1.3 Confirmation of Timing of Bridge Opening

1.3.1 Confirmation of Socio-economic Framework

(1) GDP

Annual GDP growth in 2009 is estimated at the lowest level (4.8% p.a.) in the last 5 years. IMF Staff Report identified several factors causing this lowest economic growth: decrease in export of garments, decrease in the number of tourist, shrinkage of real estate market and construction industry, and decline in the foreign direct investment. However, in the long run, GDP growth in Cambodia is expected to maintain as high as 6.0% p.a. or more.

Table 1.3-1 GDP Growth Projection

Year	2009	2010	2011	2012	2013	2014	-2028
Real Growth (%)	4.8	6.0	6.6	7.1	7.4	7.6	6-7

Source: IMF Staff Report

(2) Population

National Institute of Statistics (NIS) projected future population up to Year 2020 in 2000. The future population was once revised in 2004 and was estimated to grow by 2.3% p.a. and to reach 18.7 million by 2020.

Table 1.3-2 Population Projection

Unit: 1000

Year	Population
1998	12,132
2010	15,269
2020	18,724

Source: NIS (2004) First Revision Population Projection for Cambodia 1998 – 2020

Table 1.3-3 Population Projection by Province

Province	1998	2010	2020	2020/1998 Annual Growth Rate
Banteay Meanchey	577,772	886,198	1,152,152	3.2%
Battambang	793,129	1,101,461	1,358,445	2.5%
Kampong Cham	1,608,914	2,006,924	2,358,926	1.8%
Kampong Chhnang	417,693	579,779	749,791	2.7%
Kampong Speu	598,882	816,615	1,026,473	2.5%
Kampong Thom	569,060	751,298	911,441	2.2%
Kampot	528,405	647,056	759,162	1.7%

Kandal	1,075,125	1,343,407	1,582,712	1.8%
Koh Kong	132,106	232,495	326,002	4.2%
Kratie	263,175	379,494	482,725	2.8%
Mondul Kiri	32,407	48,913	65,394	3.2%
Phnom Penh	999,804	1,529,301	1,983,104	3.2%
Preah Vihear	119,261	173,486	223,613	2.9%
Prey Veng	946,042	1,096,298	1,223,193	1.2%
Pursat	360,445	469,014	579,665	2.2%
Ratanak Kiri	94,243	139,693	187,401	3.2%
Siemreap	696,164	970,666	1,229,432	2.6%
Sihanoukville	155,690	246,900	335,186	3.5%
Stung Treng	81,074	118,866	154,126	3.0%
Svay Rieng	478,252	571,141	651,073	1.4%
Takeo	790,168	964,947	1,125,349	1.6%
Oddar Meanchey	68,279	111,079	144,242	3.5%
Kep	28,660	44,306	60,002	3.4%
Pailin	22,906	39,251	54,706	4.0%
TOTAL	11,437,656	15,268,588	18,724,315	2.3%

Source: NIS (2004) First Revision Population Projection for Cambodia 1998 – 2020

(3) Confirmation of Socio-economic Framework

1) Projected GDP

Three development scenarios were examined in the previous Study: high GDP growth rate (8% p.a.), medium growth rate (6%) and low growth rate (4%). The medium growth rate of 6% was applied as the socio-economic framework to the Study. As discussed in Section 1.1.3 Socio-economic Situation, Cambodia enjoyed significant economic growth in recent years and GDP growth exceeded 10% p.a. from 2004 to 2007. Cambodia still keeps a high pace in economic growth and GDP growth in 2008 and 2009 is projected to reach 6.5% p.a. and 4.8% p.a., respectively. In the long run, GDP growth in Cambodia is expected to maintain at more than 6.0% p.a. Accordingly, the medium growth rate scenario applied to this study is confirmed appropriate.

Table 1.3-4 GDP Growth Scenario

Growth Case	GDP Growth
High	8%
Medium	6%
Low	4%

Source: JICA (2006) The Study on the Construction of the Second Mekong Bridge

2) Projected Population

According to the population projection by NIS, the annual population growth is estimated at 2.3% p.a. and shows higher growth rate than the actual population growth (by 1.6% p.a.) between 1998 and 2008. The population growth rate in both Phnom Penh and Kandal, where the Project is located, is observed higher than expected by the NIS population projection. Accordingly, the future population applied to this study is judged still valid.

1.3.2 Confirmation of CBTA Progress

(1) Passenger Bus

Passengers changed their transport at the cross border of Vietnam in 2004 when the previous Study was completed. In the demand forecast of the Study, it was assumed that the cross border traffic with Vietnam would be fully operational for passenger without transferring by 2005. The real situation, as of in March 2009, shows only 40 buses in Vietnam and 23 buses in Cambodia are registered to cross the border without transferring.

(2) Truck

In the previous study, it was assumed that no transshipment between trucks at the border with Vietnam would be fully operational by 2007, following an agreement in the CBTA. As of March 2009, trucks and trailers, however, are still required to transfer their cargoes at the cross border or at the industrial park and dry port near the border in Cambodian.

1.3.3 Traffic Survey

(1) Result of Traffic Count Survey

Table 1.3-5 tabulates the classified traffic volume at Neak Loeung surveyed between 2004 and 2009. This table shows that more traffic is observed during the weekend than during the weekday, expect for trucks (Type 6) and trailers (Type 7). It also indicates that the number of vehicles tends to increase year by year, expect for pedestrians (Type 10), trucks (Type 6) and trailers (Type 7).

Table 1.3-5 Classified Traffic Volume

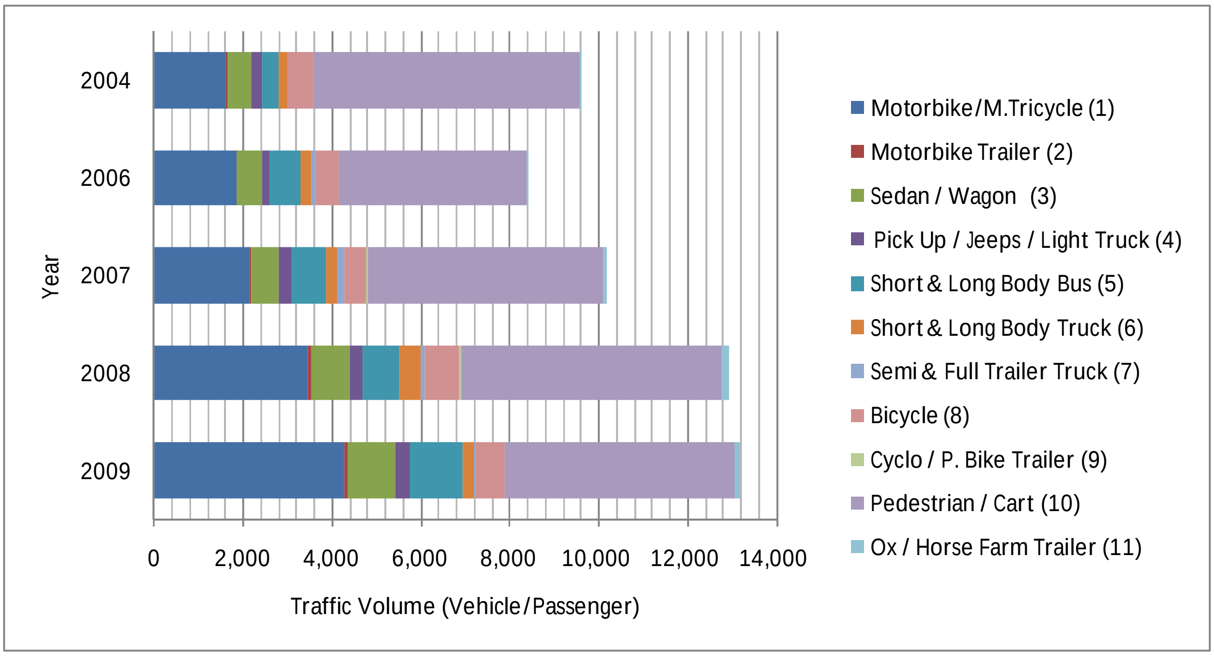
Unit: Vehicles/Passengers

Year	Survey Day	Vehicle Type											
		Motorbike/ M.Tricycle (1)	Motorbike Trailer (2)	Sedan / Wagon (3)	Pick Up / Jeeps / Light Truck (4)	Short & Long Body Bus (5)	Short & Long Body Truck (6)	Semi & Full Trailer Truck (7)	Bicycle (8)	Cyclo / P. Bike Trailer (9)	Pedestrian / Cart (10)	Ox / Horse Farm Trailer (11)	(PCU)
2009	Weekday	4,293	59	1,082	308	1,191	260	31	656	4	5,140	101	5,120
	Weekend	5,070	48	1,382	324	1,138	208	27	661	7	5,786	106	5,259
	All	4,515	56	1,168	312	1,175	245	30	658	5	5,325	102	5,159
2008	Weekday	3,487	48	871	299	792	488	79	798	34	5,841	166	4,988
	Weekend	3,659	41	1,391	490	980	565	54	610	15	6,119	92	6,256
	All	3,536	46	1,019	354	845	510	72	744	29	5,920	145	5,350
2007	Weekday	2,172	20	615	290	764	281	133	498	31	5,282	71	4,107
	Weekend	2,865	22	849	302	1,031	248	135	549	8	6,716	103	4,824
	All	2,370	20	682	293	840	271	133	512	24	5,691	80	4,312
2006	Weekday	1,875	14	571	147	710	246	73	511	0	4,200	59	3,342
	Weekend	2,187	13	723	179	848	264	52	488	0	4,569	51	3,777
	All	1,964	14	615	156	749	251	67	504	0	4,305	57	3,466
2004	Weekday	1,649	14	535	268	351	184	14	580	0	5,948	36	2,376
	Weekend	1,788	18	534	327	319	211	11	593	0	6,304	57	2,499
	All	1,709	15	536	293	337	195	12	586	0	6,100	45	2,426

Source: JICA Study Team

Note: Trucks for the construction work at the NR1 observed in 2007 are excluded.

Figure 1.3-1 illustrates the average weekday traffic volume. The number of river-crossing traffic in total is observed decreasing between 2004 and 2006 due to the decrease in the pedestrians (Type 10). However, the number of vehicular traffic, that of motorbikes (Type 1) in particular, increases year by year.



Source: JICA Study Team

Figure 1.3-1 Weekday Classified Traffic Volume

Table 1.3-6 compares growth rates of the traffic volume between 2004 and 2009. As the table indicates, most traffic, especially that of motorbikes (Type 1), motorbike trailers (Type 2), sedans and wagons (Type 3), buses (Type 5), tends to increase year by year. The recent trend shows significant decrease in the number of trucks (Type 6) and trailers (Type 7). This trend is observed due to the decrease in both export and import between Cambodia and Vietnam.

Table 1.3-6 Growth Rate of Traffic Volume

Year	Vehicle Type						
	Motorbike/ M.Tricycle (1)	Motorbike Trailer (2)	Sedan / Wagon (3)	Pick Up / Jeeps / Light Truck (4)	Short & Long Body Bus (5)	Short & Long Body Truck (6)	Semi & Full Trailer Truck (7)
2009/2008	23%	22%	24%	3%	50%	-47%	-60%
2009/2007	98%	196%	76%	6%	56%	-7%	-76%
2009/2006	129%	313%	89%	110%	68%	5%	-57%
2009/2004	160%	319%	102%	15%	239%	41%	124%

Source: JICA Study Team

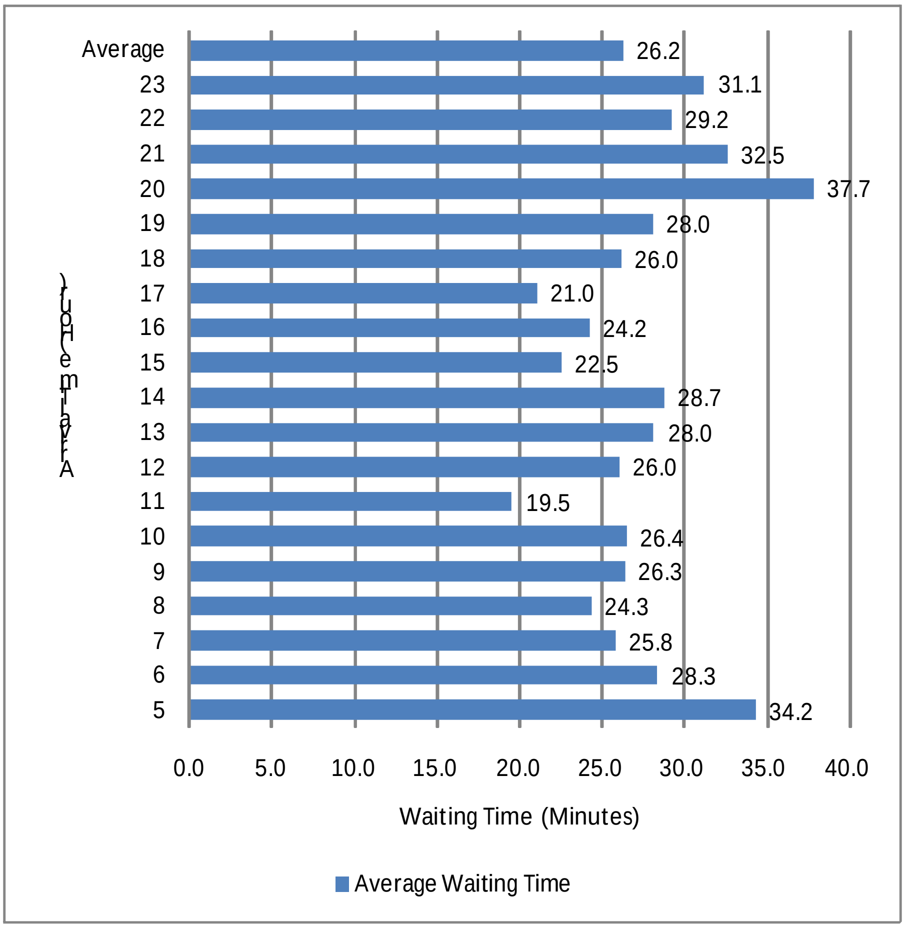
(2) Waiting Time Survey

1) Number of Ferry in Operation

Three ferries are in operation when heavy river-crossing traffic is observed. According to the waiting time and ferry operation survey, total operation hours when the three ferries are observed in operation amounts to 16 hours during the survey in 2006 (surveyed in November and December). The total operation hours with three ferries are increasing as observed at 25 hours in 2007 (May) and 40 hours in 2009 (February and March). Also, the peak hours with three ferries increase as peak hours are observed between 9 AM and 11 AM in 2006, 8 AM and 12 PM in 2007 and 8 AM and 4 PM in 2009.

2) Waiting Time at Ferry Terminal

Figure 1.3-2 illustrates average waiting time at the river crossing point in Neak Loeung and arrival time at the ferry terminal. Long waiting time is observed and reaches 34 minutes at 5 AM when the ferry starts to operate. Waiting time decreases when three ferries are in operation but still records at 29 minutes at 2 PM. Waiting time then increases when the number of ferries in operation decreases and reaches 38 minutes at 8 PM.



Note: Considering the time for rest at/around ferry terminal, waiting time observed at over 70 minutes are assumed at 90 minutes in average.

Source: JICA Study Team

Figure 1.3-2 Average Waiting Time on Weekdays (2009)

1.3.4 Confirmation of Timing of Bridge Opening

(1) Revision of Traffic Demand

Some preconditions applied to the previous Study are different from those of the Preparatory Survey. These differences are summarized below.

- Traffic demand in the previous Study was forecasted assuming the toll road/bridge. Traffic demand needs to be revised assuming that the project road and bridge is open without any charge.
- Incremental traffic demand was estimated and added assuming that flood-free area development would generate additional river-crossing traffic. Considering less possibility that flood-free area development would be realized, this incremental traffic demand from area development needs to be omitted from the traffic demand forecast.

- Considering the implementation plan of the Project, the opening year of the bridge needs to be altered to Year 2015.

Revising these preconditions to the traffic demand forecast, the future river-crossing traffic is estimated at 7,118PCU in 2015 and 9,436PCU in 2020.

Table 1.3-7 Revised Traffic Demand (in PCU)

	2005	2010	2015	2020
MC	232	299	902	1,180
LV	1,020	1,312	2,283	3,248
HV MB	9	20	906	1,039
HV Combined	1,336	1,657	2,499	3,288
HV Truck	60	339	528	681
Total	2,658	3,627	7,118	9,436

Source: JICA Study Team

Note: MC: motorbikes, HV MB: buses, HV Combined: buses plus trucks/trailers, HV Truck: trucks and trailers

(2) Confirmation of Timing of Bridge Opening

1) Comparison between Surveyed Traffic and Estimated Traffic

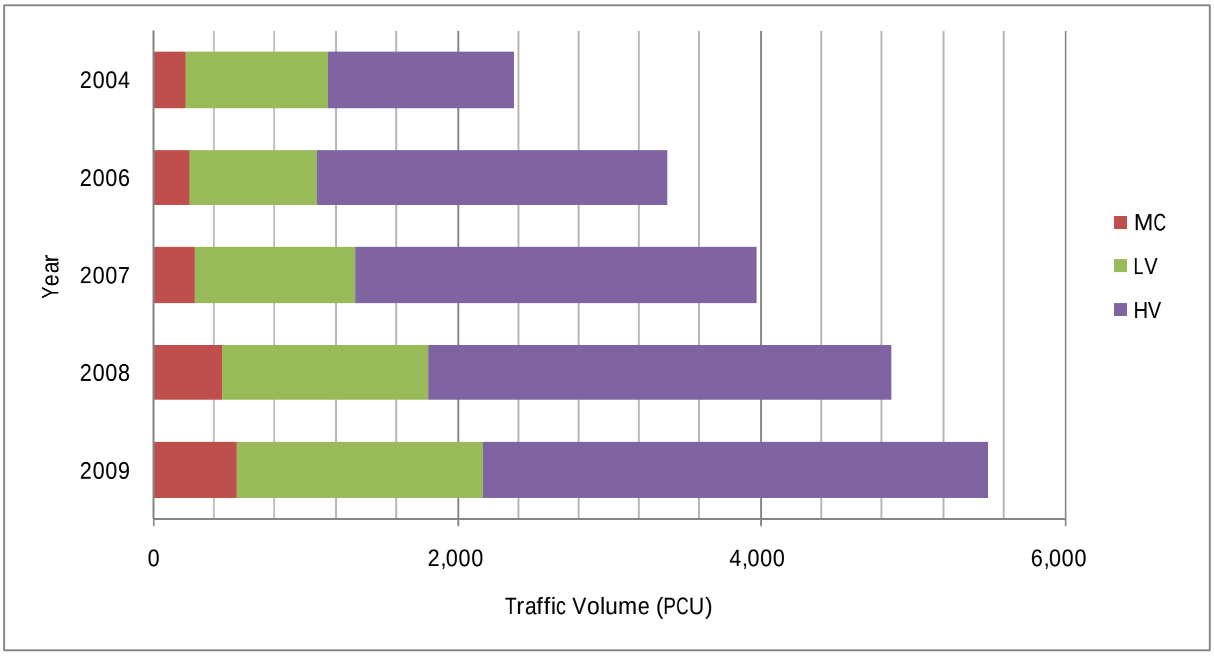
Table 1.3-8 and Figure 1.3-3 shows the number of vehicular traffic by type (motorbike, light vehicles and heavy vehicles) surveyed in the previous and current studies. The number of traffic is observed increasing and reached at 5,497PCU in 2009.

Table 1.3-8 Classified Traffic Volume (in PCU)

	MC	LV	HV	Total (PCU)
2009	557	1,619	3,321	5,497
2008	452	1,363	3,046	4,861
2007	281	1,054	2,637	3,972
2006	242	837	2,307	3,385
2004	213	935	1,230	2,379

Source: JICA Study Team

Note: MC: motorbikes (for vehicle classification in the traffic survey, Type 1 and 2), LV: light vehicles (Type 3 and 4), HV: heavy vehicles (Type 5, 6 and 7)

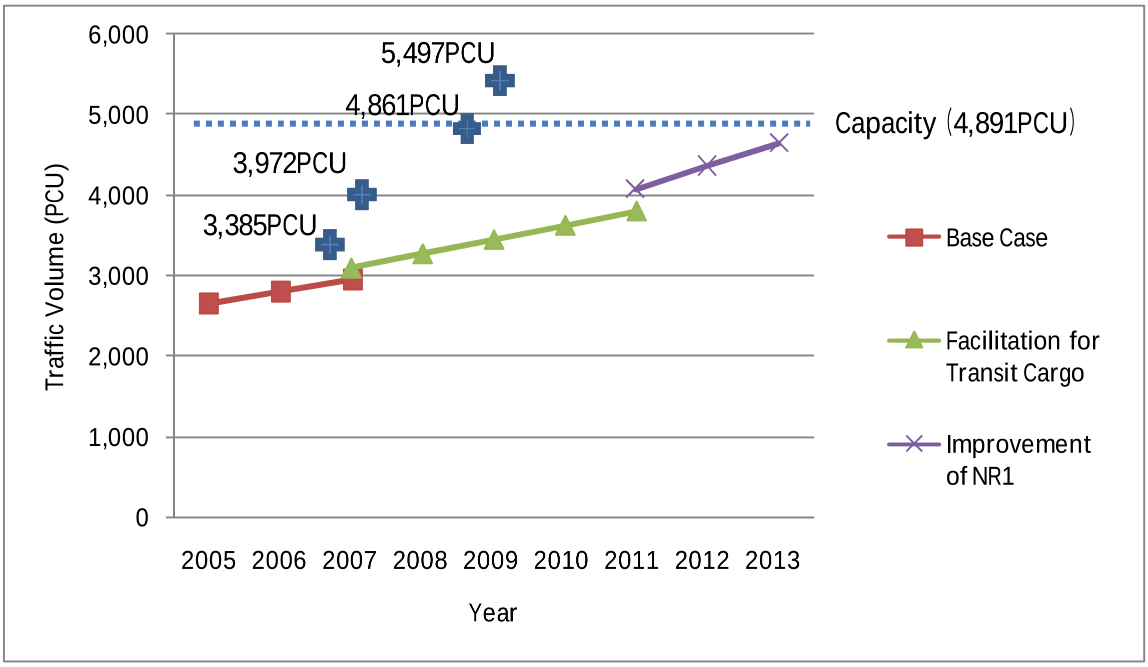


Source: JICA Study Team

Note: MC: motorbikes (for vehicle classification in the traffic survey, Type 1 and 2), LV: light vehicles (Type 3 and 4), HV: heavy vehicles (Type 5, 6 and 7)

Figure 1.3-3 Classified Traffic Volume (in PCU)

Figure 1.3-4 compares the observed traffic volume in the previous traffic surveys and traffic volume estimated by the demand forecast. The actual traffic volume observed during the traffic survey considerably exceeds the estimated traffic volume and the gap between these two figures remains quite large.



Source: JICA Study Team

Figure 1.3-4 Comparison between Surveyed Traffic and Estimated Traffic

2) Appropriate Timing of Bridge Opening

As discussed in the previous sections, the number of river-crossing traffic at Neak Loeung significantly increases though some traffic, including trucks and trailers, are observed decreasing. The number of river-crossing traffic at Neak Loeung shows oversaturated and reaches 5,497PCU, exceeding the traffic capacity of the ferry (4,891PCU).

The result of waiting time and ferry operation survey also shows oversaturated traffic at Neak Loeung as the operation hours with three ferries are increasing year by year and average maximum waiting time reaches 29 minutes even when three ferries are in operation. As a consequence, it can be concluded that Neak Loeung Bridge should be opened to public at earliest timing.

1.4 Present Situation and Future Plan of Phnom Penh Port

1.4.1 Port Facilities and Handling Cargo

(1) Natural Condition

According to the seasonal climate changes, the Phnom Penh Port shows different features. The variation of the water depth between dry and rainy seasons is approximately 9m to 10m. The water depth of the Port is 5.2m in the dry season. The width of the River around the Port changes about 700m to 900m between the two seasons. The flow velocity of the River in front of the Port ranges from 2.1m/sec to 0.4m/sec.

(2) Facilities

Approximately 2,000DWT vessels can be navigable and called all year round at the Port. The channel is maintained to accommodate 6,000DWT vessels during the highest water level. Maintenance dredging is carried out along the Ka-orm Somnor-Phnom Penh-Kompong Cham channel in the dry season by two dredgers and the annual dredging volume reaches around 100,000 m^3.

There are two ports at the Phnom Penh Port namely Port No.1 and Port No.2: Port No.1 has three berths with a total length of 300m and apron width of 20m. Port No.2 has two pontoon type berths for handling passengers and is located about 1km downstream from Port No.1. Petroleum products are handled at eight private facilities between 4km and 13km upstream from Phnom Penh. Ships ranging from 600 to 1,000DWT berth along the pier.

Phnom Penh Autonomous Port also operates two container yards: CY1 (3,772m^2) and CY2 (3,638m^2). These yards are mainly stacked with laden containers; dwelling time ranges 2 or 3 days (in 2007).

(3) Handling Cargo

Total port traffic increased from 496.2 thousand tons in 2001 to 737.5 thousand tons in 2005. Traffic at the Port is predominately import cargos, showing 680.1 thousand tons imports cargos in 2005 which accounts for 78.1 % of total traffic. The volume of import cargos increases rapidly at 10.1% p.a. between 2001 and 2005. 464,366 tons or 68.3 % of these import cargos are fuel.

Total export cargos in 2005 reach 57,418 tons and increased at 14.3% p.a. between 2001 and 2005. 31,739 tons or 55.3 % of these export cargos is container cargos.

1.4.2 Port Activities

In 2006, 1,264 vessels called at the Phnom Penh Port. 64.6 % of the vessels or 853 called the port are oil tankers. 27.7 % of the vessels or 342 are container vessels. The average berthing/operation time per ship is 30.7 hours for container vessels, 49.2 hours for tankers. The average volume of cargoes handled per vessels is 700 tons per tanker and 55 TEU per container vessel. The berth occupancy rate at the Port is 40.5 % at berth No.1, 35.9 % at No.2 and 40.5 % at oil berth in 2006.

Table 2.4.1 summarizes the maximum capacities, and types of vessels, currently operating at Phnom Penh Port. Table 2.4.2 shows the vessel size called at Phnom Penh Port and indicates that a large ship and barge with a total length of 100m or more called at Phnom Penh Port.

Table 1.4-1 Maximum Capacity and Type of Vessel at Phnom Penh Port

	Petroleum	Containers	General Cargo	Tourist Cruise	Speedboats
Dead Weight Tonnage (ton)	1,000	1,900	1,500	50-65 passenger	25 Passengers
Type of Ship	Tanker Barges	Barges	Barges	-	-
Draught (m)	4.0	3.8	4.0	1.5	Shallow

Source: Design of a Master Plan for Waterborne Transport on the Mekong River System in Cambodia

Table 1.4-2 Vessel Size Called at Phnom Penh Port

PHNOM PENH PORT
HARBOUR MASTER OFFICE

KINGDOM OF CAMBODIA
NATION RELIGION KING

PARTICULARS OF VESSELS CALLED AT PPAP (2006 -13/03/2009)

NAME OF SHIP	NATIONALITY	NRT	GRT	DW	BREADTH	LOA	SPEED	HORSE POWER	F.L DRAFT	CAPACITY	AIR DRAFT	CARGO	CALLED IN
M/T GAS BAGLE	THAI											LPG	02-Oct-06
T/B SANHANG TUO 2002 BARGE SANHANG GONG 2	CHINA	254 1062	848 3542		11.60M 35.30M	54M 92.64M		1940KW 2600HP	3.30M		27M		18-Dec-07
M/T YOTO	INDONESIA	676	1318		11.20M	76M	11.5KNOTS	2000HP		2000 M3		CONSTRUCTION	03-Nov-07
M/V ANDA 66	PANAMA	1466	2618		14.60M	87.06M	10KNOTS	1765KW	6.80M			CONSTRUCTION	03-Nov-07
M/V HOU EI	PANAMA	996	1781	2850	12.5M	77.75M	10KNOTS	735HP	5.10M			CONSTRUCTION	02-Nov-07
M/T THALASSIC	THAI	327	1088		11.8M	61.52M	11.8KNOTS	1170HP				LPG	13-Jul-07
M/T DENDRO	BOLAVIA	513	903	1528.82	11M	67.4M	12KNOTS	1600HP	4.30M			DO	30-Jun-07
T/B VIKING 28 BARGE ATTILA 30	PAPUA GUINEA	48 320	157 1067		7.25M 18.29M	24.57M 61.45M		671*2HP				MACHINERY	28-Jun-07
T/B VIKING 27 BARGE ATTILA 29	PAPUA GUINEA	48 126	157 419		7.25M 12.19M	24.57M 43.89M	16KNOTS	671HP*2				MACHINERY	28-Jun-07
M/V PRINCE	S.LEONE	3196	4898		17.25M	93.61M		450/2400KW					24-Jun-07
T/B TRANS POWER 202 BARGE GOLD TRANS 302	INDONESIA	83 923	275 3074									SAND IN BULK	31-May-07
T/B PIONEER 89 BARGE CS 2575	SINGAPORE	39 548	133 1826		7.32M 21.34M	21.69M 73.15M		462*2HP	4.57M				22-May-07
T/B PIONEER 92 BARGE CS 2576	SINGAPORE	39 548	133 1826									SAND IN BULK	28-Apr-07
M/T PICNIC 1	THAI	424	1413		12.20M	69.30M	10KNOTS	441HP*2	4.00M			LPG	08-Mar-07
M/T EAGLE	THAI											LPG	27-Jan-07
TUG WHALE BARGE SINOBEST 2501	SINGAPORE	69 511	227 1705		8.53M 21.35M	25.18M 76.15M	11KNOTS	632KW*2					20-Mar-08
M/V TAI RONG 16	CAMBODIAN	1292	1575	2980	12.80M	82.25M	12KNOTS	2000HP	5.10M				05-Jul-08
M/T PORNSUREE	THAI	593	992	1838.55	11.20M	75.75M	11KNOTS		4.66M				08-Jul-08
M/V JISONG 5	KOREA	888	1580		12.80M	83.10M		1325KW	5.90M				05-Jul-08
TUG KALTIM DOLPHIN 1706 BARGE INTAN 7502	SINGAPORE	154 969	179 3231		8.10M 24.40M	23.37M 91.50M	12KNOTS		5.00M				08-Jul-08
TUG ABADI 7 BARGE INTAN 7504	SINGAPORE	54 969	179 3231		8.10M 24.40M	25M 87.86M	7KNOTS	848*2KW					25-May-08
M/T RUANG RAIWIN 01	THAI	613	1558	2511.93	12M	85.92M	9.50KNOTS	2200HP					28-Jul-08
M/V POLE STAR	CAMBODIA	1498	2660	4217	14.50M	84.45M	11KNOTS	2000HP	5.40M		35M	CONSTRUCTION	16-Oct-08
M/V DAI JIANG	HONG KONG	2033	4042	5278.30	16M	105.90M		2205KW	6.70M				19-Nov-08
M/V POLE STAR	CAMBODIAN	1498	2660	4217	14.50M	84.45	11KNOTS	2000HP	5.40M		35M		28-Jul-08
TUG BINA OCEAN 6 BARGE SI NOBEST 2501	SINGAPORE	43 511	142 1705		7.32M 21.35M	23.50M 76.15M	10KNOTS	896KW					29-May-08
BARGE SI NOBEST 2501	SINGAPORE	512	1706		21.35M	76.15M	10KNOTS	448*2HP					29-May-08
M/T KINGBIRD	THAI	423	1112		11.20M	68.00M	10.5KNOTS					LPG	17-Feb-09
M/V HIGH SEA	CAMBODIAN	1168	1886		13M	88.62M	10KNOTS	1800HP	5.30M				10-Jan-09

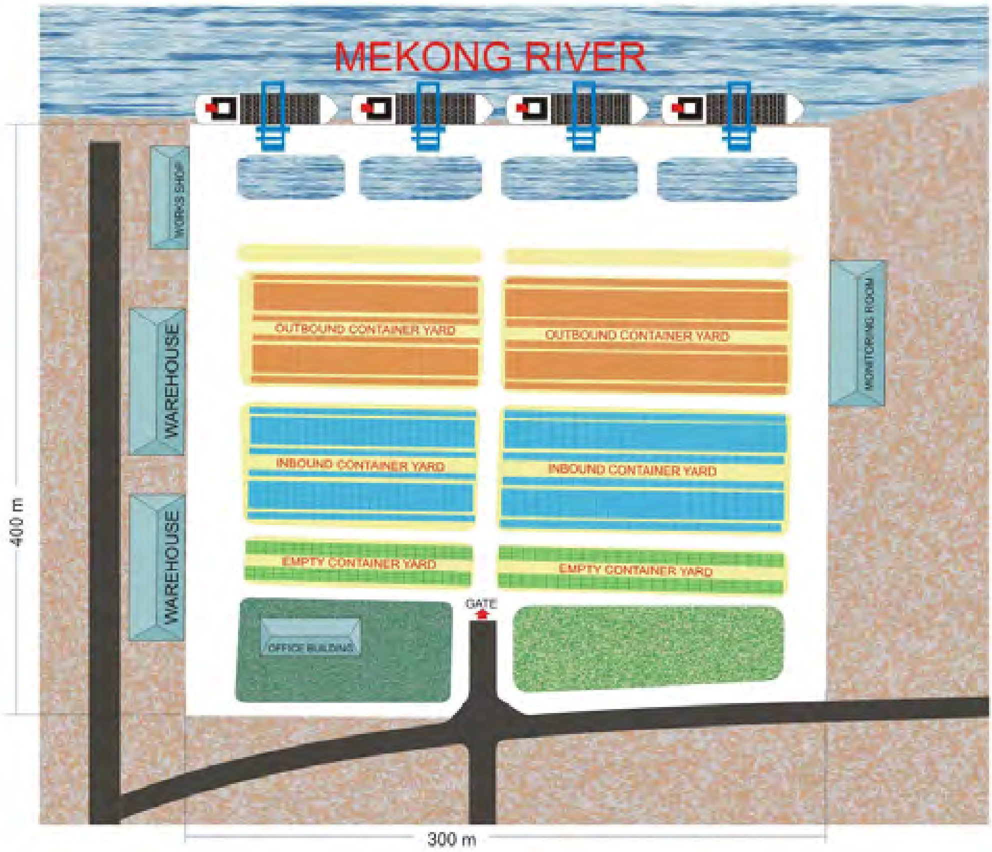
Source: Phnom Penh Autonomous Port

1.4.3 Future Development Plan of Phnom Penh Port

According to the interview held between Phnom Penh Autonomous Port and JICA Study Team held on 3 March, 2009, future development plan of the Phnom Pend Port is summarized below.

- Following two major studies: the Study on the Master Plan for Maritime and Port Sectors in Cambodia by JICA (2007) and the Master Plan for Waterborne Transport on the Mekong River System in Cambodia by Belgian Technical Cooperation, the Phnom Penh Autonomous Port is planning to develop its port to allow container traffic by sea-going vessels up to 5,000 DWT.
- Phnom Penh Autonomous Port is developing a new terminal of 300m length and 20m width. This terminal is originally designed to accommodate four vessels in the same time and its capacity 300,000TEU per year. Moreover, Phnom Penh Autonomous Port will expand its port capacity by building a new container terminal located 20 or 30 km on the south of the old terminal along the Mekong River.

Figure 2.4.1 shows the layout plan of the future container terminal of the Phnom Penh Port. The official letter issued by Phnom Penh Autonomous Port is also attached.



Source: Phnom Penh Autonomous Port

Figure 1.4-1 Layout Plan of Future Container Terminal of Phnom Penh Port

Official Letter issued by Phnom Penh Autonomous Port (1/2)

ព្រះរាជាណាចក្រកម្ពុជា
ជាតិ សាសនា ព្រះមហាក្សត្រ
KINGDOM OF CAMBODIA
Nation Religion King

កំពង់ផែស្វយ័តភ្នំពេញ
Phnom Penh Autonomous Port
No.: ...166.......... ក.ស.ភ (PPAP)

Phnom Penh, March 06th, 2009

To: JICA Study Team for Preparatory Survey on Design for Construction of the Second Mekong Bridge

Subject: Future Development Plan of the Phnom Penh Autonomous Port

With my capacity as Chairman and CEO of Phnom Penh Autonomous Port, I first would like to express my sincere gratitude to the JICA Study Team for the Preparatory Survey on Design for Construction of the Second Mekong Bridge, for your continuous effort to facilitate the traffic and transport along the National Road No. 1. As discussed in the meeting held at Phnom Penh Autonomous Port on the 3rd of March, 2009, I would like to confirm that Phnom Penh Autonomous Port is committed to develop the future container terminal together with the necessary dredging work to accommodate 5,000 DWT sea-going vessels in the near future. The outline of the development plan and its progress is summarized below.

1. Following two major studies: the Study on the Master Plan for Maritime and Port Sectors in Cambodia by JICA (2007) and the Master Plan for Waterborne Transport on the Mekong River System in Cambodia by Belgian Technical Cooperation, the Phnom Penh Autonomous Port is planning to develop its port to allow container traffic by sea-going vessels up to 5,000 DWT (400 TEU capacity and 6 to 6.5 draught) directly between overseas ports, including Singapore, Hong Kong, and Phnom Penh by 2015.

2. Looking at the history of the Phnom Penh Autonomous Port, the Port once operated for sea-going ships before 2003 and the ships with its length of nearly 100 m were frequently called at the Port. (Please see the attached specification of ships called at the Phnom Penh Port.)

3. The Phnom Penh Autonomous Port is to conduct the Feasibility Study on the New Container Terminal at the Phnom Penh Port, allowing 5,000 DWT container vessels to enter to the port, to confirm the technical and financial viability of the project. Based on the result and recommendation of the study, Phnom Penh Autonomous Port will seek for the soft loan for the construction work of the new container terminal.

Prah Sisowat, Sangkat Sras Chork, Khan Daun Penh, Phnom Penh
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Official Letter issued by Phnom Penh Autonomous Port (2/2)

As Chairman and CEO of PPAP and on behalf of our organization, we trust that the port development plan and our efforts to accomplish this project shall be taken into consideration for the design of the Second Mekong Bridge.

High Regards,

Hei Bavy

Delegate of Royal Government
in charge as
Chairman and CEO of PPAP

Prah Sisowat, Sangkat Sras Chork, Khan Daun Penh, Phnom Penh
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Chapter 2. Impact of Project Implementation on Social and Natural Environments

2.1 Resettlement Issues and Social Considerations

2.1.1 Resettlement Issues

(1) Identification of Project Affected Areas and Assistance in Minimizing PAPs

On the basis of the final alignment, the distribution, number and basic profiles of PAPs were identified. Involuntary resettlement as well as the loss of income opportunities should be avoided at every possible cost. At the same time, where avoidance is not possible, the negative impacts must be kept to the minimum. Based on this philosophy, the following measures for the avoidance and reduction of involuntary resettlement have been implemented with respect to the project affected areas identified at the time of the feasibility study. As a result, the number of PAPs (households) has been reduced from 260 (at the time of the feasibility study) to 230, and the number of affected housing assets has been significantly reduced from 127 (at the time of the feasibility study) to 82.

- In order to minimize the scale and impact of land and asset acquisition, involuntary resettlement was avoided as much as possible without creating technical problems through minor changes in the alignment as it was at the time of the feasibility study. On this occasion, alignment options were selected to avoid involuntary resettlement wherever possible in populated areas close to the National Route No. 1 or crossed by the National Route No. 11.
- At the same time, the area for land acquisition at the time of the feasibility study was set in accordance with the ROW (Right of Way: 30 meters either side of the centerline in the case of this Project, which would be the roadway of the NR-1). On the other hand, in this Study, it has been agreed with the Cambodian side that the land acquisition area should be limited to the PRW (the minimum required road width set by the Project taking into consideration the adjacent working space, in addition to the approach roads and bridge section including road surface, slope and embankment) so as to minimize the project affected area. This resulted in a further reduction of the need for involuntary resettlement.
- As a result, Zone B1 in the PAPs distribution map is regarded as the PRW subject to land acquisition. However, since Zones D1 and D2 are on a state-owned island, land acquisition will not be required (only assistance for land use). On the other hand, Zones B3 and B4

(excluding Zone B3-d which is a candidate site for a roadside station) which are adjacent to the PRW will not be acquired but only leased during the construction period.

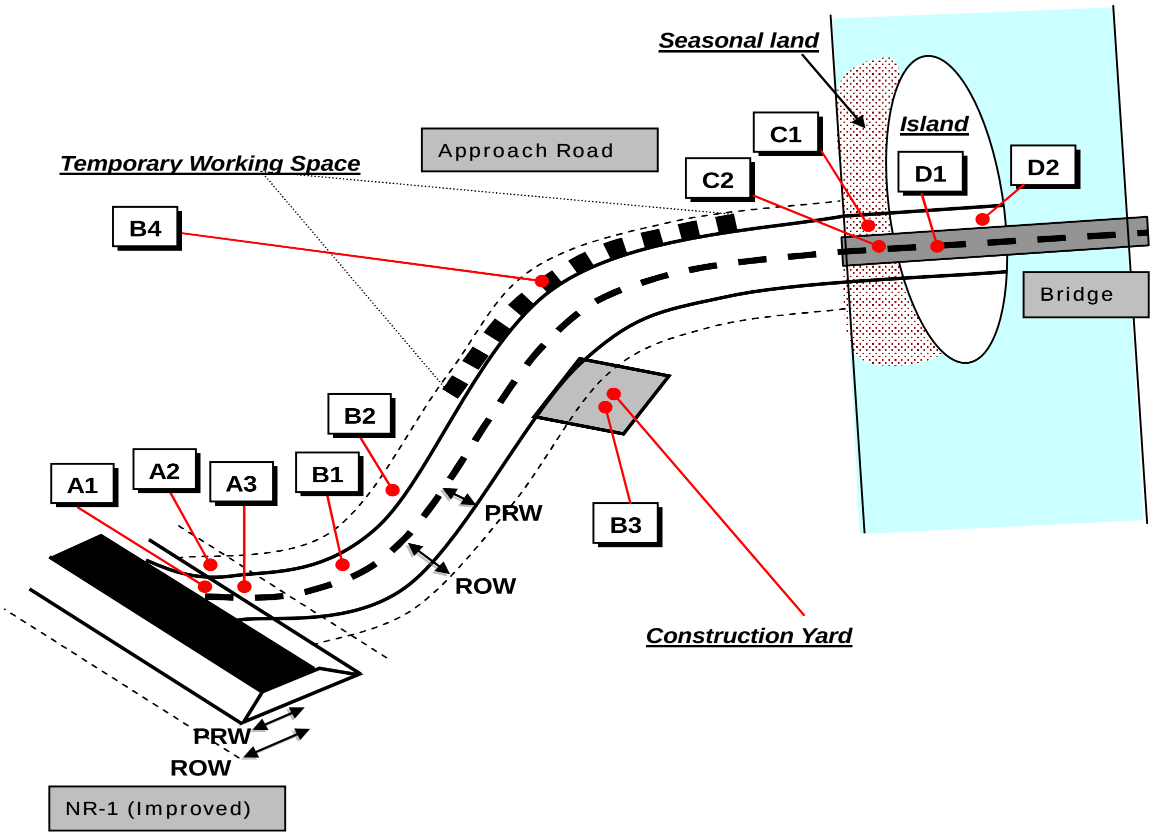


Figure 2.1-1 Illustration of Distribution of PAPs by Type of Zone

Table 2.1-1 Explanation of Zones

Category	Zone	Compensation: Land	Compensation: Housing Assets	Legal Status	Relation to Project Area
Area Connected to NR-1	A1	×*	●*	Public	Inside PRW of NR-1
	A2			Public	Inside ROW of NR-1, Outside PRW of NR-1
	A3				
Land Section	B1	●	●	Private	Inside PRW of Neak Loeung Bridge (NB)
	B2	Not subject to Land Acquisition			Outside PRW of NB
	B3-a	▲	●	Private	Construction Yard (To be leased, West)
	B3-c	▲	●	Private	Construction Yard (To be leased, East)
	B3-d	●	●	Private	Construction Yard （To be acquired, East）
	B4	▲	●	Private	Working Spaces(To be leased)
River Section	C1	×	No Housing Assets	Public	Inside PRW of NB
	C2	×	No Housing Assets	Public	
Island Section	B3-b	■	No Housing Assets	Public	Construction Yard (To be leased, Island)
	D1	■	●	Public	Inside PRW of NB
	D2	■	●	Public	

●Compensation for Ownership
■Compensation for Use
▲Payment of Leasing Fees
×No Compensation

Note: * PAPs still living within the ROW of the existing NR-1 after resettlement under the former project should not be compensated in the Neak Loeung Bridge Project in accordance with the agreement between the Government and PAPs. However, the Government will provide alternative land to double PAPs in cases where the PAPs become landless after resettlement due to the construction of the bridge.

Table 2.1-2 Number of PAPs and Affected Assets

Area	Commune	Number of PAPs	Number of Affected Assets	Number of Affected Assets (House and Land / House Only)	Number of Affected Assets (Land Only)
Eastern Side	Prek Ksay Ka	31	35	5	30
	Prek Ksay Kha	77	81	36	45
Western Side	Kampong Phnom	122	132	41	91
Total		230	248	82	166
At the time of Development Study		260	272	127	145

Source: JICA Study Team

(2) Results of Simple Survey and Announcement of Cut-off Date

① Results of Simple Survey

Mapping of the area affected by the construction of the Neak Loeung Bridge was undertaken during updating of the Simple Survey conducted in July 2009. The results of the updated Simple Survey were used to prepare a list of PAPs in accordance with the existing compensation policies and to identify the PAPs who are eligible for entitlements. At the same time, all the housing assets of PAPs have been photographed and compiled as materials recording the assets at the time of the cut-off date.

② Announcement of Cut-off Date

The establishment of a cut-off date aims to protect the legal rights of PAPs with regard to compensation and to prevent the inflow of ineligible persons who might claim compensation. The cut-off date determines who is entitled to compensation under the Project. Any person moving into the PRW after the cut-off date will not be considered as PAPs and will not be eligible for compensation. As noted before with the Simple Survey, the cut-off date is set as the last date of the Simple Survey, and it was confirmed that the cut-off date is July 25, 2009, the actual completion date of the Simple Survey following the following procedures:

(a) Notification of Simple Survey, Public Consultation and Procedures for Declaration of Cut-off Date: July 7-8, 2009
(b) Kick-off of Simple Survey: July 9, 2009
(c) Implementation of Simple Survey: July 9-25, 2009
(d) Completion Date of Simple Survey (Cut-off Date): July 25, 2009
(e) Preparation of Simple Survey Report: July 26-31, 2009
(f) Sending of Official Letter on Cut-off Date from IRC to PAPs: August 6, 2009
(g) Explanation of Announcement of Cut-off Date in a Public Consultation: August 7, 2009

(3) Formulation of Resettlement Action Plan (RAP) Version 1

① Basic Policies for Formulating RAP Version 1

The Resettlement Action Plan (RAP) Version 1 has been prepared in order to:

- ensure that the social and economic livelihood of PAPs is restored at least to the pre-project level;
- provide policy and procedural guidelines for the acquisition of land and other assets, compensation, and resettlement;
- identify households that will be adversely affected by the Project, where they are located, what compensation and related alleviating measures are to be provided and how and when these measures will be implemented;
- estimate an overall budget of the required resources and the actual assessed compensation needed to implement the RAP.

The RAP will reflect the results of the DMS (Detailed Measurement Survey) and the RCS (Replacement Cost Study) which will be conducted at the appropriate time.

The major contents of the RAP Version 1 are as follows:

- Outline and Background of Project
- Legal Framework for Land Acquisition and Resettlement
- Process to Minimize Resettlement by Alignment Change
- Scope of Affected Area and PAPs
- Outline of Socio-economic Profiles of PAPs
- Outline of Resettlement and Compensation Policies
- Outline of Entitlement Matrix
- Outline of Income Restoration Measures
- Outline of Mitigation Measures for Socio-economically Vulnerable PAPs
- Framework for Relocation of Residents
- Budget Arrangements and Implementation Schedule
- Mechanism for Redressing Grievances
- Public Consultations and Disclosure of Information
- Monitoring and Evaluation

② Compensation Policies in the RAP Version 1

The major compensation policies in the RAP Version 1 are as follows:

i) Every possible solution should be considered in order to avoid the negative impacts caused by the acquisition of land and other assets, and resettlement;

ii) Where it is not possible to avoid these negative impacts, the living standard of PAPs should be restored at least to the pre-project level; and

iii) The compensation rates to be applied will be based on “Replacement Cost” reflecting the market value of the affected assets.

Other important issues include the following.

- **Compensation for Land on the Island:** Compensation for the PAPs on the island will be in accordance with the following basic compensation policies:
  - In accordance with the Constitution of Cambodia, the island is “State Property”.
  - The Government will not provide compensation for land titles on the island.
  - All properties other than land will be compensated at a replacement cost that is the same as for properties in the main land areas of the project site.
  - The Government will provide cash assistance for persons who use the land on the island. In the case of farm land, cash assistance for land use will be provided based on land productivity over a number of years. In addition, PAPs who become landless will be allocated a plot of land in lieu.

- **Border Areas between Banks and River:** Cash assistance will be provided for land that is seasonally submerged by the river water in the flood season, based on land productivity over a number of years. The following borders will be decided at the time of the implementation of the DMS, taking into account the individual characteristics of the relevant PAPs:
  - Border between the Western Bank and the River
  - Border between the River and the Eastern Bank of the Island
  - Border between the River and the Eastern Bank
  - Eroded Western Bank of the Island

- **Landless PAPs:** Prakas No.6 on "Measures to Crack Down on Anarchic Land Grabs and Encroachments" issued on September 27, 1999 specifies that the ROW is 30 m either side of the centerline of NR-1, and prohibits private ownership of the ROW. Meanwhile, the Ministry of Economy and Finance (MEF) Decree No. 961 (2000) also declares that the Government of Cambodia will not pay compensation to people who occupy the ROW for any structures or assets located on the land. Although the PAPs in the ROW should basically be treated in accordance with these regulations, as a special case the landless PAPs in the ROW will be provided with alternative land under the conditions set out in the entitlement matrix.

- **Double PAPs:** PAPs who were already relocated once under the NR-1 Project by JICA or ADB will be treated as follows:

  - PAPs still living within the ROW of the existing NR-1 after resettlement under the former project should not be compensated under the Neak Loeung Bridge Project, in accordance with the agreement between the Government and PAPs;
  - The Government will provide alternative land to double PAPs in cases where the PAPs become landless after resettlement due to the construction of the bridge; and
  - The Government will consider the provision of assistance for double PAPs' properties and resettlement activities to mitigate the second impact caused by the construction of the bridge.

- **Assistance to Vulnerable Households:** Vulnerable groups who will experience a considerable degree of social and economic disruption, ie households headed by a female or a disabled person and households below the Cambodian poverty line will be provided with special assistance. This countermeasure is part of the income restoration activities. In this connection, a cash allowance of USD 22.4 per household will be provided to each eligible household within the framework of current practice.
- **Disruption Allowance:** Those whose houses are affected and lives disrupted will be provided with a disruption allowance of USD 44.8 per household as support for meals and/or income loss during reconstruction/repair of their homes. No disruption allowance will be provided for the reconstruction of buildings other than for residential purposes.
- **Resettlement Allowance:** Those whose houses are affected so that they have to move to a relocation site or elsewhere will be provided with a resettlement allowance of USD 44.8 per household in addition to the disruption allowance mentioned above.

(4) Public Consultation for PAPs

① Outline of Public Consultation

The public consultations for PAPs have been held as follows so as to explain the outline of the Project and the compensation policies.

- Date: August 7, 2009 (9:00 AM – Noon: PAPs in Prey Veng Province, 2:00 PM – 5:00 PM: PAPs in Kandal Province)
- Venue: Neak Loeung Ferry Conference Room
- Participants: 113 PAPs for the Morning Session, 115 PAPs for the Afternoon Session

A public information booklet with the following content was prepared in the Khmer language and distributed to PAPs at the time of the public consultation. At the same time, the contents of the booklet were converted into Power Point materials and explained verbally to illiterate PAPs.

- Outline of Project
- Scope of PAPs and Process of Minimization
- Announcement of Cut-off Date
- Outline of Compensation Policies and Entitlement Matrix
- Procedures for Redressing of Grievances
- Explanation of Terminologies used in Resettlement Action Plan

② Outline of Program, and Major Questions and Answers

After the public consultation was declared in session, the program included i) opening remarks by MPWT and IRC officials, ii) explanation of the outline of the Project and compensation policies, procedures for resettlement, the implementation schedule, the procedures for redressing grievance , etc., and iii) questions and answers. The main questions and answers include the following. Basically, the questions focus on concerns about compensation and the future of landless PAPs, and interest in specific compensation rates by PAPs who own the land. The provision of alternative land was the answer to the former question, while compensation based on the RAP was the answer to the latter question.

- Is there any difference in compensation rates between the areas close to the NR-1 and the areas far from the NR-1?
- What about compensation for houses under construction?
- What about compensation for land inside the ROW?
- When will the construction of the bridge start?

(5) Preparation of the Detailed Measurement Survey (DMS) and Replacement Cost Study (RCS)

① Preparation of the Detailed Measurement Survey (DMS)

In order to accurately calculate the details of the affected assets, a Detailed Measurement Survey (DMS) will be carried out at the appropriate time. The information to be collected in the DMS includes (i) floor area and number of structures, (ii) land category and accurate measurements of the land to be acquired, (iii) description and specifications of building materials, and (iv) eligibility for receipt of various allowances. The procedure manual and standard questionnaires for the DMS were finalized in consultation with the IRC. The questionnaires are divided into items for PAPs inside the existing ROW and items for PAPs inside the PRW on the new alignment.

② **Preparation of the Replacement Cost Study (RCS)**

In order to provide the basic information to estimate the “Replacement Cost”, a Replacement Cost Study (RCS) will be carried out at the appropriate time. The “Replacement Cost” is the amount of compensation which will be paid to PAPs to compensate for the loss of land and other assets based on current market prices so that PAPs can obtain at the current market price/value land or property with a productive capacity equivalent to or better than that of the acquired land or property, without deduction of any salvage or depreciation and taking no account of the influence of the development project on the value of the acquired land or property, plus the cost of transferring or registering the rights to the new land or property. The procedure manual and standard questionnaires for the RCS were finalized in consultation with the IRC.

The methodology employed for estimating the cost of structures consisted of quantity surveying and detailed measurements of the component parts of each structure. Labor costs were also assessed at market prices for the structure as a whole based on the information provided by local building contractors on a regional basis. The following 14 categories of housing structures are proposed with reference to recent similar projects:

- 4 categories of low-cost thatch and timber houses, shops and stalls.
- 6 categories of higher cost and more permanent mainly timber houses, shops or stalls using other permanent materials.
- 2 categories of permanent, mainly masonry town houses or shop houses.
- 2 categories of permanent, mainly masonry villas.

In the case of walls, floors, columns or roofs of structures being missing, when these categories were applied to past projects, there were some cases where the amount of compensation was reduced by multiplying in some adjustment factors. In this Project, no such adjustment factors will be applied.

Table 2.1-3 Proposed Sub-categories of Structures for RCS

Roof	Wall	Floor	Column	Storey	Type
Thatch	Thatch	None or Weak	Pole (Wood)	Single	1A
	Thatch	Solid	Pole (Wood)	Single	1B
	More than 25% permanent material	More than 25% permanent material	Pole (Wood)	Single	1C
Iron sheeting, Asbestos or Plastic	Thatch	None or Weak	Pole or Timber	Single	1D
Iron sheeting, Asbestos or Plastic Sheet	Iron sheeting, Asbestos	None or Weak	Pole or Timber	Single	2A
	Wood	None or Weak	Pole or Timber	Single	2B

Roof	Wall	Floor	Column	Storey	Type
	Wood	Wood or Concrete	Timber	Single	2C
Textile, Asbestos or Plastic	Brick	Concrete	Concrete	Single	2D
Tile	Wood or Brick	Wood or Concrete	Timber	Single	
Textile, Asbestos or Plastic	Wood or Brick	Wood or Concrete	Concrete	Multi	2E
Tile	Wood or Brick	Wood or Concrete	Timber	Multi	2F
Tile	Wood or Brick	Concrete	Concrete	Single	3A
Concrete	Brick	Concrete	Concrete	Single	3B
Tile	Wood or Brick	Concrete	Concrete	Multi	4A
Concrete	Brick	Concrete	Concrete	Multi	4B

(6) Meeting with the NGO Forum

The Study Team visited the office of the NGO Forum which is interested in resettlement issues in Cambodia, explained the outline of the Project, and exchanged views with the Forum. The major comments from the Forum included the following:

- The road and bridge construction projects funded by Japan contribute greatly to the development of Cambodia;
- The experiences of the NR-1 improvement project should be put to good use in improving the resettlement activities; and
- If there are any further comments, the Forum will submit them to the JICA Cambodia office.

Although the Forum was notified of the date of the public consultation, there were no participants from the Forum.

2.1.2 Social Considerations

1) Implementation of Baseline Survey on Indirectly Affected Persons (IAPs)

The baseline survey was conducted in order to collect basic information on the mitigation measures for the Indirectly Affected Persons (IAPs) who might be affected by the downsizing of the ferry services in association with the construction of the bridge.

The IAPs include the following stakeholders who are engaged in economic activities around the ferry terminals:

- Ferry Staff
- Vendors
- Owners of Mobile Kiosks
- Owners of Restaurants and Shops
- Owners of Stalls in Large-scale Markets

Source：JICA Study Team

Figure 2.1-2 Snapshots of Eastern and Western Terminals

Interview surveys of the above-mentioned stakeholders were carried out to assess the negative impacts of the downsizing of ferry services in association with the construction of the bridge. Apart from these stakeholders, it was confirmed that all the staff of the Neak Loeung Ferry had been permanent employees since 2006.

The objective, method, date and survey results for each baseline survey are as follows.

① **Baseline Survey 1: Survey of Vendors**

(a) Survey Objective: To grasp basic, socio-economic and business profiles of vendors at both terminals and estimate the negative impacts on the livelihood of vendors caused by the downsizing of ferry services in association with the construction of the bridge, as reference for the formulation of the mitigation measures.

(b) Survey Method: Direct interview method targeting 200 selected sample vendors (population : 545 vendors at maximum) at both terminals (Sampling method: On-site random sampling）

(c) Survey Date: March 11-20, 2009

(d) Survey Results: Ferry passengers are relatively important customers for vendors. Accordingly, the decrease in the number of ferry passengers due to the downsizing of the ferry services might have a considerable impacts on the income of vendors. In addition, since vendors are likely to purchase what they sell from local shops and markets, there might also be some effect on the local economy. (The details of the survey results are given in Appendix 11.2)

② **Baseline Survey 2: Survey of Mobile Kiosks**

(a) Survey Objective: To grasp basic, socio-economic and business profiles of owners of mobile kiosks at both terminals and estimate the negative impacts on the livelihood of those owners caused by the downsizing of ferry services in association with the construction of the bridge, as a reference for the formulation of the mitigation measures.

(b) Survey Method: Direct interview method targeting 18 mobile kiosks (Sampling method: Survey of all 18 mobile kiosks)

(c) Survey Date: March 14-15, 2009

(d) Survey Results: The main customers for mobile kiosk owners are not only ferry passengers but also local residents. Accordingly, the decrease in the number of ferry passengers due to the downsizing of the ferry services might affect their income to some extent. Although the decline in their earnings would have some influence on their household budget, the degree of the impact does not seem to be so serious. In the same manner as vendors, mobile kiosk owners also purchase what they sell from local shops and markets. As a result, there would be an impact on the local economy to some extent. (The details of the survey results are given in Appendix 11.2)

③ **Baseline Survey 3: Survey of Restaurants and Shops**

(a) Survey Objective: To grasp basic, socio-economic and business profiles of owners of restaurants and shops at both terminals and estimate the negative impacts on the livelihood of those owners caused by the downsizing of ferry services in association with the construction of the bridge, as reference for the formulation of the mitigation measures.

(b) Survey Method: Direct interview method targeting 81 restaurants and shops within 100 meters of both terminals (Sampling method: Survey of all 81 restaurants and shops)

(c) Survey Date: March 16-17, 2009

(d) Survey Results: Ferry passengers are the main customers of restaurants and shops. Accordingly, the decrease in the number of ferry passengers due to the downsizing of the ferry services might have a considerable effect on these commercial facilities. (The details of the survey results are given in Appendix 11.2)

④ **Baseline Survey 4: Survey of Large Markets**

(a) Survey Objective: To grasp basic, socio-economic and business profiles of owners of stalls in the large markets near both terminals and estimate the negative impacts on the livelihood of those owners caused by the downsizing of ferry services in association with the construction of the bridge, as reference for the formulation of the mitigation measures.

(b) Survey Method: Direct interview method targeting a total of 155 sample stalls (population: 750 stalls) in the large-scale Phsar Thmey market on the eastern side and Phsar Char market on the western side.（Sampling method: On-site random sampling）

(c) Survey Date: March 18–20, 2009

(d) Survey Results: The western and eastern markets are both located at some distance from the ferry terminals. For these locations, the number of ferry passengers who stop off at the large markets is relatively smaller, accounting for less than 10 percent of the total number of the markets' customers. Hence, the decrease in the number of ferry passengers would not have a serious effect on these market workers, since the main customers are local residents. However, since these markets function as suppliers to the commercial activities at the ferry terminals including vendors and mobile kiosks, these markets might suffer some negative impact due to the decline of such businesses. (The details of the survey results are given in Appendix 11.2)

⑤ **Baseline Survey 5：Survey of Drivers and Passengers**

(a) Survey Objective: To grasp basic profiles and purchasing patterns of ferry users (drivers and passengers) and estimate the change in patterns of purchasing from vendors, mobile kiosks, restaurants, shops and markets caused by the shift in crossing method from the ferry to the bridge, as reference for the formulation of the mitigation measures.

(b) Survey Method: Direct interview method targeting a total of 252 sample ferry users (The number of users fluctuates daily.): (Sampling Method: On-site random sampling)

(c) Survey Date: March 21-22, 2009

(d) Survey Results: Since the majority of drivers and ferry passengers would enjoy a smoother crossing than they get from the present ferry services, there might be almost no negative impact after the construction of the bridge. They would enjoy the same convenient services as at present in purchasing from vendors as well as using the restaurants and shops around the terminals, if similar commercial facilities continue to be available after the construction of the bridge. (The details of the survey results are given in Appendix 11.2)

Figure 2.1-3 provides snapshots of the IAPs at the two terminals.

Source：JICA Study Team

Figure 2.1-3 Snapshots of IAPs at Eastern and Western Terminals

(2) Study of Mitigation Measures for Vendors and other IAPs

① Use of the Construction Yard as a Roadside Station

The construction yard on the eastern bank will be used as a multi-functional roadside station in order to provide selling opportunities for vendors. The government of Cambodia will be responsible for further detailed studies regarding these facilities. The major functions of a roadside station include:

- Provision of parking spaces, rest area, toilet facilities, petrol station and other facilities for passengers;
- Provision of a sales area for vendors and other IAPs;
- Utilization of tourism resources such as bridge-viewing areas;
- Provision of local community facilities; and
- Provision of operating and maintenance facilities for the bridge and approach roads.

Items requiring further study include:

- Content and specifications of the facilities;
- Estimated cost of facilities;
- Budget arrangements and institutional set-up;
- Operation and maintenance of facilities;
- Provision of licenses for use of facilities; and
- Estimate of demand.

② Promotion of Local Employment Opportunities for Construction Workers during the Construction Period

The huge job opportunities in construction works during the construction of the bridge should be made available to the IAPs as far as possible.

③ Promotion of Local Employment Opportunities for Road Maintenance Works

Job opportunities in road maintenance works after the construction of the bridge should be made available to the IAPs as far as possible.

④ Exploitation of Economic Boom Instigated by Huge Inflow of Construction Workers

The increase in consumption caused by the inflow of huge numbers of construction workers during the construction period, will significantly increase sales opportunities for the IAPs at both ferry terminals. This boom and momentum should be effectively exploited to provide economic opportunities for the IAPs.

⑤ Assistance for IAPs in Product Development and Marketing

Assistance in the field of product development and marketing should be provided to IAPs making use of the roadside stations.

⑥ Possibility of Small-scale Local Boat Services

The possibility of and demand for small-scale local boat services even after the construction of the bridge should be studied.

⑦ **Possibility of a Mini-bus Shuttle Service between the Former Ferry Terminals**

The possibility of and demand for a mini-bus shuttle service between the former ferry terminals should be studied.

(3) Public Consultation for IAPs

① **Outline of Public Consultation**

Public consultations for IAPs have been held as follows so as to explain the outline of the Project and assess the demand for mitigation measures in the future.

- Date: August 10, 2009 (9:30 AM– 11:00 AM: IAPs in Prey Veng Province, 2:30 PM – 4:00 PM: IAPs in Kandal Province)
- Venue: Neak Loeung Ferry Conference Room
- Participants: 109 IAPs for the Morning Session, 57 IAPs for the Afternoon Session

② **Outline of Program, and Major Questions and Answers**

After the opening remarks by a MPWT official, the outline of the Project and the implementation schedule were explained, and a question and answer session was held. The main questions from the participants were as follows. Basically, the construction of the bridge is welcomed, while many participants requested mitigation measures such as the provision of alternative marketing opportunities for vendors after the construction of the bridge.

- Some families are concerned about losing their jobs. The livelihoods of such families depend on sales activities at the ferry terminals.
- Although the construction of the bridge is welcomed, the government is asked to promote the construction of factories to create job opportunities.
- Although there are no objections to the construction of the bridge, vendors request the securing of places where they can continue their current business.
- There are no concerns about future job opportunities, since it will be possible to find a new job.

2.2 Environmental Impact Assessment and the Natural Environment

2.2.1 Outline of the procedures for EIA approval

On the basis of the results of the Initial Environment Impact Assessment (IEIA) for Neak Loeung Bridge construction project, the Cambodian Ministry of Environment (MOE) determined the need to implement a study of the Environment Impact Assessment (EIA). In response to this decision, the Ministry of Public Works and Transportation (MPWT) prepared an Environment Impact Assessment (EIA) report, which was submitted to the MOE in March, 2007. After the review of the EIA, the approval of the EIA was notified to MPWT by the MOE in January 2008. Thus, the MOE approved the EIA with the following supplementary conditions:

The MPWT responsible for the implementation of the Project shall:

1. Abide by the EIA report submitted to the MOE, and follow the comments noted there;
2. Report to the MOE any modification of or addition to the project site not later than one month before completion of the construction; and
3. Observe the Law on Environmental Protection and Natural Resources Management, in instances where the above conditions do not apply.

In this study, the environmental impact resulting from the adjustment to the road alignment and road structure was reviewed. A further step was taken in this study to examine and prepare measures to mitigate the environmental impact during and after the construction work, and the proposed environment management plan (EMP) including a monitoring plan to ensure these measures are carried out.

The survey was implemented based on the JICA Guidelines for Environmental and Social Considerations.

2.2.2 Environmental Management Plan (EMP)

The Environmental Management Plan covers a series of mitigation measures taken during the period of project implementation and operation to avoid or cancel the negative impact on the environment and communities or to reduce the impact to a permissible level, as well as monitoring and structural improvements related to these measures.

1) Related laws and regulations

The EMP will be drawn up in accordance with the following laws and institutions:

1) Law on Environmental Protection and Natural Resources Management
2) Sub-Decree on Water Pollution Control
3) Sub-Decree on Solid Waste Management
4) EIA Report of Neak Loeung Bridge Construction
5) JICA Guidelines for Environmental and Social Considerations.

2) Environment monitoring

Environment monitoring plans shall be implemented in two phases: prior to the start of construction and during construction.

a) Proposed monitoring items

The monitoring items listed in Table 2.2-1 are proposed, with consideration given to the following items:

- Current status and characteristics of this Project
- Monitoring items implemented for other projects of the same type (large scale bridges)
- Requirements by the MOE appended at the time of the EIA approval

Table 2.2-1 Proposed monitoring items and method

Item			Method
1	Air quality	TSP CO NO_2 SO_2	Air quality survey to be carried out at the height at which contaminants are generated, in the periphery of the environmental protection area subjected to the most serious impact.
2	Noise	L_{eq}	Noise survey to be carried out on the road boundary and in the periphery of the environmental protection area closest in the construction area and subjected to the most serious impact.
3	Water quality * (surface layer water and waste water from construction work)	pH Turbidity DO BOD COD Conductivity Water temperature SS Number of coli form groups Water level	Survey the water quality of the Mekong River and water quality of the waste water from construction work.
4	Soil ** (hazardous substances)	Heavy metals Oil and grease	Measure the amount of hazardous substances contained in the excavated soil and waste material.
5	Land subsidence	Land subsidence	Observe the land subsidence around the banked section.
6	Verification of biota	Fauna and flora	.Verify changes through daily observation.

* Water quality monitoring items will be set based on the list of contaminants and reference values listed in the Sub-Decree on Water Pollution Control.

** Waste monitoring items will be set based on the list of contaminants and reference values listed in the Sub-Decree on Solid Waste Management.

b) Monitoring points and frequency

Table 2.2-2 shows the proposed monitoring points and frequency. During the construction period, a detailed monitoring plan will be drawn up and implemented according to the construction site and type of work.

Table 2.2-2 Proposed survey points and frequency

Item		Survey point	Frequency		
			At the start of construction	During construction (48 months)	After opening (2 years)
1	Air Quality	-Ampil Tuek Village -Kaoh Chamraeung Village -Otdam Village	Once	Every three months	Once a year
2	Noise				
3	Surface Water Quality	-At three points about 1 km downstream from Neak Loeung Bridge -Similarly at one point in the tributary	Once	Twice during the dry season Twice during the rainy season	Once during the dry season Once during the rainy season
4	Waste Water Quality from Construction Site	Construction site	-	As needed	-
5	Soil	Land waste disposal site	-	Every three months	-
6	Subsidence	-Phum 1 Village	-	Every three months	Once a year
7	Verification of biota	Around the site	-	Constantly	-

3) Mitigation measures

The method of mitigating the environmental impact, the work plan, machines to be used, operating procedures and mitigation measures are specified below. Contractors shall take the following environmental measures as measures to mitigate environmental impact during the construction work, in conformance with the Contract.

- Air pollution
  Around the storage yard, or where dust particles are generated by the operation of large trucks and construction machinery, it is essential that seat covers be used, that dust be kept down by sprinkling water, that restrictions on driving speed be observed, and appropriate maintenance of the construction equipment be carried out.

- Water contamination
  Excavation work conducted in rivers or wetlands may have an impact on water quality due to the drainage of water used in excavation. The excavation water shall be subjected to drainage treatment in a sand sedimentation basin to be newly constructed. Should the water quality level fail to meet Cambodian standards, necessary measures including use of a condensate shall be taken in order to abide by the waste water standards. Necessary and sufficient measures shall be taken for the appropriate treatment of the waste water discharged from concrete plants.

  A septic tank shall be installed to dispose of the night soil discharged from the offices and sleeping quarters at the construction site, to ensure that effluent standards are observed.

When fuels and chemicals such as coagulants are stored, measures shall be taken to prevent spillage in the event of flooding and to prevent them from combusting in the event of fire.

- Treatment of excavated soil and construction waste
  Efforts shall be made to recycle the construction waste. Contractors shall organize sanitation squads to recover the waste from the construction workers' sleeping quarters and to dispose of it appropriately in cooperation with the local municipalities.

- Noise and vibration
  Noise and vibration will be generated during the construction work by the excavation work and the operation of large trucks and construction machinery. The construction machinery and vehicles must be appropriately maintained so as to minimize unwanted noise and vibration. Taking into consideration hospitals, schools and other facilities where quiet surroundings are required, work at the concrete plant involving crushing operations should be performed only during the daytime. When work is to be performed at night, prior permission must be obtained from the government, and notification made to the residents.
  Steps shall be taken to ensure that residential properties are not damaged by the vibrations generated by hammering or excavation work. In residential areas, temporary enclosures for construction work or noise barriers will be installed whenever necessary. During the construction work, noise monitoring shall be carried out to ensure appropriate implementation of environmental measures.

The construction work contract shall incorporate notes on environmental protection during the construction work、 including strict observance of the construction work hours, traffic safety and observance of legal speed limits, and the appointment of traffic safety personnel. Before the start of the work, the contractors shall appoint personnel to be responsible for environmental management and work to ensure the implementation of appropriate environmental management. The environmental management plan shall include the following:

- Selection of an appropriate borrow pit, quarry, material and equipment storage yard, asphalt plant etc.
- Materials transportation plan (routes, time zones)
- Planning of excavated soil and waste disposal site
- Measures to prevent soil spillage and ensure stability at the excavated soil disposal site
- Sewage collection and disposal facilities
- Management of construction worker sleeping quarters
- Traffic control and traffic safety management
- Noise prevention measures such as the installation of a noise barrier
- Anti-dust measures
- Handling and storage of fuel and other hazardous materials
- Night soil collection and treatment
- Repair of public facilities such as water channels

Chapter 3. Contents of the Project

3.1 Outline of the Project

3.1.1 Overall Goal and Project Objective

The Cambodian Ministry of National Planning worked out the National Strategic Development Plan (NSDP) 2006-2010, including the National Poverty Reduction Strategy and National Population Plan, in July 2006. The NSDP states the importance of the renovation and maintenance of the road network as one of the measures needed to accomplish the plan, and the quantitative target during NSDP 2006-2010 is to upgrade another 2,000 km of primary and secondary roads, bringing the total length of such upgraded roads to 4,100 km.

The concept of the Asian Highway was agreed at the United Nations Economic Commission for Asia and the Far East (“ECAFE”) in 1959. The aim is improvement of the road traffic which supports the promotion of regional development, trade and tourism. As a part of the Asian Highway No.1 (AH-1), the National Road No.1 of Cambodia is designated an international highway (Southern Economic Corridor) connecting Ho Chi Minh, Phnom Penh and Bangkok.

As noted above, the National Road No.1 is one of the most important roads, not only as the primary highway of Cambodia, but also as a major road serving the southern area of the Indochina Peninsula.

On both sides of the Mekong River, i.e., the road between Phnom Penh and Neak Loeung (west side), and the road between Neak Loeung and Babette on the Vietnamese border (east side) the National Road No.1 of Cambodia is being improved under ODA Projects of Japan and ADB respectively. However, at the present time the crossing of the Mekong River by ferry at Neak Loeung remains a bottleneck for traffic.

The objective of the Project for Construction of Neak Loeung Bridge (“the Project”) is to construct Neak Loeung Bridge at this crossing site of the Mekong River that is a traffic bottleneck at present, to provide a safe and comfortable traffic infrastructure.

3.2 Outline Design of the Requested Japanese Assistance

3.2.1 Design Policy

The Construction of Neak Loeung Bridge is a new bridge construction project including bridges with a total length of 2.2 km crossing over both the main stream and a tributary of the Mekong River. The total length of the Project including the bridges and embankment section is about 5.5 km.

Figure 3.2-1 shows an explanatory diagram of the Project location. The Project includes the road on the west side (0.84 km), the approach bridge on the west side (0.90 km), the main bridge (0.64km) crossing over the main stream, the approach bridge on the east bank (0.68 km), and the road on the east bank (2.4km) which connects with National Highway No.1.

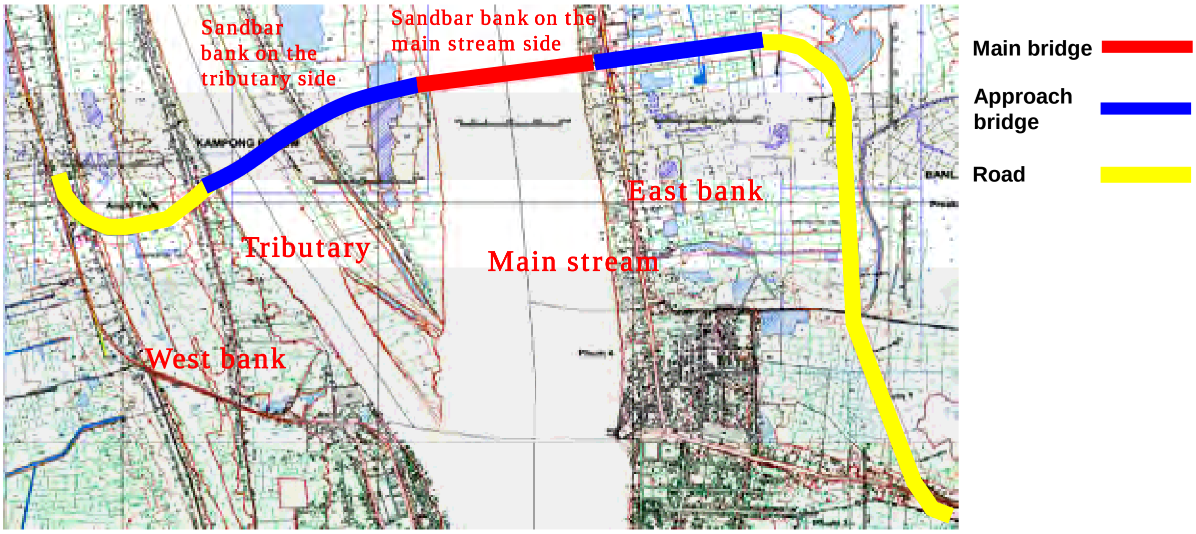


Figure 3.2-1 Explanatory diagram of the Project Location

In principle Cambodian standards are adopted for the design of a road. A road alignment is determined to minimize the number of the houses needing to be relocated. On the west bank, the approach road crosses the local road via a grade separation. On the east bank, box culverts are installed at appropriate positions to maintain the flow of water in time of flooding.

It is expected that large vessels (container carriers) of 5,000 DWT calling at Phnom Penh Port will navigate the main stream at the Project site. Thus the main bridge is designed to allow these vessels to pass a main navigation channel in the center of the river allowing one-way traffic. In addition, as there is heavy traffic of small vessels for inland transportation at the Project site, subsidiary navigation channels are arranged in parallel on either side of the main navigation channel. Under these navigation conditions, the main bridge is expected to be a long span bridge with a main span of over 200 meters. Hence, in the planning of the main bridge, several bridge types are studied in terms of cost and technical feasibility.

The approach bridges are divided into three sections -- the tributary section and the sandbar section on the west side of the river, and the east section. The terrain on the west side is flat, composed of the tributary which runs dry in the dry season and a sandbar, and the east section crosses over National Road No.11. The bridge type of the approach bridges is selected from the common types of girder bridges, in terms of cost and construction safety.

(1) Road Planning

1) Road Design Standards

In the determination of the geometric design standards for the Project, comparisons were made between the various road standards and criteria of donor countries and standards applied to neighboring sections such as the Asian Highway Standards, Japanese Road Standards, Road Improvement Project for National Road No. 1, etc. as shown in Table 3.2-1.

Table 3.2-1 List of Related Geometric Design Standards

Items	Asian Highway		ASEAN Highway		GMS Corridor		Cambodia		Japan		USA***		NR-1 (JICA)	NR-1 (ADB)
Classification	Class II		Class Ⅱ		Class II		R5		3-1	3-2	Rural Arterials		Class Ⅱ of Asian Highway	-
No. of lanes	2		2		2		dependent on LOS		dependent on traffic volume		depend on LOS		2	2
Terrain	Level	Rolling	Level	Rolling	Level	Rolling	Flat	Rolling	Plain with heavy traffic	Plain with low traffic	Level	Rolling	Level	-
Design speed [km/h]	80	60	80-100	60-80	80-100	60-80	100	80	80	60	120-100	100-80	80	100
Right-of-way width [m]	(40)		(40-60)		(40-60)		60*		-		-		-	-
Lane width [m]	3.5		3.5		3.5-3.75		3.5		3.5	3.25	3.6		3.5	3.75
Shoulder [m]	2.5		2.5		1.5-2.5		3.0		1.25	0.75	2.4		2.5+1.0	2
Pavement slope [%]	2		-		-		2.5-3.0 (BC)		1.5-2.0 (BC)		1.5-2.0 (BC)		3.0	3.0
Shoulder slope [%]	3-6		-		-		3.0-4.0 (Sealed)		1.5-2.0 (BC)		1.5-2.0 (BC)		4.0	3.0 (sealed) 6.0 (others)
Max. superelevation [%]	10		10		10		10		6		12		4.0	5.5
Pavement type	Asphalt or cement		Asphalt or cement		Asphalt or cement		-		-		-		Asphalt	DBST
Min. horizontal curve radius [m]	210	115	200	110	200	110	345	210	280	150	328	194	280	500
Min. horizontal curve radius to omit transition curves [m]	900	500	-		-		-		900	500	592	379	900	-
Min. transition curve length [m]	70	50	-		-		-		70	50	56****	44****	70	-
Max. vertical grade [%]	4.0	5.0	6.0	7.0	6.0	7.0	3.0**	4.0**	4.0	5.0	3.0	5.0	4.0	4.0
Vertical clearance [m]	4.5		4.5		4.5		-		4.5		4.9		-	-

Note;
BC: Bituminous Concrete,
*: By circulation,
**: without critical grade length,
***: applicable design speed is 100km/h and 80km/h for level and rolling terrains respectively,
****: desirable value.

The study showed that the Cambodian Standards satisfy international standards such as the Asian Highway Standards, and the standards are widely applied in Cambodia. Therefore, the Cambodian Standards are applied to the Project in principle. Further, other design standards such as those of the Japan Road Association and AASHTO are applied for reference when design criteria are not specified or are unclear in the Cambodian Standards.

According to the Cambodian Road Design Standards, a design speed of 80 km/h is selected in compliance with the following conditions,

- Functional Road Category: Highway in rural area
- Design Class: R5

- Access Control: Partial access control (refer to Table 3.2-3)
- Geographic features: Rolling terrain

The traffic volume in 2020, 11 years from the present time, will be 95 thousand vehicles per day, and it is expected to be over 100 thousand vehicles per day after 30 years.

Table 3.2-2 Road Category of Rural Roads and Traffic Volume

Road Category	ADT after 30 years					
	All traffic volume	>10,000	10,000 to 3,000	3,000 to 1,000	1,000 to 150	<150
Expressway	R6	-	-	-	-	-
Highway	-	R5	R4	-	-	-
Provincial	-	-	R4	R3	-	-
District	-	-	-	-	R2	R1

Source: Cambodia Road Design Standards 2003

Table 3.2-3 Road Category of Rural Roads and Access Control

Road Category	Design Classification					
	R6	R5	R4	R3	R2	R1
Expressway	F	-	-	-	-	-
Highway	F	P	P	-	-	-
Provincial	-	-	P	P	-	-
District	-	-	-	N	N	N

Note: F-Full access control, P-Partial access control, N-No access control

Source: Cambodia Road Design Standards 2003

Table 3.2-4 Design Classification of Rural Roads and Design Speed

Design Classification	Design Speed (km/h)		
	Flat Terrain	Rolling Terrain	Mountainous Terrain
R6	120	100	80
R5	100	80	60
R4	90	70	60
R3	70	60	50
R2	60	50	40
R1	40	30	20

Source: Cambodia Road Design Standards 2003

Based on the Cambodian Road Design Standards, the design criteria for the Project were established taking the traffic characteristics into consideration, as shown in Table 3.2-5. A maximum superelevation of 4.0% was selected in consideration of local road users including slow-moving vehicles such as motor bikes. The Road Improvement Project for National Road No. 1 (Phnom Penh – Neak Loueng Section) also adopted 4.0% as the maximum superelevation for the same reason.

Table 3.2-5 Adopted Road Design Criteria

Items	Applied	Remarks
Road Category	R5	Cambodian standard
Number of lanes	2	Same as adjacent improved projects
Terrain	Rolling	Cambodian standard
Design speed [km/h]	80	Cambodian standard
Carriageway width [m]	3.5	Cambodian standard
Motorbike lane width [m]	2.5	
Shoulder width [m]	1.0	
Gradient on pavement [%]	3.0	Cambodian standard
Gradient on unpaved shoulder [%]	4.0	Cambodian standard
Maximum superelevation [e_{max}, %]	4.0	Considering to road users
Type of pavement	Asphalt	
Stopping sight distance [m]	115	Cambodian standard
Minimum horizontal curve radius [m]	280	Value for e_{max} according to Cambodian Road Design Standards
Min. horizontal curve radius without superelevation [m]	1,250	Cambodian standard
Min. horizontal curve radius to omit transition curves [m]	900	
Minimum transition curve length [m]	70	
Minimum horizontal curve length (m)	140	Cambodian standard
Maximum gradient* [%]	4.0	Cambodian standard
Minimum vertical curve radius (crest) [K-value]	30	Cambodian standard
Minimum vertical curve radius (sag) [mK-value	28	Cambodian standard
Vertical clearance [m]	4.5	

Notes:
*: not including critical gradient,

2) Typical Cross Section

Two lanes were adopted for the Project because the existing Road No. 1, which has already been improved by ADB and JICA, has this number of lanes. A typical cross section of an embankment section conforms to the National Road No.1 Improvement Project, in consideration of road continuity and the high volume of motor bike traffic. The typical cross section is shown in Figure 3.2-2.

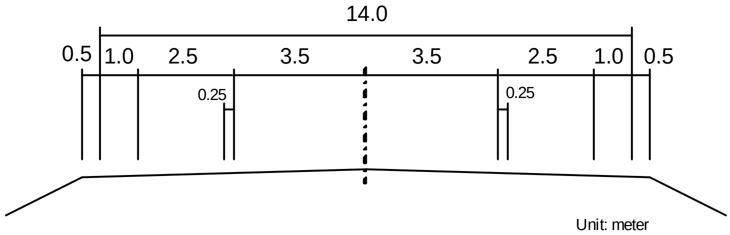


Figure 3.2-2 Typical Cross Section Adopted for Embankment Section

3) Road Centerline

In setting the road centerline, basically the following matters were considered,

- Required road functions should be satisfied,
- The socio-environmental impact should be minimized, in particular the number of houses affected.

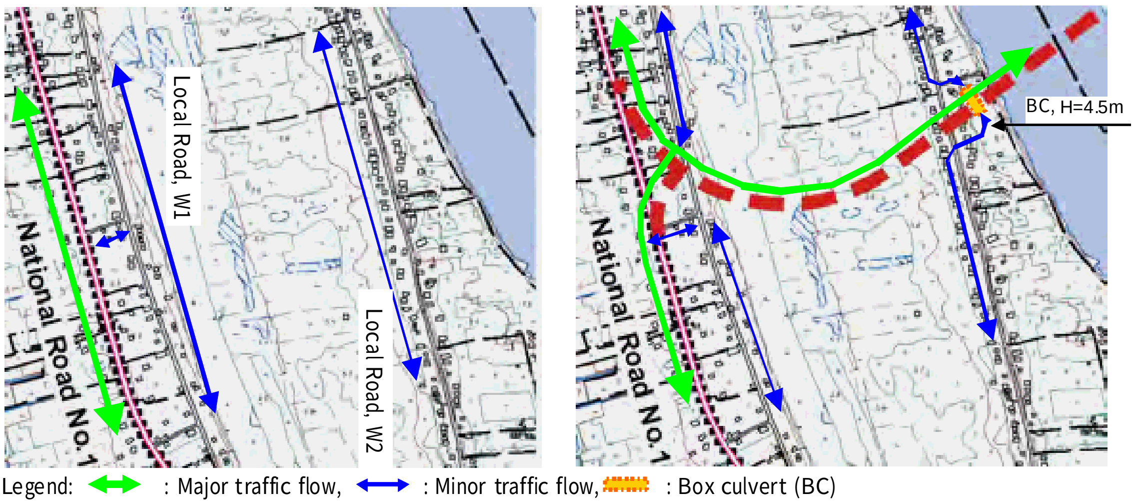
Prior to the determination of the alignment, the major design conditions affecting PRW were set as follows.

a) Approach Road (Service Road)

The need for approach roads was considered as follows.

- West Bank Side (Phnom Penh Side)

It is possible for the traffic flow from Local Road W1 to access to/from the Project Road via the existing National Road No. 1. A grade separation with a box culvert is planned at the crossing point between the Project Road and Local Road W2 in consideration of traffic safety, because the crossing point is located near the abutment. Vertical clearance of Local Road W2 shall satisfy the regulation height (H = 4.5 m) because there is no detour road for heavy vehicles around the crossing point. Therefore, a detour road to the abutment is planned to satisfy the clearance requirements and to minimize embankment height. Specifications for Design Class R1, which is categorized as a local road in Cambodia, will be applied to both local roads. Therefore, the design speed will be 20 km/h and the road width was set at 6.0 m, which is almost the same as the existing road width.



Present Condition Proposed Condition

Figure 3.2-3 Traffic Flow on West Bank Side (Phnom Penh Side)

- East Bank Side (Neak Loueng Side)

Although the NR-11 bypass was planned in the F/S, it is not planned into the Project to keep the national environment as it is. Serious congestion will not be expected on the NR-11, which passes through Neak Loueng without the bypass.

b) Basic Configuration of Intersections

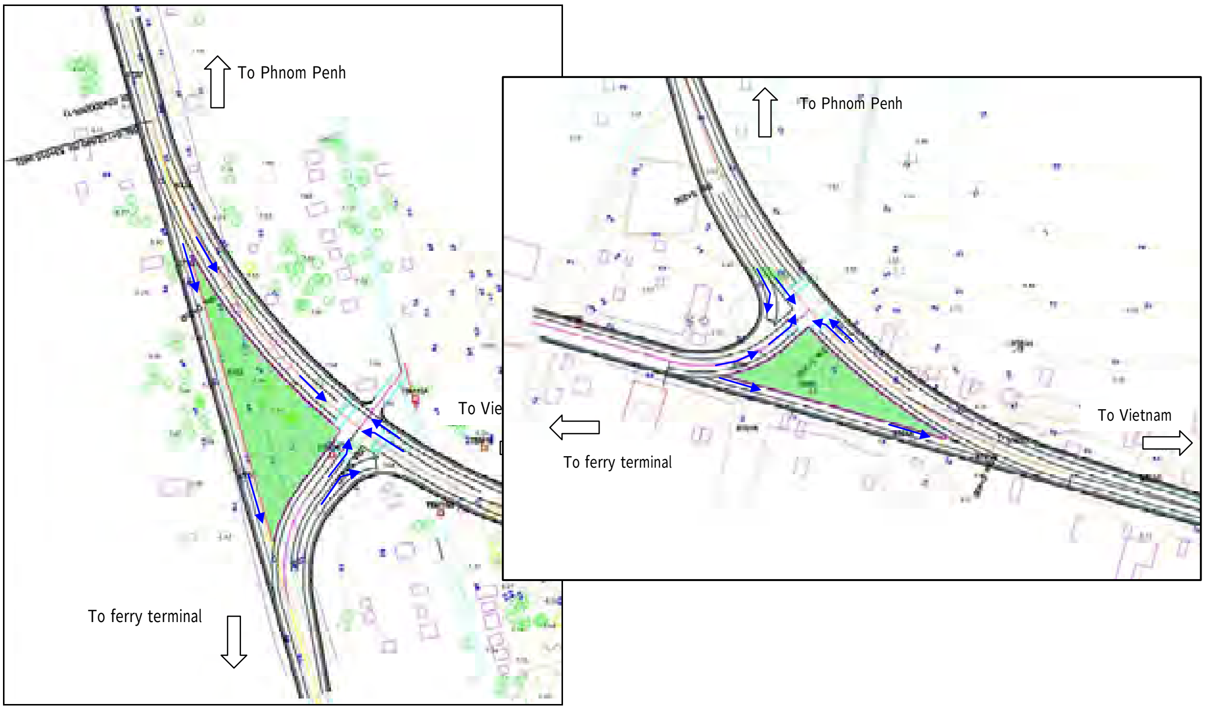
The basic configuration of intersections was considered as follows.

- Kampong Phnom Intersection (with National Road No. 1 on the West Bank side)

This intersection is planned as shown on the left side of Figure 3.2-4, using the existing National Road No. 1. A design speed of 60 km/h for shifting and tapering was adopted to minimize the number of houses affected and the adopted regulation speed is 60 km/h.

- Neak Loueng Intersection (with National Road No. 1 on the East Bank side)

This intersection is planned as shown on the right side of Figure 3.2-4, using the existing National Road No. 1 as well as the Kampong Phnom Intersection. A design speed of 60km/h for shifting and tapering was adopted to keep the number of houses affected to a minimum and because the adopted regulation speed is 60 km/h.



Kampong Phnom Intersection (West Bank Side) Neak Loueng Intersection (East Bank Side)

Figure 3.2-4 Basic Configuration of Intersections with Existing NR-1

- Intersection with the Construction Yard Site

Taking into account the utilization of the construction yard site after the construction of road, and traffic safety including access to and from the site during the construction, the left-turn lane for traffic from Neak Loueng to Phnom Penh is planned as shown on the right side of Figure 3.2-5. The main construction yard is located near the abutment on the east bank side.

- Intersection with the local road on the East Bank Side

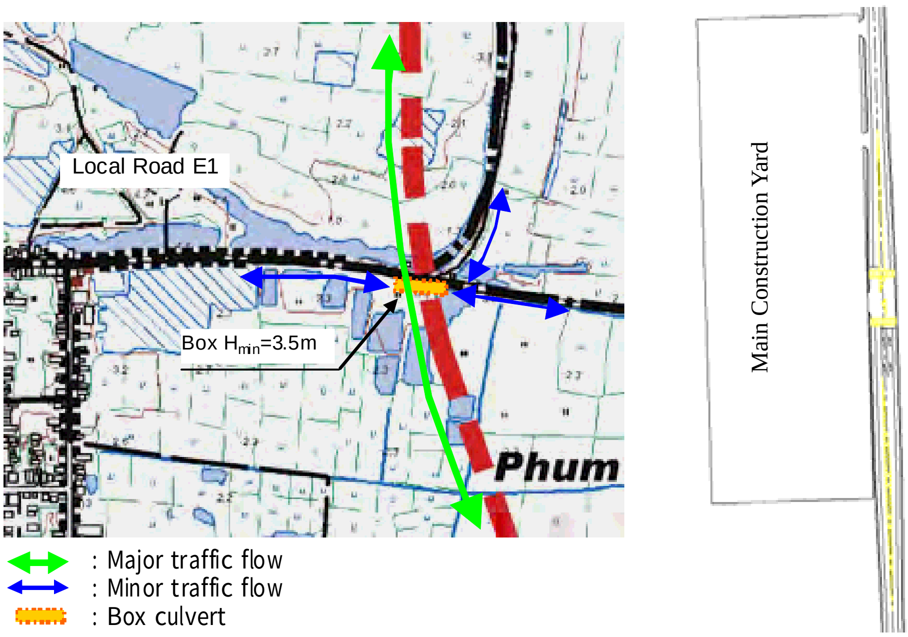
A grade separation is planned at the point where the Project Road and the local road cross, to mitigate flood discharge and to partially control access, as shown on the left side of Figure 3.2-5. Vertical clearance of 3.5 m is secured for the local road with the following considerations:

The existing road is not paved..

Taking the local road conditions into consideration, heavy vehicles is not expected to pass the road; and they can detour around the crossing point via the NR-1

From an economic viewpoint, the height of the embankment shall be kept roughly the same as around the crossing point.

The specifications used for other local roads of Design Class R1 are applied. As a result, the road width is 6.0m and the design speed is 20 km/h.



Intersection with Local Road　　　　Intersection with Construction Yard Site

Figure 3.2-5　Basic Configuration of Intersections with Existing National Road No.1

c) High Water Level and Road Elevation

The water level of 100-year flood probability was adopted as the design high-water level. As there is no regulation in the Cambodian Standards regarding the minimum road elevation against high water level of a flood, the following two conditions was adopted for the design of road elevation, taking the Japanese Standards as reference;

Condition 1: the design high water level plus an allowance of 50cm

Condition2: the design high water level plus pavement thickness, taking the deterioration of road surface into consideration.

Table 3.2-6 shows the relationship between the design high water level and the design road elevation.

Table 3.2-6 Relationship between Design HWL and Design Road Elevation

Section		Sta.0+000 to 2+500	Sta.2+500 to 5+400
Design HWL (m)		7.930	8.360
Road Elevation by Hydrology	Allowance (m)	0.500	
	Minimum Road Elevation (m)	8.430	8.860
Road Elevation by Pavement Structure	Pavement Thickness (m)	0.530	
	Maximum Superelevation (%)	4.000%	
	Difference in Height due to Superelevation (m)	0.280	0.280
	Difference in Surface Level (m)	0.100	0.100
	Minimum Road Elevation (m)	8.840	9.270
Minimum Design Elevation (m), [A]		8.840	9.270
Minimum Design Elevation per Section (m), [B]		9.260	9.560
B-A (m)		0.420	0.290

Note: Not including tapering section

d) Other Major Factors

Other major factors which affect the alignment were set as follows.

- Counterweight Embankment

In the feasibility study, a counterweight embankment was proposed as a countermeasure for settlement of road embankment at a soft ground. The analysis of the soft ground in the design shows that there will be stability of road embankment without the counterweight embankment. Therefore, the construction of a counterweight embankment is not adopted.

- Flood Discharge Openings

3 box culverts are planned at the embankment on the Neak Loueng side for the discharge of flood water.

- Surface Water Drainage

Surface water drainage is not planned for the project site because the site is located in a rural area and the surrounding area is not an urban area. The Road Improvement Project for National Road No. 1 conducted by JICA and ADB also did not install surface water drainage along the roads

- Truck Scale

Truck scales were installed on National Highway No. 1 near the Vietnam border by ADB, and started to operate from July 2009. Installation requires an efficient installation and operating plan that takes the national road network into consideration. There is a few alternative routes from Bavet to Phnom Penh, and the installation of truck scales at Bavet by ADB will give fewer overloaded vehicles that cross Neak Loeung Bridge. If the present number of overloaded vehicles cross Neak Loeung Bridge, the impact on the bridge will be negligible. For the above reasons, truck scales have not been included in the scope of works of the Project.

- Traffic Safety Facilities

Traffic safety facilities such as traffic signs, road markings and guide posts will be installed in accordance with the Standards of Traffic Control Devices in Cambodia.

e) Road Centerline

Based on the results of the F/S in addition to the above major design conditions and the temporary construction area (area affected by construction works), the road centerline will be determined so as to minimize the number of houses affected by the Project, using the topographic survey data obtained in this project.

(2) Bridge Planning

1) Design conditions

i) Standards to be applied

Cambodia has its own standards for bridge design based on Australian standards. Although these standards include basic provisions such as live loads, details including standards for structures are not specified. Thus, each donor country usually applies its own detailed standards when implementing their project. For this Project, it has been determined, on the basis of discussions with the Government of Cambodia, that Japanese standards are applied for the design of the bridge structures. However, for conditions specific to the bridge construction site, such as natural conditions, reference will be made to the Cambodian standards or to the Australian standards. Further, with regard to the live load, as a result of a comparative study of the Cambodian standards, it has been determined that the B live loading of the Japanese standards will be applied.

ii) Navigation conditions

The planning of the main bridge is subject to the restrictions imposed by the navigation channels set out in the river. At the main bridge are set out a main navigation channel (180 m x 37.5 m) which allows one-way traffic of 5,000 DWT vessels, and subsidiary navigation channels (90 m x 15 m) for local ships of less than 500 DWT for inland transportation. The conditions of the navigation channels are given in Figure 3.2-6, Table 3.2-7 and Table 3.2-8:

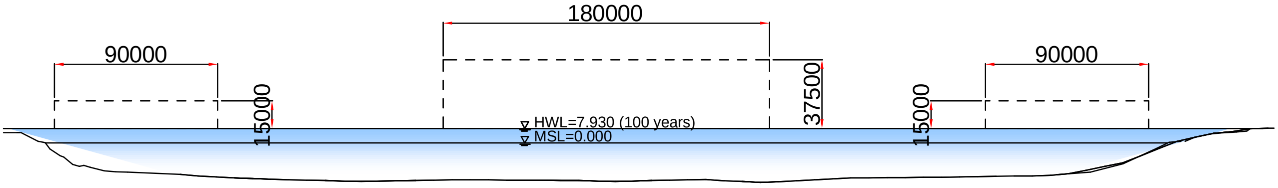


Figure 3.2-6 Navigation Channel Layout

Table 3.2-7 Width of Main Navigation Channel

	One way traffic	Two way traffic
Size of vessel	5,000DWT (Bulk Carrier)	500DWT
Vessel length LoA [m]	109m*1	51m*2
Main channel width	B=1.6 x LoA =175 < 180m	B= 3.5 x LoA =179 < 180m

1) Values given are for: cargo ship (Technical Standards for Port Facilities, 1999, Japan), and bulk carrier (PIANC Marcom Report W33 (2002))

Table 3.2-8 Width of Subsidiary Navigation Channel

Size of vessel	500DWT Coaster
Vessel length LoA [m]	51m*2
Subsidiary channel	B=1.6 x LoA =81.6 < 90m

2) Source: "Principal dimensions of a small cargo ship when the vessel cannot be specified", Technical Standards for Port Facilities, 1999, Japan

The height of the main navigation channel is 37.5m, which accommodate the height of a 5,000 DWT vessel. This height has been agreed between Cambodia and Vietnam.

The height of the subsidiary navigation channels is the same as the Kizuna Bridge and the Prek Tamak Bridge.

iii) Bridge width

The roadway width shown in Figure 3.2-7 was adopted for the bridges of the Project, taking as reference the roadway width standard for the Asian Highway and the roadway width adopted for the National Road No.1.

The railings installed along both sides of the bridge are planned as combination traffic-pedestrian railings to guarantee the safety of both vehicles and pedestrians. For the approach bridges, RC hard railings with handrails on the top were adopted from the perspective of construction cost and high performance in the against a collision with vehicles. For the main bridge, steel railings were adopted to reduce the impact from wind force. The height of the curbstone separating the pedestrian walkways and the roadway is 25 cm -- the maximum height for this type of curbstone -- to prevent vehicles riding up onto the walkways.

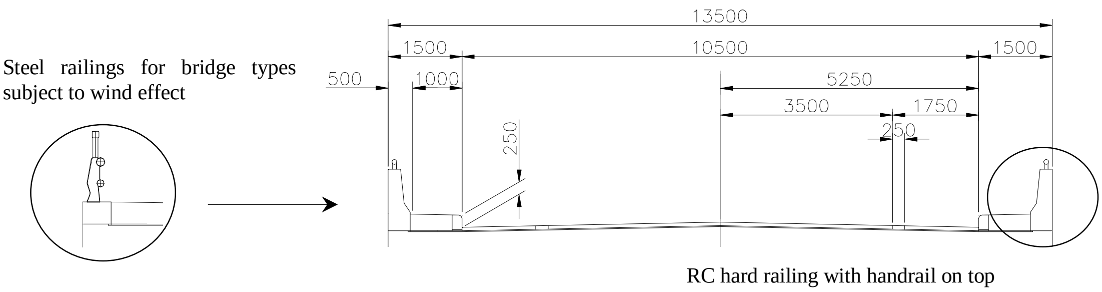


Figure 3.2-7 Typical Cross Section of the Road (on Bridge)

iv) Earthquake-resistant design

In this Project, the basic concept and methods for the earthquake-resistant design for the bridges follows the Specification for Highway Bridges by the Japan Road Association ("JRA Bridge Specifications"). However, the Cambodian standards will be taken into account in determining the magnitude of seismic effect, which is dependent on the region. Acceleration coefficient a = 0.05 is used in the Cambodian bridge design standard (Bridge Design Standard CAM PW:04.102.99.2003). Thus, the design horizontal seismic coefficient (kh) = 0.05 will be adopted for the earthquake-resistant design of the bridges in this Project.

v) Wind resistant design

For the approach bridge, the basic concept for the wind resistant design (static design) follows the JRA-Bridge Specifications (basic wind velocity V = 40 m/s).

Since it has been verified that the V_{10} (10 minute average wind velocity) obtained from the local wind observation data does not exceed V_{10} = 30 m/s (100 year probability value), the "Wind Resistant Design Manual for Highway Bridges" of the Japan Road Association is applied for the design of the main bridge, where U_{10} = 30 m/sec (static and dynamic wind resistant design).

vi) Temperature variation

Temperature variation: 15 deg to 45deg (average temperature: 28deg)

Structure temperature: 15 deg to 45 deg for concrete structure, 5 deg to 65 deg for steel structure

The temperature variation for the calculation of displacement of bearings and expansion joints is 15 to 45 deg, in accordance with AUSTROADS 2.9.1 (a) and 2.9.2.

vii) Relative humidity

The average value for relative humidity at Prey Veng is 82.6 %, according to the survey of natural conditions. The relative humidity of this value will be applied in bridge design will be determined on the basis of this value.

viii) Design water level

The HWL (High Water Level) is 7.93m (100 year return), and the LWL (Low Water Level) is 0.43m (20 year return) according to the survey of natural conditions. The HWL values used for the design of river structures etc., are determined by taking into consideration the degree of importance of the structure and conditions in the surrounding areas. For the design in this preparatory survey, the 100-year return HWL will be applied as the case of the main rivers in Japan, taking into account the importance of the road, the service life of the structure, and the small variation in the water level of the Mekong River over the period of probability. A 20-year return period will be used for the LWL, considering the small impact on the design of the structure and the past records.

ix) Design discharge and water velocity

The design discharge and water velocity being applied for the design and construction planning of the bridges are as follows:
Maximum design discharge: 33,000 m^3/sec (observation results from 2002 to 2004)
Maximum water velocity: 2.24 m/sec (observation results for 2008)

x) Measures against the sandbar erosion

The possible range of future erosion of sandbar will be 255 m. The structures within this area shall be designed to withstand the possible future erosion. Specifically, the following two points will be taken into account in the design of piers P15 to P19 :

① The river bed height in the event of erosion will be -18.0 m.

② In order to keep the base of the pile cap below water level, the height of the base will be the dry season's water level + 0.43 m.

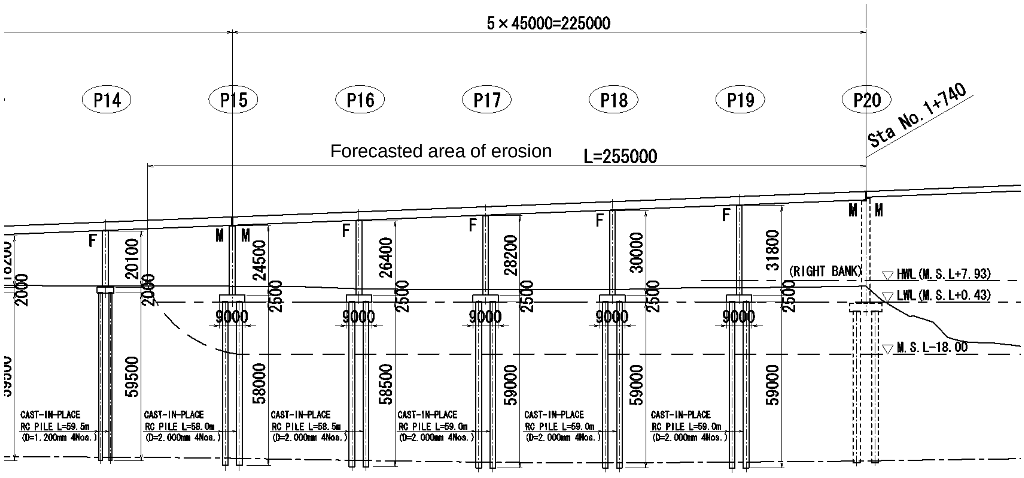


Figure 3.2-8 Structure in consideration of future erosion of sandbar

xi) Scouring

Scouring depths at the Kizuna Bridge are studied in this Project, and scouring of about 5 m was observed at several area of the pier foundations of the bridge. Thus, even if the same measures are taken as for the Kizuna Bridge, a certain amount of scouring must be taken into account for the Project. The scour depth will not be estimated exactly when the scour protection work is carried out. In order to minimize the scour, it is necessary that anti-suction mats be laid in the river bed. However, it is preferable to take into account the theoretical scour depth into design because of a poor reliability of a scour protection work, difficulty of maintenance and cost of construction. Because of the above reasons, scour protection work will not be planned for the bridges in this Project, and the theoretical scour depth will be taken into consideration in the design of the foundations of the bridges. Table 3.2-9 shows the design scour depth at each pier.

Table 3.2-9 Design Scour Depth

	P15 to P19	P20 (End pier)	Towers (WP, EP)
Erosion depth ①	EL-18.0m	EL-18.0m	-
Local scour depth ②	6.62m	8.25m	11.59m
Design scour depth y_s ①+②	**EL=-24.70m**	**EL=-26.30m**	**EL=-29.90m(EP)** **EL=-30.30 m(WP)**

* Evaluating Scour At Bridges, Fourth Edition, Federal Highway Administration 2001, FHWA NHI01-0001, Hydraulic Engineering Circular No.18

xii) Protection against Vessel Collision

As shown in Figure 3.2-9, in the event of collision by a 5,000 DWT ship, a ship collision against the tower shafts or the piles will not be expected. Accordingly, the foundations in the river are designed ageinst a ship, and vessel collision protectors are not provided. Table 3.2-10 shows the ship collision loads acting on the pile cap:

Table 3.2-10 Ship collision conditions

		Major channel (main tower foundation)
Size of Vessel DWT (ton)		5,000
Vessel Length LOA (m)		103.0
Collision Speed V (kt)		4.4
Collision load Ps	Along the bridge axis (ton)	975
	Perpendicular to the bridge axis (ton)	1,950

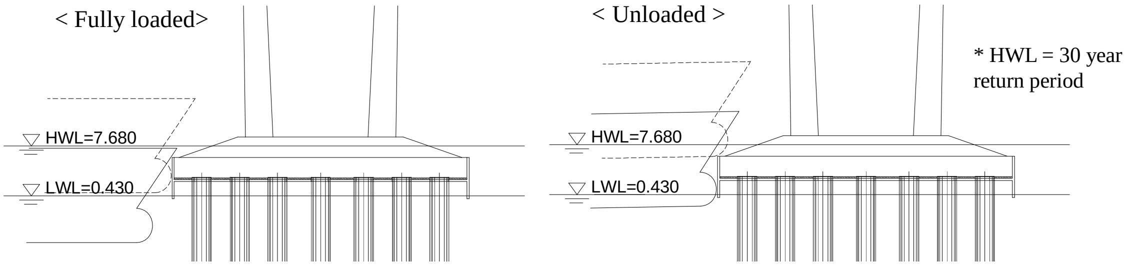


Figure 3.2-9 Hypothetical Cases of Ship Collision

2) Bridge Length

The bridge length is determined through the following procedure:

Determination of the position of the end piers of the main bridge — Determine the position of the end piers to be installed on the river banks. The main bridge and approach bridges are separated at these piers. The piers are installed on land.

↓

Determine the position of abutments — Determine the positions of abutments taking into consideration the topographic conditions, critical height of embankments, abutment height and span length of superstructure.

↓

Determine the bridge length

i) Location of Piers of the Main Bridge at River Bank

- River Width

The river width is 630 m in the dry season according to the topographic and hydrological survey in the Project.

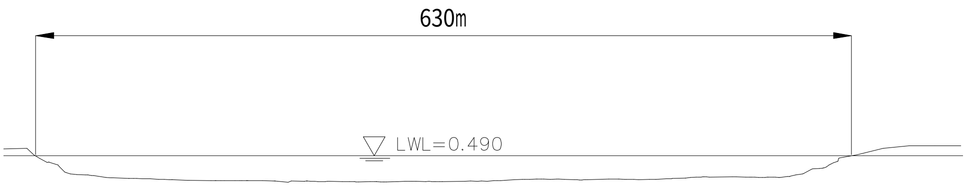


Figure 3.2-10 River width (in dry season)

- Position of the Piers for the Main Bridge

Since the piers are constructed on land, the distance from the pier center to the water's edge needs to have an allowance of 4 m or more taking into account the pilecap width and space for construction.

Figure 3.2-11　Pier erection position

- Bridge Length of the River Section

The 640m length of the main bridge is determined on the basis of the river width and location of piers determined in the above procedure. The pier station on the right bank is Sta.No.1 + 740 and Sta.No.2 + 380 on the left bank.

Bridge length L = river width + distance from river bank line to pier position = 630m+4~5m+4~5m　640m

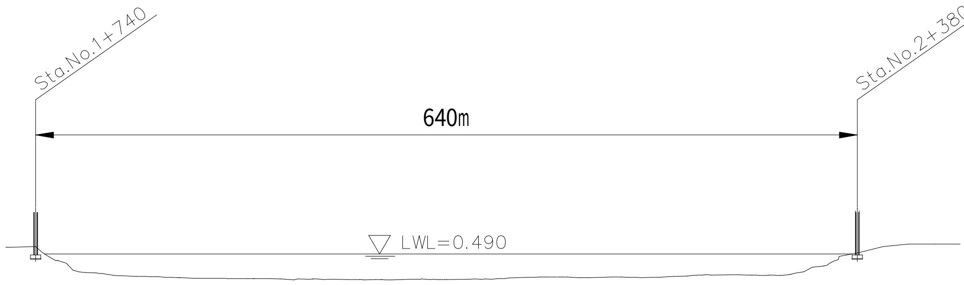
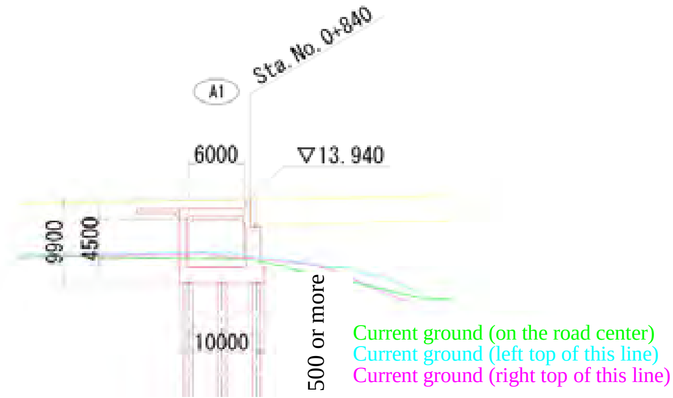
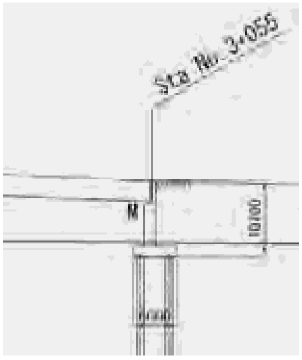


Figure 3.2-12　Length of main bridge

ii) Position of Abutments

Since a local road (width: 6.0 m, vertical clearance: 4.5 m) cross the approach road at the abutment A1, abutment A1 should be installed where the ground is level. The station of the abutment will be Sta.No.0 + 840 in order to minimize the bridge length. For abutment A2, the station of abutment will be Sta.No.3 + 055 based on the study of construction cost.





Abutment A1 Abutment A2

Figure 3.2-13 Explanation of abutment position

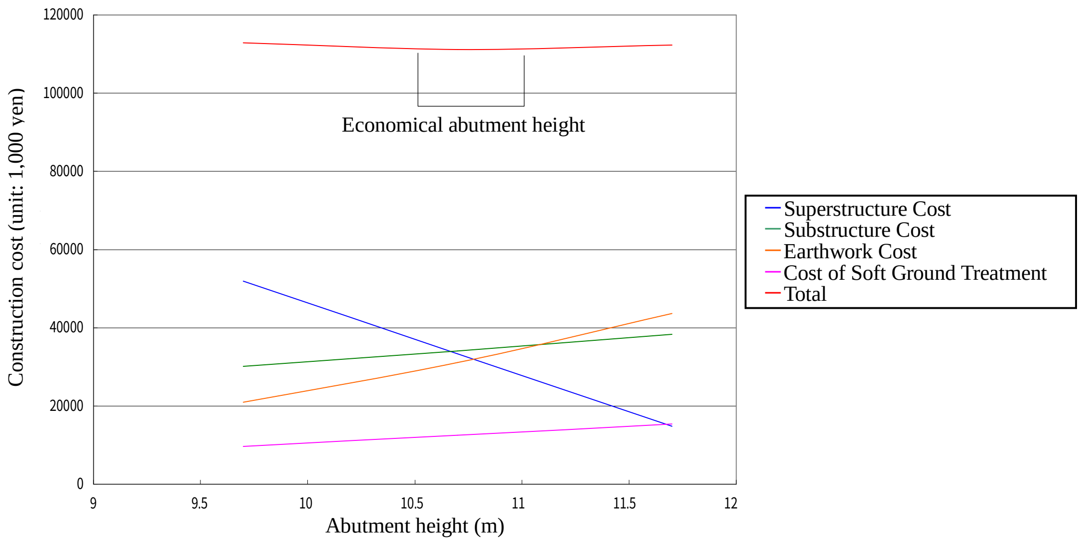


Figure 3.2-14 Cost-wise comparison of abutment A2 position on the terminal side

iii) Bridge length

From the above, the bridge lengths are as shown in the following Table:

Table 3.2-11 Bridge length list

	Position		Section length (m)	Bridge length (m)
Approach bridge (west side)	No.0+840		900.0	2,215
Main bridge	No.1+740	No.2+380	640.0	
Approach bridge (east side)	No.3+055		675.0	

(3) Main Bridge

1) Procedure to Determine the Type of Main Bridge

The type of Main Bridge is determined by the following procedure.

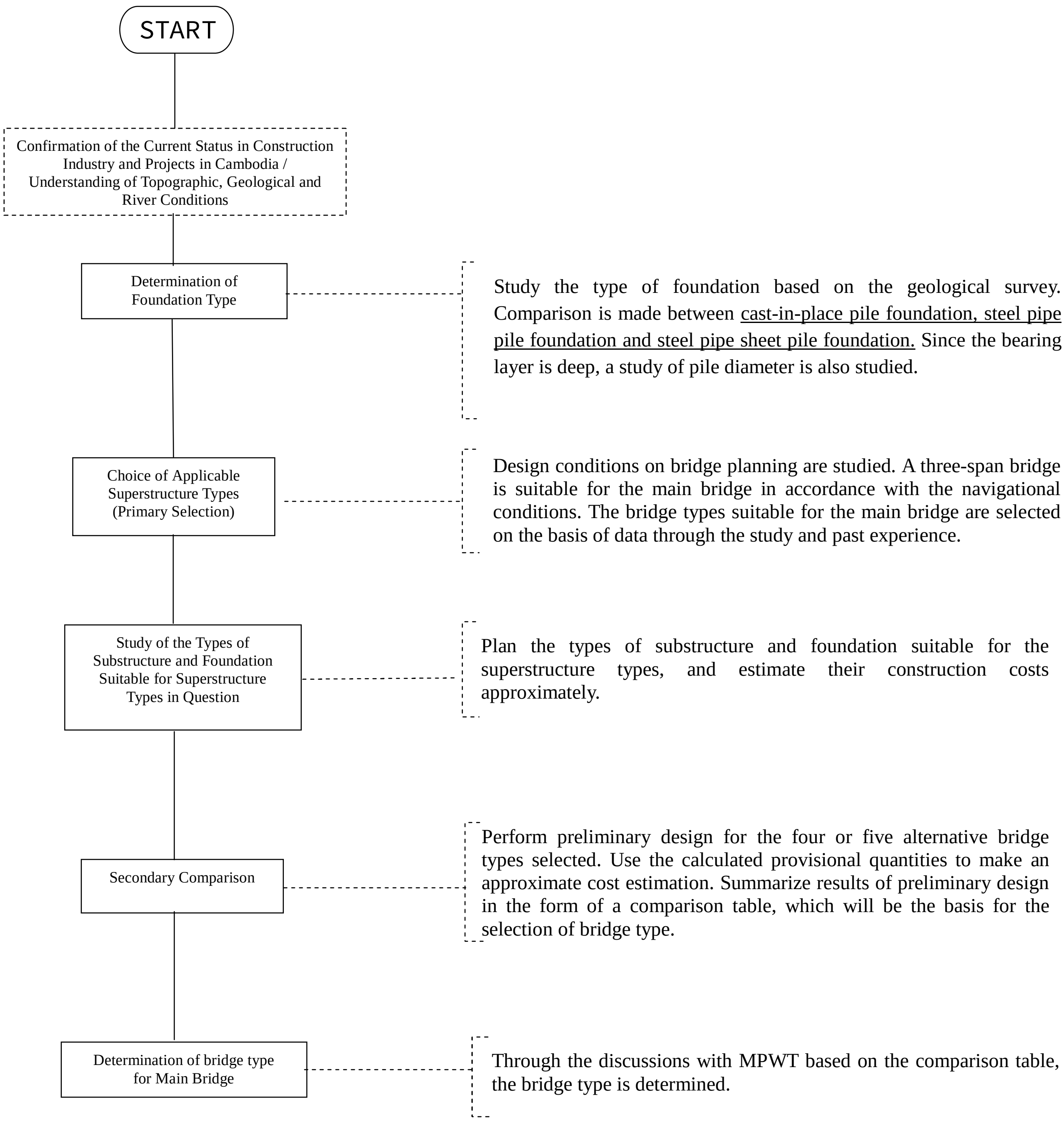


Figure 3.2-15 Flow Chart for Selection of Bridge Type for Main Bridge

2) Type of Foundation

The site of Main Bridge has the following characteristics:

- Deepwater located at about 20 m in the dry season and 27.0 m in the rainy season
- Deep bearing layer for a foundation measuring about 40 m from the river bed (about MSL.-60m)
- Variation of the water level between the dry season and the rainy season is about 7.5m
- 2.0 m/sec of water flow

The foundation types possible to be constructed under the conditions are the cast-in-place pile foundation, the steel pipe pile foundation, the steel pipe sheet pile foundation and the caisson foundation. In case of the cast-in-place pile foundation, the reverse circulation drilled method is recommended. The floating open caisson method can be used for the caisson foundation, considering the water depth at the site, the depth of bearing layer, and special properties of the facilities. However, this type is less economical than other types since it requires a fabrication of large steel shells with a height greater than the water depth (for the first rod),. Therefore, the cast-in-place pile foundation (reverse circulation drilled method), the steel pipe foundation and the steel pipe sheet pile foundation will be selected as alternatives for study. The foundation type will be studied and selected among these alternatives.

a) Study conditions

The foundation types are studied at the east tower of the PC cable stayed bridge:

① Load conditions

The loads at normal condition and at earthquake are taken into account the study. The dimensions of the foundation are calculated for the loads in the longitudinal direction, in the critical conditon.

- Reaction from Superstructure

	Normal time (dead load + live loads)	During earthquake (dead load + earthquake)
V: Vertical force	196,000kN	185,000kN
H: Horizontal force	1,500kN	9,300kN
M: Bending moment	120,900kNm	840,900kNm

* The above values indicate approximate values for comparative study and differ from the final values.

- Design horizontal seismic coefficient: kh=0.05

② Ground conditions

The study is carried out based on the boring result as shown in Table 3.2-12.

Table 3.2-12 Results of boring

Layer	Type	Depth (m)		Thickness	Ave N Value
		From	To	(m)	
1	Sand	0.0	6.0	6.0	9
2	Sand	6.0	8.0	2.0	14
3	Clay	8.0	10.0	2.0	0
4	Sand	10.0	13.0	3.0	35
5	Sand	13.0	15.0	2.0	38
6	Clay	15.0	20.0	5.0	37
7	Clay	20.0	22.0	2.0	23
8	Clay	22.0	26.0	4.0	42
9	Clay	26.0	37.0	11.0	50
10	Sand	37.0	-	-	50

③ Other conditions

The following conditions are taken into account in the comparative study:

- Riverbed height: M.S.L-19.0m (based on the drawings made in the Feasibility Study)
- Scouring is not taken into consideration.
- Embedment of piles into the bearing layer is approximately 1.0 D (where D = pile diameter).

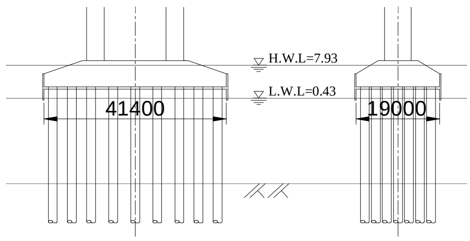
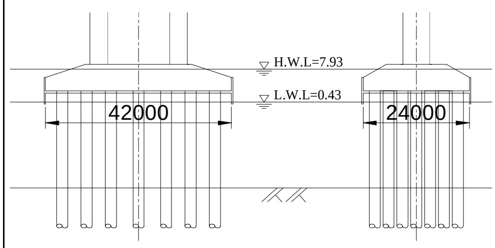
b) Cast-in-Place Pile Foundation

Because of deep water depth at the piers, casing pipes are used to construct the piles for the portion above the riverbed in the water. This type of foundation with casing pipes has been successfully applied at the bridges constructed in the Mekong River, for example in the Kizuna Bridge and Prek Tamak Bridge in Cambodia, and the Can Tho Bridge and the My Thuan Bridge in Vietnam.

① Deameter of Pile

The pile diameter 2.0 or 2.5m is compared in this study from the past experience in order to minimize the number of piles and thus reduce construction costs, Layer 10 in Table 3.2-12 is chosen as the bearing layer. The piles will be embedded approximately 1.0 D into the layer.

Table 3.2-13 Comparison of Diameter of Cast-in-place Piles

	ϕ2000		ϕ2500	
	L=61.0m n=30 piles		L= 61.5m n=22 piles	
General View				
Direction of Check	Longitudinal to Bridge Axis		Longitudinal to Bridge Axis	
Load Condition	Normal times	During earthquake	Normal times	During earthquake
P_{max} (kN/piles)	11,088≦13,389	19,728≦21,092	15,629≦17,927	26,125≦28,480
P_{min} (kN/piles)	8,312≧-8,122	-1,062≧-13,353	12,307≧-11,254	811≧-17,946
δ_{fx} (mm)	1.23≦15.00	8.90≦15.00	1.16≦15.00	8.85≦15.00
Rebar Arrangement	D38 ctc157, one layer		D35 ctc 157, one layer	
σ_c (N/mm^2)	3.41≦8.0	10.90≦12.0	3.25≦8.0	9.59≦12.0
σ_s (N/mm^2)	-	264.42≦300.0	-	290.58≦300.0
Estimated Quantities	Footing + P.C.House: 3,900m^3 Pile: 1,830m		Footing + P.C.House: 4,450m^3 Pile: 1,353m	
Construction Cost (Ratio)	1.01 (△)		1.00 (◎)	

* The general view, quantities etc., in the Table are those used at the time of the comparative study, and do not reflect the final design result.

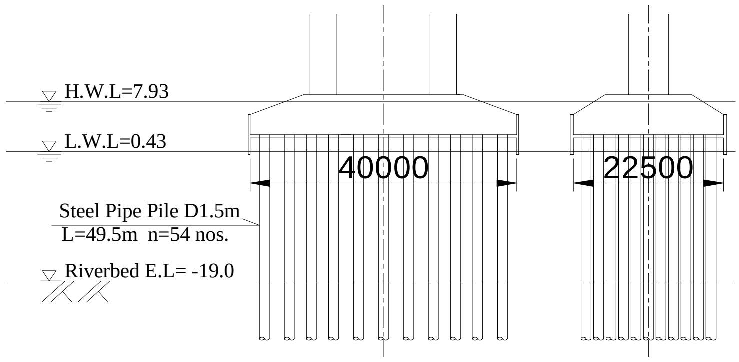
As shown in the above Table 3.2-13, a pile diameter of 2.5m is more economical than a pile diameter 2.0m.

c) Steel Pipe Foundation

On the site in this Project, with the deep water depth and the soft ground at an intermediate layer, a steel pipe pile foundation is preferred for its workability. However, there are not many examples of this type of foundation being used for long span bridges. In Japan, there is no example of steel pipe piles with a diameter greater than 2.0 m being used in bridge foundations. Further, considering the recent rise in steel price, the feasibility of steel pipe piles shall be thoroughly checked.

The main bridge is a long span bridge with a main span length greater than 300 meters, and it is preferable for the number of piles to be reduced by using large-diameter steel piles if possible. However, there are few examples of piles with a diameter greater than 2.0 meters being used for the bridge foundation. Accordingly, a steel pile with a diameter of 1.5 meters (maximum size in common application) will be studied for the main bridge. It is assumed that the piles will be hammered into place, and thus Layer 9 shown in Table 3.2-12 is chosen as the bearing layer.

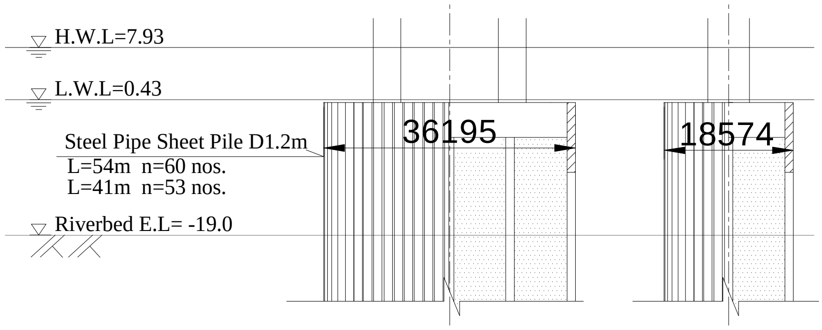
Table 3.2-14 Study of Steel Pipe Pile Foundation

	ϕ1500	
	L=49.5m n=54 piles	
General drawing		
Direction of Check	Longitudinal to Bridge Axis	
Load Condition	Normal times	During earthquake
P_{max} (kN/piles)	6,476≦8,791	11,241≦13,213
P_{min} (kN/piles)	4,928≧-2,274	-257≧-4,160
δ_{fx} (mm)	1.31≦15.00	8.85≦15.00
Material and Thickness	SKK400, t=25mm	
σ_c (N/mm^2)	-72.58≧-140.0	-197.97≧-210.0
σ_t (N/mm^2)	-54.73≦140.0	90.03≦210.0
Estimated Quantities	Footing + P.C.House: 4,020m^3 Steel Pipe Pile: 2,673m	

d) Steel Pipe Sheet Pile Foundation

Steel pipe sheet piles are used for structures such as a retaining wall with a deep excavation or a high-wall river revetments, which are difficult to construct using ordinary sheet piles. Since this method also provides a temporary cofferdam during construction of the bridge foundation in deep river or sea water, there are many instances in Japan. Also this type of foundation was adopted for the Chruoy Changvar Bridge (the Cambodia–Japan Friendship Bridge) in Phnom Penh City.

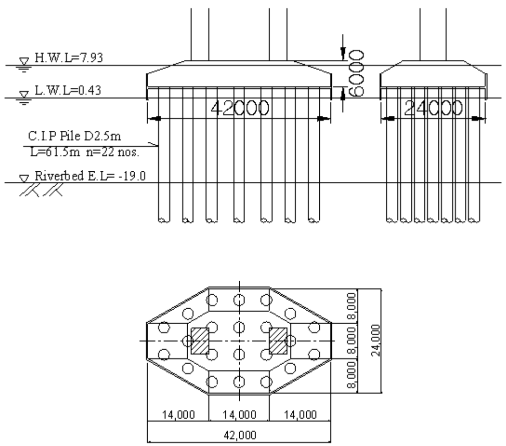
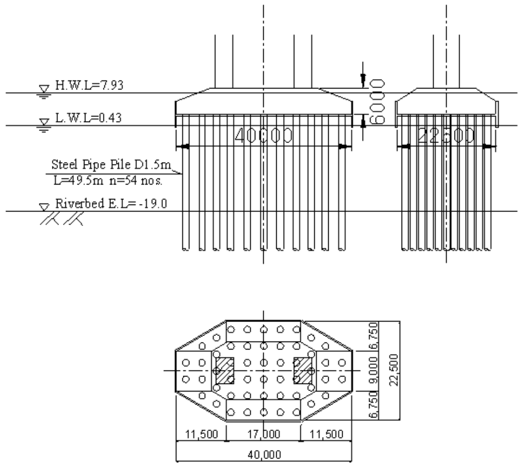
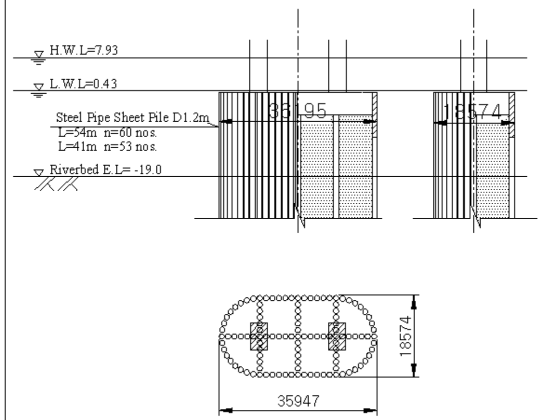
Table 3.2-15 Study of Steel Pipe Sheet Pile Foundation

	ϕ1200	
	L=54.0m n=70 piles, L=41m n=44 piles	
General View		
Direction of Check	Longitudinal to Bridge Axis	
Load Condition	Normal times	During earthquake
P_{max} (kN/piles)	2,193≦2,424	2,435≦3,635
P_{min} (kN/piles)	2,048≧-1,286	1,620≧-1,986
Δ (mm)	5.6≦50.0	32.4≦50.0
Material and Thickness	SKY400, t=15mm	
σ_{max} (N/mm^2)	Outer Sheet Pile: 51.9≦140.0 Sheet Pile for Inner Wall: 50.9≦140.0	Outer Sheet Pile: 122.6≦210.0 Sheet Pile for Inner Wall: 114.6≦210.0
Estimated Quantities	Pile Cap Concrete: 2,360m^3 Filling Concrete: 680m^3 Filling Earth: 5,770m^3 Steel Pipe Sheet Pile: 5,413m	

e) Selection of Foundation Type

As a result of the study of each of the above alternatives, the cast-in-place pile foundation which offers optimum workability and reasonable construction cost was selected, as shown in Table 3.2-16:

Table 3.2-16 Comparison of Foundation Types

	Option 1 Cast-in-place pile foundation φ 2500	Option 2 Steel pipe pile foundation φ 1500	Option 3 Steel pipe sheet pile foundation
General drawing			
Structural characteristics	- The casing for the protruding part is not considered a structural member and the piles are designed as concrete piles. - As the number of piles is small, the overall river disruption rate is low. (○)	- Anti-corrosion treatment is required for the steel piles. - Despite the smaller diameter, the greater number of piles causes a greater overall river disruption rate than in the case of the cast-in-place pile foundation. (△)	- Because of the greater rigidity of the structural body, the volume of deformation is small. - The large dimensions of the structural body give this option the highest overall river disruption rate. (△)
Workability	- Guide works such as guiding frames are required for the installation of the casings because of the depth and fast flow of the water. - Use of pre-cast formwork (PCH) for the pile cap work eliminates the need for form installation over the water. - There are many instances in Cambodia and neighboring countries. (○)	- It is difficult to maintain vertical accuracy in the pile work because of the depth and fast flow of the water, and the 50m length of the pile. - Use of pre-cast formwork (PCH) for the pile cap work eliminates the need for form installation over the water. - There are few instances of this type of foundation for large bridges. (△)	- The depth of the water and fast flow make form guiding frames necessary for the piling of the peripheral pile sheet piles. - As the steel pipe sheet piles also function as a temporary cofferdam, the structural body can be easily constructed in a dry environment. - There are very few instances of this option outside Japan. (△)
Aesthetic value	- A large structure is constantly exposed above the river surface. (△)	- A large structure is constantly exposed above the river surface. (△)	- As the top plates can be placed below the water surface, no major structure is exposed above the river surface. (○)
Economy	6,345,000 USD per unit (1.00)	6,447,000 USD per unit (1.05)	6,871,000 USD per unit (1.28)
Evaluation	◎	△	△

3) Type of Superstructure

a) Design Conditons

- Navigational Clearance and Location of Bridge Piers

In view of the navigation clearance and pier dimensions, the possible location of bridge piers are as below:

Within the bridge length L = 640 m over the main stream of the river, piers shall not be installed within 123 m from the river banks (width of subsidiary channel plus allowance) and over a distance of 210 m in the center of the river (width of main channel plus allowance for the pile cap of the pier). Hence, piers can be installed within the range of 93 m between the main channel and subsidiary channel.

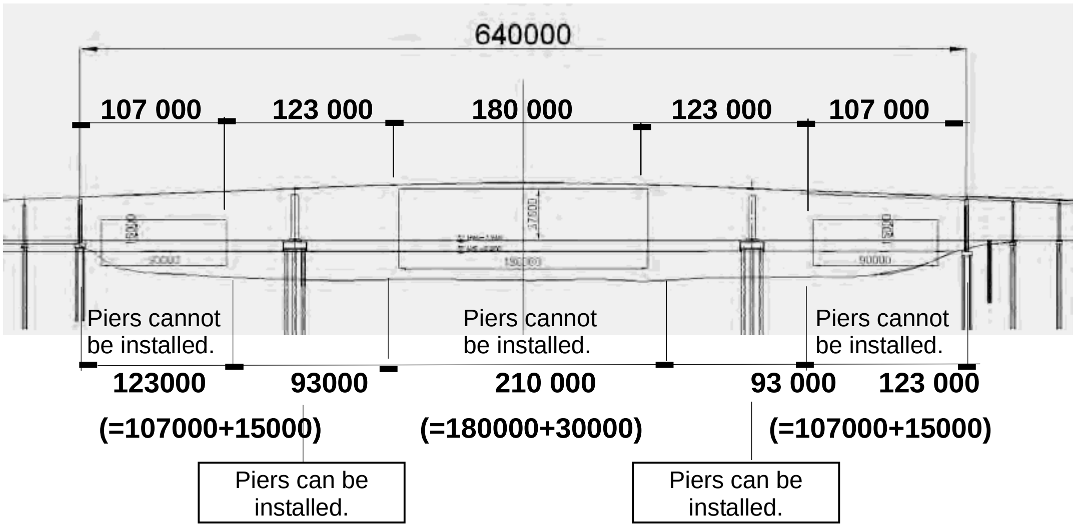


Figure 3.2-16 Possible Installation Range for Bridge Piers

On the basis of the above, the minimum main span length will be L_{min} = 180 + 30 = 210 m obtained as the sum of the pile cap width, the design allowance of 30 m and the channel width of 180 m. As the bridge length of the river section is 640 m and the bridge is to have 2 piers (3 spans) in accordance with Figure 3.2-16, the span will be 640 m/3 = 213.3m if uniform span lengths are adopted. Further, the span composition is 195 + 250 + 195 = 640 m when the ideal span ratio 1.0 : 1.3 : 1.0 for a 3-span continuous bridge is applied.

- Other conditions for the comparison
  - Major construction materials such as a cement and a steel will be imported from third countries or from Japan.
  - Skilled workers and bridge specialist workers also need to be recruited from third countries.
  - Heavy machineries, special machineries, ships and plant barges also need to be procured from Japan or from third countries.

- Ships used for the construction shall be navigable through the My Thuan Bridge or the Can Tho Bridge downstream of the construction site. Thus, a large-sized floating crane cannot navigate under these bridges.

b) Bridge Type

The bridge over the main stream is required to have a minimum center span length of 210 m. For reference, Table 3.2-17 shows typical bridge types used for long span bridges, and examples of their use.

Table 3.2-17 Examples of Maximum Span Lengths for Bridge Types

Bridge type		World			Japan		
		Name	Span (m)	Location / Year	Name	Span	Year
PC Box Girder	Hinged	Stolmasudet	301	Norway/1998	Eshima Bridge	250	2004
	Continuous	-	-	-	Heigen Bridge	170	1990
	Rigid Frame	-	-	-	Nagaragawa Viaduct	156	1999
Steel Deck Box Girder		Ponte Costa e Silva	300	Brazil/1974	Kaita Bridge	250	1991
Truss Bridge	Continuous	Astoria Bridge	376	USA/1966	Ikutsuki Bridge	400	1991
	Gerber	Quebec Bridge	549	Canada/1917	Minato Bridge	510	1974
Arch Bridge	Steel	Shanghai Lubu Bridge	550	China/2003	Airport Bridge	380	(2011)
	Concrete	Wanjian Changjiang Bridge	425	China/1997	Fujigawa Bridge	265	2005
Extradosed Bridge	PC Girder	-	-	-	Tokunoyama Hatoku Bridge	220	2006
	Hybrid	Japan-Palau Friendship Bridge	247	Palao/2003	Kisogawa Bridge	275	2002
Cable Stayed Bridge	PC Girder	Skarnsund Bridge	530	Norway/1991	Yabegawa Bridge	261	2007
	Steel Girder / Hybrid	Sutong Changjiang Gonglu Bridge	1,088	China/2007	Tatara Bridge	890	1999
Suspension Bridge		Great Belt East	1,624	Denmark/1998	Akashi-Kaikyo Bridge	1991	1998

With reference to the above examples, the suitability of the bridge types to the main bridge can be considered as follows:

① PC box girder bridge with center hinge

- In the PC box girder bridge with center hinge, the center span can easily be deformed due to creep and a high possibility of functional failure. Thus, this type is not included in the alternatives of bridge types.

② Steel deck box girder bridge

- There are many examples of this type, and it is technologically feasible. Thus this type is included in the alternatives.

③ Truss bridge

- Previous examples show that this type of bridge is technologically feasible. This type is thus included in the alternatives.

- In order to keep the bridge as low over the navigation channel as possible, and also to reduce the length of the approach bridge, the through truss bridge is selected as an alternative.

④ Through arch bridge

- Through arch bridge is technologically feasible as shown in the table and included in the alternatives.
- As same as the truss bridge, the through type steel arch bridge called Nielsen type bridge is selected as an alternive in better aesthetic point of view.

⑤ Extradosed bridge

- If a three-span continuous type is adopted for a PC extradosed bridge, the limitation of maximum center span will be 250 m. If the combination of the PC girder and steel girder called hybrid type is adopted, the center span shall be at least half the length of the bridge (> 320m). The span length is over the limitation of maximum span length for extradosed bridges. Thus, this type is not included in the alternatives.

⑥ Cable stayed bridge

- There are two types of cable stayed bridge – the PC cable stayed bridge with a PC girder, and the steel cable stayed bridge with a steel girder. There are many bridges of this type in a similar size all over the world, both in PC and steel (e.g. My Thuan Bridge (PC girder) and Binh Bridge (steel girder)). Thus both types are included in the alternatives.
- For the PC cable stayed bridge, the <u>edge girder type</u> will be adopted, because the structure of the main girder is simple and construction costs can be reduced. For the steel cable stayed bridge, the <u>steel I girder type</u> will be adopted, because of the reasonable construction costs.
- Cable stayed bridges mainly use concrete pylons throughout the world. Although steel pylons have normally been used for the steel cable stayed bridges in Japan so far, concrete pylons is increasing in number for this type of bridge in Japan recently, because of its economical construction cost. Concrete pylons for the cable stayed bridge for the Project will be applied.
- There are two types of stay cable arrangement -- single-plane arrangement where the stay cables are arranged on a centre strip, and double-plane arrangement where the stay cables are arranged on either side of the girder. For the single-plane arrangement, the weight of steel is about three times heavier than that of the double-plane arrangement, because the stay cables shall be anchored at a centre strip (2.0 m) and bridge width shall be 2.0 m wider than the double-plane arrangement, and the girder must be a box girder to give it sufficient rigidity to resist the torsion of the girder. The construction cost of the single plane arrangement will be higher than that of the double-plane arrangement. Thus, the cable stayed bridge with single-plane stays is not taken into account in this project.

⑦ Suspension bridge

- A suspension bridge with anchorages could be applied for long span bridges technically such as the main bridge in this Project. However, there is no rigid bearing layer capable of supporting heavy anchorages close to the ground surface at this project site. Hence it is obvious that this bridge type is not feasible technically for this Project, and therefore, it is not included in the alternatives.

On the basis of the above considerations, the following types of bridge are selected as the alternatives for the main bridge:

Type 1: 3-span continuous steel deck box girder bridge

Type 2: 3-span continuous steel through truss bridge

Type 3: Steel through arch bridge (3 spans)

Type 4: 3-span continuous PC cable stayed bridge

Type 5: 3-span continuous steel cable stayed bridge

c) Comparison of Bridge Types

Table 3.2-18 Comparison of Main Bridge Types (1)

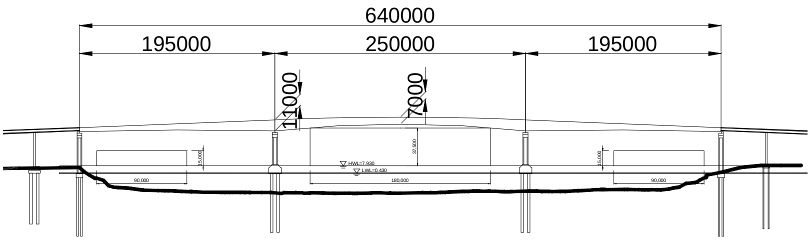
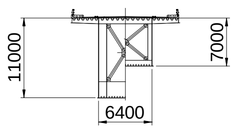
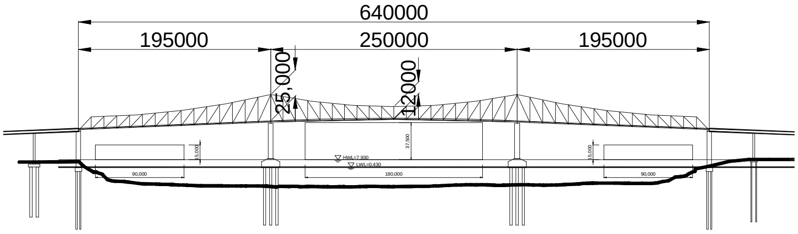
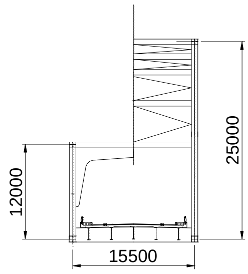
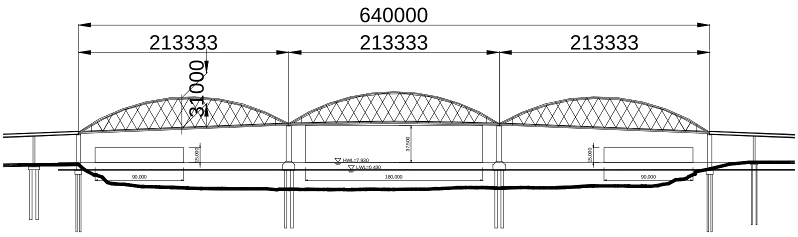
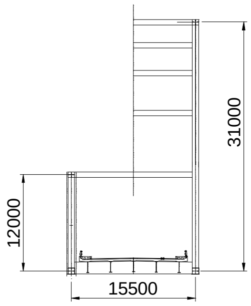
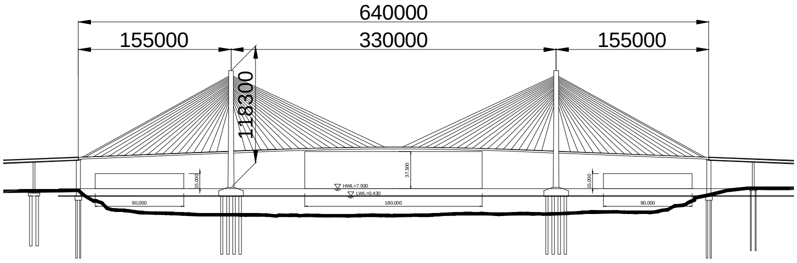
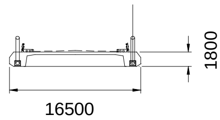
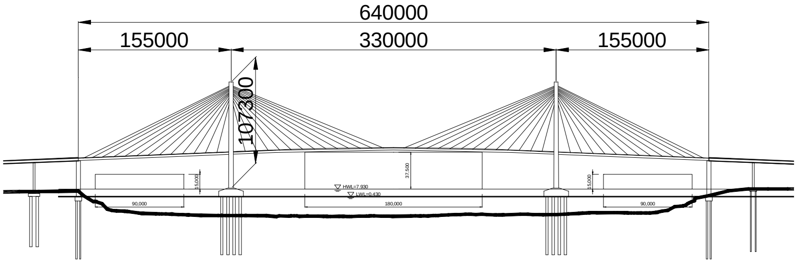
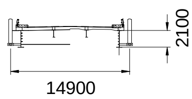
	Profile	Cross section
Type 1: Steel Deck Box Girder Bridge		
Type 2: Steel Truss Bridge		
Type 3: Steel Arch Bridge		
Type 4: PC Cable Stayed Bridge		
Type 5: Steel Cable Stayed Bridge		

Table 3.2-19 Comparison of Main Bridge Types (2)

		Description	
Type 1: Steel Deck Box Girder Bridge	Construction Cost[1]	Superstructure: 1.039; Substructure: 0.165; Total 1.204	△
	Structural Properties	Although the steel deck box girders cannot be manufactured in Cambodia, they can be procured from third countries such as Thailand or Vietnam. There are many instances of this bridge type in Japan. The proposed bridge size poses no technic al problems. However, the elevation height must be 7m higher than other bridge types, and this causes the length of the Approach Bridge to be longer.	×
	Construction	Side spans are erected on temporary bents using a crawler crane (450 tons) and a barge. The center span is erected by the lifting method (block weight: 1,600 tons) using a barge. An assembly yard for steel girders is required at the side of the Mekong River. Many bents must be set up in the deep river. It is necessary to provide large-scale facilities to carry the large block for the center span from the assembly yard to a barge.	△
	Maintenance	Long-life rust-proof painting (fluorine coating material) shall be used. When this paint is used for partial re-painting for maintenance, the painting is expected to last for 20-30 years, although full re-painting will eventually be required.	○
	Aesthetics	Neat and tidy, but not so impressive as a symbol or landmark.	○
Type 2: Steel truss bridge	Construction Cost	Superstructure: 0.972; Substructure: 0.272; Total 1.244	△
	Structural Properties	Although the truss members cannot be manufactured in Cambodia, they can be procured from third countries such as Thailand or Vietnam. Many bridges of this type have been built in Japan, with no structural or scale-related problems	○
	Construction	To install the side span section, a 120-ton tower crane is set up on the intermediate pier portion, and the side spans are erected using the cantilever method in combination with bents. Upon completion of the side spans, the center span is erected by the cantilever method in a similar manner. The members are carried by barge to a position immediately below the erection site, and are lifted by an on-bridge crane. Bents are required for the erection of the side spans. The center span is erected by lifting single members one by one from immediately below.	△
	Maintenance	To prevent rust, long-life rust-proof painting shall be used, as in the case of Type 1. Maintenance frequency (partial re-painting for repair) is increased due to the greater number of complicated members. In terms of maintenance, this type is inferior to others.	△
	Aesthetics	A rhythmical impression can be created through the arrangement of members, and the slenderness of the members can provide a sense of transparency. However, the height of the truss has to be modified upwards due to restrictions below the girder, and this gives the impression of an old-fashioned bridge.	×
Type 3: Steel arch bridge	Construction Cost	Superstructure: 0.958; Substructure: 0.245; Total 1.203	△
	Structural Properties	Although the arch members cannot be manufactured in Cambodia, they can be procured from third countries (Thailand or Vietnam). Many bridges of this type have been built in Japan, with no structural or scale-related problems	○
	Construction	The arch bridge is transported by barge and lifted to the designated height by lifting apparatus on the temporary bents installed by the side of the pier. After lifting, the arch is moved into the final position by sliding jacks. All three arches are erected by the same process. As in the case of Type 1, an arch assembly yard is required beside the river. Large-scale facilities are required, including temporary bents to lift the arch.	△
	Maintenance	Long-life rust-proof painting (fluorine coating material) shall be used. When this paint is used for partial re-painting for maintenance, the painting is expected to last for 20-30 years, although full re-painting will eventually be required.	○
	Aesthetics	Type 3 gives a better impression as a symbol or a landmark than Types 1 and 2.	

[1] Construction cost is shown as a ratio of the total construction cost (direct cost) of the most recommended option. The figure for the substructure includes the cost of the foundation work.

		Description	
Type 4: PC cable stayed bridge	Construction Cost	Superstructure: 0.638; Substructure: 0.362; Total 1.000	◎
	Structural Properties	Main girders can be manufactured either by precasting or by casting in situ. The latter is selected because of the lower costs required for smaller yard and erection facilities. Although the scale is greater than examples of the same type in Japan, there are no special problems. However, wind stability must be verified.	○
	Construction	After the construction of the pylons using lifting forms, the main pylon girders are erected. The girders are erected by cantilever method, balanced in both directions. Since this method does not require large temporary facilities, it is easy for construction than the other types.	◎
	Maintenance	As concrete construction, maintenance requirements are minimum, except for the pavements and accessories.	◎
	Aesthetics	Generally speaking, the cable stayed bridge has a high aesthetic value.	◎
Type 5: Steel cable stayed bridge	Construction Cost	Superstructure: 0.733; Substructure: 0.281; Total 1.014	○
	Structural Properties	This is a steel/concrete composite cable stayed bridge using twin I-girders. The pylons and the deck are made of concrete. It is expected that the cables will be imported from Japan or a third country. A bridge of this type is found in Binh Bridge, Vietnam, and the Ring Road Bridge, Thailand. Because of the narrow width of the bridge, countermeasure for wind stability shall be implemented.	○
	Construction	The girder is constructed by the balanced cantilever method from the pylons. The girders are transported by barge to a position immediately below the lifting position and are erected by a traveling crane set on the girder. The deck plates are precast concrete and are connected to the steel girders as construction progresses. As the construction work does not require any large-scale facilities, this method is better in terms of construction than the other types.	◎
	Maintenance	The maintenance of the steel girder is the same as for Type 1. However, the area to be painted is very small. The cable requires hardly any maintenance, but inspection and monitoring are essential.	○
	Aesthetics	Generally speaking, the cable stayed bridge has a high aesthetic value.	◎

d) Evaluation of bridge types

Structural properties: The application of any of these alternative types for the Main Bridge for this Project will be technically feasible. However, in the case of Type 1 (Steel deck box girder bridge), because of its girder height, the alignment must be about 7 meters higher than the other alternatives to keep sufficient navigation clearance. Considering a longitudinal gradient of 4 %, the approach bridge shall be longer than the other alternatives extended 7m/4% = 175 m.

Construction: A floating crane (FC) with a lifting capacity of a few thousand tons cannot pass under the bridges located downstream of the Project site in the Mekong River. Superstructures could be installed on substructures in block by a floating crane for Types 1, 2 and 3, but this erection method cannot be used because of this restriction. Type 1 (Steel deck box girder bridge) and Type 2 (Steel truss bridge) are continuous bridges, where the side span section shall be erected first. To erect the intermediate span section, it is necessary to adopt an erection method that does not disturb the river navigations for a long time. Erection by the cantilever method using a temporary bent is convenient, however the side span shall be constructed by the erection method using temporary bents. A great number of temporary piles for the temporary bents must be driven into deep water, so that this method is not advantageous in terms of construction costs and period. In Type 3, since superstructure shall be installed on substructures in block, the lifting erection support member and lifting equipment are set up at the pier position. After the block lifted at the top of substructures, the blocks are slid horizontally into position. This procedure requires the large-scale erection facilities, such as the facilities for loading the bridge assembled in the yard onto a barge, and lifting and sliding facilities. Types 4 and 5 (cable stayed bridges) allow erection to be accomplished by cantilever method, without heavy temporary facilities and equipments, and therefore, these two types of bridges are nominated as the best alternatives for the Project site.

Maintenance: The steel bridges are less advantageous than Type 4 (PC cable stayed bridge) in terms of re-painting. A long-life rust-proof paint (fluorine coating material) is applied to the steel bridges, to extend a re-painting interval.

Aesthetics: Although each type of bridge has its own advantages, the cable stayed bridges are preferrable with aesthetic point of view.

Utilization of domestic products: The bridge construction materials available in Cambodia including aggregates used for concrete shall be utilized to the Project as much as possible. From the viewpoint of effective use of domestic products, Type 4 (PC cable stayed bridge) is recommended.

Construction Cost: Cost of the steel bridges (Types 1, 2 and 3) is higher than the cable stayed bridge. Type 5 (Steel cable stayed bridge) and Type 4 (PC cable stayed bridge) are the same type of structure, with the exception of the main girder . The PC cable stayed bridge is slightly reasonable in cost than the steel cable stayed bridge.

From the above examination, conclusions come to followings:

- The Types 1, 2 and 3 are clearly less advantageous in terms of the workability and the construction cost compared to the Types 4 and 5 (steel cable stayed bridges). Thus, they will be excluded from the alternatives.
- Of the Types 4 and 5 (cable stayed bridges), the PC cable stayed bridge has some advantage than the others in terms of ease of maintenance and construction cost.
- Generally speaking, a cable supported bridges such as a suspension bridge and a cable stayed bridge shall be paid enough attention for wind stability. In this sense, the Type 4 (PC cable stayed bridge) is superior to the Type 5 (Steel cable stayed bridge). For the final selection, wind tunnel tests has been conducted in this Survey to verify the wind stability and wind stability of the PC cable stayed bridge was certified.

Conclusion: From the viewpoint of the construction cost, effective use of the Cambodian national products and the wind stability, the Type 4 (PC cable stayed bridge) is selected as the optimum bridge type.

(4) Approach Bridge

1) Type of Approach Bridge

i) Approach Bridge Type Options

- Appropriate Span Length

Taking economic efficiency into consideration, the appropriate span length is determined by the relationship between the height of the pier and the depth of the foundation, using the following equation:

$$L = (1.0\text{-}1.5) \times (H + 1/3 \times D)$$

Where L: Appropriate span length (m)

H: Height of pier (m)

D: Depth of foundation (m)

Source: Design Manual, Nippon Expressway Company (July 2006)

The height of piers for approach bridges ranges from 8 m to 31 m (average height 20 m), and the depth of pile foundations ranges from 54 m to 62 m (average depth 50 m). From the above equation, the appropriate span length is calculated between 35 m and 55 m.

- Proposed Bridge Type

Bridge type options for the approach bridge are selected from Table 3.2-20 for steel bridges and Table 3.2-21 for concrete bridges. These tables are based on previous experience in Japan, taking construction cost into consideration.

Table 3.2-20 Relationship between Appropriate Span Length and Steel Bridge

Bridge Type		Span (m) 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160	Evaluation
Plate Girder Bridge	Simple Composite Steel H-Beam		-
	Simple Steel I-Girder		-
	Simple Composite Steel I-Girder		-
	Simple Steel Box Girder		-
	Simple Composite Steel Box Girder		-
	Continuous Steel Multi I-Girder		△
	Continuous Steel Double I-Girder		○
	Continuous Steel Box Girder		△
	Steel U-shape Box Girder		○
	Steel Slender Box Girder		-
	Steel Deck I-Girder		-
	Steel Deck Box Girder		-
π - shaped Rigid Frame			-
Rigid Frame Bridge			-
Truss	Simple Steel Truss		-
	Continuous Steel Truss		-
	Truss with Shaped Steel		-
Arch	Langer Type		-
	Deck Langer Type		-
	Lohse Type		-
	Deck Lohse Type		-
	Langer Truss Type		-
	Trussed Langer Type		-
	Nielsen Type		-
	Arch Type		-
Cable Stayed Bridge			-
Suspension Bridge (stiffening girder type)			-

Note: (1) [grey band] : Span range commonly used. Red lines indicate span range of 35 to 55m.
Yellow shading indicates suitable candidates.

Source: Design Manual, Ministry of Land, Infrastructure, Transport and Tourism (May 2005)

Table 3.2-21 Relationship between Appropriate Span Length and Concrete Bridge Types

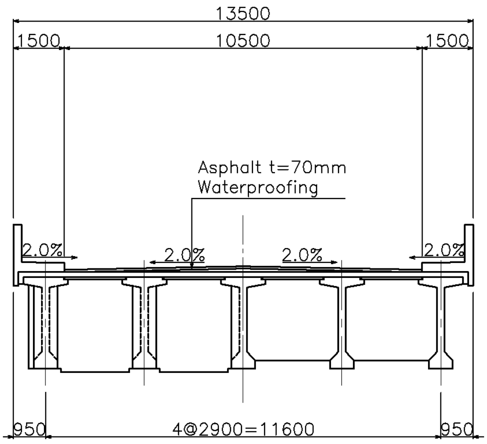
Classification		Type	Erection Method	Span (m) 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160	Evaluation
Reinforced Concrete	Cast-in-place	Simple Slab	All-Staging		-
		Continuous Slab			-
		Simple Hollow Slab			-
		Continuous Hollow Slab			-
Simple Girder	Precast Girder	Pretension Slab	Crane Erection		-
		Pretension T-Girder	Crane Erection		-
		Post-tension Slab	Crane Erection, Erection Girder		-
		Post-tension T-Girder	Crane Erection, Erection Girder		-
		Post-tension I-Girder	Crane Erection, Erection Girder		-
		Post-tension U-Girder	Crane Erection, Erection Girder		-
	Cast-in-place	Hollow Slab	All-Staging		-
		Box Girder	All-Staging		-
Splice Girder	Precast Girder	Pretension Slab	Crane Erection		-
		Pretension T-Girder	Crane Erection		-
		Post-tension Slab	Crane Erection, Erection Girder		-
		Post-tension Bulb T-Girder	Crane Erection, Erection Girder		△
		Post-tension I-Girder	Crane Erection, Erection Girder		○
		Post-tension U-Girder	Crane Erection, Erection Girder		-
Continuous Girder		Hollow Slab	All-Staging, Movable Scaffolding		-
		Box Girder	All-Staging		○
			Movable Scaffolding		○
			Launching		○
			Balanced cantilevered		-
		I-Girder	All-Staging, Movable Scaffolding		-
Rigid Frame	T-shape	Hollow Slab	All-Staging		-
		Box Girder	All-Staging		-
			Balanced cantilevered		-
	Continuous	Hollow Slab	All-Staging		-
		Box Girder	All-Staging		△
			Balanced cantilevered		-
Cable-Stayed Bridge		Hollow Slab, Box Girder, Edge-Girder	All-Staging		-
			Balanced cantilevered		-
Extradosed Bridge		Box Girder	All-Staging		-
			Balanced cantilevered		-
Arch Bridge		Hollow Slab, Box Girder	All-Staging		-
			Balanced cantilevered		-
			Lowering		-
			Melan		-
Hybrid Structure		Corrugated Steel-Web T-Girder	Crane Erection, Erection Girder		-
		Corrugated Steel-Web Box Girder	Erection Girder		-
			All-Staging		-
			Launching		-
			Balanced cantilevered		-
		Steel Truss Web Box Girder	Balanced cantilevered		-

Note (1) [grey bar] Span range commonly used. Red lines indicate span range of 35 to 55m. Yellow shading indicates suitable candidates.
(2) Site inspection indicates difficulty in building a factory to manufacture girders. Girders will be cast on site.

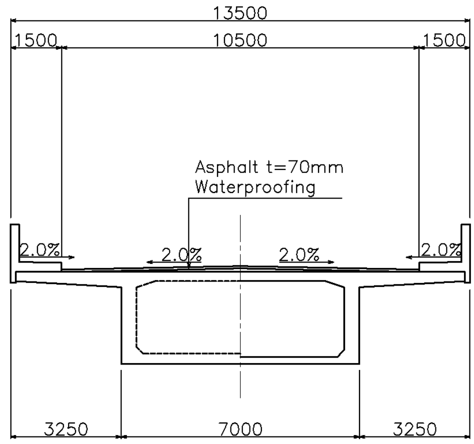
Source: Design Manual, Ministry of Land, Infrastructure, Transport and Tourism (May 2005)

The bridge types shown in Figure 3.2-17 below were selected as candidate bridge types.

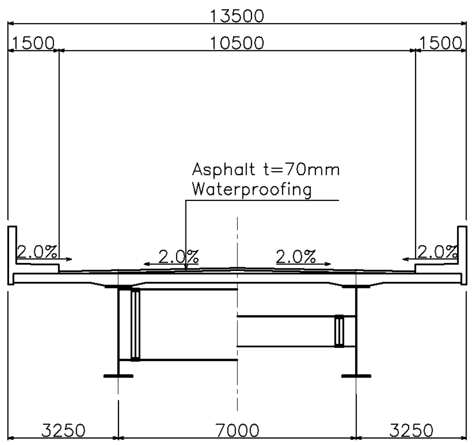
Type 1: PC Post-tension I Girder



Type 3: PC Box Girder



Type 2: Steel Double I Girder



Type 4: Steel U-Shape Box Girder

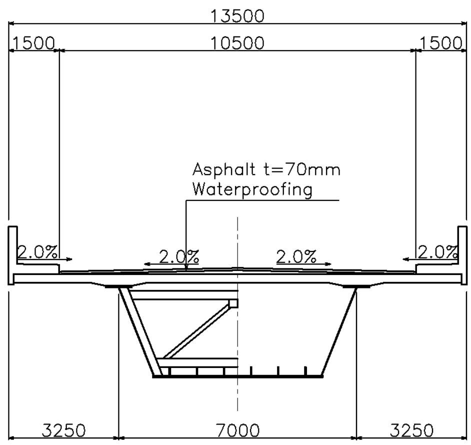


Figure 3.2-17 Bridge Type Options for Approach Bridge

ii) Optimum Bridge Type for the Approach Bridge

Table 3.2-22 and Table 3.2-23 shows the results of a comparison study of the four bridge types.

Following overall evaluation, "Type 1: PC Post-tension I Girder" was selected as the optimum type for approach bridge. This bridge type has the following advantages:

- The lowest construction cost
- Many instances in Cambodia, such as NR 1, NR 6 and the Kizuna Bridge.

Table 3.2-22 Comparison Study of Approach Bridge Types (1)

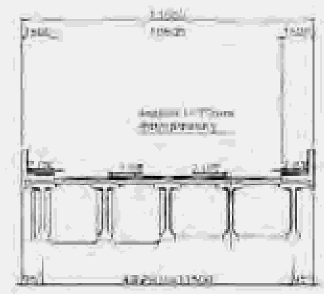
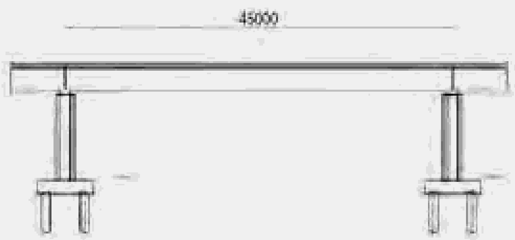
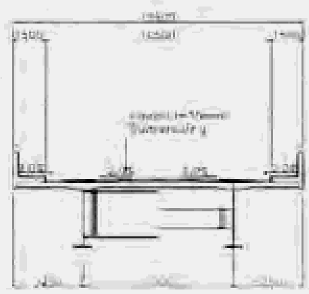
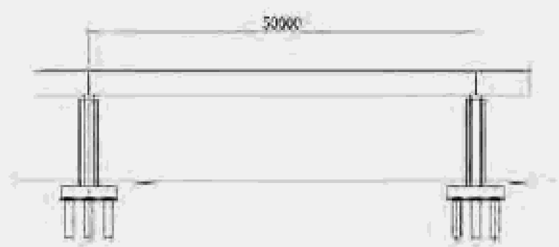
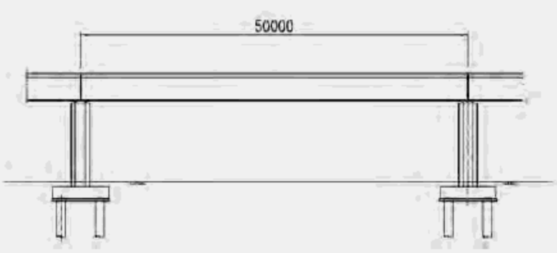
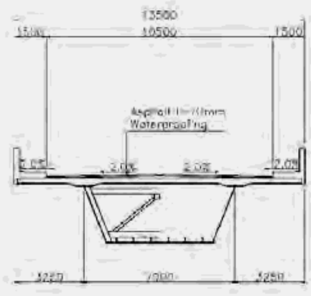
	Profile	Cross Section	Cost
Option-1 Post-tension I-Girder			1.00
Option-2 Steel Double I-Girder			1.10
Option-3 Prestressed Concrete Box Girder			1.29
Option-4 Steel U-Shape Box Girder			1.22

Table 3.2-23 Comparison Study of Approach Bridge Types (2)

		Outlines	
Option-1 Post-tension I-Girder	Construction Cost	* The cost is the lowest of the four options	(1.00) ○
	Structure	* Prestressed concrete composite girder using precast Prestressed concrete plate * Advanced bridge type developed with the aim of saving on labor and cost * Installation/removal of wooden form unnecessary except for cantilever deck using precast prestressed concrete plate between adjacent girders * Less waste	○
	Ease of construction	* Use of precast members saves labor on site * The same type of bridge has already been constructed on National Highway No.1 and No.6 and at the Kizuna Bridge	○
	Ride Quality	* Continuous slab structure reduces number of expansion joints * Ride quality is good	○
	Maintenance	* Needs very little maintenance work	○
	Bridge Aesthetics	* Concrete structure is in harmony with the surrounding environment	○
	Overall Evaluation	* Top in terms of economy, constructability and maintenance	○
Option-2 Steel Double I-Girder	Construction Cost	* The cost is the second lowest	(1.10) △
	Structure	* Small number of steel girders using prestressed concrete deck slab * No sway bracing is required	○
	Ease of construction	* Use of precast members saves labor on site	○
	Ride Quality	* Ride quality is good due to the small number of expansion joints	○
	Maintenance	* Re-painting is required periodically. Requires more frequent maintenance work than Options 1 and 3	△
	Bridge Aesthetics	* Harmonization with surrounding environment is possible through choice of paint color	○
	Overall Evaluation	* Inferior to Option 1 in terms of economy and maintenance	△
Option-3 Prestressed Concrete Box Girder	Construction Cost	* Most costly of the four options	(1.29) △
	Structure	* Prestressed concrete bridge with box section * It has high resistance to compressive force due to flexural moment * It has high torsional rigidity and good load distribution performance to live loads	○
	Ease of construction	* A lot of the work must be done on site	△
	Ride Quality	* Ride quality is good due to the small number of expansion joints	○
	Maintenance	* Needs very little maintenance work	○
	Bridge Aesthetics	* Concrete structure is in harmony with the surrounding environment	○
	Overall Evaluation	* Inferior to Option 1 in terms of economy and ease of construction	△
Option-4 Steel U-Shape Box Girder	Construction Cost	* The cost is the second highest	(1.22) △
	Structure	* It uses prestressed concrete or composite deck with long span * No lateral bracing and floor system such as stringer, cross beam and bracket is required	○
	Ease of construction	* The lack of a need to use forms and scaffolding saves labor on site	△
	Ride Quality	* Ride quality is good due to the small number of expansion joints	○
	Maintenance	* Re-painting is required periodically. Requires more frequent maintenance work than Options 1 and 3	△
	Bridge Aesthetics	* Harmonization with surrounding environment is possible through choice of paint color	○
	Overall Evaluation	* Inferior to Option 1 in terms of economy and maintenance	△

2) Foundation Type

i) Foundation Type Options for Approach Bridge

The geological conditions and characteristics of the structure for the selection of a foundation type are as follows:

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

Therefore, a pile foundation should be used and the types of pile foundation options are shown in Table 3.2-24.

Table 3.2-24 Types of Pile Foundation Options

Pile Type		Diameter(mm)	Evaluation
Steel Pile	Driving Method	φ600～φ1000	○
	Inner Excavation Method	φ600～φ1000	× *1
Steel-Concrete Composite Pile		φ800～φ1200	× *2
Cast-in-Place Concrete Pile	Reverse-Circulation Method	φ1000～φ1500	○

*1: For steel piles, the inner excavation method is not recommended due to the great pile depth of 50 m or greater and construction cost.

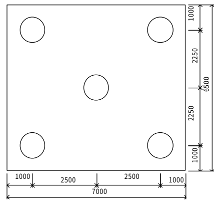
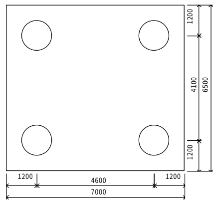
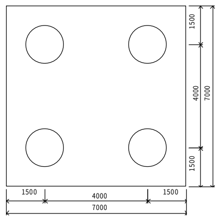
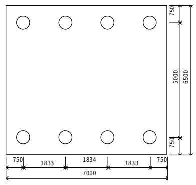
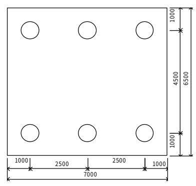
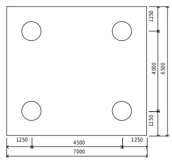
*2: The cost of steel-concrete composite piles is quite high compared to steel piles due to the large quantity of material. The advantage of composite piles is the high resistance of the pile itself. The number of piles is determined by the bearing capacity of each pile.

The foundation type options are driving steel piles with a diameter of 600 mm to 1000 mm, and cast-in-place concrete piles using the reverse circulation method with a diameter of 1000 mm to 1500 mm as shown in Table 3.2-25.

Cast-in-place concrete piles using the reverse circulation method with a diameter of 1000 mm or 1200 mm was selected.

ii) Selection of Foundation Type

Table 3.2-25 Foundation Type Options.

	Type of Pile	Diameter		Cost	Evaluation
1	Cast-in-Place Concrete Pile (Reverse Circulation Pile)	φ1000		1.0	○
2		φ1200		1.0	○
3		φ1500		1.3	
4	Steel Pile (Driving Pile)	φ 600		1.1	
5		φ 800		1.2	
6		φ1000		1.1	

3) Configuration of Approach Bridges

A 5-span continuous structure will be used for the Project, taking economy into consideration. The Span arrangements are shown in the General View.

3.2.2 Basic Plan

(2) Road Planning

1) Outline of Route Alignment

The geometric design standard and typical cross section for the Project are explained in Section 2.1 Design Policy. The route alignment of the Project is shown in Figure 3.2- which was determined in line with the Design Policy.

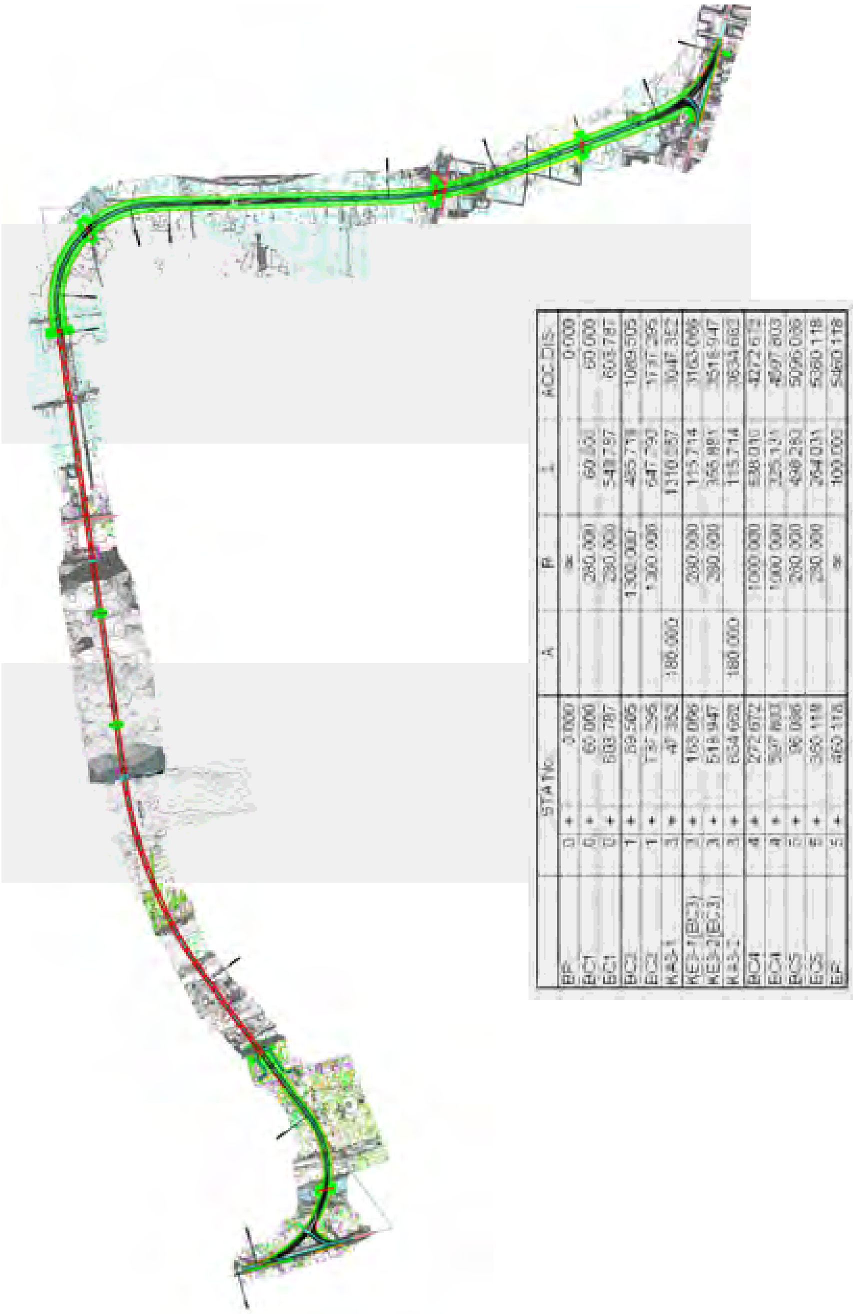


Figure 3.2-18 Route Alignment

2) Pavement

- Design Conditions

The AASHTO standards will be applied to the design of the pavement structure. The following design conditions have been considered.

- The traffic load will take into account standard-sized cars and large-sized vehicles.
- The Equivalent Conversion Factor of 18 kip Equivalent Single Axle Load (ESAL), which was applied to the Road Improvement Project for National Road No. 1 by JICA will also be applied in this Project.
- The design life will be 10 years after opening to traffic.

- Evaluation of Subgrade Soil and Traffic Loads

The project road is planned as a new construction road, and subgrade materials will be prepared by the contractors. Therefore, a design CBR of 5 will be used, assuming that subgrade materials with a good CBR-value will be procured. Table 3.2 shows the results of the CBR tests for the embankment materials at the site.

Table 3.2-26 Results of CBR Tests

Sampling Location	No.1	No.16	No.17	No.19
CBR-Value	5.33	2.67	2.67	2.00

When the CBR-value is higher than 3, subgrade improvements are not always needed. However, a thicker pavement structure is required to support the traffic load when a subgrade is not sufficient. The overall construction cost of such a thicker pavement is frequently higher than the cost of a thinner pavement where the subgrade has been improved and the CBR-value is higher. Therefore, in order to propose the most appropriate pavement structure, a comparative study for several design CBRs for subgrade improvements shall be carried out.

Cumulative 18 kip ESAL (W_{18}) per lane which is the traffic load for this project is calculated as 3.052×10^6.

- Required Structural Number for the Main Line

The coefficients used to determine the Structural Number (SN) are as follows;

- Reliability (R) ：80%（Lowest recommended level for arterial roads）
- Standard Deviation（S_o） ：0.45（Standard value of AC pavement）
- Initial Serviceability（P_o） ：4.2（Standard value of AC pavement）
- Terminal Serviceability（P_t） ：2.5（Lowest recommended level required for arterial roads）

The required SNs corresponding to the design CBR are shown in Table 3.2-27.

Table 3.2-27 Required SNs corresponding to Design CBR

Design CBR	CBR=5	CBR=6	CBR=7
Structural Number (SN)	3.865	3.611	3.406

Here, the minimum thickness of the AC layer and a crushed-stone base course layer for the project road are 9 cm and 15 cm respectively, in accordance with the AASHTO standard.

- Required SN for Motorbike Lanes

It was considered that 4-wheeled vehicles pass along the motorbike lanes as they enter and exit roadside facilities and stop on a shoulder. When 25% of the cumulative 18 kip ESAL of 3.052×10^6 on the main line is loaded on the motorbike lane, the cumulative 18 kip ESAL on the motorbike lane is calculated as 0.763×10^6, and the required SN is estimated as 2.707 when the design CBR is 7. To secure uniformity in the stabilized subgrade and lower subgrade course, the subgrade structure of the motorbike lane shall be the same as the main lane. Therefore, it is planned to satisfy the required SN by adjusting the thickness of the AC layer.

- Subgrade

In order to propose the most appropriate pavement structure, the subgrade is improved and a comparative study carried out of a variety of the design CBRs. It is usual for a subgrade stabilization to be done using a lime stabilization and a cement stabilization. At the project site, however, the lime is difficult to obtain, while the cement is comparatively easy to procure. In addition, the cement stabilization is suitable for a sandy soil because the sandy soil with clay is the standard local embankment material. Therefore, the cement stabilization was adopted for the Project. The target CBR for the stabilized subgrade materials was set at 15, and the stabilized subgrade thickness corresponding to each design CBR is shown in Table 3.2-28.

Table 3.2-28 Stabilized Subgrade Thickness corresponding to Design CBR

Design CBR	CBR=5	CBR=6	CBR=7
Stabilized Subgrade Thickness	0cm	10cm	25cm

- Pavement Structure for the Main Line

The type of pavement adopted is asphalt concrete, because it is popular in Cambodia and has many advantages such as durability, ease of maintenance, etc. With regard to the base layer, the cost becomes generally expensive because the quarry site is far from the project site, which results in high transportation costs. Gravel is also indispensable for top layer stabilization. Therefore, mechanically stabilized base materials which are more economical than the cement stabilization base course were adopted for the base course. On the other hand, local embankment materials and other local materials are available for the sub-base course stabilization, and gravel is unnecessary. Therefore, the use of the sub-base stabilization will be considered because low-priced materials such as sand etc., are available.

Pavement structures corresponding to each design CBR are shown in Table 3.2-29. As a result, the most economical case was a design CBR of 7 with improved subgrade and sub-base course stabilization (pavement thickness of 53 cm). In addition, the proportions are well-balanced and suitable for load transmission. The socio-environmental impact along the roadside will be mitigated because the road elevation is lowered as much as possible while securing an allowance of the HWL +50cm.

Table 3.2-29 Pavement Structure corresponding to Design CBR

Items	Design CBR＝5		Design CBR＝6		Design CBR＝7	
Stabilized Subgrade	Without	With	Without	With	Without	With
Surface Course	4cm	4cm	4cm	4cm	4cm	4cm
Binder Course	6cm	6cm	6cm	6cm	6cm	6cm
Base Course	24cm	19cm	21cm	15cm	18cm	13cm
Sub-base Course	37cm	35cm	33cm	33cm	31cm	30cm
Pavement Thickness	71cm	64cm	64cm	58cm	59cm	53cm
Stabilized Subgrade Thickness	0cm	0cm	10cm	10cm	25cm	25cm
Normal Subgrade Thickness	100cm	100cm	90cm	90cm	75cm	75cm
Direct Construction Cost（$/m^2）	23.712	23.248	22.504	22.106	21.655	21.225

- Pavement Structure for Motorbike Lanes

As a result of a study, a design CBR of 7 was adopted as the pavement structure for the main lanes. When the design CBR is 7, the required SN for a motorbike lane is 2.707, as previously explained. The SN for a main lane excluding the surface course is calculated as 2.746, and this satisfies the required SN for a motorbike lane. Therefore, the pavement structure was adopted as below. At the same time, it is desirable to prevent 4-wheel vehicles from entering the motorbike lane unnecessarily, because the pavement structure of the motorbike lane is weaker than that of the main lanes. A difference in height of 4 cm on the asphalt concrete surface between the main lanes and the motorbike lane is secured, though the base course levels remain at the same height.

Surface Course（AC） ： 6 cm

Base Course（Mechanical Stabilization） ： 13 cm

Sub-base Course（Cement Stabilization） ： 30 cm

3) Typical Cross Section

In formulating a standard cross section, the following points were considered;

- Measures for flood

The approach roads run across the flood plain of the Mekong River connectiong National Road No. 11 and National Road No.1. Therefore, an embankment structure shall be designed enough durable against flooding.

In Japan, there are detailed regulations specifying the materials to be used for dykes and grain-size distribution. However, the aim of this project is to build a new approach road, not to build a river dyke. Construction cost will be raised and construction time will be extended if the reculation for river dyke is adopted to the embankment of the new approach road. Also, the embankment material which is excavated locally is generally sandy soil with clay, and it is difficult to obtain cohesive soil which is suitable for a dyke embankment. Therefore, into the road embankment, cement-treated soil will be used for a waterproof layer with a low coefficient of permeability in the vicinity of the embankment surface. A thickness of 50 cm along the embankment slope will be secured.

- Slope Protection

To prevent the embankment slope from erosion, scouring and collapse by a rainfall and wave action by a flood, vegetation at the slope will be applied. The material for vegetation is wild grass which is easily obtained locally. When wild grass is transplanted directly into the waterproof layer, it is difficult for the vegetation to take root. Therefore, soil cover will be provided over the waterproof layer. The minimum thickness of the soil cover will 20 cm along the embankment slope, allowing for adequate compacting.

- Sand Mats and Geotextiles

The surface soil at the project site consists of alluvial cohesive soil. Because the ground is soft subsidence shall be taken into consideration. Therefore, the sand mats and geotextiles will be placed at the basement of embankment to improve trafficability during construction. It is also effective in accelerating the settlement of the soft ground and expected to improve the stability of the embankment.

- Embankment Slope and Maximum Embankment Height

Slope of embankment is 1:2.0 because of the soft ground at the Project site. The maximum single step height of embankment is 5 m on the east bank side. The maximum embankment height on the west bank side is 7 m because the ground condition is better than the east side.

- Standard Cross Section

Standard cross sections reflecting the pavement structure adopted and the above-mentioned considerations are shown in Figure 3.2-19.

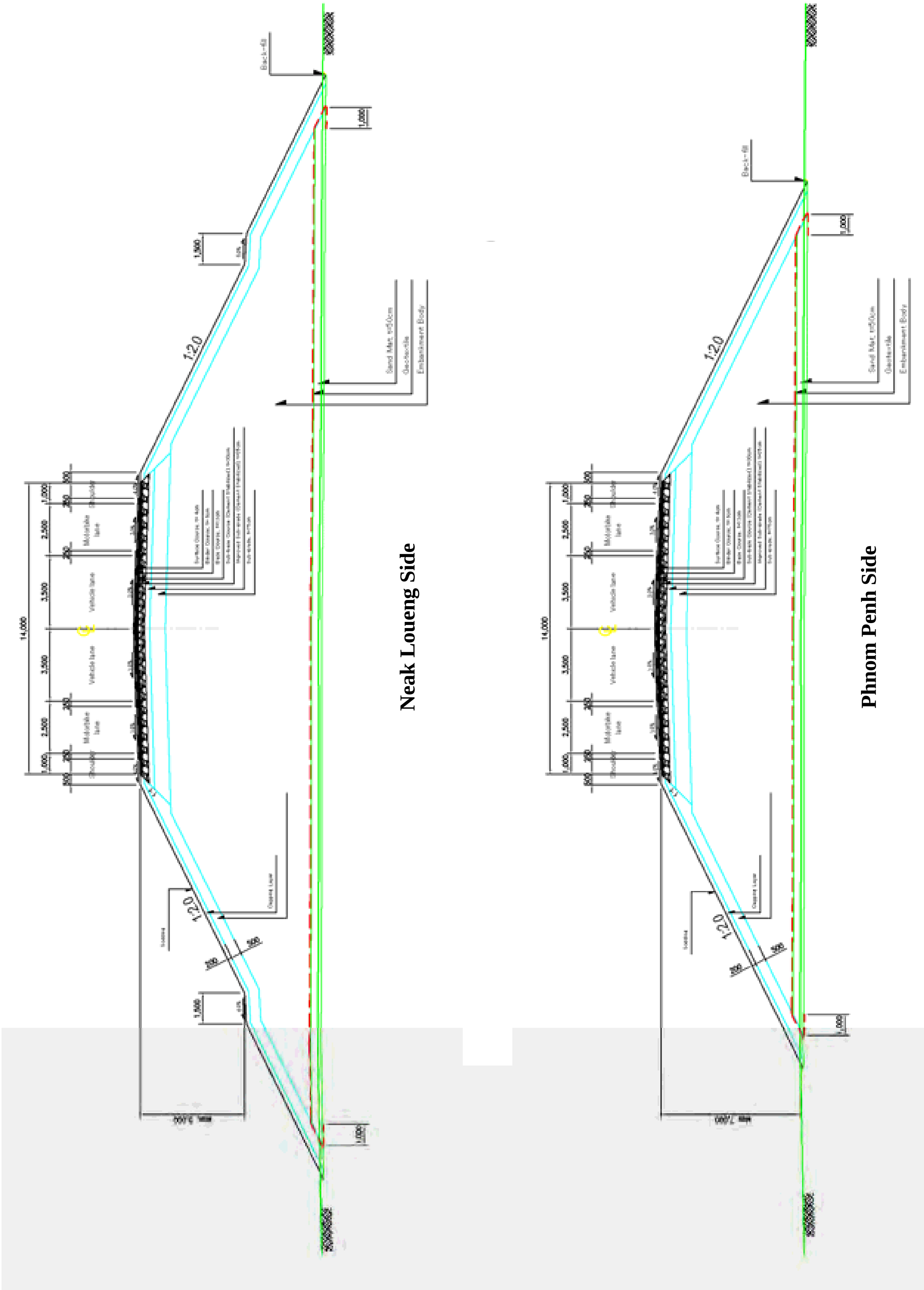


Figure 3.2-19 Standard Cross Section

4) Box Culverts

Three box culverts will be installed in the embankment section on the east bank side for the flood water control. In addition, two box culverts will be installed for an intersection of the main highway. A box abutment will be installed at Sta. 0+836.3 to make the embankment height as low as possible.

The former tributary is located on the west bank side, and while there is no flow of water it is filled with water. A small box culvert will be provided to allow water through, to maintain the natural environment.

Table 3.2-30 shows the location and size of box culverts.

Table 3.2-30 List of Box Culverts

Box Culvert	Station	Purpose	Internal Width (m)	Internal Height (m)	Floor Level (m)	Crossing Angle (Degree)	Finished Height of Road (m)	Remarks
BC1	0+373.0	Irrigation	2.000	2.000	3.000	70.000	9.260	
A1BC	0+836.3	Road crossing	6.000	4.700	8.164	90.000	13.873	Box Abutment
BC2	3+377.0	Flood control	6.500	6.700	2.030	75.000	10.297	
BC3	4+410.0	Flood control	6.500	6.700	2.000	75.000	10.232	
BC4	4+436.5	Road crossing	6.000	3.600	5.100	71.616	10.231	
BC5	4+861.0	Flood control	6.500	6.700	2.100	75.000	10.320	

- Joints and Waterproof Wall

There is a possibility of differential settlement at the soft ground because the loads at the center and the ends of the embankment are different. Joints will be placed to minimize the effect of differential settlement on the box culverts. One joint will be provided at the center of the culvert. The thickness of waterproof wall is 40 cm .

- Foundations

A spread foundation is used for the box culverts. Where the base ground is soft, the site material is replaced with good quality soil or sand to avoid the differential settlement. The depth of replacement is 1.0 m below the bottom slab.

- Diaphragm Wall

A diaphragm wall is installed below the bottom slab to prevent infiltrating water at the foundation. The length of the diaphragm wall will be 3.0 m, taking into consideration the study of the length of the route of infiltrationg water and the minimum embedment length of 3.0 m.

5) Revetment and Riverbed Protection

When the size of the flood discharge openings of the culvert is examined, a non-uniform flow with a water level difference of 1.0 m and a water flow velocity 2.0 m/s are adopted. However, the water flow velocity around the abutments and the gateway and exit of the box culverts is usually higher than the other sections, and there is the possibility of scouring. Therefore, revetment and riverbed protection shall be settled around the abutments and the gateway and exit of the box culverts.

- Riverbed Protection Work

Site conditions are examined to determine the range of a riverbed protection, refer to the past experience in Cambodia and the Road Improvement Project for National Road No. 1. Table 3.2-31 shows the range of riverbed protection for each structure. A gabion mat reaching to the end of the slope will be installed on the front of abutment A1 to provide a natural levee. A gabion mat retaining wall will be installed at BC3 where the water collides with the structure.

Table 3.2-31 Range of Riverbed Protection

Type of Work	Length of Gabion Mat (m)		Length of Rip Rap (m)	
Bridge	Front side of Abutment	Back side of Abutment	Front side of Abutment	Back side of Abutment
A1	15.4-32.9	10.000	-	10.500
A2	5.000	11.000	-	4.000
Box Culvert	Left Side	Right Side	Left Side	Right Side
BC1	5.000	5.000	2.000	2.000
BC2	10.000	10.000	5.000	5.000
BC3	29.240	10.000	-	5.000
BC5	10.000	10.000	5.000	5.000

With regard to the box culverts for vehicles, wearing course with 4 cm thickness will be provided within the box culvert and 5 m before and after each culvert.

- Revetment Work

As with riverbed protection, the range of each revetment is determined by the same means as the riverbed protection. Wet masonry is adopted for the revetment. Compared with the bridge, the size of the opening of the box culvert is small, and there is a possibility that the water flow is fast. Therefore, a gabion will be installed on the outer side of the revetment. Table 3.2-32 shows the range of revetment work for each structure.

Table 3.2-32 Range of Revetment Work

Location		Range of Wet Masonry	Width of Gabion
Bridge	A1	Up to the tapering end of embankment for the wing wall of box abutment. Both upstream and downstream	-
	A2	15 m from the front of the abutment parapet. Both upstream and downstream	-
Box Culvert	BC1	10 m from the end of the wing wall. Both entrance and exit	2.0 m
	BC2,3,4,5		3.0 m

- Steps

For the purpose of maintenance, inspection and cleaning of the embankment and box culverts, maintenance steps will be settled on both side of banks. The width of the steps will be 1.0 m to allow for workers passing each other. One flight of steps will be installed for box culverts BC3 and BC4 because the two box culverts are located close to each other.

The basic plan for the riverbed protection, revetments and steps at the box culvert are shown in Figure 3.2-20. Figure 3.2-21 shows the structure of a wet masonry revetment with a pile foundation.

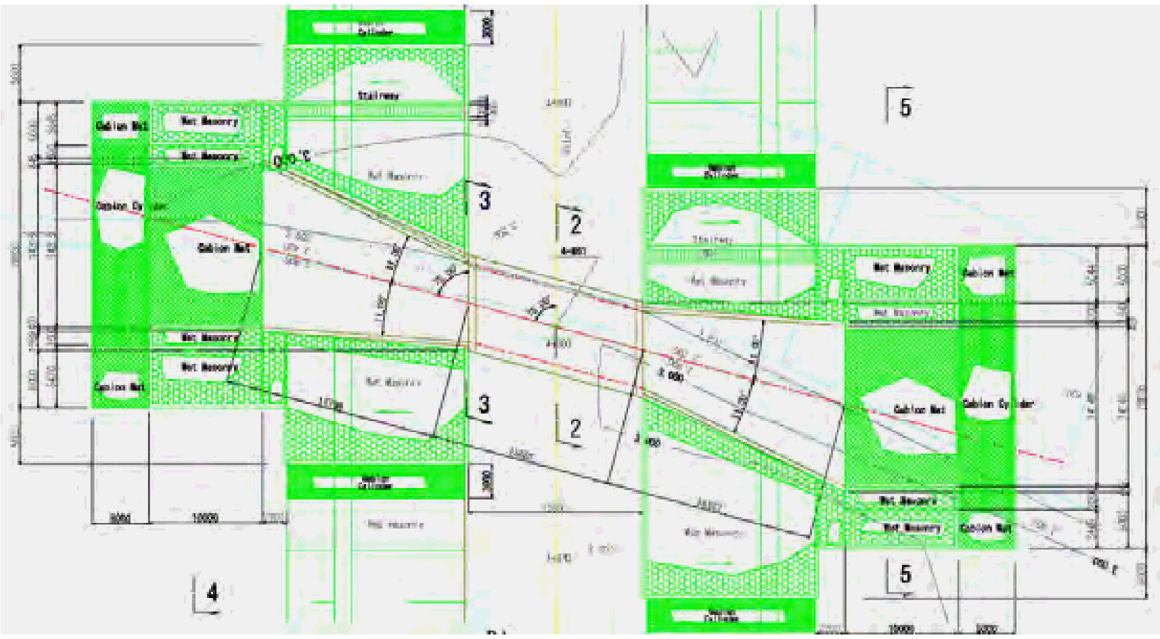


Figure 3.2-20 Layout of Riverbed Protection, Revetments and Steps for Box Culvert

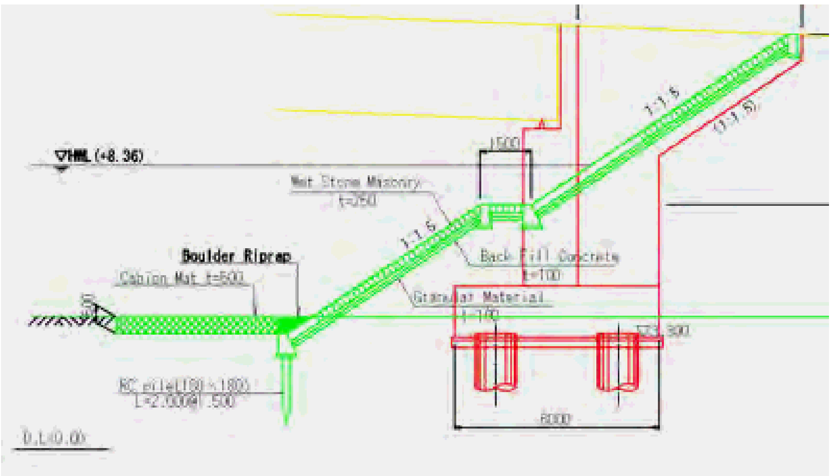


Figure 3.2-21 Structure of Wet Masonry Revetment with Pile Foundation

6) Retaining Wall

To minimize the number of houses affected by the Project, retaining walls will be installed. A construction space 2.0 m wide is required for setting up scaffolding. Therefore, a retaining wall shall be installed where houses 2.0 m or more distant from the edge of the roadway. The characteristics of the retaining walls are shown in Table 3.2-33. The type of retaining wall adopted is an L-shaped retaining wall because the ground conditions are soft and an L-shaped retaining wall is lightweight. Retaining wall RW1 is less than 3.0 m high, and the ground conditions at the site are better than the left side bank. Thus both L-shaped and gravity-type retaining walls were selected.

Table 3.2-33 Structure of Retaining Walls

L-Shaped Retaining Wall	Station	Location	Length (m)	Height (m)	Piling Length (m)	No. of Houses left unaffected
RW1	0+017.338(W1) – 0+283(Main)	Right	29.0	2.467 – 2.6	-	1
RW2	0+710 – 0+770	Left	60.0	4.730 – 5.5	13.0	2
RW3	5+270 – 5+313.5	Left	43.5	4.6 – 4.315	13.0	2

Figure 3.2-22 shows the L-shaped retaining wall structure with pile foundation.

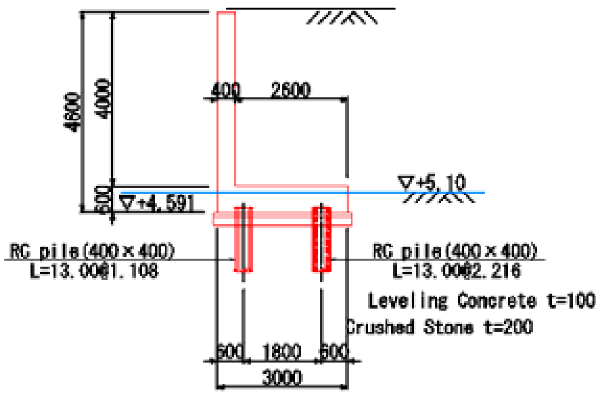


Figure 3.2-22 L-shaped Retaining Wall Structure with Pile Foundation

7) Soft Ground Treatment

The project site is located in the floodplain of the Mekong River, and road elevation shall accord to the HWL, and the road embankment will be high. However, the ground around the project site is soft, and there is a possibility of harmful settlement of embankment . Therefore, soft ground treatment are planned as follows.

- Extent of Soft Ground Treatment

Table 3.2-34 shows the relationship between the depth of the soft ground layer and the embankment height. From the results showing that there is comparatively large-scale consolidation settlement, measures to accelerate consolidation settlement are needed in Sections 1 and 2. On the other hand, the layer of soft ground is thinner around abutment A1 (Sta. 0+820). Also, the embankment height is lower than on the east bank side. Therefore, no special measures have been taken for the approach road on the west bank side.

Table 3.2-34 Relationship between Depth of Soft Ground Layer and Embankment Height

Cross Section	Station	Depth of Soft Ground Layer ((m)m)	Embankment Height ((m)m)
Section-1	3+057.9 (A2 Abutment)	20.9	8.60
Section-2	3+300	20.9	7.20
Section-3	3+700	20.6	5.85
Section-4	4+140	9.1	5.60
Section-5	5+120	7.5	5.98
Section-6	0+820 (A1 Abutment)	5.5	6.90

- Limitation of Embankment Height

The maximum embankment height is determined as the limitation of embankment height on soft ground. The limitation of embankment height is used as a indicator for soft ground treatment or the determination of the counterweight height.

The limitation of embankment height for the clay layer (Ac1) where cohesion is the lowest of the soft ground layers on the east bank side is 1.93 m. It is concluded that some soft ground treatment is required because the design embankment height is higher than the limitation of embankment height.

- Stability of the Untreated Embankment

The untreated embankment stability analysis is an analysis assuming instantaneous loading of the design embankment height in the absence of soft ground treatment. The results of the analysis given in Table 3.2-35 show that all of the design cross sections satisfy the limitation of safety factors. Therefore, it is concluded that embankment stability will be maintained under conditions of instantaneous loading.

Table 3.2-35 Results of Untreated Embankment Stability Analysis under Conditions of Instantaneous Loading

Cross Section	Target Safety Factor (Fsp)			Calculated Safety Factor (Fs)	
	Completion of Banking	Open to Public	Seismic	Normal	Seismic
Section- 1	1.10	1.25	1.00	1.656	1.481
Section-2				1.558	1.384
Section-4				1.972	1.688
Section-5				1.663	1.431

- Consolidation Settlement and Time

The approach to the relationship between the time and the settlement of the embankment is shown in Figure 3.2-23. The 365th day from the start of the embankment work is taken as the “completion of the embankment”. The 600th day from the start of the embankment work is taken to be the “public opening”. The settlement which will take place between the completion of the embankment to the public opening is defined as the consolidation settlement. The settlement which has taken place after two and five years from the public opening is defined as long-term settlement.

The time span from the commencement of embankment work for each design cross section is shown in Table 3.2-36.

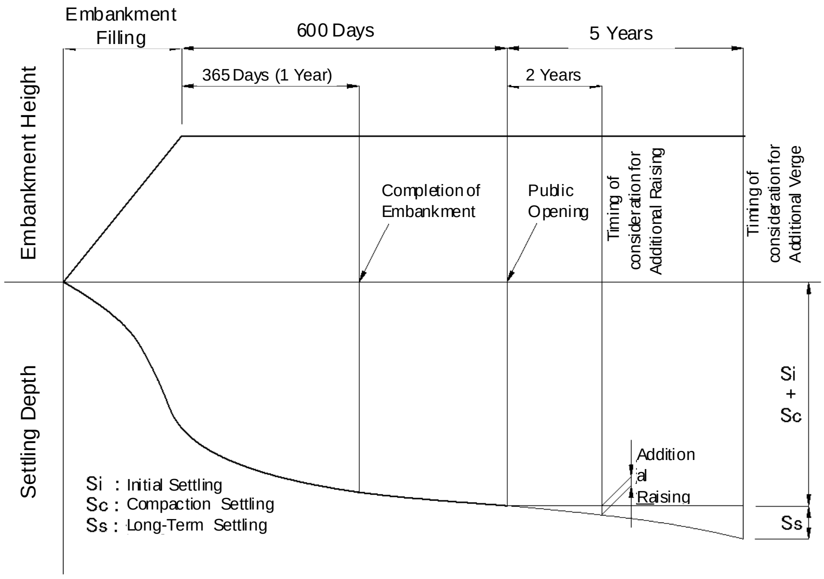


Figure 3.2-23 Concept of Relationship between Passage of Time and Embankment Settlement

Table 3.2-36 Time Span from Commencement of Embankment Work (Unit: Days)

Design Cross Section	Planned Embankment Height HE (m)	Time required for banking VE = 5 cm/day (days)	Completion of Banking	After Banking		After Opening	
			Time to Implementation of Settlement Measures	365 days (completion of embankment)	600 days (open to public)	2 years	5 years
Section-1	8.595	172 → 200	200	565	800	1,530	2,625
Section-2	7.200	144 → 160	160	525	760	1,490	2,585
Section-3	5.850	117 → 140	140	505	740	1,470	2,565
Section-4	5.600	112 → 130	130	495	730	1,460	2,555
Section-5	5.980	120 → 140	140	505	740	1,470	2,565

A distribution load of 10 kN/m^2 at the top of the embankment is calculated from the traffic load after the public opening,.

- Results of Settlement Analysis and Area to be Subjected to Accelerated Compaction Work

Total depth of settlement at the center of the embankment without soft ground treatment is shown for each design cross section in Table 3.2-37. The settlements are in the range of about 22 – 37 cm for each design cross section.

According to the construction plan, the embankment behind abutment A2 will be used as the construction yard for girders. It is desirable to accelerate compaction as fast as possible before the yard open to use. Therefore, the accelerated compaction method is applied when a residual settlement depth of less than 10 cm at the completion of the embankment.

With the above examinations, the height of the embankment and structures, the accelerated compaction method shall be carried out from abutment A2 to Sta. 3+700, because the residual settlement in this section is 10 cm or more.

Table 3.2-37 Total Settlement Depth at Center of Embankment

Design Cross Section	Depth of Settlement			Completion of Banking	Completion of Embankment	Open to Public	After Public Opening		Total Settlement
	Type of Settlement		Unit	Day 0 (Standard Time)	Day 365	Day 600	2 Years	5 Years	S' (U=100%)
Sta.3+057.9	Initial Settlement	: Si	cm	2.8	2.8	2.8	2.8	2.8	2.8
	Compaction Settlement	: Sc	cm	30.7	32.9	32.9	32.9	32.9	34.5
	Long-Term Settlement	: Ss	cm				0.6	1.6	
	Total Settlement	: S	cm	33.5	35.7	35.7	36.3	37.3	37.3
	Degree of Compaction	: U	cm	89.0	95.5	95.5	97.3	100.0	100.0
Sta. 3+300	Initial Settlement	: Si	cm	2.8	2.8	2.8	2.8	2.8	2.8
	Compaction Settlement	: Sc	cm	21.9	32.6	32.9	32.9	32.9	34.5
	Long-Term Settlement	: Ss	cm				0.6	1.6	
	Total Settlement	: S	cm	24.7	35.4	35.7	36.3	37.3	37.3
	Degree of Compaction	: U	cm	63.6	94.5	95.4	97.2	100.0	100.0
Sta.3+700	Initial Settlement	: Si	cm	2.8	2.8	2.8	2.8	2.8	2.8
	Compaction Settlement	: Sc	cm	15.3	25.4	25.7	25.7	25.7	27.3
	Long-Term Settlement	: Ss	cm				0.6	1.6	
	Total Settlement	: S	cm	18.1	28.2	28.5	29.1	30.1	30.1
	Degree of Compaction	: U	cm	56.1	93.4	94.1	96.4	100.0	100.0
Sta. 4+140	Initial Settlement	: Si	cm	2.8	2.8	2.8	2.8	2.8	2.8
	Compaction Settlement	: Sc	cm	9.6	23.5	25.1	25.1	25.1	27.3
	Long-Term Settlement	: Ss	cm				0.8	2.2	
	Total Settlement	: S	cm	12.4	26.3	27.9	28.7	30.1	30.1
	Degree of Compaction	: U	cm	35.4	86.0	92.0	94.8	100.0	100.0
Sta. 5+120	Initial Settlement	: Si	cm	2.8	2.8	2.8	2.8	2.8	2.8
	Compaction Settlement	: Sc	cm	9.6	23.5	25.1	25.1	25.1	27.3
	Long-Term Settlement	: Ss	cm				0.8	2.2	
	Total Settlement	: S	cm	12.4	26.3	27.9	28.7	30.1	30.1
	Degree of Compaction	: U	cm	35.4	86.0	92.0	94.8	100.0	100.0

- Selection of Accelerated Compaction Method and Interval of Drains

The vertical drain method is adopted as the accelerated compaction method because it is a commonly-used and an economical method. The cardboard drain (plastic board drain) method is selected, taking into consideration the construction costs and the ease of procurement of materials.

A range of 0.6 to 1.5 m is a usual interval for an installment of the cardboard drains. The interval of the drain is set at 1.0 to 2.0 m, and a case study of vertical drain intervals is shown in Table 3.2-38, taking care to avoid remarkable differential settlement between the treated and untreated sections.

Table 3.2-38 Case Study of Vertical Drain Intervals

Design Cross Section	Purpose	Vertical Drain Placement Interval		Remarks
		Case-1	Case-2	
STA.3+057.9	To ensure the construction schedule at the back side of the abutment	1.0×1.0m, Square	1.5×1.5m, Square	
STA.3+300	Embankment tapering section	1.5×1.5m, Square	2.0×2.0m, Square	

The results of the consolidation settlement analysis show that the residual settlement is less than 10 cm in all cases and they are shown in Table 3.2-39. With respect to the difference in the degree of compaction, there was a large degree of settlement at the completion of banking in Case-1, in which the interval of drains is short. However, the degree of compaction at the completion of the embankment is almost the same in each case.

Table 3.2-39 Summary of Consolidation settlement by Vertical Drain Method

Design Cross Section		Depth of Settling			Completion of Banking	Completion of Embankment	Open to Public	After Public Opening		Total Settling
		Type of Settling		Unit	Day 0 (Standard Time)	Day 365	Day 600	2 Years	5 Years	S' (U=100%)
Sta.3+057.9	Case-1 (@=1.0x1.0m)	Initial Settling	: Si	cm	2.8	2.8	2.8	2.8	2.8	2.8
		Compaction Settling	: Sc	cm	30.7	32.9	32.9	32.9	32.9	34.5
		Long-Term Settling	: Ss	cm				0.6	1.6	
		Total Settling	: S	cm	33.5	35.7	35.7	36.3	37.3	37.3
		Degree of Compaction	: U	cm	89.0	95.5	95.5	97.3	100.0	100.0
	Case-2 (@=1.5x1.5m)	Initial Settling	: Si	cm	2.8	2.8	2.8	2.8	2.8	2.8
		Compaction Settling	: Sc	cm	21.9	32.6	32.9	32.9	32.9	34.5
		Long-Term Settling	: Ss	cm				0.6	1.6	
		Total Settling	: S	cm	24.7	35.4	35.7	36.3	37.3	37.3
		Degree of Compaction	: U	cm	63.6	94.5	95.4	97.2	100.0	100.0
Sta.3+300	Case-1 (@=1.5x1.5m)	Initial Settling	: Si	cm	2.8	2.8	2.8	2.8	2.8	2.8
		Compaction Settling	: Sc	cm	15.3	25.4	25.7	25.7	25.7	27.3
		Long-Term Settling	: Ss	cm				0.6	1.6	
		Total Settling	: S	cm	18.1	28.2	28.5	29.1	30.1	30.1
		Degree of Compaction	: U	cm	56.1	93.4	94.1	96.4	100.0	100.0
	Case-2 (@=2.0x2.0m)	Initial Settling	: Si	cm	2.8	2.8	2.8	2.8	2.8	2.8
		Compaction Settling	: Sc	cm	9.6	23.5	25.1	25.1	25.1	27.3
		Long-Term Settling	: Ss	cm				0.8	2.2	
		Total Settling	: S	cm	12.4	26.3	27.9	28.7	30.1	30.1
		Degree of Compaction	: U	cm	35.4	86.0	92.0	94.8	100.0	100.0

On the basis of the above results, the intervals of the cardboard drains were selected as shown in Table 3.2-40.

Table 3.2-40 Intervals for Cardboard Drains

Section	Purpose	Vertical Drain Placement Interval	Remarks
STA.3+040 ～ STA.3+120	To ensure the construction schedule at the back side of the abutment	1.5×1.5m, Square	
STA.3+120 ～ STA.3+700	Embankment tapering section	2.0×2.0m, Square	

- Lateral Movement of Abutment A2

In the design of structural foundations subject to uneven earth pressure such as abutments on soft ground, a lateral movement shall be examined. When there is a high possibility of the lateral movement, countermeasures such as a pre-loading and/or other ground improvement methods are required. The Abutment A2, which is constructed on a thick soft ground layer, will be examined.

According to the specifications for highway bridges in Japan, the possibility of the lateral movement is examined by the lateral movement coefficient "I-value". When the I-value is more than 1.2, countermeasures are required. The I-value of the abutment A2 without countermeasures is calculated to be 7.84, which is higher than 1.2. Therefore, the abutment A2 requires measures to prevent the lateral movement.

- Measures against the Lateral Movement of the Abutment A2

Taking an overall construction schedule into consideration, the construction of the abutment A2 may be considered critical. To examine the measure exactly, it is important to establish countermeasures. With safety side, the ground shall be strengthened by achieving 100% consolidation settlement by the completion of the embankment.

A combination of the pre-loading method and the vertical drain method is used for the embankment section. The interval for vertical drains is 1.0 m. With regard to the shape of the embankment for the pre-loading method, the cross section conforms to the standard cross section, and the profile is as shown in Figure 3.2-24.

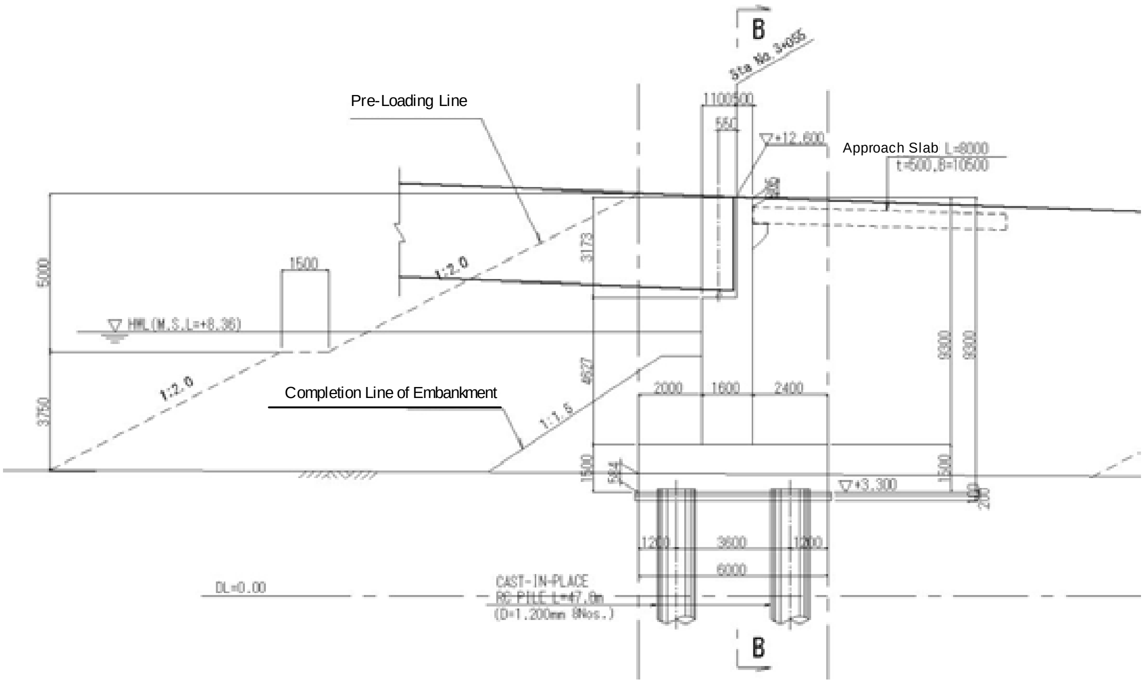


Figure 3.2-24 Profile of Pre-Load Method Used at A2 Abutment

Based on the analysis and past experience, idle time for pre-loading shall be 6 months after the completion of the embankment. The start times for the embankment as the pre-loading and the abutment work are shown in Table 3.2-41.

Table 3.2-41 Construction Schedule for Vertical Drain and Pre-Load Methods

Items	Work Items	Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Remarks
											Rainy Season												
Pre-load	Sand Mat																						
	Cardboard Drain																						
	Embankment Filling																						5 cm/day
	Slope Works																						
	Idle Time																						6 months
	Removal of Embankment																						
A2 Abutment	Foundation																						
	Substructure																						

The results of the consolidation settlement analysis applied to the pre-load and the vertical drain methods at the abutment A2 are shown in Table 3.2-42. The degree of compaction using both methods is expected to reach approximately 93% by the completion of embankment , and 100% after the pre-loading with 6 month's idle time.

Table 3.2-42 Summary of Consolidation settlement by Pre-Load and Vertical Drain Methods

Design Cross Section		Depth of Settling			Completion of Banking	Completion of Embankment	Total Settling
		Type of Settling		Unit	Day 0 (Standard Time)	Day 365	S' (U=100%)
A2 Abutment	Front side of A2 Footing	Initial Settling	: Si	cm	2.8	2.8	2.8
		Compaction Settling	: Sc	cm	29.6	31.7	31.7
		Total Settling	: S	cm	32.4	34.5	34.5
		Degree of Compaction	: U	cm	93.5	100.0	100.0
	Back side of A2 Footing	Initial Settling	: Si	cm	2.8	2.8	2.8
		Compaction Settling	: Sc	cm	33.3	35.6	35.6
		Total Settling	: S	cm	36.1	38.4	38.4
		Degree of Compaction	: U	cm	93.4	100.0	100.0

When the above-mentioned countermeasures are taken, the I-value becomes 0.72 which is less than 1.2.

- Summary of Soft Ground Treatment

The tardy banking method will be adopted along the whole approach road. The banking speed will be 5 cm/day, taking into consideration the soft ground layer mainly consists of a cohesive soil and the embankment area is vast. In addition, as a supplementary method 50 cm sand mats and geotextiles will also be installed.

In addition to the above methods, the cardboard drains will be installed (2.0 x 2.0m square) from Sta. 3+120 to Sta. 3+700.

In addition to the above methods to be adopted throughout the site, in the section from around Sta. 3+040 located at the front of footing A2 to Sta. 3+120 the pre-loading method will be used in combination with the vertical drain method (1.0 m x 1.0 m, square).

The settlement will not stop completely even when the above measures are carried out. However, it is concluded that the residual settlement of the soft ground layer can be adequately dealt with through maintenance and a management of the embankment .

8) Irrigation Channels and Road Surface Drainage

Road surface drainage facilities are planned for the following sections due to site conditions.

- Earth Ditch

The embankment crosses an existing irrigation channel at Sta. 4+692, and it would be necessary to install a culvert, a small opening would increase the possibility of a scouring of the embankment. Therefore, an earth ditch running parallel to the road embankment are installed to the flood discharge opening at Sta. 4+861 in order to secure the irrigation water. As a result, the total length of the earth ditch will be 360.2 m. Figure 3.2-25 shows the cross section of the earth ditch.

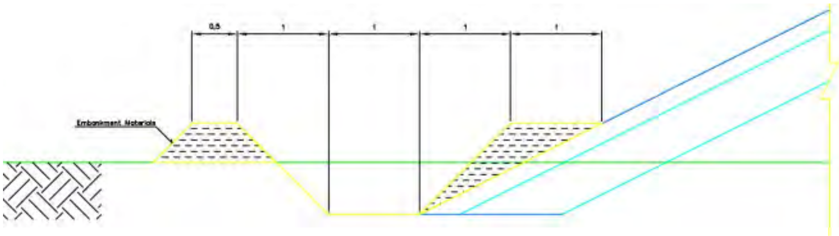


Figure 3.2-25 Cross Section of Earth Ditch

- Variable Depth V-Shaped Ditch

Around the end point of the approach road, the existing road elevation is lower than the elevation of the residential embankments along the road, and the existing road gradient is almost flat. This means that rainfall on the residential embankments flows onto the road surface, and tends to remain there. Therefore, drainage facilities will be installed along the roadside in this section.

The section is about 40 m long (from Sta. 5+360 to Sta. 5+400). A V-shaped ditch as shown in Figure 3.2-26 is adopted as side ditch. Taking into consideration an access of vehicles onto the road, the V-shaped ditch will be constructed by a reinforced concrete. Moreover, a variable-depth type ditch is selected in order to maintain a discharge gradient of 0.1% or more. As a result, the length of the variable depth V-shaped ditches will be 49m and of the vertical drains, 18m; and there will be 2 terminal drainage facilities.

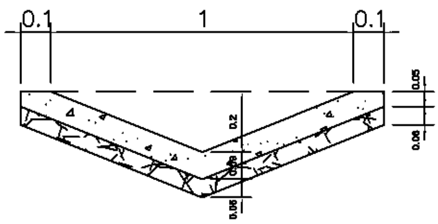


Figure 3.2-26 Variable Depth V-Shaped Ditch

9) Intersections

Traffic safety and the minimization of the impact on the houses affected by the Project are examined for the planning of the intersection, and a design speed of 60 km/h has been adopted for the Kampong Phnom Intersection and the Neak Loeung Intersection, and 80 km/h for the Construction Yard Intersection. The existing National Road No. 1 will be used as an additional lane at the Kampong Phnom Intersection and the Neak Loeung Intersection. When a minor road merges with a main road, traffic on the minor road must be regulated. When a major road merges with a minor road, an additional lane for turning right or left is provided to avoid rear-end collisions. Figure 3.2-27 to Figure 3.2-29 show the alignment of each intersection.

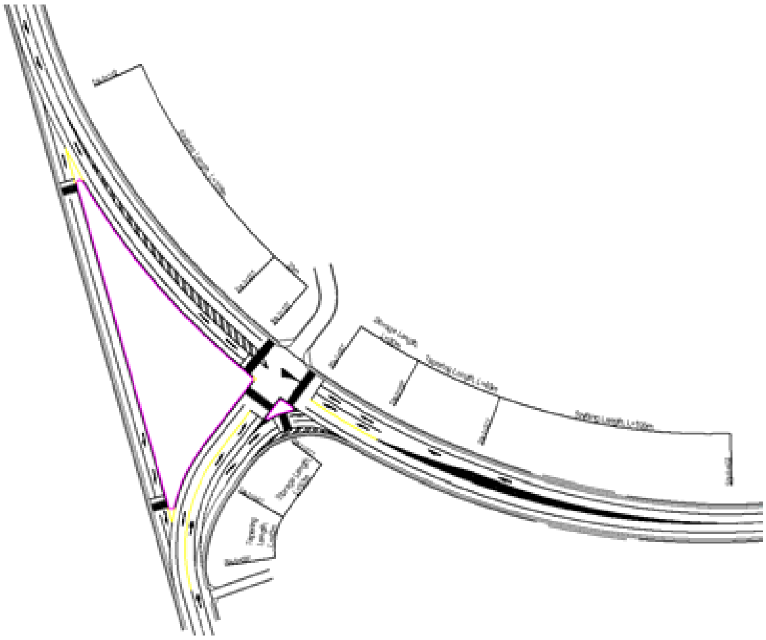


Figure 3.2-27 Kampong Phnom Intersection

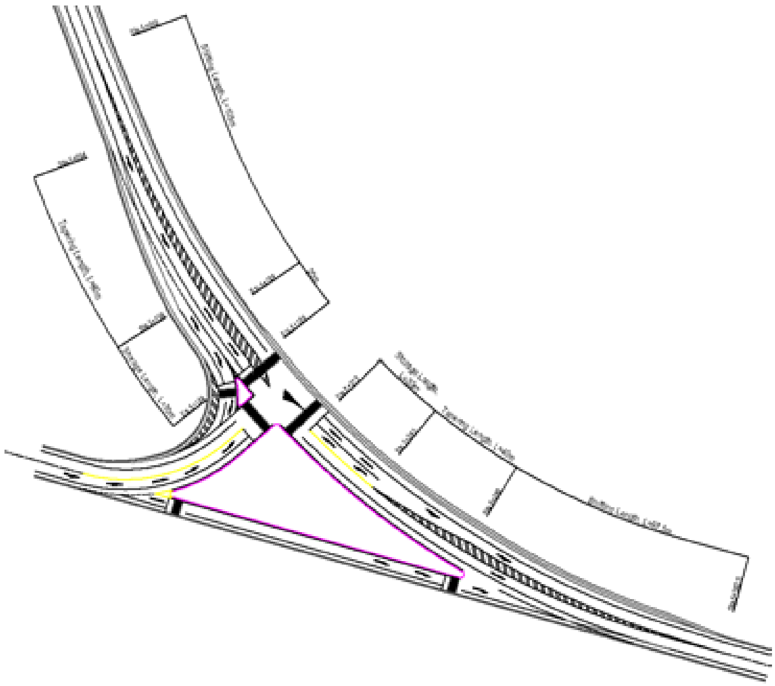


Figure 3.2-28 Neak Loueng Intersection

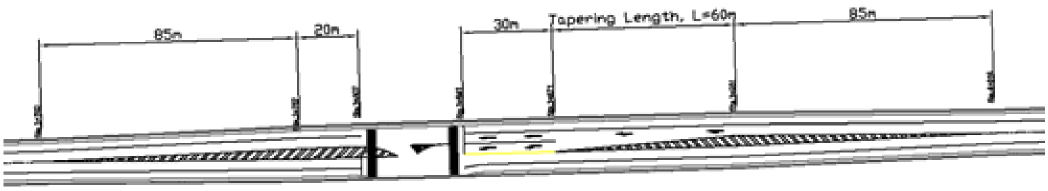


Figure 3.2-29 Construction Yard Intersection

10) Ancillary Facilities

- Street Lighting at Intersections

Street lights will be installed as a traffic safety measure at the two major intersections at Kampong Phnom and Neak Loeung. The average road surface luminance will be 0.5 cd/m^2. Street lights will not be installed for normal section except the intersections above, in accordance with the existing NR1.

- Guardrails and Guard Posts

Guardrails will be installed as a traffic safety measure at approach areas of the bridge, the culvert and the retaining wall, the outside of the curved sections with a radius of less than 500 m, and on sections of the embankment with a height of 5 m or more. In addition, guard posts will be erected on sections of the embankment with a height of 5 m or more other than the sections mentioned above.

- Road Markings and Road Studs

As a traffic management measure, road markings such as a center line, lane lines, crosswalks, arrows, etc. will be marked in, and cat's-eye road studs will be installed every 24 m in general along the center line. The cat's-eye road studs will be installed every 5 m along the center line and along both lane lines, at an intersections and a curved sections with a radius of less than 280 m.

- Traffic Signs and Kilometer Posts

As a traffic management measure, the regulatory boards and warning traffic signs will be installed, and kilometer posts will be set up every 1 km on one side of the embankment.

- Rumble Strips

As a traffic management measure, rumble strips will be laid in the approach sections of the two major intersections; two sets on the main road, and one set on the minor road.

(2) Main Bridge

The approach to the selection of the main components of the bridge and their basic dimensions as a result of the outline design are discussed in this section.

1) Stay Cable Layout

The arrangement of stay cables in the transverse direction can be a single-plane or a double-plane. Since this bridge has no median strip, an additional space for cable anchorages must be secured if the single-plane cables are to be used. When the road is divided by a median strip, sufficient width is necessary for a large vehicle to pass by a car in trouble parked on the roadside. This requires a wider road, resulting in increased construction costs. Therefore, the double-plane arrangement was adopted for the cable layout for this Project.

As this two-lane bridge is comparatively narrow, when the cables are sloped in the horizontal direction, the triangular space created by the cables imparts a feeling of oppression to the drivers and pedestrians. To reduce the feeling of oppression, a parallel double-plane layout was adopted.

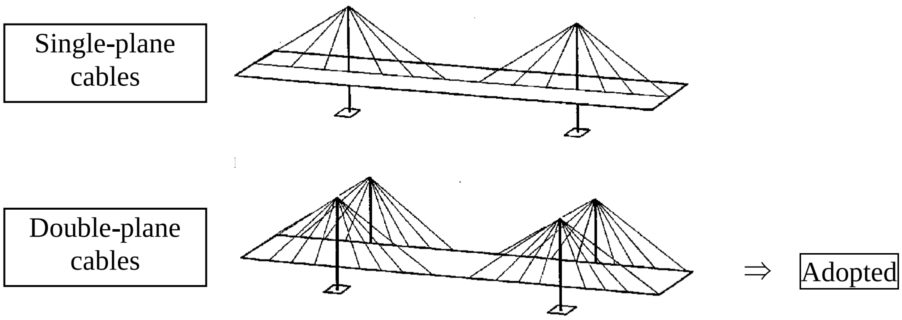


Figure 3.2-30   Horizontal suspension type

Cable layouts in the longitudinal direction can be a radial type, a fan type, or a harp type. Although the radial type is the most efficient structurally, the anchoring system on the tower side is complicated. The harp type is aesthetically superior since the cables on both sides do not cross over even when viewed from the side; however, the cable weight tends to increase. A complicated anchoring structure and increased weight are less economical. The fan type is half-way between both types and is the most popular type. The fan type is adopted is adopted for this Project because of the structural effectiveness, and the simple anchoring system.

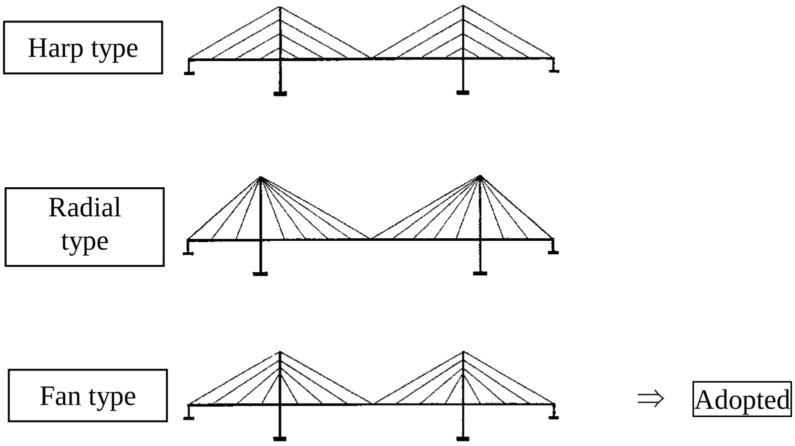


Figure 3.2-31 Cable layout in the bridge axis direction

2) **Girder Type**

A box girder or an edge girder can be examined as the girder of the PC cable-stayed bridge. As a result of a comparative examination, the edge girder was adopted for the main bridge due to its excellent construction features and the weight-saving.

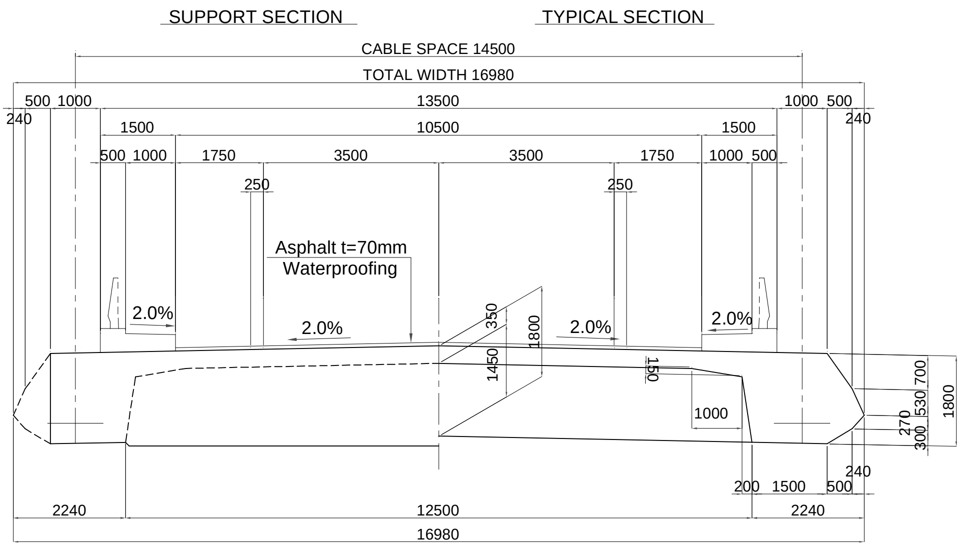


Figure 3.2-32 Profile of the main girder (main bridge)

3) **Type of Stay Cables**

The type of stay cables is an on-site construction, non-ground type, for its ease of transport and installation and high reliability.

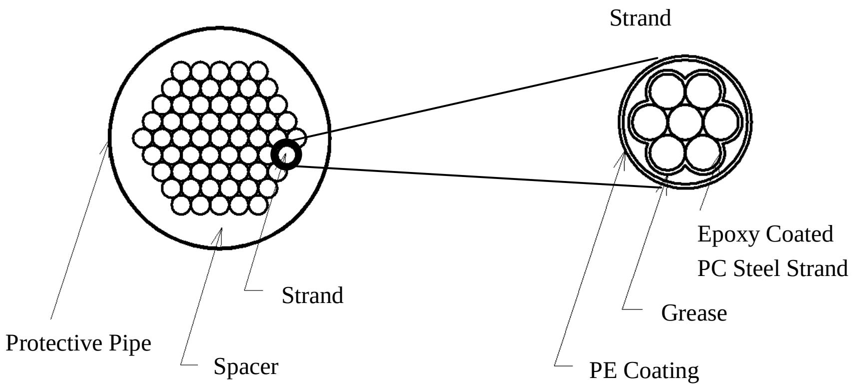


Figure 3.2-33 On-site construction, non-ground type

4) Tower Type

The tower is an H shape as the cable layout uses a parallel double-plane arrangement. As the main tower is the most prominent part of the bridge, the scenic profile is examined to improving the aesthetic aspect.

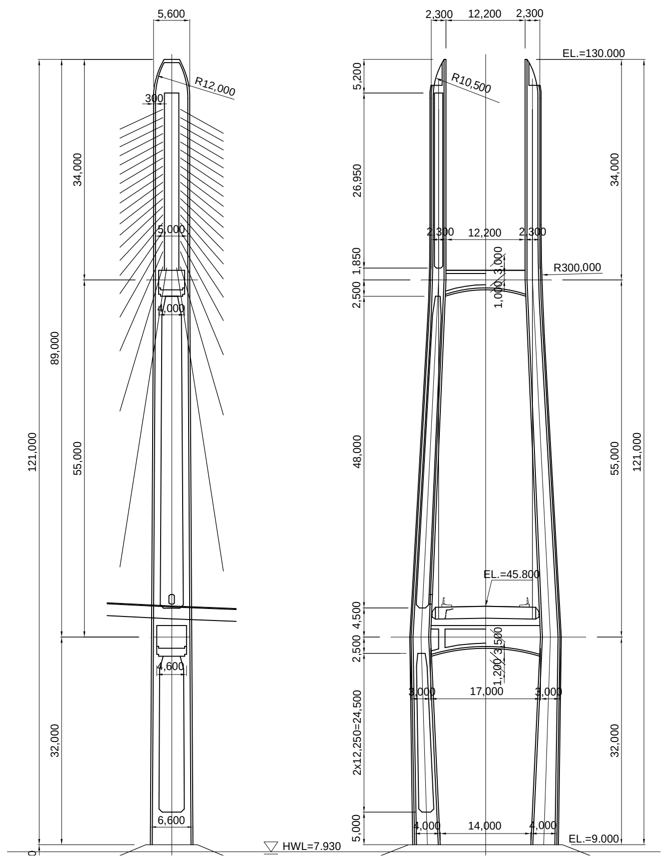


Figure 3.2-34 Side and Front Views of the Tower

5) Bearing System

Possible bearing system at the towers and at the end piers are elastic bearing, fixed bearing and movable bearing. A possible bearing system was studied and bearing conditions were selected that will provide balance in the cross-sectional force generated at the base of the tower and end piers.

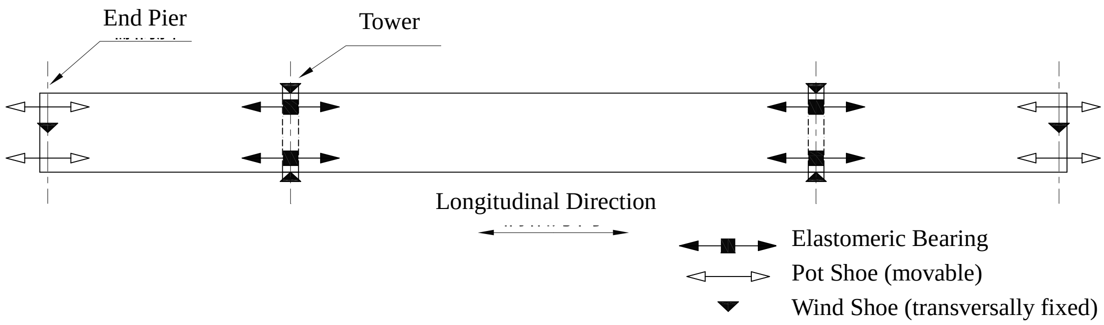


Figure 3.2-35 Bearing conditions

6) Foundation

A cast-in-place pile foundation of diameter 2.5m was selected for the foundation of the tower and end piers. The pile cap transfer a reaction from superstructure to the pile through the tower or the end pier, and it shall be sufficiently strong structurally. As a pile cap may be fully exposed at the water surface due to the water level fluctuation and a pile may be exposed when the water level is low, the shape and structure shall be studied carefully by the aesthetic point of view. A flat octagon pile cap was adopted for the tower foundation to be installed in the river so as to minimize the flat area against the water flow, and also for ease of the construction. The topside is sloped to create a sense of lightness. Skirts are provided around the pile cap to prevent exposure of the pile when the water level is low.

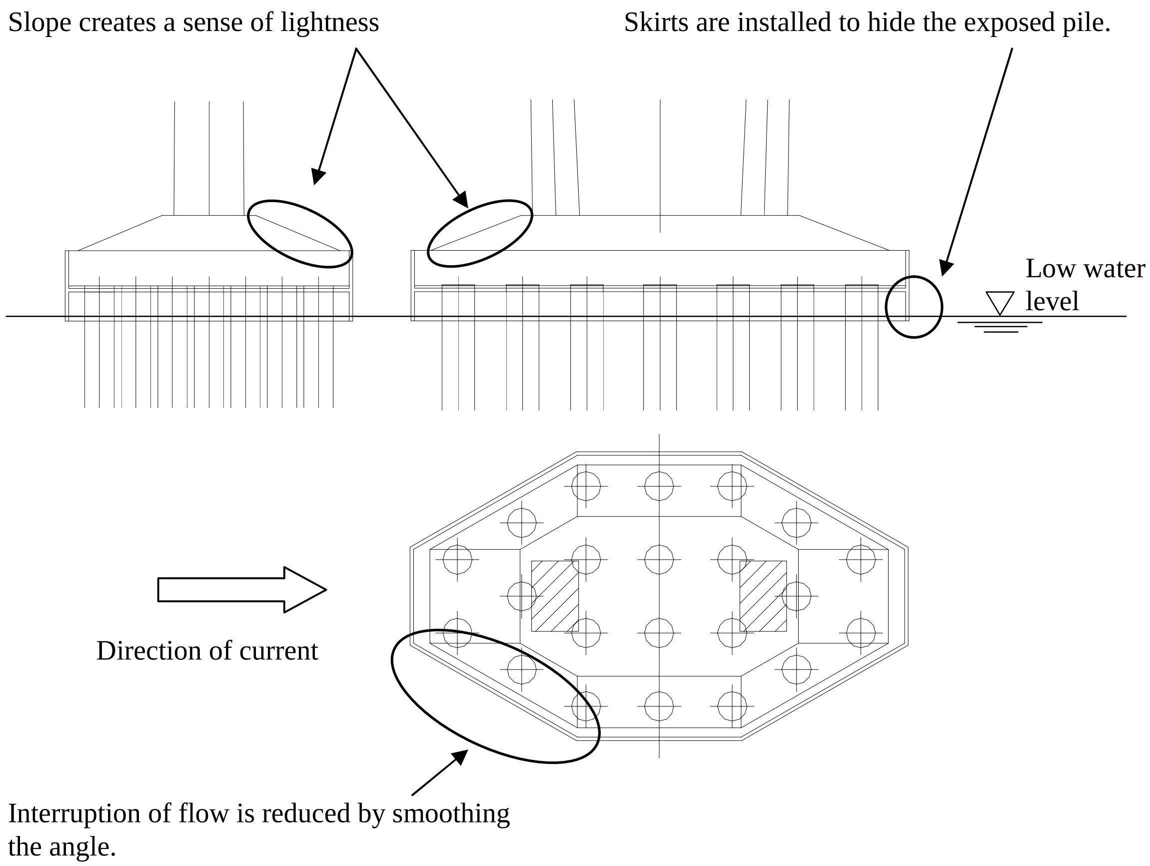
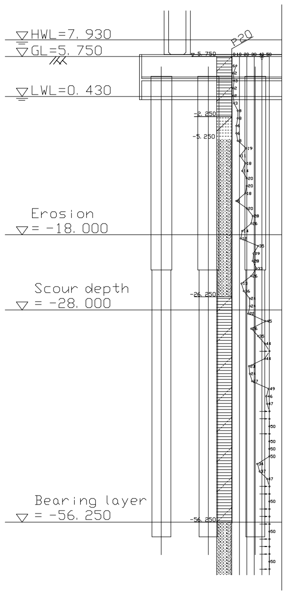
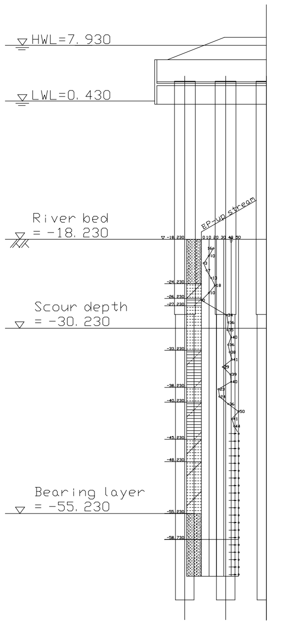
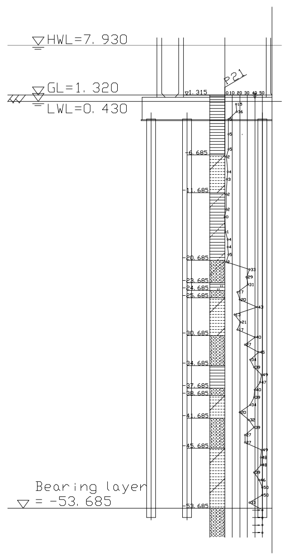


Figure 3.2-36 Shape of the pile cap

Localized scouring that occurs due to fluctuation of the riverbed and installation of the foundation must be taken into consideration in determining the ground level for the design of the tower foundation. Survey results indicate that 10m to 12m of scouring is expected.

Table 3.2-43 Natural conditions for the Foundation Design

	P20	Tower foundation	P21
H.W.L	E.L 7.93 m		
L.W.L	E.L 0.43 m		
Design current velocity	2.24 m/sec		
Design horizontal seismic coefficient	0.05		
Site ground level	E.L 5.75 m	E.L -18.23 m	E.L 1.32 m
Erosion depth	E.L -18.0 m	—	—
Localized scouring	10.0 m	12.0 m	—
Design ground level	E.L -28.00 m	E.L -30.23 m	E.L 1.32 m
Schematic diagram			

As a navigation route for the 5,000DWT class vessels runs under the central span, there is the possibility that an unloaded vessel may run onto a pile cap when the water level is high. However the energy loss caused by the slope of the pile cap it is thought that the bow of the vessel will not come into contact with the tower shaft and the vessel collision force is taken into consideration in the design of the foundation. The maximum water level at which vessel collision may be expected to occur is the 30-year return high water level. When the water level is low enough for the piles to be exposed, large vessels will not collide directly to the piles (See Figure 3.2-38.). Collision force is culculated by the following formula:

$$P_s = 220(DWT)^{1/2}\left[\frac{V}{27}\right]$$

Where:

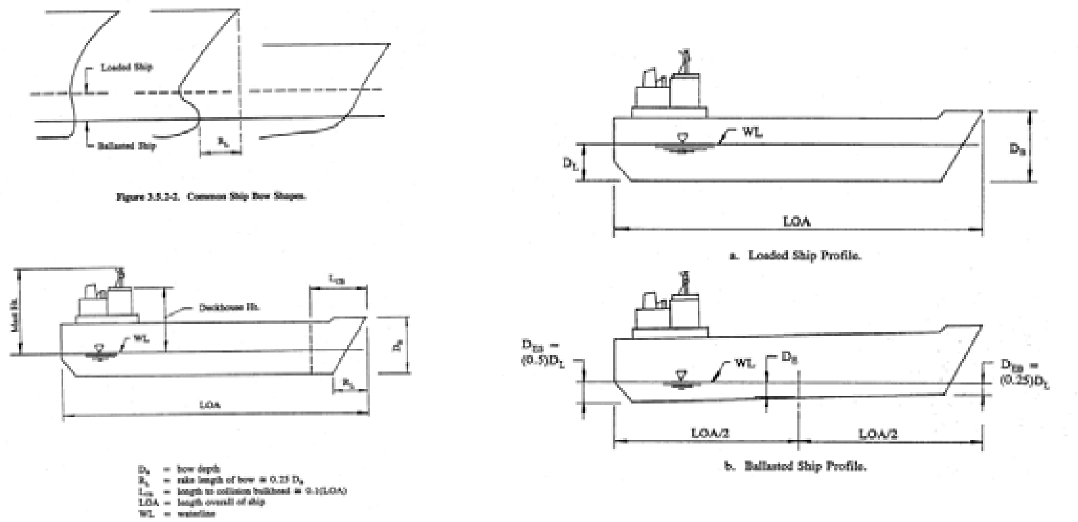
Size of the vessel: 5,000DWT

Collision speed (V): 4.4kt (=2.24m/sec)

Collision force Ps: Longitudinal direction 975ton, transverse direction 1,950ton

*Guide Specification and Commentary for Vessel Collision Design of Highway Bridges, AASHTO 1991

Dimensions					Full load	No load	
DWT	LOA(m)	D_B(m)	R_L(m)	L_{CB}(m)	D_L(m)	D_{EB}(m)	D_{BS}(m)
5,000	109.0	13.7	3.5	10.9	6.8	1.7	3.4



* Guide Specification and Commentary for Vessel Collision Design of Highway Bridges, AASHTO 1991.

Figure 3.2-37 Dimensions of vessel under consideration

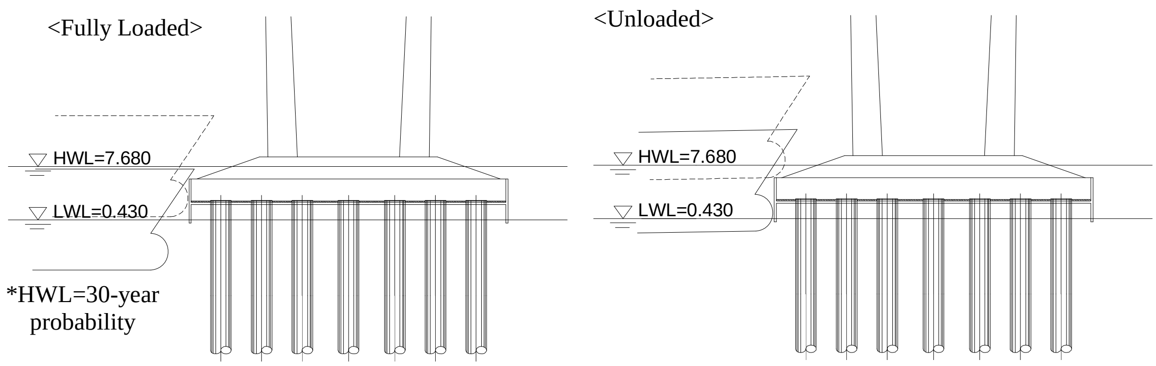


Figure 3.2-38 Case of a Vessel Collision to the Foundation

(3) Approach Bridge

1) Structure of the Main Girder and Floor Slab

A PC composite girder with a T-shape cross section is adopted for the main girder.

For the deck structure, PC panels manufactured in a factory are installed on top of the main girder, and the panels are then joined to the main girder with cast in place concrete. Figure 3.2-39 shows the cross section of the approach bridge.

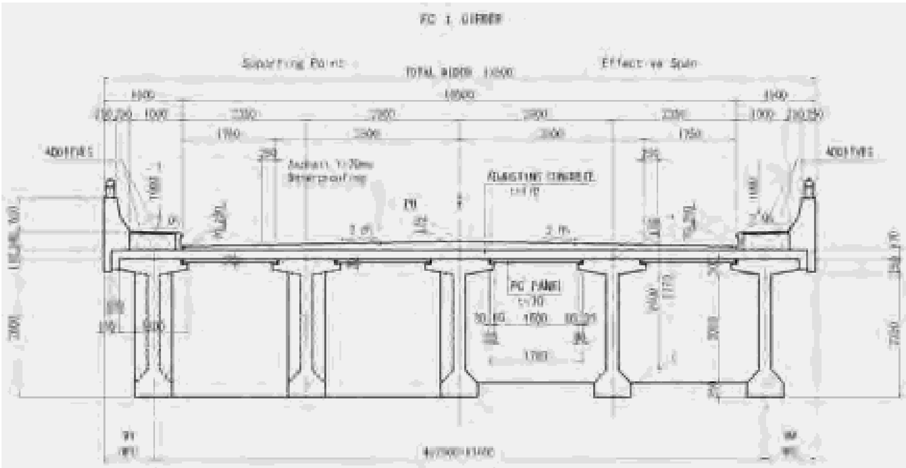
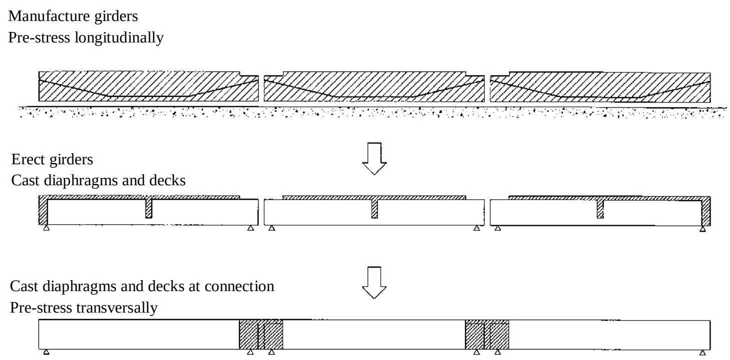


Figure 3.2-39 Cross section of the Approach Bridge

2) Connecting Sections

Adjacent girders are connected using reinforced concrete thus reducing the number of expansion joints with the aim of improving driving comfort. Figure 3.2-40 shows the procedure for construction of connecting section. The main girders are installed as simple girders, and then connected as an RC structure to resist the negative bending moment on the intermediate supports.



Source: Manual for Planning of PC Highway Bridges (Japan Prestrssed Concrete Contractors Association October 2007)

Figure 3.2-40 Construction of Connecting Section

3) Substructure and Foundation

For the A1 abutment, a rigid frame abutment is adopted since local road is diverted through the abutment. For the A2 abutment, a reverse T-type abutment is adopted as there is no local road cross under the abutment.

Cast-in-place piles 1.0m to 2.0m in diameter are adopted as a result of the comparative study of pile types and pile diameters.

Table 3.2-44 shows the construction formats of the substructures and foundation, and Figure 3.2-41 shows the profile of the typical pier.

Table 3.2-44 Profile of the Substructures and Foundations

Substructure	A1 abutment	Rigid frame abutment (H=8.3m)
	P1 to P35 piers	Disc-shaped RC piers (H=9.8m to 34.3m)
	A2 abutment	Reverse T abutment (H=9.3m)
Foundation	A1, A2 abutment	Cast-in-place pile (ϕ1.2m)
	P1 to P5, P8 to P10, P31 to P35 piers	Cast-in-place pile (ϕ1.0m)
	P6, P7, P11 to P14, P22 to P30 piers	Cast-in-place pile (ϕ1.2m)
	P15 to P19 piers	Cast-in-place pile (ϕ2.0m)

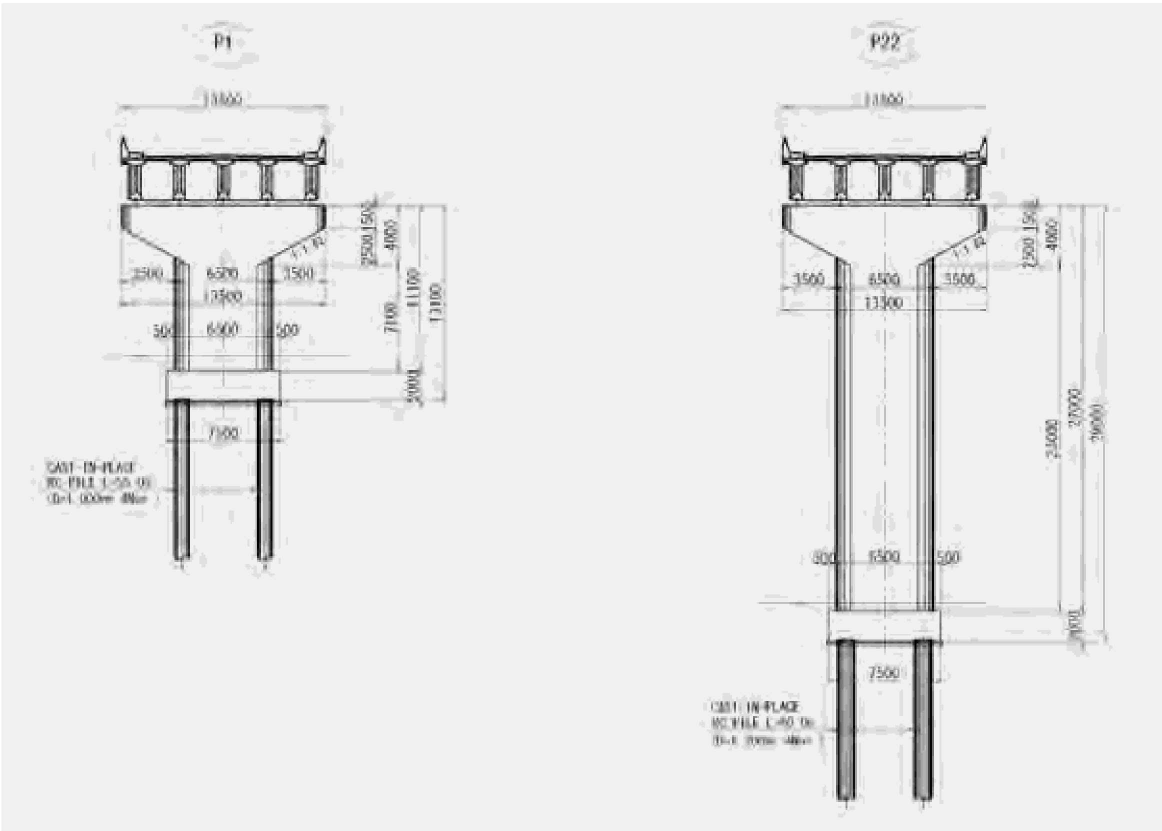


Figure 3.2-41 Substructure and Foundation of Approach Bridge

(4) Accessories

1) Guardrail

The design speed on the bridge is 80km/h and the road surface is 40m or more in height from the water surface of the river. As a fall from the bridge may cause serious damage to a vehicle and its passengers, the SB type guardrail will be adopted. Table 3.2-45 shows the types of guard rail.

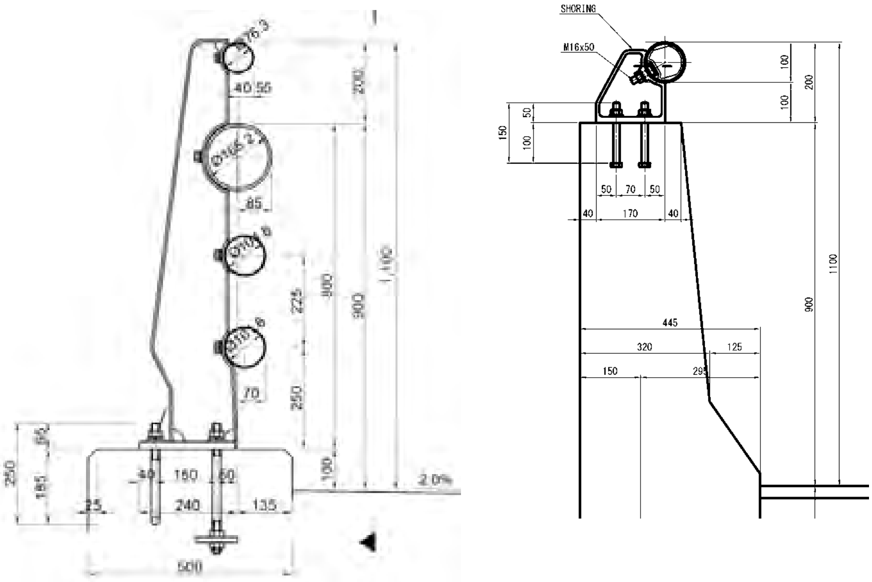
Table 3.2-45 Types of guard rail

Road category	Design speed	General section	Section where serious damage may occur	Section where Super Express Trains intersect or approach
Expressway, national road Vehicle- only road	80km/h or more	A, Am	**SB, SBm**	SS
	Under 60km/h		SC, SCm	SA
Other roads	60km/h or more	B, Bm, Bp	A, Am, Ap	SB, SBp
	Under 50km/h	C, Cm, Cp	B, Bm, Bp Note)	

Note: C, Cm, or Cp may be used on roads with the design speed of 40km/h or less.

Source: Specifications and Commentary for Installation of Guardrails (Japan Road Association, January 2008)

A beam type steel guardrail which has superior wind-resistant properties will be used for the main bridge section. An economic RC wall type guardrail will be used for the approach bridge section, and handrails will be provided to reduce the feeling of oppression of drivers and pedestrians as shown in Figure 3.2-42.

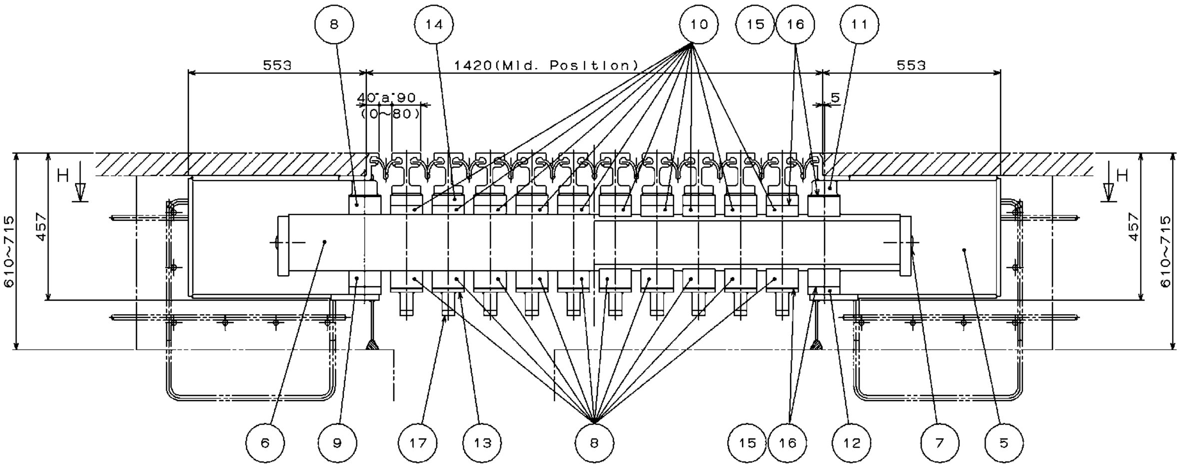


Main bridge section　　　　Approach bridge section

Figure 3.2-42 Guardrail

2) Expansion joints

A modular type expansion joint is generally used for the expansion joints of a long-span cable-stayed bridge due to its high capability of expansion and contraction and excellent durability. For the approach bridge also, a modular type expansion joint will be used in order to enhance durability. Examples of the modular type expansion joints are shown in Figure 3.2-43 and Figure 3.2-44.



Approach bridge side   Main bridge side

Figure 3.2-43 Expansion Joint between Approach Bridge and Main Bridge

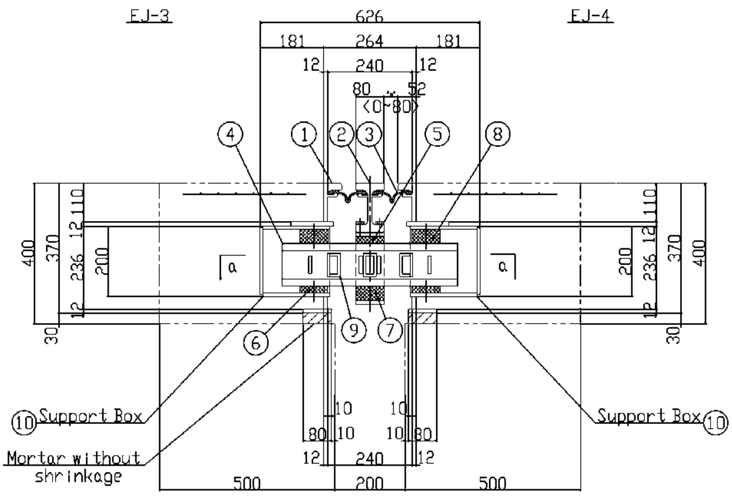


Figure 3.2-44 Expansion Joint for Approach Bridges

3) Drainage system

Assuming that direct drainage from the bridge surface does not cause any problem since the main bridge section crosses over the river, water on the bridge will be directly drained into the river. A sprinkler will be provided at the lower end of the drainage pipe in consideration of the influence to the vessels that navigate the river. (See Figure 3.2-45.)

As the approach bridge is placed on land, water will be basically drained through the pipes to the bottom of the piers. The pipes will be laid horizontally to the pier position between the girders of the approach bridge and the water will be directed to the base of the piers via vertical pipes installed inside the piers. (See Figure 3.2-46.)

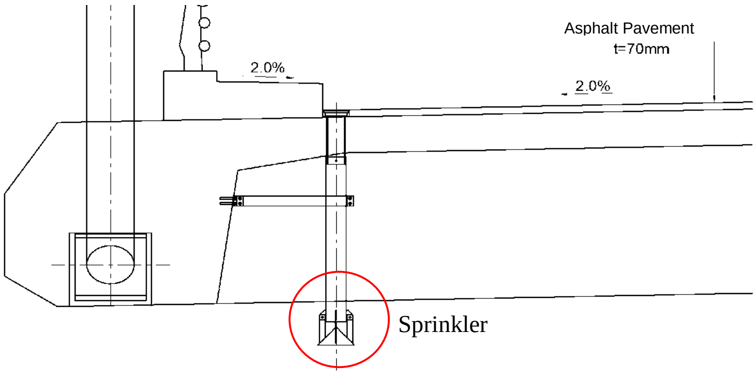


Figure 3.2-45 Main bridge drainage plan

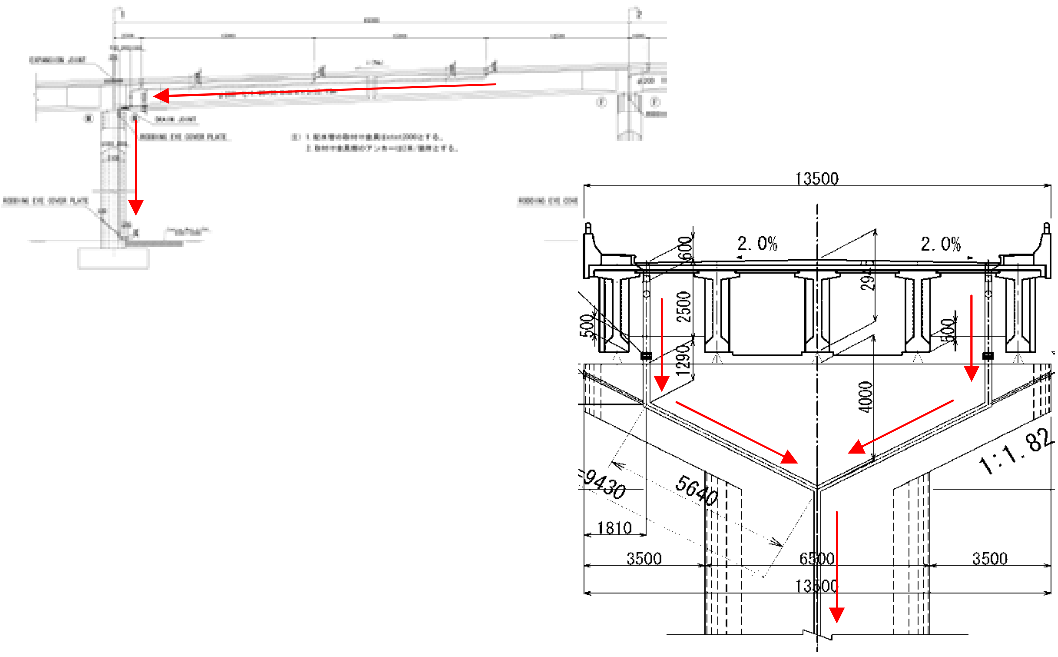


Figure 3.2-46 Approach bridge drainage plan

4) Road lighting

Pole lighting will be used within the scope of the Project. Lighting poles with 12m in height will be used and will be installed on one side of the road at 45m intervals as shown in Figure 3.2-47.

For the main bridge section, 14 poles will be installed symmetrically from the center of the main span (13x45m). For the approach bridge, poles will be installed adjacent to the pier positions, as the support interval is 45m. In the road section also, lighting poles will be installed at 45m intervals, continuing from the approach bridge. For the intersections at the starting and ending points of the project, the lighting layout will be determined separately, taking visibility into consideration.

<Arrangement of Road Lighting>

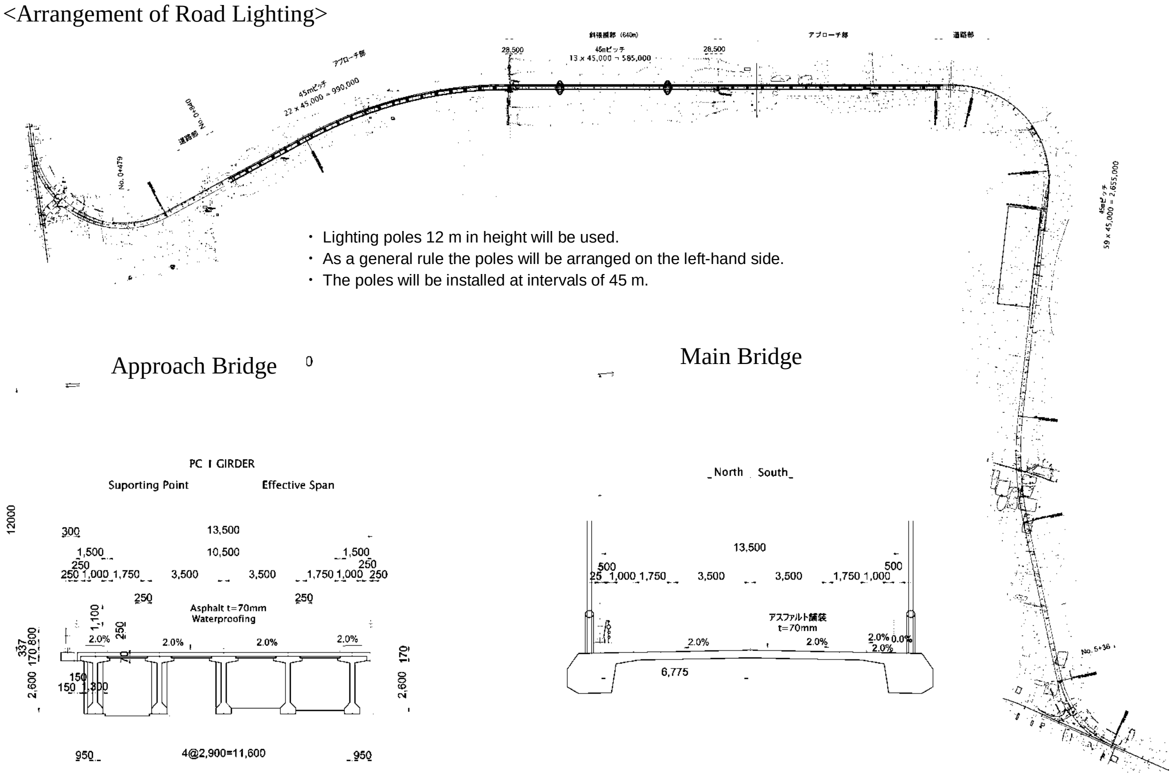


Figure 3.2-47 Road lighting plan

5) Aircraft warning lights

Medium-altitude white aircraft warning lights will be installed at the top of the towers of the main bridge, taking as reference the "Explanation and Implementation Guidelines for the Installation of Aircraft Warning Lights/Day and Night Warning Indicators".

6) Navigation light

With regard to navigation lights, a center light and side lights (on both the left and right sides) will be installed over the main channel. Pier lights will not be installed since the position of the towers can be verified by means of the decorative illumination of the towers as shown in Figure 3.2-48.

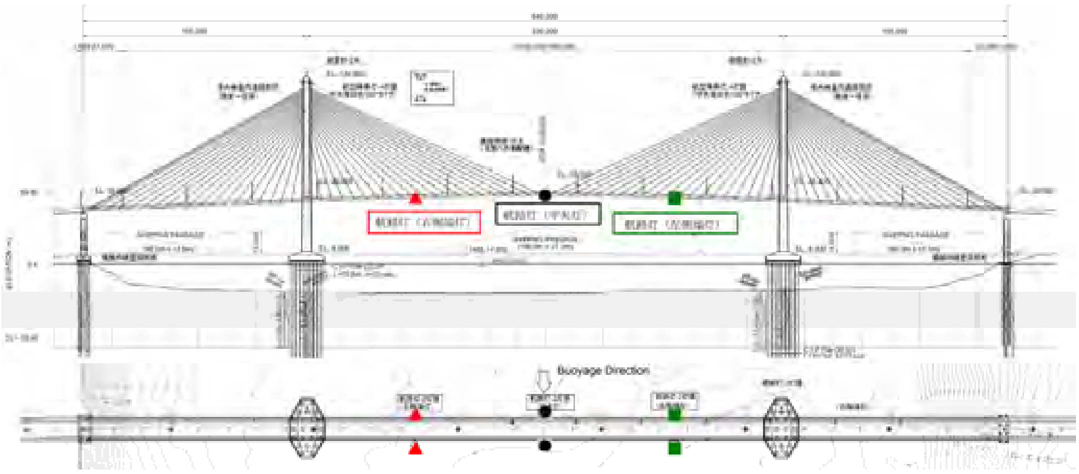


Figure 3.2-48 Navigation light installation plan

(5) Aesthetic Study

Since this bridge is a large structure crossing over the Mekong River that will become a landmark for Neak Leung, and a symbol for the country, the aesthetic aspect is an important issue. An aesthetic study is carried out in this study.

1) Main bridge

① Design of Towers

Design the slender towers to appear more slender, and gives an impression of high tower.

② Design of juncture between main bridge and approach bridge

The pier head at juncture is designed to alleviate the sense of disharmony between the cable-stayed bridge and the approach bridge with the difference of girder shape.

2) Approach bridge

As a result of a comparative study of pier shapes of approach bridge, oval-shaped pier with pier head was adopted for its balance with the tower and feeling of openness, and for its ease of construction and reasonable cost.

(6) Wind Tunnel Test

1) Overview

Vibration can easily occur in a cable-stayed bridge by the dynamic action of the wind, and wind tunnel test is carried out to verify the safety of the bridge in this study. In this wind tunnel test, a spring support model test using a partial model of "PC cable-stayed bridge" is carried out. Vortex oscillation and divergent oscillation are examined through the test to get deflection and torsion of the main girders. The implementation of the wind tunnel test was commissioned to Yokohama National University.

The results of the wind tunnel test indicate that a flutter has occurred around angle-3 at wind velocity 45m/s. The original main girder profile is improved based on the test results.

2) Elements of wind resistance design

- Basic wind speed: 30 m/s (Based on on-site observation records)
- Roughness class: Ⅱ (Power index)
- Average girder height: 45.8m
- Design standard wind speed (vortex-inducing reference wind speed):
  30 × 1.28 = 38.3 m/s
- Reference galloping wind speed: 38.3 × 1.2 = 46.0 m/s
- Reference flutter wind speed 38.3 × 1.2 × 1.15 = 52.9 m/s
- Permissible vortex-induced oscillation (Road and Bridge Wind Resistance Design Manual)
- Deflection: 0.16 m (= 0.04 / 0.248)
- Torsion: 0.8 degrees (= 2.28 / 4.25 / 0.671)

3) Wind tunnel test

a. Wind tunnel facility

The major specifications of the simulation are as follows.

- Maximum wind speed: About 35m/sec
- Minimum stable wind speed: 1/100 of the maximum wind speed (In reality, practically 0m/s)
- Contracted flow ratio: (4m × 4m) / (1.8m × 1.8m) 5
- Fan and motor : 7 stator vanes + 6 rotor vanes 110kW DC motor, FA control
  : Average wind speed deflection at the downstream end of the contracted flow tunnel (at the top end of the upstream measurement tunnel) 0.7%
  : Degree of disturbance at the downstream end of the contracted flow tunnel (at the top of the upstream measurement tunnel) 0.1%

Dimensions of the measurement section: W1.8m × H1.8 × L17.7m

: From the downstream end of the contracted flow tunnel to the test model: about 10.3m

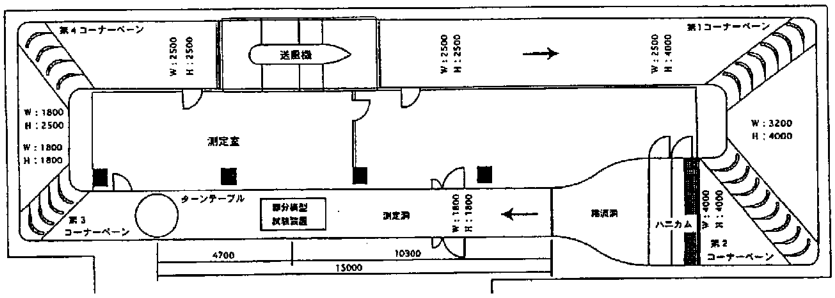
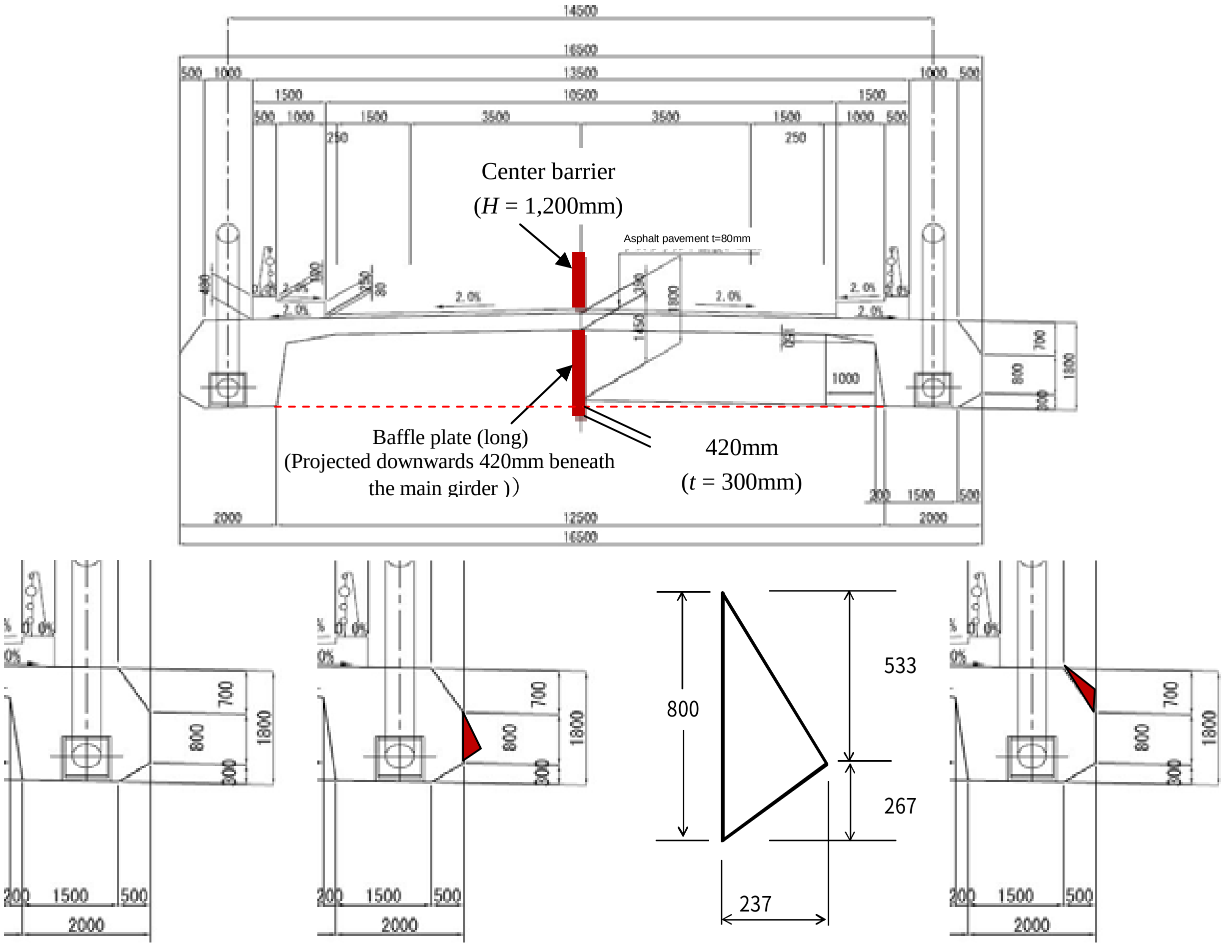


Figure 3.2-49 General diagram of the circuit wind tunnel of Yokohama National University

b. Wind tunnel test results

Table 3.2-46 Test case

	Profile	Angle	Air current
1	Basic	0 degrees	Uniform flow
2	Basic	+3 degrees	Uniform flow
3	Basic	-3 degrees	Uniform flow
4	Baffle plate (long)	0 degrees	Uniform flow
5	Baffle plate (long)	+3 degrees	Uniform flow
6	Baffle plate (long)	-3 degrees	Uniform flow
7	Fairing (triangle)	0 degrees	Uniform flow
8	Fairing (triangle)	+3 degrees	Uniform flow
9	Fairing (triangle)	-3 degrees	Uniform flow
Reference 1	Center barrier	-3 degrees	Uniform flow
Reference 2	Fairing (upper 30 degrees)	-3 degrees	Uniform flow



(1) Basic profile

(2) Fairing (triangle)

(3) Fairing (triangle) details

(4) Fairing (upper 30 degrees) (Symmetrical at the top and bottom of the main girder)

Figure 3.2-50 Profile of the model

■Test conditions: Scale of the model 1/60

The following table shows the test preconditions.

Table 3.2-47 Test conditions

		Actual bridge	Model required value	Model measured value	Deviation (tolerance)
Girder width *B* (m)		16.5	0.275	0.275	0%
Girder height *D* (m) (Main girder)		1.8	0.03	0.03	0%
Mass *m* (kg/m)		33.52×10^3	9.31	9.31	0% (<5%)
Polar moment of inertia (kgm^2/m)		$1,087.8\times10^3$	0.0839	0.0839	0% (<5%)
Natural frequency (Hz)	Deflection	0.248	-	1.90	Wind velocity scaling factor 7.83
	Torsion	0.671	-	5.23	Wind velocity scaling factor 7.70
Logarithmic damping rate	Deflection	-	0.02	0.015	+0.00 (±0.005)
	Torsion	-	0.02	0.027	+0.007 (±0.005)

■Basic profile

Although there was stability in tests conducted at 0° and +3°, at -3° there was limited torsion oscillation and deflection flutter. The wind speed - amplitude diagram (V-A diagram) is shown in Figure 3.2-51.

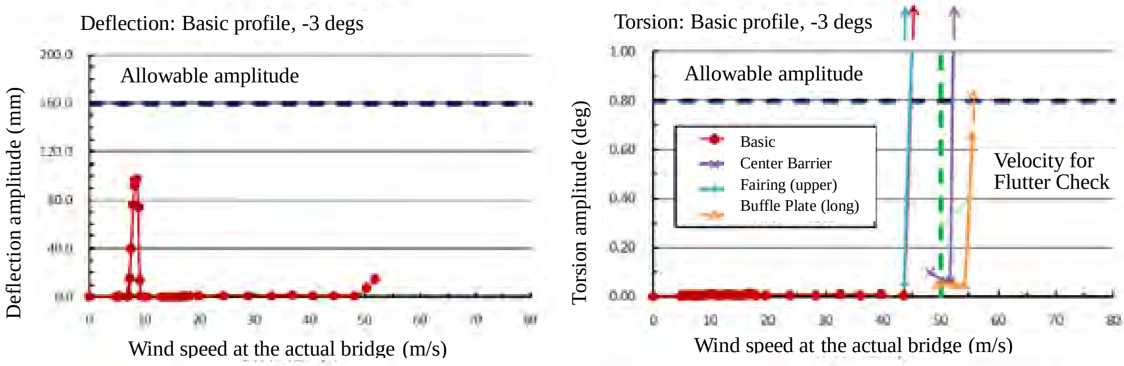


Figure 3.2-51 V-A diagram of the basic profile (-3°)

■Improved profile (Fairing <triangle>)

Although a slight limited torsion oscillation was detected under -3° in tests conducted at 0 degrees and ±3°, no flutter was detected even with a wind speed equivalent to V=80m/s at the actual bridge. Accordingly, this profile was adopted.

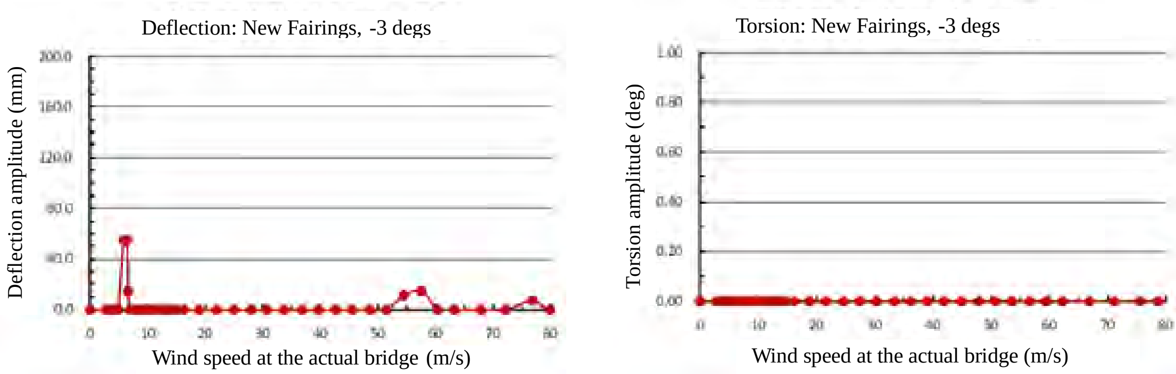
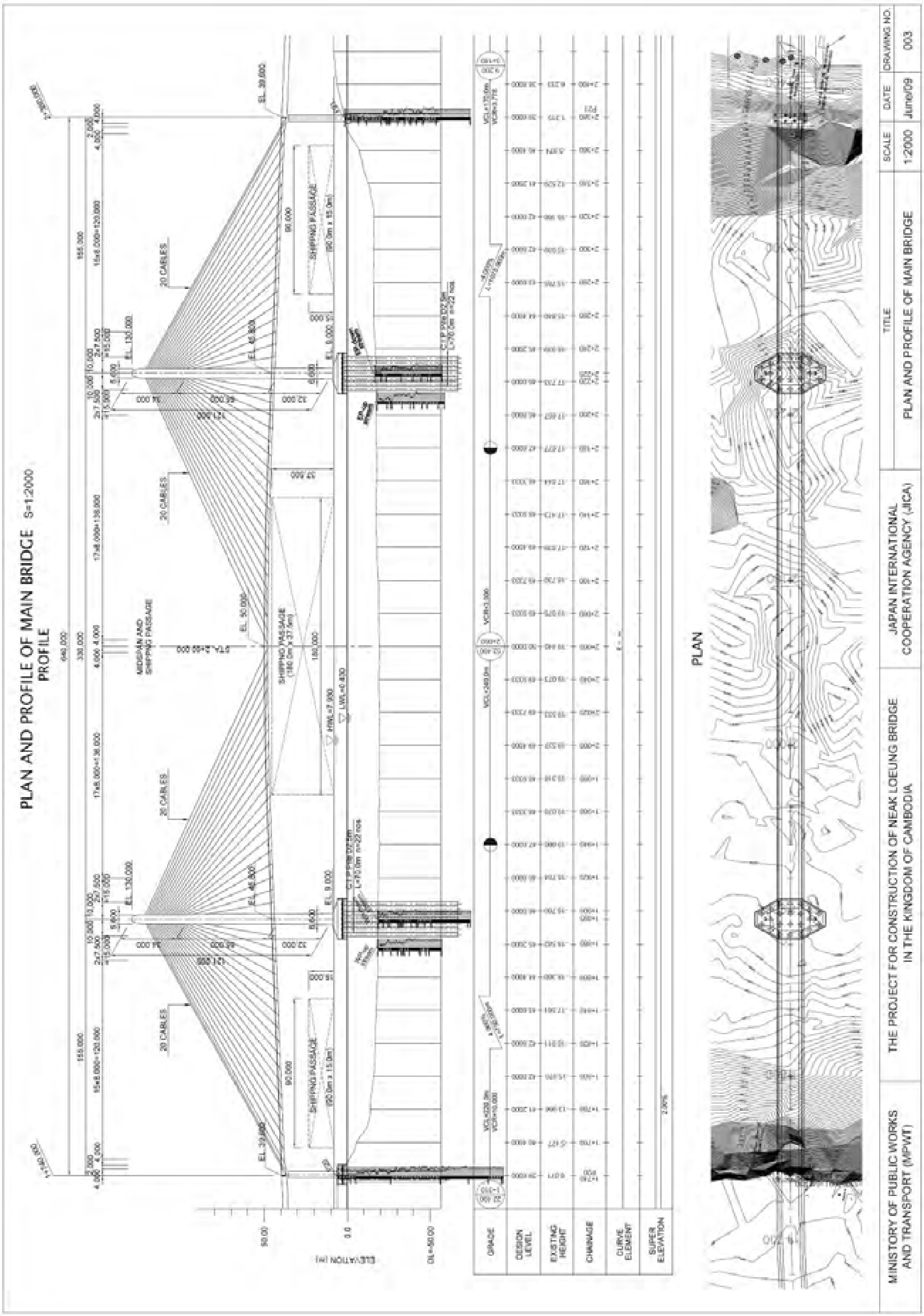
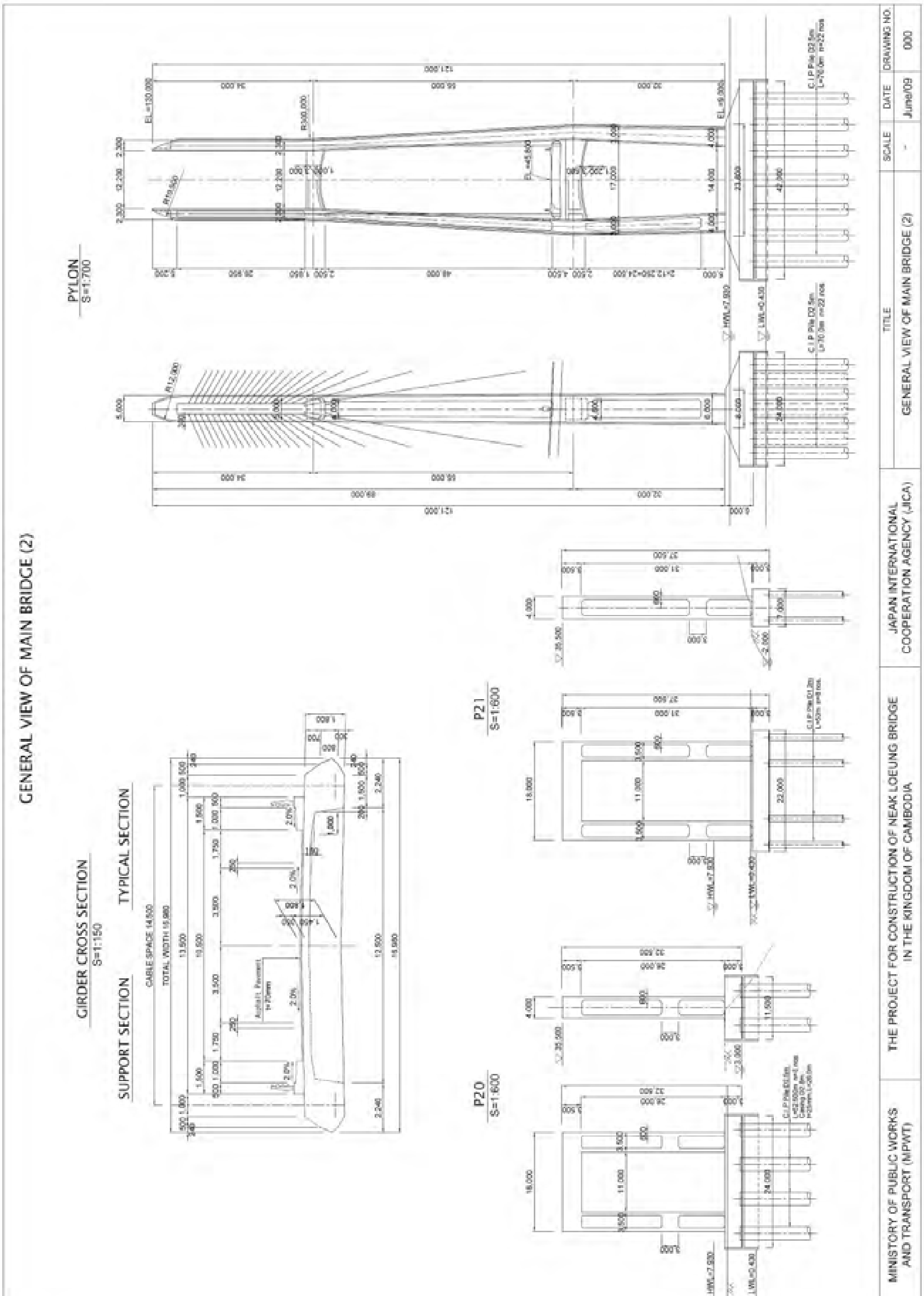


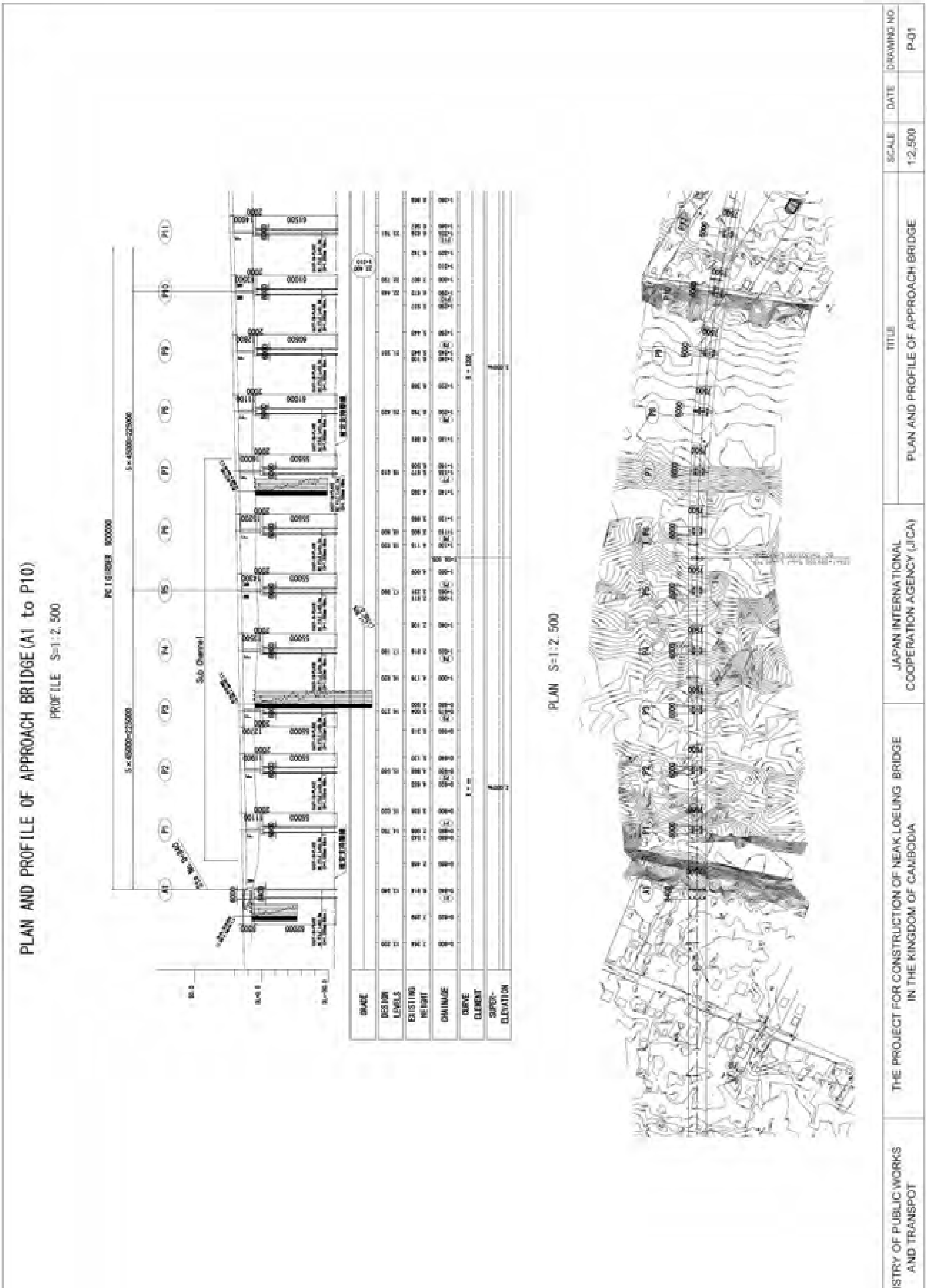
Figure 3.2-52 V-A diagram of the improved profile (-3°)

3.2.3 Design Drawings

This section shows the outline design drawings of the project to which this assistance applies.


PLAN AND PROFILE OF MAIN BRIDGE S=1:2000
PROFILE
PLAN
GRADE
DESIGN LEVEL
EXISTING HEIGHT
CHAINAGE
CURVE ELEMENT
SUPER ELEVATION
ELEVATION (m)
20 CABLES
MIDSPAN AND SHIPPING PASSAGE
SHIPPING PASSAGE
MINISTRY OF PUBLIC WORKS AND TRANSPORT (MPWT)
THE PROJECT FOR CONSTRUCTION OF NEAK LOEUNG BRIDGE IN THE KINGDOM OF CAMBODIA
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
TITLE
PLAN AND PROFILE OF MAIN BRIDGE
SCALE
1:2000
DATE
June/09
DRAWING NO.
003


GENERAL VIEW OF MAIN BRIDGE (2)
PYLON
S=1:700
GIRDER CROSS SECTION
S=1:150
SUPPORT SECTION
TYPICAL SECTION
P20
S=1:600
P21
S=1:600
MINISTRY OF PUBLIC WORKS AND TRANSPORT (MPWT)
THE PROJECT FOR CONSTRUCTION OF NEAK LOEUNG BRIDGE IN THE KINGDOM OF CAMBODIA
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
TITLE
GENERAL VIEW OF MAIN BRIDGE (2)
SCALE
-
DATE
June/09
DRAWING NO.
000


PLAN AND PROFILE OF APPROACH BRIDGE (A1 to P10)
PROFILE S=1:2,500
PLAN S=1:2,500
GRADE
DESIGN LEVELS
EXISTING HEIGHT
CHAINAGE
CURVE ELEMENT
SUPER-ELEVATION
MINISTRY OF PUBLIC WORKS AND TRANSPOT
THE PROJECT FOR CONSTRUCTION OF NEAK LOEUNG BRIDGE IN THE KINGDOM OF CAMBODIA
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
TITLE
PLAN AND PROFILE OF APPROACH BRIDGE
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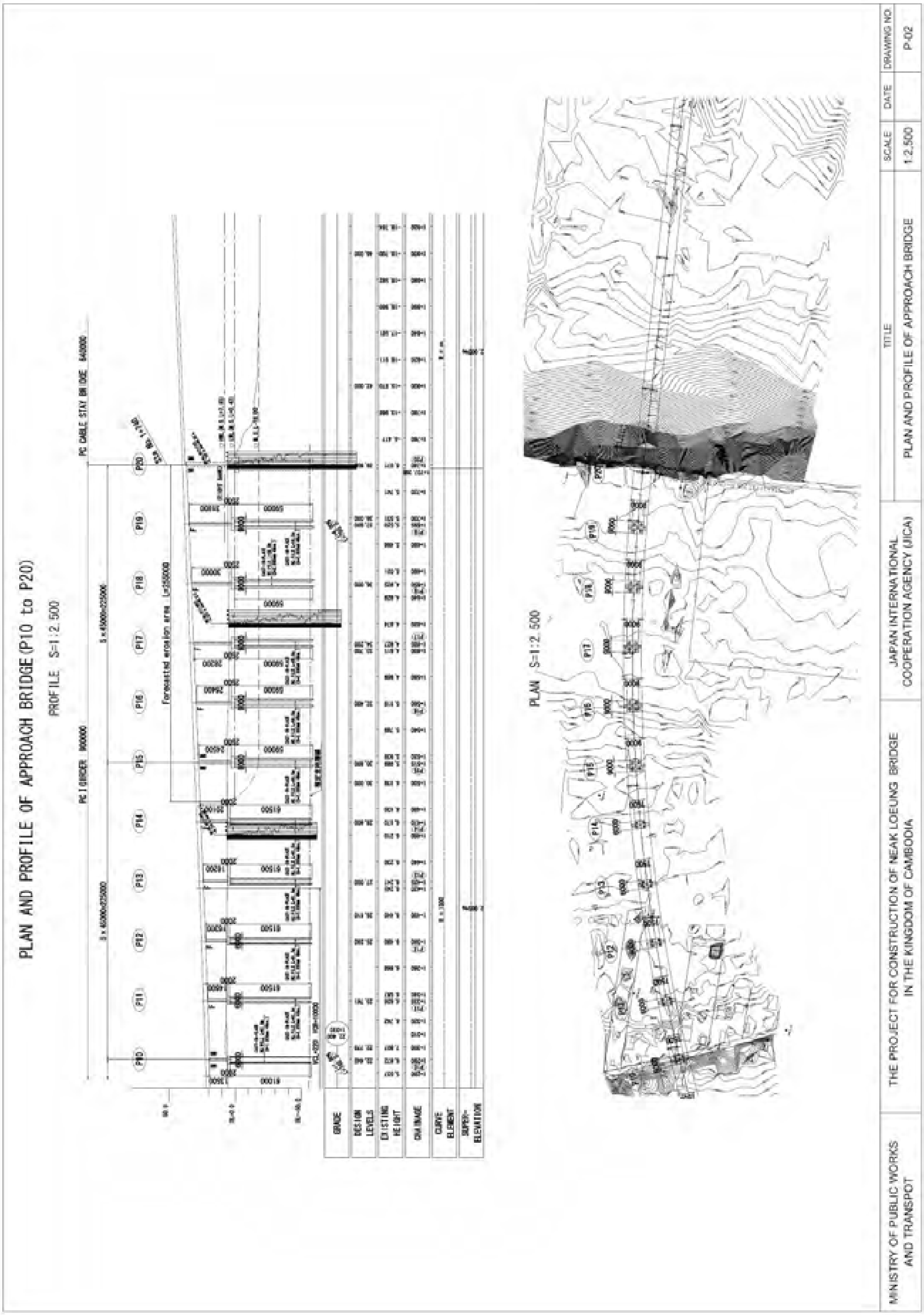
DATE
DRAWING NO.
P-01


PLAN AND PROFILE OF APPROACH BRIDGE (P10 to P20)
PROFILE S=1:2,500
PLAN S=1:2,500
GRADE
DESIGN LEVELS
EXISTING HEIGHT
CHAINAGE
CURVE ELEMENT
SUPER-ELEVATION
MINISTRY OF PUBLIC WORKS AND TRANSPOT
THE PROJECT FOR CONSTRUCTION OF NEAK LOEUNG BRIDGE IN THE KINGDOM OF CAMBODIA
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
TITLE
PLAN AND PROFILE OF APPROACH BRIDGE
SCALE
1:2,500
DATE
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P-02