SOCIALIST REPUBLIC OF VIET NAM
PROJECTS MANAGEMENT UNIT NO.2

FINAL REPORT

FOR ROAD & BRIDGE PORTION ON LACH HUYEN PORT INFRASTRUCTURE CONSTRUCTION PROJET IN VIET NAM

MARCH 2013

Japan International Cooperation Agency (JICA)

ORIENTAL CONSULTANTS CO., LTD. (OC)
NIPPON KOEI CO., LTD. (NK)
PADECO CO., LTD. (PADECO)
JAPAN BRIDGE & STRUCTURE INSTITUTE, INC. (JBSI)

CONTENTS

List of Tables

List of Figures

CHAPTER 1 GENERAL

1.1 Introduction

1.1.1 Background

Owing to the Government's policy "Doi Moi", Vietnam economy has remarkably expanded and, sea-borne trade through the ports in the north of Vietnam has experienced a significant increase both in quantities and kinds of commodities.

Along the area connecting Hai Phong in the northern coastal region of Vietnam and Hanoi, there exist various enterprises that contribute to the development of the region. Major ports supporting commercial activities of these enterprises include Hai Phong and Cai Lan Port, which received JICA's loan assistance in the past for rehabilitation and expansion works. While the capacity of these ports and other ports in the region is planned to cope with total 40.2 million tons of containerized cargo in 2015, the demand is expected to surpass this figure in 2015 and expand to 58.9 million in 2020, making it necessary to build a new port with enough capacity to cover the demand that would overflow. Against this backdrop, the Government of The Socialist Republic of Vietnam (hereinafter referred to as "GOV") carried out a feasibility study on the Lach Huyen Port Infrastructure Construction Project, based on which GOV requested the government of Japan (hereinafter called as "GOJ) to provide a Japanese ODA Yen loan in order to enforce the development plan proposed in its feasibility study.

In response to the request of GOV, the Japan International Cooperation Agency (hereafter referred to as "JICA") conducted the Preparatory Survey for Lach Huyen Port Infrastructure Construction in Vietnam from October 2009 to June 2010. The survey team recommended the development of Lach Huyen Port Infrastructure Construction Project as a priority project under the finance by Japanese Government ODA Loan Project (hereinafter referred to as "the Project")

Responding to the recommendation of the JICA study, GOV requested GOJ to provide an ODA loan for the Project by JICA, and to conduct the Detailed Design Study for Lach Huyen Port Infrastructure Construction Project (hereafter referred to as "the Design Study") by the technical cooperation program of GOJ in June 2010.

GOJ decided to extend Design Study, and JICA and the Ministry of Transport of GOV (hereinafter referred to as "MOT"), a responsible organization for the Design Study in GOV, have agreed that both sides shall sincerely cooperate with each other in implementing the Design Study and confirmed the implementation details of the Design Study.

This report was prepared to show the Detailed Design result as a part of Design Study. The contents of this report has been discussed and confirmed at the initial stage & second stage by the both sides of the Design Study Team and GOV to ensure successful implementation of the Design Study for the Project.

1.1.2 Outline of Design Study

1.1.2.1 Objectives of Design Study

The Design Study is intended to assist the implementing agencies for the Project, Maritime Project Management Unit No.2 (MPMU II) under Vietnam Maritime Administration for the port portion and Project Management Unit No.2 (PMU2) under Directorate of Roads for Vietnam for the road and bridge portion to implement smoothly and successfully Lach Huyen Port Infrastructure Project. The objectives of the Design Study are to prepare the tendering documents and detailed design for the Project. It is confirmed by MOT that the drawing and documents formulated by the Design Study (hereinafter referred to as “the Design Documents”) shall be fully utilized for the procurement procedure of the Project.

1.1.2.2 Project Profile

1) Name of the Project: Lach Huyen Port Infrastructure Construction Project
2) Signing L/A: Under processing
3) Proposed Facilities of the Project:

The Project (under the finance by Japanese Government ODA Loan) consists of the construction of land reclamation for two (2) berths of international container terminal and the related port and access road/bridge infrastructures. The following highway facilities and relative equipment are to be provided for the Project.

(Road and Bridge Portion)

Construction of Access Road and Bridges from Tan Vu to Lach Huyen for 15.63 km long, consisting of:

a) Road of about 10.19 km long,
b) Bridges of totally 5.44 km long,
c) 4 lanes of 3.5 m lane width

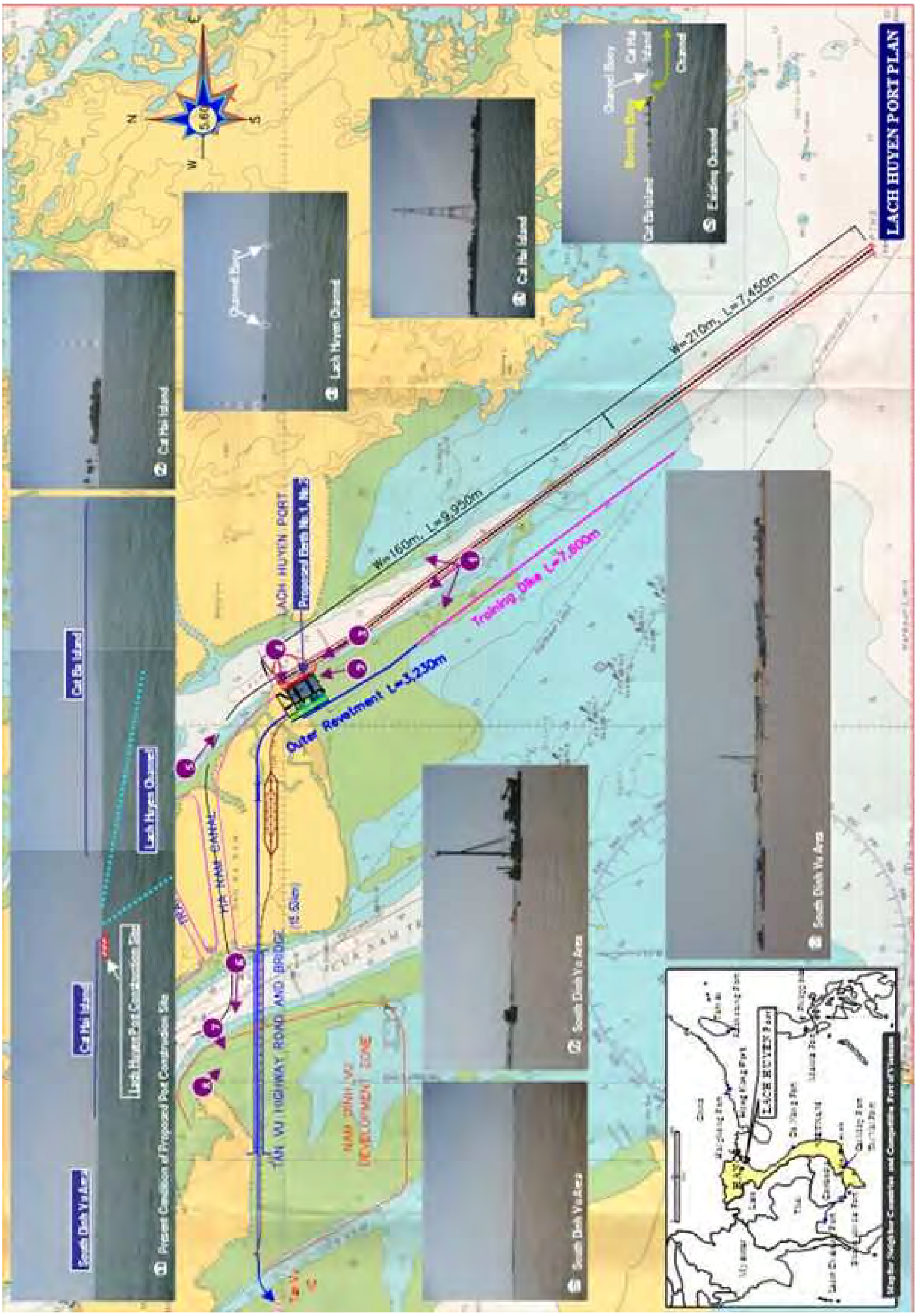
4) Implementing Agencies

Ministry of Transport (MOT) of GOV

(Road and Bridge): PMU2 under Directorate of Roads for Vietnam (DRVN)

1.1.3 Study Area

Hai An District & Cat Hai Island and their surrounding area in Hai Phong City, Vietnam



Source : Study Team

Figure 1.1.3-1 Study Area

1.2 Scope of Design Study

1.2.1 Scope of Design Study

In order to achieve the objectives mentioned above, the Design Study shall cover, but not limited to, the following study works.

(1) Review of previous studies

(2) Establishment of framework for the detailed design

(3) Implementation of Design Study (detailed design including cost estimation and preparation of tender documents)

1.2.1.1 Review of Previous Studies and Plans

(1) Review previous master plans, feasibility studies, Environmental Impact Assessment (EIA), Resettlement Action Plan (RAP), and other records and data related to the Project based on the latest information on traffic data, social and economic conditions, traffic forecast of the target year of 2015 in short term and 2020 in medium term among others, and

(2) Review plans, scope, scale, location or layout, if necessary and appropriate, and operation and maintenance system for the Project.

In the basic design stage, the above said items were completed.

1.2.1.2 Establishment of Design Study Framework

(1) Establish design criteria and design/technical standards to be applied for the Project.

(2) Recommend and agree with PMU2 the format and content for the Bills of Quantities and cost estimate for construction of each contract package of the Project.

(3) Recommend and agree with PMU2 the division of each categorized package for construction,

(4) Recommend and agree with PMU2 the format and content for prequalification and tender documents for each package of construction,

(5) Recommend and agree with PMU2 the time schedule for implementation of the detailed design, the Bills of Quantities, cost estimate, prequalification documents and bidding documents to allow the tendering of works and construction for each contract package to commence immediately after the completion of necessary design and documentation work and the gaining of necessary approvals, and,

(6) Agree with the Technical Advisory Committee of GOV the schedule, item and content of technical aspect for authorization of Design Study and Design Documents

In the basic design, the above said items have been being discussed with Vietnamese relative agencies due to delayed schedule for establishment of Technical Advisory Committee. The results are reflected in this final report.

1.2.1.3 Design Study

The Design Study Team has used the reference documents of previous studies approved by GOV as the basis for the Design Study. The Design Study Team has carried out surveys and investigation, basic design of road and bridge/structures, study of operation and maintenance system, preparation of construction method and schedule, cost estimate, preparation of prequalification documents and tender documents, preparation of implementation program, etc. as listed below:

(1) Conduct the following survey and investigations required for the Design Study (basic and detailed design):

(Field Survey and Investigation)

- Soil investigation at the area along the construction of road and bridges,
- Topographic survey at the area along the construction of road and bridges,
- Evaluation survey on availability and suitability of material sources for road and bridge construction,
- Hydro- and meteoro-logical (Data Collection) Survey
- Environmental survey around the Project site

(2) Prepare detailed design for roads, bridges and other structures,

(3) Establish an operation and maintenance system for the Project,

(4) Prepare the detailed environmental management and monitoring program,

(5) Monitor the progress of land acquisition and resettlement,

(6) Recommend appropriate construction methods and prepare a construction schedule,

(7) Prepare a cost estimate for the Project and study the effectiveness of the Project,

(8) Prepare prequalification and tender documents

(9) Prepare and implementation program, and

(10) Prepare HIV/AIDS prevention program together with the People’s Committee of Hai Phong City.

1.2.2 Work Schedule

The Design Study has been commenced immediately after the agreement on the Contract for Design Study in March 2011. The Design Study is scheduled to carry out within 10-month period subject to obtaining comments in time from Technical Advisory Committee to be established by GOV.

The overall Design Study schedule is shown in Figure 1.2.2-1 as the original schedule, and in Figure 1.2.2-2 as the actual design schedule. The detailed study schedules for each portion are indicated in Figure 1.2.2-3.

Year / Month	2011										2012
	3	4	5	6	7	8	9	10	11	12	1
Work in Vietnam											
Work in Japan											
Report		△ IC/R			△ CD/R		△ PQ/R EIA/R	△ DF/R			△ F/R

IC/R	: Inception Report	EIA/R	: Draft Supplemental EIA Report
CD/R	: Basic Design Report	DF/R	: Draft Final Report
PQ/R	: Draft Prequalification Documents	F/R	: Final Report

Figure 1.2.2-1 Overall Study Schedule (Original)

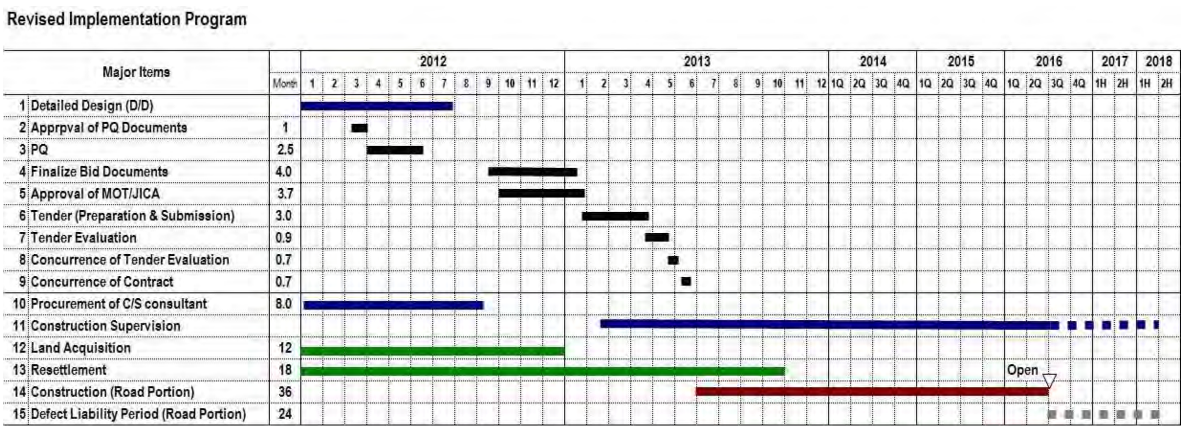


Figure 1.2.2-2 Overall Study Schedule (Actual)

TIME	TASK	REPORTS
March 2011	**Preparatory Work in Japan** ★Collection & analysis of existing data / information ★Preparation of Inception Report (IC/R) & Questionnaires	
April 2011	**1st Work in Viet Nam** ★Presentation / Discussion of Inception Report (IC/R) ★Existing Data Collection and Review of Previous Studies and Plans ★Review of EIA and monitor land aquisition, etc. ★Estabilshment of Framework for Design Study ★Field Surveys for Natural & Environmental Conditions ★Basic Design: Establishment of Design Criteria, Road and Bridge Facilities ★Preliminary Construction Planning & Time Schedule ★Preliminary Cost Estimate of Construction and Procurement Package for Construction	Inception Report (IC/R)
July 2011	**1st Work in Japan** ★Preparation/Finalization of Basic Design Report (CD/R)	Basic Design Report (CD/R)
August 2011 October 2011	**2nd Work in Viet Nam** ★Presentation / Discussion of Basic Design Report (CD/R) ★Preparation of Confirmation of Details on Design Contents ★Preparation of Prequalification Documents (PQ) ★Detaild Design ★Detailed Construction Planning ★Detailed Project Cost Estimates ★Procurement Program of Construction Materials and Equipment ★Overall Project Evaluation by Economic Analysis and Financial Analysis ★Formulation of Construction Work Safety Program ★Preparaion of Tender Documents ★Preparation of Draft Supplemental EIA report (EIA) and Environmental Management/Monitoring Plan ★Preparation of HIV/AIDS Prevention Program ★Operation and Management Plan ★Preparation of Draft Final Report and Draft Tender Documents (DF/R)	Prequalification Documents (PQ) Draft Supplemental EIA Report (EIA) Draft Final Report (DF/R)
December 2011	**2nd Work in Japan** ★Follow-up GOV Comments on DF/R	
January 2012	**3rd Work in Viet Nam** ★Finalization of Final Report and Revised Tender Documents (F/R)	Final Report (F/R)

Figure 1.2.2-3 Work Schedule of Design Study of Road/Bridge Portion for Lach Huyen Port Infrastructure Construction (Original)

1.2.3 Main History of the Study

The Design Study Team has executed the kick off meeting at MOT on 23rd March 2011 together with JICA and continuously at PMU-2 on 29th March 2011. The site visit was carried out on 25th March 2011. All previous study data were handed over to the Study Team on 31st March 2011 from PMU-2. The pre-bid meeting for site investigations was held on 30th March 2011 and bid opening was on 6th April 2011. The topographic survey was completed in July 2011 and geotechnical survey was completed in September 2011 including the final reports. Although the all technical issues were studied carefully and the results were submitted as discussion papers to Vietnamese sides and there were numbers of technical meetings held, in order to implement the study work in time, JICA requested MOT to hold the official meeting so that the outstanding matters in the basic design can be settled. The meeting at MOT was held on 7th June and 12th August 2011. After the first meeting at MOT, the TAC was established and main points of design subjects were discussed at TAC meeting and the both sides (JICA Study Team and Vietnamese sides) shared understanding in the all technical issues. The major items which have been discussed and agreed by the both sides are as follows:

(1) Main bridge's foundation (SPSP) was designed under the assumption of stage construction. It deferred from the Preparatory Study of JICA in 2010. The span component (95m + 2@150m + 95m) and the superstructure construction method (cantilever erection with cast-in-situ) was not changed.

(2) The span component in the approach bridges was concluded that 60m span length & single wall pier. This plan can be applied to all approach bridges including two (2) flyovers at Hai An side. Construction method for approach bridges was decided that SBS method is for Hai An side and cantilever erection method with cast-in-situ is for Cat Hai side.

(3) The pile foundation for approach bridges consists of steel pipe piles and bored piles after considering technical issues and economical aspects.

(4) Based on the discussion results between the Study Team and the local authorities, there are some changes in numbers of box culverts. Major change was that the box culvert at Cam River was changed into three (3) continuous PC girder bridge.

(5) Tan Vu-IC was designed as at grade intersection with traffic signal control after considering some technical request from VIDIFI.

(6) Pavement structure was designed based on the Vietnamese Standards that is different from AASHTO which has been adopted in Hanoi – Hai Phong Expressway. The pavement structure is bigger than the above expressway.

(7) Typical cross section of highway was basically not changed, but it was modified a little after considering the environmental impact to the local resident's assets and requests from the local authorities in some areas.

(8) Retaining wall behind abutments was omitted, and embankment was designed instead of that from economical and technical view points.

(9) EIA supplementary report was planned at the initial stage of this study. And social & natural EIA works were completed in October 2011. However, new EIA report was required in accordance with the new regulation since the temporary access for construction by dredging was designed in some areas. That supplementary EIA has been carried out in 2012 and the appraisal conference at MOT was held on 15th August 2012 for the approval procedure.

(10) Operation & maintenance plan was prepared for future O & M organization after opening highway. Due to unknown factors in future plan of the Vietnamese Government (MOT), it was concluded that the Study Team shall propose practical plan as much as possible based on the current conditions.

(11) HIV/AIDS Prevention was prepared based on technical researches and a numbers of hearings from each authority (not only central government but also local authorities). As the results, the HIV/AIDS prevention program was established in this report and it complies with the national and local framework. Regarding the application of the program to the tender documents including BOQ, the discussion is still under conducting.

(12) The Project cost increased by some reasons like temporary facilities, temporary road structure, and pavement structure from the Preparatory Study in 2010. As the results, Vietnamese Government requested JICA Study Team to review the all items and the JICA Study Team has re-submitted his cost estimation report in March 2012 for getting the concurrence of total investment decision for implementation of tender stage. However, the study results on effectiveness of the project shows still high level.

CHAPTER 2 TOPOGRAPHIC AND HYDROLOGICAL SURVEY

2.1 Topographic Survey

2.1.1 Applied Standards

Coordinate system of Vietnam used: VN2000 system, central meridian 105 degree 45 minutes with 3 degree projection zone and the following parameters;

1) Reference ellipsoid: WGS – 84
   - Major semi-axis: a = 6,378.137km
   - Flatness: f = 1/298.257223563
2) Projection: Transverse Mercator
   - Scale factor k = 0.9999

Elevation system used: National elevation system (data from Hon Dau Island - Hai Phong province)

The Standards to be applied in this project are as follows;

Table 2.1.1-1 Standards System

No.	Code	Title	Issued by
1	22TCN 263 - 2000	Standards for Motorway Survey	Ministry of Communications and Transport
2	22TCN 262 - 2000	Standards for Highway Survey and Design on weak ground	Ministry of Communications and Transport
3	TCXDVN364:2006	Standards for Engineering Survey GPS Monitoring and Processing	Ministry of Construction
4	96TCN 43 - 90	Standards for Topography Map Survey	Department of Survey and Mapping
5	QCVN 11:2008 BTNMT	Standards for establishment of leveling network	Ministry of Natural Resources and Environment

Source: Study Team

Work Volume

The contracted and actual work volume of the topographic survey is as follows;

Table 2.1.1-2 Contracted and Actual Work Volume

No.	Work Item	Volume	Remarks
1	Grade IV control points (GPS)	15 points	
2	IV-class leveling network	34.9 km	
3	Secondary control points (TS)	88 points	
4	Technical leveling network	16.4 km	
5	Center Line Survey (20m intervals)	10.2 km	Road Portion
6	Longitudinal Survey	10.2 km	Road Portion
7	Cross-section Survey (50m on each side)	510 sections	Road Portion
8	Plan metric survey (50m on each side)	102 ha	Road Portion
9	Longitudinal Survey	5.44 km	Bridge Portion
10	Cross-section Survey (50m on each side)	109 sections	Bridge Portion
11	Plan metric Survey (50m on each side)	55 ha	Bridge Portion
12	Positioning of Boring Pits	155 points	
13	Plan metric Survey (Km1+500 – Km2+000)	4.9532 ha	Additional
14	Plan metric Survey (Km12+100 – Km13+300)	1.2 ha	Additional
15	Plan metric Survey(Km14+920 – Km15+340)	4.0243 ha	Additional
16	Plan metric Survey (Km3+400 – Km4+000)	12 ha	Additional
17	Cross-section survey(Km3+400 – Km4+000)	13 sections	Additional

Source: Study Team

Equipment for Survey

The equipment for the survey was as follows;

Table 2.1.1-3 Equipment for Survey

No	Equipment	Unit	Qnty.	Remarks
1	GPS receiver	set	4	Topcon HiPer Ga
2	Total station	set	4	Topcon, Sokkia
3	Level	set	4	SDL30,B21,Ni025,Leica
4	Echo sounding instrument	set	1	Bruttour International PTY
5	Hand-held GPS receiver	set	4	Topcon
6	Prism	set	4	Topcon, Sokkia
7	Leveling staff	set	4	
8	Walkie-talkie	set	8	
9	Laptop PC	set	10	

Source: Study Team

2.1.2 Control Point Survey

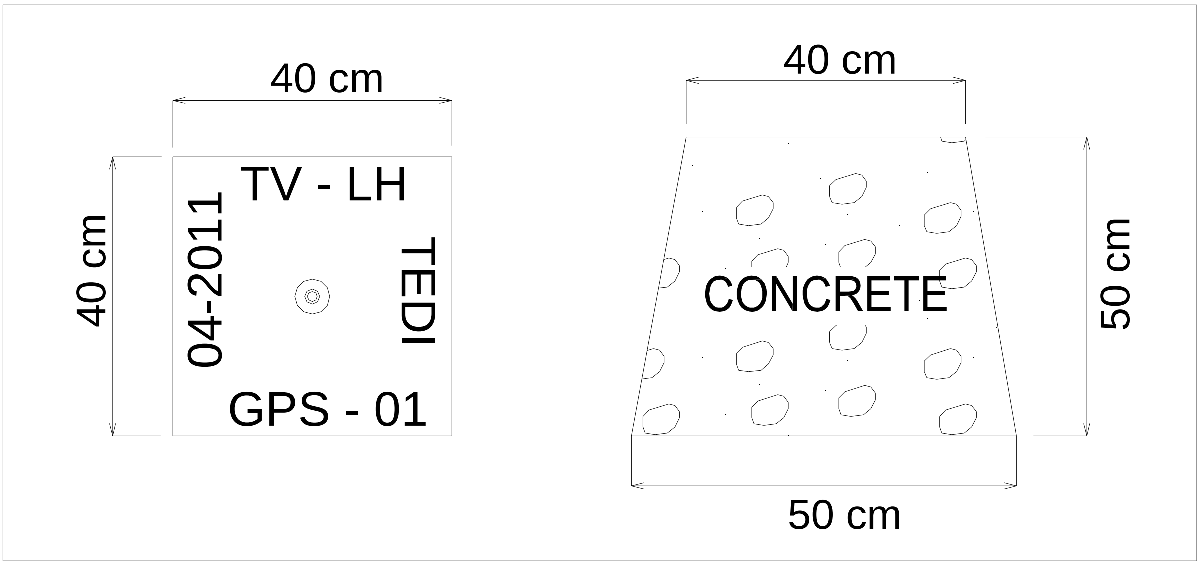
2.1.2.1 Survey of Grade IV Control Points

(1) Implementation of Grade IV control point survey

The Grade IV control point survey was performed by the Contractor (Transport Engineering Design Inc.) in April 2011. And the positioning for the Grade IV control points is as follows;

- The control points were set at the following important areas;
    - Area of start point;
    - Area of end point;
    - Both ends area of bridge portion;
- The distance of the each Grade IV control points were approximate interval of between 1km and 1.5km along the route.
- The Grade IV control points were positioned so as to be connected to the original azimuths for secondary traverse networks later.
- The Grade IV control points network was connected to two (2) upper national control points.

- The material specifications for Grade IV control points were as following figure;



Source: Study Team

Figure 2.1.2-1 Specifications for a Grade IV control point

2.1.2.2 IV-class Leveling Network

The IV-class leveling network survey was performed by the Contractor (Transport Engineering Design Inc.) in April 2011 in accordance with the basic specifications of the QCVN 11:2008/BTNMT standards.

(1) Work volume

- Leveling line of the riverside in the direction of Hai An District: ~21.2 km
- Leveling line of the Trieu River between Dinh Vo and Cai Hai Island District: ~5.7 km
- Leveling line of the riverside in the direction of Cai Hai Island District: ~8.0 km

(2) Rules for leveling observation

- The network was measured by the geometric levelling method. The observer took readings on the leveling staff above, below and in the centre of the crosshairs.
- Height closure error $f_h < \pm 20\ mm\sqrt{L}$ (where L = distance between each pair of GPS points, in km).
- The leveling network was adjusted on the computer using professional software.
- Cross-leveling at the Trieu River (GPS04A-GPS06A) was performed using the hydrostatic method and the RTK (Real-time kinematic) method because of the very wide (approx. 5 km) river mouth.

2.1.2.3 Secondary Control Points and Technical Leveling Network

(1) Secondary control points:

Secondary control points were established along the center line and each point was observed using Total Station (Topcon GTS510 or Sokkia SET5 30R3 type, with equivalent accuracy), conforming to the 22 TCN 263-2000 standards.

The average distance between two consecutive control points was approx. 150m. Secondary control points were positioned stable ground and were optimally suited for topographic survey work.

Form of Secondary control points: The dimensions are as follows:

Table 2.1.2-1 Dimensions of secondary control point

Top	20cm x 20cm
Bottom	30cm x 30cm
Height	40cm
Benchmark base	40cm x 40cm x 10cm

Source: Study Team

(2) Technical leveling network:

This conformed to Standard 22 TCN 263-2000.

The technical leveling network coincides with the Secondary control points.

The leveling machines were used Leica NA720, Sokkia B21 and other machines of equivalent accuracy. The allowable error was fh < 30mm$\sqrt{L}$ (L is measured in km).

(3) Quantity

The number of Secondary control points is as follows;

Trang Cat and Dong Hai 2 areas: 45 points covering 7.5 km.

Cat Hai Island Area: 50 points covering 8.4 km

2.1.3 Route Survey for Road Portion

2.1.3.1 Center Line Survey

The center-line was marked using wooden pegs or long bamboo sticks along the center-line except where there was more than 2m depth of water in a river or fish-pond, or in vegetated areas of a fish pond (km0+60 to km0+500).

The alignment staked out was as follows;

- Start and end point
- 20m interval station
- SC: point of change from spiral to circular curve
- CS: point of change from circular curve to spiral
- TS: point of change from tangent to spiral
- ST: point of change from spiral to tangent

2.1.3.2 Longitudinal Survey

A longitudinal survey was performed along the center-line using Total Station except for several parts of the survey area that are covered by water. The points which were surveyed are station markers, changed terrain, ground objects and culverts, etc.

Distances covered by the longitudinal survey are as follows;

- Trang Cat and Dong Hai 2 areas: approx. 4.50km
- Cat Hai Island area: approx. 5.69km

The drawing scale of the profile chart is as follows;

- Horizontal scale: 1: 1,000
- Vertical scale: 1: 100

2.1.3.3 Cross-section Survey

A cross-section survey was performed along the center-line. A RTK system survey by GPS (Topcon Hiper Ga) was carried out between km0+000 and km0+500. The other areas (km0+520 to km4+700, km9+945 to km15+630) were surveyed using Total Station. The width of each cross-section was 50m on each side of the center-line.The volume of the cross-section survey is as follows;

- Trang Cat and Dong Hai 2 areas : 226 sections
- Cat Hai Island area : 284 sections

The drawing scale of the cross-section chart is as follows;

- Horizontal scale: 1: 200
- Vertical scale: 1: 200

2.1.3.4 Plan-metric Survey

The plan-metric survey was performed along the center-line to a width of 50m on each side. The residential area of Cat Hai Island was surveyed in particular detail. The main specifications for the plan are as follows;

- Plan scale : 1: 1,000
- Surveyed objects: irrigation ditch, sluice gate, high- and low-voltage lines, communication lines, historical sites, temples, pagodas, cemeteries, control points, etc.
- Interval of intermediate contour: 0.5m
- Interval of index contour: per 2.5m

The area covered by the Plan-metric survey is as follows;

- Trang Cat and Dong Hai 2 areas : approx. 45 ha
- Cat Hai Island area : approx. 57 ha

2.1.4 Route Survey for Bridge Portion

2.1.4.1 Longitudinal Survey

A longitudinal survey was performed along the center-line.

The length of the longitudinal survey is approx. 5.44km.

The drawing scale of the profile chart is as follows;

- Horizontal scale : 1: 1,000
- Vertical scale : 1: 100

2.1.4.2 Cross-section Survey

A cross-section survey was performed along the center-line at 50m intervals. The width of each cross-section was 50m on each side of the center-line.

The volume of the cross-section survey is 109 sections.

The drawing scale of the cross-section chart is as follows;

- Horizontal scale : 1: 200
- Vertical scale : 1: 200

2.1.4.3 Plan-metric Survey

The plan-metric survey was performed along the center-line to a width of 50m on each side. The main specifications for the plan are as follows;

- Plan scale : 1: 1,000
- Interval of intermediate contour: 0.5m
- Interval of index contour: per 2.5m

The area covered by the plan-metric survey is approx. 55ha.

2.1.4.4 Additional Survey

The additional survey was performed about 4 areas, 1) Km1+500 - Km2+000, 2) Km3+400 - Km4+000, 3) Km12+100 - Km13+300 and 4) approximately Km14+920 - Km15+340. The plan-metric survey was performed about all of the additional area and the cross-section survey was performed about only Km3+400 to Km4+000.

The main specifications for the plan are as follows;

- Plan scale : 1: 1,000
- Interval of intermediate contour: 0.5m
- Interval of index contour: per 2.5m

The drawing scale of the cross-section chart is as follows;

- Horizontal scale : 1: 200
- Vertical scale : 1: 200

2.1.5 Positioning of Boring Pits

The boring pit positioning survey was performed along the center-line.

The coordinates of the boring pits for the Road section and the Bridge section were provided by JICA consultant.

2.2 Hydrological Survey

2.2.1 Supplemental Hydrological Survey

2.2.1.1 Purpose of Survey

In order to update the results of the hydrological survey in FS stage, supplemental survey and analysis are planned. The items of the survey are base line survey, water level investigations and data collection.

2.2.1.2 Scope of survey

(1) Water Level Investigation for Bridge Section

The clusters of maximum flood water level within the scope of bridge's plan (10 clusters) were investigated. Water level groups were allocated in the surveyed area and on 2 river banks. Investigation data in each water level group include:

- Historically highest water level in 3 years
- Average annual flood water level
- Lowest water level
- Peak flood-tide water level, lowest tide
- Water level in survey time.

(2) Water Level Investigation for Road Sections

The clusters of water level along the route were investigated (18 clusters: In Hai An side 8 clusters and in Cat Hai side 10 clusters). On the route on average each km there are 2 groups of water level and calculating at frequencies of 1%, 2%, 4%, and 10% to design elevation of the profile along the route. Each group of water level includes:

- Highest water level of 3 historical flood years caused by rain.
- Regular flood water level
- Lowest water level
- Effect of tide, tidal amplitude.
- Determination of flow, clearance, and elevation of the expected culvert slabs (working with local hydraulic agency and reaching agreement in writing).

(3) Collection of Data of gauging station, marine station and meteorological station

- Collection of data of 01 gauging station, 01 marine station for calculation of water level, current, design speed. In the FS stage, the marine data at the Hon Dau station used for the calculation was only up to the year 2004. Data from the year 2005 to 2010 has been added in basic design calculation.
- Updating, collection of data on meteorology of Phù Lien station up to the year of 2010.

2.2.1.3 Update of Water Level

In this section, update of water level is discussed based on supplemental data collected in this survey.

(1) Design water level calculate by discrepancy at Hon Dau Station

Discrepancy between max water level corresponding to frequencies and actual max water level in 2005 at Hon Dau station is equal with discrepancy between max water level corresponding to frequencies and actual max water level in 2005 at the Site position:

$$H_{P\%} = H_{max2005} + \Delta H_{P\%}$$

$H_{P\%}$- water level along the route, m;

$H_{max2005}$- max water level is observed in 2005 at Hon Dau Station, m;

$\Delta H_{P\%}$ - discrepancy between max water level corresponding to frequencies and actual max water level in 2005 at Hon Dau Station, m.

Discrepancy between max water level corresponding to frequencies and actual max water level in 2005 From maximum water lever data trip of Hon Dau Station during (1974 - 2010), it will be draw frequency line with Cv = 0.05, Cs = 0.60:

ΔH1% = +0.10m; ΔH4% = -0.05m; ΔH5% = -0.09m; ΔH10% = -0.18m.

(2) Bridge Section

1) Investigation water lever along route and bridge

Following survey result, which is implemented by the Flood and storm prevention commander board, Hai Phong city, in 2005, maximum water lever occur in study area as following.

- At the right side of Ninh Tiep Ferry (around Km9+900): H_{2005} = 2.94m (national chart level).

- At the left of Got Terminal (around Km15+500): H_{2005} = 2.77m (national chart level).

Based on the above collected data, it has basis to confirm investigation water level along route and bridge is reliable and can be used in subsequent calculations.

2) Design water levels

Following study results of wave regime and flow on using mathematical model prepared by TEDI-Port in May 2008 for Nam Dinh Vu Industrial Zone infrastructure construction investment project - Hai Phong City. When having Nam Dinh Vu Industrial Zone, in case of disadvantages for water level due to narrow contraction flow at the upstream is **15cm** in comparison with downstream.

Water level for bridge design has considered effect of increasing water when having industrial zone which is corresponding to frequencies as following table:

Table 2.2.1-1 Design Water Level in Bridge Section

Position	***Design water level* (m)**			
	Natural		**When having Nam Dinh Vu Industrial Zone**	
	$H_{1\%}$	**$H_{5\%}$**	**$H_{1\%}$**	**$H_{5\%}$**
Bridge	2.93	2.74	***3.08***	***2.89***

Source: Study Team

The major design values are summarized as follows,

Design High Water Level (P = 1%)=3.08 m

High Water Level (P = 5%)=2.89 m

Mean High Water Level=1.97 m

Mean Water Level=0.15 m

Mean Low Water Level=-1.67 m.

* Note: - All above elevation is in the National Chart.

- EL National Chart = EL Sea Chart - 1.86 (m)

(3) Road Sections

1) Section Km0 -:- Km10+060 and Km14+670 up to ending route

Design profile grade line depends on implementation schedule of Lach Huyen Construction Infrastructure Project and Nam Dinh Vu IZ Project.

In case of the Nam Dinh Vu IZ has not established yet, water level for route is proposed as following table:

Table 2.2.1-2 Design water level at Section Km0 - Km10+060 and Km14+670 to End

Ord	Station			Water level (m)				Note
	Km	+	.....	$H_{max2005}$	$H_{1\%}$	$H_{4\%}$	$H_{5\%}$	
1	0	-	41.10	2.80	2.90	2.75		Water level point
2	0	+	780.00	2.82	2.92	2.77		Shrimp pond
3	0	+	940.00	2.82	2.92	2.77		Drainage Culvert
4	1	+	474.60	2.81	2.91	2.76		Water level point
5	1	+	929.20	2.83	2.93	2.78		Water level point
6	2	+	930.70	2.88	2.98	2.83		Water level point
7	3	+	409.50	2.81	2.91	2.76		Water level point
8	3	+	962.50	2.83	2.93	2.78		Water level point
9	4	+	511.80	2.83	2.93	2.78	2.74	Water level point
10	9	+	723.20	2.75	2.85	2.70	2.66	Water level point
11	14	+	880.00	2.87	2.97	2.82		Drainage Culvert
12	15	+	100.00	2.87	2.97	2.82		Drainage Culvert

Source: Study Team

2) Section Km10+060 to Km14+670

Design water level of this section is shown in the table below:

Table 2.2.1-3 Design Water Level at Section Km 10+060 to Km14+670

Ord	Station			Water level (m)				Note
	Km	+	.....	$H_{max2005}$	H_{TX}	$H_{1\%}$	$H_{4\%}$	
1	10	+	820.00	1.50	1.22	2.09	1.93	Drainage Culvert
2	12	+	620.50	1.21	1.12	1.80	1.64	Water level point
3	13	+	248.50	1.24	0.98	1.83	1.67	Water level point
4	13	+	980.00	1.39	1.05	1.98	1.82	Water level point
5	14	+	620.00	1.40	1.05	1.99	1.83	Drainage Culvert
6	14	+	650.00	1.40	1.05	1.99	1.83	Drainage Culvert

Source: Study Team

CHAPTER 3 SUBSOIL CONDITIONS

3.1 Conclusions

(1) The subsoil of project area is mainly composed of ten clay layers (Layer-D, 1, 3, 4, 6, 7A, 7B, 8, 9 and 11), four sand layers (Layer-2, 5, 10A and 10B) and two weathered siltstone (Layer-12A and 12B) as shown in Table 3.1-1. Furthermore, there are some lens layers in some main layers.

(2) Regarding clay layers, Layer-D, 1, 3, 4, 7A, 7B and 9 are evaluated to be very soft to medium stiff, while Layer-6, 8 and 11 are evaluated to be stiff to very stiff.

(3) Regarding sand layers, Layer-2 is evaluated to be very loose to medium dense, while Layer-5 and 10A are evaluated to be loose to medium dense. On the other hand, Layer-10B is evaluated to be dense to very dense.

(4) Layer-12A and 12B are weathered siltstone having N-value of more than 50. Therefore, these layers are evaluated to be the bearing strata for pile foundation.

(5) In Approach Road Area in Hai An side, Layer-1, 2, 5, 7A and 11 are not found out. Layer-3 distributes thickest with the thickness of 7.5 to 30.5 m, 17.3 m in average.

(6) In Bridge Area, Layer-D and 1 are not found out. Layer-3 distributes thickest with the thickness of 1.8 to 20.5 m, 11.0 m in average.

(7) In Approach Road Area in Cat Hai side, all main layers are found out. Layer-3 distributes thickest with the thickness of 2.0 to 14.3 m, 6.6 m in average. Furthermore, Layer-L5-1 of lens layer in Layer-5 is found out having N-value of 57 in average.

Table 3.1-1 Stratum Classification (Main Layer)

Layer	Soil Discription
D	**Filling soil and agriculture soil**
1	**Clay** with sand, very soft to soft
2	**Sand** with silt/clay, very loose to medium dense
3	**Clay** with sand, very soft to soft
4	**Clay** with sand, medium stiff
5	**Sand** with silt/clay, loose to medium dense
6	**Clay** with sand, stiff to very stiff
7A	**Clay** with sand, soft
7B	**Clay** with sand, medium stiff
8	**Clay** with sand, stiff to very stiff
9	**Clay**, medium stiff
10A	**Sand** with silt/clay, loose to medium dense
10B	**Sand** with silt/clay, dense to very dense
11	**Clay**, stiff to very stiff
12A	Completely to highly weathered **Siltstone**
12B	Moderately weathered **Siltstone**

Source: Study Team

(8) As a result of laboratory tests, shear strength analysis and consolidation analysis, the soil parameters for design of Approach Road Area in Hai An side are proposed as shown in following table.

Table 3.1-2 Soil Parameters for Design (Hai An side)

Item					3 (Clay)	4 (Clay)	6 (Clay)	7B (Clay)	8 (Clay)	9 (Clay)	10A (Sand)	10B (Sand)
N-value					2	7	13	7	14	6	21	49
Unit Weight			γt	(g/cm³)	1.70	(1.76)	1.86	1.76	1.88	(1.76)	(2.00)	(2.05)
Shear Strength	For Short Term		Su or Cd	(kg/cm²)	Note (2)	0.25	0.50	0.25	0.60	(0.25)	0.00	0.00
			φu or φd	(degree)	0.0	0.0	0.0	0.0	0.0	0.0	35.0	40.0
	For Long Term	Total Stress	Ccu	(kg/cm²)	0.13	0.06	0.16	0.06	0.16	0.06	-	-
			φcu	(degree)	14.3	17.1	15.9	17.1	15.9	17.1	-	-
		Effective Stress	C'	(kg/cm²)	0.06	0.09	0.12	0.09	0.12	0.09	-	-
			φ'	(degree)	26.5	22.5	23.3	22.5	23.3	22.5	-	-
	Rate of Strength Increase		m		0.2	0.2	0.2	0.2	0.2	0.2	-	-
Consolidation	Initial Void Ratio		eo		1.384	1.225	0.943	1.225	0.851	1.225	-	-
	Compression Index		Cc		0.435	0.420	0.302	0.420	0.262	0.420	-	-
	Swell Index		Cs		0.050	0.060	0.039	0.060	0.039	0.060	-	-
	Preconsolidation Pressure		Pc	(kg/cm²)	0.74	1.59	1.70	1.59	1.73	1.59	-	-
	Coefficient of Consolidation		Cv	(cm²/day)	50	70	100	70	100	70	-	-

Note (1): The value in ( ) is assumed.
Note (2): Su = 0.1 kg/cm² (Down to EL 0.0m), Su = 0.1 + 0.005 x Z kg/cm² (below EL 0.0m, Zo = EL 0.0m)
Note (3): Adopt the soil parameters (Ccu, φcu, C', φ') of Layer-6 for Layer-8
Note (4): Adopt the soil parameters (Ccu, φcu, C', φ', eo, Cc, Cs, Pc, Cv) of Layer-7B for Layer-4 and Layer-9

Source: Study Team

(9) As a result of laboratory tests of soil and rock, shear strength analysis and consolidation analysis, the soil and rock parameters for design of Bridge Area are proposed as shown in following table.

Table 3.1-3 Soil and Rock Parameters for Design (Bridge Area)

Item				2 (Sand)	3 (Clay)	4 (Clay)	5 (Sand)	6 (Clay)	7A (Clay)	7B (Clay)	8 (Clay)	9 (Clay)	10A (Sand)	10B (Sand)	11 (Clay)	12A (Highly Weathered Siltstone)	12B (Moderately Weathered Siltstone)
N-value				3	2	6	11	12	4	7	15	7	21	38	18	Over 50	Over 50
Unit Weight		γt	(g/cm³)	(1.90)	1.72	1.75	(1.95)	1.95	1.75	1.83	1.92	1.82	(2.00)	(2.05)	(1.95)	2.08	2.60
Absorption			(%)	-	-	-	-	-	-	-	-	-	-	-	-	-	3.20
Shear Strength	For Short Term	Su or Cd	(kg/cm²)	0.00	0.15	0.25	0.00	0.60	0.25	0.30	0.60	0.30	0.00	0.00	(1.20)	-	-
		φu or φd	(degree)	21.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0	0.0	35.0	40.0	0.0	-	-
	Rate of Strength Increase	m		-	0.2	0.2	-	0.2	0.2	0.2	0.2	0.2	-	-	-	-	-
Unconfined Strength of Rock	On Dry Condition		(kg/cm²)	-	-	-	-	-	-	-	-	-	-	-	-	14.0	53.9
	On Saturated Condition		(kg/cm²)	-	-	-	-	-	-	-	-	-	-	-	-	9.0	(25.3)
	Softening Ratio			-	-	-	-	-	-	-	-	-	-	-	-	0.64	0.47
Consolidation	Initial Void Ratio	eo		-	1.314	1.297	-	0.777	1.297	1.056	0.838	1.082	-	-	-	-	-
	Compression Index	Cc		-	0.390	0.385	-	0.234	0.385	0.345	0.200	0.367	-	-	-	-	-
	Swell Index	Cs		-	0.042	0.076	-	0.052	0.076	0.057	0.058	0.061	-	-	-	-	-
	Preconsolidation Pressure	Pc	(kg/cm²)	-	0.70	1.58	-	2.67	1.58	1.64	1.98	1.74	-	-	-	-	-
	Coefficient of Consolidation	Cv	(cm²/day)	-	60	70	-	80	70	70	80	70	-	-	-	-	-

Note (1): The value in ( ) is assumed.
Note (2): Adopt the soil parameters (γt, Su, eo, Cc, Cs, Pc, Cv) of Layer-4 for Layer-7A
Note (3): Adopt the soil parameters (γt, Su, eo, Cc, Cs, Pc, Cv) of Layer-7B for Layer-9

Source: Study Team

(10) As a result of laboratory tests, shear strength analysis and consolidation analysis, the soil parameters for design of Approach Road Area in Cat Hai side are proposed as shown in following table.

Table 3.1-4 Soil Parameters for Design (Cat Hai side)

Item					Layer													
					1 (Clay)	2 (Sand)	3 (Clay)	4 (Clay)	5 (Sand)	L5-1 (Sand)	6 (Clay)	L6-1 (Sand)	7A (Clay)	7B (Clay)	8 (Clay)	9 (Clay)	10A (Sand)	10B (Sand)
N-value					2	5	3	5	10	57	11	9	4	5	14	6	14	42
Unit Weight			γt	(g/cm^3)	1.65	1.90	1.73	1.73	1.93	(2.10)	1.86	(1.93)	1.75	1.81	1.93	1.76	(1.95)	(2.05)
Shear Strength	For Short Term		Su or Cd	(kg/cm^2)	Note (2)	0.00	0.15	Note (3)	0.00	0.00	0.60	0.00	0.20	0.25	0.80	0.25	0.00	0.00
			φu or φd	(degree)	0.0	23.0	0.0	0.0	25.0	45.0	0.0	25.0	0.0	0.0	0.0	0.0	30.0	40.0
	For Long Term	Total Stress	Ccu	(kg/cm^2)	0.11	-	0.01	0.19	-	-	0.22	-	0.31	0.31	0.08	0.20	-	-
			φcu	(degree)	13.5	-	21.2	9.7	-	-	17.6	-	19.5	19.5	20.0	13.8	-	-
		Effective Stress	C'	(kg/cm^2)	0.10	-	0.02	0.14	-	-	0.16	-	0.12	0.12	0.03	0.11	-	-
			φ'	(degree)	25.2	-	30.5	21.5	-	-	24.9	-	26.3	26.3	25.2	24.5	-	-
	Rate of Strength Increase		m		0.2	-	0.2	0.2	-	-	-	-	0.2	0.2	-	-	-	-
Consolidation	Initial Void Ratio		eo		1.595	-	1.294	1.317	-	-	0.962	-	1.185	1.078	0.825	1.200	-	-
	Compression Index		Cc		0.527	-	0.397	0.386	-	-	0.220	-	0.430	0.351	0.193	0.457	-	-
	Swell Index		Cs		0.070	-	0.054	0.054	-	-	0.042	-	0.059	0.054	0.031	0.067	-	-
	Preconsolidation Pressure		Pc	(kg/cm^2)	0.34	-	0.66	0.83	-	-	1.46	-	1.15	1.13	1.44	1.51	-	-
	Coefficient of Consolidation		Cv	(cm^2/day)	40	-	60	70	-	-	150	-	80	80	150	80	-	-

Note (1): The value in ( ) is assumed.
Note (2): Su = 0.1 kg/cm^2 (Down to EL 0.0m), Su = 0.1 + 0.02 x Z kg/cm^2 (below EL 0.0m, Zo = EL 0.0m)
Note (3): Su = 0.1 + 0.02 x Z kg/cm^2 (below EL -5m, Zo = EL -5.0m)
Note (4): Adopt the soil parameters (Ccu, φcu, C', φ') of Layer-7B for Layer-7A

Source: Study Team

3.2 Propose of Additional Geotechnical Investigation

The borings in Bridge Area were conducted at every pier (one borehole/pier for approach bridge and two boreholes/pier for main bridge). On the other hand, in Approach Road Area of Hai An side and Cat Hai side, there are some places where sufficient borings were not conducted due to the permission problem from land owner of shrimp pond.

Therefore, the additional geotechnical investigation shown in Table xxx is recommended to be carried out in construction stage.

Table 3.2-1 Additional Geotechnical Investigation in Construction Stage

	Hai An side		Cat Hai side		Total
	Center Line	Cross Section	Center Line	Cross Section	
Number of Boring Location	16	2	18	2	38 locations
Drilling Length	40m x 16 = 640m	40m x 2 = 80m	30m x 18 = 540m	30m x 2 = 60m	1,320 m
Standard Penetration Test 1)	640 − 32 − 10 x 16 = 448	80 − 10 x 2 = 60	540 − 36 − 10 x 18 = 324	60 − 10 x 2 = 40	872 tests
Undisturbed Sampling	2depths x 16locations = 32samples	–	2depths x 18locations = 36samples	–	68 samples
Physical Tests of Soil 2) (Specific Gravity, Natural Water Content, Grain Size Analysis, Atterberg Limits)	3 x 16(disturbed) + 32(undisturbed) = 80	–	3 x 18(disturbed) + 36(undisturbed) = 90	–	170 samples
Unit Weight Test of Soil 3)	32	–	36	–	68 samples
Unconfined Compression Test of Soil 3)	32	–	36	–	68 samples
Triaxial Compression Test of Soil (UU) 3)	32	–	36	–	68 samples
Consolidation Test 3)	32	–	36	–	68 samples
Number of Field Vane Shear Test Location 4)	16	2	18	2	38 locations
Accumulated Depth of Field Vane Shear Test 4)	20m x 16 = 320m	20m x 2 = 40m	20m x 18 = 360m	20m x 2 = 40m	760 m

Note: 1) It shall be performed at every 1.0m intervals except for the depth of undisturbed sampling and FVST.
2) (disturbed) means the SPT samples, while (undisturbed) means the undisturbed samples by undisturbed sampling.
3) Unit Weight Test, Unconfined Compression Test, Triaxial Compression Test (UU) and Consolidation Test shall be carried out using the undisturbed samples.
4) Field Vane Shear Test will be carried out up to the depth of 20 m at every 2.0m intervals.

Source: Study Team

CHAPTER 4 ATERIAL SURVEY

4.1 Outline of Material Survey

4.1.1 Contents of Survey

For the construction materials, soil, sand and aggregate, the contents of the survey are as follows,

-Survey on the location, exploited capacity, quality, initial reserve of quarries by quarries management unit has to offer.

-The products of the mine.

-Type of road, transport distance, transport means from quarries to the works.

-Investigate the existence of regional environmental conservation or irrigation canals around the material mines.

-Taking samples for testing laboratory.

-Investigation of mixing concrete plant

4.1.2 Quantities of Survey

The quantities of the survey are shown in the table below.

Table 4.1.2-1 Quantities of Construction Material Source Survey

No	**Work items**	**Unit**	**Quantity**	**Remark**
1	**Mobilization and Demobilization**	LS	1	
2	**Borrow pit survey**	day	4	
2.1	Investigation of Borrow Pit	No	12	
2.2	Laboratory test for physical properties	No	52	
2.3	Standard compaction test	No	39	
2.4	CBR test	No	13	
3	**Sand pit survey**	No	6	
3.1	Investigation of Sand Pit for Filling	day	6	
3.2	Laboratory test for physical properties	No	9	
3.3	Standard compaction test	No	9	
3.4	CBR test	No	9	
4	**Sand Pit Survey for Soft Soil Treatment**	No	6	
4.1	Investigation of Sand Pit for Soft Soil Treatment	day	6	
4.2	Laboratory test for physical properties	No	6	
5	**Rock Quarries**	No	3	
5.1	Investigation of Rock Quarries	day	9	
5.2	Laboratory test for mechanical-physical properties	No	9	
5.3	Abrasion of Aggregate LA test	No	9	
6	**Investigation of Concrete Mixing Plant**	day	3	
7	**Established material report**	LS	1	

Source: Study Team

4.2 Results of Survey

4.2.1 List of Material Sources

The list of material sources is as follows.

Table 4.2.1-1 List of Material Sources

Pit/ Plant	Name		Location	Remarks
Borrow Pit (Soil)	1-1	Thien Hoi	An Tien Commune – An Lao – Hai Phong	
	1-2	Thien Dong Soil Pit	Dong Son Commune – Thuy Nguyen – Hai Phong	Not available
	1-3	Lien Khe Soil Pit	Lien Khe Commune – Thuy Nguyen – Hai Phong	Not available
	1-4	Minh Duc Soil Pit	Minh Duc Town – Thuy Nguyen – Hai Phong	
	1-5	**Doc Do Soil Pit**	**Uong Bi District – Quang Ninh**	**Replaced**
	1-6	**Dia Moi Soil Pit**	**Dia Moi – An Sinh – Dong Trieu – Quang Ninh**	**Replaced**
Sand Pit	2-1	TL353 Sand Pit	Yards along provincial road No.353	
	2-2	Rao Sand Pit	Yards near Rao Bridge	
	2-3	Niem Sand Pit	Yards near Niem Bridge	
	2-4	Dong Hai Sand Pit	Yards along the Cua Cam River, Dong Hai Ward	
	2-5	**Tram Bac Sand Pit**	**Yards in the vicinity of Van Uc River tributaries**	**Replaced**
	2-6	Tien Cuu Sand Pit	Yards near Tien Cuu Bridge	Not available
	2-7	Quy Cao Sand Pit	Yards near Quy Cao Bridge	
Quarry Pit	3-1	Lien Khe Quarry	Lien Khe – Thuy Nguyen – Hai Phong	
	3-2	Phuong Mai Quarry	Phuong Nam – Uong Bi – Quang Ninh	
	3-3	Minh Duc Quarry	Minh Duc Town – Thuy Nguyen – Hai Phong	Not available
	3-4	Thong Nhat Quarry	Phu Thu Town – Kinh Mon - Hai Duong	
Concrete Mixing Plant	**4-1**	**Niem Bridge**	**Vinh Niem – Le Chan – Hai Phong**	**Newly Surveyed**
	4-2	**Hoang Truong -TL353**	**Anh Dung – Duong Kinh – Hai Phong**	**Newly Surveyed**
Asphalt Mixing Plant	5-1	Hoang Truong - TL353	Anh Dung – Duong Kinh – Hai Phong	
	5-2	Rao Bridge	Anh Dung Ward – Duong Kinh – Hai Phong	

Source: Study Team

4.2.2 Locations, Reserves and Capacities

At the survey time, reserves of borrow pits, sand stockpiles and rock quarries to meet the materials required volume of the project, favorable exploiting and supplied conditions.

Transport distance from borrow pits, rock quarries to the project to be rather large, It will be increased construction costs. Transport distance from the sand stockpiles to work relatively close.

The asphalt concrete and cement concrete mixing plants are located in areas relatively close distance to the project.

Table 4.2.2-1 Reserve, Capacities and Transportation Distance of Borrow Pits

Location of mines/ stockpiles	Reserve (m^3)	Supplied capacity (m^3/day)	Route from quarry / sand stockpile to the Project	Transportation distance	
				Highway (Km)	Water way (Km)
Thien Hoi borrow pit	1.000.000	2000	From the borow pits to material stockpile at Km11 +00 (weter way) & *Km4 (highway)*	30.1	42.3
Minh Duc borrow pit	1.000.000	2000		34.2	29.1
Doc Do borrow pit	100.000	500		40.8	44.5
Diem Moi borrow pit	3.000.000	3000		71.6	60.7

Source: Study Team

Table 4.2.2-2 Reserve, Capacities and Transportation Distance of Sand Stockpile

Location of mines/ stockpiles	Material resource	Reserve (m^3)	Supplied capacity (m^3/day)	Route from quarry / sand stockpile to the Project	Transportation distance	
					Highway (Km)	Water way (Km)
PR 353 stockpile	Thai Binh and Kinh Thay sand pit river	100.000x4	1000	From the quarry/ stockpile to material stockpile at Km11+00 (weter way) & *Km4 (highway)*	20.6	20.2
Rao bridge stockpile		100.000x3	1000		18.1	22.4
Niem bridge stockpile		50.000x2	200		15.6	28.7
Dong Hai stockpile	Kinh Thay sand pit river	50.000x2	200		7.4	13.7
Tram Bac stockpile	Kinh Thay and Thai Binh sand pit river	100.000	200		30.5	44.0
Quy Cao stockpile	Thai Binh sand pit river	50.000	200		41.6	54.8

Source: Study Team

Table 4.2.2-3 Reserve, Capacities and Transportation Distance of Sand Stockpile for soft soil treatment

Location of mines/ stockpiles	Material resource	Reserve (m^3)	Supplied capacity (m^3/day)	Route from quarry / sand stockpile to the Project	Transportation distance	
					Highway (Km)	Water way (Km)
PR 353 stockpile	Lo sand pit, Viet Tri, Phu Tho	100.000x4	200	From the quarry/ stockpile to material stockpile at Km11+00 (weter way) & *Km4 (highway)*	20.6	20.2
Rao bridge stockpile		100.000x3	200		18.1	22.4
Niem bridge stockpile		50.000x2	200		15.6	28.7
Tram Bac stockpile		100.000	200		30.5	44.0
Dong Hai stockpile		50.000x2	200		7.4	13.7
Quy Cao stockpile		50.000	200		41.6	54.8
Lo river, Viet Tri-Phu Tho		Very large				272

Source: Study Team

Table 4.2.2-4 Reserve, Capacities and Transportation Distance of Rock Quarries

Location	Material resource	Reserve (m^3)	Supplied capacity (m^3/day)	Route from quarry / sand stockpile to the Project	Transportation distance	
					Highway (Km)	Water way (Km)
Lien Khe quarry	Limestone	600.000	800	From the quarry to material stockpile at Km11+00 (weter way) & *Km4 (highway)*	33.0	36.9
Phuong Mai quarry		>1.000.000	200		33.7	34.5
Thong Nhat quarry		>1.500.000	6000		47.5	48.5

Source: Study Team

4.2.3 Quality of the borrow pits:

The quality of the borrow pits basically meets the technical requirements of the project. However, Thien Hoi borrow pit, components are heavily weathered sandstone, silty stone clay with clayey sand, contains many grain with large size (large gravel, cobble-stone), must be removed before use. If other borrow pits have sufficient reserves to provide for the project, should not use Thien Hoi borrow pit.

4.2.4 Quality of sand resources :

- Fine sand for embankment meets technical requirements of the project.

- Coarse sand used to make fine aggregate for asphalt concrete and cement concrete meets technical requirements of the project.

- Fine sand for soft soil treatment meets technical requirements of the project.

4.2.5 Quality of rock quarries:

The qualities of rock quarries are satisfactory as coarse aggregate for asphalt concrete and cement concrete and base/ subbase.

CHAPTER 5 SURROUNDING CONDITION OF HIGHWAY

5.1 Natural characteristics of project area

5.1.1 Climate features

The climate characteristics in the project area are the same as in the Northern Coastal Delta. Researched climate features of Project were referred to observed data in the long-term period of Phu Lien meteorological station. The followings are climate features collected by this station.

➢Air temperature

Annual average temperature in project area is about 23.0^{0}C. The coldest month is January with average temperature at 16.3^{0}C. The hottest month is July with average temperature of 28.2^{0}C.

➢ Humidity

Annual average humidity is around 85%.

➢ Rain

Annual average total rainfall in the area is about 1808 mm. Annual average number of rainy days is about 150 days.

➢ Evaporation

According to collected data in many years, annual average evaporation reaches about 700mm.

➢ Sunshine

Annual average number of sunny hour is about 1631 hours.

➢ Wind

The prevalent wind direction is North East or North in winter, and South and South East in summer. Annual average wind speed is about 3.6m/s.

➢ Typhoon and tropical low pressure

According to the statistics in the long period of 1972 and 2005, there was at least one typhoon affecting directly to Hai Phong region per year. The greatest wind speed in typhoon was at the 12th level (about 36m/s) measured on 23/7/1980 and 27/9/2005.

5.1.2 Hydrological features

It can be seen that the hydrology regime of the study area is complicated. This is caused by the combination between interior field inundation by rainfall, flood in the river and tide effect.

5.1.3 Sea conditions

➢ Tide

The tide regime in the project area is diurnal and homogeneous.

➢ Wave

<u>Wave at the Hon Dau station:</u>

In year, the months of great wave height are in the period from May to September, in which, the greatest wave height often occurs in July and September.

5.2 FUTURE DEVELOPMENT PLAN OF DINH VU - CAT HAI ECONOMIC ZONE

5.2.1 Dinh Vu - Cat Hai Economic Zone Master Plan

Tan Vu-Lach Huyen Highway runs through Dinh Vu - Cat Hai Economic Zone which is under management of the Hai Phong Economic Zone Authority (HEZA). There is a master plan for this area which is being prepared by Nikken Sekkei Civil Engineering Ltd. According to information from Hai Phong City as of April 2011, the master plan was being reviewed by Hai Phong City and prepared to be submitted for approval of Prime Minister. And the procedure for getting the approval would take several months after the submission.

5.2.2 Current States and Future Development Plan of Dinh Vu Industrial Zone

Dinh Vu Industrial Zone (DVIZ) is invested by Dinh Vu Industrial Zone Joint Stock Company (DVIZ JSC). According to answer for our questionnaire survey, land development work is being carried out based on Notice No.304-TB-UB dated 29th December 2004 issued by Hai Phong City People's Committee on detailed plan of Dinh Vu General Economic Zone with DVIZ.

5.2.3 Current States and Future Plan of Nam Dinh Vu Industrial Zone

Nam Dinh Vu Industrial Zone (NDVIZ) is divided into two zones, Zone-1 and Zone-2. Nam Dinh Vu Investment Joint Stock Company (NDVIJSC) is an investor for Zone-1 and Hai Phong Industrial Park (HPIP) is an investor for Zone-2.

5.3 DESIGN CONCEPT IN CAT HAI AREA

As mentioned above, a master plan for Dinh Vu - Cat Hai Economic Zone which is being prepared by Nikken Sekkei Civil Engineering Ltd. has not been officially approved yet. Therefore, the Study Team carries out Detailed Design in Cat Hai area considering present life of local people. Meetings were held between local authorities and the Study Team discussing on the updated plan. The Study Team received some comments and requests from local authorities after the discussion and sent a letter to local authorities to request them to approve th

CHAPTER 6 TRAFFIC DEMAND FORECAST

6.1 General

Two traffic demand forecasts were carried out in the past in order to determine traffic flows for the Tan Vu-Lach Huyen Highway (i.e., the Project road). The final results of the first forecast were submitted in July 2009 as part of a Feasibility Study (hereafter referred to as the FS). Then, a second forecast was executed under a JICA preparatory survey (hereafter referred to as the SAPROF) and the results were submitted in July 2010. Based on these results the Governments of Japan and Vietnam agreed to carry out the Lach Huyen Port Infrastructure Construction Project (hereafter referred to in this chapter as the “LH Project”), which will produce detailed designs for both the port and road/bridge facilities. Project staff was mobilized in March 2011.

6.2 Objective

The objective of this chapter is to review the traffic demand forecasts of the FS and SAPROF and to make revisions as necessary in order to produce a final traffic demand forecast for the design of the Tan Vu-Lach Huyen Highway. Given the time and resource constraints of the Project, no new large-scale surveys were planned and existing data and modeling was applied to the fullest extent possible.

6.3 Conclusion

Comparisons of the traffic demand forecasts for the LH Project, FS, and SAPROF are given in Tables 6.3-1 and 6.3-2. As both tables indicate, the traffic flows forecasted by this report are significantly less than that of the FS and SAPROF for the years 2015 and 2020 for the Tan Vu-Dinh Vu Section, which can be partially explained by the LH Project’s assumption that Ring Road#3 will not be completed until after 2020. As for 2030, the difference between the traffic flows of this report and the FS are insubstantial (i.e., variations are from 8% to 16%), while in the case of the SAPROF they are minimal (with differences ranging from 4% to 7%).

On the other hand, in the case of the Dinh Vu-Cat Hai Section, the traffic flows forecasted by this report are significantly less than that of the FS for the years 2015 and 2020, while in 2030 the LH Project’s traffic flow for the Dinh Vu-Cat Hai direction exceeds that of the FS by 1.5 times. This can be attributed to the FS’s assumption that a train will be in operation between LH Port and Dinh Vu, which is not assumed by this report. In the case of the SAPROF, the trend is the same, with the traffic flows of this report being significantly greater in 2030 (i.e., from 1.46 to 1.56 times larger). In 2015, the traffic flows of the SAPROF and this report are almost the same, while in 2020 the traffic flows of this report are greater by 1.05 to 1.25 times and which can be attributed to the larger number of tourists assumed by the LH Project..

Required number of lanes calculated in Vietnamese Standard and Japanese Standard is shown in Table 6.3-3.

According to the calculation based on Vietnamese Standard, 6-lane and 8-lane will be required in 2024 and 2027 for Tan Vu - Dinh Vu section, and 6-lane will be required in 2026 for Dinh Vu - Cat Hai section.

According to the calculation based on Japanese Standard, 6-lane will be required in 2029 for Tan Vu - Dinh Vu section, although 4-lane will be enough for capacity even in 2030 for Dinh Vu - Cat Hai section.

Table 6.3-1Comparison of FS & LH Project Traffic Forecasts for Morning Peak Hour (unit: PCU)

Section	Direction	Year 2015			Year 2020			Year 2030		
		FS (A)	LH Project (B)	Change (B/A)	FS	LH Project (B)	Change (B/A)	FS	LH Project (B)	Change (B/A)
Tan Vu - Dinh Vu	To Tan Vu	2,272	438	0.19	3,789	1,112	0.29	4,624	3,868	0.84
	From Tan Vu	1,304	437	0.34	2,457	1,110	0.45	3,515	3,812	1.08
Dinh Vu - Cat Hai	To Dinh Vu	1,680	910	0.54	2,691	1,569	0.58	2,888	2,922	1.01
	From Dinh Vu	583	743	0.62	1,157	932	0.81	1,392	2,089	1.50

Note: LH Project assumes no railway to be in place by 2030 while the FS assumes the opposite.

Source: Study Team

Table 6.3-2 Comparison of SAPROF & LH Project Traffic Forecasts for Morning Peak Hour (unit: PCU)

Section	Direction	Year 2015			Year 2020			Year 2030		
		SAPROF (A)	LH Project (B)	Change (B/A)	SAPROF (A)	LH Project (B)	Change (B/A)	SAPROF (A)	LH Project (B)	Change (B/A)
Tan Vu IC - Dinh Vu	To Tan Vu	1,276	438	0.34	2,149	1,112	0.52	4,140	3,868	0.93
	From Tan Vu	745	437	0.59	1,451	1,110	0.76	3,967	3,812	0.96
Dinh Vu - Cat Hai	To Dinh Vu	927	910	0.98	1,494	1,569	1.05	2,002	2,922	1.46
	From Dinh Vu	351	743	1.03	745	932	1.25	1,350	2,089	1.55

Note: LH Project assumes no railway to be in place by 2030 while the SAPROF assumes the opposite

Source: Study Team

Table 6.3-3 Required Number of Lanes

Year	Tan Vu – Dinh Vu								Dinh Vu – Cat Hai							
	Traffic Volume (pcu/h)		Required Number of lanes						Traffic Volume (pcu/h)		Required Number of lanes					
	to TV	from TV	In VN Standard			In JP Standard			to DV	from DV	In VN Standard			In JP Standard		
2015	438	437	0.9	->	2	0.5	->	2	910	743	1.7	->	2	1.0	->	2
2020	1,112	1,110	2.2	->	4	1.3	->	2	1,569	932	2.5	->	4	1.5	->	2
2021	1,388	1,380	2.8	->	4	1.7	->	2	1,704	1,048	2.8	->	4	1.7	->	2
2022	1,663	1,650	3.3	->	4	2.0	->	4	1,840	1,163	3.0	->	4	1.8	->	2
2023	1,939	1,921	3.9	->	4	2.3	->	4	1,975	1,279	3.3	->	4	2.0	->	2
2024	2,214	2,191	4.4	->	6	2.7	->	4	2,110	1,395	3.5	->	4	2.1	->	4
2025	2,490	2,461	5.0	->	6	3.0	->	4	2,246	1,511	3.8	->	4	2.3	->	4
2026	2,766	2,731	5.6	->	6	3.3	->	4	2,381	1,626	4.0	->	6	2.6	->	4
2027	3,041	3,001	6.1	->	8	3.7	->	4	2,516	1,742	4.3	->	6	2.6	->	4
2028	3,317	3,272	6.7	->	8	4.0	->	4	2,651	1,858	4.6	->	6	2.7	->	4
2029	3,592	3,542	7.2	->	8	4.3	->	6	2,787	1,973	4.8	->	6	2.9	->	4
2030	3,868	3,812	7.8	->	8	4.7	->	6	2,922	2,089	5.1	->	6	3.0	->	4

Source: Study Team

CHAPTER 7 HIGHWAY DESIGN

7.1 HIGHWAY DESIGN

7.1.1 Design Standard

Based on Decision No.3139/QD-BGTVT dated 29th October 2010, following design standard is applied for the highway design;

➢Design standard: TCVN4054-2005

7.1.2 Basic Design Concept

7.1.2.1 Geometric Design

Based on Decision No.3139/QD-BGTVT dated 29th October 2010, road classification of the highway is decided as follows;

➢Design Grade: Grade III, plain terrain

➢Design speed: 80km/h

➢Total width: W=29.5m

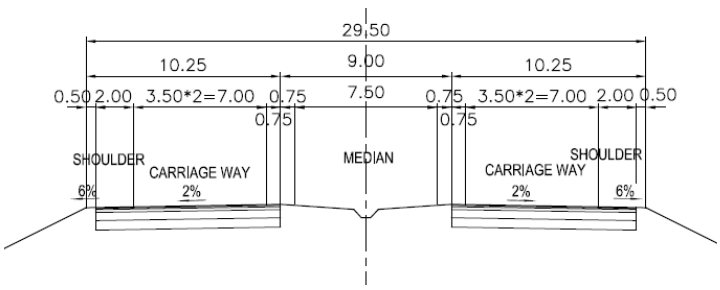
➢Number of lane: 4 lanes

7.1.2.2 Cross Section Layout

Cross sections of the main carriageway are shown below. In Phase-2, pavement is planned to be extended toward inside to 6 lanes. Scope of this project is Phase-1 construction only.

<Phase-1>

Carriageway	2 x 3.50m both side (total 4 lanes)
Shoulder	2.50m both side
(Paved portion	2.00m both side)
(Non-paved portion	0.50m both side)
Median	9.00m (including inner shoulder)
Total width	29.50m



Source : Study Team

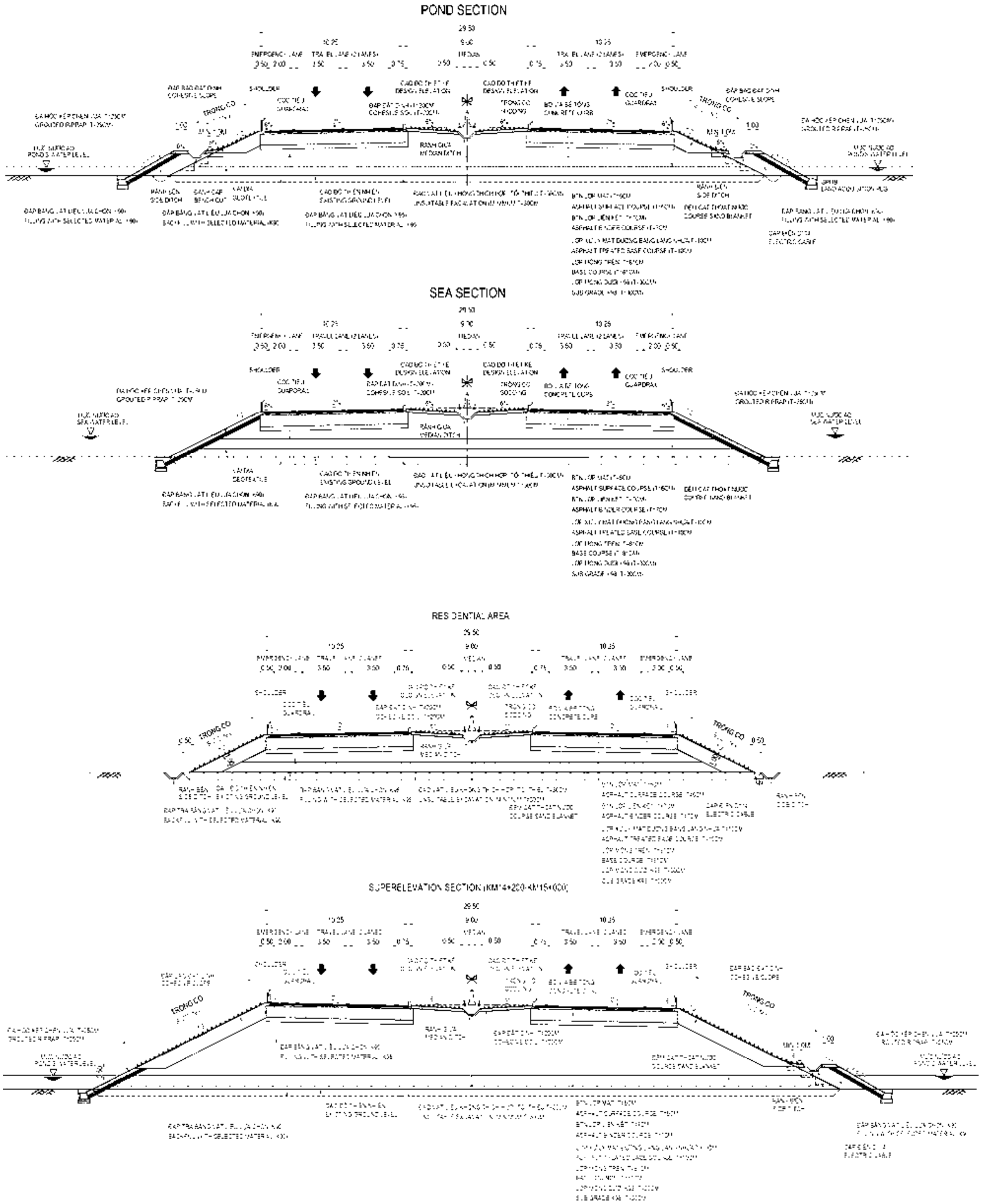
Figure 7.1.2-1 Cross Section (Phase-1)

7.1.2.3 Transition section

Total width of approach bridge in Phase-1 is 16m only, while total width of embankment is 29.5m. Therefore, transition of carriage ways is necessary at the section behind both A1 and A2 abutment of approach bridge.

7.1.3 Typical Cross Section

Typical cross section for each section as shown in Figure 7.1.3-1.



Source : Study Team

Figure 7.1.3-1 Typical cross section

7.1.4 Land acquisition and ROW

Decree No.11/2010/ND-CP issued by the Government of Vietnam dated 24th February 2010 is applied for land acquisition of the project. According to the Decree, PMU2 decided the land acquisition area for the project as shown below;

➢Land acquisition area: 2m from the edge of riprap foundation

➢ROW: 15m from the end of fill slope

Note) Area between land acquisition and ROW (13m width) will not be acquired by the project owner.

7.1.5 Horizontal and Longitudinal Alignment

7.1.5.1 Horizontal Alignment

(1) Alignment Elements

Alignment elements and coordinates of IP are shown below table;

Table 7.1.5-1 Alignment Elements and Coordinates of IP

Alignment elements

No.	STA	X	Y	Start Radius	A	End Radius	Length	Direction	Type
1	0+000	2301375.271	604148.960				2401.5	82-10-15.37	Tangent
2	2+401.50	2301702.399	606528.073		916.515	6000	140.0	82-10-15.37	Clothoid
3	2+541.50	2301720.929	606666.840	6000		6000	482.0	82-50-21.79	Circular curve
4	3+023.49	2301761.747	607146.972	6000	916.515		140.0	87-26-31.49	Clothoid
5	3+163.49	2301766.907	607286.876				10960.0	88-6-37.91	Tangent
6	14+123.48	2302128.275	618240.907		409.878	1200	140.0	88-6-37.91	Clothoid
7	14+263.48	2302130.169	618380.873	1200		1200	1144.5	91-27-10.02	Circular curve
8	15+407.96	2301599.893	619346.435	1200	409.878		140.0	146-5-50.90	Clothoid
9	15+547.96	2301480.764	619419.936				81.98	149-26-23.02	Tangent
10	15+629.94	2301410.172	619461.618						

IP Coordinate

No	STA	X	Y
BP	0+000	2301375.271	604148.960
IP1		2301754.336	606905.801
IP2		2302154.055	619022.383
EP	15+629.94	2301410.172	619461.618

Source : Study Team

7.1.5.2 Longitudinal Alignment

(1) Basic concept and control points for longitudinal alignment design

Basic concept for longitudinal alignment design was determined as follows in SAPROF report in 2010.

➢Design elevation of approach road in Hai An is equal to the planned formation of Dinh Vu Industrial Zone.

➢Design elevation for bridge section is decided to ensure vertical clearances of future railways and navigation clearance for Bach Dang River.

➢Design elevation of approach road in Cat Hai is equal to the planned elevation of Lach Huyen Port.

➢Minimum vertical gradient (0%) is applied both road and bridge section.

In addition to the above concept, follows are added in Detailed Design Stage;

➢Vertical alignment is set as lower as possible in order to minimize filling volume.

➢Design elevation of approach road in both Hai An and Cat Hai is determined considering design high water level (HWL), which is updated based on hydrological survey result in Detailed Design Stage, to ensure the control levels of hydraulic frequency (P=1%).

➢The elevation of shoulder edge is set 0.5 or 0.6m higher than the flooded water level (P=1%). According to Highway Design Standard, Chapter 7.3.2 in TCVN 4054: 2005, minimum 0.5m must be kept at the edge of shoulder. Therefore, 0.5 or 0.6m is applied for safety which satisfies the Standard.

➢Minimum vertical gradient (0.3%) is applied for bridge section in order to drain surface water properly.

7.1.5.3 Local Approach Road Design

The Study Team applies 3.2m clearance for all local approach roads based on existing road condition. Size of underpass box culver is B4.0m x H3.2m uniformly and agreement between local authorities and the Study Team has been made.

Summary of underpass box culvert is shown in below table.

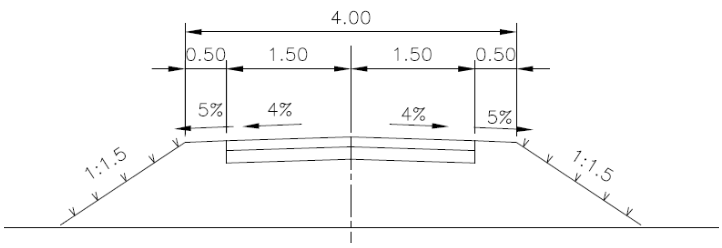
Table 7.1.5-2 Summary of underpass box culvert

No	Location			Size			Length (m)	Invert Elevation (m)			Skew (Degree)	Remarks
	Km..	+	.....	B		H		Left	Center	Right		
1	Km10	+	75.00	4.0	x	3.2	35.480	1.854	2.209	1.854	90.00	Relocation of dike road
2	Km10	+	414.00	4.0	x	3.2	34.085	1.277	1.540	1.788	90.00	
3	Km13	+	600.00	4.0	x	3.2	34.255	1.599	1.650	1.701	90.00	
4	Km14	+	651.50	4.0	x	3.2	35.215	0.635	0.121	-0.421	90.00	Relocation of dike road
5	Km15	+	340.00	4.0	x	3.2	35.370	0.436	0.491	0.440	90.00	Relocation of dike road

Source : Study Team

7.1.5.4 Design Concept for frontage road

According to the highway Standard, frontage road should be arranged at both sides along the highway class I and II. Tan Vu-Lach Huyen Highway is classified as class III, therefore, it is basically not necessary to design frontage road throughout the alignment except for sections where local people requested.



Source : Study Team

Figure 7.1.5-1 Typical Cross Section of Frontage Road

Summary of frontage road is shown in below table.

Table 7.1.5-3 Summary of frontage road

No	Location			L - R	Width (m)	Length (m)
	Km..	-	Km..			
1	Km10+047	-	Km10+075	L	4.0	39.2
2	Km10	+	75.00	R	4.0	25.2
3	Km10+391	-	Km10+414	L	4.0	36.0
4	Km10+414	-	Km10+471	R	4.0	70.0
5	Km13+302	-	Km13+731	L	4.0	428.7
6	Km13	+	600.00	L	4.0	13.0
7	Km13	+	600.00	R	4.0	13.0
8	Km14	+	651.50	L	4.0	30.4
9	Km14+651.5	-	Km14+685	R	4.0	45.4
10	Km15	+	340.00	L	4.0	44.7
11	Km15	+	340.00	R	4.0	44.8

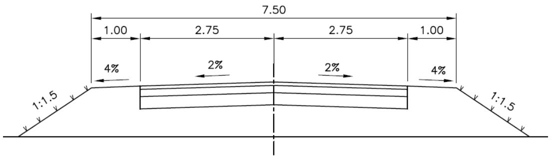
Source : Study Team

7.1.5.5 Additional Intersections in Cat Hai Island

(1) At-grade Intersection at Km11+520

Local authority requested to add a connecting road which will be located between the highway and District Road 356 at right side of Km11+520. Classification of the road is defined as follows based on Highway Standards;

- Design Grade: Grade V, plain terrain
- Design speed: 40km/h
- Width of roadbed: W=7.50m
- Number of lane: 2 lanes

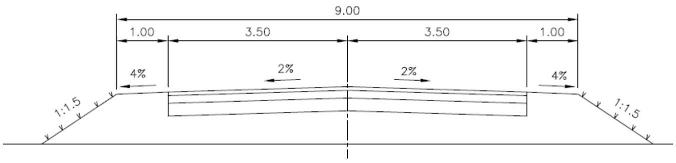


(2) At-grade Intersection at Km15+576

There is a reservation area for MPMU2's facilities at the end point of the highway as shown in Figure 7.2.6-7. Two existing roads, District Road 356 and 2A, will be occupied in the reservation area, therefore, relocation of the roads is required.

Local authority requested to consider a relocation of District Road 356 road which connects to both District Road 356 and 2A and an at-grade intersection is added at Km15+576. Classification of the relocated road is defined as follows based on Highway Standards;

- Design Grade: Grade IV, plain terrain
- Design speed: 60km/h
- Width of roadbed: W=9.0m
- Number of lane: 2 lanes



7.2 Pavement Design

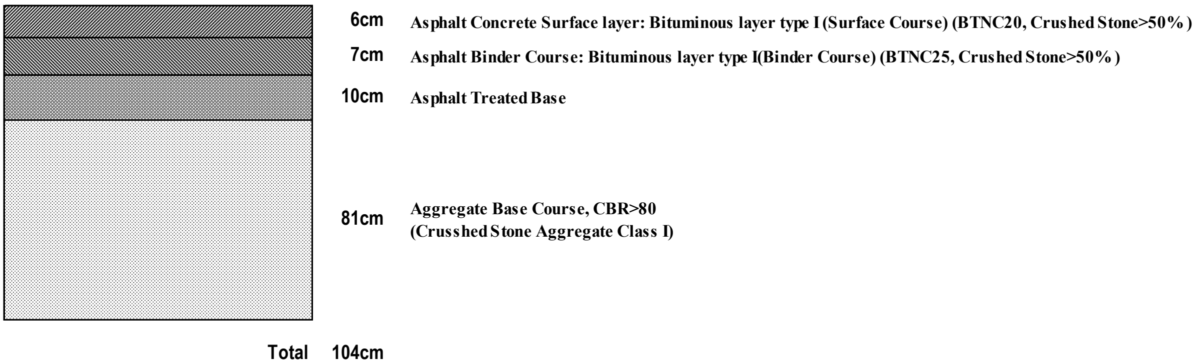
7.2.1 Design Condition

7.2.1.1 Pavement Design Standard

Vietnamese Standard for Pavement Design, 22TCN 211-06 was proposed to be used in the design of Pavement structure in this Project.

7.2.2 Design Result

Following Pavement Structure (total thickness is 104cm) is proposed based on the pavement calculation result.



Source : Study Team

Figure 7.2.2-1 Pavement Structure

7.3 Interchange/Intersection Design

7.3.1 Location of Interchange/Intersections

Six interchanges and intersections are planned in the Tan Vu-Lach Huyen Higway.

The location of interchanges/intersections is shown in Table 7.3.1-1.

Table 7.3.1-1 Location of Intersections

Km	Name	Leg	Note
0+000	Tan Vu Interchange	Three-leg	Connected with Hanoi-Haiphong Expressway at Km 100+891.11.
2+836.32	No.1 Intersection	Four-leg	Connected with Dinh Vu Ring Road, which will be constructed as the trunk road in the Dinh Vu Industrial Zone area.
5+149.11	No.2 Intersection	Four-leg	Tan Vu-Lach Huyen Highway will pass over the Dinh Vu Ring Road by bridge. Two roads will not be connected, but pier position will be planned so as not to disturb the intersection development.
7+521.05	No.3 Intersection	Four-leg	Tan Vu-Lach Huyen Highway will pass over the Dinh Vu Ring Road by bridge. Two roads will not be connected, but pier position will be planned so as not to disturb the intersection development.
11+520	-	Three-leg	Connected with local road in Cat Hai.
15+576	-	Four-leg	Connected with local road which is the way to the existing ferry terminal in Cat Hai.

Source : Study Team

7.3.1.1 Interchange/Intersection Design

(1) Tan Vu Interchange

Four alternatives are evaluated with comprehensive aspects.

Summary of evaluation is shown in Table 7.3.1-2. As a result, “Signalized Intersection” is selected as the appropriate intersection type for Tan Vu Interchange at the initial stage from the following viewpoints.

- Enough traffic capacity (Capable until 2026)
- Cheaper initial construction cost ((c) Signalized Intersection: 15 billion VND, (d) Grade Separated Interchange: 354 billion VND)
- High traffic safety
- No additional land acquisition
- Easy future upgrade

Table 7.3.1-2 Evaluation of Interchange/Intersection Type for Tan Vu Interchange

Alternative / Evaluation Item (Basic Score)	(a) Roundabout with Direct Ramps (F/S Design)	(b) Roundabout without Direct Ramps	(c) Signalized Intersection	(d) Grade Separated Interchange
Description	- At grade intersection. - Two roads are connected with roundabout. - Additional 2 direct ramps (east to north, south to east) are provided to secure smooth traffic flow on these directions.	- At grade intersection. - Two roads are connected with roundabout.	- At grade intersection. - Two roads are connected with signalized intersection.	- Grade separated interchange. - Two roads are connected with ramps - Two bridges are required.
Capacity Analysis *2 (30)	- Degree of saturation for all entries is less than 1.0 in Year 2015 and 2020. - Enough traffic capacity is secured. (24, Moderate)	- Degree of saturation for all entries is less than 1.0 in Year 2015 and 2020. - Enough traffic capacity is secured. (24, Moderate)	- v/c ratio for all lane groups and intersection itself are less than 1.0 in Year 2015 and 2020. - Enough traffic capacity is secured. (24, Moderate)	- Two roads are grade separated. - Enough traffic capacity is secured. (30, Good)
Construction Cost (20)	- Higher since two ramps are constructed. (16, Moderate)	- Cheap since only earth work is made. (20, Good)	- Cheap since only earth work is made. (20, Good)	Highest since four ramps including two bridges are constructed. (10, Poor)
Safety (20)	- Safety is secured by installing traffic signs to inform drivers of the existence of roundabout before entering roundabout. (16, Moderate)	- Safety is secured by installing traffic signs to inform drivers of the existence of roundabout before entering roundabout. (16, Moderate)	- Each traffic is separated by signal phasing. (20, Good)	- Each traffic is separated by grade separation. (20, Good)
Land Acquisition (20)	- Approximately 44,000 m2 of additional land acquisition is required. (16, Moderate)	- No additional land acquisition is required. (20, Good)	- No additional land acquisition is required. (20, Good)	- Approximately 84,000 m2 of additional land acquisition is required. (10, Poor)
Future Upgrade (10)	- Easy since only earthwork is made at initial stage. (8, Moderate)	- Easy since only earthwork is made at initial stage. (8, Moderate)	- Easy since only earthwork is made at initial stage. (8, Moderate)	- Easiest since initial construction is made in consideration of ultimate interchange type. (10, Good)
Recommendation (100) *1	(80)	(88)	Recommended (92)	(80)

Note: *1: Score is basic score x evaluation (Good=1.0, Moderate=0.8, Poor=0.5).

Source : Study Team

(2) No.1 Intersection

Two alternatives are evaluated with comprehensive aspects.

Summary of evaluation is shown in Table 7.3.1-3. As a result, "Roundabout" is selected as the appropriate intersection type for No.1 Intersection at the initial stage.

Table 7.3.1-3 Evaluation of Interchange/Intersection Type for No.1 Interchange

Alternative / Evaluation Item (Basic Score)	(a) Roundabout	(b) Signalized Intersection
Description	At grade intersection. Two roads are connected with roundabout.	At grade intersection. Two roads are connected with signalized intersection.
Capacity Analysis *2 (30)	Degree of saturation for all entries is less than 1.0 in Year 2015 and 2020. Enough traffic capacity is secured. (24, Moderate)	v/c ratio for all lane groups and intersection itself are less than 1.0 in Year 2015. However, v/c ratio for some lane groups and intersection itself exceed 1.0 in Year 2020. Enough traffic capacity is not secured in Year 202. (15, Poor)
Construction Cost (20)	Cheap since only earth work is made. (20, Good)	Cheap since only earth work is made. (20, Good)
Safety (20)	Safety is secured by installing traffic signs to inform drivers of the existence of roundabout before entering roundabout. (16, Moderate)	Each traffic is separated by signal phasing. (20, Good)
Land Acquisition (20)	No additional land acquisition is required. (20, Good)	No additional land acquisition is required. (20, Good)
Future Upgrade (10)	Easy since only earthwork is made at initial stage. (8, Moderate)	Easy since only earthwork is made at initial stage. (8, Moderate)
Recommendation (100) *1	Recommended (88)	(83)

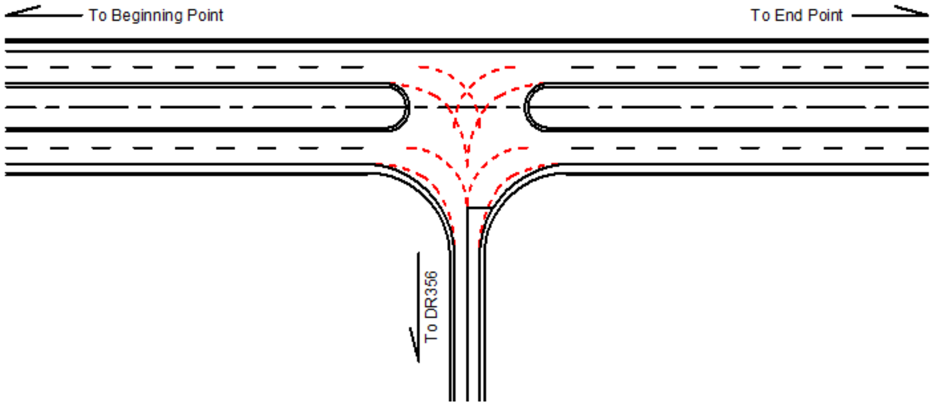
Note: *1: Score is basic score x evaluation (Good=1.0, Moderate=0.8, Poor=0.5).

Source : Study Team

(3) Local Intersection at Km11+520

This intersection is planned as unsignalized intersection since there will be not much traffic in this intersection.

The plan of the intersection is shown in Figure 7.3.1-1.



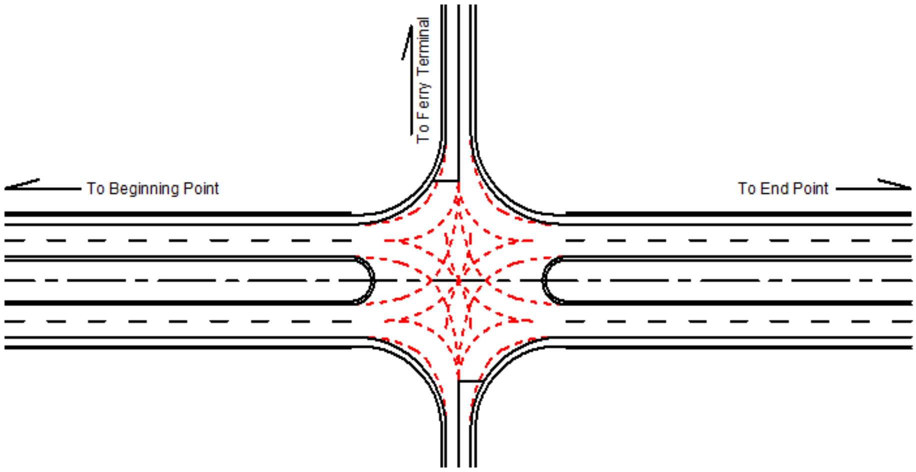
Source : Study Team

Figure 7.3.1-1 Plan of Local Intersection at Km11+520

(4) Local Intersection at Km15+576

This intersection is planned as unsignalized intersection since there will be not much traffic in this intersection.

The plan of the intersection is shown in Figure 7.3.1-2.



Source : Study Team

Figure 7.3.1-2 Plan of Local Intersection at Km11+576

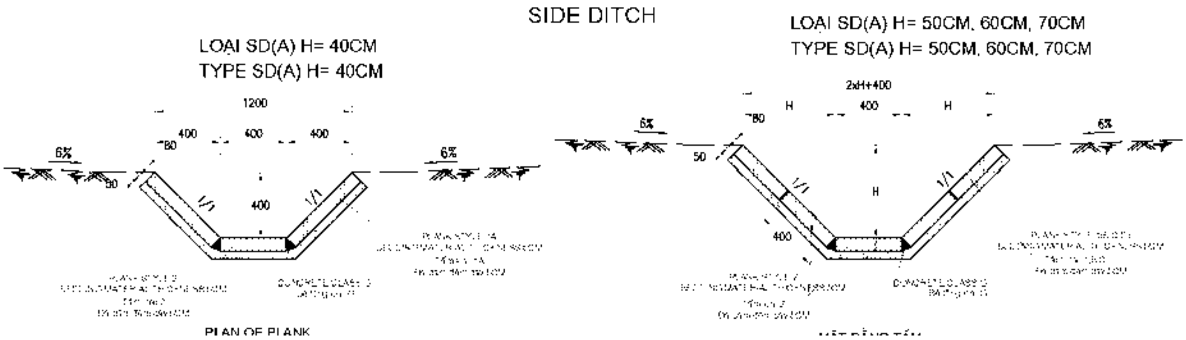
7.4 DRAINAGE DESIGN

7.4.1 Road Surface Drainage

7.4.1.1 Drainage Items

(1) Side Ditch

Longitudinal side ditches are installed at toe of slope. Sizes (depth) of ditches are determined by drainage design calculation. Minimum depth is 40cm.

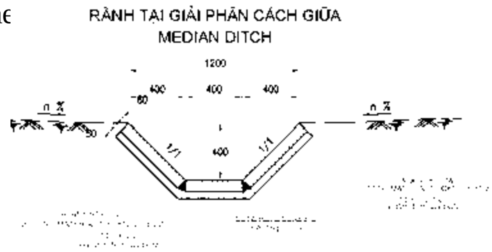


Source : Study Team

Figure 7.4.1-1 Side Ditch

(2) Median Ditch

Longitudinal median ditch is installed in median strip. Depth of ditch is fixed 40cm.Gradient of ditch is controlled by cross fall of me



Source : Study Team

Figure 7.4.1-2 Median Ditch

(3) Crossing Drainage Pipe

Crossing drainage pipe is set to flow down surface water from median ditch. There are two types of pipe culvert in this Project, namely D=0.75m and D=1.00m.

(4) Catch Basin

Types of catch basins are named below generally.

Catch Basin in median strip -------- Catch Basin Type A

Catch Basin at road side --------- Catch Basin Type B

(5) Outlet of Drainage Pipe

There are three types of outlet drainage pipe in this Project.

7.4.2 Irrigation

7.4.2.1 Irrigation Culvert

Function of Irrigation Culverts is classified 4 types below.

(1) Crossing River and Channel

(2) Connect between pond and pond

(3) Navigation

(4) Water Gate Relocation

Table 7.4.2-1 List of Irrigation Culvert

No	D/D Stage													Installation purpose
	Location			Direction of water	Type	Size						Angle deg.	Length m	
	Km..	+	…..			No		F (B)		H				
	Irrigation Culvert													
	Hai An district													
1	Km0	+	225.00		Pipe			1.50				115	39.820	Ditch
2	Km0	+	788.00	R-L	Box			2.00	x	2.00		120	40.497	Shrimp pond
3	Km0	+	915.00	L-R	Box			3.00	x	3.00		60	39.426	Channel
4	Km2	+	390.00	L-R	Box			2.00	x	2.00		120	44.824	Shrimp pond
5	Km2	+	650.00		Box			2.00	x	2.00		120	46.833	Shrimp pond
6	Km4	+	140.00	L-R	Box	2	x	3.00	x	3.00		60	37.326	Channel and Sea
	Cat Hai district													
7	Km10	+	90.00	R-L	Pipe			1.50				90	48.280	Ditch
8	Km10	+	659.00		Pipe			1.50				100	43.270	Ditch
9	Km10	+	805.00	L-R	Box			3.00	x	3.00		60	42.475	Channel
10	Km14	+	620.00	L-R	Box			4.00	x	4.00		90	33.941	Pond
11	Km14	+	650.00	No Crossing	Box	2	x	2.00	x	4.00		90	4.094	Watergate for pond(Out of Highway)
12	Km14	+	907.00		Box			2.00	x	2.00		105	40.156	Shrimp pond
13	Km15	+	100.00		Box	3	x	4.00	x	6.00		90	33.773	Channel and Navigation
14	Km15	+	520.00	R-L	Pipe			1.50				75	36.220	Ditch

- Function of Culverts in Hai An district will finish working by the reclamation of industrial zone.

Source : Study Team

7.4.2.2 Channel relocation

Tan Vu-Lach Huyen Highway runs through Cat Hai island and there is a section where the embankment overlaps existing water channel at section Km12+200 to Km13+240. According to a request from Cat Hai PC on relocation of the channel, Cat Hai PC and JST had a discussion in order to decide the size and type of the relocated channel.

An agreement was made between Cat Hai PC and JST in the discussion held on 20 May 2011.

➢Size of relocated channel:
Bottom width=2.0m, Bottom elevation=-1.0m, Depth=2.5m, Slope gradient=1:1
➢Type of relocated channel:
Soil channel (same as existing condition)

7.5 SOFT SOIL TREATMENT

7.5.1 Design Criteria

(1) Design standards

The following standards are applied for soft soil treatment design:

➢Standard for Investigation and Design of Embankment on Soft Ground 22TCN262-2000,

➢Highway Design Standard TCVN4054-2005.

(2) Condition of settlement and consolidation

Soft ground shall be treated to satisfy following conditions;

1) Residual settlement (Sr) is decided to be less than: 10cm for section behind bridge abutment and box culvert (H>2.0m), 20cm for sections including small size culvert (H≤2.0m) and 30 cm for normal embankment section. Value of allowable settlement for each section is summarized in Table 7.5.3-1.

2)Settlement due to creep consolidation is ignored in residual settlement.

3) Total period of treatment is decided to be less than: 16 months for normal embankment section and 12 months for box culvert section and section behind bridge abutment which is calculated from construction schedule.

7.5.2 Result of the analysis

(1) Sectioning

Based on soil profile prepared in Detailed Design stage, sectioning for the calculation is updated. In addition to the soil investigation result, location of box culvert is also considered for the sectioning because of different value of allowable settlement from normal embankment section.

(2) Soft soil layer for settlement calculation

Soft soil layer to be considered for calculation of total settlement is as follows;

➢Hai An side: all the clay layer up to layer-8 (layer-8 is included)

➢Cat Hai side: all the clay layer up to layer-7B (layer-7B is included)

➢

(3) Result of calculation

Calculation results are shown in the next page.

Table 7.5.2-1 Selected countermeasures and result of calculation of the treatment (Hai An side)

No.	SECTION	Type of section	Locaton(STA.)			Length (m)	Height of embankment (m)	Method of treatment	Height of surcharge (m)	No. of Geotextile layer(200KN/m)	No. of Geotextile layer(400KN/m)	No. of embankment step	Treatment depth(m)	Spacing of drain (m)	Treatment period(month)	Degree of consolidation (%)	Total Settlement (cm)	Residual settlement Sr (cm)	Allowable residual settlement (cm)	Sand mat thickness (m)	Filling progress 1st Step Height(m)	1st Step Δh	1st Step embank speed (cm/day)	1st Step waiting time for consolidation (mon)	2nd Step Height(m)	2nd Step Δh	2nd Step Embankment speed (cm/day)	2nd Step Waiting time for consolidation (mon)	3rd Step Height(m)	3rd Step Δh	3rd Step Embankment speed (cm/day)	3rd Step Waitin[g time] fo[r] consol[idation]
1	HA-1	Normal embankment	Km+20.00	~	Km+260	240	3.3	PVD	0.0	-	2	2	29.5	1.2	15.5	90.6	107.7	10.1	30	0.6	2.9		10	3	FG+Δh	0.8	10	11.0				
2	HA-2	Normal embankment	Km+260	~	Km+762	502	3.4	PVD	0.0	-	2	2	30.0	0.8	16.1	90.27	121.22	11.8	30	0.6	2.9		10	3	FG+Δh	0.9	10	11.5				
3	HA-3	DR-BOX(2x2)	Km+762.00	~	Km+814	52	3.9	PVD	1.0	-	4	2	30.0	0.8	11.9	93.28	141.07	9.5	20	0.7	3.9		10	4	FG+Δh	1.9	10	6.0				
4	HA-4	Normal embankment	Km+814.00	~	Km+888	74	4.7	PVD	0.0	-	4	2	30.0	0.8	15.7	90.69	167.44	15.6	30	0.8	3.9		10	4	FG+Δh	1	10	9.5				
5	HA-5	DR-BOX	Km+888.00	~	Km+980.00	92	5.3	SD	0.0	-	3	2	30.0	1.6	11.4	96.68	167.54	5.6	10	0.9	4.8		10	4	FG+Δh	0.6	10	5.0				
6	HA-6a	Normal embankment	Km+980.00	~	Km1+160	180	3.5	PVD	0.0	-	2	2	30.0	0.8	14.6	91.41	116.02	9,97	30	0.6	3.9		10	4	FG+Δh	0.7	10	9.0				
7	HA-6b	Normal embankment	Km+160	~	Km1+260	100	3.3	PVD	1.0	-	3	2	15.0	1.2	15.5	83.55	87.91	14.5	30	0.5	4		10	4	FG+Δh	1.7	10	10.0				
8	HA-6c	Normal embankment	Km1+260	~	Km1+475.00	215	3.4	PVD	1.0	-	4	2	21.0	1.1	15.6	94.62	100.72	5.4	30	0.5	4		10	4	FG+Δh	1.8	10	10.0				
9	HA-7	Normal embankment	Km1+475.00	~	Km1+640.00	165	5.5	SD	0.0	-	3	3	30.0	1.5	11.5	94.21	170.88	9.9	10	0.9	3.7		10	3	5		10	3.0	FG+Δh	0.5	10	3
10	HA-8	Behind bridge abutment	Km1+640.00	~	Km1+665	25	6.7	LRS	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-
11	Cam River Bridge	Bridge	Km1+665	~	Km1+735	70	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	HA-9	Behind bridge abutment	Km1+735	~	Km1+760	25	6.7	LRS	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-
13	HA-10	Normal embankment	Km1+760	~	Km2+000	240	5.5	SD	0.0	-	3	3	30.0	1.5	11.5	95.83	169.28	7.1	10	0.8	3.7		10	3	5		10	3.0	FG+Δh	0.5	10	3
14	HA-11	Normal embankment	Km2+000.00	~	Km2+364	364	3.5	SD	0.0	-	2	2	30.0	2.0	11.4	90.88	63.69	5.8	30	0.5	3.4		10	4	FG+Δh	0.4	10	6.0				
15	HA-12	DR-BOX(2x2)	Km2+364.00	~	Km2+416	52	4.2	SD	0.0	-	2	2	30.0	2.0	11.8	90.87	99.35	9.1	20	0.7	3.9		10	4	FG+Δh	0.5	10	6.0				
16	HA-13	Normal embankment	Km2+416.00	~	Km2+624	208	4.4	SD	0.0	-	2	2	29.3	2.0	11.8	93.27	95.29	6.0	30	0.8	3.9		10	4	FG+Δh	0.5	10	6.0				
17	HA-14	DR-BOX(2x2)	Km2+624.00	~	Km2+676	52	4.5	SD	0.0	-	3	2	28.3	2.0	10.8	91.36	90.55	7.8	20	0.5	3.9		10	4	FG+Δh	0.5	10	5.0				
18	HA-15	Normal embankment	Km2+676.00	~	Km3+000	324	6.0	SD	0.0	-	4	2	30.0	2.0	13.3	93.97	71.42	4.3	30	0.6	3.9		10	3	FG+Δh	0.5	10	8.0				
19	HA-16	Normal embankment	Km3+000.00	~	Km3+375	375	5.4	PVD	0.0	-	3	3	32.0	0.8	14.3	90.77	140.89	13.0	30	0.8	3.9		10	3	5.5		10	3.0	FG+Δh	0.6	10	6
20	HA-17	Normal embankment	Km3+375.00	~	Km3+675	300	4.5	PVD	0.0	-	3	2	17.5	0.8	15.9	86.36	118.91	16.2	30	0.6	3.8		10	4	FG+Δh	0.7	10	10.0				
21	HA-18	Normal embankment	Km3+675.00	~	Km4+111	436	4.5	SD	0.0	-	3	2	28.5	2.0	11.8	92.12	92	7.3	30	0.6	3.9		10	4	FG+Δh	0.5	10	6.0				
22	HA-19	DR-BOX	Km4+111.00	~	Km4+169	58	4.4	SD	0.0	-	3	2	30.0	2.0	11.7	90.86	72.96	6.7	10	0.6	3.9		10	4	FG+Δh	0.4	10	6.0				
23	HA-20a	Normal embankment	Km4+169.00	~	Km4+280	111	4.6	SD	0.0	-	3	2	12.0	1.8	11.8	93.32	66.28	4.4	10	0.5	3.9		10	4	FG+Δh	0.3	10	6.0				
24	HA-20b	Normal embankment	Km4+280	~	Km4+457	177	6.7	SCP	0.0	-	1	3	30.0	1.5	10.7	96.49	134.03	4.7	10	0.9	4.5		10	3	FG+Δh	0.5	10	5.0				
25	HA-21	Behind bridge abutment	Km4+457	~	Km4+497	40	7.3	LRS	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-

Notes:

1)Installation of Geotextile (number, location, etc.) should be decided by the Engineer with careful checking during construction stage based on soil test result.

2)Installation of Course Sand Blanket (setting elevation, thickness, etc.) should be decided by the Engineer during construction checking the site condition.

Source: Study Team

Table 7.5.2-2 Selected countermeasures and result of calculation of the treatment (Cat Hai side)

No.	SECTION	Type of section	Locaton(STA.)	Length (m)	Height of embankment (m)	Method of treatment	Height of surcharge (m)	No. of geotextile layer (400KN/m)	No. of geotextile layer (200KN/m)	No. of embankment step	Treatment depth(m)	Spacing of drain (m)	Treatment period(mon)	Degree of consolidation (%)	Total Settlement(cm)	Residual settlement Sr (cm)	Allowable residual settlement (cm)	Sand mat thickness (m)	Filling progress: 1st Step Height(m)	1st Step Δh	1st Step Embankment speed (cm/day)	1st Step Waiting time for consolidation (mon)	2nd Step Height(m)	2nd Step Δh	2nd Step Embankment speed (cm/day)	2nd Step Waiting time for consolidation (mon)	3rd Step Height(m)	3rd Step Δh	3rd Step Embankment speed (cm/day)	3rd Step Waiting time for consolidation (mon)	Total treatment period (day)	Safety factor of slope stability: 1st Step	2nd Step	3rd Step	Finish improvement
1	CH-1	Behind bridge abutment (Piled slab)	Km9+948 ~ Km9+973	25	6.8	LRS	0.0				20.0																								
2	CH-2	Normal embankment	Km9+973 ~ Km10+048	75	6.7	SCP	0.0		1	3	28.0	1.5	11.7	99.94	128.15	0.08	10	0.9	3.5		10	3	5.2		10	3	FG+Δh	0.2	10	3	350	1.848	1.526	1.406	1.464
3	CH-3	UP-BOX	Km10+048 ~ Km10+103	55	6.5	SD	0.0	3		3	28.0	1.4	11.7	99.28	162.82	1.18	10	1.0	3.6		10	3	5		10	3	FG+Δh	0.2	10	3	351	1.733	1.539	1.345	1.44
4	CH-4	Normal embankment	Km10+103 ~ Km10+387	284	5.6	SD	0.0		4	3	20.0	1.5	15.4	82.08	158.84	28.47	30	0.8	3.7		10	3	5.2		10	3	FG+Δh	0.5	10	7	462	1.489	1.33	1.299	1.446
5	CH-5	UP-BOX	Km10+387 ~ Km10+442	55	5.6	SD	0.0		4	3	27.0	1.8	11.3	94.6	135.99	7.34	10	0.8	3.8		10	3	5.2		10	3	FG+Δh	0.2	10	3	339	1.411	1.323	1.344	1.439
6	CH-6	Normal embankment	Km10+442 ~ Km10+625	183	5.5	PVD	0.0		4	3	20.5	1.4	15.8	90.22	126.84	12.41	30	0.7	3.9		10	3	5.6		10	3	FG+Δh	0.5	10	7.5	473	1.32	1.229	1.27	1.413
7	CH-7	Normal embankment	Km10+625 ~ Km10+778	153	5.8	PVD	0.0		3	3	9.5	0.8	15.2	69.92	87.96	26.46	30	0.6	3.9		10	3	5.6		10	3	FG+Δh	0.4	10	7	457	1.403	1.263	1.249	1.48
8	CH-8	DR-BOX	Km10+778 ~ Km10+832	54	5.8	PVD	0.0		3	3	21.5	0.8	12.0	98.06	114.2	2.22	10	0.8	3.8		10	3	5.3		10	3	FG+Δh	0.1	10	3.7	360	1.358	1.239	1.261	1.463
9	CH-9	Normal embankment	Km10+832 ~ Km11+250	418	5.7	PVD	0.0		2	2	13.0	0.8	15.3	79.06	127	26.59	30	0.7	3.7		10	4	FG+Δh	0.6	10	9					460	1.515	1.251		1.429
10	CH-10	Normal embankment	Km11+250 ~ Km11+650	400	4.9	PVD	0.0		2	2	11.5	1.2	14.9	85.35	84.09	12.32	30	0.6	3.9		10	4	FG+Δh	0.4	10	9					447	1.384	1.287		1.438
11	CH-11	Normal embankment	Km11+650 ~ Km11+790	140	4.9	PVD	0.0		3	2	18.5	1.2	15.0	93.86	120.62	7.41	30	0.7	3.9		10	4	FG+Δh	0.6	10	9					451	1.347	1.223		1.516
12	CH-12	Normal embankment	Km11+790 ~ Km12+050	260	4.9	PVD	0.0		2	2	11.0	1.2	15.0	76.03	100.2	24.02	30	0.6	3.9		10	4	FG+Δh	0.6	10	9					449	1.316	1.218		1.476
13	CH-13	Normal embankment	Km12+050 ~ Km12+300	250	5.0	PVD	0.0		3	2	22.0	1.2	14.1	93.4	121.92	8.05	30	0.7	3.8		10	4	FG+Δh	0.5	10	8					422	1.361	1.246		1.516
14	CH-14	Normal embankment	Km12+300 ~ Km12+580	280	5.0	PVD	0.0		3	2	14.0	1.4	14.9	91.76	66.61	5.49	30	0.5	3.9		10	4	FG+Δh	0.3	10	9					446	1.571	1.357		1.484
15	CH-15	Normal embankment	Km12+580 ~ Km12+950	370	5.2	PVD	0.0		2	2	22.0	1.5	14.0	93	94.28	6.6	30	0.6	3.8		10	4	FG+Δh	0.4	10	8					421	1.409	1.238		1.423
16	CH-16	Normal embankment	Km12+950 ~ Km13+573	623	5.8	PVD	0.0		2	2	11.5	1.2	16.0	77.51	131.8	29.64	30	0.7	3.7		10	4	FG+Δh	0.6	10	9.6					480	1.52	1.218		1.444
17	CH-17	UP-BOX	Km13+573 ~ Km13+628	55	5.9	PVD	1.5		3	2	12.0	0.8	11.8	88.68	83.59	9.46	10	0.7	3.8		10	4	FG+Δh	1.8	10	5.5					354	1.68	1.207		1.57
18	CH-18	Normal embankment	Km13+628 ~ Km13+910	282	5.9	PVD	0.0		2	2	11.5	1.4	15.2	78.47	82.1	17.68	30	0.6	3.9		10	4	FG+Δh	0.4	10	9					457	1.449	1.213		1.435
19	CH-19	Normal embankment	Km13+910 ~ Km14+070	160	6.5	SD	0.0	3		2	8.5	1.5	13.5	98.98	92.29	0.94	30	0.7	3.8		10	3	5.5		10	3	FG+Δh	0.1	10	5	404	1.666	1.415	1.34	1.42
20	CH-20	Normal embankment	Km14+070 ~ Km14+370	300	6.8	SD	0.0	3		2	10.0	1.5	13.7	98.66	126.18	1.69	30	0.8	3.8		10	3	5.3		10	3	FG+Δh	0.3	10	5	410	1.637	1.47	1.295	1.424
21	CH-21	Normal embankment	Km14+370 ~ Km14+593	223	5.3	No need	0.0		1	2	10.0		11.9	81.97	41.31	7.45	30	0.5	3.8		10	4	FG+Δh	0.1	10	6					356	1.522	1.335		1.429
22	CH-22	DR-BOX & UP-BOX	Km14+593 ~ Km14+679	86	7.0	SD	0.0		2	2	8.0	1.8	11.5	91.39	52.75	4.54	10	0.6	3.9		10	3	5.7		10	3	FG+Δh	0.1	10	3	345	1.823	1.528	1.417	1.458
23	CH-23	Normal embankment	Km14+679 ~ Km14+881	202	5.8	SD	0.0		2	2	9.5	2.0	13.1	90.85	61.22	5.6	30	0.6	3.9		10	4	FG+Δh	0.2	10	7					394	1.565	1.345		1.495
24	CH-24	DR-BOX(2x2)	Km14+881 ~ Km14+933	52	6.1	SD	0.0		4	2	13.5	1.8	11.8	79.92	91.94	18.46	20	0.7	3.9		10	4	FG+Δh	0.4	10	5.5					355	1.471	1.246		1.465
25	CH-25	Normal embankment	Km14+933 ~ Km15+068	135	7.3	SD	0.0		4	3	13.5	1.6	14.7	81.46	105.41	19.54	30	0.7	3.8		10	3	5.5		10	3	FG+Δh	0.3	10	6	443	1.817	1.596	1.395	1.457
26	CH-26	DR-BOX	Km15+068 ~ Km15+132	64	7.6	SD	0.0	3		3	20.0	1.5	11.8	99.35	88.87	0.58	10	0.8	3.7		10	3	5.4		10	3	FG+Δh	0.1	10	3	355	1.991	1.648	1.388	1.474
27	CH-27	Normal embankment	Km15+132 ~ Km15+313	181	6.9	SD	0.0		4	3	10.0	1.8	11.6	89.46	80.95	8.53	30	0.7	3.9		10	3	5.6		10	3	FG+Δh	0.2	10	3	347	1.739	1.446	1.356	1.431
28	CH-28	UP-BOX	Km15+313 ~ Km15+368	55	5.1	PVD	0.0		1	2	10.5	1.5	11.9	92.82	54.7	3.93	10	0.5	3.8		10	4	FG+Δh	0.1	10	6					356	1.611	1.456		1.563
29	CH-29	Normal embankment	Km15+368 ~ Km15+630	262	4.4	PVD	0.0		2	2	11.5	1.5	12.6	91.85	53.61	4.37	30	0.5	3.9		10	4	FG+Δh	0.2	10	7					379	1.309	1.327		1.468
30	CH-30	Terminal road	Km15+630 ~ Km15+884	254	2.5	No need	0.0			2	11.5		10.9	44.74	33.62	18.58	30	0.5	FG+Δh	0.2	10	10									328	1.389			1.518

Notes:

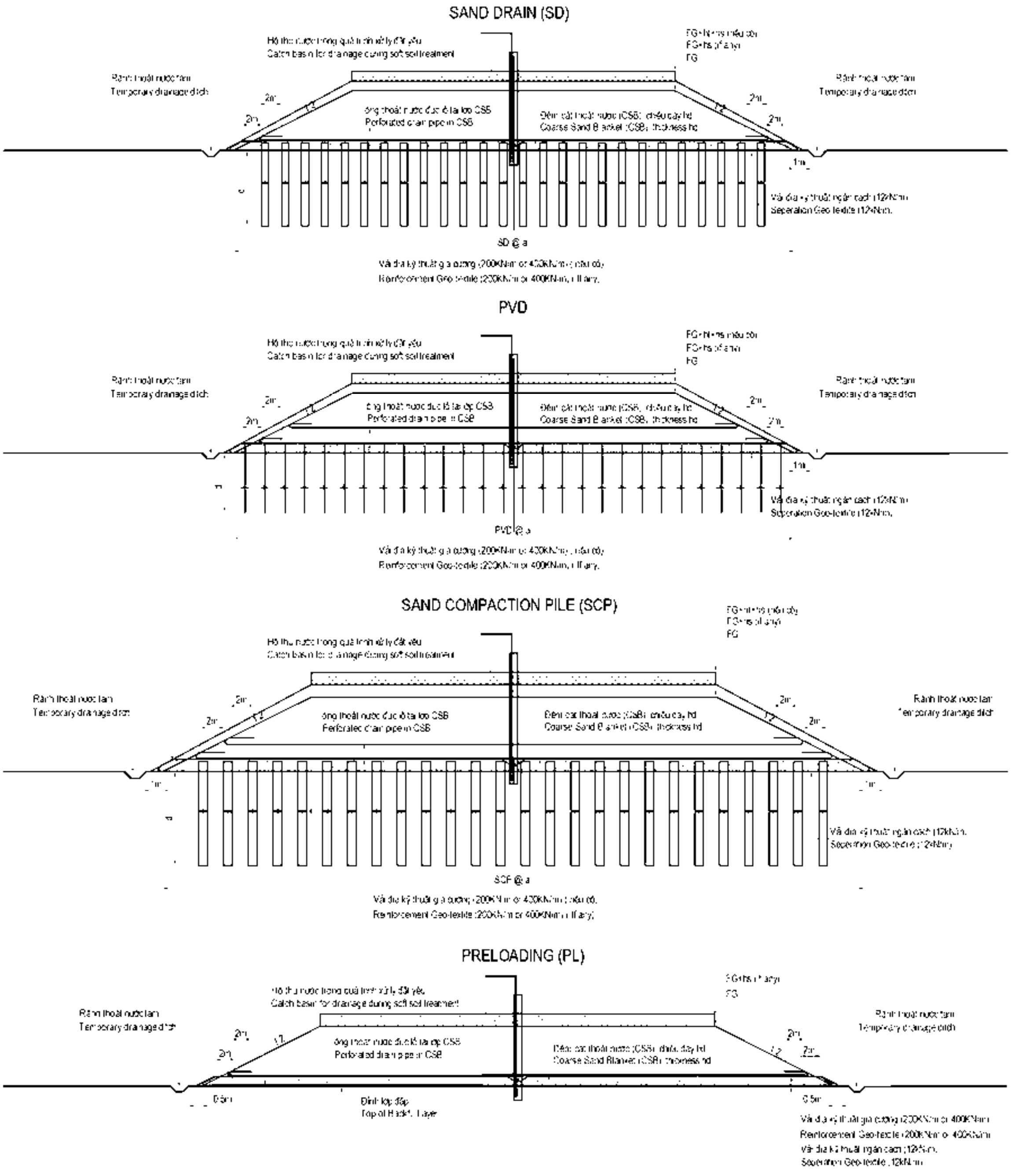
1)Installation of Geotextile (number, location, etc.) should be decided by the Engineer with careful checking during construction stage based on soil test result.

2)Installation of Course Sand Blanket (setting elevation, thickness, etc.) should be decided by the Engineer during construction checking the site condition.

Source : Study Team

7.5.3 Typical Cross Section of Soft Soil Treatment

Typical cross section of soft soil treatment is as shown in Figure 7.5.3-1.



Source : Study Team

Figure 7.5.3-1 Typical cross section of soft soil treatment

7.6 ROAD STRUCTURE DESIGN

7.6.1 Road Structures

Road structures in this project are listed below (exclude bridge structure);

- ➢Underpass box culvert
- ➢Drainage/Irrigation box culvert and pipe culvert
- ➢Retaining wall
- ➢Piled slab behind bridge abutment

7.6.1.1 Drainage/Irrigation Box Culvert and Pipe Culvert

Type of culvert for drainage and irrigation is classified as follows.

Table 7.6.1-1 List of Drainage/Irrigation Box Culvert

Type	B(m) x H(m)	Location	Note
1	2.00 x 2.00	Km 0+788, Km 2+390, Km 2+650, Km 14+907	
2	3.00 x 3.00	Km 0+915, Km 10+805	
3	4.00 x 4.00	Km 14+620	
4	2 x 2.00 x 4.00	Km 14+650 (Left side)	With water gates
5	2 x 3.00 x 3.00	Km 4+140	
6	3 x 4.00 x 6.00	Km 15+100	

Source : Study Team

Table 7.6.1-2 List of Drainage/Irrigation pipe culvert type

Type	Diameter(m)	Location	Note
1	1.50	Km 0+225, Km 10+090, Km 10+659,Km 15+520	Length is over 30m for all culverts.

Source : Study Team

7.6.1.2 Retaining wall in Cat Hai Island

Retaining wall is installed at following section;

- ➢Km13+722-Km13+753: L=31m, Dong Bai Commune, near pagoda

Type of retaining wall is “Concrete sheet pile wall (with anchor rod)”. In case of applying normal retaining wall, excavation for the foundation will affect the pagoda area and wall of the pagoda needs to be removed. And it is also necessary to ensure passage of local people in front of the pagoda even during construction. Therefore, concrete sheet pile wall which doesn’t need temporary excavation is applied in order to minimize the impact by the construction.

7.6.1.3 Piled Slab

At the high embankment section near bridge abutment, piled slab is applied instead of soft soil treatment at following locations.

1) Km1+635.569-Km1+660.019 (L=24.45m, A1 abutment of Cam River Bridge)
2) Km1+739.981-Km1+764.431 (L=24.45m, A2 abutment of Cam River Bridge)
3) Km4+456-Km4+497 (L=41m, A1 abutment of Approach Bridge)
4) Km9+948.5-Km9+971.9 (L=23.4m, A2 abutment of Approach Bridge)

7.7 Traffic Safety

Traffic safety devices are defined as devices to direct and assist road users so that they may be able to travel safely and efficiently on a road network. Items of traffic safety in this project are as follows;

- Guardrail
- Guard post
- Concrete curb
- Delineators
- Traffic signs
- Road marking

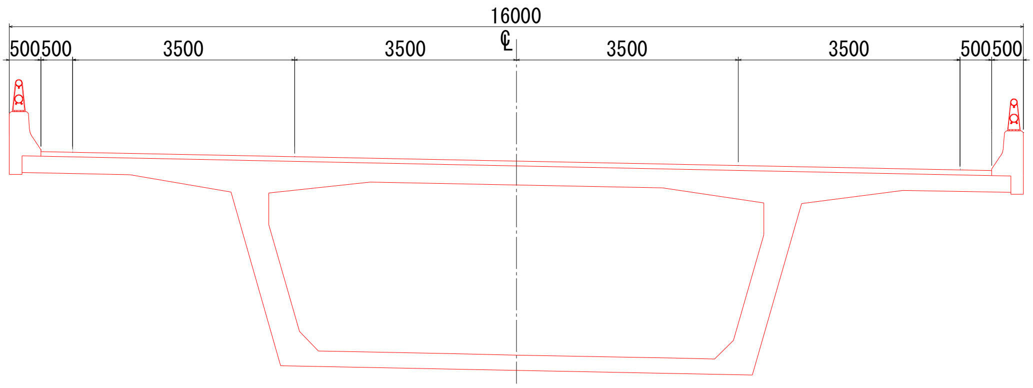
CHAPTER 8 DESIGN OF BRIDGES

8.1 Design Conditions

8.1.1 Basic Conditions

- Bridge Type : Prestressed Concrete Bridge
- Structure Type : PC continuous box girder (except for Cam River Bridge)
- Bridge Length : 4433.7m + 490.0m + 519.2m (except for Cam River Bridge)
- Road Spec : Highway class III , plain terrain
- Design Speed : 80km/h
- Live Load : AASHTO LRFD

- Width Composition



Source: Study Team

Figure 8.1.1-1 Width Composition of Superstructure

- Longitudinal Grade : less than 5.0%
- Cross Grade : 2.0%

8.1.2 Material to be used

8.1.2.1 Superstructure

- Concrete for Main Girder : σck = 40N/mm^2 [for main bridge]
  : σck = 40, 50N/mm^2 [for approach bridge]
- Reinforcing Bars : SD345
- PC Tendon: 19S15.2 [Internal for Main Bridge, External for Approach Bridge] SWPR7BL
  : 12S15.2 [Internal for Approach Bridge] SWPR7BL
  : 1S28.6 [Transversal for Main Bridge and Approach Bridge] SWPR19L
  : 7S12.7 [Internal for Cam River Bridge] SWPR7BL
  : 1S19.3 [Transversal for Cam River Bridge] SWPR19L

8.1.2.2 Substructure & Foundation

- Concrete : : σck = 40, 28N/mm2 [for Substructure]
  : σck = 30N/mm2 [for Pile]
- Reinforcing bars : SD345
- Steel pipe pile : SKK400
- Steel sheet pile : SKY400，SKY490

8.1.3 Conditions of Design Load

The design loads are complied with the chapter 3 in the standard 22TCN272-05.

8.1.4 Concrete Cover

Basic concept for protection of reinforcing steels and PC tendons is made following Vietnamese standards (Article 5.12.3 of 22 TCN-272-05 and Table1 in Article 4 of TCXDVN327:2004)

8.1.5 Site Condition

8.1.5.1 Soil Condition

The ground conditions by D/D study are shown in Chapter 3. The weathered rock layer that can be regarded as the bearing layer is distributed E.L.-40.0m to E.L.-50.0m depth, and has a thick surface layer predominant with clay on top. Specialty, very sensitive clay is thickly deposited from ground surface to GL-15m, of which N-value is 0 to 2, will be affected by consolidation occurs.

8.1.5.2 Structure Height and Seawater Depth

Following Table is summary for the pier height and seawater depth with classification of study type for approach bridge and main bridge.

Table 8.1.5-1 Pier Height and Seawater Depth

Pier No.	Pier Height* (m)	Column Height (m)	Water depth (m)	Pier No.	Pier Height* (m)	Column Height (m)	Water depth (m)
P1	6.0	3.5	2.54	***P45***	10.0	7.5	3.48
P2	7.5	5.0	2.67	P46	10.5	8.0	3.50
P3	8.5	6.0	2.65	P47	10.5	8.0	3.51
P4	8.5	6.0	2.70	P48	10.5	8.0	3.42
P5	8.5	6.0	2.58	P49	10.5	8.0	3.31
P6	8.5	6.0	2.60	***P50***	15.0	12.5	7.51
P7	9.0	6.5	2.66	P51	15.0	12.5	7.51
P8	9.5	7.0	2.69	P52	15.5	13.0	7.51
P9	10.0	7.5	2.71	P53	15.5	13.0	7.51
P10	10.0	7.5	2.81	P54	15.0	12.5	7.51
P11	10.5	8.0	2.92	***P55***	15.0	12.5	7.51
P12	10.5	8.0	3.18	P56	15.0	12.5	7.51
P13	10.5	8.0	3.28	P57	15.0	12.5	7.51
P14	10.5	8.0	3.25	P58	14.5	12.0	7.51
P15	10.0	7.5	3.15	P59	14.5	12.0	2.55
P16	10.0	7.5	3.16	***P60***	14.0	11.5	2.55
P17	10.0	7.5	3.19	P61	14.0	11.5	7.51
P18	10.0	7.5	3.25	P62	14.0	11.5	7.51
P19	9.5	7.0	3.27	P63	14.0	11.5	7.51
P20	9.5	7.0	3.27	P64	13.5	11.0	7.51
P21	9.5	7.0	3.29	***P65***	13.5	11.0	7.51
P22	9.0	6.5	3.32	P66	13.5	11.0	7.51
P23	9.0	6.5	3.37	P67	13.0	10.5	7.51
P24	9.0	6.5	3.39	P68	13.0	10.5	7.51
P25	8.5	6.0	3.46	P69	13.0	10.5	7.51
P26	8.5	6.0	3.50	***P70***	14.0	11.5	7.51
P27	8.5	6.0	3.46	P71	15.0	12.5	7.51
P28	8.5	6.0	3.48	P72	16.5	14.0	7.51
P29	8.5	6.0	3.44	P73	18.5	16.0	7.51
P30	8.5	6.0	3.61	P74	20.0	17.5	7.51
P31	8.5	6.0	3.64	***P75***	21.5	**19.0**	7.51
P32	8.5	6.0	3.71	P76	23.5	21.0	6.94
P33	8.5	6.0	3.78	P77	27.0	24.5	8.67
P34	8.5	6.0	3.79	P78	28.0	25.5	10.80
P35	8.5	6.0	3.77	***P79***	20.0	**17.5**	**11.53**
P36	9.0	6.5	3.82	P80	19.0	**16.5**	**11.13**
P37	9.0	6.5	3.71	P81	17.0	**14.5**	**9.98**
P38	9.0	6.5	3.65	P82	17.0	14.5	7.87
P39	9.5	7.0	3.65	P83	13.5	11.0	3.75
P40	9.5	7.0	3.64	***P84***	10.5	8.0	2.42
P41	9.5	7.0	3.62	P85	8.5	6.0	2.11
P42	9.5	7.0	3.58	P86	7.5	5.0	1.84
P43	10.0	7.5	3.51	P87	6.0	3.5	1.46
P44	10.0	7.5	3.50				

*pier Height : Column + Pile Cap Height

Source: Study Team

8.1.5.3 Design Scour Depth

The results on the design scour depth are shown in the following table. The depth of construction scour is assumed around 1.0m. Furthermore, the relationship between depth of pile cap and elevation of each scour are shown in following Figure.

However, due to the local scouring with design flow velocity ware not continued in the long-term, the seismic design was considered to 50% of Normal condition(as service and strength condition).

Table 8.1.5-2 Results of Design Scour Depth

Pier No	Ground Elevation (m)	Depth of Ground Elevation (m)	Depth of contraction scour (m)	Depth of local scour (m)	Total depth of scour (m)	Level after scour of Normal(m)	Level after scour of Seismic (m)	Foundation Type
P61~P75	-4.96	7.51	0.35	6.81	**7.15**	-12.11	-8.71	Pile Foundation
Pier 76	-4.39	6.94	0.18	6.24	**6.42**	-10.81	-7.69	SPSP
Pier 77	-6.12	8.67	0.73	7.46	**8.19**	-14.31	-10.58	
Pier 78	-8.25	10.80	1.57	11.20	**12.77**	-21.01	-15.41	
Pier 79	-8.98	11.53	1.90	6.32	**8.22**	-17.19	-14.03	Multi Column Pile
Pier 80	-8.58	11.13	1.72	6.06	**7.78**	-16.36	-13.33	
Pier 81	-7.25	9.80	1.16	5.66	**6.82**	-14.07	-11.24	
Pier 82	-5.32	7.87	0.46	6.75	**7.21**	-12.53	-9.16	Pile Foundation
Pier 83	-1.20	3.75	0.00	6.17	**6.17**	-7.37	-4.29	
Pier 84	0.14	2.42	0.00	5.89	**5.89**	-5.75	-2.81	
Pier 85	0.44	2.11	0.00	6.08	**6.08**	-5.65	-2.61	
Pier 86	0.71	1.84	0.00	5.80	**5.80**	-5.09	-2.19	
Pier 87	1.10	1.46	0.00	5.78	**5.78**	-4.69	-1.80	

Note) Design water EL = 2.72m(1% HHWL)

Design flow velocity = 1.45m/s (assumed at ebb and flow condition by F/S report)

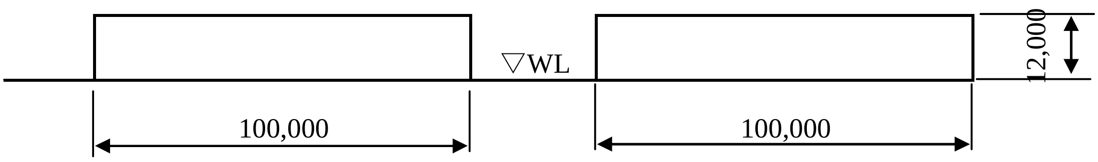
Source: Study Team

8.2 Span Length and Span Arrangement

8.2.1 Study on Span Length of Main Bridge

8.2.1.1 Navigation Clearance

The navigation channel for large vessels will be shifted to the northern side of deep sea port. The bridge shall have navigation for vessels of 1,000 DWT. The navigation clearance at Nam Trieu Channel was agreed with Vinamarine by the letter No. 192/TB-BGTVT dated 17 May 2009 as shown in the figure below.



Source: Study Team

Figure 8.2.1-1 Navigation Clearance

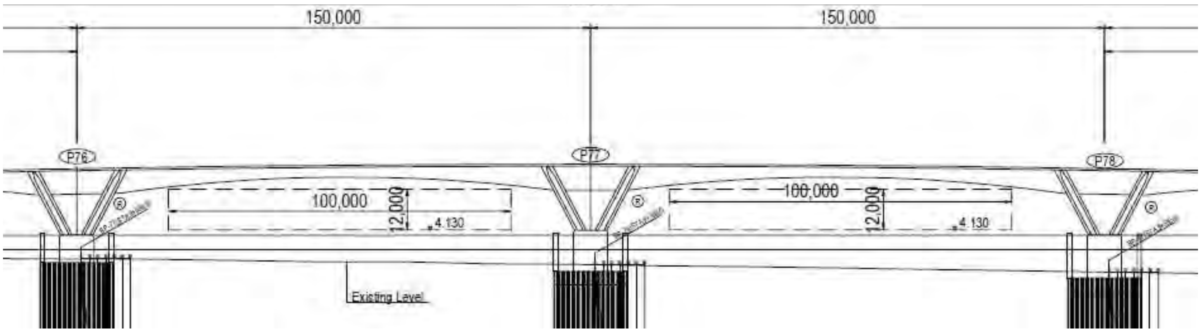
WL (Water Level) for navigation clearance is calculated as follows:

WL = 2.72m (DHWL) + 1.41m (Effect of wave) = 4.13m

DHWL: Design High Water Level = 2.72m (High tide water level at 1% probability)

8.2.1.2 Span Length of Main Bridge

Two main spans are subjected to clearance of navigation channel and construction limit. The proposed main bridge (Prestressed Concrete Box Girder with V-shaped Pier) is required 150.0m for main span length in consideration with the navigation clearance at the level of WL (4.13m) as shown in the figure below.



Source: Study Team

Figure 8.2.1-2 Span Length determined from Navigation Clearance

Two main spans are secure to be 150.0m each. Side span length of the main bridge are economically determined by ratio of main span length (L) which is 0.60～0.65*L. Side span on both sides are also secured to be 95.0m which is 0.633*L. The end of side span is constructed on the falsework supported steel staging in the sea.

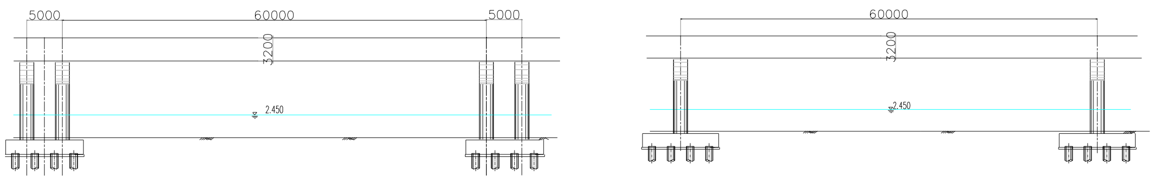
8.2.2 Study on Span Length of Approach Bridge

In order to realize appropriate spanning plan to adjust bridge length in accordance with the site conditions such as intersections with cross roads and railways, comparison study for the appropriate span of the approach bridge is performed.

In this study, the following four alternatives are studied.

(i) Alternative-1: 60m span with double wall piers (10@ (5m+ 60m), SAPROF)
(ii) Alternative-2: 65m span with single wall piers (10@65m)
(iii) Alternative-3: 60m span with single wall piers (10@60m)
(iv) Alternative-4: 50m span with single wall piers (10@50m)

As a result of the comparative study, Alternative-3:60m span with single wall pier is recommended from comprehensive view points, economic, technical and other viabilities.



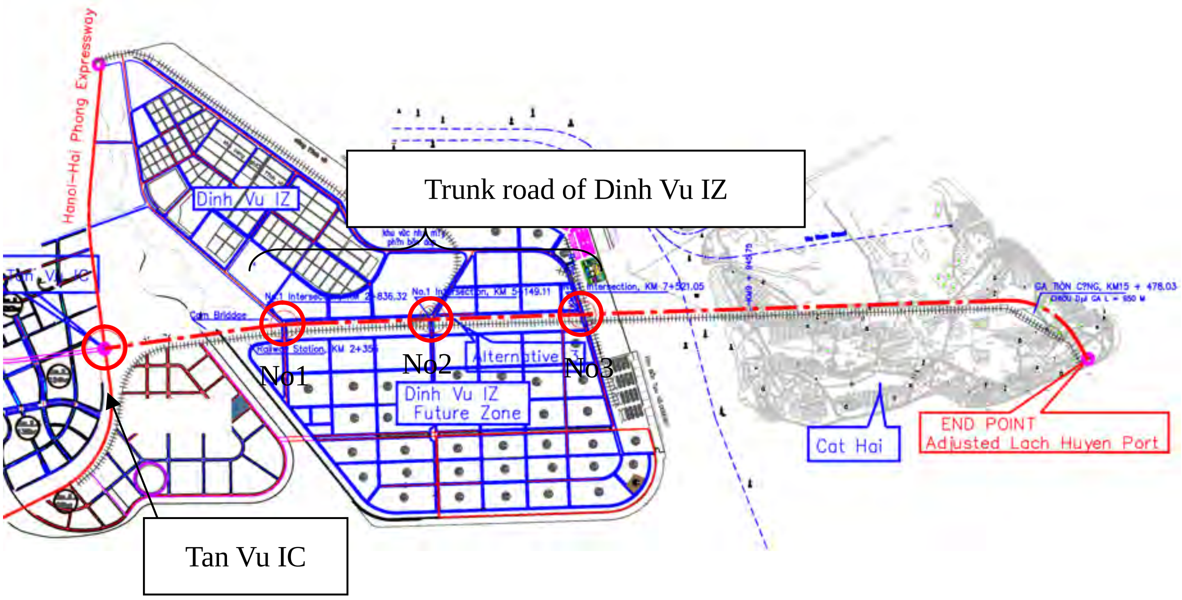
(a)Alternative-1 (b)Alternative-3

Source: Study Team

Figure 8.2.2-1 Span Length of Approach Bridge

8.2.3 Study on Span Length of Flyover Bridge

In this study, the location of the cross roads and railways in Nam Dinh Vu erection is based on the General Plan Adjustment of Haiphong City in 2025 and Orientation to 2050.



Source: Study Team

Figure 8.2.3-1 Location of Interchange and Intersections

In SAPROF Study, the span length with 71.25m + 83.5m + 71.25m with double wall pier is recommended and approved by MOT. In this study, the following three alternatives are studied.

a) Alternative-1: Span arrangement of 71.25m+83.5m+71.25m with double wall piers

Cast-in-place PC Box Girder with Cantilever Method is assumed as recommended in SAPROF Study.

b) Alternative-2: Span arrangement of 64m+84m+64m with single wall piers

Cast-in-place PC Box Girder with Cantilever Method is assumed same as Alternative-1.

c) Alternative-3: General span length of 60m with single wall piers

As a result of comparative study, Alternative-3:60m span with single wall pier is recommended from comprehensive view points. The one of the significant advantages of Alternative-3 is the fact that the bridge type and the erection method are the same as the adjacent approach bridges, so that the erection girder can be commonly utilized and the construction can be continuously arranged, which results in the lowest construction cost and the shortest construction period among the alternatives.

8.2.4 Recommended Span Arrangement in Bridge Section

In consequence, optimum bridge spans are arranged for the entire bridge section as shown in the table below. Several adjusting spans less than 60m are introduced around the intersections and Main Bridge.

Table 8.2.4-1 Recommended Span Arrangement in comparison with SAPROF Study

	Recommended by JICA Study Team	SAPROF Study
	Span Arrangement	Span Arrangement
Approach Bridge(1)	2@(5@60m) +(51.5m+4@60m) +6@(5@60m) +(4@60m+58.36m) +(5@60m) +4@(52.98m+3@60m+52.98m)	46.6m+7@65m+46.6m
Flyover Bridge(1)		71.25m+83.5m+71.25m
Approach Bridge (2)		53.5m+32@65m
Flyover Bridge(2)		71.25m+83.5m+71.25m
Approach Bridge (3)		20@65m
Main Bridge	95m+150m+150m+95m	95m+150m+150m+95m
Approach Bridge (4)	(54.8m+3@60m+54.8m) +(54.8m+2@60m+54.8m)	7@65m+64.2m
Total Length	5,442.9m	5,442.9m

Source: Study Team

8.3 Study of Main Bridge

8.3.1 Selection of Type of Main Bridge

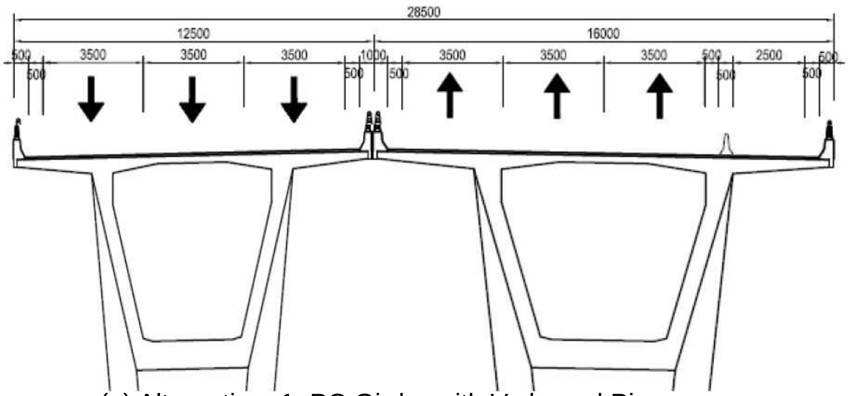
In JICA's Preparatory Survey, PC Girder Bridge with V-shaped Piers is recommended and approved by MOT. In this study, the following two alternatives are studied.

(i) Alternative-1: PC Girder with V-shape piers (Approved by MOT)

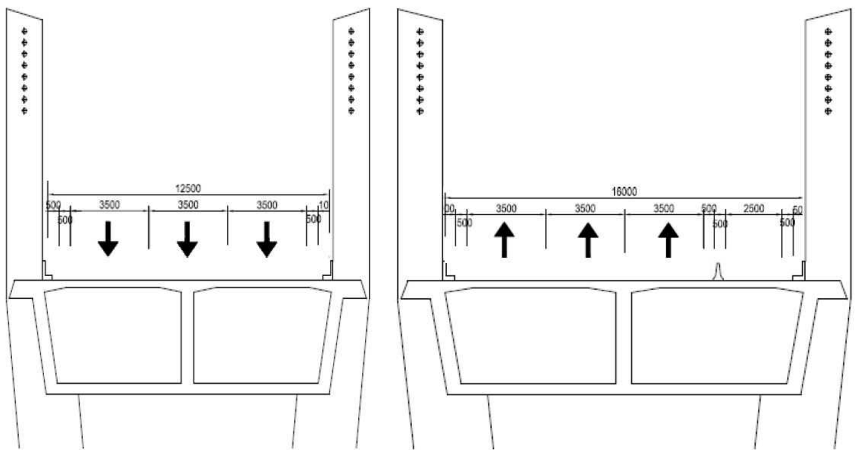
(ii) Alternative-2: Extradosed Bridge

Because of the lane arrangement in the future as shown in the figure below, the pylons for the extradosed bridge is to be located at the outside of the girder.

As a result of comparative study, Alternative-1: PC Girder with V-shaped piers is recommended from comprehensive view points, economic, technical and other viabilities.



(a) Alternative -1: PC Girder with V-shaped Piers



(b) Alternative -2: Extradosed Bridge

Source: Study Team

Figure 8.3.1-1 Cross Section of Main Bridge at Pier (Second Stage)

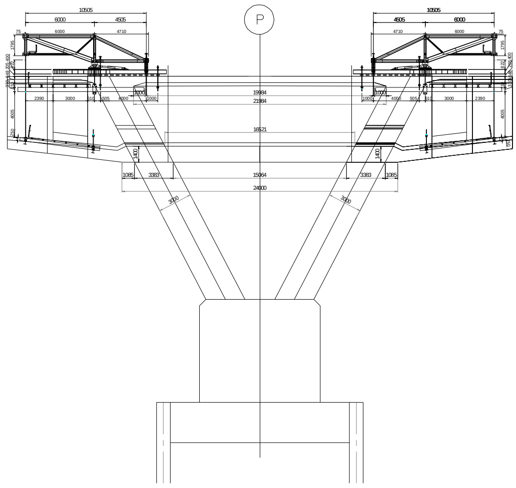
8.3.2 Selection of Erection Method for Main Bridge

As the results on the comparative study, cast-in place balanced cantilever segment method is selected by the following main points;

-Precast balanced cantilever segment method can be shorten construction period by two months in comparison with cast-in-place balanced cantilever segment method but the construction period of cast-in-place is not in critical pass of total construction schedule.

-Precast segments are erected by crawler cranes mounted on the barges that disturb ship traffic in the navigation channel during construction.

-Wide precast yard and casting equipment are required for fabrication of box segment in the Cut Hi side where is in the limited small island.



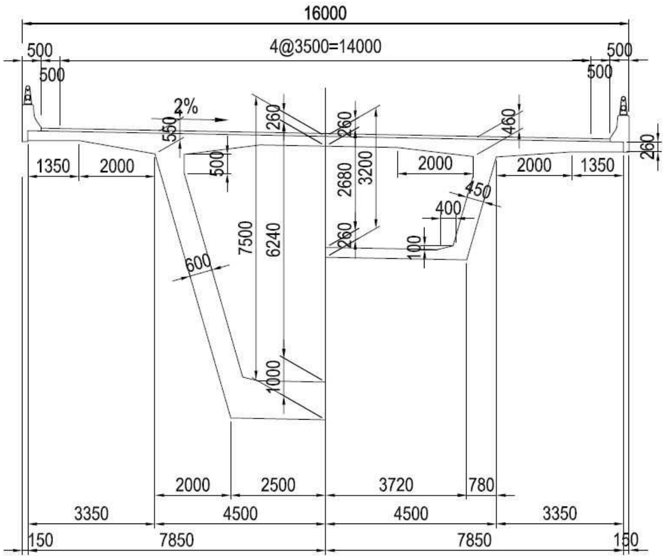
Source: Study Team

Figure 8.3.2-1 Erection of Main Girder with Form traveler

8.3.3 Superstructure of Main Bridge

8.3.3.1 Cross Section of Main Girder

The cross-section of the main bridge is a single-cell box girder, consisting of the upper slab with cantilevering flanges, webs, and the lower slab as shown in the Figure below.

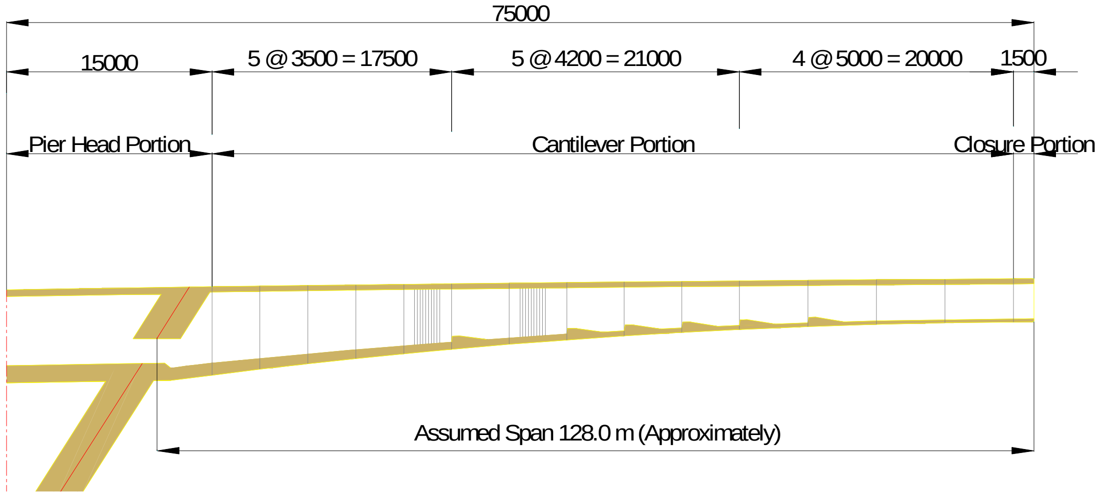


Source: Study Team

Figure 8.3.3-1 Cross Section for Main Girder of the Initial Stage

8.3.3.2 Cantilever Segments and Pier Head

A pier table length of 15.0m with an asymmetry of to the pier centerline, and several types of segments, being 5.0m long in the spans and 3.0m at the closure segments but only 3.5m near the pier table as shown in the figure below.

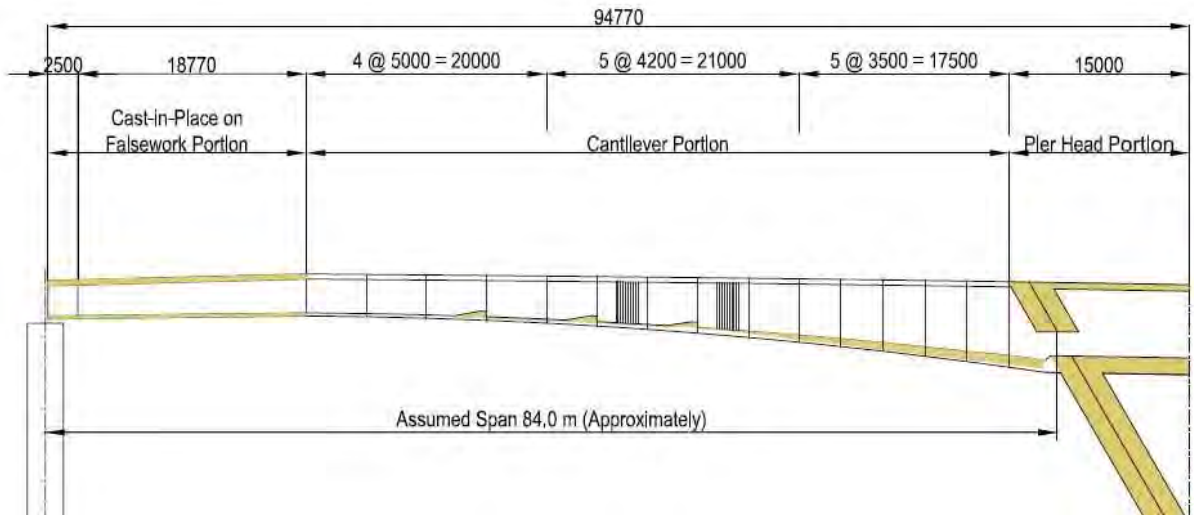


Source: Study Team

Figure 8.3.3-2 Cantilever Segments and Pier Head

8.3.3.3 Cast-in-Place Segments on the False work

At the end segments of side span, the long segments out of cantilever portion are built on-site using formwork supported by temporary false work as shown in the figure below.

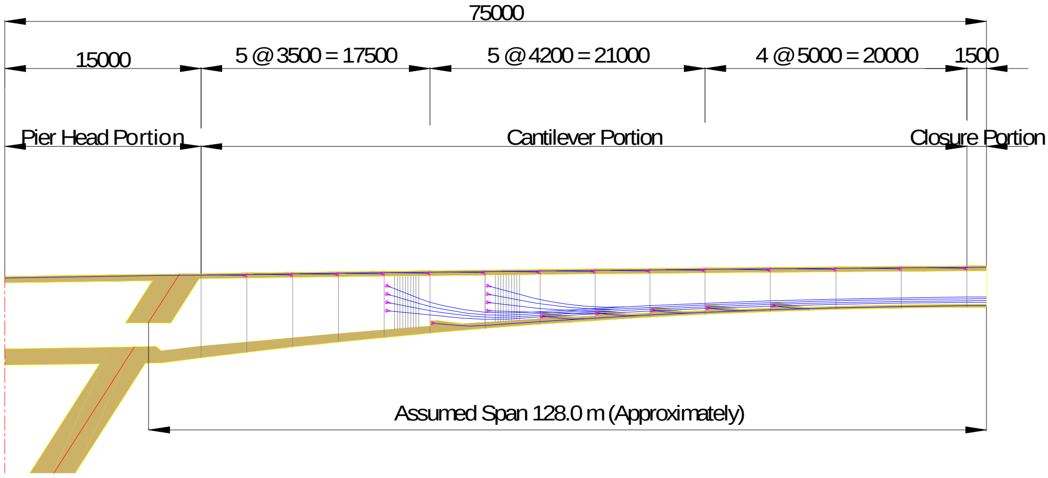


Source: Study Team

Figure 8.3.3-3 Cast-in-place Segments on False Work

8.3.3.4 Post-Tensioning System

The arrangement of the longitudinal cantilever tendons in the upper slab is shown in the figure below.



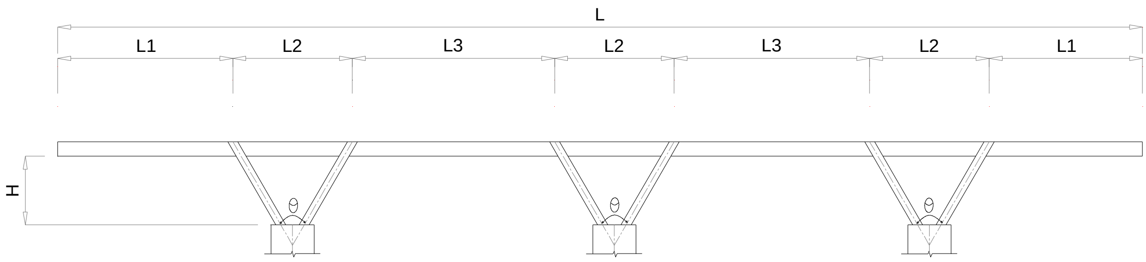
Source: Study Team

Figure 8.3.3-4 Arrangement of Longitudinal Cantilever Tendons

8.3.4 Substructure of Main Bridge

8.3.4.1 Skelton Balance of V-shaped Pier

The V-type pier of main Bridge is determined by the balance of 6 elements (skeleton) of θ, L, L1, L2, L3 and H as shown in the figure below considering the natural and structural conditions and aesthetic view point. The comparative study of V-shape varying θ from 30°to 90°is conducted and angle at the vertex of triangle (θ) of approximate 60°is selected for V-shaped pier from structural and economical viewpoints.



Source: Study Team

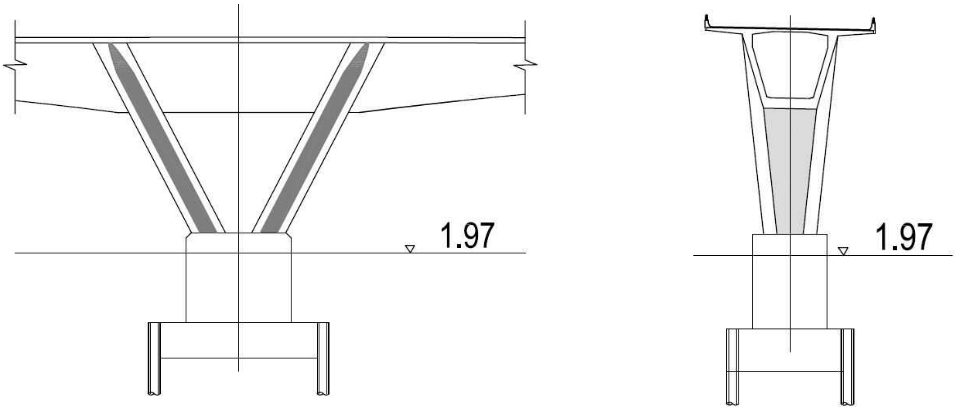
Figure 8.3.4-1 Skelton of V-shaped Piers

8.3.4.2 Comparative Study on Pier Appearance in Longitudinal Direction

The V-shaped pier in longitudinal direction has 3 alternative configurations planned considering structural stability and aesthetic point.

a) Alternative-1: Simple solid rectangular type
b) Alternative-2: Reversed trapezoid with void
c) Alternative-3: Reversed trapezoid with slit

Alternative-3, which is shown in the figure below, is recommended in aesthetical point.



Source: Study Team

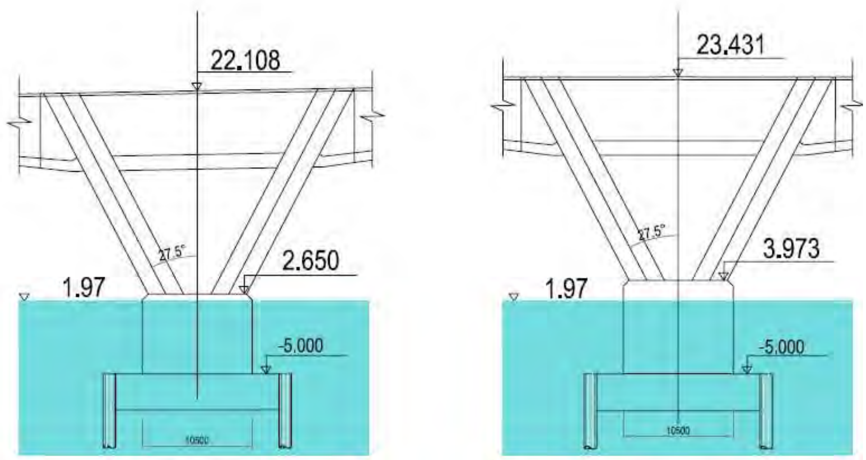
Figure 8.3.4-2 Vertical Slit for Aesthetical Aspect

8.3.4.3 Level on Bottom of V-shaped Wall (Level of Pier Top)

Level of bottom of V-shape wall should be determined by the following points;

a) Sea water level
b) Size of triangle of V-shape wall
c) Planning height of bridge

Based on the result of comparative study, the level of pier top is designed both by comparing with the water level of 2.55 m (High Water Level) for easy maintenance and by comparing with the water level of 1.97m (Mean High Water Level) for aesthetical view.



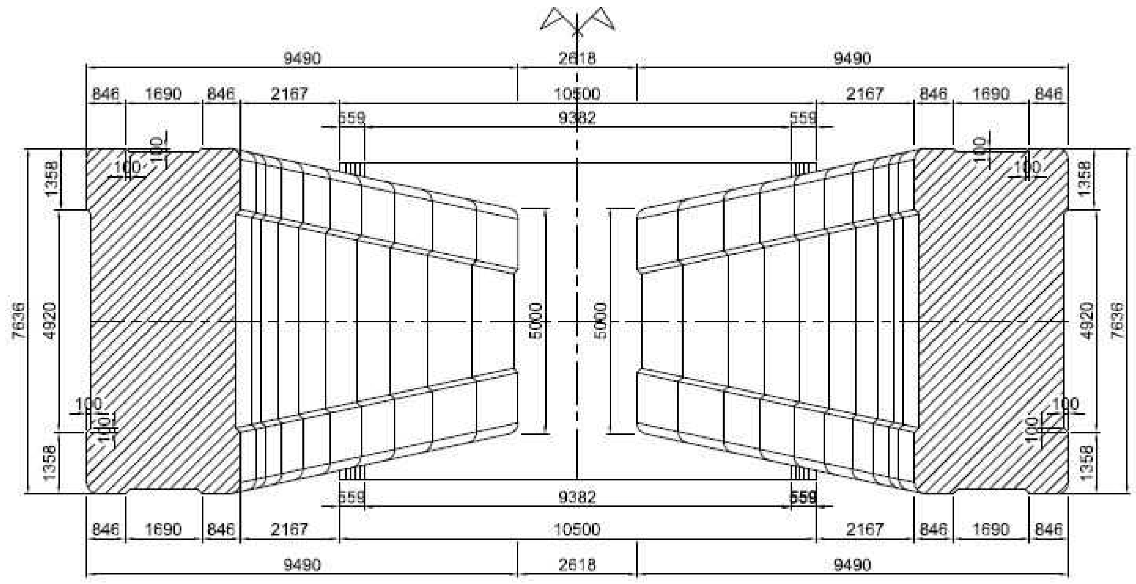
Side Piers Center Pier

Source: Study Team

Figure 8.3.4-3 Projected Pier (2.650m) above Mean High Water Level

8.3.4.4 Aesthetic Considerations of V-shaped Pier

One of creativity on structure is aesthetics of pier. We create smooth and soft appearance by creating curved line. Walls of V-shaped pier make a slim on concrete wall with moderate curve and straight lines. At the corner of column, curves of 250mm radius are provided to make a soft line corners as shown in the figure below.



Source: Study Team

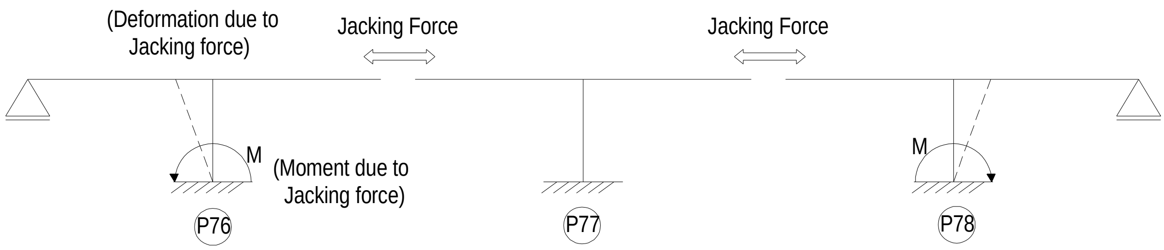
Figure 8.3.4-4 Corner Arrangement of V-shaped Wall Pier

8.3.4.5 Effect of Creep and Shrinkage on V-shaped Pier

Main bridge consists a pre-stressed concrete 4-span continuous rigid-frame bridge with 2 spans of 150m in the center. The main bridge, which is constructed by cantilever method, is not flexible enough to accommodate longitudinal movement due to creep and shrinkage through its long time behavior.

In order to reduce the mall effects induced by creep and shrinkage a subsidiary measure is required.

The recommended measure is pressurization immediately after the segments are constructed by cantilever method, in which jacking forces are loaded just before closing segments.



Source: Study Team

Figure 8.3.4-5 Deformation and Moment due to Pressurization (Jacking Force)

8.3.5 Study on Main Bridge Foundation

8.3.5.1 Selection of Foundation Type for Main Bridge

(1) Introduction

In Preparatory Survey of JICA, it is recommended to install steel pipe sheet pile (SPSP) foundation for Main Bridge which is located in deep water. In this section, a comparative study is presented for selection of type of foundation for Main Bridge. The study consists of 2 sub studies, 1) comparative study between steel pipe sheet pile foundation and cast in place pile foundation, 2) comparative study for steel pipe sheet pile foundation between Integrated foundation and separate foundation of main bridge. The point of this study is construction period and safety construction at the deep water need to focus on detail.

(2) Selection of Foundation Type for Main Bridge

In this comparative study, the following three alternatives are studied.

Altenative-1: Steel pipe pile foundation (recommended by SAPROF Study)

Altenative-2: Cast in place pile foundation

The result of comparative study is shown in the table 8.3.5-2 following Table. As the table indicates, Altenative-1, Steel pile sheet pile foundation, is most recommendable foundation type of main bridge. Since Altenative-1 is advantages in construction cost and workability in the sea.

(3) Selection of Foundation Style for Main Bridge

In this comparative study, the following three alternatives are studied.

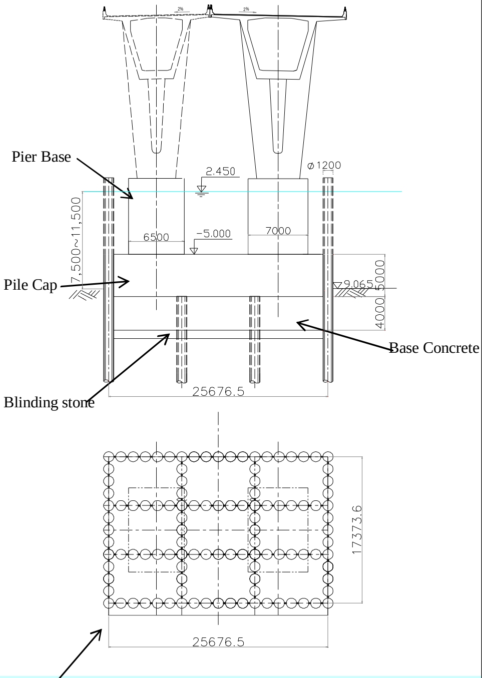
Altenative-1: Integrated Type of Steel pipe pile foundation (recommended by SAPROF)

Altenative-2: Separate Type of Steel pipe pile foundation

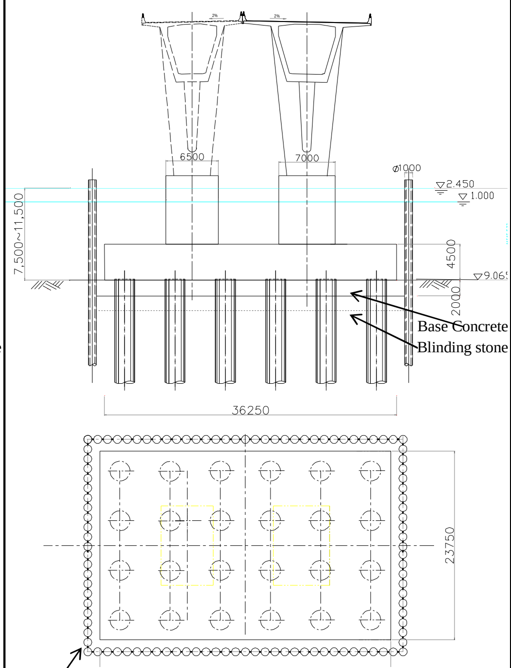
The result of comparative study is shown in following Table. As the table indicates, Altenative-2, Separate type of Steel pile sheet pile foundation, is most recommendable foundation type of main bridge. Since Altenative-2 is advantages in construction period and cost. Especially, in the Integrated foundation type could not have been in time construction period.

Table 8.3.5-1 Comparison on Foundation for Main Bridge

<table>
<tr><th>Evaluation Items</th><th>Max. Point</th><th colspan="2">Alternative-1
SPSP Foundation Type</th><th colspan="2">Alternative-2
C.I.P. Pile Foundation with SPSP cofferdam Type</th></tr>
<tr><td>Side View</td><td></td><td colspan="2">SAPROF Study
Diameter of pile : 1200 mm
Total number of pile : 9
Total length of pile : 47.0 m

Future Construction Interim construction


Steel Pipe Sheet Pile (SPSP) Foundation (D=1.2m,t=16,SKY490)</td><td colspan="2">Diameter of pile : 2500 mm
Total number of pile : 24
Total length of pile : 50.0 m

Future Construction Interim construction


Steel Pipe Sheet Pile (SPSP) Foundation (D=1.0m,t=12,SKY490)</td></tr>
<tr><td>Structural Aspect and Stability</td><td>10</td><td>- Small number of Pile Cap concrete</td><td>8</td><td>- Large number of Pile Cap concrete and C.I.P. Piles due to Large statically indeterminate force of rigid-frame pier.
- Furthermore, the design of C.I.P. Foundation Separate type is inferior due to large statically indeterminate force and construction clearance</td><td>4</td></tr>
<tr><td>Construction Cost (due to main items of SPSP Foundation)</td><td>40</td><td><table>
<tr><th colspan="2">Quantity (for 1 foundation)</th><th>Unit Cost (VND)</th><th>Total (1,000VND)</th></tr>
<tr><td>Pile Cap + Pier Base Co</td><td>3,419m3</td><td>6,859,258</td><td>23,451,118</td></tr>
<tr><td>Steel Pipe Sheet Pile</td><td>2,507 t</td><td>44,003,858</td><td>110,318,244</td></tr>
<tr><td>Base Concrete (h=4m</td><td>1,933m3</td><td>1,723,811</td><td>3,331,506</td></tr>
<tr><td>Blinding stone (h=1m</td><td>483m3</td><td>737,139</td><td>356,156</td></tr>
<tr><td>Excavation</td><td>4,832m3</td><td>318,066</td><td>1,536,768</td></tr>
<tr><td>C.I.P. Pile</td><td>0m</td><td>49,217,400</td><td>0</td></tr>
<tr><td></td><td></td><td>Total</td><td>138,993,792</td></tr>
<tr><td></td><td></td><td>Ratio</td><td>1.000</td></tr>
</table></td><td>40</td><td><table>
<tr><th colspan="2">Quantity (for 1 foundation)</th><th>Unit Cost (VND)</th><th>Total (1,000VND)</th></tr>
<tr><td>Pile Cap + Pier Base Cor</td><td>5,035m3</td><td>6,859,258</td><td>34,537,866</td></tr>
<tr><td>Steel Pipe Sheet Pile</td><td>1,139 t</td><td>44,003,858</td><td>50,111,593</td></tr>
<tr><td>Base Concrete (h=2m)</td><td>1,970m3</td><td>1,723,811</td><td>3,395,692</td></tr>
<tr><td>Blinding stone (h=1m)</td><td>985m3</td><td>737,139</td><td>726,036</td></tr>
<tr><td>Excavation</td><td>2,955m3</td><td>318,066</td><td>939,825</td></tr>
<tr><td>C.I.P. Pile (D=2.5m)</td><td>1200m</td><td>49,217,400</td><td>59,060,880</td></tr>
<tr><td></td><td></td><td>Total</td><td>148,771,893</td></tr>
<tr><td></td><td></td><td>Ratio</td><td>1.070</td></tr>
</table></td><td>32</td></tr>
<tr><td>Construction Plan and Period</td><td>10</td><td>- Workability is superior with small number of foundation work.</td><td>4</td><td>- Workability is inferior due to large number of Cast in Place Pile work to rock.</td><td>4</td></tr>
<tr><td>Maintenance</td><td>15</td><td>- Inferior in Maintenance due to large column base of future construction on the sea.
- Superior in Maintenance with small number of pile cap in the sea.</td><td>10</td><td>- Inferior in Maintenance due to large column base of future construction on the sea.
- Inferior in Maintenance with rarge number of pile cap in the sea.</td><td>6</td></tr>
<tr><td>STEP Clearance</td><td>10</td><td>- 85% (Preliminary Estimate)
- Large number of steel pipe pile acceptance a contribution.</td><td>10</td><td>- 32% (Preliminary Estimate)
- Small number of steel pipe pile acceptance a contribution</td><td>8</td></tr>
<tr><td>Aesthetics</td><td>5</td><td>- Slender appearance of Pier
- Column base of future construction to be exposed above water level.</td><td>3</td><td>- Slender appearance of Pier
- Column base of future construction to be exposed above water level.</td><td>3</td></tr>
<tr><td>New Technology</td><td>5</td><td>- Steel Pipe Pile Foundation is new technology in Vietnam</td><td>5</td><td>- Steel Pipe Pile Foundation is new technology in Vietnam</td><td>2</td></tr>
<tr><td>Environmental Aspect</td><td>5</td><td>- Superior in Environmental aspect with small number of excavated soil.</td><td>5</td><td>- Inferior in Environmental aspect due to large number of excavated</td><td>3</td></tr>
<tr><td>Evaluation</td><td>100</td><td>- Construction cost is highest with long construction period.
- Workability is superior with small number of foundation work.

Most Recommended</td><td>85</td><td>- The design of C.I.P. Foundation Separate type is inferior due to large statically indeterminate force and construction clearance
- Workability is inferior due to large number of Cast in Place Pile work t

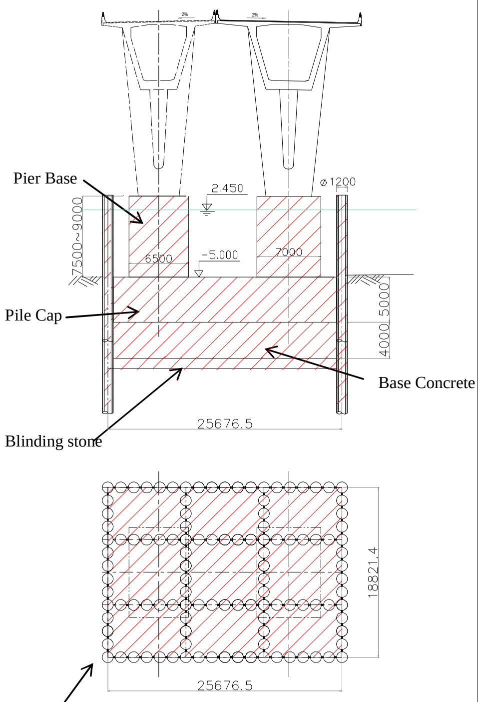
Less Recommended</td><td>62</td></tr>
</table>

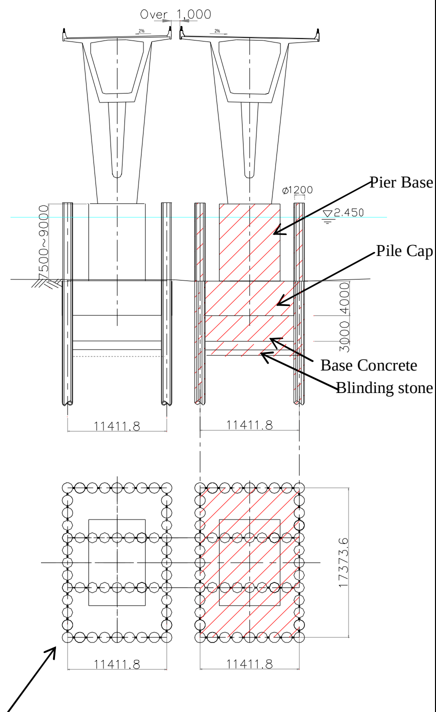
*Not consider for scour

Source: Study Team (consideration in B/D)

Table 8.3.5-2 Comparison on Foundation Style for Main Bridge

<table>
<tr><th>Evaluation Items</th><th>Max. Point</th><th colspan="2">Alternative-1
Integrated Foundation Type</th><th colspan="2">Alternative-2
Separate Foundation Type</th></tr>
<tr><td>Side View

▨ : for Interim construction</td><td></td><td colspan="2">SAPROF Study


Steel Pipe Sheet Pile (SPSP) Foundation (D=1.2m,t=16,SKY490)</td><td colspan="2">Future Construction Interim construction


Steel Pipe Sheet Pile (SPSP) Foundation (D=1.2m,t=19,SKY490)</td></tr>
<tr><td>Structural Aspect and Stability</td><td>10</td><td>- Eccentric load by pier dead load always act on foundation.
- Large number of Pile Cap concrete
- Large number of steel pipe sheet piles</td><td>6</td><td>- Consideration of construction clearance (over 1m) for future foundation construction is required.
- Small number of
- Small number of steel pipe sheet piles</td><td>8</td></tr>
<tr><td>Construction Cost (due to main items of SPSP Foundation)</td><td>40</td><td><table>
<tr><th>Quantity (for 1 foundation)</th><th></th><th>Unit Cost (VND)</th><th>Total (1,000VND)</th></tr>
<tr><td>Pile Cap + Pier Base Co</td><td>3,419m3</td><td>6,859,258</td><td>23,451,118</td></tr>
<tr><td>Steel Pipe Sheet Pile</td><td>2,507 t</td><td>44,003,858</td><td>110,318,244</td></tr>
<tr><td>Base Concrete (h=4m</td><td>1,933m3</td><td>1,723,811</td><td>3,331,506</td></tr>
<tr><td>Blinding stone (h=1m</td><td>483m3</td><td>737,139</td><td>356,156</td></tr>
<tr><td>Excavation</td><td>4,832m3</td><td>318,066</td><td>1,536,768</td></tr>
<tr><td></td><td></td><td>Total</td><td>138,993,792</td></tr>
<tr><td></td><td></td><td>Ratio</td><td>1.000</td></tr>
</table></td><td>40</td><td><table>
<tr><th>Quantity (for 1 foundation)</th><th></th><th>Unit Cost (VND)</th><th>Total (1,000VND)</th></tr>
<tr><td>Pile Cap + Pier Base Cor</td><td>1,318m3</td><td>6,859,258</td><td>9,043,521</td></tr>
<tr><td>Steel Pipe Sheet Pile</td><td>1,373 t</td><td>44,003,858</td><td>60,431,818</td></tr>
<tr><td>Base Concrete (h=3m)</td><td>595m3</td><td>1,723,811</td><td>1,025,805</td></tr>
<tr><td>Blinding stone (h=1m)</td><td>198m3</td><td>737,139</td><td>146,219</td></tr>
<tr><td>Excavation</td><td>1,587m3</td><td>318,066</td><td>504,733</td></tr>
<tr><td></td><td></td><td>Total</td><td>72,318,790</td></tr>
<tr><td></td><td></td><td>Ratio</td><td>0.520</td></tr>
</table></td><td>32</td></tr>
<tr><td>Construction Plan and Period</td><td>10</td><td>- Workability is inferior due to large number of foundation work in the sea.</td><td>4</td><td>- Workability is superior with small number of foundation work.</td><td>8</td></tr>
<tr><td>Maintenance</td><td>15</td><td>- Inferior in Maintenance due to large column base of future construction on the sea.</td><td>6</td><td>- Superior in Maintenance with small number of Maintenance points.</td><td>8</td></tr>
<tr><td>STEP Clearance</td><td>10</td><td>- 85% (Preliminary Estimate)
- Large number of steel pipe pile acceptance a contribution.</td><td>10</td><td>- 32% (Preliminary Estimate)
- Small number of steel pipe pile acceptance a contribution</td><td>8</td></tr>
<tr><td>Aesthetics</td><td>5</td><td>- Slender appearance of Pier
- Column base of future construction to be exposed above water level.</td><td>3</td><td>- Slender appearance of Pier
- Column base of future construction to not be exposed above water level.</td><td>5</td></tr>
<tr><td>New Technology</td><td>5</td><td>- Steel Pipe Pile Foundation is new technology in Vietnam</td><td>5</td><td>- Steel Pipe Pile Foundation is new technology in Vietnam</td><td>5</td></tr>
<tr><td>Environmental Aspect</td><td>5</td><td>- Inferior in Environmental aspect due to large number of excavated soil.</td><td>3</td><td>- Superior in Environmental aspect with small number of</td><td>5</td></tr>
<tr><td>Evaluation</td><td>100</td><td>- Construction cost is highest with long construction period.
- Eccentric load by pier dead load always act on foundation.
- Inferior in Aesthetics due to column base of future construction to be exposed above water level.

Less Recommended</td><td>77</td><td>- Minimum Construction cost with construction period.
- Superior in Aesthetics due to column base of future construction to not be exposed above water level.

Most Recommended</td><td>79</td></tr>
</table>

*Not consider for scour

Source: Study Team (consideration in B/D)

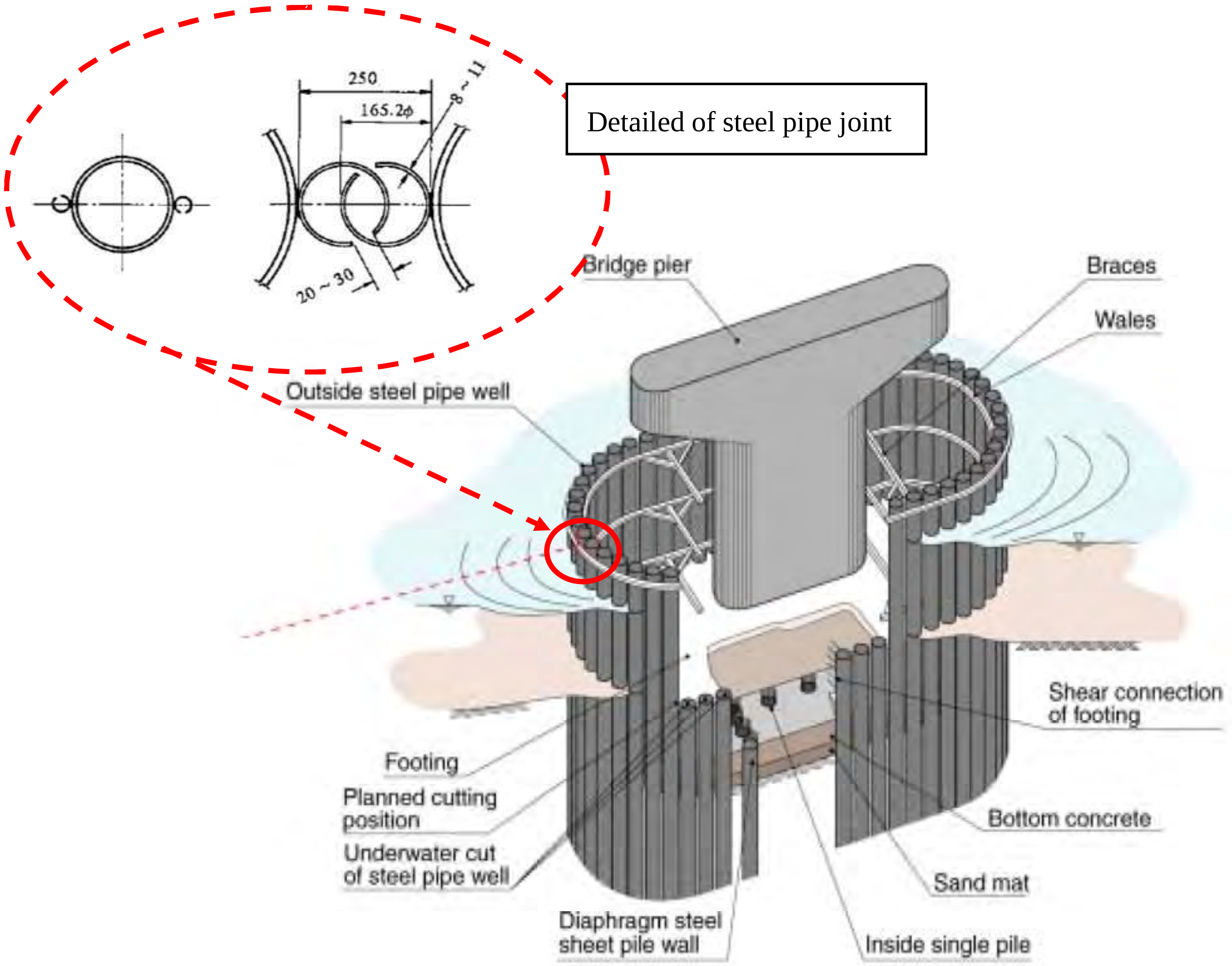
8.3.5.2 Study on Design Condition for Steel Pipe Sheet Pile

(1) General

A Steel pipe sheet pile consists of a steel pipe pile as the main component member, to with the joints illustrated in detail of following figure are attached. Compared to an ordinary steel sheet pile, it has an advantage of considerable rigidity; witch lends itself highly useful for wall structures such as earth retaining walls for deep excavation and deep water foundations.

Steel pipe sheet pile foundation is consisted of outside steel pipe sheet pile well and diaphragm steel pile sheet pile well. Open end steel pipe sheet piles are driven to the designated depth, loads from superstructure are transmitted to the upper slab and then to the sheet piles and finally to soil by friction and tip bearing.

Steel pipe sheet pile foundation lets the Outside sheet pipe well itself get up over the water surface, its joints being filled with cut off materials to serve as temporary cofferdam with temporary braces and wales. The inside of well is dried, and after a pile cap and a pier are erected there, the pipe pile temporary cofferdam planning cutting passion around above the top end of the footing is underwater cut and removed.

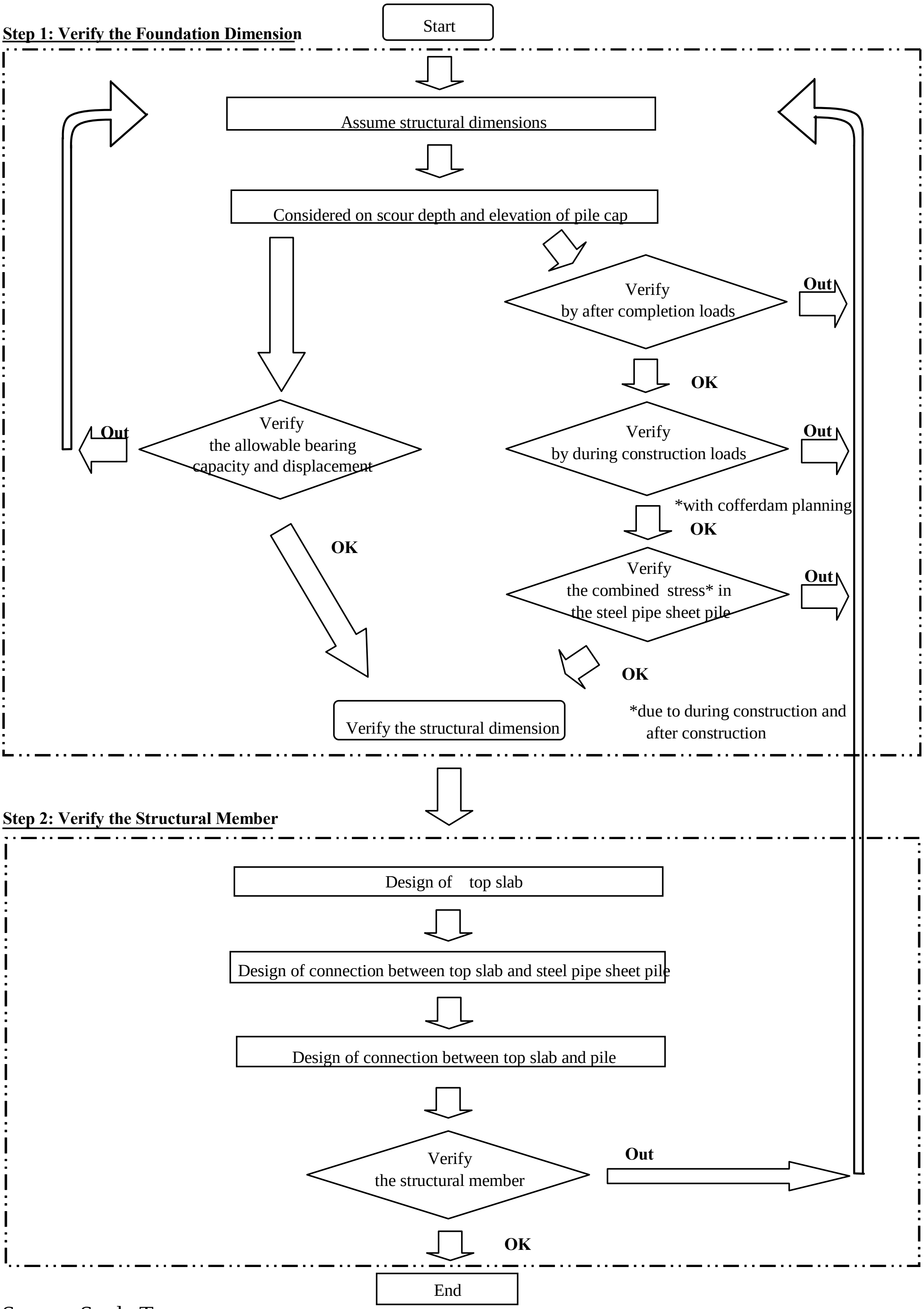


Source: Study Team

Figure 8.3.5-1 Conceptual View of Steel Sheet Pile Foundation

(2) Design Flow

Detail Design of steel pipe sheet pile foundation based on following flow.



Source: Study Team

Figure 8.3.5-2 Design Flow for basic design of steel pipe sheet pile foundation

8.3.5.3 Design Considerations

(1) Design Principal

1) Design Specifications

Basically, the bridges and structures in this project shall be designed with the Vietnamese Design Standard (22 TCN 272-05) and AASHTO-LRFD (Load and Resistance Factor Design, 3rd Edition 2004). However, the design of steel pipe sheet pile not fit for these standards, therefore it design shall be determined referring to Japanese Standard of "Specifications for Highway Bridges -Part IV" (SHB-2002).

2) Design soil condition

Boring Data

A total of 6 boreholes, two boreholes for each main bridge foundation were performed. The soil is consisted clay and silt, layers up to approximately top 30 m are clay and N-SPT values are low. Soil constants and the elevation of bearing stratum for foundation design of main bridge are decided by comparing the 2 boring logs of each foundation, the smaller N-SPT and deeper elevation were applied as follows.

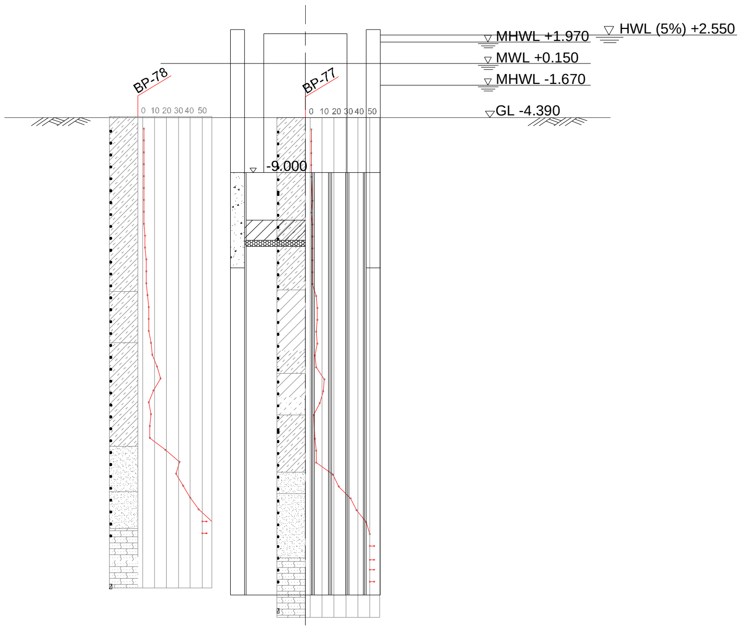
Table 8.3.5-3 Determined design boring No.

Pier No	Boring No	Boring Location
P76	BP-77	center of foundation
P77	BP-80	14m from center of foundation
P78	BP-81	center of foundation

Source: Study Team

Liquefaction

Liquefaction potential at earthquake is excluded in foundation design of main bridge due to there is no saturated soil layer having ground water level higher than 10m below the ground surface and located at a depth less than 20 m below the ground surface.



Source: Study Team

Figure 8.3.5-3 P76 Foundation with Boring No BP- 77 & BP-78

3) Loading Combination and Safety factors

The design cases and corresponding safety factor for stability and allowable stress for members is shown in the following table.

Table 8.3.5-4 Safety Factor for Bearing Capacity and Allowable Stress in Steel Pipe

Loading Combinations	Safety factor (n) for stability	Increase of allowable stress
1.Ordinary Condition : (DC+DW)+EV+CR+SH+EL+LL+WA	3.0	1.00
2.Temperature Condition : (DC+DW)+EV+CR+SH+EL+LL+WA + TG+TU	3.0	1.15
3.Wind Condition: (DC+DW)+EV+CR+SH+EL+LL +WA +WS	2.0	1.25
4.Seismic Condition: (DC+DW)+EV+CR+SH+EL+WA' +EQ	2.0	1.50
5.Vessel Collision force (DC+DW)+EV+CR+SH+EL+LL+WA' + CV	2.0	1.70

DC = Dead load of structural components and non-structural attachments
DW = Dead load of wearing surfaces and utilities
EV = Vertical pressure from dead load of earth fill
CR = Creep
SH = Shrinkage
EL = Accumulated locked-in force effects resulting from the construction process, including the secondary forces from post-tensioning
LL = Vehicular live load
TG = Temperature gradient
TU = Uniform temperature
WA,WA' = Water load (WA': due to MWL)
WS = Wind load on structure
EQ = Earthquake, Includes effect of liquefaction due to earthquake
CV = Vessel collision force

Source: Article 4 of Part IV, SHB-2002 & Article 4 of 22 TCN 272-05

4) Material

Steel Pipe Sheet Pile

Two types of steel pipe of steel pipe sheet pile Grade SKY400 and Grade SKY 490 based on the Japanese Standard JIS 5530 or equivalent international standard shall be used. The properties and strength are as follows.

Table 8.3.5-5 Properties and Stress Limit of Steel Pipe for Steel Pipe Sheet Pile

Type	Yield Strength f y (MPa)	Tensile Strength f u (MPa)	Modulus of Elasticity (Mpa)
Grade SKY 400	235	400	200,000
Grade SKY 490	315	490	200,000

Source: JIS 5530

Estimated Corrosion Thickness of Steel Pile

The estimated corrosion thickness of steel pipe pile and steel pipe sheet pile based on the Report No PMU2/110422-1 shall be used. The design of corrosion thickness is as follows.

Table 8.3.5-6 Design of Estimated Corrosion Thicknesses

	Cast against earth	Direct exposure to selt water
Estimated Corrosion Thickness	2mm	7mm

Source: Study Team

(2) Design Model

1) General

The steel pipe sheet pile foundation has a very wide range of βLe, which indicates the applicable scope of the design method, and generally belongs to elastic foundations of finite length. Judging from βLe, some are regarded as an elastic foundation with a value less than 1, however, the steel pipe sheet pile foundation is a structure consisting of steel pipe sheet pile mutually joined by joint pipes of smaller rigidity than the steel pipe body and with mortar filled in the joint pipes, and a shear slippage deformation easily occurs in it. Therefore, verification of the slippage at the foundation bottom may be omitted. That is, stability should be verified on vertical bearing capacity and horizontal displacement.

An outline of the stability calculation model used in verification for ordinary, storm and seismic condition is shown in Table 8.3.5-7.

Table 8.3.5-7 Stability Calculation model

		Verification for ordinary conditions, storm and Level 1 earthquake conditions	
		$B \leqq 30$m , $L/B > 1$ and $\beta L_e > 1$	$B > 30$m , $L/B \leqq 1$ or $\beta L_e \leqq 1$
Design model		Finite-length beam on an elastic floor (Beam Model)	Analysis by an imaginary well beam that considering shear slippage of the joints (Well Model)
Foundation body	Steel pipe sheet pile	Linear	
	Shear resistance of joint	Evaluation by composite efficiency and moment distribution factor	Bilinear
Ground hesitance element	Horizontal ground resistance at the foundation front face	Linear considering strain dependency	
	Horizontal shear ground resistance at the foundation peripheral faces	Included in the horizontal resistance of the front ground	
	Vertical shear ground resistance at the foundation outer and inner peripheral faces	Included in the bearing capacity of the steel pipe sheet pile	
	Vertical ground resistance at the foundation bottom face	Linear	Linear
	Horizontal shear ground resistance at the foundation bottom faces	Linear	Linear

Source: Article 13 of Prt IV, SHB-2002

2) Determined of Design Model

Design model for Steel Pile Sheet Pile foundation design of main bridge are decided by table 8.3.5-8 as follows.

Table 8.3.5-8 Determined design model

			D(m)	L(m)	L/D	β(m^{-1})	Le(m)	βLe	Design Model*	
P76	Normal	LL	21.469 <30m	35.50	1.6535 >1	0.0340	33.69	1.145 >1	Beam	Beam
		TT	12.782 <30m	35.50	2.7773 >1	0.0394	33.69	1.327 >1	Beam	
	Seismic	LL	21.469 <30m	35.50	1.6535 >1	0.0328	36.81	1.207 >1	Beam	Beam
		TT	12.782 <30m	35.50	2.7773 >1	0.0378	36.81	1.391 >1	Beam	
P77	Normal	LL	21.469 <30m	35.50	1.6535 >1	0.0345	30.19	1.042 >1	Beam	Beam
		TT	12.782 <30m	35.50	2.7773 >1	0.0429	30.19	1.295 >1	Beam	
	Seismic	LL	21.469 <30m	35.50	1.6535 >1	0.0324	33.92	1.099 >1	Beam	Beam
		TT	12.782 <30m	35.50	2.7773 >1	0.0392	33.92	1.330 >1	Beam	
P78	Normal	LL	21.469 <30m	35.50	1.6535 >1	0.0426	23.49	**1.001 ≒1**	**Well**	**Well**
		TT	12.782 <30m	35.50	2.7773 >1	0.0499	23.49	1.172 >1	Beam	
	Seismic	LL	21.469 <30m	35.50	1.6535 >1	0.0354	29.09	1.030 >1	Beam	Beam
		TT	12.782 <30m	35.50	2.7773 >1	0.0443	29.09	1.289 >1	Beam	

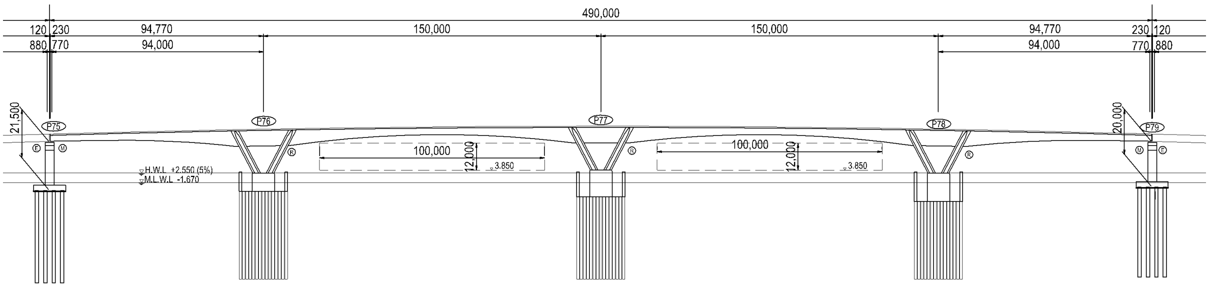
Note) Beam : Finite-length beam on an elastic floor (Beam Model)
Well : Imaginary well beam that considering shear slippage of the joints (Well model)

8.3.6 Detailed Design of Main Bridge

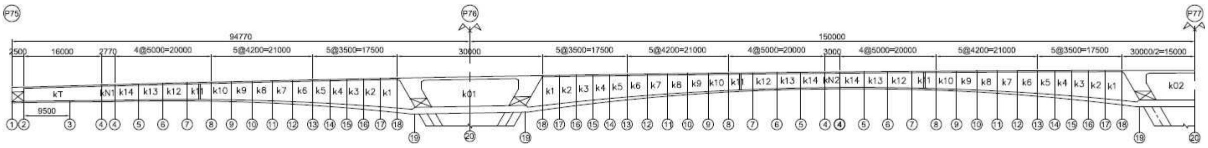
8.3.6.1 Design Condition

1) Profile

The profile of Main Bridge is as shown in the figure below.



(a) Whole Profile of Main Bridge



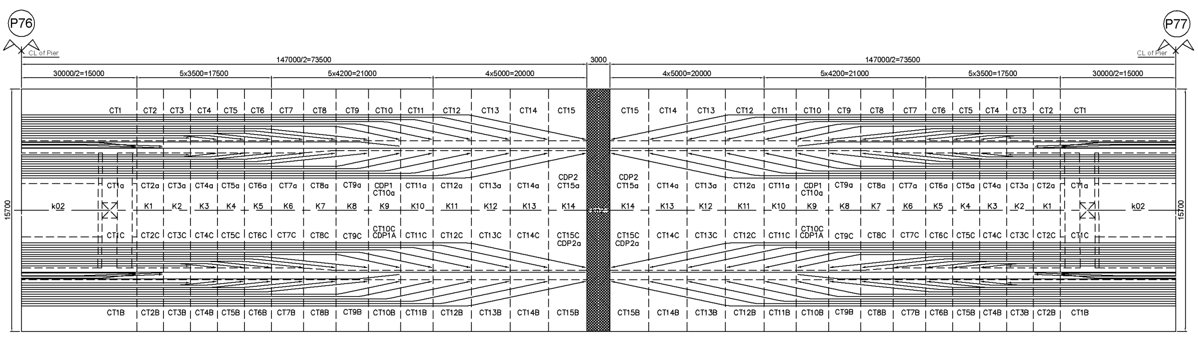
(b) Segments and Sections of Superstructure

Source: Study Team

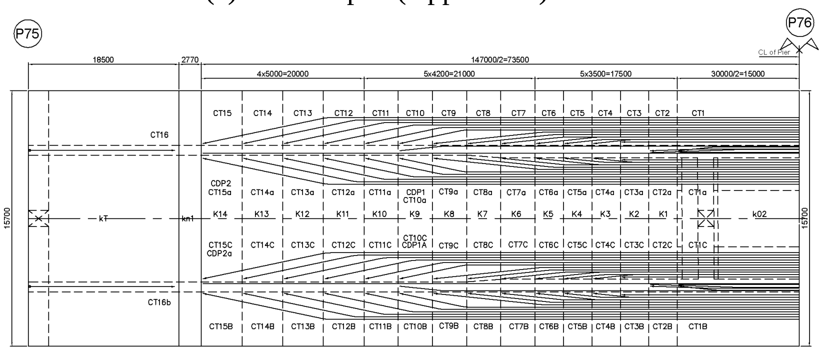
Figure 8.3.6-1 Profile of Main Bridge

2) Arrangement of PC Tendons

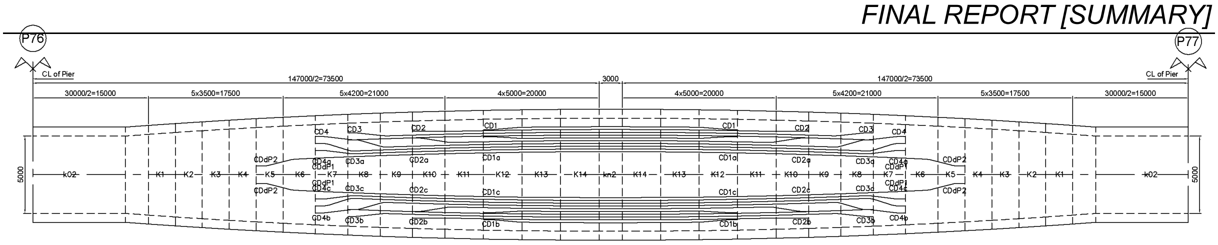
The arrangement of PC tendons is shown in the figure below.



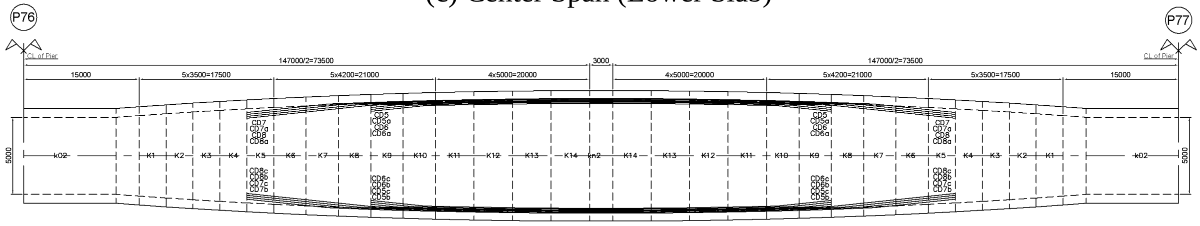
(a) Center Span (Upper Slab)



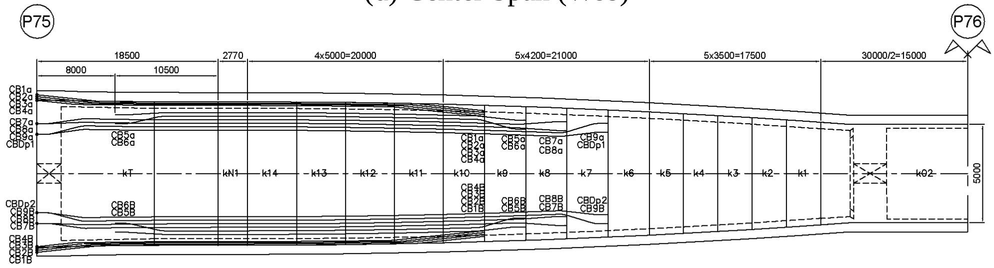
(b) Side Span (Upper Slab)



(c) Center Span (Lower Slab)



(d) Center Span (Web)



(e) Side Span (Lower Slab and Web)

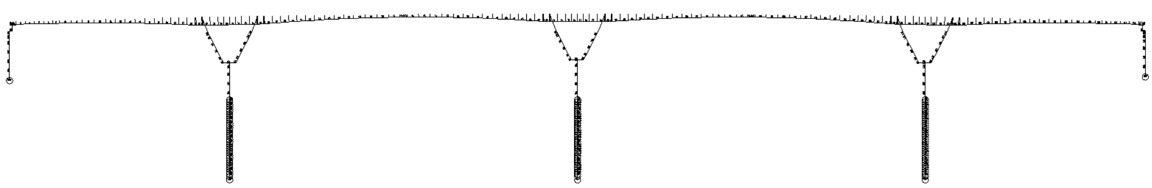
Source: Study Team

Figure 8.3.6-2 Arrangement of PC Tendons

8.3.6.2 Design of Superstructure for Longitudinal Direction

(1) Model for Analysis

The structural model for the analysis is shown in the figure below.



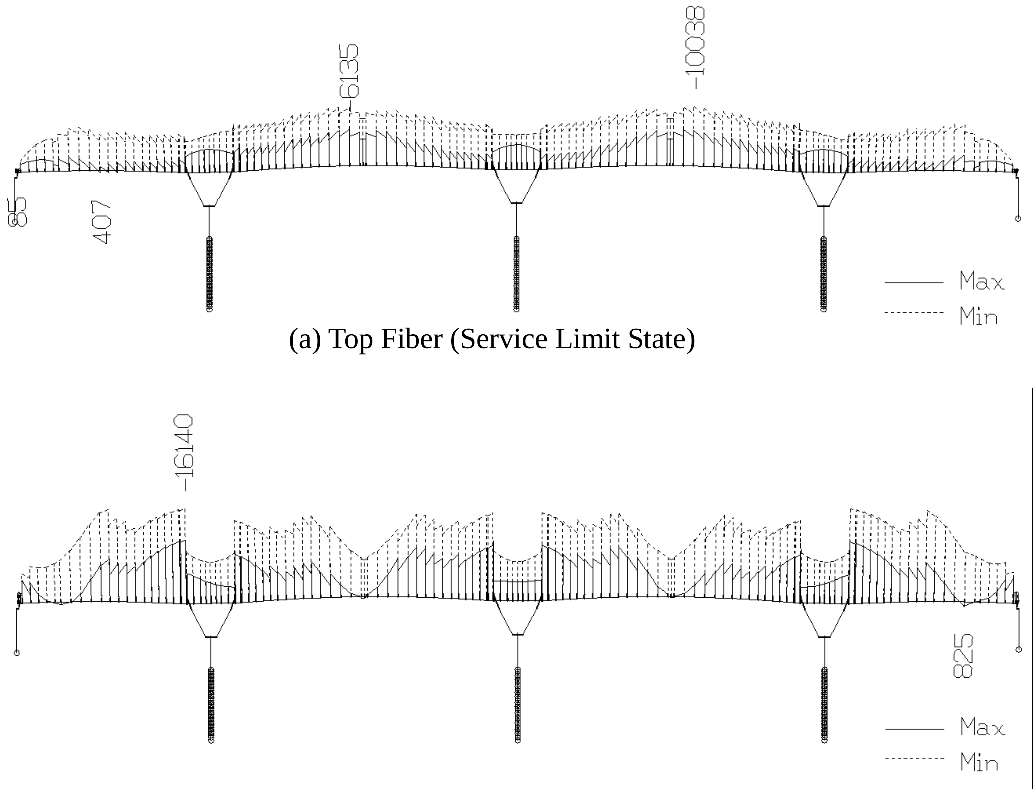
Source: Study Team

Figure 8.3.6-3 Model for Structural Analysis

(2) Results

1) Fiber Stress

All the resultant stresses in superstructure in Service Limit State are less than the limit stress of full prestressing, 3.2 MPa. The following figure shows the results of fiber stress in one of the unfavorable combinations in the Service Limit.



(a) Top Fiber (Service Limit State)

(b) Bottom Fiber (Service Limit State)

Source: Study Team

Figure 8.3.6-4 Fiber Stress

(3) Reinforcement

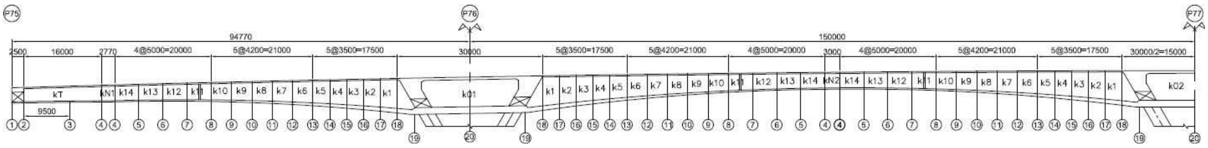
1) Reinforcement for Bending Moment in Longitudinal Direction

The nominal flexural resistance of the girder according to the formula 5.7.3.2.2-1 of the specification for bridge design 22TCN272-05 with minimum reinforcement is always larger than the 1.33 times the factored moment required by applicable strength load combinations specified in Section 8.1.3. Therefore, minimum reinforcement, approximately 0.3% of gross area in accordance with the formula 5.7.3.3.2-1 of 22TCN272-05, is applied for the main girder.

2) Reinforcement for Shear Force in Longitudinal Direction

The required amount of reinforcement is summarized in the table below.

Table 8.3.6-1 Required Reinforcement for Shear Force in Longitudinal Direction



Section	Factored Shear Force Vu min (kN)	Factored Shear Force Vu max (kN)	Component of Prestressing Force Vp (kN)	Nominal Shear Resistance of Concrete Vc (KN)	Required Shear Resistance by Reinforcement Vs (kN)	Required Area of Reinforcement As (cm^2)*
S1	-7170	-12541	2469	2797	8669	12.6
S2	-5671	-10600	1695	2871	7213	11.1
S3	1213	-2663	-368	2583	744	1.8
S4	2767	-1265	-1126	2425	0	1.8
S5	5136	1091	-989	2350	2368	3.4
S6	7358	3180	-1228	2645	4303	4.6
S7	9621	5168	-1211	3231	6247	4.5
S8	11935	7096	-2904	3531	6826	5.0
S9	14050	8808	-2666	3678	9266	8.3
S10	16193	10523	-3638	3821	10534	8.9
S11	18390	12270	-4954	4035	11445	9.3
S12	21028	14444	-5217	5954	12193	9.7
S13	23439	16440	-5853	6317	13873	10.7
S14	25512	18168	-6983	6736	14628	10.5
S15	27652	19977	-7873	7164	15688	10.4
S16	29859	21867	-9177	7589	16411	10.1
S17	32133	23841	-11979	8046	15679	8.9
S18	34479	25933	-14151	8537	15622	7.3
S21	34798	26196	-13729	8606	16330	7.8

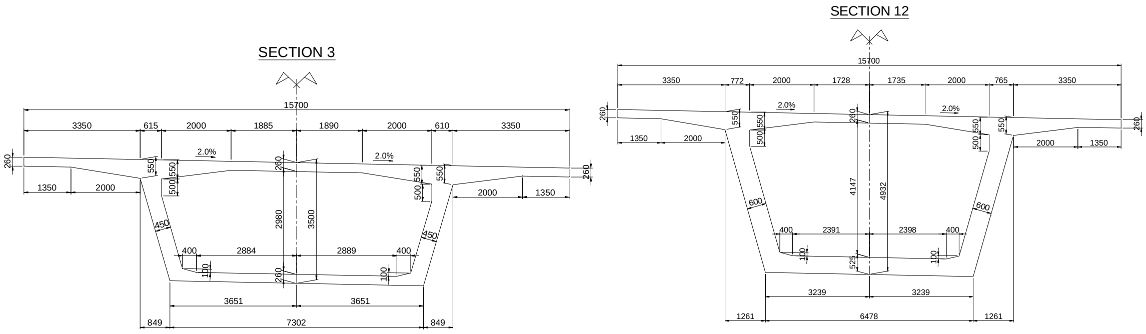
* Spacing of Stirrup : 0.15m,   number of stirrup in a section: 4

Source: Study Team

8.3.6.3 Design of Superstructure in Transversal Direction

(1) Sections for Analysis

The design calculation was performed for the two unfavorable sections, Section 3 with 450mm web at the center of the span and Section 12 with 600mm, shown in the following figure.



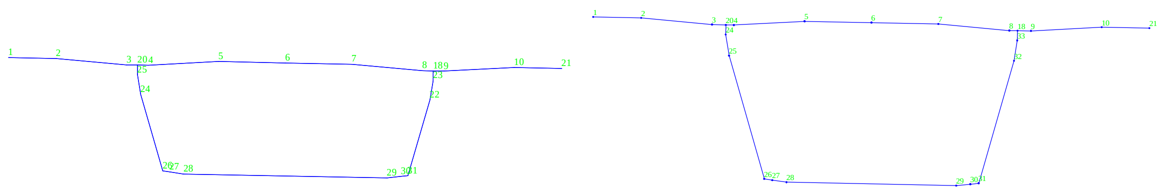
(a) Section 3 (b) Section 12

Source: Study Team

Figure 8.3.6-5 Sections for Transversal Analysis

(2) Model of Analysis

The structural models for the analysis are shown in the figure below.



(a) Section 3 (b) Section 12

Source: Study Team

Figure 8.3.6-6 Model for Transversal Analysis

(3) Result of Analysis

1) Service Limit State

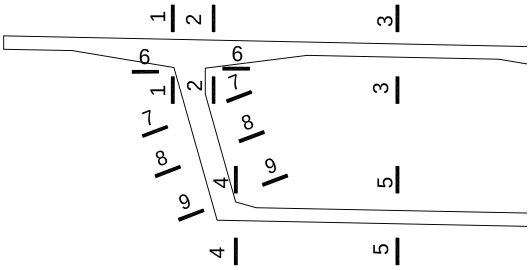
All the resultant stresses in the upper slab in Service Limit State are less than the limit stress of full prestressing, 3.2 MPa. The following figure shows the results of fiber stress in one of the unfavorable combinations in the Service Limit.

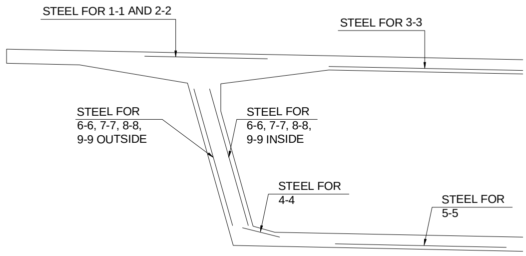
(4) Reinforcement

1) Reinforcement for Bending Moment in Transversal Direction

The required amount of reinforcement is summarized in the table below.

Table 8.3.6-2 Required Reinforcement in Transversal Direction





Location	Required Amount of reinforcement		Adopted Amount of Reinforcement	
	Section 3	Section 12	Section 3	Section 12
1-1	-	-	D14@150mm = 10cm^2	D14@150mm = 10cm^2
2-2	-	-	D14@150mm = 10cm^2	D14@150mm = 10cm^2
3-3	-	-	D14@150mm = 10cm^2	D14@150mm = 10cm^2
4-4	16cm^2	12cm^2	D18@150mm = 17cm^2	D16@150mm = 13cm^2
5-5	5cm^2	5cm^2	D14@150mm = 10cm^2	D14@150mm = 10cm^2
6-6 inside	11cm^2	9cm^2	D16@150mm = 13cm^2	D16@150mm = 13cm^2
7-7 inside	10cm^2	8cm^2	D16@150mm = 13cm^2	D16@150mm = 13cm^2
8-8 inside	11cm^2	10cm^2	D16@150mm = 13cm^2	D16@150mm = 13cm^2
9-9 inside	12cm^2	13cm^2	D16@150mm = 13cm^2	D16@150mm = 13cm^2
6-6 outside	21cm^2	17cm^2	D22@150mm = 25cm^2	D18@150mm = 17cm^2
7-7 outside	22cm^2	17cm^2	D22@150mm = 25cm^2	D18@150mm = 17cm^2
8-8 outside	20cm^2	7cm^2	D22@150mm = 25cm^2	D18@150mm = 17cm^2
9-9 outside	5cm^2	5cm^2	D22@150mm = 25cm^2	D18@150mm = 17cm^2

Source: Study Team

2) Reinforcement for Shear Force in Transversal Direction

It was verified that the capacities of the sections are beyond the maximum shear forces.

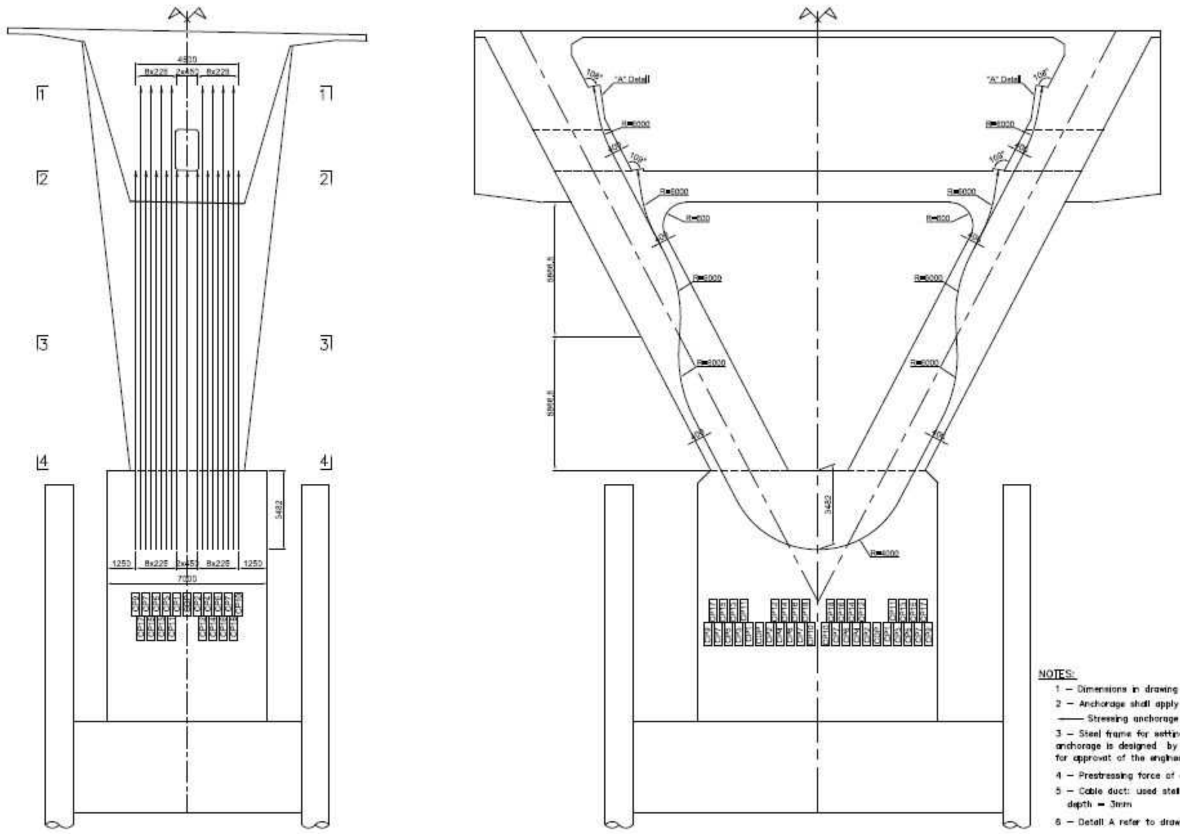
8.3.6.4 Design of Substructure of Main Bridge

(1) Structural Analysis

The results of structural analysis for longitudinal direction presented in Section 8.3.6.2 are also used for designing the substructure.

(2) Conditions of Analysis

The geometric parameters are as presented in the previous section. The cross sections of piers are shown in the figure below. As shown in the figure, 18 PC tendons are installed in the V-shaped walls for avoiding cracking in Service Limit State.



(a) Transversal Section of Pier

(b) Longitudinal Section of Pier

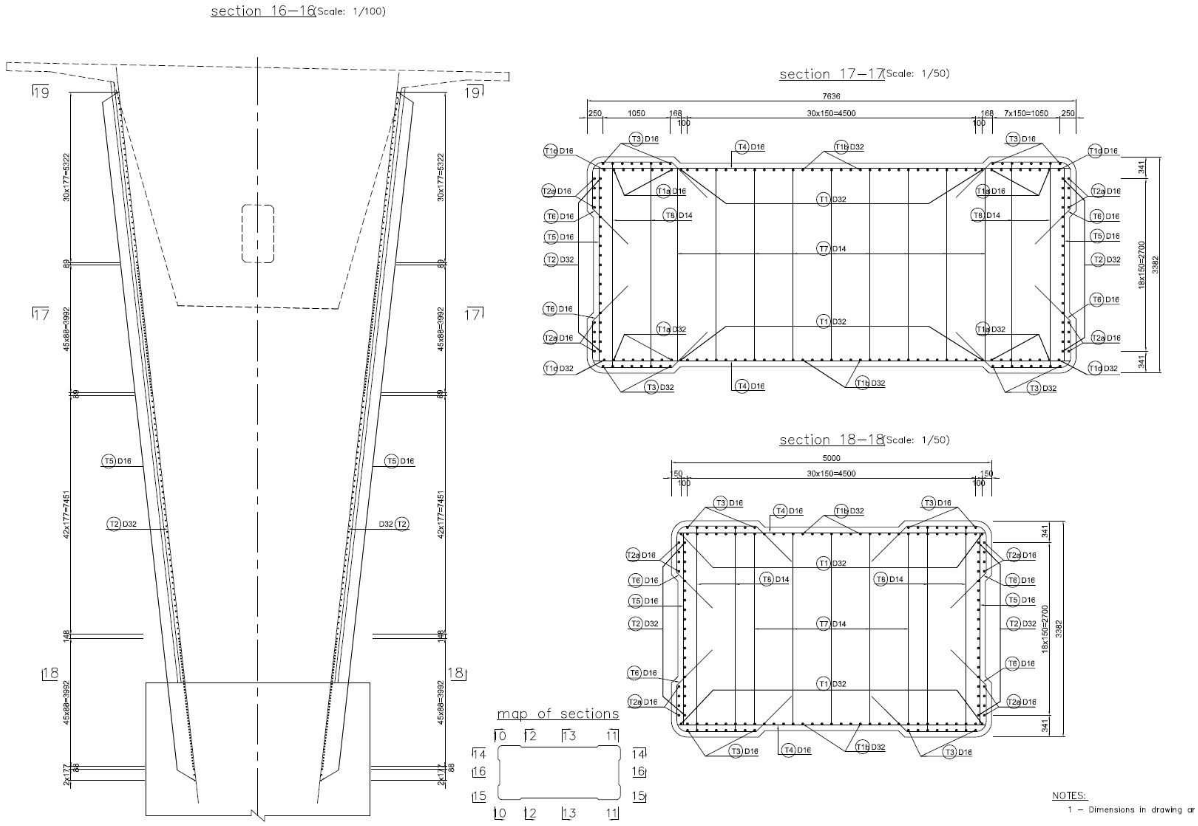
Source: Study Team

Figure 8.3.6-7 Arrangement of PC Tendons

(3) Reinforcement of Piers

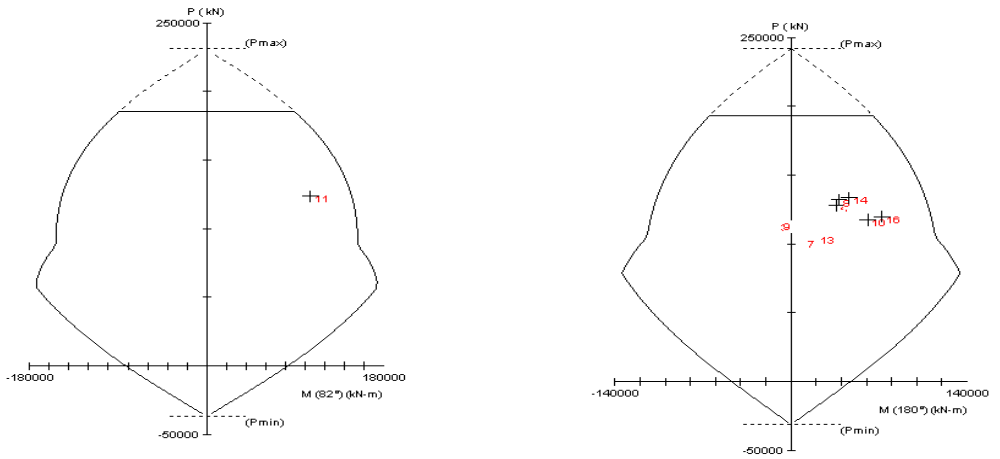
1) Reinforcement of V-shaped Wall

The reinforcement in the V-shaped wall is shown in the figure below. The relationships between the resistance capacity and sectional forces by unfavorable loading combinations in Strength Limit State are shown in the following figure.



Source: Study Team

Figure 8.3.6-8 Reinforcement of V-shaped Wall



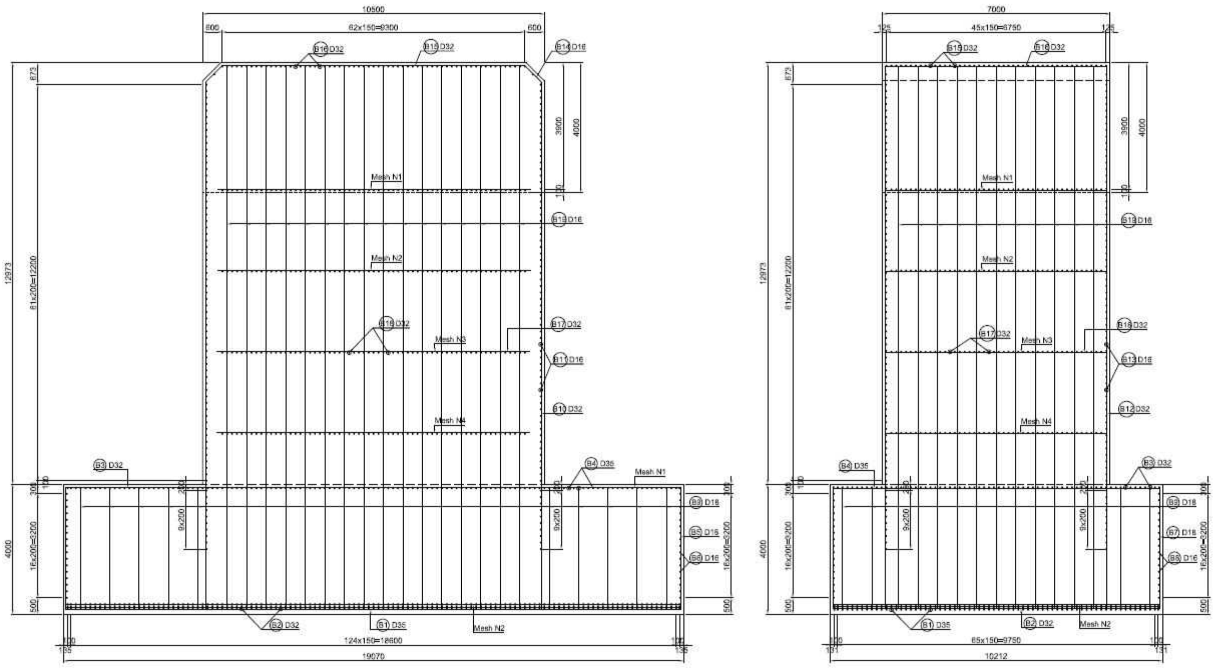
(a) Bottom Section of V-shaped Wall (b) Top Section of V-shaped Wall

Source: Study Team

Figure 8.3.6-9 Relationships between resistance capacity and sectional force in Pier Members

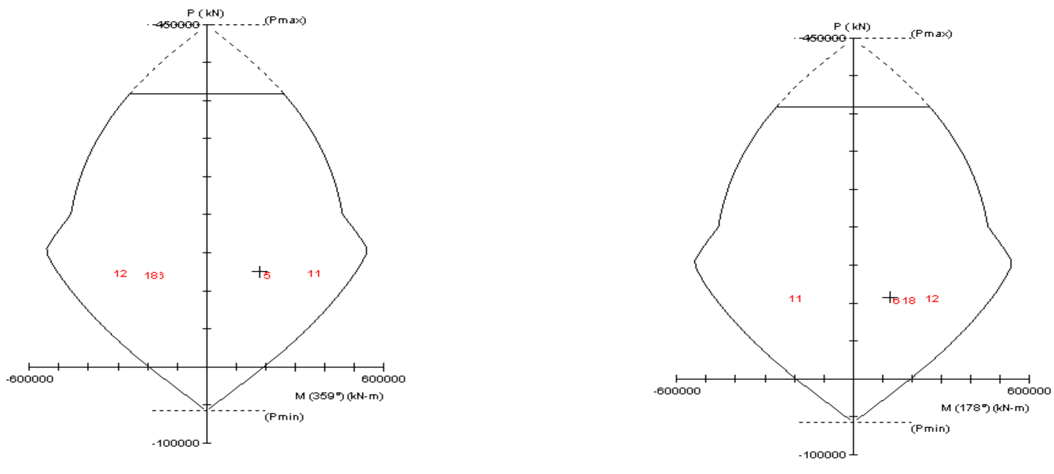
2) Reinforcement of Lower Pier Column

The reinforcement in the lower pier column is shown in the figure below. The relationships between the resistance capacity and sectional forces by unfavorable loading combinations in Strength Limit State are shown in the following figure.



Source: Study Team

Figure 8.3.6-10 Reinforcement of Lower Pier Column and Pile Cap



(a) Bottom Section of Lower Pier Column (b) Top Section of Lower Pier Column

Source: Study Team

Figure 8.3.6-11 Relationships between resistance capacity and sectional force in Pier Members

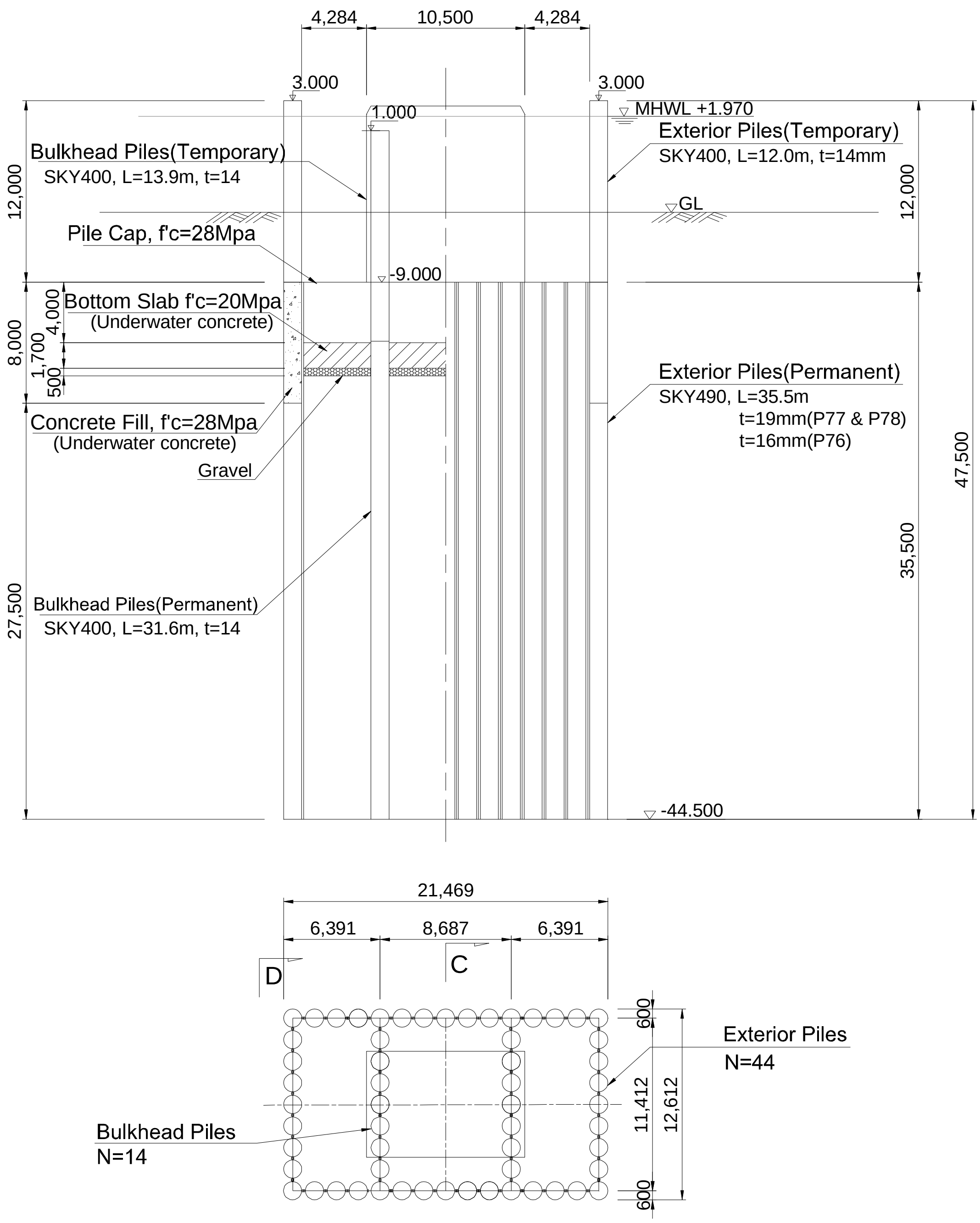
8.3.6.5 Design of Foundation of Main Bridge

(1) General

1) Design Results

Figure 8.3.6-12 shows major dimensions and materials of Steel sheet pipe pile foundations for P76~78 as design results. Dimensions and materials of steel pipe sheet pile for all foundation are same, only thickness of exterior pile at permanent part is different (t=19 for P77 & P78, t=16 for P76).

Material of steel pipe sheet piles is SKY400 except exterior sheet pile at permanent part is SKY490.



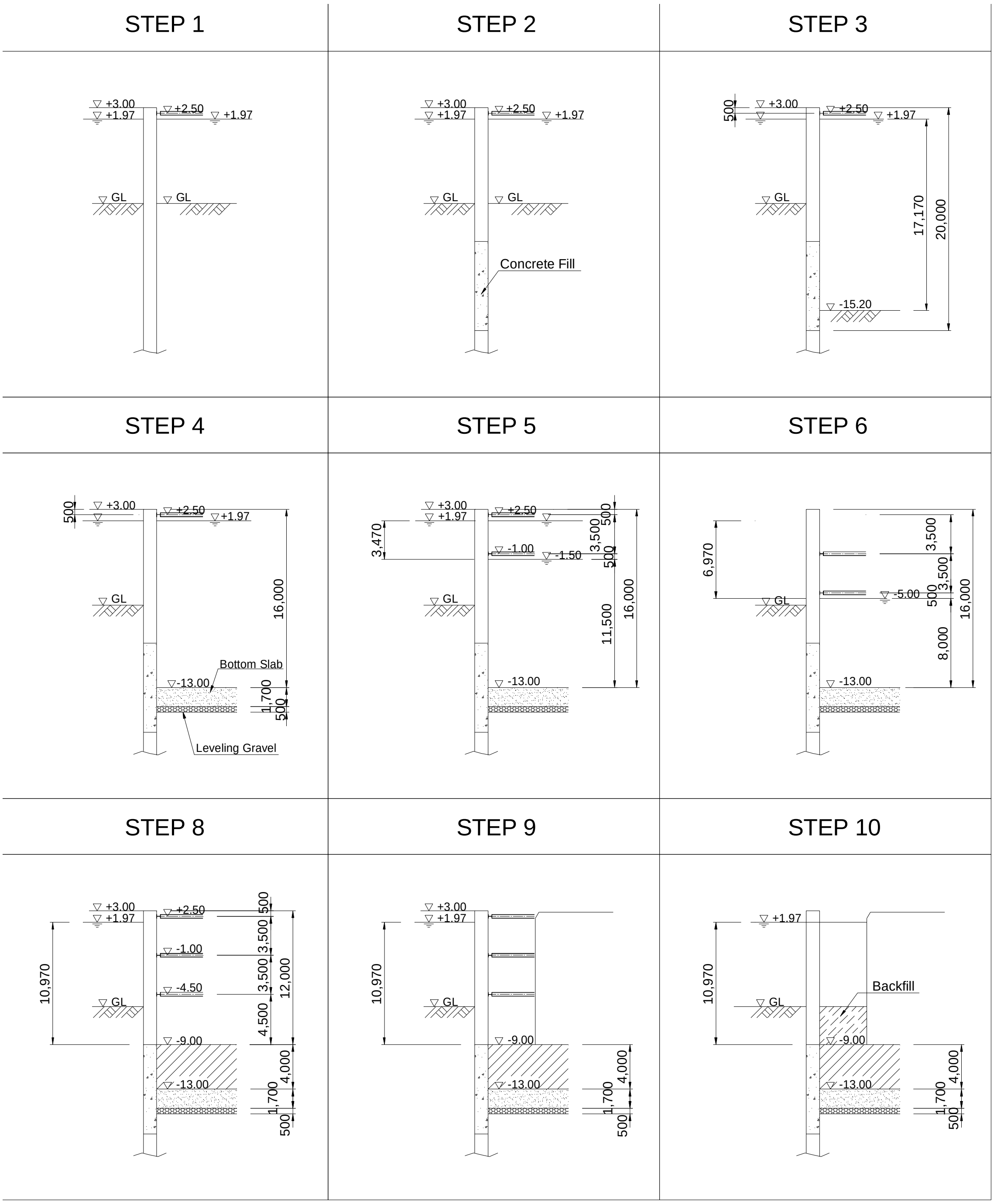
Source: Study Team

Figure 8.3.6-12 Major Dimension and Materials used for SPSP Foundation for P76~P78

2) Construction Step

The section design of external sheet pile, it was required to combine pile stress at during construction and at after construction. Therefore, in order to reduce residual stress in external sheet piles due to hydrostatic with soil pressure during construction, construction step was planed to cast the bottom slab concrete by keeping water inside cofferdam at +1.97m (assumed construction water level) at before the draining inside cofferdam.

In the scour depth at during construction, it was neglected due to safety design.



Source: Study Team

Figure 8.3.6-13 Plan of Construction Step

(2) Design Results

1) Design steel pipe sheet pile

A summary of calculation results for steel pipe sheet pile foundation is shown as following tables. And the stress diagrams of exterior sheet piles is shown as following figures.

<u>Longitudinal direction</u>

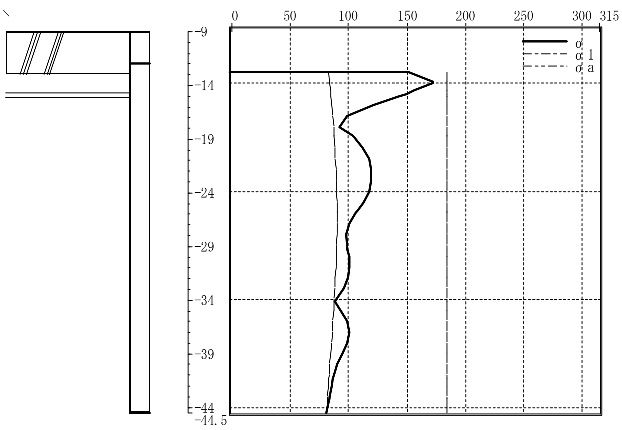
Table 8.3.6-3 Design Results of SPSP for Longitudinal Direction

Item			Unit	P76		P77		P78	
				Ordinary	Seismic	Ordinary	Seismic	Ordinary	Seismic
Forces*2		Vo	kN	127,238.5	126,156.5	126,828.0	122,009.0	120,699.7	121,049.7
		Ho	kN	5,311.0	22,663.0	1,798.0	19,890.0	7,759.0	21,844.0
		Mo	kN.m	52,921.0	252,181.0	7,783.0	162,160.0	49,478.0	220,995.0
Displacement*2									
At Top of Top Slab	Displacement	δ1	cm	0.762	2.524	0.207	1.785	1.160	2.510
	Allowable	δa	cm	5.000	5.000	5.000	5.000	5.000	5.000
Pile Bearing*2 (L=47.5m)									
Vertical Reaction	Max	Rmax	kN/pile	2,547	3,319	2,504	3,199	2,731	3,549
	Min	Rmin	kN/pile	2,088	1,277	2,355	1,476	1,893	1,089
	Bearing	Ra	kN/pile	3,446	5,169	3,046	4,569	3,520	5,353
	Pull-out	Pa	kN/pile	-926	-1,417	-1,193	-1,728	-939	-1512
Pile Stresses									
Exterior (SKY490)	Thickness	t	mm	16		19			
	After Construction	σ_1*2	MPa	85.33	137.74	57.65	93.61	67.88	107.91
	During construction	σ_2	MPa	87.55	87.55	90.04	90.04	97.41	97.41
	Combined	σ_{max}	MPa	172.87	225.29	147.68	183.65	165.29	205.32
	Allowable	σa	MPa	185.00	280.00	185.00	280.00	185.00	280.00
Bulkhead*2 (SKY400) t=14mm	After Construction	σ_1	MPa	96.64	137.16	58.79	97.20	76.69	119.36
	Allowable	σa	MPa	140.00	210.00	140.00	210.00	140.00	210.00

*1:Designed by Well Model according

*2:due to after construction loads

Source: Study Team



Longitudinal Direction – Ordinary Condition

Figure 8.3.6-14 Stress Diagram of SPSP for P76

Transversal direction

Table 8.3.6-4 Design Results of SPSP for Transversal Direction

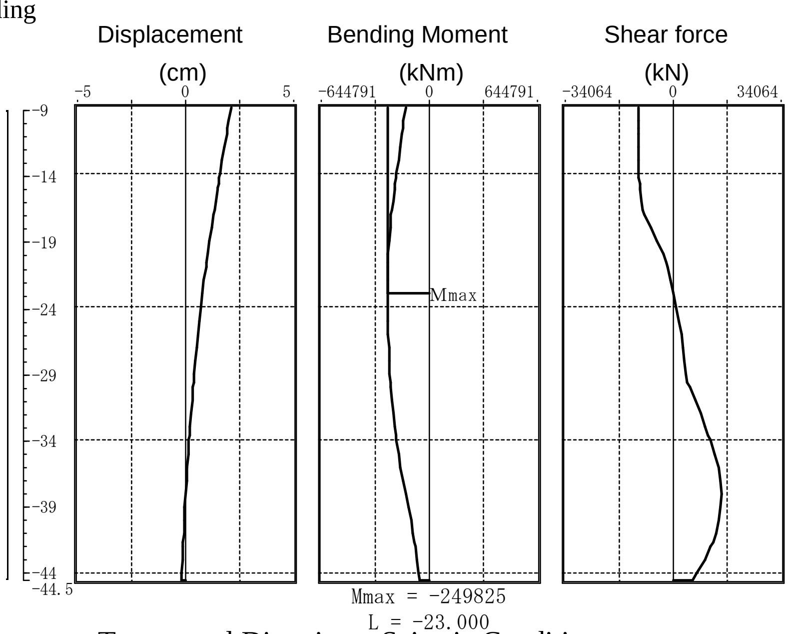
Item			Unit	P76		P77		P78	
				Ordinary	Seismic	Ordinary	Seismic	Ordinary	Seismic
Forces*2		Vo	kN	127,238.5	126,156.5	119914.0	122009.0	113,881.7	121,049.7
		Ho	kN	1,495.0	11,356.0	3027.0	20317.0	5,424.0	15,920.0
		Mo	kN.m	2,613.0	263,971.0	3742.0	484289.0	-7,314.0	331,268.0
Displacement*2									
At Top of Top Slab	Displacement	δ1	cm	0.174	1.819	0.344	4.080	0.753	3.274
	Allowable	δa	cm	5.000	5.000	5.000	5.000	5.000	5.000
Pile Bearing*2 (L=47.5m)									
Vertical Reaction	Max	Rmax	kN/pile	2,338	2,431	2347	2991	2,300	2,807
	Min	Rmin	kN/pile	2,296	2,164	2247	1684	2,064	1,831
	Bearing	Ra	kN/pile	3,446	5,169	3,046	4,569	3,520	5,353
	Pull-out	Pa	kN/pile	-870	-1,417	-1,193	-1,728	-939	-1512
Pile Stresses									
Exterior (SKY490)	Thickness	t	mm	16		19			
	After Construction	σ_1*2	MPa	71.67	132.92	55.01	148.57	52.69	120.78
	During construction	σ_2	MPa	92.39	92.39	95.69	95.69	103.08	103.08
	Combined	σ_{max}	MPa	164.06	225.31	150.70	244.26	155.77	223.86
	Allowable	σa	MPa	185.00	280.00	185.00	280.00	185.00	280.00
Bulkhead*2 (SKY400) t=14mm	After Construction	σ_1	MPa	87.96	136.93	57.23	142.13	61.00	124.35
	Allowable	σa	MPa	140.00	210.00	140.00	210.00	140.00	210.00

*1:Designed by Well Model according

*2:due to after construction loads

*:Designed by Well Model according

Source: Study Team



Transversal Direction – Seismic Condition

Figure 8.3.6-15 Calculation results of Steel Pipe Sheet Pile for P7

2) Design of top slab

A summary of calculation results for Top Slab is shown as following tables.

<u>Longitudinal direction</u>

b = 100.0 (cm), h = 400.0 (cm)

The lower tensile(As = 228.000 (cm^2))

3layers reinforcement cover, 130 (mm) D38 @ 150

The upper tensile(As = 76.000 (cm^2))

1layer reinforcement cover, 100 (mm) D38 @ 150

Table 8.3.6-5 Design Results of Top Slab for Longitudinal Direction

				P76		P77		P78	
			Unit	Ordinary	Seismic	Ordinary	Seismic	Ordinary	Seismic
Lower tensile	Bending moment	MA	kN.m	6934.0	10072.0	6857.0	9339.0	7529.0	10284.0
	Necessary reinforcement	Asr	cm^2	115.856	00.327	129.561	92.717	142.920	102.531
	Neutral axis	x	cm	130.0	30.0	130.0	130.0	130.0	130.0
	Stresses	σc σs	N/mm^2 N/mm^2	3.20 94.74	4.64 137.61	3.16 93.69	4.30 127.61	3.47 102.86	4.74 140.51
	Resultant tensile force Reinforcement requirements	T As	kN cm^2	3081.7 171.203	476.3 149.209	3047.6 190.474	4150.8 138.361	3346.0 209.126	4570.5 152.349
Upper tensile	Bending moment	MA’	kN.m	5166.0	1901.0	6492.0	3406.0	5565.0	2854.0
	Necessary reinforcement	Asr	cm^2	0.000	0.000	0.000	0.000	0.000	0.000
	Neutral axis	x	cm	7.5	7.5	7.5	7.5	7.5	7.5
	Stresses	σc σs	N/mm^2 N/mm^2	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
	Resultant tensile force Reinforcement requirements	T As	kN cm^2	0.0 0.000	0.0 0.000	0.0 0.000	0.0 0.000	0.0 0.000	0.0 0.000
Allowable stresses		σca σsa	N/mm^2 N/mm^2	9.00 180.00	14.00 300.00	9.00 160.00	14.00 300.00	9.00 160.00	14.00 300.00
Average shearing force		QB τm τa1’	kN N/mm^2 N/mm^2	1676.0 0.44 0.72	2330.0 0.62 1.08	1614.0 0.43 0.72	2128.0 0.56 1.08	1715.0 0.46 0.72	2303.0 0.61 1.08
Average shearing force		S τm τa1’	kN N/mm^2 N/mm^2	1801.0 0.48 0.72	517.0 0.67 1.08	1692.0 0.45 0.72	2237.0 0.59 1.08	1838.0 0.49 0.72	2469.0 0.65 1.08
Shearing force carried by concrete		Sca	kN	2714.0	4071.0	2714.0	4071.0	2714.0	4071.0
Diagonal tension reinforcement	Shearing force	Sh’	kN	0.0	0.0	0.0	0.0	0.0	0.0
	Longitudinal spacing	s	cm	90.0	90.0	90.0	90.0	90.0	90.0
	Reduction coefficient	Cds	—	0.455	0.455	0.455	0.455	0.455	0.455
	Allowable tensile stresses	σsa	N/mm^2	180.00	300.00	160.00	300.00	160.00	300.00
	Used reinforcement	Aw	cm^2	2.207	2.207	2.207	2.207	2.207	2.207
	Necessary reinforcement	Awreq	cm^2	0.000	0.000	0.000	0.000	0.000	0.000

Source: Study Team

Transversal direction

b = 100.0 (cm) , h = 400.0 (cm)

The lower tensile(As = 158.840 (cm^2))

layer 1~3 reinforcement cover, 168 (mm), D32 @ 150

The upper tensile(As = 52.947 (cm^2))

layer 1 reinforcement cover, 100 (mm), D32 @ 150

Table 8.3.6-6 Design Results of Top Slab for Transverse Direction

			Unit	P76 Ordinary+W	P76 Seismic	P77 Ordinary	P77 Seismic	P78 Ordinary	P78 Seismic
Lower tensile	Bending moment	MA	kN.m	4610.0	6008.0	3624.0	8130.0	3485.0	6800.0
	Necessary reinforcement	Asr	cm^2	60.707	59.282	67.278	81.083	64.616	67.349
	Neutral axis	x	cm	111.7	111.7	111.7	111.7	111.7	111.7
	Stresses	σc	N/mm^2	2.46	3.20	1.93	4.32	1.85	3.62
		σs	N/mm^2	89.61	116.77	70.38	157.92	67.69	132.09
	Resultant tensile force	T	kN	2049.0	2670.1	1610.5	3613.3	1548.8	3022.3
	Reinforcement requirements	As	cm^2	91.068	89.002	100.653	120.443	96.797	100.744
Upper tensile	Bending moment	MA'	kN.m	2510.0	1045.0	3368.0	-1003.0	3253.0	400.0
	Necessary reinforcement	Asr	cm^2	0.000	0.000	0.000	8.804	0.000	0.000
	Neutral axis	x	cm	7.0	7.0	7.0	71.1	7.0	7.0
	Stresses	σc	N/mm^2	0.00	0.00	0.00	0.77	0.00	0.00
		σs	N/mm^2	0.00	0.00	0.00	51.72	0.00	0.00
	Resultant tensile force	T	kN	0.0	0.0	0.0	445.8	0.0	0.0
	Reinforcement requirements	As	cm^2	0.000	0.000	0.000	14.860	0.000	0.000
Allowable stresses		σca	N/mm^2	10.00	14.00	9.00	14.00	9.00	14.00
		σsa	N/mm^2	205.00	300.00	160.00	300.00	160.00	300.00
Average shearing force		QB	kN	1923.0	2496.0	1538.0	3416.0	1470.0	2850.0
		τm	N/mm^2	0.52	0.67	0.41	0.91	0.39	0.76
		τa1'	N/mm^2	1.43	1.72	1.15	1.72	1.15	1.72
Average shearing force		S	kN	1923.0	2496.0	1538.0	3416.0	1470.0	2850.0
		τm	N/mm^2	0.52	0.67	0.41	0.91	0.39	0.76
		τa1'	N/mm^2	1.43	1.72	1.15	1.72	1.15	1.72
Shearing force carried by concrete		Sca	kN	4281.0	6421.0	4282.0	6423.0	4282.0	6423.0
Diagonal tension reinforcement	Shearing force	Sh'	kN	0.0	0.0	0.0	0.0	0.0	0.0
	Longitudinal spacing	s	cm	90.0	90.0	90.0	90.0	90.0	90.0
	Reduction coefficient	Cds	—	0.181	0.181	0.181	0.181	0.181	0.181
	Allowable tensile stresses	σsa	N/mm^2	225.00	300.00	160.00	300.00	160.00	300.00
	Used reinforcement	Aw	cm^2	2.207	2.207	2.207	2.207	2.207	2.207
	Necessary reinforcement	Awreq	cm^2	0.000	0.000	0.000	0.000	0.000	0.000

Source: Study Team

1) Design of connection between Top Slab and Steel Pipe Sheet Pile

A summary of calculation results for connection between Top Slab and Steel Pipe Sheet Pile is shown as following tables.

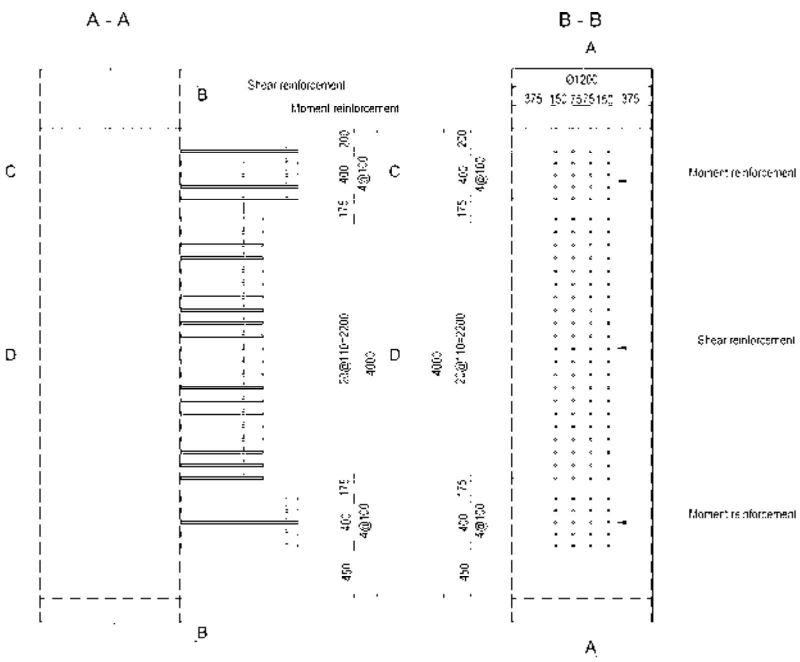
Design condition

- Type of steel : SS400,SM400
- Type of reinforcing bars : SD345（underwater）
- Design strength of concrete : σck = 27 (N/mm^2) *Treated as equivalent to an C28
- Material of sheet pile : SKY490
- Diameter of sheet pile : D = 1200.0 (mm)
- Section modulus of sheet pile : Z = 12859.9 (cm^3)
- Connection method : reinforcement stud welding

Table 8.3.6-7 Design Results connection between Top Slab and SPSP

	Load case	σs1 (N/mm^2)	σs2 (N/mm^2)	σs (N/mm^2)	σsa (N/mm^2)	nb nba (nos/layer)	τs (N/mm^2)	τsa (N/mm^2)	ns nsa (nos)
P76	Ordinary	78.72	7.81	86.54	160.00	20 ≧ 11	74.61	96.00	84 ≧ 65
P77	Wind	160.65	15.82	176.48	200.00	20 ≧ 18	93.89	120.00	84 ≧ 66
P78	Ordinary	104.17	11.37	115.53	160.00	20 ≧ 15	76.39	96.00	84 ≧ 67

Source: Study Team



Source: Study Team

Figure 8.3.6-16 Detail of connection between Top Slab and SPSP

8.4 Basic design of Approach Bridge

8.4.1 Study on Structural type of Approach

The span length of approach bridge was decided a continuous girder structure of 60m span with single wall piers as aresult of 8.2.2 Study of span length of Approach bridge. A continuous structure of equal height was adopted in the structure of the approach bridge in consideration of the spectacle and the intersection condition. Moreover, five span continuous structure was adopted by the comparative study of a multi span.

8.4.1.1 Selection of Erection Method for Approach Bridge

In this project, as discussed in the report of JICA's Preparatory Survey (SAPROF Study), the construction period is planned as short as 32 months for aiming at opening in 2015 and the construction period of Approach Bridge which is approximately 5km long is critical.

It reviewed it in consideration of the thing that the construction method of the approach bridge greatly influences the economy and the construction schedule before a detailed design. In the review of the construction method, it was assumed that the study of construction method was separated to Hai an side approach bridge and Cat hai side approach bridge and it did.

The reason is divided into parts by a main bridge and the sea route, and it is not possible to construct continuously, and the construction period of Cat hai side approach doesn't become critical in a whole schedule.

8.4.1.2 Comparative Study

(1) Alternative

The following four ideas are compared with the selection of the construction industrial method.

Alternative-1: Span-by-Span Erection Method (PrecastSegment)

Alternative-2: Moving Scaffolding System

Alternative-3: Catilever method by P&Zerection girder

Alternative-4: Ordinary cantilever method

Table 8.4.1 and Table 8.4.2 show the comparative study result of the above-mentioned construction method.

8.4.1.3 Conclusion

As a result of the comparative study of the construction method, the Erection method of Hai an side approach bridge and Cat hai side approach bridge is as follows.

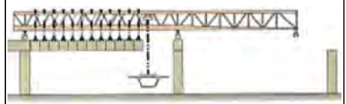
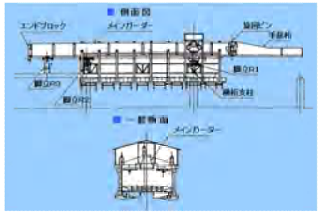
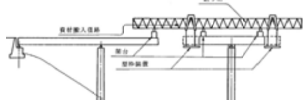
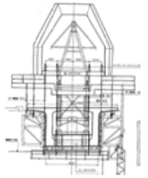
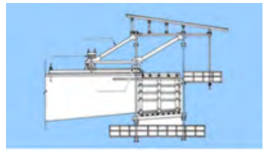
(1) Hai an side approach Bridge

The most excellent SBS erection method (Span-by-Span erection method) is adopted as shortening the construction schedule and the overall evaluation of the economy etc.

(2) Cat hai side approach Bridge

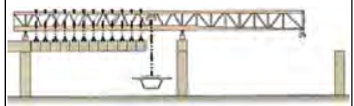
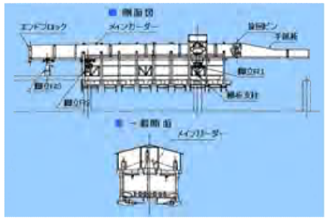
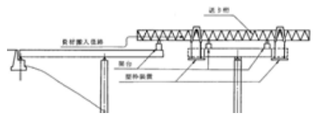
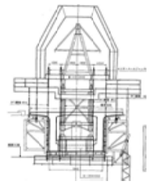
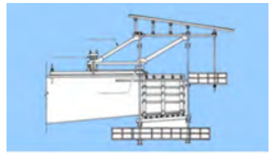
Because the construction schedule doesn't become critical, Ordinary cantilever method is adopted by the economy.

Table 8.4.1-1 Comparison on Erection for Approach Bridge (A1-P75)

Evaluation Items		Alternative-1 Span by Span Erection Method		Alternative-2 Moving Scaffolding System		Alternative-3 P&Z Election Method		Alternative-4 Cantilever Consturuction	
Length of Bridge		4,433.7m		4,433.7m		4,433.7m		4,433.7m	
Schematics and Photos		 		 		  		 	
Structural Aspect and Stability	10	・Pre-cast segment is fabricated at yard, then they are transported to the erection site. Segment is placed lifted and placed by SBS erection girder one span by one span. ・There are a lot of achievemnt in Japan and other countries.	10	・Form is supported by MSS erection girder, and one span girder is construted by cast-in-situ construction method. ・Thanh Tri Bridge is only one achievement in Vietnam. ・Max span is 50m due to scale (weight) of erection girder.	10	・P&Z method is one kind of cantilever erection methods with long segment (max 10m). After construction of pier table, cantilever will start as same as ordinary cantilever construction method. ・This was developed in Germany and transferred to Japan in 1995. There are numbers of achievement in Japan. (Max span is 100m.)	10	・After construction of pier table, travelers are fabricated and then balanced cantilever erection is started with cast-in-situ construction method. ・This is most popular construction method for long span (more than 60m), and there are a lot of achievements all over the world.	10
Construction Cost	40	Superstructure 1,086,118,000,000 VND Erection girder 273,712,500,000 VND Fabrication Yard 250,000,000,000 VND Substructure 1,361,491,275,000 VND Total 2,971,321,775,000 VND Ratio 1.11	32	Superstructure 1,221,955,000,000 VND Erection girder 427,500,000,000 VND Fabrication Yard 25,000,000,000 VND Substructure 1,470,410,568,000 VND Total 3,144,865,568,000 VND Ratio 1.17	24	Superstructure 1,063,768,000,000 VND Erection girder 503,100,000,000 VND Fabrication Yard 25,000,000,000 VND Substructure 1,361,491,275,000 VND Total 2,953,359,275,000 VND Ratio 1.10	32	Superstructure 1,063,708,000,000 VND Traveler 234,000,000,000 VND Fabrication Yard 25,000,000,000 VND Substructure 1,361,491,275,000 VND Total 2,684,199,275,000 VND Ratio 1.00	40
Construction Plan and Period	10	From order of erection girder to installation of girder at the site takes 1 year. ・In A1～P75, 3 nos. of SBS girder are necessary to meet the requirement from construction period. It takes 480 days exclusive order & transportation of erection girder (365 days). This required period is shortest among 4 alternatives (845 days)	10	From order of erection girder to installation of girder at the site takes 1 year. ・In A1～P75 (4,423.7m), 4 nos. of MSS girder are necessary to meet the requirement from construction period. It takes 565 days exclusive order & transportation of erection girder (365 days). This required period (930 days) is longer than Alternative 1(845 days)	8	From order of erection girder to installation of girder at the site takes 1 year. ・In A1～P75 (4,423.7m), 8 nos. of P&Z girder are necessary to meet the requirement from construction period. It takes 506 days for 9 numbers of span exclusive order & transportation of erection girder (365 days). This required period is 29 months (871 days) and longer than Alternative 1 & 4.	8	Due to wide width, large scale traveler is required. In Japan, there are a lot of this type and easy to procure them in short time (5 months). However, sub-structure requires at least 6 months for first group completion. ・In A1～P75 (4,423.7m), 32 nos. of traveler are necessary to meet the requirement from construction period. It takes 590 days for 10 numbers of span. This required period is 6 months for sub-structures and 24.7 months for superstructures. (Sub-structure will be constructed in order and cannot be constructed at the same time.) Total period is 30.7 months (921 days). This alternative is not realistic after considering sub-structure schedule.	4
Maintenance	15	・This is similar to Alternative 3 & 4 due to same span arrangement.	15	・Due to shorter span (50m), the numbers of pier & bearing shoes increase.	9	・This is similar to Alternative 1 & 4 due to same span arrangement.	15	・This is similar to Alternative 1 & 3 due to same span arrangement.	15
STEP Clearance	10	56% (Preliminary Estimate)	10	58% (Preliminary Estimate)	10	64% (Preliminary Estimate)	10	44% (Preliminary Estimate)	8
Aesthetics	5	・This is similar to Alternative 3 & 4 due to same span arrangement.	5	・Due to large numbers of piers copared with Alternative 1, 3, & 4, this alternative is not superior to the others.	3	・This is similar to Alternative 1 & 4 due to same span arrangement.	5	・This is similar to Alternative 1 & 3 due to same span arrangement.	5
New Technology	5	・First case in Vietnam.	5	・There is one achievement in Vietnam. (Thanh Tri Bridge)	4	・First case in Vietnam.	5	・There are many achievements in Vietnam.	2
Environmental Impact	5	・There is no difference between Alternative 1,3 & 4.	5	・Due to increased number of pier, noise at expansion joint is louder than the other alternatives.	3	・There is no difference between Alternative 1,3 & 4.	5	・There is no difference between Alternative 1,3 & 4.	5
Evaluation	100	Most Recommended ・Construction period is shortest among 4 alternatives. After considering this point and cost, this alternaive is most recommendable.	92	Less Recommended ・Construction period is longer than Alternative 1 & 3 and scale of ercton girder is very big and it costs much more than Alternative 1.	71	Less Recommended ・ From the economic & construction speed view points, this alternative is secondly recommendable among 4 alternatives.	90	Less Recommended ・ This alternative is not recommendable from the view point of construction schedule.	89

Source : Study Team

Table 8.4.1-2 Comparison on Erection for Approach Bridge (P79-A2)

Evaluation Items		Alternative-1 Span by Span Erection Method		Alternative-2 Moving Scaffolding System		Alternative-3 P&Z Election Method		Alternative-4 Cantilever Consturuction	
Length of Bridge		54.8+3@60+54.8m、54.8+2@60+54.8m =519.2m		42.3+4@50+42.3m、42.3+3@50+42.3m =519.2m		54.8+3@60+54.8m、54.8+2@60+54.8m =519.2m		54.8+3@60+54.8m、54.8+2@60+54.8m =519.2m	
Schematics and Photos		 		 		  		 	
Structural Aspect and Stability	10	・Pre-cast segment is fabricated at yard, then they are transported to the erection site. Segment is placed lifted and placed by SBS erection girder one span by one span. ・There are a lot of achievemnt in Japan and other countries.	10	・Form is supported by MSS erection girder, and one span girder is construted by cast-in-situ construction method. ・Thanh Tri Bridge is only one achievement in Vietnam. ・Max span is 50m due to scale (weight) of erection girder.	10	・P&Z method is one kind of cantilever erection methods with long segment (max 10m). After construction of pier table, cantilever will start as same as ordinary cantilever construction method. ・This was developed in Germany and transferred to Japan in 1995. There are numbers of achievement in Japan. (Max span is 100m.)	10	・After construction of pier table, travelers are fabricated and then balanced cantilever erection is startted with cast-in-situ construction method. ・This is most popular construction method for long span (more than 60m), and there are a lot of achievements all over the world.	10
Construction Cost	40	Superstructure: 189,675,750,687 VND (Including erection girder) Substructure: 141,736,360,000 VND Total: 331,412,110,687 VND Ratio: 1.20	24	Superstructure: 209,356,995,996 VND (Including erection girder) Substructure: 177,170,450,000 VND Total: 386,527,445,996 VND Ratio: 1.40	16	Superstructure: 163,560,590,992 VND (Including erection girder) Substructure: 141,736,360,000 VND Total: 305,296,950,992 VND Ratio: 1.11	32	Superstructure: 134,166,608,228 VND (Including traveler) Substructure: 141,736,360,000 VND Total: 275,902,968,228 VND Ratio: 1.00	40
Construction Plan and Period	10	From order of erection girder to installation of girder at the site takes 1 year. ・In P79～A2 (519.2m), construction period is shortest among 4 alternatives (270 days) and no influence in the total construction period. ・Erection girder weight is approximately 815 ton, and total ・It is required to carefully considered in transportation of segment.	10	From order of erection girder to installation of girder at the site takes 1 year. ・In P79～A2 (519.2m), construction period is 355 days. It is longer than Alternative 1. ・Erection girder weight is approximately 950ton for 50m span length. If roof and other facility are added, construction is available in any weather condition. And total numbers of are 5.	4	From order of erection girder to installation of girder at the site takes 1 year. ・In P79～A2 (519.2m), construction period is longest among 4 alternatives. (506 days) ・Erection girder weight is approximately 559 ton.	4	Due to wide width, large scale traveler is required. In Japan, there are a lot of this type and easy to procure them in short time (5 months). However, sub-structure requires at least 6 months for first group completion. ・InP79～A2,If 4 numbers of travelers are set, the construction period is 464 days. This period is not critical pass for total construction period. (Critical pass in schedule is in Hai An side.) ・Traveler's weight is 117 ton X 32 = 3,744 ton(Hai An) ・Traveler's weight is 117 ton X 4 = 468 ton(Cat Hai)	4
Maintenance	15	・This is similar to Alternative 3 & 4 due to same span arrangement.	15	・Due to shorter span (50m), the numbers of pier & bearing shoes increase.	9	・This is similar to Alternative 1 & 4 due to same span arrangement.	15	・This is similar to Alternative 1 & 3 due to same span arrangement.	15
STEP Clearance	10	65% (Preliminary Estimate)	10	68% (Preliminary Estimate)	10	60% (Preliminary Estimate)	10	44% (Preliminary Estimate)	8
Aesthetics	5	・This is similar to Alternative 3 & 4 due to same span arrangement.	5	・Due to large numbers of piers copared with Alternative 1, 3, & 4, this alternative is not superior to the others.	3	・This is similar to Alternative 1 & 4 due to same span arrangement.	5	・This is similar to Alternative 1 & 3 due to same span arrangement.	5
New Technology	5	・First case in Vietnam.	5	・There is one achievement in Vietnam. (Thanh Tri Bridge)	4	・First case in Vietnam.	5	・There are many achievements in Vietnam.	2
Environmental Impact	5	・There is no difference between Alternative 1,3 & 4.	5	・Due to increased number of pier, noise at expansion joint is louder than the other alternatives.	3	・There is no difference between Alternative 1,3 & 4.	5	・There is no difference between Alternative 1,3 & 4.	5
Evaluation		Less Recommended ・ Construction period is shortest among 4 alternatives.	84	Not Recommended ・ Construction cost is high and period is long.	59	Less Recommended ・ Construction period is longtest among 4 alternatives.	86	Most Recommended ・ Cheepest. Construction period is longer than Alternative-1, but the section of P79-A2 is not on the critical path.	89

Source : Study Team

8.4.2 Supper structure

8.4.2.1 Dimensions of main girder

Dimension of main girder section is provided respectively in Hai an side Approach bridge and Cat hai side Approach bridge.

(1) Hai an side Approach Bridge

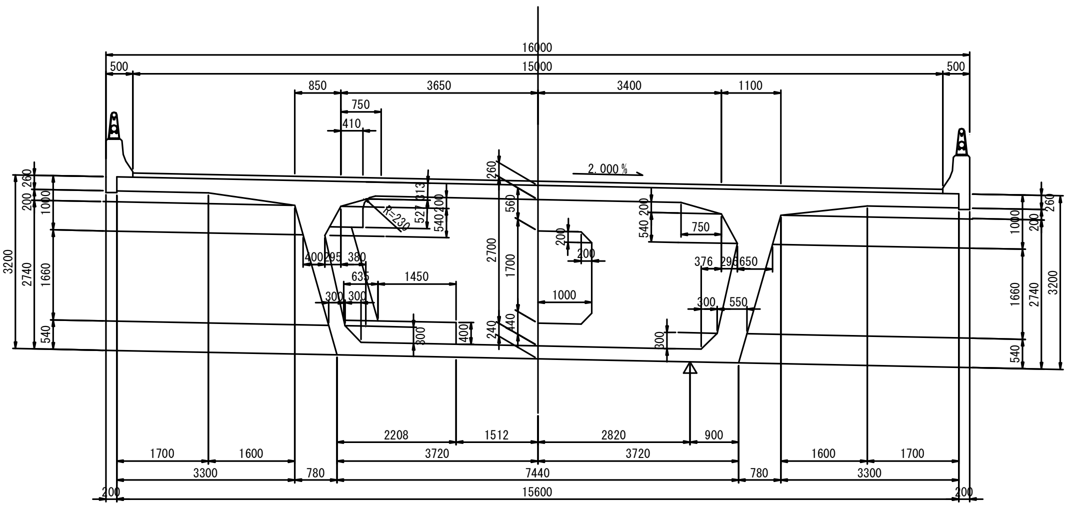
1) Arrangement of members of main girder

Dimension of each member for main girder shall be determined as follows.

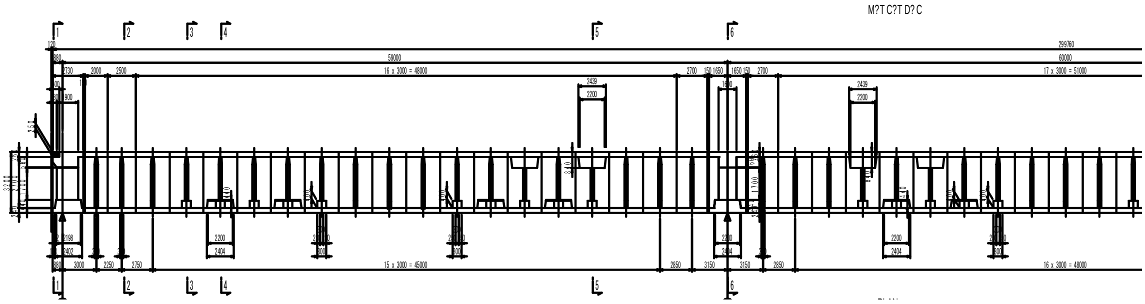
Member	Span center	Middle support	Reasons	Remarks
Girder heightH (m)	3.20m	3.20m	By Previous data (1/15~1/20)	
Upper slab	0.260m	0.260m	From the steel material arrangement	1S28.6mm,12S15.2mm
Web	0.350m	0.500m	By Previous data (0.3~0.5m)	
Lower slab	0.240m	0.240m	From the steel material arrangement	12S15.2mm

2) Main girder section

Span center section　　　　　Middle support section



3) Side view of main girder



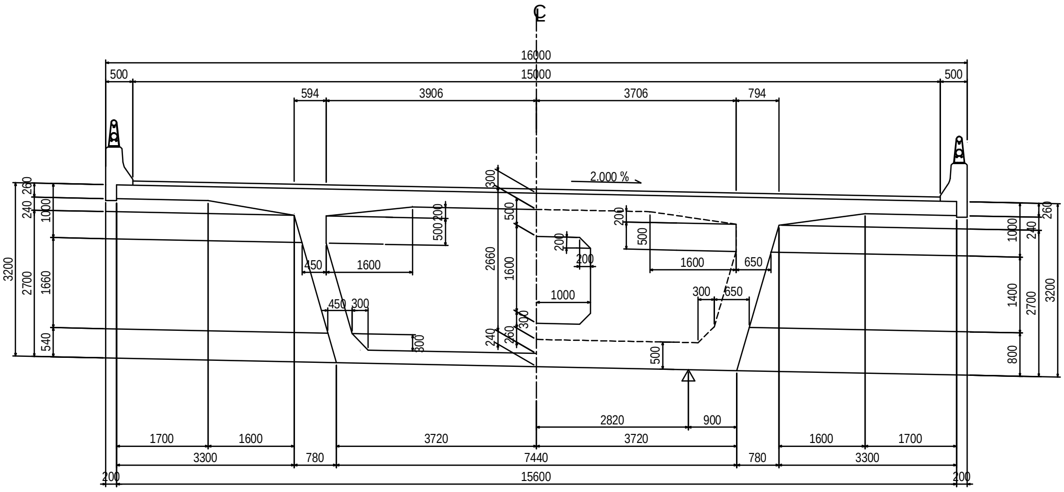
(2) Cat hai side Approach Bridge

1) Arrangement of members of main girder

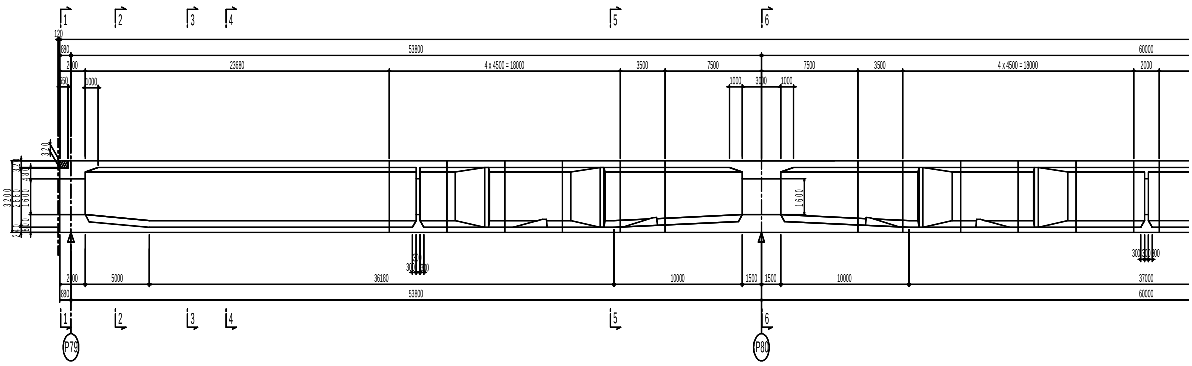
Dimension of each member for main girder shall be determined as follows.

Member	Span center	Middle support	Reasons	Remarks
Girder height H	3.20m	3.20m	By Previous data (1/15~1/20)	
Upper slab	0.260m	0.260m	From the steel material arrangement	1S28.6mm、12S12.7mm
Web	0.450m	0.500m	From the steel material arrangement	12S12.7mm
Lower slab	0.240m	0.240m	From the steel material arrangement	12S12.7mm

2) Main girder section



3) Side view of main girder

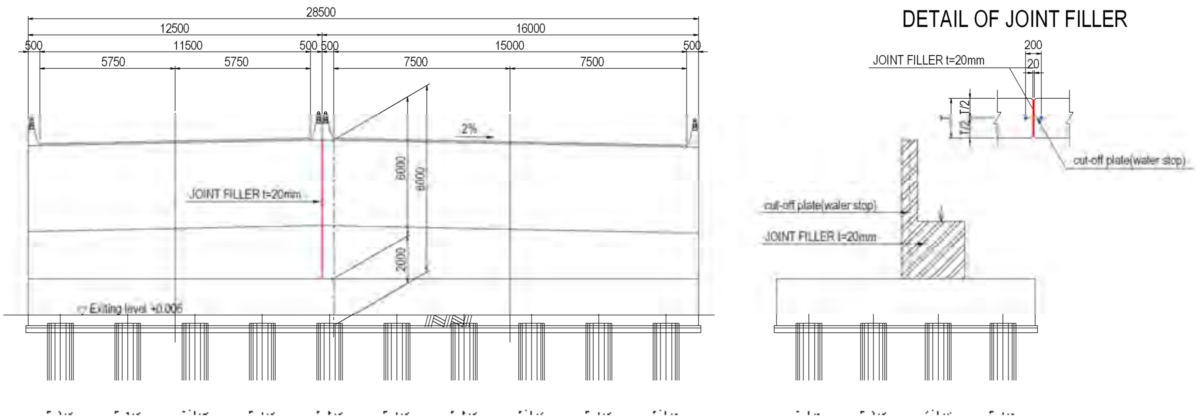


8.4.3 Substructure of Approach Bridge

8.4.3.1 Abutment

(1) Abutment with large width

Abutment with large width shall be designed in consideration of temperature changes, vertical cracks due to drying shrinkage and vertical loads, and uneven settlement in the lateral direction. For body width exceeding about 15m, it is good to install vertical joints having a V-groove in the body surface or the expansion joint. In this project adopt the expansion joint.



Source : Study Team

Figure 8.4.3-1 Joint Filler

(2) Rear side of abutment

The backfill behind an abutment may be deformed not only by settlement due to consolidation or the like but also by settlement accompanying abutment vibration or liquefaction during earthquakes. Therefore, it is desirable to install an approach cushion in order to ensure smooth road traffic after the earthquake in addition consideration for not imparting shocks to running vehicles or the abutment.

The length of approach cushion slab adopt 8.0m based on JSHB.

Table 8.4.3-1 Length of approach cushion slab

Height of abutment \ back filling material \ ground condition	orrdinary ground		soft ground
	unscreened gravel hard rock	except for left column material	All kind of material
H < 6.0m	–	5.0m	8.0m
6.0m ≦ H < 15.0m	5.0m	5.0m	8.0m
15.0m < H	8.0m	5.0m	8.0m

Source : Study Team

8.4.3.2 Pier

(1) Study on Shape of Pier

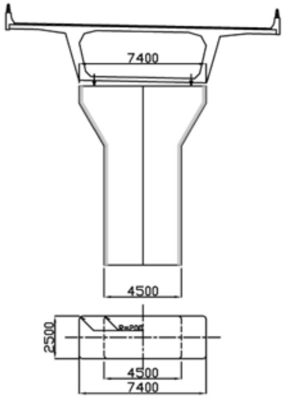
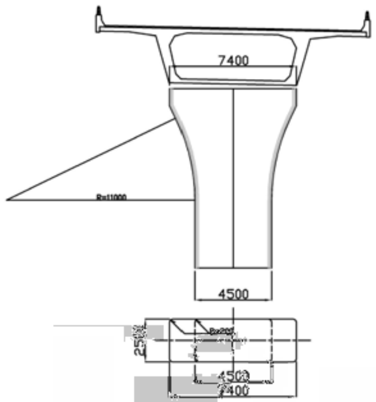
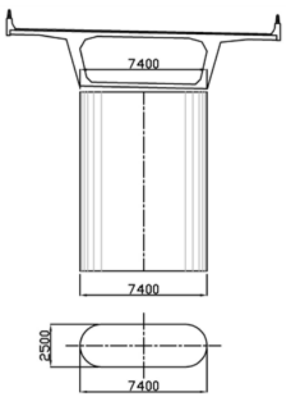
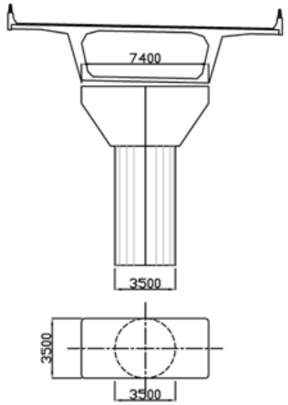
The study was implemented by comparing the following alternatives:

(1) Alternative-1:Rectangle shape column(SAPROF)
(2) Alternative-2:Rectangle shape column smoothing angle between column and Pier head.
(3) Alternative-3:Oval shape column
(4) Alternative-4:Round shape column

Results of Comparative Study

As shown in the Table 8.4.3-2, Alternative-2 Rectangle shape column smoothing angle between column and Pier head is recommended because of its advantage in aesthetics and construction cost.

Table 8.4.3-2 Results of Comparative Study

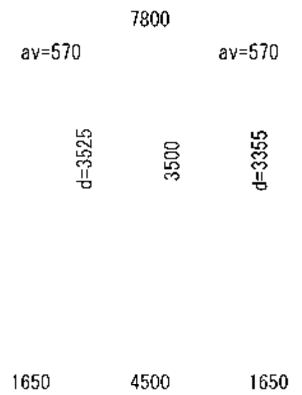
Evaluation Items		Alternative-1 (SAPROF) Rectangle shape column		Alternative-2 Rectangle shape column smoothing angle between column and Pier head		Alternative-3 Oval shape column		Alternative-4 Round shape column	
Side View									
Structural Aspect and Stability	10	-Bearing weight for the foundation will reduce because of deduction of its own weight.	8	-Bearing weight for the foundation will reduce because of deduction of its own weight.	8	-Bearing weight for the foundation will increase because of adding its own weight. -No necessity to establish the timbering.	4	-The arrangement of bar at the connection between column,beam and pile cap will be comlicated. So this shape is inferior in constructbility.	6
Construction Cost (for Foundation)	40	Quantity / Unit Cost (VND) / Total (1,000VND) Concrete 107m3 / 5,867,864 / 627,861 Total 627,861 Ratio **1.000**	40	Quantity / Unit Cost (VND) / Total (1,000VND) Concrete 108m3 / 5,867,864 / 633,729 Total 633,729 Ratio **1.009**	40	Quantity / Unit Cost (VND) / Total (1,000VND) Concrete 137m3 / 5,867,864 / 805,658 Total 805,658 Ratio **1.283**	24	Quantity / Unit Cost (VND) / Total (1,000VND) Concrete 119m3 / 5,867,864 / 698,863 Total 698,863 Ratio **1.113**	32
Construction Plan and Period	10	column and beam 11 days Total **11 days**	8	column and beam 11 days Total **11 days**	8	column and beam 14 0 days Total **14 days**	8	column and beam 13 days Total **13 days**	6
Maintenance	15	-No necessity to maintenance.	9	-No necessity to maintenance.	9	-No necessity to maintenance.	9	-No necessity to maintenance.	9
STEP Clearance	10	- 32% (Preliminary Estimate)	10	- 32% (Preliminary Estimate)	10	- 32% (Preliminary Estimate)	10	- 32% (Preliminary Estimate)	10
Aesthetics	5	-Sharp corner makes inorganic and hard impressions.	2	-Smoothing the angle between pier head and column makes soft impression .	5	-Wide width of column makes a sense of oppression.	2	-Round shape of column makes soft impression.	3
New Technology	5	-Nothing new technology is used.	3	-Nothing new technology is used.	3	-Nothing new technology is used.	3	-Nothing new technology is used.	3
Environmental Aspect	5	-No major emvironmental impact.	3	-No major emvironmental impact.	3	-No major emvironmental impact.	3	-No major emvironmental impact.	3
Evaluation	100	-This alternative is superior in economic ,but inferior in aesthetic points compared to alternative.2. Less Recommended	**83**	-This alternative is superior to other cases in aesthetic points. -Construction Cost is the second lowest in the alternatives, but almost same as alternative-1. Most Recommended	**86**	-This alternative is most inferior in economic and in aesthetic points. Not Recommended	**63**	-This alternative is most inferior in constructbility. **Not Recommended**	**72**

Source : Study Team

(2) Design of Beam

a) Analysis

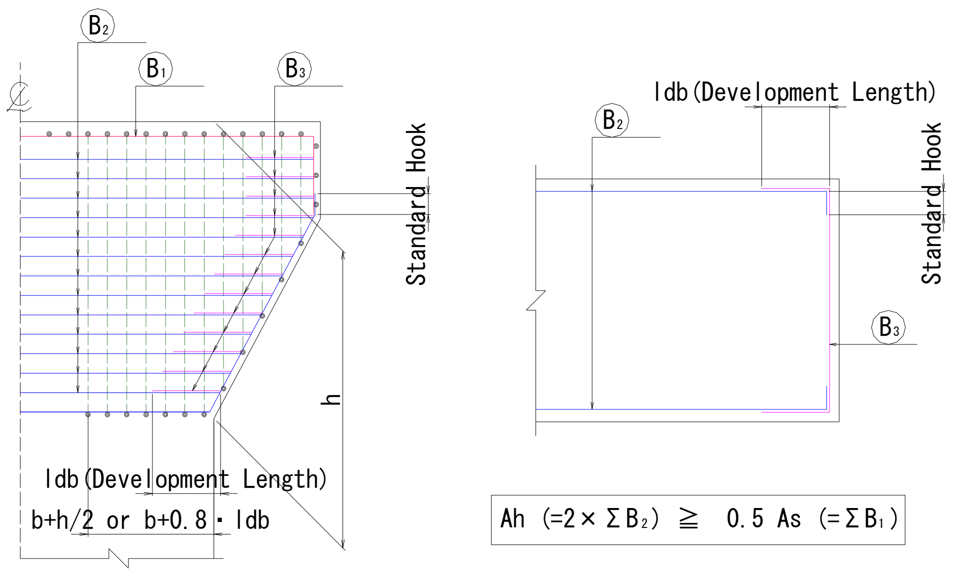
Components in which "av", as shown in following Figure, is less than "d" shall be considered to be corbels. Strut-and-tie models to analysis the corbels.



Source : Study Team

Figure 8.4.3-2 Sectional view of Beam

b) Arrangement of reinforcement



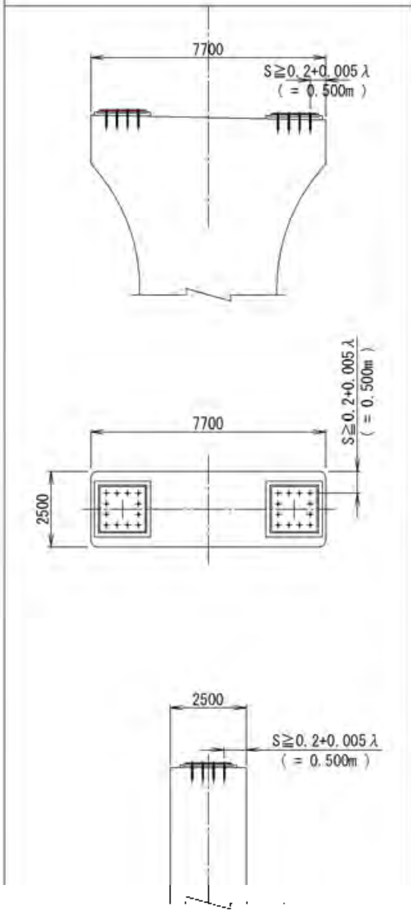
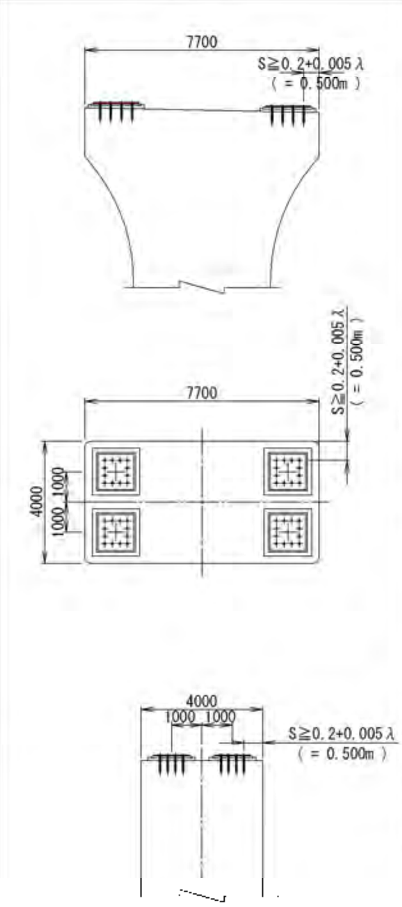
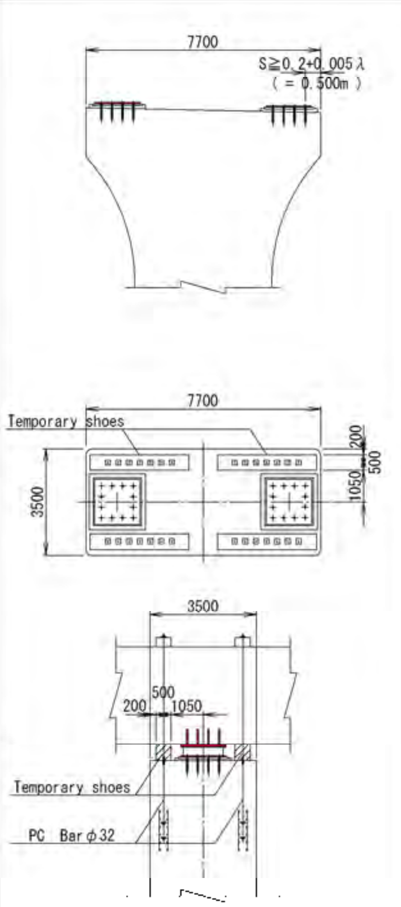
Source : Study Team

Figure 8.4.3-3 Arrangement of reinforcement at beam

(3) Width of bridge seats

The width of bridge seats is decided by bearings edge distance based on Japanese Standard of Highway Bridge or the arrangement of temporary shoes which is used to erect the superstructure by cantilever construction.

Table 8.4.3-3 Width of bridge seats

Erection method of superstructure Span by span Erection Location of Pier Intermediate Pier	Erection method of superstructure Span by span Erection Cantilever Construction Location of Pier End Pier	Erection method of superstructure Cantilever Construction Location of Pier Intermediate Pier
		

Source : Study Team

2) -The distance,S(m), between the edge of bearings and the edge of the top of the substructure (or bearing support edge distance) shall be equal to or larger than the following value:

$$S = 0.2 + 0.005\ \lambda \qquad (8.6.1)$$

where,

S : bearings edge distance (m)

λ : span length (m)

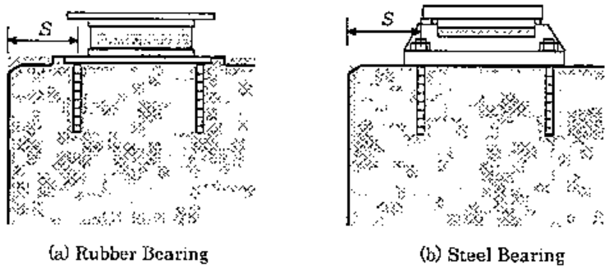


Fig.-C.8.6.4 Bearing Support Edge Distance S

Figure 8.4.3-4 Refer from JSHB

8.4.4 Study on Foundation

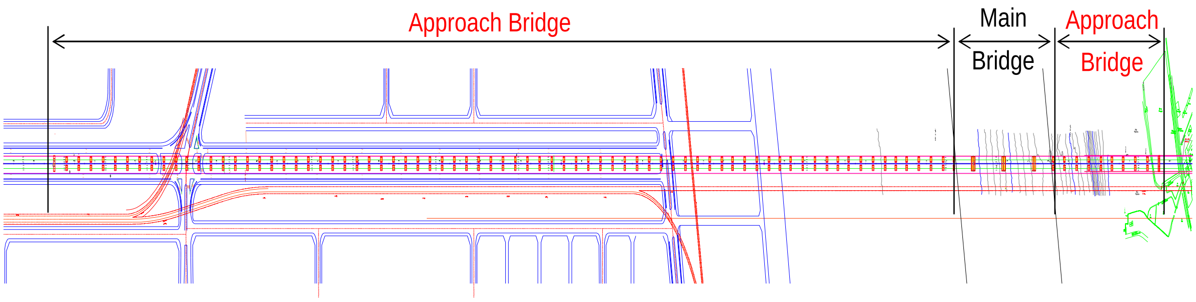
8.4.4.1 General

(1) Objectives of Condition

In the SAPROF Study, steel pipe pile foundation was selected for approach bridge and steel pipe sheet pile for main bridge substructures in terms of its rapid construction speed comparing with Cast in place pile foundation. This study aimed to carry out verifies the foundation type of SAPROF Study by comprehensive evaluation in terms of structural stability, construction cost, construction planning, and aesthetic point of view including re-evaluation of construction conditions for foundation of approach bridge and main bridge.

(2) Scope of Study

This study consists of two (2) sub-studies; the study on steel pipe sheet pile foundation, and the study on selection of bridge foundation. In the study on steel pipe sheet pile foundation, design principal and design elevation of pile cap is the key discussion. In the study on selection of bridge foundation, study of site conditions for selecting an appropriate foundation type is a key discussion.



Source : Study Team

Figure 8.4.4-1 Plan Layout for Approach Bridge and Main Bridge

8.4.4.2 Condition of Study

(1) Soil Condition

Refer to CHAPTER.3.

(2) Structure Height and Seawater Depth

Following Table is summary for the pier height and seawater depth with classification of study type for approach bridge and main bridge.

Table 8.4.4-1 Pier Height and Seawater Depth

Type	Pier No.	Pier Height* (m)	Column Height (m)	Water depth (m)
Type-1	P1	6.0	3.5	2.54
	P2	7.5	5.0	2.67
	P3	8.5	6.0	2.65
	P4	8.5	6.0	2.70
	P5	8.5	6.0	2.58
	P6	8.5	6.0	2.60
	P7	9.0	6.5	2.66
	P8	9.5	7.0	2.69
	P9	10.0	7.5	2.71
	P10	10.0	7.5	2.81
	P11	10.5	8.0	2.92
	P12	10.5	8.0	3.18
	P13	10.5	8.0	3.28
	P14	10.5	8.0	3.25
	P15	10.0	7.5	3.15
	P16	10.0	7.5	3.16
	P17	10.0	7.5	3.19
	P18	10.0	7.5	3.25
	P19	9.5	7.0	3.27
	P20	9.5	7.0	3.27
	P21	9.5	7.0	3.29
	P22	9.0	6.5	3.32
	P23	9.0	6.5	3.37
	P24	9.0	6.5	3.39
	P25	8.5	6.0	3.46
	P26	8.5	6.0	3.50
	P27	8.5	6.0	3.46
	P28	8.5	6.0	3.48
	P29	8.5	6.0	3.44
	P30	8.5	6.0	3.61
	P31	8.5	6.0	3.64
	P32	8.5	6.0	3.71
	P33	8.5	6.0	3.78
	P34	8.5	6.0	3.79
	P35	8.5	6.0	3.77
	P36	9.0	6.5	3.82
	P37	9.0	6.5	3.71
	P38	9.0	6.5	3.65
	P39	9.5	7.0	3.65
	P40	9.5	7.0	3.64
	P41	9.5	7.0	3.62
	P42	9.5	7.0	3.58
	P43	10.0	7.5	3.51
	P44	10.0	7.5	3.50
Type-1	***P45***	10.0	7.5	3.48
	P46	10.5	8.0	3.50
	P47	10.5	8.0	3.51
	P48	10.5	8.0	3.42
	P49	10.5	8.0	3.31
	P50	15.0	12.5	7.51
	P51	15.0	12.5	7.51
	P52	15.5	13.0	7.51
	P53	15.5	13.0	7.51
	P54	15.0	12.5	7.51
	P55	15.0	12.5	7.51
	P56	15.0	12.5	7.51
	P57	15.0	12.5	7.51
	P58	14.5	12.0	7.51
	P59	14.5	12.0	2.55
	P60	14.0	11.5	2.55
Type-2	P61	14.0	11.5	7.51
	P62	14.0	11.5	7.51
	P63	14.0	11.5	7.51
	P64	13.5	11.0	7.51
	P65	13.5	11.0	7.51
	P66	13.5	11.0	7.51
	P67	13.0	10.5	7.51
	P68	13.0	10.5	7.51
	P69	13.0	10.5	7.51
	P70	14.0	11.5	7.51
	P71	15.0	12.5	7.51
	P72	16.5	14.0	7.51
	P73	18.5	16.0	7.51
	P74	20.0	17.5	7.51
	P75	21.5	**19.0**	7.51
Type-3	P76	23.5	21.0	6.94
	P77	27.0	24.5	8.67
	P78	28.0	25.5	10.80
Type-4	***P79***	20.0	**17.5**	**11.53**
	P80	19.0	**16.5**	**11.13**
	P81	17.0	**14.5**	**9.98**
	P82	17.0	14.5	**7.87**
Type-1	P83	13.5	11.0	3.75
	P84	10.5	8.0	2.42
	P85	8.5	6.0	2.11
	P86	7.5	5.0	1.84
	P87	6.0	3.5	1.46

*pier Height : Column + Pile Cap Height

Source : Study Team

8.4.4.3 Principle of Study

(1) Classification of Foundation based on Study Conditions

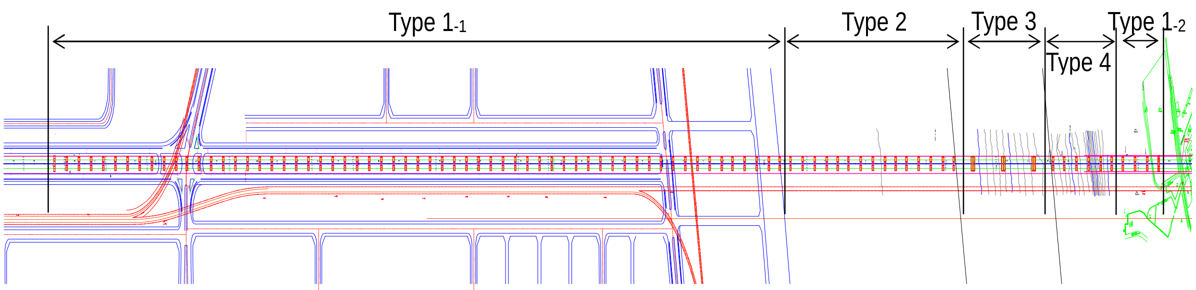
As the first step, the foundations to be studied are classified into four (4) main types as shown in below table based on study conditions. In the study of Type-1, the downdrag effect for piles due to consolidation of clay layer needs to be examined in detail. In the study of Type-2, there is less number of piers; the point of this study is that the construction costs are needed to be focused on the detail. In the study of Type-3, there is planning to steel pipe sheet pile (SPSP) foundation of critical for construction period at deep water. The point to be focused in detail for this type is construction period and safe construction at the deep water. In the study of Type-4, there is planning closed the navigation channel with Cat Hai Island at deep water. The point of this study is the structural aesthetics which shall be harmonized with scenery of Cat Hai Island and safe construction at the deep water.

Table 8.4.4-2 Foundation Study Type for Approach Bridge and Main Bridge

Study Type	Type-1_{-1}	Tupe-2	Type-3	Type-4	Type-1_{-2}
Bridge Type	Approach	Approach	Main Br.	Approach	Approach
Station	Km +561.3 ~8+77.12	Km +561.3 ~8+77.12	Km +561.3 ~8+77.12	Km +561.3 ~8+77.12	Km +561.3 ~8+77.12
Pier No.	A1 ~ P60	P61 ~ P75	P76 ~ P78	P70 ~ P82	P84 ~ P87
Reclamation Plan	in operation	No	No	No	planning for the future
Bridge Span length (m)	60.0	60.0	150.0	60.0	60.0
Estimated Corrosion Thickness of Steel Pile (mm)	2*1	7*2	7*2	7*2	2*1
Water depth (m)	2.5~3.8	3.2~6.5	7.1~11.0	8.3~11.5	1.63~3.8
E.L. of Pile Cap	Variation 2	Variation 2 or 3	E.L.-5.0 (Top of Pile Cap)	Variation 4	Variation 1

Note, *1; protected due to reclamation by filling up

*2; according to report of Refer No PMU2/110422-1

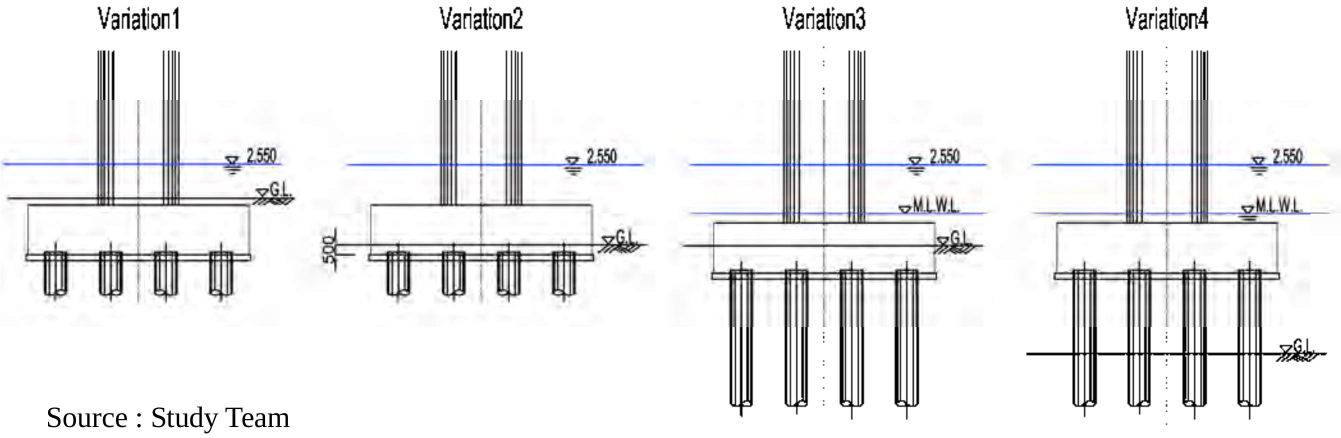


Source : Study Team

Figure 8.4.4-2 Plan Layout for Approach Bridge and Main Bridge

(2) Classification on Elevation of Pile Cap

After due consideration of site conditions, pile caps for approach bride are classified into four (4) alternatives (refer to below figures). In the Variation 1, top of pile cap is seated below the seabed when the sea is shallow and pier height is low. Variation 2, bottom of pile cap is seated on the sea bed of deepwater. The construction of pile cap at below the sea bed is difficult in terms of structure of cofferdam. Furthermore, the pile cap is backfilled by reclamation in the future. In the Variation 3, top of pile cap shall be set below Mean Low Water Level (EL-1.670) in order to comply with the regulation which prohibits exposure of pile cap body above Mean Low Water Level. In the Variation 4, top of pile cap is seated below the Mean Low Water Level (EL-1.670) as same as Variation 3. In addition to the condition, bottom of pile cap does not contact onto seabed due the deepwater; construction of pile cap at seabed is difficult in terms of structure of cofferdam.



Source : Study Team

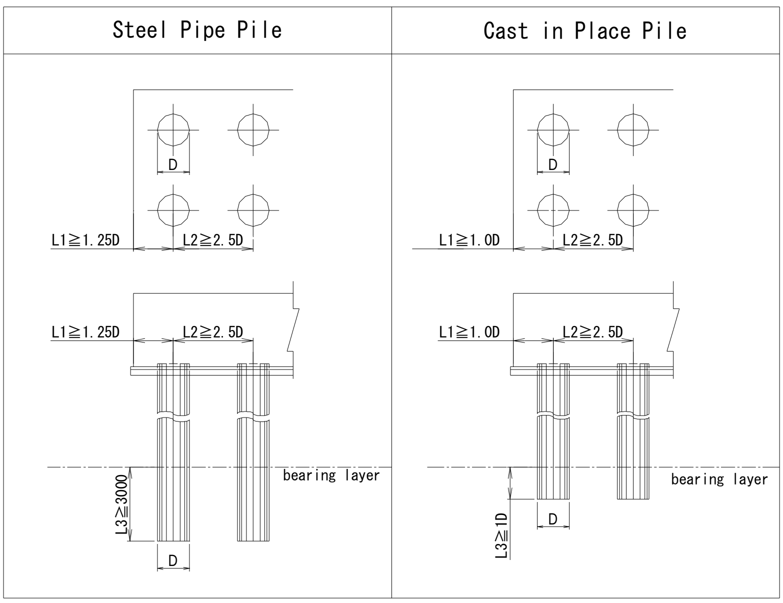
Figure 8.4.4-3 Variations for Pile Cap Elevation

(3) Pile arrangement and type of pile connection

1) Pile arrangement of Steel pipe pile and cast in place pile

Pile arrangement of steel pipe pile and cast in place based on following table.

Table 8.4.4-3Pile arrangement

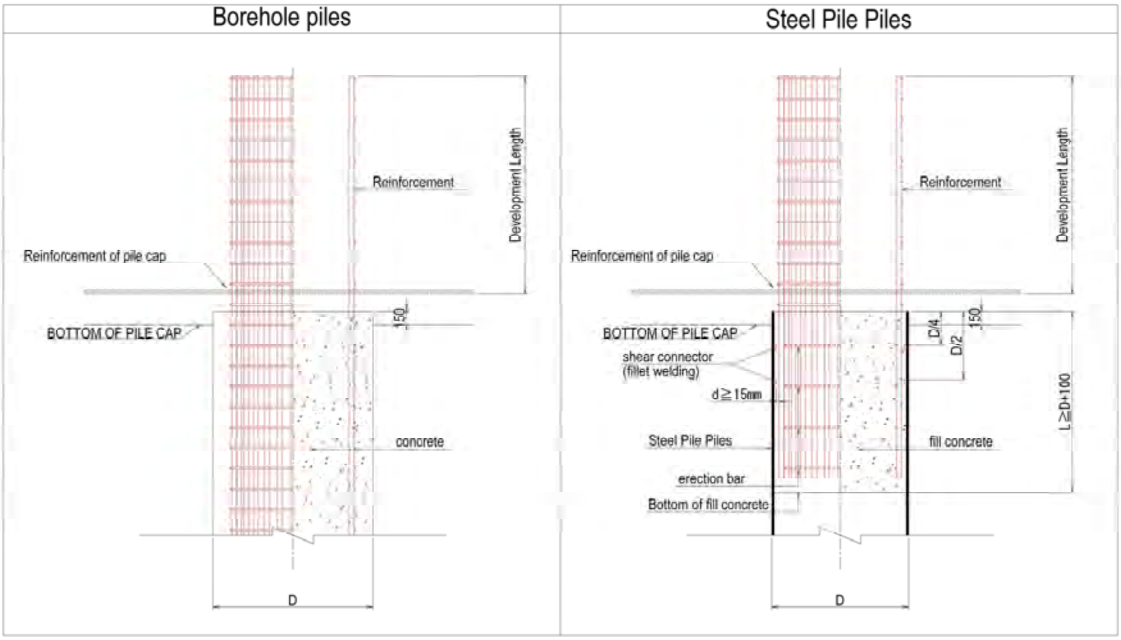


Source : Study Team

Connections between pile and pile cap

Connections between pile and pile cap shall be designed as rigid connections, and shall be verified against all forces acting at the pile head including push-in forces, pull-out forces, lateral forces, and bending moments. When reinforcing bars are used to reinforce pile heads, the stresses in the concrete and reinforcing bars in the footing is reviewed by assuming a virtual RC pile section in the pile cap.

Table 8.4.4-4Connections between pile and pile cap



Source : Study Team

2) Pile diameter for comparison

The results of review of SAPROF study by B/D design condition are shown in Table.13.5.3-7. In this comparative study, the following alternatives are studied.

Steel pipe pile(Pier)

- ●SAPROF study : D=0.8m, 4x4-2=14nos
- ●Altanative-1 : D=0.8m, 5x5 =25nos
- ●Altanative-2 : D=1.1m, 4x4 =16nos
- ●Altanative-3 : D=1.4m, 3X4 =12nos

Steel pipe pile(Abutment)

- ●Altanative-1 : D=0.8m, 4x11 =44nos
- ●Altanative-2 : D=1.1m, 4x10 =40nos
- ●Altanative-3 : D=1.4m, 4X 9 =36nos

Cast in place pile;

- ●Altanative-1 : D=1.2m, 3x4 =12nos
- ●Altanative-2 : D=1.5m, 3x3 = 9nos
- ●Altanative-3 : D=2.0m, 2X3 = 6nos

As theses table indicates, the changing condition design of SAPROF study, D=0.8m for 14nos steel pipe pile is not enough bearing capacity, Altenative-2, D=1.1m for 16nos steel pipe pile is the most recommendable for approach bridge because of its advantages in lowest construction cost. Therefore, the B/D study is applied D=1.1m for 16nos steel pipe pile as modified “SAPROF study”.

Table 8.4.4-5 Comparison for pile diameter of steel pipe pile at Pier

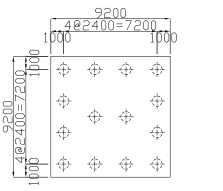
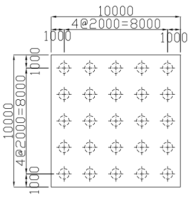
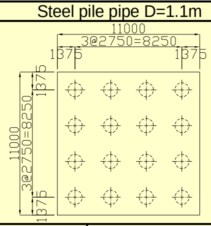
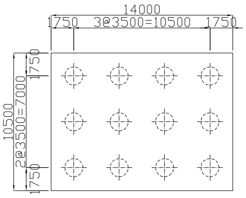
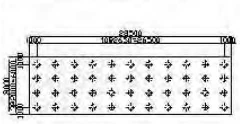
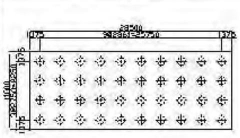
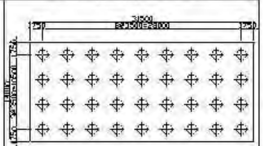
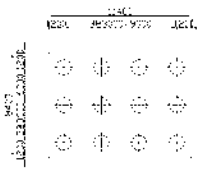
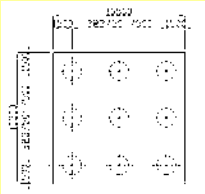
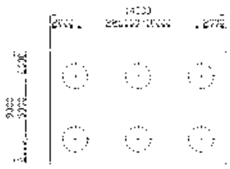
Alternative				SAPROF study		Altrenative-1		Altrenative-2		Altrenative-3	
Pile Type				Steel pile pipe D=0.8m		Steel pile pipe D=0.8m		Steel pile pipe D=1.1m		Steel pile pipe D=1.4m	
Plan of Pile Cap											
				L=46.0m	n=14nos	L=46.0m	n=25nos	L=46.0m	n=16nos	L=46.0m	n=12nos
Displacement		mm		δx=1.8≦δa=15 (OK)		δx=1.0≦δa=15 (OK)		δx=1.7≦δa=15 (OK)		δx=1.4≦δa=15 (OK)	
Pile Reaction		kN		P_{nmax}=3120 > Ra=2050 (NG)		P_{nmax}=1850 < Ra=2050		P_{nmax}=3000 < Ra=3160		P_{nmax}=4370 < Ra=4530	
Pile body	thickness	mm		t=11mm(SKK400)		t=11mm(SKK400)		t=11mm(SKK400)		t=11mm(SKK400)	
	Mu	kN.m		483.2		280.1		575.2		762.2	
	Mn	kN.m		1193.8		1556.9		2512.5		4024.8	
	fs	-		2.47		5.56		4.37		5.28	
	Extreme	ft	N/mm^2	86.7 < 140.0		50.9 < 140.0		72.1 < 140.0		76.1 < 140.0	
		ft	N/mm^2	101.0 < 140.0		59.0 < 140.0		80.0 < 140.0		83.0 < 140.0	
Cost Estimate				Material Quantities	Cost (VND)	Material Quantities	Cost (VND)	Material Quantities	Cost (VND)	Material Quantities	Cost (VND)
Item		unit	Unit cost (VND)								
Pile cap											
Concrete 28MPa		m^3	5,867,864			250.0	1,466,966,000	302.5	1,775,028,860	367.5	2,156,440,020
Lean Concrete		m^3	1,723,811			10.0	17,238,110	12.0	20,685,732	15.0	25,857,165
Blinding stone		m^3	696,000			20.0	13,920,000	24.0	16,704,000	29.0	20,184,000
Excavation		m^3	318,066			113.0	35,941,458	128.0	40,712,448	147.0	46,755,702
Cofferdam		ton	24,798,638			87.0	2,157,481,506	93.0	2,306,273,334	101.0	2,504,662,438
Sub total							3,691,547,074		4,159,404,374		4,753,899,325
Foundation											
Steel Pile (Diameter)	0.8m	m	0				15,063,501,667				
	1.1m	m	0						12,923,273,000		
	1.4m	m	0								14,980,518,000
Sub total							15,063,501,667		12,923,273,000		14,980,518,000
Total							18,755,048,741		17,082,677,374		19,734,417,325
ratio						1.098		1.000		1.155	
Evaliation								Most Recommended			

Table 8.4.4-6 Comparison for pile diameter of steel pipe pile at abutment

Alternative				Altrenative-1		Altrenative-2		Altrenative-3	
Pile Type				Steel pile pipe D=0.8m		Steel pile pipe D=1.1m		Steel pile pipe D=1.4m	
Plan of Pile Cap									
				L=43.5m	n=44nos	L=43.5m	n=40nos	L=43.5m	n=36nos
Displacement		mm		δx=7.8 ≦ δa=15 (OK)		δx=5.5 ≦ δa=15 (OK)		δx=5.7 ≦ δa=15 (OK)	
Lateral resistance		kN		Qr =5530 < N=5977		Qr =5530 < N=6116		Qr =5975 < N=6039	
Pile Reaction		kN		P_{nmax} =66109 < Ra=83512		P_{nmax} =82279 < Ra=120116		P_{nmax} =110930 < Ra=160088	
Pile body	thickness	mm		t=12mm(SKK400)		t=12mm(SKK400)		t=12mm(SKK400)	
	Mu	kN.m		732.8		1208.6		1858.7	
	Mn	kN.m		1657.7		3328.3		5190.1	
	fs	-		2.26		2.75		2.79	
	Extreme	ft	N/mm^2	5.6 < 140.0		1.4 < 140.0		21.4 < 140.0	
		ft	N/mm^2	98.0 < 140.0		84.0 < 140.0		84.0 < 140.0	
Cost Estimate				Material Quantities	Cost (VND)	Material Quantities	Cost (VND)	Material Quantities	Cost (VND)
Item		unit	Unit cost (VND)						
Pile cap									
Concrete 28MPa		m^3	5,867,864	782.3	4,590,576,704	996.1	5,844,832,634	1,314.8	7,715,214,284
Lean Concrete		m^3	1,723,811	23.5	40,568,168	32.1	55,410,181	45.0	77,595,628
Blinding stone		m^3	696,000	47.1	32,759,328	64.3	44,744,448	90.0	62,659,488
Excavation		m^3	318,066	372.4	118,435,056	468.7	149,064,812	617.8	196,488,452
Cofferdam		ton	24,798,638	78.8	1,955,124,620	126.4	3,133,555,898	142.6	3,535,293,833
Sub total					6,737,463,876		9,227,607,972		11,587,251,686
Foundation									
Steel Pile (Diameter)	0.8m	m	0	1,914.0	26,511,762,933				
	1.1m	m	0			1,740.0	32,308,182,500		
	1.4m	m	0					1,566.0	54,928,566,000
Sub total					26,511,762,933		32,308,182,500		54,928,566,000
Total					33,249,226,809		41,535,790,472		66,515,817,686
ratio				1.000		1.249		2.001	
Evaliation				Most Recommended					

Source : Study Team

Table 8.4.4-7 Comparison for pile diameter of cast in place pile

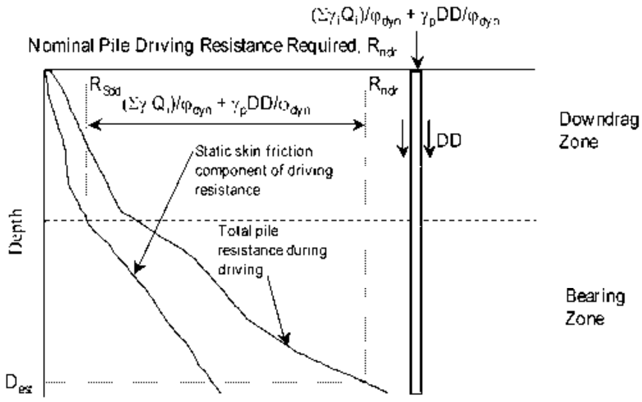
Alternative				Altrenative-1		Altrenative-2		Altrenative-3	
Pile Type				Cast-in-place pile D=1.2m		Cast-in-place pile D=1.5m		Cast-in-place pile D=2.0m	
Plan of Pile Cap									
				L=46.5m	n=12nos	L=46.5m	n=9nos	L=46.5m	n=6nos
Displacement		mm		δx=1.3≦δa=15 (OK)		δx=1.2 ≦δa=15 (OK)		δx=1.5 ≦δa=15 (OK)	
Pile Reaction		kN		P_{nmax} =43003 ≦ Ra=43812		P_{nmax} =43005 ≦ Ra=44005		P_{nmax} =43003 ≦ Ra=43469	
Pile body	As	nos		D25-24nos(minimum)		D28-24nos(minimum)		D32-32nos	
	Mu	kN.m		1050.2		1587.1		3320.4	
	Mn	kN.m		2124.6		3464.2		8904.2	
	fs	-		2.02		2.18		2.68	
	Extreme	fc	N/mm^2	2.6 < 11.2		2.3 < 11.2		1.9 < 11.2	
		fs	N/mm^2	30 < 202		26 < 202		21 < 182	
Cost Estimate				Material Quantities	Cost (VND)	Material Quantities	Cost (VND)	Material Quantities	Cost (VND)
Item		unit	Unit cost (VND)						
Pile cap									
Concrete 28MPa		m^3	5,867,864	239.4	1,404,766,642	275.6	1,617,183,318	315.0	1,848,377,160
Lean Concrete		m^3	1,723,811	10.0	17,238,110	11.0	18,961,921	13.0	22,409,543
Blinding stone		m^3	696,000	19.0	13,224,000	22.0	15,312,000	25.0	17,400,000
Excavation		m^3	318,066	110.0	34,987,260	120.0	38,167,920	133.0	42,302,778
Cofferdam		ton	24,798,638	86.0	2,132,682,868	90.0	2,231,877,420	97.0	2,405,467,886
Sub total					3,602,898,880		3,921,502,579		4,335,957,367
Foundation									
Bord Pile (Diameter)	1.2m	m	14,553,000	576.0	8,382,528,000				
	1.5m	m	17,423,000			432.0	7,526,736,000		
	2.0m	m	27,343,000					288.0	7,874,784,000
Sub total					8,382,528,000		7,526,736,000		7,874,784,000
Total					11,985,426,880		11,448,238,579		12,210,741,367
ratio				1.047		1.000		1.067	
Evaliation						Most Recommended			

Source : Study Team

(4) Downdrag load

1) Analysis of downdrag by consolidation

For clay, the drainage time after the application of a load is long because the permeability of clay is small thus consolidation occurs over a long period of time. In contrast, sand and gravel have large permeability's and after the application of a load, the water drains rapidly. Consolidation occurs quickly because water in sand or gravel moves easily through the pores. Also, the amount of compression is small in sand and gravel. For this reason, consolidation is usually used for fine grained soil, such as clay and silt. In the case of a pile driving into the ground where consolidation will occur by reclamation, the foundation should be designed so that the available factored geotechnical resistance is greater than the factored loads applied to the pile, including the downdrag (DD), as following drawing.



Source : Study Team

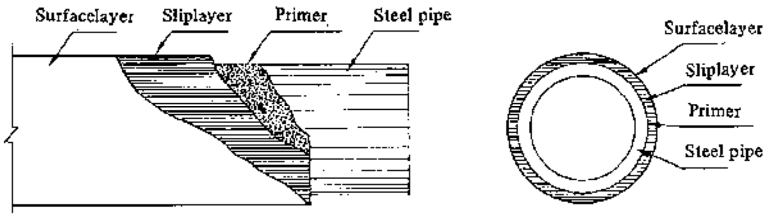
Figure 8.4.4-4Design of pile foundations for downdrag

2) Countermeasure to downdrag

Conventional measures against negative friction, such friction was reduced by increasing the strength of piles or forming a pile group new techniques have recently been utilized , where reduction in negative friction is achieved by use of piles covered with the special asphalt called "Slip layer compound"-SL piles. In this project, countermeasure to downdrag adopts the SL piles due to its economical efficiency.

3) Principles of Reducing Negative Friction on SL pile and standard section

The slip layer material, that is, special asphalt is one of the typical viscoelastic materials, of which physical properties depend on the velocity of shearing. When instantaneous load acts on a pile, especially at the time of pile driving, the velocity of shearing developed on the pile surface increases and thus, asphalt applied on the pile surface present an elastic property. In this case, a great shear resistance attributable to the elastic property enables the pile to be driven without any slippage of the slip layer. On the other hand, where a pile is subject to a slow ground movement such as land subsidence, the velocity of shearing developed on the pile surface is very low; asphalt applied on the pile surface presents a viscous property. In this case, slippage occurring in the slip layer due to the subsidence serves to prevent shearing force from being transmitted to the pile, thus permitting negative friction to be reduced. (Appendix Ap-113)



Source : Study Team

Figure 8.4.4-5Standard Sections of a SL piles

4) Load combination take account of downdrag

Downdrag is not combined with transient loads because transient loads caused downdrag movement of the pile or pier relative to the ground, causing temporary reduction or elimination of downdrag loads. Therefore, only permanent loads need be included with the drag loads as follows:

Load combination and load factor.

Table 8.4.4-8Load combination and load factor

Load combination and Load factor for Abutment

Load Combination Limit State		Permanent							Transient						WA	WS	WL	FR				TG	SE	EQ	CT	CV
		DC	DD	DW	EH	EV	ES	EL	LL	IM	CE	BR	PL	LS					TU	CR	SH					
STRENGTH- Ⅰ	max	1.25	1.80	1.50	1.50	1.35	1.50	1.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	min	0.90	0.45	0.65	0.9	0.90	0.75	1.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
STRENGTH- Ⅱ	max	1.25	1.80	1.50	1.50	1.35	1.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	min	0.90	0.45	0.65	0.90	0.90	0.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
STRENGTH-Ⅲ	max	1.25	1.80	1.50	1.50	1.35	1.50	1.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
	min	0.90	0.45	0.65	0.9	0.90	0.75	1.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EXTREME	max	1.25	-	1.50	1.5	1.35	1.50	0.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	mini	0.90	-	0.65	0.9	0.90	0.75	0.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SERVICE		1.00	1.00	1.00	1.00	1.00	1.00	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Load combination and Load factor for Pier

Load Combination Limit State		Permanent							Transient						WA	WS	WL	FR				TG	SE	EQ	CT	CV
		DC	DD	DW	EH	EV	ES	EL	LL	IM	CE	BR	PL	LS					TU	CR	SH					
STRENGTH- Ⅰ	max	1.25	1.80	1.50	-	-	-	1.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	min	0.90	0.45	0.65	-	-	-	1.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
STRENGTH- Ⅱ	max	1.25	1.80	1.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	min	0.90	0.45	0.65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
STRENGTH-Ⅲ	max	1.25	1.80	1.50	-	-	-	1.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
	min	0.90	0.45	0.65	-	-	-	1.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EXTREME	max	1.25	-	1.50	-	-	-	0.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	mini	0.90	-	0.65	-	-	-	0.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SERVICE		1.00	1.00	1.00	-	-	-	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

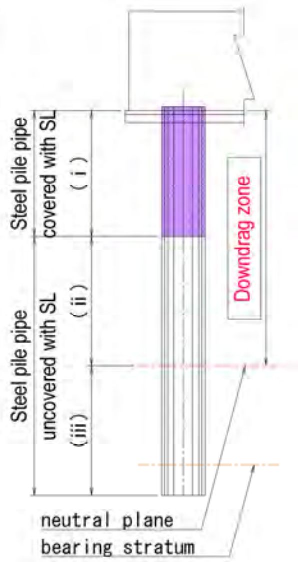
DC : Component and Attachment
DD : Downdrag
DW : Wearing Surfaces and Utilities
EH : Horizontal Earth Pressure
EL : Locked-in Erection Stress
EV : Vertical Earth Pressure
ES : Earth surcharge load
BR : Vehicular braking force
CE : Vehichlar centrifugal forth
CR : Creep
CT : Vehicular collision force
CV : Vessel collision force
EQ : Earthquake
FR : Friction
IM : Vehicular dynamic load allowance
LL : Vehicular live load
LS : Live load surcharge
PL : Pedestrian live load
SE : Settlement
SH : Shrinkage
TG : Temperature gradient
TU : Uniform temperature
WA : Water load and stream pressure
WL : Wind on live load
WS : Wind load on structure

Source : Study Team

5) Downdrag load and the range of SL pile

SL piles should be used as middle pile at a level above neutral point on which a greater negative friction acts. Downdrag loads can be estimated in a similar way to calculation of positive shaft resistance. Pile shaft resistance to calculate the downdrag loads shows as follows:

	Load Combination	
	Combined with only permanent load	Combined with transient loads
(i)	Negative shaft resistance Downdrag loads : estimate calculation of shaft resistance qs : -2 kN/m^2	Take no account of shaft resistance Downdrag loads : — qs : 0 kN/m^2
(ii)	Negative shaft resistance Downdrag loads : estimate calculation of shaft resistance qs : Using α or λ method.	Positive shaft resistance Downdrag loads : — qs : Using α or λ method.
(iii)	Positive shaft resistance Downdrag loads : — qs : Using α or λ method.	Positive shaft resistance Downdrag loads : — qs : Using α or λ method.



Source : Study Team

Figure 8.4.4-6 Downdrag load and the range of SL pile

8.4.4.4 Conclusions of Study

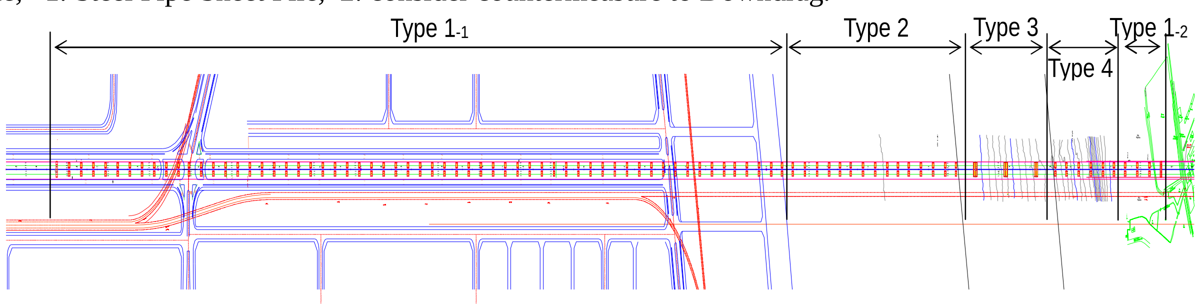
(1) Results of Study for Foundation Type

The results of study of foundation type for Approach bridge and main bride are shown in the following table. The underlined parts indicate the changes from the results in SAPROF Study.

Table 8.4.4-9 The results of Study of Foundation Type

Study Type	Type-1$_{-1}$	Tupe-2	Type-3	Type-4	Type-1$_{-2}$
Bridge Type	Approach	Approach	Main Br.	Approach	Approach
Station	STA.4+501.3~ STA.8+77.12	STA.8+130.1~ STA.8+935.0	STA.9+30.0~ STA.9+330.0	STA.9+425.0~ STA.9+599.8	STA.9+659.8~ STA.9+944.2
Pier No.	A1 ~ P60	P61 ~ P75	P76 ~ P78	P79 ~ P82	P83~ A2
Reclamation Plan	in operation	No	No	No	planning for the future
Bridge Span length (m)	60.0	60.0	150.0	60.0	60.0
Estimated Corrosion Thickness of Steel Pile (mm)	2	7	7	7	2
Water depth (m)	2.5~3.8	3.2~6.5	7.1~11.0	8.3~11.5	1.63~3.8
E.L. of Pile Cap*1	Variation 2	Variation 2 or 3	E.L.-5.0 (Top of Pile Cap)	Variation 4	Variation 2
Temp. Cofferdam	Sheet Pile	Sheet Pile	Pipe Pile	Sheet Pile	Sheet Pile
Type of Foundation	Pile Foundation	Pile Foundation	SPSP*1 Foundation **(Separate Type)**	**Multi Column Pile (under water)**	Pile Foundation
Type of Pile	Steel Pipe pile **with surface treating***2	**Cast in Place Pile**	Steel Pipe Sheet Pile	**Cast in Place Pile**	Steel Pipe pile **with surface treating***3
Determining Factor	Countermeasure to Downdrag	Construction Cost	Construction Period	Constructability and Aesthetics	Countermeasure to Downdrag
SAPROF Study for Type of Pile	Steel Pipe Pile	Steel Pipe Pile	SPSP Integrated Type	Steel Pipe Pile	Steel Pipe Pile

Note, *1: Steel Pipe Sheet Pile,*2: consider countermeasure to Downdrag.



Source : Study Team   Figure 8.4.4-7 Grouping for Foundation Study

8.4.5 Study on Type of Bridge Foundation

8.4.5.1 General

This study consists of two (2) sub-studies; the study on selection of approach bridge foundation, and the study on selection of main bridge foundation. In the study on selection of approach bridge foundation, study of site conditions for selecting an appropriate foundation type is a key discussion. In the study on selection of main bridge foundation, study of an appropriate foundation type and comparison of structure (integrated type and separate type) are the key discussions.

8.4.5.2 Study on Approach Bridge Foundation

(1) Selection of Foundation Type for Approach Bridge (Type-1)

1) General

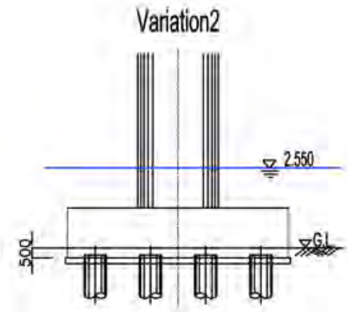
In the study of Type-1, there is reclamation planning with large number of pier. Therefore, the downdrag effect for pile by the definition of consolidation of clay layer and construction period needs to be examined in detail.

2) Site Condition

The site conditions are shown in below table. In the Variation 1, top of pile cap is seated below the seabed when the sea is shallow and pier height is low. Variation 2, bottom of pile cap is seated on the sea bed of deepwater. The construction of pile cap at below the sea bed is difficult in terms of structure of cofferdam. Furthermore, the pile cap is backfilled by reclamation in the future.

Table 8.4.5-1 Site Condition for Study of Type-1

Study Type	Type-1$_{-1}$	Type-1$_{-2}$
Bridge Type	Approach	Approach
Station	STA.4+561.3 ~8+77.12	STA.9+561.3~9+944.2
Pier No.	A1 ~ P60	P84 ~ A2
Reclamation Plan	Have a project	Have a plan
Bridge Span length (m)	60.0	60.0
Estimated Corrosion Thickness of Steel Pile (mm)	2	2
Water depth (m)	2.5~3.8	1.63~3.8
E.L. of Pile Cap	Variation 2	Variation 2



Source : Study Team

Figure 8.4.5-1Pile Cap Elevation of Variations 2

3) Comparative Study

a) Foundation Types for Comparison

In this comparative study, the following three (3) alternatives are studied.

Altenative-1: Steel pipe pile foundation
(Without countermeasures against downdrag)

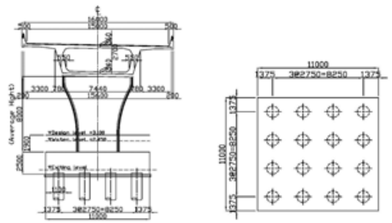
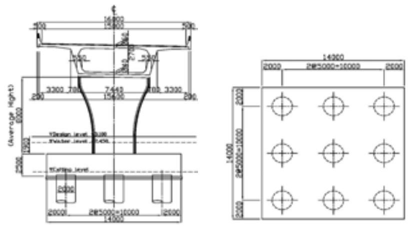
Altenative-2: Steel pipe pile foundation
(With countermeasures against downdrag by pile surface treatment)

Altenative-3: Cast in place pile foundation
(Countermeasure against downdrag is increasing the number of piles. Surface treatment can't be applied to this pile type)

b) Result of Comparative Study

The result of comparative study is shown in the Table 13.5.5-2. As this table indicates, Altenative-2, Steel pipe pile foundation with treatment of pile surface for downdrag, is the most recommendable foundation type for Type-1 of approach bridge because of its advantages in low construction cost and shortest construction period on account of consider countermeasure to downdrag.

Table 8.4.5-2 Comparison on Foundation Type-1 for Approach Bridge

EvaGuation Items		Area to take account of negative friction STATION : STA.4+500～STA.8+77, Pier number : P1～P61 Alternative-1 Steel Pipe Pile Foundation with Sheet Pile Cofferdam		Alternative-2 Steel Pipe Pile covered with thin coat of bitumen Foundation with Sheet Pile Cofferdam		Alternative-3 Cast In Place Pile Foundation with Cofferdam	
Side View PiGe arrangement		Diameter of pile : 1100 mm Total number of pile : 25 Total lenlth of pile : 46.0 m Thickness : 12.0 mm 		Diameter of pile : 1100 mm Total number of pile : 16 Total lenlth of pile : 46.0 m Thickness : 12.0 mm 		Diameter of pile : 2000 mm Total number of pile : 9 Total lenlth of pile : 48.0 m 	
Structural Aspect and Stability	10	- Pile Bearing Ratio (Pile Reaction/Pile Bearing) is 0.96 - Temporary coffer dam work for foundation construction is necessary. - Total number of Pile should magnify from 16nos to 25nos for countermeasure to negative friction.	8	- Pile Bearing Ratio (Pile Reaction/Pile Bearing) is 0.96 - Temporary coffer dam work for foundation construction is necessary. - Large number of Steel Sheet Piles and steel pipe. piles - Use steel Pipe Pile covered with thin coat of bitumen for countermeasure to negative friction.	8	- Pile Bearing Ratio (Pile Reaction/Pile Bearing) is 0.94 - Temporary coffer dam work for foundation construction is necessary. - Large number of Steel Sheet Piles and C.I.P. piles. - Diameter of Pile should magnify from 1500mm to 2000mm for countermeasure to negative friction.	4
Construction Cost (for Foundation)	40	Item / Quantity / Unit Cost (VND) / Total (1,000VND) Pile Cap Concrete / 473m3 / 5,867,864 / 2,773,739 Pile / 1213m / 14,106,802 / 17,104,497 Lean Concrete / 19m3 / 1,723,811 / 32,752 Blinding stone / 38m3 / 696,000 / 26,448 Excavation / 176m3 / 318,066 / 55,980 Cofferdam / 111ton / 24,798,638 / 2,752,649 Driving *1 / 834m / 622,237 / 518,946 Total 23,265,011 Ratio **1.441**	16	Item / Quantity / Unit Cost (VND) / Total (1,000VND) Pile Cap Concrete / 303m3 / 5,867,864 / 1,775,029 Pile / 736m / 17,558,795 / 12,923,273 Lean Concrete / 12m3 / 1,723,811 / 20,686 Blinding stone / 24m3 / 696,000 / 16,704 Excavation / 128m3 / 318,066 / 40,712 Cofferdam / 93ton / 24,798,638 / 2,306,273 Driving *1 / 702m / 622,237 / 436,810 Total 17,519,488 Ratio **1.085**	32	Item / Quantity / Unit Cost (VND) / Total (1,000VND) Pile Cap Concrete / 490m3 / 5,867,864 / 2,875,253 Pile / 432m / 22,743,000 / 9,824,976 Lean Concrete / 20m3 / 1,723,811 / 34,476 Blinding stone / 39m3 / 696,000 / 27,144 Excavation / 181m3 / 318,066 / 57,570 Cofferdam / 113ton / 24,798,638 / 2,802,246 Driving *1 / 846m / 622,237 / 526,413 Total 16,148,078 Ratio **1.000**	40
Construction Plan and Period	10	- Workability is inferior due to large temporary cofferdam work in the sea. Cofferdam Work 14 days Pile work *2 (1.5pile/day) 21 days Pile Cap 48 days Total **83 days**	4	- Workability is inferior due to large temporary cofferdam work in the sea Cofferdam Work 9 days Pile work *2 (1.5pile/day) 13 days Pile Cap 29 days Total **51 days**	6	- Workability is inferior due to large temporary cofferdam work in the sea Cofferdam Work 14 days Pile work *2 (0.5pile/day) 22 days Pile Cap 50 days Total **86 days**	4
Maintenance	15	- Superior in Maintenance with small number of maintenance points.	9	- Superior in Maintenance with small number of maintenance points.	9	- Superior in Maintenance with small number of maintenance points.	9
STEP Clearance	10	- 90% (Preliminary Estimate) - Large number of steel pipe pile acceptance a contribution	10	- 90% (Preliminary Estimate) - Large number of steel pipe pile acceptance a contribution	10	- 21% (Preliminary Estimate) - small number of Cast in place pile acceptance a contribution	8
Aesthetics	5	- Slender appearance of Pier - Pile cap not to be exposed above water level.	3	- Slender appearance of Pier - Pile cap not to be exposed above water level.	3	- Slender appearance of Pier - Pile cap not to be exposed above water level.	3
New Technology	5	- Steel Pipe Pile Foundation is new technology in Vietnam	4	- Steel Pipe Pile Foundation is new technology in Vietnam - Steel Pipe Pile covered with thin coat of bitumen for countermeasure to negative friction is new technology in Vietnam.	5	- Cast in pile (D=2.0m) is no special technology in Vietnam.	3
Environmental Aspect	5	- Superior in Environmental aspect with small number of excavated soil & bentonite water.	5	- Superior in Environmental aspect with small number of excavated soil & bentonite water.	5	- Environmental measures for surplus soil and discharging water is necessary.	2
Evaluation	100	- Superior in Environmental aspect with small number of excavated soil & bentonite water. Not Recommended	**59**	- Construction cost is lowest in area to take account of negative friction. - Minimum Construction period with efficient workability. - Superior in Environmental aspect with small number of excavated soil & bentonite water. Most Recommended	**78**	- Environmental measures for surplus soil and discharging water is necessary. Not Recommended	**73**

*1. Including for Puling of steel sheet pile. *2. Including for Pile top treatment

Source : Study Team

(2) Selection of Foundation Type for Approach Bridge (Type-2)

1) General

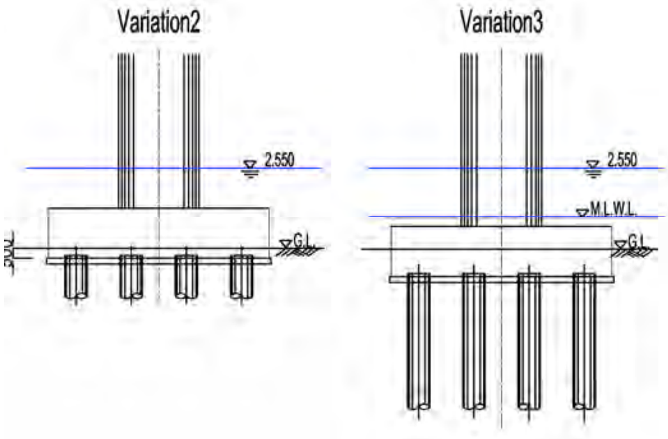
In the study of Type-2, there is less number of piers; the point of this study is the construction costs need to focus on the detail.

2) Site Condition

The site conditions indicate as following. In the Alternative 3, top of pile cap shall be set below Mean Low Water Level (EL.0.000) in order to comply with the regulation which prohibits exposure of pile cap body above Mean Low Water Level.

Table 8.4.5-3 Site Condition for Study of Type-2

Study Type	Tupe-2
Bridge Type	Approach
Station	STA.4+561.3 ~8+77.12
Pier No.	P61 ~ P75
Reclamation Plan	No
Bridge Span length (m)	60.0
Estimated Corrosion Thickness of Steel Pile (mm)	7
Water depth (m)	3.2~6.5
E.L. of Pile Cap	Variation 2 or 3



Source : Study Team

Figure 8.4.5-2 Pile Cap Elevation of Variation 2 or 3

3) Comparative Study

a) Foundation Types for Comparison

In this comparative study, the following three alternatives are studied.

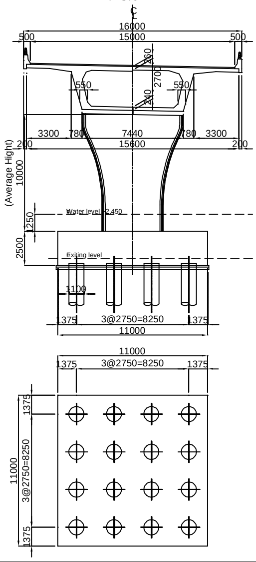
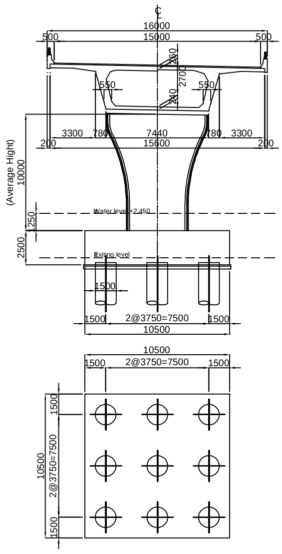
Altenative-1: Steel Pipe Pile Foundation

Altenative-2: Cast in Place Pile Foundation

b) Result of Comparative Study

The result of comparative study is shown in following Table. As this table indicates, Altenative-2, cast in place pile foundation, is the most recommendable foundation type for Type-2 of approach bridge because of its advantages in lowest construction cost.

Table 8.4.5-4 Comparison on Foundation Type-2 for Approach Bridge

Evaluation Items		Area to take no account of negative friction STATION :STA.8+77～STA.9+944, Pier number : P61～P75 Alternative-1 Steel Pipe Pile Foundation with Sheet Pile Cofferdam		Alternative-2 Cast In Place Pile Foundation with Cofferdam	
Side View Pile arrangement		Diameter of pile : 1100 mm Total number of pile : 16 Total length of pile : 43.5 m Thickness : 19.0 mm  		Diameter of pile : 1500 mm Total number of pile : 9 Total length of pile : 42.0 m  	
Structural Aspect and Stability	10	- Pile Bearing Ratio (Pile Reaction/Pile Bearing) is 0.91. - Temporary cofferdam work for foundation construction is necessary. - Large number of Steel Sheet Piles and steel pipe piles	6	- Pile Bearing Ratio (Pile Reaction/Pile Bearing) is 0.91. - Temporary cofferdam work for foundation construction is necessary. - Small number of Steel Sheet Piles and C.I.P. piles.	6
Construction Cost (for Foundation)	40	Item / Quantity / Unit Cost (VND) / Total (1,000VND) Pile Cap Concrete / 303m3 / 5,867,864 / 1,775,029 Pile / 696m / 15,728,273 / 10,946,878 Lean Concrete / 12m3 / 1,723,811 / 20,686 Blinding stone / 24m3 / 696,000 / 16,704 Excavation / 128m3 / 318,066 / 40,712 Cofferdam / 93ton / 24,798,638 / 2,306,273 Driving *1 / 702m / 622,237 / 436,810 Total 15,543,093 Ratio **1.418**	16	Item / Quantity / Unit Cost (VND) / Total (1,000VND) Pile Cap Concrete / 276m3 / 5,867,864 / 1,617,183 Pile / 378m / 17,514,043 / 6,620,308 Lean Concrete / 11m3 / 1,723,811 / 18,962 Blinding stone / 22m3 / 696,000 / 15,312 Excavation / 120m3 / 318,066 / 38,168 Cofferdam / 90ton / 24,798,638 / 2,231,877 Driving *1 / 678m / 622,237 / 421,877 Total 10,963,688 Ratio **1.000**	40
Construction Plan and Period	10	- Workability is inferior due to large temporary cofferdam work in the sea. Cofferdam Work 9 days Pile work 13 days Pile Cap 29 days Column & Column Beam 23 days Total **74 days**	8	- Workability is inferior due to large temporary cofferdam work in the sea. Cofferdam Work 9 days Pile work *2 20 days Pile Cap 29 days Column & Column Beam 23 days Total **81 days**	6
Maintenance	15	- Superior in Maintenance with small number of maintenance points.	9	- Superior in Maintenance with small number of maintenance points.	9
STEP Clearance	10	89%(preliminary Estimate) - Large number of steel pipe pile acceptance a contribution	10	- 27% (Preliminary Estimate) - small number of Cast in place pile acceptance a contribution	8
Aesthetics	5	- Slender appearance of Pier - Pile cap not to be exposed above water level.	3	- Slender appearance of Pier - Pile cap not to be exposed most of time above water level.	3
New Technology	5	- Steel Pipe Pile Foundation is new technology in Vietnam.	5	· Cast in pile (D=1.5m) is no special technology in Vietnam.	3
Environmental Aspect	5	- Superior in Environmental aspect with small number of excavated soil & bentonite water.	5	- Environmental measures for surplus soil and discharging water is necessary.	2
Evaluation	100	- Superior in Environmental aspect with small number of excavated soil & bentonite water. - Minimum Construction period with efficient workability. Not Recommended	**62**	- Environmental measures for surplus soil and discharging water is necessary. - Construction cost is lowest in area to take no account of negative friction. Most Recommended	**77**

Note） *1. Including for Pile top treatment *2.Including for Pile top treatment

Source : Study Team

(3) Selection of Foundation Type for Approach Bridge (Type-4)

1) General

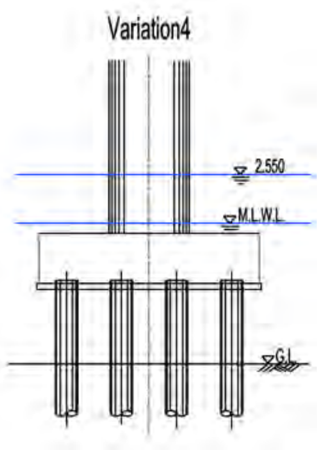
In the study of Type-4, there is planning closed the navigation channel with Cat Hai Island at deep water. The point of this study is the structural aesthetics which shall be harmonize with scenery of Cut Hai Island and safe construction at the deep water.

2) Site Condition

The site conditions indicate as following. In the Alternative 4, top of pile cap is seated below the Mean Low Water Level (EL-1.670) as same as Alternative 3. In addition to the condition, bottom of pile cap is not contact onto seabed due the deepwater; construction of pile cap at riverbed is difficult in terms of structure of cofferdam.

Table 8.4.5-5 Site Conditions for Study of Type-4

Study Type	Type-4
Bridge Type	Approach
Station	STA.9+425.0 ~9+599.8
Pier No.	P79 ~ P82
Reclamation Plan	No
Bridge Span length (m)	60.0
Estimated Corrosion Thickness of Steel Pile (mm)	7
Water depth (m)	8.3~11.5
E.L. of Pile Cap*	Variation 4



Source : Study Team

Figure 8.4.5-3 Pile Cap Elevation of Variation 4

3) Comparative Study

a) Foundation Types for Comparison

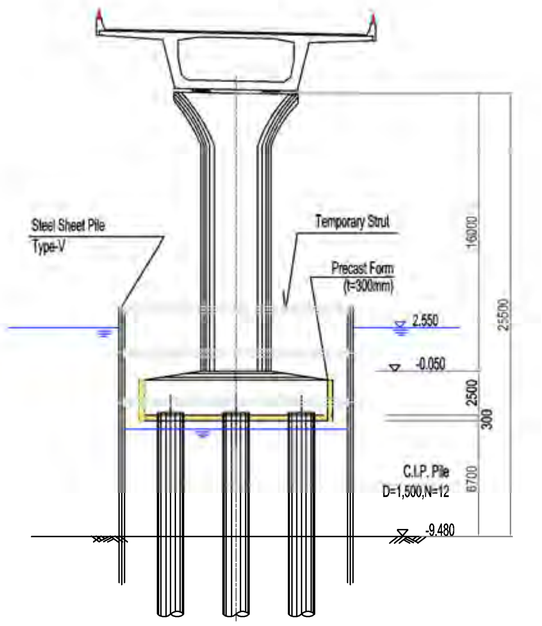
In this comparative study, the following three (3) alternatives are studied. In the Alternative-1 and 2, due to the deepwater, cofferdam work by steel sheet pile is risky work. Therefore, steel sheet pipe pile is selected for the cofferdam work for Alternative-1 and 2. For this reason, in the Alternative-3 is selected multi column foundation by cast in place pile. However, Alternative-3, the portion of pile cap to be exposed above water level is large. The Alternative-4 can be cootch the pile cap to below the mean low water level (refer to following construction drawing).

Alternative-1: Steel Pipe Pile Foundation with Steel Pipe Sheet Pile Cofferdam

Alternative-2: Cast in Place Pile Foundation with Steel Pipe Sheet Pile Cofferdam

Alternative-3: Multi Column Foundation by Cast in Place Pile

Alternative-4: Multi Column Foundation by Cast in Place Pile with Steel Sheet Pile Cofferdam



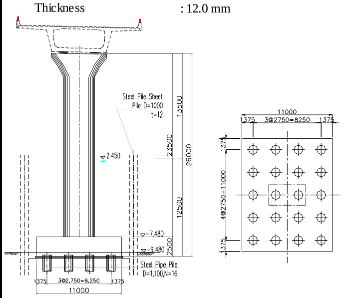
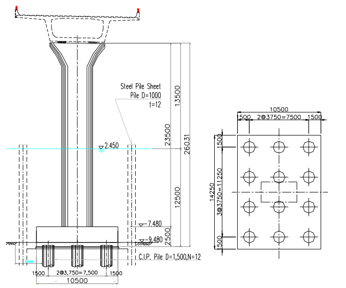
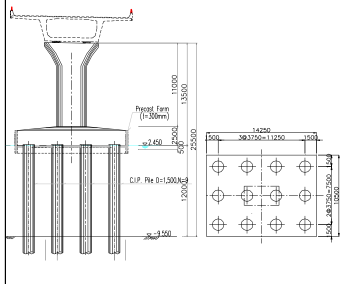
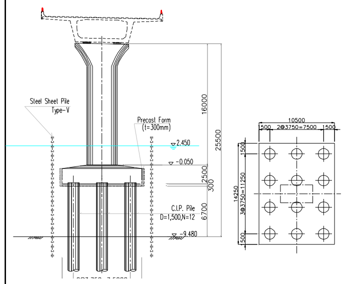
Source : Study Team

Figure 8.4.5-4 Construction Plan of Alternative-4

b) Result of Comparative Study

The result of comparative study is shown in following Table. As the table indicates, Altenative-4, Multi Column Foundation by Cast in Place pile with Steel Sheet Pile Cofferdam, is the most recommendable foundation type for Type-4 of approach bridge because of its advantages in construction cost, construction period and aesthetics. .

Table 8.4.5-6 Comparison on Foundation type-4 for Approach Bridge

Evaluation Items	Max. Point	Alternative-1 Steel Pipe Pile Foundation with Steel Pipe Pile Cofferdam		Alternative-2 Cast in Place Pile Foundation with Steel Pipe Pile Cofferdam		Alternative-3 Cast In Place Multi Column Foundation		Alternative-4 C.I.P. Pile Multi Column Foundation with Steel Sheet Pile Cofferdam	
Side View		Diameter of pile : 1100 mm Total number of pile : 20 Total length of pile 40m Thickness : 12.0 mm 		Diameter of pile : 1100 mm Total number of pile : 12 Total length of pile : 40.0 m 		Diameter of pile : 1500 mm Total number of pile : 12 Total length of pile : 52.0 m 		Diameter of pile : 1500 mm Total number of pile : 12 Total length of pile : 49.5 m 	
Structural Aspect and Stability	10	- Pile Bearing Ratio (Pile Reaction/Pile Bearing) is 0.91. - Temporary coffer dam work for foundation construction is necessary. - Large number of - Large number of steel pipe piles	8	- Pile Bearing Ratio (Pile Reaction/Pile Bearing) is 0.92. - Temporary coffer dam work for foundation construction is necessary. - Large number of - Small number of C.I.P. piles	8	- Pile Bearing Ratio (Pile Reaction/Pile Bearing) is 0.92. - Steel casing is neglected from Cross-section calculation. - Temporary Precast form for pile cap construction is necessary. - Protection of Ship allision for pile is necessary.	4	- Pile Bearing Ratio (Pile Reaction/Pile Bearing) is 0.89. - Steel casing is neglected from Cross-section calculation. - Temporary Precast form for pile cap construction is necessary. - Temporary coffer dam work for foundation construction is necessary. - Vertical force can be reduced due to buoyancy of Pile Cap.	10
Construction Cost (for Foundation)	40	Item / Quantity / Unit Cost (VND) / Total (1,000VND) Pile Cap Concrete 378m3 2,652,255 1,002,884 Column Concrete 264m3 2,652,255 1,002,884 Pile 258ton 43,982,414 11,329,870 Antiwaashout water Concrete 15m3 1,723,811 26,073 Precast Form 30m3 696,000 21,054 Excavation 102m3 318,066 32,562 Cofferdam 317ton 43,982,414 13,933,629 Driving *1 2340m 622,237 1,456,035 Total 28,804,990 Ratio **1.997**	0	Item / Quantity / Unit Cost (VND) / Total (1,000VND) Pile Cap Concrete 374m3 2,652,255 992,109 Column Concrete 264m3 2,652,255 992,109 Pile 480m 17,514,043 8,406,741 Antiwaashout water Concrete 15m3 1,723,811 25,793 Precast Form 30m3 696,000 20,828 Excavation 102ton 318,066 32,304 Cofferdam 317ton 43,982,414 13,933,629 Driving *1 2160m 622,237 1,344,032 Total 25,747,544 Ratio **1.785**	16	Item / Quantity / Unit Cost (VND) / Total (1,000VND) Pile Cap Concrete 337m3 2,652,255 892,898 Column Concrete 124m3 2,652,255 892,898 Pile 624ton 17,514,043 10,928,763 Antiwaashout water Concrete 67m3 5,304,510 357,159 Precast Form 170m3 7,956,765 1,349,766 Excavation ton 318,066 0 Cofferdam ton 43,982,414 0 Driving *1 m 622,237 0 Total 14,421,484 Ratio **1.000**	40	Item / Quantity / Unit Cost (VND) / Total (1,000VND) Pile Cap Concrete 337m3 2,652,255 892,898 Column Concrete 180m3 2,652,255 892,898 Pile 594ton 17,514,043 10,403,342 Antiwaashout water Concrete m3 5,304,510 0 Precast Form 170m3 7,956,765 1,349,766 Excavation ton 318,066 0 Cofferdam 73ton 24,798,638 1,812,284 Driving *1 m 622,237 0 Total 15,351,188 Ratio **1.064**	32
Construction Plan and Period	10	- Workability is inferior due to large temporary cofferdam work in the sea Cofferdam Work 39 days Pile work 16 days Pile Cap 40 days Column & Column Beam 33 days Total **128 days**	4	- Workability is inferior due to large temporary cofferdam work in the sea Cofferdam Work 38 days Pile work*2 27 days Pile Cap 39 days Column & Column Beam 33 days Total **137 days**	6	- Workability is superior due to no cofferdam work. Precast Form Work 15 days Pile work*2 29 days Pile Cap 39 days Column & Column Beam 16 days Total **99 days**	10	- Workability is superior with precast form and steel pipe pile Precast Form Work 18 days Pile work*2 29 days Pile Cap 39 days Column & Column Beam 23 days Total **109 days**	8
Maintenance	15	- Superior in Maintenance with small number of maintenance points.	10	- Superior in Maintenance with small number of maintenance points.	10	- Inferior in Maintenance due to large precast form and pile cap on the sea.	10	- Inferior in Maintenance due to large precast form and pile cap on the sea.	10
STEP Clearance	10	- 85% (Preliminary Estimate) - Large number of steel pipe pile acceptance a contribution	10	- 32% (Preliminary Estimate) - small number of Cast in place pile acceptance a contribution	4	11%(preliminary Estimate) - small number of Cast in place pile acceptance a contribution	6	11%(preliminary Estimate) - small number of Cast in place pile acceptance a contribution	6
Aesthetics	5	- Slender appearance of Pier - Pile cap not to be exposed above water level.	5	- Slender appearance of Pier - Pile cap not to be exposed above water level.	5	- Large pile cap to be exposed above water level is large.	0	- Pile cap not to be exposed above water level.	5
New Technology	5	- Steel Pipe Pile Foundation is new technology in Vietnam	3	- Cast in pile (D=1.5m) is no special technology in Vietnam	3	- Multi Column Foundation with Cast in pile (D=1.5m) is no special technology in Vietnam	3	- Multi Column Foundation with Cast in pile (D=1.5m) is no special technology in Vietnam	4
Environmental Aspect	5	- Superior in Environmental aspect with small number of excavated soil & bentonite water	5	- Environmental measures for surplus soil and discharging water is	3	- Environmental measures for surplus soil and discharging water is necessary.	3	- Environmental measures for surplus soil and discharging water is necessary.	3
Evaluation	100	- Construction cost is highest - Workability is inferior due to temporary coffer dam work in the sea.	**45**	- Workability is inferior due to temporary coffer dam work and C.I.P work in the sea. - Environmental measures for surplus soil and discharging water is excavated soil & bentonite water	**55**	- Minimum Construction cost with construction period.	**76**	- Minimum Construction cost with construction period.	**78**
		Less Recommended		Not Recommended		Not Recommended		**Most Recommended**	

Note) *1. Including for Pile top treatment *2.Including for Pile top treatment

Source : Study Team

8.4.6 Detailed Design of Approach Bridge

8.4.6.1 Hai an side Approach Bridge

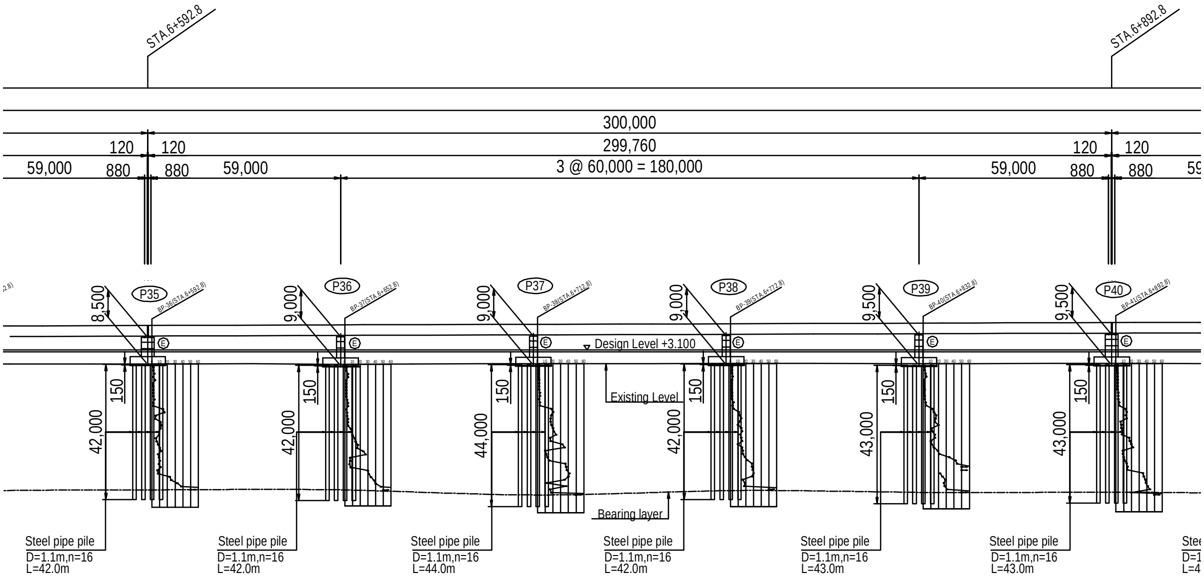
To construct it by the Span-by-Span erection method of a precast segment, the Hai an side approach bridge is designed in consideration of an actual construction process. Main girder is designed about four cases where the span length of the approach bridge is different depending on the crossroad condition.

(1) Span length of Approach Bridge

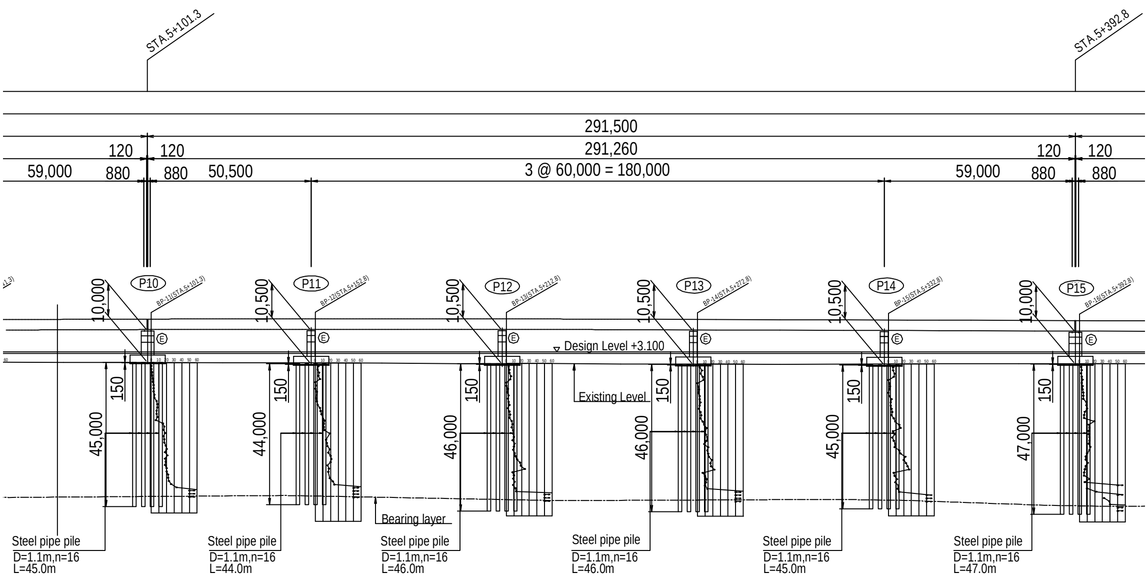
There are four kinds of span length of Hai an side approach bridge as follows.

1) PC 5 span continuous box girder bridge (A line), P35~P40 (59.0m+3@60.0m+59.0m)

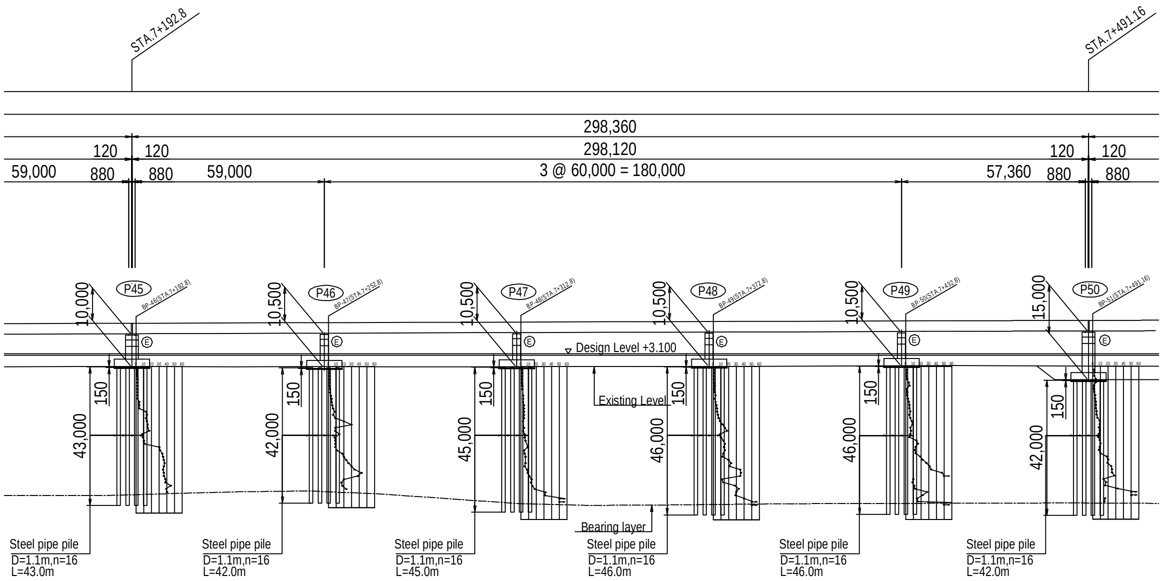
The same approach bridge is A1-P5, P5-P10, P15-P20, P20-P25, P25-P30, P40-P45, P50-P55.



2) PC 5 span continuous box girder bridge (A line), P10~P15 (50.5m+3@60.0m+59.0m)

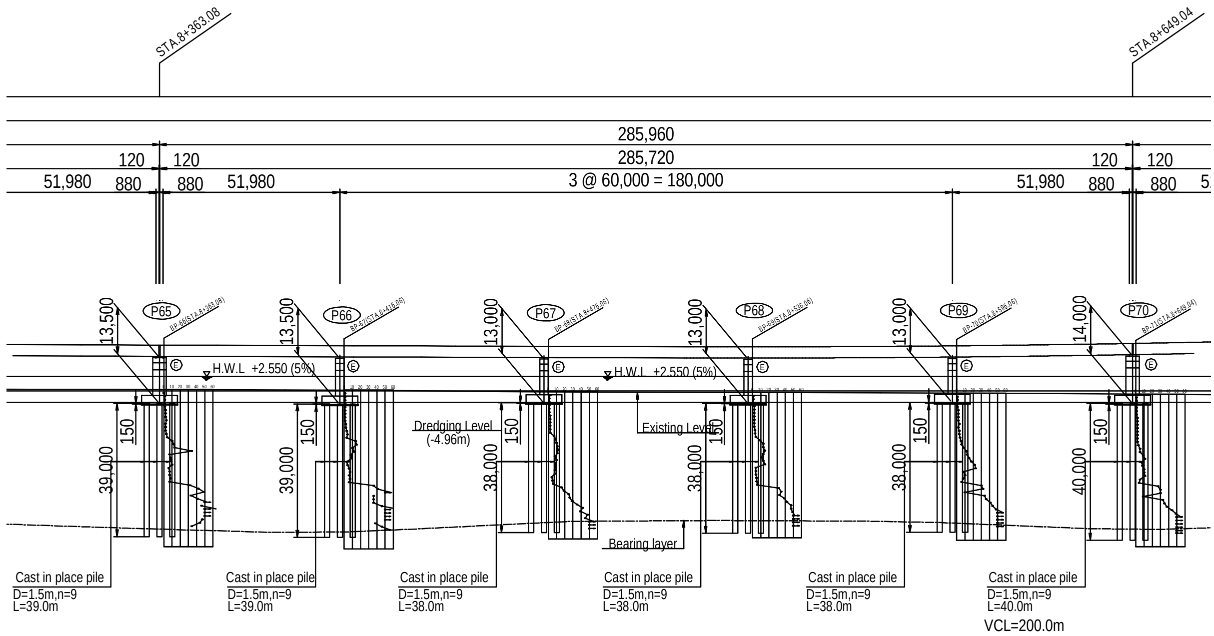


3) PC 5 span continuous box girder bridge (A line), P45~P50 (59.0m+3@60.0m+57.36m)



4) PC 5 span continuous box girder bridge (A-line) P65~P70 (51.98m+3@60.0m+51.98m)

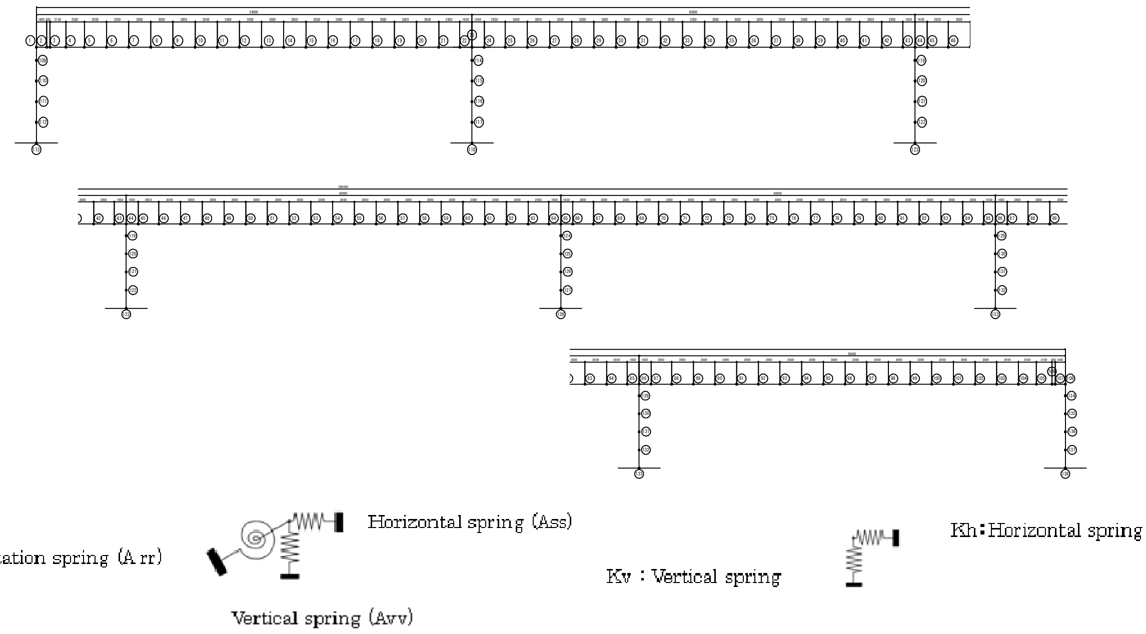
The same approach bridge is P55-P60, P60-P65, P70-P75.



(2) Model for structural analysis

The structure model shall consist of the lines connecting the centroid axes of the members, with the axis of the girder made to coincide with the design profile alignment of the completed system.

The foundation structure and ground and bearig shall be modelled as elastic springs having equivalent behaviour.



Spring model of the foundation　　　　Spring modele of bearing

Source : Study Team

Figure 8.4.6-1 Analysis Model

(3) Construction schedule

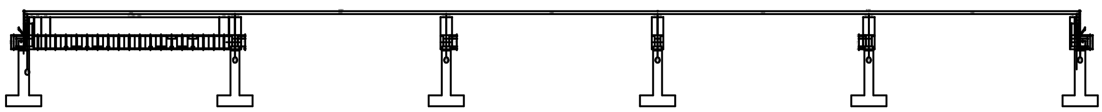
The process and the schedule of the structure analysis are as following figure.

Step 1.Construction of Pier and Foundation (360 days)

Step 2. Construction of Pier Table（60 days）

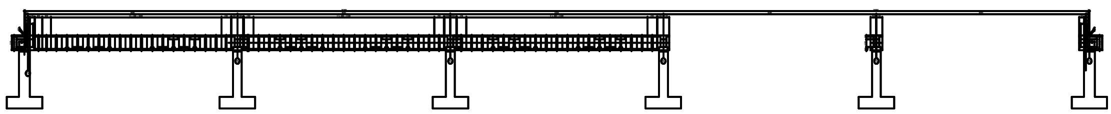
Step3. Construction of First Span (30 days)

（It is assumed that concrete age at erection time is 120 days.）

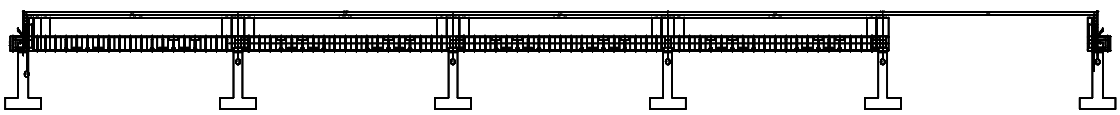


Step4. Construction of Second Span (15 days)

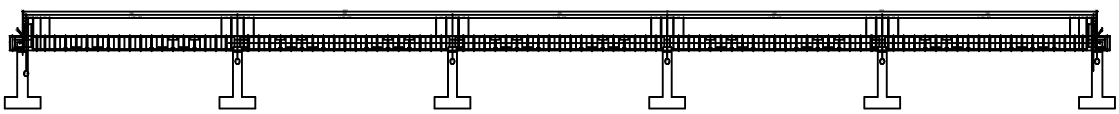
Step5. Construction of third Span (15 days)



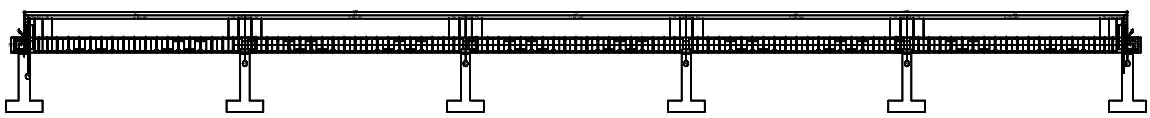
Step6. Construction of 4th Span (15 days)



Step7. Construction of 5th Span (15 days) (Completion of Structure)

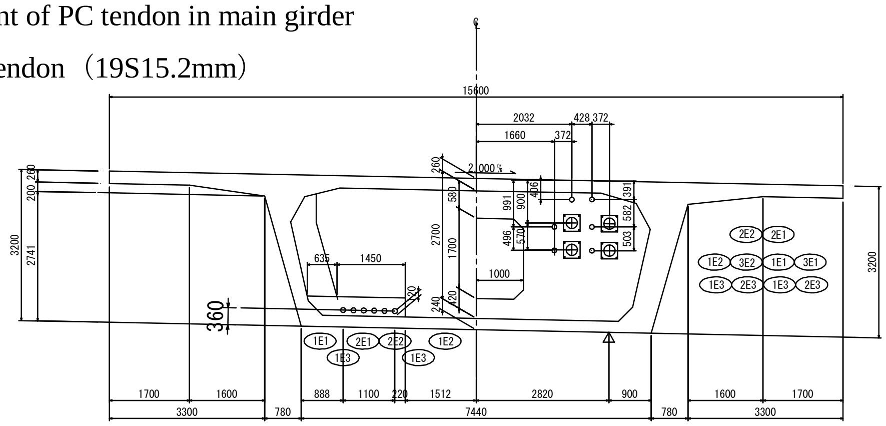


Step8. Construction of Surfacing (60days)

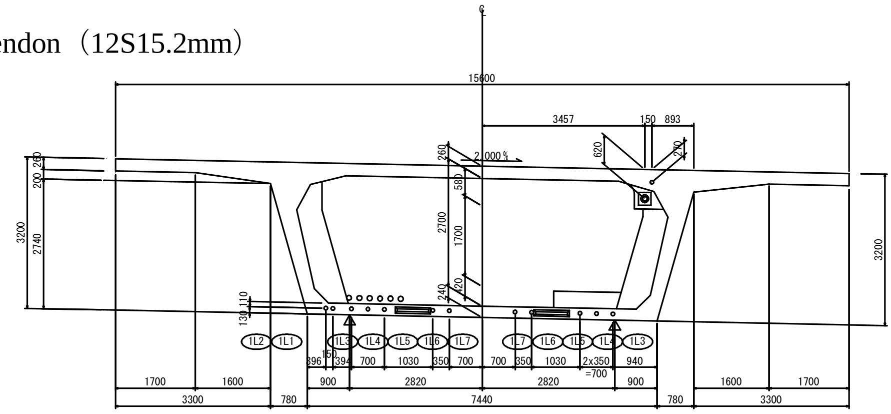


(4) Arrangement of PC tendon in main girder

1) External tendon（19S15.2mm）



2) Internal tendon（12S15.2mm）



(5) Design result of main girder

1) Design result of longitudinal direction of girder P35-P40 (59.0m+3@60.0+59.0m)

Table 8.4.6-1 Design result of longitudinal direction of girder P35-P40

P35-P40 59.0m+3@60.0m+59.0m			unit	Side span Center Sec.12	Middle support Sec.23	Middle span CenterSec.75
Dimension of Girder	height		m	3.200	3.200	3.200
	Slab thickness	Upper	m	0.260	0.260	0.260
		Lower	m	0.240	0.240	0.240
	Web thickness		m	0.40-0.30	0.65-0.55	0.4-0.30
Arrangement	PC tendon	External		19S15.2mm - 12 nos.		
		Inner		12S15.2-14nos	12S15.2-4nos	12S15.2-12nos
	Reinforcement bar	Upper slab		D13ctc250(up),D13ctc125(under)		
		Lower slab		D13ctc125(up),D13ctc250(under)		
		Stirrup		D19ctc125	D19ctc125	D19ctc125
Section Force Bending moment	Dead load	Mdc	kNm	81418	-43654	56616
	Super imposed	Mdw	kNm	12095	-17591	5543
	2nd Effect by PS	Mp	kNm	21887	45849	53083
	CR&SH	Mcs	kNm	-1626	-5235	-6274
	Live load	Ml+im	kNm	19807	-18631	16461
	Temperature(TG)	Mtg	kNm	6066	13159	11322
	Dead load state		kNm	119840	-24578	120289
	Service limit state		kNm	136731	-41858	131143
Fiber stress	Dead load (D+CR+SH)	Upper	N/mm2	7.32	4.55	7.00
		Bottom	N/mm2	3.72	15.01	3.08
	Service limit state	Upper	N/mm2	11.95	2.02>0.0	11.62
		Bottom	N/mm2	0.53>0.0	17.79	0.12>0.0
Strength limit state	Factored moment	Mu	kNm	174654	-74738	153510
	Resisting moment	Mr	kNm	296546	-221567	282936
	Safety factor	Mr/ Mu		1.70 >1.0	2.96> 1.0	1.84 > 1.0
Shearing and Torsional Resistance				End Sec.2	Middle Sec.24	Middle Sec.64
Shear stress	Diagonal tensile stress		N/mm2	-0.57	-0.62	-0.62
Strength limit state	Factored shear force Vu		kN	12407	13794	13766
	Shear resistance of con. Vc		kN	5016	4161	4164
	Component of pre-stress Vp		kN	3567	3758	3754
	Shear resistance of rebarVs		kN	8723	7287	7216
	Nominal Vn=Vc+Vp+Vs		kN	17306	15206	15134

Source : Study Team

2) Design result of main girder P10-P15 (51.0m+3@60.0+59.0m)

Table 8.4.6-2 Design result of main girder P10-P15

P10-P15 51.0m+3@60.0+59.0m			unit	Side span Center Sec.13	Middle support Sec.23	Middle span CenterSec.75
Dimension of Girder	height		m	3.200	3.200	3.200
	Slab thickness	Upper	m	0.260	0.260	0.260
		Lower	m	0.240	0.240	0.240
	Web thickness		m	0.40-0.30	0.65-0.55	0.4-0.30
Arrangement	PC tendon	External		19S15.2mm - 12 nos		
		Inner		12S15.2-6nos	12S15.2-4nos	12S15.2-12nos
	Reinforcement bar	Upper slab		D13ctc250(up),D13ctc125(under)		
		Lower slab		D13ctc125(up),D13ctc250(under)		
		Stirrup		D19ctc125	D19ctc125	D19ctc125
Section Force Bending moment	Dead load	Mdc	kNm	53728	-46587	56639
	Super imposed	Mdw	kNm	8346	-14566	5628
	2nd Effect by PS	Mp	kNm	21051	47377	53069
	CR&SH	Mcs	kNm	-1884	-6133	-6325
	Live load	Ml+im	kNm	16337	-15705	16454
	Temperature(TG)	Mtg	kNm	5573	-617	11315
	Dead load state		kNm	83277	-23794	120326
	Service limit state		kNm	97126	-38173	131184
Fiber stress	Dead load (D+CR+SH)	Upper	N/mm2	5.32	5.23	7.46
		Bottom	N/mm2	4.12	12.60	2.93
	Service limit state	Upper	N/mm2	9.50	2.54>0.0	11.63
		Bottom	N/mm2	1.34>0.0	15.03	0.12>0.0
Strength limit state	Factored moment	Mu	kNm	127224	-68289	153588
	Resisting moment	Mr	kNm	231055	-223867	282995
	Safety factor	Mr/ Mu		1.82 >1.0	3.28 > 1.0	1.84 > 1.0
Shearing and Torsional Resistance				End Sec.2	Middle Sec.24	Middle Sec.64
Shear stress	Diagonal tensile stress		N/mm2	-0.27	-0.61	-0.61
Strength limit state	Factored shear force Vu		kN	10617	13695	13734
	Shear resistance of con. Vc		kN	3789	5980	6342
	Component of pre-stress Vp		kN	4645	4039	4034
	Shear resistance of rebarVs		kN	8726	7287	7322
	Nominal Vn=Vc+Vp+Vs		kN	16792	15167	15202

Source : Study Team

3) Design result of main girder P45-P50 (59.0m+3@60.0m+57.36m)

Table 8.4.6-3 Design result of main girder P45-P50

P45-P50 59.0m+3@60.0m+57.36m				unit	Side span Center Sec.12	Middle support Sec.23	Side span Center Sec.97
Dimension of Girder	height			m	3.200	3.200	3.200
	Slab thickness	Upper		m	0.260	0.260	0.260
		Lower		m	0.240	0.240	0.240
	Web thickness			m	0.40-0.30	0.65-0.55	0.4-0.30
Arrangement	PC tendon	External			19S15.2mm - 12 nos.		
		Inner			12S15.2-14nos	12S15.2-4nos	12S15.2-14nos
	Reinforcement bar	Upper slab			D13ctc250(up),D13ctc125(under)		
		Lower slab			D13ctc125(up),D13ctc250(under)		
		Stirrup			D19ctc125	D19ctc125	D19ctc125
Section Force Bending moment	Dead load	Mdc		kNm	81394	-43712	72892
	Super imposed	Mdw		kNm	12095	-17593	11451
	2nd Effect by PS	Mp		kNm	21897	45889	28630
	CR&SH	Mcs		kNm	-1615	-5186	-3418
	Live load	Ml+im		kNm	19808	-18612	19176
	Temperature(TG)	Mtg		kNm	6064	-602	5852
	Dead load state			kNm	119836	-24548	115407
	Service limit state			kNm	136734	-41789	131682
Fiber stress	Dead load (D+CR+SH)	Upper		N/mm2	7.33	4.47	6.97
		Bottom		N/mm2	3.72	15.30	4.58
	Service limit state	Upper		N/mm2	11.95	1.90>0.0	11.53
		Bottom		N/mm2	0.53>0.0	18.03	1.50>0.0
Strength limit state	Factored moment	Mu		kNm	174655	-74658	166407
	Resisting moment	Mr		kNm	296559	-221578	294747
	Safety factor	Mr/ Mu			1.70 >1.0	2.97 > 1.0	1.78 > 1.0
Shearing and Torsional Resistance					End Sec.2	Middle Sec.24	Middle Sec.64
Shear stress	Diagonal tensile stress			N/mm2	-0.57	-0.62	-0.62
Strength limit state	Factored shear force Vu			kN	12407	13800	13785
	Shear resistance of con. Vc			kN	5016	4160	4165
	Component of pre-stress Vp			kN	3567	3758	3753
	Shear resistance of rebarVs			kN	8723	7288	7313
	Nominal Vn=Vc+Vp+Vs			kN	17306	15206	15231

Source : Study Team

4) Design result of main girder P65-P70 (52.98m+3@60.0+52.98m)

Table 8.4.6-4 Design result of main girder P65-P70

P65-P70（52.98m+3@60.0+52.98m）				unit	Side span Center Sec.12	Middle support Sec.23	Middle span CenterSec.75
Dimension of Girder	height			m	3.200	3.200	3.200
	Slab thickness	Upper		m	0.260	0.260	0.260
		Lower		m	0.240	0.240	0.240
	Web thickness			m	0.40-0.30	0.65-0.55	0.4-0.30
Arrangement	PC tendon	External			19S15.2mm - 12 nos.		
		Inner			12S15.2-6nos.	12S15.2-4nos.	12S15.2-12nos.
	Reinforcement bar	Upper slab			D13ctc250(up),D13ctc125(under)		
		Lower slab			D13ctc125(up),D13ctc250(under)		
		Stirrup			D19ctc125	D19ctc125	D19ctc125
Section Force Bending moment	Dead load	Mdc		kNm	58331	-45939	61358
	Super imposed	Mdw		kNm	9193	-15029	6491
	2nd Effect by PS	Mp		kNm	19130	47392	47644
	CR&SH	Mcs		kNm	-1177	-5119	-5927
	Live load	Ml+im		kNm	16782	-15841	16228
	Temperature(TG)	Mtg		kNm	5058	13019	11272
	Dead load state			kNm	90535	-22600	120838
	Service limit state			kNm	104988	-37071	131464
Fiber stress	Dead load (D+CR+SH)	Upper		N/mm2	5.48	4.86	7.07
		Bottom		N/mm2	4.36	13.38	3.01
	Service limit state	Upper		N/mm2	9.80	2.51>0.0	11.66
		Bottom		N/mm2	1.58>0.0	15.73	0.09>0.0
Strength limit state	Factored moment	Mu		kNm	134030	-67138	155406
	Resisting moment	Mr		kNm	245332	-223075	283174
	Safty factor Mr/ Mu				1.83 >1.0	3.32 > 1.0	1.82 > 1.0
Shearing and Torsional Resistance					End Sec.2	Middle Sec.24	Middle Sec.66
Shear stress	Diagonal tensile stress			N/mm2	-0.38	-0.60	-0.63
Strength limit state	Factored shear force Vu			kN	10962	13700	13840
	Shear resistance of con. Vc			kN	4264	4186	4151
	Component of pre-stress Vp			kN	3862	3760	3763
	Shear resistance of rebarVs			kN	8723	7287	7322
	Nominal Vn=Vc+Vp+Vs			kN	16849	15233	15236

Source : Study Team

(6) Main girder design result of transvers direction

The method by the FEM analysis is shown as a design result in the transvers direction of main girder.

Bending moment calculated by FEM analysis of slab structure which is directly loaded wheel load P

(P=100 kN)

1) Span center section

Table 8.4.6-5 Design result of Span center section

Member			unit	Cantilever slab joint	Middle slab joint	Middle slab Center
Upper slab				Pre-stress concrete(Full pre-stress)		
Arrangement of transvers PC tendon				1S28.6mm ctc 500mm (interval)		
Service limit state	design force M		kNm	-198.738	-209.370	31.043
	Fiber stress	Upper	N/mm2	0.28	1.10	4.94
		under	N/mm2	4.11	2.67	3.17
	Allowable stress		N/mm2	> 0.0	> 0.0	> 0.0
Strength limit state	Factored bending moment Mv		kNm	-320.288	-330.379	79.445
	Resistance moment Mr		kNm	-598.847	-736.402	220.590
Member			unit	Web	Lower slab joint	Lower slab center
Web and Lower slab				Reinforced concrete		
Arrangement of reinforcement bar				D19 ctc 125	D19 ctc 125	D13 ctc 125
Service limit state	design force M		kNm	55.221	34.157	18.019
	Stress	Concrete	N/mm2	2.1	3.5	2.7
		Reinforcement	N/mm2	48.8	64.5	82.2
	Allowable stress(Rebar)		N/mm2	140	140	140
Strength limit state	Factored bending moment Mv		kNm	55.221	34.157	18.019
	Resistance moment Mr		kNm	280.116	142.964	65.044

Source : Study Team

2) Support section

Table 8.4.6-6 Design result of Span center section

Member			unit	Cantilever slab joint	Middle slab joint	Middle slab Center
Upper slab				Pre-stress concrete (Full pre-stress)		
Arrangement of transverse PC tendon				1S28.6mm ctc 500mm (interval)		
Service limit state	design force M		kNm	-195.974	-196.700	35.594
	Fiber stress	Upper	N/mm2	0.10	1.15	4.40
		under	N/mm2	4.31	2.62	3.66
	Allowable stress		N/mm2	> 0.0	> 0.0	> 0.0
Strength limit state	Factored bending moment Mv		kNm	-315.451	-316.161	76.445
	Resistance moment Mr		kNm	-581.201	-718.755	239.144
Member			unit	Web	Lower slab joint	Lower slab center
Web and Lower slab				Reinforced concrete		
Arrangement of reinforcement bar				D19 ctc 125	D19 ctc 125	D13 ctc 125
Service limit state	design force M		kNm	32.913	18.925	11.488
	Stress	Concrete	N/mm2	0.9	2.8	2.2
		Reinforcement	N/mm2	31.1	51.1	67.0
	Allowable stress(Rebar)		N/mm2	140	140	140
Strength limit state	Factored bending moment Mv		kNm	51.320	26.828	14.407
	Resisting bending moment Mr		kNm	402.764	142.964	65.044

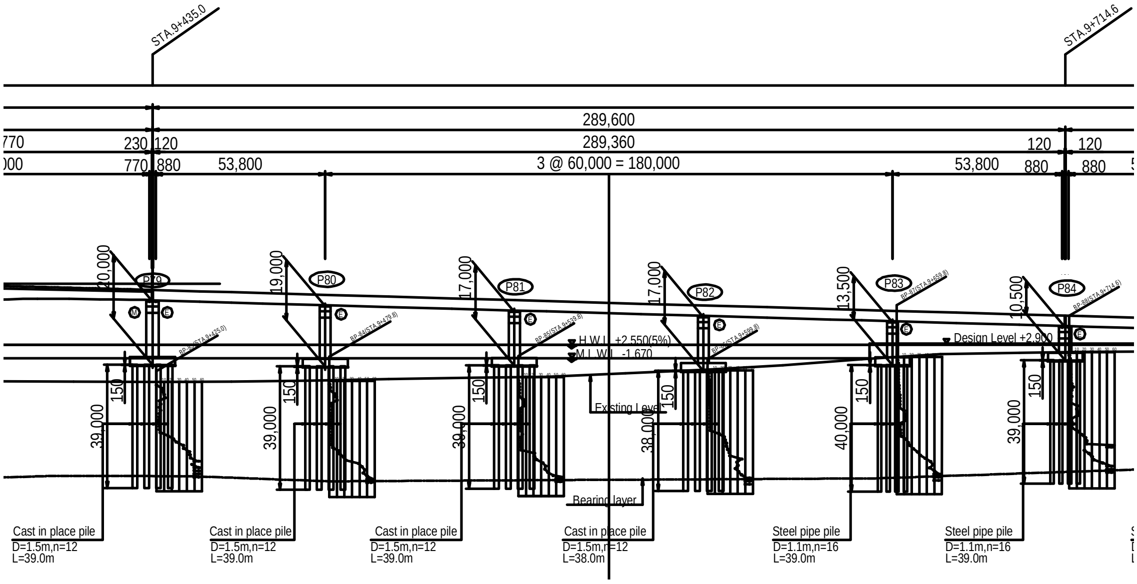
Source :Study Team

8.4.6.2 Cat hai side approach bridge

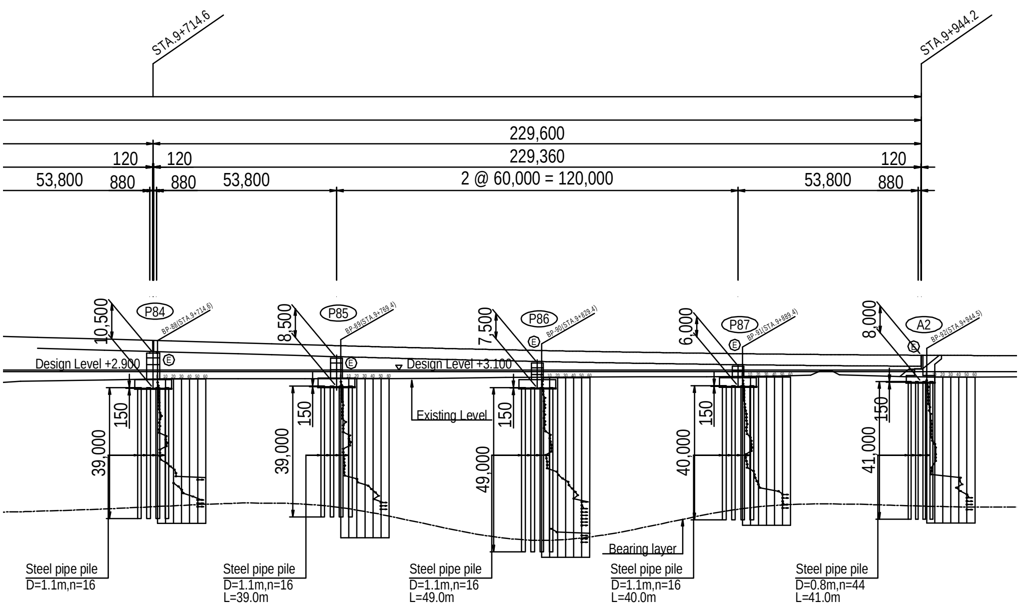
Cat hai side approach bridge is constructed by the ordinary cantilever method as well as Main Bridge. A main girder is designed in Cat hai side approach bridge as well as Hai an side approach according to an actual construction schedule.Two case are designed because there are two kinds of span length of Cat hai side approach bridge.

(1) Span length of Approach Bridge

1) PC 5span continuous box girder bridge (A-line), P79~P84 (53.8m+3@60.0m+53.8m)



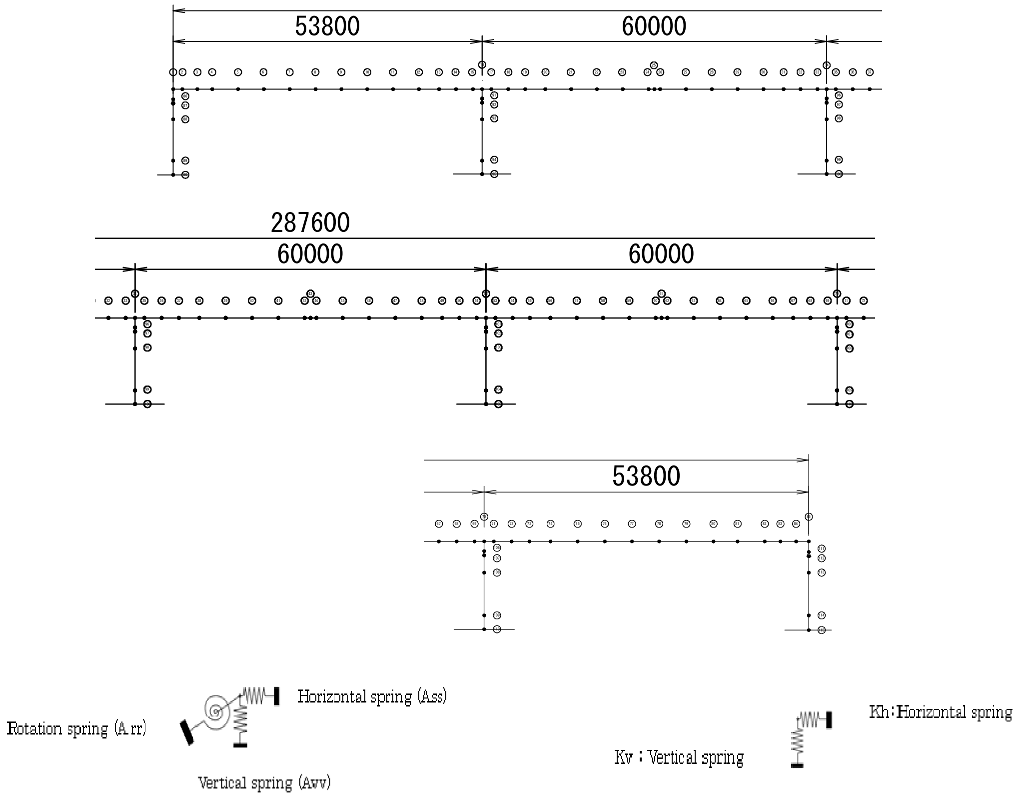
2) PC 4 span continuous box girder bridge (A-line),P84~A2 (53.8m+2@60.0m+53.8m)



(2) Model for structural analysis

The structure model shall consist of the lines connecting the centroid axes of the members, with the axis of the girder made to coincide with the design profile alignment of the completed system.

The foundation structure and ground and bearig shall be modelled as elastic springs having equivalent behaviour.



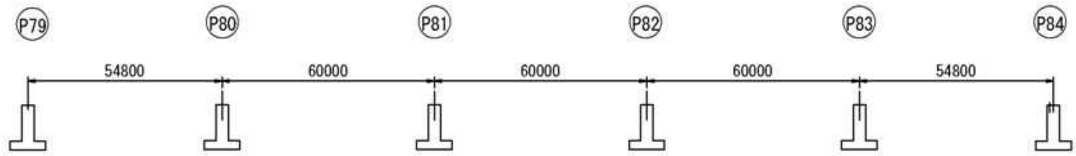
Spring model of the foundation Spring modele of bearing

Source : Study Team

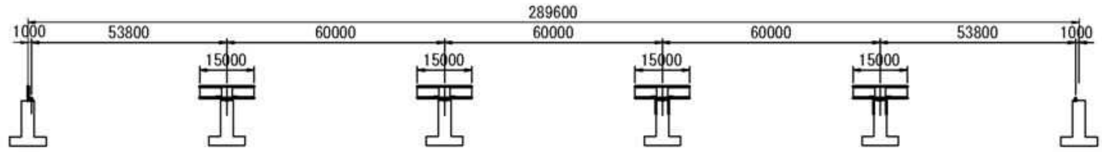
Figure 8.4.6-2 Analysis Model

(3) Construction schedule

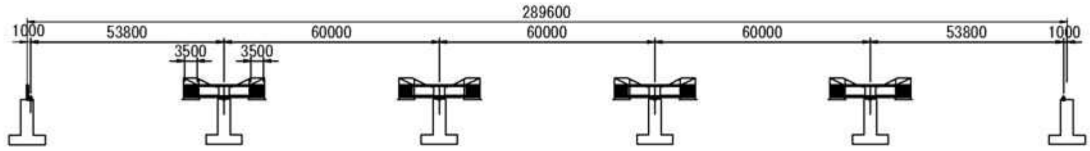
Step 1.Construction of Pier and Foundation (360days)



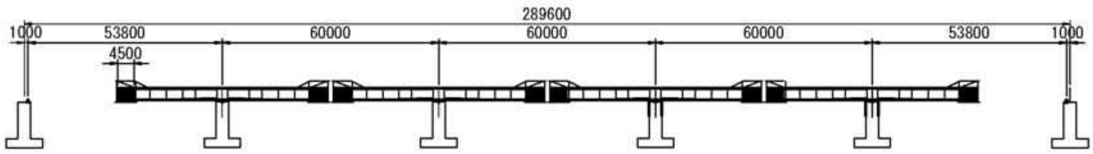
Step 2. Construction of Pier Table（60 days）



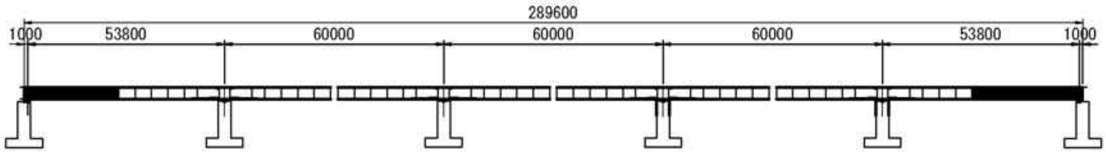
Step3. Construction of First Segment (12 days)



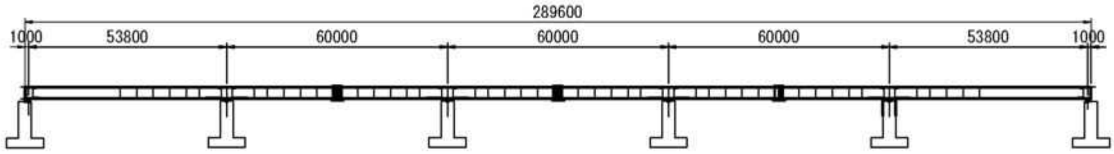
Step4.～Step7 Construction of Second Segment from 5th Segment (cycle time12 days)



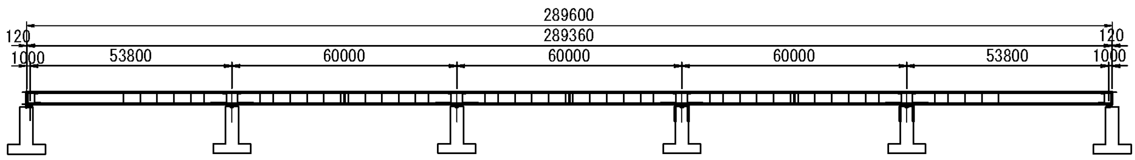
Step8. Construction of Side span (60 days)



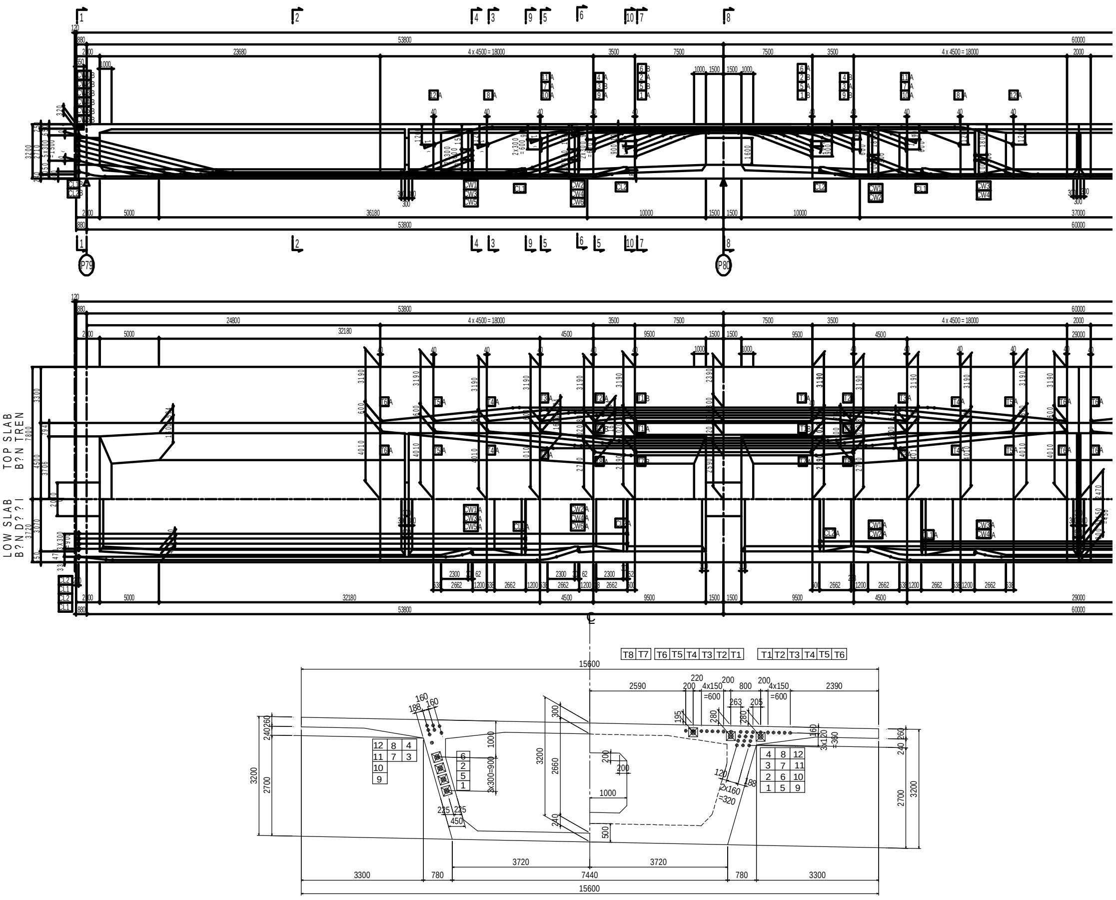
Step9. Construction of center closer (20 days) (Completion of Structure)



Step10. Construction of Surfacing (60days)



(4) Arrangement of PC tendon in main girder



(5) Design result of main girder

1) Design result of longitudinal direction P79-P84 (52.98m+3@60.0+52.98m)

Table 8.4.6-7 Design result of longitudinal direction P79-P84

P79-P84 (52.98m+3@60.0+52.98m)			unit	Side span Center Sec.7	Middle support Sec.16	Middle span CenterSec.43
Dimension of Girder	height		m	3.200	3.200	3.200
	Slab thickness	Upper	m	0.260	0.260	0.260
		Lower	m	0.240	0.240	0.240
	Web thickness		m	0.594	0.794	0.594
Arrangement	PC tendon	Cantilever cab.		-	12S12.7-52nos	-
		Continuous cab.		12S12.7-20nos	-	12S12.7-16nos
	Reinforcement bar	Upper slab		D13 ctc250(up) , D13ctc125(low)		
		Lower slab		D16ctc125(250)	D13ctc125(250)	D13ctc125（250）
		Stirrup		D19ctc125	D22ctc125	D22ctc125
Section Force Bending moment	Dead load	Mdc	kNm	39755	-117277	3804
	Super imposed	Mdw	kNm	9741	-16417	6707
	2nd Effect by PS	Mp	kNm	4029	10357	22787
	CR&SH	Mcs	kNm	1951	5082	2588
	Live load	Ml+im	kNm	17223	-17166	16323
	Temperature(TG)	Mtg	kNm	5342	14130	10581
	Dead load state		kNm	55477	-118254	35885
	Service limit state		kNm	75504	-137838	57623
Fiber stress	Dead load (D+CR+SH)	Upper	N/mm2	3.24	1.72	1.75
		Bottom	N/mm2	1.21	9.63	2.13
	Service limit state	Upper	N/mm2	7.58	-0.60	6.32
		Bottom	N/mm2	-1.45	11.35	-0.57
Strength limit state	Factored moment	Mu	kNm	100996	-189375	69517
	Resisting moment	Mr	kNm	119406	-290033	94843
	Safty factor	Mr/ Mu		1.18>1.0	1.53 > 1.0	1.36 > 1.0
Shearing and Torsional Resistance				End Sec.2	Middle Sec.15	Middle Sec.35
Shear stress	Diagonal tensile stress		N/mm2	-0.80	-1.78	-1.69
Strength limit state	Factored shear force Vu		kN	9299	16186	14939
	Shear resistance of con. Vc		kN	5517	4726	4915
	Component of prestress Vp		kN	2263	103	0
	Shear resistance of rebaVs		kN	7287	11731	11769
	Nominal Vn=Vc+Vp+Vs		kN	15067	16560	16684

Source : Study Team

2) Design result of longitudinal direction P84-A2 (52.98m+2@60.0m+52.98m)

Table 8.4.6-8 Design result of longitudinal direction P84-A2

P84-A2 (52.98m+2@60.0m+52.98m)			unit	Side span Center Sec.7	Middle support Sec.16	Middle span CenterSec.25
Dimension of Girder	height		m	3.200	3.200	3.200
	Slab thickness	Upper	m	0.260	0.260	0.260
		Lower	m	0.240	0.240	0.240
	Web thickness		m	0.594	0.794	0.594
Arrangement	PC tendon	Cantilever cab.		-	12S12.7-52nos	-
		Continuous cab.		12S12.7-20nos	-	12S12.7-16nos
	Reinforcement bar	Upper slab		D13 ctc250(up) , D13ctc125(low)		
		Lower slab		D16ctc125(250)	D13ctc125(250)	D13ctc125（250）
		Stirrup		D19ctc125	D22ctc125	D22ctc125
Section Force Bending moment	Dead load	Mdc	kNm	39727	-117023	4772
	Super imposed	Mdw	kNm	9691	-16548	6089
	2nd Effect by PS	Mp	kNm	3673	9308	17956
	CR&SH	Mcs	kNm	2071	5020	3280
	Live load	Ml+Im	kNm	17215	-17004	16040
	Temperature(TG)	Mtg	kNm	5423	14390	12009
	Dead load state		kNm	55163	-120186	32098
	Service limit state		kNm	75269	-139949	54239
Fiber stress	Dead load (D+CR+SH)	Upper	N/mm2	3.22	1.68	1.51
		Bottom	N/mm2	1.23	9.70	2.72
	Service limit state	Upper	N/mm2	7.57	-0.62	6.07
		Bottom	N/mm2	-1.43	11.40	-0.01
Strength limit state	Factored moment	Mu	kNm	100702	-189948	65254
	Resisting moment	Mr	kNm	119477	-290117	95998
	Safety factor	Mr/ Mu		1.19>1.0	1.53 > 1.0	1.47 > 1.0
Shearing and Torsional Resistance				End Sec.2	Middle Sec.15	Middle Sec.33
Shear stress	Diagonal tensile stress		N/mm2	-0.81	-1.82	-1.62
Strength limit state	Factored shear force Vu		kN	9282	16194	14650
	Shear resistance of con. Vc		kN	5507	4717	5505
	Component of prestress Vp		kN	2222	103	102
	Shear resistance of rebar		kN	7287	11731	11765
	Nominal Vn=Vc+Vp+Vs		kN	15016	16551	17372

source : Study Team

(6) Design result of transvers direction

The method by the FEM analysis is shown as a design result in the transvers direction of main girder.

Bending moment calculated by FEM analysis of slab structure which is directly loaded wheel load (P=100 kN)

1) Span center section

Table 8.4.6-9 Design result of Span center section

Member			unit	Cantilever slab joint	Middle slab joint	Middle slab Center
Upper slab				Pre-stress concrete(Full pre-stress)		
Arrangement of transvers PC tendon				1S28.6mm ctc 500mm (interval)		
Service limit state	design force M		kNm	-199.732	-226.784	2.886
	Fiber stress	Upper	N/mm2	0.98	0.41	2.99
		under	N/mm2	2.97	3.60	4.00
	Allowable stress		N/mm2	> 0.0	> 0.0	> 0.0
Strength limit state	Factored bending moment Mv		kNm	-321.819	-344.841	63.396
	Resistance moment Mr		kNm	-677.837	-677.837	225.587
Member			unit	Web	Lower slab joint	Lower slab center
Web and Lower slab				Reinforced concrete		
Arrangement of reinforcement bar				D19 ctc 125	D19 ctc 125	D13 ctc 125
Service limit state	design force M		kNm	57.046	20.741	10.805
	Stress	Concrete	N/mm2	1.8	3.0	2.0
		Reinforcement	N/mm2	76.7	56.0	63.0
	Allowable stress(Rebar)		N/mm2	140	140	140
Strength limit state	Factored bending moment Mv		kNm	95.305	29.340	13.230
	Resistance moment Mr		kNm	276.952	141.089	64.666

Source : Study Team

2) Support section

Table 8.4.6-10 Design result of Support section

Member			unit	Cantilever slab joint	Middle slab joint	Middle slab Center
Upper slab				Pre-stress concrete (Full pre-stress)		
Arrangement of transvers PC tendon				1S28.6mm ctc 500mm (interval)		
Service limit state	design force M		kNm	-196.850	-225.255	-1.886
	Fiber stress	Upper	N/mm2	1.05	0.44	2.67
		under	N/mm2	2.91	3.56	4.32
	Allowable stress		N/mm2	> 0.0	> 0.0	> 0.0
Strength limit state	Factored bending moment Mv		kNm	-316.775	-344.058	56.524
	Resistance moment Mr		kNm	-677.837	-677.837	225.587
Member			unit	Web	Lower slab joint	Lower slab center
Web and Lower slab				Reinforced concrete		
Arrangement of reinforcement bar				D16 ctc 125	D16 ctc 125	D13 ctc 125
Service limit state	design force M		kNm	51.862	28.000	31.769
	Stress	Concrete	N/mm2	1.0	1.1	1.5
		Reinforcement	N/mm2	50.1	43.1	75.4
	Allowable stress(Rebar)		N/mm2	140	140	140
Strength limit state	Factored bending moment Mv		kNm	84.856	47.071	40.713
	Resisting bending moment Mr		kNm	382.529	242.548	155.848

Source : Study Team

8.4.6.3 Design of Substructure of Approach Bridge

(1) Abutment

1) Material to be used

a) Concrete

Concrete σck : 28N/mm2

b) Reinforcement

Reinforcement : SD345

c) Back filling material

Density : 19kN/m3

Internal friction angle : 30°

2) Reclamation plan

There is reclamation plan from A1 to P60 and P83 toA2.

In case of analyze the stability and sectional force to take account of the cover soil weight due to reclamation plan as follow;

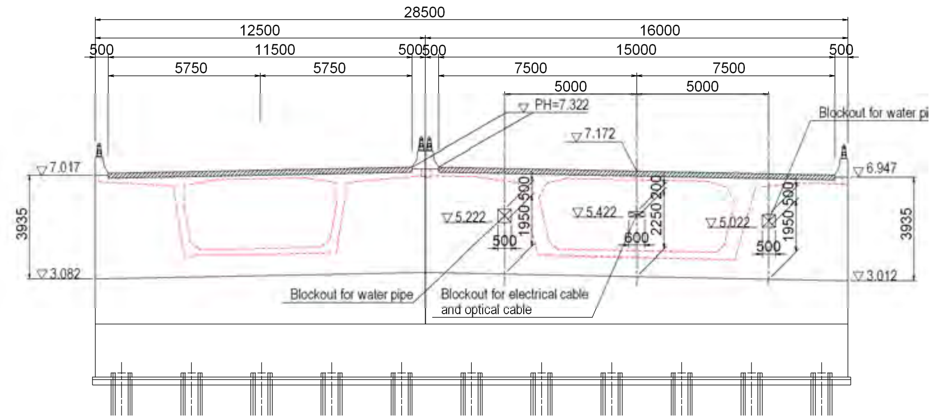
	Elavation of Design Level (m)	Elavation of bottom of pilecap (m)	Reclamation thickness from bottom of pile cap (m)
A1	3.10	-0.68	3.8
P1	3.10	-1.99	5.1
P2	3.10	-2.77	5.9
P3	3.10	-3.05	6.2
P4	3.10	-2.33	5.4
P5	3.10	-1.75	4.8
P6	3.10	-0.89	4.0
P7	3.10	-0.77	3.9
P8	3.10	-0.78	3.9
P9	3.10	-0.92	4.0
P10	3.10	-0.82	3.9
P11	3.10	-1.11	4.2
P12	3.10	-1.14	4.2
P13	3.10	-1.30	4.4
P14	3.10	-1.48	4.6
P15	3.10	-1.28	4.4
P16	3.10	-1.34	4.4
P17	3.10	-1.52	4.6
P18	3.10	-1.70	4.8
P19	3.10	-1.38	4.5
P20	3.10	-1.68	4.8
P21	3.10	-1.74	4.8
P22	3.10	-1.42	4.5
P23	3.10	-1.60	4.7
P24	3.10	-1.78	4.9
P25	3.10	-1.58	4.7
P26	3.10	-1.64	4.7
P27	3.10	-1.82	4.9
P28	3.10	-2.00	5.1
P29	3.10	-2.17	5.3
P30	3.10	-2.40	5.5
P31	3.10	-2.30	5.4
P32	3.10	-2.26	5.4
P33	3.10	-2.15	5.3
P34	3.10	-1.98	5.1
P35	3.10	-1.93	5.0
P36	3.10	-2.12	5.2
P37	3.10	-1.94	5.0
P38	3.10	-1.76	4.9
P39	3.10	-2.08	5.2
P40	3.10	-2.03	5.1
P41	3.10	-1.72	4.8
P42	3.10	-1.54	4.6

	Elavation of Design Level (m)	Elavation of bottom of pilecap (m)	Reclamation thickness from bottom of pile cap (m)
P43	3.10	-1.86	5.0
P44	3.10	-1.68	4.8
P45	3.10	-1.63	4.7
P46	3.10	-1.82	4.9
P47	3.10	-1.64	4.7
P48	3.10	-1.46	4.6
P49	3.10	-1.28	4.4
P50	3.10	-5.74	8.8
P51	3.10	-5.50	8.6
P52	3.10	-5.94	9.0
P53	3.10	-5.93	9.0
P54	3.10	-5.48	8.6
P55	3.10	-5.70	8.8
P56	3.10	-5.71	8.8
P57	3.10	-5.89	9.0
P58	3.10	-5.57	8.7
P59	3.10	-5.75	8.9
P60	3.10	-5.54	8.6
P61	-	-5.57	-
P62	-	-5.75	-
P63	-	-5.93	-
P64	-	-5.61	-
P65	-	-5.90	-
P66	-	-5.93	-
P67	-	-5.61	-
P68	-	-5.76	-
P69	-	-5.48	-
P70	-	-5.92	-
P71	-	-5.64	-
P72	-	-5.48	-
P73	-	-5.80	-
P74	-	-5.62	-
P75	-	-5.78	-
P79	-	-4.18	-
P80	-	-4.63	-
P81	-	-4.31	-
P82	-	-5.99	-
P83	3.10	-4.17	7.3
P84	3.10	-2.78	5.9
P85	3.10	-2.24	5.3
P86	3.10	-2.67	5.8
P87	3.10	-2.13	5.2
A2	3.10	-0.61	3.7

3) Blockout at parapet

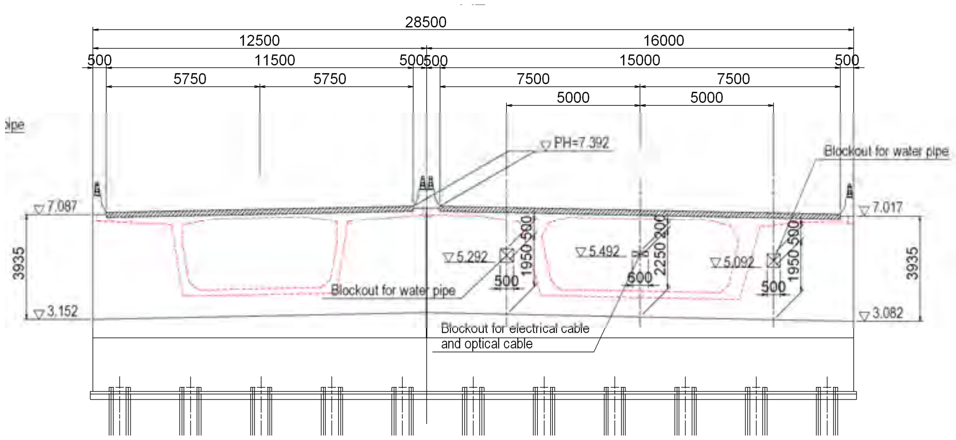
Detail of blockout at parapet for the Affixed articles.are as below

2-1.Detail of blockout



Source : Study Team

Figure 8.4.6-3 Blockout at A1 abutment



Source : Study Team

Figure 8.4.6-4 Blockout at A2 abutment

2-2.Affixed articles

a) Electrical cable

(Technical parameter from THE NORTHERN ELECTRIC CORPORATION)

External diameter : 93mm
Cable weight : 16.690kg/m
Number of cable : 2nos

b) Optical cable

(Technical parameter from THE NORTHERN ELECTRIC CORPORATION)

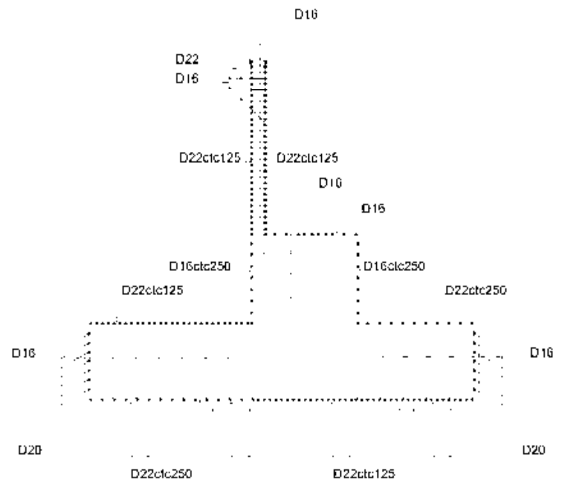
External diameter : 13-14.2mm
Cable weight : 125-145kg/m
Number of cable : 1nos

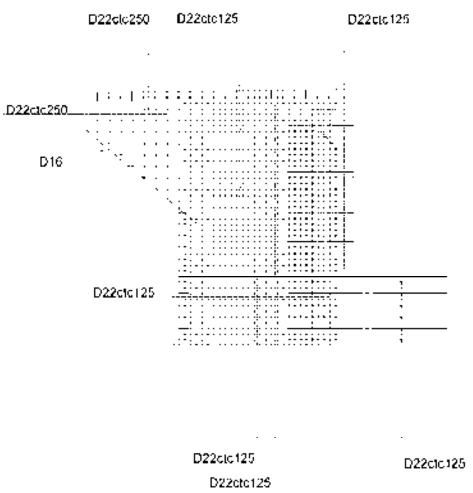
c) Water pipe

Diameter : 400mm
Number of cable : 2nos

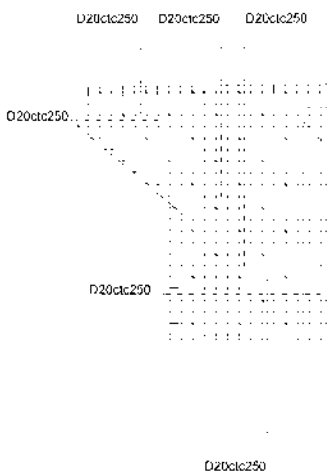
4) Arrangement of reinforcement

Arrangement of reinforcement at A1 abutment shows as below.(A2 abutment is same as A1)





(inside)



(outside)

(2) Pier

1) Material to be used

a) Concrete

Concrete : σck=28N/mm2

b) Reinforcement

Reinforcement :SD345

2) Reclamation plan

Refer to CHAPTER 8.1.4.1

3) Dimension of Substructure

Table 8.4.6-11 Dimension list of Substructure(1/2)

Span length of Superstructure	Number of Substructure	Total height of Pier	Column: Dimensions of column	Pile: Type of pile	Pile: Diameter	Thickness of reclamation (From bottom of pile cap)	Thickness of consolidation layer (From bottom of pile cap)
5@60.0 =300.0m	A1	8.0m	28.5m × 2.5m	Steel pipe pile	0.8m	3.8m	24.7m
	P1	6.0m	7.8m × 2.5m		1.1m	5.1m	23.8m
	P2	7.5m	4.5m × 2.5m			5.9m	30.7m
	P3	8.5m	4.5m × 2.5m			6.2m	25.9m
	P4	8.5m	4.5m × 2.5m			5.4m	23.4m
	P5	8.5m	4.5m × 4.0m			4.8m	26.8m
5@60.0 =300.0m	P6	8.5m	4.5m × 2.5m			4.0m	29.7m
	P7	9.0m	4.5m × 2.5m			3.9m	26.1m
	P8	9.5m	4.5m × 2.5m			3.9m	23.1m
	P9	10.0m	4.5m × 2.5m			4.0m	23.1m
	P10	10.0m	4.5m × 4.0m			3.9m	23.9m
51.5+4@60.0 =291.5m	P11	10.5m	4.5m × 2.5m			4.2m	23.9m
	P12	10.5m	4.5m × 2.5m			4.2m	28.9m
	P13	10.5m	4.5m × 2.5m			4.4m	28.0m
	P14	10.5m	4.5m × 2.5m			4.6m	26.2m
	P15	10.0m	4.5m × 4.0m			4.4m	30.8m
5@60.0 =300.0m	P16	10.0m	4.5m × 2.5m			4.4m	35.7m
	P17	10.0m	4.5m × 2.5m			4.6m	37.6m
	P18	10.0m	4.5m × 2.5m			4.8m	36.0m
	P19	9.5m	4.5m × 2.5m			4.5m	36.9m
	P20	9.5m	4.5m × 4.0m			4.8m	35.8m
5@60.0 =300.0m	P21	9.5m	4.5m × 2.5m			4.8m	34.4m
	P22	9.0m	4.5m × 2.5m			4.5m	29.9m
	P23	9.0m	4.5m × 2.5m			4.7m	27.6m
	P24	9.0m	4.5m × 2.5m			4.9m	26.7m
	P25	8.5m	4.5m × 4.0m			4.7m	27.0m
5@60.0 =300.0m	P26	8.5m	4.5m × 2.5m			4.7m	27.4m
	P27	8.5m	4.5m × 2.5m			4.9m	25.2m
	P28	8.5m	4.5m × 2.5m			5.1m	27.8m
	P29	8.5m	4.5m × 2.5m			5.3m	28.7m
	P30	8.5m	4.5m × 4.0m			5.5m	32.4m
5@60.0 =300.0m	P31	8.5m	4.5m × 2.5m			5.4m	23.7m
	P32	8.5m	4.5m × 2.5m			5.4m	25.7m
	P33	8.5m	4.5m × 2.5m			5.3m	20.9m
	P34	8.5m	4.5m × 2.5m			5.1m	22.8m
	P35	8.5m	4.5m × 4.0m			5.0m	34.1m
5@60.0=300.0m	P36	9.0m	4.5m × 2.5m			5.2m	27.8m
	P37	9.0m	4.5m × 2.5m			5.0m	29.1m
	P38	9.0m	4.5m × 2.5m			4.9m	24.1m
	P39	9.5m	4.5m × 2.5m			5.2m	22.6m
	P40	9.5m	4.5m × 4.0m			5.1m	33.0m
5@60.0 =300.0m	P41	9.5m	4.5m × 2.5m			4.8m	28.0m
	P42	9.5m	4.5m × 2.5m			4.6m	29.0m
	P43	10.0m	4.5m × 2.5m			5.0m	22.1m
	P44	10.0m	4.5m × 2.5m			4.8m	21.8m
	P45	10.0m	4.5m × 4.0m			4.7m	23.3m
4@60.0+58.36 =298.36m	P46	10.5m	4.5m × 2.5m			4.9m	25.6m
	P47	10.5m	4.5m × 2.5m			4.7m	34.8m
	P48	10.5m	4.5m × 2.5m			4.6m	28.0m
	P49	10.5m	4.5m × 2.5m			4.4m	28.1m
	P50	15.0m	4.5m × 2.5m			8.8m	22.6m

Source : Study Team

Table 8.4.6-12 Dimension list of Substructure(2/2)

Span of Superstructure	Number of Substructure	Column	Dimensions of column	Pile: Type of pile	Pile: Diameter	Thickness of reclamation (From bottom of pile cap)	Thickness of consolidation layer (From bottom of pile cap)
5@60.0 =300.0m	P50	15.0m	4.5m × 4.0m	Steel pipe pile	1.1m	8.8m	22.6m
	P51	15.0m	4.5m × 2.5m			8.6m	22.9m
	P52	15.5m	4.5m × 2.5m			9.0m	23.4m
	P53	15.5m	4.5m × 2.5m			9.0m	23.4m
	P54	15.0m	4.5m × 2.5m			8.6m	23.8m
52.98+3@60.0 +52.98=285.96m	P55	15.0m	4.5m × 4.0m			8.8m	27.5m
	P56	15.0m	4.5m × 2.5m			8.8m	28.6m
	P57	15.0m	4.5m × 2.5m			9.0m	20.5m
	P58	14.5m	4.5m × 2.5m			8.7m	11.9m
	P59	14.5m	4.5m × 2.5m			8.9m	13.6m
52.98+3@60.0 +52.98=285.96m	P60	14.0m	4.5m × 4.0m			8.6m	22.0m
	P61	14.0m	4.5m × 2.5m	Bored Pile	1.5m	-	-
	P62	14.0m	4.5m × 2.5m				
	P63	14.0m	4.5m × 2.5m				
	P64	13.5m	4.5m × 2.5m				
52.98+3@60.0 +52.98=285.96m	P65	13.5m	4.5m × 4.0m				
	P66	13.5m	4.5m × 2.5m				
	P67	13.0m	4.5m × 2.5m				
	P68	13.0m	4.5m × 2.5m				
	P69	13.0m	4.5m × 2.5m				
52.98+3@60.0 +52.98=285.96m	P70	14.0m	4.5m × 4.0m				
	P71	15.0m	4.5m × 2.5m				
	P72	16.5m	4.5m × 2.5m				
	P73	18.5m	4.5m × 3.5m				
	P74	20.0m	4.5m × 3.5m				
Main Bridge	P75	21.5m	4.5m × 4.0m				
	P76						
	P77						
54.8+3@60.0 +54.8=289.6m	P78						
	P79	20.0m	4.5m × 4.0m	Bored Pile	1.5m	-	-
	P80	19.0m	4.5m × 3.5m				
	P81	17.0m	4.5m × 3.5m				
	P82	17.0m	4.5m × 3.5m				
54.8+2@60.0 +54.8=229.6m	P83	13.5m	4.5m × 3.5m	Steel pipe pile	1.1m	7.3m	7.3m
	P84	10.5m	4.5m × 4.0m			5.9m	5.9m
	P85	8.5m	4.5m × 3.5m			5.3m	5.3m
	P86	7.5m	4.5m × 3.5m			5.8m	5.8m
	P87	6.0m	4.5m × 3.5m			5.2m	5.2m
	A2	8.0m	4.5m × 4.0m		0.8m	3.7m	3.7m

Source : Study Team

8.4.6.4 Grouping of Pier

Table 8.4.6-13 Grouping of Pier

Type No.	Total height of column	Dimensions of column	Type of pile	Pier number	Representative calculation Pier
Type1	6.0m	7.8×2.5	Steel pipe pile	P1	P1
Type2	6.0m	7.8×3.5		P87	P87
Type3	10.5m	4.5×2.5		P11.P12.P13.P14.P46.P47.P48.P49	P14
Type4	7.5m			P2	P2
Type5	8.5m			P3.P4.P6.P26.P27.P28.P29.P31.P32.P33.P34	P4,P29,P31
Type6	9.0m			P7.P22.P23.P24.P36.P37.P38	P36
Type7	9.5m			P8.P19.P39.P41.P42	P41
Type8	10.0m			P9.P16.P17.P18.P21.P43.P44	P9,P16,P21
Type9	14.5m			P58.P59	P59
Type10	15.0m			P51.P54.P56.P57	P54,P56
Type11	15.5m			P52.P53	P52
Type12	7.5m	4.5×3.5		P86	P86
Type13	8.5m			P85	P85
Type14	13.5m			P83	P83
Type15	8.5m	4.5×4.0		P5.P25.P30.P35	P5,P25,P30,P35
Type16	9.5m			P20.P40	P20,P40
Type17	10.0m			P15.P10.P45	P10,P15,P45
Type18	10.5m			P84	P84
Type19	14.0m			P60	P60
Type20	15.0m			P50.P55	P50,P55
Type21	13.0m	4.5×2.5	Bored Pile	P67.P68.P69	P69
Type22	13.5m			P64.P66	P66
Type23	14.0m			P61.P62.P63	P61
Type24	15.0m			P71	P71
Type25	16.5m	4.5×3.5		P72	P72
Type26	17.0m			P81.P82	P81,P82
Type27	18.5m			P73	P73
Type28	19.0m			P80	P80
Type29	20.0m			P74	P74
Type30	13.5m	4.5×4.0		P65	P65
Type31	14.0m			P70	P70
Type32	20.0m			P79	P79
Type33	21.5m			P75	P75

Source : Study Team

8.4.6.5 Reinforcement arrangement for each type of pier

Table 8.4.6-14 List of reinforcement for each type of Pier(1/2)

				Type1	Type2	Type3	Type4	Type5	Type6	Type7
Beam	Dimension	Thickness at joint		-	-	3.5	3.5	3.5	3.5	3.5
		Length of overhanging		-	-	1.65	1.65	1.65	1.65	1.65
		width		-	-	2.5	2.5	2.5	2.5	2.5
	Upper side			-	-	D32-12nos	D32-12nos	D32-12nos	D32-12nos	D32-12nos
	Lower side			-	-	D20-12nos	D20-12nos	D20-12nos	D20-12nos	D20-12nos
	Side			-	-	D22-13nos	D22-13nos	D22-13nos	D22-13nos	D22-13nos
	Reinforcement for shear			-	-	D20-4nos-ctc200	D20-4nos-ctc200	D20-4nos-ctc200	D20-4nos-ctc200	D20-4nos-ctc200
Column	Dimension	Plane		7.8×2.5	7.8×3.5	4.5×2.5	4.5×2.5	4.5×2.5	4.5×2.5	4.5×2.5
		Height		3.5	3.5	8.0	5.0	6.0	6.5	7.0
	Reinforcement for bending	Longitudinal		D16 ctc250	D16 ctc250	D22 ctc125	D16 ctc125	D16 ctc125	D16 ctc125	D20 ctc125
		Transverse		D16 ctc250	D16 ctc250	D22 ctc250	D16 ctc250	D16 ctc250	D16 ctc250	D20 ctc250
	Reinforcement for shear	Longitudinal		D16-10nos	D16-10nos	D16-10nos	D16-7nos	D16-7nos	D16-7nos	D16-7nos
		Transverse		D16-4nos	D16-5nos	D16-4nos	D16-4nos	D16-4nos	D16-4nos	D16-4nos
Pile cap	Dimension	Plane		11.0×11.0	11.0×11.0	11.0×11.0	11.0×11.0	11.0×11.0	11.0×11.0	11.0×11.0
		Thickness		2.5	2.5	2.5	2.5	2.5	2.5	2.5
	Longitudinal	Upper side	1	D25ctc250	D25ctc250	D30ctc250	D30ctc250	D30ctc250	D30ctc250	D30ctc250
			2	-	-	-	-	-	-	-
		Lower side	1	D30ctc125	D30ctc125	D35ctc125	D35ctc125	D35ctc125	D35ctc125	D35ctc125
			2	-	-	-	-	-	-	-
		Reinforcement for shear		D16-10nos-ctc500	D16-10nos-ctc500	D16-10nos-ctc500	D16-10nos-ctc500	D16-10nos-ctc500	D16-10nos-ctc500	D16-10nos-ctc500
	Transverse	Upper side	1	D16ctc250	D16ctc250	D30ctc250	D30ctc250	D30ctc250	D30ctc250	D30ctc250
			2	-	-	-	-	-	-	-
		Lower side	1	D20ctc125	D20ctc125	D35ctc125	D35ctc125	D35ctc125	D35ctc125	D35ctc125
			2	-	-	-	-	-	-	-
		Reinforcement for shear		D16-10nos-ctc500	D16-10nos-ctc500	D16-10nos-ctc500	D16-10nos-ctc500	D16-10nos-ctc500	D16-10nos-ctc500	D16-10nos-ctc500

				Type8	Type9	Type10	Type11	Type12	Type13	Type14
Beam	Dimension	Thickness at joint		3.5	3.5	3.5	3.5	3.5	3.5	3.5
		Length of overhanging		1.65	1.65	1.65	1.65	1.65	1.65	1.65
		width		2.5	2.5	2.5	2.5	3.5	3.5	3.5
	Upper side			D32-12nos	D32-12nos	D32-12nos	D32-12nos	D32-18nos	D32-18nos	D32-18nos
	Lower side			D20-12nos	D20-12nos	D20-12nos	D20-12nos	D20-18nos	D20-18nos	D20-18nos
	Side			D22-13nos	D22-13nos	D22-13nos	D22-13nos	D22-13nos	D22-13nos	D22-13nos
	Reinforcement for shear			D20-4nos-ctc200	D20-4nos-ctc200	D20-4nos-ctc200	D20-4nos-ctc200	D20-4nos-ctc200	D20-4nos-ctc200	D20-4nos-ctc200
Column	Dimension	Plane		4.5×2.5	4.5×2.5	4.5×2.5	4.5×2.5	4.5×3.5	4.5×3.5	4.5×3.5
		Height		7.5	12.0	12.5	13.0	5.0	6.0	11.0
	Reinforcement for bending	Longitudinal		D20 ctc125	D35 ctc125	D35 ctc125	D35 ctc125	D16 ctc125	D16 ctc125	D16 ctc125
		Transverse		D20 ctc250	D35 ctc250	D35 ctc250	D35 ctc250	D16 ctc250	D16 ctc250	D16 ctc250
	Reinforcement for shear	Longitudinal		D16-7nos	D16-7nos	D16-7nos	D16-7nos	D16-7nos	D16-7nos	D16-7nos
		Transverse		D16-4nos	D16-4nos	D16-4nos	D16-4nos	D16-5nos	D16-5nos	D16-5nos
Pile cap	Dimension	Plane		11.0×11.0	11.0×11.0	11.0×11.0	11.0×11.0	11.0×11.0	11.0×11.0	11.0×11.0
		Thickness		2.5	2.5	2.5	2.5	2.5	2.5	2.5
	Longitudinal	Upper side	1	D30ctc250	D30ctc250	D30ctc250	D30ctc250	D30ctc250	D30ctc250	D30ctc250
			2	-	-	-	-	-	-	-
		Lower side	1	D35ctc125	D38ctc125	D38ctc125	D38ctc125	D35ctc125	D35ctc125	D38ctc125
			2	-	-	-	-	-	-	-
		Reinforcement for shear		D16-10nos-ctc500	D16-10nos-ctc500	D16-10nos-ctc500	D16-10nos-ctc500	D16-10nos-ctc500	D16-10nos-ctc500	D16-10nos-ctc500
	Transverse	Upper side	1	D30ctc250	D30ctc250	D30ctc250	D30ctc250	D30ctc250	D30ctc250	D30ctc250
			2	-	-	-	-	-	-	-
		Lower side	1	D35ctc125	D35ctc125	D35ctc125	D35ctc125	D35ctc125	D35ctc125	D35ctc125
			2	-	-	-	-	-	-	-
		Reinforcement for shear		D16-10nos-ctc500	D16-10nos-ctc500	D16-10nos-ctc500	D16-10nos-ctc500	D16-10nos-ctc500	D16-10nos-ctc500	D16-10nos-ctc500

				Type15	Type16	Type17	Type18	Type19	Type20	Type21
Beam	Dimension	Thickness at joint		3.5	3.5	3.5	3.5	3.5	3.5	3.5
		Length of overhanging		1.65	1.65	1.65	1.65	1.65	1.65	1.65
		width		4	4	4	4	4	4	2.5
	Upper side			D32-19nos	D32-19nos	D32-19nos	D32-19nos	D32-19nos	D32-19nos	D32-12nos
	Lower side			D20-19nos	D20-19nos	D20-19nos	D20-19nos	D20-19nos	D20-19nos	D20-12nos
	Side			D22-13nos	D22-13nos	D22-13nos	D22-13nos	D22-13nos	D22-13nos	D22-13nos
	Reinforcement for shear			D20-4nos-ctc200	D20-4nos-ctc200	D20-4nos-ctc200	D20-4nos-ctc200	D20-4nos-ctc200	D20-4nos-ctc200	D20-4nos-ctc200
Column	Dimension	Plane		4.5×4.0	4.5×4.0	4.5×4.0	4.5×4.0	4.5×4.0	4.5×4.0	4.5×2.5
		Height		6.0	7.0	7.5	8.0	11.5	12.5	10.5
	Reinforcement for bending	Longitudinal		D16 ctc125	D16 ctc125	D16 ctc125	D16 ctc125	D16 ctc125	D16 ctc125	D32 ctc125
		Transverse		D16 ctc250	D16 ctc250	D16 ctc250	D16 ctc250	D16 ctc250	D16 ctc250	D32 ctc250
	Reinforcement for shear	Longitudinal		D16-7nos	D16-7nos	D16-7nos	D16-7nos	D16-7nos	D16-7nos	D16-7nos
		Transverse		D16-5nos	D16-5nos	D16-5nos	D16-5nos	D16-5nos	D16-5nos	D16-4nos
Pile cap	Dimension	Plane		11.0×11.0	11.0×11.0	11.0×11.0	11.0×11.0	11.0×11.0	11.0×11.0	10.5×10.5
		Thickness		2.5	2.5	2.5	2.5	2.5	2.5	2.5
	Longitudinal	Upper side	1	D30ctc250	D30ctc250	D30ctc250	D30ctc250	D30ctc250	D30ctc250	D28ctc125
			2	-	-	-	-	-	-	-
		Lower side	1	D35ctc125	D35ctc125	D35ctc125	D35ctc125	D38ctc125	D38ctc125	D32ctc125
			2	-	-	-	-	-	-	D32ctc125
		Reinforcement for shear		D16-10nos-ctc500	D16-10nos-ctc500	D16-10nos-ctc500	D16-10nos-ctc500	D16-10nos-ctc500	D16-10nos-ctc500	D25-21nos-ctc500
	Transverse	Upper side	1	D30ctc250	D30ctc250	D30ctc250	D30ctc250	D30ctc250	D30ctc250	D25ctc125
			2	-	-	-	-	-	-	-
		Lower side	1	D35ctc125	D35ctc125	D35ctc125	D35ctc125	D35ctc125	D35ctc125	D32ctc125
			2	-	-	-	-	-	-	D32ctc250
		Reinforcement for shear		D16-10nos-ctc500	D16-10nos-ctc500	D16-10nos-ctc500	D16-10nos-ctc500	D16-10nos-ctc500	D16-10nos-ctc500	D25-21nos-ctc500

Source : Study Team

Table 8.4.6-15 List of reinforcement for each type of Pier(1/2)

				Type22	Type23	Type24	Type25	Type26	Type27	Type28
Beam	Dimension	Thickness at joint		3.5	3.5	3.5	3.5	3.5	3.5	3.5
		Length of overhanging		1.65	1.65	1.65	1.65	1.65	1.65	1.65
		width		2.5	2.5	2.5	3.5	3.5	3.5	3.5
	Upper side			D32-12nos	D32-12nos	D32-12nos	D32-18nos	D32-18nos	D32-18nos	D32-19nos
	Lower side			D20-12nos	D20-12nos	D20-12nos	D20-18nos	D20-18nos	D20-18nos	D20-19nos
	Side			D22-13nos	D22-13nos	D22-13nos	D22-13nos	D22-13nos	D22-13nos	D22-13nos
	Reinforcement for shear			D20-4nos-ctc200	D20-4nos-ctc200	D20-4nos-ctc200	D20-4nos-ctc200	D20-4nos-ctc200	D20-4nos-ctc200	D20-4nos-ctc200
Column	Dimension	Plane		4.5×2.5	4.5×2.5	4.5×2.5	4.5×3.5	4.5×3.5	4.5×3.5	4.5×3.5
		Height		11.0	11.5	12.5	14.0	14.5	16.0	16.5
	Reinforcement for bending	Longitudinal		D32 ctc125	D35 ctc125	D35 ctc125	D25 ctc125	D25 ctc125	D32 ctc125	D32 ctc125
		Transverse		D32 ctc250	D35 ctc250	D35 ctc250	D25 ctc250	D25 ctc250	D32 ctc125	D32 ctc125
	Reinforcement for shear	Longitudinal		D16-7nos	D16-7nos	D16-7nos	D16-7nos	D16-7nos	D16-7nos	D16-7nos
		Transverse		D16-4nos	D16-4nos	D16-4nos	D16-5nos	D16-5nos	D16-5nos	D16-5nos
Pile cap	Dimension	Plane		10.5×10.5	10.5×10.5	10.5×10.5	10.5×14.25	10.5×14.25	10.5×14.25	10.5×14.25
		Thickness		2.5	2.5	2.5	2.5	2.5	2.5	2.5
	Longitudinal	Upper side	1	D28ctc125	D28ctc125	D28ctc125	D32ctc125	D32ctc125	D32ctc125	D32ctc125
			2	-	-	-	-	-	-	-
		Lower side	1	D32ctc125	D32ctc125	D32ctc125	D38ctc125	D38ctc125	D38ctc125	D38ctc125
			2	D32ctc125	D32ctc125	D32ctc125	D38ctc125	D38ctc125	D38ctc125	D38ctc125
		Reinforcement for shear		D25-21nos-ctc500	D25-21nos-ctc500	D25-21nos-ctc500	D25-10nos-ctc250	D25-10nos-ctc250	D25-10nos-ctc250	D25-10nos-ctc250
	Transverse	Upper side	1	D25ctc125	D25ctc125	D25ctc125	D32ctc125	D32ctc125	D32ctc125	D32ctc125
			2	-	-	-	-	-	-	-
		Lower side	1	D32ctc125	D32ctc125	D32ctc125	D32ctc125	D32ctc125	D32ctc125	D32ctc125
			2	D32ctc250	D32ctc250	D32ctc250	D32ctc125	D32ctc125	D32ctc125	D32ctc125
		Reinforcement for shear		D25-21nos-ctc500	D25-21nos-ctc500	D25-21nos-ctc500	D25-14nos-ctc500	D25-14nos-ctc500	D25-14nos-ctc500	D25-14nos-ctc500

				Type29	Type30	Type31	Type32	Type33
Beam	Dimension	Thickness at joint		3.5	3.5	3.5	3.5	3.5
		Length of overhanging		1.65	1.65	1.65	1.65	1.65
		width		3.5	4	4	4	4
	Upper side			D32-19nos	D32-19nos	D32-19nos	D32-19nos	D32-19nos
	Lower side			D20-19nos	D20-19nos	D20-19nos	D20-19nos	D20-19nos
	Side			D22-13nos	D22-13nos	D22-13nos	D22-13nos	D22-13nos
	Reinforcement for shear			D20-4nos-ctc200	D20-4nos-ctc200	D20-4nos-ctc200	D20-4nos-ctc200	D20-4nos-ctc200
Column	Dimension	Plane		4.5×3.5	4.5×4.0	4.5×4.0	4.5×4.0	4.5×4.0
		Height		17.5	11.0	11.5	17.5	19.0
	Reinforcement for bending	Longitudinal		D32 ctc125	D16 ctc125	D16 ctc125	D32 ctc125	D32 ctc125
		Transverse		D32 ctc125	D16 ctc125	D16 ctc125	D32 ctc125	D32 ctc125
	Reinforcement for shear	Longitudinal		D16-7nos	D16-7nos	D16-7nos	D16-7nos	D16-7nos
		Transverse		D16-5nos	D16-5nos	D16-5nos	D16-5nos	D16-5nos
Pile cap	Dimension	Plane		10.5×14.25	10.5×10.5	10.5×10.5	10.5×14.25	10.5×14.25
		Thickness		2.5	2.5	2.5	2.5	2.5
	Longitudinal	Upper side	1	D32ctc125	D28ctc125	D28ctc125	D32ctc125	D32ctc125
			2	-	-	-	-	-
		Lower side	1	D38ctc125	D32ctc125	D32ctc125	D38ctc125	D38ctc125
			2	D38ctc125	D32ctc125	D32ctc125	D38ctc125	D38ctc125
		Reinforcement for shear		D25-10nos-ctc250	D25-21nos-ctc500	D25-21nos-ctc500	D25-10nos-ctc250	D25-10nos-ctc250
	Transverse	Upper side	1	D32ctc125	D25ctc125	D25ctc125	D32ctc125	D32ctc125
			2	-	-	-	-	-
		Lower side	1	D32ctc125	D32ctc125	D32ctc125	D32ctc125	D32ctc125
			2	D32ctc125	D32ctc250	D32ctc250	D32ctc125	D32ctc125
		Reinforcement for shear		D25-14nos-ctc500	D25-21nos-ctc500	D25-21nos-ctc500	D25-14nos-ctc500	D25-14nos-ctc500

Source : Study Team

8.4.6.6 Design of Foundation of Approach Bridge

(1) Steel pipe pile (A1-P60,P83-A2)

1) Material to be used

1-1. Steel Pipe Pile

a) Properties and Stress Limit of Steel Pipe

Table 8.4.6-16 Properties and Stress Limit and used Steel Pipe

Type	Yield Strength fy (Mpa)	Tensile Strength fu (Mpa)	Modulus of Elasticity (Mpa)	used
Grade SKK400	235	400	200000	○
Grade SKK490	315	490	200000	

Source : Study Team

b) Thickness of Steel pipe pile

Table 8.4.6-17 Range of thickness and used thickness

Diameter(mm)	thickness(mm)	Used thickness(mm)
400	9~12	
500	9~14	
600~800	9~16	12
900~1100	12~19	12
1200~1400	14~22	
1500~1600	16~25	
1800~2000	19~25	

Source : Study Team

c) Design of Estimated Corrosion Thicknesses

Table 8.4.6-18 Design of Estimated Corrosion Thicknesses

	Cast against earth	Direct exposure to selt water
Estimated Corrosion Thickness	2mm	7mm

Source : Study Team

1-2. Fill Concrete for pile head

Concrete : σck=28N/mm2

1-3. Reinforcement

Reinforcement : SD345

2) Site condition

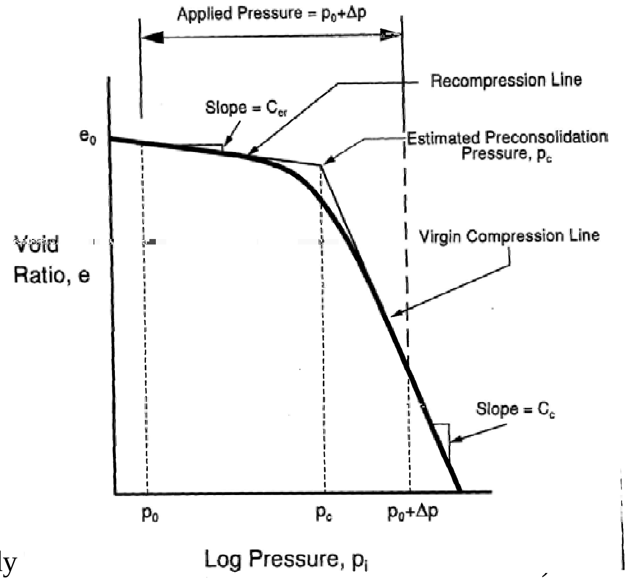
2-1. Soil Condition

Refer to CHAPTER8.1.4.1

2-2. Layer to take account of downdrag

Settlement of Embankment in Cohesive Soils

Consolidation settlements of cohesive soils are usually computed on the basis of laboratory tests. For pressure increases less than the reconsolidation pressure, p_c, settlement is computed using a value of the compression index representing recompression, C_{cr}. For pressure increases greater than the reconsolidation pressure, settlement is computed using the compression index, C_c. are shown in Figure 1



Source: Study

Figure 8.4.6-5 Typical e-log p curve from laboratory Consolidation Test

The following equations are used to calculate settlements of cohesive soils depending upon the pressure increase and whether the soil is over consolidated or normally consolidated. The terms used in these equations are as follow:

$$s = H\left[\frac{C_{cr}}{1+e_o}\log\frac{p_o+\Delta p}{p_o}\right] \leq \qquad \text{when } p_o+\Delta \ \leq \ p_c$$

$$= H\left[\frac{C_{cr}}{1+e_o}\log\frac{p_c}{p_o}\right] + H\left[\frac{C_c}{1+e_o}\log\frac{p_o+\Delta p}{p_c}\right] \qquad \text{when } p_o+\Delta \ > p_c$$

where

s : Total settlement, (mm).

H : Original thickness of stratum, (mm).

C_{cr} : Recompression index.

e_o : Initial void ratio.

p_o : Effective overburden pressure at midpoint of compressible stratum prior to pressure increase, (kpa).

p_c : Estimated pre-consolidation pressure, (kpa).

C_c : Compression index.

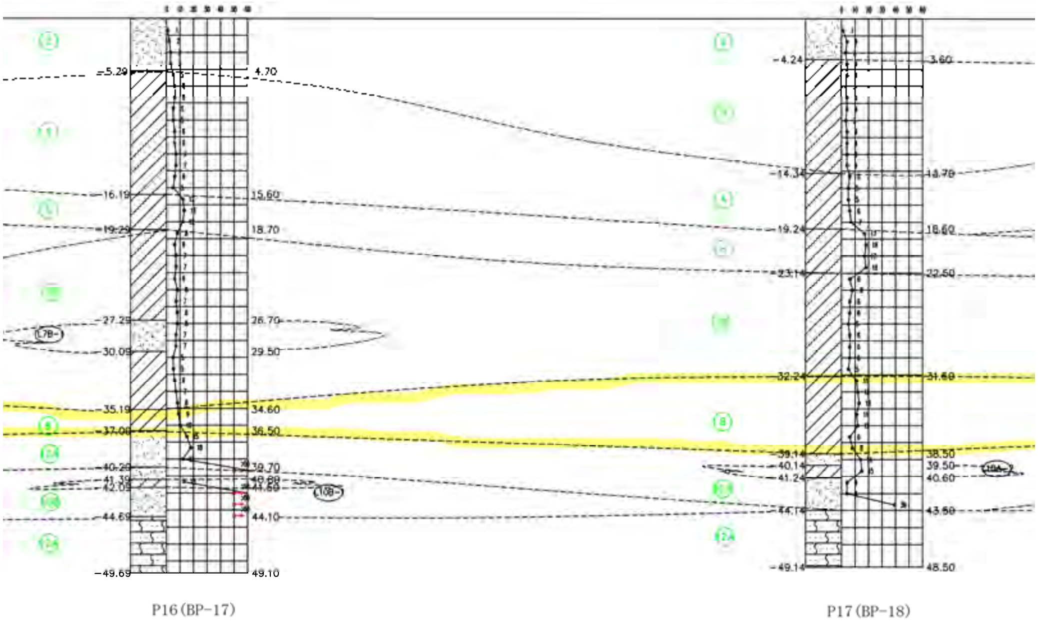
Δp :Average change in pressure in the compressible stratum, (kpa)

The settlement of each layer for P16 is summarized in settlement computations in Table- 1.

Negative shaft resistance occurs due to the settlement between soil and pile. The amount of settlement between soil and pile necessary to mobilize the negative shaft resistance is about 10mm. Therefore, negative shaft resistance will occur on the pile shaft in each layer or portion of a soil layer with a settlement greater than 10mm.

The existing ground surface will experience a total consolidation settlement of 0.549m. The table also shows that the settlement between soil and pile due the 10% consolidation settlement at EL-36.5m (Layer No8) depth above existing ground is already around greater than 10mm which is the minimum required to mobilized the negative shaft resistance.

Therefore, the pile segment above the 36.5m depth will be subject to the negative shaft resistance (downdrag) from lower end of soil layer No8 while the pile segment below the 36.5m depth will provide the positive shaft resistances (or capacity) to sustain loads from the structure and the negative shaft resistance(downdrag).



Source: Study Team

Figure 8.4.6-6 Geological Profile at P16 (BP-17) to P17(BP-18)

Table 8.4.6-19 Settlement calculations Table for Pier 16(Boring No.BP-17

1						2	3	4	5		6	7	8	10	11
Soil Type						Layer	Layer	Depth					layer	Depth	Total
Layer No	Pc (kpa)	eo (-)	Cc (-)	Ccr (-)	γ' (kN/m³)	EL (m)	Thickness (m)	EL (m)	Po (kPa)	K	ΔP (kPa)	Po+ΔP (kPa)	settlement (m)	(m)	Settlement (m)
														0	0.549
2	0	0.000	0.000	0.000	9.0	-0.6 - -2.9	2.4	-1.18	9.1	0.500	33.2	42.3	0.000	-2.9	0.549
						-2.9 - -5.3	2.4	-3.53	30.2	0.500	33.2	63.4	0.000	-5.3	0.549
4	158	1.297	0.385	0.076	7.5	-5.3 - -8.9	3.6	-7.11	57.1	0.500	33.2	90.3	0.024	-8.9	0.525
						-8.9 - -12.6	3.6	-10.74	84.3	0.500	33.2	117.5	0.017	-12.6	0.507
						-12.6 - -16.2	3.6	-14.37	111.6	0.500	33.2	144.8	0.014	-16.2	0.494
6	267	0.777	0.243	0.052	9.5	-16.2 - -17.2	1.0	-16.71	133.8	0.500	33.2	167.0	0.003	-17.2	0.491
						-17.2 - -18.3	1.0	-17.74	143.6	0.500	33.2	176.8	0.003	-18.3	0.488
						-18.3 - -19.3	1.0	-18.77	153.4	0.500	33.2	186.6	0.003	-19.3	0.486
7B	164	1.056	0.345	0.057	8.3	-19.3 - -24.6	5.3	-21.94	179.7	0.500	33.2	212.9	0.095	-24.6	0.391
						-24.6 - -29.9	5.3	-27.24	223.7	0.500	33.2	256.9	0.153	-29.9	0.237
						-29.9 - -35.2	5.3	-32.54	267.7	0.500	33.2	300.9	0.203	-35.2	0.034
8	198	0.838	0.200	0.058	9.2	-35.2 - -36.0	0.8	-35.59	295.7	0.500	33.2	328.9	0.015	-36.0	0.019
						-36.0 - -36.5	0.5	-36.24	301.7	0.500	33.2	334.9	0.010	-36.5	**0.010**
						-36.5 - -37.0	0.5	-36.74	306.3	0.500	33.2	339.5	0.010	-37.0	**0.000**
												Total	**0.549**		

Source: Study Team

3) Result of Steel pipe pile

a) Type of Steel pipe

Steel pipe piles classified as follows;

Table 8.4.6-20 Type of Steel pipe pile

TYPE	Pier	Diameter (m)	Length of pile (m)	Range of SLC coating (from top of the pile) (m)	thickness (mm)
Type1-1	P58	1100	37.0	12.0	12.0
Type1-2	P57			21.0	
Type1-3	*P3*			26.0	
Type2	*P5*	1100	38.0	27.0	12.0
Type3-1	P59	1100	39.0	14.0	12.0
Type3-2	P84			22.0	
Type3-3	*P4*			23.0	
Type3-4	P85			27.0	
Type3-5	*P6*			30.0	
Type3-6	*P2*			31.0	
Type4-1	P60	1100	40.0	22.0	12.0
	P83			22.0	
Type4-2	P87			25.0	
Type6-5	P50	1100	42.0	23.0	12.0
	P51			23.0	
	P52			23.0	
Type6-1	P31			24.0	
	P1			24.0	
	P54			24.0	
	P38			24.0	
Type6-2	P46			26.0	
Type6-3	P36			28.0	
Type6-4	P35			34.0	
Type7-1	P44	1100	43.0	22.0	12.0
	P43			22.0	
Type7-2	P39			23.0	
	P34			23.0	
	P45			23.0	
Type7-3	P24			27.0	
Type7-4	P55			28.0	
	P41			28.0	
Type7-5	P56			29.0	
	P42			29.0	
Type7-6	P40			33.0	
Type7-7	P20			36.0	
Type8-1	P11	1100	44.0	24.0	12.0
Type8-2	P27			25.0	
Type8-3	P23			28.0	
Type8-4	P29			29.0	
	P37			29.0	
Type8-6	P21			34.0	
Type8-7	P18			36.0	
Type9-1	P9	1100	45.0	23.0	12.0
	P8			23.0	
	P53			23.0	
Type9-2	P10			24.0	
Type9-3	P32			26.0	
	P14			26.0	
Type9-4	P25			27.0	
Type9-5	P28			28.0	
Type9-7	P47			35.0	
Type10-1	P33	1100	46.0	21.0	12.0
Type10-2	*P7*			26.0	
Type10-3	P26			27.0	
Type10-4	P13			28.0	
	P48			28.0	
	P49			28.0	
Type10-5	P12			29.0	
Type10-8	P22			30.0	
Type10-9	P30			32.0	
Type10-6	P19			37.0	
Type10-7	P17			38.0	
Type11-1	P15	1100	47.0	31.0	12.0
Type11-2	P16			36.0	
Type12-1	P86	1100	49.0	24.0	12.0
Type13-1	A1	800	36.0	25.0	12.0
Type14-1	A2	800	41.0	25.0	12.0

Source : Study Team

b) Length of Steel pipe pile

Table 8.4.6-21 List of Steel pipe pile(1/2)

Number of substructure	A1	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18
Diameter of pile (m)	0.8	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Thikness of pile (mm)	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Length of pile (m)	36.0	42.0	40.0	37.0	39.0	38.0	39.0	46.0	45.0	45.0	45.0	44.0	46.0	46.0	45.0	47.0	47.0	46.0	44.0
Thickness of consolidation layer (From bottom of pile cap)	24.7	23.8	30.7	25.9	23.4	26.8	29.7	26.1	23.1	23.1	23.9	23.9	28.9	28.0	26.2	30.8	35.7	37.6	36.0
Range of SL pile (m)	25.0	24.0	31.0	26.0	23.0	27.0	30.0	26.0	23.0	23.0	24.0	24.0	29.0	28.0	26.0	31.0	36.0	38.0	36.0
Number of pile (nos)	44	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Top of the pile	-0.53	-1.84	-2.62	-2.90	-2.18	-1.60	-0.74	-0.62	-0.63	-0.77	-0.67	-0.96	-0.99	-1.15	-1.33	-1.13	-1.19	-1.37	-1.55
Bottom of pilecap	-0.68	-1.99	-2.77	-3.05	-2.33	-1.75	-0.89	-0.77	-0.78	-0.92	-0.82	-1.11	-1.14	-1.30	-1.48	-1.28	-1.34	-1.52	-1.70
Bottom of pile	-36.53	-43.84	-42.62	-39.90	-41.18	-39.60	-39.74	-46.62	-45.63	-45.77	-45.67	-44.96	-46.99	-47.15	-46.33	-48.13	-48.19	-47.37	-45.55
Bor.No	BP-1	BP-2	BP-3	BP-4	BP-5	BP-6	BP-7	BP-8	BP-9	BP-10	BP-11	BP-12	BP-13	BP-14	BP-15	BP-16	BP-17	BP-18	BP-19
Name of bearing layer	10B	12B	10B	10B	10B	10B	10B	12B	12B	12B	12B	12B	12B	12B	12B	12B	12B	12B	12B
Depth of bearing layer (m)	-29.0	-40.0	-34.0	-29.0	-30.0	-34.0	-31.0	-38.0	-37.0	-41.8	-42.0	-41.9	-43.2	-43.3	-43.2	-45.1	-44.7	-44.1	-42.4
Embeded length into bearing layer (m)	7.5	3.8	8.6	10.9	11.2	5.6	8.7	8.6	8.6	4.0	3.7	3.1	3.8	3.8	3.1	3.0	3.5	3.2	3.1
Determination factor of pile length and number (1)	b,c,d	a,b	b	b	b	b	b	b	b	a,b	a,b	a,b	a,b	a,b	a,b	a,b	a,b	a,b	a,b

Number of substructure	P19	P20	P21	P22	P23	P24	P25	P26	P27	P28	P29	P30	P31	P32	P33	P34	P35	P36	P37
Diameter of pile (m)	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Thikness of pile (mm)	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Length of pile (m)	46.0	43.0	44.0	46.0	44.0	43.0	45.0	46.0	44.0	45.0	44.0	46.0	42.0	45.0	46.0	43.0	42.0	42.0	44.0
Thickness of consolidation layer (From bottom of pile cap)	36.9	35.8	34.4	29.9	27.6	26.7	27.0	27.4	25.2	27.8	28.7	32.4	23.7	25.7	20.9	22.8	34.1	27.8	29.1
Range of SL pile (m)	37.0	36.0	34.0	30.0	28.0	27.0	27.0	27.0	25.0	28.0	29.0	32.0	24.0	26.0	21.0	23.0	34.0	28.0	29.0
Number of pile (nos)	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Top of the pile	-1.23	-1.53	-1.59	-1.27	-1.45	-1.63	-1.43	-1.49	-1.67	-1.85	-2.02	-2.25	-2.15	-2.11	-2.00	-1.83	-1.78	-1.97	-1.79
Bottom of pilecap	-1.38	-1.68	-1.74	-1.42	-1.60	-1.78	-1.58	-1.64	-1.82	-2.00	-2.17	-2.40	-2.30	-2.26	-2.15	-1.98	-1.93	-2.12	-1.94
Bottom of pile	-47.23	-44.53	-45.59	-47.27	-45.45	-44.63	-46.43	-47.49	-45.67	-46.85	-46.02	-48.25	-44.15	-47.11	-48.00	-44.83	-43.78	-43.97	-45.79
Bor.No	BP-20	BP-21	BP-22	BP-23	BP-24	BP-25	BP-26	BP-27	BP-28	BP-29	BP-30	BP-31	BP-32	BP-33	BP-34	BP-35	BP-36	BP-37	BP-38
Name of bearing layer	12B	12B	12B	12B	12B	12B	12B	12B	12B	12B	12B	12B	12B	12B	12B	12B	12B	12B	12B
Depth of bearing layer (m)	-43.3	-41.5	-42.2	-43.0	-41.9	-40.9	-42.5	-43.6	-42.1	-43.6	-42.1	-42.8	-40.4	-43.4	-44.2	-40.9	-40.3	-40.3	-41.9
Embeded length into bearing layer (m)	3.9	3.0	3.4	4.3	3.5	3.7	4.0	3.9	3.6	3.3	3.9	5.4	3.8	3.7	3.8	3.9	3.4	3.6	3.9
Determination factor of pile length and number (1)	a,b	a,b	a,b	b	a,b	a,b	b	a,b	a,b	a,b	a,b	b	a,b	a,b	a,b	a,b	a,b	a,b	a,b

Source : Study Team

Table 8.4.6-22 List of Steel pipe pile(2/2)

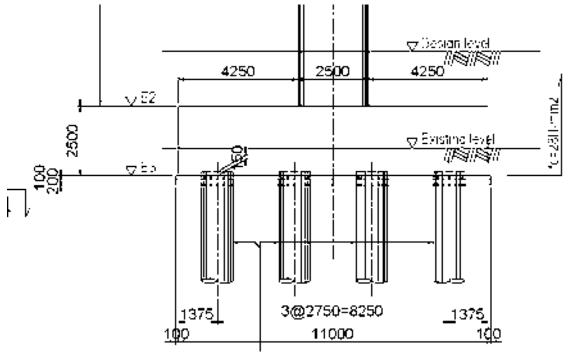
Number of substructure	P38	P39	P40	P41	P42	P43	P44	P45	P46	P47	P48	P49	P50	P51	P52	P53	P54	P55	P56
Diameter of pile (m)	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Thikness of pile (mm)	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Length of pile (m)	42.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	42.0	45.0	46.0	46.0	42.0	42.0	42.0	45.0	42.0	43.0	43.0
Thickness of consolidation layer (From bottom of pile cap)	24.1	22.6	33.0	28.0	29.0	22.1	21.8	23.3	25.6	34.8	28.0	28.1	22.6	22.9	23.4	23.4	23.8	27.5	28.6
Range of SL pile (m)	24.0	23.0	33.0	28.0	29.0	22.0	22.0	23.0	26.0	35.0	28.0	28.0	23.0	23.0	23.0	23.0	24.0	28.0	29.0
Number of pile (nos)	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Top of the pile	-1.61	-1.93	-1.88	-1.57	-1.39	-1.71	-1.53	-1.48	-1.67	-1.49	-1.31	-1.13	-5.59	-5.35	-5.79	-5.78	-5.33	-5.55	-5.56
Bottom of pilecap	-1.76	-2.08	-2.03	-1.72	-1.54	-1.86	-1.68	-1.63	-1.82	-1.64	-1.46	-1.28	-5.74	-5.50	-5.94	-5.93	-5.48	-5.70	-5.71
Bottom of pile	-43.61	-44.93	-44.88	-44.57	-44.39	-44.71	-44.53	-44.48	-43.67	-46.49	-47.31	-47.13	-47.59	-47.35	-47.79	-50.78	-47.33	-48.55	-48.56
Bor.No	BP-39	BP-40	BP-41	BP-42	BP-43	BP-44	BP-45	BP-46	BP-47	BP-48	BP-49	BP-50	BP-51	BP-52	BP-53	BP-54	BP-55	BP-56	BP-57
Name of bearing layer	12B	12B	12B	12B	12B	12B	12B	12B	12B	12B	12B	12B	12B	12B	12A	12A	12B	12B	12B
Depth of bearing layer (m)	-40.5	-41.1	-41.8	-41.3	-40.4	-41.0	-41.0	-40.8	-39.7	-43.5	-43.7	-43.4	-43.3	-43.0	-42.7	-47.0	-43.8	-43.9	-42.9
Embeded length into bearing layer (m)	3.1	3.9	3.1	3.3	4.0	3.7	3.5	3.7	3.9	3.0	3.6	3.8	4.3	4.4	5.1	3.8	3.5	4.6	5.7
Determination factor of pile length and number (1)	a,b	a,b	a,b	a,b	b	a,b	a,b	a,b	a,b	a,b	a,b	a,b	b	b	b	a,b	a,b	a,b	a,b

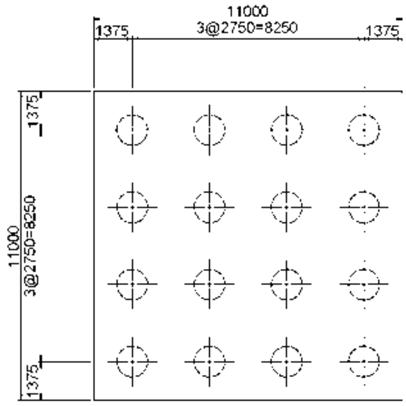
Number of substructure	P57	P58	P59	P60	P83	P84	P85	P86	P87	A2
Diameter of pile (m)	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	0.8
Thikness of pile (mm)	12	12	12	12	12	12	12	12	12	12
Length of pile (m)	37.0	37.0	39.0	40.0	40.0	39.0	39.0	49.0	40.0	41.0
Thickness of consolidation layer (From bottom of pile cap)	20.5	11.9	13.6	22.0	22.4	22.1	26.8	24.2	25.0	28.3
Range of SL pile (m)	21.0	12.0	14.0	22.0	22.0	22.0	27.0	24.0	25.0	28.0
Number of pile (nos)	16	16	16	16	16	16	16	16	16	44
Top of the pile	-5.74	-5.42	-5.60	-5.39	-4.02	-2.63	-2.09	-2.52	-1.98	-0.46
Bottom of pilecap	-5.89	-5.57	-5.75	-5.54	-4.17	-2.78	-2.24	-2.67	-2.13	-0.61
Bottom of pile	-42.74	-42.42	-44.60	-45.39	-44.02	-41.63	-41.09	-51.52	-41.98	-41.46
Bor.No	BP-58	BP-59	BP-60	BP-61	BP-87	BP-88	BP-89	BP-90	BP-91	BP-92
Name of bearing layer	12B	12B	12B	12B	12B	12B	12B	12B	12B	12B
Depth of bearing layer (m)	-39.4	-39.4	-41.2	-40.5	-39.5	-37.7	-38.0	-47.8	-38.3	-37.6
Embeded length into bearing layer (m)	3.3	3.0	3.4	4.9	4.5	3.9	3.1	3.7	3.7	3.9
Determination factor of pile length and number (1)	a,b	a,b	a,b	b	b	a,b	a,b	a,b	a,b	b,c,d

Source : Study Team

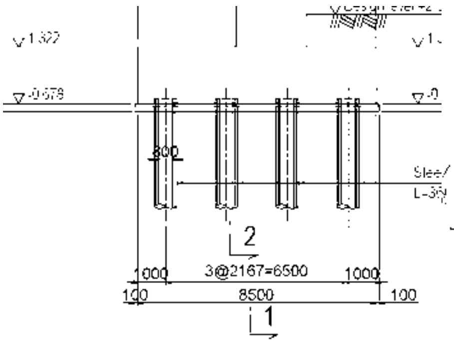
c) Pile arrangement

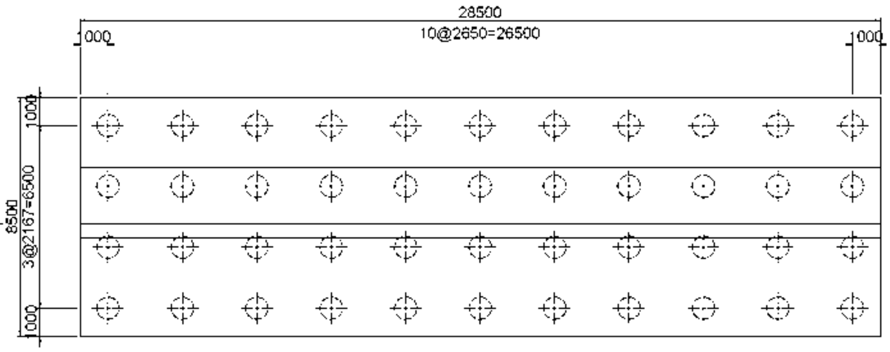
1. Pile arrangement for Pier





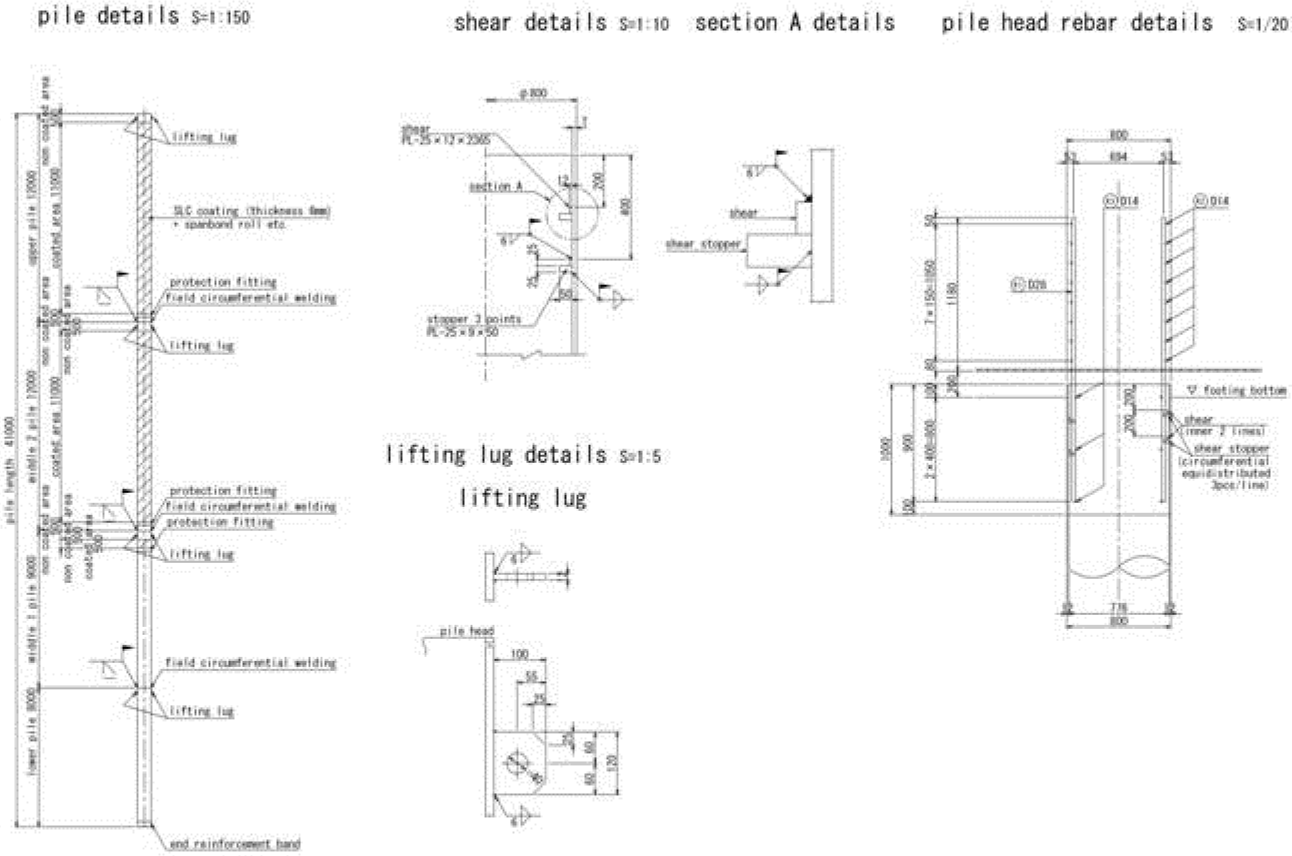
2. Pile arrangement for Abutment

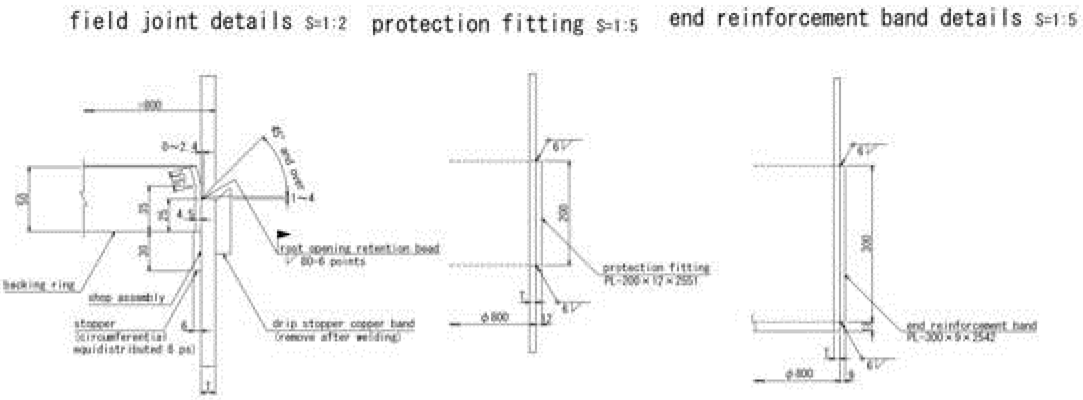




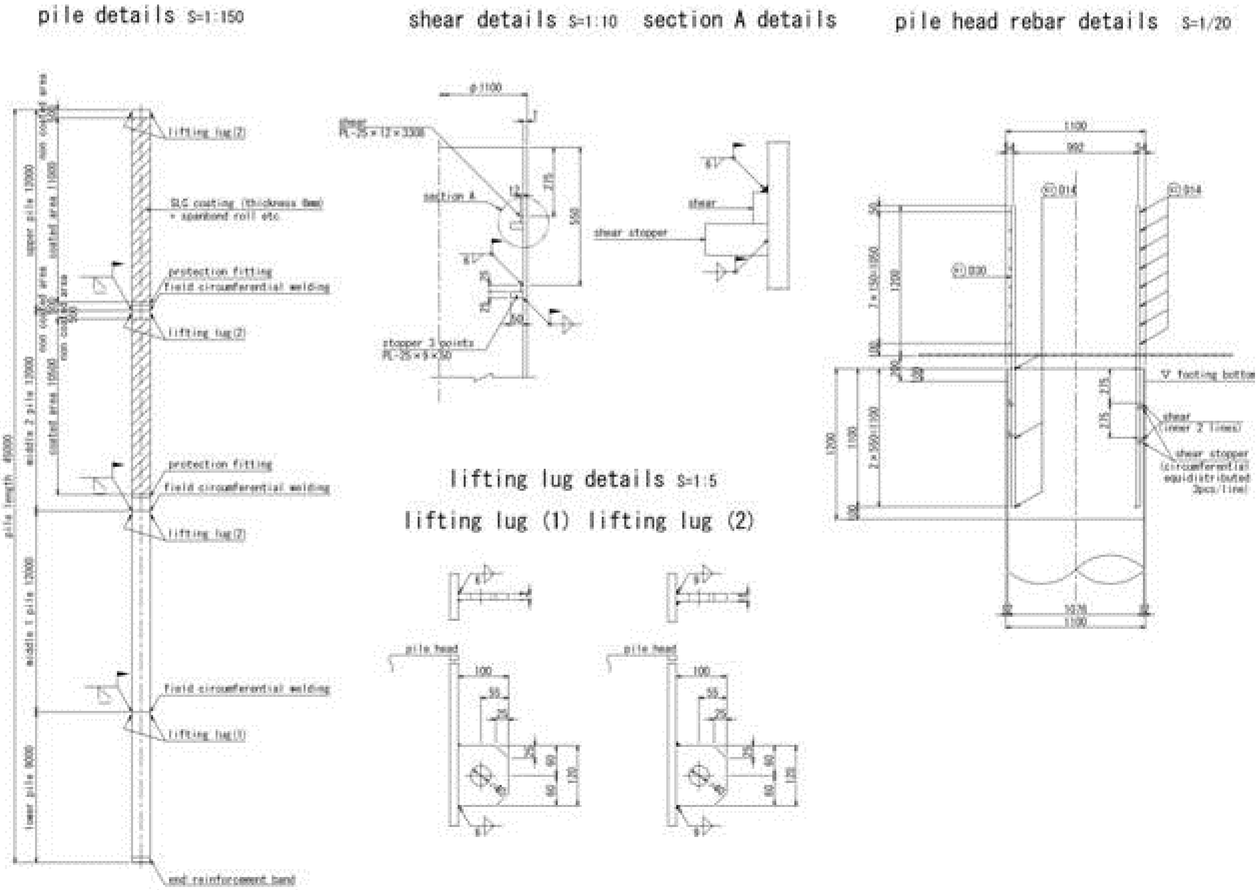
d) Detail of Steel pipe pile

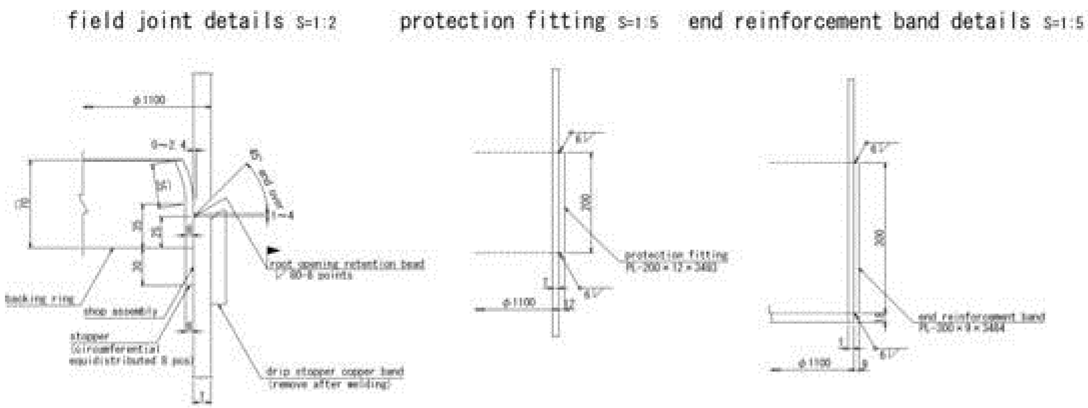
1. Steel pipe pile D=800mm (A2 abutment)





2. Steel pipe pile D=1100mm (P8,P9,P53)





(2) Bored Pile (P61～P75,P79～P82)

1) Material to be used

1-1. Concrete

Concrete : σck=30N/mm2

1-2. Reinforcement

Reinforcement : SD345

2) Soil Condition

Refer to CHAPTER8.1.4.1

3) Scour Depth

Refer to CHAPTER.2

4) Result of Bored pile

a) Type of Bored pile

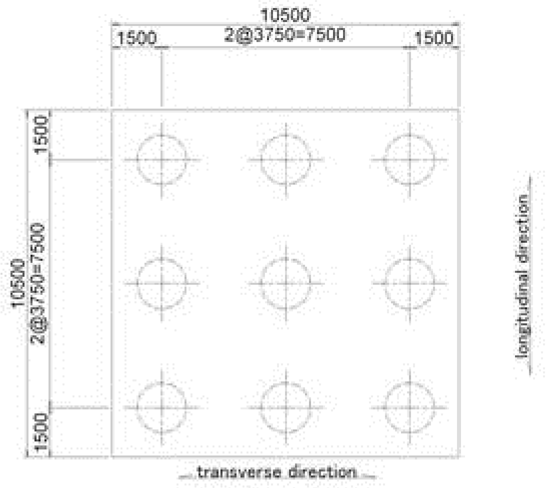
Bored piles classified as follows;

Table 8.4.6-23 Type of Bored pile

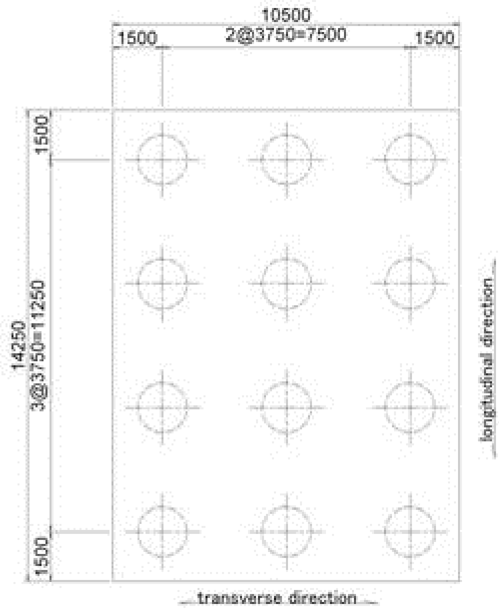
TYPE	Pier	Length of pile (m)	Number of pile (nos)
Type1	P63,P67,P68,P69	38.0	9
Type2	P61,P62,P64,P65,P66,P71	39.0	9
Type3	P70	40.0	9
Type4	P82	38.0	12
Type5	P72,P73,P74,P79,P80,P81	39.0	12
Type6	P75	40.0	12

Source : Study Team

b) Pile arrangement



Pile arrangement for Type1,2,3



Pile arrangement for Type4,5,6

c) Length of Bored pile

Table 8.4.6-24 List of Bored pile

Number of substructure	P61	P62	P63	P64	P65	P66	P67	P68	P69	P70	P71	P72	P73	P74	P75	P79	P80	P81	P82
Diameter of pile (m)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Length of pile (m)	39.0	39.0	38.0	39.0	39.0	39.0	38.0	38.0	38.0	40.0	39.0	39.0	39.0	39.0	40.0	39.0	39.0	39.0	38.0
Number of pile (nos)	9	9	9	9	9	9	9	9	9	9	9	12	12	12	12	12	12	12	12
Top of the pile	-5.42	-5.60	-5.78	-5.46	-5.75	-5.78	-5.46	-5.61	-5.33	-5.77	-5.49	-5.33	-5.65	-5.47	-5.63	-4.03	-4.48	-4.16	-5.84
Bottom of pilecap	-5.57	-5.75	-5.93	-5.61	-5.90	-5.93	-5.61	-5.76	-5.48	-5.92	-5.64	-5.48	-5.80	-5.62	-5.78	-4.18	-4.63	-4.31	-5.99
Bottom of pile	-44.42	-44.60	-43.78	-44.46	-44.75	-44.78	-43.46	-43.61	-43.33	-45.77	-44.49	-44.33	-44.65	-44.47	-45.63	-43.03	-43.48	-43.16	-43.84
Bor.No	BP-62	BP-63	BP-64	BP-65	BP-66	BP-67	BP-68	BP-69	BP-70	BP-71	BP-72	BP-73	BP-74	BP-75	BP-76	BP-83	BP-84	BP-85	BP-86
Name of bearing layer	12B	12B	12B	12B	12B	12B	12B	12B	12B	12B	12B	12B	12B	12B	12B	12B	12B	12B	12B
Depth of bearing layer (m)	-41.0	-40.4	-40.0	-40.4	-42.2	-42.9	-40.0	-39.6	-40.3	-42.2	-40.7	-41.1	-41.5	-40.3	-41.0	-38.6	-40.5	-40.2	-39.5
Embeded length into bearing layer (m)	3.4	4.2	3.7	4.0	2.5	1.9	3.5	4.0	3.0	3.5	3.8	3.3	3.2	4.1	4.6	4.4	3.0	3.0	4.4
Determination factor of pile length and number (1)	b	b	b	b	b	b	b	b	b	b	b	b,c	b,c	b,c	b,c	b,c	b,c	b,c	b,c,d

※Note

(1)Determination factor

a : Minimum penetration length into bearing layer（Steel pipe pile:3.0m,Bored pile:1.5m)

b : Bearing resistance

c : Horizontal displacement

d : Lateral movement identifying index

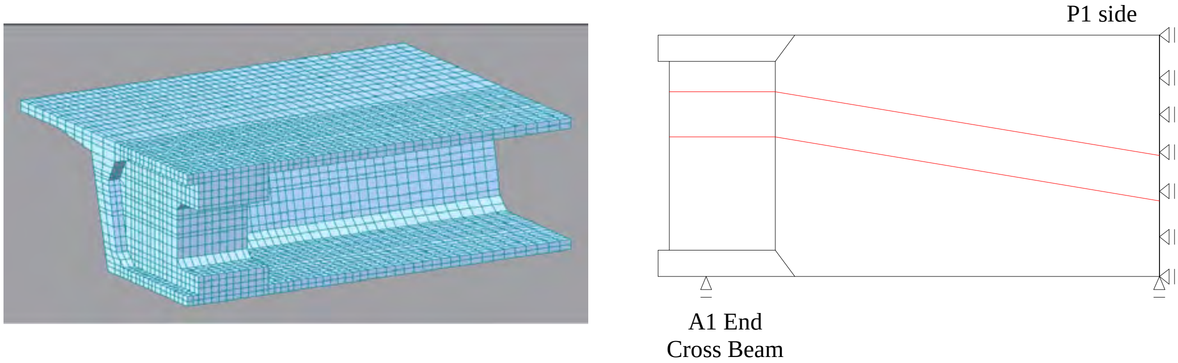
Source : Study Team

8.4.7 FEM analysis of Cross Beam

Because external cables are going through cross beam, it generates complicated local stress on the transverse direction and vertical direction. As for the local stress, it is needed to reinforce so that all their structure can fulfill the function.For designing the bridge, the local stress is calculated by 3D FEM analysis that can simulate almost truly, accordingly the stress, the amount of reinforcing bar shall be calculated.

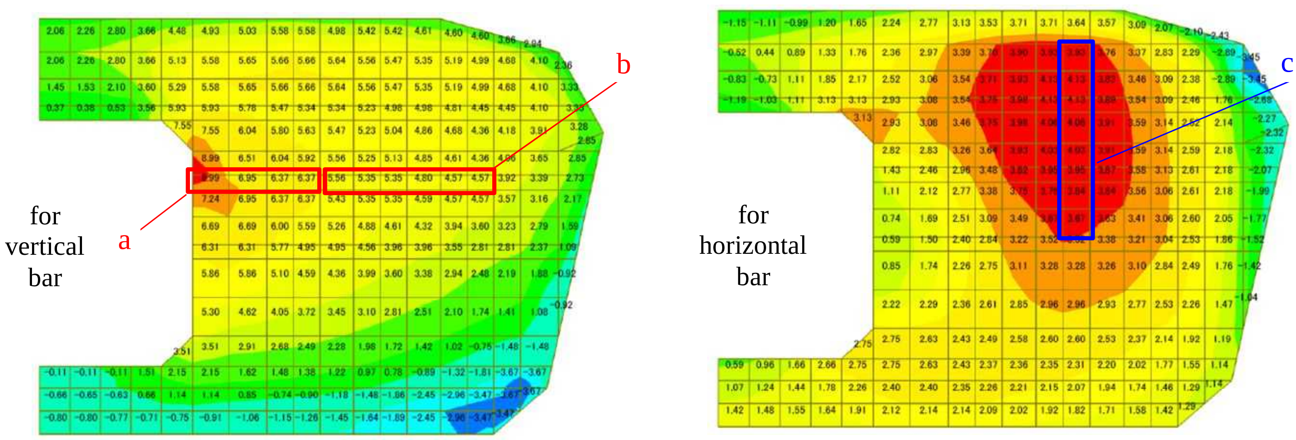
< Result of study >

1) End cross beam



Source : Study Team

Figure 8.4.7-1 End cross beam in FEM mesh and restraint condition



Source : Study Team

Figure 8.4.7-2 Result of FEM analysis (tensile side ; side of intermediate cross beam)

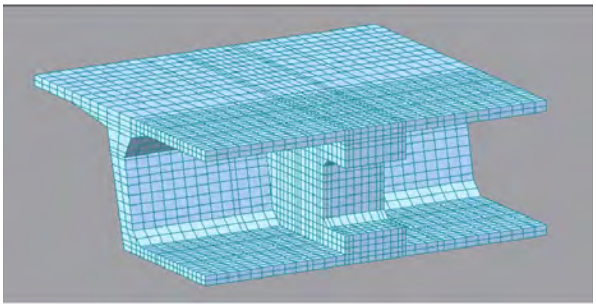
Table 8.4.7-1 Reinforcing bar arrangement of end cross beam

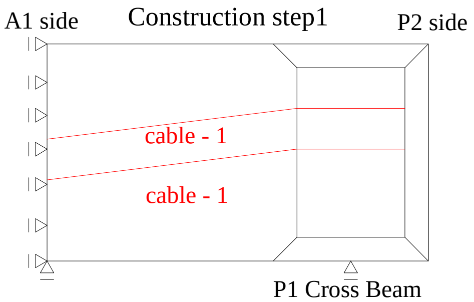
		direction	Point	Size	Interval	Number of Layer	Area of bar		
							Areq	Aarr	
End (A1) cross beam	P1 sides	vertical	a	D22	125mm	2	4729 mm2	5079 mm2	ok
			b	D22	125mm	2	4473 mm2	6934 mm2	ok
		horizontal	c	D22	200mm	2	3843 mm2	4752 mm2	ok

*Areq : Required area of bar
*Aarr : Arranged area of bar

Source : Study Team

2) Intermediate cross beam





Source :
Study Team

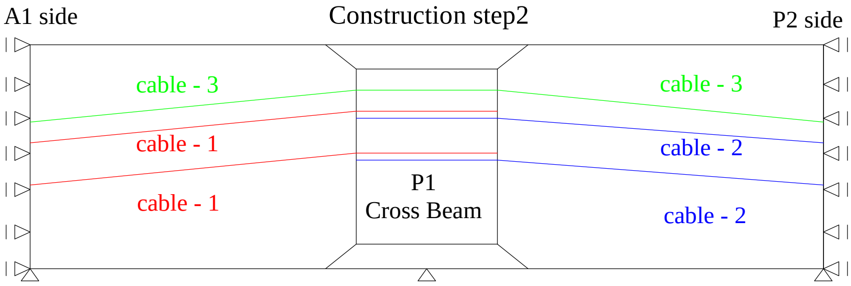
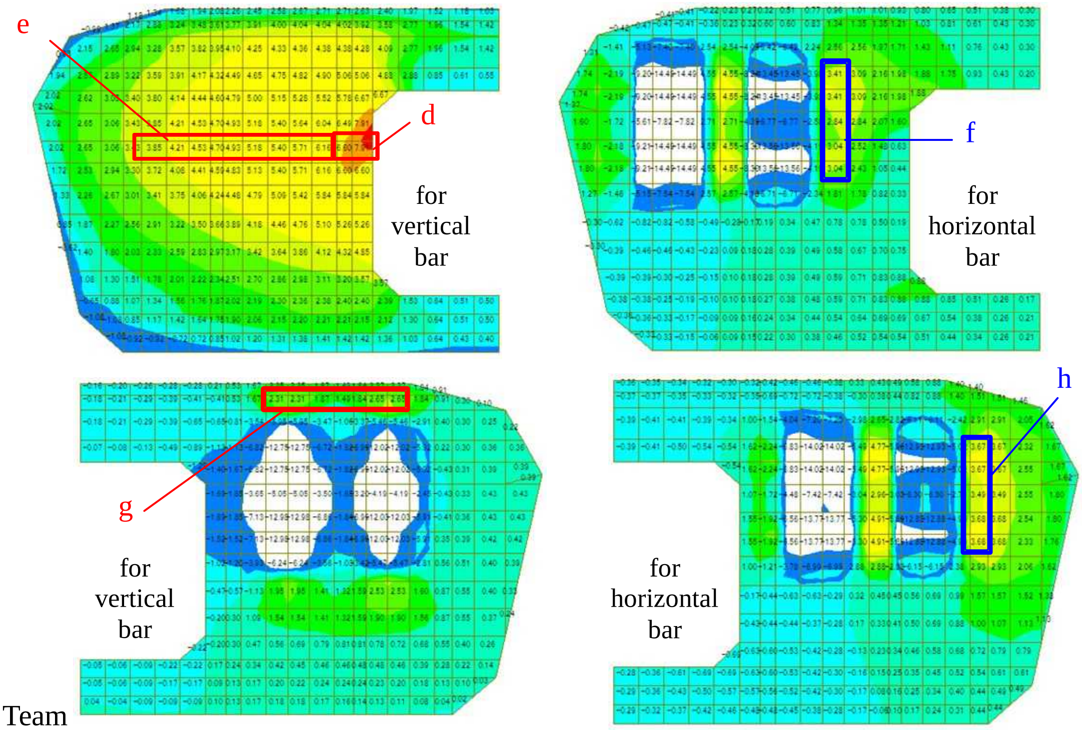


Figure 8.4.7-3 Intermediate cross beam in FEM mesh and restraint condition

[Design A1 side]
Construction step1
prestressed with
cable-1

[Design P1 side]
Construction step2
prestressed with
cable-1,cable-2,
and cable-3.



Source : Study Team

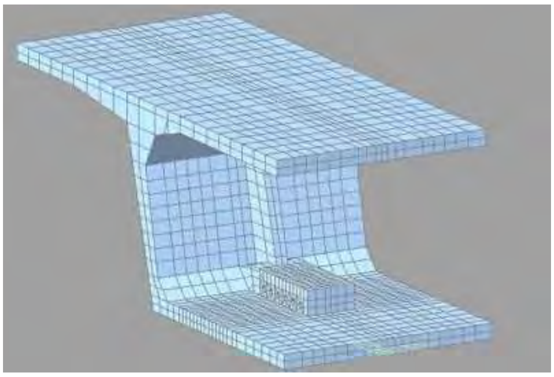
Figure 8.4.7-4 Result of FEM analysis

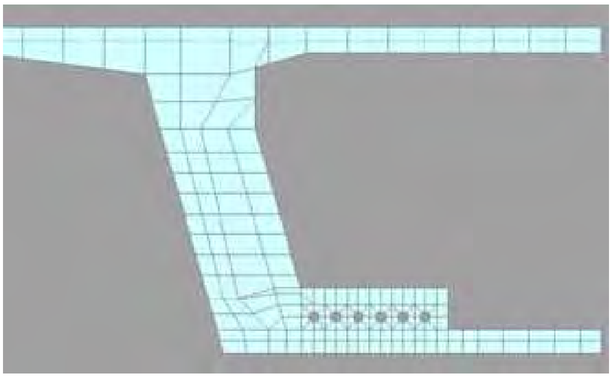
Table 8.4.7-2 Reinforcing bar arrangement of intermediate cross beam

		direction	Point	Size	Interval	Number of Layer	Area of bar		
							Areq	Aarr	
P1 (P2/P3/P4) cross beam	A1 side	vertical	d	D22	150mm	2	1176 mm2	1460 mm2	ok
			e	D22	200mm	2	4268 mm2	5862 mm2	ok
		horizontal	f	D22	250mm	2	1601 mm2	2798 mm2	ok
	P2 side	vertical	g	D22	150mm	2	1176 mm2	1460 mm2	ok
		horizontal	h	D22	250mm	2	1716 mm2	2570 mm2	ok

8.4.8 Design of Deviator

Though deviator is the specific device for external cable, it generates complicated local stress on the longitudinal direction, transverse direction and vertical direction. As for the local stress, it is needed to reinforce so that all their structure can fulfill the function.



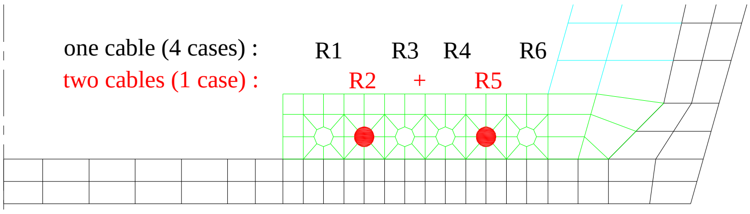


Source : Study Team

Figure 8.4.8-1 Deviator examination in FEM mesh

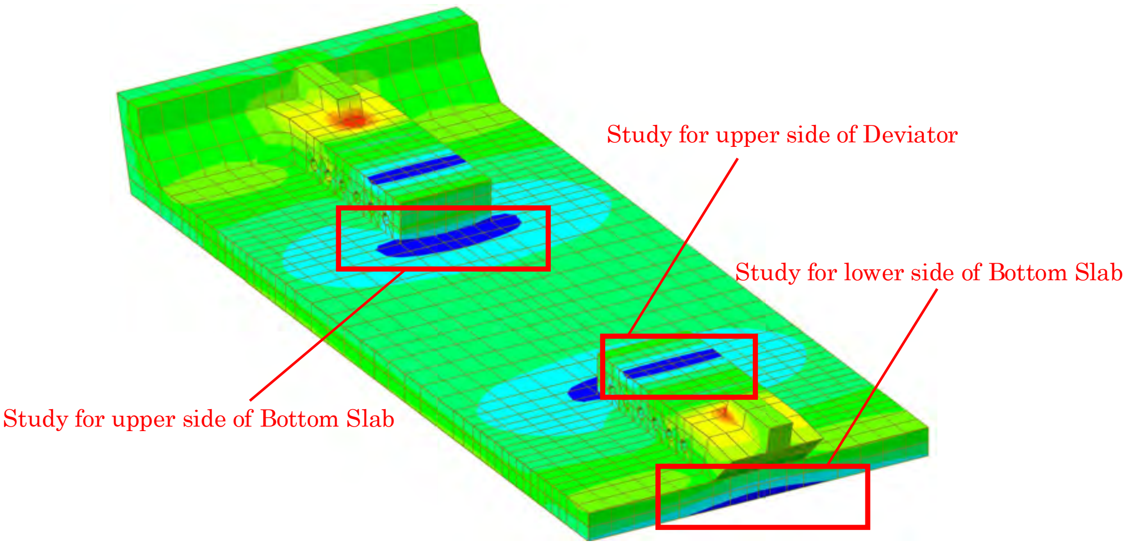
< Result of study >

Generally, one external cable is arranged per a deviation on one side. But in this design, at some deviators, two external cables are arranged per a deviator on one side. In the case, stronger tensile force is added to the deviator than others arranged one external cable.



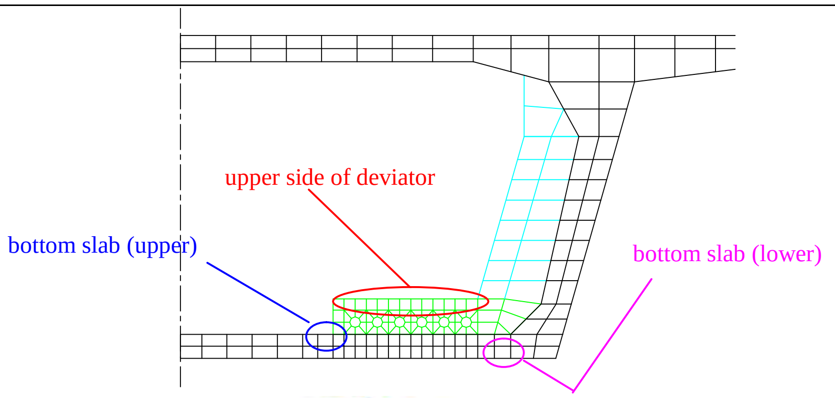
Source :
Study Team

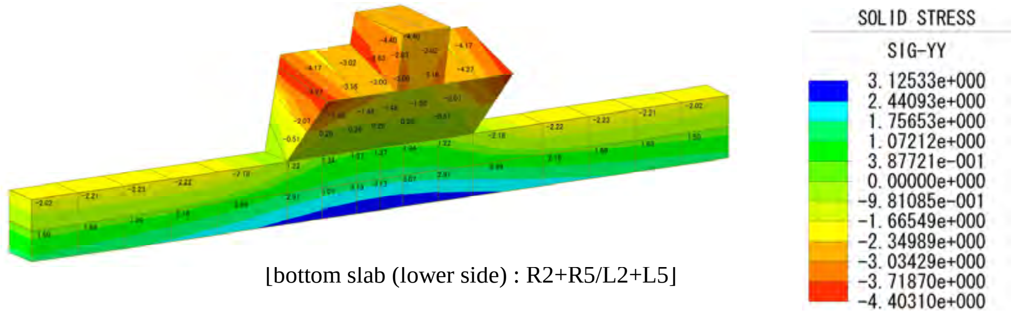
Figure 8.4.8-2 Arrangement of external cables and deviator



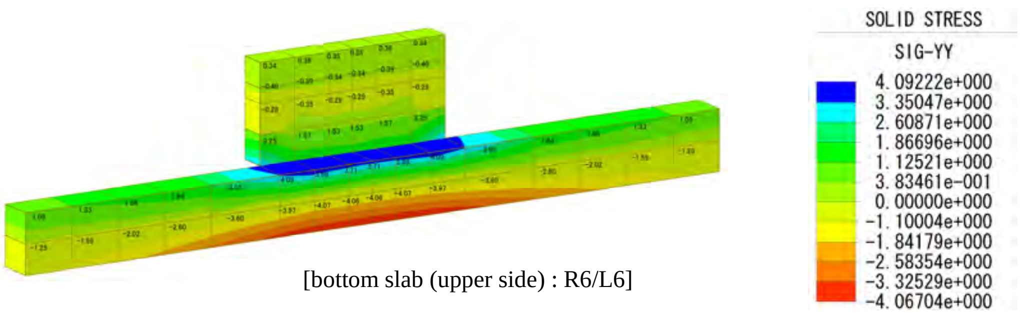
Source : Study Team

Figure 8.4.8-3 Tendency of stress in FEM analysis

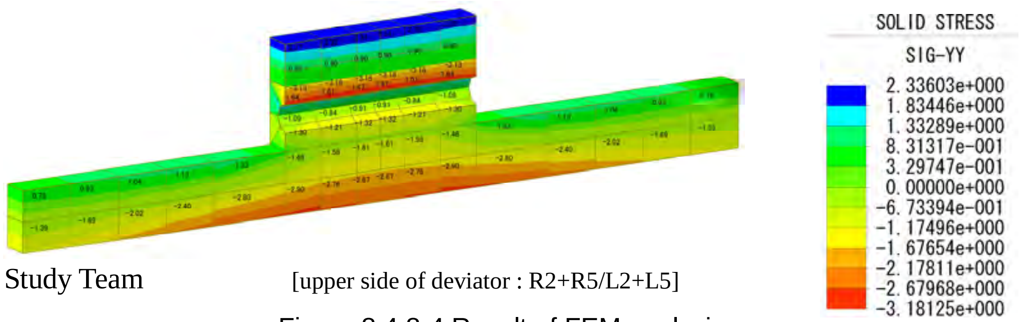




[bottom slab (lower side) : R2+R5/L2+L5]



[bottom slab (upper side) : R6/L6]



Source : Study Team

[upper side of deviator : R2+R5/L2+L5]

Figure 8.4.8-4 Result of FEM analysis

Table 8.4.8-1 Reinforcing bar arrangement around deviator

deviator	number of cables	arrangement of cables	Size	Interval	Area of bar		
					Areq	Aarr	
bottom slab (lower side)	2	R2+R5	D22	125mm	1963 mm2	2433 mm2	ok
	1	R1/R3/R4/R6	D19	125mm	1733 mm2	1815 mm2	ok
bottom slab (upper side)	2	R2+R5	D19	125mm	1688 mm2	1815 mm2	ok
	1	R1/R6	D22	125mm	1757 mm2	2433 mm2	ok
	1	R3/R4	D16	125mm	1118 mm2	1287 mm2	ok
upper side of deviator	2	R2+R5	D16	125mm	1265 mm2	1407 mm2	ok
	1	R1/R3/R4/R6	D16	125mm	1337 mm2	1407 mm2	ok

*Cables of L side are arranged at the same time.

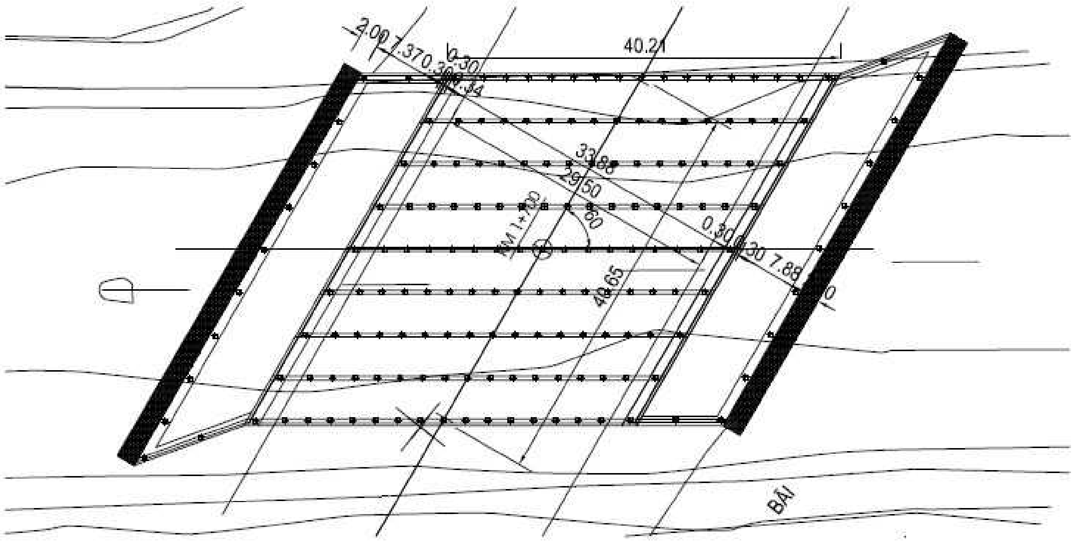
8.5 Design of Cam River Bridge

8.5.1 Background

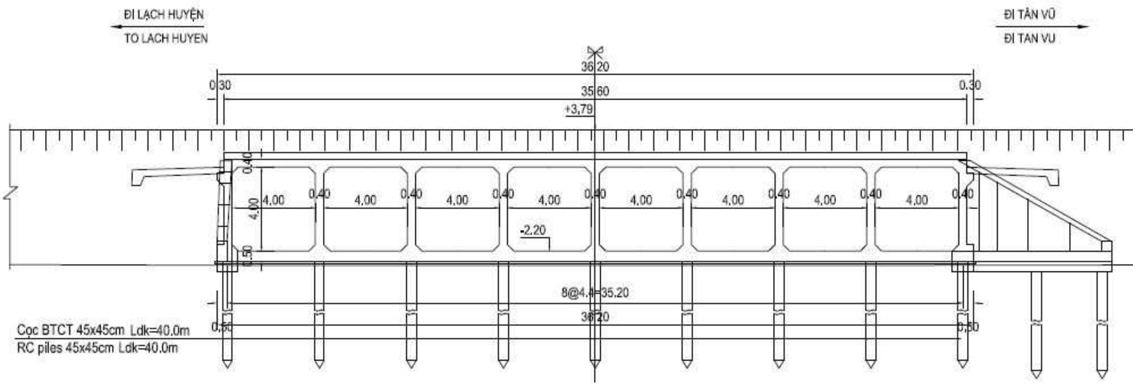
Tan Vu – Lach Huyen Highway is crossing Cam River at Km 1+700 and a box culvert with 8 cells, 8 x (4m x 4m), was planned, which is approved by 3139/QD-BGTVT dated 29th of October, 2010. The plan view and crosssection of box culvert is shown in the figure below.

On 5th of August, 2011, a meeting was held between Hai Phong PC and JICA Study Team, chaired by Mr Le Van Thanh, Vice Chairman, and concluded that the box culvert would be replaced by a bridge as stated in Notice No.242-TB/UBND dated 8th of August, 2011.

In accordance with the conclusion, a study was conducted to select an appropriate bridge type for crossing Cam River.



(b) Plan View



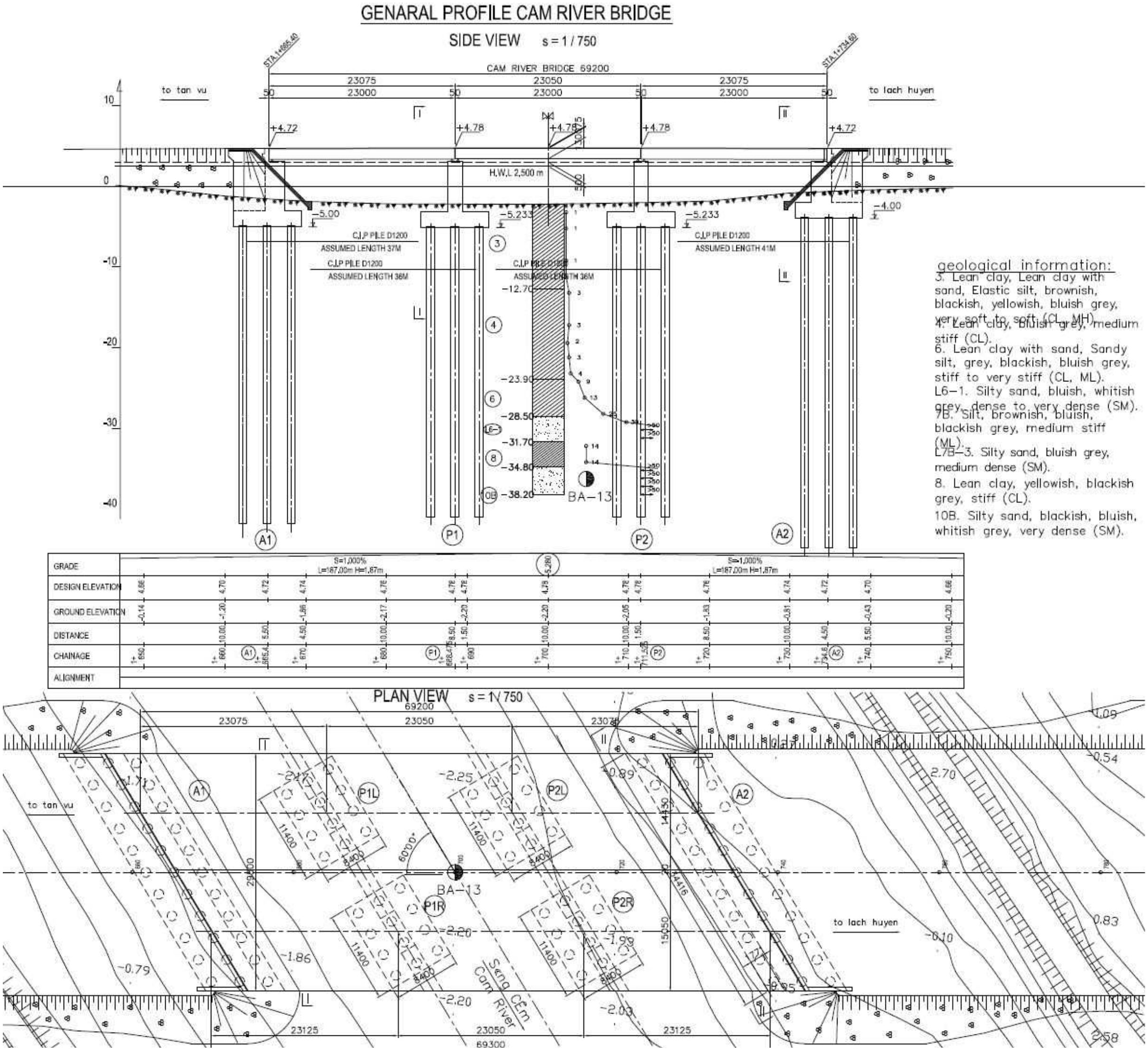
(b) Crosssection

Source: Study Team

Figure 8.5.1-1 Cam River Box Culvert

8.5.2 General Plan and Site Conditions of Cam River Bridge

The general plan of Cam River Bridge is as shown in the figure below.



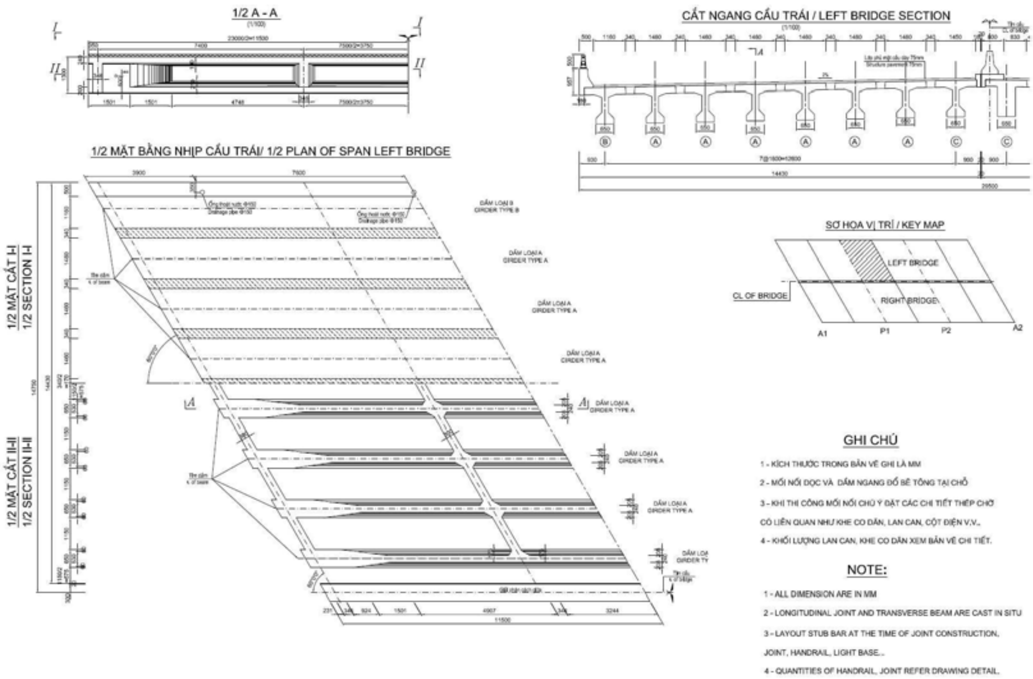
Source: Study Team

Figure 8.5.2-1 General view of Cam River Bridge

8.5.3 Design of Superstructure

(1) Girder Arrangement

The girder arrangement is as shown in the figure below.

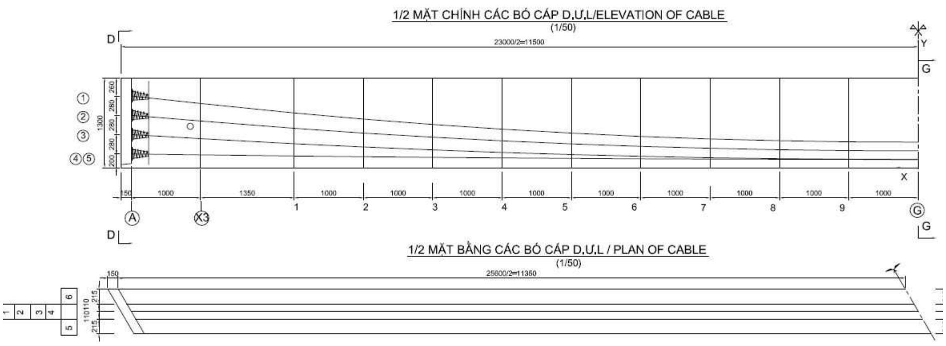


Source : Study Team

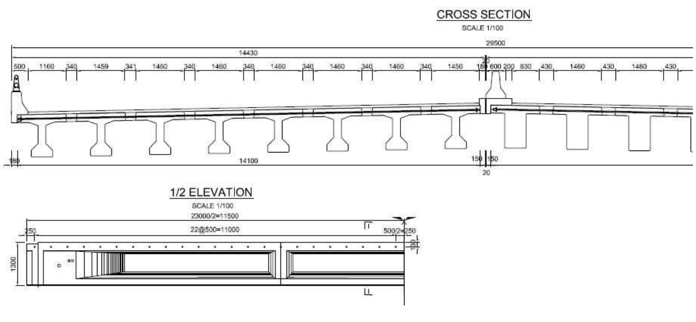
Figure 8.5.3-1 Girder Arrangement

(2) Tendon Arrangement

The tendon arrangement in is as shown in the figure below.



(a) Longitudinal PC Tendons



(b) Transversal PC Tendons

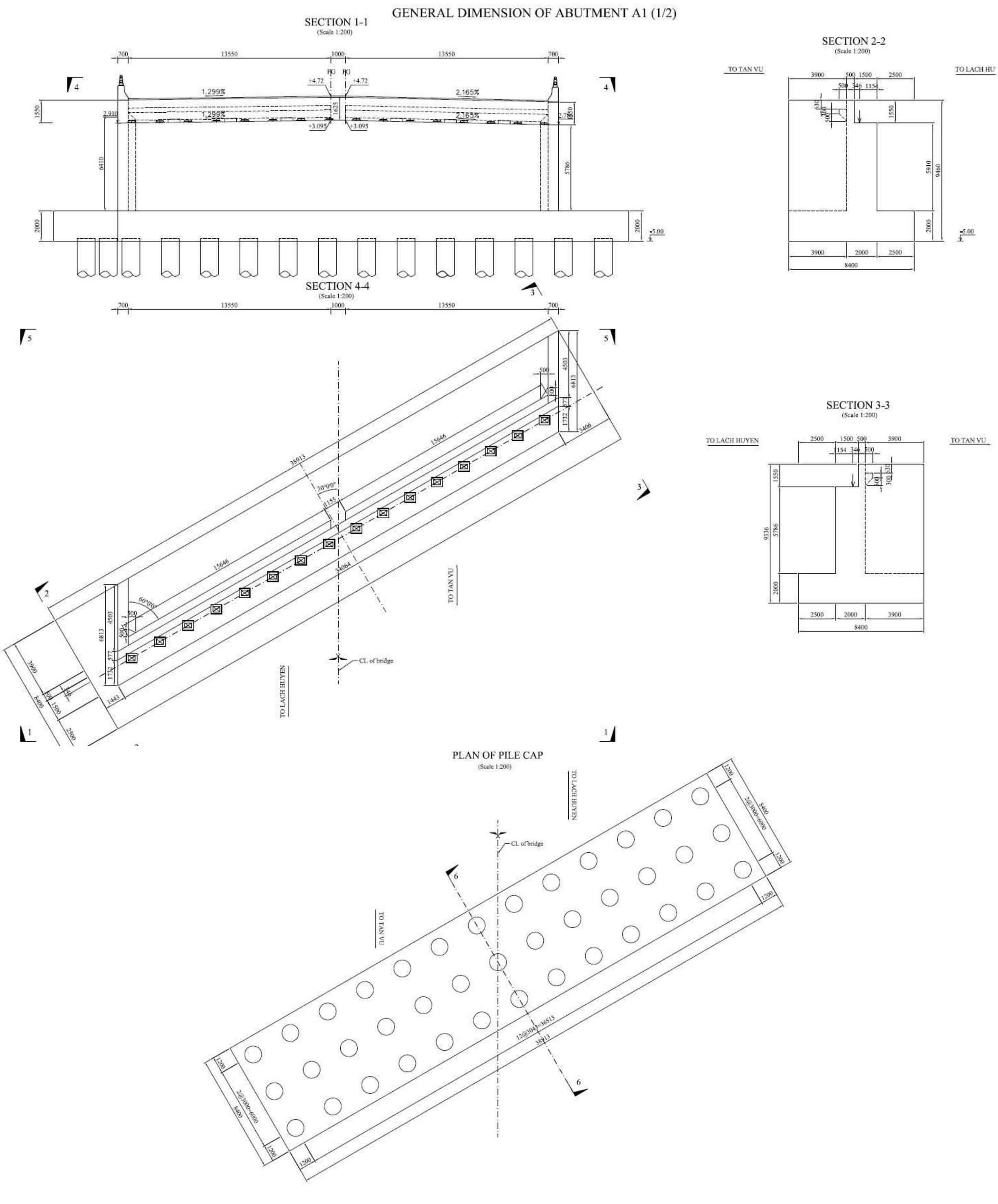
Source: Study Team

Figure 8.5.3-2 Arrangement of PC Tendons

8.5.4 Design of Substructure

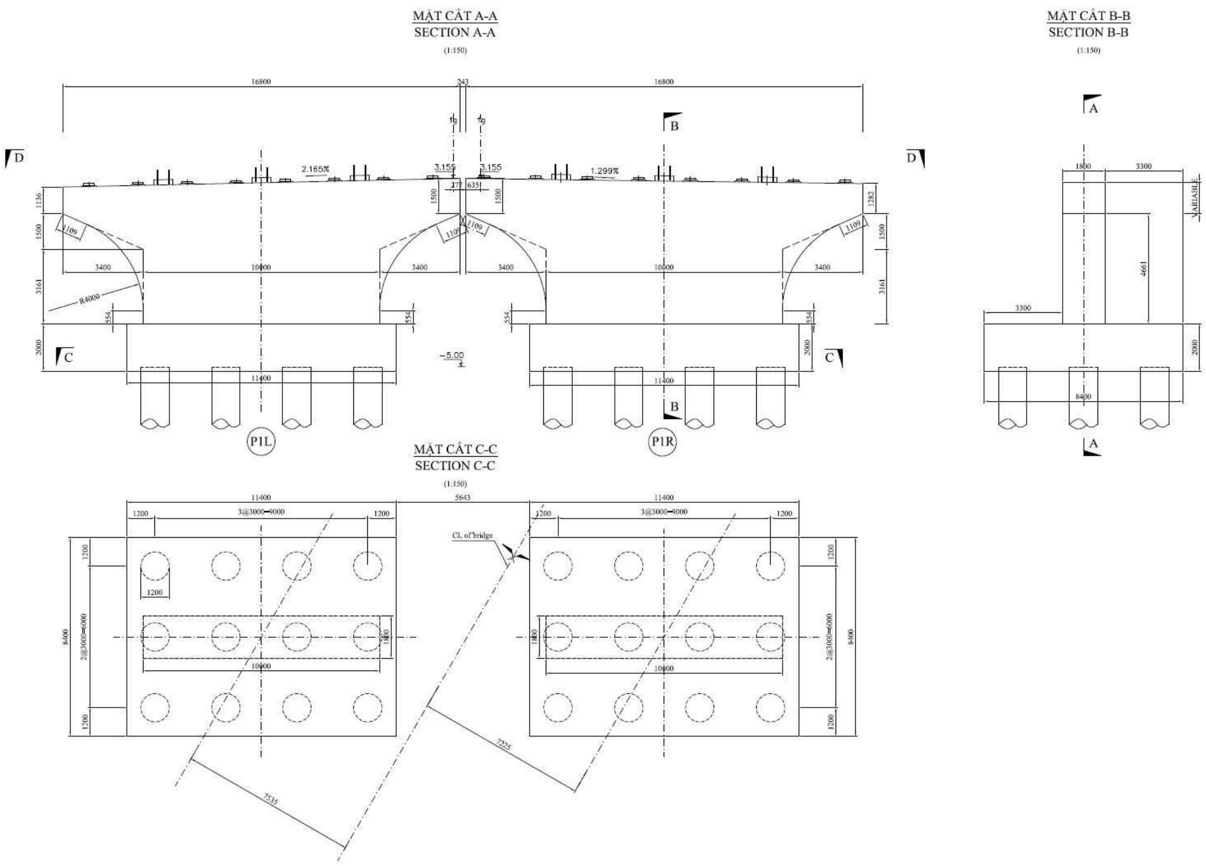
(1) Structure Dimensions

The Dimensions of substructure are as shown in the figure below.



Source : Study Team

Figure 8.5.4-1 Dimensions of Abutment



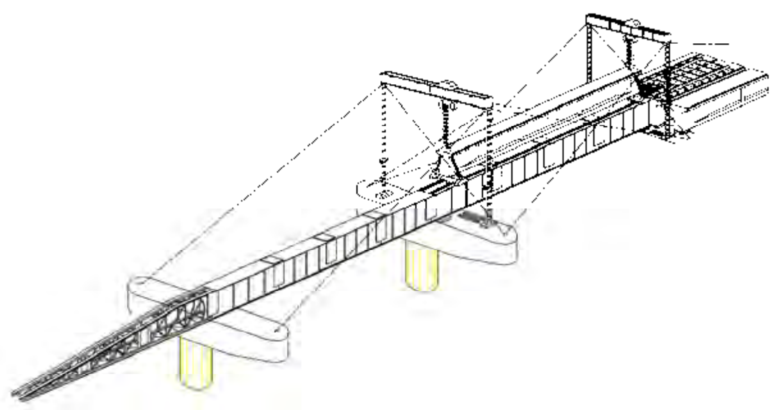
Source : Study Team

Figure 8.5.4-2 Dimensions of Pier

8.5.5 Precast T Girder Erection Method

On the Cam River, 3 continuous PC Post tension T girders will be constructed by erection girder after fabricating PC Girder behind abutment.

Outline of erection is shown below.



Source: Study Team

Figure 8.5.5-1 PC T girder erection method

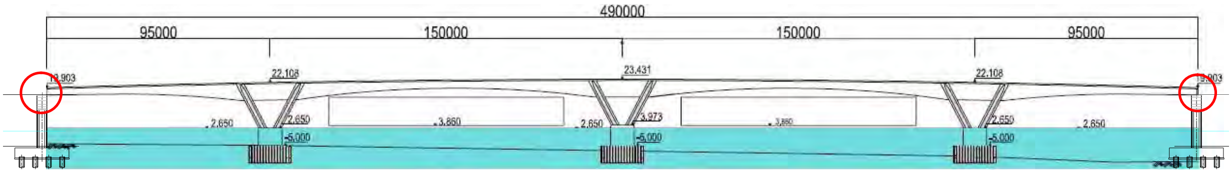
8.6 Study on Bridge Accessories

8.6.1 Bearings

8.6.1.1 Design of Bearings for Main Bridge

(1) Selection of Bearing type for Main Bridge

On the contrary to the continuous girder bridge like Approach Bridge, the bearings are needed only at the end piers for Main Bridge which is supported by 3 V-shaped piers with rigid connection. Therefore, not only vertical force but also horizontal force are dispersed to the piers and it is not necessarily the case that the assembly of laminated elastomeric shoes for dispersing horizontal force is applied.



Source: Study Team

Figure 8.6.1-1 Location for installation of Bearings in Main Bridge

As a result of comparative study, pot bearing is recommended because of its advantages in investment cost and adaptability for large displacement.

(2) Design of Bearings for Main Bridge

1) Conditions

The conditions for designing the bearings are as follows,

Table 8.6.1-1 Reaction Forces and Displacements at Bearings

(1) Service Limit State

Items		Displacement (m)	Reaction Forces (kN)		Note
			Vertical	Transversal	
P75	Uni-directional	153.4	5855	623	
	Multi-directional	153.4	5728	-	
P79	Uni-directional	151.9	5917	621	
	Multi-directional	151.9	5770	-	

(2) Extreme Event Limit State

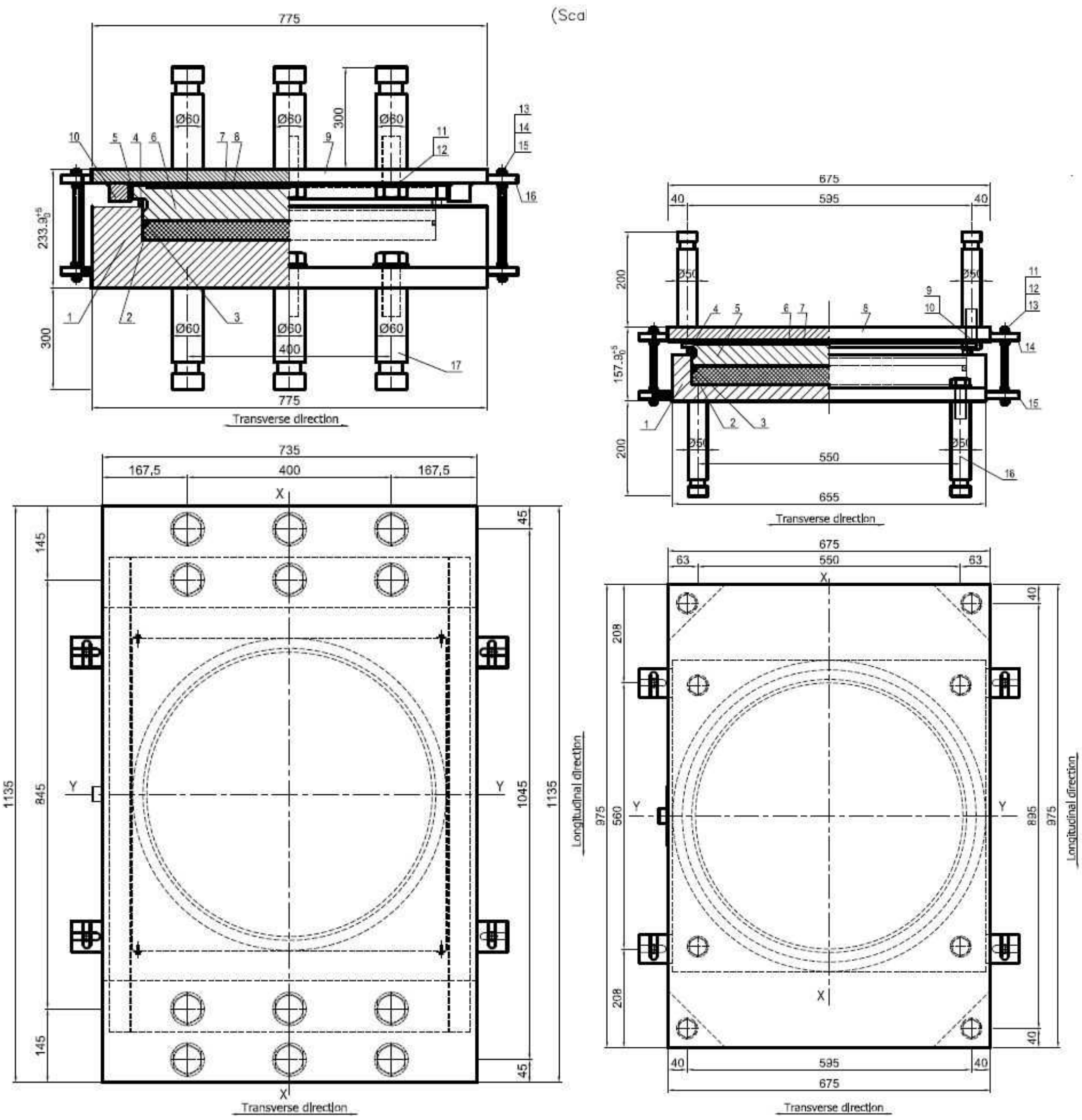
Items		Displacement (m)	Reaction Forces (kN)		Note
			Vertical	Transversal	
P75	Left	107.1	9100	2777	
	Right	107.1	9107	-	
P79	Left	109.8	10220	2990	
	Right	109.8	10211	-	

Source: Study Team

2) Results of Design

The items for checking are as follows,

- Thickness of Pot Ring
- Thickness of Pot Bottom
- Dimensions of Upper Plate
- Dimensions of Lower Plate
- Dimensions of Anchor Bolts
- Dimensions of Anchor Dowels
- Checking of Separation



(1) Unidirectional Sliding (2) Free Sliding

Source: Study Team

Figure 8.6.1-2 Dimensions of Pot Bearings

8.6.1.2 Design of Bearings for Approach Bridge

(1) Hai an side Approach Bridge

1) Design result of P35-P40 (59.0m+3@60.0m+59.0m)

Design of bearing P35-P40is applied to the Approach bridge A1-P55.

a) Reaction and movement

Bearing No.	Shape of Bearing			Reaction (kN)		Movement (mm)	
	a (mm)	b (mm)	Σte	Rmax	Rmin	+40℃	-40℃
P35	950	950	210	5690	4520	24.1	143.3
P36	1200	1200	128	10810	8860	12.0	84.0
P37	1200	1200	128	10680	8800	-0.4	36.6
P38	1200	1200	128	10770	8890	-6.5	-30.5
P39	1200	1200	128	10750	8800	-9.8	-81.8
P40	950	950	210	5670	4500	-11.2	-130.4

b) Bearing stress

Bearing No.	Bearing area	Effective bearing area	Bearing stress				
			Maximum		Minimum	Stress amplitude	
	Ae	Acn	σmax	≦ σmaxa	σmina	Δ σ	≦ Δ σa
	m2	m2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2
P35	0.9025	0.7664	7.42 <	8.0	5.01	2.42 <	5.0
P36	1.4400	1.3393	8.07 <	9.4	6.15	1.92 <	5.5
P37	1.4400	1.4117	7.57 <	9.4	6.11	1.45 <	5.5
P38	1.4400	1.4033	7.67 <	9.4	6.17	1.50 <	5.5
P39	1.4400	1.3418	8.01 <	9.4	6.11	1.90<	5.5
P40	0.9025	0.7786	7.28 <	8.0	4.99	2.30 <	5.0
Judgement			OK		OK>1.50	OK	

c) Local shear strain and tensile stress of steel plate

Bearing No.	Local shear strain					Tensile stress of inner steel plate	
	Vertical	Horizontal	Rotation	Amount	Allowable strain		
	γc	γs	γr	γt	≦γu/1.5	σs	≦ σsa
	%	%	%	%	%	N/mm2	N/mm2
P35	100.2	68.2	23.9	192.3	333	74.2	140
P36	92.2	65.6	29.3	187.1	333	86.1	140
P37	86.4	18.4	29.3	134.1	333	80.7	140
P38	87.7	23.9	29.3	140.8	333	81.9	141
P39	91.5	63.9	29.3	184.8	333	85.5	142
P40	98.3	62.1	23.9	184.3	333	72.8	140
Judgement	----	≦ 70 ok	----	Ok	----	Ok	----

2) Design result of P65-P70 (52.98m+3@60.0m+52.98m)

Design of bearing P65-P70 is applied to the approach bridge P55-P75.

a) Reaction and movement

Bearing No. (P65-P70)	Shape of Bearing			Reaction (kN)		Movement (mm)	
	a (mm)	b (mm)	Σte	Rmax	Rmin	+40℃	-40℃
P65	950	950	210	5140	4000	19.0	132.6
P66	1200	1200	128	10250	8340	11.5	83.5
P67	1200	1200	128	10770	8850	-0.1	23.9
P68	1200	1200	128	10770	9300	-6.4	-30.4
P69	1200	1200	128	10200	8290	-9.7	-81.7
P70	950	950	210	5130	3990	-6.9	-120.5

b) Bearing stress

Bearing No.	Bearing area	Effective bearing area	Bearing stress				
			Maximum		Minimum	Stress amplitude	
	Ae	Acn	σmax	≦ σmaxa	σmina	Δσ	≦ Δσa
	m2	m2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2
P65	0.9025	0.7765	6.62 <	8.0	4.43	2.19 <	5.0
P66	1.4400	1.3398	7.65 <	9.4	5.79	1.86 <	5.5
P67	1.4400	1.4113	7.58 <	9.4	6.15	1.44 <	5.5
P68	1.4400	1.4035	7.67 <	9.4	6.46	1.22 <	5.5
P69	1.4400	1.3420	7.60 <	9.4	5.76	1.84<	5.5
P70	0.9025	0.7880	6.51 <	8.0	4.42	2.09 <	5.0
Judgment			OK		OK>1.50	OK	

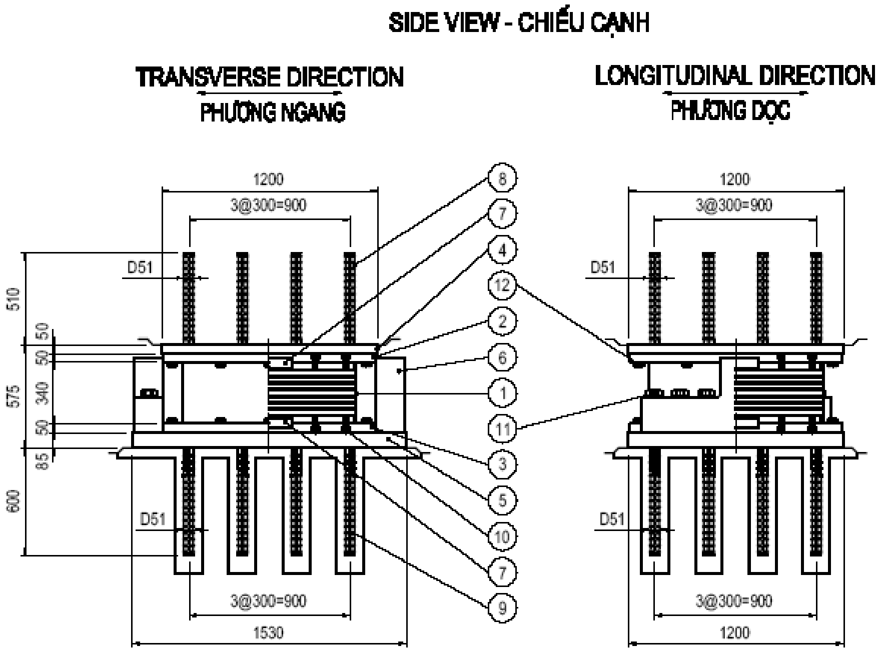
c) Local shear strain and tensile stress of steel plate

Bearing No.	Local shear strain					Tensile stress of inner steel plate	
	Vertical	Horizontal	Rotation	Amount	Allowable strain		
	γc	γs	γr	γt	≦γu/1.5	σs	≦ σsa
	%	%	%	%	%	N/mm2	N/mm2
P65	89.4	63.1	23.9	176.4	333	66.2	140
P66	87.4	65.2	29.3	181.9	333	81.6	140
P67	86.6	18.7	29.3	134.6	333	80.9	140
P68	87.7	23.7	29.3	140.7	333	81.9	141
P69	86.8	63.8	29.3	179.9	333	81.1	142
P70	87.9	57.4	23.9	169.1	333	65.1	140
Judgment	----	≦ 70 ok	----	Ok	----	Ok	----

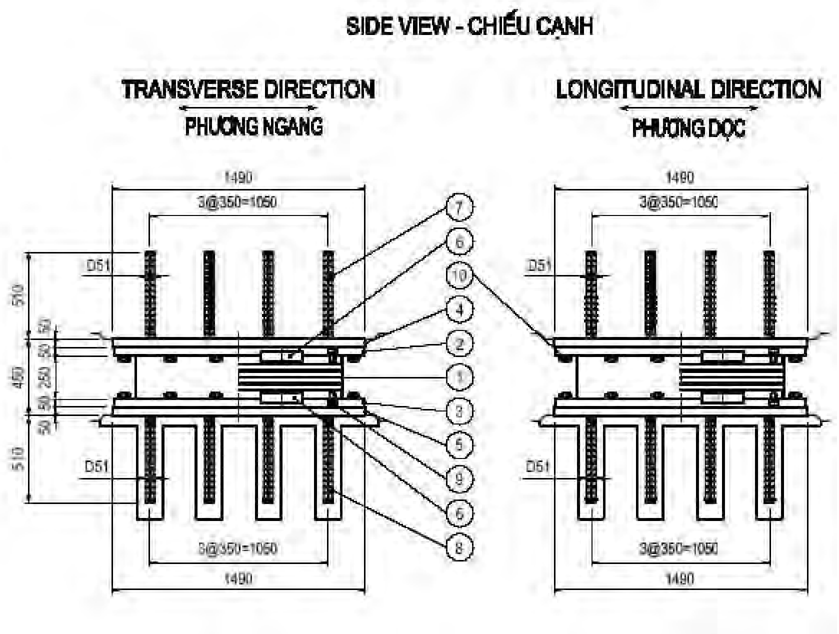
3) Detailed dimension of rubber bearing

Detailed dimension of bearing is as shown in the below from bearing design result.

a) End support bearing



b) Middle support Bearing



(2) Cat Hai side Approach Bridge

1) Design result of P79-P84

Bearing design result of P79-P84（51.98m+3@60.0m+51.98m）is shown below.

a) Reaction and movement

Bearing No.	Shape of Bearing			Reaction (kN)		Movement (mm)	
	a (mm)	b (mm)	Σte	Rmax	Rmin	+40℃	-40℃
P79	850	850	160	4440	3290	-10.5	104.5
P80	1300	1300	96	12360	10400	-8.9	63.1
P81	1300	1300	96	11770	9880	-2.8	21.2
P82	1300	1300	96	11770	9880	3.0	-21.0
P83	1300	1300	96	12360	10400	8.7	-63.3
P84	850	850	160	4440	3290	10.5	-104.5

b) Bearing stress

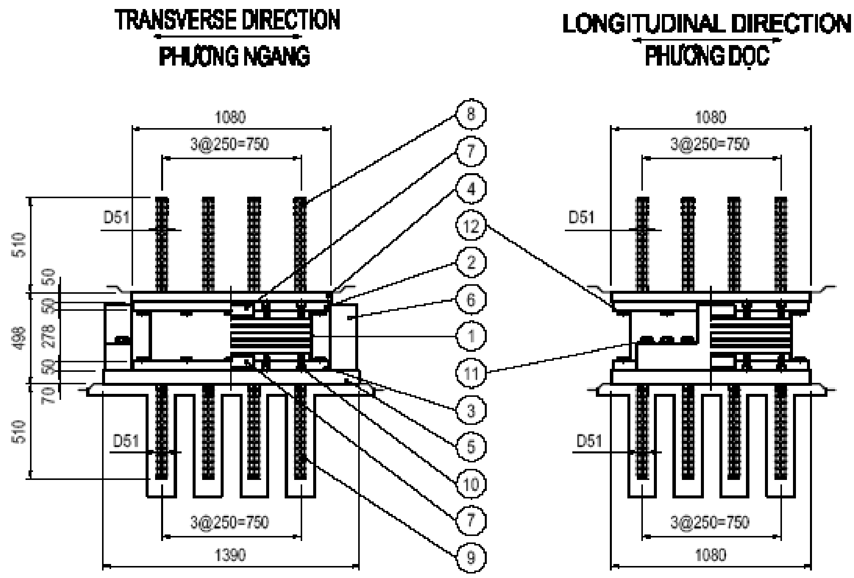
Bearing No.	Bearing area	Effective bearing area	Bearing stress				
			Maximum		Minimum	Stress amplitude	
	Ae	Acn	σmax	≦ σmaxa	σmina	Δσ	≦ Δσa
	m2	m2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2
P79	0.7225	0.6346	7.01 <	8.0	4.55	2.46 <	5.0
P80	1.6900	1.6089	7.68 <	10.2	6.24	1.44 <	5.8
P81	1.6900	1.6625	7.09 <	10.2	5.85	1.24 <	5.8
P82	1.6900	1.6626	7.09 <	10.2	5.85	1.25 <	5.8
P83	1.6900	1.6088	7.68 <	10.2	6.24	1.44 <	5.8
P84	0.7225	0.6346	7.01 <	8.0	4.55	2.46 <	5.0
Judgment			OK		OK>1.50	OK	

c) Local shear strain and tensile stress of steel plate

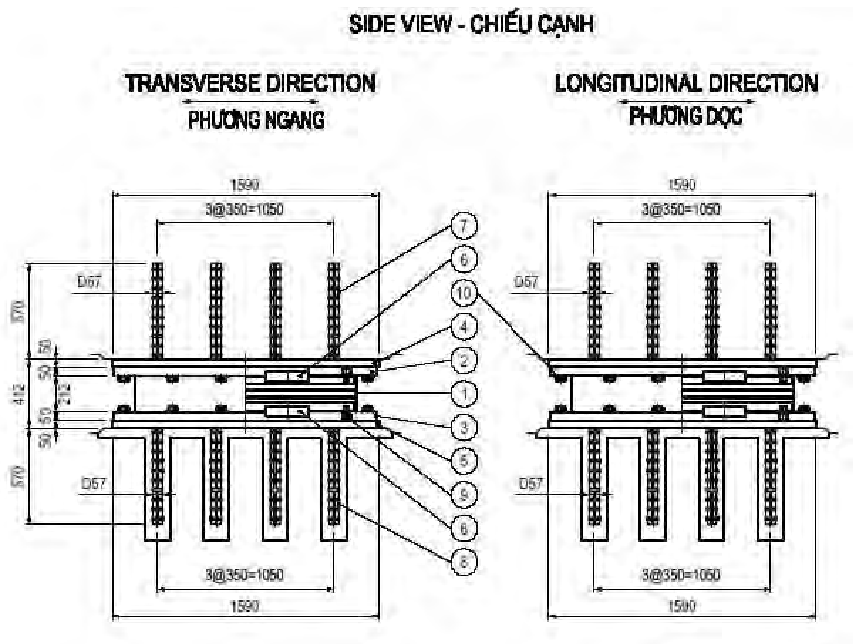
Bearing No.	Local shear strain					Tensile stress of inner steel plate	
	Vertical	Horizontal	Rotation	Amount	Allowable strain		
	γc	γs	γr	γt	≦γu/1.5	σs	≦ σsa
単位	%	%	%	%	%	N/mm2	N/mm2
P79	112.5	64.6	23.5	200.7	333	74.8	140
P80	81.1	65.0	45.8	191.9	333	81.9	140
P81	74.8	22.0	45.8	142.6	333	75.6	140
P82	74.8	21.9	45.8	142.6	333	75.6	141
P83	81.1	65.1	45.8	192.0	333	82.0	142
P84	112.5	64.7	23.5	200.7	333	74.8	140
Judgment	----	≦ 70 ok	----	Ok	----	Ok	----

d) Detailed dimension of Rubber bearing

＜End support Bearing＞



＜Middle support Bearing＞



2) Design result of P84-A2

Bearing design result of P84-A2（51.98m+2@60.0m+51.98m）is shown below.

a) Reaction and movement

Bearing No.	Shape of Bearing			Reaction (kN)		Movement (mm)	
	a (mm)	b (mm)	Σ te	Rmax	Rmin	+40℃	-40℃
P84	850	850	128	4440	3290	-8.7	82.3
P85	1300	1300	96	12400	10400	-6.7	41.3
P86	1300	1300	96	11700	9740	0.0	0.0
P87	1300	1300	96	12300	10590	6.7	-41.3
A2	850	850	128	43000	3290	8.7	-82.3

b) Bearing stress

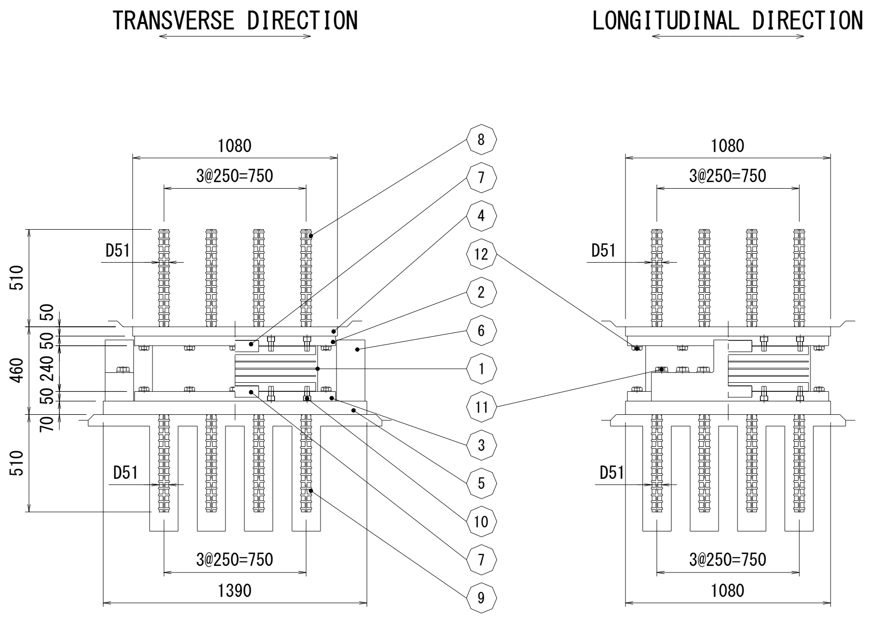
Bearing No.	Bearing area	Effective bearing area	Bearing stress				
			Maximum		Minimum	Stress amplitude	
	Ae	Acn	σmax	≦ σmax,a	σmina	Δ σ	≦ Δ σa
	m2	m2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2
P84	0.7225	0.6525	6.80 <	8.0	4.55	2.25 <	5.0
P85	1.6900	1.6363	7.58 <	10.2	6.18	1.40 <	5.8
P86	1.6900	1.6900	6.92 <	10.2	5.76	1.16 <	5.8
P87	1.6900	1.6363	7.58 <	10.2	6.27	1.25 <	5.8
A2	0.7225	0.6525	6.80 <	8.0	4.55	2.04<	5.0
Judgment			OK		OK>1.50	OK	

c) Local shear strain and tensile stress of steel plate

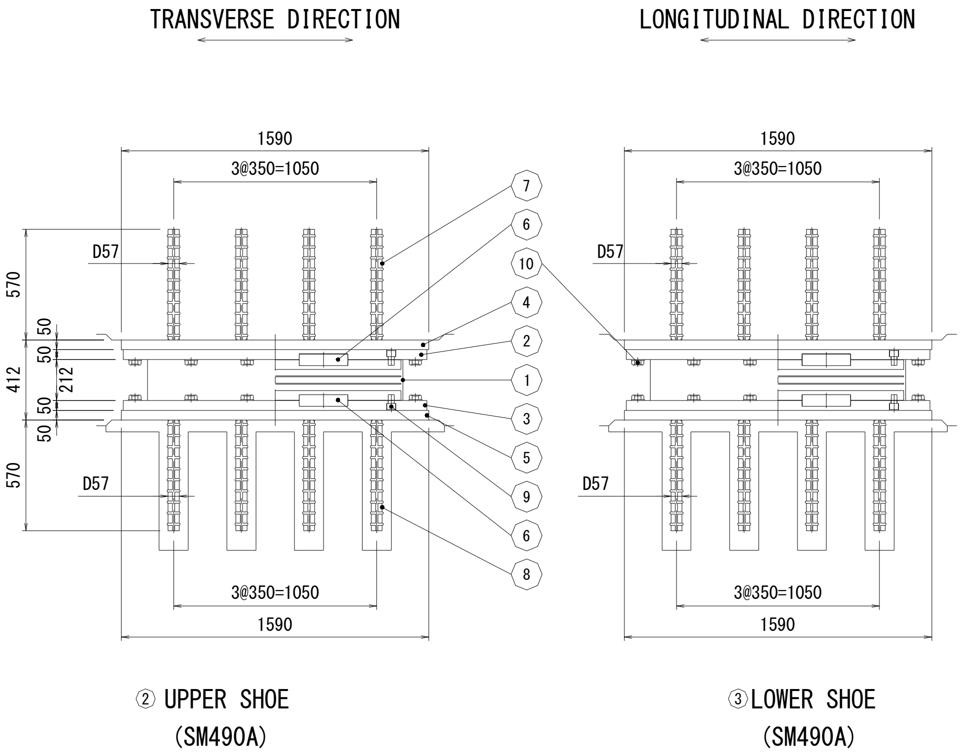
Bearing No.	Local shear strain					Tensile stress of inner steel plate	
	Vertical	Horizontal	Rotation	Amount	Allowable strain		
	γc	γs	γr	γt	≦γu/1.5	σs	≦ σsa
unit	%	%	%	%	%	N/mm2	N/mm2
P84	109.2	64.3	29.4	202.9	333	72.6	140
P85	80.0	43.0	45.8	168.8	333	80.8	140
P86	73.1	0	45.8	118.9	333	73.8	140
P87	79.3	43.0	45.8	168.2	333	80.2	142
A2	105.7	64.3	29.4	199.5	333	70.3	140
Judgment	----	≦ 70 ok	----	Ok	----	Ok	----

d) Detailed dimension of Rubber bearing

< End support Bearing (P84 and A2）>



＜Middle support Bearing＞



8.6.2 Expansion Joint

8.6.2.1 Design of Expansion Joint for Main Bridge

The necessary expansion between Main Bridge and Approach Bridge was calculated based on the results of the structural analyses for the design of the main girders.

The conditions are as follows;

- Temperature Range: 40 degrees
- Coefficient of thermal expansion: 1.08E-05
- Model of Creep and Shrinkage: CEB-FIP90
- Degree of Humidity: 80%

The results of analysis are as follows;

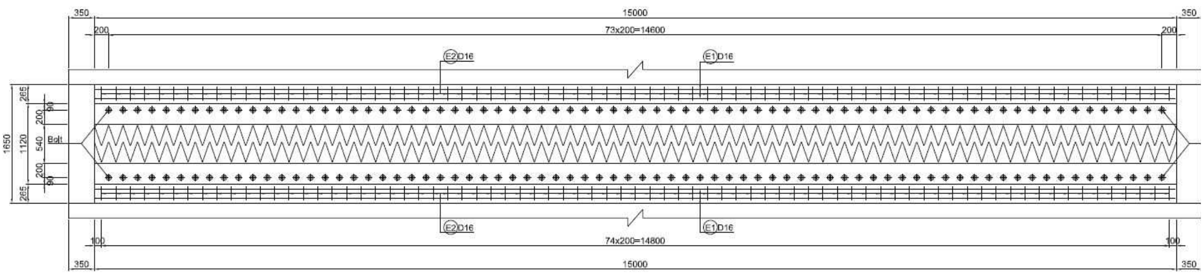
Table 8.6.2-1 Longitudinal Movement at Ends of Main Girders

	Main Bridge	Approach Bridge	Total
Movement due to Temperature Alternation	103.8	59.0	162.8
Movement due to Creep & Shrinkage	84.2	58.3	142.5
Total	187.9	117.3	305.2

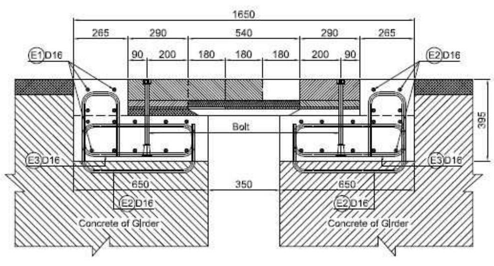
Unit: mm

Source : Study Team

The expansion joint to be applied between Main Bridge and Approach Bridge is a steel finger type joint as shown in the figure below because the necessary expansion is more than 250mm. The gap between the edges of the main girders is set as the standard gap of the type of the joint.



(a) Plan View



(b) Longitudinal Cross Section

Source: Study Team

Figure 8.6.2-1 Expansion Joint between Main Bridge and Approach Bridge

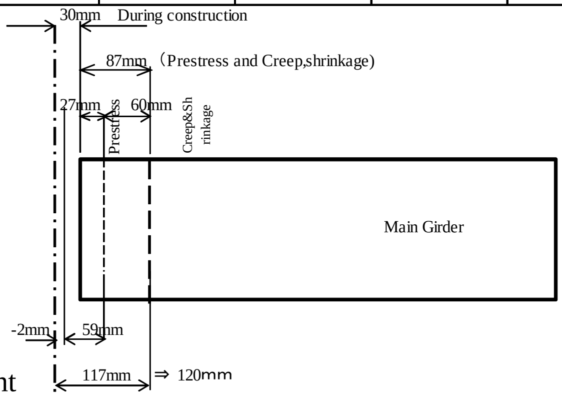
8.6.2.2 Design of Expansion Joint for Approach Bridge

(1) Hai an side Approach Bridge

The expansion joint and girder gap of Hai an side approach bridge are decided in P35-P40（59.0 ｍ+3＠60.0+59.0m） of the maximum length of the bridge.

a) Movement of main girder

Item	Position / Node Num,	E1 1	P1 23	P2 44	P3 65	P4 86	E2 108
①	Dead Load	-8.9	-8.5	-3.8	-2.1	-0.7	-0.7
②	Prestress	26.9	16.1	3.8	-3.1	-7.7	-10.4
③	Creep and Shrinkage	59.6	34.7	10.6	-12.6	-35.3	57.6
④	Temperture 40℃	58.9	35.5	11.7	11.9	35.7	59.2
⑤	Earth Quick Kh=0.18	142.7	142.6	142.6	142.6	142.6	142.7



b) Design movement of expansion joint

Item	unit	Movement		Remarks
		P35-P40	P65-P70	
1. Creep and Shrinkage	mm	59.6	55.3	
2. Temperature change(40℃)	mm	58.9	56.4	
3. design margin	mm	1.5	8.3	
Design movement	mm	120.0	120.0	

2) Selection of expansion joint

< A1Abuttment >

Cipec joint Wj -160.			Design movement	
Tolerable movement :	160mm	＞	120	mm
Tolerable expansion gap :	150mm	＞	120	mm
		Ok		

< Pier >

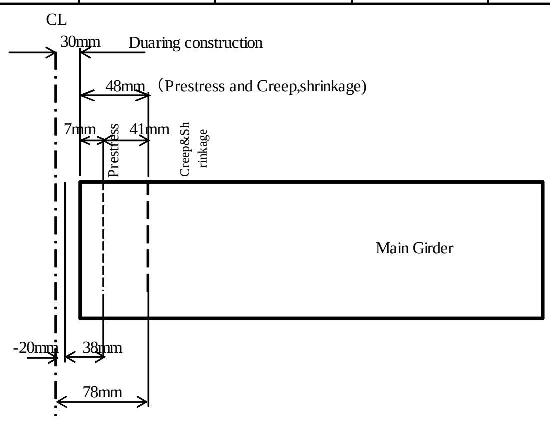
Cipec joint WY-320.			Design movement	
Tolerable movement :	250mm	＞	240	mm
Tolerable expansion gap :	435mm	＞	240	mm
		OK		

(2) Cat hai side Approach Bridge

The expansion joint and girder gap of Cat hai side approach bridge are decided in P79-P84(59.0m+3@60.0+59.0m)of the maximum length of the bridge.

a) Movement of main girder

Item	Position / Node Num,	E1 1	P1 16	P2 34	P3 52	P4 70	E2 85
①	Dead Load	-1.6	-0.9	0.0	0.0	1.0	1.7
②	Prestress	6.7	3.0	1.1	-0.8	-3.0	-6.6
③	Creep and Shrinkage	41.2	25.0	9.0	-7.3	-23.4	-39.5
④	Temperture 40℃	58.2	36.7	13.0	10.6	34.3	-55.7
⑤	Earth Quick Kh=0.18	117.6	117.5	117.4	117.3	117.3	117.3



b) Design movement of expansion joint

Item	unit	Movement		Remarks
		P79-P84	P84-A2	
1. Creep and Shrinkage	mm	41.2	31.4	
2.Temperature change(40℃)	mm	58.2	44.0	
3. design margin	mm	20.6	44.6	
Design movement	mm	120.0	120.0	

c) Selection of expansion joint

< A2 Abuttment >

Cipec joint Wj -160.			Design movement	
Tolerable movement :	160mm	>	120	mm
Tolerable expansion gap :	150mm	>	120	mm
		Ok		

< Pier >

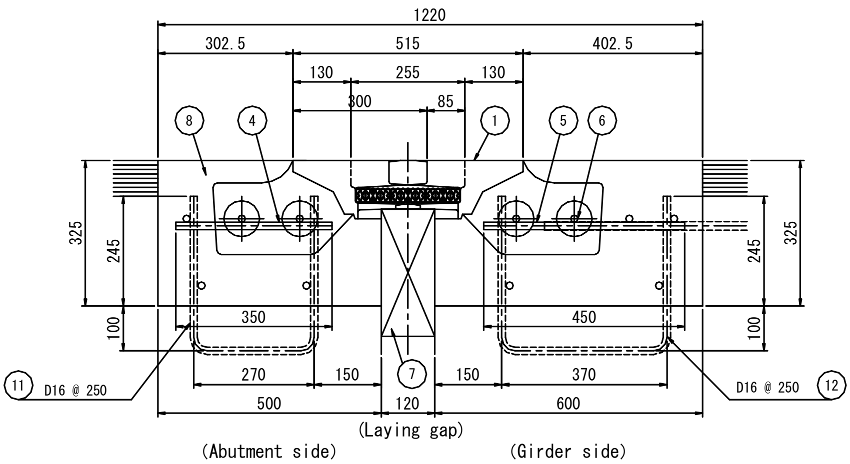
Cipec joint WY-320.			Design movement	
Tolerable movement :	250mm	>	240	mm
Tolerable expansion gap :	435mm	>	240	mm
		OK		

(3) Detailed dimension of Expansion joint

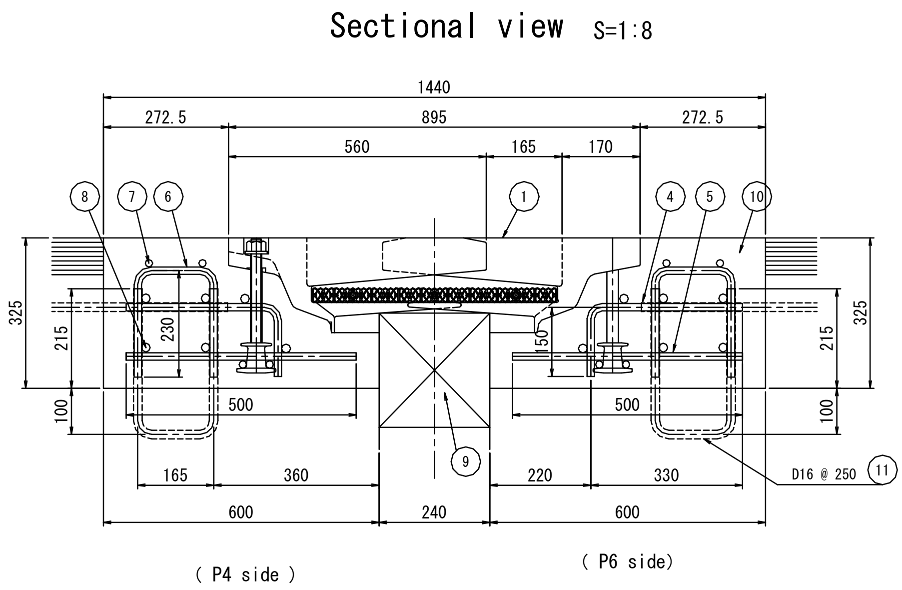
Both Hai an side approach bridges and Cat hai side approach bridges apply the same expansion joint. The expansion joint is shown in the figure below.

1) A1 Abuttment and A2 Abuttment

Sectional view S=1:8



2) Pier



Source: Study Team

8.6.2.3 Joint Protectors

For Main Bridge, the unidirectional pot bearing guides the girder to move in the longitudinal direction so that the joint can be protected from transversal movement of the girder.

For Approach bridge, the laminated elastomeric shoe with side blocks guides the girder to move in the longitudinal direction so that the joint can be protected from transversal movement of the girder.

8.6.3 Railing

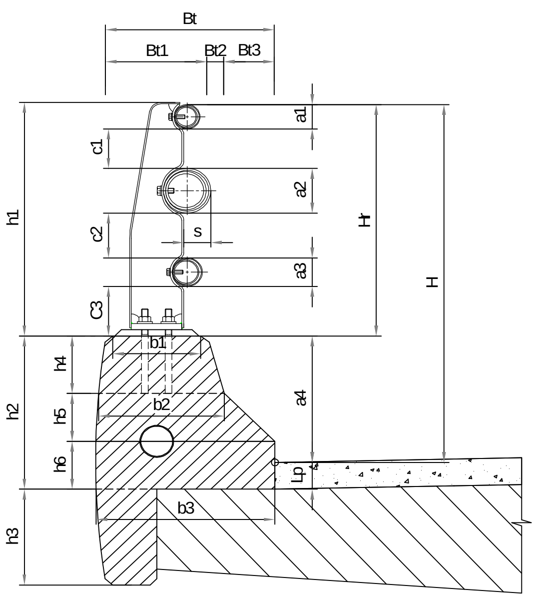
In order to select the most reasonable type of Guardrail, alternatives for comparison are introduced as follows,

- Alternative -1: Aluminum Handrail
- Alternative -2: Steel Handrail
- Alternative -3: Concrete Wall + Steel Handrail
- Alternative -4: Concrete Wall

As a results of comparison reveal that Alternative-3, Concrete Wall + Steel Handrail, is most preferable for the following reasons;

- Reinforced concrete wall resists the impact of collision.
- Reasonable Cost.
- Superior in Aesthetics.

The structure and the dimensions of the guardrail is shown in the following figure.



Sign	Value (mm)	Sign	Value (mm)
h1	500	b1	300
h2	700	b2	319
h3	300	b3	500
h4	279		
h5	321		
h6	100		
S	25		
Hr	500		
H	1126		
c1	150		
c2	140		
c3			
a1	88		
a2	112		
a3			
a4	626		
Lp	74		
Bt1	300		
Bt2	19		
Bt3	181		
Bt	500		

Source: Study Team

Figure 8.6.3-1 Expansion Joint on Approach Bridge

CHAPTER 9 ELECTRIC WIRING AND LIGHTING FACILITY

9.1 General

This Chapter describes the design base of the electric wiring and lighting facility for the Lach Huyen Port Construction Project.

9.1.1 Scope of Works

The work covers the design of the complete lighting facility for the following items;

1) The road lighting facility for Tan Vu Interchange, Dinh Vu Intersection and approach and main Bridge.
2) The navigation bridge light at the main Bridge for the ship.
3) The signal system on Tan Vu interchange shall be considered since the previously planned run-about has been changed to T-junction.
4) The lighting system inside the box girders in the bridge section between Km 4.5 and Km 9.99.

9.2 Design conditions

9.2.1 Service conditions

The project area has a hot, humid and tropical atmosphere. Moreover, the surrounding environment has a high degree of salinity.

All electrical equipment, cables, accessories and fittings which form part of the electrical installation shall be fully suitable for use in the following specified service conditions:

1)	Altitude above mean sea level (approx.)		: 2.0 m
2)	Ambient temperature	- Maximum	: 45 °C
		- Minimum	: 5 °C
3)	Relative humidity	- Maximum	: 100%
4)	Climatic atmosphere		: Tropical
5)	Wind pressure	: This value shall be followed the design criteria of Road and Bridge in this Project.	
6)	Earthquake	: This value shall be followed the design criteria of Road and Bridge in this Project.	
7)	Salt contamination	: This value shall be followed the design criteria of Road and Bridge in this Project.	

9.2.2 Design criteria

(1) Electrical system

It is connected with Network of the following electric power company, and the electric power is supplied to substation in four places.

These substations shall be connected by 35kV or 22kV underground transmission line and equipped 35(22) kV/400-220V or 22 kV/400-220V receiving transformer, lighting distribution panel and associated accessory

Table 9.2.2-1 Technical parameters of power receiving and distribution system

Power Supply Substation (Power company)	Power Receiving Substation		
	Name	Location	Transformer
Tan Vu Power Station (Hai An Power Company)	SUBSTATION “A”	Around Tan Vu Interchange	3ph/4w-31.5kVA-**22**/0.4 kV
	SUBSTATION “B”	Around Dinh Vu Intersection	3ph/4w-31.5kVA-**22**/0.4 kV
	SUBSTATION “C”	At the West Side of Bridge	3ph/4w-50 kVA-**22**/0.4 kV
Ninh Tiep Power Station (Cat Hai Power Company)	SUBSTATION “D”	At the Eest Side of Bridge	3ph/4w-31.5 kVA-**35**/0.4kV

Source : Study Team

(2) Allowable Voltage Drop

The maximum allowable voltage drops between distribution transformer and the furthest fixture shall not exceed 5%.

(3) Cable sizing

The cables shall be covered to the maximum current demand.

The voltage drop was calculated, and the size of the cable for the wiring to each substation and the illuminator confirmed and selected the tolerance.

(4) Lighting Arrangement

The lighting fixture shall be designed and arranged for each area so as to meet the following illumination level:

The acceptable value has been shown in the Chapter 4.2 of TCXDVN 259-2001 as below.

Interchange and Intersection: $\geq$ 1.2 Cd/m^2 (Minimum luminance on ground)

Bridge: $\geq$ 1.2 Cd/m^2 (Minimum luminance on ground)

(5) Earthing system

The exposed metal frames of all electrical apparatus and machinery not forming parts of the electric circuits, neutral of transformers, etc., shall be earthed.

1) Earthing conductor, plate and rods

The following materials shall be used for earthing systems;

a) Earthing conductor: Annealed copper stranded conductor.

b) Earthing plate: 90 cm square, 1.5 mm thickness copper plate or equivalent.

c) Earthing rods: 16 mm diameter, 3 m length copper clad steel rod with coupling.

d) Connectors: Compression type connectors which shall be able to connect the annealed copper stranded conductors each other, earthing plate and rod.

2) Earthing works

a) Earthing rods, plate and conductors shall be buried deeper than 0.6 M or more from the ground surface.

b) The connection between earthing conductor and ground rod, plate and equipment connection conductor shall be electrically and mechanically rigid.

c) Earthing systems of the instruments equipment shall be done by separately from common ground.

d) The earthing for transformer neutrals and lightning arresters, earthing rod shall be installed in additionally for interconnections with earthing mesh.

e) Boundary fences shall be earthed by means of earthing rods, separately from the main earthing mesh.

(6) Lightning Protection

Structures which are made of metal and be electrically continuous do not require a separate down conductors for lightning connection.

Structures and equipment outside the protection zones shall be directly earthed as close to the base as possible.

(7) Wiring design

1) Medium voltage wiring:

Medium voltage wire line supply between transformers and supply from connection power which is using underground cable, will has anti-proof and anti-corrosion, it will pass in HDPE pipe and bury underground with minimum depth 0.7 m along side walk.

2) Low voltage wiring:

- Low voltage wiring for electric supplying on the road will pass in HDPE pipe and bury underground with minimum depth 0.7 m to lighting poles.
- Lighting axial cable low voltage wiring on the bridge will pass on cable support bar inside box girder to the lighting control box.
- Low voltage wiring for lighting supply on the bridge will pass in HDPE pipe inside parapet concrete of the bridge.

9.3 Figures

Several typical drawings listed below are shown in the next pages for illustration of the works.

Figure 9.3-1: Typical Lighting Pole and High Mast
Figure 9.3-2: Lighting Pole Material
Figure 9.3-3: Street luminaries
Figure 9.3-4: Lighting transformer Station
Figure 9.3-5: Navigation Light
Figure 9.3-6: 17m High Mast
Figure 9.3-7: 25m High Mast
Figure 9.3-8: Plan of Lighting Inside Box Girder

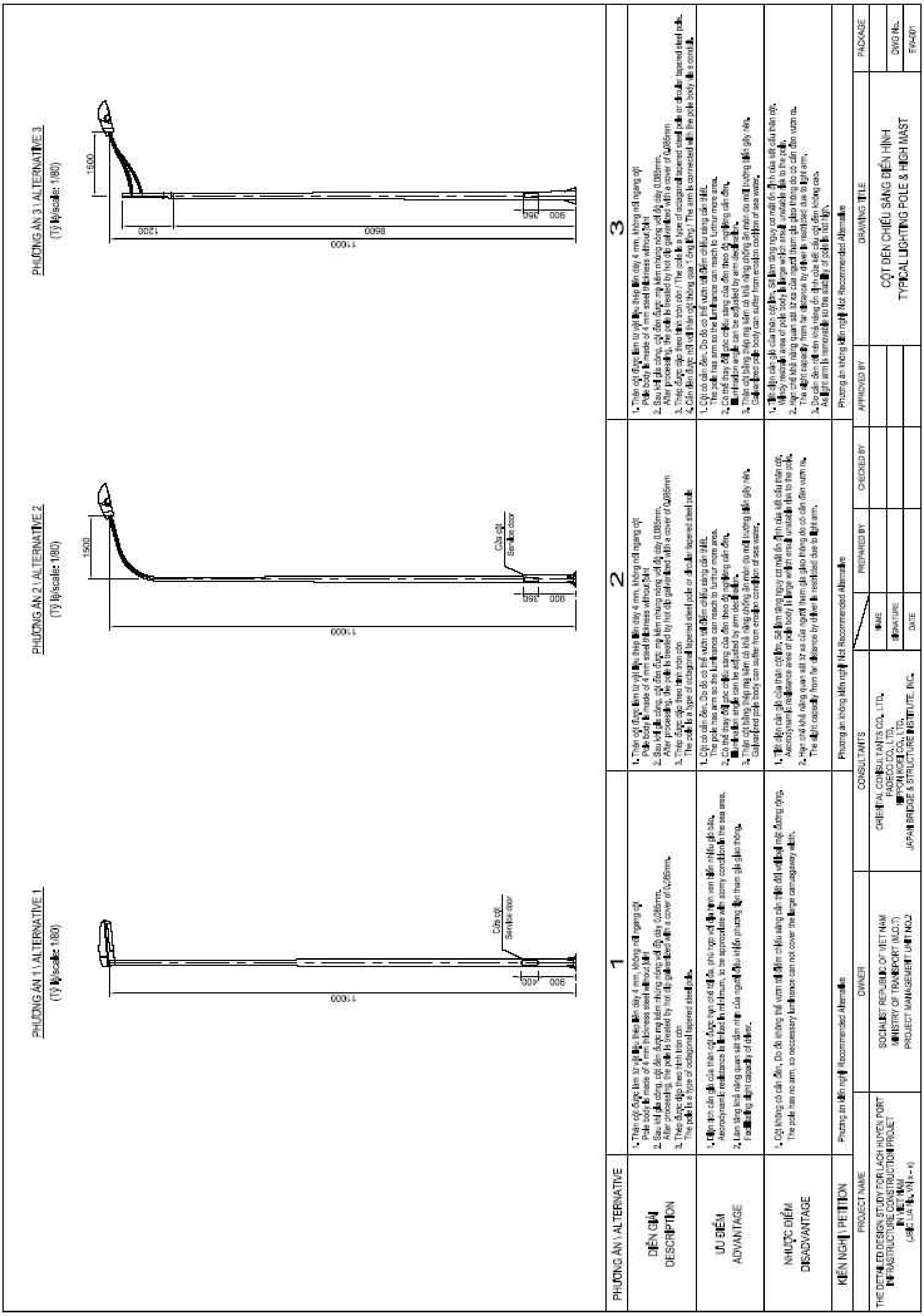
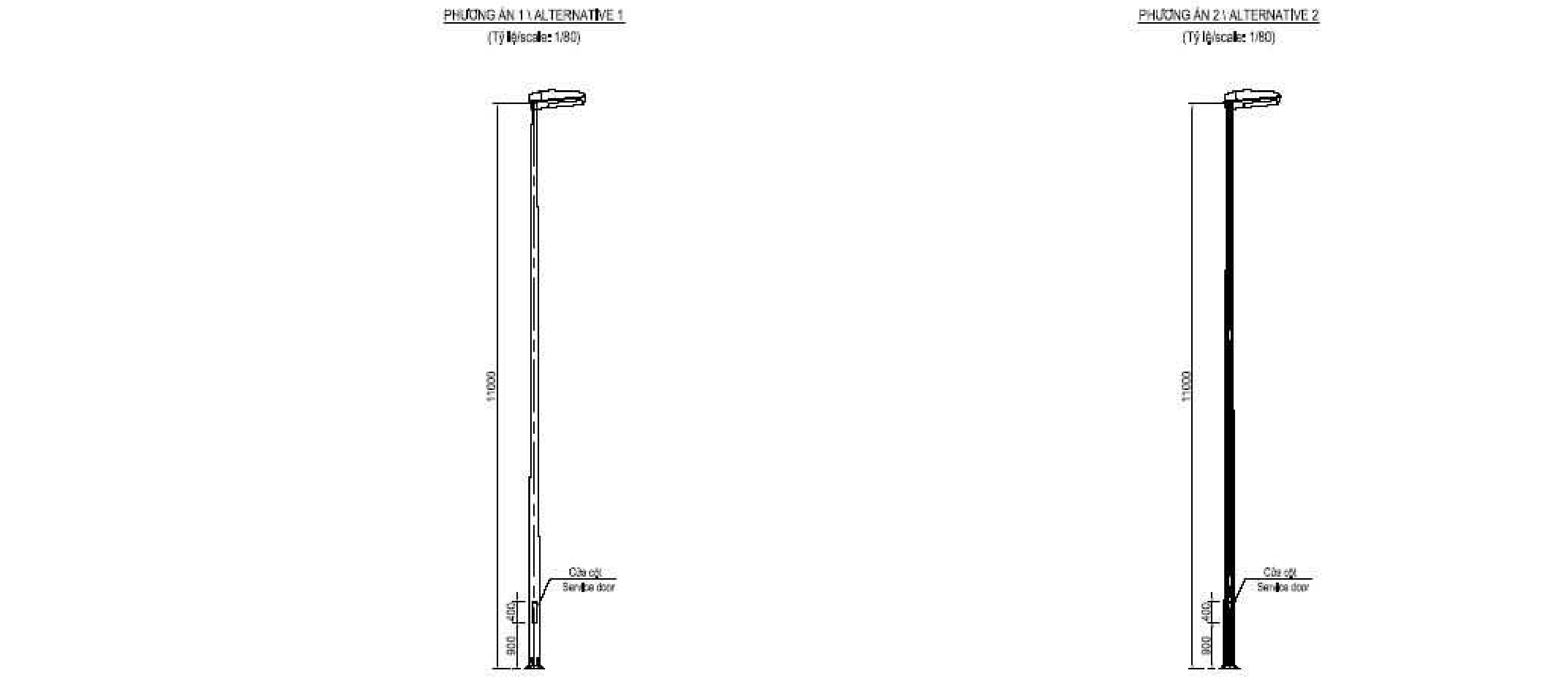


Figure 9.3-1 TYPICAL LIGHTING POLE & HIGH MAST

Source : Study Team

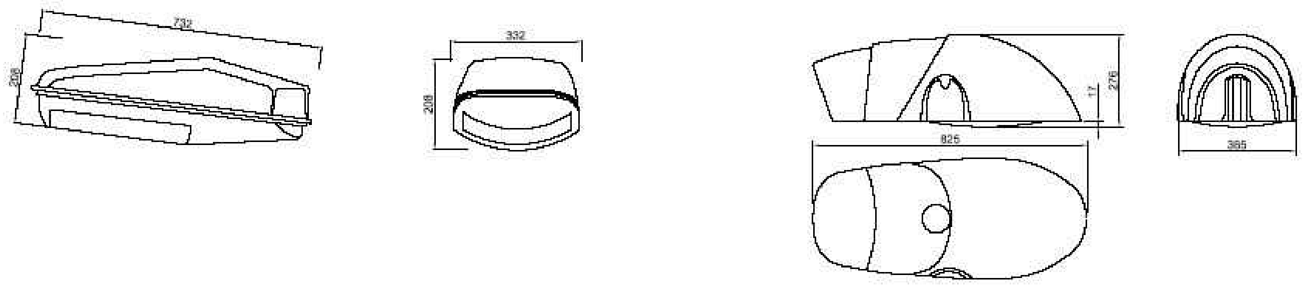


PHƯƠNG ÁN \ ALTERNATIVE	1	2
DIỄN GIẢI DESCRIPTION	1. Thân cột được làm từ vật liệu thép liền dày 4 mm, không nối ngang cột Pole body is made of 4 mm steel thickness without joint 2. Sau khi gia công, cột đèn được mạ kẽm nhúng nóng với độ dày 0,086mm. After processing, the pole is treated by hot dip galvanized with a cover of 0,086mm 3. Thép được dập theo hình tròn côn The pole is a type of octagonal tapered steel pole or circular tapered steel pole	1. Thân cột được làm từ vật liệu nhôm đúc, không nối ngang cột. The pole body is made of moulded aluminium without joint
ƯU ĐIỂM ADVANTAGE	1. Thân cột làm bằng thép tạo nên kết cấu cột chắc chắn với môi trường ven biển nhiều gió. The pole body is made of steel so its structure will be protected from windy condition 2. Thân cột làm bằng thép phù hợp với địa hình ven biển nhiều gió. Steel pole body is suitable with the windy condition in the coastal 3. Dễ gia công chế tạo trong nước. 4. Giá thành sản xuất cột thấp / the cost for pole fabrication is low	1. Trọng lượng cột đèn nhẹ. The weight of pole is light 2. Cột làm từ vật liệu nhôm nên có khả năng chống ăn mòn do môi trường biển gây nên. The aluminium pole will resist errosion by sea water
NHƯỢC ĐIỂM DISADVANTAGE	1. Thân cột làm bằng thép nên dễ bị ăn mòn trong môi trường biển gây nên, nếu không được mạ kẽm The steel pole body will be eroded by sea salty water if it will not be applied with galvanized cover 2. Trọng lượng cột đèn lớn. The weight of pole is heavy	1. Giá thành xây lắp cao / Fabrication of cost is high 2. Phải nhập khẩu đồng bộ. Không làm chủ được tiến độ xây lắp công trình. Intergration Import is required so the construction process can not be controlled. 3. Kết cấu nhôm kém bền vững ở địa hình có vận tốc gió lớn. Aluminium structure will not be stable and firm in codition of strong windy weather.
KIẾN NGHỊ \ PETITION	Phương án kiến nghị Recommended Alternative	Phương án không kiến nghị Not Recommended Alternative

PROJECT NAME	OWNER	CONSULTANTS		PREPARED BY	CHECKED BY	APPROVED BY	DRAWING TITLE	PACKAGE
THE DETAILED DESIGN STUDY FOR LACH HUYEN PORT INFRASTRUCTURE CONSTRUCTION PROJET IN VIET NAM (JBIC LA No. VN x-x)	SOCIALIST REPUBLIC OF VIET NAM MINISTRY OF TRANSPORT (M.O.T) PROJECT MANAGEMENT UNIT NO.2	ORIENTAL CONSULTANTS CO., LTD. PADECO CO., LTD. NIPPON KOEI CO., LTD. JAPAN BRIDGE & STRUCTURE INSTITUTE, INC.	NAME SIGNATURE DATE				VẬT LIỆU CỘT ĐÈN LIGHTING POLE MATERIAL	DWG No. EW-002

Source : Study Team

Figure 9.3-2 LIGHTING POLE MATERIAL

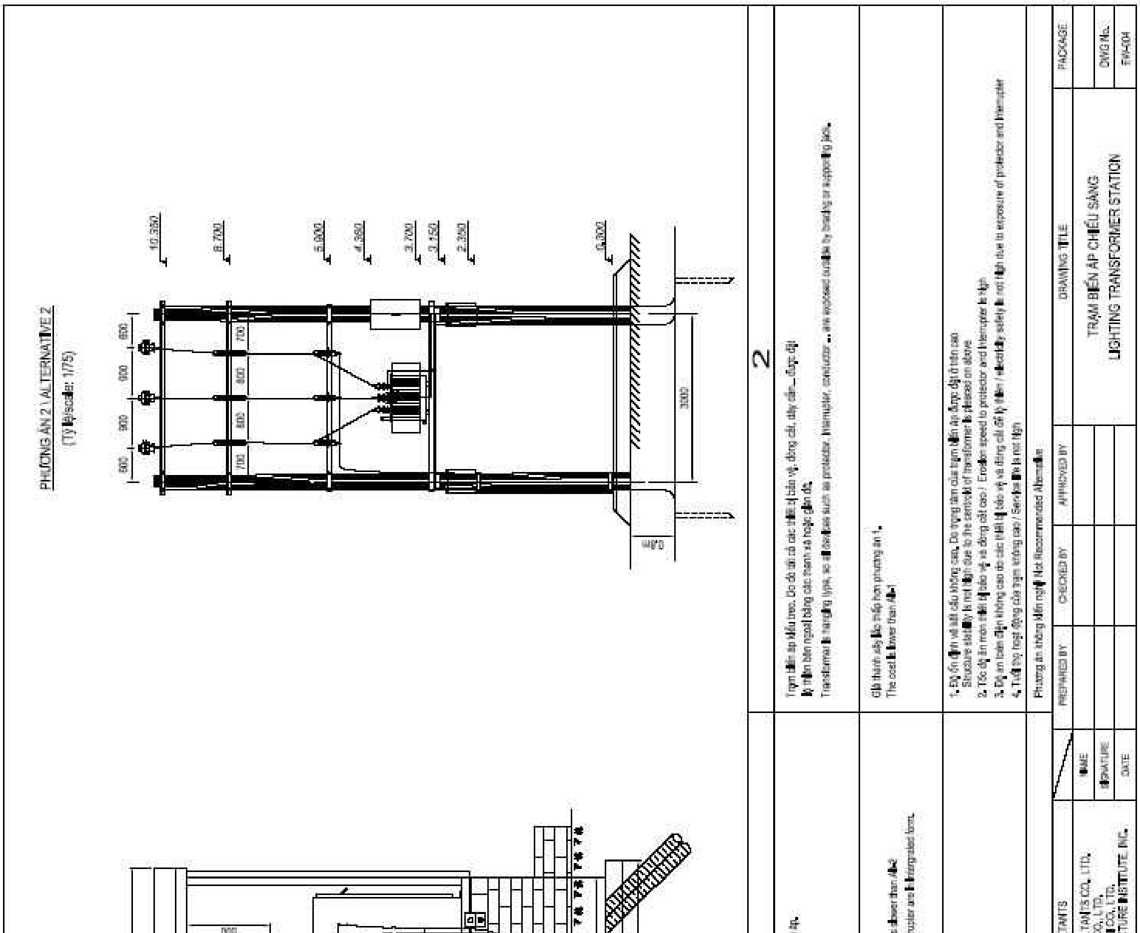


PHƯƠNG ÁN \ ALTERNATIVE	1	2
DIỄN GIẢI DESCRIPTION	1. Thân đèn được làm bằng hợp kim nhôm đúc, bên ngoài sơn tĩnh điện chống ăn mòn / Light body is made of moulded aluminium and painted by electrostatic coating 2. Chóa phản quang bằng nhôm tinh khiết được đánh bóng và anot hóa / Reflector is made of pure aluminium, polished and anodized 3. Cấp cách điện của bộ đèn Class 1 / Insulation class of luminair unit is class 1 4. Bộ điện 2 cấp công suất có chức năng tự động điều chỉnh tăng giảm công suất đèn 2-level capacity power has automatic function to adjust light intensity of the luminair	1. Thân đèn được làm bằng hợp kim nhôm đúc, bên ngoài sơn tĩnh điện chống ăn mòn / Light body is made of moulded aluminium and painted by electrostatic coating 2. Chóa phản quang bằng nhôm tinh khiết được đánh bóng và anot hóa / Reflector is made of pure aluminium, polished and anodized 3. Cấp cách điện của bộ đèn Class 1 / Insulation class of luminair unit is class 1 4. Bộ điện 2 cấp công suất có chức năng tự động điều chỉnh tăng giảm công suất đèn 2-level capacity power has automatic function to adjust light intensity of the luminair
ƯU ĐIỂM ADVANTAGE	1. Độ kín ngăn linh kiện điện IP65, tránh được sự ăn mòn linh kiện điện do khí hậu vùng ven biển Control gear tightness level of IP65 to prevent from erosion of electrical detail due to sea condition. 2. Diện tích cản gió của bộ đèn thấp 0,048m2 / Aerodynamic resistance area = 0,048 m2 of luminair unit is small. 3. Độ kín ngăn quang học IP66 theo công nghệ Sealsafe / Optical comparment tightness level of IP66 is folowed by sealsafe technology. 4. Tuổi thọ hoạt động của đèn lâu bền / Service life of the luminair is durable.	1. Giá thành: Đơn giá trước thuế một bộ đèn chưa bao gồm cột = 4,9 triệu VNĐ/ bộ đèn Nên tổng giá thành đất hơn phương án 2 thấp hơn phương án 1. Cost: Unit price (excluded VAT) not consisting of pole shall be = 4.9 million VND/ set; Thus, total cost is lower than Alt-1.
NHƯỢC ĐIỂM DISADVANTAGE	1. Giá thành: Đơn giá trước thuế một bộ đèn chưa bao gồm cột = 6 triệu VNĐ/ bộ đèn; Nên tổng giá thành cao hơn phương án 2. Cost: Unit price (excluded VAT) not consisting of pole shall be = 6 million VND/ set; Thus, total cost is higher than Alt-2.	1. Độ kín ngăn linh kiện IP43, không đảm bảo chống ăn mòn bằng pa 1/ Control gear tightness level of IP43 is not ensure to prevent from erosion as much as Alt-1 2. Muối biển có khả năng thâm nhập vào bên trong ngăn linh kiện điện / Salty air can penetrate in to the compartment. 3. Diện tích cản gió lớn hơn 0,0909 m2 / Aerodynamic resistance area is more than 0,0909 m2 4. Tuổi thọ hoạt động thấp hơn phương án 1 / Service life is shorter than Alt-1
KIẾN NGHỊ \ PETITION	Phương án kiến nghị Recommended Alternative	Phương án không kiến nghị Not Recommended Alternative

PROJECT NAME	OWNER	CONSULTANTS		PREPARED BY	CHECKED BY	APPROVED BY	DRAWING TITLE	PACKAGE
THE DETAILED DESIGN STUDY FOR LACH HUYEN PORT INFRASTRUCTURE CONSTRUCTION PROJET IN VIET NAM (JBIC LA No. VN x - x)	SOCIALIST REPUBLIC OF VIET NAM MINISTRY OF TRANSPORT (M.O.T) PROJECT MANAGEMENT UNIT NO.2	ORIENTAL CONSULTANTS CO., LTD. PADECO CO., LTD. NIPPON KOEI CO., LTD. JAPAN BRIDGE & STRUCTURE INSTITUTE, INC.	NAME SIGNATURE DATE				ĐÈN CHIẾU SÁNG ĐƯỜNG PHỐ STREET LUMINAIRE	DWG No. EW-003

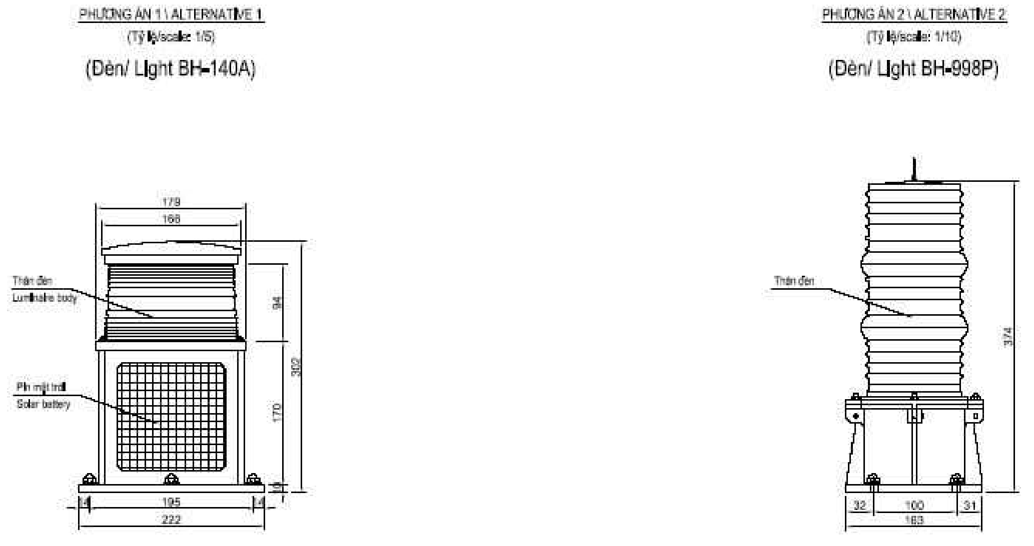
Source : Study Team

Figure 9.3-3 STREET LUMINAIRE



Source : Study Team

Figure 9.3-4 LIGHTING TRANSFORMER STATION



PHƯƠNG ÁN \ ALTERNATIVE	1	2
DIỄN GIẢI DESCRIPTION	Đèn LED phát sáng, dùng công nghệ năng lượng mặt trời Luminous LED bulb is fabricated by solar energy technology	Đèn phát sáng dùng điện trực tiếp Luminous bulb is supplied by direct power input
ƯU ĐIỂM ADVANTAGE	1. Chế độ hoạt động không phụ thuộc vào tính ổn định của lưới điện khu vực / Operating regime doesn't depend on stability of local electricity network. 2. Tiết kiệm năng lượng / Economizing energy 3. Không phải bố trí dây điện cấp điện cho đèn / Input conductor to the bulb is not requied	Giá thành xây lắp thấp / the cost is low
NHƯỢC ĐIỂM DISADVANTAGE	Giá thành xây lắp cao hơn phương án 2 / The cost of construction is more expensive than Alt-2	1. Chế độ hoạt động phụ thuộc vào tính ổn định của lưới điện khu vực / Operating regime depends on stability of local electricity network. 2. Không tiết kiệm năng lượng như phương án 1 / Energy can not be economized as much as Alt-1 3. Phải bố trí dây điện cấp điện cho đèn / Input conductor to the bulb is requied
KIẾN NGHỊ \ PETITION	Phương án kiến nghị Recommended Alternative	Phương án không kiến nghị Not Recommended Alternative

PROJECT NAME	OWNER	CONSULTANTS		PREPARED BY	CHECKED BY	APPROVED BY	DRAWING TITLE	PACKAGE
THE DETAILED DESIGN STUDY FOR LACH HUYEN PORT INFRASTRUCTURE CONSTRUCTION PROJET IN VIET NAM (JBIC LIA No. VN x – x)	SOCIALIST REPUBLIC OF VIET NAM MINISTRY OF TRANSPORT (M.O.T) PROJECT MANAGEMENT UNIT NO.2	ORIENTAL CONSULTANTS CO., LTD. PADECO CO., LTD. NIPPON KOEI CO., LTD. JAPAN BRIDGE & STRUCTURE INSTITUTE, INC.	NAME				ĐÈN TÍN HIỆU THÔNG THUYỀN NAVIGATION LIGHT	
			SIGNATURE					DWG No.
			DATE					EW-006

Source : Study Team

Figure 9.3-5 NAVIGATION LIGHT

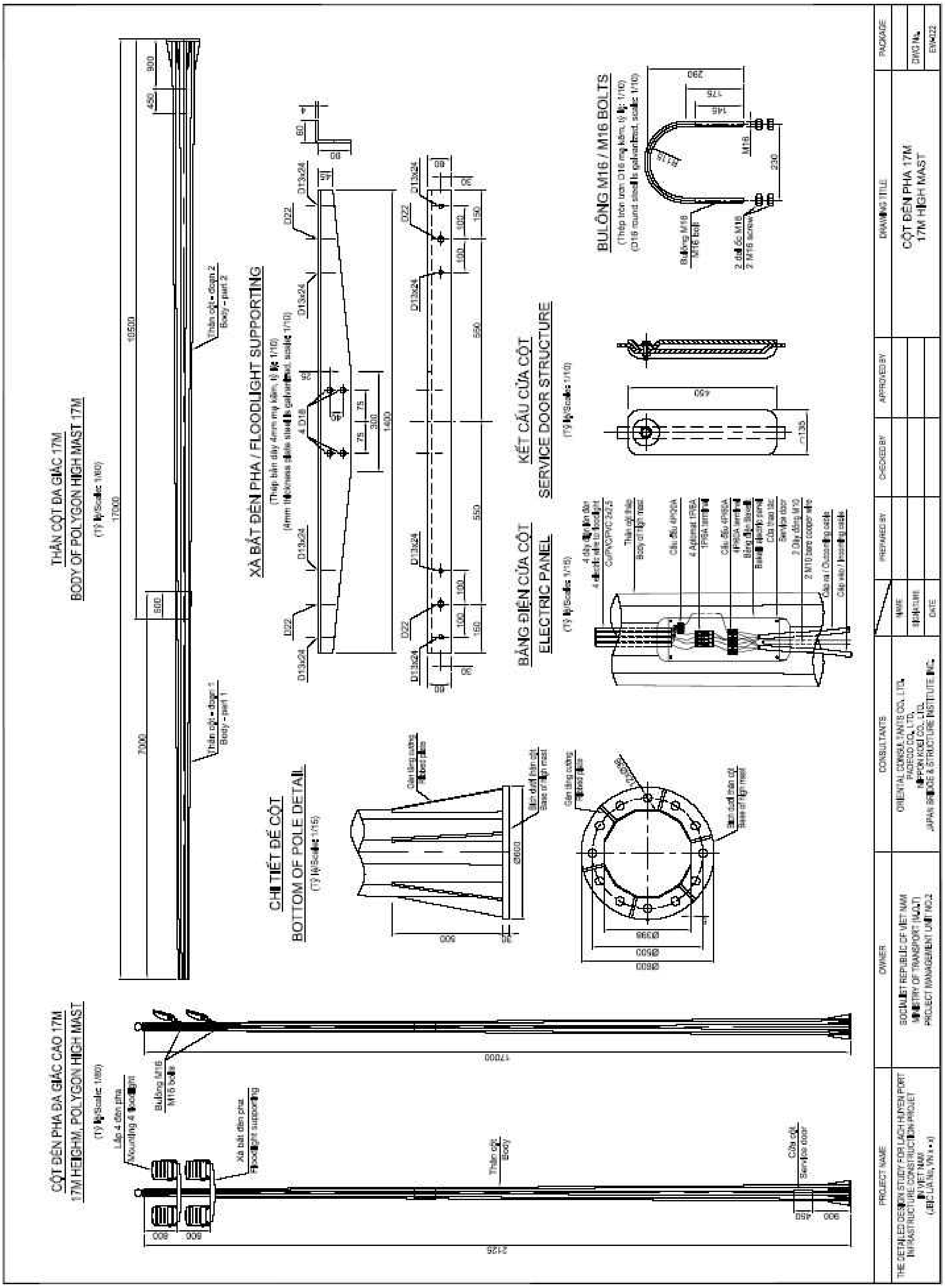


Figure 9.3-6 17M HIGH MAST

Source : Study Team

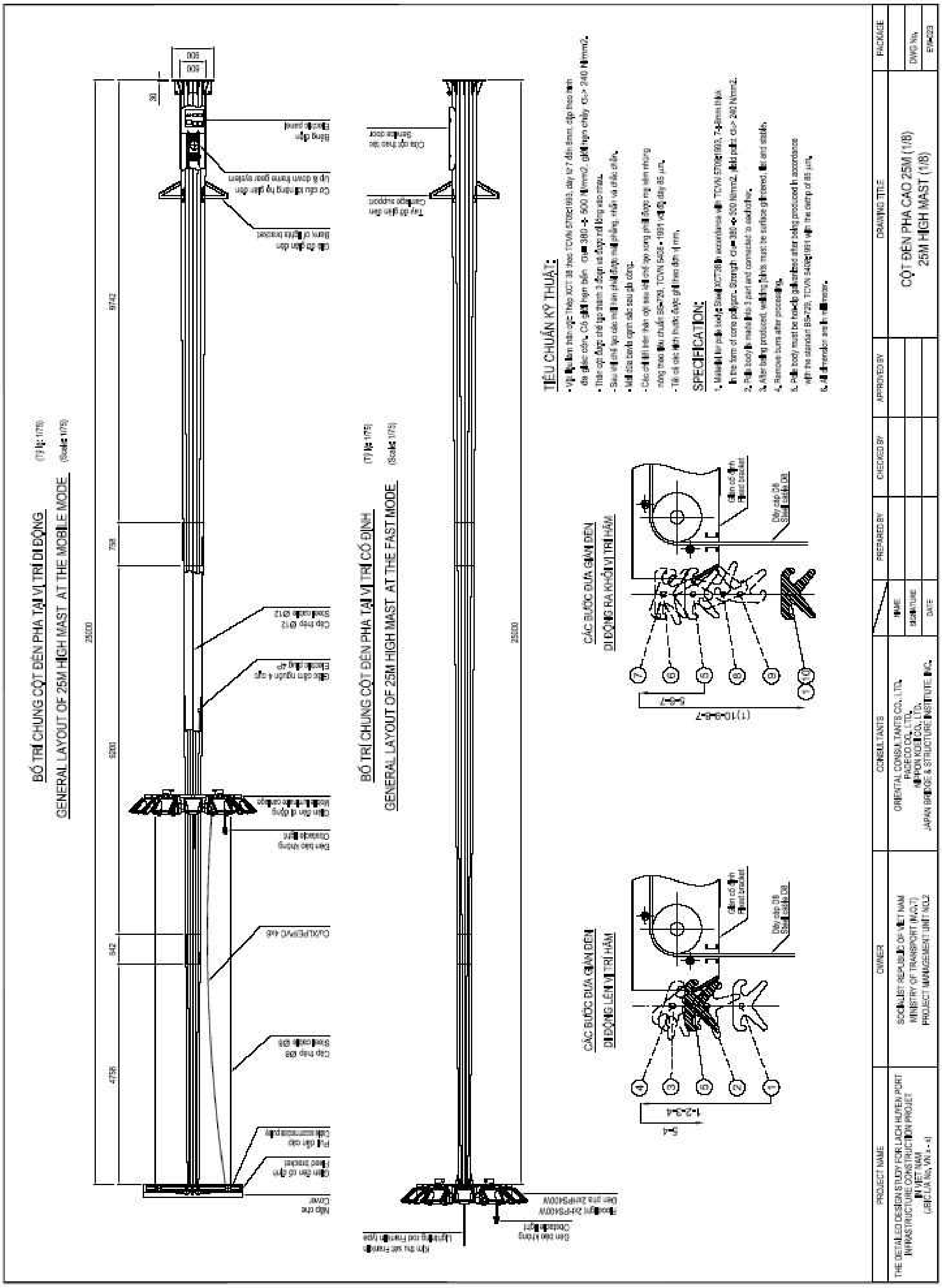


Figure 9.3-7 25M HIGH MAST

Source : Study Team

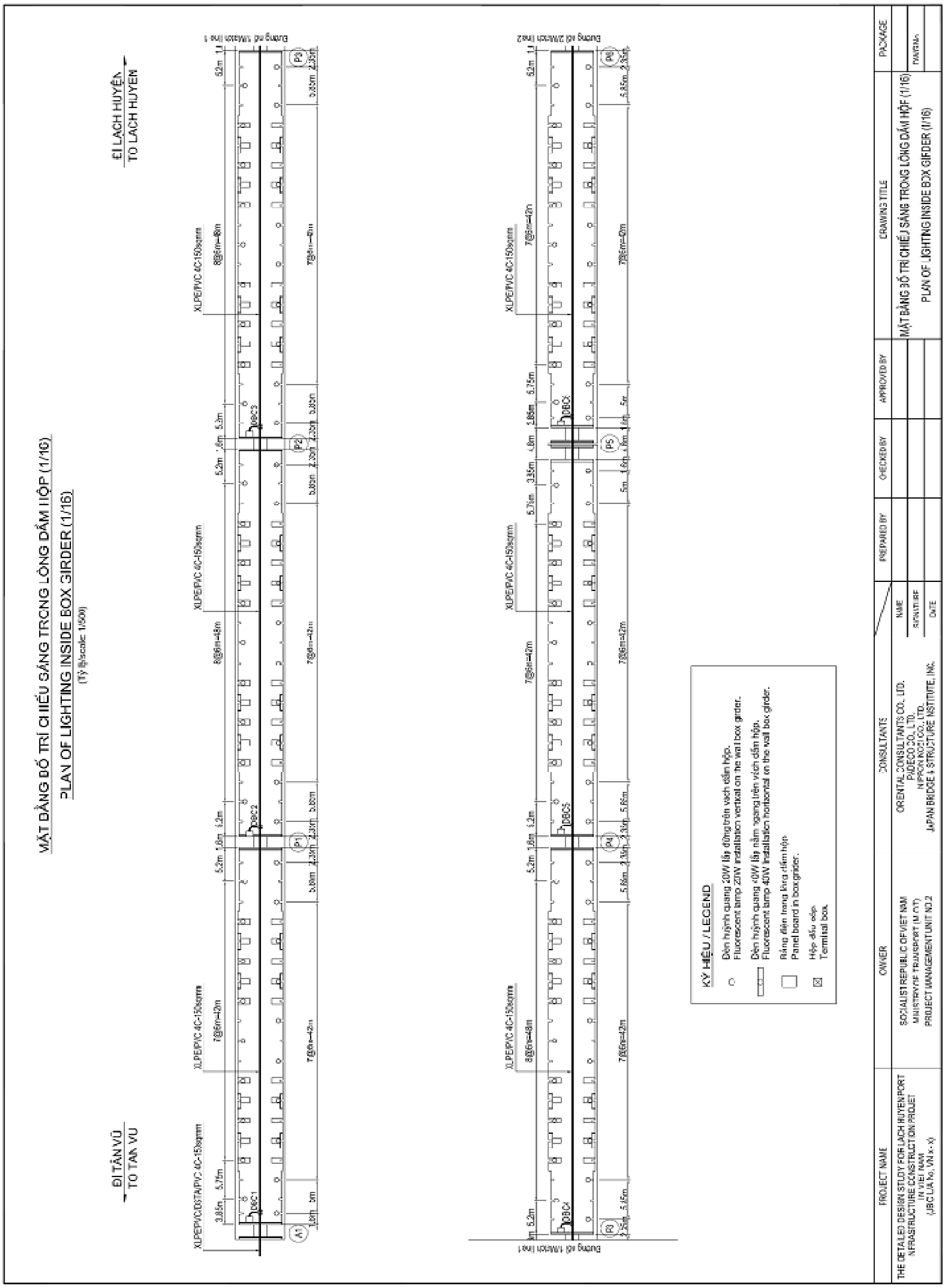


Figure 9.3-8 Plan of Lighting Inside Box Girder

Source : Study Team

CHAPTER 10 CONSTRUCTION PLANNING

10.1 PROJECT OUTLINE

10.1.1 Work Content

10.1.1.1 Work Content

The Works contain following major items.

1) Temporary Works
2) Hai An side works
   (1) Soft soil treatment works
   (2) Road works
   (3) Approach Bridge works
   (4) Box culvert and pipe culvert works
   (5) Cam river bridge works

3) Main bridge works
4) Cat Hai side works
   (1) Soft soil treatment works
   (2) Road works
   (3) Approach bridge works
   (4) Box culvert and pipe culvert work

10.1.1.2 Bridge type and working method

Bridge type and working method are as follows.

1) Approach Bridge
   - Foundation Steel Pipe Pile and Bored Pile
   - Superstructure PC Segment Span-By-Span Method (SBS Method)-Hai An side
     Cast in-place Cantilever Method -Cat Hai side

2) Main Bridge
   - Foundation Steel Pipe Sheet Pile (SPSP) serving for temporary cofferdam as well
   - Superstructure Cast in-place cantilever method

10.1.2 Major Works

Major work quantity is shown below table.

Table 10.1.2-1 Major Work Quantity

Construction Components		**Contents**
Length	Total Length	15,629.94m
	Road Length	10,187.04m(Hai An side:4,501.3m,Cat Hai side:5,685.74m)
	Bridge Length	Total : 5,442.9m Approach Bridge - Hai An side :4,433.7m Main Bridge : 490.0m Approach Bridge - Cat Hai side : 519.2m
Number of Lanes		4-lane
Width	Width of Road Width of Bridge	29.50m 14.5m
Structure Type	Main Bridg	Pre-stressed Concrete (PC) Box Girder with V-shaped pier Superstructure: Cast in-place Balanced Cantilever Method Span:95m+150m+150m+95m Foundation: Steel Pipe Pile Cofferdam: Steel pipe pile
	ApproachBridge (Hai An Side)	Pre-stressed Concrete(PC) Box Girder Superstructure:Span-by-Span(SBS) Erection Method 25 spans@60m x 3 erection girders Foundation:Steel Pipe Pile and Cast-in-place Concrete Pile Cofferdam: Steel Sheet Pile
	ApproachBridge(Cat Hai Side)	Pre-stressed Concrete(PC) Box Girder Superstructure: Cast in-place Cantilever Erection Method Span: 4 x 54.8m + 5@60m Foundation:Steel Pipe Pile and Cast-in-place Concrete Pile Cofferdam: Steel Sheet Pile
Intersection (IS)	Tan Vu IC IS No.1(Din Vu)	At-grade Intersection(without a flyover structure) At-grade Intersection(without a flyover structure)
Other Major Components		Soft ground treatment: Sand Drain Method and PVD(Prefabricated Vertical Drain) Method Box Culvert construction Asphalt Pavement Work

Source: Study Team

10.2 TEMPORARY FACILITIES

10.2.1 Summary of Temporary Facilities

Summary of temporary facilities are shown on the table below.

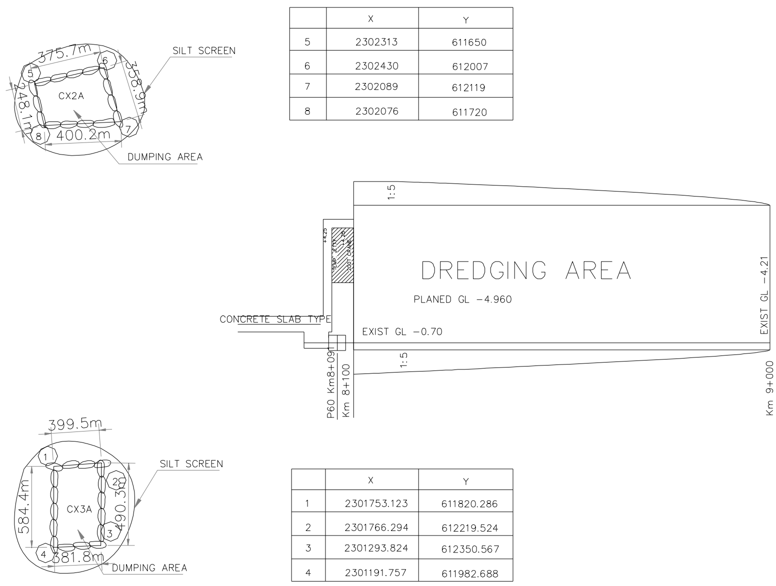
Table 10.2.1-1 Summary of Temporary Facilities

Description	Location	Code Name	Length or Area	Top width	Controlled By		Note
1. Temp. Road							
1-1 Entrance Acces sRoad							
Hai An side	KM 0	A-1		3m	Hai An PC	VIDIFI	Access from public road to KM0 (Existing Road)
		A-2		3m	Hai An PC		Access from A-1 to KM0.4 (Existing Road)
	KM 2.4	B	1.5km	6m	Hai An PC	DVIZ	Access from DVIZ internal road to
	KM 3.2	C	2.3km	6m	Hai An PC	DVIZ	Access from DVIZ internal road to Compound-2
	KM 8.1	Temp Jetty					Access to marine vessel and Cat Hai
Cat Hai side	KM 9.6	Temp Jetty					Access to marine vessel and Hai An
1-2 Site Accsee Road and Bridge	KM 0-KM4.1	Type-A	4.1km	5m x 2	Hai An PC		Including temporary bridge at KM1.7
	KM4.1-KM8.1	Type-B	4.0km	5m x 2			
	KM10.5-KM10.9	Type-C	6.0km	6m	CatHai PC		
2. Site Compound							
	KM 1.8	Compound-1	50,731m2		Hai An PC		Road material stockpile
	KM3.4 North	Compound-2	91,800m2		Hai An PC	DVIZ	Concrete, Asphalt, Segment Plant
							Contractor's office
	KM 7.9	Compound-3	40,171m2			NAMDV	Stockpile for piling, Erection girder
	KM 9.8	Compound-4	28,019m2		CatHai PC		Stockpile for piling,
	KM 10.0	Compound-5	45,295m2		CatHai PC		Road material stockpile, Traveller, (asphalt plant-altanative)
		Compound-6	16,028m2		CatHai PC		Stockpile for unsuitable material
	KM 15.5	Compound-7	40,448m2		CatHai PC		Road material stockpile, Asphalt Plant
3. Dredging Area	KM8.1-KM9.0						
4. Dumping Area	KM7.5-KM8.1	CX2A, CX3A				NAMDV	
5. Ferry Terminals	Hai An and Cat Hai Ferry Terminals				Hai Phong One Member Waterway Traffic Protection Company		Equipment and material loading and unloading

Source: Study Team

Dredging work

Dredging work is selected in between Km8.1 and Km9.0 in order to allow marine activities instead of steel staging construction. Dumping areas are designed at the locations indicated on the figure below. The dumping area is controlled by Nam Dinh Vu Industrial Park. Therefore close discussion with them be essential in prior to commencement the dredging work.



Source: Study Team

Figure 10.2.1-1 Dredging Area and Dumping Area

10.2.2 Navigation Channel Safety

Navigation system to be employed for construction purpose and permanent system are summarized on on the table below.

Table 10.2.2-1 Navigation Safety Equipment

1. Main Bridge Foundation and Girder construction stage

Description of equipment	Number
Signal Buoys for waterway	4
Signal Buoys in construction area	6
Monitoring station	2
Speed boat	2

2. Bridge surface work stage and after completion of the bridge

All buoys, monitoring stations and speed boats are same as stage 1	
Star Board Hand Mark	4
Port Hand Mark	4
Pier Light	6

Source: Study Team

10.3 SOFT SOIL TREATMENT AND EMBANKMENT WORK

10.3.1 Soft Soil Treatment Works

Road embankment design is controlled by residual settlement value of 30cm for embankment and 10cm for behind bridge abutment. In order to achieve those requirement accelerated settlement measures using Sand Compaction Piles(SCP), Sand Piles, PV Piles together with surcharge embankment are selected for embank section. For behind bridge abutment piled slab is selected.

10.3.2 Geo-textile Sheet Spreading Works

Surface unsuitable material be removed or pushed away using either swamp type bulldozer or backhoe and the surface be replaced by sand layer. Geo-textile sheet be spread over the replace sand layer with utmost care for sheet jointing. On top of Geo-textile layer sand blanket be laid for ground water discharge purpose coming through PV drain and Sand drain piles.

10.3.3 Road Works Outline

After completion of consolidation settlement box culvert and pipe culvert work commence. Any temporarily installed pipes are to be removed and subgrade preparation work follows. Aggregate base course material and asphalt treated base course material be well compacted with tire roller, vibration roller and grader. Where working space is narrow small tandem roller or hand roller be used.

Following asphalt treated base course compaction and testing, primer be spread and asphalt binding course be laid using asphalt finisher and compacted using tire roller, macadam roller.

Asphalt treated base course, asphalt binding course and asphalt surface course be produced by site

10.4 APPROACH BRIDGE

10.4.1 Approach Bridge Works Outline

Two different types of superstructure design for Approach Bridge are selected, namely PC Segment Span By Span (SBS) Method for Hai An side and Cast-in-place Cantilever Method for Cat Hai side.

Foundation pile design has also two different types, namely Steel Pipe Pile and Bored Pile .

Working platform has three different types, namely Filled Ground, Steel Staging and off-shore.

10.4.1.1 Construction of working platform and piling works

During the time of construction of the temporary access road the working platforms be constructed.

Due to several different types of working platform piling activity require different type of machineries. Following table shows relation in between type of platform and piling machinery.

Table 10.4.1-1 Approach Bridge Piling Machinery and Working Platform

Pier Nr.	A1	P1-P50	P51-P60	P61-P75	P79-P82	P83-P87,A2
Foundation Pile Type	Steel Pipe Pile	Steel Pipe Pile	Steel Pipe Pile	Bored Pile	Bored Pile	Steel Pipe Pile
Platform Type	Filled Ground	Steel platform	Off shore	Off shore	Off shore	Filled Ground
Piling Method	Hydraulic Hammer 12.5t	Hydraulic Hammer 12.5t	Hydraulic Hammer 12.5t	Bored Pile Machine	Bored Pile Machine	Hydraulic Hammer 12.5t
Piling Machine	Crawler Crane 150t	Crawler Crane 150t	Crawler Crane 200t Barge 1000t	Crawler Crane 120t Barge 1000t	Crawler Crane 120t Barge 1000t	Crawler Crane 150t

Source: Study Team

10.4.1.2 Excavation, pile cap and pier construction works

(1) Works on the filled platform (for A1, P83-A2)

For excavation works a backhoe (0.8m3) be used and 10t dump truck be used for hauling.

After excavation truck crane (20t) be used for strut and walling works and structure concrete works follow.

(2) Works on the steel platform (P1-P50)

The works be carried out by the same procedure as described in (1) above.

(3) Works off shore (P51-P75)

The works be carried out by the marine equipment and concrete be supplied by a marine batching plant of the capacity 60m3/hr.

(4) Works off-shore (P79-P82)

After bored pile construction all procedures for pile cap and pier construction be carried out marine equipment.

After bored piles complete steel staging to receive pile cap structure be installed on those steel stand pipe for bored pile. This working platform be used for pile cap & pier form work, steel work and concrete work.

All concrete work be carried out using off shore equipment and where pier height be more than 4m one pour be limited to 4m to avoid concrete segregation.

10.4.1.3 Pier head construction work

(1) P1-P75

After pier work complete pier head work follow and pier head structure be constructed by means of cast in-place method.

For those pier head construction in between P1-P75 temporary support system be either bracket system or frame support sitting on the pile cap concrete.

(2) P79-A2

In between P79 and A2 super structure is designed as cast in-place cantilever type pier head length is 15m long in order to accommodate 2sets of traveler form on it. Pier head structure be constructed on the steel staging. Due to cast in-place cantilever method pier head structure need to be strengthen by introducing temporary shoe and temporary tie-in method into pier structure using pc bars.

10.4.2 Fabrication of PC Segments

For the purpose of PC segment production a fabrication yard be established in the plant yard with an area of approximate 40,000m2.

10.4.2.1 PC segment fabrication outline

All PC segments be fabricated with short-line match casting method, and 5 sets of casting bed be established.

10.4.2.2 Fabrication Sequence

PC segment fabrication sequence is shown below.

10.4.2.3 PC segment fabrication cycle time

PC segment fabrication cycle time is sown below.

Work Item	Working Time (min)	1	2	3	4	5	5	7	8	9	10	11	12	24
Remove curing sheet	10													
Survey	30													
Remove side & inner form	60													
Remove old segment to stock	60													
Shift fresh segment	30													
Fix bottom form	30													
Adjust new segment position	30													
Fix side form	30													
Steel bar cage positioning	60													
End shutter adjusting	30													
Main cable sheath positioning	80													
Inner form fixing	80													
Steel final positioning	30													
Cleaning	30													
Concreting	120													
Finishing	30													
Curing														

Source: Study Team

Figure 10.4.2-1 Segment Fabrication Cycle Time

10.4.2.4 Geometry control

In order to satisfy vertical and horizontal alignment geometry control be assured using survey tower and bottom form adjusting for the old segment. The new segment be always kept level and straight alignment.

10.4.2.5 Segment stockpile

Fabricated segments be transferred to stockpile yard using gantry crane.

Segments are stacked in the stockpile yard in two layers .

10.4.2.6 Segment transport

All segments be loaded on the low bed trailer (80t) using gantry crane(30m 80t) established in the segment stock pile yard and segments be transported to the desired position and lifted using the erection girder which be elected and sit on the pier heads. Only for P50-P75 all segments be lifted

Transport distance be 2.3km in average and all segments be transported through temporary access road.

10.4.3 Segment Erection Work (Span By Span Method)

10.4.3.1 Outline

Segments erection be carried out using three erection girders simultaneously.

Each erection girder be assembled on temporary supports frame by frame and finally sit on the supporting columns which sit on the pier head after adjusting.

Each PC segment be lifted by lifting devices on the erection girder and rolled to the position from one end toward other end. When new segment comes to close to adjacent segment installed already , contact surface be pasted using chemical bonding glue and temporarily stressed. This process be repeated until all segments be positioned.

Finally small gap in between be filled using cement mortar with external hanging form and whole segments be stressed.

After those works complete the erection girder be rolled forward to next pier position and finally be dismantled on the bridge.

For erection work at P50-P75 the erection girder is designed purposely to receive segment at rear portal on the deck and the erection girder carry segment through foot support, by which all segments are to be delivered on the complete deck surface from P50.

Segment erection outline is shown on Appendix Fig. No. CP-10-9 and CP-10-10.

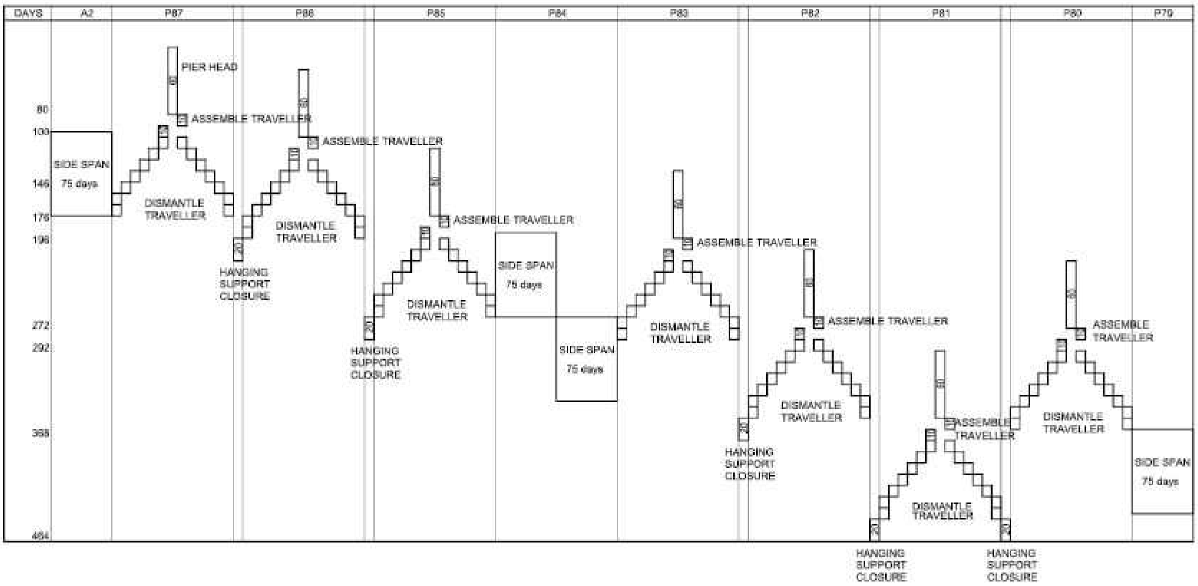
10.4.4 Cast in-place Cantilever Method

In between P79 to A2 Cast-in-place Cantilever Method be applied for super structure construction.

After completion of pier structure pier head be constructed by cast in-place method of which length be 15m at P80, P81, P82, P83, P85, P86 and P87. At P79, P84 and A2 the girder be constructed independently by cast-in place method as on those piers no form travelers will be used.

In addition at P80, P81, P82, P83, P85, P86 and P87 pier head be sit on the temporary shoes and tightened with pier structure by PC bars in order to stabilize the structure to meet additional load introduced by cantilever method.

Working program is shown below.



Source: Study Team

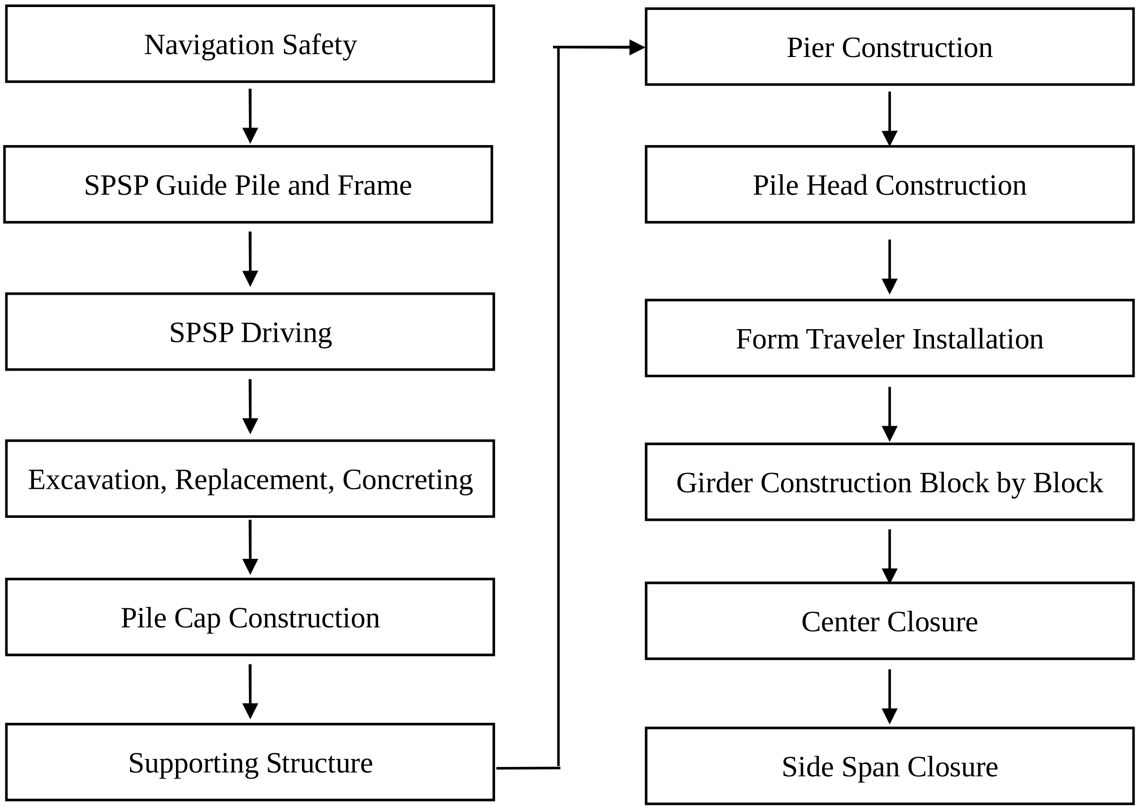
Figure 10.4.4-1 A2-P79 Cantilever Method Working Program

10.5 MAIN BRIDGE

10.5.1 MAIN BRIDGE WORK OUTLINE

In between P76 to P78 the bridge cross existing navigation channel, therefor long span bridge is designed and Cast-in-place Cantilever Method is selected. For foundation structure Steel Pipe Sheet Piles (SPSP) Foundation is selected which serves temporary cofferdam and part of the permanent structure.

Construction sequence is shown below



Source: Study Team

Figure 10.5.1-1 Construction sequence

10.6 PROGRAM

10.6.1 Total construction period

Total construction period in this report is 36 months.

In comparison with 32 months construction period in Basic Design Report following additional requirement and time impact are taken.

Reasons	Time Impact
1.No site access road outside embankment structure is allowed	
Consequence-1 Road access road need to be replaced	2 months
Consequence-2 Drainage work is to be after pavement work	
2.Pavement structure design changed from Cement Treated Base Course to Asphalt Treated Base Course	2 months
Total	4 months

10.6.2 Basis of program

10.6.2.1 Documents referred

Program is made in accordance with the guide book published for estimation work for works under Ministry of Land, Infrastructure and Transport in Japan, similar guide book and JICA guide line.

Where items are not specified in the book working rate is established using available items with reasonable adjustment or work experiences under similar nature either in Japan or Vietnam.

Time Space Diagram attached in the next page shows overall construction sequence and major critical activities.

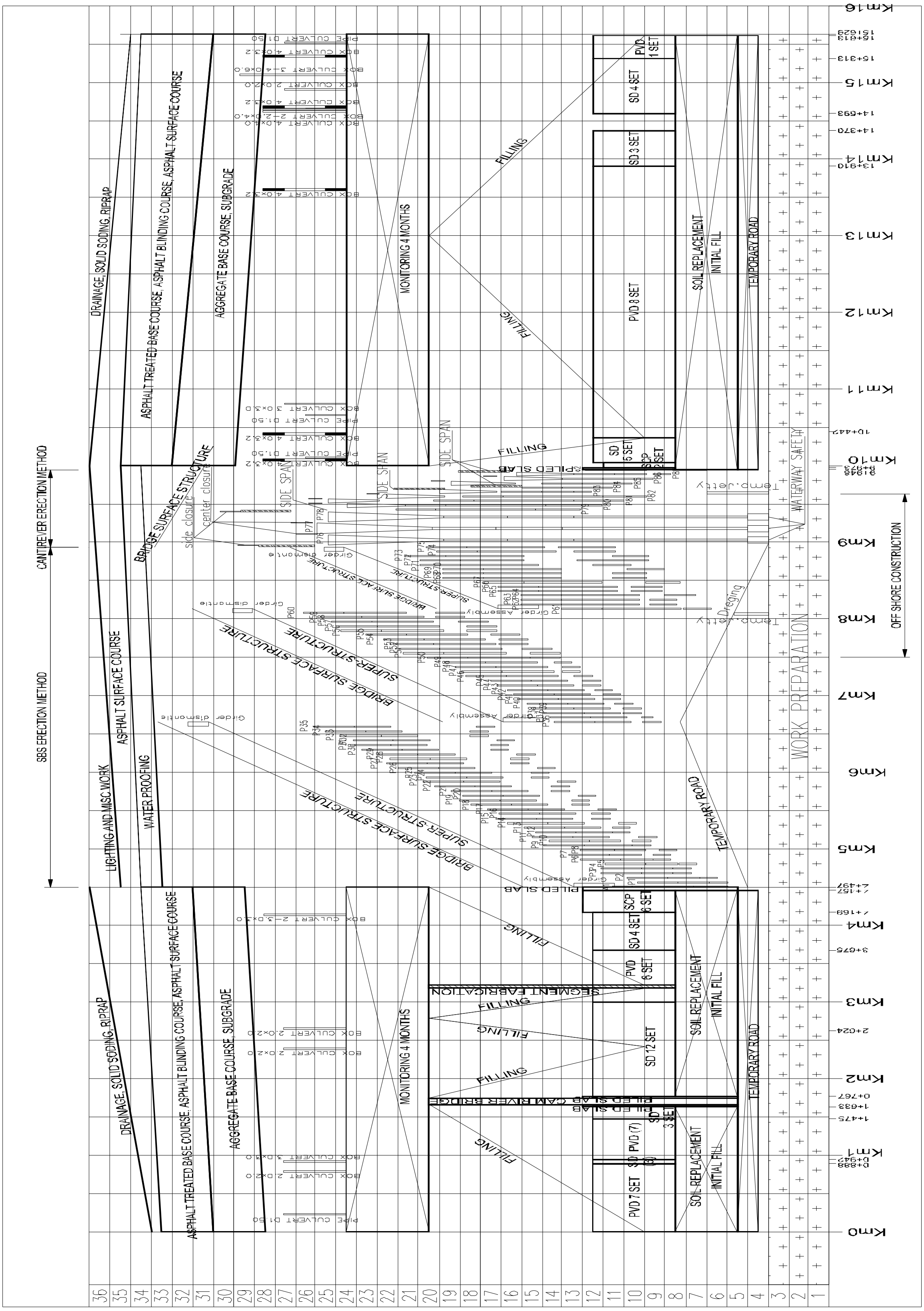


Figure 10.6.2-1 Appendix CP10-15 Time Space Diagram

Source : Study Team

CHAPTER 11 STUDY ON SAFETY IN CONSTRUCTION

11.1 Safety Plan

11.1.1 Introduction

Safety is of paramount importance at all times and consideration of such shall take precedence over any and all other consideration. The Contractor shall throughout the execution and completion of the work, having full regard for safety of all persons entitled to be upon the site and keep the site and the work in an orderly state appropriate to the avoidance of danger to such person.

The Contractor shall comply with all safety and health legislation including, without limitation, the rules and regulation of Socialist Republic of Vietnum and the authorities having jurisdiction.

The Contractor shall comply with the Consultant’s requirements insofar as displaying in each of its site offices, workshops, and cafeteria a copy of such safety and health posters and keeping on the site copies of safety and health regulations and documents. All regulations and documents shall be translated into languages which can be easily understood by the work force employed by the Contractor, its Sub-Contractors and their lower tie sub-contractors and such translations shall be displayed or kept alongside those in Vietnumese and English languages.

11.1.2 Objectives

The objectives of this Safety Plan are as follows:

a) Fulfilling the requirement of this policy and perform the work in the safest manner possible consistent together with good construction practices.
b) To have effective Safety Plan at each location where work is performed.
c) To prevent accidents, loss of production time, and damage to nearby establishment and equipment.
d) To promote safety consciousness in all management and construction staff.
e) To make every effort to achieve no accident through the proper planning and execution of safety for each project work item. The pre planning of safety will require the identification of present and future hazardous conditions in each operation to be performed on each scope of work.
f) To continue the development, motivate and updating safety education and training for all staff.

11.1.3 Safety Plan

In order to achieve the above objectives, the Contractor shall consider and submit the Safety Plan including the following items or more.

- Safety Organization Chart and Responsibility
- Safety Training
- Safety Meeting
- Personal Protective Equipment
- Access Control on Site
- Safety Control and Activity
- Safety Inspection / Remedying Defects

- Penalties for Safety Violations / Failure to Comply
- First Aid
- Special Obligations and Care of the works
- Working under Extreme Conditions
- Emergency Preparedness
- Motivation
- Effective Communication for Safety
- Safety Reports and Notification of Accidents

11.2 Safety Working Practices

11.2.1 Objectives

The objective of safe work practices is to ensure that all works are carried out in a safe manner so as to eliminate or minimize occurrence of incidents. Fundamental measure to prevent a disorder in worker’s health shall be taken.

・**Health Control**

a) Confirm status of health check and consulting for maintenance of health.
b) Confirmation of worker’s health condition.
c) Considering worker who has high blood pressure.

・ **HIV/AIDS protection practice**

a) Peer education to provide advocacy and communication to others.
b) Direct communication:
Organize training course, talks on HIV/AIDS prevention with related parties.

c) Provide periodical medical examination including clinical examination and tests for early diagnosis.

11.2.2 Stafety Working Practices

Safety working practices have to be established in compliance with the code of practice to each region. This safe work practices shall comply with the statutory requirements of Socialist Republic of Vietnum. The Contractor shall practice safety works on the following processes or more.

- Preliminary Works / Typical Erection Works
- Excavation and Backfilling
- Road Works
- Temporary Jetty Work
- Bored Piling Work
- Steel Pipe Sheet Pile and Sheet Pile Work
- Pile Cap / Pier Column Work
- Construction of Bridge Superstructure (Main Bridge)
- Construction of Bridge Superstructure (Approach Bridge)
- Breach of Safety Plan

CHAPTER 12 SUMMARY OF TASKS ON ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

12.1 Review and improve quality of the Environmental Impact Assessment (EIA) Report

A number of comments on the deficiency of the EIA Report have been raised by members of the EIA Appraisal Council in the meeting held on May 13, 2010. During the D/D Study, attempts have been made to improve these deficiencies.

12.2 Incorporate impact mitigation measures into the Project design

1) Examine possibility of the road alignment adjustment to mitigate impacts to Trung Hamlet in Dong Bai Commune

   The adjustment of the road alignment at the section from Km 13+700 to Km 14+000 had been carefully examined with aim to reduce impacts to Trung Hamlet. However, after consultation with local residents, it came to conclusion that the adjustment of road alignment is not the best option. Affected residents told that they can move to the resettlement site near their existing dwelling. In addition, impacts to the Van Co Huong Temple (Km 13+700) would be mitigated by the construction of a wall between the highway and the temple.

2) Measures to mitigate impact of noise to the populous residential areas

   Attempts also have been made to mitigate impact of noise to populous residential areas in Nghia Lo Commune and Dong Bai Commune. However, construction of the noise barriers was considered costly. And all residents in Nghia Lo Commune, Dong Bai Commune would be relocated with other residents in Cat Hai Island under the *Dinh Vu – Cat Hai Economic Zone Development Plan* planned by Hai Phong City PC. Therefore, after discussions with commune PCs, the D/D Study Team agreed to put into design the planting of trees along the sides of the highway at the sections close to the populous residential areas in Nghia Lo Commune and Dong Bai Commune.

3) Measures to mitigate impact of polluted water runoff from the road surface in operation phase

   Construction of the retention ponds to collect and regulate polluted water from the highway road surface is recommended in the approved EIA Report as a measure to mitigate impacts to the aquaculture ponds, salt pans, etc. along the highway. However, the construction, operation and maintenance of the retention ponds are considered costly. As a result, it agreed to design and construct the drainage ditches at several specified sections of the highway for this purpose.

12.3 Carry out the socio-economic survey and the hearing surveys

A socio-economic survey had been carried out to collect data and information on the project-affected persons which are necessary for the preparation of the resettlement site construction plans, the income restoration plan, and other measures to mitigate impacts to local residents. In addition, the D/D Study Team had also carried out a number of hearings and discussions with local authorities, local mass organizations, etc. on the measures to mitigate impacts to project-affected residents whose main source of income depends on salt production, aquaculture, fishery, etc.

12.4 Follow up the implementation of the Resettlement Action Plan (RAP)

1) Progress of RAP implementation

It is estimated that about 140 households and 600 tombs would be relocated as a result of land acquisition for the Project. The Trung Hamlet (Dong Bai Commune) would be disappeared because its population becomes not enough to establish a hamlet in accordance with the state regulations. Seven large-scaled aquaculture ponds/swamps in Trang Cat Ward and Dong Hai 2 Ward would be significantly affected, and several would be impossible to operate due to the Project. Residents involving in the cultivation of these ponds/swamps would lose their main source of income.

A Resettlement Action Plan (RAP) had been prepared by PMU2 and accepted by Hai Phong City PC. And Hai Phong City PC had issued the Land Acquisition Announcement. Hai An District PC and Cat Hai District PC had been nominated to be owners of the sub-projects of land acquisition (by Decision No. 610/QD-UBND issued on April 25, 2011).

Task to drive demarcation stakes to define boundary of land to be acquired (base on result of F/S) had been started in May, 2011. The Land Fund Development Center (*Trung Tâm Phát Triển Quỹ Đất*) of Cat Hai District is entrusted to carry out the IOL (inventory of loss) surveys and prepare the Plan of Compensation, Support and Resettlement (*Phương án Bồi thường, Hỗ trợ, Tái định cư*) and the Livelihood Restoration Plan (*Phương án Đào tạo và Chuyển đổi Nghề Nghiệp*) for project-affect people in Cat Hai Island.

2) Plan to construct the resettlement sites

The HP City Planning Institute is responsible for allocating a land for the resettlement site for the Project. A resettlement site is planned in Hoang Chau Commune (with about 10 ha of area) to accept about 200 households (150m^2 for a household). PMU2 and Hai Phong City PC are now trying to ask Prime Minister for a specific mechanism ("cơ chế đặc thù") for the resettlement site construction project, by which Hai Phong City PC can appoint a contractor instead of select contractor by bidding in order to shorten the time for construction.

3) Plan to construction a new cemetery for relocation of tombs

HP City Planning Institute has proposed a lot of land (about 8ha) in the northern area of Ninh Tiep Village (Nghia Lo Commune) for the new cemetery for all Cat Hai Island. The new cemetery construction plan will be soon approved by Hai Phong PC, and its construction may be started soon.

4) Livelihood Restoration Plan

It is anticipated that a large number of local residents would lose their main source of income and should be assisted in obtaining new means of livelihood. The remaining parts of affected land seem to be unsuitable for growing vegetables or raising chickens, pigs, because of its soil salinity, lack of fresh water, and high cost to buy and transport feeds for livestock from other areas. Almost all affected residents expected that their children can work as construction workers, road-builders, employees in ports, or public service personnel at the Lach Huyen Port in the future.

An Income Restoration Plan is to be prepared by the Land Fund Development Center of Cat Hai District. Local residents should be given priority to work as construction workers during construction phase of the Project, and as employees of the enterprises providing services such as logistic, transportation, hotel, restaurant, recreation, etc. in operation phase of the Project. However, Hai Phong City PC and Cat Hai District PC should assist local residents in attending vocational trainings needed for them to obtain these jobs.

For long-term socio-economic development plan of the region, Hai Phong City PC and Cat Hai District PC should consider the schemes to create new jobs for residents of Cat Hai Island as a part of the *Dinh Vu – Cat Hai Economic Zone Development Plan,* and should mobilize the participation of local residents in the implementation of the Plan. Soft loan and assistances should be given to local residents as first priority in establishing new businesses to support activities of the new port and the economic zone, such as restaurants, hotels, recreation facilities, etc.

5) Measures to mitigate impact to aquaculture cultivators

To mitigate impacts to the aquaculture ponds/swamps, especially in Hai An District, it is recommended that if the remaining parts of the affected pond/swamps are fragmented and unsuitable to cultivation, and if there is request from owners of the pond/swamps, these remaining parts should also be acquired and compensated by the state. If not, Hai Phong City PC should provide supports to owners of affected ponds/swamps in changing its land use purpose from *aquaculture* to *industry*, so that these affected people can carry out other types of business on the remaining parts of land.

12.5 Prepare the RAP Monitoring Plan

A RAP Monitoring Plan had been prepared to manage and supervise the implementation of the RAPs (prepared by the PCs of project-affected districts: Hai An District and Cat Hai District). The RAP Monitoring Plan will be used as a tool to facilitate appropriate corrective measures during resettlement implementation based on the information obtained through routine collection of data.

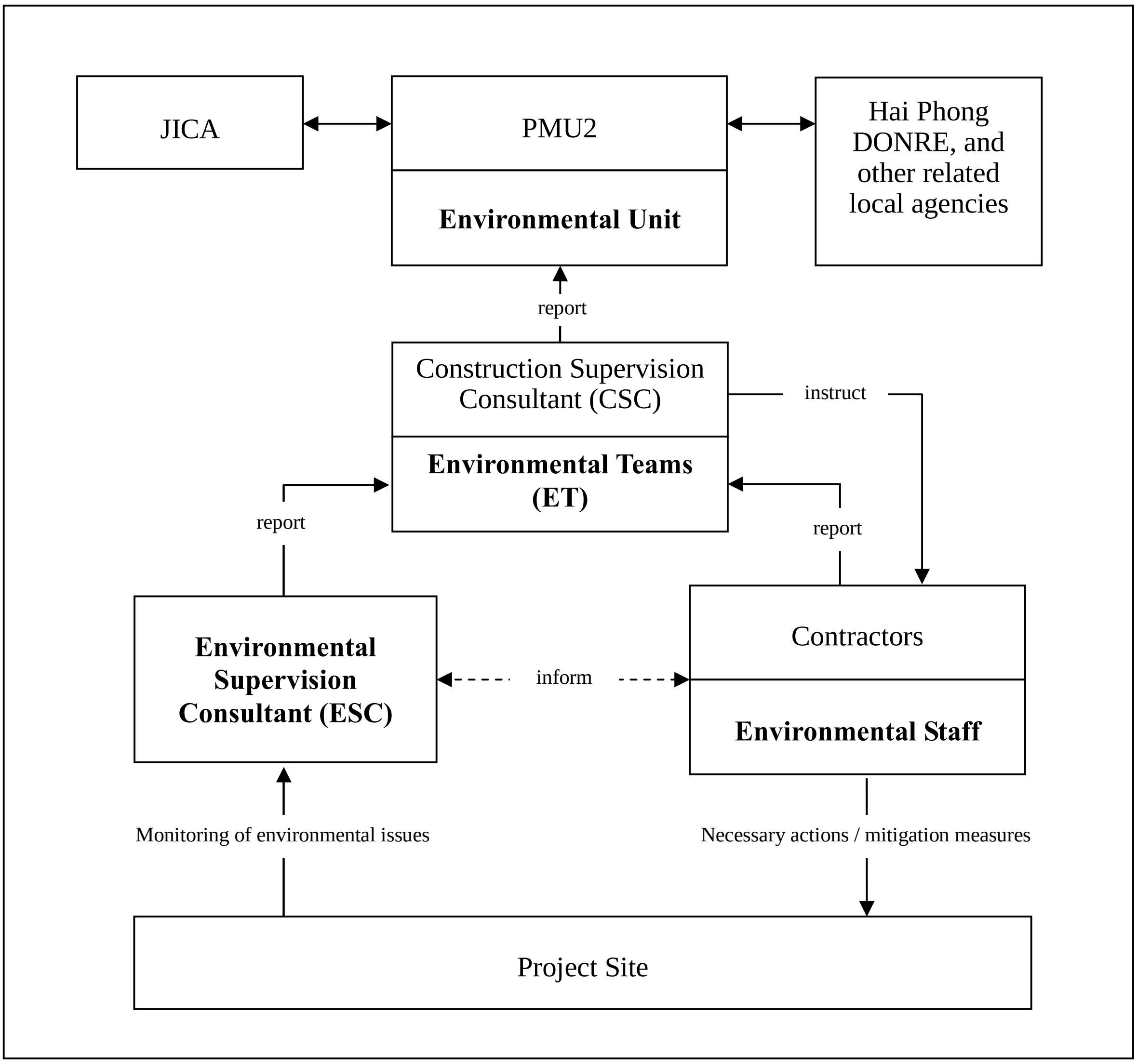
12.6 Information dissemination and public consultations

The first public consultation meeting was organized on 28 April 2010 at Civilization Center of Cat Hai Townlet. And the other 4 additional meetings were organized in September, 2010, in Nghia Lo Commune, Dong Bai Commune, Cat Hai Townlet, and Trang Cat Commune (Hai An District) respectively. It seems that residents have been informed about outlines of the Project through many formal and informal channels including hearing surveys carried out during the F/S Study.

However, in order to facilitate the Project implementation, and particularly to realize smooth implementation of resettlement and compensation, several activities relating to information dissemination and public consultation in the next stages of the Project have been proposed.

12.7 Prepare the Environmental Management Plan and the Environmental Monitoring Program

An Environmental Management Plan which includes an Environmental Monitoring Plan was prepared as a separated document attached to the main report. The proposed organization structure for the EMP implementation in construction phase is shown in Figure 12-10.



Source : Study Team

Figure 12.7-1 Proposed Organization Structure for EMP implementation (in construction phase)

12.8 Assessment of impacts caused by waste soils generated from civil works

It is estimated that about 370,000m^3 of waste soils would be generated from the construction of road and bridge (300,000m^3 from the construction of road foundation, and 70,000m^3 from the construction of bridge foundations). A part of these soils can be utilized to fill the low grounds along the sides of the highway, and the remaining unusable soils should be disposed to the designated sites. Methods to reuse and dispose these soils should be examined in further detail after the completion of the road design.

Besides, it is estimated that about 1 million m^3 of waste soil will be generated from the dredging work to make the temporary waterway necessary for construction of the approach bridge on Dinh Vu side. The Nam Dinh Vu Investment Jointstock Company had agreed to allocate two lots of land in the Nam Dinh Vu Industrial Zone as dumping sites for this dredged soil. A supplemental EIA study for the temporary dredging waterway was carried out during the period from January to April 2012. Consequently, a supplemental EIA report had been prepared and submitted to MOT for approval on 27 June 2012. After appraisal process, the report was approved by MOT in December 2012.

CHAPTER 13 HIV/AIDS prevention program

13.1 Introduction

Lach Huyen Port Infrastructure Construction Project (the Project), consists of two portion – the constructions of access roads/bridge to Lach Huyen port (Road & Bridge portion) and the civil works and constructions (Port portion) has potential social risks for the increase of HIV infection and vulnerability against AIDS among staff and labor in construction sites and to the immediate local communities.

In August 2006, JICA signed a joint initiative together with five other donor agencies to commit to reducing HIV vulnerabilities associated with infrastructure projects. In this context, Japan International Cooperation Agency (JICA) and Socialist Republic of Vietnam agreed on the inclusion of a plan to implement a prevention program against HIV/AIDS (Minuets of Discussion, 18 June 2010).

This drafted program is the product after discussion with Hai Phong City Health Department, Hai An district, and Cat Hai district, based on core components recommended in “Practice guidelines for harmonizing HIV prevention initiatives in the infrastructure sector” and past similar program in Vietnam.

13.1.1 HIV situation and Response

The HIV epidemic in Vietnam continued to rise in all 64 provinces and cities until 2000, but incidence (new cases) has declined from 67 per 100,000 adults (15-49 age group) in 2000 to 39 in 2007. Meanwhile, the number of people living with HIV (PLHIV) is estimated 243,000 cases (0.41% of the Population) in 2009, and it is predicted that the number will have reached at 280,000 by the end of 2012(0.47%).

In 2004, The Government of Vietnam formulated “The National Strategy on HIV/AIDS Prevention and Control in Vietnam for 2004–2010 with a Vision to 2020”, and in 2006, passed “The Law on Prevention and Control of HIV/AIDS (No. 64/2006/QH11)”. This law prohibits terminating an employee, denying medical care, and refusing an employment based on HIV status, guarantees the right to have HIV status kept confidential as well as encouraging the employment of PLHIV. In 2007, “Detailing the implementation of a number of articles of the law on Prevention and Control of HIV/AIDS (Decree No. 108/2007/ND-CP) defines target groups of harm reduction intervention measures in the prevention of HIV transmission, competency criteria of agency that provide such a program, and mandate on integration of HIV/AIDS prevention and control into social development program.

While Vietnam Administration for AIDS Control (VAAC), Ministry of Health is the major stakeholder of HIV/AIDS prevention program, the Ministry of Transport (MOT) also has taken part in the response to HIV prevention. MOT set out a HIV Action Plan to respond the prevention of HIV risk in transportation sector in 2009. The aim of Action Plan is to reduce the vulnerability to HIV and AIDS of those who are working in the transport sector,

13.1.2 Situation in the Project Sites

Hai Phong city is considered one of Vietnam’s highest HIV epidemic areas. According to VAAC’s data, more than 0.4% of the adult population in Hai Phong is PLHIV, while it is estimated to be 1% in urban and 0.3% in rural.

Since the first case had been found in 1993 in Hai Phong City, the total number of HIV positive has reached to 9,901 as of September 2011, in which 5,673 of AIDS. During 18 years, 3,154 people died from AIDS or AIDS related diseases. Therefore, the existing number of PLHIV in Hai Phong now is

6,747. In Hai Phong City, 64% of Injection Drug Users (IDUs) are HIV positive, and HIV prevalence among Female Sex Workers (FSWs) is 9.5%. HIV prevalence of Cat Hai district is listed as 3rd highest district among 15 districts of Hai Phong while Hai An district is listed as 8th among them. Ngo Quyen district, neighboring to Hai An district, is the first in the list, and one of the districts where entertainment establishments are prospering.

Along with the national strategy and program of actions, Hai Phogn City executes Nine(9) HIV/AIDS programs. Nine programs are (1) HIV Prevention through Information, Education and Communication (IEC) and Behaviour Change Communication (BCC), (2) Harm Reduction Prevention targeting high risk populations including Injection Drug User(IDU), (3) Care and Support for People Living with HIV (4) HIV Surveillance and Monitoring and Evaluation (M&E),(5) Access to HIV/AIDS Treatment Program, (6) Prevention of Mother to Child Transmission (PMTCT),(7) Management and Treatment of Sexually Transmitted Infections (STI), (8) Safe Blood Transfusion, and (9) Capacity Building and International Cooperation Enhancement.

The location of Hai An district is close to the center of Hai Phong City. Hai An district consists of 8 communes with population of 103,000. The size of population increase 3-4,000 people every year.

In Hai An distric, the number of PLHIV counts 513, and all PLHIV receive Antiretroviral Therapy(ART) service and other medical care. There is one methadone treatment center for IDUs under the Hai An district health center. The number of IUDs who receive the service is 92, and it will be expected to reach 145 in October 2011. HIV positive IDUs among the clients are 41 (45%), and the clients with Hepatitis B positive is 13 and with Hepatitis C is 61.

Every commune operate health station with 4-6 health staff who engaged in primary health care including STI syndromic diagnosis and community mobilizations about HIV awareness in their spare time.

Cat Hai Island, where is the center of the Port construction site, consist Cat Hai district with Cat Ba Island where the district administration office and the general hospital are located. Cat Hai district consists of 10 communes with the population of 29,800. The population of all five (5) communes in Cat Hai Island is around 14,100, where sixty-nine (69) cases are registered as PLHIV.

13.2 Planning Issues and Implementation Strategy

(1)A number of HIV mitigation programs to reduce the risk of staff and labor to HIV epidemic have been implemented in Vietnam. The experience and the practice of those programs were taken into policy progress and other program design for implementation. Since then, the main stream of HIV prevention in infrastructure sector gradually changed the HIV policy environments in infrastructure sector. Meanwhile, in Hai Phong City, various partners such International NGO take different role with their own coverage areas in different time schedule. The issue is how the Program will formulate a mechanism that coordinates continuously synergetic environment with the partners in the area, in the context of policy change.

In line with the above context, the Program will assign representative of Service Provider who attend HIV and Social Crime Steering Committee quarterly meeting for the purpose of reporting and coordination among stakeholders. A member of Service Provider also will attend the similar regular meeting held in Hai An district and Cat Hai district. In addition, the Program will organize the Program Management Coordinating Committee meeting, chaired by a member of HIV and Social Crime Steering Committee at the commencement of the Program, one year after, at the time of mid-term evaluation, 2 years after, and at the final evaluation.

The Program contains advocacy activities targeting not only for stakeholders and managers of construction companies but also managers of transportation business and entertainment establishments, and representatives from social group such as seafarer and fisherman etc. However, it is pointed out that those approach including IEC and mass media fostered stigma and discrimination unintentionally.

The Program will support executives, human resource manager, and health personal in site clinic to create better HIV and workplace in the context of health and safety. Advocacy should focus on building company support for integration of the prevention program, and all employers should receive information to promote uptake of company run prevention activities and, where needed, changes in workplace policy. This work policy will cover anti-discrimination and elimination of stigma in workplace. The Program will extend the advocacy activities, if Ca Hai district and Hai An district agree and support the approach, to involve in owners of hotels, entertainment establishments, and transport business.

(2)HIV clause under construction contracts is effective for the staff and labor to acquire certain level of knowledge about HIV/AIDS as indicated in the monitoring and evaluation reports of similar programs. However, IEC activities that is run by construction companies tend to be passive, and they cannot grab the interest of individuals.

In the Program, the response to HIV/AIDS will focus on the both organization and individuals. In principle, construction contractors are responsible for HIV/AIDS prevention activities, clarified by the HIV sub-clause under health and safety clause along with Vietnamese law. The Program support this principle though, Service Provider with its specialty and skills will be able to access individual staff and labor on site through BCC approach. Further, through collaboration with local authority, the Service Provider will also provide BCC for social groups and business communities where the local health cannot reach in general social campaigns.

(3)While construction workers know certain knowledge regarding to HIV/AIDS including protection method, the proportion of workers who know STI is lower, and most of them do not know their sero-status of HIV. If diagnosis and treatment service for STI are integrated into company health service, workers will not use them partly out of stigma and possibly because having an STI could be evidence of ‘social evils’ and grounds for dismissal. Workers do not use Voluntary Counseling and Service (VCT) even the services attached to worksites or those that are likely to give test results to employers due to fear of dismissal if HIV positive. The issue is how the Program sorts out the roles of Service Provider and construction contractor so that the site staff and labor can participate in the Program without fear and distrust.

The issues are how the Program establishes the environment that enable all site staff and labor participate in voluntary testing or STI/STD service without fear and prejudices, and how the Program enable the site staff and labor utilize VCT and ART service provided by local health providers if they require.

In the Program, Service Providers will establish a mechanism that mediates and promotes VCT, STI/STD treatment, and access to ART if required, through the collaboration with site clinic (if it is set up) and health centers in Hai An district and Cat Hai district. The Service Provider will control the budget for this service within the Program cost.

(4)Several international NGOs and organization operate their programs in the Hai Phong where the Program will be implemented; therefore, the Program continuously needs fine tuning during the Program implementation period. In addition, situational change along with private investment may lead the Program framework revised. Furthermore, it is far more difficult to predict what the measure should be taken at the end of Program. The issue is how the Program institutionalizes a modifiable adjustment mechanism in monitoring, and how the evaluation can be utilized for the future.

(5)The Program should include analyzing stakeholders and partners to find out priority activities and problems, and conducting baseline survey including behavior change and situation analysis at the time of the Project commencement. In order to reflect the change occurred during the implementation, it is required to conduct mid-term evaluation so that the Program will be able to re-design. The Program will need to conduct the evaluation together with an exit survey so that the results will reflect recommendations into the HIV/AIDS program in the post-construction period

13.3 Scope of the Program

13.3.1 Program Title

HIV/AIDS Prevention Program for Lach Huyen Port Infrastructure Construction Project

13.3.2 Objective of the Program

The overall goal of the Program is to reduce potential negative social impacts associated with the implementation and operation of Lach Huyen Infrastructure Construction Project (Roads/Bridge and Port). In order to achieve the overall goal, the Program mitigates HIV risks and vulnerability to HIV/AIDS at the construction sites and surrounding communities by following outputs.

13.3.3 The Program Period

The Program covers 42 months (3 years and 6 months) along with the construction Project.

13.3.4 Supervision, Implementing Procedure, and Service Provider

The Program implementation should be controlled by PMU2 and MPMU2 as a part of the construction project management. However, due to limited human resource and technical capability, the PMU2 and MPMU2 should employ HIV management specialist as a consultant respectively. The appointed consultants control quality of the Program through participating in the preparation of HIV clause for the contracts, monitoring and evaluation of the Program. Based on the contract between a prime contractor and Service Provider, the Service Provider operates the Program on site. The Program design proposes to set up Program Management Coordinating Committee which directs the Program and harmonizes the roles of stakeholders.

The construction project is managed by PMU2 for Roads & Bridge portion and MPMU2 for Port portion. In this regards, the Program is also divided into two portions- the Roads & Bridge program and the Port program. The Roads & Bridge program is responsible for all the staff including all contractor's employees, all sub-contractors and consultants' employees, and all truck drivers, mariners, and crew making deliveries to sites for construction activities and labor in construction sites and to the immediate local communities in Hai An district.

The Port program is responsible for all the staff including the entire contractor's employees, all sub-contractors and consultants' employees, and all truck drivers, mariners, and crew making deliveries to sites for construction activities and labor in construction sites and to the immediate local communities in Cat Hai district.

13.3.5 Participants in the Program

The number and type of the site staff and labor will vary accordingly with the actual condition of construction work. According to the past similar construction work, it is best estimated that the number of workers for the Roads & Bridge construction will be 1,500 and the number of workers for the Port will be 600 at the peak construction period. The Program encompasses managers of business community related to the construction works, entertainment establishment and local social groups in surrounding area. It is also expected to provide training to pharmacies, health staff of local health facilities in surrounding area, and health staff of site clinic.

13.4 Expected Outs and Activities

13.4.1 Implementation Mechanism

The expected output is to establish functioned management body and coordinating structure for the HIV/AIDS prevention program through proper implementation arrangement among major sub-contractors, Hai Phong City Health Department, Hai Phong City HIV/AIDS prevention center, Hai An district health center, Cat Hai district health center, Service Provider, and the Project management unit. Activities are as follows.

(1)To establish management body such a task team in MPMU II and PMU2 in order to accommodate supervision mechanisms for the Program among key stakeholders.

(2)To revise the draft Program framework and plan of operation, and to prepare TORs of the Program implementation that Service Providers undertake and HIV clause in contracts with Contractors.

(3)To conduct a Management Coordinating Committee Meeting chaired by the member of Hai Phong City HIV and Social Crime Steering Committee every year for discussing annual plans and midterm and final evaluation.

13.4.2 Advocacy and Capacity Building

The expected output is to gain increased awareness about, and applied workplace policy to address HIV, drug, stigma, and HIV resilient communities to sub-contractors and key partners including entertainment establishments, transportation business and local communities. Activities are as follows.

(1)To plan and conduct regular workshops that advocate HIV/AIDS awareness, overcome of social stigma, confidentiality obligation, and privacy protection for each potential participating group of local communities, entertainment establishment, and business communities involved in the Project.

(2)To plan and conduct "HIV and workplace" training program (workplace policy) for responsible person in contractors and business community who are interested in.

(3)To facilitate voluntary participants for introducing work place policy in their companies and local communities.

(4)To monitor and support participants of workshop and training program.

13.4.3Information, Education, and Communication (IEC) and Behavior Change Communication (BCC)

The expected output is to achieve the status of increased awareness and positive behavior change among site staff and labor and local communities through IEC and BCC. Activities are as follows.

<IEC and condom distribution>

(1)To regularly collect information on composition of site staff and labor in designated construction area for ICE approaches and Peer Education program.

(2)To select effective, locally acceptable, and IEC approaches for each group of the participants in the program with relevant local materials.

(3)To disseminate HIV/AIDS and STI information among site staff and labor including all the Contractor's employees, all Sub-Contractors and Consultants' employees, and all truck drivers, mariners, and crew making deliveries to site for construction activities.

(4)To ensure the availability of condoms with free of charge during first implementation year; afterwards condoms made available at affordable costs.

(5)To cover or complement the community mobilization activities together with local health staff based on the method applied in the Program.

<Peer Education Part>

(6)To prepare Peer Education program including curriculum and materials linking to other services such as access to condoms, medical care and Voluntary Counseling, and Testing(VCT)..

(7)To select Peer Educators from site staff and labor including all the Contractor's employees, all Sub-Contractors and Consultants' employees, and all truck drivers, mariners, and crew making deliveries to site for construction activities and to the immediate local communities.

(8)To plan and conduct training program for Peer Educators so that the ratio of Peer Educator become one for every fifteen (15) or less of site staff and labor including identified groups in the local communities.

(9)To support and monitor Peer Educators.

13.4.4 Access to Health Services

The expected output is to secure the access to quality HIV, STI and other health services including VCT and ART for all site staff and labor with trust and confidentiality, through linking to other components and existing local resources.

(1)To plan and prepare guidance and materials for staff and labor who seek for STI/HIV prevention and treatment service on site or linking to local services.

(2)To support site staff and labor to secure the access to STI/HIV prevention and treatment services linking private and public health services or/and entities where he/she can protect privacy and human rights(i.e. establishment of a confidential referral system and/or voluntary self referral system is in place for the site staff and labor) .

(3)To plan and conduct training program for health workers in STI/STD management and VCT in order to ensure efficient, quality, confidential, and client-friendly services on site or /and surrounding communities.

(4)To monitor and evaluate the provision of access to HIV/AIDS related health service and counseling.

13.4.5 Monitoring and Evaluation

The expected output is to secure performance of the Program through institutionalized monitoring and evaluation mechanism. Activities are as follows.

(1)To review the draft Program frame work and set indicators of the objectives in the Program based on baseline survey and situation analysis at the time of the Project commencement.

(2)To outline coordination, monitoring and evaluation mechanism processes to ensure that the Program is relevant to the overall goal and the program goal of the Program, and sufficiently flexible to revise the Program when it is necessary and approved by PMCC.

(3)To prepare monitoring and evaluation plan together with monitoring tools including formats for Service Providers.

(4)To design and conduct baseline and exit survey for the Program evaluation including behavior survey, complying Ministry of Health’s questionnaire and analysis method.

(5)To conduct monitoring and evaluation by a planned schedule.

13.5 Notes for Design Adjustment and Implementation

Notes for design adjustment and implementation of the draft Program are as follows.

(1)Management Coordinating Meeting revises the Draft Framework of Program before the commencement of the construction project.

(2)Collaboration among implementation teams of the both Roads & Bridge portion and the Port portion, supporting agencies such local health providers, and local authorities are key to success to the program implementation.

(3)PLHIV should be involved as much as possible in providing communication to dispel fear, stigma, and discrimination.

(4)Many similar materials and tools for IEC and BCC have been developed and used under HIV awareness and prevention program in Vietnam. Development of IEC/BCC program is not issue since those programs in both local and national level had produced number of useful materials and tools. The issue is how those materials are applied to meet their specific needs.

(5)Behavior Change Communication (BCC) through Peer Education program should be integrated into company structures and social systems.

(6)The Manager and Service Provider monitor the change of gender or culture related situation during every phase of the Program implementation so that gender-responsive and socially inclusive approach can be adapted to the situation.

13.6 Cost

The total cost of the additional scope of the Program is estimated at $866,900 in total. The cost for the Roads & Bridge portion is estimated $464,500, and the cost for the Port portion is estimated $402,400. These costs include the costs for employing management and monitoring consultants but not include costs for general operation of Health and Safety.

CHAPTER 14 OPERATION AND MAINTENANCE PLAN

14.1 Outline of Constructed Road

14.1.1 Details of the Road Facilities

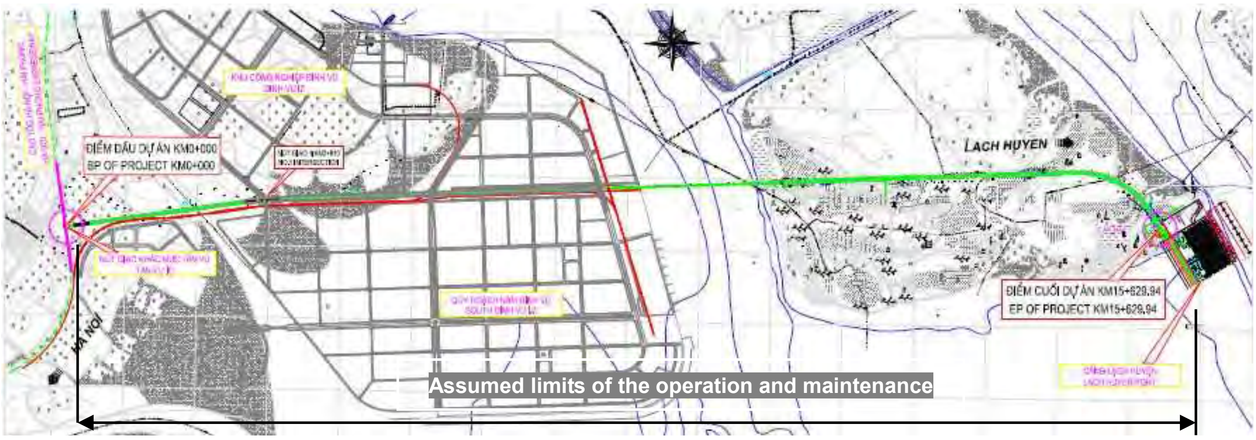
An outline of the constructed Tan Vu - Lach Huyen Highway is shown in Table 14.1.1-1. As Tan Vu - Lach Huyen Highway includes a special road and bridge structure that is 5.44km length over sea, the challenge is how to operate and maintain them.

Table 14.1.1-1 Outline of Tan Vu - Lach Huyen Highway

No	Items	Length	Details
1	Design Standard	—	Vietnam Highway Design Standard: Grade III, Flat Terrain, Design Speed 80km/hr
2	Total Length	15.63km	
	Bridge	5.44km	Main bridge (490m), East side approach bridge (519.2m), West side approach bridge (4,433.7m)
	West Side of Approach Road	4.5km	From Tan Vu IC (Intersection with Hanoi – Hai Phong Expressway) to the Abutment of West side approach bridge [Structures: Embankment, Bridge (Cam river), No1. Intersection (Dinh Vu Industrial Area)]
	East Side of Approach Road	5.69km	From the Abutment of East side approach bridge to the ending point[Structures: Embankment, Culver box (underpass, drainage)]
3	Right of Way	—	—
4	Width	—	Road Section: 29.5m / Bridge Section:16.0m
5	No. of Lane	—	Stage construction: 4 carriageways (future 6 carriageways)
6	Intersection/ Interchange	—	Stage construction: At-grade intersection (future Grade separation)
7	Other Works	—	Pavement work, Counter measure work for soft ground etc.

Source: Study Team

The assumed limits for the operation and maintenance for Tan Vu - Lach Huyen Highway are shown in Figure 14.1.1-1. There shall be no facilities transferred to another organization after the completion of the road and bridge.



Source: Study Team

Figure 14.1.1-1 Assumed Limits of the Operation and Maintenance for Tan Vu - Lach Huyen Highway

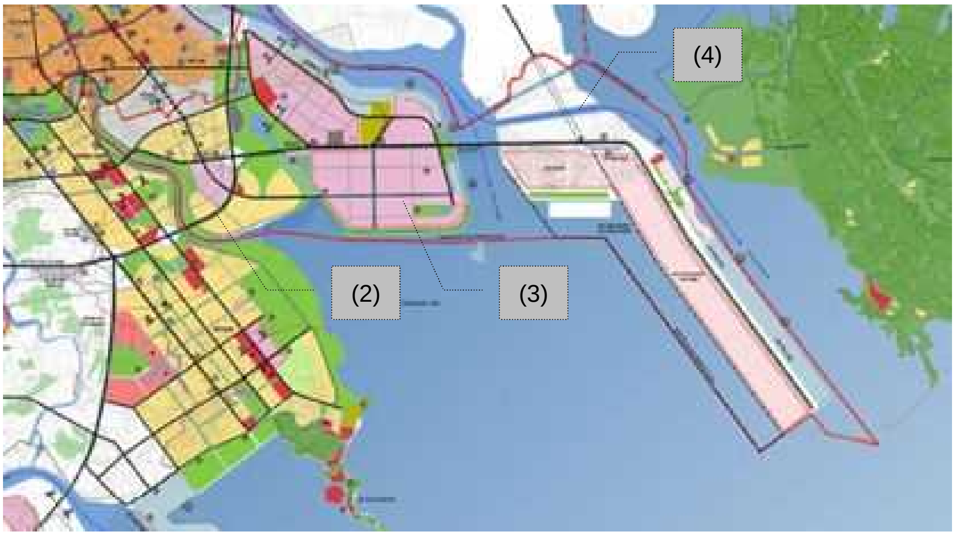
14.1.2 Ambient Circumstances of Route

The region surrounding Tan Vu - Lach Huyen Highway is described in Table 14.1.2-1 and Figure 14.1.2-1 respectively. Since Tan Vu - Lach Huyen Highway connects Lach Huyen Port to Hanoi - Hai Phong Expressway directly, it is necessary to maintain contact with the two facilities in operation and maintenance works.

Table 14.1.2-1 Ambient Surrounding Tan Vu - Lach Huyen Highway

No.	Project	Details
(1)	Lach Huyen Port	New international port and related facilities are constructed at Lach Huyen, Cat Hai District, Hai Phong City.
(2)	Hanoi – Hai Phong Expressway (Under construction)	105.5 km length of expressway between Hanoi City Third Ring Road and Hai An District of Hai Phong City
		Design speed: 120km/hr , No. of lanes: 6 lanes
		Total project cost: 24,000 bil VND
		BOT project by VIDIFI (Vietnam Infrastructure Development and Financial Investment, investment and development special company of the BIDV subsidiary).
		Land acquisition was completed in Hai Phong City area; the project will be completed in 2013.
(3)	Dinh Vu Industrial Area (Under construction)	Dinh Vu Industrial Zone: 944.49ha (by Dinh Vu Industrial Zone JSC) Nam Dinh Vu Industrial Zone: Zone-1: 1,354ha (by Nam Dinh Vu Investment JSC) None-tariff zone (southern part): 448ha Industrial zone (northern part): 906ha Zone-2: 658ha (by HAPACO)
(4)	Hai Phong City Ring Road	There is a City Ring Road Plan in Hai Phong City, but the section connected with Lach Huyen Port is a conceptual stage now.

Source: Study Team, information of Hanoi – Hai Phong Expressway is from http://news.searchina.ne.jp /disp.cgi?y = 2008 &d =0114&f



Source: Study Team

Figure 14.1.2-1 Plan for Tan Vu - Lach Huyen Highway

Sections and organizations that can adjust the plan for Tan Vu - Lach Huyen Highway are shown in Table 14.1.2-2.

Table 14.1.2-2 Related Organizations along Tan Vu - Lach Huyen Highway

Section	Road Facilities	Related Facilities	Related Organization	Remarks
Tan Vu	Tan Vu IC	Hanoi-Hai Phong Expressway	VIDIFI	—
Dinh Vu	No.1 intersection, at-grade	Dinh Vu Industrial Zone	Hai Phong People's Committee, HEZA (the Hai Phong Economic Zone Authority)	Based on Dinh Vu - Cat Hai Economic Zone Master Plan
Dinh Vu	No.2&3 intersection, inaccessible	Nam Dinh Vu Industrial Zone		
Hai An	Drainage Box Culverts	—	Hai An District People's Committee	—
Cat Hai	(Km11+520&Km15+576) Drainage Underpass Box Culverts, Frontage roads, Intersections with local approach road	—	Cat Hai District People's Committee	—
Cat Hai	(3 locations in Cat Hai Island) Relocation of dike roads	—	Department of Agriculture and Rural Development of Hai Phong City (DARD)	—

Source: Study Team

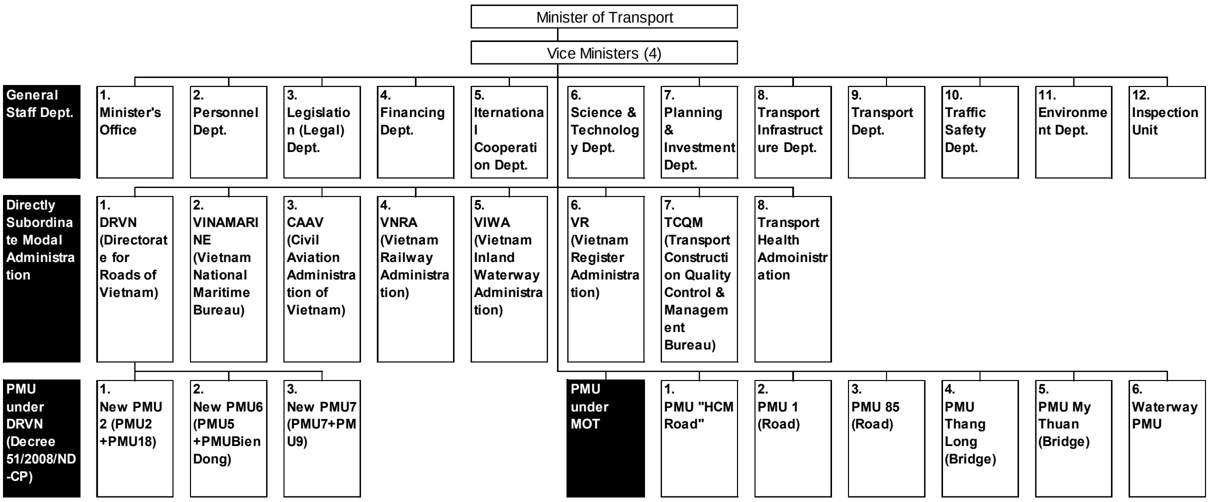
14.2 Existing State of the Road Operation and Maintenance

14.2.1 Outline of Responsible Organization for the Operation and Maintenance

14.2.1.1 Type of Maintenance Work and Responsible Organizations for the Work

(1) Road Administration Organizations

The DRVN (Directorate for Roads of Vietnam) is appointed by the MOT (Ministry of Transport) to take responsibility for the operational management of the national road network. VRA, (Vietnam Road Administration), the previous name of the DRVN, was established as a subsidiary of MOT pursuant to the Decree No 07/CP in 1993, which came into effect on January 30, 1993. Then, VRA was changed to DRVN, which is an organization with 11 departments pursuant to the Decision No.107/2009/QD-TTg since April 1, 2010. The organizational chart of MOT is shown in Figure 14.2.1-1. On the other hand, the authority of the actual maintenance work for half of the total national road's length is given to 4 RRMUs (Regional Road Management Units) and their subsidiary, RRMCs (Road Repair and Management Companies); and the remaining sections are given to 48 PDOTs (Provincial Department of Transports) and their subsidiary, PRRMCs (Provincial Road Repair and Management Companies).

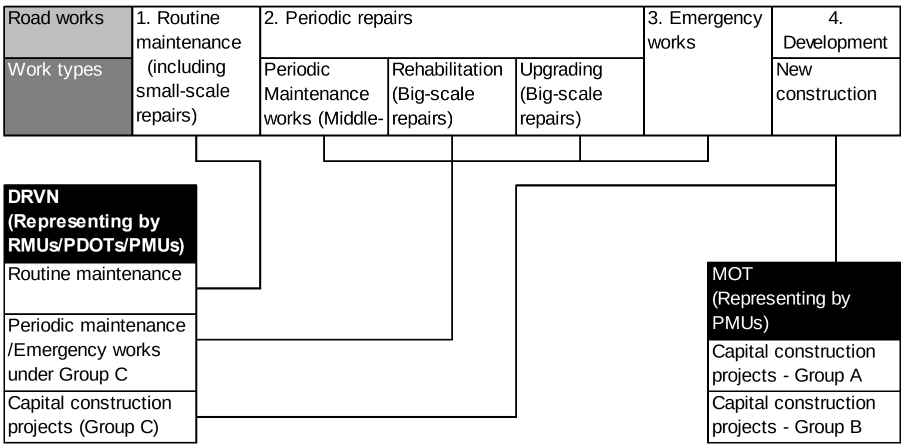


Source: Study Team (based on the MOT documents)

Figure 14.2.1-1 Organization Chart of MOT

(2) Type of Maintenance Work and Responsible Organizations for their Work

The type of maintenance work and the organization responsible for their work are shown in Figure 14.2.1-2. The MOT is responsible for the capital construction plan (new construction and rehabilitation), and the DRVN is responsible for the operational management plan in the same way. About half of the large-scale repair works in the national roads are executed by RRMUs, and the remaining work is executed by each PDOT. On the other hand, more than one half of the small/middle-scale repair work and the routine maintenance (daily maintenance work) in the national roads are executed by RRMUs, and the remaining work is executed by each PDOT. Specifically, MOT gives the authority of planning and executing the entire Group C projects to DRVN, and MOT still has the authority for executing all Group A and B projects.



Note: Group A>1,500 bil VND, 75< Group B<1,500 bil VND, Group C<75 bil VND.

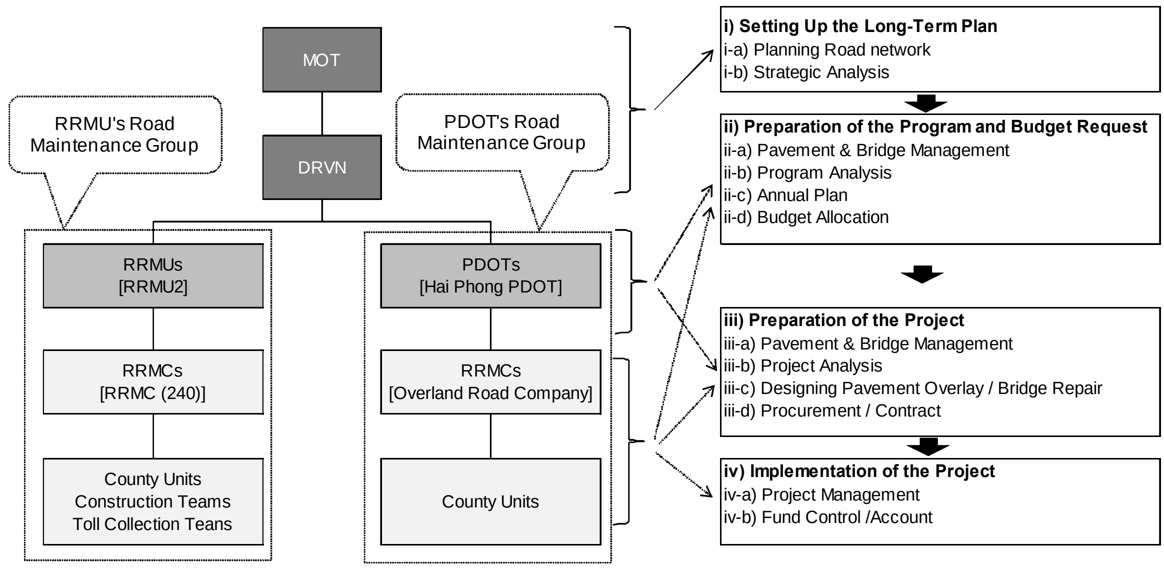
Source: Study team

Figure 14.2.1-2 Classifications of Road Maintenance Activities and Investment Projects

14.2.1.2 Flow of the Operation/Maintenance Work, Responsible Organizations at Each Stage

Road maintenance work progresses as follows: i) preparation of the mid/ long-term plan and relevant strategy, ii) survey of the project plan and the budget, iii) project preparation, and iv) project execution. Figure 14.2.1-3 shows the details of the activities and the responsible organization at each stage.

In the beginning stage, the Planning and Investment Dept. of DRVN is responsible for preparing the maintenance work to receive support from the Science, Technology, Environment and International Cooperation Dept. When in the implementation stages, the Infrastructure and Traffic Safety Dept. and Road Maintenance and Management Dept. are the responsible organizations. In the phase of actual maintenance works, execution organizations are divided into two groups, RRMU's Road Maintenance Group and PDOT's Road Maintenance Group. Local County Units carry out the actual routine maintenance works by the supervision of RRMC, and RRMU directly executes the medium and large-scale works (periodic maintenance) in the case of the RRMU Group. Similarly, the Local County Unit carries out the actual routine maintenance works under the supervision of the RRMC in the PDOT Group.



Note: [ ] shows the assumed road maintenance organization for Tan Vu - Lach Huyen Highway

Source: Study Team

Figure 14.2.1-3 Details of the Activities and the Responsible Organization at Each Stage on Road Maintenance

14.2.2 Technical Level of Operation and Maintenance Work

14.2.2.1 Status of Technical Level of Road Maintenance in DRVN

There is a possibility that the DRVN shall carry out the operation and maintenance work for Tan Vu - Lach Huyen Highway after the completion of the project. The technical level of the maintenance work in the organization shall be evaluated with the two items below, "Science, Technology, Environment and International Cooperation Dept. in DRVN" is concerned, i) What type of technical documents, standards, manuals, specifications etc. are prepared for the maintenance work? ii) What technical cooperation and assistance projects have been done before, or are planned for the future by donors?

(1) Preparation of Standards and Manuals for Road Maintenance

The department is in charge of preparing the standards and manuals for road and bridge maintenance work after the project is completed. Table 14.2.2-1 shows the prepared standards and specifications related to the road maintenance, and the maintenance work in RRMU is executed in accordance with these technological standards at present.

Table 14.2.2-1 List of Prepared Standards and Specifications on Road Operation and Maintenance by DRVN

Standards / Manuals	Document of Effect	Details
Technical Standards for Road Routine Maintenance	Decision N0. 1527/2003/QD-BGTVT dated 28/5/2003 of Ministry of Transport on promulgating 22TCVN306-03 on Technical Standards for Road Routine Maintenance	Road Maintenance Manual Items of road inspection Technological standard such as evaluation of IRI etc. Procedure regarding shoulder repair
Road Maintenance Routine Standards	Circular N0. 10/2010/TT-BGTVT dated 19/4/2010 of Ministry of Transport on regulations on management and maintenance road)	Road patrol Frequency of road inspection by each type of road Frequency of road and gutters' cleaning Technological standard such as road repair for damages and deterioration etc.
Regulations of Road Signs	(Decision N0. 4393/2001/QĐ-BGTVT dated 20/12/2001 of Ministry of Transport on promulgating 22TCN237-01 Standard of rules and road signs	Traffic regulation of traffic lane management for maintenance works on opened traffic road etc..

Source: Technical Standard on Road Maintenance Issued Pursuant to Decision No. 1527/2003/QD-BGTVT, May 28,2003 (Vietnam Transport Sector Study Task 5 Proposal for National Road Maintenance Program, JICA Feb. 2010 (P3-18))

(2) Technical Co-operation and Technical Assistance Projects

A lot of technical co-operation and technical assistance projects concerning road operation and maintenance have been executed by the VRA and DRVN until now. However, they are technical assistance projects accompanied the road improvement or reconstruction projects, and there is not the technical co-operation project that comprehensively cover the whole road operation and maintenance activities. Then, JICA has a plan to carry out the technical co-operation project intended for the entire road operation and maintenance from 2011 to 2012. The outline of it is shown in Table 14.2.2-2. By this project, the capacity of the road maintenance organization including DRVN, RRMUs, and RRMCs can be improved.

Table 14.2.2-2 Outline of Technical Co-operation Project on Road Maintenance by JICA

Items	Details
Title of the Project	Capacity Enhancement Project for Road Maintenance
Project Period	From August 2011 to March 2014
Targeted Organization	MOT (Ministry of Transport) and DRVN (Directorate for Roads of Vietnam)
Details (Terms of Reference)	. Preparation of new road data base . Preparation of Input format of related system such as road asset management system is prepared . Execution of training for road information management to develop the human resources . Preparation of training program and teaching material to apply road information management to the whole country . Development of new PMS and preparation of PMS data set format . Preparation of mid-term road maintenance plan for targeted pilot area . Execution of training for road maintenance planning to develop the human resources . Execution of OJT to improve technical level of maintenance works such as road inspection, evaluation of the damages, selection of the suitable maintenance or repair methods . Improvement of the standard for routine maintenance technology . Creation of the monitoring system for road pavement using the established new road data base . Execution of training for road inspection, evaluation of the damages, selection of the suitable maintenance or repair methods to develop the human resources . Preparation of training program and teaching material to apply road maintenance works to the whole country . Review of obligation authority of each related organization regarding the road operation and maintenance . Support of establishing the new rules and training system in DRVN for nationwide development of new road information management and road operation and maintenance works

Source: JICA Consultants Procurement Announcement, July 2011

14.2.2.2 Evaluation of Technical Level of Road Maintenance in Vietnam

Neither the capacity of the Department engaged in the technical matter in DRVN nor the preparation of technical specificationmanuals regarding road maintenance activities are sufficient to carry out the maintenance works appropriately at present. Therefore, the technical level of the road maintenance organizations in Vietnam can be improved by producing the good results of these technical co-operation projects by donors such as JICA's road maintenance project. Then, in order to do the effective and efficient technical co-operation to the road maintenance organizations it is important to coordinate the subjects appropriately in road maintenance activities among donors.

14.3 Financial and Budget Situation of Road Operation and Maintenance Organization

14.3.1 National Budget Related to Road Operation and Maintenance

14.3.1.1 Road Maintenance Strategy Plan and Amount of Plan Budget

In Vietnam, the mid/long-term road maintenance plan that has officially been approved doesn't exist at present. However, the mid/long-term maintenance plan that focuses on pavement improvement was already prepared with the donor's support at the beginning of the 2000's. Moreover, the annual road maintenance plan is prepared every year to determine the road maintenance budget. Those plans are shown as follows:

(1) Ten-Year Strategy Plan

The ten-year strategy plan was established for the national road network in RNIP (Road Network Improvement Project) that was prepared with the World Bank's support in 2003[1]. This is the general maintenance, rehabilitation and upgrading plan that shows the type of work and the amount of the fiscal resources needed for specific maintenance work in the national road network during ten years (2004 - 2013). The breakdown of the maintenance works are routine and periodic maintenance, rehabilitation, pavement improvement, pavement of the unpaved road and necessary reconstruction. In the strategy plan, the maintenance and improvement of the existing road network is particularly emphasized. Therefore, the construction of new roads is not considered in this plan. Although annual maintenance plan is prepared based on the Ten-Year Strategy Plan, the plan has not been officially approved.

The data base of the road condition for the national road network of 15,500km in 2001 was prepared. In the analysis, HDM 4 (Highway Development & Management Module 4) was used. The analysis was done by using the following three scenarios, i) Optimum budget scenario, ii) Constant roughness scenario, and iii) Current VRA budget-level scenario. The investment plan of each maintenance work during these ten years was analyzed, along with the investment amount that was estimated in each scenario, are shown in Table 14.3.1-1.[2]

[1] The Louis Berger INC. prepared it as a consultant.

[2] Contents of Ten-Year, Three-Year and Annual Plan are quoted from "Vietnam Transport Sector Study Task 5 Proposal for National Road Maintenance Program, JICA Feb. 2010".

Table 14.3.1-1 Analysis Results of Ten Years Plan

	Scenario	Proposed budget (per year)	IRI	Remarks
i)	Optimum budget scenario	93 million USD	—	Expected expenditures Overlays, Upgrading of unpaved sections
ii)	Constant roughness scenario	73 million USD	IRI; 6	—
iii)	Current VRA budget-level scenario	37 million USD	IRI; 6.6/2004 IRI; 8.7/2013	—

Source: Loan No. 1653 - VIE (SF), Third Road Improvement Project, Vietnam, Implementation of Sector Development Policy, Draft Final Report, March 2006 (Vietnam Transport Sector Study Task 5 Proposal for National Road Maintenance Program, JICA Feb. 2010 (P3-12))

(2) Three-Year Maintenance Plan

The DRVN has prepared the Three-Year Maintenance Plan for the national road network based on the Ten-Year Strategy Plan with the World Bank's support and a part of the government budget. HDM 4 was also used for this analysis. From the data base of 11,586km length of the national road network, 2,750km was selected for evaluation. Based on the result, 1,079km needs further maintenance work, which is prepared in the Three-year maintenance plan by DRVN. When the Three-Year Maintenance Plan begins, the government approval is needed.

(3) Annual Maintenance Plan

The Annual Maintenance Plan is the budget plan prepared for the entire year. RRMU and PDOT, the regional offices, play a major role in preparing the annual maintenance plan. The Annual Maintenance Plan includes the budget for routine and periodic maintenance, consisting of medium/large sized repair work. Although HDM 4 is used to prepare both the Ten-Year Plan and the Three-Year Plan, the Annual Maintenance Plan is prepared by the maintenance cost shown in the Budget Nome and Standard based on the data that has been accumulated so far.

14.3.1.2 Annual Maintenance Budget

(1) Actual Annual Budget

1) Road Maintenance Budget Changes over the Years

During the period from 1999 to 2002, the increasing ratio of the entire national budget (from 11% to 13.8%) is higher than that of GDP (from 2.7% to 3.5%). And, according to the public annual expense report in the transportation traffic sector, the annual budget allocated to road sector accounts for 82.8% of the budget of this sector. However, the road maintenance budget was only occupied by a small amount (about 5.7%-7.2%) in the entire road sector budget in the beginning of the 2000's.[3]

Table 14.3.1-2 shows the amount of the requested budget and the actual allocated budget concerning the road maintenance work from 2000 to 2009. The amount of the actual allocated budget has been increasing in recent years. However, since the increase of the unit price of the construction (materials and labor costs) exceeds the increase of the budget allocation, a decrease in the workload happens as a result. In addition, since the allocated budget cannot satisfy the requested demand, it is very hard to repair serious road damages in RRMUs and PDOTs.

[3] Statistic data (year): average of 12% during the period from 1995 to 2002

Table 14.3.1-2 State Budget for Maintenance, Repair Work and Construction

Year	Proposed Budget (mi VND)			Allocated Budget (mi VND)			
	Total	Routine Maintenance	Periodical Maintenance & Unscheduled Maintenance	Total	Routine Maintenance	Periodical Maintenance & Unscheduled Maintenance	Basic Construction (Group C)
2000	1,203,150	231,375	971,775	731,080	190,000	308,000	233,080
2001	1,257,120	248,320	1,008,800	1,012,910	180,550	329,450	502,910
2002	1,352,087	264,197	1,087,870	661,791	182,680	416,480	62,631
2003	1,694,910	311,310	1,383,600	1,382,017	243,990	640,417	497,610
2004	1,885,155	328,605	1,556,550	1,056,484	284,200	700,384	71,900
2005	2,583,809	381,502	2,202,307	1,137,392	326,180	811,212	0
2006	3,272,701	474,796	2,797,905	1,704,300	433,000	1,271,300	0
2007	3,400,400	510,060	2,890,340	2,101,992	469,797	1,405,015	227,180
2008	2,860,000	690,000	2,170,000	,2,080,889	518,892	1,384,628	177,369
2009	3,126,400	757,288	2,369,112	2,140,328	546,611	1,451,517	142,200

Note-1: 2010 (planned budget: 2,300 billion VDN / implemented budget 2,500 billion VDN), and 2011 (planned budget: 2,484 bil VDN),Total operation : 16,950km

Note: Budget Breakdown data (routine, periodic, road inspection, Clearance of Corridor (exclusion of squatters in ROW), emergency, weighbridge, office (staff salary, equipment))

Source: Vietnam Transport Sector Study Task 5 Proposal for National Road Maintenance Program, JICA Feb. 2010 (P3-15)

2) Sufficiency Ratio of the Maintenance Budget

In general, the sufficiency ratio of the maintenance budget is calculated by dividing “the Allocated Budget” over “the Proposed Budget”. Table 14.3.1-3 shows the sufficiency ratio that is calculated from the comparison between the requested amount and the actual allocated amount in Table 14.3.1-2. The ratio ranges from 44% to 82% because of the constrained budget. Since the actual needed budget is less than the actual allocated budget, the quality of the road is in poor condition. Specifically, road damages are occuring more often because more rehabilitation or reconstruction is needed before the design life cycle of the road maintenance activities.

Table 14.3.1-3 Sufficiency Ratio of the Maintenance Budget

Items	Year (mil VND)									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Proposed Budget	1,203,150	1,257,120	1,352,087	1,694,910	1,885,155	2,583,809	3,272,701	3,400,400	2,860,000	3,126,400
Allocated Budget	731,080	1,012,910	661,791	1,382,017	1,056,484	1,137,392	1,704,300	2,101,992	2,080,889	2,140,328
Ratio	61%	81%	49%	82%	56%	44%	52%	62%	73%	68%

Note: Allocated Budget includes Basic Construction (Group C)

Source: Study Team

14.4 Proposal of Operation and Maintenance to Constructed Road

14.4.1 Proposal of Management Organization for Operation and Maintenance

14.4.1.1 Legislation Process of Designation of the Management Organization

A typical process of determining the road operator (management organization for operation and maintenance) in Vietnam is shown in Table 14.4.1-1. According to this table, when the project nears completion, the project owner will hold the meeting to discuss about handing over the constructed roads and bridges with MOT, DRVN, MOC (Ministry of Construction), and the local government. In the case of Tan Vu-Lach Huyen Highway, the procedure will be started and preceded by PMU 2, the project owner, and finally the management organization will be decided.

In general, the road operator is appointed one month before road opening. However, it is necessary to make the decision six months earlier to acquire enough time to prepare for the operation and maintenance work even if the existing road agency still becomes the operator.

Table 14.4.1-1 Typical Process and Schedule to Determine the Road Operator

Stage		Schedule (Year)	Decisions for Selecting Road Operator
1	Detailed Design Period	2011	—
2	Tendering Period	2012	—
3	Construction Period	2013 - 2015	PMU reports to MOT on the time of opening to the traffic.
4	Operation Period	2015 -	MOT decides the road operator 1 or 2 months before road opening.

Source: Study Team (based on the Interview with Planning and Investment Dept. Dept. of DRVN on 31st May and 1st June in 2011)

14.4.1.2 Designation Criteria of the Management Organization

Although the road operator for the constructed road and bridge has not been determined yet, there shall be only one road operator. An official decision of a road operator after the completion of Tan Vu - Lach Huyen Highway has not been reached yet. However, the 3 options of the assumed future road operator are shown in Table 14.4.1-2.

Table 14.4.1-2 Options of the Assumed Management Organization

Option	Type of Road	Road Operator	Actual Road Maintenance Organization	Remarks
Option-1	National Road	RRMU's Road Maintenance Group	RRMU2, RRMC (240), and New established County Unit	There is a high possibility.
Option-2	National Road or Urban Road	PDOT's Road Maintenance Group	Hai Phong PDOT, Overland Road Company, and existing County Unit	There is a possibility of integral operation with other urban roads in Hai Phong City.
Option-3	Expressway	VIDIFI	New established Road Maintenance Company by BOT Concessionaire	There is little possibility.

Source: Study Team (based on the Interview with Planning and Investment Dept. Dept. of DRVN on 31st May and 1st June in 2011)

According to this table, Option-1 has a high possibility of being selected over Option-2 or Option-3. However, there is the case that the National Highway of Hanoi – Noibai Airport has been transferred from the central government to the local government two years ago. Thus, the road operator is decided by the discussion between the central government and the local government, and there is a possibility of becoming it both. Then, it examines which of RRMU 's Road Maintenance Group and PDOT' s Road Management Group is the suitable roads operator for Tan Vu - Lach Huyen Highway.

Important matters that should be considered in determining the road operator for the road operation and maintenance are as follows:

– The Organization should be experienced enough about the operation and maintenance of roads and bridges.

– The Organization should be able to secure enough number of experienced staff about the operation and maintenance of roads and bridges.

– The Organization should be able to carry out efficient and effective operation and maintenance works on Tan Vu - Lach Huyen Highway.

– The Organization must acquire enough information (meteorological conditions, geographical features, local situation, etc.) of the region where Tan Vu - Lach Huyen Highway is located.

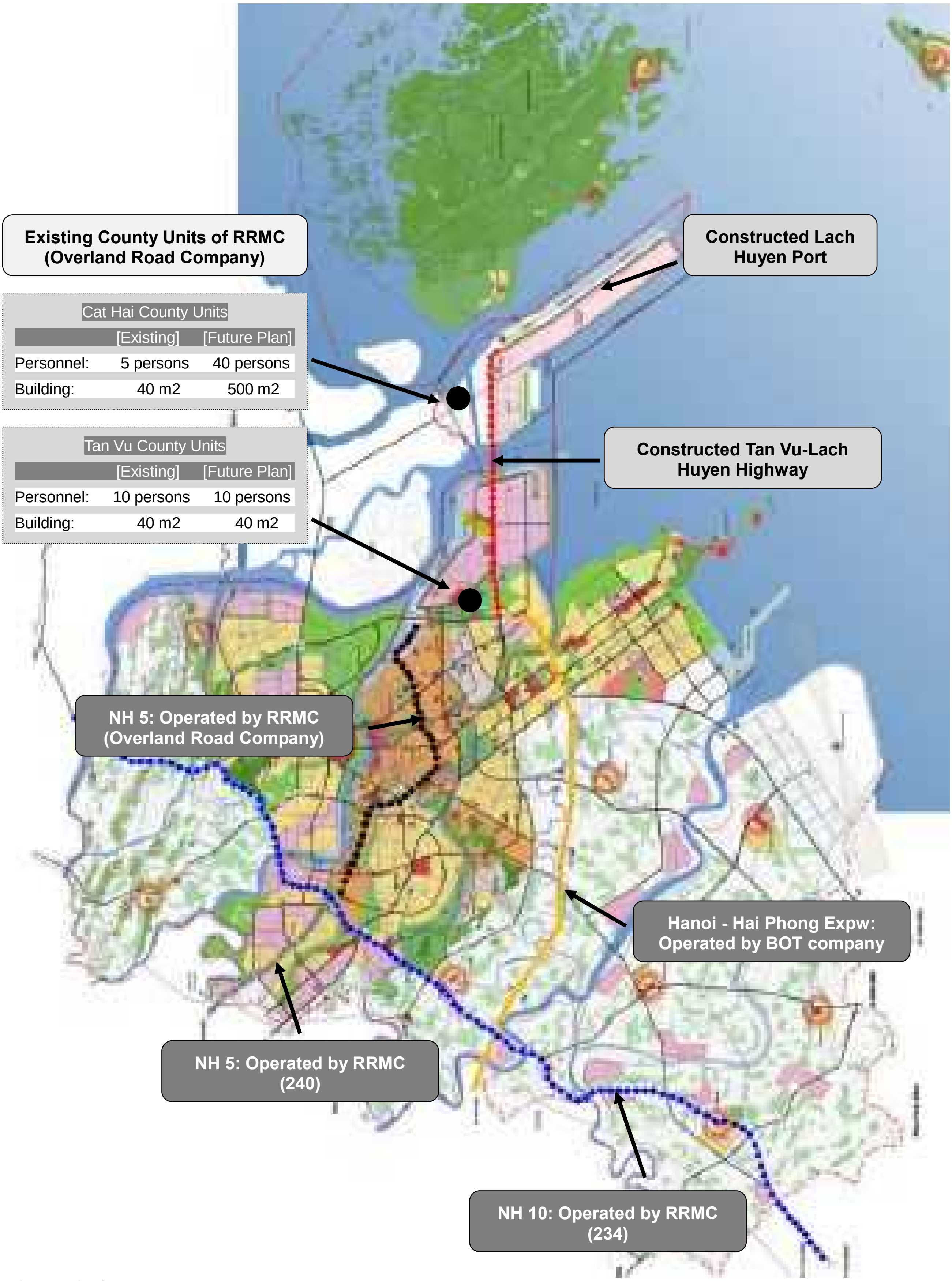
Table 14.4.1-3 shows the comparison table regarding the road operators for the RRMU's Road Maintenance Group and PDOT's Road Maintenance Group. And the road operators of trunk roads in the Hai Phong City are shown in Figure 14.4.1-1 as reference.

Table 14.4.1-3 Comparison Table of the Maintenance Organization

	Evaluation Criteria		Option-1	Option-2
			RRMU's Road Maintenance Group	PDOT's Road Maintenance Group
1	Enough experienced about the operation and maintenance of road and bridge.		There is 24 years experience of the road maintenance. Operation length of national roads is 115km, included 2030m total length of bridges	There is 50 years experience of the road maintenance. Operation length of roads is 256km, included40km national roads and 2300m total length of bridges
		Evaluation	3	3
2	Enough number of experienced staff about the operation and maintenance of road and bridge.		There are 290 employees now.(Engineers are 80 persons.) There are 224 people in 5 units and teams as technical staff and workers.	There are 309 employees now. (Engineers are 54 persons.) There are 269 people in 7 units and teams as technical staff and workers. There are some places where get the damages and not repair for long time in the city because of the insufficient road maintenance budget
		Evaluation	3	2
3	Efficient and effective operation and maintenance work on Tan Vu - Lach Huyen Highway.		It is away from the head office to site about 75km. County Unit must be set up the site. (It is needed to establish the communication system between the head office and County Unit.) As for NH 5, the pavements are maintained comparatively well.	Adjoining roads to Tan Vu-Lach Huyen Highway are operated and maintained, and 2 County Units are located at the site. There is an expansion plan of these County Units for the future.
		Evaluation	2	3
4	Enough information (meteorological conditions, geographical features, local situation, etc.) of the region where Tan Vu - Lach Huyen Highway is located.		Since it is away from the head office to site about 75km, it might be late to correspond in the emergency. There is an operation and maintenance experience NH5 in Hai Phong. County Unit is set up on the site, and it is possible to carry out the operation and maintenance activities without trouble.	A regional situation has been well known Cooperation with a regional urgent organization (police, fire fighting, and towing company) is also early. Assistance from the head office can be obtained easily, correspond time is short.
		Evaluation	2	3
5	Others		There is a high possibility that RRMU2 becomes an administration authority in the present road administrative system because Tan Vu Lach Huyen Highway will be a national road RRMC also has a positive idea about the operation and maintenance of this road. Privatization is planned by next year, and an efficient business can be expected of RRMC.	If PDOT manages, dedication of the operation and management right is necessary There are a similar procedure results of other national roads in the city RRMC has a positive idea about the operation and maintenance of this road.
		Evaluation	3	2
Overall Evaluation			13	13

Note: Evaluation Good: 3 points, Fair: 2 points, Poor: 1 point

Source: Study Team

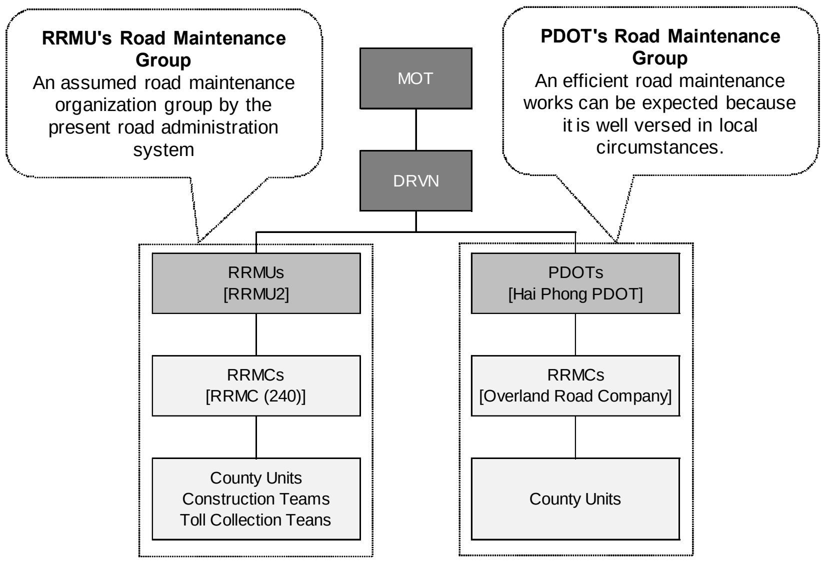


Source: Study Team

Figure 14.4.1-1 Road Operator of Trunk Roads in Hai Phong City

Figure 14.4.1-2 shows this result. It is desirable that the PDOT's Road Maintenance Group becomes the road operator from the view points, which can correspond in the emergency situation by well known a local situation, and can correspond by expanding an existing County Unit, as above-mentioned result.

However, even if RRMC (240) is designated as the road operator, it can also work on the maintenance of Tan Vu – Lach Huyen Highway, such as in the example of former and current maintenance project: NH 5, Phu Luong Bridge, Lai Vu Bridge. By that time, the structure and amount of work load shall be expanded and more diversified. Also, the company shall be able to mobilize more capital.



Source: Study Team

Figure 14.4.1-2 Possible of the Management Organization

Then, the below-mentioned proposal how to operate and maintain Tan Vu Lach Huyen Highway is focused on the activities of RRMC and County Unit. Because they will carry out the actual maintenance works regardless of whether RRMU'S Road Maintenance Group or PDOT' s Road Maintenance Group becomes the road operator.

14.4.2 Proposal of Organization and Activities in the Management Organization

14.4.2.1 Structure and Functions of the Management Organization

(1) Organizational Structure and Number of Staff

In case RRMC (240) executes the operation and maintenance work for Tan Vu - Lach Huyen Highway, the organizational structure shall be changed as shown in Table 14.4.2-1. Three people in total are increased about one staff of Traffic Management Office, one staff of Equipment Management Office, and one vice-director has a responsibility for all of Tan Vu-Lach Huyen Highway. On the other hand, it proposes to set up one newly County Unit on the site, and to deploy about 40 workers (2- 3 supervisors included).

Table 14.4.2-1 Size of the RRMC's Office by NORM

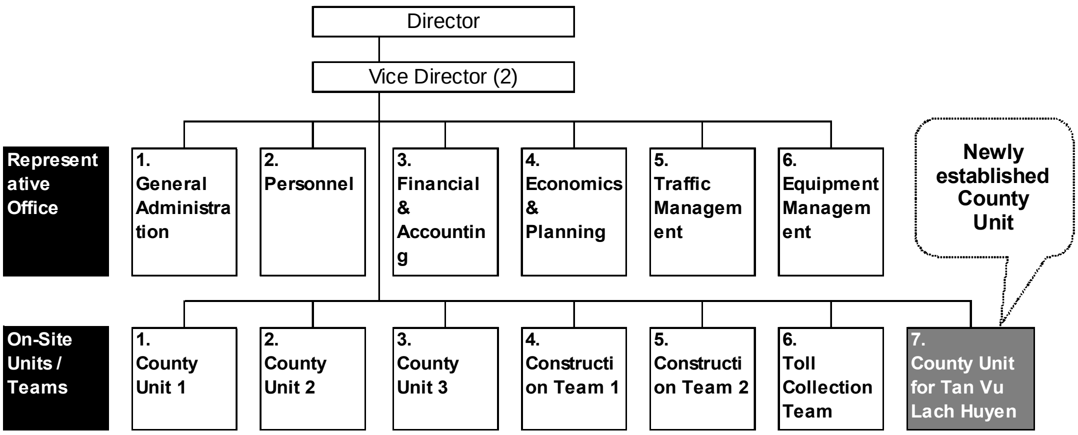
Organization	No.	Division/ Unit	No. of Persons		Remarks
			Existing	Proposal	
Head Office	1	Head of the office	1	1	—
	2	Vice Head of the office	2	**3**	
	3	General Administration	3	3	
	4	Personnel	3	3	
	5	Economic & Planning	3	3	
	6	Finance & Accounting	3	3	
	7	Traffic Management	3	**4**	
	8	Equipment Management	3	**4**	
		Sub Total	21	24	
		Persons/ km	0.16	0.18	
Site Office	1	County Unit 1	40	40	
	2	County Unit 2	50	50	
	3	County Unit 3	40	40	
	4	New County Unit		**40**	
	5	Construction Team 1	30	40	
	6	Construction Team 2	30	30	
	7	Toll Collection Team	70	70	
		Sub Total	260	300	
		Persons/ km	2.26	2.29	
Total			281	324	
		Persons/ km	2.44	2.47	

Note: Operation Length of RRMA (240) = 115km, Length of Tan Vu - Lach Huyen Highway = 16km,

Note: Based on the NORM: 6～7 persons / 10km staffs are assigned.

Source: Study Team

Figure 14.4.2-1 Shows the new organization chart of RRMC base on the above-mentioned proposal.



Source: Study Team

Figure 14.4.2-1 Proposed Organization Chart of RRMC

(2) Responsible Organization to Each Maintenance Works

Table 14.4.2-2 shows the divisions and units corresponding to different types of the maintenance work executed by RRMC in Tan Vu - Lach Huyen Highway.

Table 14.4.2-2 Responsible Organization to Each Maintenance Work

Type of Work	Responsible Organization to Each Maintenance Work				Remarks
	Site Office		Head Office		
	Units/Teams	Staff	Offices	Staff	
Daily Inspection (Road Patrolling)	County Unit	4	Traffic Manage	1	—
Routine Maintenance	County Unit	40	Traffic Manage /Equipment Management	1	—
Periodic Maintenance	Construction Team	case by case		1	—
Rehabilitation/ Reconstruction	Construction Team	case by case		1	—

Source: Study Team

14.4.2.2 Operation Office of the Management Organization

(1) Office Location and Office Building

In case RRMC (240) takes charge of the maintenance works for the constructed Tan Vu - Lach Huyen Highway, a County Unit should be preferably set up near the highway because the head office of RRMC (240) is far from Hai Phong City by about 70km. On the other hand, if RRMC (Overland Road Company) takes charge of it, RRMC (Overland Road Company) that the head office of it is located in Haiphong City makes efficient use of two existing County Unit near the highway. Then, Table 14.4.2-3 shows what kind of site office for County Unit is needed as reference of County Unit 3 of RRMC (236) that was visited as the field survey.

RRMC (236)'s site office is mentioned below as reference; there are 7 site offices under RRMU (236), in which each of them is placed at every 40-50km of road. Each site office is 500m2 at least and well furnished with the equipment, auditorium, parking and dormitories to serve all work management, material collection, and living activities of the workers. Therefore, five out of seven site offices (1500 – 2000 m2) are much bigger than the headquarters of RRMU (236) in Ngoc Hoi Street (200m2). There is an office building of about 200–300m2; and 5 or 6 dorms for the workers. The size of the dorm differs and depends on the situation of the site office, but the biggest dorm is 200m2.

Table 14.4.2-3 Details of the Site Office

Items	Details	Remarks
Name	Site Office for County Unit	—
Location	Near Tan Vu - Lach Huyen Highway	—
Area	500m2	—
Building	Building 100m2	—
	Administration office, Meeting room, Dormitory for the worker	—
Construction Cost for the building	2bil VND	—
Function	Resides about three staffs for emergency operation at night Parking lot, Space for construction materials.	—

Source: Study Team (For example, in Hanoi – Lang Son route, there is two site offices in Bac Ninh (which is 50km away from Hanoi) and in Bac Giang (which is 70km away from Hanoi)

14.4.2.3 Operation and Maintenance Activities

(1) Assumed Maintenance Works

Road maintenance works are roughly divided into five categories, such as Maintenance Works, Improvement Works, Traffic Control Works, Countermeasures for Traffic Accident, Toll Collection Works. Then, a proposal of responsible organization and the detailed activities in each works for Tan Vu - Lach Huyen Highway are shown in Table 14.4.2-4 by referring to the actual road maintenance activities in Japan

Table 14.4.2-4 Concrete Activities of the Maintenance Works

No	Type of Work	Breakdown	Responsible Organization	Detailed Activities
1	Maintenance Works	Road Inspection	RRMC County Unit	Data of road surface condition are regularly collected, and the damages condition of the roads is understood. The bridges are regularly inspected. Especially, it is important to do the visual inspection of the lower side of the box bridge directly.
		Routine Maintenance	RRMC County Unit	Pavement, lighting, bridge accessories, and drains etc. are regularly cleaned.
		Periodic Maintenance	RRMU (RRMC)	Maintenance and repair plan for damages are prepared based on the inspection result, and maintenance and repair works are executed based on it. The overlay of the pavement, the waterproof work s on the bridge slab, and replacement of expansion joints of the bridges are assumed.
		Emergency	RRMC County Unit (RRMU)	The road facilities which get damages by the traffic accidents and the natural disasters are repaired. In general, firstly temporary countermeasures are executed to secure the traffic flow and full-scale countermeasures will be done after making the plan and procure the budget for the work.
2	Improvement Works	Rehabilitation	RRMU (RRMC)	If the road facilities are damaged, and damage might, progress, the rehabilitation works will be done so that the life of the facilities may extend.
		Reconstruction	PMU	If the road facilities are greatly damaged and the recovery is difficult, re-constructs works will be done.
3	Traffic Control Works	Patrolling	RRMC County Unit	Traffic patrolling is needed to observe the traffic flow besides the patrol for road inspection.
4	Countermeasures for Traffic Accidents	Accident Handling	Traffic Police RRMC County Unit	Basically, the traffic police has a responsibility for the handing of the traffic accidents, and the road operator does the assistance to the police The road operator is requested immediately to repair the damaged road facilities to secure traffic due to the accident.
		Ambulance	Traffic Police	Basically, the traffic police call into action.
		Fire engine	Traffic Police	-ditto-
		Towing car	Traffic Police	-ditto-
5	Toll Collection Works	Toll Collection	—	Since Tan Vu - Lach Huyen Highway is the non toll road, toll collection work is not necessary.

Note: For bridge maintenance, there are 3 different regulations of DRVN which are corresponding to the 3 different size of the bridge, with the length less than 25m; from 25m to 300m; and greater than 300m.

Source: Study Team

14.4.3 Contract Method for Operation and Maintenance Works

Recent topics about the road maintenance activities in Vietnam that are described in Chapter 1.2.2 are as follows: i) the privatization of RRMCs and ii) the introduction of the Performance-Based Maintenance Contracting (PBMC). It is possible that the operation and maintenance activities of Tan Vu - Lach Huyen Highway shall be affected by these new policies.

As mentioned in Chapter 1.2.2.1., the road operation and maintenance companies that manage the national highways where a central government has authority are scheduled to be privatized by 2015. RRMC (240) with the possibility of managing Tan Vu-Lach Huyen Highway is also planned to be privatized. On the other hand, RRMC (Overland Road Company) of the operation and Maintenance Company of Hai Phong PDOT do not plan to privatize. In the viewpoint of doing an efficient and sufficient management of roads, the private management company is desirable. Moreover, PBMC that is carried out at several roads as a pilot project now will widely spread to the whole country in the future according to the government policy. Then, it is very significant in Tan Vu-Lach Huyen Highway to examine the introduction of PBMC.

14.4.4 Estimated Cost for Operation and Maintenance Activities

14.4.4.1 Method of Estimation

Factors of the road structure to determine standard unit price (per Km) for the road maintenance work are as follows: i) Number of Lanes, ii) Type of Pavement, and iii) Traffic Volume and Character. The criteria to determine the road maintenance budget are as follows: i) Existing condition、ii) Available resources、iii) Condition of materials、iv) NORM of quotation of routine maintenance.

In this study, the maintenance cost calculated by the SAPROF study of this project in 2010 is verified by the comparison with the actual maintenance expenditure of DRVN, RRMU2 and RRMCs. As a result, the maintenance cost needed for the operation and maintenance of Tan Vu - Lach Huyen Highway (road and bridge) has been calculated. An outline of each calculation method for operation and maintenance cost is shown in Table 14.4.4-1.

Table 14.4.4-1 Outline of Each Calculation Method for Operation and Maintenance Cost

Method	Outline of Each Method	Details
Method-1	Calculation Result for Operation and Maintenance Cost by SAPROF Study in 2010	Operation and maintenance cost of Tan Vu Lach Huyen Highway is calculated by the assumed unit price for each works that are 40% of unit price in Japan.
Method-2	Actual Cost of DRVN, RRMU2, and RRMC by Survey Results of This Study	In this study, actual annual operation and maintenance cost of DRVN, RRMU2, Hai Pong PDOT, RRMC240, 236, Overland Road Company are surveyed, and operation and maintenance cost per km are calculated.
Method-3	Actual Maintenance Cost of NH 3, PhapVan-CauGie Expressway, Bai Chay Bridge, Can Tho Bridge and My Thuan Bridge, and Actual Pavement Overlay Cost are obtained from DRVN.	Data for the operation and maintenance cost of roads and bridges that are the similar scale to Tan Vu Lach Huyen Highway is acquired in DRVN, and operation and maintenance cost per km are calculated.

Source: Study Team

14.4.4.2 Results of Estimation

(1) The calculation result for maintenance cost of Tan Vu - Lach Huyen Highway

1) Routine maintenance cost

Table 14.4.4-2 shows the result of calculated routine maintenance cost of Tan Vu Lach Huyen Highway referring to the above-mentioned data. Consequently, 7,631 mil VND (4 lanes) and 11,400 mil VND (6 lanes) are needed annually.

Table 14.4.4-2 Routine Maintenance Annual Cost

Items	Unit Cost (mil VND/km)	Length (km)	Cost (mil VND)	Remarks
Road	215	10.19	2,191	[Method-2] 140 mil VND (RRMC (236)) of maximum value of routine maintenance cost (road) is adopted, and consider the sufficiency ratio of the maintenance budget (65%).
Bridge	1,000	5.44	5,440	[Method-3] 1,027 mil VND of actual value of routine maintenance cost (bridge) of Can Tho Bridge is adopted.
Total		15.63	7,631	4 lane
		15.63	**7,600**	4 lanes(round to the nearest multiple of 100)
		15.63	**11,400**	6 lanes(4lanes ×4/6)

Note: Detailed data of routine maintenance costs are attached in Appendix-4.
Source: Study Team

2) Periodic maintenance cost

In periodic maintenance, costs of asphalt pavement overlay, waterproof replacement on bridge slab and expansion joints replacement for bridges are calculated as expected actual works. As for the construction frequency, the pavement overlay and waterproof replacement works are assumed every 10 years and expansion joint replacement works are assumed every 15 years. Periodic maintenance cost calculated based on the above-mentioned is shown in Table 14.4.4-3.

Table 14.4.4-3 Periodic Maintenance Cost for 10 Years

Type of Works	Year (after open to the traffic) (mil VND)				Remarks
	0 - 9	10 - 19	20 - 29	30 - 34	
Asphalt pavement overlay	65,646	98,601	98,601	—	[Method-3] Actual unit cost in Vietnam
Waterproof replacement	36,111	36,111	36,111	—	[Method-1] Unit cost by SAPROF
Expansion joints replacement	—	19,000	—	19,000	-ditto-
Total	101,757	153,712	134,712	19,000	/15.63km
	101,800	**153,700**	**134,700**	**19,000**	(round to the nearest multiple of 100)

Note: Detailed data of periodic maintenance costs are attached in Appendix-4.
Source: Study Team

3) Calculation result for the operation and maintenance cost of Tan Vu - Lach Huyen Highway

Future operation and maintenance costs for 35 years after Tan Vu Lach Huyen Highway opens the traffic is calculated based on the above-mentioned result as shown in Table 14.4.4-4.

Table 14.4.4-4 Estimate of Future Operation and Maintenance Cost

Kind of Works	Year (Unit: mil VND)										Total
	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	
Initial Investment	2,000	—	—	—	—	—	—	—	—	—	2,000
Routine Maintenance	7,600	7,600	7,600	7,600	7,600	7,600	7,600	7,600	7,600	11,400	79,800
Periodic Maintenance	—	—	—	—	—	—	—	—	—	101,800	101,800
Total	9,600	7,600	7,600	7,600	7,600	7,600	7,600	7,600	7,600	113,200	183,600
aggregate	9,600	17,200	24,800	32,400	40,000	47,600	55,200	62,800	70,400	183,600	183,600
	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	Total
Routine Maintenance	11,400	11,400	11,400	11,400	11,400	11,400	11,400	11,400	11,400	11,400	114,000
Periodic Maintenance	—	—	—	—	—	—	—	—	—	153,700	153,700
Total	11,400	11,400	11,400	11,400	11,400	11,400	11,400	11,400	11,400	165,100	267,700
aggregate	195,000	206,400	217,800	229,200	240,600	252,000	263,400	274,800	286,200	451,300	451,300
	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	Total
Routine Maintenance	11,400	11,400	11,400	11,400	11,400	11,400	11,400	11,400	11,400	11,400	114,000
Periodic Maintenance	—	—	—	—	—	—	—	—	—	134,700	134,700
Total	11,400	11,400	11,400	11,400	11,400	11,400	11,400	11,400	11,400	146,100	248,700
aggregate	462,700	474,100	485,500	496,900	508,300	519,700	531,100	542,500	553,900	700,000	700,000
	2045	2046	2047	2048	2049	Total	—	—	—	—	—
Routine Maintenance	11,400	11,400	11,400	11,400	11,400	57,000	—	—	—	—	—
Periodic Maintenance	—	—	—	—	19,000	19,000	—	—	—	—	—
Total	11,400	11,400	11,400	11,400	30,400	76,000	—	—	—	—	—
aggregate	711,400	722,800	734,200	745,600	776,000	776,000	—	—	—	—	—

Note: Office operation cost is included in the routine maintenance cost.

Source: Study Team

(2) Verification of the estimated maintenance cost of this study

Table 14.4.4-5 shows the whole maintenance cost of combined routine and periodic maintenance costs by SAPFOR.

Table 14.4.4-5 Routine and Periodic Maintenance Cost Estimation by SAPROF

	Items	Cost (mil VND)	Remarks
1	Office Operation Cost (10 times annual cost)	26,140	
2	Routine Maintenance and Repair Cost (10 times annual cost)	148,610	
3	Periodic Maintenance Cost	64,747	
Total		**239,497**	**15.88km/10 years**
		1,508	**/km/year**

Source: Study Team

In the same way, Table 14.4.4-6 shows the whole maintenance cost of combined routine and periodic maintenance costs by this study.

Table 14.4.4-6 Routine and Periodic Maintenance Cost Estimation by This Study

	Items		Cost (mil VND)	Remarks
1	Office Operation Cost (10 times annual cost)		—	
2	Routine Maintenance and Repair Cost	(year 2015 –2023)	68,400	7,600×9
	-ditto-	(year 2024 –2049)	296,400	11,400×26
3	Periodic Maintenance Cost	(year 2015 –2024)	101,800	
	-ditto-	(year 2025 –2034)	153,700	
	-ditto-	(year 2035 –2044)	134,700	
	-ditto-	(year 2045 –2049)	19,000	
Total			**774,000**	**15.88km/35 years**
			1,393	**/km/year**

Source: Study Team

Regarding the whole maintenance cost for Tan Vu Lach Huyen Highway: 1,508 mil VND and 1,393mil VND are estimated by SAPROF and this study respectively. The value of SAPROF is 108% to this study value. Equally, routine maintenance cost of Can Tho Bridge (1,027 mil VND/km/year) is 74% to this study value. It is judged that 1,393 mil VND is appropriate because it doesn't differ much from SAPROF’s value and actual long bridge maintenance costs. On the other hand, 252 mil VND of actual expenses in RRMC (240), that is, the maximum value of whole maintenance cost in all organizations surveyed area, is only about 18% to this study value, and actual maintenance cost has a large difference from this study value. It is important that the road management organization acquires an appropriate maintenance budget based on the maintenance plan to do appropriate maintenance works.

CHAPTER 15 COST ESTIMATE and PROCUREMENT

15.1 The Policy of The Cost Estimate for Road and Bridge Portion

15.1.1 Application Standard and Related Laws and Regulations

15.1.1.1 Construction expenses guideline

- Circular No. 04/2010/TT-BXD on 26/5/2010 of Ministry of Construction on Formulation and management manual of investment construction expenses.

15.1.1.2 Cost Estimate Standard and Laws

- Decision No. 957/QĐ-BXD dated 29/9/2009 of Ministry of Construction announcing standard rates of management and consultancy cost of construction investment project.
- Capital construction norms for work construction part: refer to the norms enclosed to the letter No. 1776/2007/BXD-VP dated 16 August 2007 of the Ministry of Construction.
- Capital construction norms for installation part: refer to the norms enclosed to the letter No. 1777/2007/BXD-VP dated 16 August 2007 of the Ministry of Construction.
- The norm on maternace of public ligting system No. 2274/BXD-VP dated November 10, 2008 of the Ministry of Construction.
- Document No. 2565/BXD-KTCL dated 29/11/2006 on application of traffic safety cost.
- Letter No. 1784/BXD-VP dated 16 August 2007 of the Ministry of Construction issued the norms for materials.
- Decision No. 131/2007/QD-TTg dated 9/8/2007 of Prime Minister of Vietnamese government about publishing regulation of foreign consultant choosy cost in construction activities in Viet Nam.
- Decision No. 33/2004/QD-BTC dated 12/4/2004 of Ministry of Finance about insuarance fee.
- Decree No. 123/2008/ND-CP dated 08/12/2008 of Vietnamese Goverment about VAT law
- Circular No. 194/2010/TT-BTC of December 6, 2010, guiding customs procedures; customs inspection and supervision; import duty, export duty and tax administration applicable to imports and exports (MOF)

15.1.1.3 Material Price

- Material price announcement No. 41/2012/SXD-CBG of Hai Phong People Committee dated 12/7/2012. Other spencial materials are estimated according to price announcement of supplier.

15.1.1.4 Labor Cst

- Decree No. 70/2011/ND-CP dated 22nd Aug 2011 by the Goverment providing area minimum wages rates for employees working companies, enterprises, co-operative, co-operative groups, farms, family households, individuals and other Vietnamese organaizations which hire employees.

15.1.1.5 Lease Cost of Costruction Equipment

- Machine prices mainly based on "List of machine shift prices and construction equipment" No. 131/QD-UBND of Hai Phong People Committee dated 26/01/2011.

15.1.1.6 Unit Price

- Unit price of construction No. 2542/QĐ-UBND dated 17/12/2009 of Hai Phong People Committee.
- Unit price of installation No. 2538/QĐ-UBND dated 17/12/2009 of Hai Phong People Committee.

15.1.1.7 Application of a Japanese cost estimate standard

Since there are not steel pipe pile and a SBS construction method in the Vietnam standard, they apply a Japanese standard. The Japanese standard to apply is as follows.

Table 15.1.1-1 Application of a Japanese cost estimate standard

Application standard title	Editorial supervision	Version
Ministry of Land, Infrastructure and Transport public works cost estimate standard	Ministry of Land, Infrastructure and Transport	2011
Cost estimate of bridge erection	Japan Construction Mechanization Association	2011
Construction machinery hire table	Japan Construction Mechanization Association	2010

Source: JICA study team

The composition of the laborer in connection with construction of a SBS construction method makes Japanese people those who are engaged in technical guidance.

Table 15.1.1-2 The composition of the labour in SBS construction method

Laborers' classification	Japanese	Vietnamese
Bridge labor organizer		O
Bridge specialist		O
Labor organizer		O
Usually worker		O
Technician		O
Scaffold erector		O
Reinforcement worker		O
Form worker		O
Special driver		O
Usually driver		O
Welder		O
Bridge painter		O
Electric worker		O
Traffic control worker		O
Waterproofing worker		O

Source: JICA study team

15.2 Construction Cost Structure

Construction cost structure is base on the current Vietnamese standard, Circular No 04/2010/TT-BXD dated May 26, 2010 and issued by the Ministry of Construction (MOC).

Table 3-6 of the above-mentioned standard is shown.

Table 3.6. CONSTRUCTION EXPENSES SUMMARY IS CALCULATED CONSUMPTION OF MATERIAL, LABOR AND MACHINE AND CORRESPONDED PRICE TABLE

ORD	CONTENT OF EXPENSES	FORMULA	AMOUNT	SYMBOL
I	DIRECT EXPENSES			
1	Material expenses	From table 3.5		VL
2	Labor expenses	From table 3.5		NC
3	Machine expenses	From table 3.5		M
4	Other direct expenses	(VL+NC+M) x tỷ lệ		TT
	Direct expenses	VL+NC+M+TT		T
II	General Expenses	T x rate		C
III	Pre-Determined Taxable Income	(T+C) x rate		TL
	Pre-tax construction expenses	(T+C+TL)		G
IV	VAT	$G \times T^{GTGT-XD}$		GTGT
	After-tax construction expenses	G + GTGT		G_{XD}
V	Expense for Building make-shift House on Construction Sites for Accommodation and Construction Management	$G \times rate \times (1+ T^{GTGT-XD})$		G_{XDNT}
	TOTAL	$G_{XD} + G_{XDNT}$		

Source: Circular No 04/2010/TT-BXD (MOC)

The adoption rate of each item is as follows by regulation of Circular No 04/2010/TT-BXD.

Table 15.2-1 Adoption Rate of Construction Expenses

Item	Rate
Other direct expenses	2.0%
General Expenses	5.5%
Pre-Determined Taxable Income	6.0%
VAT	10%
Expense for Building make-shift House on Construction Sites for Accommodation and Construction Management	2.0%

Source: Circular No 04/2010/TT-BXD (MOC)

15.3 Conditions of Cost Estimate

15.3.1 Time of Cost Estimate

Time of cost estimate is June 2012.

15.3.2 Currency

Japanese Yen (JPY) is used as F/C while Vietnamese Dong (VND) is used as L/C in this detail design.

15.3.3 Exchange Rate

Annex-1 of M/D as of March 19, 2010 exchanged between JICA and Vietnam is followed.

- VND 1=JPY 0.00532
- USD 1=JPY 90.5=VND 17,002

An exchange rate is due to be changed into the rate defined by L/A after L/A conclusion.

Present exchange rate: The construction costs which use the present exchange rate by the request of MOC were computed.

- VND 1=JPY 0.0037375
- USD 1=JPY 77.96=VND 20,860

15.3.4 The Currency Classification and The Tax in Project Cost Item

Table 15.3.4-1 The Currency Classification and The Tax in Project Cost Item

Project Expense Item	FOREIGN CURRENCY (JPY)	LOCAL CURRENCY (VND)
I.JICA Loan Eligible Portion		
1.Construction Cost		
1)Direct construction cost	The currency was determined based on labor's nationality, procurement place of material and equipment	
a.Material cost	material requiring individual import procedure	material distributed domestically
b.Labor cost	foreign nationality	Vietnamese labor
c.Equpment cost	equipment requiring individual import procedure	equipment distributed domestically
d.Other direct cost	Shipping cost for equipment requiring individual import procedure	-----
2)Indirect construction cost	others	Cost required at the site
e.Management cost	Travel expense for foreign nationality	others
f.Overhead and Profit	The cost was in F/C since it is expense of contractor's headquarter	-----
2.Price contingency	The cost was classified by the ratio of F/C and L/C of the cost requiring contingency	
3.Physical contingency	The cost was classified by the ratio of F/C and L/C of the cost requiring contingency	
4.Consulting services	Followed Annex I of M/D between JICA and GOVN dated on March 19, 2010	
II.State Budget Portion		
5.Environmental Management and Monitoring Cost	-----	The cost was in L/C since it was expense in Vietnam
6.Administration cost		
7.Value Added Tax (VAT)		The cost is in L/C
8.Inport Tax		Pay in Vietnam

Source: JICA study team

15.3.5 Price Contingency Rate

The same rate as SAPROF is used.

- F/C : 1.8% per annum
- L/C : 10.3% per annum

15.3.6 Physical Contingency Rate

In accordance with Circular No. 04/2010/TT-BXD on 26/5/2010 of Ministry of Construction, it is made to 5%.

15.3.7 Interest During Construction

The same rate as SAPROF is used.

- Construction cost : 0.2% per annum
- Consulting services : 0.01% per annum

15.3.8 Commitment Charge

Annex-1 of M/D as of March 19, 2010 exchanged between JICA and Vietnam is followed.

- Loan amount × number of years of disbursement period × 0.1%

15.3.9 Administration Cost

In accordance with Circular No. 04/2010/TT-BXD on 26/5/2010 of Ministry of Construction, it is made to 5%.

15.3.10 Value Added Tax

In accordance with Circular No. 32/2007/TT-BTC dated 9/4/2007 of Ministry of Finance, it is made to 10%.

15.3.11 Import Tax

Annex-1 of M/D as of March 19, 2010 exchanged between JICA and Vietnam is import tax 3.0%.

However, in drawing up a final report, it was required that DRVN should change an import tax to 10%. We made the import tax 10% according to this DRVN's request.

15.4 Project Cost

15.4.1 Structure of Project Cost

Composition of Bill item of Project cost is made into the following item from the classification of road structure.

Although contained in general, since the rate of occupying to a whole cost of construction is large, temporary facilities shall be divided into seven items by the request of MOT, and shall be measured.

Table 15.4.1-1 Composition of Bill item of Project cost

Bill Item No.		Bill Item
A1		**General**
A2		**Temporary Facility**
	A2-1	Entrance Access Road
	A2-2	Site Access Road
	A2-3	Site Compound
	A2-4	Temporary Birdge
	A2-5	Dredging to Open a Temporary Channel
	A2-6	Temporary Jetty for Loading and Unloading
	A2-7	Temporary water Cutoff
B		**Road Works Hai An Side**
	B1	Highway in Dinh Vu
	B2	Cam River Bridge
	B3	Soft Soil Ground Improvement
	B4	Drainage Culvert
C		**Approach Bridge Hai An Side**
	C1	Superstructure
	C2	Substructure
D		**Main Bridge**
	D1	Superstructure
	D2	Substructure
E		**Approach Bridge Cat Hai Side**
	E1	Superstructure
	E2	Substructure
F		**Road Works Cat Hai Side**
	F1	Highway
	F2	Soft Soil Ground Improvement
	F3	Drainage and Underpass Culvert
G		**Lighting and Electrical**
H		**Provisional Sums**

Source: JICA study team

15.4.2 Verification Cost of MOC

MOC did the next assessment to the project cost which the consultant proposed.

Based on above principles, the cost estimate of Project of Construction of motorways Tan Vu - Lach Huyen, Hai Phong City after verification is 10,823,185,117,000 VND

Table 15.4.2-1 Verification Cost of MOC

No.	Cost Item	Value of Consultant (VND)	Value of Verifier (VND)	(+) Increase (-) Decrease (VND)
1	Construction Cost	8,395,683,786,101	7,715,929,761,595	-679,754,024,506
2	Project management Cost	32,618,671,937	36,559,439,828	3,940,767,891
3	Consultancy and Other Cost	880,452,281,201	1,046,200,931,834	245,748,650,633
4	Provisional Cost	2,421,065,355,842	2,024,494,984,195	-396,570,371,646
5	Total Cost	11,649,820,095,081	10,823,185,117,452	-826,634,977,628
	Rounded value	11,649,820,095,000	10,823,185,117,000	-826,634,978,000

Source: MOC Letter No. 1009/VKT-BDS

15.4.3 Approved Cost of DRVN

Appraisal base of cost estimate is as follows:

Table 15.4.3-1 Approved Cost of DRVN

Item	Construction cost in adjusted E.C	Submitted value	Appraisal value	Difference
1	2	3	4	5=4-3
Package Value in Equivalent to VND	10,283,848,869,000	10,348,484,100,000	10,186,044,572,000	-162,439,528,000
Construction cost in equivalent to VND	8,086,852,674,000	8,088,701,354,000	8,002,139,387,000	-86,561,967,000
- Foreign currency (JPY)	11,971,573,900	10,977,076,000	10,846,828,000	-130,248,000
- Local currency (VND)	4,883,755,97,000	5,151,690,965,000	5,099,978,049,000	-51,712,916,000
Conversion contingency cost VND	2,196,996,195,000	2,259,782,746,000	2,183,905,185,000	-75,877,561,000
- Foreign currency (JPY)	1,277,367,000	1,131,620,000	1,157,357,000	25,737,000
- Local currency (VND)	1,855,225,760,000	1,957,008,054,000	1,874,244,450,000	-82,763,604,000

Source: DRVN Letter No. 1198/CQLXDDB-TD1

BẢNG TỔNG HỢP DỰ TOÁN XÂY DỰNG / SUMMARY OF PROJECT COST

DỰ ÁN ĐƯỜNG Ô TÔ TÂN VŨ - LẠCH HUYỆN, THÀNH PHỐ HẢI PHÒNG

(Kèm theo Quyết định số /QĐ-TCĐBVN ngày tháng 11 năm 2012)

TT	NG M	Items	NGOẠI TỆ/ FOREIGN CURRENCY (JPY)	NỘI TỆ / LOCAL CURRENCY (VND)	QUY ĐỔI NỘI TỆ/ COMBINED CURRENCY in VND
A1	Hạng	**General Requirements**	**229,034,884**	**92,007,830,068**	**153,288,066,552**
A2	Công	**Temporary Facilities**	**500,723,267**	**904,080,595,800**	**1,038,053,376,342**
	A2-1	Entrance Access Road	0	6,529,346,326	6,529,346,326
	A2-2	Site Access Road	0	371,232,318,645	371,232,318,645
	A2-3	Site Compound	0	154,164,959,139	154,164,959,139
	A2-4	Temporary Birdge	34,306,935	9,168,095,887	18,347,208,809
	A2-5	Dredging to Open a Temporary Channel	5,604,927	286,112,701,965	287,612,348,058
	A2-6	Temporary Jetty for Loading and Unloading	276,203,661	44,205,916,961	118,106,562,020
	A2-9	Temporary water Cutoff	184,607,745	32,667,256,878	82,060,633,345
B	Đườn	**Road Works Hai An**	**225,783,289**	**764,590,830,752**	**825,001,075,325**
	B1	Highway	18,284,815	241,427,455,445	246,319,713,518
	B2	Cam River Bridge	139,348,265	115,252,906,445	152,536,723,045
	B3	Soft Soil Ground Improvement	53,589,980	390,526,873,764	404,865,329,951
	B4	Drainage Culvert	14,560,230	17,383,595,098	21,279,308,811
C	Cầu d	**Approach Bridge Works Hai An**	**8,363,828,344**	**1,004,409,594,174**	**3,242,223,197,822**
	C1	Superstructure	5,945,449,943	501,785,606,029	2,092,541,443,548
	C2	Substructure	2,418,378,401	502,623,988,145	1,149,681,754,274
D	Cầu c	**Main Bidge Works**	**785,227,638**	**284,678,173,727**	**494,772,525,080**
	D1	Superstructure	363,520,463	240,883,786,422	338,146,786,483
	D2	Substructure	421,707,175	43,794,387,305	156,625,738,598
E	Cầu d	**Approach Bridge Works Cat Hai**	**656,641,704**	**234,147,944,192**	**409,838,032,121**
	E1	Superstructure	333,250,778	101,176,738,097	190,340,825,905
	E2	Substructure	323,390,925	132,971,206,095	219,497,206,216
F	Đườn	**Road Works Cat Hai**	**84,457,758**	**732,588,374,396**	**755,185,767,890**
	F1	Highway	16,593,412	336,135,937,650	340,575,646,498
	F2	Soft Soil Ground Improvement	19,253,614	338,617,695,536	343,769,164,068
	F3	Drainage and Under-pass Culvert	47,589,931	56,757,613,445	69,490,705,327
	F4	Frontage Road	1,020,802	1,077,127,765	1,350,251,997
G	Điện	**Lighting and Electrical**	**1,131,431**	**61,298,592,276**	**61,601,316,265**
H	H1	**Land Lease cost**		**37,126,440,532**	**37,126,440,532**
I	Các k	**Provisional Sums**	**0**	**257,582,448,572**	**257,582,448,572**
	H1	Soil Investigation Hai An Side		5,513,382,708	5,513,382,708
	H2	Soil Investigation Cat Hai Side		3,614,695,381	3,614,695,381
	H3	HIV Countermeasure		11,052,996,256	11,052,996,256
	H4	Maintenance and Protection of Traffic		4,949,488,189	4,949,488,189
	H5	Environmental Control and Protection		7,872,429,591	7,872,429,591
	H6	Temporary Navigation Roadsmarker Buoys for Existing Navigation Channel		63,384,287,271	63,384,287,271
	H7	Import Tax (10%)		161,195,169,176	161,195,169,176
J	Giá tr	**Construction cost (without VAT)**	**10,846,828,315**	**4,372,510,824,490**	**7,274,672,246,501**
	Thuế	VAT		727,467,224,650	727,467,224,650
K	Giá tr	**Construction cost (with VAT)**	**10,846,828,000**	**5,099,978,049,000**	**8,002,139,387,000**
L	Dự ph	**Contingency**	**1,157,357,000**	**1,874,244,450,000**	**2,183,905,185,000**
	K1	Price Escalation	585,729,000	1,542,138,617,000	1,698,855,406,000
	K2	Physical Contingency (5%)	571,628,000	332,105,833,000	485,049,779,000
GIÁ TRỊ XÂY DỰNG		**Construction cost (with VAT and Contingency)**	**12,004,185,000**	**6,974,222,499,000**	**10,186,044,572,000**

Source: DRVN

15.4.4 Modification Project Cost After DRVN Approval

Simplification of a unit price item and correction of the electric items were made by DRVN request. This project cost is in agreement with BOQ for a bid.

Here shows the cost based on two exchange rates about project cost.

- Present exchange rate: for bidding shown in table 2-4.
- M/D (19th March 2010) exchange rate: comparison with SAPROF shown in table 2-5.

Table 15.4.4-1 Project Cost Based On Present Exchange Rate of Road and Bridge Portion

SUMMARY OF PROJECT COST

THE DETAILED DESIGN STUDY FOR LACH HUYEN PORT INFRASTRUCTURE CONSTRUCTION PROJECT IN VIET NAM

BILL NO	CONSTRUCTION ITEMS		FOREIGN CURRENCY (J.YEN)	LOCAL CURRENCY (VND)	CURRENCY in VND	CURRENCY in JPY
A1	**General Requirements**		**231,785,113**	**93,900,307,994**	**155,916,391,617**	**582,737,514**
A2	**Temporary Facilities**		**501,222,845**	**963,088,412,468**	**1,097,194,859,169**	**4,100,765,786**
	A2-1	Entrance Access Road	0	7,225,324,877	7,225,324,877	27,004,652
	A2-2	Site Access Road	0	377,936,845,367	377,936,845,367	1,412,538,960
	A2-3	Site Compound	0	205,316,872,180	205,316,872,180	767,371,810
	A2-4	Temporary Birdge	34,394,840	9,288,115,623	18,490,748,399	69,109,172
	A2-5	Dredging to Open a Temporary Channel	5,604,927	286,112,701,965	287,612,348,058	1,074,951,151
	A2-6	Temporary Jetty for Loading and Unloading	276,615,333	44,541,295,578	118,552,086,943	443,088,425
	A2-7	Temporary water Cutoff	184,607,745	32,667,256,878	82,060,633,345	306,701,617
B	**Road Works Hai An**		**198,455,964**	**775,350,085,636**	**828,448,671,225**	**3,096,326,909**
	B1	Highway	18,284,847	248,217,896,225	253,110,163,054	945,999,234
	B2	Cam River Bridge	111,042,670	112,458,016,028	142,168,429,406	531,354,505
	B3	Soft Soil Ground Improvement	54,389,551	397,179,418,592	411,731,806,795	1,538,847,628
	B4	Drainage Culvert	14,738,895	17,494,754,791	21,438,271,969	80,125,541
C	**Approach Bridge Works Hai An**		**8,487,194,109**	**1,006,653,079,656**	**3,277,474,245,968**	**12,249,559,994**
	C1	Superstructure	6,067,735,076	502,189,261,235	2,125,663,529,159	7,944,667,440
	C2	Foundation	2,419,459,033	504,463,818,421	1,151,810,716,809	4,304,892,554
D	**Main Bidge Works**		**799,434,772**	**285,144,487,970**	**499,040,079,092**	**1,865,162,296**
	D1	Superstructure	377,693,015	241,211,828,163	342,266,815,332	1,279,222,222
	D2	Substructure	421,741,757	43,932,659,807	156,773,263,760	585,940,073
E	**Approach Bridge Works Cat Hai**		**672,576,073**	**234,391,135,988**	**414,344,600,263**	**1,548,612,943**
	E1	Superstructure	348,633,125	101,203,644,847	194,483,410,855	726,881,748
	E2	Substructure	323,942,947	133,187,491,141	219,861,189,408	821,731,195
F	**Road Works Cat Hai**		**85,276,026**	**744,230,726,250**	**767,047,054,374**	**2,866,838,366**
	F1	Highway	16,598,550	345,023,139,949	349,464,223,561	1,306,122,536
	F2	Soft Soil Ground Improvement	19,480,740	340,739,985,043	345,952,223,170	1,292,996,434
	F3	Drainage and Under-pass Culvert	48,175,935	57,392,321,303	70,282,203,455	262,679,735
	F4	Frontage Road	1,020,802	1,075,279,955	1,348,404,188	5,039,661
G	**Lighting and Electrical**		**1,131,431**	**56,611,581,892**	**56,914,305,881**	**212,717,218**
H	**Provisional Sums**		**0**	**302,869,386,036**	**302,869,386,036**	**1,131,974,330**
	H1	Soil Investigation Hai An Side		5,513,382,708	5,513,382,708	20,606,268
	H2	Soil Investigation Cat Hai Side		3,614,695,381	3,614,695,381	13,509,924
	H3	HIV Countermeasure		11,052,996,256	11,052,996,256	41,310,574
	H4	Maintenance and Protection of Traffic		9,762,017,358	9,762,017,358	36,485,540
	H5	Environmental Control and Protection		7,872,429,591	7,872,429,591	29,423,206
	H6	Temporary Navigation Roadsmarker Buoys for Existing Navigation Channel		82,976,072,424	82,976,072,424	310,123,071
	H7	Import Tax (10%)		182,077,792,318	182,077,792,318	680,515,749
I		**SUB TOTAL, A+B +C+D+E+F+G+H**	**10,977,076,332**	**4,462,239,203,890**	**7,399,249,593,625**	**27,654,695,356**
II.	**Price Escalation (I×10.3% (L), I×1.8% (F))**		557,100,309	1,408,062,216,710	1,557,119,155,693	5,819,732,844
III.	**Physical Contingency ((I+II+IV)×5%)**		626,691,832	296,617,421,030	464,294,165,392	1,735,299,443
IV.	**Cosulting Service**		999,660,000	62,047,000,000	329,514,558,528	1,231,560,663
V.	**Land Acquisition**			314,131,878,000	314,131,878,000	1,174,067,894
VI.	**Administration Cost ((I+II+III+IV+V)×5%)**			327,154,885,982	327,154,885,982	1,222,741,386
VII.	**VAT ((I+II+III+IV)×10%)**			975,017,747,324	975,017,747,324	3,644,128,831
VIII.	**Interest during Construction**		103,895,989	52,498,206,610	80,296,464,413	300,108,036
IX.	**Commitment Charge**		92,850,971		24,843,069,226	92,850,971
	TOTAL Project Cost		**13,357,275,433**	**7,897,768,559,546**	**11,471,621,518,184**	**42,875,185,424**

Source: JICA study team (Exchange rate: 1 VND=0.0037375 JPY)

15.4.5 Comparison of Construction Cost with SAPROF

Table 15.4.5-1 Project Cost based on M/D (19th March 2010) of Road and Bridge Portion of "Lach Huyen Port Infrastructure Construction Project"

SUMMARY OF PROJECT COST (The consultant's recommendation cost)

THE DETAILED DESIGN STUDY FOR LACH HUYEN PORT INFRASTRUCTURE CONSTRUCTION PROJECT IN VIET NAM

BILL NO		CONSTRUCTION ITEMS	FOREIGN CURRENCY (J.YEN)	LOCAL CURRENCY (VND)	CURRENCY in VND	CURRENCY in JPY
A1	**General Requirements**		**269,035,584**	**93,189,938,142**	**165,172,703,153**	**617,332,978**
A2	**Temporary Facilities**		**521,867,167**	**906,390,205,050**	**1,046,020,216,360**	**3,909,500,559**
	A2-1	Entrance Access Road	0	6,600,497,606	6,600,497,606	24,669,360
	A2-2	Site Access Road	0	373,470,776,614	373,470,776,614	1,395,847,028
	A2-3	Site Compound	0	154,164,959,139	154,164,959,139	576,191,535
	A2-4	Temporary Birdge	35,711,420	9,168,095,887	18,722,990,871	69,977,178
	A2-5	Dredging to Open a Temporary Channel	5,934,629	286,112,701,965	287,700,562,591	1,075,280,853
	A2-6	Temporary Jetty for Loading and Unloading	284,754,095	44,205,916,961	120,394,303,705	449,973,710
	A2-7	Temporary water Cutoff	195,467,023	32,667,256,878	84,966,125,835	317,560,895
B	**Road Works Hai An**		**202,570,062**	**775,350,085,636**	**829,549,433,280**	**3,100,441,007**
	B1	Highway	18,364,876	248,217,896,225	253,131,575,520	946,079,264
	B2	Cam River Bridge	114,709,161	112,458,016,028	143,149,430,318	535,020,996
	B3	Soft Soil Ground Improvement	54,757,129	397,179,418,592	411,830,155,472	1,539,215,206
	B4	Drainage Culvert	14,738,895	17,494,754,791	21,438,271,969	80,125,541
C	**Approach Bridge Works Hai An**		**10,171,966,275**	**989,038,911,887**	**3,710,635,239,768**	**13,868,499,209**
	C1	Superstructure	7,741,243,030	484,575,093,466	2,555,810,686,777	9,552,342,442
	C2	Foundation	2,430,723,245	504,463,818,421	1,154,824,552,991	4,316,156,767
D	**Main Bidge Works**		**806,937,375**	**285,144,487,970**	**501,047,464,437**	**1,872,664,898**
	D1	Superstructure	385,123,038	241,211,828,163	344,254,781,522	1,286,652,246
	D2	Substructure	421,814,336	43,932,659,807	156,792,682,915	586,012,652
E	**Approach Bridge Works Cat Hai**		**681,897,751**	**234,391,135,988**	**416,838,694,760**	**1,557,934,622**
	E1	Superstructure	355,166,682	101,203,644,847	196,231,519,581	733,415,304
	E2	Substructure	326,731,069	133,187,491,141	220,607,175,179	824,519,317
F	**Road Works Cat Hai**		**85,814,526**	**744,230,726,250**	**767,191,134,642**	**2,867,376,866**
	F1	Highway	16,625,226	345,023,139,949	349,471,361,050	1,306,149,212
	F2	Soft Soil Ground Improvement	19,584,100	340,739,985,043	345,979,878,019	1,293,099,794
	F3	Drainage and Under-pass Culvert	48,584,398	57,392,321,303	70,391,491,385	263,088,199
	F4	Frontage Road	1,020,802	1,075,279,955	1,348,404,188	5,039,661
G	**Lighting and Electrical**		**1,131,431**	**56,611,581,892**	**56,914,305,881**	**212,717,218**
H	**Provisional Sums**		**0**	**344,249,748,888**	**344,249,748,888**	**1,286,633,436**
	H1	Soil Investigation Hai An Side		5,513,382,708	5,513,382,708	20,606,268
	H2	Soil Investigation Cat Hai Side		3,614,695,381	3,614,695,381	13,509,924
	H3	HIV Countermeasure		11,052,996,256	11,052,996,256	41,310,574
	H4	Maintenance and Protection of Traffic		9,762,017,358	9,762,017,358	36,485,540
	H5	Environmental Control and Protection		7,872,429,591	7,872,429,591	29,423,206
	H6	Temporary Navigation Roadsmarker Buoys for Existing Navigation Channel		82,976,072,424	82,976,072,424	310,123,071
	H7	Import Tax (10%)		223,458,155,170	223,458,155,170	835,174,855
I		**SUB TOTAL, A+B +C+D+E+F+G+H**	**12,741,220,172**	**4,428,596,821,703**	**7,837,618,941,168**	**29,293,100,793**
II.	**Price Escalation (I×10.3%(L), I×1.8%(F))**		646,632,809	1,397,446,343,138	1,570,458,465,883	5,869,588,516
III.	**Physical Contingency ((I+II+IV)×5%)**		719,375,649	294,404,508,242	486,879,598,279	1,819,712,499
IV.	**Cosulting Service**		999,660,000	62,047,000,000	329,514,558,528	1,231,560,663
V.	**Land Acquisition**			314,131,878,000	314,131,878,000	1,174,067,894
VI.	**Administration Cost ((I+II+III+IV+V)×5%)**			324,831,327,554	324,831,327,554	1,214,057,087
VII.	**VAT ((I+II+III+IV)×10%)**			1,022,447,156,386	1,022,447,156,386	3,821,396,247
VIII.	**Interest during Construction**		120,456,804	52,102,801,659	84,332,046,850	315,191,025
IX.	**Commitment Charge**		106,591,418		28,519,442,952	106,591,418
	TOTAL Project Cost		**15,333,936,851**	**7,896,007,836,682**	**11,998,733,415,601**	**44,845,266,141**

Source: JICA study team (Exchange rate: 1 VND=0.00532 JPY)

The total amount of a direct cost of construction is 35,261 million yen (6,628 Billion VND).

The rate of increase of a direct cost of construction is +38.3% as compared with SAPROF. The increase items will be explained by the following paragraph.

The temporary road plan which was being taken into consideration by the basic design reconsidered the structure in consideration of reduction of the construction cost.

About the cut in the construction cost, manufacture of a SBS girder, the unit price of PC tendon, the unit price of Bearing, etc. were reconsidered.

The construction cost of the detail design is 35,261 million yen became large increase compared with 25,518 million yen of SAPROF.

The factor of construction cost increase is in increase of temporary expense. Increase of the temporary road installation expense and temporary construction expense of bridge is especially remarkable.

Table 15.4.5-2 Comparison of a direct construction cost (without VAT)

ITEM	Detail Design	SAPROF	Balance	
	(million VND)	(million VND)	(million VND)	(million JPY)
I.General	**1,210,729**	**502,560**	**708,169**	**3,767**
(1) Contractor’s Mobilization	129,639	94,050	35,589	189
(2) Temporary road	385,162	408,510	-23,348	-124
(3) Site compound	205,317	0	205,317	1,092
(4) Dredging to Open a Temporary Channel	287,336	0	287,336	1,529
(5) Temporary Jetty	120,334	0	120,334	640
(6) Temporary Water Cutoff	72,950	0	72,950	388
(7) Contractor's drawings	9,992	0	9,992	53
II. Highway works (Hai An)	**820,040**	**782,900**	**37,140**	**198**
(1) Embankment	117,310	93,226	24,084	128
(2) Soft soil treatment	409,019	377,427	31,592	168
(3) Drainage	29,176	0	29,176	155
(4) Pavement	87,733	25,709	62,024	330
(5) Traffic safety	18,773	4,845	13,929	74
(6) Culvert	21,350	17,338	4,012	21
(7) Cam river bridge	136,679	20,156	116,523	620
(8) Tan Vu IC	0	244,199	-244,199	-1,299
III. Bridge works	**3,525,208**	**2,873,974**	**651,234**	**3,465**
(1) App. Br. (Hai An) Superstructure	1,660,106	965,931	694,174	3,693
(2) App. Br. (Hai An) Substructure	1,038,283	801,958	236,325	1,257
(3) Main bridge Superstructure	316,993	154,505	162,488	864
(4) Main bridge Substructure	136,021	440,485	-304,464	-1,620
(5) App. Br. (Cat Hai) Superstructure	168,711	109,199	59,512	317
(6) App. Br. (Cat Hai) Substructure	205,095	111,312	93,782	499
(7) Retaining wall	0	290,583	-290,583	-1,546
IV. Highway works (Cat Hai)	**765,110**	**609,570**	**155,540**	**827**
(1) Embankment	196,314	177,784	18,530	99
(2) Soft soil treatment	344,710	324,234	20,476	109
(3) Drainage	26,487	0	26,487	141
(4) Pavement	104,761	55,603	49,158	262
(5) Traffic safety	21,815	7,009	14,806	79
(6) Culvert	69,674	44,939	24,735	132
(7) Frontage Road	1,348	0	1,348	7.2
V. Electric	**56,314**	**23,155**	**33,160**	**176**
(1) Lighting	56,314	23,155	33,160	176
VI. Provisional Sums	**250,592**	**0**	**250,592**	**1,333**
(1) Land Lease cost	0		0	0
(2) Soil investigation Hai An side	5,513		5,513	29
(3) Soil Investigation Cat Hai side	3,615		3,615	19
(4) HIV Countermeasure	9,009		9,009	48
(5) Maintenance and Protection of Traffic	9,759		9,759	52
(6) Environmental Control and Protection	7,872		7,872	42
(7) Temporary Navigation Roadsmarker Buoys for	82,976		82,976	441
(8) Water Connection and Power Connection	0		0	0
(9) Import Tax	131,848		131,848	701
Total	**6,627,994**	**4,792,158**	**1,835,836**	**9,767**

Source: JICA study team (Exchange Rate based on M/D)

The detail factors of increase amount are shown in the following table.

Table 15.4.5-3 The Detail Factor of Change

ITEM	Detail Design	The Breakdown According to Change Factor (million JPY)						
	(million VND)	Update of the Unit Price	Changed by site investigation	Change by a geological survey result	Design examination	Hai Phong City's request	Change quantity and Other	Total (million JPY)
I.General	**1,210,729**	**189**	**0**	**0**	**3,525**	**0**	**53**	**3,767**
(1) Contractor's Mobilization	129,639	189						189
(2) Temporary road	385,162				-124			-124
(3) Site compound	205,317				1,092			1,092
(4) Dredging to Open a Temporary Channel	287,336				1,529			1,529
(5) Temporary Jetty	120,334				640			640
(6) Temporary Water Cutoff	72,950				388			388
(7) Contractor's drawings	9,992						53	53
II. Highway works (Hai An)	**820,040**	**924**	**30**	**-637**	**-741**	**620**	**0**	**198**
(1) Embankment	117,310	27	0		101			128
(2) Soft soil treatment	409,019	805		-637				168
(3) Drainage	29,176	0			155			155
(4) Pavement	87,733	98			231			330
(5) Traffic safety	18,773	3			71			74
(6) Culvert	21,350	-9	30					21
(7) Cam river bridge	136,679					620		620
(8) Tan Vu IC	0				-1,299			-1,299
III. Bridge works	**3,525,208**	**2,282**	**-1,194**	**0**	**1,065**	**0**	**1,311**	**3,465**
(1) App. Br. (Hai An) Superstructure	1,660,106	386			2,533		773	3,693
(2) App. Br. (Hai An) Substructure	1,038,283	2,232	-975					1,257
(3) Main bridge Superstructure	316,993	23			324		518	864
(4) Main bridge Substructure	136,021	-671			-948			-1,620
(5) App. Br. (Cat Hai) Superstructure	168,711	147			149		21	317
(6) App. Br. (Cat Hai) Substructure	205,095	165	-219		553			499
(7) Retaining wall	0				-1,546			-1,546
IV. Highway works (Cat Hai)	**765,110**	**889**	**225**	**-599**	**306**	**0**	**0**	**827**
(1) Embankment	196,314	143			-44			99
(2) Soft soil treatment	344,710	708		-599				109
(3) Drainage	26,487	0			141			141
(4) Pavement	104,761	121			141			262
(5) Traffic safety	21,815	11			68			79
(6) Culvert	69,674	-94	225					132
(7) Frontage Road	1,348	0.6	5.0		1.1			6.7
V. Electric	**56,314**	**0**	**0**	**0**	**176**	**0**	**0**	**176**
(1) Lighting	56,314				176			176
VI. Provisional Sums	**250,592**	**0**	**0**	**0**	**1,333**	**0**	**0**	**1,333**
(1) Land Lease cost	0				0			0
(2) Soil investigation Hai An side	5,513				29			29
(3) Soil Investigation Cat Hai side	3,615				19			19
(4) HIV Countermeasure	9,009				48			48
(5) Maintenance and Protection of Traffic	9,759				52			52
(6) Environmental Control and Protection	7,872				42			42
(7) Temporary Navigation Roadsmarker Buoys for	82,976				441			441
(8) Water Connection and Power Connection	0				0			0
(9) Import Tax	131,848				701			701
Total	**6,627,994**	**4,284**	**-939**	**-1,236**	**5,664**	**620**	**1,365**	**9,767**
	JPY							
The rate of increase from SAPROF	**35,261**	**16.8%**	**-3.7%**	**-4.8%**	**22.2%**	**2.4%**	**5.4%**	**38.3%**

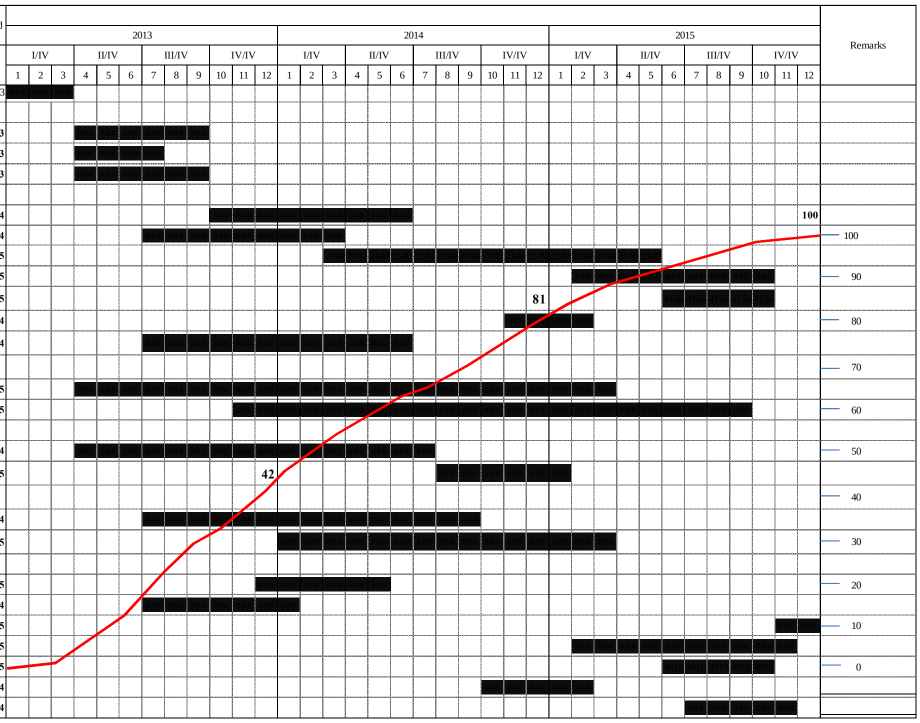
Source: JICA study team (Exchange Rate based on M/D)

15.5 Annual Fund Requirement

The output computed based on the process taken into consideration by the execution scheme is as follows.

Table 15.5-1 The output by year (Based on the construction plan)

Construction Item	Construction Direct Cost (million VND)	Construction period Start	Construction period End
Preparation Work	492,394	Jan-13	Mar-13
Temporary work	1,219,185		
Temporary road	444,018	**Apr-13**	**Sep-13**
Site Compound	225,849	**Apr-13**	**Jul-13**
Other temporary work	549,318	**Mar-13**	**Sep-13**
Highway work (Hai An)	911,294		
Embankment	129,041	**Oct-13**	**Jun-14**
Soft soil treatment	452,905	**Jul-13**	**Apr-14**
Drainage	32,093	**Mar-14**	**May-15**
Pavement	96,507	**Feb-15**	**Oct-15**
Traffic safety	20,780	**Jun-15**	**Oct-15**
Box culvert	23,582	**Nov-13**	**Oct-14**
Cam River Bridge	156,385	**Jul-13**	**Jun-14**
Approach bridge (Hai An)	3,605,222		
Substructure	1,266,992	**Apr-13**	**Mar-15**
Superstructure	2,338,230	**Nov-13**	**Sep-15**
Main bridge	548,944		
Substructure	172,451	**Apr-13**	**Jul-14**
Superstructure	376,493	**Aug-14**	**Jan-15**
Approach bridge (Cat Hai)	455,779		
Substructure	241,847	**Apr-13**	**May-14**
Superstructure	213,932	**Jan-14**	**Mar-15**
Highway work (Cat Hai)	843,752		
Embankment	217,431	**Dec-13**	**Mar-15**
Soft soil treatment	380,547	**Jul-13**	**Jan-14**
Drainage	29,135	**Feb-14**	**Apr-15**
Pavement	115,237	**Mar-15**	**Jun-15**
Traffic safety	24,091	**Feb-14**	**Jun-15**
Box culvert	77,310	**Jul-13**	**Nov-14**
Erectrical work	62,606	**Jul-13**	**Nov-14**



Source: JICA study team

The outputs at a given fiscal year are 2013 (42%), 2014 (39%), 2015 (19%).

Price escalation Rate:

Detailed information is to be referred to Section 2.7 2012

F/C portion: 1.8% per year

L/C portion: 10.3% per year

Table 15.5-2 Yearly Price Index

Yearly Price Index (Index2011=100)

Year	2011		2012		2013		2014		2015		2016	
F/C, L/C	F/C	L/C	F/C	L/C	F/C	L/C	F/C	L/C	F/C	LC	F/C	LC
Price Index	100	100	101.8	110.3	103.63	121.66	105.50	134.19	107.40	148.01	111.30	180.07

Source : JICA study team

Physical Contingency Rate: 5.0%

Interest during Construction

Construction Cost: 0.2% per year

Consulting Services : 0.01% per year

Commitment Charge: Loan Amount x number of years of the disbursement period x 0.1%

Table 15.5-3 Annual Fund Requirement

Table 3-3 Annual Fund Requirement (Eligible Portion)

(1) Eligible Portion

(F/C&Total+ Million JPY, L/C: Billion VND)

Item	Yearly Cost during Construction Period																					Total (Million JPY)		
	2012			2013			2014			2015			2016			2017			2018					
	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total
(1) Construction Cost	0	0	0	4,610	1,874	11,615	4,281	1,740	10,785	2,086	848	5,254	0	0	0	0	0	0	0	0	0	10,977	4,462	27,655
(2) Price Contingency = (1) x {Yearly Price index}	0	0	0	167	406	1,685	235	595	2,459	154	407	1,676	0	0	0	0	0	0	0	0	0	557	1,408	5,820
(3) Physical contingency = {(1)+(2)} x 5%	0	0	0	260	115	691	245	118	686	121	63	358	0	0	0	0	0	0	0	0	0	627	297	1,735
sub-total = (1)+(2)+(3)	0	0	0	5,038	2,395	13,991	4,762	2,453	13,931	2,361	1,318	7,288	0	0	0	0	0	0	0	0	0	12,161	6,167	35,210
(4) Consulting Services for Construction Supervision	0	0	0	420	26	517	390	24	480	190	12	234	0	0	0	0	0	0	0	0	0	1,000	62	1,232
(5) Interest during Consturction	0	0	0	51	24	141	38	20	112	15	8	47	0	0	0	0	0	0	0	0	0	104	52	299
(6) Commitment Charge	13	0	13	13	0	13	13	0	13	13	0	13	13	0	13	13	0	13	13	0	13	93	0	93
Total = (1)+(2)+(3)+(4)+(5)+(6)	13	0	13	5,522	2,446	14,662	5,203	2,497	14,536	2,580	1,338	7,582	13	0	13	13	0	13	13	0	13	13,358	6,281	36,834

(2) Non Eligible Portion (For Reference Only)

Item	Yearly Cost during Construction Period																					Total (Million JPY)		
	2012			2013			2014			2015			2016			2017			2018					
	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total
(7) Environmental Management and Monitoring Cost	0	140	523	0	146	546	0	22	82	0	6	22	0	0	0	0	0	0	0	0	0	0	314	1,174
(8) Administration Cost	0	20	73	0	46	171	0	196	734	0	65	245	0	0	0	0	0	0	0	0	0	0	327	1,223
(9) Value Added Tax (VAT)	0	0	0	0	388	1,451	0	386	1,441	0	201	752	0	0	0	0	0	0	0	0	0	0	975	3,644
Total = (7)+(8)+(9)	0	160	597	0	580	2,168	0	604	2,257	0	273	1,019	0	0	0	0	0	0	0	0	0	0	1,616	6,041
Grand Total Annual Requrement = sum{(1):(10)}	13	160	610	5,522	3,026	16,830	5,203	3,101	16,793	2,580	1,611	8,602	13	0	13	13	0	13	13	0	13	13,358	7,897	42,875

Souse: JICA study team

15.6 Procurement Ratio from Japan

This Project is expected to apply STEP scheme. Therefore, the procurement ratio and goods and services expected to be procured from Japan were calculated in this Study.
Table 15.6-1 shows the procurement ratio from Japan

Table 15.6-1 Summary of Procurement Ratio from Japan

Construction Cost		27,654,695,356	
Goods procured from Japan			
1	Erection Girder	747,587,664	2.7%
2	Steel Pipe Pile	2,035,712,126	7.4%
3	Steel Pipe Sheet Pile	514,746,321	1.9%
4	PC Strand	1,529,879,869	5.5%
5	Reinforcement Steel	0	0.0%
6	Cement	267,776,304	1.0%
7	Bearing	1,451,862,759	5.2%
8	Steel Sheet Pile for Cofferdam	855,038,150	3.1%
9	H-shaped Steel for Jetty	569,142,301	2.1%
10	Japanese Engineer	315,061,980	1.1%
11	Japanese Skilled Labor	0	0.0%
12	Administration Overhead	1,852,509,503	6.7%
Total		10,139,316,976	36.7%

Source: JICA study team

CHAPTER 16 Project Effectiveness

16.1 General

Based on the detailed design and forecasted demand, economic analysis is carried out in order to evaluate effectiveness of the Project. The economic effectiveness is examined quantitatively with such indicators as Net Present Value (NPV), Economic Internal Rate of Return (EIRR), and Benefit/Cost (B/C) ratio. The analysis basically follows the process used in the Preparatory Survey with revision of input values and parameters. Meanwhile, financial analysis is not conducted in This Study, since MOT and JICA agreed that Tan Vu – Lach Huyen road would be developed as a freeway without toll collection from users.

Following the economic analysis, this chapter examines operation and effect indicators for monitoring of project effectiveness after completion.

16.2 Economic Analysis

16.2.1 Review of the Existing Studies

Economic viability of the project has been assessed both in the VIDFI's Feasibility Study (hereinafter F/S, 2009) and the JICA's Preparatory Survey (2010). Economic analysis in This Study principally follows an approach in the latter survey which carefully reviewed settings in the F/S. Comparison with the past studies and This Study are summarized in the following table.

The major points revised from the Preparatory Survey are; (i) setting of traffic volume in the "without project case"; (ii) inclusion of opportunity cost of freight; and (iii) calculation of operation cost of vessels (barge and ferry). In addition, unit values of benefit are updated in This Study.

Table 16.2.1-1 Comparison of Economic Analysis of the Past Studies and This Study

Item	F/S (2009)	Preparatory Survey (2010)	This Study (2012)
Traffic Demand Forecast	Based on traffic survey in 2008 (Target year: 2015-2032)	Updated in 2010 (Target year: 2015-2035)	Updated in 2012 (Target year: 2015-2035)
Project Life for Analysis	2008-2048 (35 years after completion)	2011-2035 (20 years after completion)	2012-2035 (20 years after completion)
Benefit Items			
- VOC saving	Calculated	Unit value is revised.	Operating cost of ferry is considered.
- TTC saving	Single unit value is applied to all vehicle types.	Unit value is revised by vehicle type.	Opportunity cost of freight is considered.
- Others	Accident cost saving and financial revenue*	Container transport cost saving (as operating cost of barge)	Container transport cost saving is considered in VOC & TTC savings.

* It is not common to include such financial revenues as road toll, tax reimbursement, and advertisement to economic analysis.

Source : Study Team

16.2.2 Preconditions of the Analysis

(1) General Conditions

In accordance with recent studies on highway development in Viet Nam, general conditions of the economic analysis are set as follows.

- Base year of price: November, 2012
- Evaluation period: 2012-2035 (20 years after completion)
- Base currency: VND (USD 1 = VND 20,860, VND 1 = JPY 0.00374)
- Social discount rate: 12.0 %
- Standard Conversion Factor (SCF): 0.85
- Benefit items: Savings in Vehicle Operating Cost (VOC) and Travel Time Cost (TTC) of both passenger and freight transport
- Salvage value is not considered at the end of project life.
- Evaluation indicators: EIRR, NPV, and B/C ratio

(2) Cases for Comparison

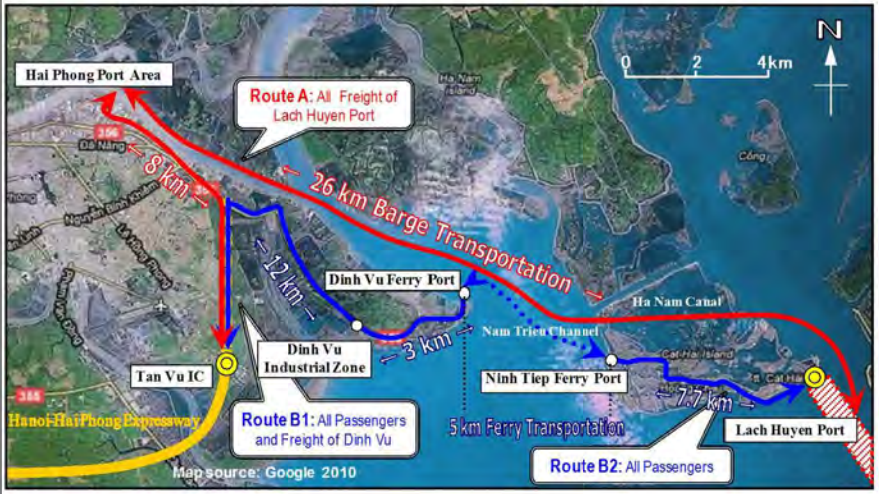
Effectiveness of the Project is figured out by comparison of two cases; “with” and “without” cases of the Project. In the “with project case”, it is assumed that the Tan Vu-Lach Huyen Highway will open in 2016 and connect directly Lach Huyen Port to Tan Vu Interchange, and all traffic of passenger and freight in and out of the Lach Huyen port pass through the road and bridge constructed by the Project.

On the other hand, the “without project case” does not assume construction of the Tan Vu-Lach Huyen Highway, though the Lach Huyen Port is supposed to start operation from 2016. In this case, passenger and freight traffic has to go over Nam Trieu Channel by using vessels. Considering capacity limitation, the existing ferry route between Dinh Vu and Ninh Tiep will be used only by passengers, and freight needs to be trans-loaded to barge and shipped between Haiphong Port and Lach Huyen Port.

The following tables summarize the concrete routes and conditions of each case.

Table 16.2.2-1 Summary of Project Cases for Evaluation

Without Project Case



With Project Case

Without Project Case	With Project Case
Route A - All freight of Lach Huyen Port use this route. - Road transport between Tan Vu IC and Haiphong Port Area (8 km) - Barge transport between Haiphong Port and Lach Huyen Port (26 km)	**Route C** - All passengers and freight use this route. - Road transport between Tan Vu IC and Lach Huyen Port (15.6 km)
Route B1 - All passengers and freight of industrial zones in Dinh Vu use this route. - Road transport between Tan Vu IC and Dinh Vu Industrial Zone (12 km)	**<Common Preconditions in Both Cases>** - Lach Huyen Port starts operation in 2015. - Industrial zones in Dinh Vu are developed as planned. - Hanoi-Haiphong Expressway starts operation until 2015.
Route B2 - All passengers use this route. - Road transport between Dinh Vu Industrial Zone and Dinh Vu ferry port (3 km) + between Ninh Tiep ferry port and Lach Huyen Port (7.7 km) - Ferry transport between Dinh Vu ferry port and Ninh Tiep ferry port (5 km)	

Source : Study Team

Table 16.2.2-2 Conditions of Each Section

Case	Route and Section		Distance (km)	Travel Time by Vehicle Type (hour)				
				MC	Car	Bus	HGV	Barge/ Ferry
Without Project	**Route A**		**34.0**				**0.20**	
		Tan Vu IC - Hai Phong Port Area	8.0				0.20	
		Hai Phong Port - Lach Huyen Port	26.0					4.00
	Route B		**22.7**	**0.57**	**0.57**	**0.57**	**0.57**	
		Tan Vu IC - Dinh Vu Industrial Zone	12.0	0.30	0.30	0.30	0.30	
		Dinh Vu Industtrial Zone - Ferry Port	3.0	0.08	0.08	0.08	0.08	
		Dinh Vu Ferry Port - Ninh Tiep Ferry Port*						1.00
		Ninh Tiep Ferry Port - Lach Huyen Port	7.7	0.19	0.19	0.19	0.19	
	Typical Speed on Local Roads (km/h)			40	40	40	40	
With Project	**Route C**		**15.6**	**0.26**	**0.20**	**0.20**	**0.20**	
		Tan Vu IC - Dinh Vu Intersection No. 1	2.8	0.05	0.04	0.04	0.04	
		Dinh Vu Intersection No. 1 - Lach Huyen Port	12.8	0.21	0.16	0.16	0.16	
	Typical Speed on Highway (km/h)			60	80	80	80	

* Waiting time is included.

Source : Study Team

(3) Traffic Demand

The evaluation is based on the result of traffic demand forecast done by four vehicle types updated in This Study. The forecasted volume is regarded as traffic for the “with case” at target years (2020, 2030 and 2035), from which traffic volume of each year is derived. Meanwhile in the case of “without project”, different routes are used by type of transport (i.e. route A, B1 and B2) and traffic volume of each route is estimated from that in the “with case”.

Passengers use the aforementioned routes B1 and B2, where the traffic is bottlenecked by capacity of ferries over Nam Trieu Channel. In this analysis, the maximum number of ferry is assumed, and it determines possible traffic volume in one direction between Dinh Vu and Cat Hai Island. Specifically, it is assumed that 8 ferries carrying 90 PCU each are operated every 15 minutes during the whole day (24 hours) at both sides of the existing ferry route. Under this condition, trips can be made up to 96 times/day in one direction and it can accommodate 8,640 PCU/day. This capacity is considered as the maximum transport volume in the route B2, and it also affects demands in the route B1. That means decreased demand in the route B2 is deducted from that in the route B1 as summarized in figure below.

Table 16.2.2-3 Traffic Volume Used for Benefit Calculation

Without Project Case — Unit: vehicle/day (both directions)

Route	Route A	Route B1					Route B2			
Section	TV - HPP	Tan Vu IC - Dinh Vu Industrial Zone					Dinh Vu Industrial Zone - Lach Huyen Port			
Vehicle	HGV*	MC***	Car	Bus***	HGV**	Total	MC***	Car	Bus	Total
2016	1,601	0	1,346	2,061	597	4,003	25,494	828	936	27,259
2017	2,510	0	1,732	2,231	525	4,488	25,939	996	975	27,910
2018	3,420	0	2,119	2,400	454	4,973	26,383	1,163	1,015	28,561
2019	4,329	0	2,338	2,478	365	5,181	26,383	1,163	1,015	28,561
2020	5,238	0	2,557	2,555	286	5,398	26,383	1,163	1,015	28,561
2021	6,152	0	3,374	2,670	637	6,680	26,383	1,163	1,015	28,561
2022	7,066	0	4,190	2,785	973	7,948	26,383	1,163	1,015	28,561
2023	7,980	0	5,006	2,900	1,300	9,206	26,383	1,163	1,015	28,561
2024	8,894	0	5,823	3,015	1,618	10,456	26,383	1,163	1,015	28,561
2025	9,808	0	6,639	3,130	1,932	11,701	26,383	1,163	1,015	28,561
2026	10,722	0	7,456	3,245	2,242	12,942	26,383	1,163	1,015	28,561
2027	11,636	0	8,272	3,360	2,548	14,180	26,383	1,163	1,015	28,561
2028	12,550	0	9,088	3,475	2,852	15,415	26,383	1,163	1,015	28,561
2029	13,464	0	9,905	3,589	3,154	16,648	26,383	1,163	1,015	28,561
2030	14,378	28,632	10,721	3,704	3,684	46,741	26,383	1,163	1,015	28,561
2031	16,267	28,632	13,346	3,897	4,722	50,597	26,383	1,163	1,015	28,561
2032	18,156	28,632	15,970	4,089	5,756	54,448	26,383	1,163	1,015	28,561
2033	20,044	28,632	18,595	4,281	6,787	58,295	26,383	1,163	1,015	28,561
2034	21,933	28,632	21,220	4,474	7,815	62,141	26,383	1,163	1,015	28,561
2035	23,822	28,632	23,844	4,666	8,842	65,984	26,383	1,163	1,015	28,561

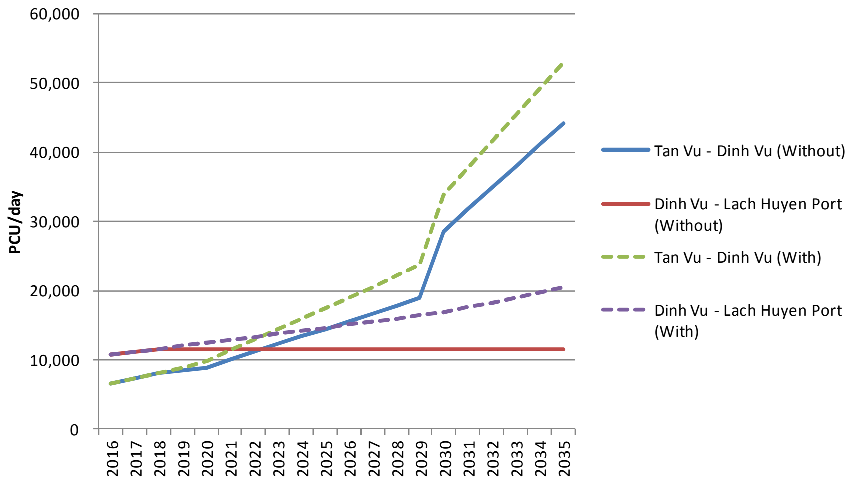
Note: (*) This route is used for freight of Lach Huyen Port.
(**) This route is used for freight of industrial zones in Dinh Vu.
(***) Reduced traffic volume of MC is converted to that of bus in route B1.

With Project Case — Unit: vehicle/day (both directions)

Route	Route C									
Section	Tan Vu IC - Dinh Vu Intersection #1					Dinh Vu Intersection #1 - Lach Huyen Port				
Vehicle	MC	Car	Bus	HGV	Total	MC	Car	Bus	HGV	Total
2016	0	1,346	2,061	2,198	5,604	25,494	828	936	1,601	28,860
2017	0	1,732	2,231	3,036	6,998	25,939	996	975	2,510	30,420
2018	0	2,119	2,400	3,873	8,393	26,383	1,163	1,015	3,420	31,981
2019	0	2,505	2,570	4,711	9,787	26,828	1,331	1,054	4,329	33,541
2020	**0**	**2,892**	**2,740**	**5,549**	**11,181**	**27,272**	**1,498**	**1,093**	**5,238**	**35,101**
2021	0	3,942	2,939	6,868	13,748	27,617	1,731	1,135	6,152	36,635
2022	0	4,991	3,137	8,186	16,315	27,961	1,964	1,178	7,066	38,169
2023	0	6,041	3,336	9,505	18,881	28,306	2,198	1,220	7,980	39,703
2024	0	7,090	3,534	10,823	21,448	28,650	2,431	1,262	8,894	41,237
2025	0	8,140	3,733	12,142	24,015	28,995	2,664	1,305	9,808	42,772
2026	0	9,190	3,932	13,461	26,582	29,340	2,897	1,347	10,722	44,306
2027	0	10,239	4,130	14,779	29,149	29,684	3,130	1,389	11,636	45,840
2028	0	11,289	4,329	16,098	31,715	30,029	3,364	1,431	12,550	47,374
2029	0	12,338	4,527	17,416	34,282	30,373	3,597	1,474	13,464	48,908
2030	**28,632**	**13,388**	**4,726**	**18,735**	**65,481**	**30,718**	**3,830**	**1,516**	**14,378**	**50,442**
2031	28,632	16,472	5,022	21,874	72,000	31,133	4,289	1,570	16,267	53,259
2032	28,632	19,555	5,318	25,013	78,519	31,549	4,748	1,624	18,156	56,076
2033	28,632	22,639	5,615	28,153	85,038	31,964	5,207	1,678	20,044	58,894
2034	28,632	25,722	5,911	31,292	91,557	32,380	5,666	1,732	21,933	61,711
2035	**28,632**	**28,806**	**6,207**	**34,431**	**98,076**	**32,795**	**6,125**	**1,786**	**23,822**	**64,527**

Note: Bold letters represent target years of demand forecast in This Study.

Source : Study Team



Source : Study Team

Figure 16.2.2-1 Comparison of Passenger Transport PCU

On the other hand, freight of Lach Huyen Port is transported by barge on the route A, since the volume is too heavy to be handled by the limited ferry capacity. Following the assumption in the Preparatory Survey, freight equivalent to 90 TEU is loaded on one barge and shipped with a tugboat. Based on this condition and demand forecast, the total number of trip reaches 394 times per day in 2035 to carry more than 35,000 TEU of freight between two ports, for instance. It requires 99 barges and 60 tugboats. The following analysis grounds on this assumption for comparison, though this "without project case" is not realistic considering the actual capacity of Haiphong Port and Nam Trieu Channel.

Table 16.2.2-4 Demand of Barge Transport

	Freight Demand	Number of Trip	Number of Barge	Number of Tugboat
	TEU/day	trip/day	ship/day	ship/day
2016	1,833	21	6	4
2017	2,742	31	8	5
2018	3,652	41	11	7
2019	4,561	51	13	8
2020	5,471	61	16	10
2021	7,464	83	21	13
2022	9,458	106	27	17
2023	11,452	128	32	20
2024	13,445	150	38	23
2025	15,439	172	43	26
2026	17,432	194	49	30
2027	19,426	216	54	33
2028	21,419	238	60	36
2029	23,413	261	66	40
2030	25,407	283	71	43
2031	27,400	305	77	47
2032	29,394	327	82	50
2033	31,387	349	88	53
2034	33,381	371	93	56
2035	35,374	394	99	60

Source : Study Team

Besides of ocean cargo, there exist freight transport between Tan Vu and Dinh Vu in the “without project case”, since industrial zones in Dinh Vu would be developed regardless of the Project. This traffic is also counted in This Study, while it may have overlooked in the Preparatory Survey.

16.2.3 Evaluation of Project Benefits

(1) Benefit Items

Savings of VOC and TTC are assessed as the most common benefit items quantified in evaluation of road development projects. The difference of VOC and TTC between “with” and “without” conditions can be seen as benefits, and it is calculated following the equation below. According to the Preparatory Survey, the large portion of benefits came from savings in freight transport, so saving of accident cost is not counted as a benefit item in This Study. Specific items considered as VOC and TTC are summarized in the table below.

$$(Saving\ of\ VOC) = VOC_O - VOC_W$$

$$VOC_i = \sum_j \sum_l (Q_{ijs} \times L_l \times \alpha_j) \times 365$$

$$(Saving\ of\ TTC) = TTC_O - TTC_W$$

$$TTC_i = \sum_j \sum_l (Q_{ijs} \times T_{ijs} \times \beta_j) \times 365$$

Where:

- VOC_i : Vehicle operating cost in case i (VND/year)
- TTC_i : Travel time cost in case i (VND/year)
- Q_{ijs} : Traffic volume of vehicle type j on section s in case i (vehicle/day)
- L_l : Length of section s (km)
- T_{ijs} : Travel time of vehicle type j on section s in case i (hour)
- α_j : Unit value of VOC of vehicle type j (VND/vehicle/km)
- β_j : Unit value of TTC of vehicle type j (VND/vehicle/hour)
- i : Without case (O) and With case (W)
- j : Vehicle types
- s : Section

Table 16.2.3-1 Benefit Items Considered in This Study

	VOC	TTC
Passenger	●Operating cost of passenger vehicles (MC, car and bus) ●Operating cost of ferry (without project case)	●Passengers' value of time
Freight	●Operating cost of trucks ●Operating cost of barge and tugboat (without project case)	●Drivers' value of time ●Opportunity cost of freight

Note: Underlined items were not considered in the Preparatory Survey

Source : Study Team

(2) Saving of Vehicle Operating Cost

VOC consists of major expenses needed for vehicle operation such as fuel, lubricants, tires, maintenance, and depreciation of vehicles. The unit values of VOC are given by vehicle types and operating speeds, and those are determined by escalating that shown in the "Study on Road Improvement in Lam Dong and Binh Thuan Provinces" released by the Ministry of Economy, Trade and Industry of Japan on 2010.

Table 16.2.3-2 Unit Value of VOC

Unit: VND/vehicle/km

Speed (km/hour)	MC	Car	Bus	HGV
5	1,237	8,955	20,437	32,363
10	919	6,635	13,891	21,105
20	724	5,221	10,404	15,443
30	654	4,679	9,300	11,549
40	601	4,282	8,561	9,703
50	586	4,185	9,046	9,026
60	618	4,405	10,195	8,799
70	663	4,715	11,703	9,138
80	713	5,065	13,352	9,906
90	780	5,516	14,753	10,946

Source: Adjusted to the 2012 current price based on Study on Road Improvement in Lam Dong and Binh Thuan Provinces, 2010, Ministry of Economy, Trade and Industry of Japan

In the "without project case", ocean freight shuttles between Lach Huyen Port and Haiphong Port on barge, so costs for using barge and tugboat are also calculated as VOC. In addition, trans-shipment charge between container ship and barge is included as a part of the operating costs (40 USD/TEU). Though loading/unloading charge of truck was also counted in the Preparatory Study, This Study regards that it is cancelled out between "with" and "without" cases.

Likewise, This Study counts operating cost of passenger ferry as an opportunity cost to be saved by the Project, though it was not included in the Preparatory Survey. These operating costs of vessels are summarized as shown in the following tables.

Table 16.2.3-3 Unit Value of Vessel Operating Cost

		Freight		Passenger
Item	Unit	Barge	Tugboat	Ferry
Vessel Hiring Cost	**VND/ship/day**	**9,668,800**	**13,812,500**	**19,431,233**
Fuel Cost*	**VND/ship/trip**		**24,840,000**	**7,486,500**
Diesel Gasoline Requirement	liter/hour		540	434
Time Required per Trip	hour		2	0.75
	(Capacity per Trip)	90 TEU	1 barge	90 PCU

* Fuel costs 23,000 VND/liter as of 3rd quarter 2012 at Singapore MDO price (http://www.bunkerworld.com/markets/prices/sg/sin/)

Source: Study Team based on the Preparatory Survey

(3) Saving of Travel Time Cost

TTC of passengers is measured as wage rate per hour and summarized by vehicle types as shown in the table below. Although opportunity cost of freight is not considered in the Preparatory Survey, This Study estimates the cost as a part of TTC based on the equation below, because facilitation of freight transport is the main objective of the Project. Total value of transported goods is represented by gross output of each industry shown in the national statistics, and the opportunity cost of freight is calculated as 51 VND/ton/hour by multiplying hourly interest rate.

$$(Opportunity\ Cost\ of\ Freight\ per\ Ton\ per\ Hour)$$
$$= \frac{(Total\ Value\ of\ Transported\ Goods)}{(Total\ Volume\ of\ Transported\ Goods)} \times \frac{(Interest\ Rate)}{365\ days \times 24\ hours}$$

Table 16.2.3-4 Estimation of Freight Opportunity Cost

Item	Unit	Value
Gross Output Value	**Bil. VND**	**3,717,270**
Agriculture, Forestry and Fishing	Bil. VND	561,070
Mining and Manufacturing	Bil. VND	2,173,000
Retail Sale	Bil. VND	983,200
Freight Transport Volume	**'000 ton**	**699,810**
Interest Rate per Hour	percent/hour	0.00103
Value of Freight Transport Time	VND/ton/hour	46
Adjusted Price at 2010	**VND/ton/hour**	**65**

Source: Study Team based on data from General Statistics Office

Table 16.2.3-5 Unit Value of TTC

Item	Unit	Vehicle Type			
		MC	Car	Bus	HGV
Driver & Passenger	**VND/h**	**20,565**	**45,700**	**305,822**	**49,900**
Driver Monthly Wage	'000 VND		**3,656**	**4,562**	**4,562**
Assistant Monthly Wage	'000 VND			**3,422**	**3,422**
Driver & Assistant Hourly Rate	VND/h		**22,850**	**49,900**	**49,900**
Passenger Monthly Wage	'000 VND	**3,656**	**3,656**	**3,656**	
Passenger Work Time Ratio	%	**78**	**52**	**52**	
Passenger Time Cost	VND/h	**13,710**	**9,140**	**9,140**	
Vehicle Occupancy	Persons	**2**	**3**	**36**	
Freight	**VND/h**				**1,520**
Average Volume	ton				**23**
Value per Ton Hour	VND/ton				**85**
TTC per Hour by Vehicle Type	**VND/h**	**20,565**	**45,700**	**305,822**	**51,420**

Source: Study Team based on data from General Statistics Office

(4) Total Benefits of the Project

Based on the assumed unit values, total benefits of the Project are calculated by vehicle types for both "with" and "without" cases. The result is summarized in the following table. According to the result, most part of the benefits is explained by saving of operating cost in freight transport by barge.

Table 16.2.3-6 Summary of Project Benefit

Without Project Case

Item	VOC ('000 VND/day)					TTC ('000 VND/day)				
Route	Route A	Route B1		Route B2	Total	Route A	Route B1		Route B2	Total
Type	Freight	Freight	Passenger	Passenger		Freight	Freight	Passenger	Passenger	
2016	2,288,966	69,466	280,836	1,790,602	4,429,871	22,037	9,203	172,535	878,560	1,082,335
2017	3,399,526	61,153	318,143	1,849,637	5,628,459	34,149	8,102	189,807	908,431	1,140,489
2018	4,533,799	52,839	355,450	1,908,673	6,850,761	46,262	7,000	207,079	938,302	1,198,644
2019	5,644,823	42,538	374,650	1,908,673	7,970,684	58,376	5,636	215,419	938,302	1,217,733
2020	6,779,561	33,248	393,851	1,908,673	9,115,332	70,491	4,405	223,759	938,302	1,236,956
2021	9,150,205	74,171	447,606	1,908,673	11,580,655	85,948	9,826	241,599	938,302	1,275,675
2022	11,569,170	113,338	501,362	1,908,673	14,092,543	101,405	15,015	259,439	938,302	1,314,162
2023	13,939,814	151,315	555,117	1,908,673	16,554,919	116,862	20,047	277,280	938,302	1,352,490
2024	16,320,126	188,448	608,873	1,908,673	19,026,120	132,319	24,966	295,120	938,302	1,390,707
2025	18,690,770	224,962	662,628	1,908,673	21,487,033	147,776	29,804	312,961	938,302	1,428,842
2026	21,084,895	261,007	716,384	1,908,673	23,970,959	163,233	34,579	330,801	938,302	1,466,915
2027	23,455,539	296,689	770,139	1,908,673	26,431,041	178,690	39,306	348,642	938,302	1,504,940
2028	25,835,852	332,085	823,895	1,908,673	28,900,505	194,147	43,996	366,482	938,302	1,542,927
2029	28,254,817	367,250	877,650	1,908,673	31,408,391	209,604	48,654	384,323	938,302	1,580,883
2030	30,625,461	428,940	1,137,810	1,908,673	34,100,884	225,061	56,827	544,968	938,302	1,765,158
2031	33,095,255	549,821	1,292,424	1,908,673	36,846,173	250,543	72,842	588,770	938,302	1,850,457
2032	35,541,567	670,214	1,447,037	1,908,673	39,567,491	276,024	88,792	632,572	938,302	1,935,691
2033	37,997,549	790,242	1,601,651	1,908,673	42,298,114	301,506	104,693	676,374	938,302	2,020,876
2034	40,443,861	909,990	1,756,265	1,908,673	45,018,789	326,988	120,558	720,176	938,302	2,106,025
2035	42,938,495	1,029,519	1,910,878	1,908,673	47,787,566	352,470	136,394	763,978	938,302	2,191,144

With Project Case

Item	VOC ('000 VND/day)			TTC ('000 VND/day)		
Route	Route C		Total	Route C		Total
Type	Freight	Passenger		Freight	Passenger	
2016	264,683	512,677	777,360	17,173	188,162	205,335
2017	403,454	545,720	949,174	26,177	195,718	221,895
2018	542,224	578,763	1,120,987	35,181	203,275	238,456
2019	680,995	611,806	1,292,800	44,185	210,832	255,016
2020	819,765	644,849	1,464,614	53,189	218,388	271,577
2021	972,652	692,510	1,665,162	63,108	227,526	290,634
2022	1,125,538	740,171	1,865,709	73,028	236,664	309,692
2023	1,278,425	787,832	2,066,257	82,948	245,802	328,749
2024	1,431,311	835,493	2,266,804	92,867	254,940	347,807
2025	1,584,198	883,154	2,467,352	102,787	264,077	366,865
2026	1,737,084	930,816	2,667,900	112,707	273,215	385,922
2027	1,889,971	978,477	2,868,447	122,626	282,353	404,980
2028	2,042,857	1,026,138	3,068,995	132,546	291,491	424,037
2029	2,195,744	1,073,799	3,269,543	142,466	300,629	443,095
2030	2,348,630	1,171,675	3,520,305	152,386	337,598	489,984
2031	2,676,212	1,269,440	3,945,652	173,640	353,622	527,262
2032	3,003,794	1,367,205	4,371,000	194,894	369,647	564,541
2033	3,331,377	1,464,971	4,796,347	216,149	385,671	601,820
2034	3,658,959	1,562,736	5,221,695	237,403	401,695	639,098
2035	3,986,541	1,660,501	5,647,042	258,658	417,719	676,377

Annual Benefit*

VOC	TTC	Total
(Mil. VND/year)		
1,333,166	320,105	1,653,271
1,707,939	335,287	2,043,226
2,091,368	350,469	2,441,836
2,437,428	351,391	2,788,819
2,792,512	352,363	3,144,876
3,619,155	359,540	3,978,695
4,462,794	366,631	4,829,426
5,288,362	373,665	5,662,027
6,117,150	380,659	6,497,809
6,942,184	387,622	7,329,805
7,775,617	394,562	8,170,179
8,600,347	401,485	9,001,832
9,428,501	408,395	9,836,896
10,270,680	415,293	10,685,972
11,161,911	465,439	11,627,350
12,008,690	482,966	12,491,656
12,846,719	500,470	13,347,189
13,688,145	517,956	14,206,101
14,525,939	535,428	15,061,367
15,381,291	552,890	15,934,181

Note: Value in each year is not discounted.
(*) Benefit in the first year comes out from the second half after completion.

Source : Study Team

16.2.4 Evaluation of Project Benefits

(1) Construction Cost and Annual Spending

Total financial project costs as a Yen loan project are estimated in this detailed design study. Economic cost needs to be derived for the analysis by excluding price escalation and transfer items such as taxes and subsidies from the cost in a financial term. Also, financial cost in local currency has to be converted into border price by multiplying Standard Conversion Factor (SCF), which is set to 0.85 in accordance with generally used values in the recent studies in Viet Nam's transport sector. Expenditure of the economic investment costs in the initial construction phase is scheduled as shown in the table below.

Although the Yen loan targets the first stage of construction, the cost for the second stage is also included to the economic project cost for evaluation as the full-scaled project. The cost used in the Preparatory Survey is referred and adjusted as an estimated value for the second stage, though it would be re-examined afterward with timing of construction. In This Study, the cost for the second stage is assumed to be 150% of that in the previous study in accordance with increase of the first stage cost.

Table 16.2.4-1 Breakdown of Economic Cost of the Project (First Stage)

Items	Local Currency	Foreign Currency	Total Cost
	VND	JPY	VND
I. Construction Cost	3,792,903,323,307	10,977,076,332	6,727,950,470,803
II. Price Escalation	-	-	-
III. Physical Contingency	252,124,807,876	626,691,832	419,689,468,853
IV. Consulting Service	52,739,950,000	999,660,000	320,028,720,053
V. Land Acquisition, HIV/AIDS Prevention	267,012,096,300	0	267,012,096,300
VI. Administration Cost	278,081,653,084	0	278,081,653,084
VII. VAT	-	-	-
VIII. Import Tax	-	-	-
IX. Interest during Construction	-	-	-
X. Commitment Charge	-	-	-
TOTAL Economic Cost	**4,642,861,830,567**	**12,603,428,164**	**8,012,762,409,093**

Note: Gray rows represent items not counted as economic cost.

Source : Study Team

Table 16.2.4-2 Annual Requirement of Economic Project Cost (First Stage)

	F/C	L/C	Total
	Mil. JPY	Bil. VND	Bil. VND
2012	0	136	136
2013	5,290	1,876	3,291
2014	4,916	1,786	3,100
2015	2,397	845	1,486
Total	12,603	4,643	8,013

Source : Study Team

(2) Cost Benefit Flow and Evaluation

Cash flow of the Project is summarized in the following table through the evaluation period. In addition to the construction cost, the Project requires cost for maintenance, which is based on the proposed operation and maintenance plan. Indicators of effectiveness are calculated from this cash flow table. As the result, every economic indicator substantially exceeds the cut-off standard (i.e. EIRR>12%, NPV>0, B/C>1). Also, accumulation of the net undiscounted benefit turns to positive at the ninth year of the Project (2020).

Table 16.2.4-3 Result of Economic Evaluation

(Unit: Million VND)

Year	Investment Cost	2nd Stage Investment Cost	Routine Maintenance	Initial Cost & Periodic Maintenance	Annual Total Cost	Annual Incremental Benefit	Annual Net Benefit	Accumulated Net Benefit
2012	135,735				135,735	0	-135,735	-135,735
2013	3,290,734				3,290,734	0	-3,290,734	-3,426,469
2014	3,100,140				3,100,140	0	-3,100,140	-6,526,609
2015	1,486,153				1,486,153	0	-1,486,153	-8,012,762
2016			6,460	1,700	8,160	1,653,271	1,645,111	-6,367,651
2017			6,460		6,460	2,043,226	2,036,766	-4,330,885
2018			6,460		6,460	2,441,836	2,435,376	-1,895,509
2019			6,460		6,460	2,788,819	2,782,359	886,850
2020			6,460		6,460	3,144,876	3,138,416	4,025,266
2021		1,246,025	6,460		1,252,485	3,978,695	2,726,211	6,751,476
2022		1,661,366	6,460		1,667,826	4,829,426	3,161,600	9,913,077
2023		1,246,025	6,460		1,252,485	5,662,027	4,409,543	14,322,619
2024			9,690	86,530	96,220	6,497,809	6,401,589	20,724,208
2025			9,690		9,690	7,329,805	7,320,115	28,044,323
2026			9,690		9,690	8,170,179	8,160,489	36,204,812
2027			9,690		9,690	9,001,832	8,992,142	45,196,955
2028			9,690		9,690	9,836,896	9,827,206	55,024,160
2029			9,690		9,690	10,685,972	10,676,282	65,700,443
2030			9,690		9,690	11,627,350	11,617,660	77,318,103
2031			9,690		9,690	12,491,656	12,481,966	89,800,068
2032			9,690		9,690	13,347,189	13,337,499	103,137,567
2033			9,690		9,690	14,206,101	14,196,411	117,333,978
2034			9,690	130,645	140,335	15,061,367	14,921,032	132,255,010
2035			9,690		9,690	15,934,181	15,924,491	148,179,501
				Present Value	7,160,490	25,448,788		

EIRR =	28.7%
NPV =	18,288,299
B/C =	3.6
Discount Rate =	12%

Source : Study Team

(3) Sensitivity Analysis

Sensitivity of the evaluation indicators is analyzed against change in cost (+10% and +20% from the base case) and benefit (-10% and -20%) of the Project. The result is tabulated as follows.

Table 16.2.4-4 Summary of Sensitivity Analysis

(a) EIRR

		Benefit		
		Base Case	-10%	-20%
Cost	Base Case	28.7%	27.0%	25.2%
	+10%	27.1%	25.5%	23.7%
	+20%	25.8%	24.2%	22.5%

(b) NPV (Million VND)

		Benefit		
		Base Case	-10%	-20%
Cost	Base Case	18,288,299	15,743,420	13,198,541
	+10%	17,572,250	15,027,371	12,482,492
	+20%	16,856,201	14,311,322	11,766,443

(c) B/C

		Benefit		
		Base Case	-10%	-20%
Cost	Base Case	3.6	3.2	2.8
	+10%	3.2	2.9	2.6
	+20%	3.0	2.7	2.4

Source : Study Team

As another scenario, sensitivity against freight demand of Lach Huyen Port is examined as well, since it accounts for the large portion of traffic demand of the Project road. According to the result shown in the table below, the total amount of benefit dramatically decreases in parallel of decrease in ocean freight, though the indicators remain above acceptable standards even in the scenarios.

Table 16.2.4-5 Result of Lower Container Scenario

Decrease in Ocean Freight	Decrease in Benefit	EIRR	NPV (Mil. VND)	B/C
-10%	-8.6%	27.4%	16,232,170	3.3
-30%	-25.8%	24.7%	12,119,913	2.7
-50%	-43.0%	21.5%	8,007,656	2.1

Source : Study Team

(4) Conclusion of Economic Analysis

The above results indicate high economic validity of the Project, showing that the values of EIRR are much higher than 12%, very much positive figures of NPV (>0), and B/C ratios higher than unity (>1) in any case undertaken for the sensitivity analysis. This result mainly comes from high operating cost of barge transport for freight in the "without project case", however the case could be said almost impossible in practice considering severe congestion on Nam Trieu Channel. It is indicated from the result of the sensitivity analysis that freight demand of Lach Huyen Port is the most sensitive factor to the evaluation indicators.

In conclusion, it is numerically verified that this road and bridge project has quite high economic validity on the condition that Lach Huyen Port would attract freight as much as forecasted. On the contrary, there would be huge opportunity loss in freight transport without the Project road. Therefore, well-coordinated development of port and road is highly recommended to maximize the effectiveness of the Project.

16.3 Monitoring of Project Performance

16.3.1 Qualitative Benefit of the Project

Besides of the benefits quantitatively evaluated in the previous section, a variety of benefit can be expected from the Project. Through improvement of the logistics environment of the region, the Project will activate economic activities.

(1) Direct Benefit

The Project provides direct benefits as listed below to users of the route. The road and bridge will be able to reduce not only travel cost and time, but also possible accidents and uncertainty on transport by alternating ferry and barge transport.

- Avoiding disastrous maritime traffic congestion at Nam Trieu Channel and possible accidents
- Reducing possible damages and delays in freight transport
- Stimulating industrial development in the coastal side of Haiphong
- Promoting tourism activity in Cat Ba Island

(2) Indirect Benefit

Logistics environment of Haiphong City and surrounding region will be improved by the Project, and it will stimulate industrial production and distribution. As a result, economy of the region is expected to keep growing steadily.

- Expanding the market sphere
- Integrating the regional economy
- Streamlining the logistics environment
- Promoting and attracting investment for new industries
- Enhancing industrial productivity

16.3.2 Indicators and Targets

Continuous monitoring of performance given by the Project is essential to maximize the benefit. For that purpose, indicators should be specified and properly collected during operation period of the Project road. The table below summarizes proposed operation indicators and benchmark values for evaluation after completion.

As a current practice, traffic volume of highway is counted in monthly basis by the road management county under RRMC. The county (unit) counts traffic by eleven different vehicle types and reports the data to RRMC for routine maintenance works. It can be assumed that one RRMC would be assigned for management of the Project road and traffic data would be available at the level. On the other hand, data on travel time or speed of specific road sections is not collected under the current maintenance structure. It can be recommended that the data would be measured periodically with routine maintenance activities at the RRMC level.

Table 16.3.2-1 Proposed Operation Indicators and Benchmarks

Indicator	Unit	Description	Baseline on 2010*	Target on 2017**
Annual Average Daily Traffic (AADT)	vehicles/day	24 hour traffic volume by vehicle type at specific points/timing	●150 vehicles/day at Ninh Tiep Ferry Port ●412 vehicles/day on the existing Cat Hai road (excluding MC)	●6,998 vehicles/day on Tan Vu IC- Dinh Vu section ●4,481 vehicles/day on Dinh Vu- Lach Huyen Port section (excluding MC)
Travel Time	minutes	Time required for driving through the project route in peak and off-peak hour	●Passenger: 155 minutes (including ferry section) ●Freight: N/A	●12 minutes (average speed: 80km/h)

Note: (*) Based on traffic survey in the Preparatory Survey
(**) Based on forecast in This Study

Source : Study Team

Based on the operation indicators above, the following effect indicators should be also measured. These indicators are able to quantify core benefits substantially generated by the Project and will be referred for ex-post evaluation by both Vietnamese and Japanese sides.

- Saving of VOC (Million VND/year)
- Saving of TTC (Million VND/year)
- EIRR (%)

CHAPTER 17 PROJECT IMPLEMENTATION PLAN

17.1 Loan Agreement

The Loan Agreement of JICA consists of two (2) portions as follows,

Port Portion: Loan Agreement No. VN10-P3, signed date; November 2, 2011

Road/Bridge Portion: Loan Agreement No. VN10-P4, signed date; November 2, 2011

17.2 Implementation Structure

The organizations related to project implementation for the road/bridge portion are as follows,

1) Funding Agency: JICA
2) Borrower: Ministry of Finance
3) Line Agency: MOT
4) Project Owner: Directorate of Roads of Viet Nam (DRVN)
5) Implementing Agency: PMU 2
6) Land Acquisition, Resettlement Action Plan and Land Clearance:
   Hai Phong People's Committee

17.3 Implementation Schedule

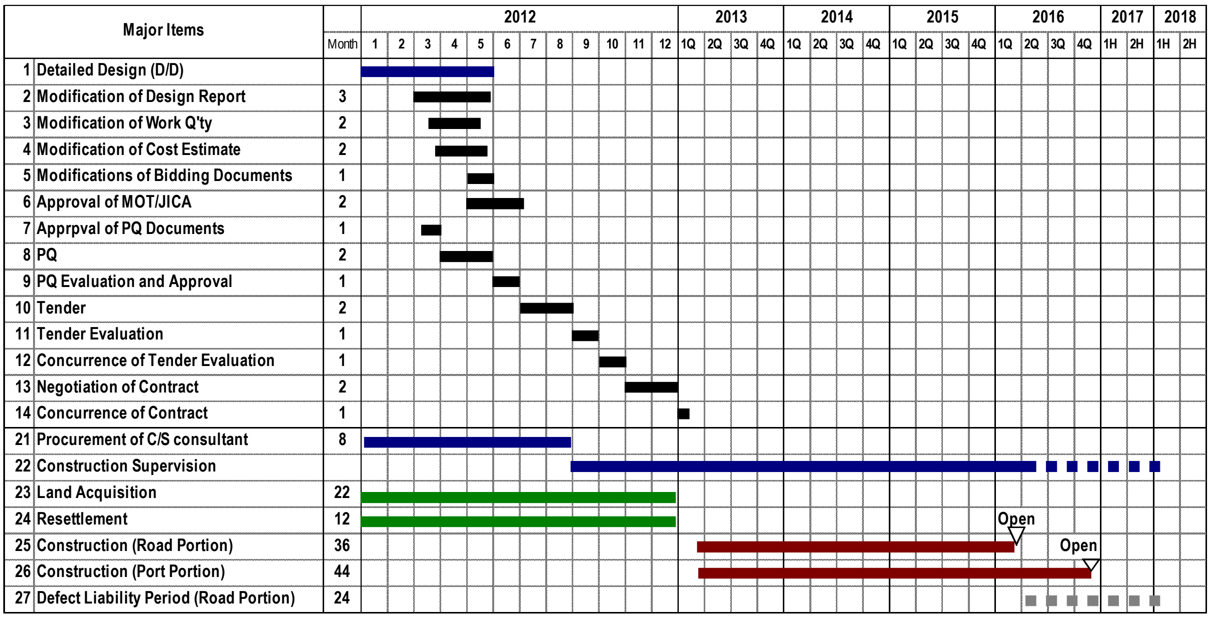
17.3.1 Estimated Implementation Schedule

The estimated implementation milestone and schedule are shown in the following table and the following figure, respectively.

Table 17.3.1-1 Implementation Milestone

Event/ Milestone	Time/ Period
Exchange Note & Loan Agreement	November 2011
Detail Design	March 2011 to May 2012
Finalization and Approbation of Tender Documents	November 2011 to May 2012
Procurement of Contractor	April 2012 to January 2013
Prequalification and Tender Period	April 2012 to August 2012
Tender Evaluation	September 2012
Concurrence of Tender Evaluation	October 2012
Negotiation of Contract	November 2012 to December 2012
Concurrence of Contract	January 2013
Procurement of C/S consultant	January 2011 to August 2012
Construction Supervision	September 2012 to March 2018
Land Acquisition	March 2011 to December 2012
Resettlement	January 2012 to December 2012
Construction	March 2013 to February 2016
Defect Liability Period	March 2016 to February 2018

Source: Study Team



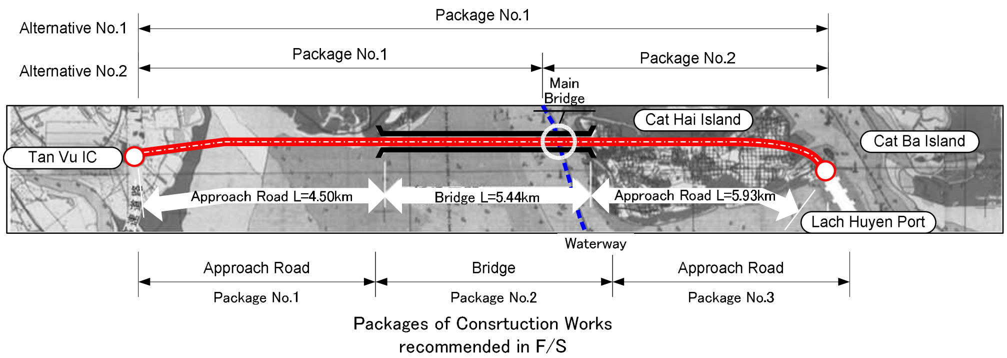
Source: Study Team

Figure 17.3.1-1 Estimated Implementation Program

17.4 Construction Packaging Plan

17.4.1 Alternatives of Packaging Plans

In order to select appropriate construction packaging plan, alternatives shown in the figure below are studied and discussed in the following sections.



Source: Study Team

Figure 17.4.1-1 Alternatives on Construction Packaging Plan

17.4.2 Construction costs

The locations and construction costs of the alternatives are summarized in the tables blow.

Table 17.4.2-1 Alternatives in Procurement Plan and Construction Cost

		Alternative No.1	Alternative No.2	
		Package No.1	Package No.1	Package No.2
Location		All Section	Tan Vu IC, Din Vu area and West Approach Bridges	Main Bridge, East Approach Bridges and Cat Hai Island
Construction Cost*	mil. VND	6,949,545	4,877,051	2,106,677
	mil. Yen**	36,972	25,946	11,208

		Packages recommended in F/S		
		Package No.1	Package No.2	Package No.3
Location		Tan Vu IC and Din Vu area	Main Bridge and Approach Bridges	Cat Hai Island
Construction Cost*	mil. VND	1,323,450	4,621,758	1,132,476
	mil. Yen**	7,041	24,588	6,025

*preliminary estimation

**converted by using an exchange rate:1VND=0.00532Yen

Source: Study Team

17.4.2.1 Results of Comparative Study

As a result of comparative study, one package for the whole work is the most preferable for the following reasons;

- Temporary facilities can be concentrated and minimized
- Schedule and quality are controlled and optimized for the entire project with the biggest liquidated damage.
- The problems concerning interference can be solved as part of the scope of one contractor or JV.
- The problems concerning material source capture can be solved as part of the scope of one contractor or JV.
- Superior in implementation of electric wiring and lighting which is not dividable.
- Superior in implementation of pavement which can be realized continuously for whole length of the highway.
- Since the package is attractive for big general contractors, competitive tender is expected.

Since, in particular, the controllability on construction schedule is crucial for the project to open before the inauguration of the port, Alternative-1 with one package is most recommended.

On the meeting between JICA and MOT on 14th of December 2011, the both parties agreed on the package plan of Alternative-1 with one package recommended by Study Team.

CHAPTER 18 FUTURE UPGRADE PLAN

18.1 General

18.1.1 Basic Concept

The outline of the stage construction is shown in the table below.

Table 18.1.1-1 Outline of Stage Construction

	First Stage	Second Stage
Tan Vu IC	At Grade	Separate Grade
Embankment Road	4 Lanes(Pavement width for 4 lanes and embankment width for 6 lanes)	6 Lanes
Bridge	4 Lanes	6 Lanes

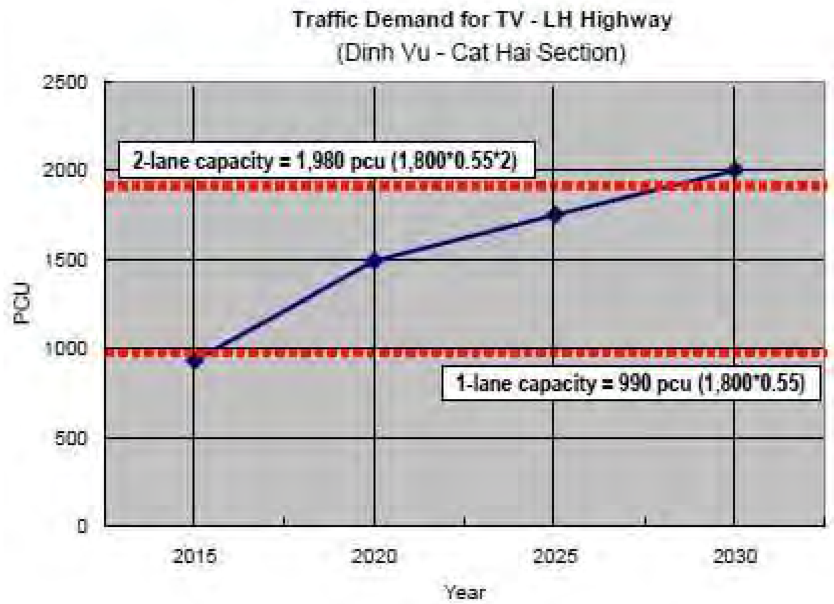
*6 lane shall be installed in Cam River Bridge since it is in the section of embankment road.

Source: Study Team

18.1.2 Expected Timing of Second Stage

(1) Expected Timing of Second Stage for Road and Bridge

Based on the results of the comparison study on investigation timing conducted in JICA's Preparatory Survey, two lanes par direction could sufficiently accommodate traffic capacity until 2027.



Source: JICA's Preparatory Survey, 2010

Figure 18.1.2-1 Future Lane Requirement in JICA's Preparatory Survey

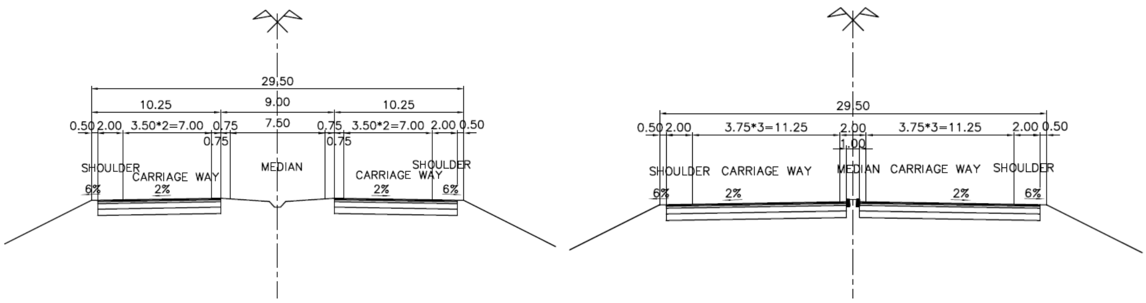
(2) Expected Timing of Second Stage for Tan Vu Interchange

As discussed in the section 7.3.1.1 and shown in Table 7.3.1-3, the signalized at-grade intersection could sufficiently accommodate traffic capacity until 2026.

18.2 Facilities of Second Stage

18.2.1 Embankment Road Section

The width with 7m (2x3.5m) of the median shall be paved for adding 2 more lanes at the second stage. The typical cross sections at the first stage and the second stage are shown in the figure below.



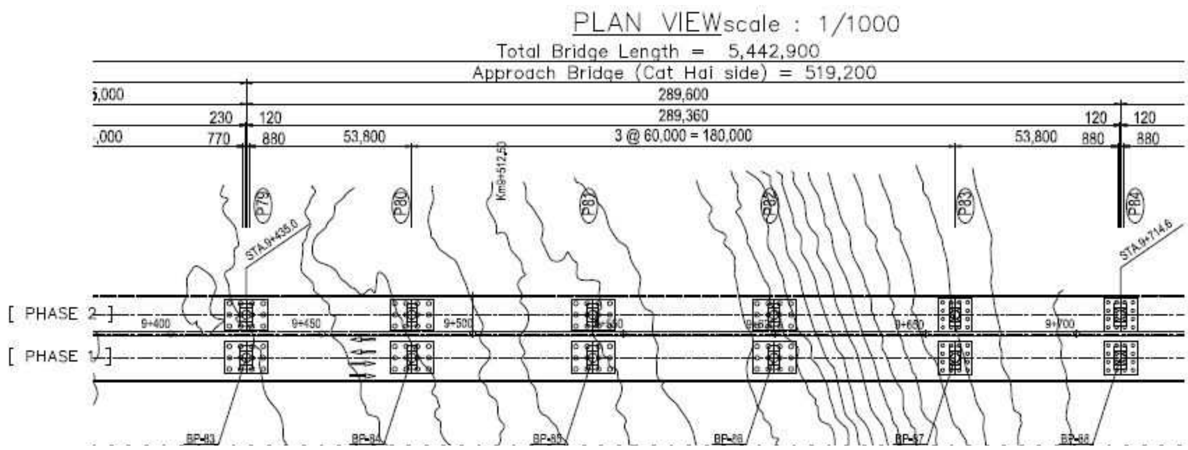
(a) First Stage (b) Second Stage

Source: Study Team

Figure 18.2.1-1 Typical Cross Section of Road Section

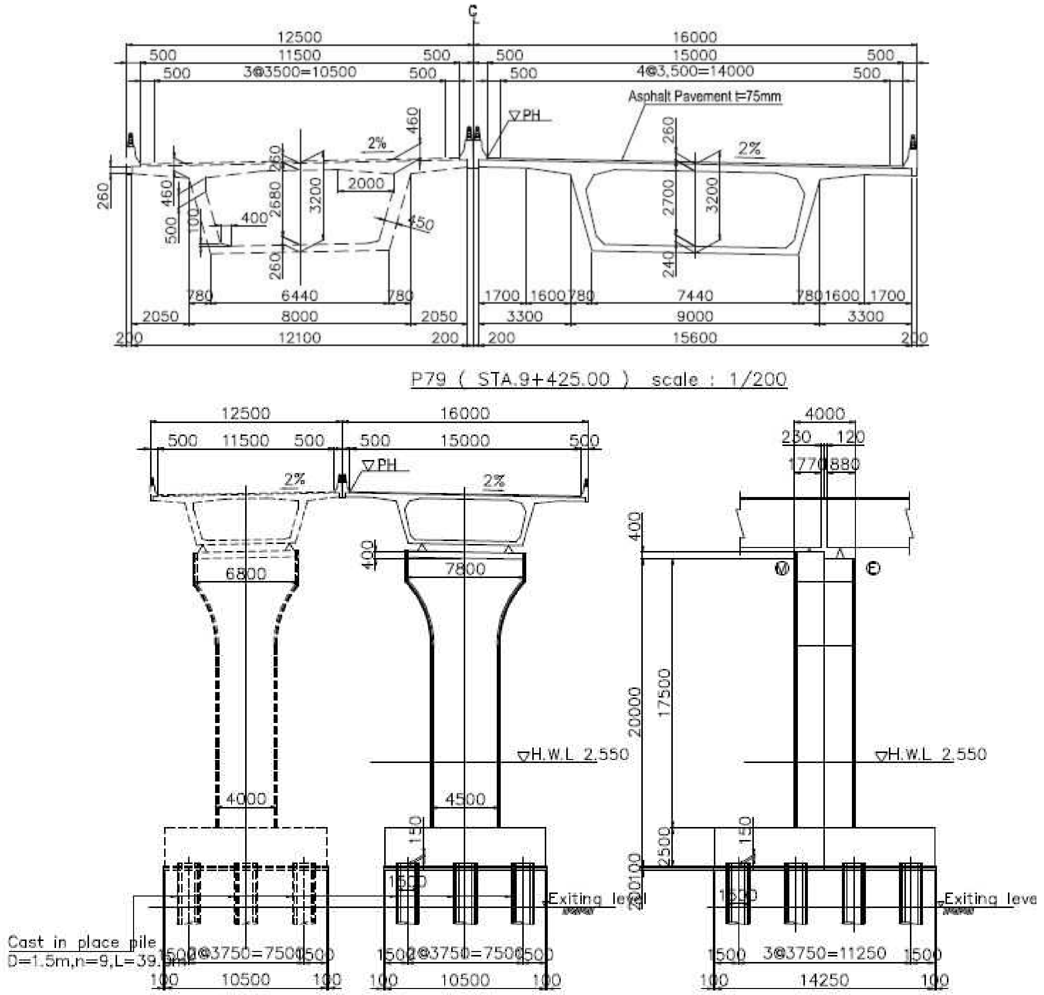
18.2.2 Approach Bridge

In the second stage, an additional bridge with 3 lanes is planned to be constructed adjacent to the bridge for first stage as shown in the following figures.



Source: Study Team

Figure 18.2.2-1 Plan View of Approach Bridge (P79 – P83)

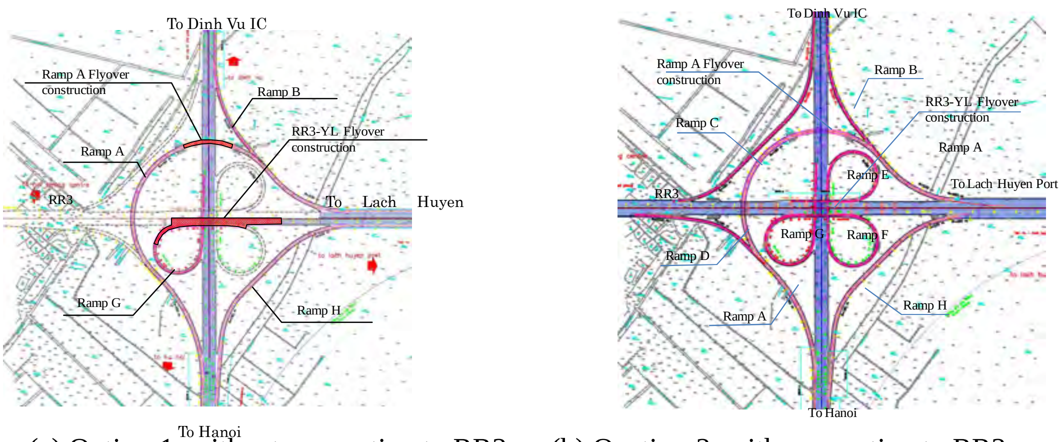


Source: Study Team

Figure 18.2.2-2 General View of Approach Bridge with Second Stage

18.2.3 Tan Vu IC

At the Second stage, the separate grade interchange is planned depending on the actual situation of Ring Road No.3 (RR3) as the figures below.



(a) Option-1: without connection to RR3 (b) Opetion-2: with connection to RR3

Source: F/S, June 2009

Figure 18.2.3-1 Separate-grade Interchange