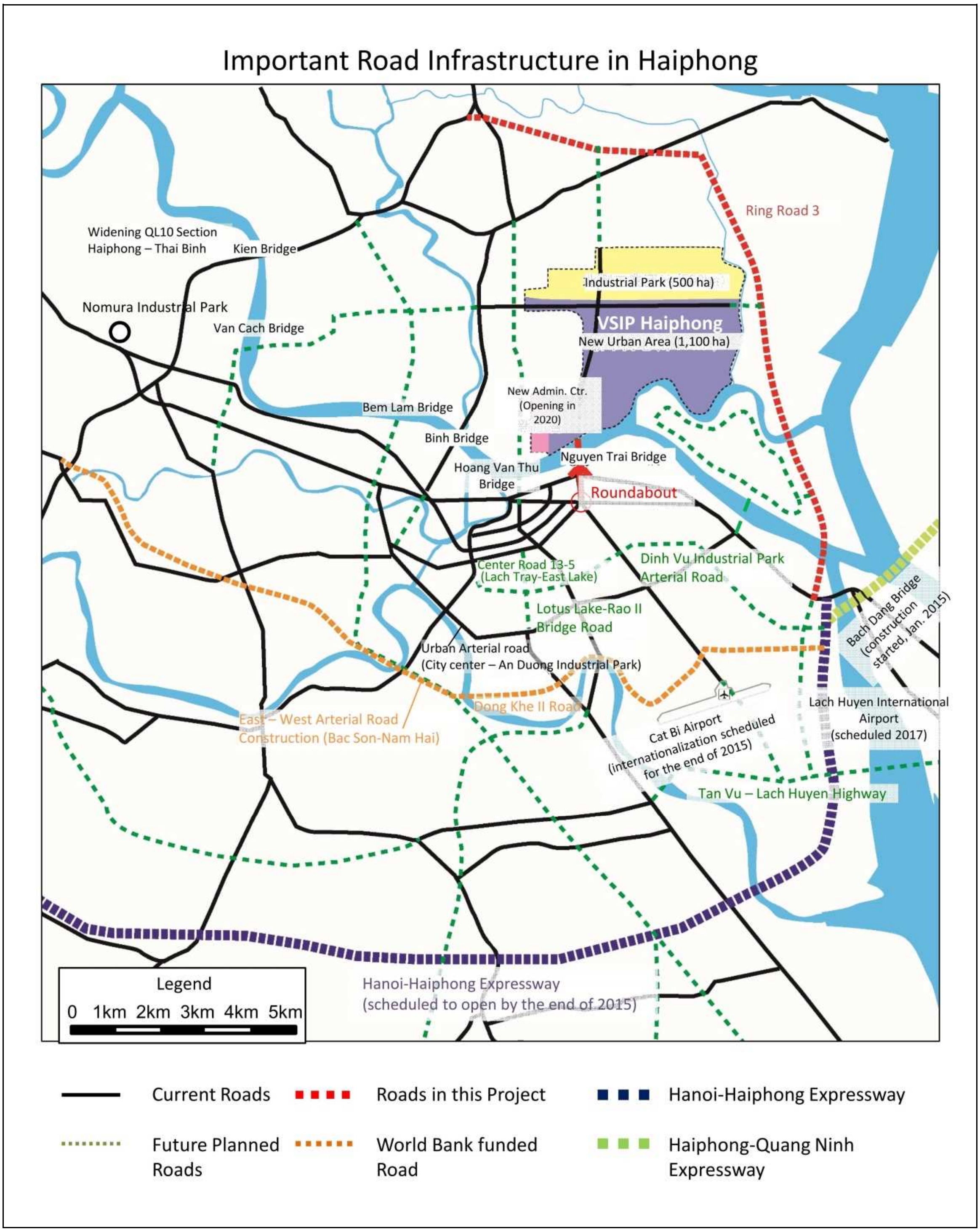
According to the road network plans formulated by Hai Phong's Department of Transport, the roads that are planned to be operational by 2020 are shown as follows. As a result, the traffic demand forecast is based on the future road network of Hai Phong which includes the road network plans shown here.

Table 4.4-2 Future Road Network Plans

Roads that are assumed to be operational from 2015-2020[6]
Tan Vu-Lach Huyen Highway (including Dinh Vu-Cat Hai Bridge)
Southeast Hai An District Road
Dinh Vu Industrial Park Arterial Road
Center Road 13-5 (Lach Tray-East Lake)
East-West Arterial Road (Bac Son-Nam Hai)
Hanoi-Hai Phong Expressway
Widening of QL10 from Hai Phong to Thai Binh (km25-km58)
Lotus Lake-Rao II Bridge Road
Dong Khe II Road
Upgraded section of QL27 in Hai Phong
Urban Arterial Road (City Center-An Duong Industrial Park)
Hai Phong-Quan Ninh Expressway
Included Bridges
Nguyen Trai Bridge
Vu Yen Bridge

Source: Study Team

6 In decision No.11448/QD-TTG dated 16 September 2009 by the Prime Minister about adjustment of master plan up to 2025 vision to 2050, the 1st Stage (2009-2015)



Source: Study Team

Figure 4.4-5 Map of the Planned Road Network in Hai Phong

(2) Urban Development Plans

There are several urban development plans in Hai Phong and the ones listed as follows are the ones that have been approved by the People's Committee of Hai Phong. As a result, the urban development plans that were judged to have a high accuracy were reflected in the traffic demand forecasts. Furthermore, the traffic volume data that are included in various existing reports and materials were used to incorporate these urban development plans in the traffic demand forecasts.

Table 4.4-3 Methodology for Considering the Urban Development Plans

Development Plan	Consideration Method
Lach Huyen Port	• Used the traffic generation data from industry, ports and tourism from an existing report titled "Consulting Services for Planning Construction Investment Project Tan Vu-Lach Huye Highway Project in Hai Phong City, Traffic Demand Forecast, 2008" • Maintaining the freight handled in the existing port in 2008 and assuming a surpassed amount, confirmed the lower bound estimate of the freight handling volume from the report "The Preparatory Survey on Lach Huyen Port Infrastructure Construction in Vietnam, Final Report"
VSIP Hai Phong Development Area[1]	• Updated the traffic volume that crosses the Cam River based on an existing report • The VSIP Hai Phong development is broken up into 4 phases. Phases 1 and 2 are scheduled to be completed by 2020 while Phases 3 and 4 are scheduled for completion by 2030. o Phase 1: Industrial Park o Phase 2: Universities, Medical Institutions as well as attached housing o Phase 3: Commercial Area o Phase 4: Residential Area
Cat Bi Airport	• The passenger volume and freight volume were assumed based on the connection with the GDP value and based on the GDP growth rate, the traffic volume was extended. • In the plan, it calls for passenger numbers to double due to internationalization of the airport. Therefore, it was assumed that by 2020, the future passenger demand would be double the current level.
Note: 1. From "Pre-Feasibility Study for the Nguyen Trai Bridge Project at Thuy Nguyen District in Hai Phong, Vietnam, Final Report, AECOM"	

Source: Study Team

Table 4.4-4 Assumed Freight Handling Volume at Lach Huyen Port

Unit: 1000t/year	2000	2002	2004	2006	2008	2015	2020
Hai Phong Port	5,606	8,920	10,527	13,087	23,777	23,777	23,777
Cai Lan Port	888	812	1,193	2,854	1,563	1,563	1,563
Lach Huyen Port	For these years, the 2008 figures from the Hai Phong and Cai Lan Ports were used and projected upwards to assume the freight handling volume at Lach Huyen Port.					21,965	37,156
Total	6,494	9,732	11,720	15,941	25,340	47,305[1)] 52,796[2)] 58,288[3)]	62,496[1)] 71,785[2)] 81,074[3)]

Notes:
1) Lower case for the forecasted freight volume in 2015 and 2020
2) Middle case for the forecasted freight volume in 2015 and 2020
3) Upper case for the forecasted freight volume in 2015 and 2020

Source: Study Team based on the "Pre-Feasibility Study for the Nguyen Trai Bridge Project at Thuy Nguyen District in Hai Phong, Vietnam, Final Report, AECOM"

Table 4.4-5 Assumptions about the VSIP Hai Phong Development

Thuy Nguyen District	2011	2015	2020	2040
District Population (persons)	308,000	401,000	456,000	533,000
New Urban Area Population (persons)	16,000	109,000	150,000	175,000
Industrial Park Employment Population	0	33,000	50,000	50,000
New Administrative Area, Employment Population (persons)	0	2,000	5,000	8,000
Car Ownership (vehicles/1000 persons)	14	33	80	360
Traffic Volume across the Cam River	2011	2015	2020	2040
Motorcycle Traffic Volume (vehicles/day)	55,003	105,172	155,179	170,566
Car Traffic Volume (vehicles/day)	5,500	10,400	30,100	133,200

Source: Pre-Feasibility Study for the Nguyen Trai Bridge Project at Thuy Nguyen District in Hai Phong, Vietnam, Final Report, AECOM

Table 4.4-6 Assumptions Regarding Cat Bi Airport

	2014	2015	2020	2030
GDP of Hai Phong[1]	77,882	85,748	132,541	276,970
Annual Growth Rate (AGR) for GDP[2]	8.5%	10.1%	9.1%	7.6%
Passengers (persons/year)	851[3]	871	2,011	3,117
AGR for Passengers (2015=1.000)[3]	0.976	1.000	2.308	3.577
Cargo (tons/year)[3]	5,862	6,352	10,199	42,427
AGR for Cargo (2015=1.000)	0.923	1.000	1.606	6.680

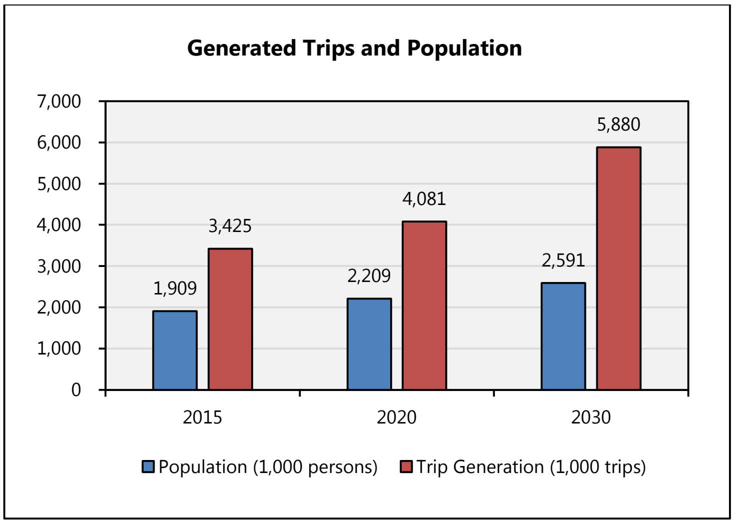
Notes:

1. 2014 value from the Hai Phong city webpage. Used the GDP annual growth rate to estimate the 2015 value.
2. 2014 value from the Hai Phong city webpage. The 2015 GDP annual growth rate was taken from the value assumed in the report "Pre-Feasibility Study for the Nguyen Trai Bridge Project at Thuy Nguyen District in Hai Phong, Vietnam, Final Report, AECOM".
3. 2014 value from the Hai Phong Statistical Book 2014 (updated January 28, 2015). The values for 2015 and onwards were estimated using the GDP annual growth rate.

Source: Study Team

4.4.4 Calculation of Trips Generated

The number of trips generated was calculated based on the population indicators from the socioeconomic framework. As a result, 3,425,000 trips were estimated for 2015, 4,081 thousand trips were estimated for 2020, and 5,880 thousand trips were estimated for 2030. Also, the high growth rate for trip generation for the target years of 2020 and 2030 was confirmed from the assumptions of continued economic and population growth.



Source: Study Team

Figure 4.4-6 Number of Trips Generated for 2015, 2020 and 2030

4.4.5 Calculation of Trip Distribution Figures

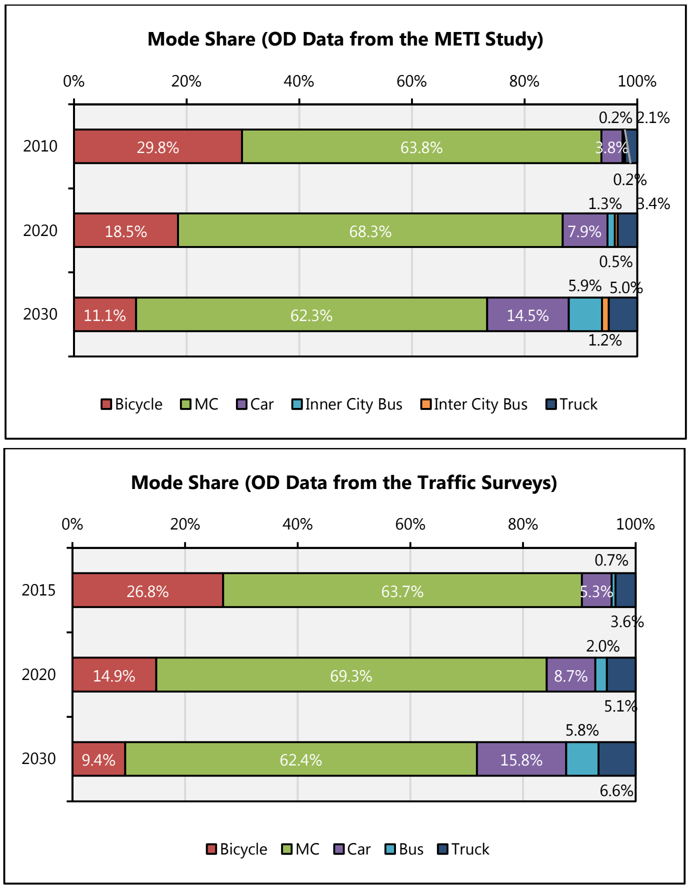
The distributed trips from the METI study[7] were used for the trip distribution for this project, while the distributed trips from the roadside interview OD survey were used for the trip origin destinations that passed through the traffic survey locations.

4.4.6 Mode Share

The mode share data from the traffic surveys were used and revised based on the traffic mode share data obtained from the METI study. As a result, for the bicycle mode, there is a trend of the mode share declining while for motorcycles, after 2020, there is a trend of the mode share declining. On the other hand, for the car, bus and truck modes, there is a trend of the mode share increasing. The mode share of the origin destination data from the METI study is almost the same as the future mode share and in general, as the economy continues the develop, it can be seen that the share of motorcycles and other motorized 2-wheeled vehicles will shift to cars.

For the truck traffic that will have a large influence on the design of the bridges for this project, from 2015 to 2030, it is estimated that the mode share will increase from 3.6% to 6.6%.

[7] Study on the Highway Bridge in the New Urban Area of Hai Phong, the Socialist Republic of Vietnam, February 2014, Study on Economic Partnership Projects in Developing Countries in FY2013, Ministry of Economy, Trade and Industry, Japan (METI study)



Source: Study Team

Figure 4.4-7 Confirmation of the Mode Share

4.4.7 Implementation of the Traffic Assignment

The traffic demand forecast for this project is focused on the planned Vu Yen Bridge and Nguyen Trai Bridge. For this chapter, the items for analysis, setting of the base cases and the results of the estimation are shown.

(1) Items for Analysis

Keeping in mind that the future traffic demand is focused on the planned two bridges, the following three items are analyzed:

1. Results from reproducing the current situation
2. Comparison with the METI study traffic demand forecast
3. Results of the future traffic demand forecast[8]
    - Traffic volume for the bridges and the years that the traffic volume will exceed capacity
    - Results of the traffic demand forecast for Ring Road 3 and the main arterial

[8] With regards to a simplified analysis on the necessity of a grade-separated roundabout, refer to Appendix A4.

roads
- Effect on the roundabout located on the south end of Nguyen Trai Bridge
- Years when the traffic volume will exceed capacity on the Le Thanh Tong Street access road to Nguyen Trai Bridge

(2) Defining the Different Cases

The traffic demand forecast was conducted by defining 6 cases as shown below.

Table 4.4-7 Definitions for the Different Cases

Case	Case Name	Forecast Years	Case Details
Case 0	Current Situation	2015	Reproduce the current situation
Case 1	Do Nothing	2020 2030	The case where traffic is managed for only the existing Kien and Binh Bridges.
Case 2	Nguyen Trai and Vu Yen Bridges	2020 2030	The case where the construction schedules of the Nguyen Trai and Vu Yen Bridges are taken into account.
Case3	Nguyen Trai Bridge	2020 2030	The case where only the construction of the Nguyen Trai Bridge is considered. The necessary construction period of Vu Yen Bridge is also considered.
Case 4	Vu Yen	2020 2030	The case where only the construction of Vu Yen Bridge is considered. The necessary construction period of Nguyen Trai Bridge is also considered.
Case 5	Nguyen Trai Bridge without Roundabout Access and Vu Yen Bridge	2020 2030	The case where access to Nguyen Trai Bridge is via Le Thanh Tong Street and cannot be accessed by the roundabout. The access from Le Thanh Tong Street to the bridge is one lane in each direction. The period where access to the bridge reaches capacity is considered and the construction period of the roundabout access to the bridge is estimated.

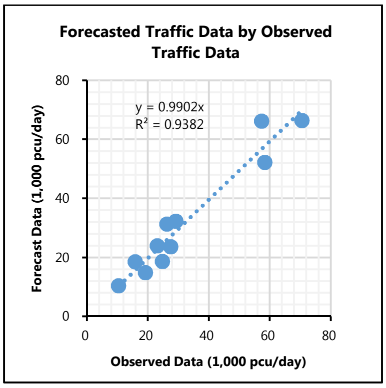
Source: Study Team

(3) Results from the Traffic Assignment

The demand forecasts for the various cases are shown as follows.

1) Case 0 – Results from Reproducing the Current Situation

The results from reproducing the current traffic conditions compared with the actual situation as per the data from the traffic survey are shown as follows. Because the coefficient of determination was above 0.9 and the regression coefficient was near 1.0, it was determined that the traffic assignment model sufficiently reproduced the current situation. (In Japan, one of the criteria is for the coefficient of determination to be above 0.81)

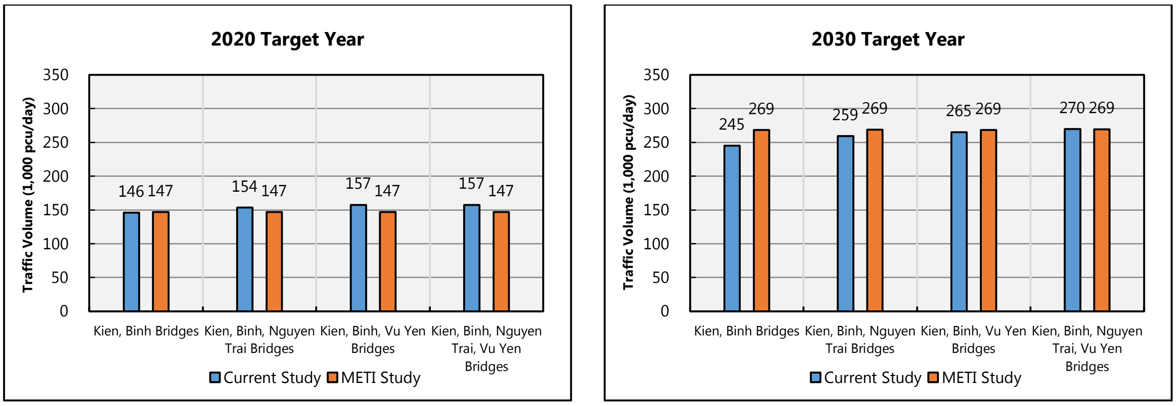


Source: Study Team

Figure 4.4-8 Forecasted Data by Observed Data (Results from Reproducing the Current Situation

2) Comparison with the METI Study

The below figures show the total traffic volume that was estimated to cross the Cam River and the estimated traffic volume from this project was compared with the traffic forecast from the METI study. Based on the comparison of the estimated traffic volume between the METI study and this project, it was confirmed that the traffic demand forecast model used in this study was reasonable.



Source: Study Team

Figure 4.4-9 Traffic Volume Across the Cam River (1,000 PCU/day)

3) Case 1–5: Results from the Future Traffic Demand Forecasts

a) Traffic volume for the 2 bridges and the years that the traffic volume will exceed capacity

The following are the estimated traffic volumes for the different bridge scenarios. The year that the traffic volume will exceed capacity was estimated via linear interpolation.

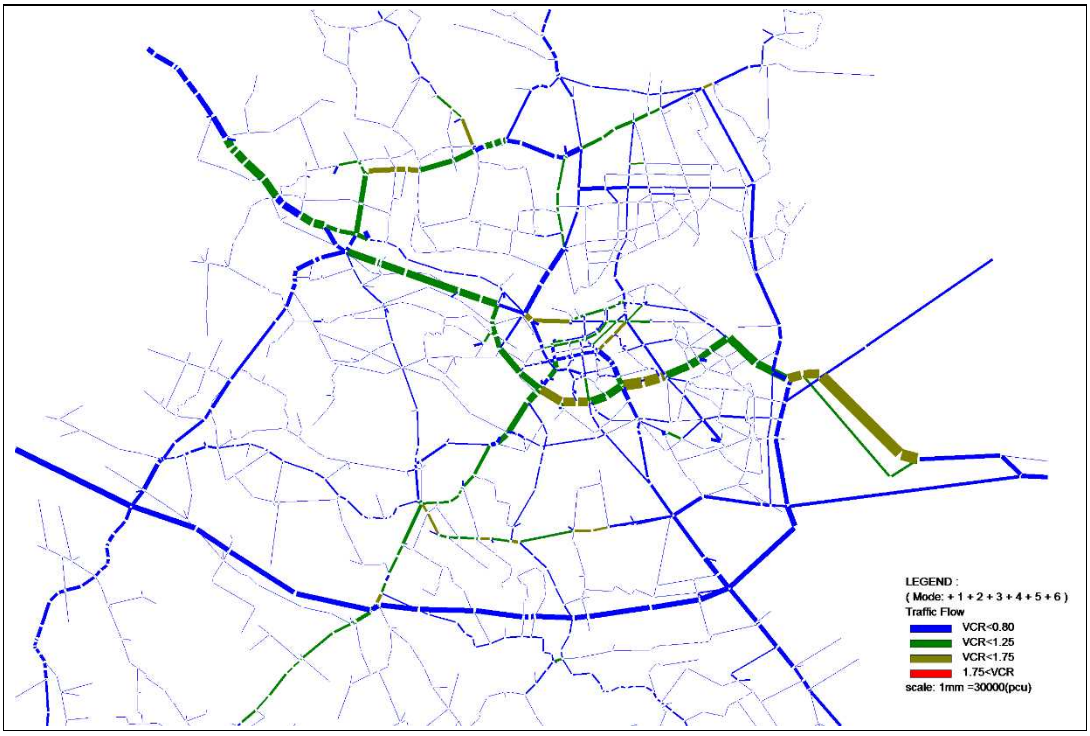
According to the forecast, by 2020 the traffic volume will exceed the design highway capacity of Binh Bridge and Kien Bridge and there is a possibility that it will be impossible to manage the traffic volume that will cross the Cam River. Also, looking at the year that the traffic volume will exceed capacity, in 2020, for reducing congestion at the traffic saturated Binh Bridge, it can be seen that provision of Nguyen Trai Bridge would be more helpful than Vu Yen Bridge.

On the other hand, looking at the target year of 2030, with the provision of only one of either Nguyen Trai Bridge or Vu Yen Bridge, it will become impossible to manage the traffic volume that will cross the Cam River. As a result, both Nguyen Trai and Vu Yen Bridges will be required at least by 2030.

Table 4.4-8 Forecast of when the Traffic Volume will Exceed Capacity

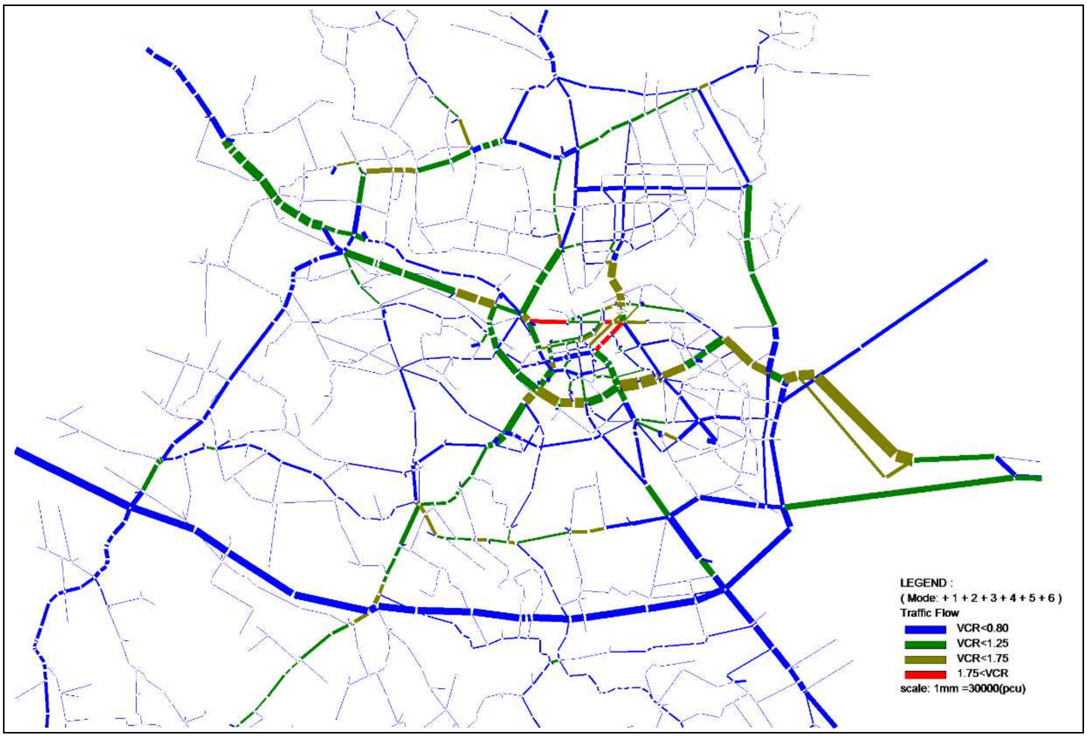
Scenarios	Bridge Name	Traffic Volume Capacity (PCU/day)	Traffic Volume (PCU/day)			Year that the traffic volume exceeds capacity
			2015	2020	2030	
Binh, Kien Bridges	Kien Bridge	30,000	31,400	49,200	68,600	2015
	Binh Bridge	61,000	38,800	84,900	164,600	2017
	Nguyen Trai Bridge	61,000				–
	Vu Yen Bridge	70,000				–
Bien, Kien, Nguyen Trai Bridges	Kien Bridge	30,000	31,400	42,100	50,000	2015
	Binh Bridge	61,000	38,800	56,000	89,800	2021
	Nguyen Trai Bridge	61,000		42,400	108,400	2023
	Vu Yen Bridge	70,000				–
Binh, Kien, Vu Yen Bridges	Kien Bridge	30,000	31,400	50,300	51,800	2015
	Binh Bridge	61,000	38,800	59,400	107,500	2020
	Nguyen Trai Bridge	61,000				–
	Vu Yen Bridge	70,000		35,200	96,300	2026
Binh, Kien, Nguyen Trai, Vu Yen Bridges	Kien Bridge	30,000	31,400	49,800	50,200	2015
	Binh Bridge	61,000	38,800	45,600	72,000	2026
	Nguyen Trai Bridge	61,000		20,800	81,300	2027
	Vu Yen Bridge	70,000		28,700	55,100	Will not exceed capacity

Source: Study Team



Source: Study Team

Figure 4.4-10 Traffic Volume Map for Case 2 in 2020



Source: Study Team

Figure 4.4-11 Traffic Volume Map for Case 2 in 2030

b) *Traffic Volume by Mode for Case 2: Nguyen Trai and Vu Yen Bridges*

The traffic volume forecast by mode for Case 2 (when both Nguyen Trai and Vu Yen Bridges are provided) is shown in the following two tables. The top table shows the traffic volume in terms of PCU/day while the bottom table shows the traffic volume in terms of vehicles/day.

Looking at the forecast results in terms of vehicles/day, in 2020 at Nguyen Trai Bridge, the proportion of trucks in the traffic volume (in terms of vehicles) is estimated at 3.4% in 2020 and 6.8% in 2030. However, at Vu Yen Bridge, the proportions are estimated at 17.1% in 2020 and 17.2% in 2030.

Therefore, it can be seen that the number of trucks that is estimated to travel over Vu Yen Bridge is high and therefore will have a big impact on the pavement of Vu Yen Bridge and as a result, the pavement design of this bridge should be designed accordingly.

Table 4.4-9 Traffic Volume by Mode Excluding Trucks (Unit: PCU/day)

Traffic Volume (PCU/day)		Bicycle	MC	Car	Bus
2020	Kien Bridge	200	5,100	10,500	3,800
	Binh Bridge	500	12,300	23,600	10,000
	Nguyen Trai Bridge	300	8,900	37,500	14,700
	Vu Yen Bridge	Less than 100	3,100	16,300	11,600
	Total	1,000	29,400	87,900	40,100
2030	Kien Bridge	300	6,500	8,400	2,700
	Binh Bridge	600	14,000	11,400	5,900
	Nguyen Trai Bridge	100	6,200	7,300	3,000
	Vu Yen Bridge	Less than 100	2,900	7,200	4,100
	Total	1,000	29,600	34,300	15,700

Source: Study Team

Table 4.4-10 Traffic Volume by Truck Type (Unit: PCU/day)

Traffic Volume (PCU/day) (Truck)		Pickup Truck	Rigid-Chassis Truck (2 axles)	Rigid-Chassis Truck (=>3 axles)	Truck/Tractor-Trailer (separated)	Total	Proportion of Trucks
2020	Kien Bridge	1,000	14,100	3,900	11,700	50,200	61.0%
	Binh Bridge	6,100	14,200	2,400	2,900	72,000	35.7%
	Nguyen Trai Bridge	4,400	10,200	2,100	3,400	81,300	24.6%
	Vu Yen Bridge	600	8,800	2,900	11,700	55,100	43.7%
	Total	12,100	47,300	11,300	29,700	258,600	38.8%
2030	Kien Bridge	1,000	14,700	4,000	12,200	49,800	64.1%
	Binh Bridge	3,300	7,600	1,300	1,600	45,600	30.0%
	Nguyen Trai Bridge	900	2,100	400	700	20,800	19.7%
	Vu Yen Bridge	400	5,300	1,700	7,100	28,700	50.5%
	Total	5,600	29,700	7,400	21,600	144,900	44.3%

Source: Study Team

Table 4.4-11 Traffic Volume by Mode Excluding Trucks (Unit: vehicles/day)

Traffic Volume (vehicles/day)		Bicycle	MC	Car	Bus
2020	Kien Bridge	1,100	20,300	10,500	1,400
	Binh Bridge	2,400	49,100	23,600	3,600
	Nguyen Trai Bridge	1,500	35,500	37,500	5,200
	Vu Yen Bridge	200	12,500	16,300	4,200
	Total	5,200	117,400	87,900	14,400
2030	Kien Bridge	1,400	26,000	8,400	1,000
	Binh Bridge	2,800	56,200	11,400	2,100
	Nguyen Trai Bridge	500	24,900	7,300	1,100
	Vu Yen Bridge	100	11,600	7,200	1,400
	Total	4,800	118,700	34,300	5,600

Source: Study Team

Table 4.4-12 Traffic Volume by Truck Type (Unit: vehicles/day)

Traffic Volume (vehicles/day)		Pickup Truck	Rigid-Chassis Truck (2 axles)	Rigid-Chassis Truck (=>3 axles)	Truck/Tractor-Trailer (separated)	Total	Proportion of Trucks
2020	Kien Bridge	400	5,600	1,300	2,900	43,500	20.9%
	Binh Bridge	2,400	5,700	800	700	88,300	8.6%
	Nguyen Trai Bridge	1,800	4,100	700	900	87,200	6.8%
	Vu Yen Bridge	200	3,500	1,000	2,900	40,800	17.2%
	Total	4,800	18,900	3,800	7,400	259,800	11.4%
2030	Kien Bridge	400	5,900	1,300	3,100	47,500	20.0%
	Binh Bridge	1,300	3,000	400	400	77,600	5.1%
	Nguyen Trai Bridge	400	800	100	200	35,300	3.4%
	Vu Yen Bridge	200	2,100	600	1,800	25,000	17.1%
	Total	2,300	11,800	2,400	5,500	185,400	10.2%

Source: Study Team

c) *Results of the traffic demand forecast for Ring Road 3 and the main arterial roads*

In the following table, the traffic demand forecast for the main arterial roads of Hai Phong is shown. Looking at the results by case, compared to the Do Nothing Case 1, Cases 2, 4 and 5 which include the provision of Vu Yen Bridge, shows that by 2020, for each of these cases, the traffic volume is estimated to increase to above around 10,000 PCU in 2020 while by 2030, the traffic volume is estimated to increase to above around 20,000 PCU. These traffic forecasts approach the 30,000 PCU road capacity of a 2 lane road.

If it is assumed that the project period of Ring Road 3 is after 2030, there is a high possibility that the 2030 traffic volume will exceed 30,000 PCU and as a result, it is desirable for Ring Road 3 to be built as a 4 lane road.

Table 4.4-13 Traffic Forecasts for Ring Road 3 and the Main Arterial Roads

Main Arterial Roads		Traffic Volume (pcu/day)				
		Case 1	Case 2	Case 3	Case 4	Case 5
2020	Hai Phong-Quang Ninh Expressway(up to the eastern border with Quang Ninh Province)	17,500	17,500	18,100	17,400	17,400
	Hanoi-Hai Phong Expressway (up to the western border of Hai Phong)	58,800	57,900	59,600	57,900	57,800
	QL5 (up to the western border of Hai Phong)	45,400	46,300	44,600	46,300	46,400
	Ring Road 3 (northeast section)	9,600	21,800	4,600	22,900	21,600
	Ring Road 3 (northern section)	8,100	10,200	6,400	10,600	10,000
2030	Hai Phong-Quang Ninh Expressway(up to the eastern border with Quang Ninh Province)	34,300	35,600	35,400	35,800	36,800
	Hanoi-Hai Phong Expressway (up to the western border of Hai Phong)	75,900	74,800	74,600	77,700	76,800
	QL5 (up to the western border of Hai Phong)	44,900	46,000	46,300	43,200	44,100
	Ring Road 3 (northeast section)	9,200	29,400	7,700	32,000	30,000
	Ring Road 3 (northern section)	14,200	17,800	8,600	26,600	21,300

Notes:
Case 1 – Do Nothing
Case 2 – Construction of Nguyen Trai Bridge and Vu Yen Bridge
Case 3 – Construction of Nguyen Trai Bridge only
Case 4 – Construction of Vu Yen Bridge only
Case 5 – Construction of Nguyen Trai Bridge without roundabout access and Vu Yen Bridge

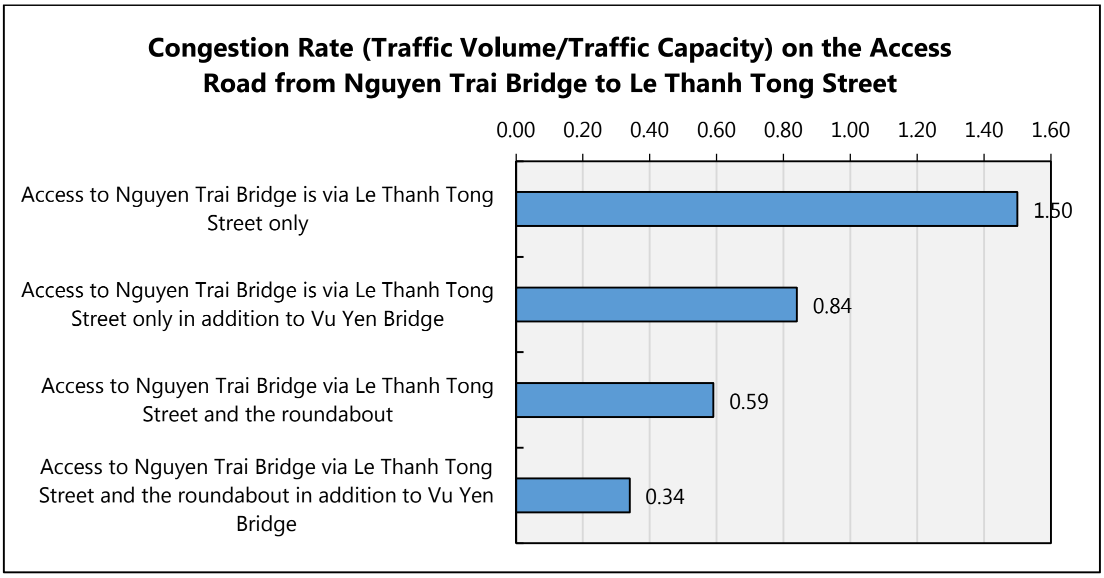
Source: Study Team

d) *Years when the traffic volume will exceed capacity on the Le Thanh Tong Street access road to Nguyen Trai Bridge*

If access to Nguyen Trai Bridge is via Le Thanh Tong Street only, the access road to the bridge will be 1 lane and depending on the provision of Nguyen Trai Bridge and Vu Yen Bridge, it is necessary to analyze the effects of the traffic volume from the bridge to the access road that will connect to Le Thanh Tong Street.

Assuming a traffic capacity of 16,000 PCU/day for the access road to the bridge that will be connected to Le Thanh Tong Street, the congestion is estimated as follows.

According to the estimation results, if access to Nguyen Trai Bridge is via Le Thanh Tong Street only, the access road will be congested several hours per day. In addition, if Vu Yen Bridge is provided, the congestion rate on the access road is estimated to be reduced to 0.84. However, it is confirmed that by 2021, there is a possibility that the traffic volume will exceed the capacity of the access road. Also, if Vu Yen Bridge is provided and if access to Nguyen Trai Bridge is via the roundabout, then it is confirmed that by 2027, there is a possibility that the traffic volume will exceed the capacity of the access road.



Source: Study Team

Figure 4.4-12 Congestion Rate on the Access Road from Nguyen Trai Street to Le Thanh Tong Street

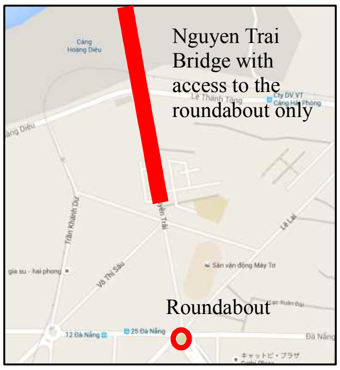
Table 4.4-14 Year When the Volume Exceeds Capacity for Provision of Nguyen Trai Bridge in 2020

By 2020	Traffic Volume (PCU/day)	Traffic Capacity (PCU/day)	Congestion Rate	Year where the volume exceeds capacity
Access to Nguyen Trai Bridge is via Le Thanh Tong Street only	48,024	32,000	1.50	2020
Access to Nguyen Trai Bridge is via Le Thanh Tong Street only in addition to Vu Yen Bridge	26,845	32,000	0.84	2021
Access to Nguyen Trai Bridge via Le Thanh Tong Street and the roundabout	18,767	32,000	0.59	2026
Access to Nguyen Trai Bridge via Le Thanh Tong Street and the roundabout in addition to Vu Yen Bridge	10,918	32,000	0.34	2027

Source: Study Team

e) *Effect on the roundabout located at the south end of Nguyen Trai Bridge*

At the southern end of Nguyen Trai Bridge, there is an existing concentration of residential and commercial areas. As a result, there is a concern that the land acquisition for extending Nguyen Trai Street to the bridge could possibly be delayed. For this project, if it is assumed that land acquisition may be delayed, a 2-stage method for accessing Nguyen Trai Bridge is proposed. The first stage would be for access roads to be built to the bridge from Le Thanh Tong Street and the second stage would involve extending the bridge to the roundabout.



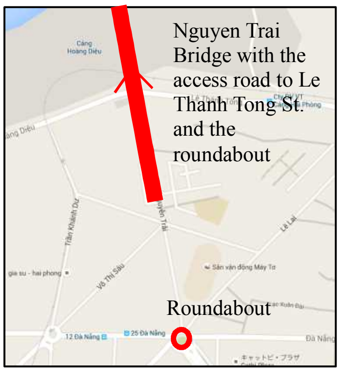
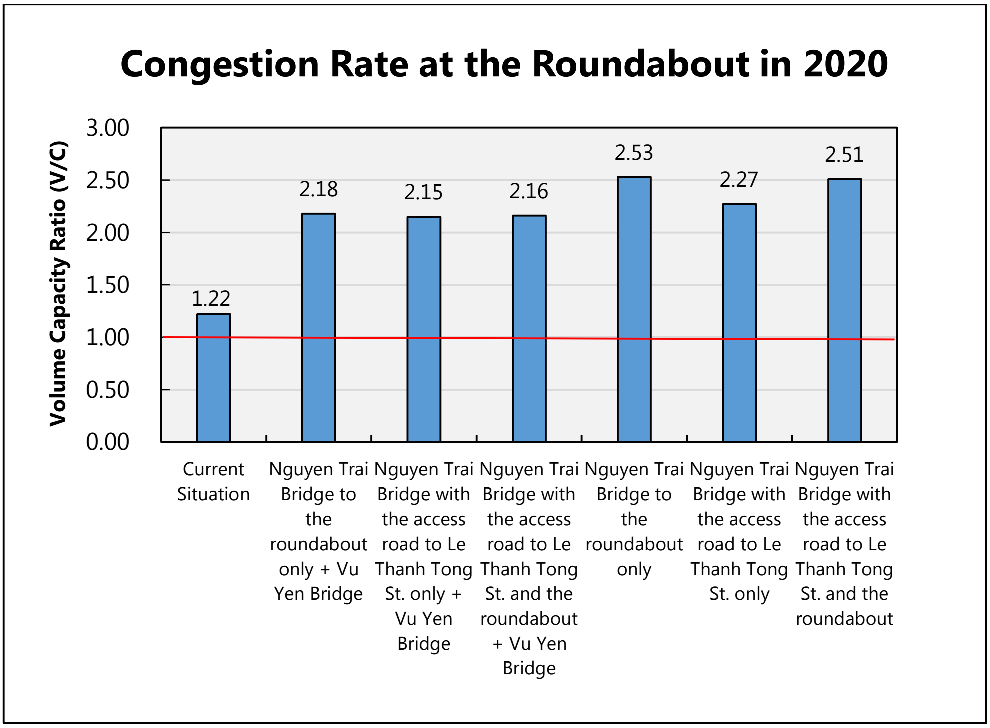


Figure 4.4-13 Access to Nguyen Trai Bridge (3 Cases)

Currently during peak hours, the roundabout located at the southern end of the proposed Nguyen Trai Bridge is congested. If Nguyen Trai Bridge is connected to the roundabout, it can be inferred that the traffic volume from crossing the Cam River via the bridge would have a large impact on the roundabout.

Referencing the Highway Capacity Manual 2010, the average traffic volume for the above 3 cases along with the provision of Vu Yen Bridge was calculated and the largest value for the congestion rate at the roundabout was calculated. As a result, the traffic volume at the extension of Nguyen Trai Street to the roundabout was estimated at 1,540 PCU/hour and it is estimated that by 2020, the traffic volume would exceed the capacity so in the future the roundabout needs to be changed to either a signalized intersection or be grade separated.



Source: Study Team

Figure 4.4-14 Congestion Rate at the Roundabout for the Various Cases for 2020