MINISTRY OF PUBLIC WORKS AND TRANSPORT,
THE KINGDOM OF CAMBODIA

PREPARATORY SURVEY REPORT
FOR
THE PROJECT FOR REHABILITATION OF THE CHROY CHANGWAR BRIDGE
IN
THE KINGDOM OF CAMBODIA

March 2016

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

CENTRAL CONSULTANT INC.
CTI ENGINEERING INTERNATIONAL CO., LTD.
ASIAN TECHNOLOGY INSTITUTE CO., LTD.

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PREFACE

International Cooperation Agency decided to conduct the preparatory survey on the Project for Rehabilitation of the Chroy Changwar Briege in the Kingdom of Cambodia, and entrusted the survey to the joint venture consisting of Central Consultant Inc., CTI Engineering International Co., Ltd., and Asian Technology Institute Co., Ltd.

The survey team held a series of discussions with the officials concerned of the Government of Cambodia from January 19 to March 16, 2015 (First Field Survey) and from May 24 to June 10, 2015 (Second Field Survey), and conducted field investigations in the project area. As a result of further studies in Japan, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Cambodia for their close cooperation extended to the survey team.

March 2016

Takahiro Sasaki,
Director General,
Financial Cooperation Implementation Department
Japan International Cooperation Agency

SUMMARY

Summary

(1) Outline of the Country

Cambodia is located in the southern part of the Indochinese Peninsula, sharing borders with Thailand in the west, Laos in the north, and Vietnam in the east, and facing the Gulf of Thailand in the southwest. The country has a land of 181,000 km^2. The Mekong, which is an international river, flows from Laos in the north to south direction. Almost at the center of the country is Tonle Sap, the largest lake in Southeast Asia. The total population is 1,514 in 2013 statistics (The World Bank), and population density is 83.6 persons/km^2.

Topographically, a large part of the country is occupied by the plains in the basins of the Mekong and the Tonle Sap River, and the rest can be broadly divided into the central plain, hills, plateaus, and surrounding mountainous areas.

Cambodia is located in the tropical monsoon region, and this dictates the occurrence of floods in the basins of the Mekong and Tonle Sap Lake. The capital city Phnom Penh has distinct rainy and dry seasons. The rainy season generally extends from June to November, and the dry season from December to May. Most of the annual rainfall occurs during the rainy season. The annual rainfall in Phnom Penh is about 1,500 mm, which is slightly lower than the national average, and varies widely from year to year. Minimum temperature is 19°C in January and 22°C in annual average. Maximum temperature is 38°C in April and 36°C in annual average.

The most important industry in Cambodia is agriculture, which represents 45.2% of working population (2014) and 28.7% of GDP (2014). However, manufacturing is growing rapidly in recent years, as the United States' adoption of preferential tariffs on imports has revitalized the textile industry and the infrastructure construction has been making progress. With the per capita national income of 1,040 US dollars (2014), ranked 181st among the 213 countries in the world, Cambodia is a least developed country (LDC).

(2) Background and Outline of the Project

The transport infrastructures of Cambodia include roads, railroads, ports and inland water transportation, and air transportation. Among these, road infrastructure is placed as the most important mode of transportation. The road network managed by the Ministry of Public Works and Transport consists of national roads with one-digit numbers (2,243 km), national roads with two-digit numbers (8,664 km), and provincial roads with three- and four-digit numbers (4,407 km).

Traffic volume has been increasing rapidly reflecting economic development in Cambodia. Road construction and improvement projects are promoted with the assistance from Japan and other donors, mainly focusing on major national roads in the country. In particular, National Road 6A is an important trunk road providing direct access to the nine northeastern provinces from the capital city Phnom Penh through the northern suburbs of the city. Chroy Changwar Bridge (hereinafter referred to as "this bridge") at the origin of this road is crucial for the transport and physical distribution in Cambodia.

While this bridge was constructed in 1963 by the Government of Cambodia including funds under Agreement of Technical and Economic Cooperation between Japan and Cambodia, it collapsed in 1972 when the center span was blasted during the civil war, and had since been unusable for a long time. After the civil war, the bridge was reopened as a result of the rehabilitation work including the center span conducted from 1992 to 1995 under Japanese grant aid.

While the approach bridges on the Phnom Penh side and the Chroy Changwar side (5-span simple PC girder bridges) had not been repaired or renovated since the construction in 1963, tilting of rocker bearings on the Phnom Penh side had been observed starting in about 2010. A joint inspection was conducted in December 2013 by the Cambodian Ministry of Public Works and Transport and JICA, and it was recommended to perform emergency repair of rocker bearings on both the Phnom Penh side and the Chroy Changwar side. Emergency repair of rocker bearings on the Phnom Penh side was performed in May 2014 using the repair budgets of the Cambodian side. When JICA sent a survey team to assess the condition of the bridge in June 2014, significant damage was found in the rocker bearings and main girder end parts on the Chroy Changwar side during visual inspection of the approach bridges. JICA therefore considered that serious accidents were likely to occur on this bridge, and recommended the Cambodian side to close the bridge and perform inspection immediately. The Cambodian side has since been restricting the passage of vehicles of 2.5 t and larger sizes.

The Government of Cambodia, in response to the rapid increase in traffic demand, constructed the Second Chroy Changwar Bridge in parallel to this bridge with the assistance from China (opened to traffic on November 1, 2014; hereinafter referred to as the China bridge), with the intention to resolve the traffic bottleneck through the use of this bridge and the China bridge. However, it is feared that the above-mentioned condition of this bridge may cause difficulty in meeting the traffic demand. To the end of resolving the traffic bottleneck, it is urgently needed to rehabilitate this bridge for ensuring the stability of service. Based on this situation, the Government of Cambodia in August 2014 requested the Government of Japan to provide grant aid assistance for the rehabilitation of this bridge.

The present survey was conducted for the purpose of confirming the necessity and relevance of the requested project through bridge inspection, developing outline design that is relevant for implementation as a grant aid project, formulating the project plan, and calculating the estimated project cost.

(3) Outline of Survey Results and Contents of the Project

JICA sent preparatory survey teams (outline design survey) to Cambodia from January 19 to March 16, 2015 (First Field Survey) and from May 24 to June 10, 2015 (Second Field Survey). The survey included close visual inspection, loading tests, magnetic particle tests, materials survey, geological survey, traffic survey, survey on environmental and social consideration, survey on procurement situation, survey on operation and maintenance systems, etc. after consultation with the relevant persons in Cambodia.

Based on the survey results, tasks in Japan were performed including evaluation of the results of bridge inspection, formulation of bridge rehabilitation policies, formulation of bridge rehabilitation plan (draft), outline design of the project, environmental impact assessment, preparation of abbreviated

resettlement plan, and calculation of estimated project cost. Thereafter, the survey team for outline design explanation was sent to Cambodia from January 11 to January 17, 2016. The team conducted consultation and confirmation with the Cambodian side concerning the responsibilities of the Cambodian side, and reached an agreement. With respect to the selection of work methods, it was decided to use the methods with economic efficiency while aiming at the earliest possible completion.

The basic concept of the project in the final proposal is as follows.

1) New Construction Work (Approach Parts, Two 4-span Connected PC Bridges)

Item			Type / Specifications
Bridge location			National Road 6A crosses the Tonle Sap River
Width	Bridge part		Carriageway 3.5m×2=7.0m, bike lanes 1.9m×2=3.8m, sidewalks 1.1m×2=2.2m: total 13.0m (effective width) Wheel guards 0.4m×2=0.8m: Total 13.8m (total width)
Bridge style			PC 4-span pretensioned hollow deck bridge
Bridge length, spans	Phnom Penh side		L = 4@21.3m = 85.2m
	Chroy Changwar side		L = 4@19.3m = 77.2m
Bridge surface pavement			Modified asphalt pavement (80mm on carriageway)
A1 abutment (Phnom Penh side) A2 abutment (Chroy Changwar side)		Type	Inverted T-type abutment
		Height of structure	A1 abutment: H=5.5m A2 abutment: H=8.3m
		Foundation	A1 abutment: Cast-in-place piles (φ1.0m, L=27.5m, n=8) A2 abutment: Cast-in-place piles (φ1.2m, L=23.5m, n=12)
PN1-PN3 piers (Phnom Penh side) PN6-PN8 piers (Chroy Changwer side)		Type	Elliptical pier
		Height of structure	PN1-PN3 piers: H=5.3m-7.4m PN6-PN8 piers: H=9.9m-8.1m
		Foundation	PN1-PN3 piers: Cast-in-place piles (φ1.0m, L=27.0m, n=8) PN6 pier: Cast-in-place piles (φ1.2m, L=21.5m, n=12) PN7-PN8 piers: Cast-in-place piles (φ1.2m, L=21.0m, n=12)
PN4 pier (Phnom Penh side) PN5 pier (Chroy Changwar side)		Type	Rigid frame pier
		Height of structure	PN4 pier: H=8.2m PN5 pier: H=9.1m
		Foundation	PN4 pier: Cast-in-place piles (φ1.0m, L=27.0m, n=6) PN5 pier: Cast-in-place piles (φ1.2m, L=31.0m, n=6)
Other			Curb work, lighting work, lane marking work

2) Repair Work (River-crossing Part, 2-span + 3-span + 2-span Continuous Steel Box Bridge, Eight RC Piers)

Item	Target structure	Remarks
Bridge surface pavement work	Entire superstructure	Modified asphalt pavement (surface layer: 30 mm) SFRC pavement (base layer: 50 mm)
Painting work	Entire superstructure	Only on outer surfaces of steel box girders
	Parts with standing water (in box girders)	Painting after cleaning
Expansion devises	On P1, P3, P6, and P8 piers	Reuse of existing expansion devices after conversion to no-draining type
Crack injection work	Entire substructure	Crack width 0.2 mm or more
Full surface coating work	Entire substructure	Application of impregnant
Section repair work	Entire substructure	Peeling, rebar exposure, concrete loss, etc.
Railing work	Entire superstructure	Replacement (1.1 m or more above road surface)
Curb work	Entire superstructure	Replacement
Lighting work	Entire superstructure	Replacement
Lane marking work	Entire superstructure	

3) Improvement Work (Approach Road Part, Embankment)

Item	Target structure	Remarks
Elongation	Approach road part	Phnom Penh side: approx. 206 m Chroy Changwar side: approx.190 m Total 396 m
Width	Approach road part	Carriageway 3.5m×2=7.0m, bike lanes 1.9m×2=3.8m, sidewalks 1.1m×2=2.2m, protective shoulders 0.3m×2=0.6m: Total 13.6m (total width)
Pavement work	Approach road part	Modified asphalt pavement (surface layer: 50 mm) Asphalt pavement (base layer: 100 mm)
Drainage work	Approach road part	Installation of drainage facilities
Guardrail work	Approach road part	Replacement
Curb work	Approach road part	Replacement
Lighting work	Approach road part	Replacement
Lane marking work	Approach road part	

(4) Project Period and Project Cost Estimation

When this project is implemented under Japanese grant aid, the required time will be 8.0 months for implementation design and 21 months for facility construction. The estimated project cost to be borne by the Cambodian side is 202 million yen.

(5) Project Evaluation

1) Relevance

For the following reasons, it is considered relevant to implement the cooperation project under Japanese grant aid.

① The beneficiaries of the project are a large number of general citizens in the nine northeastern provinces including Phnom Penh city and the northern suburbs of the city (directly 1.33 million citizens of Phnom Penh and indirectly 4.92 million inhabitants of the nine northeastern provinces).

② The bridge requires prompt actions in view of the urgency of needs, since it has been severely damaged from deteriorating and the increase in traffic volume, and there is a concern about bridge collapse due to a lack of sufficient durability for the passage of large vehicles.

③ Operation and maintenance after completion can be conducted by the Cambodian side using its own personnel and technologies, without requiring excessively advanced technologies.

④ This project has been positioned as a concrete strategy in the National Strategic Development Plan (NSDP 2014-2018) of Cambodia, and is included in the improvement program for National Road 6A, which is one of the most important trunk roads in Cambodia.

⑤ While this project involves relocation of inhabitants and businesses, there will be no particular problems, as approval and understanding concerning the project have been obtained from those affected.

⑥ The project can be implemented without particular difficulty using the grant aid scheme of Japan.

⑦ Because the bridge is a long PC bridge with the length of 85.2 m (4 @ 21.3 m) on the Phnom Penh side and 77.2 m (4 @ 19.3 m) on the Chroy Changwar side, it is difficult to design and construct using the technologies available in Cambodia, and the use of Japanese technologies is supported by necessity and advantage.

2) Effectiveness

i) Quantitative Effects

The quantitative effects expected from the implementation of this project are as follows.

Indicator	Baseline value (actual in 2015)	Target value (2021) 【3 years after project completion】
Increase in mean travel speed (km/h)	26.8	40.0
Increase in the use by large vehicles (vehicles/day)	0 (*)	1,278

(*) Because restriction is imposed on the passage of large vehicles.

ii) Qualitative Effects

The qualitative effects expected from the implementation of this project are as follows.

① While the existing bridge has been severely damaged from deteriorating and the increase in traffic volume, and a risk of bridge collapse has been pointed out, replacement with a new bridge will eliminate the risk of bridge collapse and ensure stable physical distribution and movement of people.

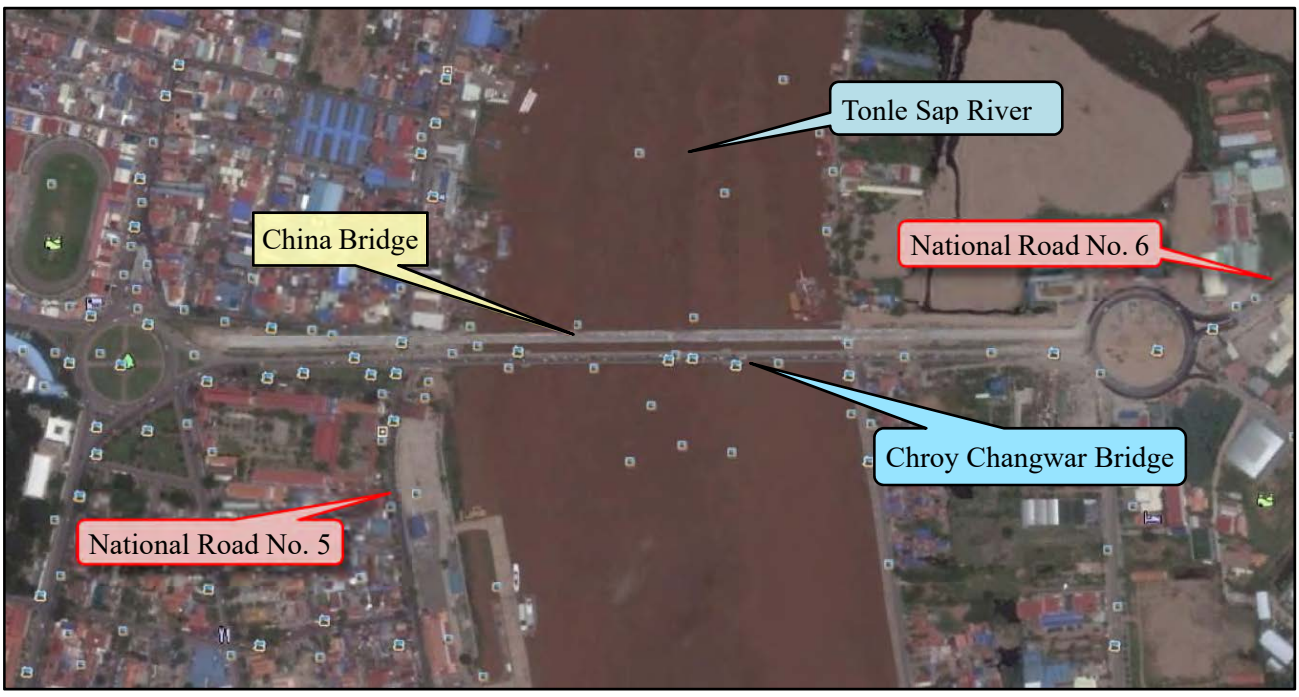
② For the inhabitants in the northern part of Phnom Penh, this project will help improvement of the basic human needs (BHN) through the improvement of access to schools, hospitals, and workplaces in the city.

③ This project will help vitalization of local economic activities through stable transport of agricultural and forestry products from the nine northeastern provinces of Cambodia to Phnom Penh city.

Based on the above, this project is considered highly relevant and expected to be effective.

CONTENTS

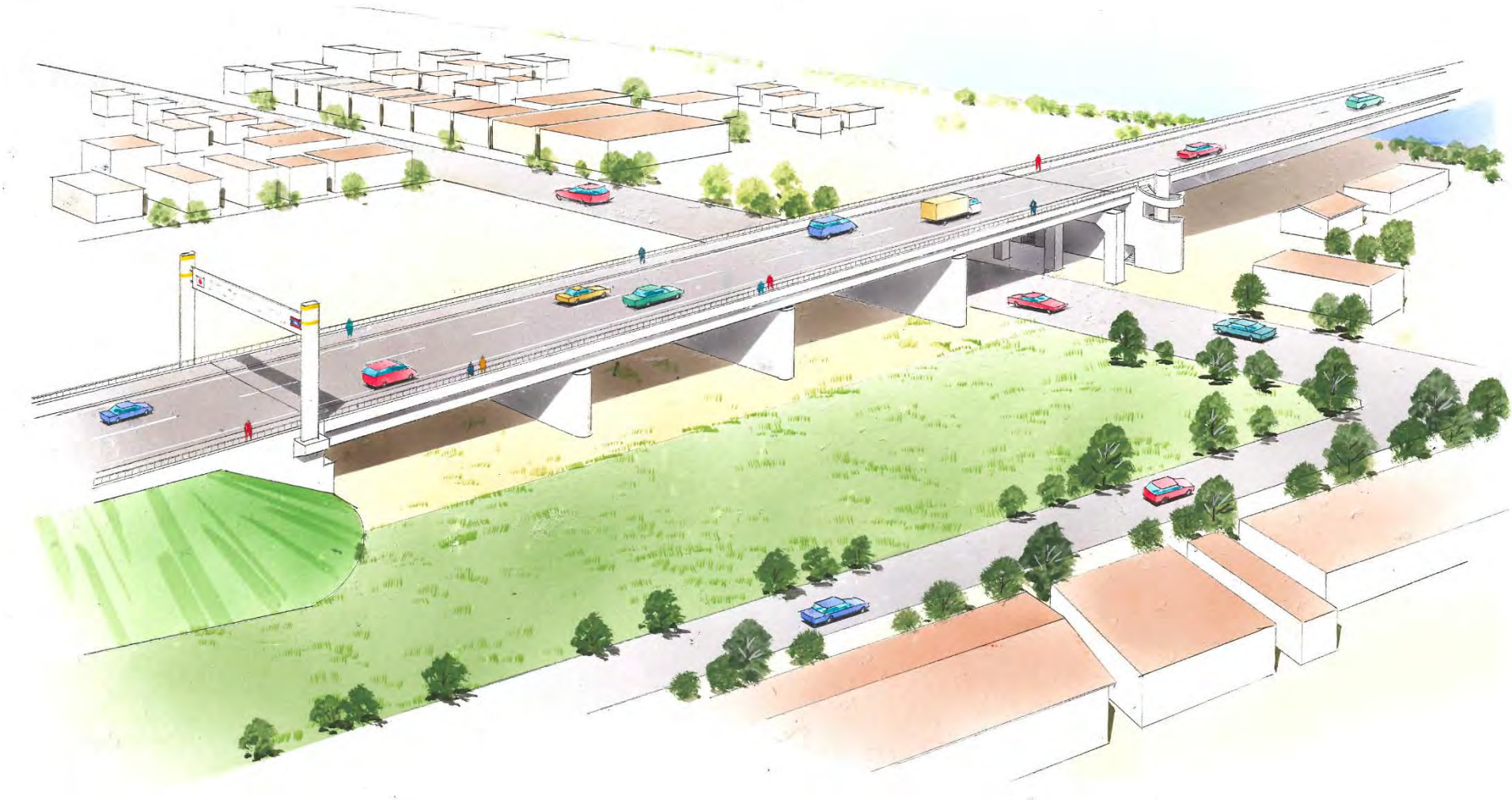
[Appendices]



Project Location Map

← To Phnom Penh

To Chroy Changwar →



Chroy Changwar Bridge Rendering (Phnom Penh side)

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Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
AC	Asphalt Concrete
ADB	Asian Development Bank
AH	Asian Highway
ARAP	Abbreviated Resettlement Action Plan
AusAID	Australian Agency for International Development
CBR	California Bearing Ratio
DBST	Double Bitumineux Surface Treatment
DPWT	Department of Public Works and Transport
EDC	Electricite du Camboge
EIA	Environmental Impact Assessment
E/N	Exchange of Notes
ESAL	Equivalent Single Axle Load
GDP	Gross Domestic Product
GNI	Gross National Income
HIV/AIDS	Human immunodeficiency virus infection / acquired immunodeficiency syndrome
HWL	High Water Level
IEE	Initial Environmental Evaluation
IMF	International Monetary Fund
IRC	Inter-Ministerial Resettlement Committee
JICA	Japan International Cooperation Agency
LDC	Least Developed Country
M/D	Minutes of Discussion
MPWT	Ministry of Public Works and Transport
NSDP	National Strategic Development Plan
O/D	Outline Design Study
ODA	Official Development Assistance
PAPs	Project Affected Persons
PC	Prestressed Concrete
PCU	Passenger Car Unit
PPWSA	Phnom Penh Water Supply Authority
PQ	Pre-Qualification
RA	Roundabout
RC	Reinforced Concrete
RID	Road Infrastructure Department
SN	Structural Number
TC	Telecom Cambodia
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
WB	World Bank

Chapter 1 Background of the Project

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1-1 Background and Outline of the Request for Grant Aid

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1-2 Survey on Natural Conditions

1-2-1 Soil Survey

(1) Survey objective

To obtain N-values and verify the bearing layer through the implementation of a soil survey.

(2) Survey results

Land boring began on February 19, with river boring beginning on February 28 and continuing concurrently. Boring of the eight planned holes (5 land, 3 river) was completed on March 6. The P2 pier location originally planned for river boring was done on land instead due to low water levels and land elevation.

Table 1-2-1 Soil survey details

No.	Location	Type	Status	Excavated length	Remarks
Br. No1	Between A1 abutment and P1 pier	Land	Complete	32.5m	Completed March 1
Br. No2	P1 pier	Land	Complete	30.0m	Completed Feb. 24
Br. No3	P2 pier	Land	Complete	26.0m	Completed Feb. 20
Br. No4	P3 pier	River	Complete	7.0m	Completed March 6
Br. No5	P6 pier	River	Complete	9.0m	Completed March 5
Br. No6	P7 pier	River	Complete	11.0m	Completed March 3
Br. No7	P8 pier	Land	Complete	21.0m	Completed March 6
Br. No8	Between P8 pier and A2 abutment	Land	Complete	27.0m	Completed March 4

Photo 1-2-1 P2 pier boring (land)

Photo 1-2-2 P3 pier boring (river)

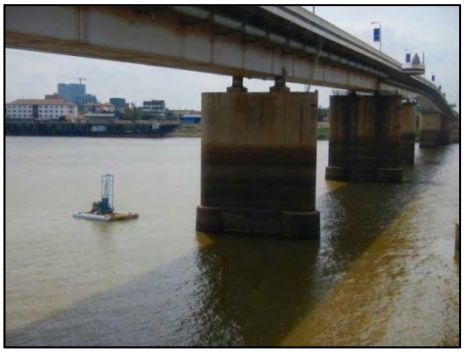


Photo 1-2-3 P7 pier boring (river)

Photo 1-2-4 P8 pier boring (land)

(3) Evaluation of survey results

Table1-2-2 Geological outline

No.	Location	Type	Geological outline (on-site findings)	Geological conditions
Br. No1	Between A1 abutment and P1 pier	Land	Low N-value cohesive soil layer and sandy soil layer continues for 27 m from surface. Rock was confirmed for a depth of about 1.0 m from the 28.6 m mark. High N-value cohesive soil layer confirmed from the 30 m mark.	
Br. No2	P1pier	Land	Low N-value cohesive soil layer and sandy soil layer continues for 26 m from surface. High N-value cohesive soil layer confirmed beneath this.	
Br. No3	P2pier	Land	Low N-value cohesive soil layer and sandy soil layer continues for 23 m from surface. High N-value cohesive soil layer confirmed beneath this.	
Br. No4	P3pier	River	Deposited sediment for 1.0 m from the river bed surface. A very hard sand soil layer was found from the 2.0 m mark, with rock appearing from about 2.5 m.	
Br. No5	P6pier	River	Gravel-mixed cohesive soil layer for 1.0 m from the river bed surface. Rock was found from the 2.0 m to 3.7m, with a layer of very hard cohesive soil beneath that.	
Br.No6	P7pier	River	Sandy soil for 1.0 m from the river bed surface, with a cohesive soil layer continuing from the 2.0 m mark. From the 5 m mark, a high N-value cohesive soil layer (including weathered rock pieces) continues.	
Br. No7	P8pier	Land	Low N-value cohesive soil layer and sandy soil layer continues for 17 m from surface. Very high N-value gravel-mixed cohesive soil confirmed beneath this. Extremely hard rock layer found from the 20 m mark.	
Br. No8	Between P8 pier and A2 abutment	Land	Low N-value cohesive soil layer and sandy soil layer continues for 19 m from surface. Rock was confirmed for a depth of about 1.0 m from the 20.0 m mark. High N-level cohesive soil layer confirmed from the 23 m mark.	

1-3 Environmental and Social Consideration

1-3-1 Environmental Impact Assessment (EIA)

1-3-1-1 Component Overview

(1) Project Content and JICA Environmental Categories

This project involves rehabilitation of the Chroy Changwar Bridge over National Road 6A in downtown Phnom Penh. This project does not qualify as a large-scale road sector project as given in the JICA Guidelines for Environmental and Social Considerations (April 2010; hereinafter JICA Environmental Guidelines). It also is not judged to have a major adverse impact on the environment, has no environmentally sensitive features, and is not in an environmentally sensitive region as given in the JICA Environmental Guidelines. Given this, the project is Category B based on the JICA Environmental Guidelines.

(2) Project Site

The project site is in Phnom Penh. A map of the project site is given in Figure 1-3-1.

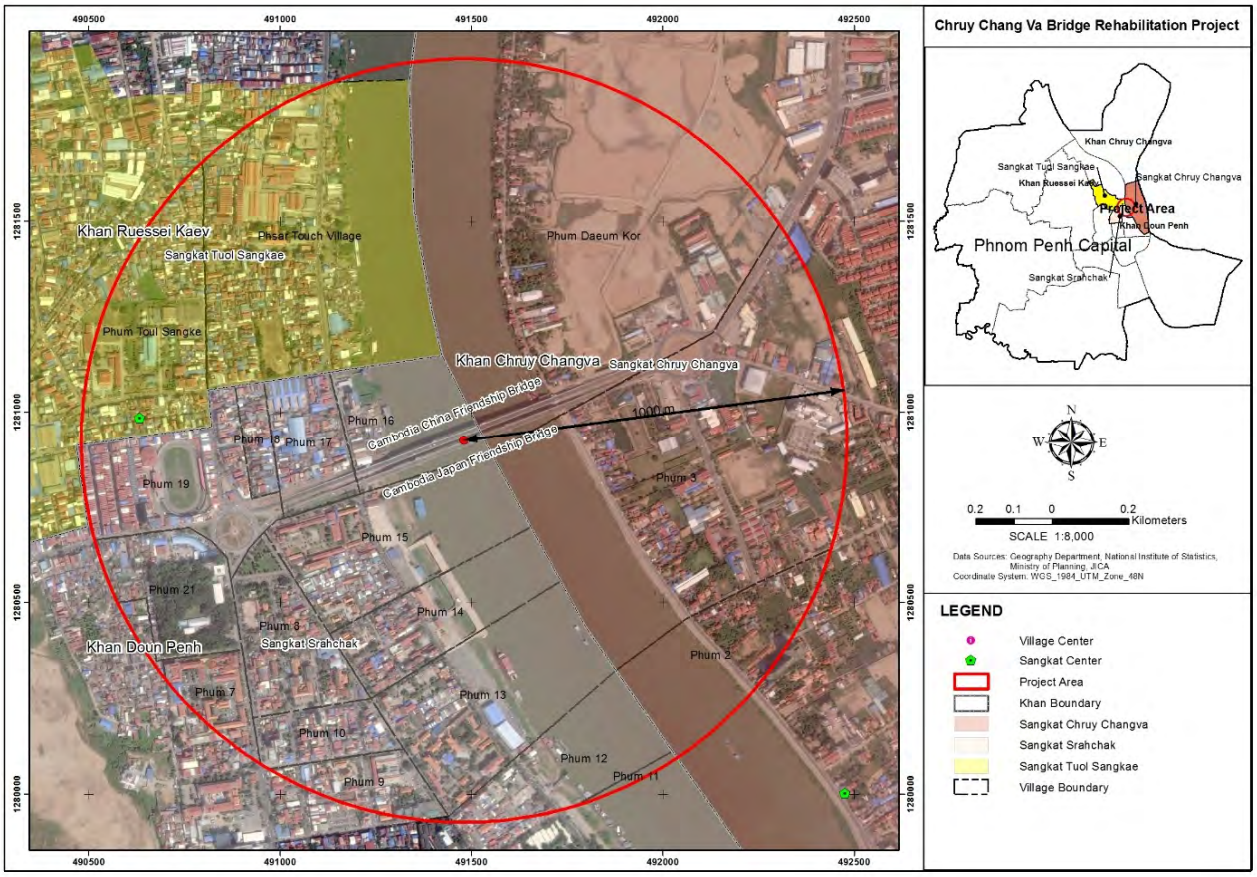


Figure 1-3-1 Location map of the project site

(3) Component Overview

Project components are as given in Table 1-3-1.

Table 1-3-1 Table List of project components

Work Type	Structures	Item		Remarks
New Construction	4-span PC hollow girder (2 bridges)	Superstructure	PC girders (2 bridges)	
		Substructure	A1 and A2 abutments	
			T1, T2, T3, T6, T7 and T8 piers	Intermediate pier
			T4 and T5 piers	Overlapping piers
		Foundation work	A1 and A2 abutments, T1-T8 piers	Cast-in-place piles (φ1.0 m, φ1.2 m)
	Pavement	PC bridge section	A1-P1 pier span, P8-A2 abutment	Improved asphalt paving
		Earthwork	Connected road	Improved asphalt paving
	Bridge railing	PC bridge section	A1-P1 pier span, P8-A2 abutment	New construction (1.1 m and above from road surface)
	Expansion joints	PC bridge section	On A1, T4, T5, and A2 abutments	New construction
	Bearings	PC bridge section	On A1, T1-T8, and A2 abutments	New construction
Repair work	Pavement	Steel bridge section	P1-P8 pier span	SFRC pavement
	Painting	Steel bridge section	P1-P8 pier span	Exterior of steel box girder only
			Submerged section (box girder interior)	Clean, then paint
	Bridge railing	Steel bridge section	P1-P8 pier span	Replace (1.1 m and above from road surface)
	Guardrails	Earthwork	Connected road	Replace
	Expansion joints	Steel bridge section	On P1, P3, P6, and P8 piers	Convert current expansion joint to non-draining type and reuse
	Lighting	All lanes		Replace
	Crack filling work	Steel bridge section	P1-P8 piers	For cracks 0.2 mm or wider
	Coating work for all surfaces	Steel bridge section	P1-P8 piers	Apply penetrant
	Cross section repairs	Steel bridge section	P1-P8 piers	Spalling, exposed rebar, missing concrete, etc.
	Earthwork	Earthwork	Connected road profile adjustments	Not needed for adjustment with pavement only
	Road marking	All lanes		
	Curb work	All lanes		
Improvements	Embankment work	Earthwork	Connected road	
	Ditches	Earthwork	Connected road	
	Intersection	Roundabout		Phnom Penh side only
Old bridge removal	5-span PC girder bridge (2 bridges)	Superstructure	PC girders	10 continuous
		Substructure	All abutments and piers	10 bases (excl. P1 and P8 piers)
		Foundation	Concrete ready-made piles	Cut
Construction plan	Scaffolding work	Superstructure	P1-P8 pier span	Full suspended scaffolding (for painting steel bridge)
		Substructure	P1-P8 piers	Suspended scaffolding (stepped)

1-3-1-2 Base Environmental and Social Conditions

(1) Natural Environment

1) Weather

As listed in 2-2-1-2(1) Weather.

2) Flora and Fauna Habitats

a) Flora and Fauna

The project area (near the Chroy Changwar Bridge) is located in residential and industrial areas of Phnom Penh. No unique flora or fauna confirmed in the vicinity.

b) Fish

The Chroy Changwar Bridge crosses the Tonle Sap River connecting the Mekong River and Tonle Sap Lake. Tonle Sap Lake is the largest habitat for freshwater fish in Cambodia and boasts some of the best fishing production in Southeast Asia.

There are over 1,200 fish species living in the Lower Mekong Basin. The Mekong River and Tonle Sap Lake are highly diverse, with more than 500 species confirmed to be living in the Mekong River within Cambodian borders including the 296 species in Tonle Sap Lake. (Source: "Current status fisheries resources in Cambodia" by Dr. So Nam)

According to field interviews with local fishermen conducted in the 2015 survey, there are 149 fish species living in Tonle Sap River near the project area. The major fish living near the project area are given inTable 1-3-2.

Table 1-3-2 Major fish living in Tonle Sap River

Order	Family	Scientific name	English name
Osteoglossiformes	**Notopteridae**	*Notopterus notopterus*	Bronze featherback
Clupeiformes	**Engraulidae**	*Coilia macrognathos*	Longjaw grenadier anchovy
	Engraulidae	*Coilia lindmani*	Lindman's grenadier anchovy
	Cyprinidae	*Hypsibarbus lagleri*	
		Puntioplites falcifer	
		Puntioplites proctozysron	
		scaphoognathops stejnegeri	
		Morulius chrysophekadion	Black sharkminnow
		Barbodes schwanefeldi	Tinfoil barb
		Corica laciniata	Bangkok river sprat
		Rasbora tornieri	Yellowtail rasbora
		Hypsibarbus malcolmi	Goldfin tinfoil barb
		Esomus metallicus	Striped flying barb
		Henicorhynchus siamensis	
		Henicorhynchus lobatus	
	Cobitidae	*Botia lecontei*	Silver botia
		Botia helodes	Tiger botia
		Botia modesta	Redtail botia

Order	Family	Scientific name	English name
		Acantopsis sp.5	
		Acantopsis sp	
		Acantopsis sp.1	Speckled horseface loach
	Gyrino-cheilidae	*Gyrinocheilus pennocki*	Spotted algae eater
Siluriformes	**Bagridae**	*Hemibagrus spilopterus*	
	Heteropneu-stidae	*Arinus maculatus*	Spotted sea catfish
	Pangasiidae	*Pangasius lamaudiei*	
		Pangasius macronema	
	Siluridae	*Kryptopterus cryptopterus*	
		Kryptopterus hexapterus	
		Kryptopterus limpok	
		Ompok sp.cf.eugeneriatus	
		Micronema bleekeri	
		Micronema micronema	
		Wallago attu	
Perciformes	**Polynemidae**	*Polynemus borneensis*	Borneo threadfin
	Sciaenidae	*Boesemania microlepis*	Smallscale croaker
	Belontiidae	*Trichogaster microlepis*	Moonlight gourami
		Trichogaster pectoralis	Snakeskin gourami
	Gobiidae	*Glossogobius sparsipapillus*	
Beloniformes	**Mastacem-belidae**	*Macrognathus circumcinctus*	

Source: Field interview with fisherman, September 25, 2015

3) Air Quality

While the Chroy Changwar Bridge is located in a residential area close to the center of Phnom Penh, there is almost no activity on the bridge on in the vicinity of the ends of the connected road other than goods transport.

As a baseline study before the start of the project, air quality was measured on the west side (Phnom Penh side) of Chroy Changwar Bridge. Air quality and noise measurements are shown in Table 1-3-3

According to the measurements taken, air quality on the west side (Phnom Penh side) of Chroy Changwar Bridge is within Cambodia reference values (ambient air quality standards (Ministry of Environment (MOE))). Thus, air quality near the project area is currently good.

Table 1-3-3 Air quality measurements (24-hours)

Parameters	Units	Ambient air quality standards (MOE), 24-hrs.	Results	
			West Side	East Side
Carbon Monoxide (CO)	mg/m^3	20(i)	5.50	3.50
Nitrogen Dioxide (NO2)	mg/m^3	0.1	0.04	0.029
Sulfur Dioxide (SO2)	mg/m^3	0.3	0.03	0.023
Total Suspended Particles (TSP)	mg/m^3	0.33	0.01	0.192
PM10	mg/m^3	-	0.07	0.108

Note: (i) 8-hr. average

4) Noise

As a baseline study before the start of the project, noise was measured on the west side (Phnom Penh side) of Chroy Changwar Bridge. Noise measurements are shown in Table 1-3-4Noise is lower than the maximum tolerance values for commercial service areas for both day (6:00 to 19:00) and evening (19:00 to 23:00). At night (23:00 to 6:00), however, equivalent sound levels were measured as 58-62 dB (A), which exceeds the Cambodia MOE standard maximum tolerance value of 50 dB (A). This is likely due to vehicle traffic on National Road 5, National Road 6 and other roads.

Table 1-3-4 Noise measurements (24-hours)

Time	Standard(*), dB(A)	Results dB(A)		
		LAeq	Lmax	Lmin
Station 1 at Phnom Penh side, sampling date 28 Sept. 2015				
Day (06:00 - 19:00)	70	61-67	69-79	59-60
Evening(19:00 - 23:00)	65	60-63	71-75	57-60
Night (23:00 - 06:00)	50	58-62	68-71	54-59
Station 2 at Chrouy Changvar side				
Day (06:00 - 19:00)	70	60-62	71-77	54-57
Evening(19:00 - 23:00)	65	57-61	73-77	51-56
Night (23:00 - 06:00)	50	55-59	66-71	49-53

Note: (*) Sub-Decree on Air Pollution Control and Noise Disturbance, Annex 6: Maximum permitted noise in public and residential area, point 3 Commercial and service areas and mix.

5) Water Quality

As a baseline study before the start of the project, water quality was surveyed for Tonle Sap River at the points shown in Figure 1-3-2.

Figure 1-3-2 Water quality survey points

Table 1-3-5 Water quality survey results

Parameters	Units	Standard(i)	Results			
			S1	S2	S3	S4
Temperature		–	31	31	31	31
pH		6.5 – 8.5	7.1	6.8	6.8	6.9
DO	mg/l	2 - 7.5	3.20	4.00	4.15	4.10
Turbidity	mg/l	–	8.00	9.00	8.00	8.00
TSS	mg/l	25 - 100	104.00	98.00	89.00	82.00
BOD_5	mg/l	1 - 10	1.85	1.80	1.90	1.30
COD_{Mn}	mg/l	1 – 8	3.74	3.52	3.33	2.35
Oil and Grease	mg/l	–	8.40	7.55	5.69	5.07
Tot.N	mg/l	0.1 - 0.6	1.97	0.71	0.75	0.61
Tot-P	mg/l	0.005 – 0.05	0.17	0.03	0.08	0.08
Total Coliform	MPN/100ml	<5000	$1.6x10^4$	$2.1 x10^4$	$2.9 x10^4$	$2.4 x10^4$

Note: (i) Water quality standard in public water areas for bio-diversity conservation, for rivers and lakes

6) Geology and Soil Quality

As listed in 2-2-2-8-1(2)b)Soil Profile.

7) Land Use

Phnom Penh is 678.46 km^2 in area, most of which is residential area (Source: Phnom Penh Municipality Development Plan 2015-2019). Generally, commercial and industrial areas are mixed into residential zones. Also, there are small-scale agricultural areas on the outskirts of Phnom Penh.

The project area (within a 1-kilometer radius of Chroy Changwar Bridge) lies in 3 communes, or sangkats: Srah Chork, Toul Sangkar, and Chrouy Changvar. Land in Srah Chork and Toul Sangkar is 100 percent residential. Land in Chrouy Changvar is 83.3 percent residential, 0.28 percent agricultural, and 16.42 percent industrial. (Source: Statistical Book of Sangkat year 2014)

Table 1-3-6 Land use in Chrouy Changvar

No.	Type of Land Use	Area, ha	Percentage
1	Residential area	887.67	83.30
2	Rice field		
	- dry season rice field	0	0
	- wet season rice field	0	0
3	Farm land		
	- short tem crop	3	0.28
	- long term crop	0	0
4	Other land (industrial, resort, etc.)	175	16.42
	Total land	1,065.67	100.00

Source: Statistical Book of Sangkat year 2014

(2) Social Environment

1) Administrative Divisions

Cambodia is divided into the following administrative districts. There are 25 provinces in total (including Phnom Penh Municipality). Phnom Penh is the capital of Cambodia.

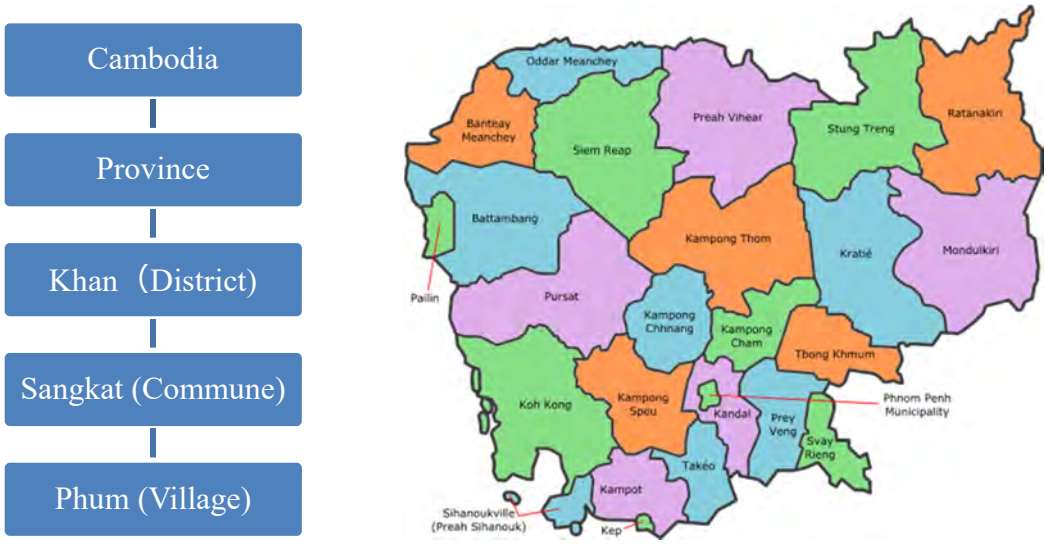


Figure 1-3-3 Cambodian administrative divisions

Located at the confluence of the Mekong River, Tonle Sap River, and Tonle Bassac, Phnom Penh Municipality is subdivided into 12 districts (Khans), 96 communes (Sangkats), and 909 villages (Phums). (Source: Phnom Penh Municipality Development Plan 2015-2019) The project area (area around Chroy Changwar Bridge) spans 3 communes: Srah Chork, of the Daun Penh district; Toul Sangkar, of the Russei Keo district; and Chrouy Changvar, of the Chrouy Changvar district.

2) Project Area Population

Phnom Penh Municipality is the administrative, economic, industrial and cultural capital of Cambodia. Its population is 1,447,085 (as of 2014). Phnom Penh population by district is given in Table 1-3-7

Table 1-3-7 Phnom Penh population by district

No.	District Name	No. of Households	Total Population	Female Population
1	Chamkarmon	24,508	135,061	68,638
2	Daun Penh	16,035	83,995	42,229
3	7 Makara	14,366	75,589	38,135
4	Toul Kouk	25,876	139,256	71,340
5	Dangkor	17,781	79,365	40,641
6	Meanchey	34,098	186,107	98,906
7	Russei Keo	31,206	147,983	77,840
8	Sen Sok	27,779	132,984	71,560
9	Pursenchey	37,242	212,843	124,014
10	Chrouy Changvar	14,293	67,798	33,630

No.	District Name	No. of Households	Total Population	Female Population
11	Prek Phnov	12,097	53,875	26,062
12	Cba-Ampov	26,773	132,229	67,749

Source: Population Statistic of Phnom Penh Municipality, 2014
Note: Colored districts are within the project area

As mentioned in 1)Administrative Divisions, the project area (within a 1-kilometer radius of Chroy Changwar Bridge) spans 3 districts: Chrouy Changvar, Daun Penh, and Russei Keo. Chrouy Changvar is sub-divided into 5 communes and 22 villages and has a total population of 67,798. Located in central Phnom Penh, Daun Penh is sub-divided into 11 communes and 134 villages and has a total population of 83,995. Russei Keo is sub-divided into 6 communes and 21 villages and has a total population of 147,983. District populatations by village are given in Table 1-3-8to Table 1-3-10.

Table 1-3-8 Donphen population by commune

No.	Commune Name	No. of Households	Total Population	Female Population
1	Phsa Thmei Mouy	1,004	5,260	2,787
2	Phsa Thmei Pir	1,085	5,645	2,940
3	Phsa Thmei Bei	1,447	7,611	3,962
4	Bung Raing	944	4,879	2,422
5	Phsa Kandal Mouy	1,280	6,794	3,571
6	Phsa Kandal Pir	1,231	6,587	3,554
7	Chak Tomouk	1,515	8,291	3,922
8	Chey Chumnesh	1,576	9,447	4,197
9	Phsa Chas	1,268	6,235	3,263
10	Srah Chork	3,579	17,357	8,509
11	Wat Phnom	1,106	5,889	3,102
	Total:	**16,035**	**83,995**	**42,229**

Source: Population Statistic of Phnom Penh Municipality, 2014
Note: Colored commune is within project area

Table 1-3-9 Russei Keo population by commune

No.	Commune Name	No. of Households	Total Population	Female Population
1	Toul Sangker	13,122	56,515	29,593
2	Svay Pak	2,726	13,164	7,052
3	Kilometer No. 6	3,670	18,936	10,242
4	Russei Keo	6,556	31,542	15,829
5	Chraing Chamres Mouy	2,050	11,518	5,991
6	Chraing Chamres Mouy	3,082	16,308	8,751
	Total:	**31,206**	**147,983**	**77,840**

Source: Population Statistic of Phnom Penh Municipality, 2014
Note: Colored commune is within project area

Table 1-3-10 Chrouy Changvar population by commune

No.	Commune Name	No. of Households	Total Population	Female Population
1	Chrouy Changvar	3,870	20,541	10,364
2	Prek Leap	3,668	16,774	8,060
3	Prek Ta-Sek	1,402	8,882	4,053
4	Koh Dach	3,483	14,028	7,382
5	Bak Khaing	1,870	7,600	3,771
	Total:	**14,293**	**67,798**	**33,630**

Source: Population Statistic of Phnom Penh Municipality, 2014
Note: Colored commune is within project area

3) Education

As of 2014, Phnom Penh had 152 preschools, 164 primary schools, 66 secondary schools, 34 high schools, and 32 universities or vocational institutes. (Source: Education Statistics and Indicators (2013-2014), Ministry of Education, Youth, and Sport (MEYS)) Attendance for general education institutions (preschool through high school) was 309,651, and attendance for universities and vocational institutions was 12,730 (see Table 1-3-11).

Table 1-3-11 Education institutions in Chrouy Changvar Commune

Description	Schools	Classrooms	Classes	Total Students	Total Teachers
Preschool	152	258	291	17,767	389
Primary school	164	2,269	3,475	131,184	4,573
Secondary school	66	1,305	1,961	86,715	6,266
High school	34	1,064	1,634	73,985	5,151
University/Institute	32	241	327	12,730	1,115

Source: Education Statistics & Indicators, 2013-2014

The status of general education institutions in the 3 communes near to the project site are given in Table 1-3-12.

Table 1-3-12 Status of general education institutions in the 3 communes near the project site

Description	Schools	Classrooms	Classes	Total students	Total teachers
Chrouy Changvar					
Preschools	2	3	3	122	4
Primary Schools	4	51	58	2,115	67
Secondary Schools	1	12	12	616	74
High Schools	1	12	12	476	30
Toul Sangker					
Preschools	8	61	70	2,161	63
Primary Schools	2	45	80	3,682	80
Secondary Schools	1	16	14	640	41
High Schools	0	0	0	0	0
Srah Chork					
Preschools	6	153	182	2,441	158
Primary Schools	1	46	86	3,215	86
Secondary Schools	0	0	0	0	0
High Schools	1	57	60	3,001	208

Source: Sangkat Profile, 2014

4) Religion

In terms of religion, more than 95 percent of Cambodians are Buddhist (Hinayana), about 2 percent are Muslim and about 2 percent are Catholic. There is a Muslim community on the east side of Chroy Changwar Bridge (the Chrouy Changvar side).

5) Poverty

The Ministry of Planning (MOP) sets the poverty lines for different areas in Cambodia. The poverty line in Phnom Penh Provincial Municipality, where the project site is located, is 1.53 USD/day. The poverty lines and poverty rates in Cambodia are shown in the Table below.

Table 1-3-13 Poverty Lines and Poverty Rates (2009)

Area	Poverty line (riel)	Poverty line ($/day)	Poverty line ($/month)	Poverty rate (%)
Phnom Penh	6,341	1.53	46.55	12.8
Other cities	4,352	1.05	31.92	19.3
Rural areas	3,503	0.84	25.69	24.6
Cambodia	**3,871**	**0.93**	**28.39**	**22.9**

Source: Ministry of Planning (MOP)

According to the household survey conducted in September 2015, the households in the project area are above the poverty line, and no poor people are considered to exist in the area.

Table 1-3-14 Monthly and Annual Income of Inhabitants in the Area Near the Project Site

Occupation	Monthly income ($)	Annual income ($)
Farmer	280	3,360
Government employee	250	3,000
Employed worker (company, factory, NGO, etc.)	390	4,680
Small storekeeper	375	4,500
Bike taxi driver	240	2,880
Construction worker	300	3,600
Other	340	4,080

Source: Social Survey (September 2015)

6) Ethnic Minorities

While the largest ethnic group in Cambodia is the Khmers (97.6%), there also are the Chams (1.2%) and other peoples (Chinese, Vietnamese, etc.) (2013). The three communes in the area near the project site have ethnic composition shown below. The Chams are Muslims, and it is possible that there are Islamic Cham communities in the area near the project site.

Table1-3-15 Ethnic Composition in the Area Near the Project Site

Commune	Ethnicity	No. of households	Population
Sangkat Chrouy Changvar	Khmer	2,991	14,120
	Cham	744	3,935
	Vietnamese	79	390
	Chinese	5	6
	Thai	1	1
	Lao	3	10
	Other	39	69
Sangkat Toul Sangker	Khmer	14,972	59,819
	Cham	2	17
	Vietnamese	183	798
	Chinese	2	3
	Thai	0	0
	Lao	0	0
	Other	12	16
Sangkat Srah Chork	Khmer	3,346	24,440
	Cham	3	18
	Vietnamese	118	748
	Chinese	0	0
	Thai	0	0
	Lao	0	0
	Other	1	7

Source: Police Post of Sangkat (2015)

7) Public Hygiene and Sanitation

a) Water Supply

Phnom Penh water supply facilties have been vastly improved in terms of service standards, efficiency, cost recovery, and maintenance. Household coverage is approximately 95.7 percent. The Phnom Penh Water Supply Authority (PPWSA) has four treatment plants with a maximum daily supply capacity of 460,000 m^3 and supplies 409,746 m^3 of water per day as of 2014 (see Table 1-3-16).

Table 1-3-16 Phnom Penh water treatment plants

No.	Plant Name	Maximum Supply Capacity (m^3/da.)
1	Phum Prek WTP	170,000
2	Chroy Changva WTP	140,000
3	Niroth WTP	130,000
4	Chamkar Mon WTP	20,000
	Total:	**460,000**

Source: PPWSA web site, accessed Sept. 2015

In conformance with WHO and Cambodian standards for potable water, PPWSA inspects water quality at treatment plants 3 times daily and inspects water quality for 80 samples in its supply network once a week. Additionally, potable water quality is reported annually in the Report on Water Quality for

PPWSA, conducted by laboratories in Singapore and Shanghai. Results for 2014 water quality inspections at each treatment plant are shown in Table 1-3-17.

Table 1-3-17 PPWSA treatment plant water quality inspections

No.	Parameters	Unit	WHO Standards	Water Quality Compared With WHO Standards			
				Phum Prek	Chamka Mon	Chroy Changwa	Distribution Network
1	Turdibity	NTU	<= 5	<0.89	<1.97	<0.97	<1.03
2	pH		6.5-8.5	7.04	7.38	7.84	7.58
3	Free Chloride	mg/l	0.1-1	0.88	0.85	0.81	0.26
4	Total Chloride	mg/l	< 2	1.02	1.02	0.95	0.42
5	Total Coliform	cfu/100ml	0	0	0	0	0
6	Faecal Coliform	cfu/100ml	0	0	0	0	0
7	E. coli	cfu/100ml	0	0	0	0	0

Source: PPWSA web site, accessed Sept. 2015

According to the Phnom Penh Municipality Development Plan (2015-2019), water service penetration rates are 100 percent within the city but low in the outskirts of town. In the vicinity of the project area, the Daun Penh and Russei Keo districts on the Phnom Penh side have penetration rates of 100 percent and 99.6 percent, respectively, whereas Chrouy Changvar district has a penetration rate of 52.1 percent.

Table 1-3-18 Water service penetration rates in the study area

No.	District Name	Water Service Penetration Rate (%)
1	Daun Penh	100
2	Russei Keo	99.6
3	Chrouy Changvar	52.1

Source: Extracted from Planning Development of Phnom Penh Capital, 2015-2019.

b) Drainage and Sewerage

The sewer system in Phnom Penh is starting to improve due to commune budgets, and donor assistance through city hall. Sewerage penetration rates for the project area are given in Table 1-3-19.

Table 1-3-19 Sewerage penetration rates for the project area

Commune Name	Village Name	Sewerage Penetration Rate (%)
Chrouy Changvar	Phum 2	98.2
	Phum 3	100.0
	Phum Doemkor	72.9
Toul Sangker	Phum Toul Sangketr	100.0
	Phum Phsa Toch	97.7
Srah Chork	Phum 8	100.0
	Phum 13	100.0
	Phum 14	100.0
	Phum 15	100.0
	Phum 16	100.0
	Phum 17	100.0
	Phum 18	100.0
	Phum 19	100.0
	Phum 21	100.0

8) Solid Waste

According to the Sub-Decree on Solid Waste Management, waste management is established as being under MOE responsibilities. Further, the Cambodian Government stipulated guidelines by joint decree of the Ministry of Interior (MOI) and MOE defining penalties for illegal dumping of waste, as well as establishing dump sites for garbage in both urban and rural areas.

Waste is generally categorized by source into general waste, industrial waste, and agricultural waste. In Phnom Penh, general waste includes garbage from residential areas, markets, public facilities, office buildings, restaurants, hotels, guest houses, and recreational facilities.

General waste is collected, transported and disposed of by CINTRI, a private company. Waste disposal fees are charged monthly at $0.75-3.00 for residential districts, $5-30 for smaller commercial facilities, and $50-100 for medium- to large-scale commercial facilities (hotels, restaurants, supermarkets, bus stations, etc.).

Industrial waste is collected, transported and disposed of by Sarom Trading, another private company. Monthly disposal fees vary by industry, location, and total waste amount, with contracts signed between individual offices and the waste disposal service to decide collection frequency and other details.

As given in Table 1-3-20, access to waste collection systems in the study area by commune is 100 percent in the Srah Chork, 95 percent in Toul Sangker, and 64-97 percent in Chrouy Changvar.

Table 1-3-20 Waste collection rates for the project area

Commune Name	Village Name	Waste Collection Rate (%)
Chrouy Changvar	Phum 2	64.1
	Phum 3	97.1
	Phum Doemkor	95.9
Toul Sangker	Phum Toul Sangketr	94.8
	Phum Phsa Toch	100.0
Srah Chork	Phum 8	100.0
	Phum 13	100.0
	Phum 14	100.0
	Phum 15	100.0
	Phum 16	100.0
	Phum 17	100.0
	Phum 18	100.0
	Phum 19	100.0
	Phum 21	100.0

Source: Sangkat Profile, 2015

1-3-1-3 Cambodia Environmental and Social Systems and Organizations

(1) Legislation regarding Environmental Social Consideration

Legislation regarding environmental social considerations in Cambodia are as given in the following table:

Table 1-3-21 List of legislation regarding environmental social considerations

No.	Name of Legislation	Year Issued
1.	Constitution of Kingdom of Cambodia	1993
2.	Law on Environmental Protection and Natural Resource Management	1996
3.	Labor Law	1997
4.	Expropriation Law	2010
5.	Law on Water Resources Management	2007
6.	Sub-Decree on Environmental Impact Assessment	1999
7.	Sub-Decree on Water Pollution Control	1999
8.	Sub-Decree on Solid Waste Management	1999
9.	Sub-Decree on Air Pollution and Noise Disturbance Control	2000

Source: EURONET Consortium (2012)

(2) Environmental Standards

Cambodia environmental standards are as follows.

1) Air Quality

Table 1-3-22 Ambient Air Quality Standard

No.	Parameters	Period 1h Average mg/m^3	Period 8h Average mg/m^3	Period 24h Average mg/m^3	Period 1year Average mg/m^3
1	Carbon monoxide (CO)	40	20	-	-
2	Nitrogen dioxide (NO2)	0.3	-	0.1	-
3	Sulfur dioxide (SO2)	0.5	-	0.3	0.1
4	O zone (O3)	0.2	-	-	-
5	Lead (Pb)	-	-	0.005	-
6	Total Suspended Particulate (TSP)	-	-	0.33	0.1

Source: Sub-Decree on Air Pollution Control and Noise Disturbance, 2000
Note: This standard applies to evaluation of ambient air quality and to monitoring of air pollution status.

2) Noise

Table 1-3-23 Noise control standards for workshop, factory, and industry locations

Noise Level (dB(A))	Maximum period of time (Hour)	Level
75	32	Support ear prevention equipment to worker in place has 80 (dB(A)) over noise
80	16	
85	8	
90	4	
95	2	
100	1	
105	0.5	
110	0.25	
115	0.125	

Source: Sub-Decree on Air Pollution Control and Noise Disturbance, 2000

3) Water Quality

Table 1-3-24 Water quality standards (Rivers)

No	Parameter	Unit	Standard Value
1	pH	mg/l	6.5 – 8.5
2	BOD5	mg/l	1 – 10
3	Suspended Solid	mg/l	25 – 100
4	Dissolved Oxygen	mg/l	2.0 - 7.5
5	Coliform	MPN/100ml	< 5000

Source: Sub-Decree on Water Pollution Control, 1999

Table 1-3-25 Water quality standards (Lakes and reservoirs)

No	Parameter	Unit	Standard Value
1	pH	mg/l	6.5 – 8.5
2	COD	mg/l	1 – 8
3	Suspended Solid	mg/l	1 – 15
4	Dissolved Oxygen	mg/l	2.0 - 7.5
5	Coliform	MPN/100ml	< 1000
6	Total Nitrogen	mg/l	– 0.6
7	Total Phosphorus		

Source: Sub-Decree on Water Pollution Control, 1999

Table 1-3-26 Water quality standards (Coastal waters)

No	Parameter	Unit	Standard Value
1	pH	mg/l	7.0 – 8.3
2	COD	mg/l	2 – 8
3	Dissolved Oxygen	mg/l	2 - 7.5
4	Coliform	MPN/100ml	< 1000
5	Oil content	mg/l	0
6	Total Nitrogen	mg/l	– 1.0
7	Total Phosphorus	mg/l	0.02 – 0.09

Source: Sub-Decree on Water Pollution Control, 1999

4) Soil

Cambodia does not have any environmental standards for soil.

(3) Environmental Social Consideration-Related Organizations

The Cambodian MOE is the authority for supervision and management of environmental organizations in Cambodia, according to sub-decrees and related legislation on Environmental Impact Assessments (EIA), air and water pollution management, and solid waste management. Article 3 of the Sub-Decree on Environmental Impact Assessment Process lists the following roles for the MOE:

1) Evaluation and review of EIA reports in cooperation with relevant ministries
2) Monitoring and observing that the project sponsor is in compliance with the environmental management plan

(4) Environmental Permit Authorization Process

The process for authorization of environmental permits is stipulated in the Law on Environmental Protection and Natural Resource Management and the Sub-Decree on the Environmental Impact Assessment Process.

The project sponsor (MPWT for this project) submits an application to the MOE, with an EIA report attached. The MOE reviews and evaluates the EIA report within 30 days of submission and decides whether or not to approve the application. For re-applications, the project sponsor re-submits to the MOE with a revised EIA report, and the MOE again reviews and evaluates the re-submitted EIA report within 30 days to decide whether or not to approve.

1-3-1-4 Scoping

Based on the JICA Guidelines for Environmental Social Consideration (April 2010), scoping was performed for this project to select items expected to have environmental impact. The scoping results are given in Table 1-3-27.

Table 1-3-27 Scoping plan

Impacts			Evaluation		Reasons for Assessment
			Before/During Construction	After Handoff	
Contamination Measures	1	Air pollution	D/B-	B-	Before: No work that will cause air pollution. During: Air quality expected to worsen due to traffic jams during road closures. Air pollution could be temporarily worsened due to moving of equipment and operation of heavy machinery. After: Depending on level of traffic increases, some impact to air quality expected from vehicle emissions. Conversely, impact of air pollution from vehicles will be mitigated by improved travel performance.
	2	Water pollution	D/B-	D	Before: No work that will cause water pollution. During: Wastewater from the construction site/worker camp and oil/grease from heavy machinery and vehicles may leak and result in water pollution. After: No water pollution expected that would impact the area environment.
	3	Solid waste	D/B-	D	Before: No work that will produce waste. During: Earthwork could produce soil waste. After: No waste expected that would impact the area environment.

Impacts			Evaluation		Reasons for Assessment
			Before/During Construction	After Handoff	
	4	Soil pollution	D/B-	D	Before: No work that will cause soil pollution. During: Oil and fluids may leak from heavy machinery and vehicles and cause soil pollution. After: No soil pollution expected that would impact the area environment.
	5	Noise and vibration	D/B-	B-	Before: No work that will make noise or vibration. During: Operation of heavy machinery and equipment during construction may cause noise and vibration. After: Noise impact from vehicle traffic is possible.
	6	Ground Subsidence	D	D	As bridge repair and renovation work in this project will not include any large-scale pumping, there will be no ground subsidence.
	7	Foul odors	D	D	No work producing foul odors is anticipated in bridge repair and renovation work in this project.
	8	Sediment	D	D	No work impacting sediment is anticipated in bridge repair and renovation work in this project.
Natural Environment	9	Protected areas	D	D	There are no national parks or protected areas in or near the project site.
	10	Ecosystems	D	D	Bridge repair and renovation work in this project is not anticipated to bring about any major changes to ecosystems. Also, there are no rare species living in or near the project site.
	11	Hydrological phenomena	D/B-	C-	Before: No work that will impact hydrology. During: With bridge replacement, in-river work on piers and other areas may impact river flow patterns. After: New erection of piers in the river is expected to make localized changes to river flow patterns.
	12	Topography and geology	D	D	While this project is for construction of new bridges and banking and earthwork is planned around the connected road, there will be no large alterations made to terrain and thus almost no impact is expected to topography and geology.
Social environment	13	Resettlement	C-/D	D	Before: While this project is for bridge repairs and rehabilitation, some residents are expected to be relocated, depending on where the construction yard is located. During/After: No resettlement.
	14	Poverty	C-/C-	C-	Before: There may be some poor living in the vicinity of the existing bridges. During: As the levels of poverty in the vicinity of the project site are unknown, impacts are unknown. After: Repair and rehabilitation of the existing bridges is expected to have a positive effect on the Cambodian economy, but the economic ripple effects on the poor are unknown.
	15	Ethnic minorities and indigenous peoples	D	D	There are no ethnic minorities or indigenous peoples living in or near the project site.
	16	Local economy (employment, livelihood, etc.)	B-/B+	B+	Before: Resettlement could have some impact on the local economy and the livelihood of some. During: Construction is expected to have a positive effect on the local economy. After: Repair and rehabilitation of the existing bridges is expected to have a positive effect on the Cambodian economy and a certain positive effect on the local economy.
	17	Land and local resource usage	B-/D	D	Before: Resettlement could have an impact on how some land is used. During/After: As this project is for repair and rehabilitation of existing bridges, it is not anticipated to impact local land and resource usage during the work.
	18	Water usage	D/C-	D	Before: No work that will impact water usage. During: Since the project is bridge repair and rehabilitation, substructure work, etc. to be conducted in the river is anticipated, causing impact from turbid water. After: No work that will impact water usage.

		Impacts	Evaluation		Reasons for Assessment
			Before/During Construction	After Handoff	
	19	Existing social infrastructure and services	D/B-	B+	Before: No work that will impact existing social infrastructure and services. During: Road closures on the existing bridge are expected to cause traffic jams. Also, noise and vibrations from demolition of the existing bridge could impact area schools. After: Bridge repair and rehabilitation is expected to have a positive impact on access to existing social infrastructure and services.
	20	Social organization (social capital, local deciding bodies, etc.)	D	D	This project is for bridge repair and rehabilitation and should not impact social capital or local deciding bodies much at all.
	21	Maldistribution of damage and benefits	D	D	This project is for bridge repair and rehabilitation and should not impact distribution of damage and benefits in the local area much at all.
	22	Local conflicts of interest	B-/D	D	Before: Some land acquisition and resettlement is expected, which could cause local conflicts of interest. During/After: There should be almost no local conflicts of interest.
	23	Cultural heritage sites	D	D	There are no cultural heritages sites located in or near the project area.
	24	Landscape	D	D	No work that will impact landscape.
	25	Gender relations	D	D	No gender discrimination expected due to the project.
	26	Children's rights	D/C-	D	Before: No impacts expected. During: Study is required regarding the possibility of unfair child labor and other practices. After: No impacts expected.
	27	Infectious disease (HIV/AIDS, etc.)	D/C-	D	Before: No impacts to HIV/AIDS and other infectious diseases expected. During: While an increase HIV/AIDS and other infections due to an influx of workers is possible, this is unknown. After: No impacts from HIV/AIDS and other infectious diseases expected.
	28	Work environments (incl. work safety)	D/C-	D	Before: No impacts expected. During: Study is required regarding the possibility of workers being forced to work under poor conditions. After: No impacts expected.
Other	29	Accidents	D/B-	D	Before: No work is expected to cause an accident. During: There could be an accident during the work. After: No work is expected to cause an accident.
	30	Transnational impacts and climate change	D	D	This project is for bridge repair and rehabilitation and should not result in any transnational impacts or climate change.
Overall evaluation			B+	B+	

Assessments:

A+/-: Expected to have major (serious) positive/negative impact
B+/-: Expected to have a somewhat positive/negative impact
C+/-: Level of positive/negative impact currently unknown
D: Almost no negative impact.

1-3-1-5 Terms of Reference for Environmental Impact Assessment

Study methods for the environmental items narrowed down from the scoping assessments is given in the Terms of Reference (TOR) in Table 1-3-28.

Table 1-3-28 TOR for environmental impact items

Environmental Item	Study Item	Study Method
Air pollution	▪ Environmental standards, etc. ▪ Current air quality conditions ▪ Impacts during construction	▪ Evaluate existing material ▪ Evaluate existing material, measure air quality ▪ Confirm work details
Water pollution	▪ River water quality	▪ Evaluate existing material, measure water quality
Solid waste	▪ Impacts during construction	▪ Confirm work details
Soil pollution	▪ Impacts during construction	▪ Confirm work details
Noise and vibration	▪ Environmental standards, etc. ▪ Distance from sources to impacted areas ▪ Impacts during construction	▪ Evaluate existing material ▪ Field exploration and interviews ▪ Confirm work details
Hydrological phenomena	▪ Impacts during construction	▪ Confirm work details
Resettlement	▪ Scale of land acquisition and resettlement ▪ Simple resettlement plan	▪ Field exploration, confirm scope with UAV images ▪ Adjust MPWT proposed plans
Poverty	▪ Current conditions for the poor	▪ Field exploration and interviews
Local economy (employment, livelihood, etc.)	▪ Area resident employment and livelihoods	▪ Field exploration and interviews
Land and local resource usage	▪ Land use survey ▪ Current local resource usage	▪ Evaluate existing material, field exploration ▪ Field exploration and interviews
Water usage	▪ Current local water usage	▪ Field exploration and interviews
Existing social infrastructure and services	▪ Social infrastructure existing in the area	▪ Evaluate existing material, field exploration
Local conflicts of interest	▪ Items related to compensation for land acquisitions and resettlement	▪ Evaluate existing materials, interview relevant agencies
Children's rights	▪ Working conditions	▪ Evaluate existing materials, interview relevant agencies
Infectious disease (HIV/AIDS, etc.)	▪ HIV/AIDS infection rates near the project area	▪ Evaluate existing material
Work environments (incl. work safety)	▪ Working conditions	▪ Evaluate existing materials, interview relevant agencies
Accidents	▪ Working conditions	▪ Evaluate existing materials, interview relevant agencies

1-3-1-6 Study of Environmental and Social Considerations

Results for the study of environmental and social considerations of the environmental items based on the TOR for EIAs follow below.

(1) Air Pollution

With Chroy Changwar Bridge acting as origin point for National Road 6A, heavy traffic was confirmed with motorcycles, scooters and cars traveling at slow speeds (there are restrictions on heavy vehicle traffic). Pre-construction air quality is currently being confirmed. With Chroy Changwar Bridge closed to traffic during the construction period, traffic in both directions will use the adjacent China Bridge. This is expected to cause heavy traffic jams and have a negative impact on the area. Additionally, exhaust and particulate from heavy machinery during construction is another possible negative. After bridge maintenance, heavy vehicles will be permitted, and traffic is expected to increase. Still, the bridge will ensure smooth flow of traffic, and local air pollution should be limited.

(2) Water pollution

With repairs on the steel bridge section taking place in the river, there are concerns of water pollution during construction, both from wastewater from the work site and worker camp as well as from oil and grease leaks from heavy machinery and work vehicles. Also, it has been confirmed that the steel bridge section of the current bridge was painted with lead-based paint, which is hazardous. When the paint is peeled, some of the paint may be scattered.

(3) Solid Waste

The PC bridge section will be dismantled and removed, producing much industrial waste in the form of concrete scraps. Earthwork could also produce soil waste, but not a significant amount.

(4) Soil Pollution

Oil and fluids may leak from heavy machinery and construction equipment at the construction site and cause localized soil pollution. As materials requiring care will be handled in the construction yard and plant installation area, such as oil from heavy machinery and construction equipment in the parking area and heavy oil from the asphalt plant, there are also concerns of operations polluting the soil in borrowed land.

(5) Noise and Vibration

With there being residential areas adjacent to the Chroy Changwar Bridge, particularly around the PC bridge on the Phnom Penh side, where there are primary schools, middle schools, and high schools, there are concerns of the noise and vibrations from operation of heavy machinery and construction equipment during construction. The dismantling and removal of the PC bridge section is expected to result in considerable noise and vibrations.

(6) Hydrological Phenomena

Of the piers on the steel bridge section, piers P3 through P7 are located in the river. However, as the work on the steel bridge section is to be for repairs of the existing bridge, some in-river work is expected, but it should not impact river flow. After handoff as well, there will be no change in positioning for the piers and other in-river structures, and no changes to river flow are anticipated.

(7) Resettlement

There will be no resettlement on the Phnom Penh side of Chroy Changwar Bridge. On the Chrouy Changvar side, there are residences directly adjacent to the bridge. At most, up to a confirmed 21 residences will have to be relocated. In terms of compensation for land acquisitions and resettlement, care will be needed not to deviate too greatly from market rates. In addition to compensation payment, monitoring for project-affected persons (PAPs) will also be needed.

(8) Poverty

Household income for local residents around the Chroy Changwar Bridge is equal to or above the range of $2,000-3,000 per year. There are no poor living in the area.

(9) Ethnic Minorities and Indigenous People

Ethnic minorities and indigenous people who are politically and socially marginalized and have troubles of living their life and economi activities as the Cambodian are not confirmed.

(10) Local Economy (Employment, Livelihood, Etc.)

Bridge repair and rehabilitation will ensure safe bridge passage and allow for use by heavy vehicles. This is expected to benefit regional distribution and grow the local economy.

(11) Land and Local Resource Usage

The work and resettlement will have almost no impact on land usage and local resource usage.

(12) Water Usage

Usage of river water for daily water and drinking water has not been confirmed. Some of the work is expected to take place in the river during construction, but impacts will be limited.

(13) Existing Social Infrastructure and Services

Clinics and mosques have been confirmed to be in the vicinity of Chroy Changwar Bridge. Safe access to this social infrastructure will need to be secured during the construction period. After handoff, access is expected to improve slightly.

(14) Local Conflicts of Interest

There will be some involuntary resettlement on the Chrouy Changvar side of the Chroy Changwar Bridge. If PAPs are mistreated before construction commences, there could be local conflicts of interest. Care must be taken.

(15) Children's Rights

School attendance among children around the project area is high, and children's rights are thought to be upheld.

(16) Infectious Disease (HIV/AIDS, Etc.)

Care must be taken that infection rates for HIV/AIDS and other infection diseases does not increase with the influx of workers for the work.

(17) Working Conditions

In order to ensure proper work conditions for workers during the construction period, considerations are needed to improve working conditions, including the work camp, provision of worker transportation, and upholding the legal minimum wages.

(18) Accidents

Confirmations near Chroy Changwar Bridge showed that there was much motorcycle, scooter and tuk-tuk traffic, as well as many vehicles that did not follow traffic rules (driving against traffic, etc.). With Chroy Changwar Bridge closed during construction work, traffic is expected to be concentrated on the China Bridge, which will increase traffic accident rates and road fatalities. Measures to ensure road traffic safety will likely be necessary.

1-3-1-7 Impact Assessment

The following is an impact assessment of the project components based on the Environmental and Social Evaluation results in the previous section.

Table 1-3-29 Environmental Impact ssessment

Impacts			Impact Assessment at Scoping		Impact Assessment Based on Study Results		Reasons for Assessment
			Before/During Construction	After Handoff	Before/ During Construction	After Handoff	
Contamination Measures	1	Air pollution	D/B-	B-	D/B-	B-	During: Air quality expected to worsen due to traffic jams during road closures. Air pollution could be temporarily worsened due to moving of equipment and operation of heavy machinery. After: While there may be an impact from noise from vehicle traffic, it is expected to meet environmental standards the same as it does currently. Also, impact of air pollution from vehicles may be mitigated by improved travel performance.
	2	Water pollution	D/B-	D	D/B-	D	During: Wastewater from the construction site/worker camp and oil/grease from heavy machinery and vehicles may leak and result in water pollution.
	3	Solid waste	D/B-	D	D/B-	D	During: Dismantling and removal of the old bridge will produce much industrial waste in the form of concrete scraps. Earthwork will produce soil waste, but this would be small in scale.
	4	Soil pollution	D/B-	D	D/B-	D	During: Oil and fluids may leak from heavy machinery and vehicles and cause soil pollution on the work site and in the construction yard.
	5	Noise and vibration	D/B-	C-	D/B-	B-	During: Operation of heavy machinery and equipment during construction may cause noise and vibration. In particular, the dismantling and removal of the PC bridge section will result in considerable noise and vibrations. After: Depending on how much traffic increases, vehicle traffic could impact noise. Conversely, the smoother travel could reduce noise from current levels.
	6	Ground subsidence	D	D	D	D	－
	7	Foul odors	D	D	D	D	－
	8	Sediment	D	D	D	D	－
Natural Environment	9	Protected areas	D	D	D	D	－
	10	Ecosystems	D	D	D	D	－
	11	Hydrological phenomena	D/B-	D	D/D	D	During: There will be repairs and reinforcement to the steel bridge section of the bridge in the river. There will be no in-river work or new pier installation that would impact river flow.
	12	Topography and geology	D	D	D	D	－

Impacts			Impact Assessment at Scoping		Impact Assessment Based on Study Results		Reasons for Assessment
			Before/During Construction	After Handoff	Before/ During Construction	After Handoff	
Social Environment	13	Resettlement	C-/D	D	B-/D	D	Before: There are 21 households confirmed that need to be relocated on the east side (Chrouy Changvar side) of the bridge. An appropriate resettlement plan must be prepared and executed.
	14	Poverty	C-/C-	C+	D	D	Before: There are no poor in the area near the project site. During: There are no poor in the area near the project site. After: There are no poor in the area near the project site.
	15	Ethnic minorities and indigenous peoples	D	D	D	D	―
	16	Local economy (employment, livelihood, etc.)	B-/B+	B+	D/B+	B+	Before: Resettlement could have some impact on the local economy and the livelihood of some, but it will be small in scale and limited. During: Construction is expected to have a positive effect on the local economy. After: Repair and rehabilitation of the existing bridge is expected to have a positive effect on the Cambodian economy and a certain positive effect on the local economy.
	17	Land and local resource usage	B-/D	D	B-/D	D	Before: Resettlement could have an impact on how some land is used.
	18	Water usage	D/C-	D	D	D	During: No activity is expected that will impact water usage in the area scheduled for construction.
	19	Existing social infrastructure and services	D/B-	B+	D/B-	B+	During: Road closures on the existing bridge are expected to cause traffic jams. Also, noise and vibrations from demolition of the existing bridge could impact area schools. Access must be secured to the clinic, mosque and other social infrastructure. After: Bridge repair and rehabilitation is expected to have a positive impact on access to existing social infrastructure and services.
	20	Social organization (social capital, local deciding bodies, etc.)	D	D	D	D	―
	21	Maldistribution of damage and benefits	D	D	D	D	―
	22	Local conflicts of interest	B-/D	D	B-/D	D	Before: Some land acquisition and resettlement is expected. This could cause local conflicts of interest if PAPs are not treated properly.
	23	Cultural heritage sites	D	D	D	D	―
	24	Landscape	D	D	D	D	―
	25	Gender relations	D	D	D	D	―

Impacts			Impact Assessment at Scoping		Impact Assessment Based on Study Results		Reasons for Assessment
			Before/During Construction	After Handoff	Before/ During Construction	After Handoff	
	26	Children's rights	D/C-	D	D	D	During: School attendance around the project area is high. The likelihood of unfair child labor is extremely low.
	27	Infectious disease (HIV/AIDS, etc.)	D/C-	D	D/C-	D	During: While an increase HIV/AIDS and other infections due to an influx of workers is possible, this is unknown.
	28	Work environments (incl. work safety)	D/C-	D	D/C-	D	During: Working environment for construction workers must be considered in conformance with labor laws.
Other	29	Accidents	D/B-	D	D/B-	D	During: There could be an accident during the work.
	30	Transnational impacts and climate change	D	D	D	D	―

Assessments:

A+/-: Expected to have major (serious) positive/negative impact
B+/-: Expected to have a somewhat positive/negative impact
C+/-: Level of positive/negative impact currently unknown
D: Almost no negative impact expected

1-3-1-8 Mitigation Measures and Their Implementation Costs

Mitigation measures for environmental items assessed as having negative impacts in the previous section are given in Table 1-3-30.

Table 1-3-30 Mitigation measures for anticipated impacts

No	Environmental Item	Mitigation Measure	Implementing Body	Responsibility	Costs
Before and During Construction					
1	Air pollution	▪ Install traffic signage to mitigate traffic jams ▪ Regular maintenance and inspection of heavy machinery and construction vehicles	Construction contractor	MPWT	Construction costs
2	Water pollution	▪ Using oil booms/preventive nets during pier construction ▪ Regular maintenance and inspection of heavy machinery and construction vehicles	Construction contractor	MPWT	Construction costs
3	Solid waste	▪ Reuse construction soil and waste when possible ▪ Dispose of waste appropriately at disposal sites and facilities	Construction contractor	MPWT	Construction costs
4	Soil pollution	▪ Regular maintenance and inspection of heavy machinery and construction vehicles (check for oil leaks)	Construction contractor	MPWT	Construction costs
5	Noise and vibration	▪ Use low-noise, low-vibration heavy machinery ▪ Prohibit night work	Construction contractor	MPWT	Construction costs
13	Resettlement	▪ Design to minimize resettlement ▪ Prepare an appropriate resettlement plan	MPWT	MPWT	Cambodian Government Budget

15	Ethnic Minorities and Indigenous People	▪ Prepare an appropriate resettlement plan.	MPWT	MPWT	Cambodian Government Budget
17	Land and local resource usage	▪ Prepare fair resettlement plan to prevent disputes over relocation destinations	MPWT	MPWT	Cambodian Government Budget
19	Existing social infrastructure and services	▪ Mitigate impacts of noise and vibration to schools (see 5. "Noise and vibration") ▪ Secure access to clinic and mosque during construction (design phase)	Consultant Construction contractor	MPWT	Construction costs
22	Local conflicts of interest	▪ Prepare fair resettlement plan without disparities between the relocated residents and those that stay	MPWT	MPWT	Cambodian Government Budget
27	Infectious disease (HIV/AIDS, etc.)	▪ Enact sanitation measures and HIV/AIDS and infectious disease awareness and education for construction workers	Construction contractor	MPWT	Construction costs
29	Accidents	▪ Thorough safety education for all construction workers ▪ Asisgn flaggers during heavy machinery operation	Construction contractor	MPWT	Construction costs
After Handoff					
5	Noise and vibration	▪ Install proper traffic signage ▪ Repair potholes and uneven pavement	MPWT	MPWT	Cambodian Government Budget

1-3-1-9 Monitoring Plan

The measures discussed to mitigate the expected environmental loads will be monitored and managed during and after the construction to ensure they are being implemented properly.

The required environmental items will be monitored by the construction contractor under management of the consultant, with reports made to the implementing body, MPWT. During operation, the bridge will be monitored by MPWT, who is in charge of bridge operation and maintenance.

Table 1-3-31 Monitoring plan

Environmental Item		Monitored Item	Location	Frequency	Implementing Body
Before and During Construction					
1	Air pollution	▪ CO, NO_2, SO_2, TSP	Around work site	Twice/yr.	Construction contractor
2	Water pollution	▪ pH, SS	Around work site	Twice/yr.	Construction contractor
3	Solid waste	▪ Records for transport of construction waste to disposal sites	Work site	Monthly	Construction contractor
4	Soil pollution	▪ Regular maintenance and inspection records for heavy machinery and construction vehicles (incl. oil leak inspections)	Around work site	Monthly	Construction contractor
5	Noise and vibration	▪ Noise and vibration levels ▪ Usage of low-noise, low-vibration heavy machinery	Around work site Work site	Twice/yr. Monthly	Construction contractor Construction contractor
13	Resettlement	▪ Resettlement plan	Chrouy Changvar side near bridge	Twice	MPWT

27	Infectious disease (HIV/AIDS, etc.)	▪ Infection records	Work site	Monthly	Construction contractor
29	Accidents	▪ Accident records	Work site	Monthly	Construction contractor
After Handoff					
5	Noise and vibration	Noise and vibration levels	Around work site	Twice	MPWT

The construction contractor is to assign environmental and safety staff and prepare plans for monitoring and preserving safety and sanitation to be approved by MPWT. The construction management consultant is to monitor status of this activity and report revisions made when standards are not met, and the construction contractor is to implement any such revisions.

The construction contractor and construction management consultant are to report to MPWT in monthly reports. As necessary, meetings will be held between the three parties.

1-3-1-10 Stakeholder's Meeting

Explanatory meetings for inhabitants must be held, and the meeting outcomes must be attached when the project IEIA is submitted. Stakeholder Meetings were held in three communes in the area hear the project site on September 16-23, 2015. Although inhabitants were affirmative to the implementation of the project, many were concerned about traffic congestion. The following shows the summary and contents of the Stakeholder Meetings.

Table1-3-32 Summary and contents of Stakeholder Meeting (Sangkat Chrouy Changwar)

Date	September 16, 2015 at 8:00 a.m. - 11:00 a.m.
Place	Sangkat Chroy Changwar Office
Districts	Relevant inhabitants of Villages Daeum Kor, Phum 2, and Phum 3
Participants	Village Daeum Kor: 3 men, 5 women Village Phum 2: 8 men, 10 women Village Phum 3: 5 men, 10 women Total: 16 men, 25 women
Discussion details and situation	<u>Discussion</u> ▪ The secretariat explained the Chroy Changwar Bridge project. ▪ Inhabitants gave the following opinions about the project. ▸ They agreed to the rehabilitation of Chroy Changwar Bridge, as it is very old. ▸ They wanted constructors to build a high-quality long-lasting bridge. ▸ They wanted MPWT to install traffic signs and station traffic controllers to cope with traffic congestion. ▸ They were glad to hear about bridge rehabilitation, as Chroy Changwar Bridge was showing signs of damage. ▪ Inhabitants understood the project, and were 100% supportive of the project. <u>Scenes from the meeting</u>

Source: JICA Study Team

Table1-3-33 Summary and contents of Stakeholder Meeting (Sangkat Srah Chork9)

Date	September 17, 2015 at 8:00 a.m. - 11:00 a.m.
Place	Sangkat Srah Chork Office
Districts	Relevant inhabitants of Villages Phum 8, Phum 13, Phum 14, Phum 15, Phum 16, Phum 17, and Phum 18
Participants	Village Phum 8: 2 men, 0 women Village Phum 13: 1 man, 3 women Village Phum 14: 2 men, 4 women Village Phum 15: 4 men, 7 women Village Phum 16: 2 men, 3 women Village Phum 17: 2 men, 4 women Village Phum 18: 2 men, 0 women Total: 13 men, 23 women
Discussion details and situation	Discussion ▪ The secretariat explained the Chroy Changwar project. ▪ Inhabitants gave the following opinions about the project. ▸ They wanted rehabilitation to make the bridge as good as the China bridge. ▸ They wanted traffic to be secured during rehabilitation work. ▸ They agreed to the rehabilitation of Chroy Changwar Bridge. ▸ They wanted higher handrails than those on the existing bridge. ▸ They were glad that Chroy Changwar Bridge would be rehabilitated by Japan. ▸ They support the project, and looked forward to early beginning of the project. ▸ Improvement of Chroy Changwar Bridge would facilitate safe and convenient transport to Phnom Penh. ▪ Inhabitants understood the project, and were 100% supportive of the project.

Source: JICA Study Team

Table1-3-34 Summary and contents of Stakeholder Meeting (Village Toul Sangker, Sangkat Toul Sangker)

Date	September 21, 2015 at 8:00 a.m. - 11:00 a.m.
Place	Village Toul Sangker Office
Districts	Relevant inhabitants of Village Toul Sangker
Participants	Village Toul Sangker: 7 men, 18 women
Discussion details and situation	(Discussion) ▪ The secretariat explained the Chroy Changwar Bridge project. ▪ Inhabitants gave the following opinions about the project. ▸ They agreed to the rehabilitation of Chroy Changwar Bridge. ▸ They wanted project implementing body or constructor to excercise traffic control for the benefit of passengers and students commuting to schools. ▸ They agreed to the rehabilitation of Chroy Changwar Bridge, as it is old and partially damaged. ▸ Although they supported the project, they wanted measures to prevent traffic congestion. ▪ Inhabitants understood the project, and were 100% supportive of the project.

Source: JICA Study Team

Table1-3-35 Summary and contents of Stakeholder Meeting (Village Phas Toch, Sangkat Toul Sangker)

Date	September 23, 2015 at 8:00 a.m. - 11:00 a.m.
Place	Village Phas Toch Office
Districts	Relevant inhabitants of Village Phas Toch
Participants	Village Phas Toch: 13 men, 9 women
Discussion details and situation	(Discussion) ▪ The secretariat explained the Chroy Changwar Bridge project. ▪ Inhabitants gave the following opinions about the project. ▸ Although they supported the project, they were concerned that traffic congestion might prevent them from going to work on time. ▸ They supported the project, as the rehabilitation of Chroy Changwar Bridge would improve traffic. ▸ Confirmation of water canals should be conducted before construction. During the construction of the China bridge in the past, the bridge foundation work affected water canals and prevented the flow of water from the area. ▸ Lighting fixtures should be moved to the side with handrails. ▪ Inhabitants understood the project, and were 100% supportive of the project.

Source: JICA Study Team

1-3-2 Abbreviated Resettlement Action Plan

1-3-2-1 Necessity of Land Acquisition and Resident Relocation

This project is for repair and rehabilitation of the Chroy Changwar Bridge, which crosses the Tonle Sap River and serves as the origin point of National Road 6A, heading from Phnom Penh to the northwest of Cambodia. Chroy Changwar Bridge is located in the northwest of downtown Phnom Penh.

As this project is for repair and rehabilitation of the Chroy Changwar Bridge, it will not involve any rerouting of the road, keeping the need for land acquisitions and resettlement relatively low. That being said, there are residences very close to the Chroy Changwar Bridge on the Chrouy Changvar side. Also, land acquisitions and resettlement are expected to be required to secure land for the construction yard. At most, 21 residences will need to be relocated.

1-3-2-2 Legal Framework and Relevant Agencies to Land Acquisition and Resident Relocation

(1) Legislation

Cambodian legislation and policy concerning resettlement are found in the table below.

Table 1-3-36 List of legislation regarding resettlement policy

Legal Function	Name of Legislation
Constitution	Constitution (1993)
Civil Code	Civil Code (2007)
Land Management and Registration	Land Law (2001)
	Prakas on Collection of Tax on Unused Land (1996)
Land Expropriation	Expropriation Law (2010)
Concessions	Sub-Decree on Social Land Concessions (March 19, 2003) Sub-Decree on Economic Land Concessions (December 27, 2003)
Resettlement	Sub-Decree on Addressing Socio-Economic Impacts caused by Development Projects
	Compensation Price List of Affected Property (Feb 3, 2000)
Illegal Occupation	Sechkdey Prakas No. 6: Measures to Crack Down on Anarchic Land Grabbing and Encroachment (Sep 27, 1999)
	Letter No. 961: (Sep 6, 2000)
	Circular on Settlement of the illegal construction on the state land in citieis and uban areas (May 31, 2010)
Road Rights of Way (ROW)	Sub-Decree on Right of way of National road Channels and Railroads of the Kingdom of Cambodia (Nov 23, 2009)

Source: JICA Study Team

(2) Comparison of JICA Guidelines and Partner Country Legislation

A comparison of Cambodian legislation concerning resettlement applicable to this project and JICA Guidelines is arranged below, together with the strategy proposed for the project upon review of this comparison.

Table 1-3-37 Comparison of JICA Guidelines and Cambodia Legislation

	JICA Guidelines	Cambodian Legislation	Differences with JICA Guidelines	Strategy Proposed for the Project
1	"Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives."	In Declaration No.376 Brk.bst on General Guidelines for Conducting Initial and Full Environmental Impact Assessment Reports (Sept. 2009), a checklist is given of strategies for avoiding resettlement.	No gap with JICA Guidelines.	None.
2	"When population displacement is unavoidable, effective measures to minimize impact and to compensate for losses should be taken."	While there is no effective legislation or system regarding compensation strategy, with development aid, measures basically proceed according to donor policy.	There is a gap in terms of legislation, but no perceivable gap if things are allowed to proceed according to JICA Guidelines.	Introduce a system for monitoring effective measures and confirming their relevance.
3	"People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels."	While there is no effective legislation or system built around a compensation strategy that will improve or at least restore living standards, with development aid, compensation and assistance is basically provided according to donor policy.	Compensation and assistance is not clearly defined as accounting for PAP life after relocation. There will be no perceivable gap if things are allowed to proceed according to JICA Guidelines.	Introduce a system of monitoring PAPs to check on their lives and economic activity after relocation, and taking additional measures when their living standards or income opportunities are confirmed to have dropped sharply after relocation.
4	"Compensation must be based on the full replacement cost as much as possible."	Article 22 of the Expropriation Law (2010) stipulates that monetary compensation for sites that must be expropriated is basically to be the reacquisition price.	No gap with JICA Guidelines.	Follow up with PAPs after relocation by monitoring to ensure that they are compensated at the reacquisition price. If monitoring brings up questions on adequacy of compensation, take steps to pay more or provide more support.
5	"Compensation and other kinds of assistance must be provided prior to displacement."	While there is no effective legislation or system regarding strategy on timing for compensation, with development aid, measures basically proceed according to donor policy.	There is a gap in terms of legislation, but no perceivable gap if things are allowed to proceed according to JICA Guidelines.	None.
6	"For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. Preferably, the resettlement plan will include items stipulated in OP4.12 Annex A of the World Bank Safeguard Policies."	According to Article 16 of the Expropriation Law (2010), information on compensation and other details in the resettlement plan for PAPs is to be shared in resident consultations.	Resettlement plan is not made available to the public.	Introduce an online or otherwise browseable system and make the resettlement plan available to the public.

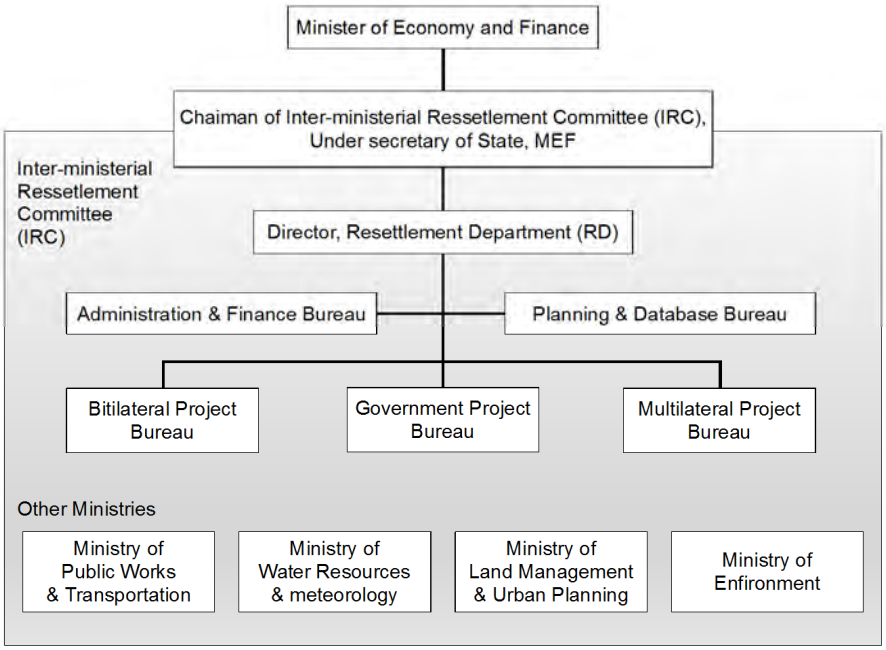
	JICA Guidelines	Cambodian Legislation	Differences with JICA Guidelines	Strategy Proposed for the Project
7	"In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance. When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people."	According to Article 16 of the Expropriation Law (2010), information on compensation and other details in the resettlement plan for PAPs is to be shared in resident consultations. The system has no stipulations on releasing the information in advance.	While the system calls for sharing information to PAPs and the community in consultations, whether or not to make sufficient information available in advance is treated on a case-by-case basis.	Take appropriate actions, including making information publicly available to PAPs in advance.
8	"Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans."	Article 16 of the Expropriation Law (2010) stipulates that consultations be conducted to share with the PAPs information on compensation and other details in the resettlement plan.	No gap with JICA Guidelines.	None.
9	"Appropriate and accessible grievance mechanisms must be established for the affected people and their communities."	Article 14 of the Expropriation Law (2010) stipulates that grievance mechanisms be established. (For public works only)	No gap with JICA Guidelines.	Introduce an initiative to review the appropriateness of grievance mechanisms.
10	"Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advance of such benefits." (WB OP4.12 Para.6)	While there are no detailed guidelines on study items for resettlement plans, with development aid, measures basically proceed according to donor policy.	There is a gap in terms of legislation, but no perceivable gap if things are allowed to proceed according to JICA Guidelines.	None.
11	"Eligibility of Benefits include, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying."	While there is no legislation defining the groups eligible for benefits, with development aid, measures basically proceed according to donor policy.	There is a gap in terms of legislation, but no perceivable gap if things are allowed to proceed according to JICA Guidelines.	None.
12	"Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based." (WB OP4.12 Para.11)	While there are no legal stipulations for land-based compensation, with development aid, measures basically proceed according to donor policy. Also, there have been cases in recent years of land-based relocation options being provided.	There is a gap in terms of legislation, but no perceivable gap if things are allowed to proceed according to JICA Guidelines.	None.

	JICA Guidelines	Cambodian Legislation	Differences with JICA Guidelines	Strategy Proposed for the Project
13	"Provide support for the transition period (between displacement and livelihood restoration)." (WB OP4.12 Para.6)	While no support in the transition period is explicitly specified for, living, farming and other economic activity on the acquired land by displaced persons has been tacitly tolerated up until work commences.	No active assistance for relocation or rebuilding of livelihoods during the transition period.	Establish a contact point to ensure relocation and livelihood assistance, and monitor PAPs for follow-up.
14	"Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc." (WB OP4.12 Para.8)	The Sub-Decree on Social Land Concessions (Mar. 19, 2003) stipulates provision of alternate sites for the poor and landless, disaster victims, and other vulnerable groups.	No gap with the JICA Guidelines. Leglislation stipulates systematic considerations for vulnerable groups when land is expropriated. No clear policies for compensation other than providing alternate land.	Monitor the situation to ensure steps are taken to consider vulnerable groups. Take steps to systematize these items so that vulnerable groups are always considered in the future.
15	"For projects that entail land acquisition or involuntary resettlement of fewer than 200 people, abbreviated resettlement plan is to be prepared." (WB OP4.12 Para.25)	While no legislation stipulates that a resettlement plan be prepared, with development aid, measures basically proceed according to donor policy.	No gap with JICA Guidelines.	None.

Source: JICA Study Team

(3) Relevant Agencies

The agency executing resettlement for the project will be the executive agency, MPWT, and MPWT is to develop a Resettlement Action Plan (RAP). However, an Inter-Ministerial Resettlement Committee (IRC) is to be arranged under the Ministry of Economy and Finance (MEF) to consider all existing legislation and historical cases and closely review the required RAP provisions on compensation, including the entitlement matrix, lost property evaluations, coordination with PAPs, and monitoring. The IRC will comprise staff from agencies with ties to the project. In addition, the IRC will have a Resettlement Department (RD) to assist with IRC activity by conducting all related clerical work when coordination with the relevant ministries and organizations is required. There is also a Municipality Resettlement Sub-Committee (MRSC), a body based on municipality-level governmental agencies comprising the Phnom Penh governor, vice governor, director-class administrators, and representatives of the districts where the resettlement is to occur. The MRSC will deliberate with MEF on RAP details as a working group and adjust plan details. The IRC organization chart is given below.



Source: Report of the Detailed Planning Study for the Project on Capacity Enhancement of Environmental and Social Considerations for Resettlement in Cambodia

Figure 1-3-4 IRC organization chart

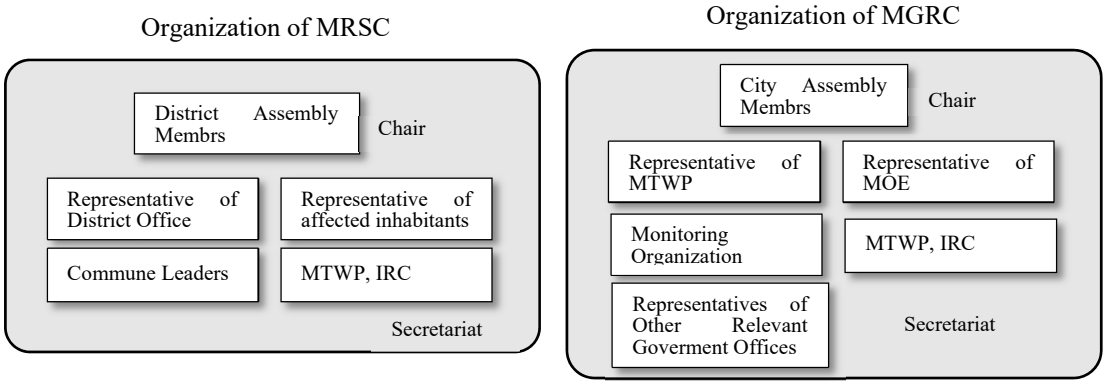


Figure 1-3-5 Organization of MRSC and MGRC committees

1-3-2-3 Scale and Scope of Land Acquisition and Resettlement

There will be involuntary resettlement near the bridge during construction for this project for repair and rehabilitation of the existing bridge. All households expected to be affected by the project are on the Chrouy Changvar side, numbering at most 21 households (see Figure 1-3-6. No residents on the Phnom Penh side will be affected. As the average household in Cambodian urban areas houses 4.8 people, involuntary resettlement is likely not to exceed 200 people. With this number of people being resettled, this should not impact the JICA environmental category.

Figure 1-3-6 Scope of land acquisition and resettlement (Chrouy Changvar side)

1-3-2-4 Study of Social Conditions for Project-Affected Persons

As confirmed in the previous section, this project will impact the Chrouy Changvar end of the Chroy Changwar Bridge. The results of a social survey of PAPs to be displaced follows below.

(1) Affected Buildings

Construction is confirmed to affect 21 buildings in the affected district, as well as 1 communal toilet. Details on the affected buildings are given below.

Table 1-3-38 Affected buildings

Municipality	Region	District	Affected Buildings				
			Residences	Storefronts	Small Stores	Other	Total
Phnom Penh	Chrouy Changwar	Chrouy Changwar	20	1		14	23
Total			20	1	1	14	23

Source: JICA Study Team

Table 1-3-39 Size of affected buildings

Building No.	Residences	Storefronts	Kitchens	Baths	Small Stores	Other	Total
2A	18.36	0.00	0.00	0.00	0.00	0.00	**18.36**
2B	80.28	10.81	17.23	0.00	13.25	0.00	**121.57**
2C	50.66	0.00	0.00	0.00	0.00	0.00	**50.66**
2D	71.55	0.00	0.00	2.25	0.00	0.00	**73.80**
2E	19.30	0.00	0.00	0.00	0.00	0.00	**19.30**
2F	97.88	0.00	0.00	0.00	0.00	0.00	**97.88**
AW1	0.00	0.00	0.00	0.00	0.00	9.02	**9.02**
AW2	0.00	0.00	0.00	0.00	0.00	21.48	**21.48**
AW3	0.00	0.00	0.00	0.00	0.00	6.46	**6.46**
AW4	0.00	0.00	0.00	0.00	0.00	6.80	**6.80**
AW5	0.00	0.00	0.00	0.00	0.00	5.28	**5.28**
SH1	0.00	0.00	0.00	0.00	0.00	10.40	**10.40**

Source: JICA Study Team

Table 1-3-40 Other facilities

Items	Unit	Total
Toilets	1	1

Source: JICA Study Team

(2) Demographics of PAPs

The demographic survey results on the project-affected persons concerning the houses that need to be relocated for the project (21 buildings) are presented below.

Table1-3-41 Demographic data of PAPs

District	No. of houses (buildings)	Average household size	Population				
			Total number	Males		Females	
				Number	%	Number	%
Chrouy Changwar	21	4	84	44	52.4	40	47.6

Source: JICA Study Team

Table1-3-42 Age and gender composition of PAPs

District	Population		Age 0-5		Age 6-13		Age 14-18		Age 19-60		Age over 60	
			Number	%	Number	%	Number	%	Number	%	Number	%
Chrouy Changwar	M	44	9	20.5	13	29.5	0	0.0	22	50.0	0	0.0
	F	40	5	12.5	9	22.5	2	5.0	22	55.0	2	5.0
	Total	84	14	16.7	22	26.2	2	2.4	44	52.4	2	2.4

Source: JICA Study Team

The Table below shows the dependent-age population of PSPs. Dependent-age population is the sum of the number of people aged under 15 (child population) and the number of people aged 65 or more (senior population). The dependency ratio, calculated as the percentage to the productive-age population (aged 15-64), provides information on the labor structure of affected households. The survey results showed the total dependency ratio of 78.6%, which, as compared with the national average of 56% in Cambodia (2014, The World Bank), indicated larger burden on the people in productive ages. In the age

distribution of dependent people, senior dependency rate was as low as 4.2% and child dependency rate was 74.5%, demonstrating that children are imposing larger burden on livelihood.

Table1-3-43 Dependent-age population and dependency rate of PAPs

District	Population		Age under 15		Age 15-64		Age 65 or more		Dependency rate		
			Number	%	Number	%	Number	%	Child	Senior	Total
Chrouy Changwar	M	44	22	50.0	22	50.0	0	0.0	74.4	4.2%	78.6%
	F	40	13	32.5	25	62.5	2	5.0			
	Total	84	35	41.7	47	55.9	2	2.4			

Source: JICA Study Team

(3) Ethnicity and Religion

The PAPs related to this project consist of Khmers and Chams, and more than 70% of them are Chams. The people in both groups are engaged in economic activities as citizens legally registered with the Government of Cambodia. As Chams are Muslims, this ethnic composition is reflected in the composition of religions. While 95% of Cambodians are Buddhist, Muslims represent more than 70% of the people in the relevant area, indicating the presence of an established Islamic community. Consideration must therefore be given to the siting conditions of alternate land, if it is offered in compensation.

Table1-3-44 Ethnicity and Religion of PAPs

District	No. of houses (buildings)	Ethnicity and religion			
		Khmr/Buddism		Cham/Islam	
Chrouy Changwar	21	6 persons	28.6%	15 persons	71.4%

Source: JICA Study Team

(4) Vulnerable Groups

While there is no clear institutional definition of vulnerable groups applied to the resettlement plan in Cambodia, they are conventionally considered to include (i) people with disability, (ii) unassisted households headed by people aged 60 or more, (iii) and households headed by women. As shown in the Table below, while the PAPs related to this project do not include households with people with disability, there are one household headed by a person aged 60 or more and two households headed by women. The details of compensation for the PAPs in this project needs to be planned paying attention to these vulnerable groups.

Table1-3-45 Vulnerable groups among PAPs

District	No. of houses (buildings)	Unassisted households headed by people aged 60 or more		Households headed by women	
		Number	%	Number	%
Chrouy Changwar	21	1	4.8	2	9.5

Source: JICA Study Team

(5) Literacy

The overall literacy rate among PAPs is 85.4% for adults aged 15 or more. This figure is relatively high, as compared with the 74.5% literacy rate in Cambodia as a whole in 2014. The Literacy rates for men and women among PAPs are 95.5% and 76.9%, respectively, which are also higher than 83% for men and 74.5% for women among all Cambodians. This is considered to reflect the fact that literacy rate is lower in the rural parts of Cambodia, and the PAPs related to this project are living in urban areas[1].

The literacy rates among the heads of households are 94.7% for male heads of households and 0.0% for female heads of households. As they will need to exchange various documents with government agencies concerning compensation in money, alternate land, etc., it is considered necessary to provide sufficient support particularly to female heads of households.

Table1-3-46 Literacy of heads of households among PAPs as a whole

District	Male heads of households			Female heads of households		
	Number	Literacy	%	Number	Literacy	%
Chrouy Changwar	19	18	94.7	2	0	0.0

Source: JICA Study Team

Table1-3-47 Literacy of adults among PAPs as a whole

District	All adults			Men			Women		
	Number	Literacy	%	Number	Literacy	%	Number	Literacy	%
Chrouy Changwar	48	41	85.4	22	21	95.5	26	20	76.9

Note: Adults are people aged 15 or more.
Source: JICA Study Team

(6) Educational Environment

With respect to the educational background of PAPs related to this project, the percentage of people who have completed the courses from primary to upper secondary education is less than one-half (43.7%) among all PAPs aged 5 years or more. However, as the school attendance rate of all Cambodians is 24%[2], this figure is higher than the national average. The school attendance rate among school age children (ages 6-14) is about 90% both for boys and for girls. The present educational environment of PAPs is considered to have no major problems.

Table1-3-48 School attendance of PAPs aged 5 or more

District	Gender	No education (%)	Primary education not completed (%)	Primary education completed (%)	Lower secondary education completed (%)	Upper secondary education completed (%)	Higher education completed (%)
Chrouy Changwar	Male	19.4	38.9	33.3	8.3	0.0	0.0
	Female	28.6	25.7	31.4	8.6	5.7	0.0
	Total	23.9	32.4	32.4	8.5	2.8	0.0

[1] National Education Profile 2014, World Bank
[2] Ibid.

Note: Cambodia has a 6-3-3-4 system of education. Which consists of 3 years of preschool education (ages 3-5) before compulsory education, primary education (elementary school) in 1st to 6th grades (ages 6-11) and lower secondary education (junior high school) in 7th to 9th grades (ages 12-14) as compulsory education, upper secondary education (high school) in 10th to 12th grades (ages 15-17) after compulsory education, and higher education (university) in 1st to 4th university years (ages 18-21).
Source: JICA Study Team

Table1-3-49 Present School Attendance of PAPs

District	Gender	Primary education (elementary school)			Lower secondary education (junior high school)		
		Age 6-11	Attending (persons)	%	Age12-14	Attending (persons)	%
Chrouy Changwar	Male	10	9	90.0	3	3	100
	Female	7	6	85.7	2	2	100
	Total	17	15	88.2	5	5	100

Source: JICA Study Team

(7) Family Finances

When the family finance situations of the PAPs related to this project are analyzed based on income sources and annual incomes, more than 90% of households are obtaining income as employed workers, more than 70% have a household income of 5,000 USD or more, and no households are making less than 2,300 USD annually. Considering the fact that the poverty line in Phnom Penh city is 46.55 USD/month (558.60 USD/year)[3], they are earning from 4 to about 10 times as much as the poverty line.

This also indicates that the PAPs in this project do not include poor people. However, some of the PAPs who opt for compensation in alternate land may suffer negative impact on family finances due to the changes in commuting conditions. Alternate land must therefore be selected carefully so that the distance from home to work may not be unreasonably large, and satisfactory agreement must be reached through consultation with PAPs.

Table1-3-50 Main income sources of PAPs

Income source	Number of persons	Remarks
Employed worker	19	
Trading	10	
Animal farming	6	
Transport services	2	Parcel delivery and taxi services
Financial services	2	Mainly money remittance services
Other	4	

Source: JICA Study Team

Table1-3-51 Annual income situations of PAPs households

District	2,300 USD or less		2,300-5,000 USD		5,000 USD or more		Total	
	Households	%	Households	%	Households	%	Households	%
Chrouy Changwar	0	0.0	5	23.8	16	76.2	21	100.0

Source: JICA Study Team

[3] Cambodia Country Pverty Analysis 2014, Asian Development Bank

In addition to household income, the Table below shows the situation of loans from financial institutions. These data show that about 40% of PAPs households have entered in some forms of loan agreements. This, in conjunction with the situations of household income, indicates that PAPs are given financial credit in society to some extent. More than 70% of the loans are made for the purpose of the expansion of business, clearly indicating that these people are benefitting from the expanding urban economy on Phnom Penh city due to the location of their dwellings.

Table1-3-52 Situation of PAPs households concerning loans from financial institutions

District	Total number of households with loan agreements		Number of households with loan agreements by type of financial organizations									
			Private financial institution		NGO		Private credit company		Relative		Other	
	Households	%	Households	%	Households	%	Households	%	Households	%	Households	%
Chrouy Changwar	8	38.1	3	37.5	1	12.5	2	25.0	1	12.5	1	12.5

Source: JICA Study Team

Table1-3-53 Reasons for loans taken out by PAPs households

Reason for loan	Households	%
Medical care	3	37.5
House rebuilding and renovation	1	12.5
Expansion of business	6	75.0
Supplementation to household budget	1	12.5
Other	2	25.0

Source: JICA Study Team

(8) Means of Transportation

With respect to the means of transportation used by PAPs, more than 80% of households have motorcycles, which are highly useful in Phnom Penh city. It seems that PAPs own highly useful means of transpiration, benefit from living in locations with good access to work, schools, and social infrastructure facilities, and nevertheless remain in the status lacking legal ownership.

Table1-3-54 Means of transportation owned by PAPs and their values

Mode of transportation	Value (USD)	Of 21 household studied	
		Households in possession	%
Bicycle	346.00	12	57.1
Motorcycle	32,150.00	18	85.7
Row boat	150.00	1	4.5
Total value	32,646.00	—	—
Average value (per household)	1,554.60	—	—

Source: JICA Study Team

(9) Housing Environment

The housing environment of PAPs is assessed based on the possession of electric home appliances and the size of living spaces. As for electric home appliances, all PAPs households have fixed-line telephones, indicating that they do not lack the tools for community information exchange. TV sets are owned by more than 90% of households, clearly demonstrating that they can obtain general information from society, and there is no segregation from society in general.

As for the size of living spaces, about 90% of PAPs are living in spaces with the area of 10-30 m^2, which is smaller than the 51.6 m^2 average area of living space in Phnom Penh city[4]. In terms of the area per person, since a household of PAPs consists of 4.0 persons in average, the area per person in PAPs households is 2.5-7.5 m^2, and this is 1/2 to 1/6 of the 15.0 m^2/person average in Phnom Penh city. This can be explained by the fact that the current dwellings of PAPs are small spaces under the existing bridge.

For this reason, if the PAPs who must be relocated for this project opt for compensation in alternate land, it will be necessary to offer dwellings with at least the same the size of living spaces as in the present situation, while pursuing the possibility to provide living spaces with the average size in Phnom Penh city.

Table1-3-55 Electric home appliances owned by PAPs households

Name	Value (USD)	Households in possession	Possession ratio (of 21 households)
Radio cassette player	3,745.00	10	47.6
Television	1,427.50	20	95.2
Electric saw	50.00	1	4.8
Refrigerator	180.00	2	9.5
Fixed-line telephone	2702.50	21	100.0
Total value	8,105.00	—	—
Total value (per household)	386.00	—	—

Source: JICA Study Team

Table1-3-56 Size of living spaces in PAPs households

District	Total No. of all households	Total area (m^2)	Average area (m^2)	Less than 10 m^2		10-30 m^2		30-50 m^2		50 m^2 or more	
				House-holds	%	House-holds	%	House-holds	%	House-holds	%
Chrouy Changwar	21	348.84	16.6	2	9.5	18	85.7	1	4.8	0	0.0

Source: JICA Study Team

[4] Housing Conditions 2007, National Institute od Statistics, Ministry of Planning

1-3-2-5 Specific Compensation and Assistance Measures

(1) Compensation for Affected Property

If land acquisition and resettlement is required in the project to convert any land from private to public use, the land acquired and buildings and structures removed will be regarded as a loss resulting from the project, and the Cambodian Government must compensate for any such losses. As explained to the area residents in the project briefing, the cutoff date for decisions on the compensated parties is the day following the start of the social survey: July 3, 2015.

Compensation will basically be paid out for amounts equivalent to market price accounting for building details. For land, either an alternate plot will be furnished or the market price equivalent paid out as compensation. Those eligible to receive compensation will be the legal owners of the land or building. For payment, PAPs are to agree to the compensation details and amount as calculated based on detailed property studies, enter into individual contracts, and be resettled by commencement of the work.

(2) Consideration of Alternate Land in the Case of Compensation in Alternate Land

During the discussion at the Stakeholder meetings, nine of the 21 households of PAPs expressed their desire to receive compensation in alternate land. In response, we examined candidate sites aiming to satisfy the present housing environment while avoiding excessive compensation which may arouse a sense of unfairness among the citizens living in similar environment in Phnom Penh city who are not entitled to compensation. The basic conditions for consideration are described here, and the outline of the alternate land recommended at the present is shown in the Figure below.

Further survey for the selection of alternate land will be performed by relevant government agencies based on the conditions defined in the present survey, and negotiations concerning candidate sites, including the one proposed here, will be conducted with the participation of PAPs.

Conditions for selection of alternate land

The land should be located in or adjacent to an Islamic community.

The distance from the central part of Phnom Penh city should be largely the same as that from there to the present dwellings.

The land should be near the river and in an environment offering good accessibility.

The land should have an area sufficient to provide all resettled households with at least the same size of living spaces.

The land should be in an area with safe natural and social environment, characterized by a low level of natural hazards and low occurrence of crimes.

Source: JICA Study Team

Figure 1-3-7 Map and photos of candidate compensation site

(3) Life Rebuilding Assistance for Project-Affected Persons

With the exception of the situation, where affected residents do not legally own any land, no other noteworthy circumstances should require assistance for residents who are involuntarily resettled due to project implementation in rebuilding their lives after resettlement. This assumes that compensation has been appropriately secured for PAPs in the form of alternate land with similar economic conditions and social infrastructure where PAPs can live similar lives as before. If such alternate land is not prepared or PAPs are monetarily compensated, depending on the circumstances, life rebuilding assistance may be required for PAPs in order to ensure that their life standards are at a minimum not reduced from their current levels. Therefore, how to handle such life rebuilding assistance is to be discussed between the relevant agencies based on monitoring and evalutions of the resettlement plan so that PAPs are treated properly.

The entitlement matrix below shows the basic strategy for compensation and assistance.

Table 1-3-57 Entitlement matrix

Type of Loss	Benefit Eligibility	Compensation Details	Issues When Executed
A. Loss of Land			
Within ROW			
Partial loss of residential or commercial land	Residence and commercial facility owners	▪ As land within the ROW will become national property, there will in principle be no compensation for this portion.	▪ PAPs will receive resettlement notifications 90 days before work commences. ▪ The IRC will compensate PAPs 30 days before work commences so that they can resettle.
Full loss of residential or commercial land	Residence and commercial facility owners	▪ As land within the ROW will become national property, there will in principle be no compensation for this portion. ▪ PAPs can receive relocation compensation. ▪ Beneficiaries can choose between monetary compensation and alternate land. ▪ For monetary compensation, land will generally be accessed at market price. (Current estimates: $18,000 per household) ▪ For alternate land, each household gets land of about 60 m^2 with electricity, water and other utilities available. ▪ If compensated with alternate land, in accordance with the law, ownership of the alternate land will be recognized with 5 years of continuous residence.	
B. Loss of Buildings			
Loss of residence or commercial building	Building owner	▪ Will generally be monetarily compensated for lost building. ▪ Compensation for lost buildings will not take into account losses for depreciation or remaining materials.	
	Renters	▪ Will be compensated $40 per person as relocation compensation. ▪ Will also be paid $50 per person in additional allowance. ▪ Will receive two months of rent for similar rental properties as rental compensation.	
Other buildings	Building owner or representative	▪ Will generally be monetarily compensated for lost building. ▪ Compensation for lost buildings will not take into account losses for depreciation or remaining materials.	
C. Loss for Resettlement-Related Expenses			
Moving compensation	Head of household for PAPs required to move	▪ Compensation for relocation of small stores will be $5-10 depending on store details. ▪ Compensation for those relocating commercial facilities or residences will be $40 per property if moving within the same district, $60 per property if moving to a neighboring district, or $80 per property if moving to a far off district.	▪ Moving compensation will only be provided once.
Vulnerable groups	Heads of household with member(s) of vulnerable groups	▪ Compensation of $100 per household will be provided to those in vulnerable groups.	
Additional allowance	Head of affected household	▪ Each affected household which relocates to neighboring areas will be compensated $50 as additional allowance. ▪ Each affected household which relocates to far off areas will be compensated $150 as additional allowance.	
Temporary business losses	Storefront owners	▪ Each storefront owner will be monetarily compensated with $50 as compensation for temporary business losses due to relocation.	

Source: JICA Study Team

1-3-2-6 Grievance Mechanism

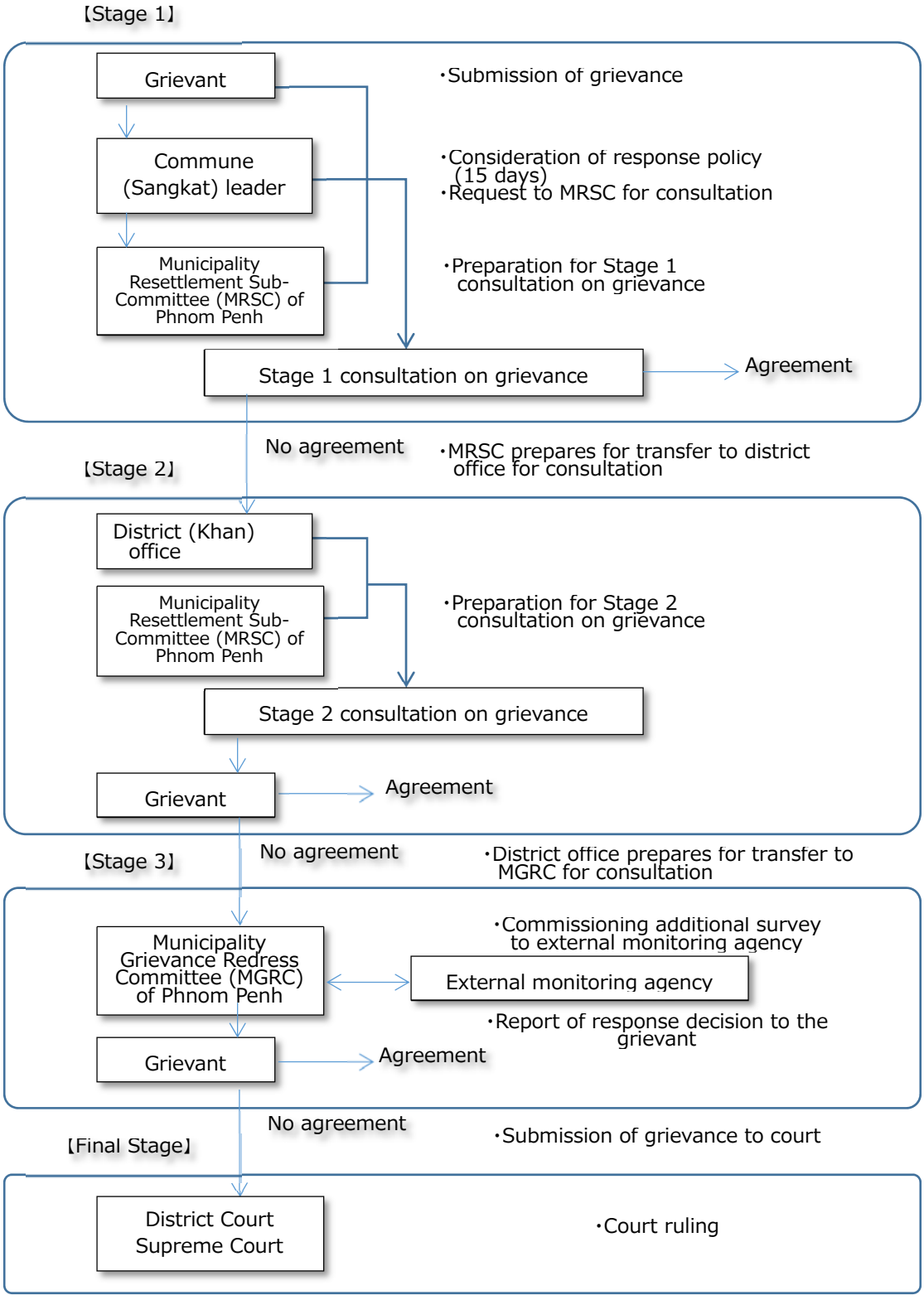
With several grievances from the stakeholders expected in project implementation, of particular importance is having a program for monitoring objections to compensation payment. In Cambodia, Article 14 of the Expropriation Law clearly states that landowners who cannot agree with the decisions of the land expropriation committee can voice their complaints to a complaint resolution committee.

The grievance mechanism for land acquisitions and resettlement in this project will handle grievances in 4 stages, as outlined below.

Table 1-3-58 Grievance mechanism overview

(Stage 1) ・Beneficiaries with grievances to voice are to submit their grievance to the district leader. The community leader is then to determine a means of resolution within 15 days and prepare for consultation. ・The district leader is to appeal to the MRSC for a consultation on the grievance. The community leader, MRSC representative, and grievant are then to consult to determine means of resolution. ・If no resolution can be found, or if the grievant is not satisfied with the resolution, the MRSC will make preparations to transfer the grievance to the district offices for consultation.
(Stage 2) ・Upon consulting with the MRSC, the district office will discuss a resolution and report its findings to the grievant. ・If the grievant is not satisfied with the findings, the district office will make preparations to transfer the grievant to the Phnom Penh Complaint Resolution Committee (PCRC) for consultation.
(Stage 3) ・The PCRC will review each stage of consultation to date and consult on how to resolve the grievance. The PCRC can request the MRSC to commission an additional condition survey to an external monitoring agency. ・Within 30 days of taking on the grievance from the district office, the PCRC will reach its conclusion and report it the MPWT, external monitoring agency, IRC, and grievant.
(Final Stage) ・If the grievant does not agree with the resolution given by the PCRC, the PCRC will make preparations to transfer the grievance to the Phnom Penh Municipal Court. ・The Phnom Penh Municipal Court will take an oral statement from the grievant and make a ruling on the grievance, with written notification of the ruling sent to the agency to resolve the grievance. In cases where there is not mutual consent on the ruling from the court consultation, the mechanism will appeal the case to Supreme Court.

Source: JICA Study Team



Source: JICA Study Team

Figure1-3-8 Flow of grievance processing

1-3-2-7 Monitoring and Evaluations

In order to implement the project resettlement plan, an Environmental Sector Project Management Unit (PMU-ES) will be established in the MPWT, the project management body, as advised by the IRC. The PMU-ES will be responsible for confirming that compensation is appropriate and managing the implementation schedule. Monitoring and evaluation items for the resettlement plan are as follows:

- Property evaluation methods for monetary compensation of property losses and appropriateness of evaluations
- Appropriateness of the beneficiary consultation process until agreement with compensation, opinions on beneficiary compensation
- Review of information disclosure, information sharing, Stakeholder meetings and consultations for PAPs
- PAP living environments and economic activity after resettlement
- Close review of the relationship between construction preparations, land acquisition, and resettlement activity; schedule management

In order to ensure that land acquisitions and resettlement for the project are handled properly, they will be monitored and evaluated by an external agency separate from MPWT monitoring. The external agency is expected to be a local NGO contracted by the IRC. Duties entrusted to the external agency will mainly be monitoring of PAP living environments and economic activity following resettlement (roughly one year after resettlement), with the IRC summarizing in a report submitted to the MPWT. External agency monitoring and evaluation items are as follows:

- Achievement levels for the resettlement plan
- Confirmation of changes and improvements in PAP living environments after resettlement
- Effects of actions related to compensation and other assistance
- Assistance expected to be required in the future
- Extracted problem areas to be handled for land acquisitions and resettlement in subsequent projects

1-3-2-8 Implementation Structure

The duties of the relevant agencies in land acquisition and resettlement for the project are summed up below.

Table 1-3-59 Overview of duties for RAP implementing bodies

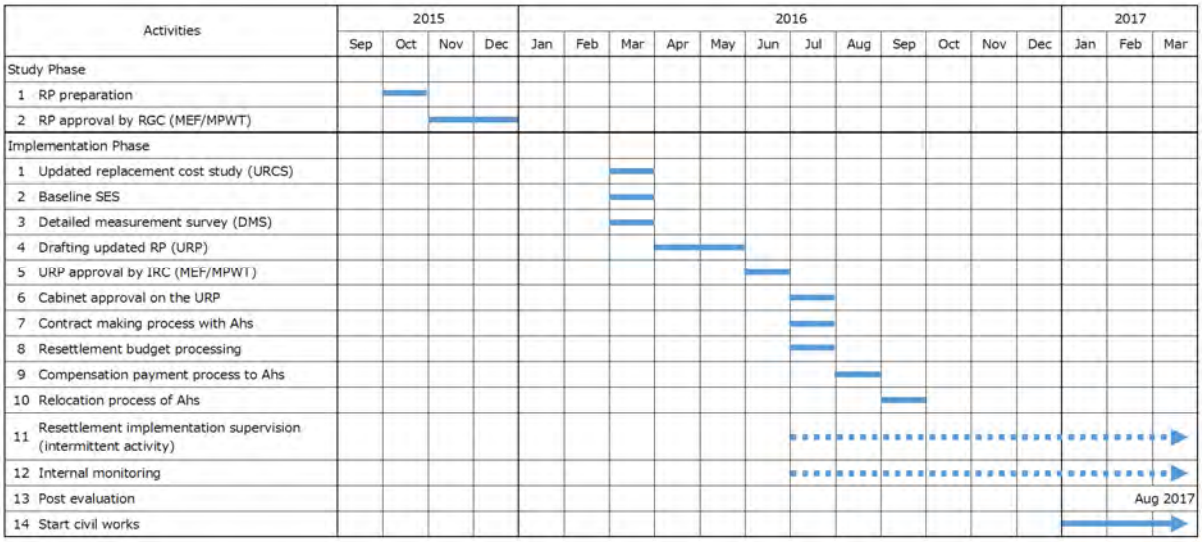
Organization Name		Duties	Remarks
MPWT	Project Management Unit-Environmental Section (PMU-ES)	・Prepare RAP ・Supervise and monitor RAP execution together with IRC ・Conduct Stakeholder meetings ・Consult and coordinate with stakeholders on matters required for project progress ・Mobilize and share information with PAPs in conformance with the RAP ・Propose details for non-land, non-building compensation ・Review all compensation details and report/coordinate with IRC ・Assist in closing compensation agreements ・Conduct studies for grievance mechanism ・Conduct post-compensation monitoring	
	Municipality Resettlement Sub-Committee (MRSC)	・Review plans to ensure smooth transparency for the RAP ・Participate in grievance system	Comprising MPWT and district office representatives and IRC
MEF	Inter-Ministerial Resettlement Committee (IRC)	・Review RAP ・Confirm that plans are in compliance with the law and standards ・Confirm land and building owners ・Evaluate land and buildings for compensation and determine compensation amounts ・Prepare agreements for land/building compensation and obtaining agreement ・Consult and negotiate with PAPs on compensation ・Secure relocation sites for land-based compensation and process land registration transfers ・Report compensation amounts for land and buildings to MPWT	
	Resettlement Department (RD)	・Arrange IRC land acquisitions and resettlement activity and provide technical support	
External	NGO	・Monitor and evaluate situation one year after resettlement	Requested by IRC

Source: JICA Study Team

1-3-2-9 Implementation Schedule

A summarized implementation schedule with the main items for resettlement in the project follows below.

Table 1-3-60 Resettlement implementation schedule



MEF: Ministry of Finance; MPWT: Ministry of Public Works and Transport; IRC: Inter-Ministerial Resettlement Committee

1-3-2-10 Estimation and Financing for Compensation Costs

In terms of estimated costs for compensation for the project for repairs and renovation of Chroy Changwar Bridge, the community affected is Islamic and the residents request to be relocated to a district with an Islamic community. According to a survey of the PAPs at the Stakeholder meeting and consultations, almost all desire land-based compensation. Based on this, an estimate of compensation costs assuming compensation with alternate lands in consideration of current PAP social and living conditions is as follows.

Table 1-3-61 Estimate of compensation costs

Item	Description	Units	Quantity	Unit Value (USD)	Total (USD)
Landless Household : 21 AHs (estimate for 21 AHs)					
1	Land price	m^2	1,260.00	230.00	289,800.00
2	Laterite access road	m^2	300.00	240.00	72,000.00
3	Site cleaning and grubbing	m^2	1,260.00	0.10	126.00
4	Land filling	m^3	1,560.00	5.00	7,800.00
5	Drainage system and main holds	lm	80.00	50.00	4,000.00
6	Latrine (WC)	set	21.00	150.00	3,150.00
7	Electrical connection fee	HH	21.00	60.00	1,260.00
8	Water supply connection fee	HH	21.00	80.00	1,680.00
Total					379,816.00

Source: JICA Study Team

1-3-2-11 Stakeholder Meetings

(1) First Stakeholder Meeting

The DPWT, JICA Study Team, and local government officials held a Stakeholder Meeting for community representatives and residents to be affected by resettlement in the project. They gave an overview of the project, explaining the positive and negative environmental and social impacts, the social survey of the affected districts and the cut-off date, and an overview of compensation for resettlement, with a discussion of the above to follow. As the Stakeholder Meetings were for the two districts expected to be impacted at either end of the bridge, two sessions were held. A summary of the Stakeholder Meetings and details covered are given in the table below.

Table 1-3-62 Summary and Contents of First Stakeholder Meeting (Chrouy Changvar district)

Date	2nd July 2015 at 9:00 a.m.
Place	Sangkat Chrouy Changvar Office
district	Khan Chrouy Changvar, Sangkat Chrouy Changvar
Participation	Organizer: DPWT, Local Authorities, and JICA Study Team Affected people: male 4, female 7
Situation of the Consultation	**Consultation:** ▪ **Question**-Representative of local authority: Satisfy with the Project, but worry about the compensation to be fair. **Answer**-DPWT: The compensation rate will be based on market price which will be studied by Independent Agency, who is widely experience for asset evaluation and resettlement issues. ▪ **Question**-Participant: When will the civil works start? Answer-DPWT: By the plan, it will be started in next year (2016), after the feasibility and detailed design finishing. ▪ **Question**-Participant: In case people have to relocate another place, he requested to move to where closer to the existing place because they need to join a mosque with their existing community. **Answer**-DPWT, suggested to all AHs, please do not worry about that because the government and our development partners were strongly considered about this. The study Team will report it to IRC to consider on your request. ▪ **Question**-Participant: The Project implementation will affect on my house. The remained land is too small. How can the Project help me? **Answer**-DPWT: During the Project implement phase the Project would have a clear policy to help AHs. In case, you do not have any land or the remained land is not suitable for living, the Project will solve the problem. **Result:** Among 21 participants, there are 9 persons prefer to have a land plot, provided by the project, for their resettle and other 12 person prefer cash for own buying land. 

Source: JICA Study Team

Table 1-3-63 Summary and Contents of First Stakeholder Meeting (Daun Penh district)

Date	2nd July 2015 at 9:00 p.m.
Place	Sangkat Sreah Chak Office
district	Khan Daun Penh, Sangkat Sreah Chak
Participation	Organizer: DPWT, Local Authorities, and JICA Study Team Affected people: male 24, female 6
Situation of the Consultation	**Consultation:** ▪ Due to this section don't have any affected private property, all participants are happy and support to the project. They just asked the project to be started soon. 

Source: JICA Study Team

(2) Second Stakeholder Meeting

Similarly to first Stakeholder Meetings, second Stakeholder Meetings were held as shown in the Table below at communal offices inviting the inhabitants of Chrouy Changvar Commune (on the Chrouy Changvar side) and Sreah Chak Commune (on the Phnom Penh side). Chaired by the Vice-Mayor of Phnom Penh City, the meetings were attended by MPWT, DPWT, JICA Office, JICA Survey Team, Khans (districts), Communal Assemblies, Village Chiefs, and the inhabitants of the areas around the project.

Table 1-3-64 Summary of Second Stakeholder Meeting

Municipality	District/Commune	Venue	Date	Participants	Language
Phnom Penh City	Khan Chrouy Changvar/ Sangkat Chrouy Changvar	Sangkat Chrouy Changvar Office	14 Mar. 2016 at 9:00 am	Male=33 Female=10	Khmer
	Khan Daun Penh/ Sangkat Sreah Chak	Sangkat Sreah Chak Office	14 Mar. 2011 at 3:00 pm	Male=43 Female=21	Khmer

The summary and contents of the Stakeholder Meeting in each commune were as described below.

Table 1-3-65 Summary and Contents of Second Stakeholder Meeting (Chrouy Changvar District)

Date	March 14, Monday, 2016 at 9:00 – 10:00
Place	Sangkat Chrouy Changvar Office
Inhabitants	Affected and nearby inhabitants in Sangkat Chrouy Changvar, Chrouy Changvar District
Participants	Project secretariat: Vice-Mayor of Phnom Penh City, MPWT, DPWT, local government officials, JICS Study Team Inhabitants: 33 men and 10 women (All households affected by resettlement were present.)
Discussion details and situation	**(Discussion details)** ▪ Mr. Pech Sereun, Chief of Sangkat Chrouy Changvar (Chrouy Changvar Commune) gave an opening address. ▪ Mr. Suy Serith, Vice-Mayor of Phnom Penh City presiding at the meeting, explained that rehabilitation of the Chrouy Changvar Bridge will be conducted next year because of deterioration, and that traffic will have to be detoured to adjacent bridges during the rehabilitation work. ▪ Mr. Dun Vandy Rygen from MPWT explained the background of the project and the present damage condition of the Chrouy Changvar Bridge. Explanation was also given concerning the positive and negative effects of the project and the cut-off dates. ▪ Mr. Bona, the resettlement consultant, explained the socioeconomic situation of affected households, such as population, education, main sources of income, and living space. The results of the survey on asset loss (IOL) were reported. Explanation was given concerning compensation policies, including inhabitant participation and discussion, compensation for asset loss, reconstruction of livelihood, and grievance procedures. ▪ The affected inhabitants basically gave consent to resettlement. **(Questions and answers)** ▪ The affected households have requested the Phnom Penh City Government to reduce the PRW from 25 m to 18 m as measured from the bridge end. → (DPWT) The project of Phnom Penh City and the present project conducted by MPWT are two different projects. The Chrouy Changvar Bridge project requires a length of 15.50 m from the bridge end. ▪ Is the area of the land offered in compensation based on the area of the present land? → (DPWT) Because the present land is national land in the ROW, it is basically not eligible for compensation. However, the project plans to provide each affected household with the title to 60 m^2 of land, although the land occupied by each household at the present is less than 50 m^2. ▪ Where are we going to relocate? → (DPWT) We choose the new location so that the people of affected households can continue living with the same standard as the present. It is tentatively planned in Prepra, Sangkat Prekpra, Khan Mean Chey. The new location will be determined finally after the detailed assessment survey by IRC. **(Discussion situation)**

Source: JICA Survey Team

Table 1-3-66 Summary and Contents of Second Stakeholder Meeting (Daun Penh District)

Date	March 14, Monday, 2016 at 15:00 – 16:00
Place	Sangkat Sreah Chak Office
Inhabitants	Affected and nearby inhabitants in Sangkat Sreah Chak, Daun Penh District
Participants	Project secretariat: Vice-Mayor of Phnom Penh City, MPWT, DPWT, local government officials, JICA Survey Team Inhabitants: 43 men and 21 women
Discussion details and situation	**(Discussion details)** ▪ The Chief of Sangkat Sreah Chak (Sreah Chak Commune) gave an opening address. ▪ Mr. Suy Serith, Vice-Mayor of Phnom Penh City presiding at the meeting, explained that rehabilitation of the Chrouy Changvar Bridge will be conducted next year because of deterioration requiring vehicle weight restrictions, and that traffic will have to be detoured to adjacent bridges during the rehabilitation work. ▪ Mr. Dun Vandy Rygen from MPWT explained the background of the project and the present damage condition of the Chrouy Changvar Bridge. Explanation was also given concerning the positive and negative effects of the project and the cut-off dates. ▪ Mr. Bona, the resettlement consultant, explained the socioeconomic situation of affected households, such as population, education, main sources of income, and living space. The results of the survey on asset loss (IOL) were reported. Explanation was given concerning compensation policies, including inhabitant participation and discussion, compensation for asset loss, reconstruction of livelihood, and grievance procedures. **(Questions and answers)** ▪ No questions were asked by participants.

Source: JICA Survey Team

Chapter 2 Contents of the Project

Chapter 2 Contents of the Project

2-1 Basic Concept of the Project

2-1-1 Overall Objectives and Project Purpose

2-1-1-1 National Strategic Development Plan (NSDP)

In their National Strategic Development Plan (NSDP 2014-2018), the Cambodian Government perceives development of transportation infrastructure, including rehabilitation and construction, as an important element in supporting economic growth and increasing economic efficiency, as well as strengthening competitiveness and diversifying the Cambodian economy. As such, the Cambodian Government places priority on the following 7 items:

1) Stepping up the construction of national, provincial and rural roads, particularly by targeting the paving of 300 to 400 Km of additional roads per year with asphalt or concete pavement.
2) Directing more attention to the repair and maintenance of the transport system, particularly roads through the strengthening of mechanisms and enhancement of road repair and maintenance system, including effective and strict enforcement of punitive measures against overloading.
3) Further focusing on traffic safety through the improvement and stricter enforcement of the “Law on Land Traffic”.
4) Designing and implementing the Master Plan for Transport Infrastructure Development to connect all parts of the country and with the neighboring countries through developing multi-modal and cross border transport systems.
5) Preparing necessary policies and legal framework for the management and development of infrastructure.
6) Preparing a Master Plan for Urban Infrastructure Development, in particular public transport in urban areas and connectivity of production centers on the outskirts of municipalities, main economic poles, industrial zones and special economic zones to reduce traffic congestion, improve national economic efficiency and competitiveness.
7) Further encouraging participation of the private sector in the development of transportation infrastructure by strengthening and improving the “public-private partnership” mechanism.

The Ministry of Public Works and Transport (MPWT) is responsible for implementing the national policy concerning construction of all public works. The MPWT is engaged in the following projects.

(1) Road sector

- Improving more than 3,500 km of road infrastructure in the next 5 years.
- Improving 1-Digit National Roads from double bituminous surface treatment (DBST) to asphalt pavement.
- Widening 1-Digit National Roads from 2 lanes to 4 lanes in and around major cities.
- Increasing a pavement ratio in 2-Digit National Roads from the current 50% to 90%.
- Installing drainage facilities for 1-Digit National Roads, for flood control.
- Increasing traffic signals in the Capital Area for smooth and safe traffic.
- Introducing bus public transportation system in Capital Area.

(2) Road transportation sector

- Continuing enforcing the sub-decree on management of repair garage and processing/assembling garage.
- Continuing enforcing the sub-decree on road transport business.
- Continuing enforcing the Prakas on the Procedure of Vehicle Registration.
- Continuing enforcing the law on road transport contracts.
- Formulating a new draft law on road traffic.
- Reducing the time for issuing vehicle registration, license plate, and driving license.
- Improving the officers' capacity.
- Modernizing vehicle registration and inspection system using IT system.

2-1-1-2 The Overall Goal and the Objective of this Project

The overall goal and the objective of this project are as follows:

- Overall goal

To eliminate the traffic bottleneck and contribute to the Cambodia NSDP and other development plans for agriculture, industry, logistics and other sectors by rehabilitating the Chroy Changwar Bridge, which is located on National Road 6A, an important domestic trunk road which passes from the capital Phnom Penh through the northern suburbs and directly accesses 9 provinces to the northeast.

- Project objective

The 5-span, simple PC girder bridge approaches on the Phnom Penh and Chroy Changwar sides had not been repaired or rehabilitated since bridge installation in 1963 until emergency repairs of the Phnom Penh side rocker bearings on the Cambodian-side rehabilitation budget in May 2014. In July 2014, JICA sent a study team to determine the status of the bridge. Visual inspections of the bridge approaches revealed severe damage on the Chroy Changwar side rocker bearings and main girder ends. With this, JICA judged a high risk of a serious accident on the bridge and recommended the Cambodian side to immediately close the bridge to through traffic and conduct inspections. In response, the Cambodian side has restricted bridge use to vehicles 2.5 t and under.

Thus, the purpose of this project is to repair and rehabilitate the bridge to ensure stable passage and extend bridge lifetime with maintenance that can be performed by the Cambodian side.

2-1-2 Basic Concept of the Project

To achieve the abovementioned goals, this project will repair and rehabilitate the Chroy Changwar Bridge and enable stable bridge service with grant aid assistance.

The direct outcomes of this plan are to enable passage of larger vehicles and stable bridge passage, and to allow the road to function as a trunk road. It is expected to reduce poverty and improve standards of living, as well as stimulate the regional economy and expand regional traffic and international distribution.

2-2 Outline Design of the Cooperation Project

2-2-1 Design Policy

After more than 50 years in service, the Chroy Changwar Bridge has been found to have significant damage in the rocker bearings and main girder end parts of the approach bridge parts, and this has resulted in restriction on the passage of large vehicles due to a high possibility of serious accidents on the bridge. To correct this situation, this project will execute improvement and repair of the Chroy Changwar Bridge, aiming at allowing the traffic of large vehicles, ensuring reliable traffic, realizing the functionality of the principal road, supporting the development of regional economy, and helping poverty reduction. Based on the request of the Government of Cambodia and the result of discussion, the project is planned according to the following policy.

2-2-1-1 Basic Policy

The basic policy for outline design is as described below.

(1) Scope of Cooperation

The government of Cambodia submitted the formal request for grant aid cooperation regarding this project to the Japanese Embassy in 2014. It was the request concerning the improvement and repair of the Chroy Changwar Bridge to correct the situation in which the passage of large vehicles was restricted due to the significant damage in the approach bridge parts.

This preparatory survey was conducted for the main purpose of reconfirming the content of request, as well as confirming the matters concerning bridge inspection survey, natural condition survey (topography and geology), traffic survey, environmental and social considerations survey, work plans/cost estimation, etc. As a result of discussion with the Cambodian side, the content of Japanese grant aid cooperation was finalized as follows:

- Replacement of the existing PC bridge parts (5-span simple girders, Phnom Penh side and Chroy Changwar side)
- Repair of superstructure of the existing steel bridge part (2-span continuous box girder + 3-span continuous box girder + 2-span continuous box girder) (repaving, repainting, replacement of railing, etc.)
- Repair of substructure of the existing steel bridge part (crack impregnation, cross-section restoration, etc.)
- Improvement of approach road (206 m on Phnom Penh side and 207 m on Chroy Changwar side, 413 m in total)

(2) Details of Requests and Matters Discussed/Confirmed

Outline design will be developed according to the conditions agreed on by the two countries and the survey team. The details of request and the matters discussed and confirmed during the first and second field surveys are shown in Table 2-2-1.

Table 2-2-1 Details of Request and Matters Discussed/Confirmed

Details of Request	Matters Discussed/Confirmed
Execution of bridge inspection and soundness evaluation	• Restoration of a two-lane bridge that can withstand B live load. • Removal of existing PC bridges on Phnom Penh side and Chroy Changwar side and construction of new approach bridges (including abutments in earthwork parts). • Repair of cracks in existing steel bridge and repainting. • Repaving of earthwork parts, newly constructed approach parts, and existing steel bridge part. • Restoration of draining facility, conversion of expansion apparatuses to non-draining type, and replacement of railing. • Planning of improvement of roundabout on Phnom Penh side. • Suspension of traffic on the bridge during construction and repair work.
Execution of repair to maintain the best condition at all times and renewal of functions, elements, members, and systems.	
Replacement of all damaged members and related structural defective parts.	
Provision of appropriate maintenance and safety plans and traffic facilities to minimize traffic disorder and hazards.	
Confirmation and correction of inadequate safety and situations.	
Execution of improvement of intersections and roundabouts.	

2-2-1-2 Policy Concerning Natural Environmental Conditions

(1) Weather

1) Temperature, Humidity, and Wind Speed

Temperature data for the past five years recorded in the vicinity of Pochentong near Phnom Penh International Airport, which is located closest to the bridge site, vary from the minimum of 19℃ in January to the maximum of 38℃ in April with the annual mean temperature of 36℃. Humidity is 68-70% from January to March and goes up to 80-82% from July to October.

Because of the considerably high temperature and humidity during the rainy season, close attention must be paid to the changes in temperature of members in design development, as well as concrete placement and curing during construction work.

Wind speed is in the range from 7.1 to 8.6 m/s year round, and the annual mean is 7.9 m/s. The area is somewhat windy.

2) Rainfall and Rain Pattern

The capital city Phnom Penh has distinct rainy and dry seasons. The rainy season generally extends from June to November, and the dry season from December to May. Most of the annual rainfall occurs during the rainy season. The annual rainfall in Phnom Penh is about 1,500 mm. It is slightly lower than the national average and varies greatly from year to year.

Flooding during the rainy season is an element that can greatly affect work plans and work schedules. Sufficient attention must be paid to weather conditions in planning. In particular, construction must be planned aiming at the completion of work in the river, such as substructure work on bridge piers and foundation work during the period without flooding.

(2) Hydraulics and Hydrology

1) Characteristics of the Tonle Sap River

The land of Cambodia mostly consists of a plain, where the Mekong River flows in a north-south direction generally along the center axis. The Tonle Sap River is a major river in the country (with a catchment area of 84,400 km^2), which joins the Mekong River in the capital city Phnom Penh. The river has its source in Tonle Sap Lake, which is located centrally in the country and acts as the reservoir for the flows of water in the surrounding areas.

A distinctive characteristic of the Tonle Sap River is the yearly repetition of forward flow (from the Tonle Sap to the Mekong) and reverse flow (from the Mekong to the Tonle Sap), because the water level in the Mekong River greatly influences the flow in the right-bank tributary.

While the water level in Phnom Penh directly upstream of the confluence point rises up to about 10 m during the rainy season, it goes down to less than 1 m in the dry season. The range of water level fluctuations in a year is nearly 10 m.

The flow speed becomes zero during the transition between the dry season and the rainy season, when the flow direction switches between forward and reverse. The flow rate ranges from zero to the annual peak flow rates are about 8,000 m^3/s in forward and reverse directions.

2) HWL

a) Highest Recorded Water Level

The water level in the Tonle Sap River reaches the maximum in September and October during the rainy season. A review of past water level records shows that the highest recorded water level is 10.09 m (2000). Including the occasion in 2000, High water levels exceeding 10 m occurred three times in the past: 10.00 m (2010) and 10.06 m (1966). The highest water level inferred from the water level marks left on existing piers (P2-P7) is 9.9 m.

b) River Conditions

The results of river condition survey and river cross-section surveying show that the bank ground level on the both banks exceeds 10 m in the areas upstream and downstream of the bridge, and the river is an excavated river lacking embankment.

c) Improvement Plan

The ground level in the previously improved bank area was planned to be 11 m in elevation in the levee road on the right bank and the Phnom Penh Municipal Drainage Pump Station on the right bank.

The HWL in the past bridge improvement project was planned to be 11.0 m (design document).

d) Result of Hydrologic Statistical Analysis

The water level gauging station in the Tonle Sap River is located on the right bank downstream of the Chroy Changwar Bridge. We conducted a hydrologic statistical analysis using the annual high water levels for the past 55 years (from 1960 to 2014). The probability formula was derived using the log-normal distribution method and the Gumbel method.

Because the Tonle Sap River is adjacent to Phnom Penh in the metropolitan area, hydrologic analysis was performed using the probable recurrence period of 200 years in addition to 100 years. The following shows the result of analysis.

Table 2-2-2 HWL (Result of Hydrologic Statistical Analysis)

(Unit: year)

Probable recurrence period	T=1/100	T=1/200	T=1/50 (for reference)
Log-normal distribution method	10.7	10.9	10.4
Gumbel method	11.0	11.4	10.7

According to the result of analysis, the water level with 1 in 100 year probability is 10.7-11.0 M, and the water level with 1 in 200 year probability is 10.9-11.4 m.

3) Scouring and Sedimentation

a) Condition of the Tonle Sap River

While the flow in the Tonle Sap River is forward from the lake to the Mekong River during the period from the rainy season to the dry season, the river flows in reverse direction during the period from the dry season to the rainy season due to the rise of water level in the Mekong River. The flow rate is reported to peak at about 8,000 m^3/s both during the period of forward flow and during the period of reverse flow. The forward flow is reported to carry fine cohesive soil particles (less than 0.1 mm in diameter) from the lake, causing sedimentation in the Tonle Sap River. During reverse flow, non-cohesive soil particles (about 0.5 mm in diameter) flows into the Tonle Sap River and settle there. Sedimentation on the riverbed due to the earth materials transported by the reverse flow of flood water from the Mekong River may reduce the cross-sectional area of the river and its flow capacity. We therefore performed a literature survey to confirm and analyze the changes in riverbed conditions at the bridge location near the confluence point.

Many studies have been conducted in Japan on The confluence of the Tonle Sap River and the Mekong River. According to the conclusion of a published study (Hiroshi Takebayashi, Kyoto University Disaster Prevention Research Institute, presented at conference of Japan Society of Erosion Control Engineering in 2011), “The Tonle Sap River experiences sedimentation of earth materials in the channel during the period of reverse flow and erosion during the period of forward flow commensurate with the sedimentation during reverse flow. As a result, the balance of riverbed changes in a year is small. This shows that the coarse earth materials in the Mekong River are hardly transported to Tonle Sap Lake, indicating that the ‘rapid burying of Tonle Sap Lake due to the earth materials from the Mekong River,’ which is a concern among local experts, is not taking place.” It is therefore considered that the souring and sedimentation at the bridge location on the Tonle Sap River do not cause a problem in the present situation.

b) Bridge Location

Based on the results of plane surveying, cross-sectional surveying, and surveying for pier scouring examination, we studied the souring around the pier footings in the river channel and assessed the situation of couring and sedimentation.

The height of the river bottom at each pier as measured in transverse and longitudinal directions was found to be higher than the foot protection work installed as a measure against scouring around piers, and the area around the foundation was beneath the river bottom. The riverbed height in transverse direction was slightly higher than the foot protection work in the areas around the piers. There were no deep water courses, and no part of the riverbed showed local scouring. On the other hand, measurements in longitudinal direction showed a slight tendency to souring on the upstream side and a slight tendency to sedimentation on the downstream side. Local scouring, however, was not found in any part of the riverbed. Despite the overall slight tendency to sedimentation, there is no scouring around pier footings and no problems are expected.

The piers of Chroy Changwar Bridge are not perpendicular to the bridge axis but have a small oblique angle in a design considering the impact of the flow of flood water. Since the result of channel situation survey did not detect significant scouring or sedimentation and our survey did no identify a problem caused by water flow during the passage of more than 20 years after construction, the present oblique angle is considered appropriate.

(3) Earthquake-Resistant Design

1) Overview of Earthquakes

In a global perspective, Cambodia is affected by much fewer earthquakes than the earthquake-prone countries such as Japan, China, Indonesia, and Myanmar. While Cambodia is surrounded by the Eurasia Plate, the Philippine Sea Plate, and the Indo-Australian Plate, it is distant from either of these plates. The country also has no past history in the distribution of seismic centers.Figure 2-2-1 shows the distribution of seismic centers in Asia.

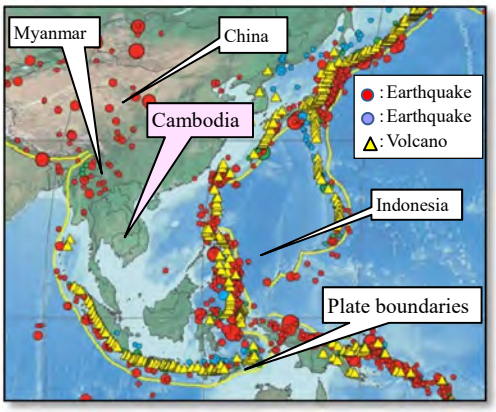


Figure 2-2-1 Distribution of Seismic Centers in Asia

2) Earthquake-Resistant Design Policy

National Road No. 6A, on which the Chroy Changwar Bridge is located, is an important trunk road connecting the capital city Phnom Penh and the nine northeastern provinces. Although earthquakes are rare in Cambodia, bridge collapse or other damage from an earthquake, once it happens may have severe impacts on the traffic of people and goods, and also severely hamper the rescue, medical care, and firefighting activities for the inhabitants in the disaster-stricken areas and the transport of emergency supplies to the affected areas. Because of the important role of this bridge, design must aim at the improvement of earthquake resistance and an appropriate design value for lateral seismic coefficient must be defined based on a survey of the earthquake resistance standards in Cambodia.

2-2-1-3 Policy Concerning Traffic

(1) Traffic Volume

A traffic survey is conducted aiming at grasping the traffic situation at the project site and obtaining the baseline for the estimation of future traffic volume and the basic data for considering pavement structure in the bridge approach parts (considering overloading). The traffic survey is conducted on four days in total, covering a weekday and a holiday, as well as the condition with the Chroy Changwar Bridge in service and during the inspection survey with the Chroy Changwar Bridge closed. The results are used for grasping the traffic of large vehicles and the impact of construction work.

The following shows the results of survey.

1) Hourly Traffic Volume

a) RA Entrances and Exits (Phnom Penh Side)

The Chroy Changwar Bridge and the China Bridge showed a morning peak hour 7:00-8:00 and an evening peak hour 17:00-18:00. The highest traffic volume during the present survey (excluding February 17) was 8,320 vehicles observed on the Chroy Changwar Bride in the hour 7:00-8:00 of February 12 (weekday). Of this number, 7,682 (92.3%) were motorcycles (including those with trailers). In the comparison of traffic volume on a weekday and a holiday, the traffic volume in morning and evening peak hours was higher on a weekday.

b) RA Entrances and Exists (Chroy Changwar Side)

Similarly to the RA on the Phnom Phen side, the RA entrance (survey point 7) showed peak hours 7:00-8:00 in the morning and 17:00-18:00 in the evening. At the RA exit (survey point 5), a largely constant hourly traffic volume was observed from 7:00 in the morning to 20:00. In a comparison between the traffic volume on a weekday and a holiday, the traffic volume in morning and evening peak hours at survey point 7 was higher on a weekday. At survey point 5, the traffic volume on a weekday was higher than that on a holiday.

c) Prek Pnov Bridge

The traffic from National Road No. 4 to No. 6 showed a morning peak your 6:00-7:00 and an evening peak hour 17:00-18:00. The traffic in the opposite direction showed a morning peak 7:00-8:00 and an evening peak 17:00-18:00. Hourly traffic volume in both directions decreased gradually from the morning peak to 12:00 and then increased gradually to the evening peak.

d) National Road No. 5

The traffic from Phnom Penh to the direction of Prek Pnov showed no notable morning peak hour, and an evening peak hour was observed 17:00-18:00. The traffic in the opposite direction showed a morning peak hour 7:00-8:00 and an evening peak hour 18:00-19:00. The hourly traffic volume in the direction from Prek Pnov to Phnom Penh showed relatively small changes from morning to evening, while the hourly traffic volume in the direction from Phnom Penh to Prek Pnov increased rapidly in the evening.

2) Annual Average Daily Traffic Volume (on a PCU Basis)

The annual average daily traffic volume on the Chroy Changwar Bridge (the Japanese Bridge and the Chinese Bridge) is as follows.

Table 2-2-3 Annual Average Daily Traffic Volume (PCU/day)

AADT													
Location	(I) Motorcycles		(II) Light Vehicles				(III) Heavy Vehicles						Total
	Motorcycle	Motorcycle trailer	Passenger car, Pick-up, Jeep/4WD	Koyun/Etan	Minibus (8-16seats)	Light truck (<4 tons)	Bus (16+seats)	Medium Truck (>4 tons)	Heavy Truck	Full trailer, Semi trailer	Semi trailer 4&5 axles	Full trailer, Semi trailer 6+ axles	
Japan Bridge	10,697	1,103	8,240	0	2,867	1,335	112	66	0	0	0	0	24,420
China Bridge	12,678	1,429	9,021	1	3,189	1,444	146	209	54	2	1	0	28,174

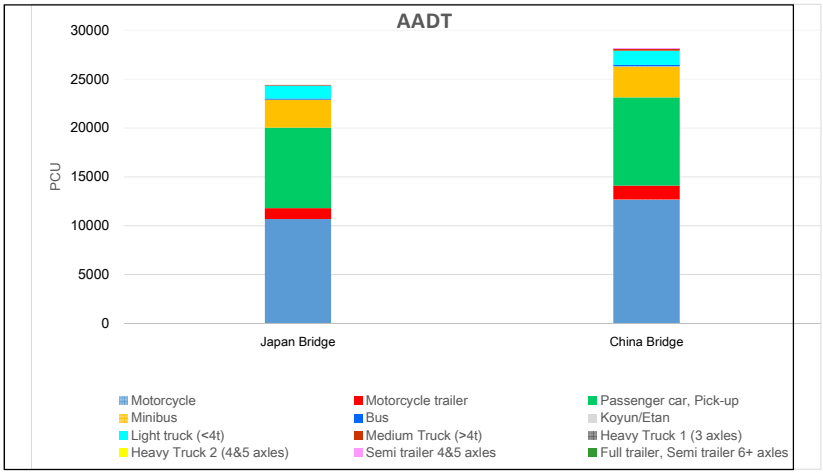


Figure 2-2-2 Annual Average Daily Traffic Volume (PCU/day)

The traffic of large vehicles on the Chroy Changwar Bridge (the Japanese Bridge) is restricted at the present, the annual average daily traffic volume shown above (calculated from the result of the traffic volume survey) does not include the traffic of large vehicles. The traffic of large vehicles assuming the presence of large vehicles has been calculated from the percentage of large vehicles on National Road No. 5. This percentage was shown to be 9% by the result of the traffic volume survey. The following shows the annual average daily traffic volume taking large vehicles into consideration.

Table 2-2-4 Annual Average Daily Traffic Volume Taking Large Vehicles into Consideration (PCU/day)

AADT (including Heavy Vehicle)													
Location	(I) Motorcycles		(II) Light Vehicles				(III) Heavy Vehicles						Total
	Motorcycle	Motorcycle trailer	Passenger car, Pick-up, Jeep/4WD	Koyun/Etan	Minibus (8-16seats)	Light truck (<4 tons)	Bus (16+seats)	Medium Truck (>4 tons)	Heavy Truck	Full trailer, Semi trailer	Semi trailer 4&5 axles	Full trailer, Semi trailer 6+ axles	
Japan Bridge	10,697	1,103	8,240	0	2,867	1,335	112	2957					27,310
China Bridge	12,678	1,429	9,021	1	3,189	1,444	146	3218					31,125

(2) Congestion Length

On February 12, a weekday, congestion occurred at the entrance on the Phnom Penh side (Oknha Kleang Mueng Blvd.) (survey point (2)) during the evening peak hours 17:00-1900, but virtually no congestion

occurred at other locations. On the Chroy Changwar side on the same day, congestion length was 0 m at all survey points.

On February 17, the day of traffic restrictions, congestion occurred at three locations other than the entrance (Preah Monivong Blvd. (survey point (3)) during the period of traffic restrictions from 9:00 to 17:00. On the Chroy Changwar side, congestion length reached about 1 km despite the temporary lifting of restrictions on the Japanese Bridge. However, it should be noted that the traffic on February 17 might have been higher than usual, because it was shortly before the Chinese New Year.

(3) Travel Speed

The travel speed survey was conducted by measuring the travel time of two cars making round trips between point A (720 m short of the RA on the Phnom Penh side) and Point B (690 m beyond the RA on the Chroy Changwar side). One car left point A and the other left point B in morning and evening peak hours.

During the morning peak hour, the speed of travel from the Chroy Changwar side (east) to the Phnom Penh side (west) was slightly slower than that in the opposite direction. In contrary, the travel during the evening peak hour was slower in the direction from Phnom Penh to Chroy Changwar than that in the opposite direction. The travel speed in this survey is considered to reflect the traffic of people commuting to the Phnom Penh side in the morning and those returning home to the Chroy Changwar side in the evening.

(4) Axle Load

The axle load survey was planned to be conducted using existing axle load measuring facilities. Because of the closure of a facility in consequence of a road improvement project and other reasons, the axle load measuring facilities actually used in the survey were somewhat distant from the survey area. However, the survey was conducted to grasp the trends in the axle load of different vehicle types in Cambodia.

Basically focusing on large vehicles, axle load measurement data were obtained from 238 vehicles (8 buses, 213 trucks, and 17 trailers).

In the analysis, we calculated the equivalent single axle load (ESAL) assuming the terminal serviceability index (pt) of 2.5 and using the structural number of SN = 5.0, which is generally considered sufficient in the AASHTO design method, as well as 3.0 and 4.0.

Recalculation of ESAL will be performed if necessary after the confirmation of the structural number in the examination of pavement structure, which will be conducted later, and then the cumulative 18kip ESAL value will be determined finally. Because this survey revealed large differences in ESAL values depending on traffic direction, ESAL values were calculated for each vehicle type in each direction, and the analytical result in the direction showing the larger value was selected for use in design. (Measurement data and the results of analysis are provided at the end of this report.)

Example) ESAL value per vehicle was 1.96 in direction 1 and 9.53 in direction 2 (when SN = 5.0)

Table 2-2-5 Per Vehicle ESAL Value for Different Vehicle Types

Structural number	Direction	Bus	Track	Trailer
5	1	1.15	2.11	0.51
	2	0.93	9.71	9.65
4	1	1.15	2.23	0.53
	2	0.95	10.21	10.22
3	1	1.17	2.72	0.56
	2	0.97	12.55	12.47

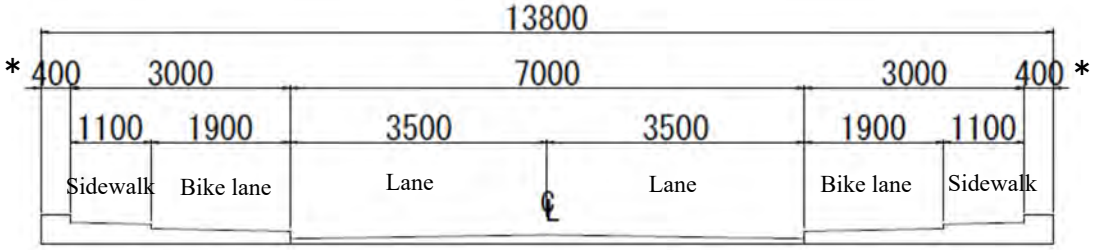
※Direction 1: Thbong Kmoum-Kg. Cham

Direction 2: Kg Cham- Thbong Khmum

2-2-1-4 Policy Concerning Road Width

Because this project will replace only the approach parts (five-span PC girder bridges on the Phnom Penh side and Chroy Changwar side) of the Chroy Changwar Bridge without replacing the center span part (steel bridge), the road cross-section of the bridge and the approach roads shall be the same as that of the existing Chroy Changwar Bridge. The road cross-section of the Chroy Changwar Bridge is illustrated below.

(Newly constructed bridge part)



*(250 in existing bridge parts)

(Newly constructed bridge part)

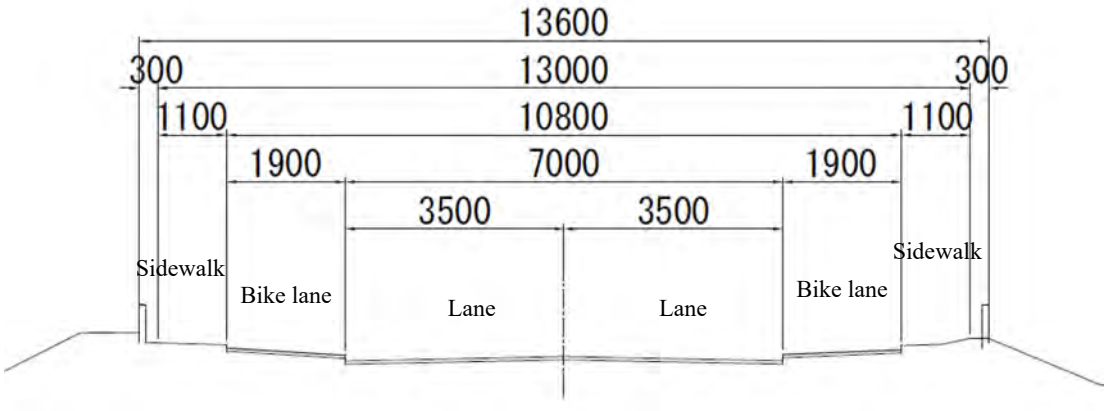


Figure 2-2-3 Road Cross-section of Bridge and Approach Road Parts

2-2-1-5 Policy Concerning Design Live Load

Because this project is a Japanese grant aid project and the Chroy Changwar Bridge (steel three-span box girder) was designed in 1992 according to the Japanese Specifications for Highway Bridges (1990), the PC bridge parts shall be designed according to the Japanese Specifications for Highway Bridges (2012). Therefore, the design live load shall be "B live load."

2-2-1-6 Policy Concerning Socioeconomic Conditions

The matters that should be considered and the measures that should be taken on the planning, designing, and construction of the bridge in the cooperation project are as follows:

① Generation of dust during construction: Use sprinkling and other dust control measures.
② Generation of noise and vibration during construction: Use construction methods producing as little noise and vibration as possible.
③ Spillage of contaminants (e.g., oil spillage): Take measures to prevent the spillage of contaminants.
④ Soil runoff and river contamination: Take measures to prevent soil runoff and river pollution.
⑤ Hindrance to general traffic: Give safety education to construction vehicle drivers.
⑥ Measures in borrow pit and stone pit: Select a borrow pit in a place where it would cause little environmental burden. Avoid stone quarrying at a new site as much as possible, opting for the use of an existing stone pit.
⑦ Occurrence of accidents: Prevent accidents through complete safety and health education for construction personnel.
⑧ Resettlement: Make sure appropriate resettlement according to the abbreviated resettlement action plan (ARAP).

2-2-1-7 Policy Concerning Construction Situation

(1) Labor Situation

Although there are construction companies, engineers, and workers in Cambodia who have experience in bridge projects through past grant aid cooperation, they are insufficient in number and their experience is limited. In particular, those with the work skills and experience concerning the construction of PC bridges are rare. Engineers shall therefore be sent from Japan for the work types requiring advanced skills and the work types that have rarely been performed, while local skills and workforce shall be used as much as possible in all other work as a rule.

Similarly to past grant aid projects, it is possible to procure workers in Cambodia. However, as they belong to construction companies and each company is more proficient in some fields than in others, it is important to ascertain this point. As for the employment of workers, the employer must conform to the current Cambodian laws and regulations concerning construction, respect appropriate work conditions and customs, prevent conflict with workers, and ensure safety.

(2) Situation of Material Procurement

1) Reinforcement bars, Steel Products, and PC Steel

Reinforcement bars produced in Cambodia, Thailand, and Vietnam are available in the market. Because the reinforcement bars made in Cambodia are poor in quality, products of a third country (Thailand, Vietnam, Japan, etc.) shall be procured. Steel products such as sheet steel and shape steel are not produced in Cambodia. These shall be procured from Japan or a third country (Thailand, Vietnam, etc.) PC steel is practically impossible to procure from the market, and no facility in Cambodia has the reliable technology to process this material into products. Therefore, the PC steel used in this project shall be ordered with arrangement for confirmation of quality, such as specifying the import source and manufacturer, and importation from Japan or a third country shall be considered.

2) Bridge Accessories

Some bridge accessories can be procured from neighboring countries, as was the case in past grant aid projects. However, procurement from Japan is desirable, because many of such products have poor quality and other problems.

3) Cement

Cement can be procured in Phnom Penh. However, experience in road and bridge construction project in the country has shown that the cement produced in Cambodia has instability in quality and may fail to produce concrete with sufficient strength. Use of the cement produced in Thailand shall be considered if such problem occurs.

4) Asphalt Concrete

The asphalt plant for the production of asphalt concrete can be procured in Cambodia. However, procurement from the neighboring countries of Thailand and Vietnam, as well as Japan, shall be considered, if there is difficulty in ensuring stable quality and supply capacity.

5) Banking Materials and Aggregate

Banking materials and aggregate for concrete can be procured locally. The aggregate plant shall be set up near the site.

(3) Situation of Construction Machine Procurement

All construction machines operating in Cambodia are imported products. There are no lease companies, and construction machines are owned by local contractors. Availability of multi-purpose heavy equipment used in this project is limited, and some of back hoes, bulldozers, and tire rollers shall be procured from a third country (Thailand) and Japan.

Special machines such as large cranes, earth drills, and Vibro Hammers shall be procured from Thailand or Vietnam. The equipment for SFRC pavement on steel plate decks shall be procured from Japan, because we could not confirm the use of such equipment in Cambodia and neighboring countries.

(4) Bridge and Road Design and Construction Standards

1) Bridge Design and Construction Standards

Starting with the technical assistance of the former USSR in 1984, Cambodia completed the development of bridge design standards in 1999 under the technical assistance of Australia.

However, various design standards chosen by different designers have been applied to many of the bridges designed and constructed with the assistance of donors, including the Tsubasa Bridge, the Kizuna Bridge, and other bridges constructed under Japanese grant aid cooperation, which are in conformity to the Japanese Specifications for Highway Bridges.

In the case of the Chroy Changwar Bridge, while it is not documented what design standards were used in the original construction in 1963, the steel girders (7 spans) in the river-crossing part manufactured by a Japanese bridge maker are considered to have been based on the Design Specifications for Steel Highway Bridges stipulated in 1956. Later, in the Project for Rehabilitation of the Chroy Changwar Bridge in 1992, the steel girders in center spans (3 spans) and the 2 reconstructed substructure pieces were designed based on the 1990 version of the Specifications for Highway Bridges. For these reasons, the design of the superstructure shall be developed in this study based on the current Specifications for Highway Bridges (2012). The PC approach bridges that will be constructed on the Phnom Penh side and the Chroy Changwar side after demolition of existing bridges shall also be designed based on the Specifications for Highway Bridges (2012) to ensure the coherence in the calculation of various loads and design parameters concerning steel girders.

However, standards used in Cambodia (e.g., BRIDGE DESIGN STANDARD 2003 by Ministry of Public Works and Transport) shall be applied to locally produced materials in the examination of standard material strength.

Because the Specifications for Highway Bridges are based on a design system using the allowable stress design method and Cambodian standards are based on the limit state design approach, it is difficult to make a direct comparison between these approaches. Nevertheless, the Specifications for Highway Bridges provides for the following verification methods corresponding to the ultimate limit state and the serviceability limit state, and it is known that the different design approaches produce largely similar results and differences occur generally on the safety side.

- Ultimate limit state: Safety against destruction is verified by the demonstration that each member of the bridge has a stress resistance against destruction that is larger than the sectional force in the member.
- Serviceability limit state: The allowable stress in rebar is verified by the crack width of generally 0.2 mm or less on concrete surfaces.

2) Road Design and Construction Standards

With respect to road design, the standards implemented in Cambodia shall be used, and any lack of coverage shall be supplemented with the use of Japanese standards. Therefore, the design standards used in road design shall be as follows:

- ROAD DESIGN STANDARD 2003 (Ministry of Public Works and Transport)
- Road Structure Standard 2015 (JAPAN)

2-2-1-8 Policy Concerning the Use of Local Companies

According to the interview survey with local companies, they have experience in the PCI girder composite deck bridges with the girder length of about 30 m, but lack experience in PC box girder bridges or continuous girder bridges. Local companies act as the contractors of road and bridge construction projects, and Thai and Vietnamese companies are used as subcontractors. The situation of road construction in the southern part of Cambodia demonstrates that they have a high level of technical capabilities in earthwork.

With respect to local consultants, our interview survey indicated that although the technical capabilities of local consultants are not poor, it is difficult for them to recruit the human resources suitable to Japanese grant aid cooperation projects. It seems that the services of local consultants are limited to surveying, geological surveys, traffic volume surveys, environmental surveys, etc.

2-2-1-9 Policy Concerning the Actions for the Operation and Maintenance Capabilities of the Implementing Organization

The government organization in charge of this project is the Ministry of Public Works and Transport (MPWT), and the implementing organization is Road Infrastructure Department (RID) of the Ministry. Maintenance after the construction of Chroy Changwar Bridge will be conducted by RID, and routine maintenance will be placed under the charge of the Department of Public Works and Transport (DPWT) of Phnom Penh, where the bridge is located.

However, considering the fact that the maintenance capabilities of RID and DPWT are not high both in terms of technical levels and budgets, bridge replacement and repair shall be conducted using structures can be maintained easily as much as possible.

2-2-1-10 Policy Concerning the Grade Setting of Facilities

National Road No. 6A is an important trunk road providing direct access from the capital city Phnom Penh to the nine northeastern provinces the northern suburbs of the city. The Chroy Changwar Bridge at the origin of this route is a strategic point for traffic and physical distribution in Cambodia.

Because the Chroy Changwar Bridge, the target of this cooperation, is a very important bridge located at the point where this National Road No. 6A crosses the Tonle Sap River, the following grades shall be used.

① Design standards:

- Bridge design: Japanese design standards for design live load and design methods, and Cambodian design standards shall be used, among others, for the standard strength of materials in the cases where local materials are used.
- Road design: Cambodian design standards shall be used and any lack of coverage shall be supplemented with the use of Japanese standards.

② Design live load: “B live load” as defined in the Japanese Specifications for Highway Bridges shall be used.

③ Width:

- Bridge part: Carriage way width 3.5 m x 2 = 7.0 m, bike lanes 1.9 m x 2 = 3.8 m, sidewalks 1.1 m x 2 = 2.2 m.

  Total 13.0 m (effective width)

- Approach roads: Carriage way width 3.5 m x 2 = 7.0 m, bike lanes 1.9 m x 2 = 3.8 m, sidewalks 1.1 m x 2 = 2.2 m.

  Total 13.0 m (effective width)

④ Road type: U5 (trunk national road)

⑤ Design vehicle speed: 60 km/h (standard value for a trunk national road)

2-2-1-11 Policy Concerning Construction Methods and Period

(1) Policy Concerning Construction Methods

The land of Cambodia mostly consists of a plain, where the Mekong River flows in a north-south direction generally along the center axis. The Tonle Sap River is a major river in the country (with a catchment area of 84,400 km^2), which joins the Mekong River in the capital city Phnom Penh. The river has its source in Tonle Sap Lake, which is located centrally in the country and acts as the reservoir for the flows of water in the surrounding areas.

A distinctive characteristic of the Tonle Sap River is the yearly repetition of forward flow (from the Tonle Sap to the Mekong) and reverse flow (from the Mekong to the Tonle Sap), because the water level in the Mekong River greatly influences the flow in the right-bank tributary.

Judging from the rainfall at the observation post in the vicinity of Pochentong near Phnom Penh International Airport, rainfall in the area including the Chroy Changwar Bridge construction site is generally extremely low from December to March, increases gradually from April, and high from June to November. In particular rainfall exceeds 300 mm from September to October, but the annual rainfall in this area is not particularly high.

It is therefore necessary to avoid substructure repair work in the river as much as possible during the flooding season from June to November. If substructure repair work must be performed in the river during this period for unavoidable reasons, utmost attention must be paid to scaffolding work.

(2) Policy Concerning Work Period

As discussed above, although the area including the Chroy Changwar Bridge construction site does not have particularly high annual rainfall, flooding occurs frequently in the period from June to November. It is therefore necessary to develop efficient work plans considering the frequent occurrence of flooding.

2-2-2 Basic Plan

2-2-2-1 Work Flow of the Basic Plan

In the basic plan, we conduct necessary tasks for the implementation of this project, including the survey of existing conditions, evaluation of the result of bridge inspection, determination of bridge repair policy, development of bridge repair plan (draft), survey on environmental and social considerations, outline design of the project, and survey on procurement situation, and then calculate the rough estimated project cost. The Figure below shows the work flow of the basic plan.

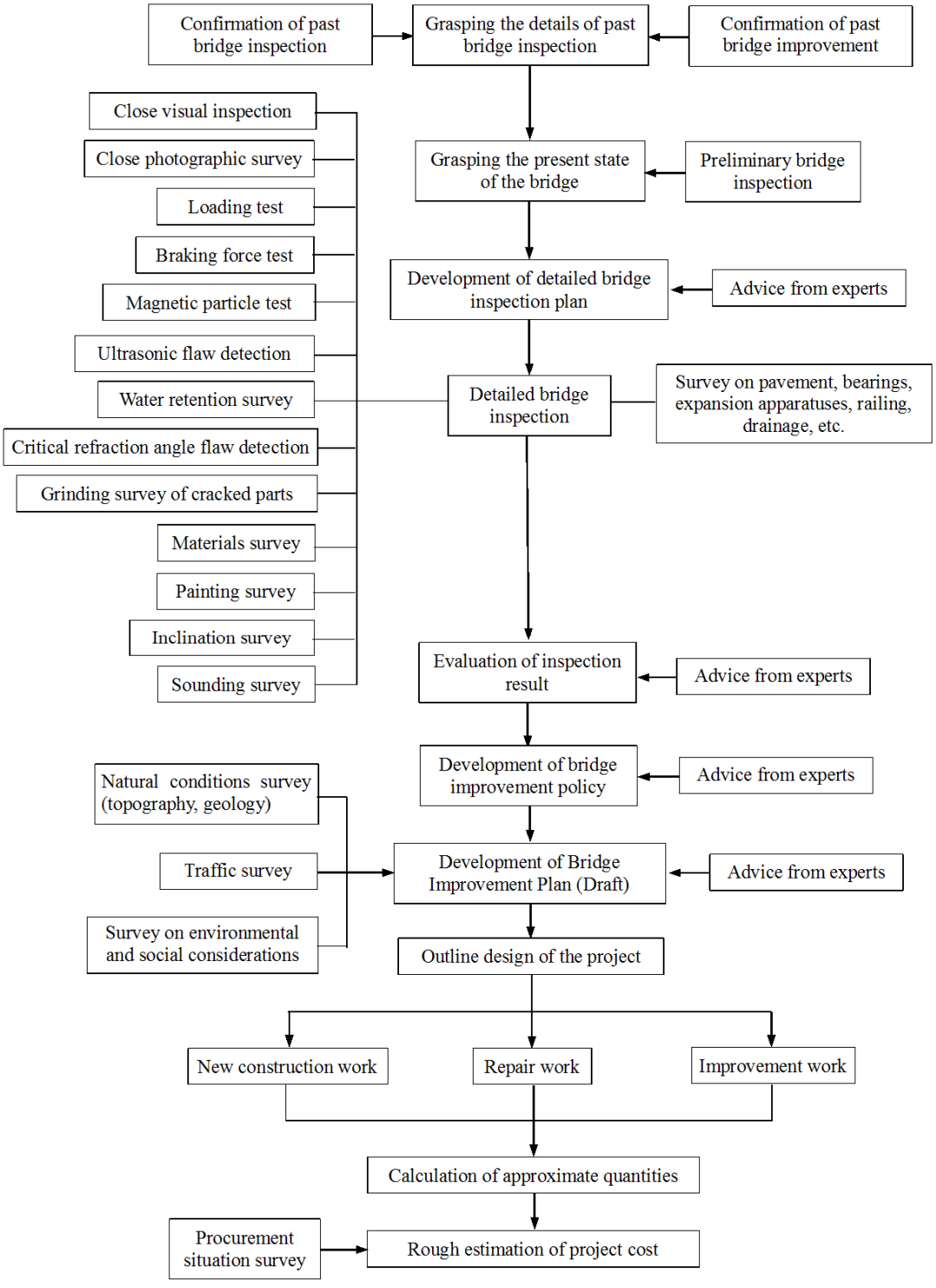


Figure 2-2-4 Basic Plan Work Flow

2-2-2-2 General view of the existing bridge

The general view of the existing bridge is shown in the Figure 2-2-5.

2-2-2-3 Details of the Survey of Existing Conditions

The details of the survey of existing conditions are shown in the Table below.

Table 2-2-6 List of the Details of the Survey of Existing Conditions

	Survey	Survey description	Survey target
1	Close visual survey (1)	Inspection survey using special aerial work skills (rope work)	Steel bridge part and 5 piers (P3-P7) in the river
2	Close visual survey (2)	Inspection survey using aerial work platform and pole camera	PC bridge parts
3	Close photographic survey	Photographic examination using UAV (small unmanned helicopter)	Outer surfaces of steel bridge part and piers in the river
4	Loading test	Examination of deflection and strain using loading test	Old steel bridge and PC bridges
5	Braking force test	Examination of rocker bearing displacement due to the braking of dump truck	Rocker bearings (in PC bridge parts)
6	Magnetic particle test	Crack detection using magnetic particles	Steel plate decks
7	Ultrasonic flaw detection	Examination using ultrasonic crack detection	Interior of old steel bridge part
8	Water retention survey	Examination of water retention in U ribs using ultrasonic flaw detector	Welds between steel plate decks and U ribs in new steel bridge
9	Critical refraction angle flaw detection	Examination of propagating cracks in steel plate decks using ultrasonic flaw detector	Welds between steel plate decks and U ribs in new steel bridge
10	Grinding survey of cracked parts	Examination using crack removal with a grinder	Notched parts of P6 pier
11	Materials survey	• Compressive strength test and neutralization test on concrete using concrete core sampling • Measurement of scleroscope hardness using a Schmidt hammer	Pier and PC girder parts
12	Painting survey	• Examination of salt deposition using chloride ion detecting tube • Examination of coating thickness using cut tape method	Steel bridge part
13	Bearing and pier inclination survey	• Examination of bearing and pier inclination using plumb bob	Bearings and piers (P2, P7 piers)
14	Sounding survey	• Ultrasonic examination of souring around pier footings	Spread foundation in the river (P3,P6,P7) and steel pipe well foundation(P4,P5)
15	Geological survey	• Land drilling (4 boreholes) • Over water drilling (4 boreholes)	• Land (T2, T7, P1, P8 piers) • Over water (P2, P3, P6, P7 piers)
16	Traffic survey	• Traffic volume survey • Congestion length survey • Travel speed survey • Axle load survey	• Chroy Changwar Bridge • Roundabouts • Prek Pnov Bridge • National Road 5 • National Road 6 (travel speed survey) • National Road 7 (axle load survey)
17	Topographic surveying	• Topographic surveying of road (100,000m^2) • River cross-sectional surveying (3 locations)	• National Road 6 and Chroy Changwar Bridge • Tonle Sap River
18	Survey on environmental and social considerations	• Survey on environmental and social considerations (baseline survey, development of EIA (draft), etc.) • Development of abbreviated resettlement action plan (RAP (draft))	Area around Chroy Changwar Bridge

2-2-2-4 Evaluation of the Result of Bridge Inspection

Table 2-2-7 shows the evaluation of the result of the survey of the existing conditions of the bridge and the detailed inspection survey conducted during the First and Second Field Surveys.

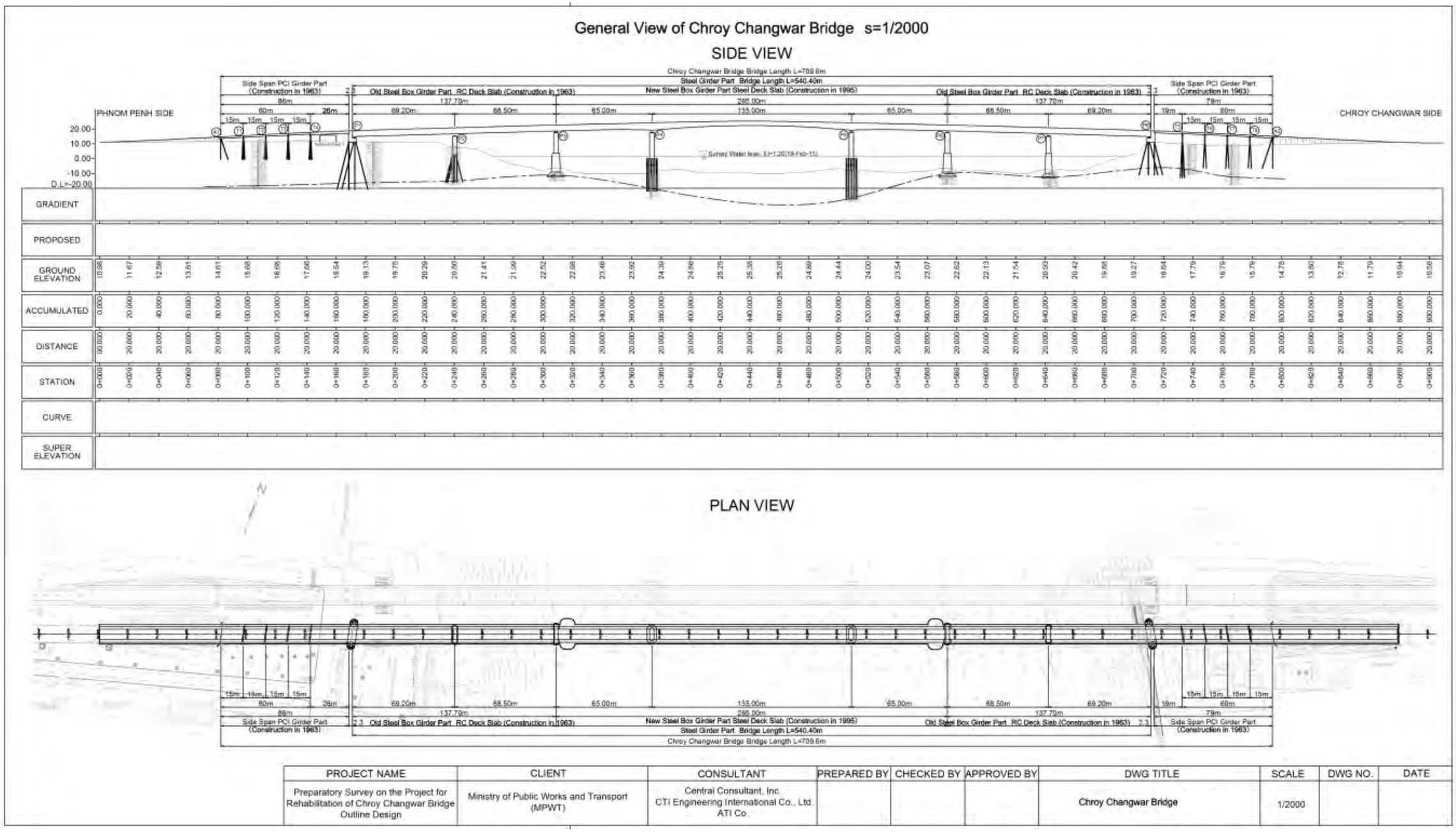


Figure 2-2-5 General view of the existing bridge

Table 2-2-7 Evaluation of Result of Bridge Inspection (1/5)

Target item		Survey method		Result of bridge inspection	Evaluation of bridge inspection result
Superstructure of steel bridge	2-span steel box girder bridges (constructed in 1963)	Inspection of appearance using small unmanned helicopter		• Paint film on the outer surfaces of box girders was in good condition, except for girder ends and localized water leakage.	• The useful life for a paint film is 15.2 years for A-grade coating systems in an average environment and 15.4 years for B-grade coating systems in somewhat harsher environments. Given how far peeling has advanced according to the adhesion tests, and that more than 20 years have passed since the last coating, the bridge needs to be repainted.
		Paint stripping test		• In an adhesion test with cut tape, stripping area was more than 50 percent.	
		Close visual inspection		• Paint film cracks were observed in 96 welds on transverse and longitudinal ribs of steel plate decks prone to fatigue cracking.	• Magnetic particle test required as paint film cracking was observed on weld points.
		Magnetic particle test		• Magnetic particle tests performed on the paint film cracking at welds on transverse and longitudinal ribs of steel plate decks revealed 40 cracks.	• Given that the cracks found were as large as 68 mm, additional testing (ultrasonic flaw detection) will be needed, and cracks must be repaired and reinforced.
		Ultrasonic flaw detection		• The maximum depth of the cracks was 4 mm near P7 pier and 2 mm near P8 pier.	• The cracks were not as deep as the weld leg lengths and so will be monitored carefully for advancement. Note that no repair will be needed if paving with SFRC or other material which can curtail fatigue deterioration of steel deck slabs.
		Grinding of cracked areas		• Upon grinding the cracked areas, cracks were limited to the weld zone and showed no progression into the parent metal.	• No repair needed. Cracks are not observed to be progressing into the parent material.
		Loading test	Deflection	• δ max = 11.482 mm (theoretical δ = 10.470 mm) (span P1-P2) • δ max = 11.358 mm (theoretical δ = 10.470 mm) (span P7-P8)	• Relative to theoretical values, the ratio of measured values γ was 1.097 for the Phnom Penh side and 1.085 for the Chroy Changwar side. While this is slightly excessive, the girders do tend to sag in the center, possibly due to the top flanges losing their rigidity. Still, as deflection is less than 1/10 of the allowable amount (138 mm), it is not an issue.
			Strain	• $\sigma1 = -10.8$ N/mm^2 (theoretical $\sigma = -13.1$ N/mm^2) • $\sigma2 = -1.6$ N/mm^2 (theoretical $\sigma = -1.8$ N/mm^2) • $\sigma3 = 30.5$ N/mm^2 (theoretical $\sigma = 35.7$ N/mm^2)	• Strain distortion from terebration was analyzed with a rosette gauge to determine the maximum residual stress level. • Relative to theoretical values, the ratio of measured values γ was 0.824, 0.889, and 0.854, respectively, indicating surplus load bearing capacity.
		Overall assessment			• While the bridge is more than 50 years old, it shows no signs of major damage or deterioration affecting the load bearing capacity of superstructure and does not need replaced. • No corrosion or similar damage was found, but the bridge should be repainted as more than 20 years has passed since the last coating. • If the cracks are observed to progress further in the future, plans will need to be made for repair and reinforcement using stop holes, cover plates, or other means. Note that future repairs will likely be minimal if paving with SFRC or other material which can curtail fatigue deterioration of steel deck slabs.
	3-span steel box girder bridges (constructed in 1994)	Inspection of appearance using small unmanned helicopter		• Paint film was observed to be peeling across the entire width of the box girder bottom flange, at a width of around 10 cm in 4 places.	• The useful life for a paint film is 15.2 years for A-grade coating systems in an average environment and 15.4 years for B-grade coating systems in somewhat harsher environments. Accordingly, although paint deterioration was localized, the bridge should be repainted as more than 20 years has passed since the last coating.
		Close visual inspection		• Paint film observed as cracking in 124 weld zones on U ribs of steel plate decks.	• Magnetic particle tests required.
		Magnetic particle test		• Cracking observed at 13 intersections between steel plate deck U ribs and cross beams.	• The largest crack observed was 135 mm. Still, no repair will be needed if paving with SFRC or other material which can curtail fatigue deterioration of steel deck slabs.
		Water retention survey		• No water retention observed.	• As no water retention was found, deck plates are not believed to have any cracks. No water retention measures required.
		Critical refraction angle flaw detection		• No cracks observed to have progressed into the deck plates of the steel plate decks.	• Cracks have not progressed into deck plates. No repairs needed.
		Overall assessment			• This bridge does not need replacing. It is only 20 years old and no significant damage or deterioration affecting the load bearing capacity of superstructure was observed. • While bridge paint film is in good condition, it should be repainted as more than 20 years has passed since the last coating.

Target item		Survey method	Result of bridge inspection	Evaluation of bridge inspection result
				• If the cracks are observed to progress in the future, plans will need to be made for repair and reinforcement using stop holes, cover plates, or other means. Note that future repairs will likely be minimal if paving with SFRC or other material which can curtail fatigue deterioration of steel deck slabs.
Substructure of steel bridge	P1-P8 piers	Close-range visual inspection using special aerial work techniques for all piers	• P1 pier: No noticeable damage observed on the pier itself, but much damage observed in the form of cracks and exposed rebar to concrete of spiral staircases on the both sides. • P2 pier: Much concrete damage observed on both faces of vertical walls. • P3 pier: Missing concrete and cracks of about 0.2 mm width observed on vertical walls. • P4 pier: Vertical cracks of up to 0.4 mm observed on the area near the center of vertical wall. What appeared from a distance to be large cracks were actually the adhesive used in crack repairs (same in P5 pier). • P5 pier: Cracks and repaired cracks observed. Cracks in areas submerged during the rainy season are repaired. There is a crack of 0.3 mm located above this area that has not yet been repaired and has calcareous ejecta on its surface. • P6 pier: Although concrete surfaces are in good condition, some exposed rebar exposure was observed due to insufficient cover. • P7 pier: Rebar exposure due to insufficient cover discovered in several places. Delamination observed in the concrete near the exposed areas. • P8 pier: Although cracks of about 0.1 mm are seen, overall no critical damage is found. However, similarly to P1, damage was observed on both sides of the spiral staircases.	• Cracks with widths of 0.4 mm or larger require repair. Relatively small cracks less than 0.4mm (hair cracks) do not require any particular plan for repairs or reinforcement. • Rebar exposure due to insufficient cover requires section repair. • Concrete delamination around exposed rebar shall be treated with section repair. • Relatively larger cracks of 0.4-1.0 mm must be repaired with impregnation.
		Compressive strength test using concrete coring	• Concrete compressive strength was 33-50 N/mm^2 for all piers.	• Compressive strength satisfies the concrete design strength of 21 N/mm^2. No work needed.
		Neutralization test using concrete coring	• Neutralization depths of 12 mm, 15 mm, and 3 mm observed for P1, P2, and P3 piers, respectively. No neutralization observed in the other piers.	• Depths satisfy the standard for neutralization residual depth of 10.0 mm. No work needed.
		Measurement of compressive strength of concrete using Schmidt hammer	• Average scleroscope hardness of piers were as follows: 51 N/mm^2 for P1, 41 N/mm^2 for P2, 50 N/mm^2 for P3, 76 N/mm^2 for P4, 66 N/mm^2 for P5, 44 N/mm^2 for P6, and 58 N/mm^2 for P8.	• Scleroscope hardness satisfied the concrete design strength of 21 N/mm^2 for all piers. No work needed.
		Inclination inspection	• Inclination of bearing parts showed large values of 32 mm on P2 pier (P1 side), 61 mm on P7 pier (P6 side), and 39 mm on P8 pier (T5 side).	Possible causes of inclination include: • Effect of temperature changes (base deformation $\delta = 0.60 \times L$; where L is length of the deformed girder) • Construction error • Effect of the blasting of the center span As there are no accurate data during construction and blasting, however, the true cause can be identified only after observing the progression of inclination long-term, using the present data as the initial values. Note that inclination for P2 and P8 piers was below the base deformation of 42 mm, but inclination for P7 pier exceeded base deformation. If inclination progresses any further than current levels, bearing replacement or other measures will be discussed.
		Subsidence survey	• No differential settlement observed.	• No repair or reinforcement plan is needed as no differential settlement was observed.
		Overall assessment		• No extensive repair and reinforcement plan is required. There is no significant damage or deterioration affecting the bearing capacity of piers, and no differential settlement was observed. • Concrete surface damage (rebar exposure, delamination, cracking, etc.) needs section repairs and crack injection work. • Bearing inclinations need to be monitored regularly.

Table 2-2-7 Evaluation of Result of Bridge Inspection (3/5)

Target item		Survey method	Result of bridge inspection	Evaluation of bridge inspection result
Foundation of steel bridge section	P1-P8 piers	Sounding survey (P3-P7 piers)	• No scouring observed in any piers.	• No repair or reinforcement plan is needed as no scouring was observed.
		Soil survey (P1-P3, P6-P8)	• Assuming that the spread footings for P3, P6, and P7 piers are constructed according to the original design and construction drawings, the spread footing bases are supported by good load-bearing ground (sandy clay with N>25). • Assuming that the bearing piles for P1, P2, and P8 piers are constructed according to the original design and construction drawings, the bearing piles are sufficiently embedded in load-bearing ground (claylike sediment with gravel, N>35).	• P3, P6, and P7 piers (spread footings) are supported by good load-bearing ground and do not require a repair and reinforcement plan. • P1, P2, and P8 piers (pile foundations) are well supported and do not require a repair and reinforcement plan.
		Overall assessment		• Upon studying the construction records from the work in detail, P4 and P5 piers (steel pipe sheet pile foundations) are sufficiently embedded in load-bearing ground and do not require a repair and reinforcement plan. • No piers show signs of scouring and all are supported by a good load-bearing ground. No particular repair and reinforcement plan is required.
Superstructure of PC bridges	5-span PC bridge (1) (Phnom Penh side)	Close visual inspection	• Cracks approximately 0.4 mm in width and 400 mm in length were observed on the ends of some main girders. Cracks approximately 0.1 mm in width and 300 mm in length were also observed on the center areas of cross beams. • No cracks observed in deck concrete. • Spalling and rebar exposure (300 mm x 300 mm) are visible on the underside of main girder at fulcrum points.	• The spalling and rebar exposure observed on the underside of main girders at fulcrum points need to be repaired and reinforced.
		Loading test (deflection)	• Deflection at the girder centers was: 0.734 mm for G1, 2.350 for G3, and 0.748 for G5. • Based on this, average elastic modulus of concrete derived from design restoration is 2.459×10^4 N/mm^2.	• The concrete of the existing PC bridge has an average elastic coefficient of 2.459×10^4 N/mm^2, which is only 87.8 percent of the 2.80×10^4 (N/mm^2) elastic modulus of concrete at a design standard strength of 30 (N/mm^2). Therefore, the existing PC bridge is deemed to lack sufficient load-bearing capacity.
		Compressive strength test using concrete coring	• Compressive strength of main girders is 36.14 N/mm^2.	• Compressive strength for the main girders satisfies the concrete design strength of 30 N/mm^2 or greater. No work needed.
		Neutralization test using concrete coring	• No neutralization observed.	• With no neutralization, no work is required.
		Schmidt hammer test	• The average scleroscope hardness for main girders is 52 N/mm^2.	• Scleroscope hardness for the main girders is greater than the concrete design strength of 30 N/mm^2. No work needed.
		Overall assessment		• The girders show signs of cracking, spalling, and rebar exposure. A repair and reinforcement plan must be developed promptly. Further, main girders are suspected to lack sufficient load-bearing capacity. Bridge replacement is required.
	5-span PC bridge (2) (Chroy Changwar side)	Close visual inspection	• Cracks of approximately 0.1 mm were observed on the main girder connections of the cross beams. • Spalling and rebar exposure (250 x 150 mm) were observed on the underside of main girder at fulcrum points. • Cracks approximately 0.3 mm in width and 600 mm in length and spalling were observed near the bearing supports for the main girders.	• A repair and reinforcement plan must be developed for the cracking and spalling concrete observed near the bearing supports for the main girders.
		Loading test (deflection)	• Deflection at the girder centers was: 0.898 mm for G1, 2.350 mm for G3, and 0.593 for G5. • Based on this, average elastic modulus of concrete derived from design restoration is 2.482×10^4 N/mm^2.	• The concrete of the existing PC bridge has an elastic coefficient of 2.482×10^4 N/mm^2, which is only 88.6 percent of the 2.80×10^4 (N/mm^2) elastic modulus of concrete at a design standard strength of 30 (N/mm^2). Therefore, the existing PC bridge is deemed to lack sufficient load-bearing capacity.
		Compressive strength test using concrete coring	• Compressive strength of main girders is 30.65 N/mm^2.	• Compressive strength for the main girders satisfies the concrete design strength of 30 N/mm^2 or greater. No work needed.
		Neutralization test using	• No neutralization observed.	• With no neutralization, no work is required.

Table 2-2-7 Evaluation of Result of Bridge Inspection (4/5)

Target item		Survey method	Result of bridge inspection	Evaluation of bridge inspection result
		concrete coring		
		Schmidt hammer test	• The average scleroscope hardness for main girders is 51 N/mm^2.	• Scleroscope hardness for the main girders is greater than the concrete design strength of 30 N/mm^2. No work needed.
		Overall assessment		• Main girders show visible cracking, spalling, and exposed rebar and are suspected to lack sufficient load-bearing capacity. Replacement required.
Substructure of PC bridges	5-span PC bridge (1) (Phnom Penh side)	Close visual inspection	• Localized spalling and rebar exposure is observed on the beam sections of all piers.	• Spalling and rebar exposure due to insufficient cover need section repair.
		Compressive strength test using concrete coring	• Concrete compressive strength of T1 pier is 31.32 N/mm^2. • Concrete compressive strength of T4 pier is 21.08 N/mm^2.	• While the concrete compression strength of T1 pier satisfies the design standard strength of 21 N/mm^2, that of T4 pier only slightly exceeds the design standard strength. • While just barely, the piers satisfy design strength and do not require any work.
		Neutralization test using concrete coring	• Neutralization depth of T4 pier is 12.0 mm. • No neutralization observed on A1 abutment or T1 pier.	• Neutralization residual depth is above the standard of 10.0 mm. No work needed.
		Schmidt hammer test	• Average scleroscope hardness is 41 N/mm^2 or higher for all piers.	• Scleroscope hardness satisfies the concrete design strength of 21 N/mm^2 or greater for all piers. No work needed.
		Overall assessment		• There is no significant damage or deterioration affecting the load bearing capacity of pier substructure (framework). • Section repair is needed to prevent deterioration from spalling, rebar exposure, and other concrete surface damage from progressing in the future.
	5-span PC bridge (2) (Chroy Changwar side)	Close visual inspection	• Concrete delamination, spalling, and exposed rebar were observed in the T5 pier beam. • Cracks approximately 0.2 mm in width and 600 mm in length were observed on the T6 and T7 pier beams. • Localized rebar exposure also observed on the T8 pier.	• Delamination, spalling, rebar exposure, and other damage require section repairs. • As the cracks are relatively small at less than 0.3 mm (hair cracks), no repair and reinforcement plan is required.
		Compressive strength test using concrete coring	• Compressive strength of T7 pier is 21.31 N/mm^2.	• Compressive strength satisfies the concrete design strength of 21 N/mm^2 or greater. No work needed.
		Neutralization test using concrete coring	• Neutralization depth of T7 pier is 4.0 mm. • No neutralization observed on A2 abutment.	• Neutralization residual depth is above the standard of 10.0 mm. No work needed.
		Schmidt hammer test	Average scleroscope hardness is 43 N/mm^2 or higher for all piers.	• Scleroscope hardness satisfies the concrete design strength of 21 N/mm^2 or greater for all piers. No work needed.
		Overall assessment		• There is no significant damage or deterioration affecting the load bearing capacity of pier substructure (framework). • Spalling, rebar exposure, and other concrete surface damage needs section repair.
Foundation of PC bridges	PC girder bridge (1) (Phnom Penh side)	Soil survey	• The end of the T2 pier pile foundation is embedded to a depth of -12 m with an N-value of just over 30. At deeper locations, the N-value drops to 10-30. • The high quality bearing stratum available in this place is rock with N ≥ 50 at the depth of -28 m.	• As the pile foundation is believed to be friction piles, it needs to either be reinforced with additional piles or have new bearing piles embedded in the good bearing layer.
	PC girder bridge (2) (Chroy Changwar side)	Soil survey	• The end of the T7 pier pile foundation is only embedded to a depth of 7 m, and the N-value at deeper locations is less than 10. • The ground has consolidated cohesive soil at a depth of -26 m with N ≧50.	• As the pile foundation is believed to be friction piles, it needs to either be reinforced with additional piles or have new bearing piles embedded in the good bearing layer.
Expansion apparatuses	Steel bridge section	Close visual inspection	• Carriageway and bike lane sections have finger-type apparatuses with the following expansion gaps: On P1: 55.0 mm > calculated movement amt. = 21 mm On P3: 97.8 mm > calculated movement amt. = 81 mm On P6: 45.9 mm > calculated movement amt. = 40 mm On P8: 47.0 mm > calculated movement amt. = 21 mm • Sidewalk sections have steel butt-welded apparatuses. No particular	• As no damage or deterioration requiring major repair or replacement was observed on the expansion apparatuses themselves, the current apparatuses will continue to be used. • The current expansion apparatuses will be converted from drained to undrained. The current gutters will be cleaned of the blocking sediment and filled with backfill material.

Table 2-2-7 Evaluation of Result of Bridge Inspection (5/5)

Target item		Survey method	Result of bridge inspection	Evaluation of bridge inspection result
			issues observed. • While the expansion apparatuses do have drainage, the drainage gutters are confirmed to be blocked with sediment and not functioning sufficiently.	
	PC bridge section	Close visual inspection	• Carriageway sections have buried joints with overlay, making visual inspection impossible. • Bike lanes have buried joints and were observed to have uneven surfaces. • Sidewalk sections have apparatuses with cover plates, most all of which are observed to be missing.	• Expansion apparatuses are significantly damaged and deteriorated and need replacing.
Bearings	Steel bridge section	Close visual inspection	• Inclination was confirmed in the bearings on P2, P7, and P8 piers: P2 (32 mm to P1 side), P7 (61 mm to P6 side), and P8 (39 mm to T5 side).	• Inclination must be measured periodically using the present data as the initial values. • Repair, reinforcement, and bearing replacement will be considered as possibilities depending on whether inclination progresses further in the future.
	PC bridge section	Close visual inspection	• All 5 rocker shoes on T4 are observed to be tilted toward the Phnom Penh side. • The shoes on the P8-T5 pier span are confirmed to have been repaired with mortar. The pier plinths are confirmed to have been reduced to gravel in certain parts due to aging.	• Rocker bearings need replacing.
		Braking force test	• Displacement of rocker bearings due to braking force was not confirmed.	• Rocker bearings have been displaced to their limits and will be replaced.
Pavement	Steel bridge section	Close visual inspection	• No damage or other abnormalities observed on the pavement on the carriageway section of new 2- and 3-span bridges. • Much road surface spalling approximately 10 mm in size was observed in the pavement and curbs of the bike lanes on the new bridges.	• The pavement of bike lanes is significantly damaged and visibly deteriorated. Repaving required. • Carriageway pavement is in good condition, but needed paving with SFRC or other material which will suppress the kind of fatigue cracking of the steel plate deck expected in the future.
	PC bridge section	Close visual inspection	• Rippling is observed in all lanes due to the overlay.	• Repaving is required to repair significant damage and deterioration to the overlay.
	Earthwork section (Phnom Penh side)	Close visual inspection	• Bumps of approximately 50 mm observed on the median of the intermediate section of pavement on the carriageway, impeding vehicle traffic. • The tops of many of the curbs between the bike lanes and the carriageway have been whittled away by damage.	• Pavement has significant damage and deterioration and requires repaving. Appropriate materials must be considered when repaving.
	Earthwork section (Chroy Changwar side)	Close visual inspection	• The pavement surface on the P8 pier side has bumps approximately 30 mm in size, and there pavement abnormalities (approx. 4 mm scratches stretching horizontally) along the median of carriageway lanes. • Pavement on the left-hand bike lane is observed to have bumps approximately 10 mm in size.	• Pavement has significant damage and deterioration and requires repaving. Appropriate materials must be considered when repaving.
Railing	Bridge section	Close visual inspection	• While 900 mm-high steel railing is installed for all lanes, 3-5 panels per clear span were either deformed from collisions or had corrosion.	• Railing is of insufficient height (needs to be 1,100 mm) and needs to be repaired and improved or replaced. • If the existing railing is used, damaged sections need to be repaired.
	Earthwork section	Close visual inspection	• Guardrails have localized beam damage and deformation from collisions.	• Damaged guardrail sections need to be improved and repaired, or replaced.
Drainage	Earthwork section	Close visual inspection	• Although there are drainage gutters laid transversely at the edges of the control gates for entry of large vehicles, these are clogged with sediment and not functional.	• Drainage gutters (transverse direction) need to be cleaned or replaced.

2-2-2-5 PC Bridge Improvement Plan

2-2-2-5-1 First Stage Plan for Bridge Improvement

Based on Evaluation of the Result of Bridge Inspection in 0 above, we compared the three options described below to prepare the policy for improvement of PC bridge parts (draft). The result of comparison is shown in Table 2-2-8. Because this project is conducted as a Japanese grant aid cooperation project, the design live load shall be the B live load, as agreed on in the Technical Note.

(1) Option 1 (Use of Existing PC Bridges)

This option uses existing PC bridges depending on the following conditions:

① The main girders that are found to have no damage by the result of bridge inspection are reused.
② The main girders that are found to have damage at girder ends are repaired.
③ The insufficiency in the load bearing capacity of main girders resulting from the use of the B live load is corrected by the reinforcement of main girders using the outside cable method.
④ Expansion of the width of shoe seats and replacement of bearings are conducted.
⑤ Foundation is reinforced with additional piles, because existing piles have not reached the bearing layer.
⑥ The increase in the reaction force on piles due to the use of the B live load is treated with additional piles.

(2) Option 2 (Replacement with Steel Bridges)

This option replaces existing PC bridges with steel bridges depending on the following conditions:

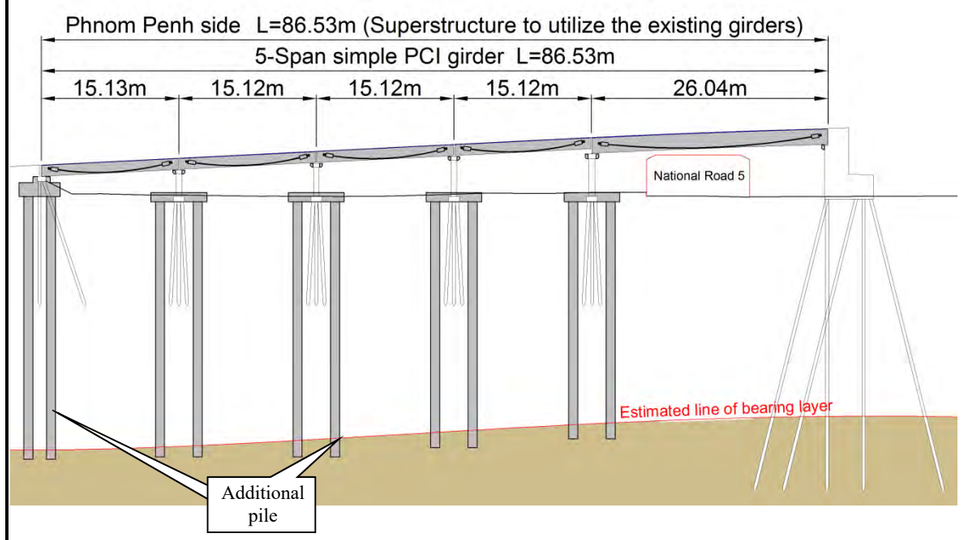
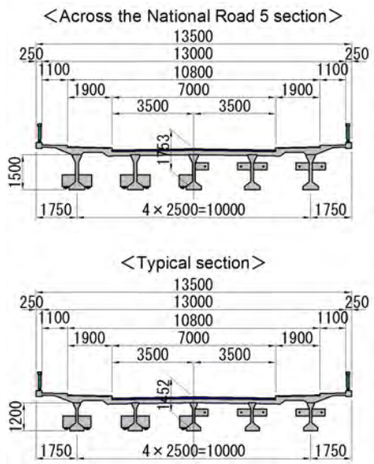
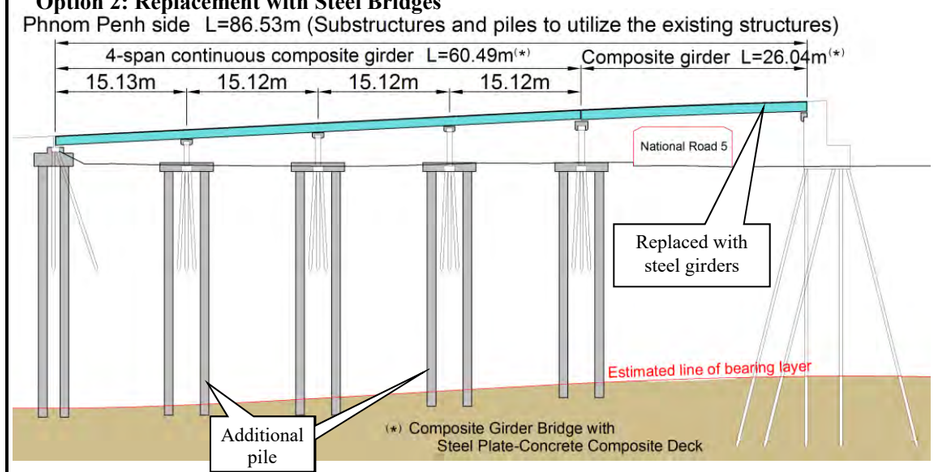
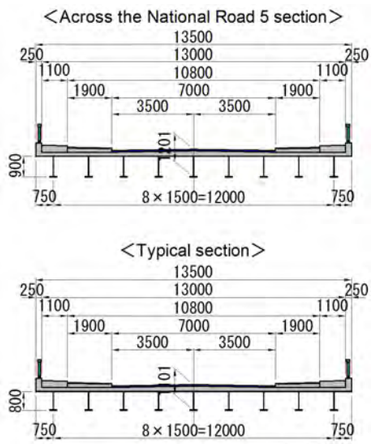
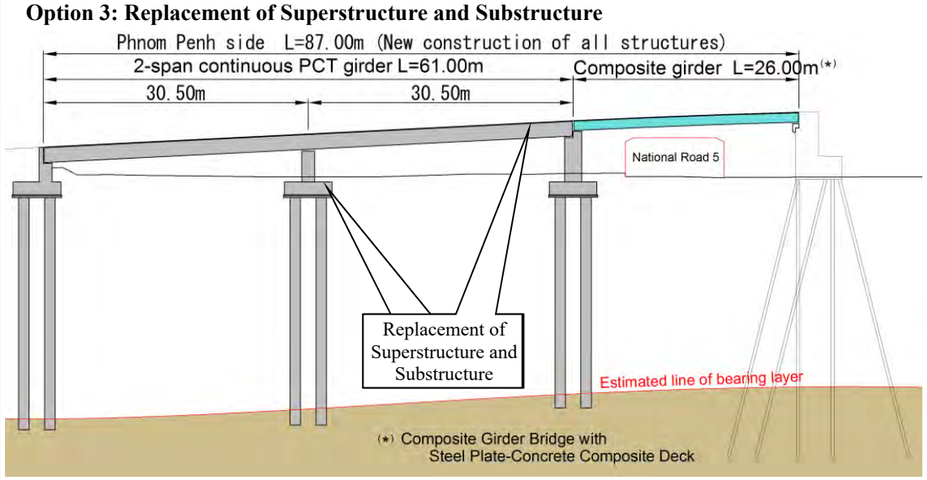
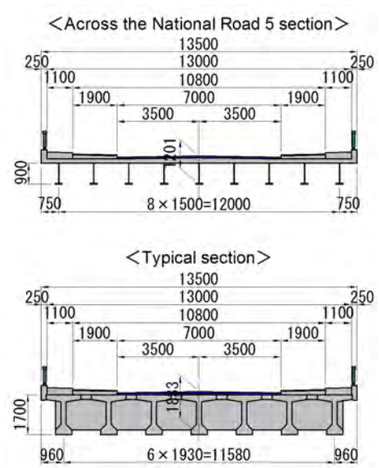
① Steel girders are used instead of heavy PC girders.
② Foundation is reinforced with additional piles, because piles have not reached the bearing layer.
③ The increase in the reaction force on piles due to the use of the B live load is treated with additional piles.

(3) Option 3 (Replacement of Superstructure and Substructure)

This option replaces both superstucture and substructure of existing PC bridges depending on the following conditions:

① To reduce the dead weight reaction force from on P1 pier and P8 pier, which are piers in the overpass parts, these parts are constructed as steel bridges.
② The bridge parts other than the overpass parts are constructed as PC girder bridges.
③ Piles are not friction piles but bearing piles.

Table 2-2-8 Comparison of Options for First Improvement Plan for PC Bridge Parts

Improvement Method	Characteristics	
Option 1: Use of Existing PC Bridges  	Improvement plan	・Continued use of Existing PC bridges, and reinforcement of pile foundations with additional piles.
	Purpose of improvement	・To be able to withstand the B live load, which is larger than the original live load (1960), main girders are reinforced with outside cables and additional piles are placed.
	Work details	・Repair of damaged main girder end parts. Reinforcement of main girders with outside cables. ・Widening of shoe seats by reinforcement of pier cross beams, and replacement of bearings. ・Placing of additional piles (cast-in-place) around existing piles. Placing of additional footings around existing footings to be integrated with them. ・Estimated construction period 【Approximately 20 months】
	Work efficiency	・Long construction period is required, because additional piles (cast-in-place) are placed under overhead clearance restriction.
	Effect of improvement	・Because existing footings (underground beams) are small, the effect of improvement depends on the extent of integration with additional footings. ・Effect of improvement is uncertain, as additional piles may not bear all of the increased load.
	Cost performance	・The cost of pile placement under overhead clearance restriction is very high. ・Relative ratio of estimated construction cost 【1.00】
	Overall assessment	・It is difficult to install outside cables on damaged girders. ・This method cannot handle the increase in reaction force on P1 pier. ・Installation of additional piles is difficult, and the effect of improvement is uncertain. **×**
Option 2: Replacement with Steel Bridges  	Improvement plan	・Replacement of existing PC girders with steel girders, and reinforcement of pile foundations with additional piles.
	Purpose of improvement	・Existing PC girders are replaced with steel girders. This reduces the weight of superstructure, reducing the load on foundation.
	Work details	・Removal of existing PC girders and installation of steel girders. ・Installation of additional piles (cast-in-place) around existing piles and additional footings. ・Estimated construction period【Approximately 19 months】
	Work efficiency	・It is difficult to install cast-in-place piles without damaging (interfering with) existing piles.
	Effect of improvement	・Reduction of the weight of superstructure reduces the dead load burden on foundation. ・Effect of improvement is uncertain, as additional piles may not necessarily bear all of the increment in the B live load.
	Cost performance	・This option provides the worst cost performance. ・Relative ratio of estimated construction cost【1.20】
	Overall assessment	・Work is easier than Option 1. ・While effective in reducing the weight of superstructure (dead load), the effect of improvement in handling the increment in the B live load is uncertain. **△**
Option 3: Replacement of Superstructure and Substructure  	Improvement plan	・Replacement of both superstructure and substructure.
	Purpose of improvement	・Constructed more than 50 years ago, the bridge needs improvement to address deterioration, damage, and insufficient load bearing capacity. ・Superstructure, substructure, and foundations are newly constructed to cope with the B live load, which is larger than the original live load (1960).
	Work details	・Removal of existing superstructure and substructure. ・Construction of a steel girder bridge and 2 PC girder bridges. ・Estimated construction period【Approximately 18 months】
	Work efficiency	・There are no particular problems. ・When the positions of existing piles and new piles overlap, new piles are placed using rotary all casing method.
	Effect of improvement	・The effectiveness of improvement is very high, as superstructure, substructure, foundation, bearings, etc. are all constructed newly.
	Cost performance	・Similarly to Option 1, this option provides the best cost performance. ・Relative ratio of estimated construction cost【1.00】
	Overall assessment	・Best work efficiency and shortest construction period. ・Best cost performance and highest effectiveness of improvement. **◎**

2-2-2-5-2 Second Stage Plan for Bridge Improvement

The option with the replacement of superstructure and substructure was selected as a result of comparison in the first stage plan for the bridge parts. Here we conduct the second stage comparison concerning the selected option with the replacement of superstructure and substructure.

(1) Examination of the Position of A1 Abutment

1) Existing Ground Level under the PC Bridge Part

An elevation drawing showing the relationship between the existing PC bridge part including A1 abutment and the existing ground level is given in Figure 2-2-6.

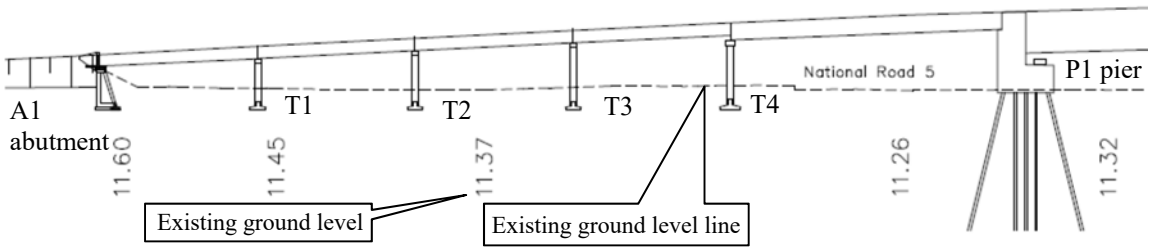


Figure 2-2-6 Existing Ground Level under PC Bridge Part

2) HWL

The water level gauging station in the Tonle Sap River is located on the right bank downstream of the Chroy Changwar Bridge. We conducted a hydroligic statistical analysis using the annual high water levels for the past 55 years (from 1960 to 2014). The probability formula was derived using the log-normal distribution method and the Gumbel method.

Because the Tonle Sap River is adjacent to Phnom Penh in the metropolitan area, hydrologic analysis was performed using the probable recurrence period of 200 years in addition to 100 years. Table 2-2-9 shows the result of analysis.

Table 2-2-9 HWL (Result of Hydrologic Analysis) (Unit: year)

Probable recurrence period	T=1/100	T=1/200	T=1/50 (for reference)
Log-normal distribution method	10.7	10.9	10.4
Gumbel method	11.0	11.4	10.7

According to the result of analysis, the water level with 1 in 100 year probability is 10.7-11.0 M, and the water level with 1 in 200 year probability is 10.9-11.4 m.

3) Position of A1 Abutment

When we assume the probable recurrence period of 200 years because of the proximity of the river to Phnom Penh in the metropolitan area, Table 2-2-9 gives the HWL of 11.4 m. In addition, Figure 2-2-6shows that the ground level is 11.60 m in front of A1 abutment, 11.45 m at the position of T1 pier, and 11.37 m at the position of T2 pier. These numbers seem to suggest that the position of A1 abutment can be moved forward to the position of T1 pier (11.45 m). However, because the HWL obtained from hydrologic analysis is correct only to the first decimal place, it is safe to interpret the HWL of 11.4 m as representing the 11.4-m range. Therefore, the position of the newly constructed A1 abutment shall be the same as the present A1 abutment.

(2) Structure Examination of Overpass Parts

1) Purpose of Structure Examination

Because P1 and P8 piers, respectively supporting the PC superstructures above National Road No. 5 and the levee road on the Chroy Changwar side, are also supporting two-span steel box girders, it is difficult to remove or replace these piers. In addition, because these piers have batter pile foundations, it is difficult to reinforce them with additional piles or other methods.

Furthermore, P1 pier and P8 pier supporting PC girders have an extremely small shoe seat width (42 cm), and this makes it extremely difficult to achieve direct supporting of the newly constructed superstructures on these piers. Even if brackets are installed to expand the shoe seat width, the bodies of the piers are hollow with the wall thickness of only 20 cm and it is extremely difficult to install adequate anchors. It is therefore necessary to devise structures that support the newly constructed superstructures in the overpass parts.

2) General Structure Drawing

a) General Drawings of Overpass Parts

The general drawings of the overpass parts above National Road No. 5 and the levee road are presented below.

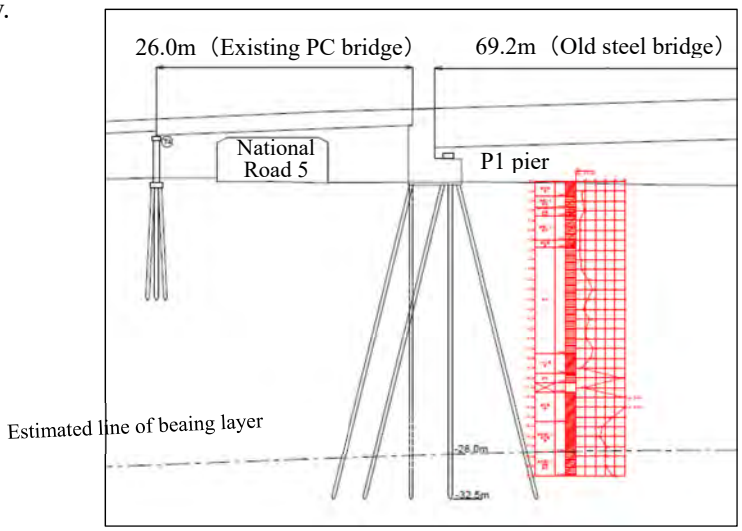


Figure 2-2-7 Overpass Part above National Road No. 5

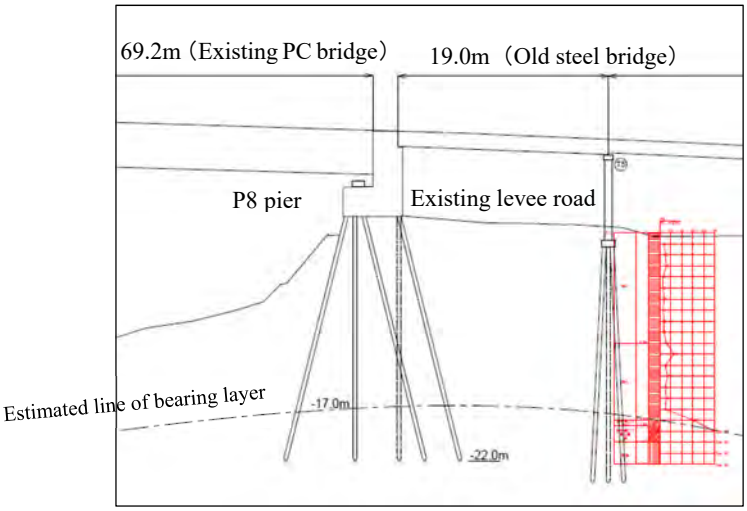


Figure 2-2-8 Overpass Part above Levee Road

b) Cross-Section of P1 (P8) Pier Body

The cross-section of P1 and P8 pier body is shown below with dimensions.

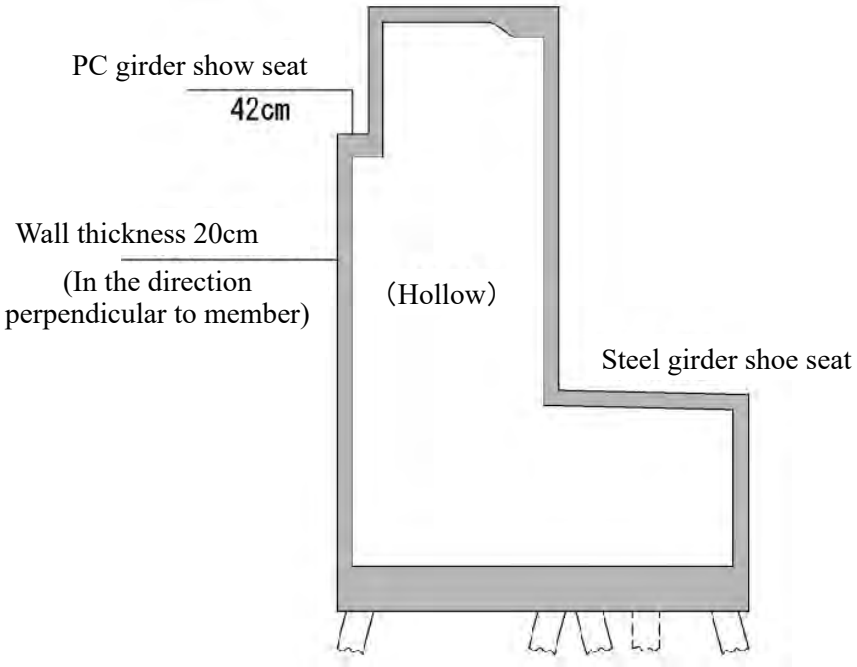


Figure 2-2-9 Cross-Section of Pier Body

c) Plan View of P1 (P8) Pier Foundation

The positions of foundation piles of P1 and P8 piers in plan view are shown in the Figure below.

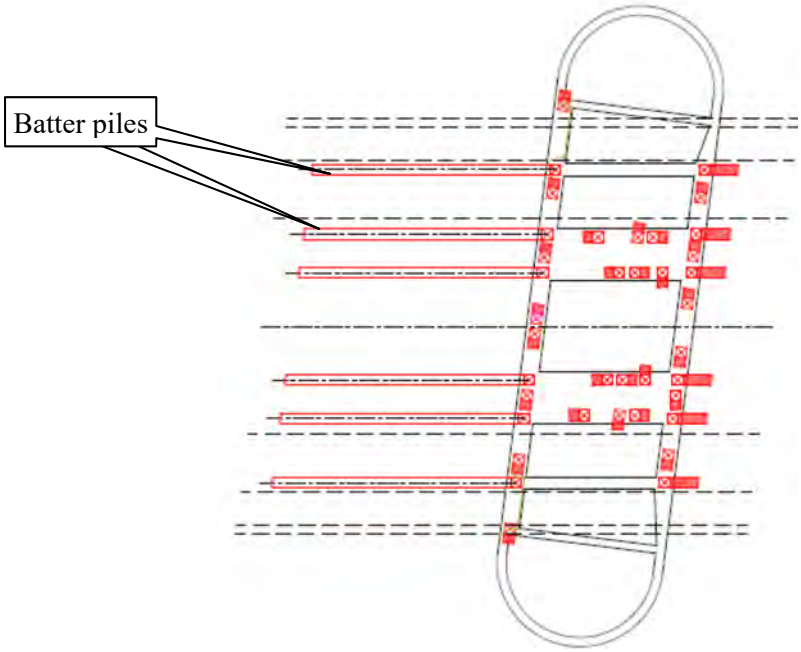


Figure 2-2-10 Plan View of Pier Foundation

3) Option with Expansion of Shoe Seat Width

The Figure below illustrates the method for expanding the shoe seats of P1 and P8 piers using the concrete bracket method or the steel bracket method. Both methods have the following problems.

① Workers must enter the inside of the pier to perform anchoring with nuts. This is extremely difficult because the structure has no admission port.

② Because the wall for the anchoring nuts is only 20-cm thick, it does not provide sufficient bearing power for anchoring.

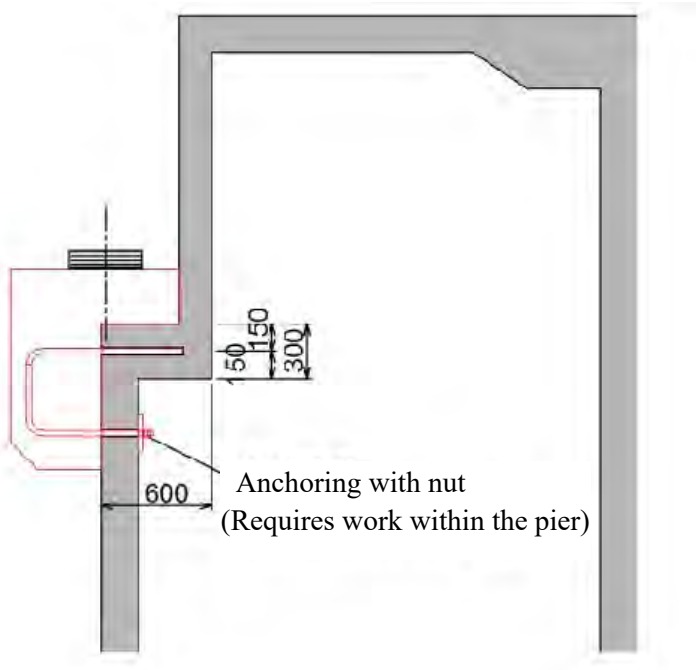


Figure 2-2-11 Option with Expansion of Shoe Seats (Concrete Bracket Method)

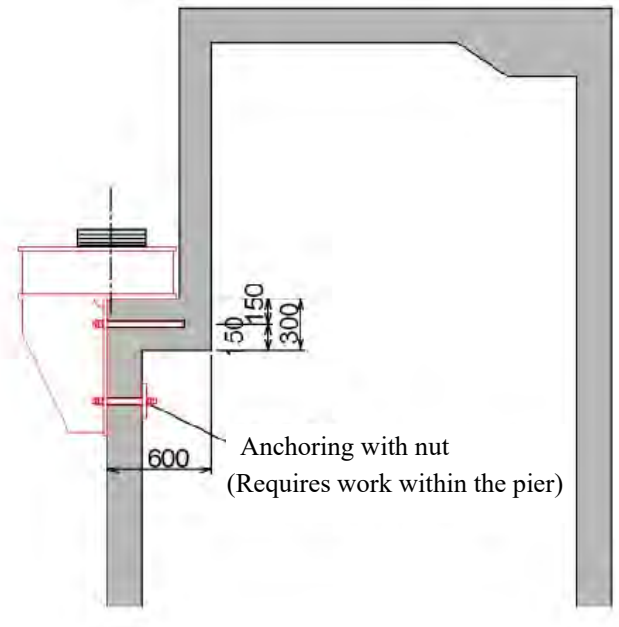


Figure 2-2-12 Option with Expansion of Shoe Seats (Steel Bracket Method)

4) Option with Construction of New Piers

Because it is extremely difficult use the shoe seats of P1 and P8 piers as the supports for the newly constructed superstructures, we opt to construct new piers in front of P1 and P8 piers and use them as the supports for the newly constructed superstructures.

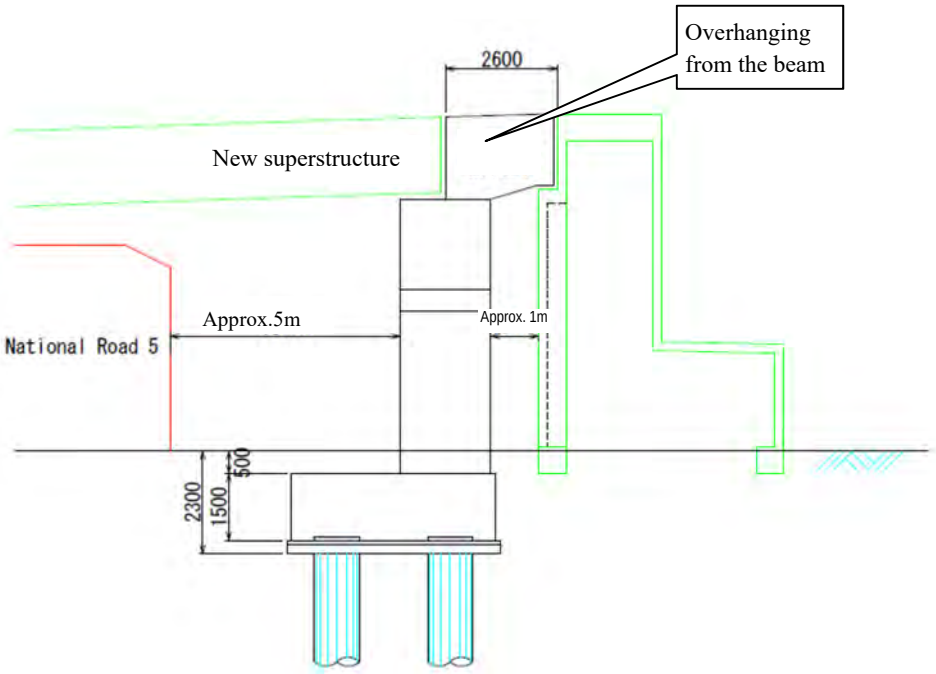


Figure 2-2-13 Side View of New Pier

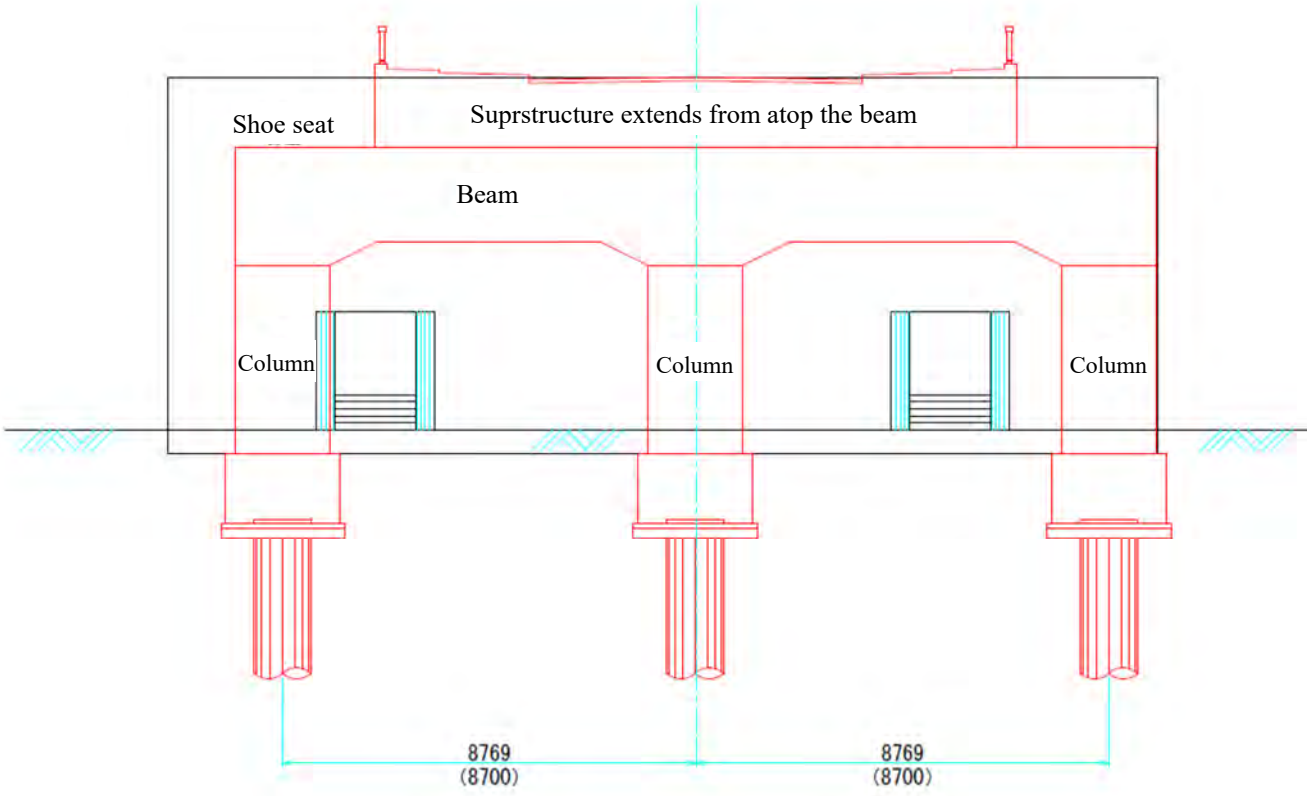


Figure 2-2-14 Front View of New Pier

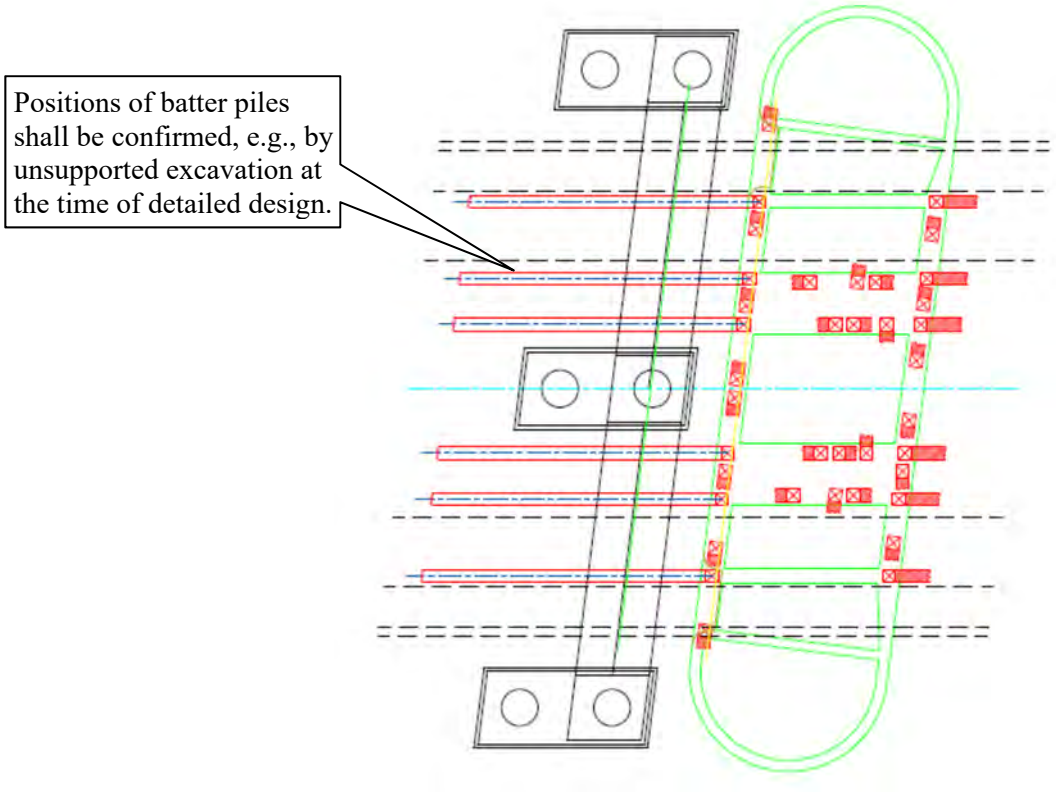


Figure 2-2-15 Plan View of New Pier

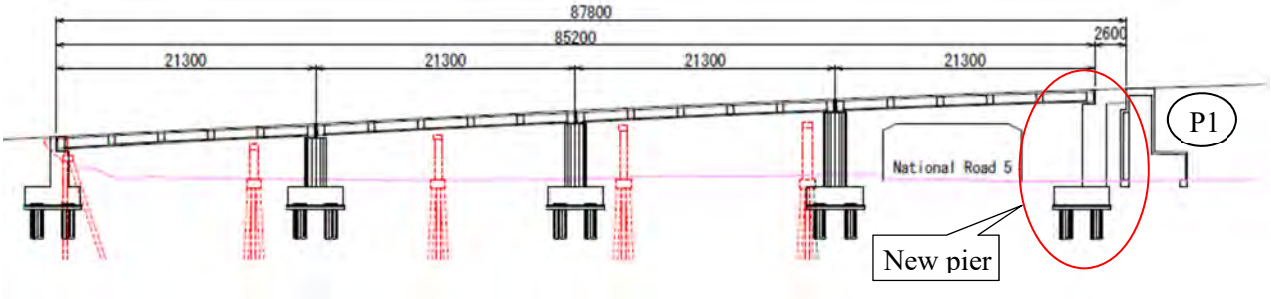


Figure 2-2-16 General View of New Bridge

(3) Construction Gauge above National Road No. 5

1) Vehicle Height Restriction

Photo 2-2-1 shows the vehicle height restriction sign (5.2 m) above National Route No. 5 near the Chroy Changwar Bridge.

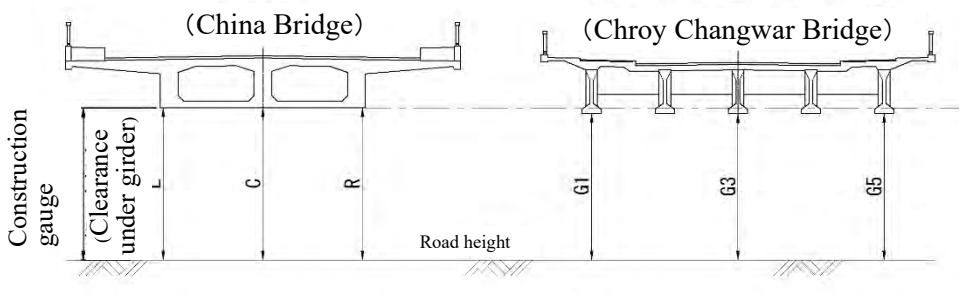
Photo 2-2-1 Vehicle Hight Restriction Sign

2) Construction Gauge of Existing Bridge (Clearance under Girder)

The construction gauge (clearance under girder) of the Chroy Changwar Bridge and the China Bridge above National Road No. 5 area as shown in the Table below.

Table 2-2-10 List of Clearance under Gider (Construction Gauge)

Bridge name	Position	Road height (m)	Height under girder (m)	Construction gauge (clearance under girder) (m)	
				Present	Required
Chroy Changwar Bridge	G1	11.31	16.37	5.06	5.20
	G3	11.33	16.33	5.00	
	G5	11.30	16.31	5.01	
China Bridge	L	11.14	16.35	5.21	5.20
	C	11.16	16.36	5.20	
	R	11.18	16.35	5.17	



(4) Comparison of Bridge Styles

Since it was decided that a new pier is constructed in front of P1 pier as discussed in "(2)Structure Examination of Overpass Parts", it became possible to use a PC bridge instead of a steel bridge in the overpass part. In addition, as shown in "Table 2-2-10 List of Clearance under Gider (Construction Gauge)," the new PC bridge is subjected to girder height restriction. Therefore, we selected two options from the bridge styles listed in Table 2-2-11 and compared them to determine the best bridge style.

The result of comparison is shown in Table 2-2-12.

① Option 1: Three-span post-tensioned T girdir bridge (3 @ 28.4 m = 85.2 m)

② Option 2: Four-span pretensioned hollow slab bridge (4 @ 21.3 m = 85.2 m)

Table 2-2-11 Styles of Superstructure and Applicable Span Ranges

	Superstructure type	Recommended span (50 m / 100 m / 150 m)	Curve applicable: Main structure	Curve applicable: Bridge deck	Girder height Span ratio
Steel bridge	Simple composite plate girder		○	○	1/18
	Simple plate girder		○	○	1/17
	Continuous plate girder		○	○	1/18
	Simple box girder		○	○	1/22
	Continuous box girder		○	○	1/23
	Simple truss		×	○	1/ 9
	Continuous truss		×	○	1/10
	Reverse Langer girder		×	○	1/6,5
	Reverse Lohse girder		×	○	1/6,5
	Arch		×	○	1/6,5
PC bridge	Pretentioned girder		×	○	1/15
	Hollow slab		○	○	1/22
	Simple T girder		×	○	1/17,5
	Simple composite girder		×	○	1/15
	Continuous T girder, composite girder		×	○	1/15
	Continuous composite girder		×	○	1/16
	Simple box girder		○	○	1/20
	Continuous box girder (cantilever method)		○	○	1/18
	Continuous box girder (Push-out or support method)		○	○	1/18
	π shaped rigid frame ridge		×	○	1/32
RC Bridge	Hollow slab		○	○	1/20
	Continuous spandrel-filled arch		○	○	1/ 2

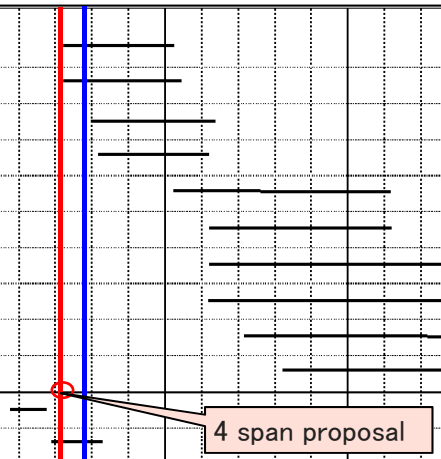
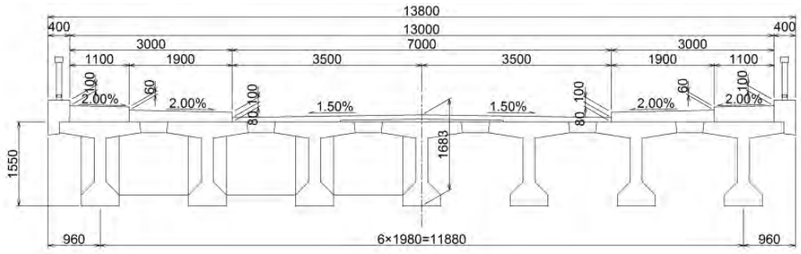
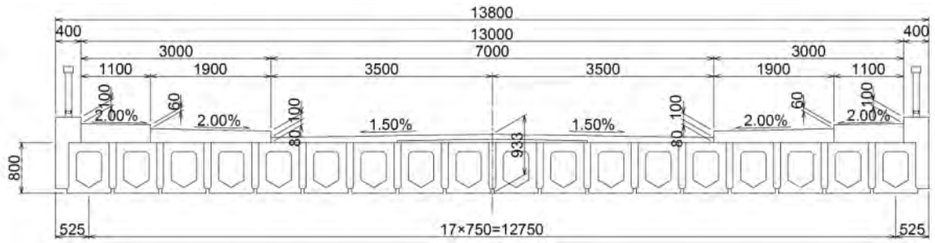
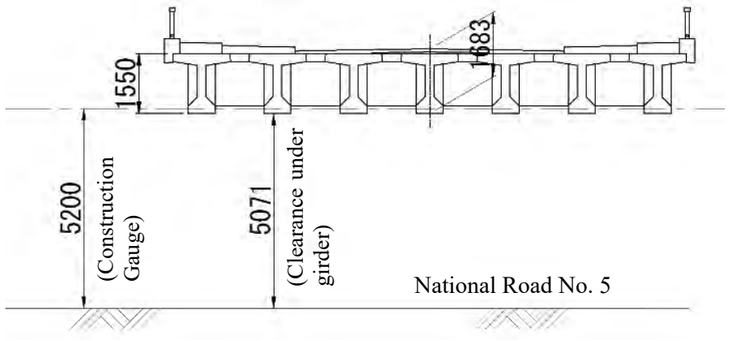
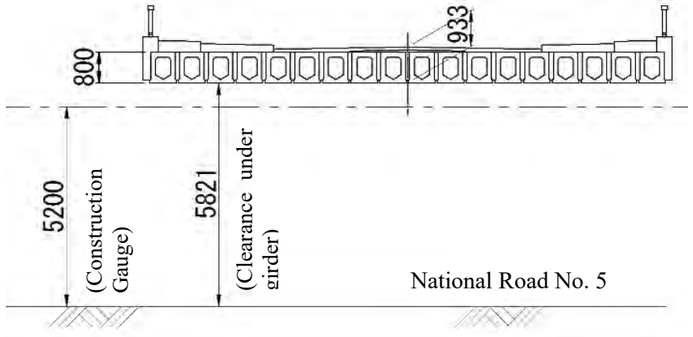


Table 2-2-12 Table of Comparison in Second Stage Plan for PC Bridge Improvement

Option	Option 1: Three-span (3 @ 28.4 m=85.2m)	Option 2: Four-span (4 @ 21.3 m=85.2m)
Style of superstructure	Post-tensioned T girder bridge	Pretensioned hollow slab bridge
Cross- section of superstructure		
Clearance under girder		
Structural properties	• Bridge with 3 longer (28.4 m) spans needs one less pier than Option 2.	• Bridge with 4 shorter (21.3 m) spans needs one more pier than Option 2.
Construction gauge	• Longer span (28.4 m) results in larger height of structure (1.55 m), reducing clearance under girder to 5.07 m and infringing with the construction gauge (5.2 m) relative to National Road 5.	• Shorter span (21.3 m) results in smaller height of structure (0.8 m), increasing clearance under girder to 5.82 m and providing sufficient space for the construction gauge (5.2 m) relative to National Road 5.
Cost performance	• While superstructure costs more, substructure costs less due to the smaller number of piers, providing good cost performance as a whole (ratio: 1.00).	• While substructure costs more because there is one more pier than Option 1, superstructure costs less. The total cost is approximately the same as Option 1 (ratio: 1.01).
Work efiiciency	• Because main girders are heavy (about 62 t), erection using cranes is difficult, and erection girders must be used.	• Because main girders are light (about 19 t), they can be erected using two cranes.
Overall evaluation	• Construction gauge over National Road 5 cannot be satisfied. • Erection girders or other facilities must be used because main girders are heavy.	• Construction gauge over National Road 5 can be satisfied sufficiently. • Light main girders can be erected using two cranes.

2-2-2-6 Steel Bridge Improvement Plan

(1) Painting

While both the old steel bridge and the new steel bridge do not show significant coating deterioration or damage, repainting shall be performed because both bridges have passed more than 20 years since painting.

(2) Pavement

Bridge inspection detected cracks in welds in the areas with paint cracking, which were found occasionally over the welds between steel plate decks and ribs. Therefore, comparative examination was conducted on the four types of pavement including guss asphalt pavement, stone mastic asphalt (SMA) pavement, epoxy asphalt pavement, and steel fiber reinforced concrete (SFRC) pavement as a measure against fatigue cracking of steel plate decks.

The result of comparison is shown in Table 2-2-13. Based on this result, it was decided to use steel fiber reinforced concrete (SFRC) pavement on steel plate decks.

(3) Railing

The height of railing in the existing steel bridge part is only 90 cm (Figure 2-2-17), and this is lower than the height required in Japan (110 cm from road surface). It is therefore necessary to replace it with the railing satisfying the requirement (Figure 2-2-17. The height of railing in the newly constructed PC bridge parts shall be 110 cm from road surface (Figure 2-2-18).

While the width of wheel guards in the existing steel bridge part is 25 cm (Figure 2-2-17), the width of wheel guards under railing in the newly constructed PC bridge part shall be 40 cm (Figure 2-2-18).

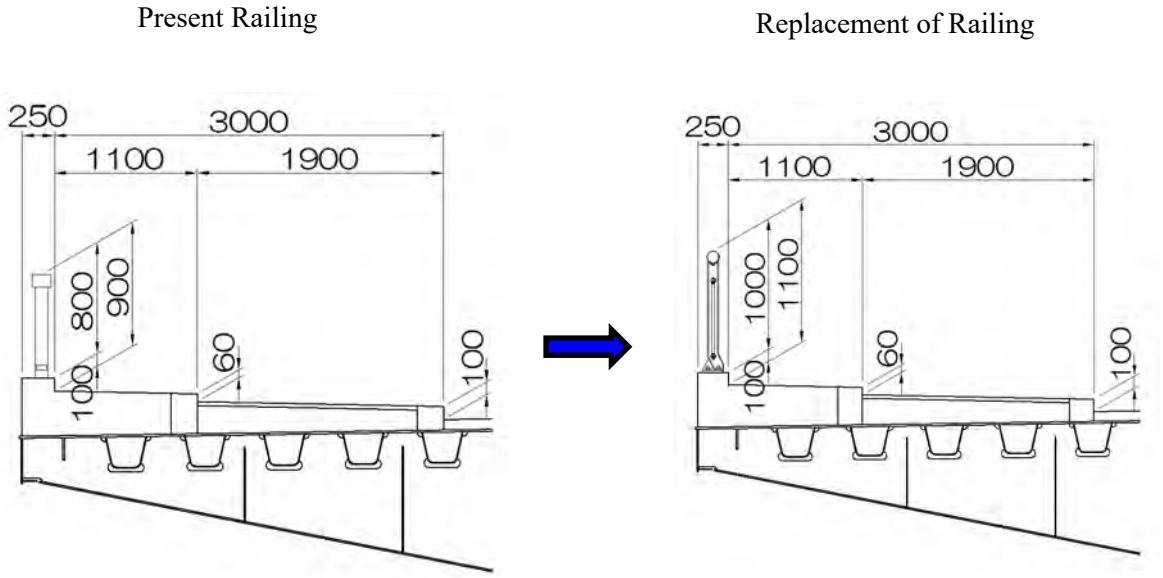


Figure 2-2-17 Replacement of Railing in Existing Steel Bridge Part

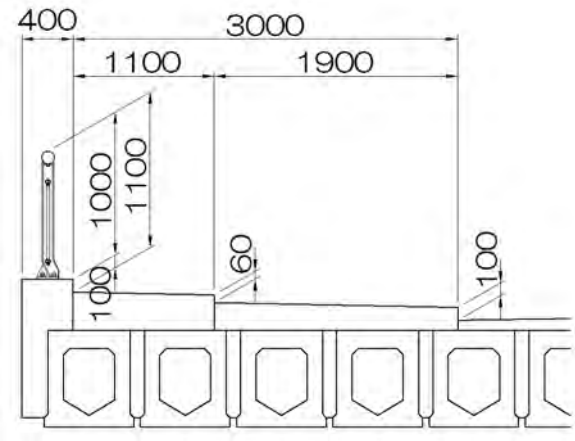
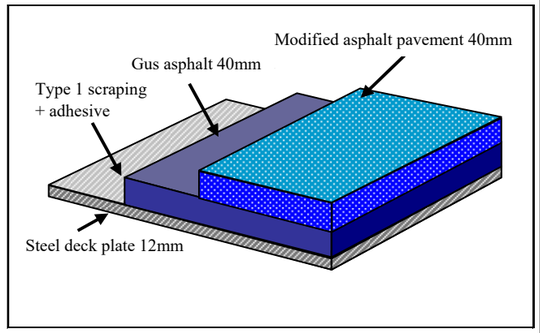
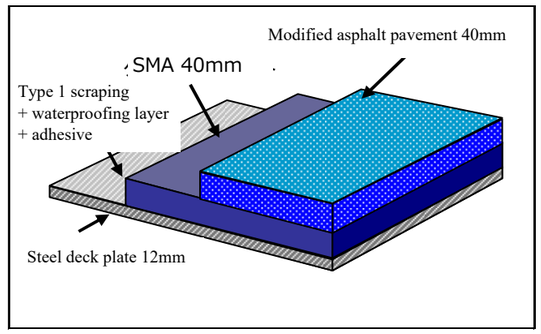
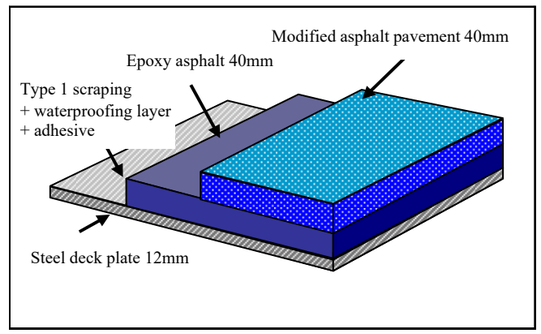
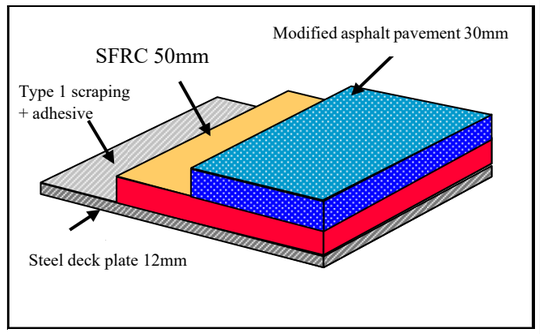


Figure 2-2-18 Railing and Wheel Guard Width in New PC Parts

(4) Substructure

Concrete peeling, flaking, chipping, rebar exposure, etc. shall be treated with section repair. Cracks less than 0.2 mm shall be treated with sealing method, and those 0.2 mm or larger with injection method.

Table 2-2-13 Comparison of Pavement Structures

	Option 1 Gus Asphalt Pavement Steel Deck Pavement	Option 2 Stone Mastic Asphalt (SMA) Pavement Steel Deck Pavement	Option 3 Epoxy Asphalt Pavement Steel Deck Pavement	Option 4 Steel Fiber Reinforced Concrete (SFRC) Pavement Steel Deck Reinforcement + Steel Deck Pavement
Schematic drawing				
Structural characteristics	・Conventionally used pavement structure. Pavement itself has waterproofing property. Good conformability to deflection of steel deck. (◎)	・Used as an alternative to gus asphalt pavement. Good dynamic stability and deflection stability. ・Poor water-tightness; requires the installation of a waterproofing layer. (○)	・Asphalt pavement with performance improved by the addition of epoxy resin. Good conformability to deflection. ・Poor water-tightness; requires the installation of a waterproofing layer. (○)	・Designed for better integration of SFRC and steel deck to suppress stress concentration by dispersing wheel loads. ・In Japan, this method is used for prevention of fatigue cracks of steel decks (12 mm) aged 20 years or more. (◎)
Adhesion performance	・Sufficient adhesion between steel deck and base layer pavement. (○)	・Due to problem in adhesion between steel deck and base layer pavement, early damage after installation has been reported. (×)	・Sufficient adhesion between steel deck and base layer pavement. (◎)	・Sufficient adhesion between steel deck and SFRC pavement using adhesive or studs. (◎)
Fatigue resistance	・This structure has been used conventionally in numerous occasions (durability over 20 years has been demonstrated on the Honshu-Shikoku Bridge). ・Good water-tightness and conformability to deformation. (◎)	・Recently developed as a pavement structure on steel decks. (○)	・Although developed for general pavement applications, the performance of this method is suitable to pavement structures on steel decks. (△)	・This material was developed recently to improve the fatigue resistance of steel decks themselves. It has high rigidity and is effective in improving the durability of pavement. (◎)
Plastic flow resistance	・Poor plastic flow resistance. Overloaded vehicles in Cambodia are likely to cause rutting and associated cracking of top layer pavement. (×)	・Better plastic flow resistance due to the use of crushed stone in the mix. Superior to Option 1 in this respect. ・Sufficient research is needed concerning conformability to deflection (crack resistance). (△)	・Good resistance to rutting. (○)	・Very good resistance to rutting, because this is a concrete pavement. (◎)
Ease of work	・Requires special paving equipment, which must be procured from Japan, Europe, etc. Inferior in ease of work in this respect. ・Equipment for steel deck surface grinding needs to be procured from Japan. ・The temperature of gus asphalt during placing is very high (240℃), and this has large impact on steel decks. (△)	・Basically can be placed using equipment that is procured locally. However, difficulty in work execution has been reported in overseas projects of Japanese companies. (The use in steel deck paving has been discontinued in Nagoya and Hanshin Expressways in Japan.) (△)	・Can be placed using general paving equipment. However, work is difficult because epoxy asphalt remains usable only for about 1.5 hours. (△)	・Although special equipment is needed, it is small in scale and poses no particular problems (can be procured locally, if necessary). ・The work process is similar to that of general concrete work and does not pose major problems. (○)
Maintenance	・Repaving work is difficult for present local contractors and requires procurement of special equipment from Japan, Europe, etc. (△)	・Maintenance is difficult because of the problems in the ease of work. (△)	・Top layer As paving can be performed using locally procured equipment (5-year intervals). ・Although re-paving can be performed using locally procured equipment, this will require improvement of the technical skills of local contractors. (○)	・Top layer As paving on SFRC can be performed using locally procured equipment (5-year intervals). (○)
Initial cost ratio	3.00 (△)	1.00 (◎)	1.50 (○)	5.00 (△)
Assessment	△	△	△	◎

2-2-2-7 Bridge Improvement Plan

(1) Details of Bridge Improvement Plan

The Table below summarizes the draft bridge improvement plan developed from 0

Evaluation of the Result of Bridge Inspection, 2-2-2-5 PC Bridge Improvement Plan, and 2-2-2-6 Steel Bridge Improvement Plan. Figure 2-2-19 shows the overall of the improvement plan.

Table 2-2-14 Summary Table of Bridge Improvement Plan

Work Type	Structures	Item		Remarks
New Construction	4-span PC hollow girder (2 bridges)	Superstructure	PC girders (2 bridges)	
		Substructure	A1 and A2 abutments	
			T1, T2, T3, T6, T7 and T8 piers	Intermediate pier
			T4 and T5 piers	Overlapping piers
		Foundation work	A1 and A2 abutments, T1-T8 piers	Cast-in-place piles (φ1.0 m, φ1.2 m)
	Pavement	PC bridge section	A1-P1 pier span, P8-A2 abutment	Modified asphalt pavement
		Earthwork	Connected road	Modified asphalt pavement
	Bridge railing	PC bridge section	A1-P1 pier span, P8-A2 abutment	New construction (1.1 m and above from road surface)
	Expansion joints	PC bridge section	On A1, T4, T5, and A2 abutments	New construction
	Bearings	PC bridge section	On A1, T1-T8, and A2 abutments	New construction
Repair work	Pavement	Steel bridge section	P1-P8 pier span	SFRC pavement
	Painting	Steel bridge section	P1-P8 pier span	Exterior of steel box girder only
			Submerged section (box girder interior)	Clean, then paint
	Bridge railing	Steel bridge section	P1-P8 pier span	Replace (1.1 m and above from road surface)
	Guardrails	Earthwork	Connected road	Replace
	Expansion joints	Steel bridge section	On P1, P3, P6, and P8 piers	Convert current expansion joint to non-draining type and reuse
	Lighting	All lanes		Replace
	Crack filling work	Steel bridge section	P1-P8 piers	For cracks 0.2 mm or wider
	Coating work for all surfaces	Steel bridge section	P1-P8 piers	Apply penetrant
	Cross section repairs	Steel bridge section	P1-P8 piers	Spalling, exposed rebar, missing concrete, etc.
	Earthwork	Earthwork	Connected road profile adjustments	Not needed for adjustment with pavement only
	Road marking	All lanes		
	Curb work	All lanes		
Improvements	Embankment work	Earthwork	Connected road	
	Ditches	Earthwork	Connected road	
	Intersection	Roundabout		Phnom Penh side only
Old bridge removal	5-span PC girder bridge (2 bridges)	Superstructure	PC girders	10 continuous
		Substructure	All abutments and piers	10 bases (excl. P1 and P8 piers)
		Foundation	Concrete ready-made piles	Cut
Construction plan	Scaffolding work	Superstructure	P1-P8 pier span	Full suspended scaffolding (for painting steel bridge)
		Substructure	P1-P8 piers	Suspended scaffolding (stepped)

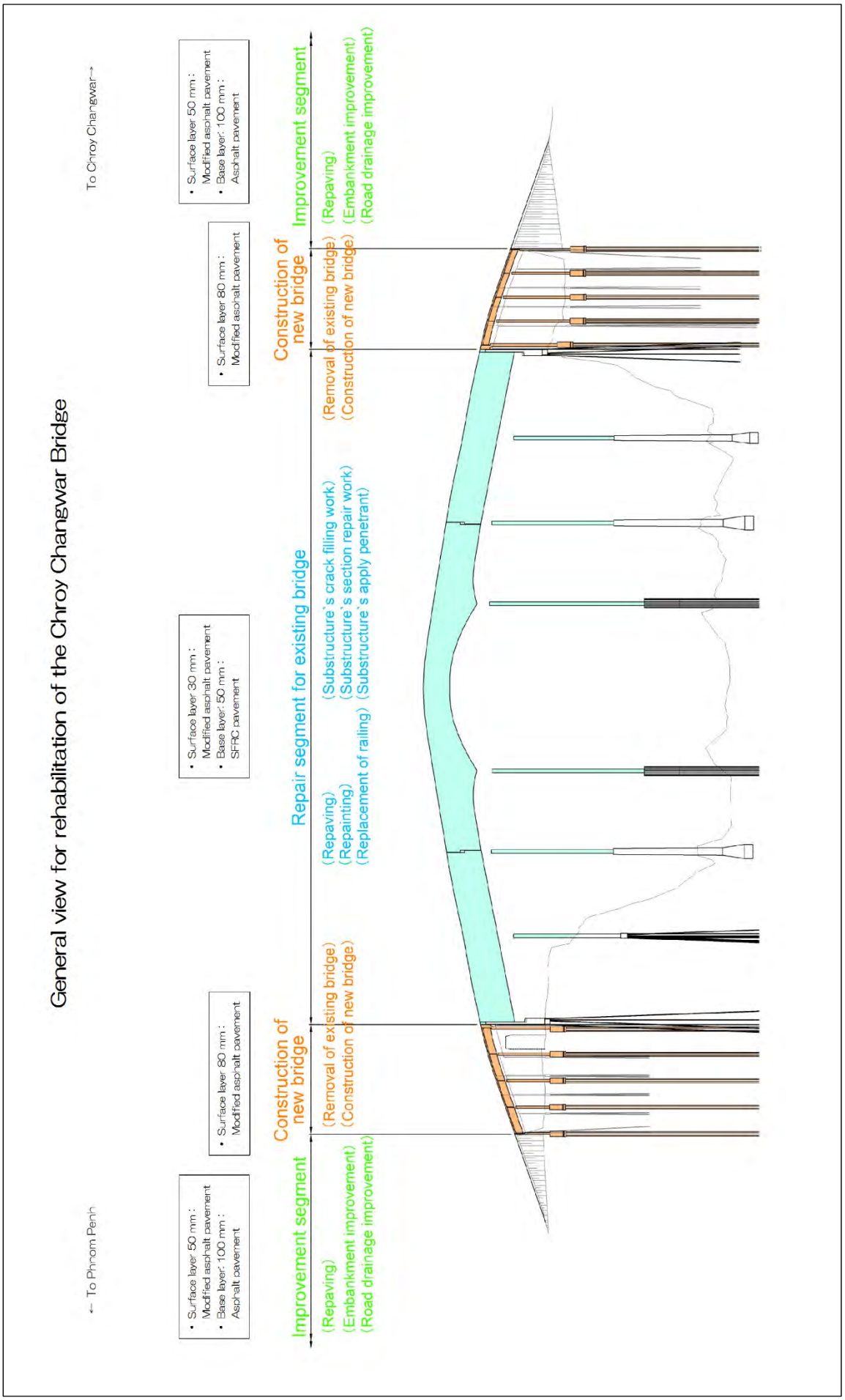


Figure 2-2-19 Overall Diagram improvement plan

2-2-2-8 Overall Plan

2-2-2-8-1 New Construction Work

(1) Applicable Design Standards

See "2-2-1-7(4) Bridge and Road Design and Construction Standards."

(2) Bridge Design Conditions

1) Superstructure

a) Structural Type

The structural type of superstructure shall be a four-span pretensioned hollow slab bridge, as examined in "Table 2-2-12 Table of Comparison in Second Stage Plan for PC Bridge Improvement." The structural type of the superstructure shall be the same on the Phnom Penh side and on the Chroy Changwar side.

b) Road Cross-Section

See "Figure 2-2-3 Road Cross-section of Bridge and Approach Road Parts" in "2-2-1-4 Policy Concerning Road Width."

c) Design Live Load

As agreed on in the Technical Note, the design live load shall be "B live load" according to the Japanese Specifications for Highway Bridges. Bike lanes shall be loaded with "sidewalk live load" according to the provisions concerning sidewalks.

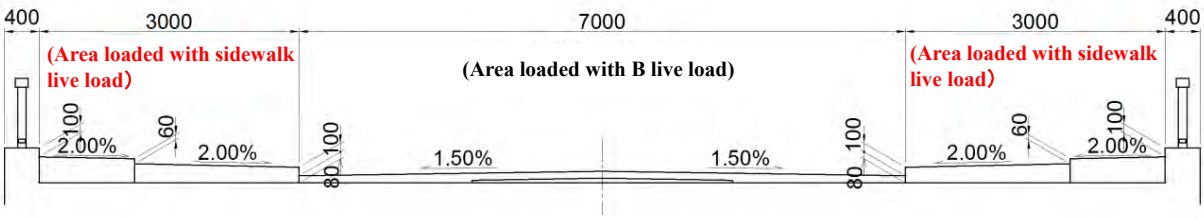


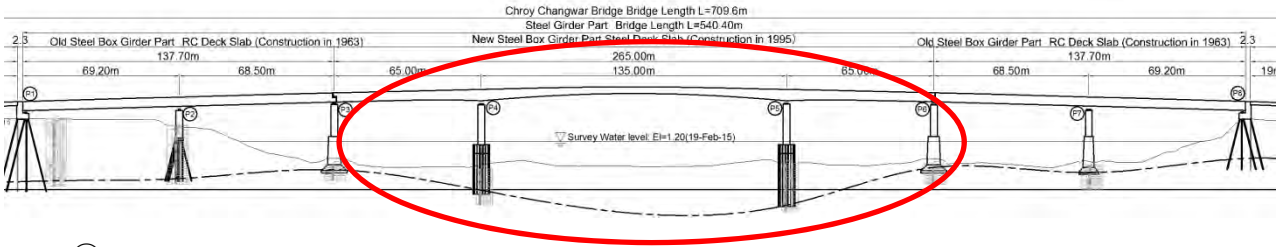
Figure 2-2-20 Areas Loaded with Design Live Load

d) Design Horizontal Seismic Coefficient

Design horizontal seismic coefficient Kh shall be Kh = 0.05 because of the following reasons:

① An acceleration coefficient of a = 0.05 is used in the bridge design standards of Cambodia [Bridge Design Standard CAM PW.04.102.99 2003].

② A design horizontal seismic coefficient of Kh = 0.05 was used in the design of the center span of the steel bridge part of the Chroy Changwar Bridge (completed in 1995).



③ A design horizontal seismic coefficient of Kh = 0.05 was used in the Neak Loeung Bridge Construction Project completed in April 2015.

e) Strength of Materials

i) Concrete

- Main girder: 50 N/mm^2
- Filling: 30 N/mm^2
- Wheel guard: 24 N/mm^2

ii) PC Steel

PC steel shall be procured from Japan, and the materials conforming to the specifications in Japan shall be used.

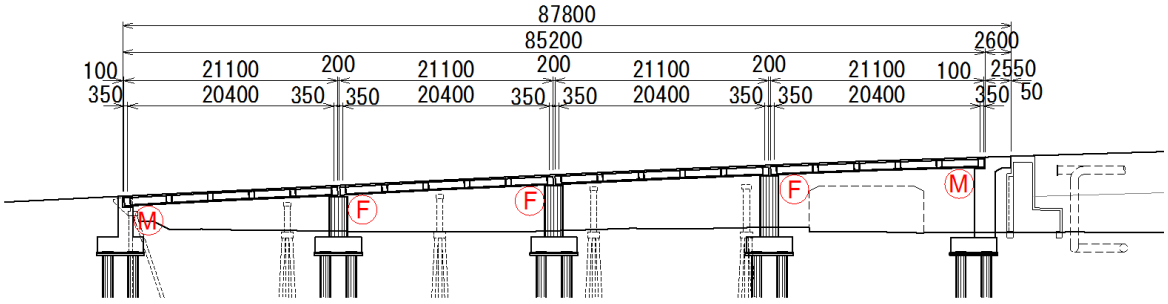
f) Dead Weight Conditions

- Carriageway asphalt pavement (t = 80 mm): γ = 22.5 kN/m^3
- Carriageway adjusting concrete: 23.0 kN/m^3
- Bike lane concrete: 24.5 kN/m^3
- Sidewalk concrete: 24.5 kN/m^3
- Railing: 1.0 kN/m

g) Support Conditions

Fixation at multiple points.

Phnom Penh Side



Chroy Changwar Side

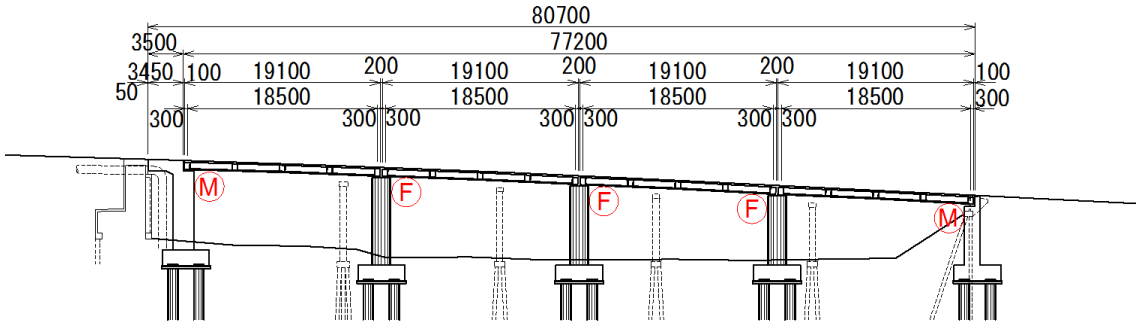


Figure 2-2-21 Support Conditions

2) Substructure

a) Selection of the Type of Substructure

The types of substructure were selected as follows from Table 2-2-15.

① A1 abutment (Phnom Penh side) and A2 abutment (Chroy Changwar side): Inverted T-type abutments

② PN1-PN3 piers (Phnom Penh side) and PN6-PN8 piers (Chroy Changwar side): Wall-type piers

③ PN4 pier (Phnom Penh side) and PN5 pier (Chroy Changwar side): Rigid frame-type piers

Table 2-2-15 Selection of the Type of Substructure

Bridge part	Structure type	Applicable height (m)	Characteristics
		10 20 30	
Abutment	1.Gravity type	①	With shallow support ground, the gravity type is suitable for direct foundation.
	2.Reverse T-style		Used in many bridges. Suitable for direct foundation/ pile foundation.
	3.Buttressed type		Suitable for tall abutments. Few materials are used for this type, but the lead time is long.
	4.Box type		Designed for tall abutments. The lead time is slightly long.
Pier	1.Column type	③	Low piers. Suitable for stringent intersection conditions and installation in a river.
	2.Rigid frame type		Relatively tall piers. Suitable for wide bridges. Their installation in a river may hinder water flow in time of flooding.
	3.Pile bent type	②	While they are the most cost efficient piers, they are not suitable for bridges with high horizontal force. Their installation in a river may hinder water flow in times of flooding.
	4.Elliptical type		Tall bridge piers. Suitable for bridges with high external force.

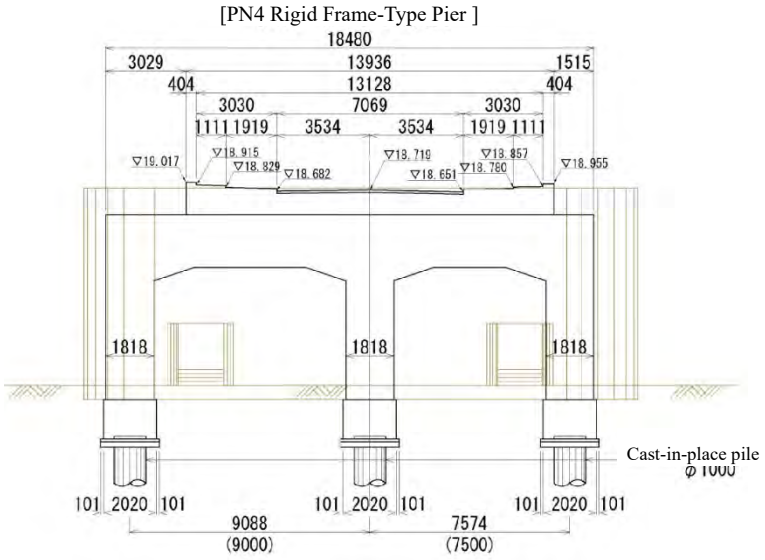


Figure 2-2-22 Elevation View of PN4 Rigid Frame-Type Pier

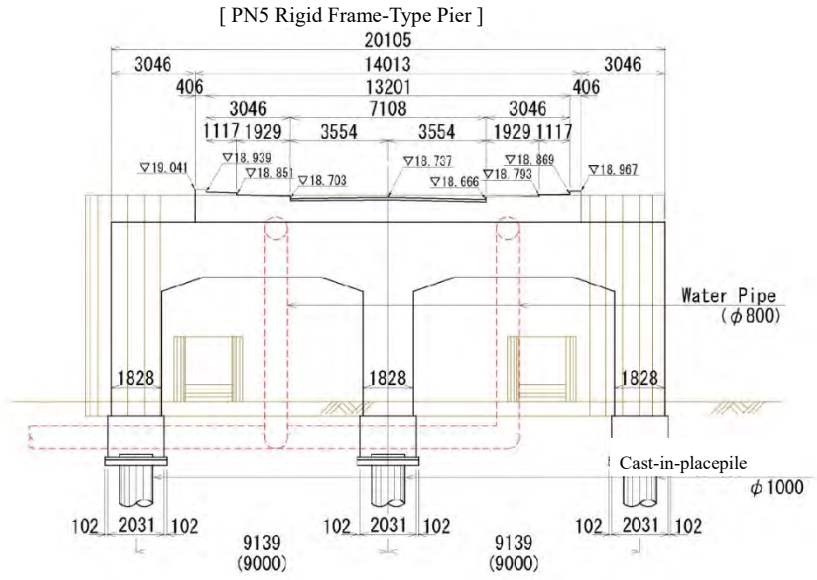


Figure 2-2-23 Elevation View of PN5 Rigid Frame-Type Pier

b) Strength of Materials

ⅰ) Concrete

- Body: 24 N/mm^2
- Footing: 24 N/mm^2
- Pile foundation: 24 N/mm^2 (target strength 30 N/mm^2)

c) Dead Load Conditions

- Abutment backfill soil: γ = 19 kN/m^3, φ=30°, assuming equivalence to sand.
- Load placed on footing: γ = 18 kN/m^3.

3) Foundation Work

a) Selection of the Type of Foundation Work

The type of foundation of the bridge shall be pile foundation, because the bearing strata are located deep. Among the foundation types in Table 2-2-16, steel pipe piles and cast-in-place piles were considered possible (PHC piles were excluded from consideration, because these cannot be produced locally). In the case of ready-made piles such as steel pipe piles, it is highly probable that pile driving may become impossible when there are obstacles in the ground. In addition, as the existing bridge is replaced in the same location and the new substructure work comes in contact with the positions of existing abutments and piers, existing foundation structures are very likely to obstruct pile driving. Therefore, the type of foundation shall be cast-in-place piles, and the method of installation shall be the rotary all casing method, which allows pile installation even in the case of contact with existing foundation structures during work.

Table 2-2-16 Table for Selection of Foundation Type

Selection requirements \ Foundation types				Direct foundation	Cast pile foundation			Inner excavation pile foundation						Cast in-situ pile foundaiton				Caisson foundation		Steel pipe sheet pile foundation	underground continuous wall foundation
								PHC pile			Steel pipe pile										
					RC pile	PHC pile	Steel pipe pile	Final impact driving method	Blast agitation	Concrete impact	Final impact driving method	Blast agitation	Concrete impact	All casing	Reverse	Earth drill	Chicago board	Pneumatic	Open		
Ground requirements	Below support layer	Soft ground in the interlayer		△	○	○	○	○	○	○	○	○	○	○	○	○	×	○	○	○	○
		An extremely hard layer inside the inter layer		○	×	△	△	○	○	○	○	○	○	△	○	△	○	○	△	△	○
		Gravel in the interlayer	Gravel size 5 cm or below	○	△	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
			Gravel size 5 cm～10 cm	○	×	△	△	△	△	△	△	△	△	○	○	△	○	○	○	△	○
			Gravel size 10 cm～50 cm	○	×	×	×	×	×	×	×	×	×	△	×	×	○	○	△	×	△
		The layer has liquefiable ground		△	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
	Conditions of the support layer	Support layer depth	Below 5 m	○	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
			5～15 m	△	○	○	○	○	○	○	○	○	○	○	△	○	○	○	○	△	△
			15～25 m	×	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
			25～40 m	×	×	○	○	○	○	○	○	○	○	○	○	△	△	○	○	○	○
			40～60 m	×	×	△	○	△	△	△	○	○	○	△	○	×	×	△	○	○	○
			60 m or above	×	×	×	△	×	×	×	×	×	×	×	△	×	×	×	△	△	△
		Soil properties of the support layer	Cohesivvve soil (20 N)	○	○	○	○	○	×	△	○	×	△	○	○	○	○	○	○	○	○
			Sand/ gravel (30 N)	○	○	○	○	○	○	×	○	○	×	○	○	○	○	○	○	○	○
		High gradient (30º or above)		○	×	△	○	△	△	△	○	○	○	○	△	△	○	○	△	△	△
		The surface of the support layer is severely uneven		○	△	△	○	△	△	△	○	△	△	○	○	○	○	○	△	△	○
	Groundwater	Groundwater level is close to the ground surface		△	○	○	○	○	○	○	○	○	○	○	○	△	△	○	○	○	○
		Significant amount of spring water		△	○	○	○	○	○	○	○	○	○	○	○	△	×	○	○	○	△
		Artesian groundwater 2 m above the ground surface		×	○	○	○	×	×	×	×	×	×	×	×	×	×	△	△	○	×
		Groundwater velocity is 3m/ min or above		×	○	○	○	○	×	×	○	×	×	×	×	×	×	○	△	○	×
Structural properties	Load size	Low vertical load (span length 20m or below)		○	○	○	○	○	○	○	○	○	○	○	○	○	○	×	△	×	×
		Moderate vertical load (span length 20m to 50m)		○	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
		High vertical load (span length 50m)		○	×	△	○	△	△	△	○	○	○	○	○	△	○	○	○	○	○
		Horizontal load is lower than vertical load		○	○	○	○	○	○	○	○	○	○	○	○	○	○	△	△	△	△
		Horizontal load is higher than vertical load		○	×	△	○	△	△	△	○	○	○	○	○	○	○	○	○	○	○
	Support type		Support pile		○	○	○	○	○	○	○	○	○	○	○	○	○				
			Friction pile		○	○								○	○	○					
Construction requirements	Construction on water		Water depth below 5m	○	○	○	○	△	△	△	△	△	△	×	○	△	×	△	△	○	×
			Water depth 5m or above	×	△	△	○	△	△	△	△	△	△	×	△	×	×	△	△	○	×
	Limited work space			○	△	△	△	△	△	△	△	△	△	△	△	△	○	△	△	×	△
	Batter pile construction				△	○	○	×	×	×	△	△	△	△	×	×	×				
	Effects of toxic gas			△	○	○	○	○	○	○	○	○	○	○	○	○	×	×	○	○	○
	Surrounding environment	Oscillation noise measures		○	×	×	×	△	○	○	△	○	○	△	○	○	○	○	○	△	○
		Effects on adjacent structures		○	×	×	△	△	○	○	△	○	○	○	○	○	△	△	△	△	○

b) Soil Profile

Soil profiles are produced from the results of boring in this project and past boring to characterize the soil conditions at the position of each pier.

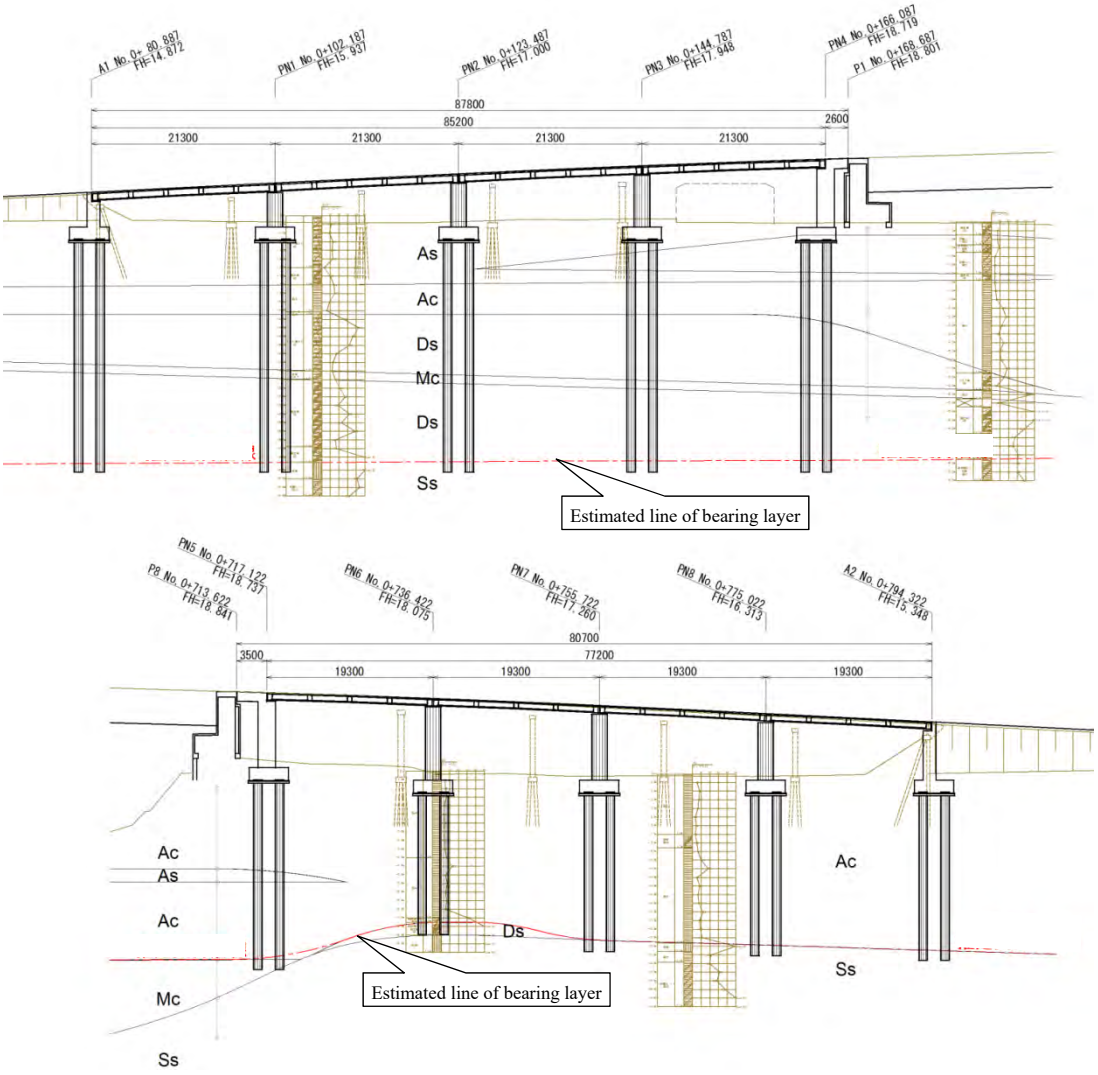
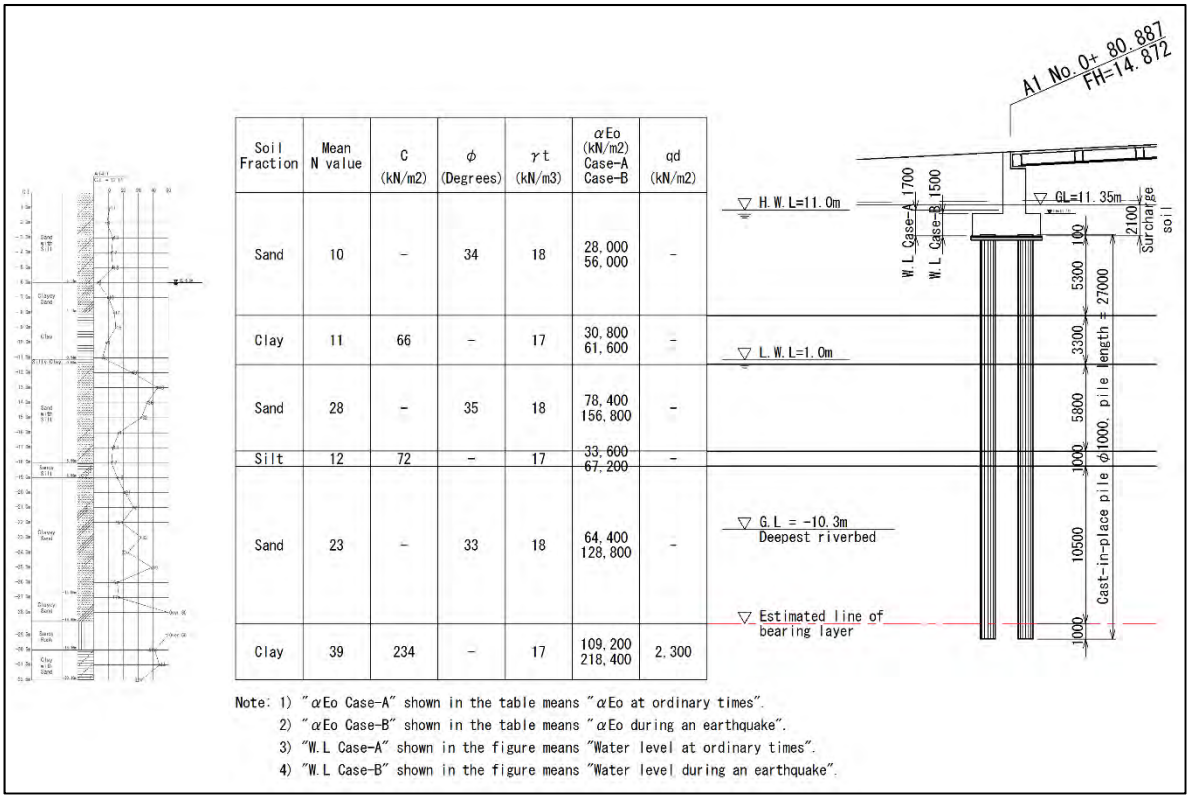


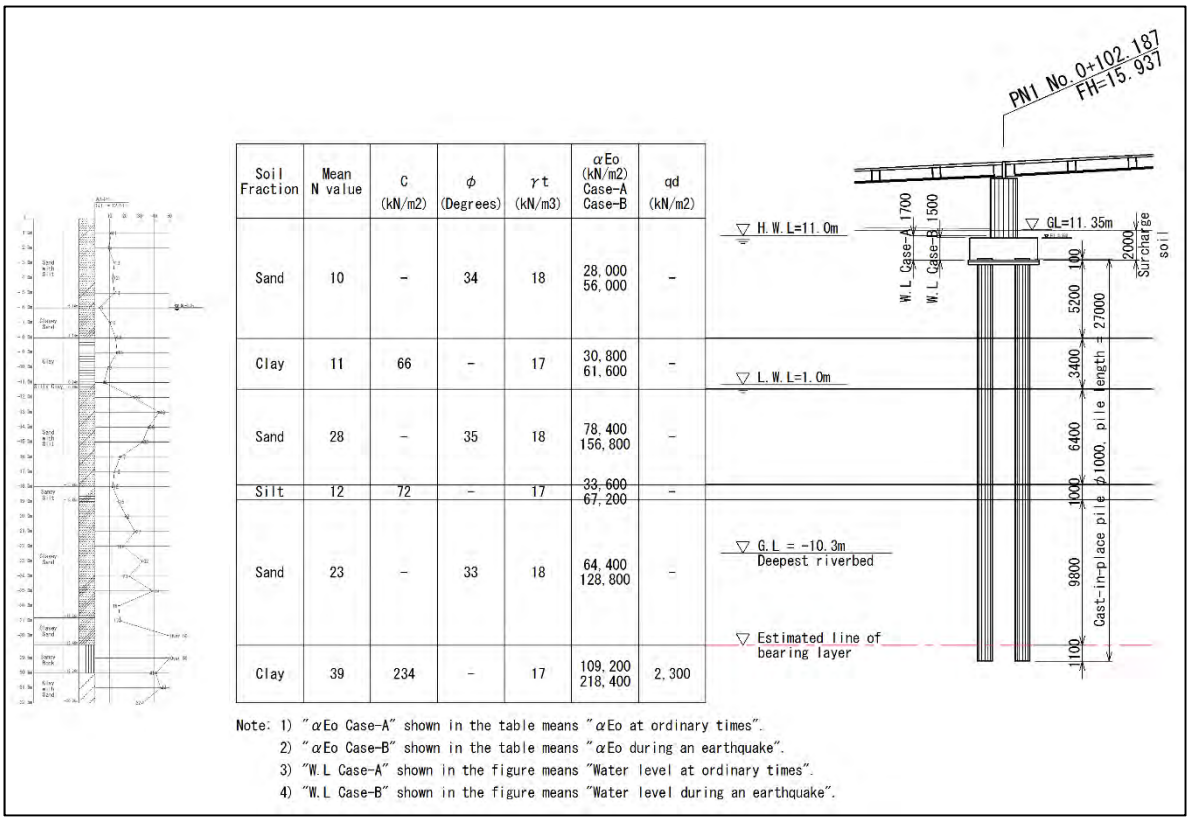
Figure 2-2-24 Soil Profile



Soil Fraction	Mean N value	C (kN/m2)	φ (Degrees)	γt (kN/m3)	αEo (kN/m2) Case-A Case-B	qd (kN/m2)
Sand	10	-	34	18	28,000 56,000	-
Clay	11	66	-	17	30,800 61,600	-
Sand	28	-	35	18	78,400 156,800	-
Silt	12	72	-	17	33,600 67,200	-
Sand	23	-	33	18	64,400 128,800	-
Clay	39	234	-	17	109,200 218,400	2,300

Note: 1) "αEo Case-A" shown in the table means "αEo at ordinary times".
2) "αEo Case-B" shown in the table means "αEo during an earthquake".
3) "W.L Case-A" shown in the figure means "Water level at ordinary times".
4) "W.L Case-B" shown in the figure means "Water level during an earthquake".

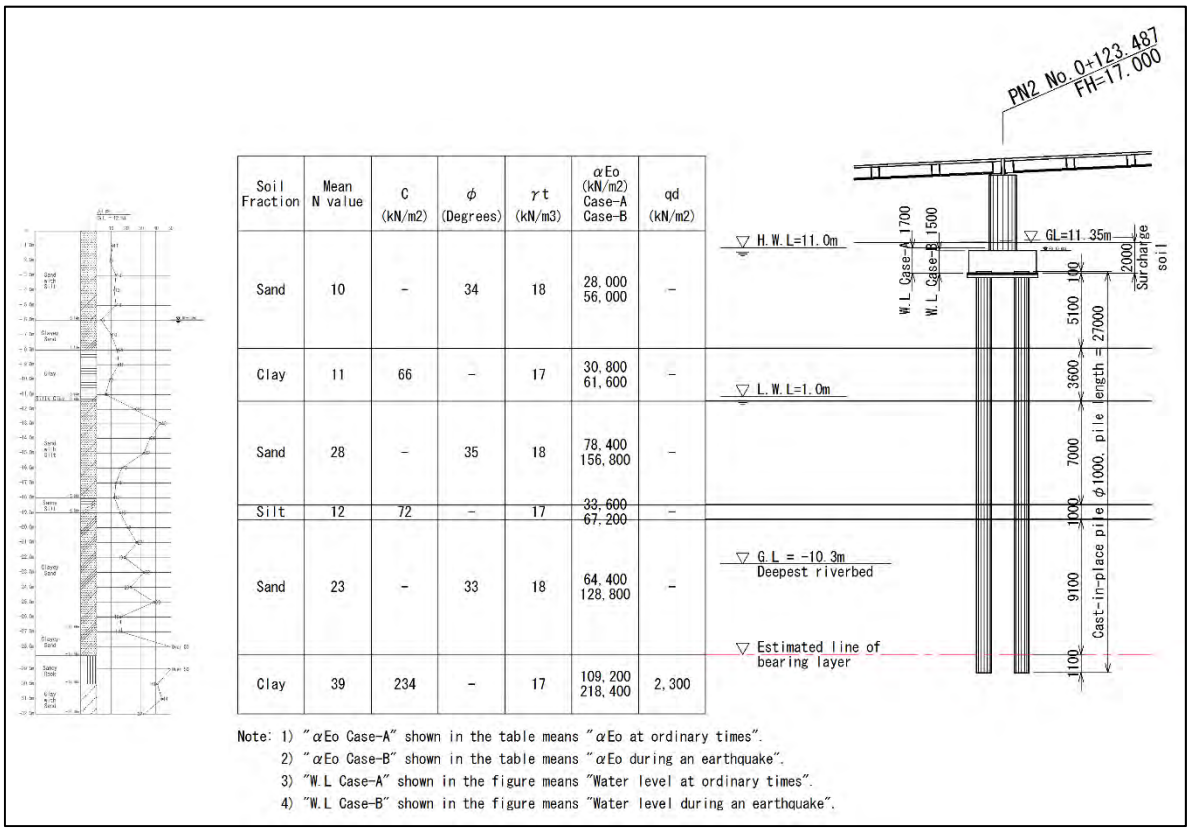
Figure 2-2-25 Soil Profile (A1)



Soil Fraction	Mean N value	C (kN/m2)	φ (Degrees)	γt (kN/m3)	αEo (kN/m2) Case-A Case-B	qd (kN/m2)
Sand	10	-	34	18	28,000 56,000	-
Clay	11	66	-	17	30,800 61,600	-
Sand	28	-	35	18	78,400 156,800	-
Silt	12	72	-	17	33,600 67,200	-
Sand	23	-	33	18	64,400 128,800	-
Clay	39	234	-	17	109,200 218,400	2,300

Note: 1) "αEo Case-A" shown in the table means "αEo at ordinary times".
2) "αEo Case-B" shown in the table means "αEo during an earthquake".
3) "W.L Case-A" shown in the figure means "Water level at ordinary times".
4) "W.L Case-B" shown in the figure means "Water level during an earthquake".

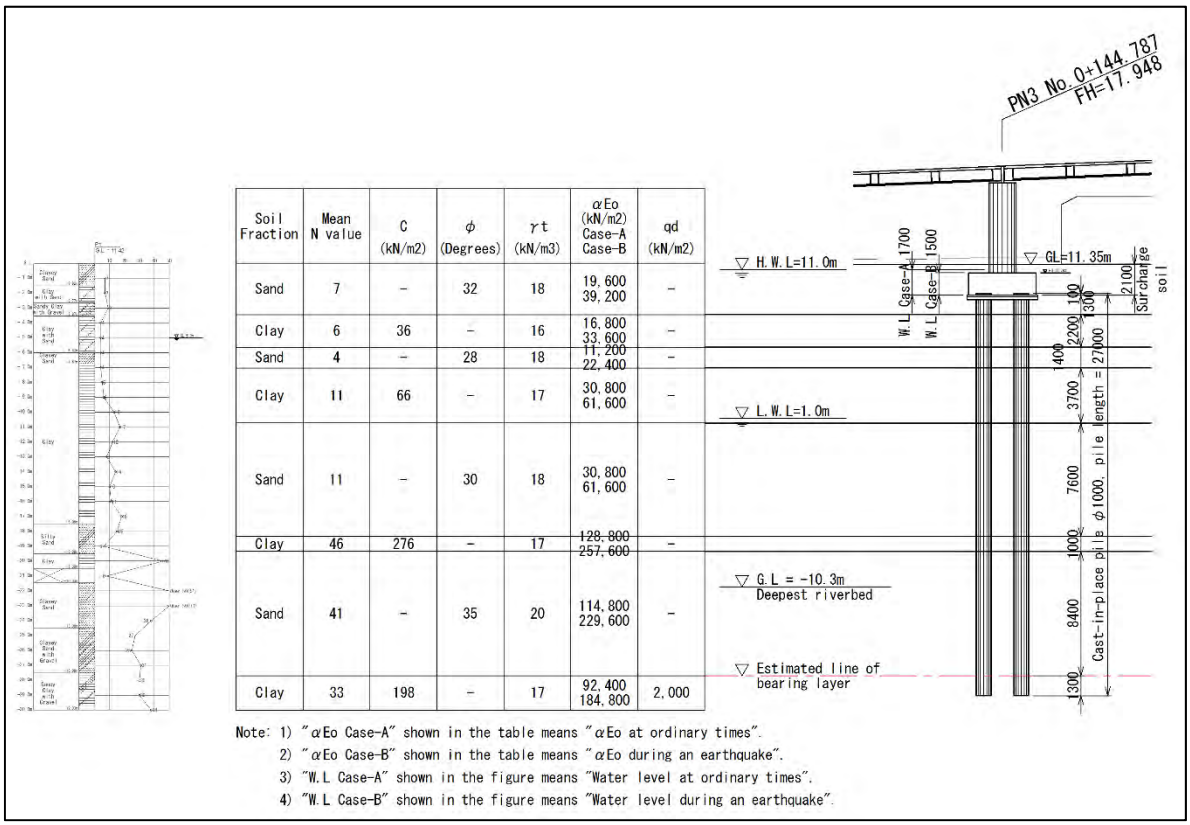
Figure 2-2-26 Soil Profile (PN1)



Soil Fraction	Mean N value	C (kN/m2)	φ (Degrees)	γt (kN/m3)	αEo (kN/m2) Case-A Case-B	qd (kN/m2)
Sand	10	–	34	18	28,000 56,000	–
Clay	11	66	–	17	30,800 61,600	–
Sand	28	–	35	18	78,400 156,800	–
Silt	12	72	–	17	33,600 67,200	–
Sand	23	–	33	18	64,400 128,800	–
Clay	39	234	–	17	109,200 218,400	2,300

Note: 1) "αEo Case-A" shown in the table means "αEo at ordinary times".
2) "αEo Case-B" shown in the table means "αEo during an earthquake".
3) "W.L Case-A" shown in the figure means "Water level at ordinary times".
4) "W.L Case-B" shown in the figure means "Water level during an earthquake".

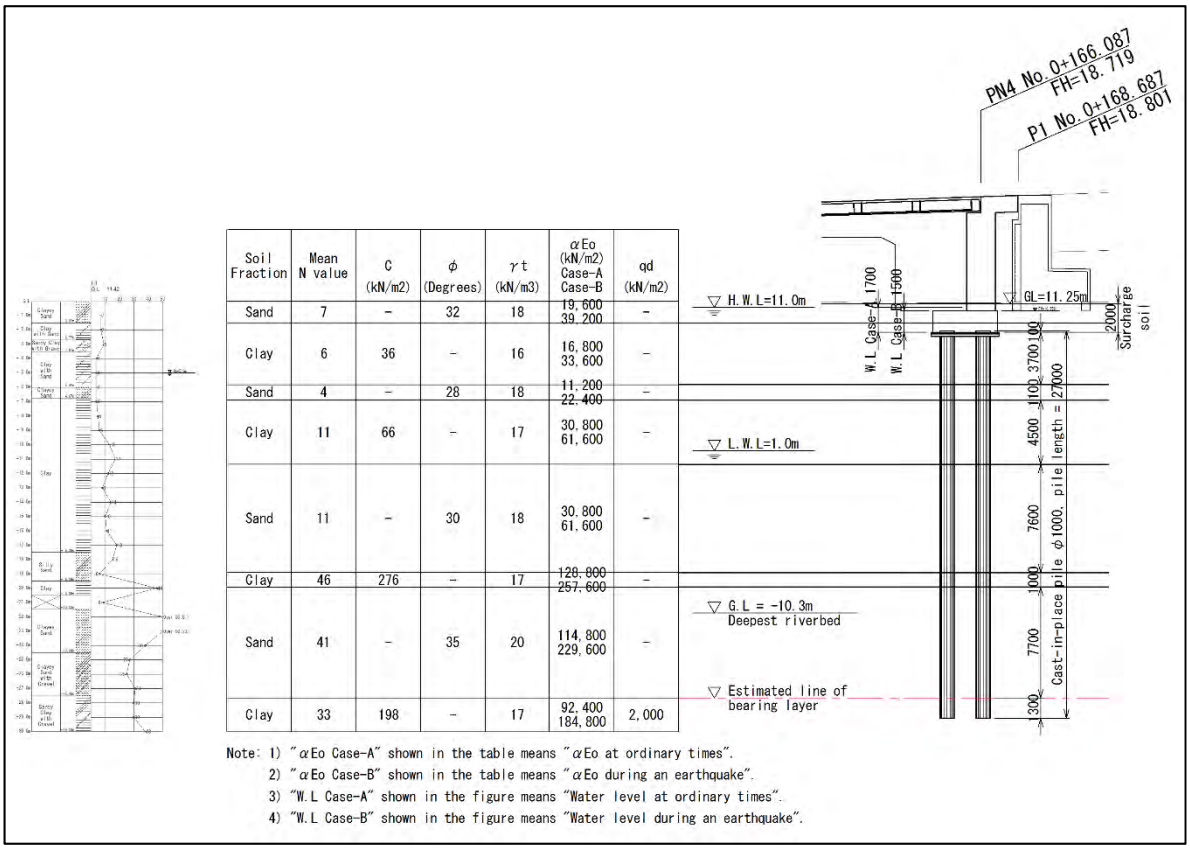
Figure 2-2-27 Soil Profile (PN2)



Soil Fraction	Mean N value	C (kN/m2)	φ (Degrees)	γt (kN/m3)	αEo (kN/m2) Case-A Case-B	qd (kN/m2)
Sand	7	–	32	18	19,600 39,200	–
Clay	6	36	–	16	16,800 33,600	–
Sand	4	–	28	18	11,200 22,400	–
Clay	11	66	–	17	30,800 61,600	–
Sand	11	–	30	18	30,800 61,600	–
Clay	46	276	–	17	128,800 257,600	–
Sand	41	–	35	20	114,800 229,600	–
Clay	33	198	–	17	92,400 184,800	2,000

Note: 1) "αEo Case-A" shown in the table means "αEo at ordinary times".
2) "αEo Case-B" shown in the table means "αEo during an earthquake".
3) "W.L Case-A" shown in the figure means "Water level at ordinary times".
4) "W.L Case-B" shown in the figure means "Water level during an earthquake".

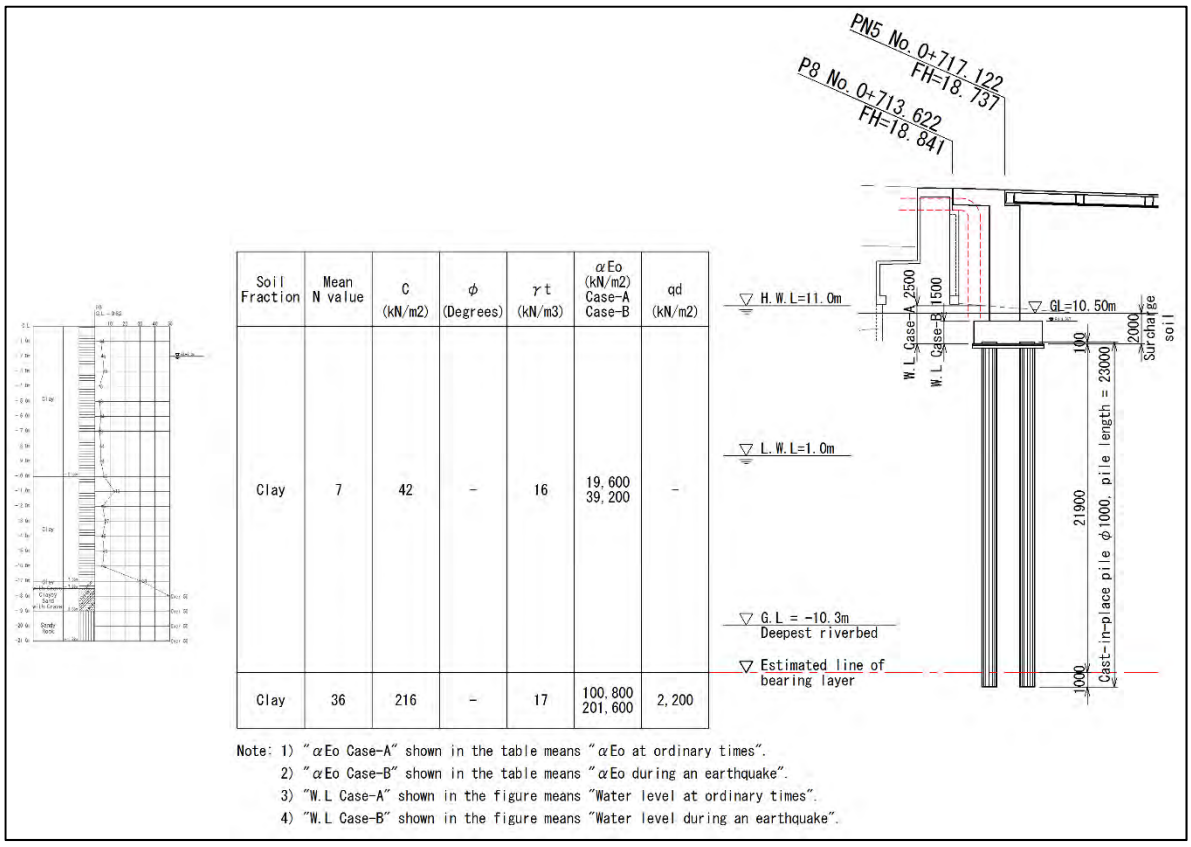
Figure 2-2-28 Soil Profile (PN3)



Soil Fraction	Mean N value	C (kN/m2)	φ (Degrees)	γt (kN/m3)	αEo (kN/m2) Case-A / Case-B	qd (kN/m2)
Sand	7	–	32	18	19,600 / 39,200	–
Clay	6	36	–	16	16,800 / 33,600	–
Sand	4	–	28	18	11,200 / 22,400	–
Clay	11	66	–	17	30,800 / 61,600	–
Sand	11	–	30	18	30,800 / 61,600	–
Clay	46	276	–	17	128,800 / 257,600	–
Sand	41	–	35	20	114,800 / 229,600	–
Clay	33	198	–	17	92,400 / 184,800	2,000

Note: 1) "αEo Case-A" shown in the table means "αEo at ordinary times".
2) "αEo Case-B" shown in the table means "αEo during an earthquake".
3) "W.L Case-A" shown in the figure means "Water level at ordinary times".
4) "W.L Case-B" shown in the figure means "Water level during an earthquake".

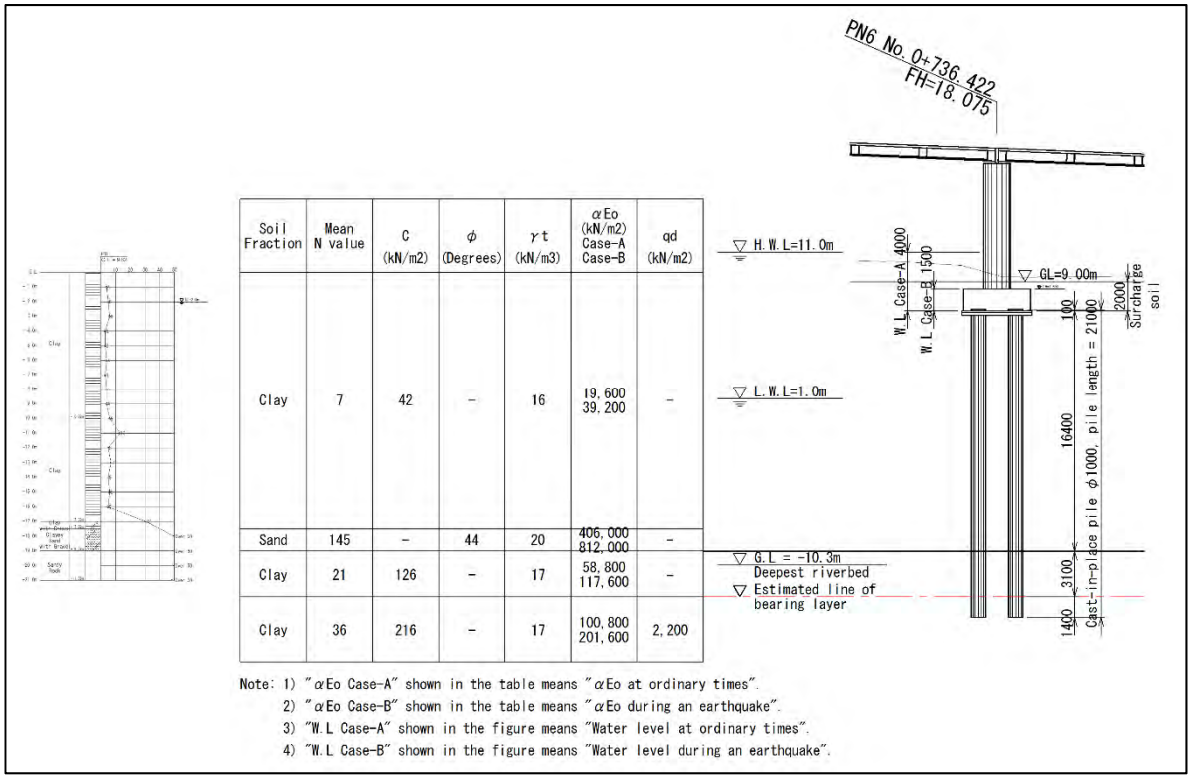
Figure 2-2-29 Soil Profile (PN4)



Soil Fraction	Mean N value	C (kN/m2)	φ (Degrees)	γt (kN/m3)	αEo (kN/m2) Case-A / Case-B	qd (kN/m2)
Clay	7	42	–	16	19,600 / 39,200	–
Clay	36	216	–	17	100,800 / 201,600	2,200

Note: 1) "αEo Case-A" shown in the table means "αEo at ordinary times".
2) "αEo Case-B" shown in the table means "αEo during an earthquake".
3) "W.L Case-A" shown in the figure means "Water level at ordinary times".
4) "W.L Case-B" shown in the figure means "Water level during an earthquake".

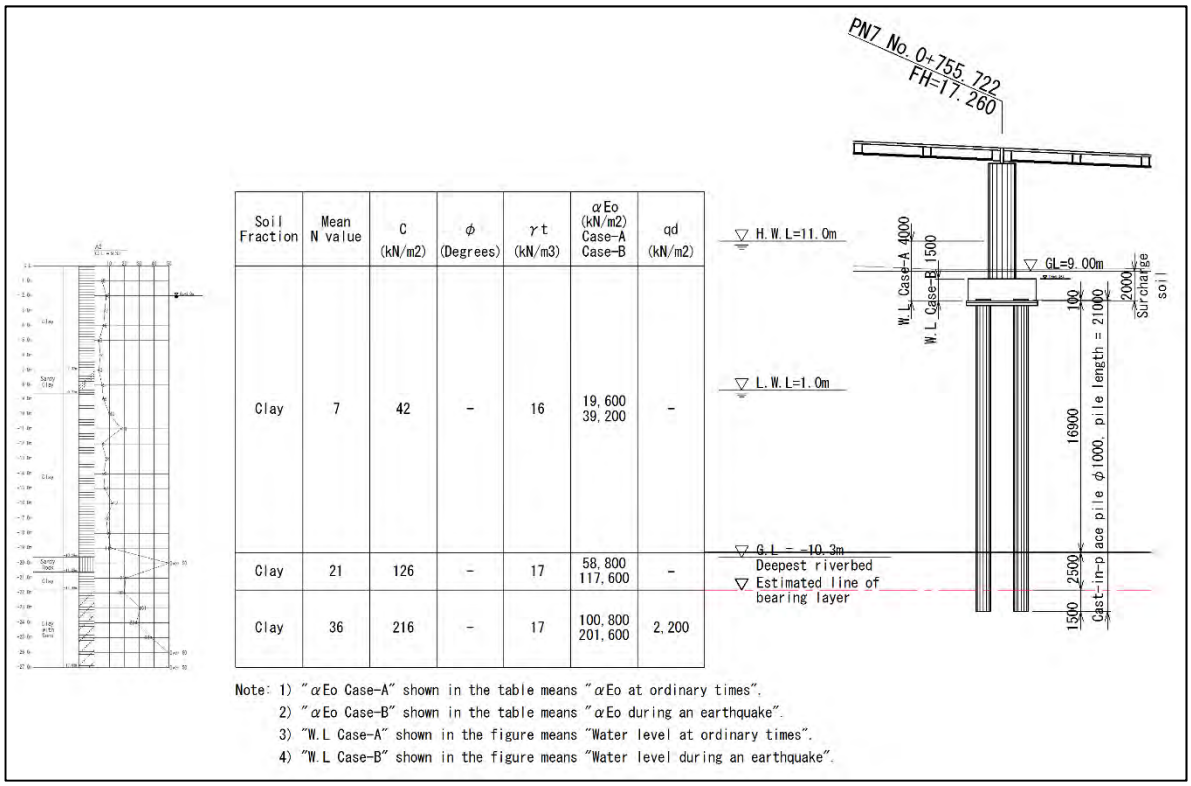
Figure 2-2-30 Soil Profile (PN5)



Soil Fraction	Mean N value	C (kN/m2)	ϕ (Degrees)	γt (kN/m3)	αEo (kN/m2) Case-A Case-B	qd (kN/m2)
Clay	7	42	-	16	19,600 39,200	-
Sand	145	-	44	20	406,000 812,000	-
Clay	21	126	-	17	58,800 117,600	-
Clay	36	216	-	17	100,800 201,600	2,200

Note: 1) "αEo Case-A" shown in the table means "αEo at ordinary times".
2) "αEo Case-B" shown in the table means "αEo during an earthquake".
3) "W.L Case-A" shown in the figure means "Water level at ordinary times".
4) "W.L Case-B" shown in the figure means "Water level during an earthquake".

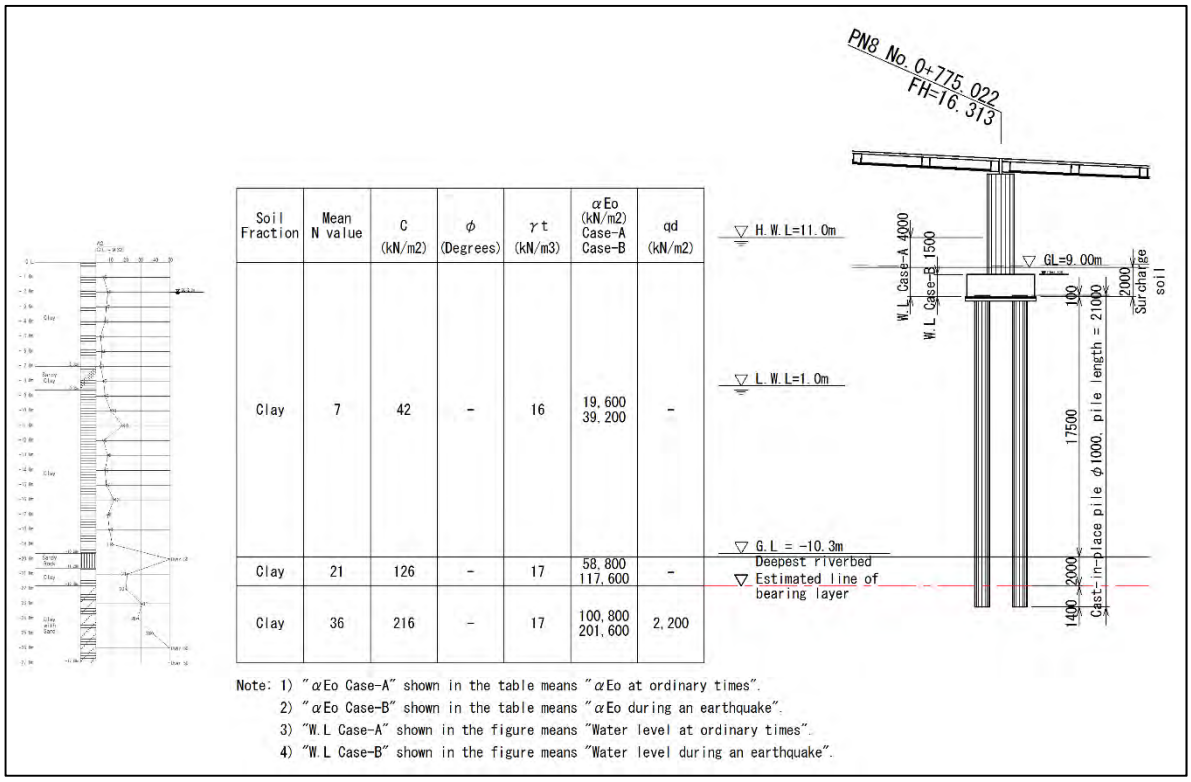
Figure 2-2-31 Soil Profile (PN6)



Soil Fraction	Mean N value	C (kN/m2)	ϕ (Degrees)	γt (kN/m3)	αEo (kN/m2) Case-A Case-B	qd (kN/m2)
Clay	7	42	-	16	19,600 39,200	-
Clay	21	126	-	17	58,800 117,600	-
Clay	36	216	-	17	100,800 201,600	2,200

Note: 1) "αEo Case-A" shown in the table means "αEo at ordinary times".
2) "αEo Case-B" shown in the table means "αEo during an earthquake".
3) "W.L Case-A" shown in the figure means "Water level at ordinary times".
4) "W.L Case-B" shown in the figure means "Water level during an earthquake".

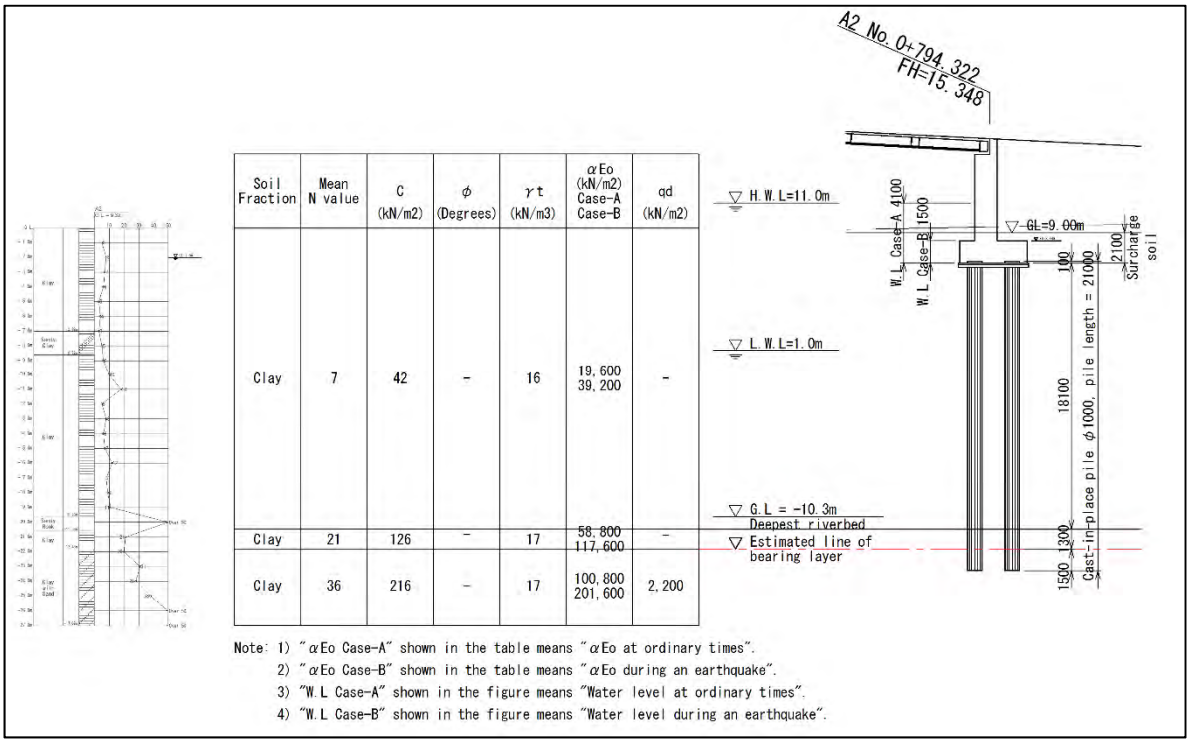
Figure 2-2-32 Soil Profile (PN7)



Soil Fraction	Mean N value	C (kN/m2)	φ (Degrees)	γt (kN/m3)	αEo (kN/m2) Case-A / Case-B	qd (kN/m2)
Clay	7	42	-	16	19,600 / 39,200	-
Clay	21	126	-	17	58,800 / 117,600	-
Clay	36	216	-	17	100,800 / 201,600	2,200

Note: 1) "αEo Case-A" shown in the table means "αEo at ordinary times".
2) "αEo Case-B" shown in the table means "αEo during an earthquake".
3) "W.L Case-A" shown in the figure means "Water level at ordinary times".
4) "W.L Case-B" shown in the figure means "Water level during an earthquake".

Figure 2-2-33 Soil Profile (PN8)



Soil Fraction	Mean N value	C (kN/m2)	φ (Degrees)	γt (kN/m3)	αEo (kN/m2) Case-A / Case-B	qd (kN/m2)
Clay	7	42	-	16	19,600 / 39,200	-
Clay	21	126	-	17	58,800 / 117,600	-
Clay	36	216	-	17	100,800 / 201,600	2,200

Note: 1) "αEo Case-A" shown in the table means "αEo at ordinary times".
2) "αEo Case-B" shown in the table means "αEo during an earthquake".
3) "W.L Case-A" shown in the figure means "Water level at ordinary times".
4) "W.L Case-B" shown in the figure means "Water level during an earthquake".

Figure 2-2-34 Soil Profile (A2)

2-2-2-8-2 Repair Work

(1) Overall Diagram of Repair Plan

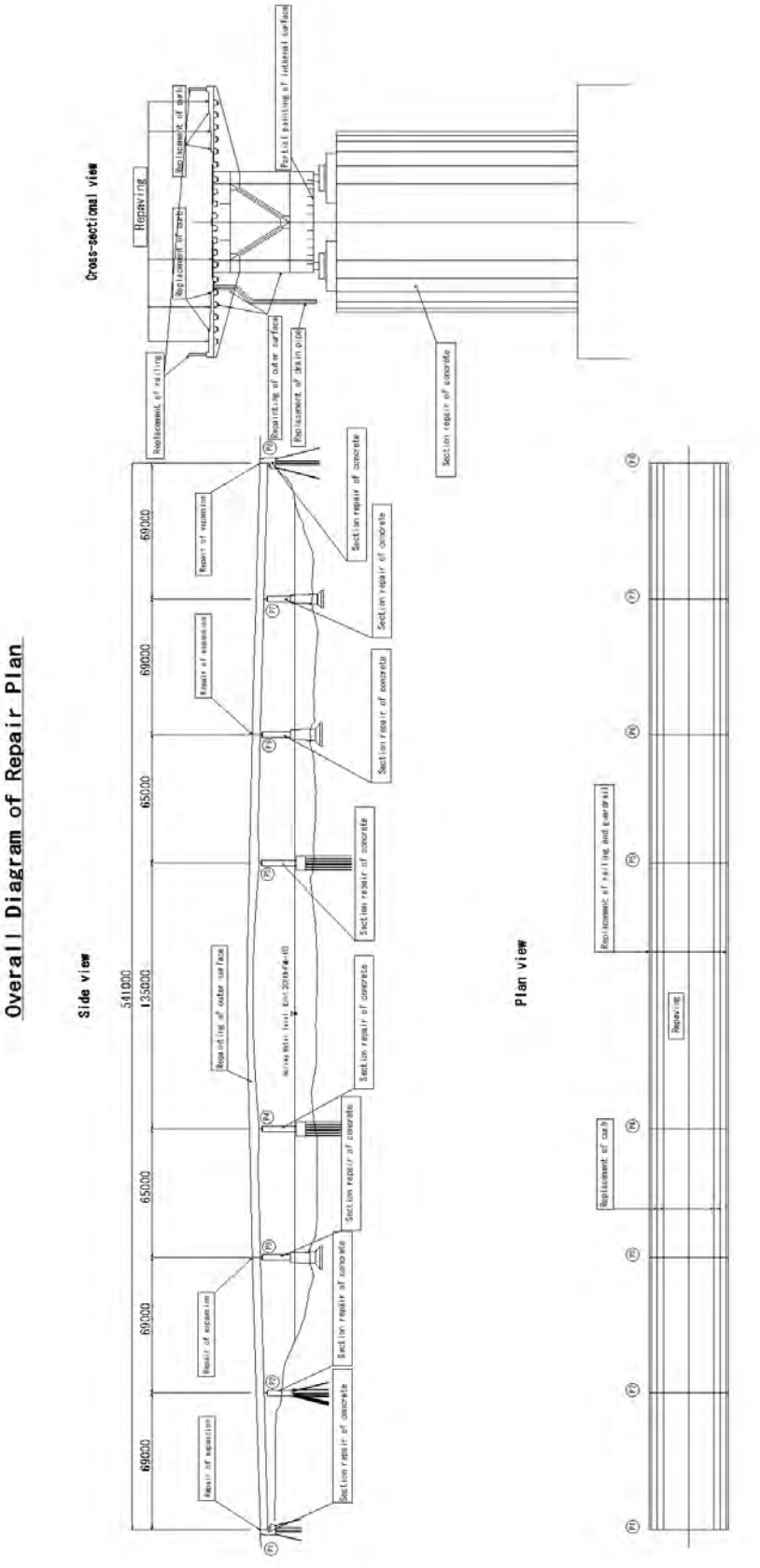


Figure 2-2-35 Overall Diagram of Repair Plan

(2) Substructure Repair Work

1) Work Procedures

The following diagram shows the procedures of repair work for the deteriorated and damaged parts of existing substructure (P1-P8 piers).

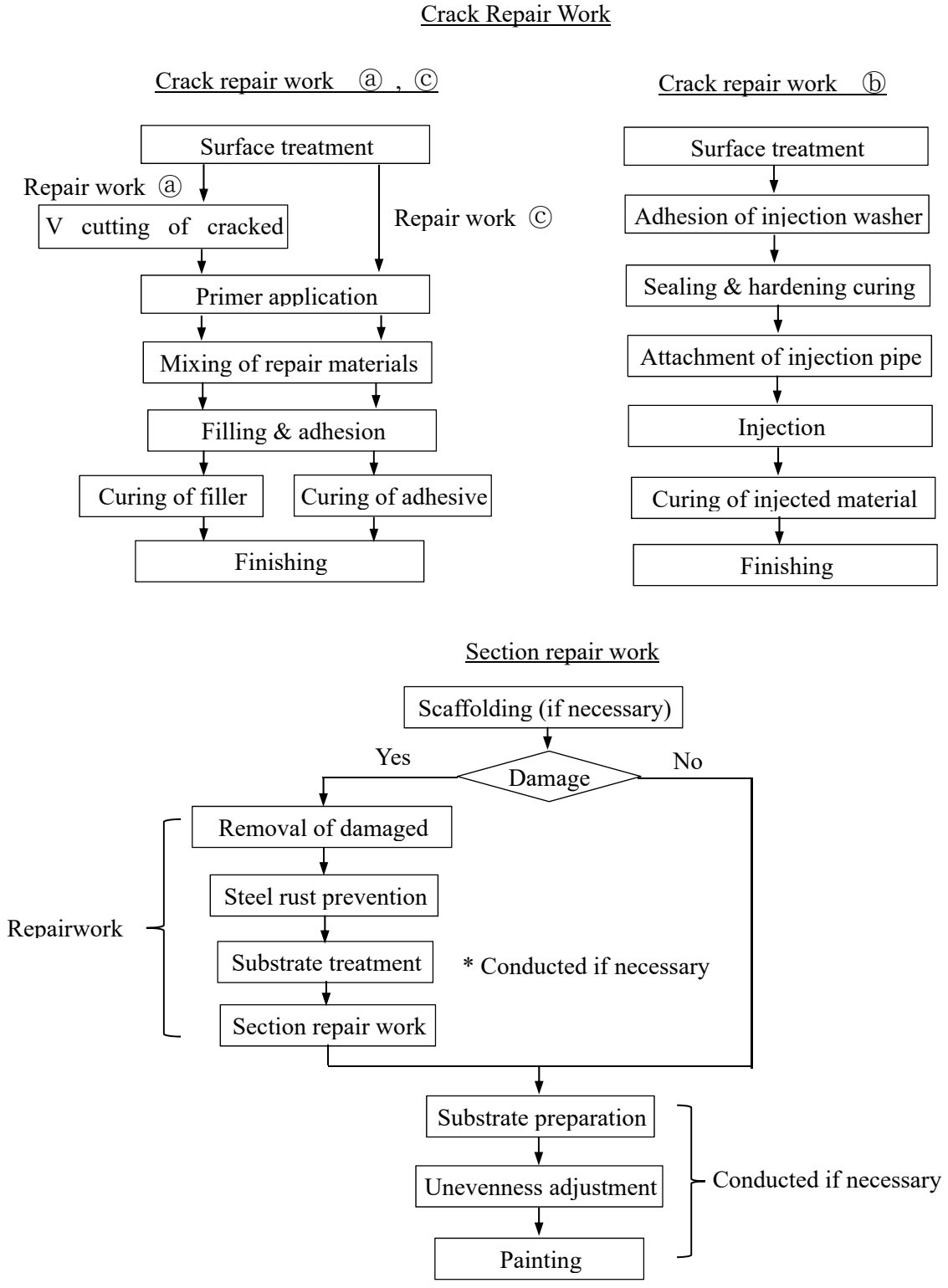
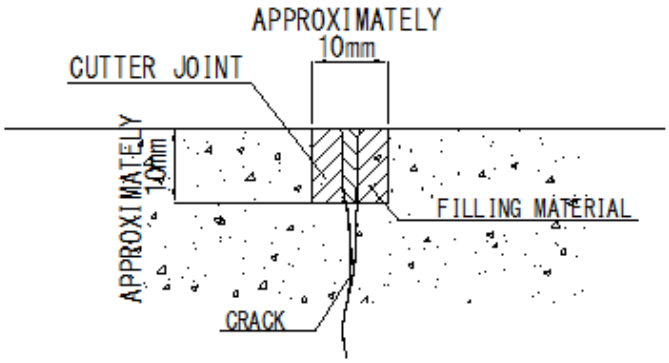


Figure 2-2-36 Flow of Repair WorkProcedures

2) Detailed Illustration of Crack Repair Work

CRACK 1.0mm OR MORE : ⓐ



(CRACK 0.2mm OR MORE～LESS THAN 1.0mm) ⓑ

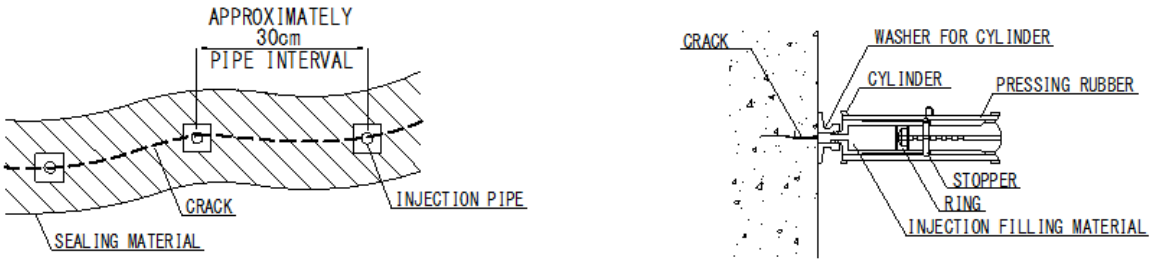


Figure 2-2-37 Detailed Illustration of Crack Repair Work

3) Detailed Illustration of Section Repair Work

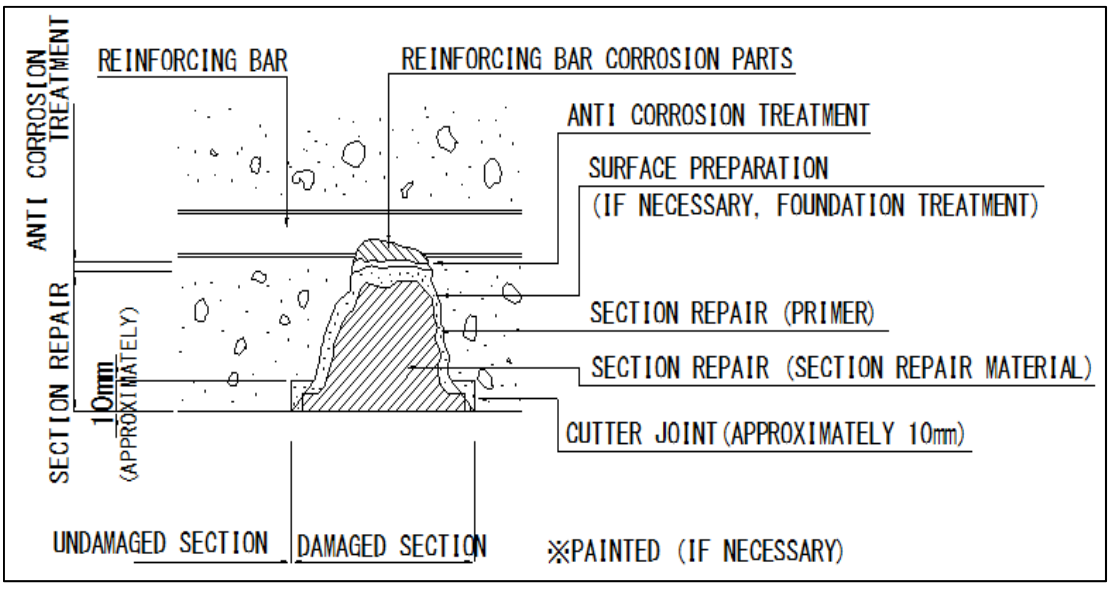


Figure 2-2-38 Detailed Illustration of Section Repair Work

(3) Pavement Work

Four types of pavement including gus asphalt pavement, stone mastic asphalt (SMA) pavement, epoxy asphalt pavement, and steel fiber reinforced concrete (SFRC) pavement were compared as a measure against fatigue cracking of the steel plate decks in the steel bridge part. The result (Table 2-2-13) showed that steel fiber reinforced concrete (SFRC) pavement was the most preferable, and this method was selected.

The pavement scheme shall consist of 50 mm steel fiber reinforced concrete (SFRC) pavement in the base layer and 30 mm modified asphalt pavement in the surface layer. Whle the bonding between the steel plate deck and the base layer pavement can be achieved by either with dhesives or with stud dowels, adhesives shall be used as a rule in this project, and stud dowels shall be used in the construction joints of SFRC pavement and the areas near the ends of pavement (Design and Construction Manual on the Reinforcement of Existing Steel Plate Decks with SFRC Pavement (Draft), Public Works Research Institute).

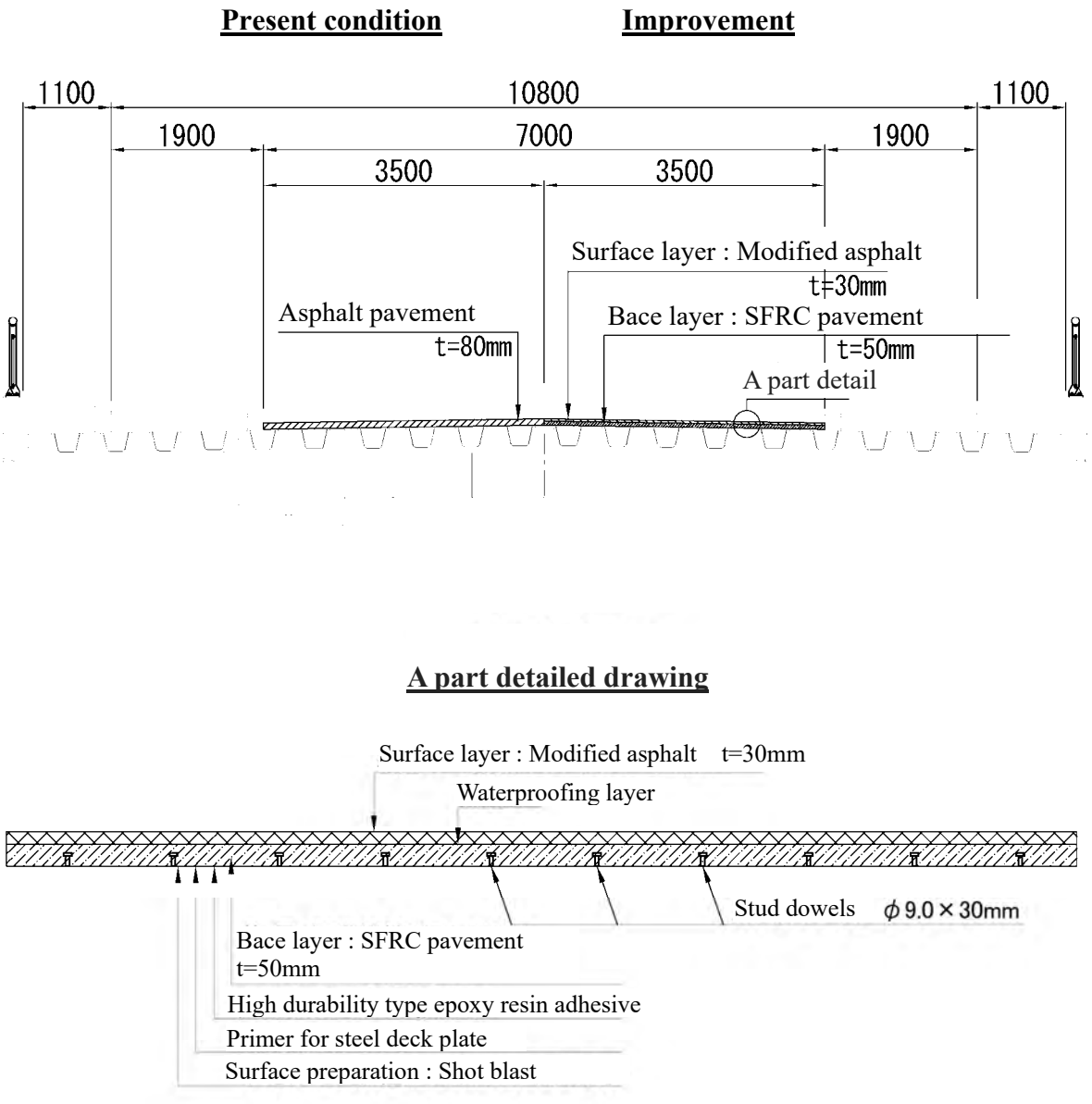


Figure 2-2-39 Diagram of SFRC Pvement

(4) Painting Work

The paint on steel girders is losing its anticorrosive function due to aging deterioration. In addition, localized rust has occurred inside of box girders due to water leakage and retention. Repainting shall therefore be performed on the all outer surfaces and the necessary areas on the inside of box girders. Although outer surfaces near girder ends show traces of past repainting, all outer surfaces shall be repainted because peeling of paint films is observed.

For environmental protection of the Tonle Sap River and to prevent noise pollution, removal of existing paint films shall be performed using the Invairowan method. This is an environmentally friendly paint film removal technology using a highly biodegradable stripping agent.

RC-I paints shall be used in the painting on outer surfaces. RD-III paints shall be used in the partial painting on internal surfaces.

Table 2-2-17 Specifications for Rc- I Paints

Painting process	Paint	Quantity used	Painting interval
Substrate preparation	Type 1	(g/m^2)	Within 4 hours
Undercoating	Organic zinc-rich paint	600	1-10 days
Undercoating	Weak solvent-type modified epoxy resin paint for undercoating	240	1-10 days
Undercoating	Weak solvent-type modified epoxy resin paint for undercoating	240	1-10 days
Intermediate coating	Weak solvent-type fluorocarbon resin paint for intermediate coating	170	1-10 days
Top coating	Weak solvent-type fluorocarbon resin paint for top coating	140	—

Table 2-2-18 Specifications for Rd-III Paints

Painting process	Paint	Quantity used	Painting interval
Substrate preparation	Type 3	(g/m^2)	Within 4 hours
1st layer	Solventless-type epoxy resin paint	300	2-10 days
2nd layer	Solventless-type epoxy resin paint	300	

(5) Expansion Apparatuses

Steel girder parts are equipped with steel finger joints to serve as expansion apparatuses. Finger members have a considerably large thickness because of the long span, and they look sound at least superficially. However, as these are draining-type devices (designed so that rainwater is received gutters), gutters have been clogged with earth, causing water leakage and retantion in girder end parts, which affect adversely on main structural members. Because of this situation, all existing expansion apparatuses shall be converted to non-draining structures by using the face plates as they are and inserting backup materials from beneath into the joint openings.

Because this bridge has been designed to have a large range of displacement, expansion joint openings are large enough to allow entry of hands. No problems are expected because existing face plates are reused as they are, although installation work must be performe from beneath. The work does not require traffic restrictions, as it is performed from beneath the road.

An example of installation is illustrated below.

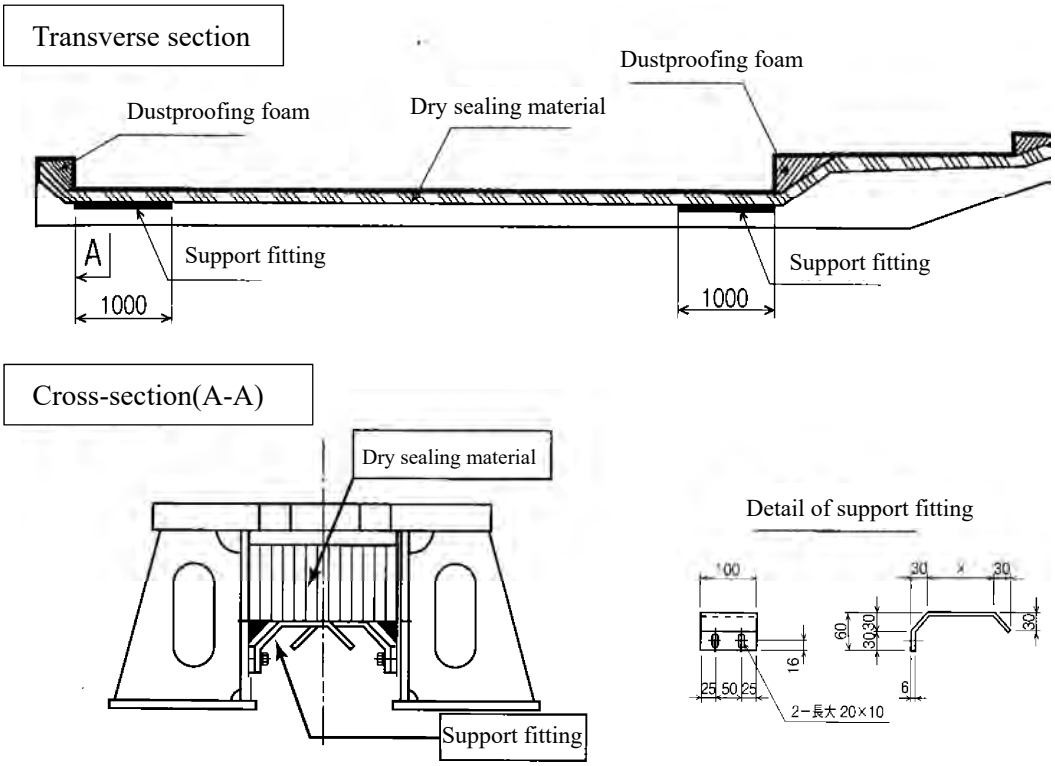


Figure 2-2-40 Example of Installation of Non-Draining Type Expansion

(6) Installation of Bridge Surface Waterproofing Work and Curb Repair

This bridge comprisess carriageway, bike lanes (both sides) and sidewalks (both sides), and each of the borders between these parts has a mount-up structure. Curbs have been mostly lost due to behicles running on them, and need to be replaced. In addition, a waterproofing layer shall be installed beneath SFRC pavement as a measure to protect steel girder members from the permeation of water thorough pavement. The waterproofing work shall be conducted during the replacement of pavement.

An example of work on a steel plate deck is illustrated below.

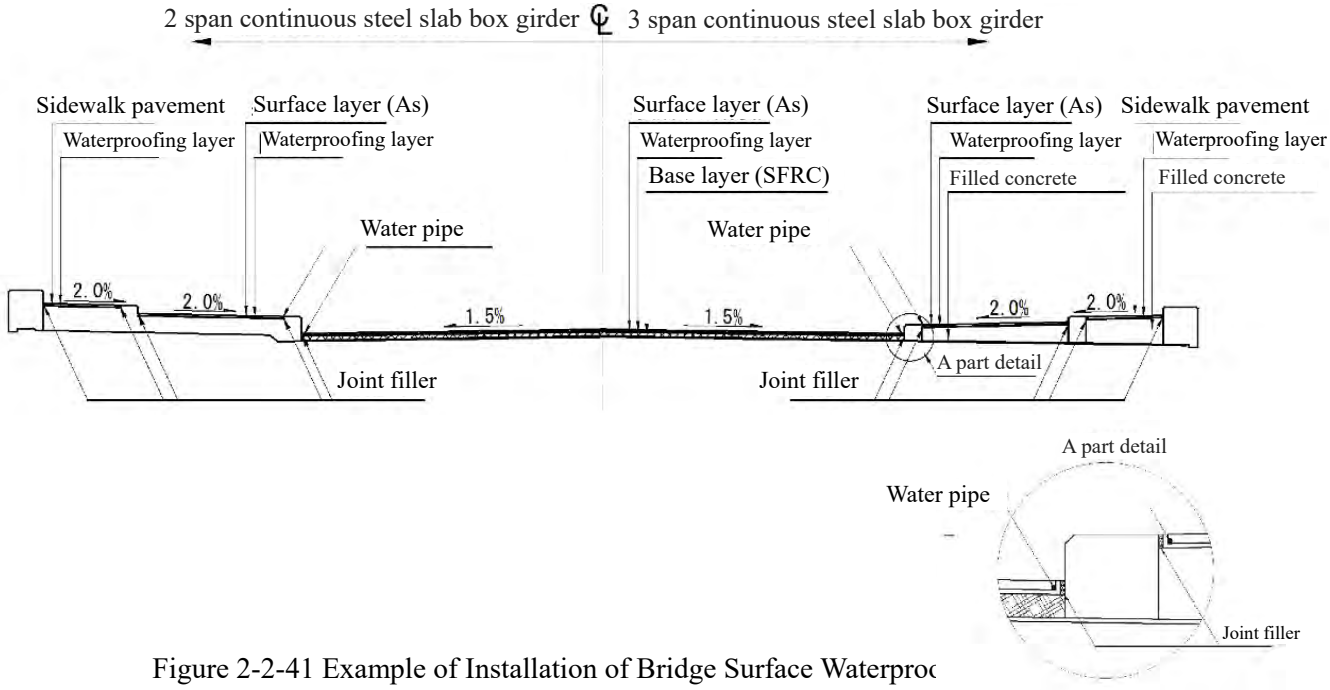


Figure 2-2-41 Example of Installation of Bridge Surface Waterproc

(7) Impregnation Repair of Concrete Surfaces

Crack repair is conducted for the flaws with the width of 0.2 mm or more. Because finer cracks cannot be repaird, a surface covered entirely with fine cracks may be treated with the application of impregnating agents on the concrete surface. Impregnation repair of concrete surfaces is a repair method that can improve the performance of a sturucture without changing its appearance.

Generally, the materials for surface protection work are classified broadly into “silane-based materials,” “silicate-based materials,” and “other.” In particular, “silane-based surface impregnating materials” are superior in work efficiency and cost performande, as they can be used without advanced skills, do not produce odor, tighen the texture of cracked areas, and can be completed in short periods.

For these reasons, “silicate-based surface impregnating materials” shall be used in this project.

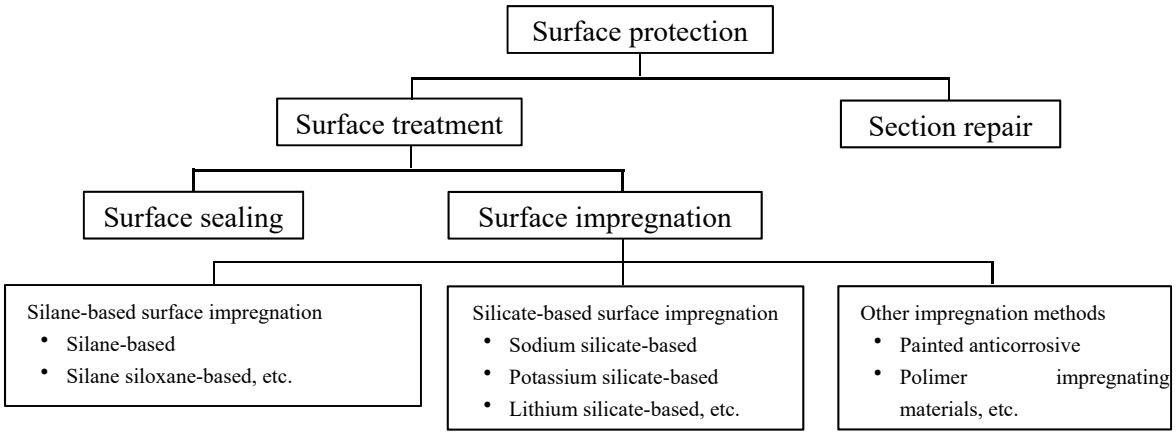


Figure 2-2-42 Classification of Surface Protection Methods

(8) Repair of Draining Pipes

The water drained from the bridge surface flows from catch basins into the river via drain pipes. These pipes have cracks and some parts are mission due to aging deterioration. In addition, because the ends of drain pipes are located near the lower edges of girders, rainwater may splash on girders. Therefore, drain pipes (from the connection to catch basins) shall be replaced and elongated so that the ends of pipes are at least 600 mm lower than the lower edges of girders.

While existing drain pipes are steel, these shall be replaced with rigid polyvinyl chloride pipes. To elongate the drain pipes to 500 mm beneath the lower edges of girders, supporers shall be installed under main girders. The Figure below illustrates an example of drain pipe replacement.

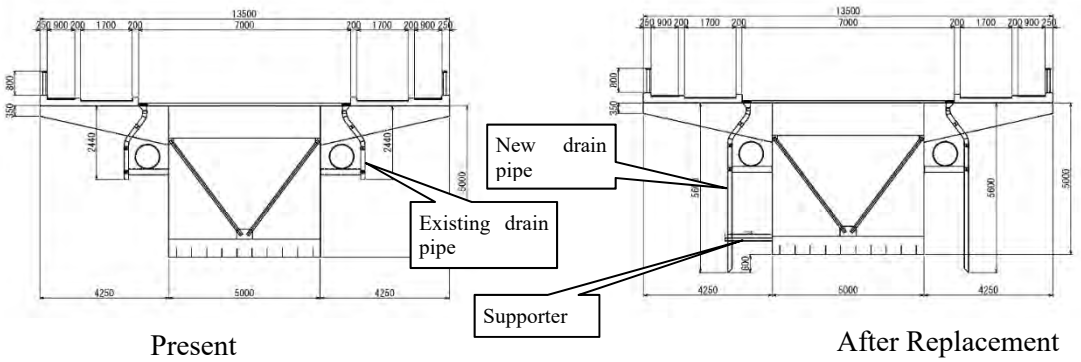


Figure 2-2-43 Drain Pipe Repair

2-2-2-8-3 Improvement Work

(1) Approach Road Parts

1) Road Design Conditions

Road design shall conform to the standards implemented in Cambodia (Road Design Standard(2003)), and any lack of coverage shall be supplemented with the use of Japanese standards. Table lists road design conditions.

Table 2-2-19 Road Design Conditions

Item			Cambodian standards	AASHTO	Road Structure Ordinance	Value used
Road type			U5		General national road	U5
Terrain type						
(Flatland / hills / mountains)			Hills	Hills	Hills	Hills
Design vehicle speed (km/h)			60	60	60	60
Design vehicle			WB-15	WB-40	Standard-sized automobiles	WB-15
Lane width (m)			3.50 x 2	3.30 x 2	3.50 x 2	3.50 x 2
Shoulder width (outside) (m)			2.00 x 2	1.5 x 2	0.75 x 2	1.90 x 2
(bike lanes)						
Steepest longitudinal gradient			5.0	8.0	5.0	5.0
Maximum one-way grade (%)			10.0	10.0	10.0	-
Standard lateral gradient (%)			2.5 – 3.0	1.5 - 2.0	2.0	2.0
Minimum longitudinal curve radius	凸	K Value	15	19	-	**-**
		(m)			1,400	**1,500**
	凹	K Value	15	18	-	**-**
		(m)			1,000	**-**
Minimum length of easement curve (m)			60		40	**-**

2) Examination of Pavement Structure

a) Basic Policy

The examination of pavement structure shall be based on "Road Design Standard PART 2. PAVEMENT," the pavement design standards in Cambodia. However, because there are some inconsistency such as the difference between the definitions of traffic classification in this standard and those shown in the list of standard pavement structures, our basic policy is to develop the structural design according to the Japanese standards in "Pavement Design Manual" (Japan Road Association, February 2006), and then to check the determined pavement structure using the AASHTO method to confirm a lack of significant discrepancy in reference with these design methods.

The scope of road pavement improvement in this project covers the stretches up to the connections to roundabouts on the Phnom Penh side and the Chroy Changwar side (from -0+123.861 to 0+983.666). The pavement of roundabouts is not included in this improvement work.

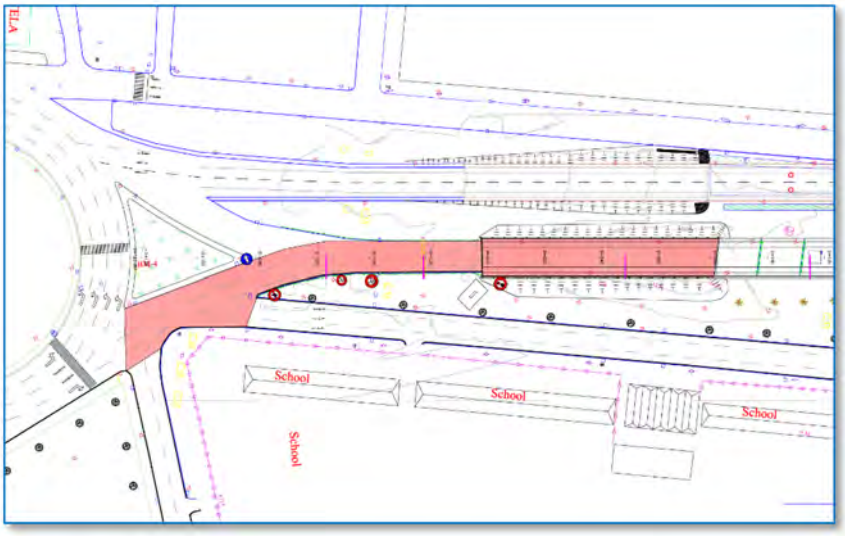


Figure 2-2-44 Scope of Pavement Improvement on the Phnom Penh Side

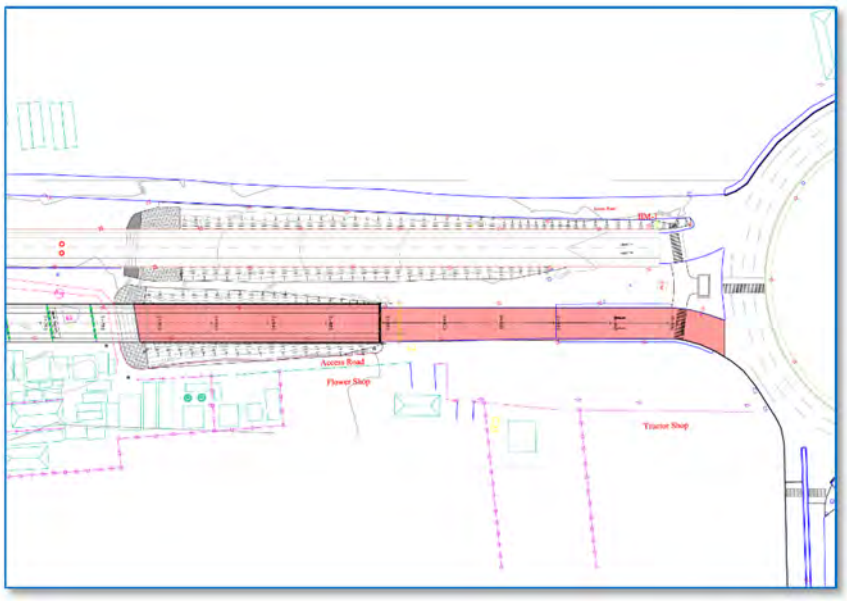


Figure 2-2-45 Scope of Pavement Improvement on the Chroy Changwar Side

b) Examination Conditions

The pavement structure of the target segments, the Chroy Changwar Bridge and its approach roads on both sides, shall basically be asphalt pavement identical to the present pavement structure.

Cambodia has seen remarkable growth in recent years, considerable urbanization has taken place on the Phnom Penh side, and land development is accelerating on the Chroy Changwar side. Considering the importance of development and the regulatory ability of the Cambodian government, it is likely that there are some overloaded vehicles. Therefore, an axle load survey of actual vehicles in traffic shall be conducted to analyze the actual axle loads of different types of vehicles and define an appropriate axle load coefficient for each vehicle type.

c) Design Service Period

The design service period of pavement is the time used for the determination of the load-bearing capacity of the pavement structure as a whole under repeated traffic loading, and is defined as the time before the formation of cracks due to fatigue fracture.

The target bridge is on a major trunk road in the capital city Phnom Penh, and the impact of the extensive pavement work on traffic is expected to be large. For a high-traffic trunk road in an urban area, the Cambodian standards in Road Design Standard PART 2. PAVEMENT (pp. 25-97) show that the period commonly used for newly installed asphalt pavement is 20-25 years. We chose 20 years from this range, as this value is also commonly used in Japan.

d) Traffic Volume for Pavement Planning

The traffic volume for pavement planning is the average traffic volume of large vehicles during the design service period of pavement, and it is expressed as daily traffic volume per direction. Here, we calculate the average traffic volume of large vehicles during 20 years after the beginning of service (assumed to be 2020-2039) based on the result of estimation of future traffic volume (Appendix 7 : Field Survey Report (Separate Volume) 3-1-3) concerning the vehicles using each vehicle. Large vehicles here include buses, trucks, trailers, and container trailers according to the vehicle classification for traffic volume survey.

After the calculation of the traffic volume for pavement planning, the traffic level is determined and the standard number of wheel passes to cause fatigue fracture corresponding to the traffic level is obtained from the Table below.

Table 2-2-20 Standard Number of Wheel Passes to Cause Fatigue Fracture

Traffic level	Traffic volume for pavement planning (Unit: vehicles/day･direction)	Number of wheel passes causing fatigue fracture (Unit: passes/10 years)
N7	≧3,000	35,000,000
N6	≧1,000, < 3,000	7,000,000
N5	≧250, < 1,000	1,000,000
N4	≧100, < 250	150,000
N3	≧40, < 100	30,000
N2	≧15, < 40	7,000
N1	< 15	1,500

e) Determination of Traffic Level

The average traffic volume of large vehicles during 20 years after the beginning of service will be 1,023 vehicles/day･direction, as shown below.

With regard to the base of growth rate of 0%, the growth rate of traffic capacity of Chroy Changwar Bridge is set to 0% from the idea that no more traffic volume increases because of having reached the limit. For more details, see the Appendix 7 : Field Survey Report (Separate Volume) 3-1-3 the estimation of future traffic volume.

Table 2-2-21 Traffic Level Calculation of Traffic Volume for Pavement Planning on Chroy Changwar Bridge

Year	Growth ratio	5 Passenger car, Pick-up	8 Koyun/Etan	6 Minibus	9 Light truck (<4t)	7 Bus	10 Medium Truck (>4t)	11 Heavy Truck 1 (3 axles)	12 Heavy Truck 2 (4&5 axles)	13 Semi trailer 4&5 axles	14 Full trailer, Semi trailer 6+ axles	Total	For Pavement design	
2015	0%	8,240	0	1,434	668	38	985					11,364	1,023	Existing
2016	0%	8,240	0	1,434	668	38	985					11,364	1,023	D/D
2017	0%	8,240	0	1,434	668	38	985					11,364	1,023	Construction
2018	0%	8,240	0	1,434	668	38	985					11,364	1,023	Construction
2019	0%	8,240	0	1,434	668	38	985					11,364	1,023	Construction
2020	0%	8,240	0	1,434	668	**38**	**985**					11,364	1,023	Common use
2021	0%	8,240	0	1,434	668	**38**	**985**					11,364	1,023	
2022	0%	8,240	0	1,434	668	**38**	**985**					11,364	1,023	
2023	0%	8,240	0	1,434	668	**38**	**985**					11,364	1,023	
2024	0%	8,240	0	1,434	668	**38**	**985**					11,364	1,023	
2025	0%	8,240	0	1,434	668	**38**	**985**					11,364	1,023	
2026	0%	8,240	0	1,434	668	**38**	**985**					11,364	1,023	
2027	0%	8,240	0	1,434	668	**38**	**985**					11,364	1,023	
2028	0%	8,240	0	1,434	668	**38**	**985**					11,364	1,023	
2029	0%	8,240	0	1,434	668	**38**	**985**					11,364	1,023	
2030	0%	8,240	0	1,434	668	**38**	**985**					11,364	1,023	
2031	0%	8,240	0	1,434	668	**38**	**985**					11,364	1,023	
2032	0%	8,240	0	1,434	668	**38**	**985**					11,364	1,023	
2033	0%	8,240	0	1,434	668	**38**	**985**					11,364	1,023	
2034	0%	8,240	0	1,434	668	**38**	**985**					11,364	1,023	
2035	0%	8,240	0	1,434	668	**38**	**985**					11,364	1,023	
2036	0%	8,240	0	1,434	668	**38**	**985**					11,364	1,023	
2037	0%	8,240	0	1,434	668	**38**	**985**					11,364	1,023	
2038	0%	8,240	0	1,434	668	**38**	**985**					11,364	1,023	
2039	0%	8,240	0	1,434	668	**38**	**985**					11,364	**1,023**	20 years
Scenario 2					Cumulative total	274,480	7,191,928					Average	**1,023**	
					EF	1.15	9.68							
					ΣESAL	315,652	69,617,862							
						69,933,514								

This traffic volume corresponds to the traffic level of N6, and the number of wheel passes causing fatigue fracture in 10 years is 7,000,000 passes/10 year. Because the design service period is 20 years, this number is doubled to give 14,000,000 passes/20 years as the number of wheel passes causing fatigue fracture in this road segment.

To ensure the 20 years of pavement design period, the overloading of heavy vehicles that give great damages to the pavement must be reliably restricted. Therefore, we recommend the implementation of strict enforcement to the Cambodia side.

f) Reliability

As discussed above under Design Service Period for Pavement, the target road is an important trunk road and the impact of maintenance and repair work on traffic is large. It is therefore desirable to ensure 90% reliability.

g) Examination of Pavement Thickness

i) Definition of Substrate Conditions

The design CBR of the roadbed is defined as a substrate condition. The following CBR value has been obtained from the result of geologic survey in this survey.

Table 2-2-22 CBR Test Result

Sampling location	Position	Maximum dry density γdmax(t/m3)	Optimal moisture content Wopt(%)	CBR (%)
Present approach road(embankment)	Phnom Penh side	1.97	7.00	7.5

Because there will be no significant alteration of longitudinal alignment in this project and the present embankment structure will be utilized as much as possible, our basic policy is to use the present roadbeds as the roadbeds of planned roads and to develop the pavement structure that can withstand these roadbed conditions and traffic conditions.

Therefore in this project, considering some disturbance due to the removal of pavement during work, plans are developed assuming the design CBR = 6% as a rule.

ii) Environmental Conditions

The weather conditions around the target bridge are those of a tropical monsoon climate with the annual mean maximum temperature of 36℃ and the annual mean minimum temperature of 22℃. The maximum temperature can reach 40℃, causing considerably severe conditon regarding the plastic flow resistance of pavement. Because the traffic volume for pavement planning is nearly 1,500 vehicles/day･direction, modified asphalt is used as a measure against rutting as a rule.

<Additional Information >

2. Prevention of Rutting

Rutting is a typical form of damage to the roads in tropical countries, and its prevention is an important issue. This is a part of road surface design in the pavement procedures in Japan. First, the traffic volume for pavement planning is estimated. If it is 1,500 vehicles/day･direction or more, a modifying agent should be used as a rule. Even in this case, complete on-site quality control must be exercised. In particular, on-site graduation control must ensure that the fine particle fraction (2.36 mm or less) is as low as possible within the permissible range.

(Excerpted from Road Improvement in Grant Aid and ODA Projects in Africa (Ethiopia, Ghana, and Tanzania) (Basic Study), March 2013, JICA Report)

h) Structural Design

Structure examination shall be conducted as a rule using the T_A method (required equivalent thickness) as a method of structural design satisfying the number of wheel passes causing fatigue fracture. The T_A that the pavement structure must provide is obtained using the following formula from the degree of reliability, design CBR, and the number of wheel passes causing fatigue fracture.

$$T_A = \frac{3.84N^{0.16}}{CBR^{0.3}} \quad \cdots \text{in the case of 90\% reliability}$$

Where, T_A : Required equivalent thickness

N : Number of wheel passes causing fatigue fracture

CBR: Design CBR of roadbed

By substituting 14,000,000 passes/20 years for the number of wheel passes causing fatigue fracture and 6% for design CBR in the above formula, we obtain:

$$T_A = \frac{3.84*14{,}000{,}000^{0.16}}{6^{0.3}} = 31.20 = 31.2$$

The equivalent thickness T_A needed in the road segment is 31.2 cm or more.

We identified the following cases of pavement structures that satisfy this required equivalent thickness and are achieved using the materials that are easily available in the region. A comparison of cost performance showed that "Case 1" is the most economic pavement structure.

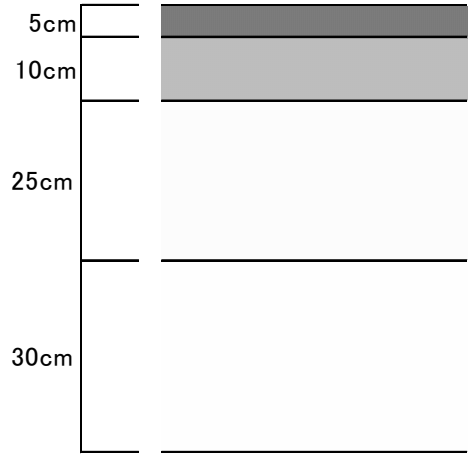
Table 2-2-23 Cost Comparison of Pavement Structures

Required TA 31.2

Material		Depth equivalency factor	Case 1	2	3	4	5
Top & base layers	Heated asphalt mix	1.00	15	15	10	10	10
Upper subgrade	Bitumen stabilization (heating & mixing)	0.80			8	10	15
	Cement & bitumen stabilization	0.55					
	Cement stabilization	0.65					
	Lime stabilization	0.45		20			
	Graded crushed stone	0.35	25		25		
Lower subgrade	Crusher run	0.25	30	30	25	55	40
T_A'		cm	31.25	31.50	31.40	31.75	32.00
Total thickness		cm	70	65	68	75	65

(円/㎡)

Cost comparison						
	Top layer	1,550	1,550	1,550	1,550	1,550
	Base layer	2,860	2,860	1,530	1,530	1,530
	Upper subgrade	1,260	5,700	2,280	2,850	4,275
				1,260		
	Lower subgrade	1,280	1,280	1,120	2,209	1,610
	Total cost	6,950	11,390	7,740	8,139	8,965
	Evaluation	○				



Top layer	Heated asphalt mix (modified As II)
Base layer	Heated asphalt mix
Upper subgrade	Graded crushed stone Modified CBR 80 or more
Lower subgrade	Crusher run Modified CBR 30 or more

Figure 2-2-46 Diagram of Pavement Structure on Approach Road (Case 1)

The equivalent thickness in the above pavement structure is $T_A' = 31.25 \geqq 31.2$, which satisfies the required thickness.

i) Verification Using AASHTO Method

Because there are no appropriate standards for pavement design in Cambodia, an agreement has been reached on the use of design according to Japanese standards. We, however, performed verification of pavement structure based on the commonly used AASHTO design method.

① Conversion from the number of wheel passes causing fatigue fracture to the number of equivalent single axle loads (ESAL)

While the pavement design standards in Japan provides for the examination of pavement structure assuming a standard wheel load of 49 kN, AASHTO specifies the axle load of 18 kip as the standard axle load for the examination of pavement structure.

From the result of future traffic demand projection and the result of the axle load survey, the cumulative number of axles for pavement design (ΣESAL) is calculated to be 70.0×10^6.

② Verification of Pavement Structure

Using this ESAL value, reliability 90%, standard deviation 0.45, service availability index Δpsi = 4.2 - 2.5 = 1.7, and design CBR = 7.5%, it is calculate that the required structural number (SN) that must be satisfied by pavement structure is SN = 5.69 (see the next page).

Here, by calculating the AASHTO structural number for the pavement structure determined using the Japanese standards, we obtain SN = 5.39 < 5.69. The structural number obtained using the AASTHO method is slightly lower than the structural number derived from the Japanese standards.

Bcause both design methods are used commonly in Japanese grant aid cooperation projects, it was considered appropriate to use a pavement structure that satisfies the both sets of standards.

The pavement structure satisfying the AASHTO standards has upper subbase and lower subbase thicker by 5 cm each than those based on the Japanese standards (see Figure 2-2-47).

Calculation of SN　　Embankment part

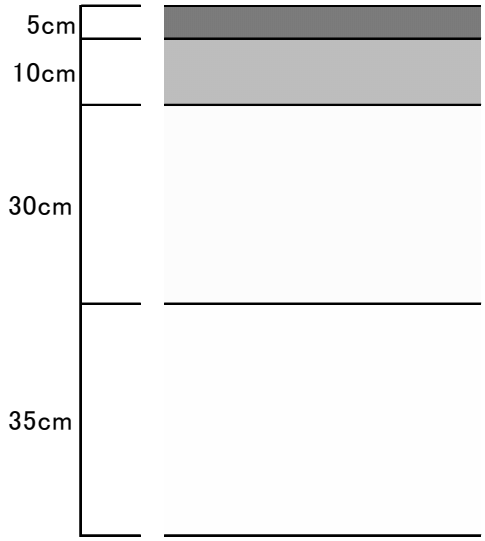
Nomogram basic formula

$$\log_{10}W_{18} = Z_R*S_0 + 9.36*\log_{10}(SN+1) - 0.20 + \frac{\log_{10}(\Delta PSI/(4.2-1.5))}{0.40 + 1094/(SN+1)^{5.19}} + 2.32*\log_{10}M_R - 8.07$$

Condition	Description		Unit	Calculation of W18			
69,933,514	W_{18}	Estimated future traffic volume for service period	18kip回	Vehicle type	EF	Cumulative numbe of vehicles	ESAL
90	R	Confidence probability	%				
-1.282	Z_R						
0.45	S_0	Overall standard deviation					
1.7	ΔPSI	Decrease in serviceability index used in design					
11,250	M_R	Effective resilient modulus 1500*CBR 7.5%	psi				

$\log_{10}W_{18}$	=	7.84
Z_R*S_0	=	-0.5769
$\log_{10}$ (ΔPSI/ (4.2-1.5))	=	-0.20
$2.32*\log_{10}M_R$	=	9.40

Right-hand side	7.29	$8.27 - Z_R*S_0 - 2.32*\log_{10}M_R + \log_{10}W_{18}$
$9.36\log_{10}(SN+1)$	7.726	
$\log_{10}(\Delta PSI/2.7)\ (SN+1)^{5.19}$	-3,863.435	Compare values
$0.4(SN+1)^{5.19}+1094$	8,785.686	
Left-hand side	7.29	$9.36\log_{10}(SN+1) + \log_{10}(\Delta PSI/2.7)*(SN+1)^{5.19}/(0.4(SN+1)^{5.19}+1094)$
SN	**5.69**	
	Trial	



Top layer	Heated asphalt mix (modified As II)
Base layer	Heated asphalt mix
Upper subgrade	Graded crushed stone Modified CBR 80 or more
Lower subgrade	Crusher run Modified CBR 30 or more

Figure 2-2-47 Diagram of Pavement Structure on Approach Road (Seledted for Use)

3) Road Drainage

As a basic policy, road drainage shall be planned to ensure the safe passage of vehicles, as well as to facilitate appropriate maintenance of road structures (earthwork and pavement) and to support operation for a long period.

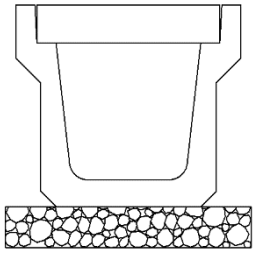


Figure 2-2-48 U-shaped gutter

At the ends of the road drainage system, water will be discharged to the Tonle Sap River as before. Considering the ease of future maintenance by the Cambodian side, installation of open channel-type drainage strictures such as U-drains should be considered as much as possible.

The scale and design of drainage facilities shall be determined considering the purpose of drainage, the situation of drainage facilities, the potential impact on surrounding areas that can occur when the planned flow rate is exceeded, and cost efficiency. Rainfall intensity shall basically be determined using the probable rainfall recurrence period shown below.

Table 2-2-24 Probable Rainfall Recurrence Period for Drainage Facilities

Drainage facilities	Probable rainfall recurrence period
General drainage facilities such as the drainage from road surfaces and small slope faces	3 years
Critical drainage facilities such as the drainage crossing the road	10 years

In addition, the flow of rainwater into the pavement adversely affect subgrades and other structures, resulting in early deterioration of pavement surfaces and loss ofroad performance for drivers. It is therefore considered desirable to use the structure that appropriately drain water from the road earthwork, roadbed, and subgrades. Therefore, these parts shall be constructed using permeable materials, and the road shall be structured with the subgrades extending to the slope face so that the water in the pavement can be appropriately guided to the slope face.

The drainage system diagram is shown on the next page.

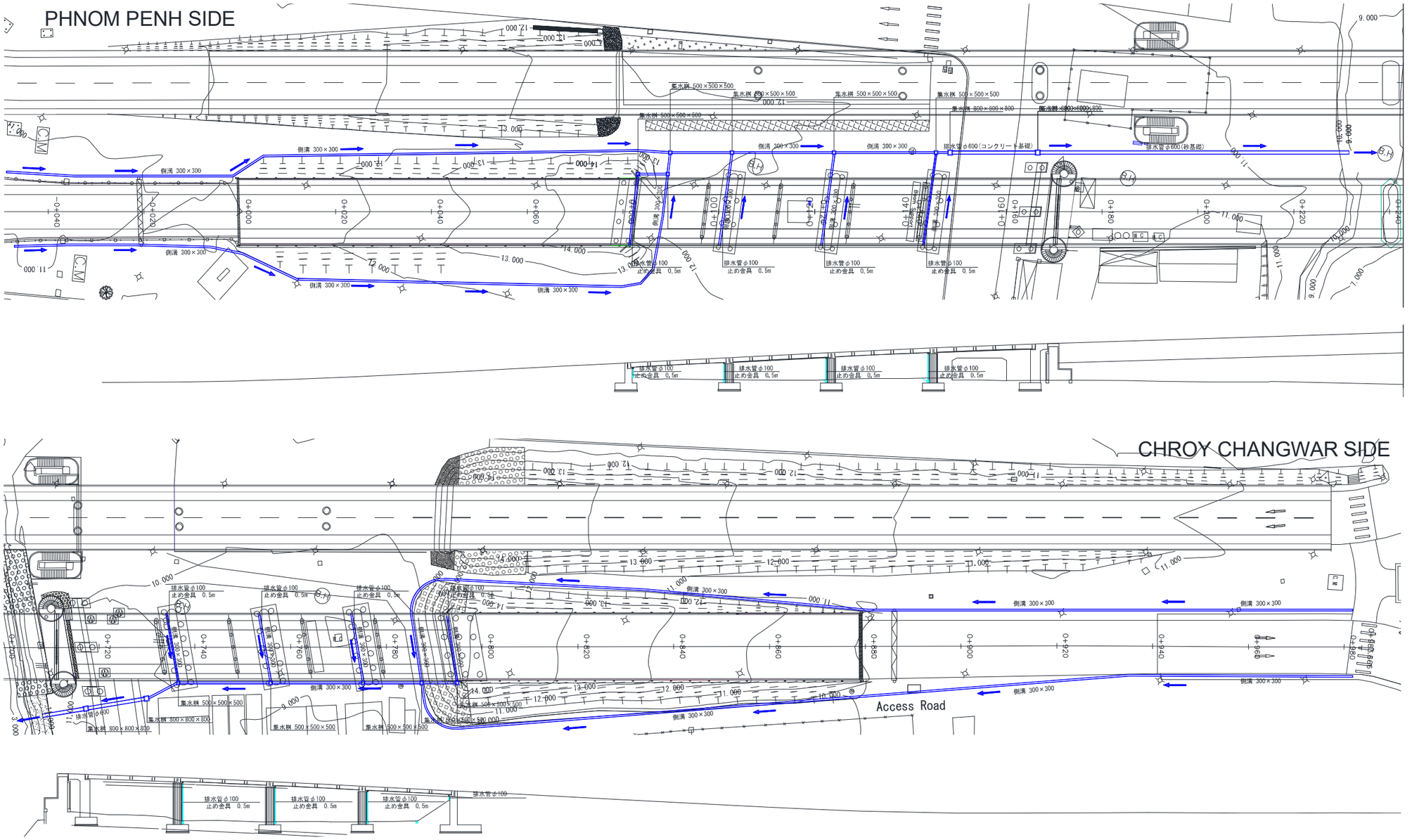


Figure 2-2-49 Drainage system diagram

2-2-2-8-4 Examination of Improvement of RA on the Phnom Penh Side

(1) Present State and Problems

Originally, the Chroy Changwar Bridge was the only bridge connected to the roundabout on the Phnom Penh side, located west of the bridge, and the bridge was carrying two-way traffic. When the China Bridge became operational last year, this bridge was converted to one-way two-lane traffic toward Chroy Changwar. Because the China Bridge was connected to the existing roundabout, the geometry of the roundabout became somewhat irregular.

Because no improvement of traffic islands and other structures was made when the China Bridge was connected, the traffic island intended for original two-way traffic operation still remains.

In addition, because of the complicated traffic flow structure with six entrances and five exits, some entrances and exits are located close to one another, causing conversion of traffic. In particular, the vehicles entering the RA from the entrance ⑪ and those moving out of the RA toward the Chroy Changwar Bridge and National Road No. 5 cross each other, and the stagnation of traffic flow at this point is considered to be greatly reducing the capacity of the intersection as a whole.

Figure 2-2-50 shows the present state of the RA.

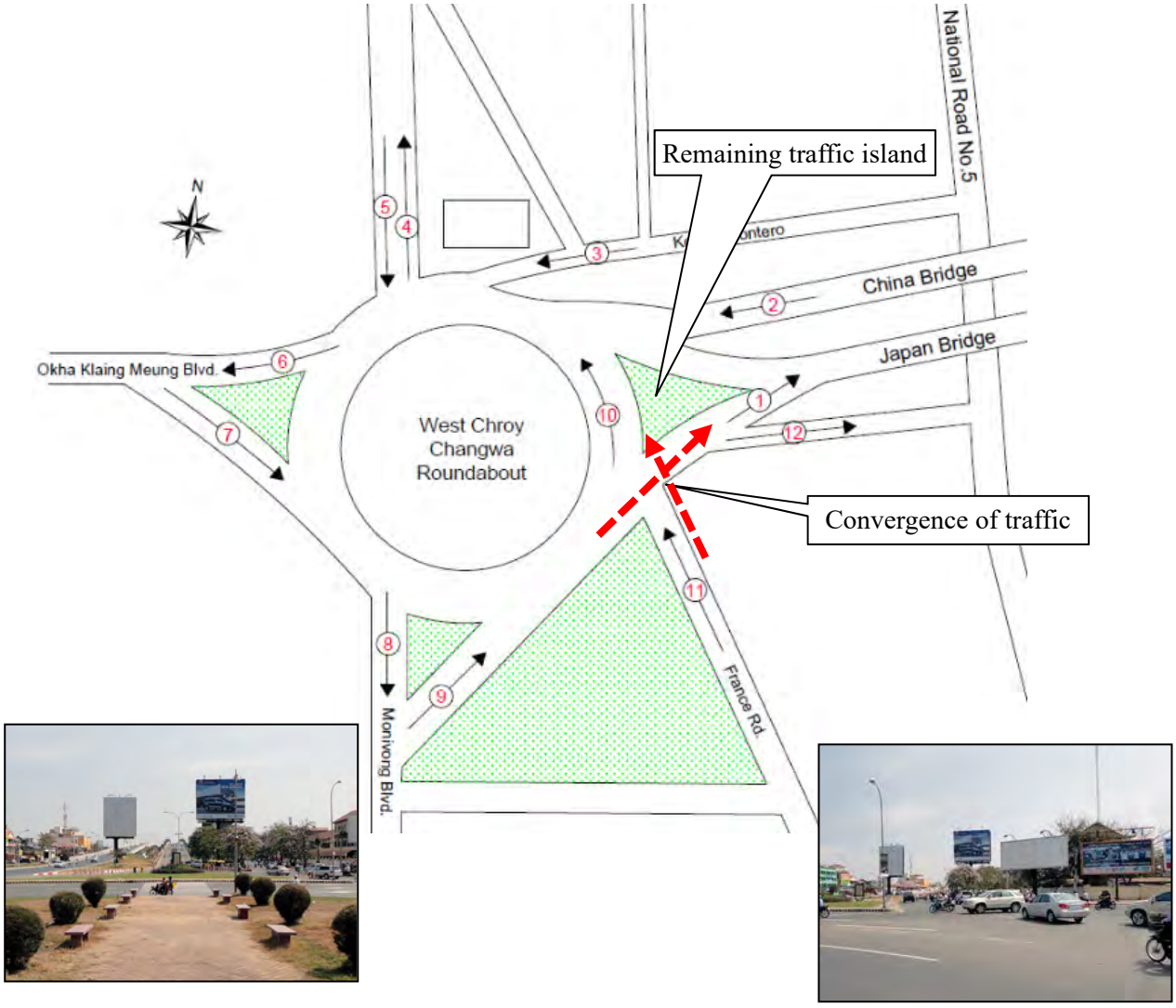


Figure 2-2-50 Prsent State of RA (Phnom Penh Side)

(2) Basic Policy of Improvement

Considering the ongoing urbanization of the roadside areas, extensive improvement of the intersection is impossible due to the unavailability of land. Our basic policy is to improve the roundabout to facilitate smooth entry and exit and to enhance the capacity of the intersection as a whole by means of the alteration of traffic operation scheme, appropriate structure suitable to the flow of traffic, and the partial improvement of the flow route.

(3) Present Traffic Volulme

The result of the traffic volume survey conducted during the First Field Survey wasasshown in Figure 2-2-51.

(4) Roundabout Improvement (Draft)

The improvement of the roundabout consist of the following points:

a) In order to change the shape of the traffic island intended for the original two-way traffic on the Chroy Changwar Bridge to the shape suitable to one-way two-lane traffic, the remaining traffic island is cut so that vehicles can smoothly flow toward the Chroy Changwar Bridge.

b) The entrance that has become unnecessary is closed by mount-up work to prevent vehicles from moving in the wrong direction.

c) As the branches to the Chroy Changwar Bridge and National Road No. 5 are located close to each other and have extra space between them, zebra painting (road surface marking) is used to clarify lanes.

d) Entrance ⑪, which crosses the exit flow from the round about to the Chroy Changwar Bridge and National Road No. 5, is used exclusively as right turn lanes.

e) A traffic island is expanded to smoothen the traffic flow and emphasize the exclusive use of entrance ⑪ as right turn lanes.

f) The traffic entering the RA from the direction of ⑪ is detoured and merged into entance ⑨.

g) In association with the merging to entrance ⑨, corner radius design is improved so that the vehicles from the direction of ⑪ can smmoothly make right turns.

Roundabout improvement (draft) is illustrated in Figure 2-2-52.

Figure 2-2-51 Traffic Volume of Roundabout Entrances and Exits (vehicles/peak hour) (Excluding Motocycles)

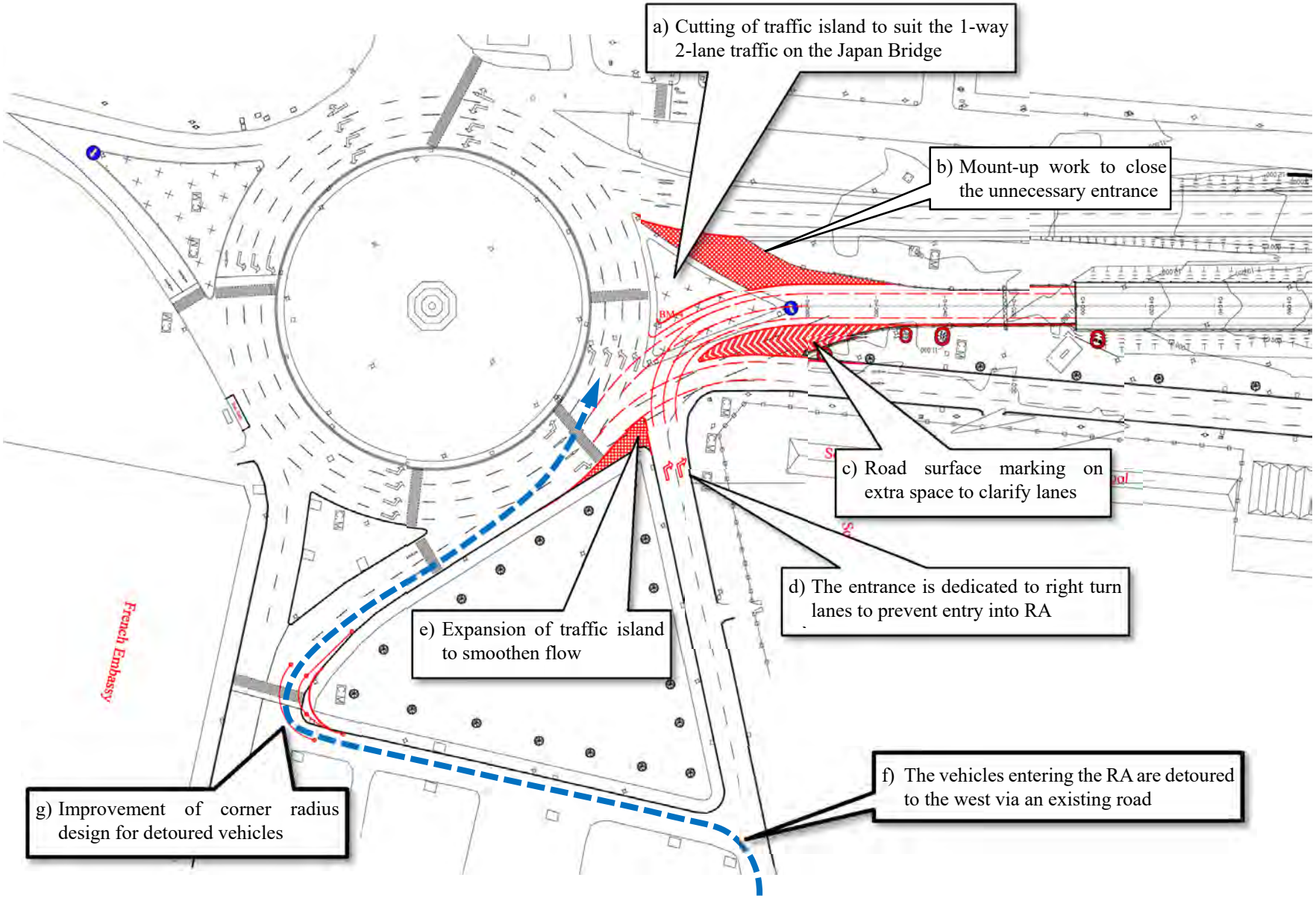


Figure 2-2-52 Roundabout Improvement (Draft)

2-2-2-8-5 Traffic Safety Work

Work for traffic safety including the following shall be considered and designed:

・Smoothing of traffic flow by the structural modification of the roundabout discussed in the previous section.

・Appropriate separation among pedestrians, automobiles, and bikes.

・Installation of guardrails to prevent vehicles from running off the road.

・Installation of road lighting to ensure night visibility (in coordination with the locations of present facilities).

・Road drainage management by the installation of appropriate drainage facilities.

・The vehicle height restriction facility at the entrance to the Chroy Changwar Bridge becomes unnecessary after the implementation of this improvement, and should be removed after discussion with the Cambodian side.

2-2-2-8-6 Summary of Facilities

The outline of the improvement plan determined based on the above examination is summarized in Table 2-2-25 to Table 2-2-27.

(1) New Construction Work

The summary of new construction work is shown in the Table below.

Table 2-2-25 Summary of New Construction Work

Item			Type / Specifications
Bridge location			National Road 6A crosses the Tonle Sap River
Width	Bridge part		Carriageway 3.5m×2=7.0m, bike lanes 1.9m×2=3.8m, sidewalks 1.1m×2=2.2m: total 13.0m (effective width) Wheel guards 0.4m×2=0.8m: Total 13.8m (total width)
	Approach road part		Carriageway 3.5m×2=7.0m, bike lanes 1.9m×2=3.8m, sidewalks 1.1m×2=2.2m, protective shoulders 0.3m×2=0.6m: Total 13.6m (total width)
Bridge style			PC 4-span pretensioned hollow deck bridge
Bridge length,	Phnom Penh side		L = 4@21.3m = 85.2m
	Chroy Changwar side		L = 4@19.3m = 77.2m
Bridge surface pavement			Modified asphalt pavement (80mm on carriageway)
・A1 abutment (Phnom Penh side) ・A2 abutment (Chroy Changwar side)		Type	Inverted T-type abutment
		Height of structure	・A1 abutment: H=5.5m ・A2 abutment: H=8.3m
		Foundation	・A1 abutment: Cast-in-place piles (φ1.0m, L=27.5m, n=8)
・PN1-PN3 piers (Phnom Penh side) ・PN6-PN8 piers (Chroy Changwer side)		Type	Elliptical pier
		Height of structure	・PN1-PN3 piers: H=5.3m-7.4m ・PN6-PN8 piers: H=9.9m-8.1m
		Foundation	・PN1-PN3 piers: Cast-in-place piles (φ1.0m, L=27.0m, n=8) ・PN6 pier: Cast-in-place piles (φ1.2m, L=21.5m, n=12) ・PN7-PN8 piers: Cast-in-place piles (φ1.2m, L=21.0m, n=12)
・PN4 pier (Phnom Penh side) ・PN5 pier (Chroy Changwar side)		Type	Rigid frame pier
		Height of structure	・PN4 pier: H=8.2m ・PN5 pier: H=9.1m
		Foundation	・PN4 pier: Cast-in-place piles (φ1.0m, L=27.0m, n=6) ・PN5 pier: Cast-in-place piles (φ1.2m, L=31.0m, n=6)

(2) Repair Work

The summary of repair work is shown in the Table below.

Table 2-2-26 Summary of Repair Work

Repair work	Target structure		Remarks
Repaving	Steel bridge part	Between P1-P8 piers	SFRC pavement (Base layer : 50mm) Modified asphalt pavement (Top layer: 30mm)
Repainting	Steel bridge part	Between P1-P8 piers	Only outer surfaces of steel box girders
		Areas with water retention (inside of box girders)	Painting after cleaning
Railing	Steel bridge part	Between P1-P8 piers	Replacement (height 1.1m or more from road surface)
Expansion apparatuses	Steel bridge part	On P1,P3,P6, & P8 piers	Reuse of existing expansion apparatuses after conversion to non-draining structure
Crack injection work	Steel bridge part	P1-P8 piers	Crack width 0.2mm or more
Surface sealing of all surfaces	Steel bridge part	P1-P8 piers	Application of impregnating material
Section repair work	Steel bridge part	P1-P8 piers	Peeling, rebar exposure, chipping, etc.
Curb work	Whole line		Replacement
Lighting	Whole line		Replacement
Line marking work	Whole line		

(3) Improvement Work

The summary of improvement work is shown in the Table below.

Table 2-2-27 Summary of Improvement Work

Repair work	Target structure		Remarks
Repaving	Approach road part	Embankment part	Modified asphalt pavement (Top layer: 50mm) Asphalt pavement (Base layer: 100mm)
Drainage	Approach road part	Embankment part	Installation of drainage facilities
Guardrails	Approach road part	Embankment part	Replacement
Improvement of intersection	Roundabout		Only on the Phnom Penh side

2-2-3 Outline Design Drawings

The following pages shows the outline design drawings produced based on the above basic plan.

- Figure 2-2-53 General View of the Whole Bridge (Phnom Penh Side)
- Figure 2-2-54 General View of Superstructure (1/2) (Phnom Penh side)
- Figure 2-2-55 General View of Superstructure (2/2) (Phnom Penh side)
- Figure 2-2-56 General View of A1 Abutment
- Figure 2-2-57 General View of PN1 Pier
- Figure 2-2-58 General View of PN2 Pier
- Figure 2-2-59 General View of PN3 Pier
- Figure 2-2-60 General View of PN14 Pier
- Figure 2-2-61 General View of the Whole Bridge (Chroy Changwar Side)
- Figure 2-2-62 General View of Superstructure (1/2) (Chroy Changwar Side)
- Figure 2-2-63 General View of Superstructure (2/2) (Chroy Changwar Side)
- Figure 2-2-64 General View of PN5 Pier
- Figure 2-2-65 General View of PN6 Pier
- Figure 2-2-66 General View of PN7 Pier
- Figure 2-2-67 General View of PN8 Pier
- Figure 2-2-68 General View of A2 Abutment
- Figure 2-2-69 SFRC Pavement Work
- Figure 2-2-70 Replacement Railing (Steel Bridge Part)
- Figure 2-2-71 Substructure Repair Work (P1 Pier)
- Figure 2-2-72 Substructure Repair Work (P2 Pier)
- Figure 2-2-73 Substructure Repair Work (P3 Pier)
- Figure 2-2-74 Substructure Repair Work (P4 Pier)
- Figure 2-2-75 Substructure Repair Work (P5 Pier)
- Figure 2-2-76 Substructure Repair Work (P6 Pier)
- Figure 2-2-77 Substructure Repair Work (P7 Pier)
- Figure 2-2-78 Substructure Repair Work (P8 Pier)
- Figure 2-2-79 Substructure Repair Work (Stairway Part of P8 Pier)
- Figure 2-2-80 Plan of Approach Road (Phnom Penh Side)
- Figure 2-2-81 Plan of Approach Road (Chroy Changwar Side)
- Figure 2-2-82 Standard Cross-Section of Approach Road

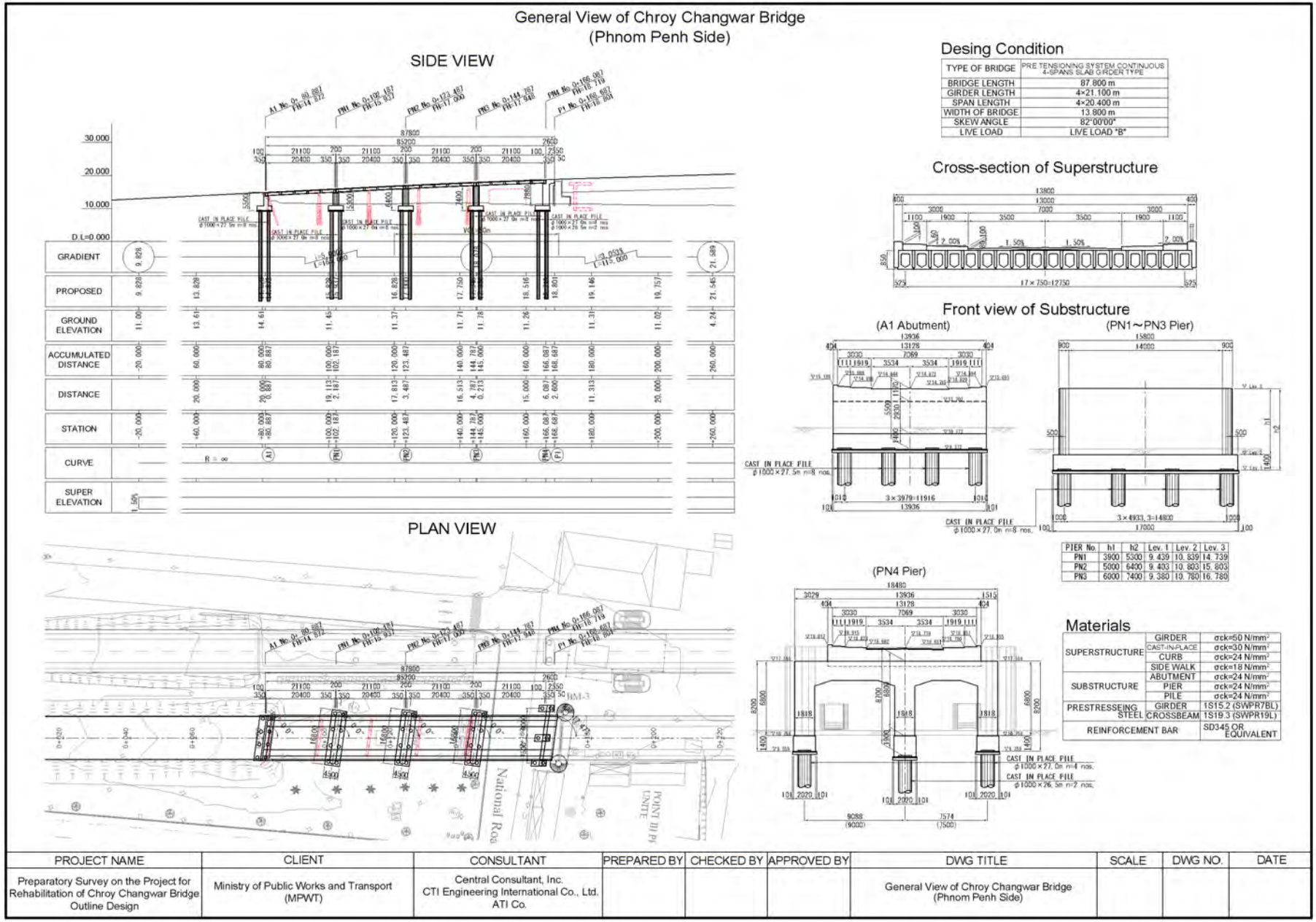


Figure 2-2-53 General View of the Whole Bridge (Phnom Penh Side)

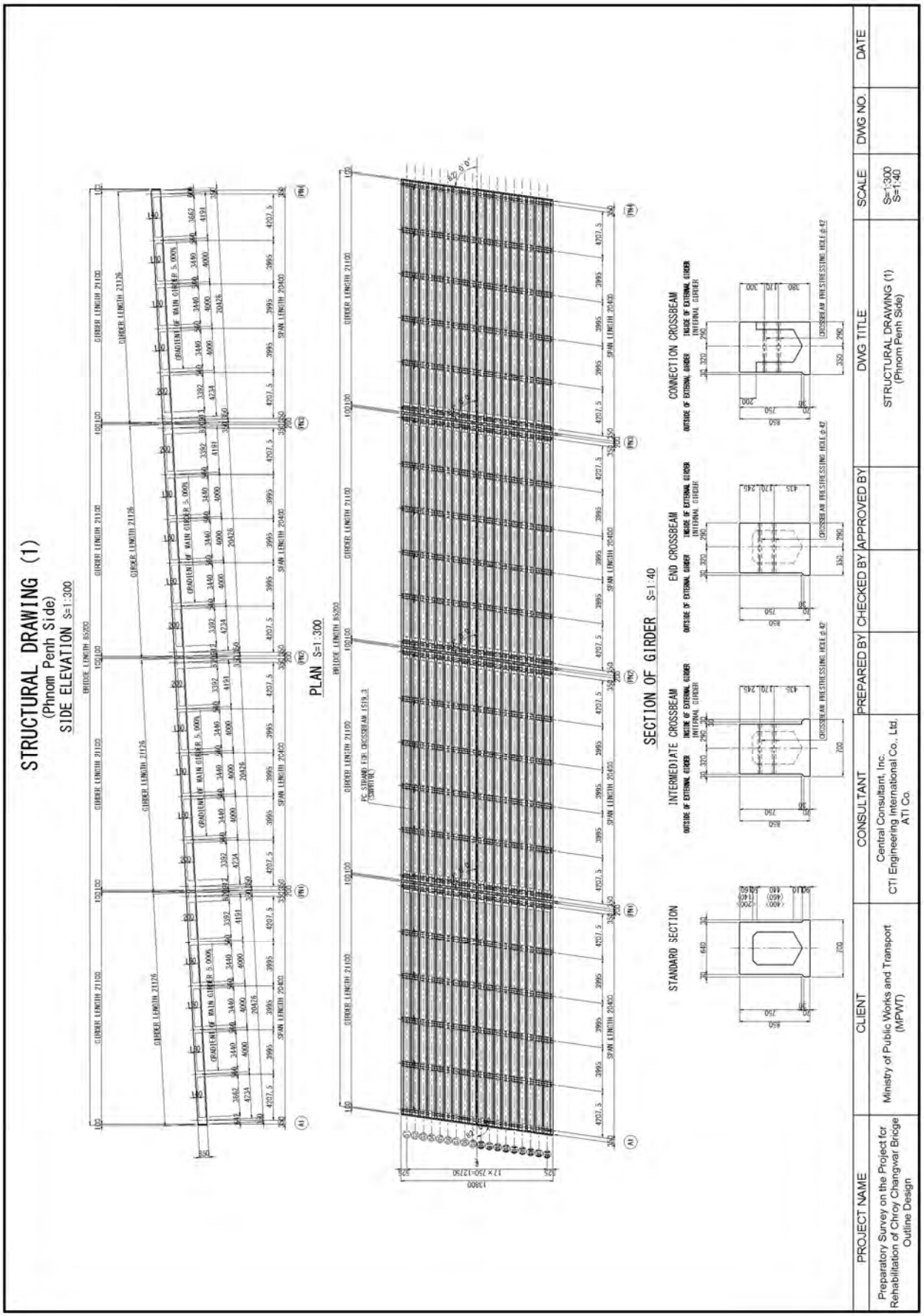


Figure 2-2-54 General View of Superstructure (1/2) (Phnom Penh side)

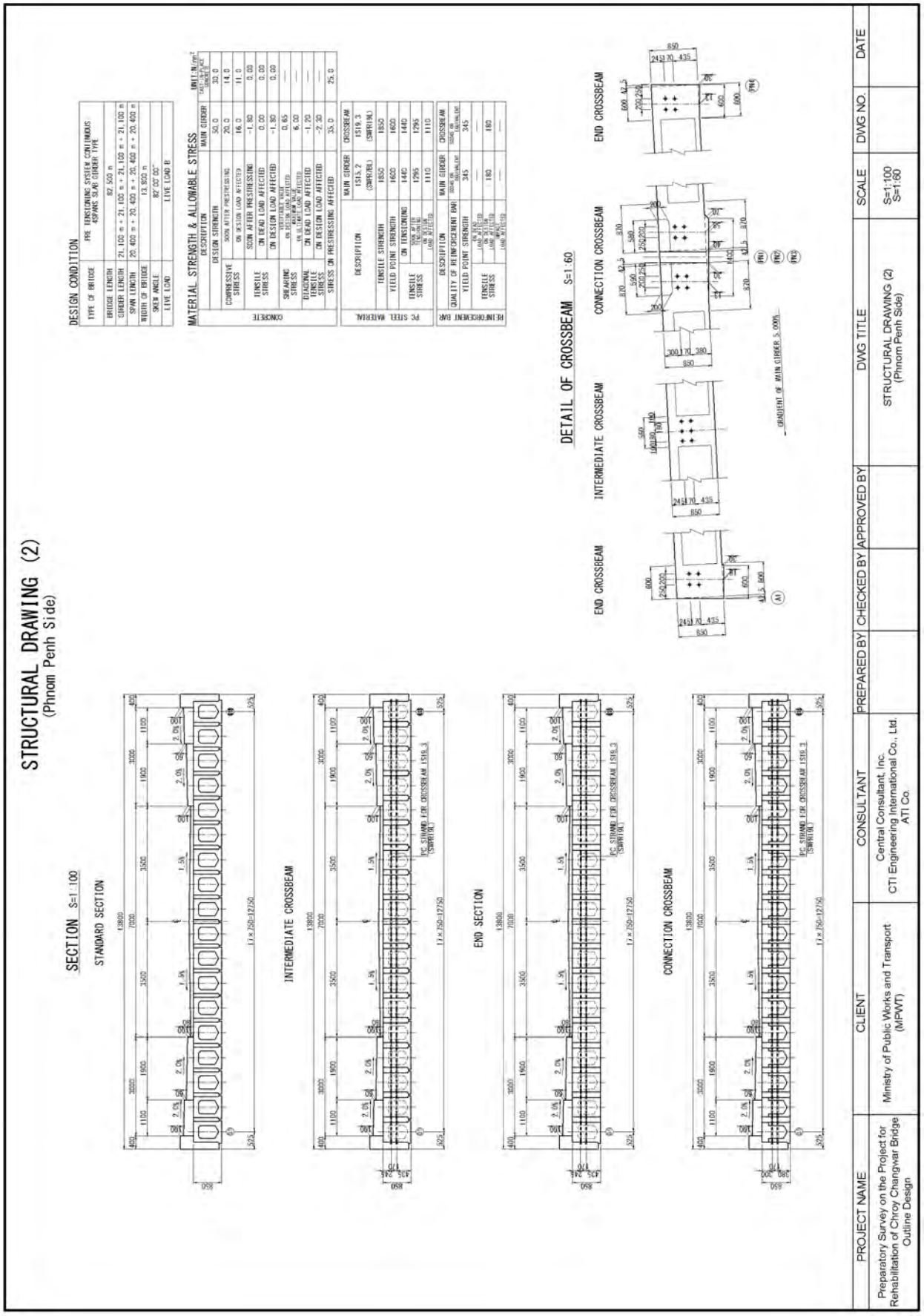
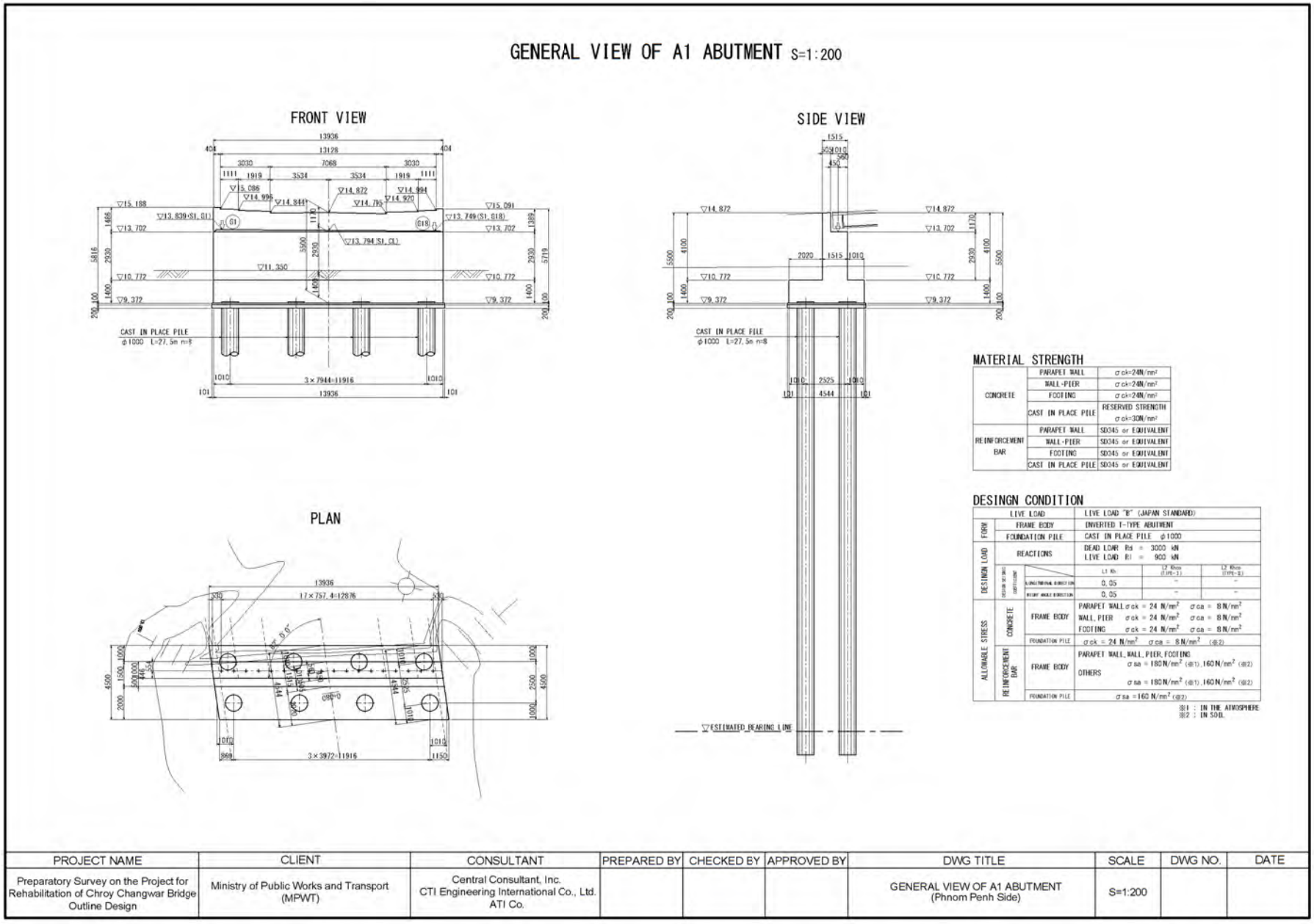
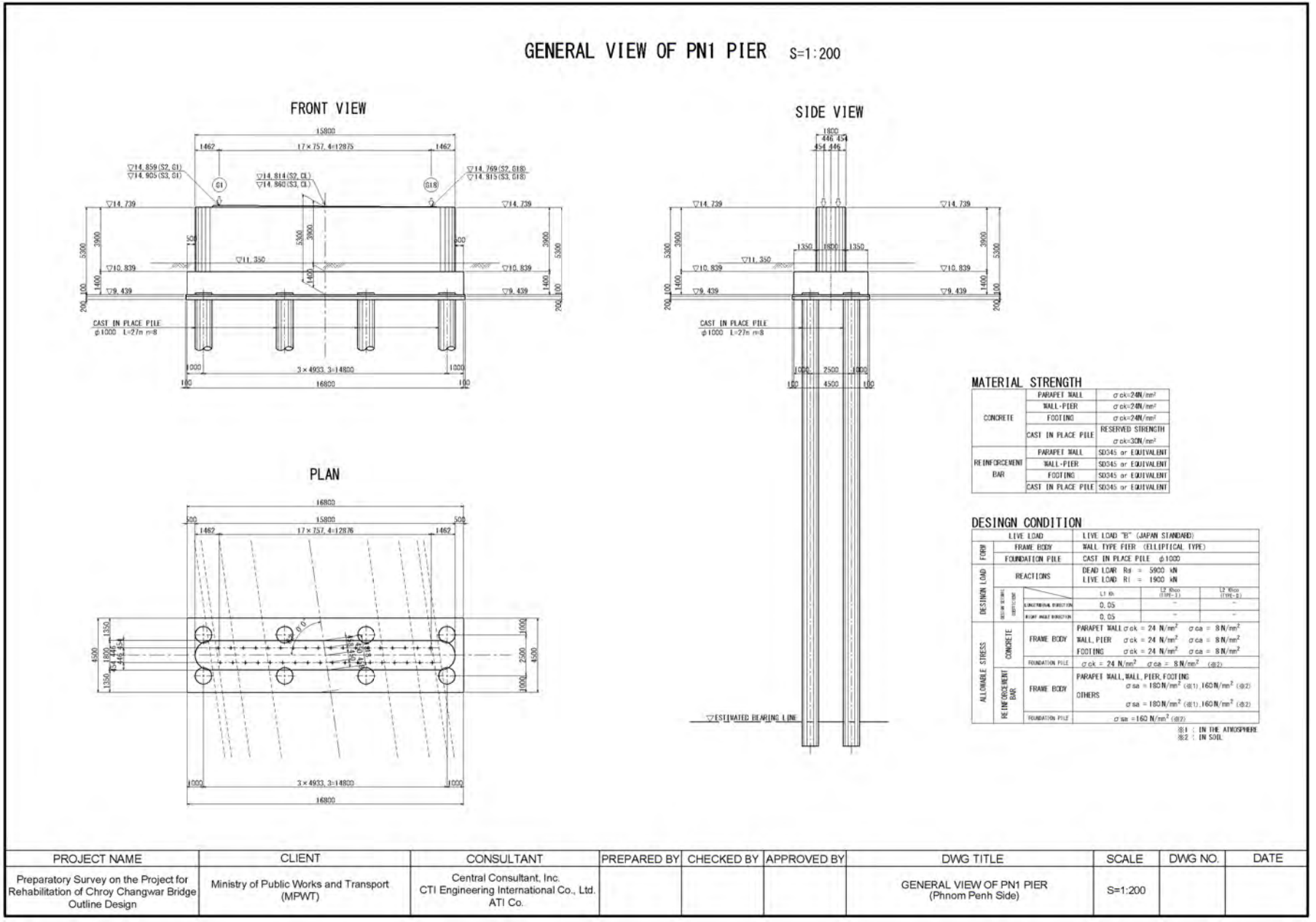


Figure 2-2-55 General View of Superstructure (2/2) (Phnom Penh side)



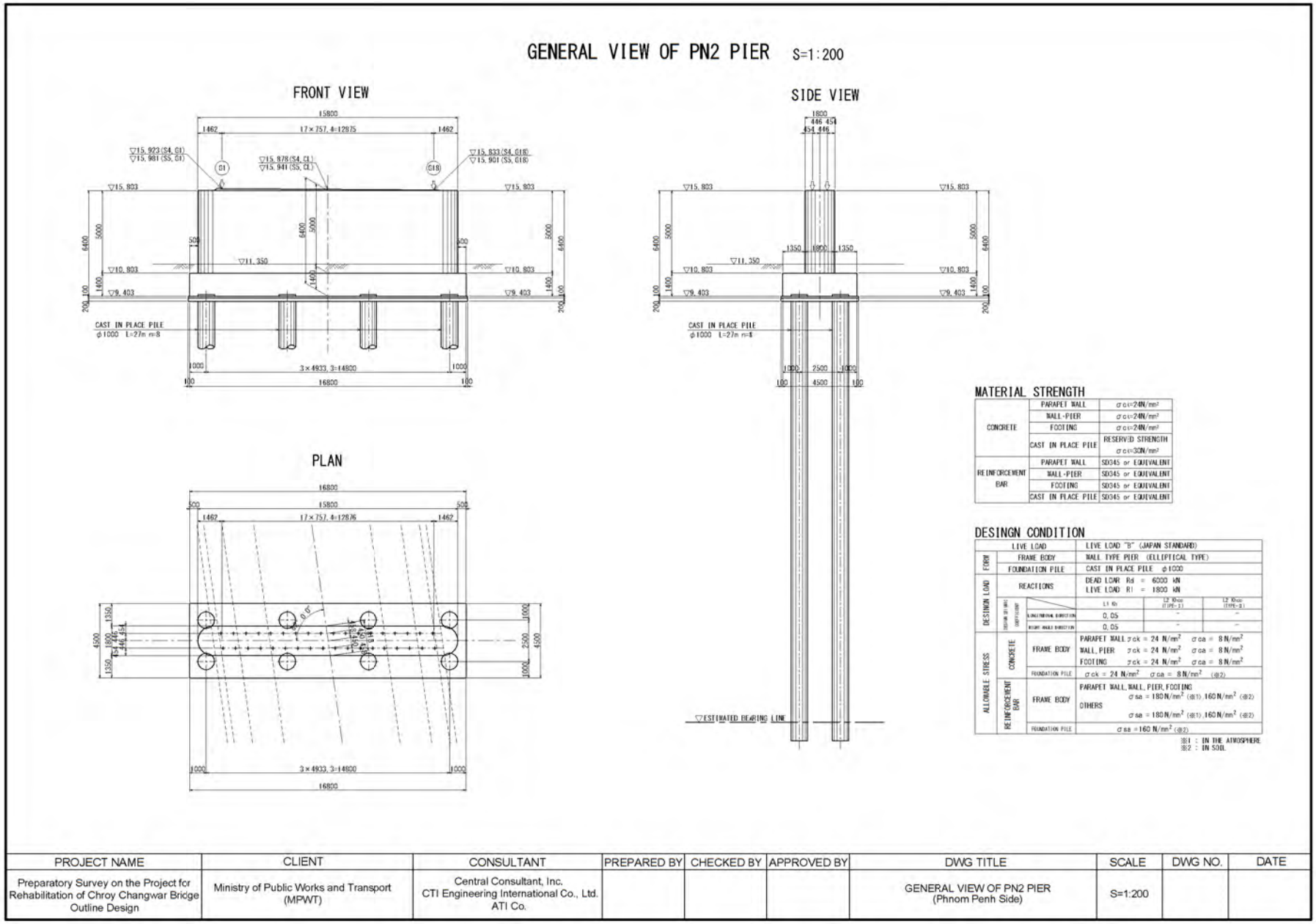
PROJECT NAME	CLIENT	CONSULTANT	PREPARED BY	CHECKED BY	APPROVED BY	DWG TITLE	SCALE	DWG NO.	DATE
Preparatory Survey on the Project for Rehabilitation of Chroy Changwar Bridge Outline Design	Ministry of Public Works and Transport (MPWT)	Central Consultant, Inc. CTI Engineering International Co., Ltd. ATI Co.				GENERAL VIEW OF A1 ABUTMENT (Phnom Penh Side)	S=1:200		

Figure 2-2-56 General View of A1 Abutment



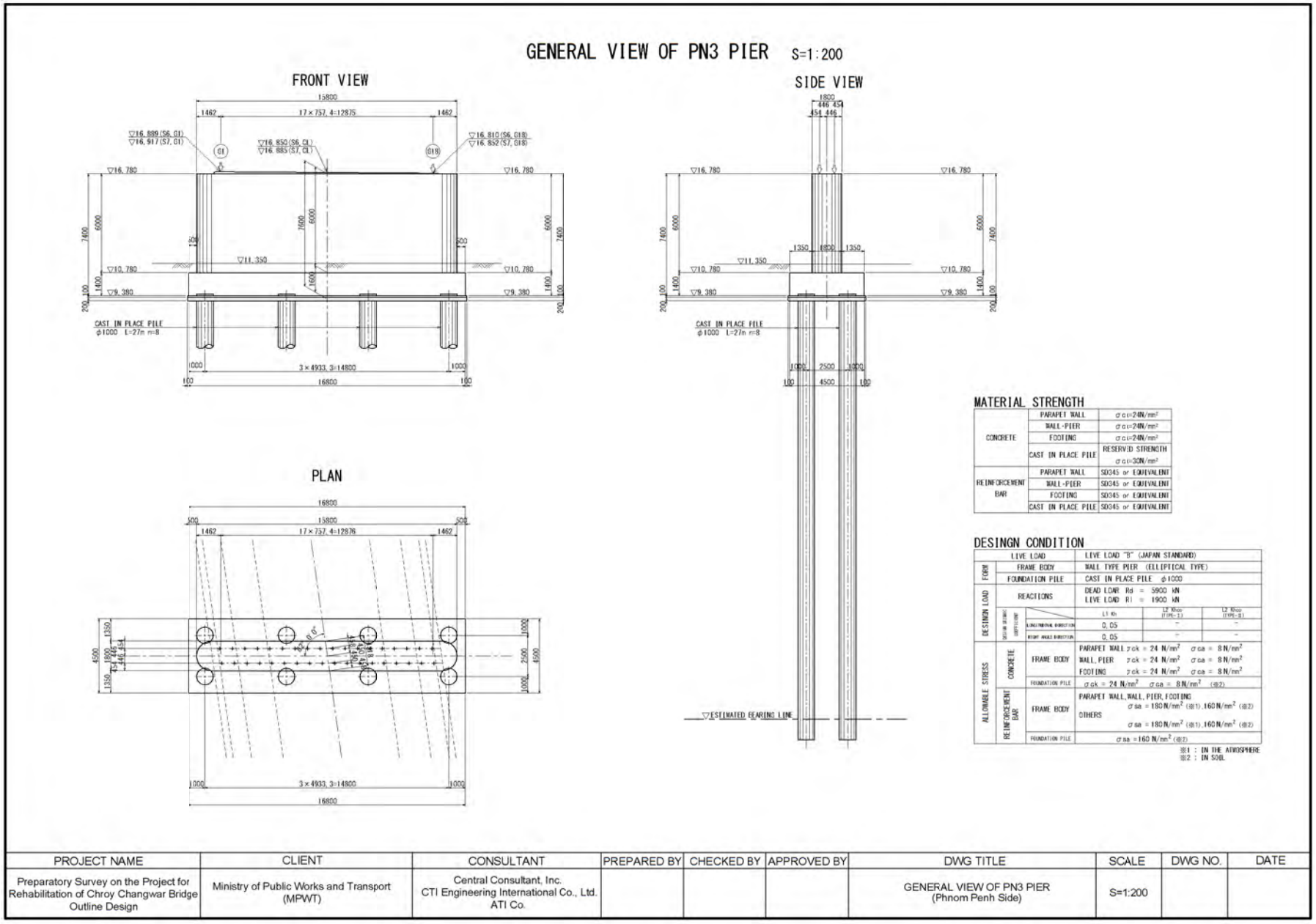
PROJECT NAME	CLIENT	CONSULTANT	PREPARED BY	CHECKED BY	APPROVED BY	DWG TITLE	SCALE	DWG NO.	DATE
Preparatory Survey on the Project for Rehabilitation of Chroy Changwar Bridge Outline Design	Ministry of Public Works and Transport (MPWT)	Central Consultant, Inc. CTI Engineering International Co., Ltd. ATI Co.				GENERAL VIEW OF PN1 PIER (Phnom Penh Side)	S=1:200		

Figure 2-2-57 General View of PN1 Pier



PROJECT NAME	CLIENT	CONSULTANT	PREPARED BY	CHECKED BY	APPROVED BY	DWG TITLE	SCALE	DWG NO.	DATE
Preparatory Survey on the Project for Rehabilitation of Chroy Changwar Bridge Outline Design	Ministry of Public Works and Transport (MPWT)	Central Consultant, Inc. CTI Engineering International Co., Ltd. ATI Co.				GENERAL VIEW OF PN2 PIER (Phnom Penh Side)	S=1:200		

Figure 2-2-58 General View of PN2 Pier



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Preparatory Survey on the Project for Rehabilitation of Chroy Changwar Bridge Outline Design	Ministry of Public Works and Transport (MPWT)	Central Consultant, Inc. CTI Engineering International Co., Ltd. ATI Co.				GENERAL VIEW OF PN3 PIER (Phnom Penh Side)	S=1:200		

Figure 2-2-59 General View of PN3 Pier

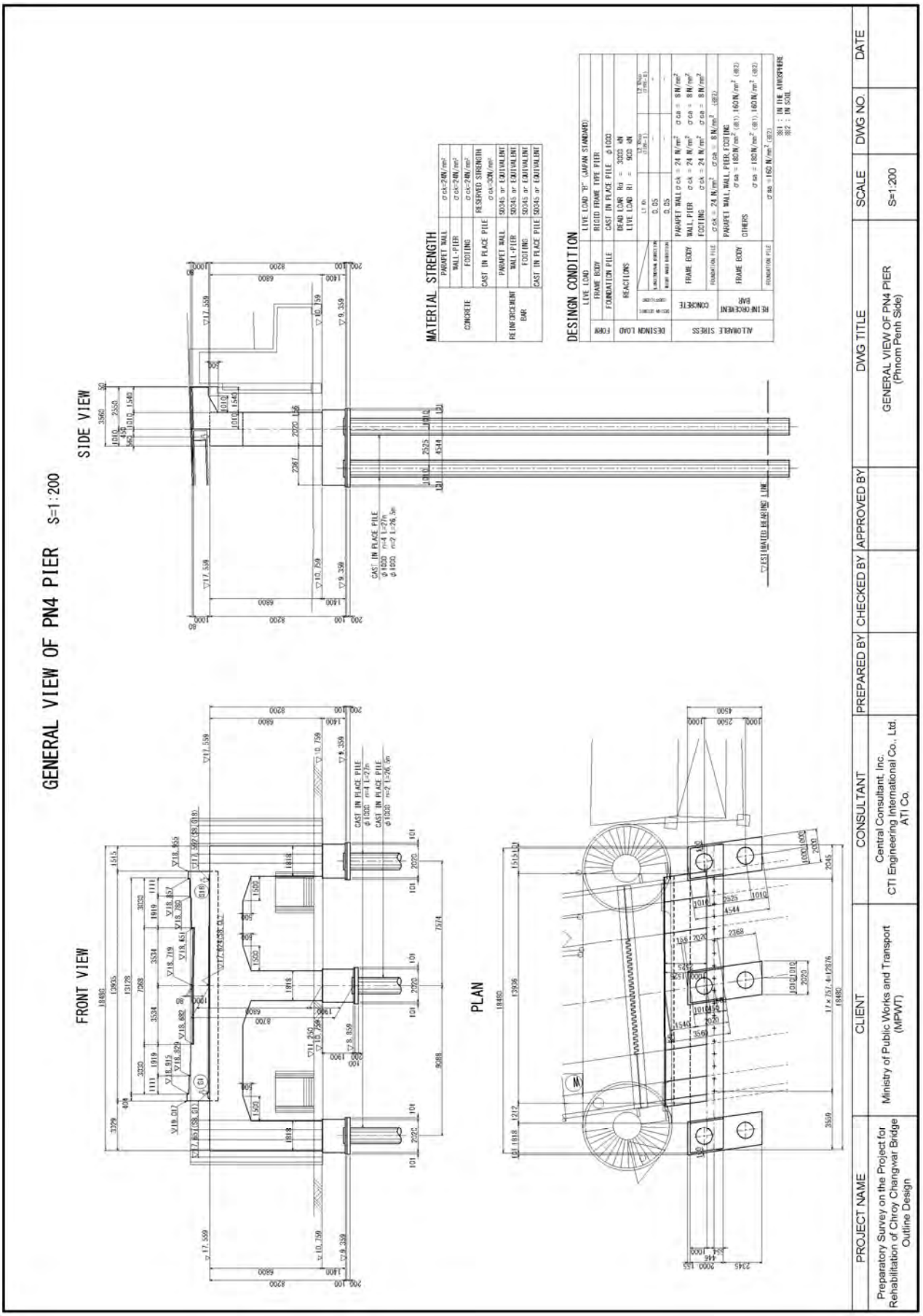


Figure 2-2-60 General View of PN4 Pier

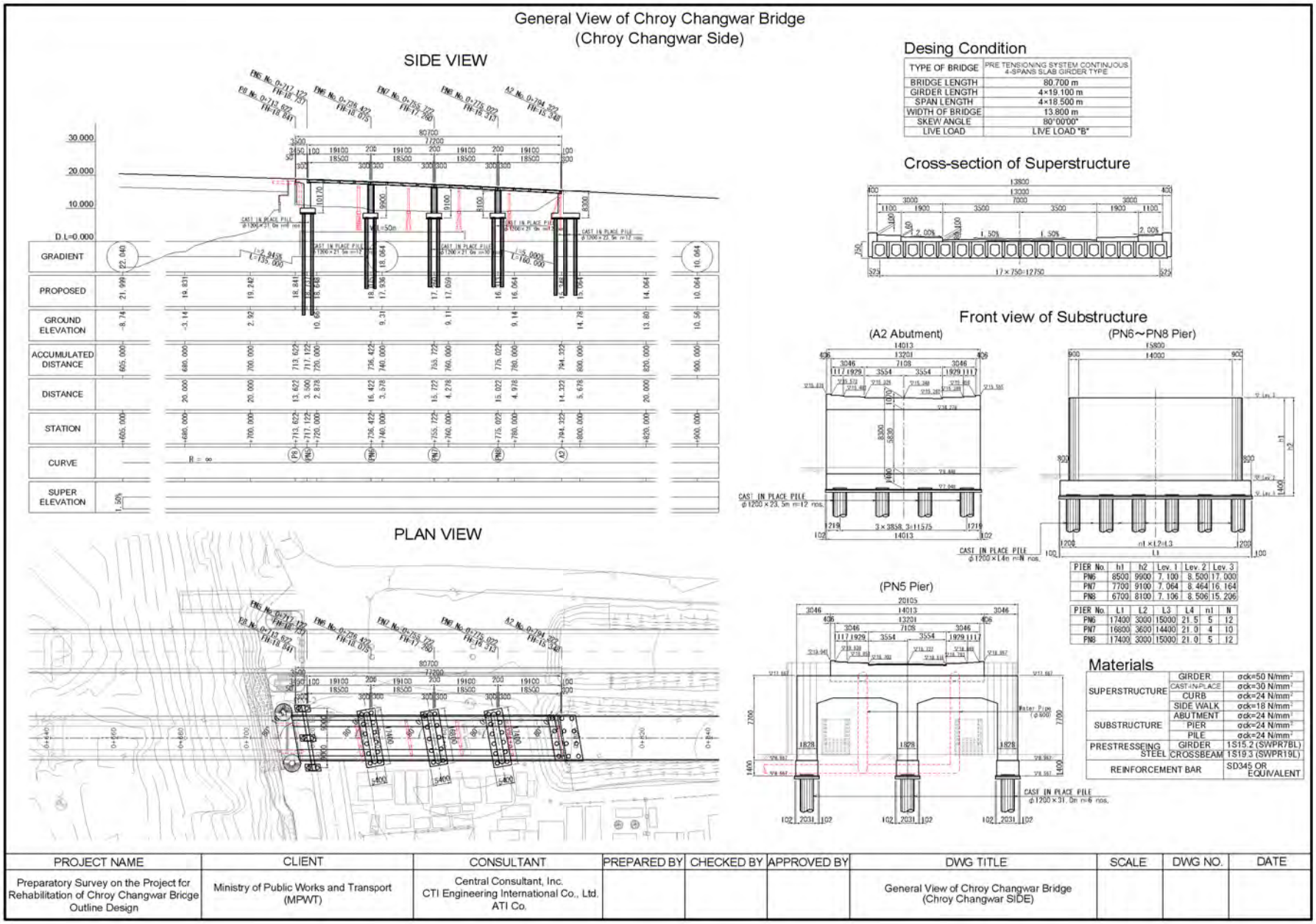


Figure 2-2-61 General View of the Whole Bridge (Chroy Changwar Side)

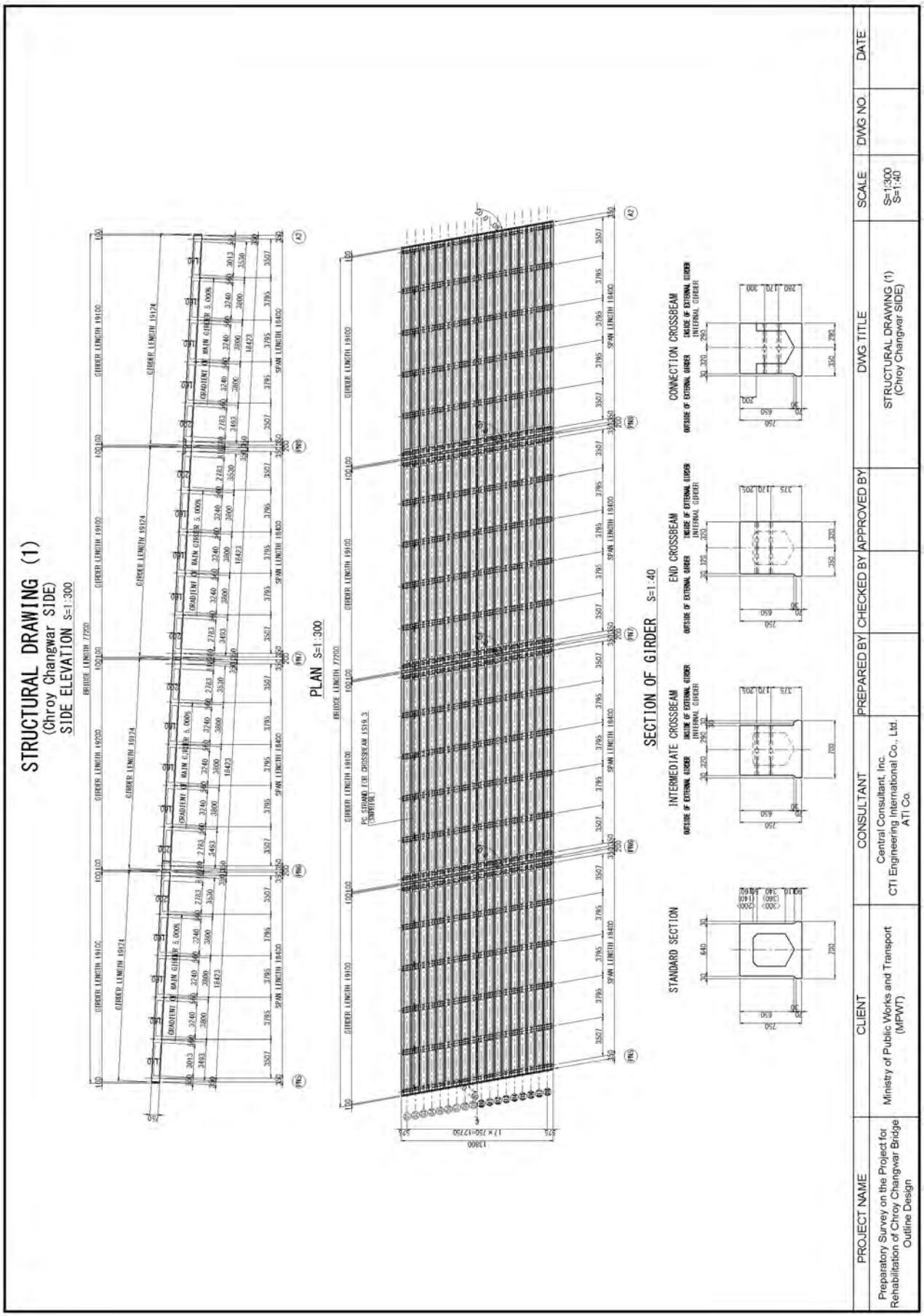
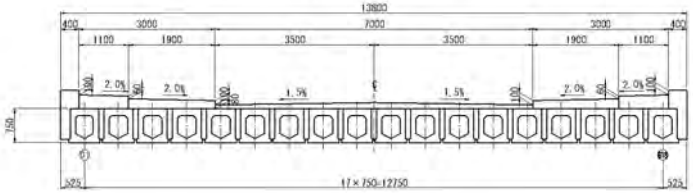


Figure 2-2-62 General View of Superstructure (1/2) (Chroy Changwar Side)

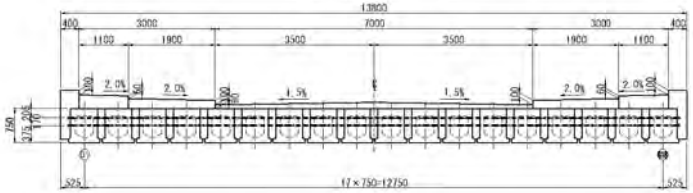
STRUCTURAL DRAWING (2)
(Chroy Changwar SIDE)

SECTION S=1:100

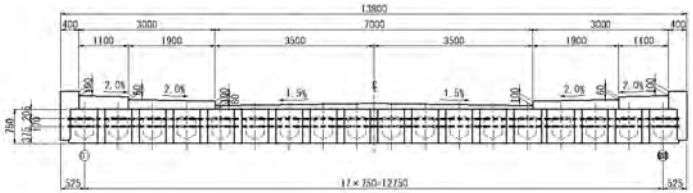
STANDARD SECTION



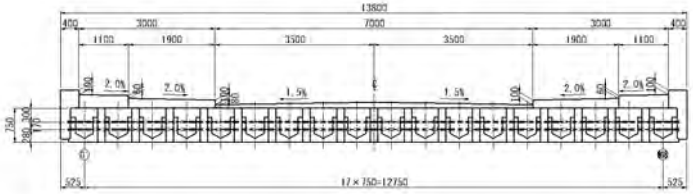
INTERMEDIATE CROSSBEAM



END SECTION



CONNECTION CROSSBEAM



DESIGN CONDITION

TYPE OF BRIDGE	PRE TENSIONING SYSTEM CONTINUOUS 4SPANS SLAB GIRDER TYPE
BRIDGE LENGTH	82.500 m
GIRDER LENGTH	21.100 m + 21.100 m + 21.100 m + 21.100 m
SPAN LENGTH	20.400 m + 20.400 m + 20.400 m + 20.400 m
WIDTH OF BRIDGE	13.800 m
SKEW ANGLE	82° 00' 00"
LIVE LOAD	LIVE LOAD B

MATERIAL STRENGTH & ALLOWABLE STRESS

UNIT: N/mm²

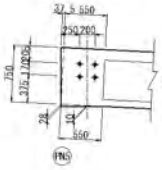
	DESCRIPTION		MAIN GIRDER	CAST-IN-PLACE CONCRETE
CONCRETE	DESIGN STRENGTH		50.0	30.0
	COMPRESSIVE STRESS	SOON AFTER PRESTRESSING	20.0	14.0
		ON DESIGN LOAD AFFECTED	16.0	11.0
	TENSILE STRESS	SOON AFTER PRESTRESSING	-1.80	0.00
		ON DEAD LOAD AFFECTED	0.00	0.00
		ON DESIGN LOAD AFFECTED	-1.80	0.00
	SHEARING STRESS	VERTICAL VALUE ON DESIGN LOAD AFFECTED	0.65	—
		MAXIMUM VALUE ON ULTIMATE LOAD AFFECTED	6.00	—
	DIAGONAL TENSILE STRESS	ON DEAD LOAD AFFECTED	-1.20	—
		ON DESIGN LOAD AFFECTED	-2.30	—
	STRESS ON PRESTRESSING AFFECTED		35.0	25.0

PC STEEL MATERIAL	DESCRIPTION		MAIN GIRDER	CROSSBEAM
			1S15.2 (SWPR7BL)	1S19.3 (SWPR19L)
	TENSILE STRENGTH		1850	1850
	YIELD POINT STRENGTH		1600	1600
	TENSILE STRESS	ON TENSIONING	1440	1440
		SOON AFTER TENSIONING	1295	1295
		ON DESIGN LOAD AFFECTED	1110	1110

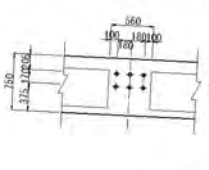
REINFORCEMENT BAR	DESCRIPTION		MAIN GIRDER	CROSSBEAM
	QUALITY OF REINFORCEMENT BAR		SD345 OR EQUIVALENT	SD345 OR EQUIVALENT
	YIELD POINT STRENGTH		345	345
	TENSILE STRESS	ON DEAD LOAD AFFECTED	—	—
		ON DESIGN LOAD AFFECTED	180	180
		IMPACT LOAD AFFECTED	—	—

DETAIL OF CROSSBEAM S=1:60

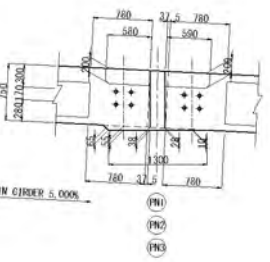
END CROSSBEAM



INTERMEDIATE CROSSBEAM



CONNECTION CROSSBEAM



END CROSSBEAM

PROJECT NAME	CLIENT	CONSULTANT	PREPARED BY	CHECKED BY	APPROVED BY	DWG TITLE	SCALE	DWG NO.	DATE
Preparatory Survey on the Project for Rehabilitation of Chroy Changwar Bridge Outline Design	Ministry of Public Works and Transport (MPWT)	Central Consultant, Inc. CTI Engineering International Co., Ltd. ATI Co.				STRUCTURAL DRAWING (2) (Chroy Changwar SIDE)	S=1:100 S=1:60		

Figure 2-2-63 General View of Superstructure (2/2) (Chroy Changwar Side)

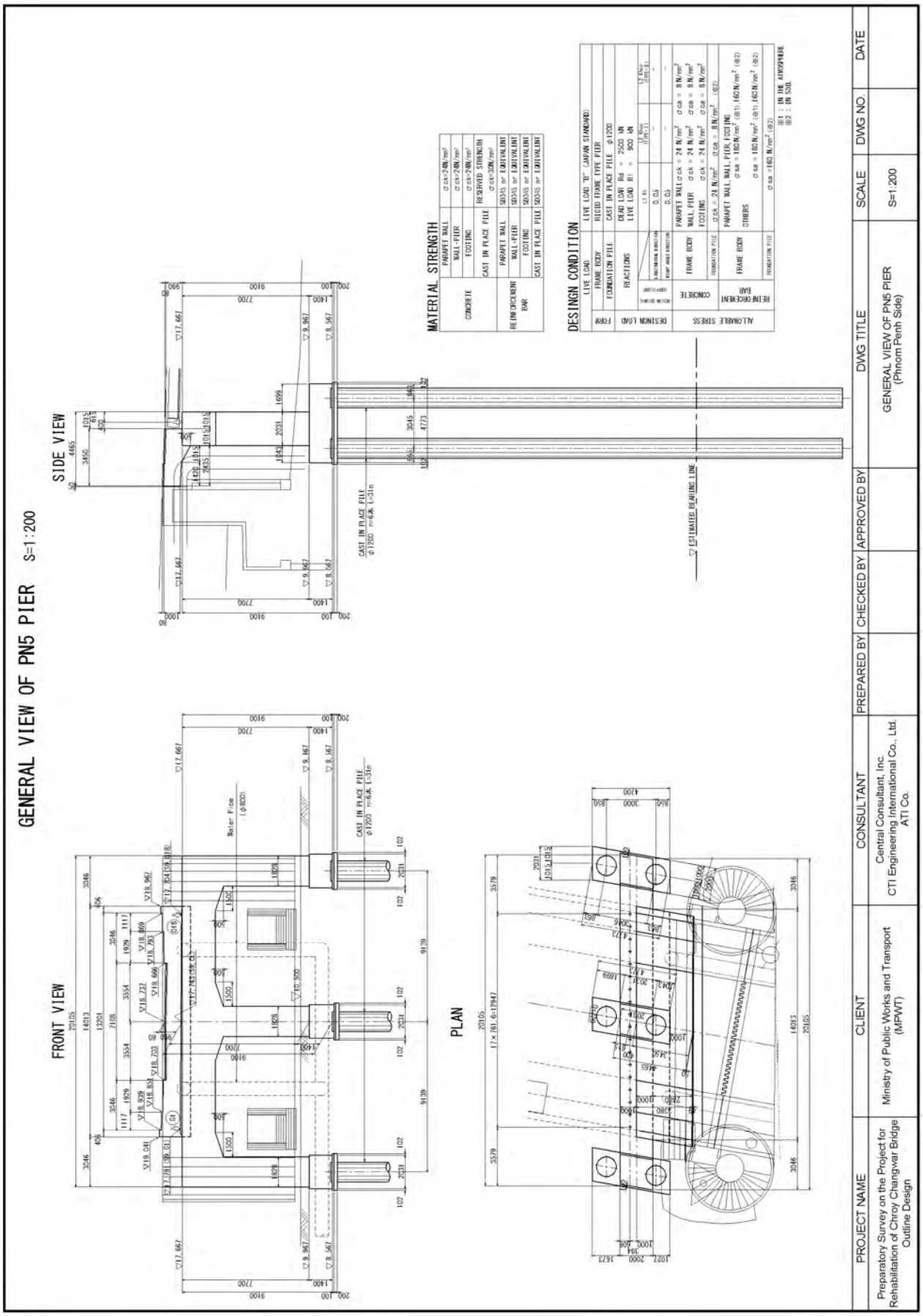


Figure 2-2-64 General View of PN5 Pier

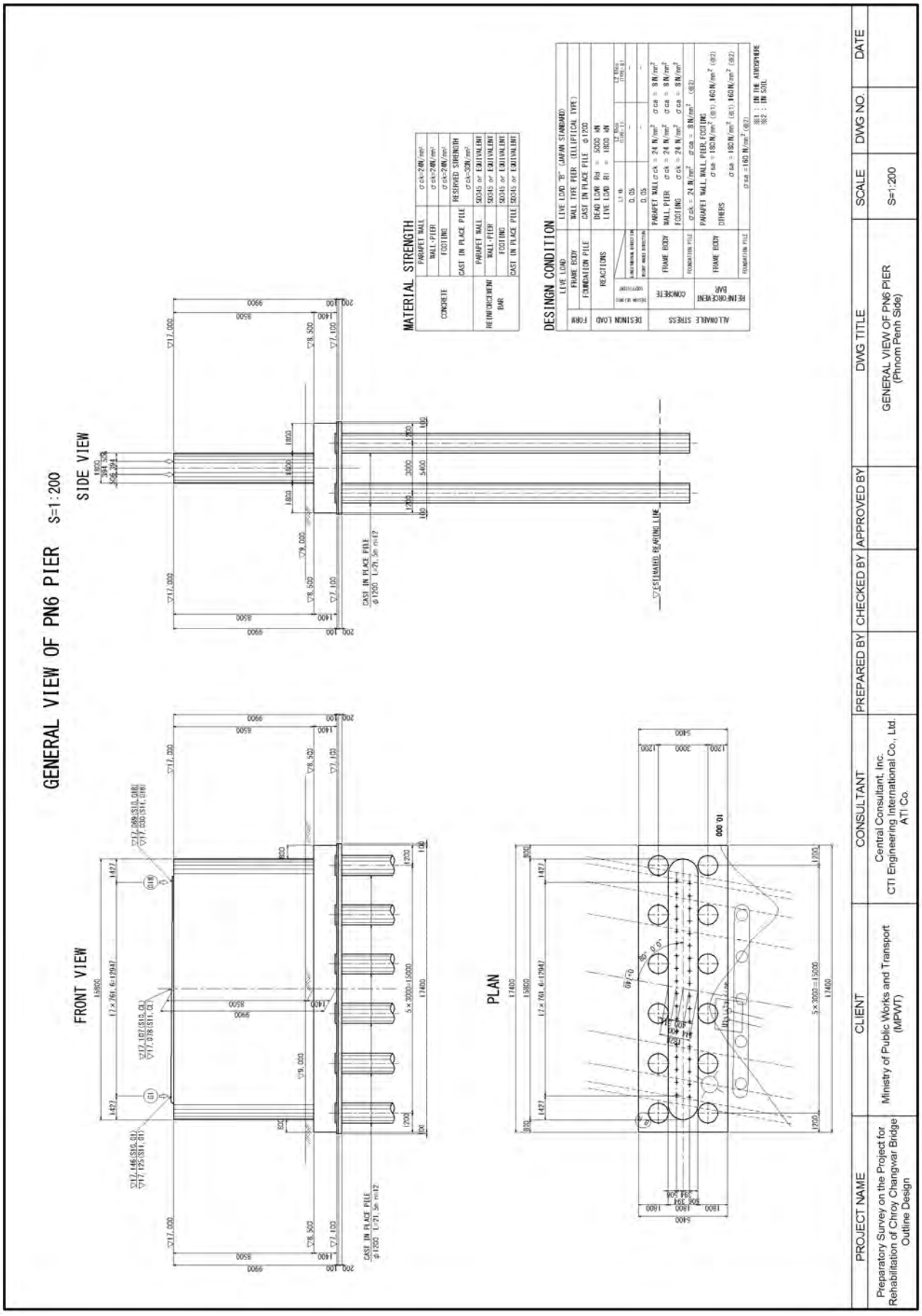


Figure 2-2-65 General View of PN6 Pier

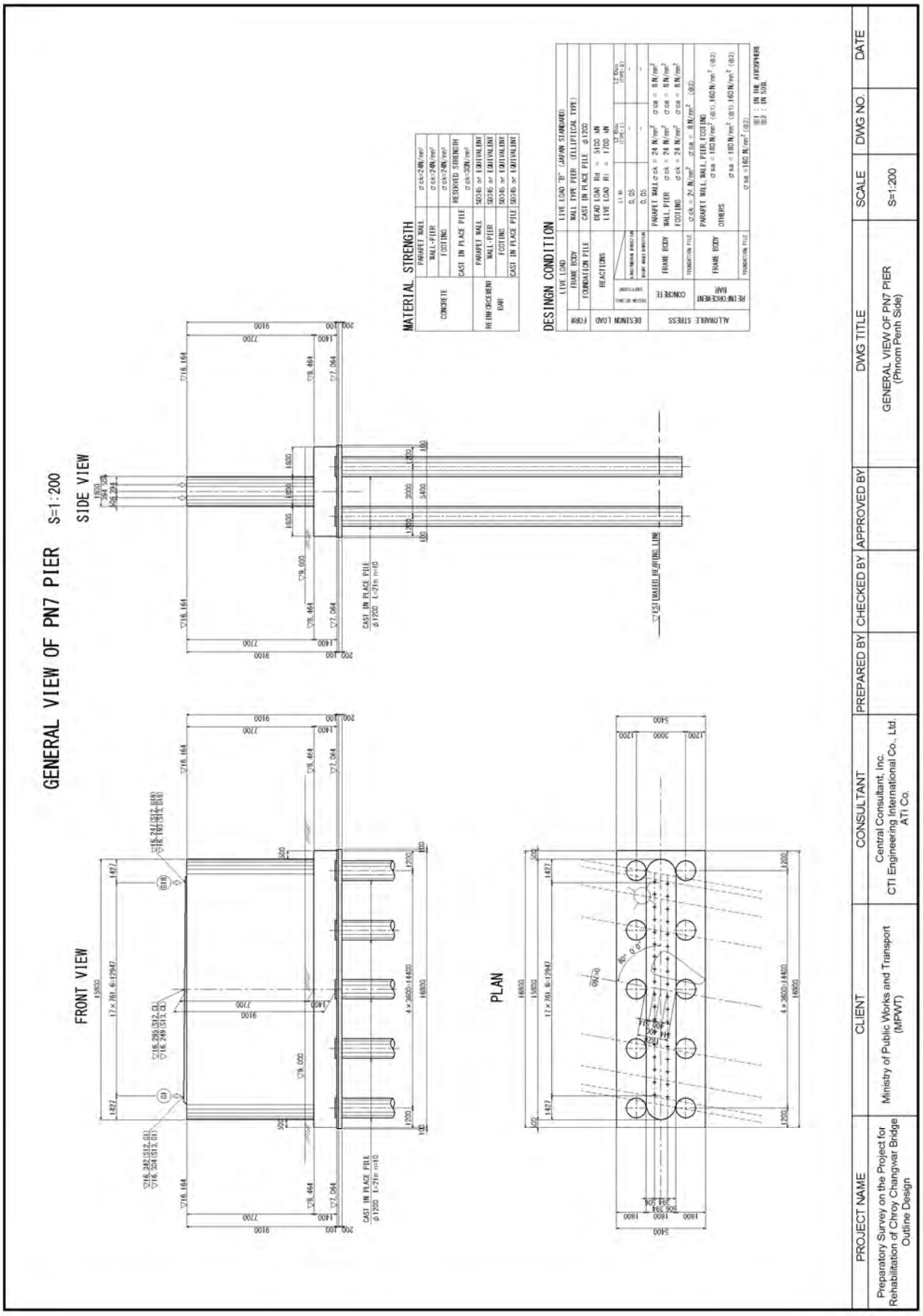
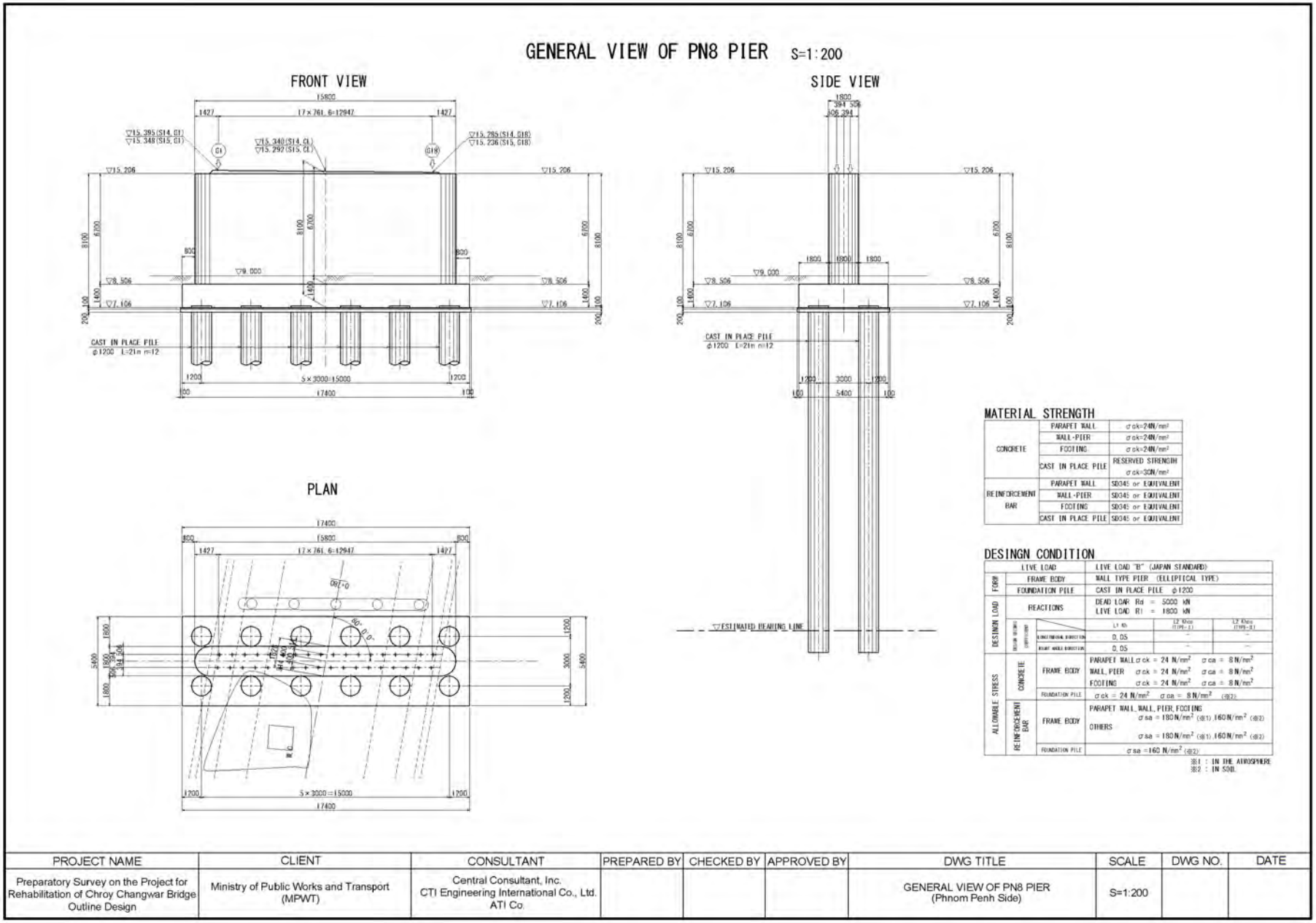


Figure 2-2-66 General View of PN7 Pier



PROJECT NAME	CLIENT	CONSULTANT	PREPARED BY	CHECKED BY	APPROVED BY	DWG TITLE	SCALE	DWG NO.	DATE
Preparatory Survey on the Project for Rehabilitation of Chroy Changwar Bridge Outline Design	Ministry of Public Works and Transport (MPWT)	Central Consultant, Inc. CTI Engineering International Co., Ltd. ATI Co.				GENERAL VIEW OF PN8 PIER (Phnom Penh Side)	S=1:200		

Figure 2-2-67 General View of PN8 Pier

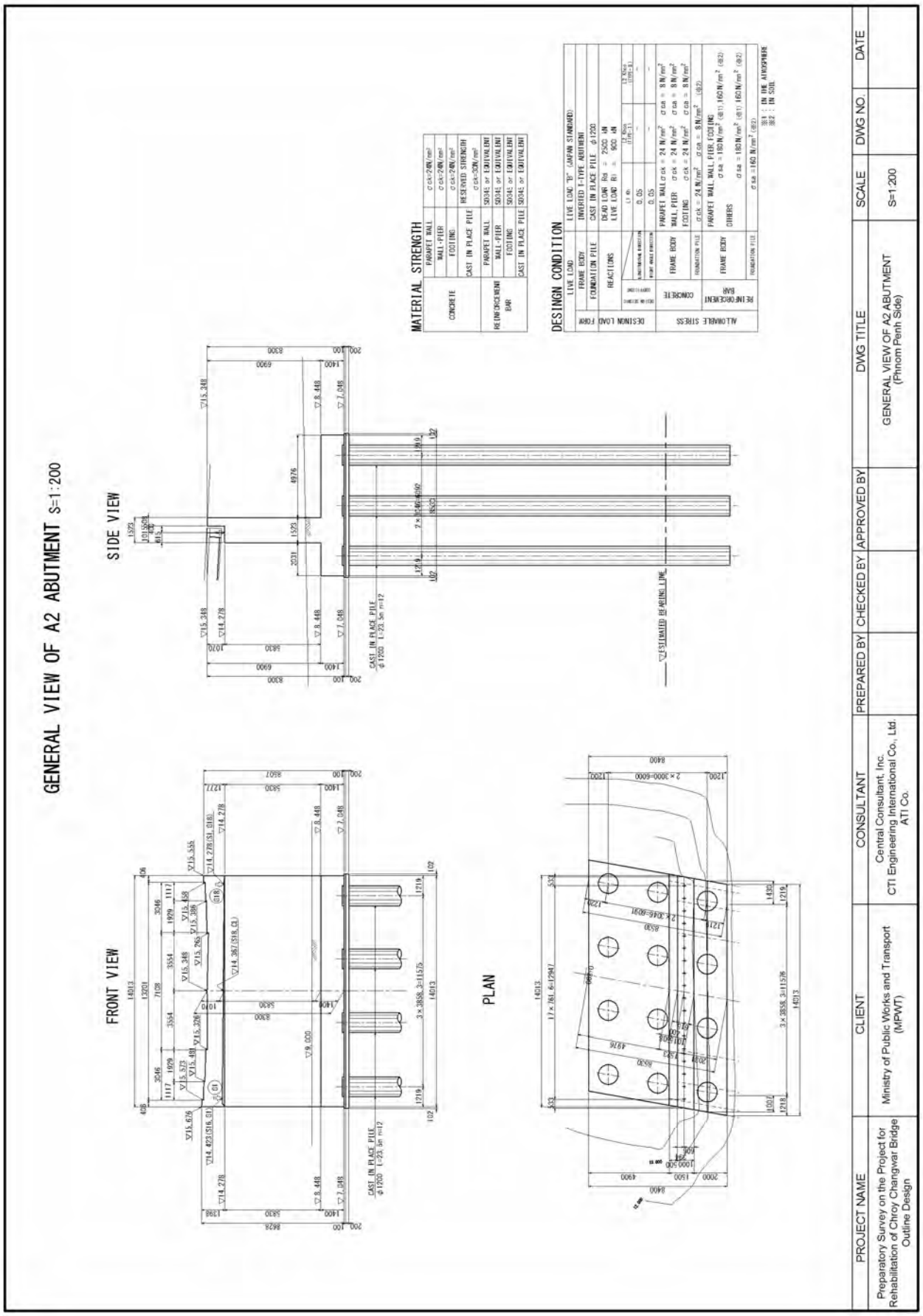


Figure 2-2-68 General View of A2 Abutment

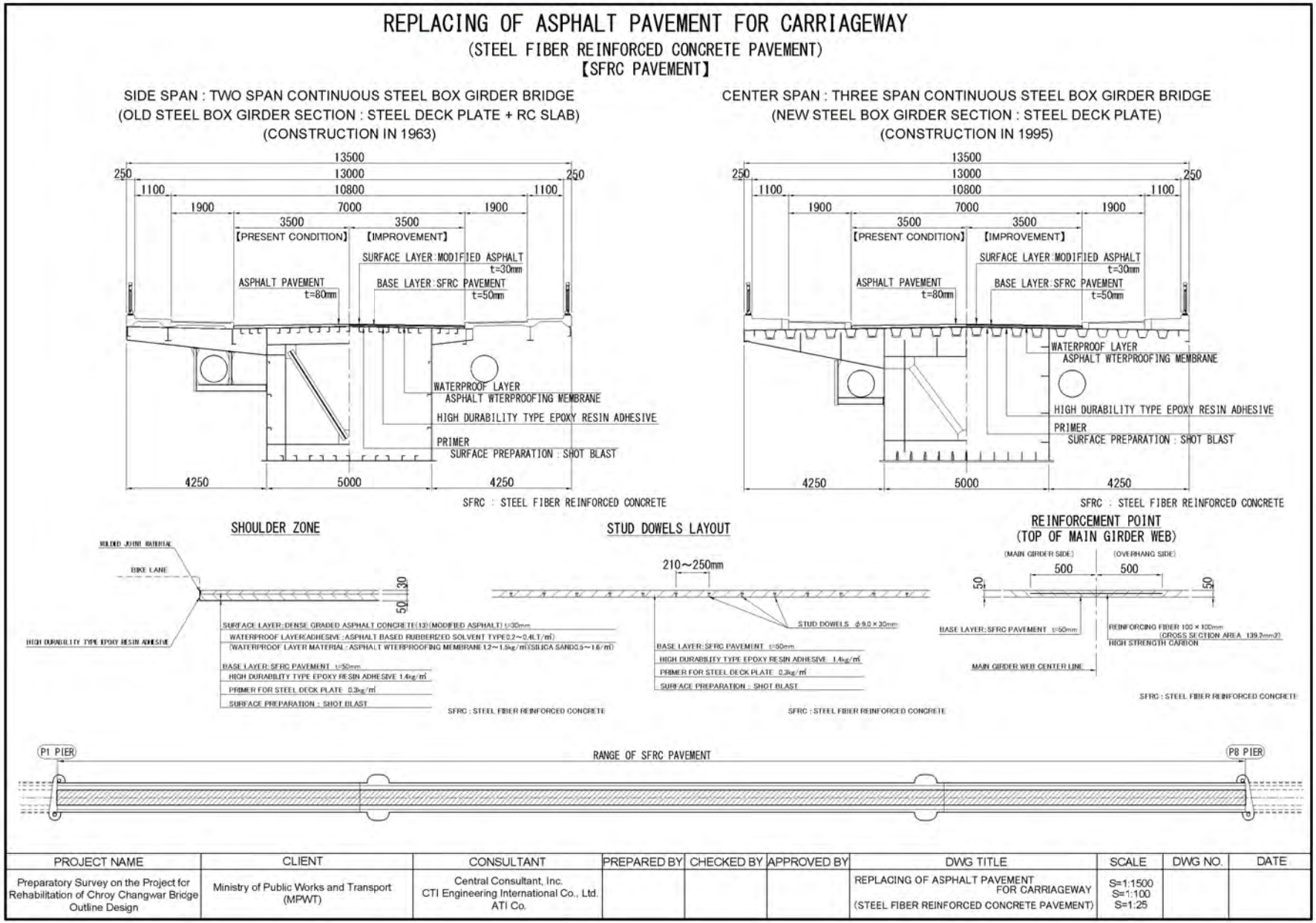


Figure 2-2-69 SFRC Pavement Work

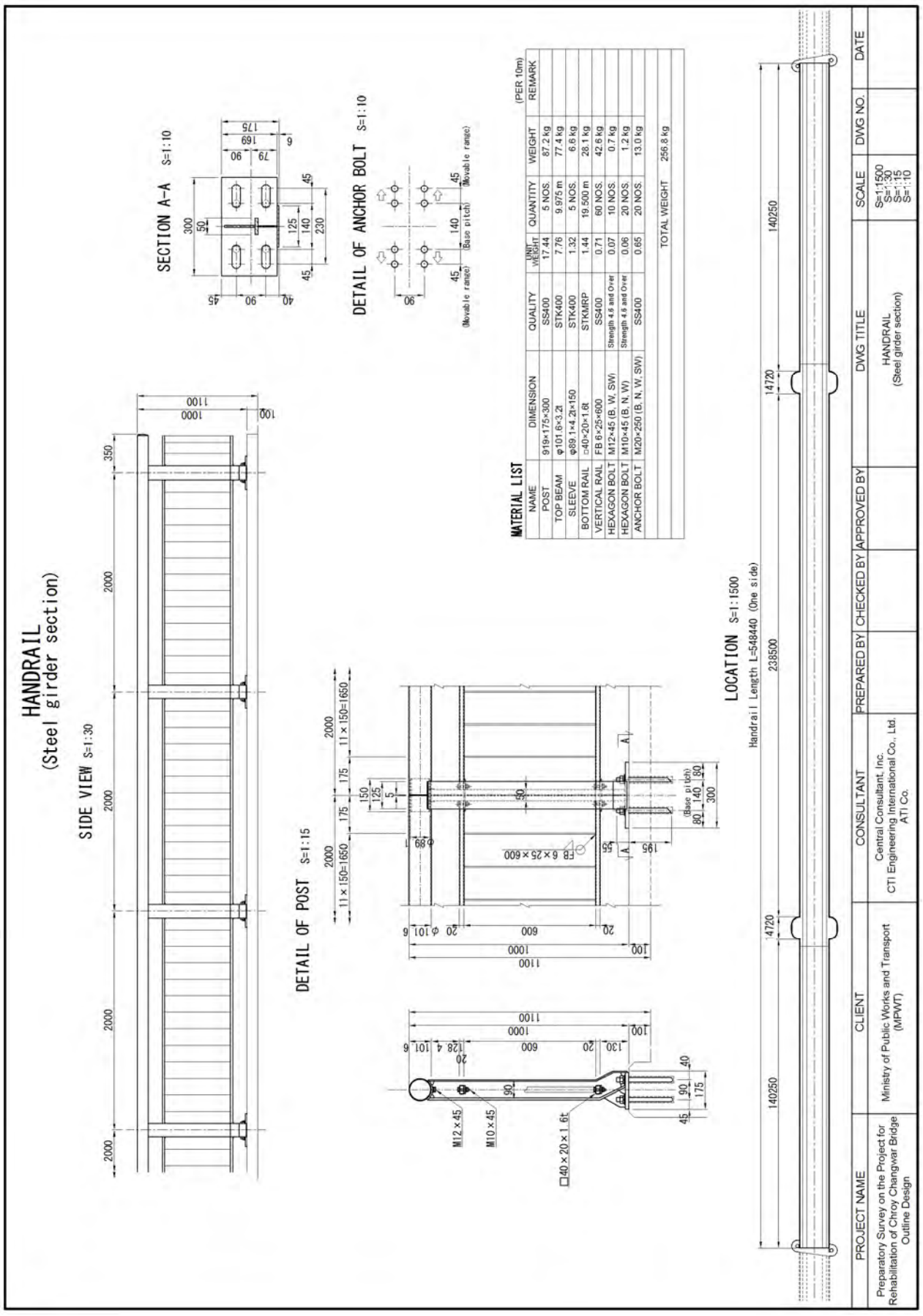


Figure 2-2-70 Replacement Railing (Steel Bridge Part)

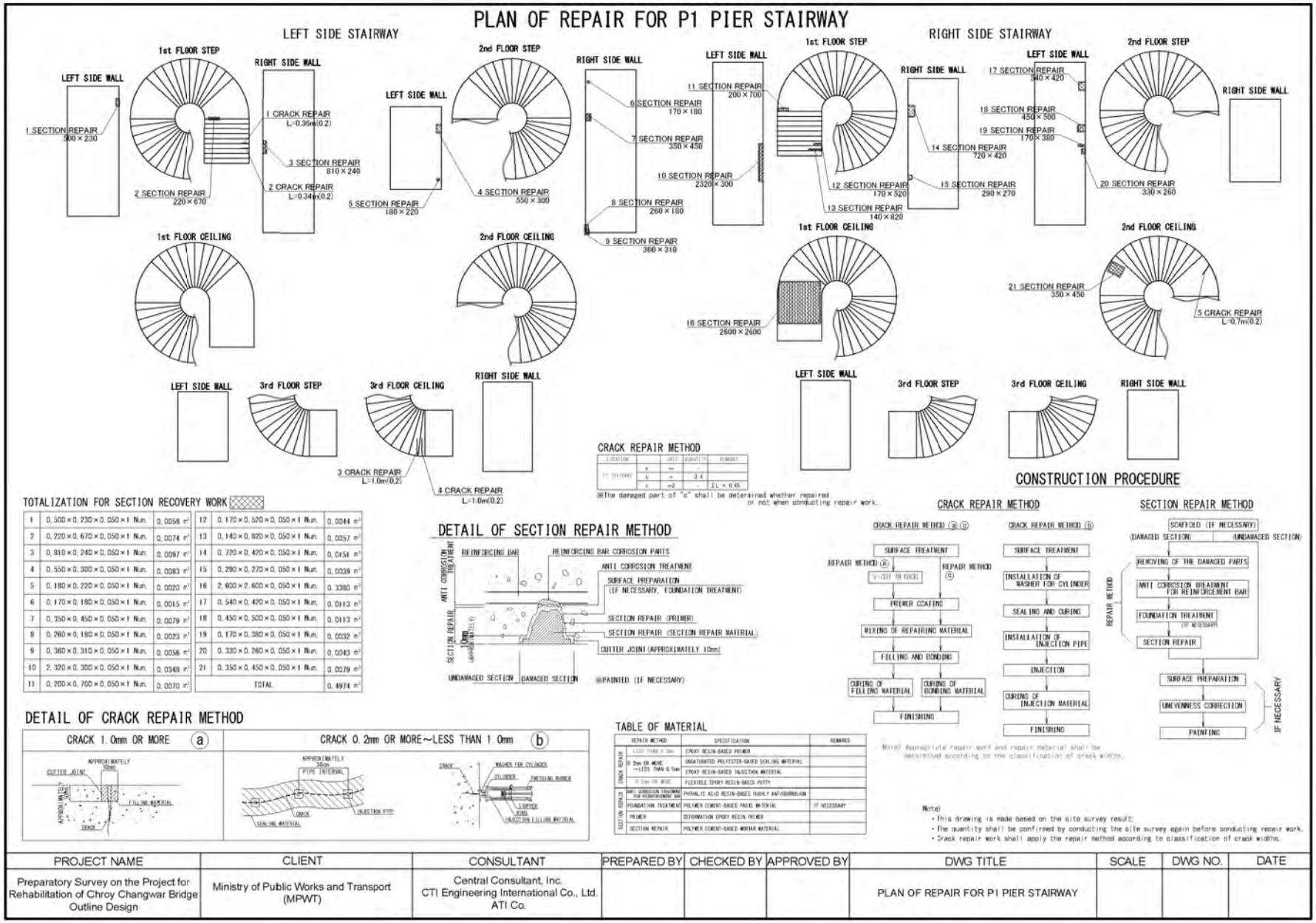


Figure 2-2-71 Substructure Repair Work (P1 Pier)

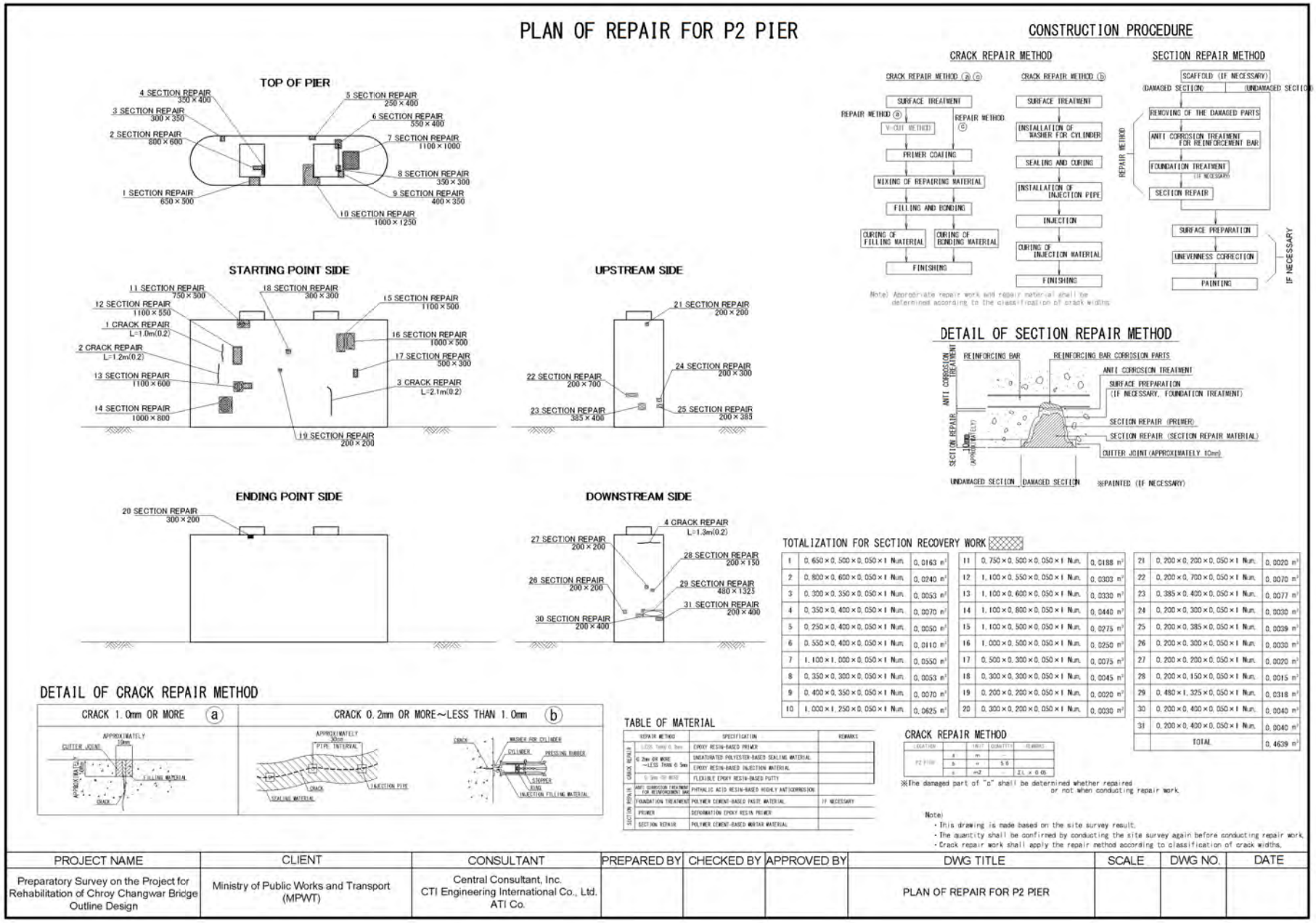


Figure 2-2-72 Substructure Repair Work (P2 Pier)

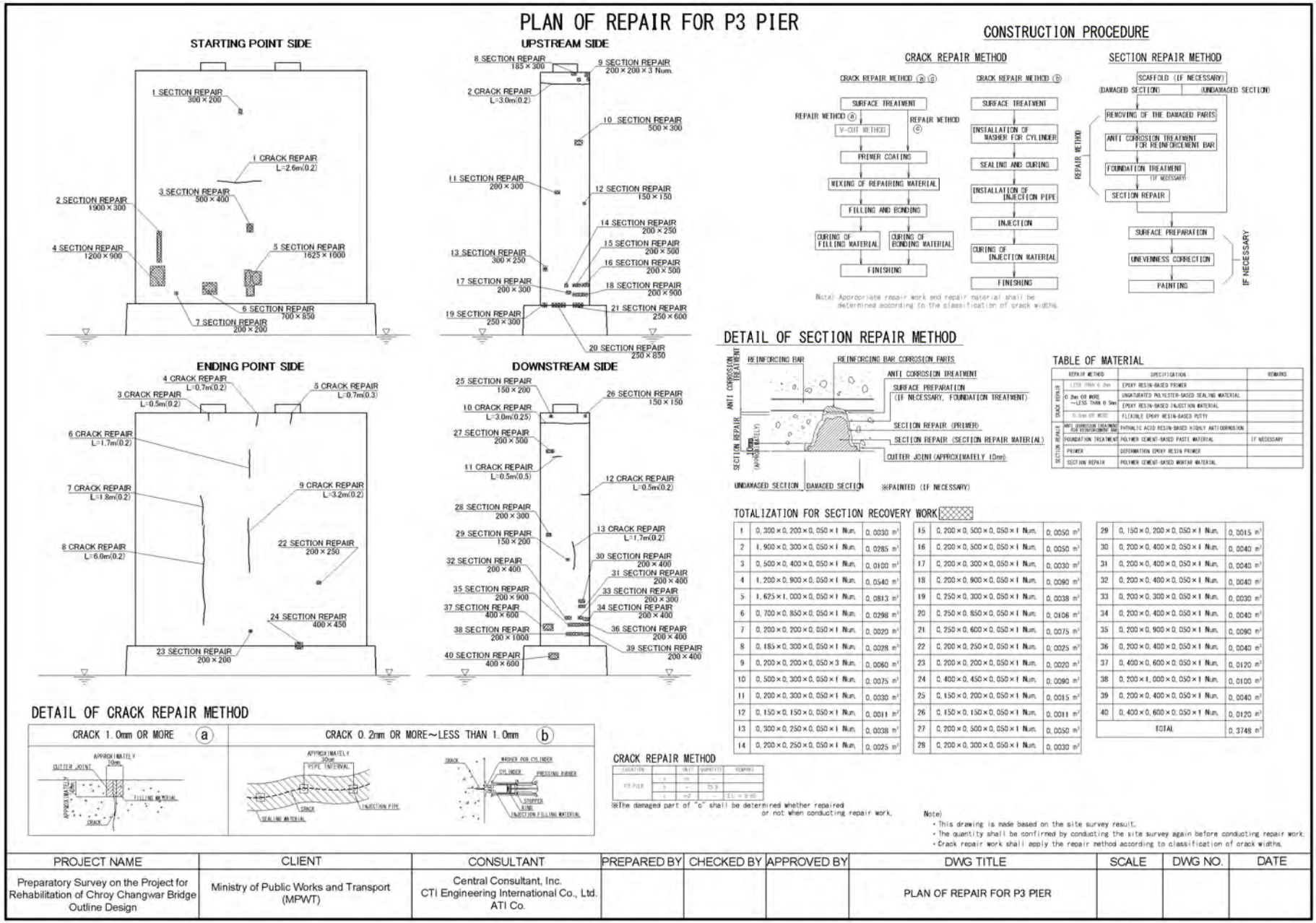


Figure 2-2-73 Substructure Repair Work (P3 Pier)

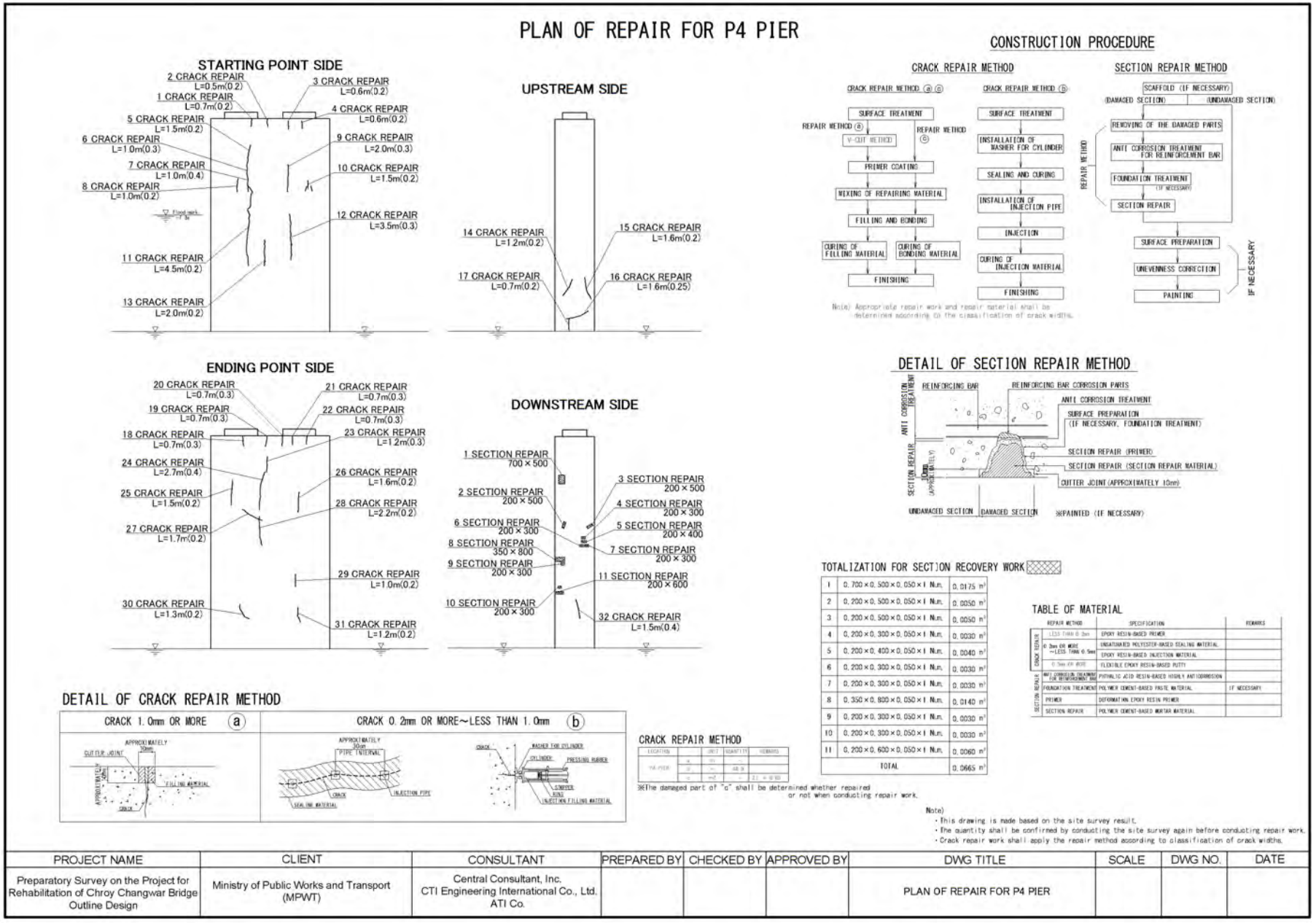
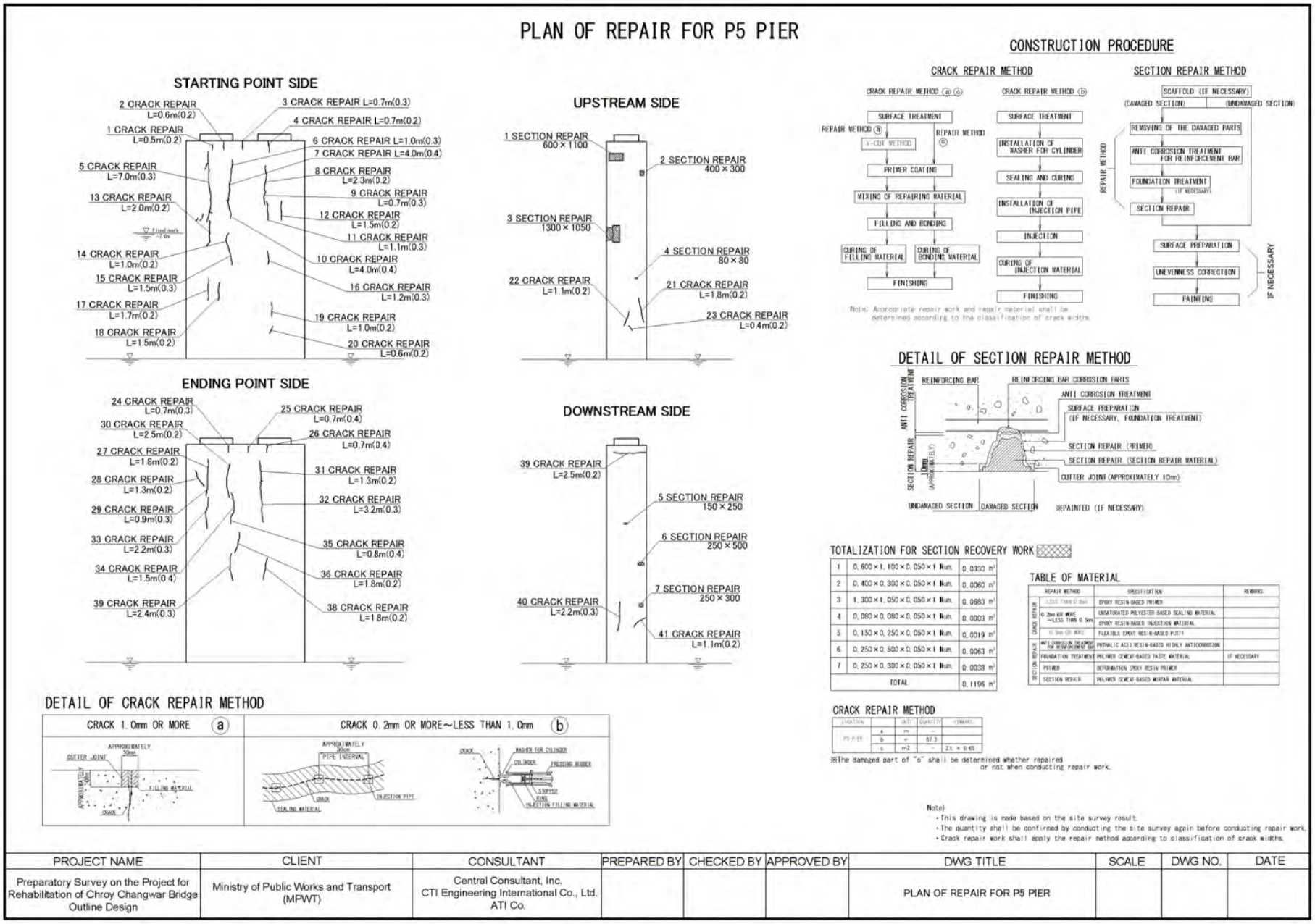


Figure 2-2-74 Substructure Repair Work (P4 Pier)



PROJECT NAME	CLIENT	CONSULTANT	PREPARED BY	CHECKED BY	APPROVED BY	DWG TITLE	SCALE	DWG NO.	DATE
Preparatory Survey on the Project for Rehabilitation of Chroy Changwar Bridge Outline Design	Ministry of Public Works and Transport (MPWT)	Central Consultant, Inc. CTI Engineering International Co., Ltd. ATI Co.				PLAN OF REPAIR FOR P5 PIER			

Figure 2-2-75 Substructure Repair Work (P5 Pier)

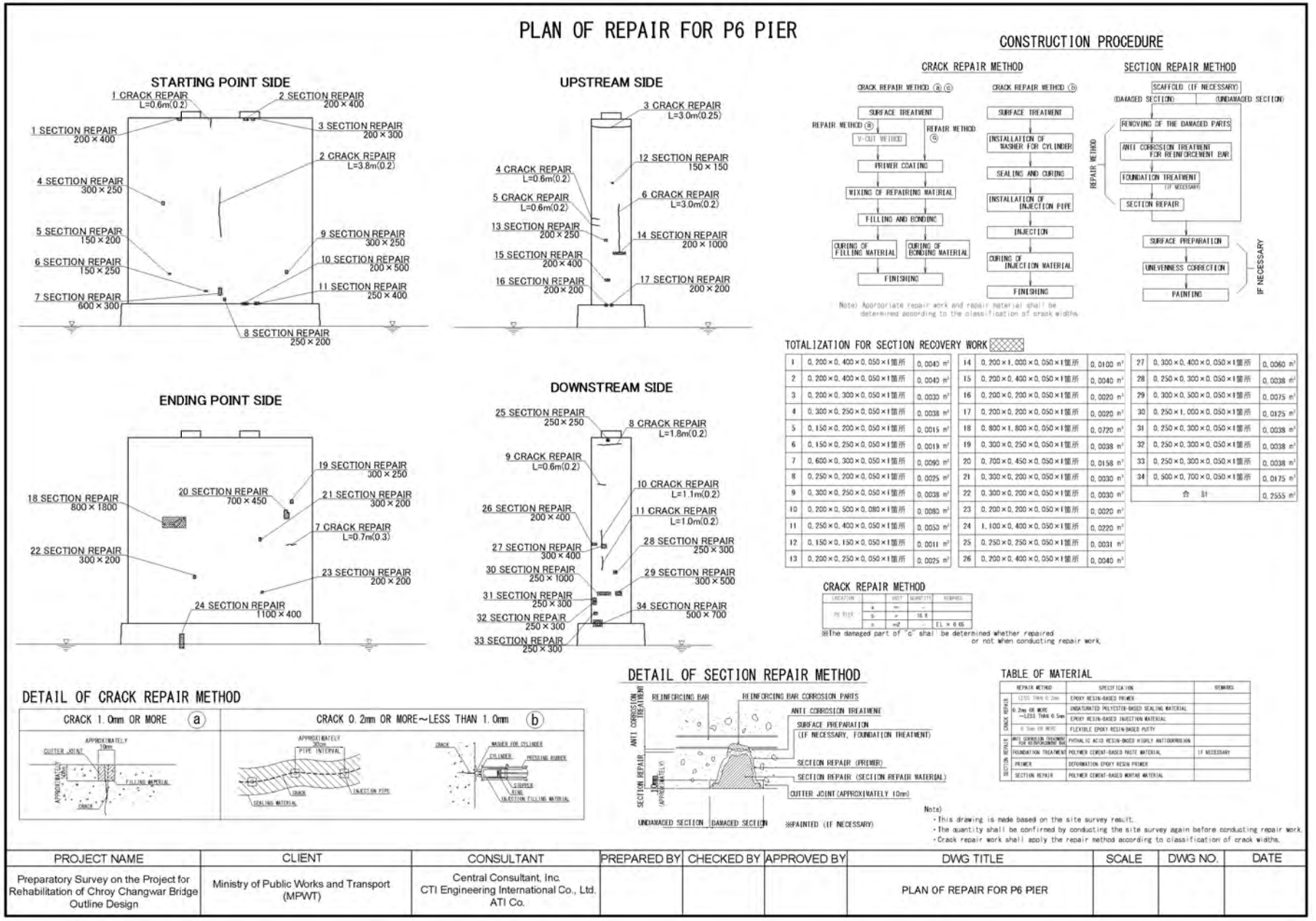


Figure 2-2-76 Substructure Repair Work (P6 Pier)

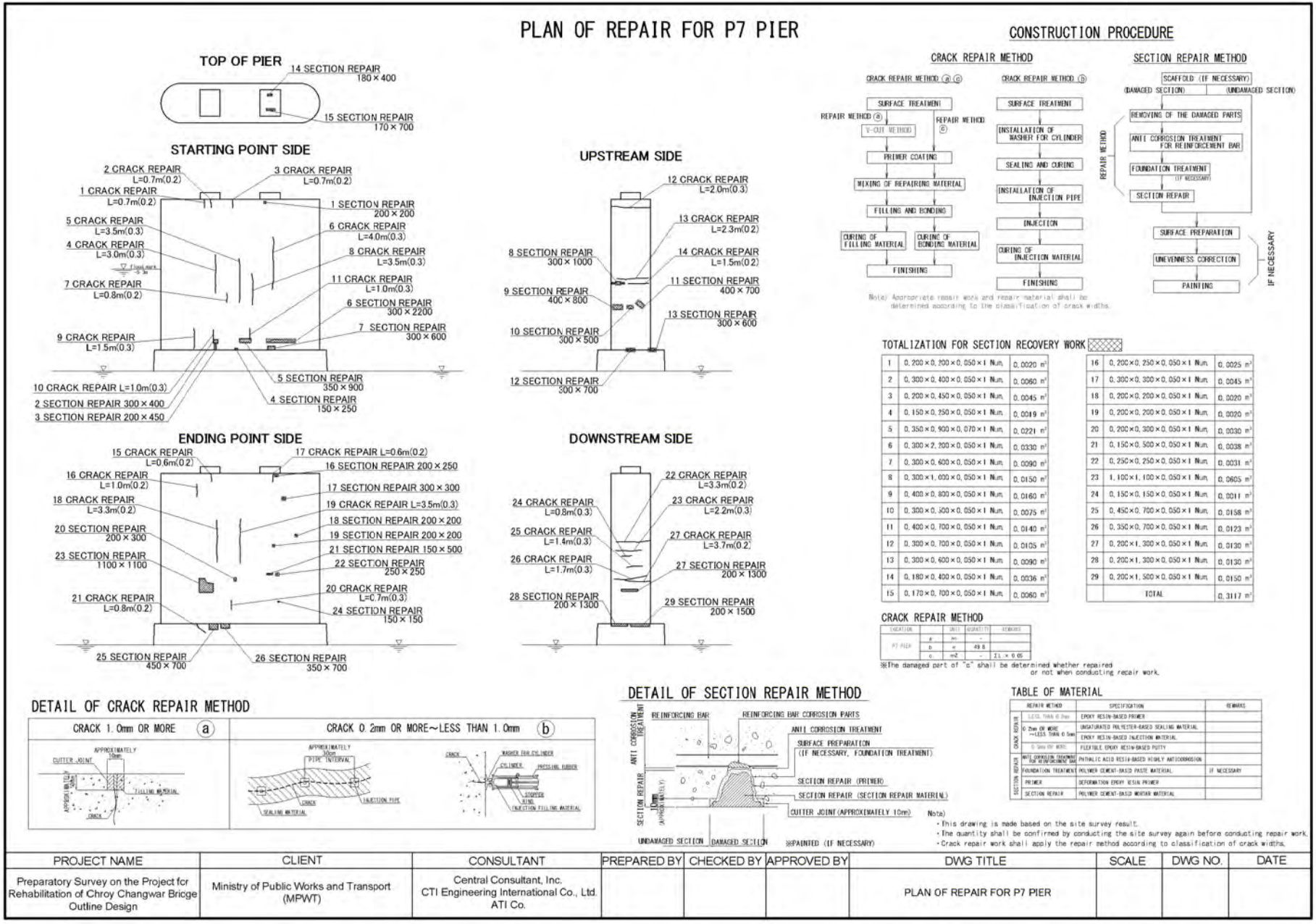


Figure 2-2-77 Substructure Repair Work (P7 Pier)

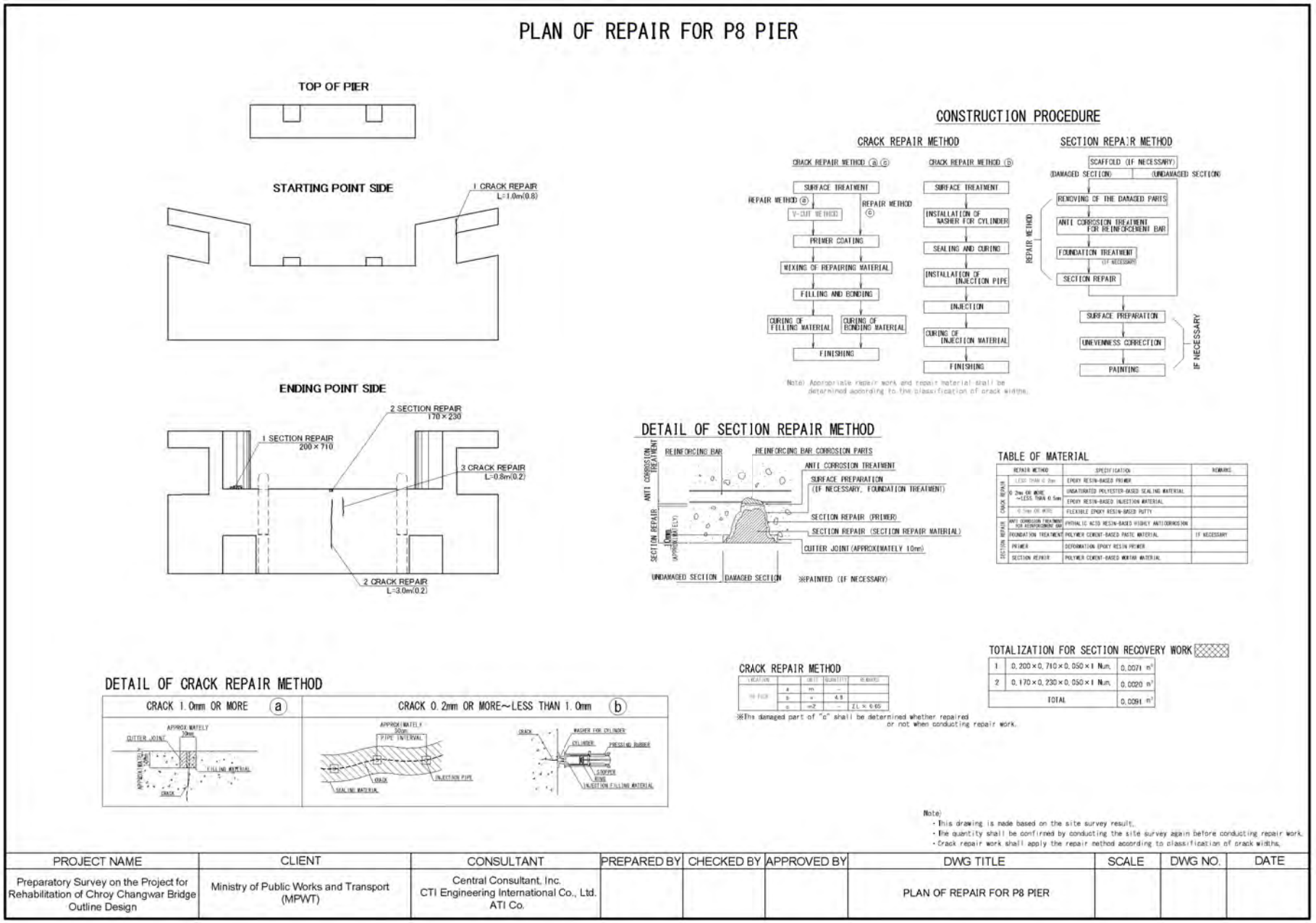


Figure 2-2-78 Substructure Repair Work (P8 Pier)

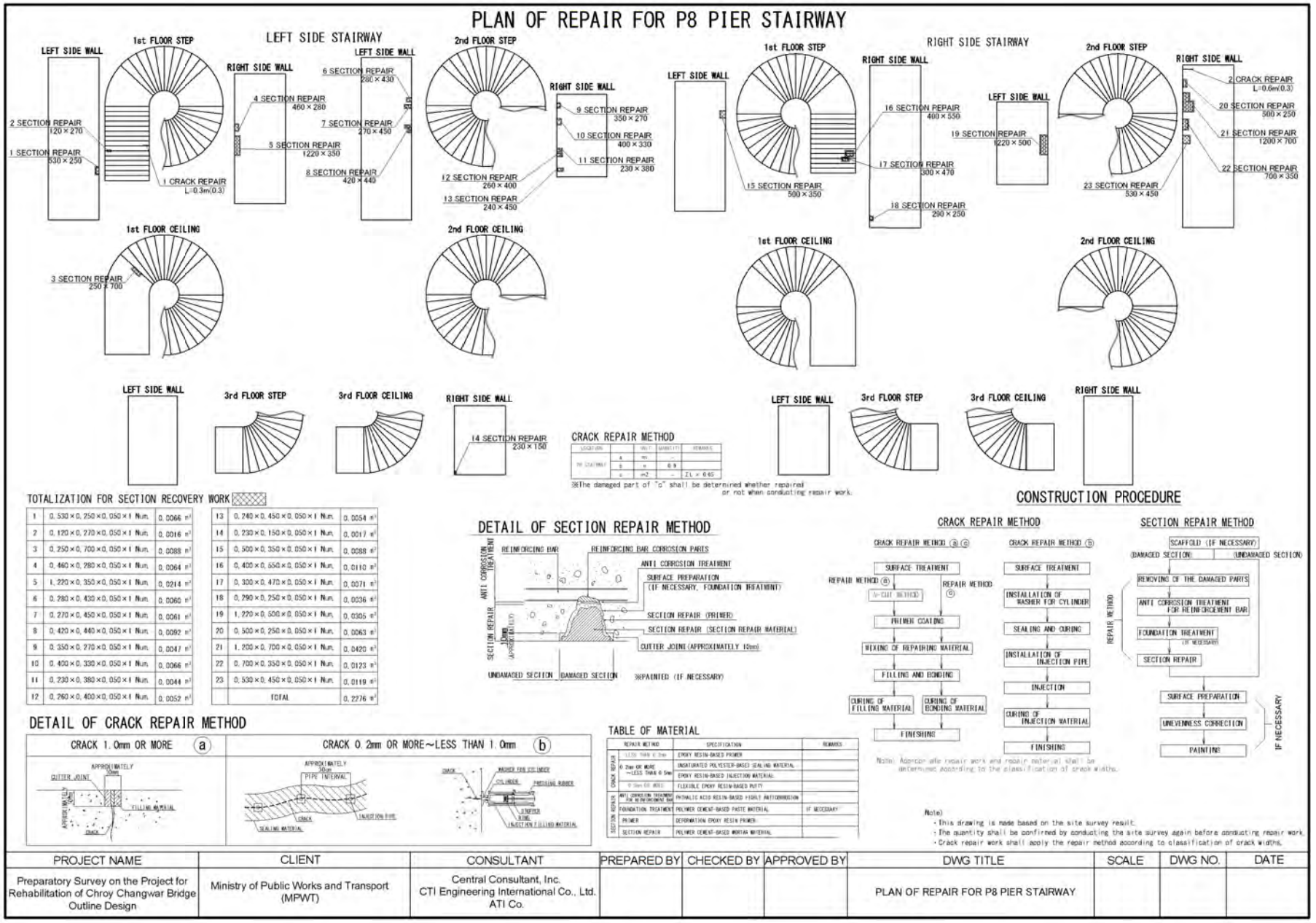


Figure 2-2-79 Substructure Repair Work (Stairway Part of P8 Pier)

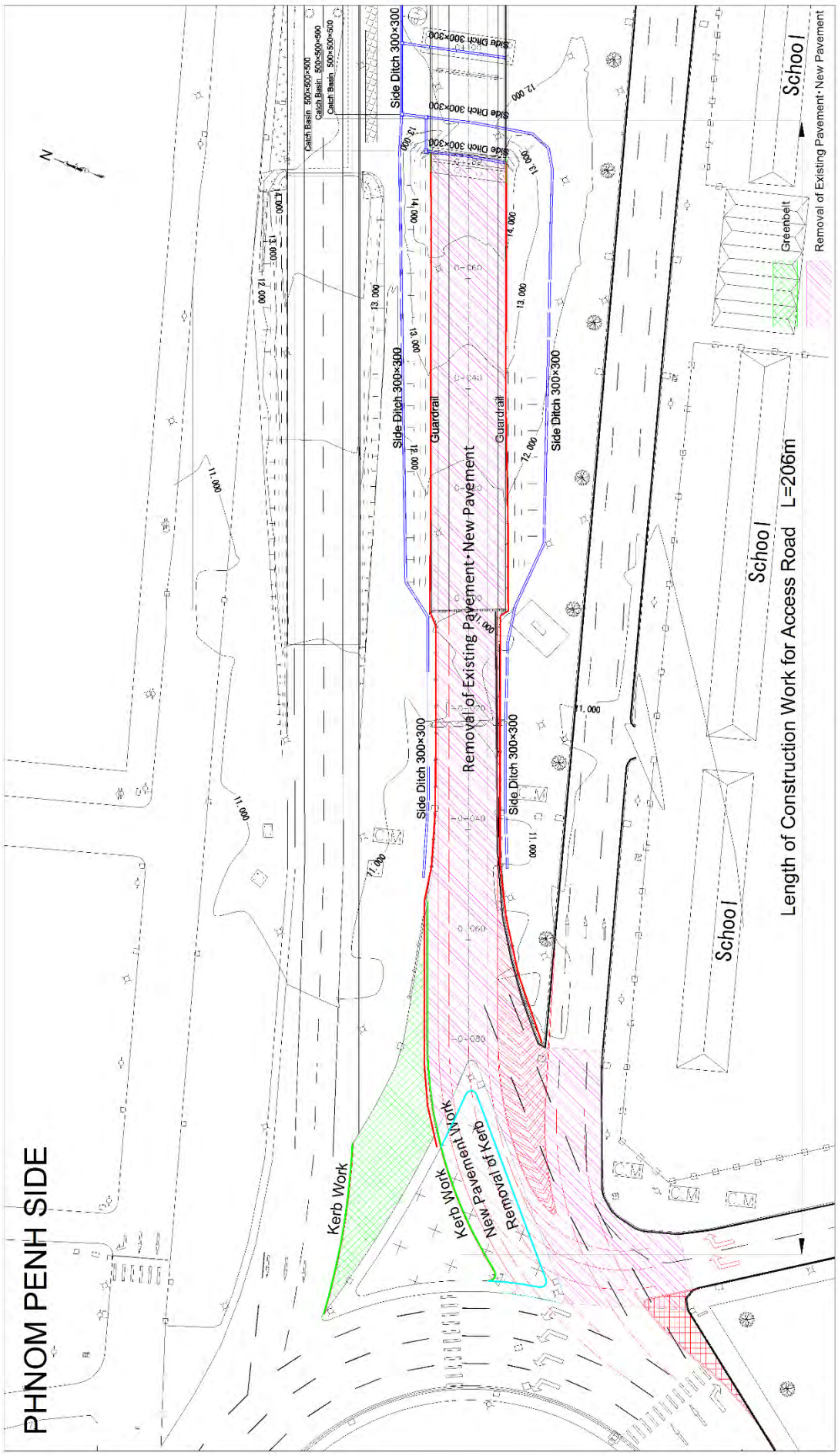


Figure 2-2-80 Plan of Approach Road (Phnom Penh Side)

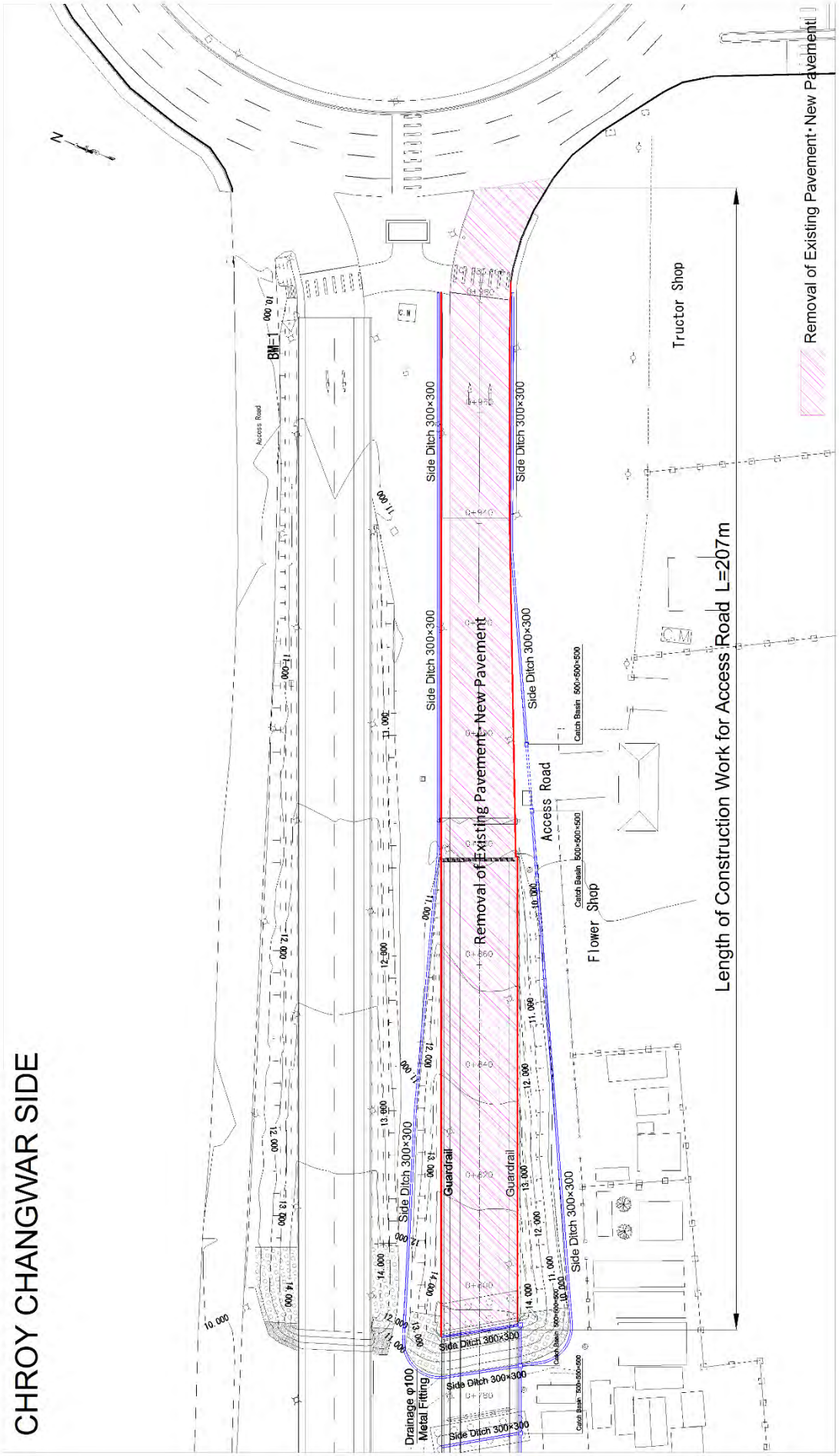


Figure 2-2-81 Plan of Approach Road (Chroy Changwar Side)

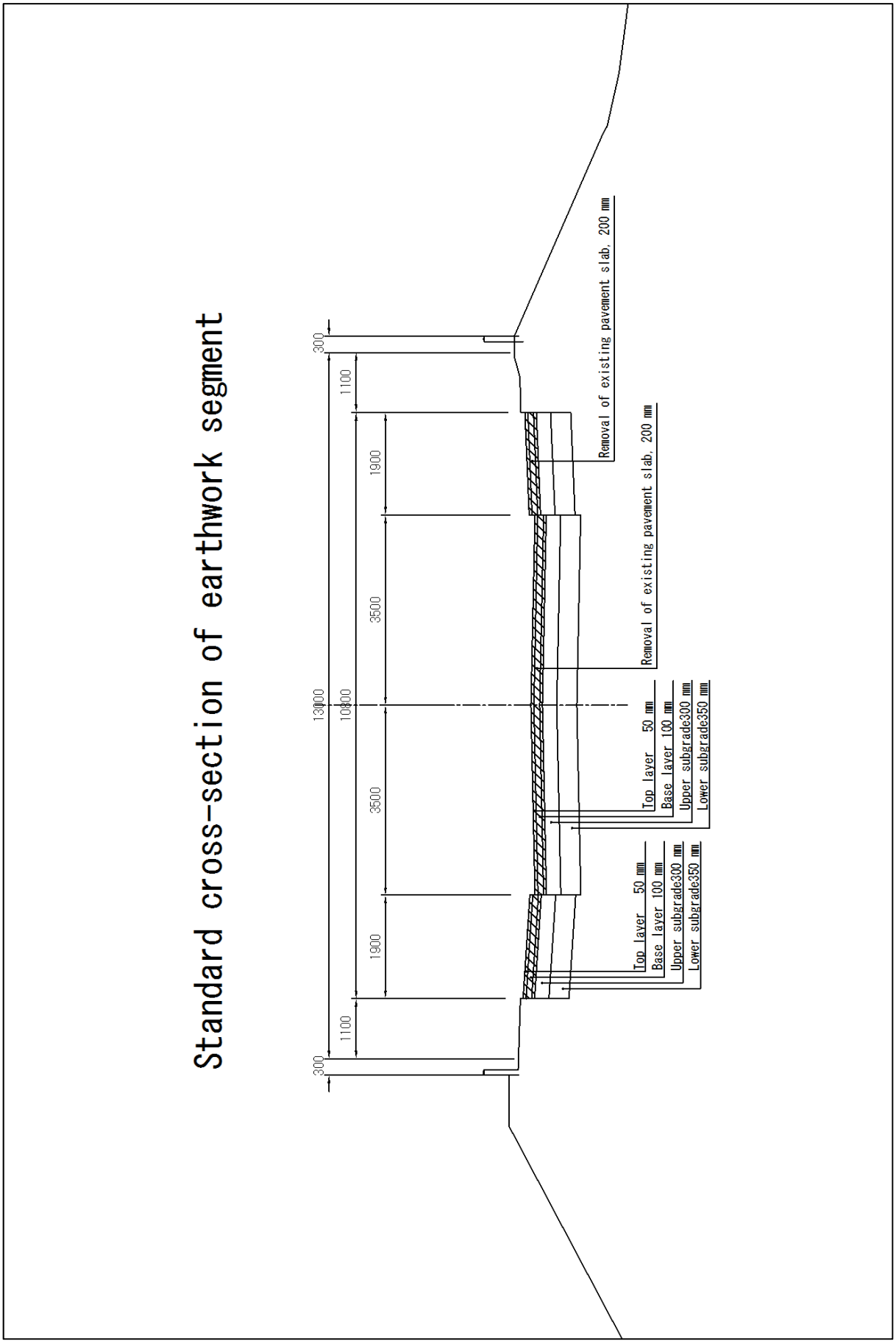


Figure 2-2-82 Standard Cross-Section of Approach Road

2-2-4 Work Execution Plan

2-2-4-1 Work Execution Policy

Assuming that the project will be implemented using a Japanese grant aid scheme, the following items will be taken into account as the basic policy for examining work execution methods.

① The number of working parties will be increased in order to shorten as much as possible the duration of the road closure and the construction period.

② Local engineers and workers will be used to the greatest extent possible in order to contribute to the creation of employment opportunities and promote technology transfer.

③ Local construction materials and machinery will be used to the greatest extent possible. However, if materials do not meet the standards of quality, supply capacity, and safety required by Japanese grant aid projects, they will be procured from Japan or a third country, also taking economic efficiency into account.

④ To ensure smooth implementation of the project, a system will be established so that the Government of Cambodia, the consultant, and subcontracted companies remain in close communication with each other.

⑤ As a responsibility of the recipient country, Cambodia is requested to secure the land (including removal of residences and providing compensation for land) necessary for implementation of the project by the start date of the project.

⑥ An appropriate work execution plan and work execution methods will be planned, taking into account natural conditions at the construction site including weather, topography, and geological features.

⑦ A realistic work execution plan will be formed to ensure safety management during the period of construction, taking into account suitable work execution methods and the period for the procurement of materials and equipment, considering rain patterns near the site, as well as water and land transport factors.

⑧ As a responsibility of the recipient country, Cambodia is requested to relocate and/or remove any utility lines that may be an obstructing the site prior to construction by the start of the project.

⑨ Care will be taken to protect the environment by taking precautions against river pollution and the spreading of toxic substances due to construction. The impacts of vibration and noise, as well as any effects on traffic in the surrounding area will kept to a minimum.

⑩ Methods and timing for maintenance and repairs, as well as operational policies after the completion of construction will be proposed. As a part of this, OJT for the Cambodian engineers who will be in charge of maintenance management will also be included in this project.

2-2-4-2 Cautionary Points for Work Execution

(1) Ensuring Safety During the Construction Period

The items noted below will be taken into consideration to ensure safety during the construction period.

- Since the entrance/exit road for construction vehicles intersects with a roundabout on both sides of the target bridge, traffic control personnel will be placed in the areas connecting this road. Additionally, construction signs, traffic signs, and traffic safety devices will be sufficiently installed.
- Safety will be ensured for surrounding traffic during bridge removal. In particular, safety will be ensured at the locations intersecting with National Road No. 5 on the Phnom Penh side, since traffic is heavy. Also, construction methods will be devised in a manner that keeps periods of traffic restriction to a minimum.
- The target region for the project is an urban area, and congestion caused by a concentration of traffic during the morning and evening rush hour is a risk which must be sufficiently recognized. Additionally, traffic restrictions are placed on large vehicles within the city of Phnom Penh, which will hinder construction for the project. Due to this situation, open lines of communication will be created with the local DPWT and police force, among other organizations. Thorough attention will be paid to information on restrictions, and safety controls will be observed.
- Attention will be given to safety, and impacts on general traffic will be kept to a minimum when selecting the girder manufacturing yard, the means ofgirders transportation from the manufacturing yard, and the girder erection methods.
- Work in the river during flood season will be kept to a minimum, and work execution and communication systems pertaining to river flooding will be created to prevent accidents caused by flooding and impacts to the surrounding areas.
- The process of returning the area to its original state after construction is complete will be conducted in a smooth and safe manner.

(2) Environmental Protection During the Construction Period

The items noted below will be taken into consideration for protecting the environment during the construction period.

- The measures will be applied to suppress dust generated by construction vehicles, such as water sprinkling and/or rectriction of the vehicles speed.
- Early morning and late night construction work will be avoided to keep the impact of noise and vibration from construction machinery on local residents to a minimum. Since the target area for construction is located in an urban district, the construction methods employed will be within the scope of stipulated restrictions for noise and vibration. However, if there are no local restrictions, the level will be determined after discussions with the implementation body, using Japanese standards as a base.
- In particular, the impacts of noise and vibration will be kept to an absolute minimum on the Phnom Penh side, where a primary school is located approximately 40 m from the concrete bridge.

(3) Compliance with Labor Laws and Regulations

The construction company will comply with current Cambodian construction laws and regulations, adhere to appropriate labor conditions and conventions pertaining to employment, prevent disputes with workers, and ensure safety.

(4) Site Security

The contractors will provide security by hiring security guards (24-hours in three shifts) in order to ensure the safety of construction workers, as well as to prevent night time theft of materials and/or construction machinery.

(5) Customs Clearance

For all materials and equipment procured from Japan or a third country (mainly Thailand and Vietnam), the number of days required for transport, unloading, and custom clearance procedures will be taken into account and factored into the work execution plan.

(6) Emphasis on Concrete Quality Control

The primary work for this project is the construction of a prestressed concrete hollow slab bridge as the substructure and superstructure of the re-bridging planned for both sides of the steel bridge. Thus, since primary construction classification is concrete work, it is necessary to execute the work with the highest level priority placed on concrete quality control items. This includes the management of ingredients used in concrete such as aggregate, water, and cement, the specification code for concrete mixing plants, and the management of concrete pouring and curing.

(7) Utility

When the construction was in the planning stages, the presence of water pipes (two φ800 pipes), high voltage lines (three 2200V lines), and fiber optic cables was confirmed on the bridge; these lines must be relocated. Other utility lines such as high voltage lines and water pipes were found underground as well, but their precise location must be assessed by excavating.

The present situations of utilities attached to the bridge are as follows.

Water pipes on the wall of the pier (ϕ 800 × 2)

Water pipes atached to the steel box girder (ϕ 800)

High-voltage cables atached to the steel box girder (22kv × 3)

Communication cables attached to PC bridge (Optical fiber cables, etc)

It has been confirmed through DPWT in field survey that 12 companies have attached utilities to bridges.

Table 2-2-28 Utilities Comapnies

No	Utility	Company	No	Utility	Company
1	Water	Water Supply Authority	7	Telecommunication	CFOCN
2	Electricity	EDC	8	〃	EZECOM
3	Telecommunication	O.S.P Camintel	9	〃	Chief Electrical Public Clarification
4	〃	Metfone	10	〃	Diretor ICI of Ministry of post
5	〃	Telecome Cambodia	11	〃	Cootel
6	〃	PPCTV	12	〃	ANOM

At the time of DOD description in the 2016 mid-January, JICA Study Team explained to MPWT which is the implementing agency of this project for the utility relocation to be a hindrance to the project, and MPWT understood the need of the utility relocation. MPWT sent a letter of request for cooperation to the ministries and agencies involved for utility relocation in late January 2016. JICA Study Team with the MPWT explained to each relevant organizations for the utility relocation at the project site in mid-February 2016.

And, the consultant will provide technical support to the MPWT until the completion of the utility relocation without any trouble.

(8) Demarcation of defects liability

The defect responsibility of the repair and the re-painting of the steel bridge is only for the repair part.

2-2-4-3 Work Execution Categories

The following table outlines the respective items to be borne by the Governments of Japan and Cambodia, in the case this Japanese grant aid project is implemented.

Table 2-2-29 Respective Items Borne by the Governments of Japan and Cambodia

Items borne by the Japanese side	Items borne by the Cambodian side
• Repair of substructure and superstructure of steel bridge section (540.4 m), rebuilding of concrete bridge section (86 m on Phnom Penh side, 79 m on Chroy Changwar side), and rehabilitation and construction of 396 m access road (206 m on Phnom Penh side, 190 m on Chroy Changwar side) of the Chroy Changwar Bridge (length of 709.6 m), as designated in the Preparatory Survey as a Japanese grant aid project. • Removal of the existing concrete bridge (86 m on Phnom Penh side, 79 m on Chroy Changwar side). • Construction and removal of temporary facilities (materials and equipment yard, office, etc.) • Safety measures for construction and for general traffic passing through construction zones during the work period. • Environmental pollution prevention measures for construction during the work period. • Procurement, import, and transport of construction materials and equipment designated in the Materials and Equipment Procurement Plan. Re-export of the imported machinery to the country of procurement. • Creation of implementation design and tendering/contract documents designated in the Construction Supervision Plan, as well as the provision of tendering assistance and construction supervision. This includes Environmental Management Plan monitoring.	• Acquisition of land necessary for the project, and the removal of impacted facilities and buildings. • Relocation/removal of utility lines obstructing construction. • Re-directing traffic in the target area to China Bridge prior to the start of construction, taking the roundabouts on both sides of the bridge into consideration. • Provision of land for temporary facilities needed for the project at no cost. • Issuing ID cards for construction work personnel and stickers for construction vehicles. • Provision of a site for waste disposal needed for the project. • Monitoring the entire construction area during the construction work period. • Provision of exemption from customs duties, domestic tax, and other taxes levied by the Government of Cambodia. • Provision of arrangements for entry and stay in Cambodia by Japanese nationals and third country nationals involved with the project. • Bank handling fees (opening of bank account (B/A), authority to pay (A/P) procedures). • Impact assessments (resident relocation, poor classes) prior to and during the construction period.

2-2-4-4 Construction Supervision Plan

(1) Basic Policy for Construction Supervision Work

Assuming that the project will be implemented using a Japanese grant aid scheme, the following items are given as the basic policy for construction supervision work.

- Since the quality of construction has a large effect on the lifespan and durability of the facility, quality control is given the highest priority and construction supervision operations will be implemented. Particular focus is placed upon concrete work, foundation work, and in-river construction work.
- After quality supervision, important supervisory items will be progress supervision, safety supervision, and payment supervision.
- In order to achieve these tasks, regular meetings and joint site inspections between the construction company and consultant will be conducted at a frequency of once per week to check for problems and to discuss policies for handling any problems.
- In addition to this, regular meetings between representatives of MPWT (client), the construction company, and the consultant will be held once per month to check for problems and to discuss policies for handling any problems.
- A local engineer will be hired as an inspector, and technology transfer will be performed in the field of construction supervision technology, which includes quality supervision, progress supervision, and safety supervision methods.
- Instructions issued to the construction company, all meeting minutes, and reports presented to the client will be preserved in written form, with all reports also given in writing.

(2) Construction Supervision Work of the Consultant

The main work items included in the consultant agreement are described below.

1) Creation of Tendering Documents Phase

An implementation design for each facility will be performed in accordance with the results of the Outline Design Survey Report. After this, construction contract documents will be drafted, and approval for the following deliverables will be acquired from the Cambodian MPWT.

- Design Report
- Design Drawings
- Tendering Documents

2) Tendering for Construction Work Phase

With the assistance of the consultant, MPWT will select a Japanese construction company through open tendering. Additionally, an agent appointed by Cambodia to participate in this open tendering

and subsequent construction contracting will have the power to approve all matters pertaining the construction contract. The consultant will assist MPWT with the following matters.

- Invitation to tender
- Prequalification
- Tendering and tender evaluation

3) Construction Supervision Phase

A contract will be signed by the construction company selected through the results of tendering and the the MPWT, representing Cambodia. After this, the consultant will issue an order to begin construction work to the construction company, and begin to engage in construction supervision work. Construction supervision work will include directly reporting construction progress conditions to MPWT, the Embassy of Japan in Cambodia, and JICA. Other relevant organizations will be kept up to date as needed through monthly reports sent through postal mail services. Supervisory items directed at the contractors will include providing suggestions for improvements in administrative tasks pertaining to work progress, quality, safety, and payments, as well as for technical construction matters. Additionally, an inspection for defects will be conducted one year after construction supervision is completed. When this task is finished, consultant services will come to an end.

(3) Personnel Plan

The personnel necessary and their roles during the phases for detail design, construction work tendering, and construction supervision are described below.

1) Detail Design Phase

- Chief Consultant: In charge of technical aspects of the detail design, overseeing all work adjustments, and acting as the primary contact point for the client.
- Bridge Engineer (superstructure): Conducts field survey, structural calculations, and quantity surveying pertaining to the superstructure design, creates design drawings.
- Bridge Engineer (substructure): Conducts field survey, structural calculations, stability analysis, and quantity surveying pertaining to the substructure design, creates design drawings.
- Road Engineer: Conducts linear confirmation calculations, confirms standard cross-section drawings, examines slope construction, designs road drainage, creates design drawings, and conducts quantity surveying for the road design.
- River Engineer: Conducts field survey, structural calculations, stability analysis, and quantity surveying pertaining to the river structure design, creates design drawings.
- Work execution plan/cost estimation: Creates work execution plan and performs costs estimations from the detail design outcome using design quantities and construction cost units.
- Tendering documents: Creates tendering documents.

2) Tendering for Construction Work Phase

Assisting MPWT in the finalization of prequalification and tendering documents, execution of prequalification judging, and construction work tender assessment.

- Chief Consultant: Supervises the consultant services described above throughout the tendering work process.
- Bridge Engineer: Approves tendering documents and assists in tender assessment.

3) Construction Supervision Phase

- Chief Consultant: Supervises all consultant services during construction supervision.
- Resident Engineer: Conduct general on-site supervision, reports construction progress to relevant Cambodian organizations and makes adjustments.
- Structural Engineer: Reviews the Work Execution Plan for bridge and revetment work, supervises concrete construction work and superstructure PC strain. Also checks the subgrade revealed after excavation and makes on-site adjustments to foundation work if necessary.

2-2-4-5 Quality Control Plan

The quality control plan for the project is shown in the table below.

Table 2-2-30 List of Quality Control Items (draft)

Item			Test Method	Frequency of Test
Subgrade (macadam)	Blended material		Liquid limit, plasticity index (<sieve No. 4)	For each blend
			Particle-size distribution (blending)	〃
			Aggregate abrasion loss test	〃
			Aggregate density test	〃
			Maximum dry density (compaction test)	〃
	Laying		Density test (compaction rate)	Once/day
Prime coat / tack coat	Material	Bituminous material	Quality certificate	For each material
			Application amount	Per 500 m^2
Asphalt	Material	Bituminous material	Quality certificate, ingredient analysis table	For each material
		Aggregates	Particle-size distribution (blending)	For each blend, once/month
			Water absorption	For each material
			Aggregate abrasion loss test	〃
	Blending test		Stability	For each blend
			Flow value	〃
			Porosity	〃
			Aggregate porosity	〃
			Tensile strength (indirect)	〃
			Residual stability	〃
			Design asphalt amount	〃
	Laying		Mixing temperature	As needed
			Rolling temperature	For each transport
			Marshall test	About once/day
Concrete	Material	Cement	Quality certificate, chemical & physical test results	For each material
		Water	Ingredient test result	For each material
		Admixture	Quality certificate, ingredient analysis table	For each material
		Fine aggregates	Oven dry density	For each material
			Grain size distribution, fineness modulus	〃
			Percentages of clay lumps and soft particles	〃
		Coarse aggregates	Oven dry density	For each material
			Flake content	〃
			Particle-size distribution (mix)	〃
			Sodium sulfide diagnosis (missing mass)	〃
	At the time of blend test		Compressive strength test	For each blend
	At the time of laying		Slump	Once/batch
			Temperature	Once/day
	Strength		Compressive strength test (7 days, 28 days)	Once/day or = 50 m^3
Steel bars	Material		Quality certificate, tensile test result	For each lot
Structural steel	Material		Mill sheet	For each lot
Coating	Material		Quality certificate, ingredient table	For each lot
Bearing	Material		Quality certificate, strength test result	For each lot
Lighting equipment	Material		Quality certificate, strength test result	For each lot

2-2-4-6 Materials and Equipment Procurement Plan

(1) Construction Materials Procurement Plan

Materials that can be procured in Cambodia are cement, sand, aggregate, roadbed material, secondary concrete products, lumber, etc. Other materials are imported goods. The procurement policy for the primary materials is described below.

- An imported product will be procured if it is consistently offered on the market and is of sufficient quality.
- Products that cannot be locally procured will be procured from Japan or a third country. The country of procurement will be determined after comparing cost, quality, and the time required to clear customs.

Possible countries for the procurement for the primary construction materials are shown in the table below.

Table 2-2-31 Possible Countries for Procurement for Major Construction Materials

Item	Country of procurement			Reason for procurement from Japan
	Cambodia	Japan	3rd country	
PC steel material		○		Not in circulation in the target country. Possible to procure from a nearby 3rd country, but it is unclear if necessary specifications are met.
Steel railing		○		Material for the railing should be easy for passersby to see. The quality of products from nearby 3rd countries is inconsistent, which may cause problems in the finished structure.
Steel for temporary facilities and construction		○		Leased products, which cannot be procured locally, will be procured from Japan.
Rubber bearings		○		Not in circulation in the target country. Possible to procure from a nearby 3rd country, but the quality of the material (rubber) is inconsistent and may not meet project specifications.
Shaped steel		○		Not in circulation in the target country. Possible to procure from a nearby 3rd country, but it may not meet the necessary specifications.
Bitumen	○			
Aggregate	○			
Asphalt bitumen	○			
Portland cement	○			
Expansion devices		○		Not in circulation in the target country. It is possible to be procured from a nearby 3rd country, but the quality is highly inconsistent and may not meet project specifications.
Cement admixture		○		Will be procured from Japan for quality reasons.
Reinforcing bars	○			
Timber for formwork	○			
Plywood for formwork		○		Will be procured from Japan for quality reasons.
Steel form for main girders		○		Will be procured from Japan since precision is necessary.
Light oil	○			
Gasoline	○			
Bridge surface waterproofing materials		○		Local procurement or from nearby countries is difficult; normally imported from Japan when used locally.

(2) Construction Machinery

All of the construction equipment operated in Cambodia is imported. There are no leasing companies; construction machinery is owned by local contractors. There are not enough of the highly versatile heavy machines to be used for this project in the country; therefore, some backhoes, bulldozers, and tire rollers will be procured from Japan and/or a third country.

Special machinery such as large cranes, earth drills, and vibratory hammers will be procured from Thailand or Vietnam. Additionally, since previous successful use of SFRC paving equipment on a steel slab could not be verified in Cambodia or neighboring countries, this will be procured from Japan.

The possible countries for procurement of major construction machinery and reasons for procuring machinery from Japan are shown in the table below.

Table 2-2-32 Possible Countries for Procurement for Major Construction Machinery

Machinery	Specification	Country of procurement	Reason for procurement from Japan		
		Cambodia	Japan	3rd country	
Bulldozer	15 t, 21 t	○			
Backhoe (crawler)	0.6 m3	○			
Backhoe (wheel)	0.4 m3	○			
Dump truck	10 t	○			
Wheel loader	1.2 m3	○			
Trailer	20 t	○			
Truck crane	25 t	○			
Crawler crane	25-50 t	○			
Crawler crane	60-150 t		○	○	Difficult to procure locally.
Motor grader	3.1 m	○			
Load roller	10-12 t	○			
Tire roller	8-20 t	○			
Vibration roller	0.8-1.1 t	○			
Tamper	60-100 kg	○			
Large breaker (attachment)	1,300 kg	○			
Concrete plant	30m^3/hr			○	Difficult to procure locally.
Sprinkler truck	5,500 L			○	Difficult to procure locally due to small quantity available.
Crusher plant			○		Cannot be procured locally. Will be procured from Japan, where a plant can be designed to suit the attributes of the raw stone.
Concrete pump vehicle	90～110 m^3/h	○			
Large generator			○		Difficult to procure locally.
Steel wire jack	225 t		○		Difficult to procure locally.
Erection girder			○		Difficult to procure locally. Since it is also difficult to lease from a 3rd country (Thailand, etc.), this will be procured from Japan.

2-2-4-7 Soft Component Plan

(1) Background of Soft Component Plan

It was decided through the Preparatory Survey of the Project for Rehabilitation of the Chroy Changwar Bridge (Grant Aid) ("cooperation project") to remove and reconstruct the five-span PC girder bridge (2 continuous) of the Chroy Changvar Bridge, which is comprised of a three-span steel box-girder bridge (1 continuous), a two-span steel box-girder bridge (2 continuous), and the five-span bridge (2 continuous), as it is badly damaged.

Only two steel bridges have been constructed in Cambodia and the majority of bridges are concrete bridges (PC and RC bridges) and more concrete bridges are likely to be constructed. Particularly, the PC bridge will become the major type of bridge. As the new bridge is a four-span PC hollow plate deck bridge and it has versatility, it will be constructed frequently in the country.

However, Cambodia has insufficient experiences of planning, design, construction and maintenance of the PC bridge and the Ministry of Public Works and Transport (MPWT) does not seem to have sufficient capacity to instruct and supervise the process as a consultant. Thus, it is necessary to implement the soft component for MPWT employees to be directly engaged in the construction of the PC hollow plate deck bridge and acquire the skills of planning, design, construction and maintenance of the bridge.

As the soft component needs to be carried out from the early phase of the construction to its completion, it is required to be implemented a total of 21 months in the entire construction period.

(2) Objectives of Soft Component

The objectives of the soft component are for the engineers of the Ministry of Public Works and Transport (MPWT) in charge of bridge construction projects to:

① Deepen their understanding of characteristics (applicability, usability, economic efficiency and maintenance features) of PC bridge, increase related skills, and acquire PC bridge construction planning capacity by directly being engaged in the bridge construction;
② Understand design approaches of PC bridge and fully familiarize themselves with the design by working on the construction site;
③ Deepen their understanding of PC bridge construction and acquire consultation skills of the construction by directly instructing and supervising it; and
④ Understand the need for PC bridge maintenance skills after construction and acquire them by working on the construction site.

Table 2-2-33 Contents of the soft component

	Field	Content
1	Investigation	Soil, River
2	Plan	Bridge plan, Bridge length・Span length plan, Bridge type comparison
3	Design	Superstructure, Substructure, Foundation
4	Supervising	Safety management, Quality management, Process management
5	Construction	Superstructure, Substructure, Foundation, Approach road
6	Maintenance	Superstructure, Substructure, Bridge surface, Accessory, Pavement, Drainage, etc.

Table 2-2-34 List of Technical Trainees

Organization	Department	Rank	No. of trainees
Ministry of Public Works and Transport (MPWT)	Department of Road Infrastructure	engineer	2
Department of Public Works and Transport (DPWT)	Phnom Penh Division	engineer	1

(3) Outcomes of Soft Component

① MPWT and DPWT employees in charge understand characteristics (applicability, usability, economic efficiency and maintenance features) of PC bridge and are capable of planning PC bridge construction.

② MPWT and DPWT employees in charge understand design approaches of PC bridge and are capable of the designing.

③ MPWT and DPWT employees in charge acquire consultation skills of PC bridge construction by deepening their understanding of the bridge construction.

④ MPWT and DPWT employees in charge understand the need for PC bridge maintenance skills after construction and acquire such skills they will need in the future.

(4) Checking of Achievement Level of Outcomes

Since the technology transfer by the soft component assistance is mainly related to the lectures and the field OJT regarding research, planning, design and management,

the level of achievement will be confirmed by questionnaires and hearing at the end of each phase in the lecture and the field OJT.

Table 2-2-35 Checking of Achievement Level of Outcomes

Outcome	Indicator (item to be checked)	Timing of the Checking during Project implementation Period
MPWT employees in charge understand characteristics of PC bridge and acquire PC bridge construction planning skills.	・Understanding of characteristics of PC bridge ・Understanding of PC bridge construction planning	Early phase
MPWT employees in charge understand PC bridge design and acquire the designing skills.	・Understanding of PC bridge design approaches ・Understanding and acquisition of PC bridge design skills	Mid-phase I
MPWT employees in charge understand PC bridge construction and acquire consultation skills for the construction.	・Understanding of PC bridge construction ・Understanding and acquisition of consultation skills for the construction	Mid-phase II
MPWT and DPWT employees in charge understand the need for PC bridge maintenance skills after construction and acquire such skills they will need in the future.	・Understanding of the need for PC bridge maintenance skills ・Understanding and acquisition of PC bridge maintenance skills	Late phase

(5) Soft Component Activities (Input Plan)

Soft component activities are carried out in four segments: early phase (5 months), mid-phase I (5 months), mid-phase II (6 months), and late phase (5 months).

- The early phase is to deepen understanding of characteristics (applicability, usability, economic efficiency and maintenance features) of PC bridge, increase related skills, and acquire PC bridge construction planning capacity.
- The mid-phase I is to understand design approaches of PC bridge and acquire the designing capacity.
- The mid-phase II is to deepen understanding of PC bridge construction and acquire consultation skills for the construction.
- The late phase is to understand the need for PC bridge maintenance skills after construction and acquire such skills they will need in the future.

Personnel in charge of the soft component are following three persons:

- Personnel 1: PC bridge planning and design
- Personnel 2: PC bridge construction and maintenance

・ Personnel 3: Outcome achievement of confirmation and reporting

The personnel 1 and 2 are planned to be input for 4M/M each and the personnel 3 is planned to be input for 1M/M from Japan (as shown in 7. Implementation Schedule).

The group of trainees shall produce a report and workshop materials as deliverables to ensure the independent development of activities.

(6) Acquisition of Implementation Resources

The personnel who help Cambodian engineers achieve the objectives described in 2 above are required to be equipped with abundant experiences and knowledge related to their themes for the achievement described below.

➢ Personnel 1

- Have experiences of PC bridge planning and capacity to provide technical training of the construction planning.
- Have experiences of PC bridge designing and capacity to provide technical training of the designing.

➢ Personnel 2

- Have experiences and consultation skills of PC bridge construction and capacity to provide technical training of the construction.
- Have experiences and skills of PC bridge maintenance and capacity to provide technical training of the maintenance.

➢ Personnel 3

- Have the knowledge of the planning, design, construction and maintenance of PC Bridge, and have the ability to verify the achievement of the soft component.
- Have the ability to report the content and achievement of the soft component to JICA and the recipient government.

However, such personnel cannot be secured in Cambodia as it has insufficient experiences of PC bridge construction projects and thus there is no other choice but to use Japanese personnel.

(7) Implementation Schedule

The overall soft component implementation schedule is shown in the figure below.

As for the weekly schedule, Mondays are for lectures given by personnel or assistant, Tuesdays are for self-study of the trainees, Wednesdays to Fridays are for on-the-job training.

Table 2-2-36 Overall Soft Component Implementation Schedule

Item \ Year/Month	Early Phase					Mid-Phase I					Mid-Phase II						Late Phase				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Construction																					
Soft Component Personnel Dispatch Schedule																					
Personnel 1	(Lectures and training)					(Lectures and training)															
Personnel 2												(Lectures and training)					(Lectures and training)				
Personnel 3			(Evaluation and reporting)						(Evaluation and reporting)				(Evaluation and reporting)					(Evaluation and reporting)			
Contractor Assistant Schedule																					
Assistant 1																					
MPWT and DPWT Trainee Schedule																					
Trainee 1 (MPWT)																	(Training in Japan)				
Trainee 2 (MPWT)																	(Training in Japan)				
Trainee 3 (DPWT)																	(Training in Japan)				

(8) Deliverables

♦ Workshop materials for PC bridge construction

♦ Completion report

(9) Responsibilities of Recipient Country

The relevant organizations of the recipient country of the soft component shall select the participants in the on-the-job training and workshop and bear travel expenses and other costs necessary for the participation. They shall also provide the venue for the indoor workshop, if organized.

2-2-4-8 Implementation Schedule

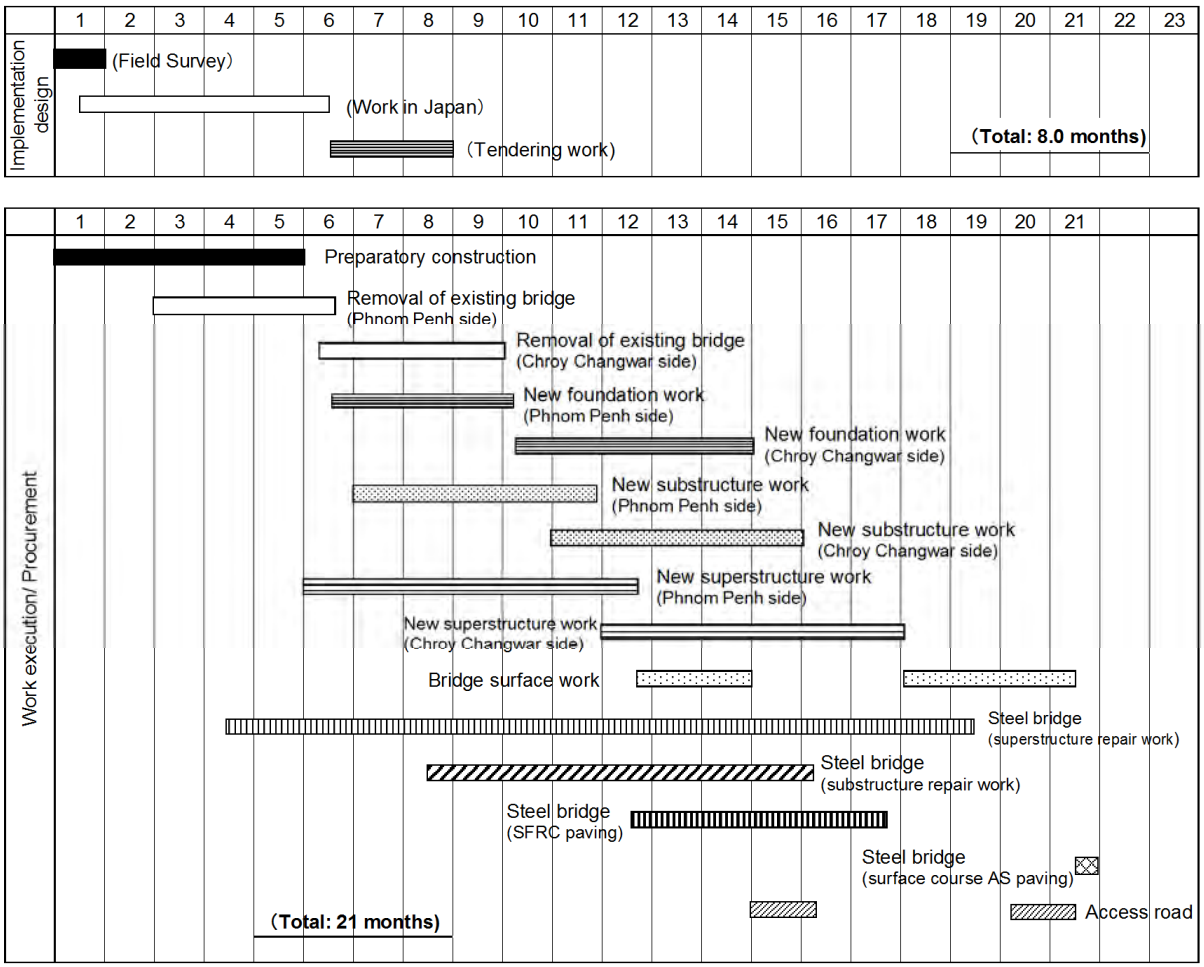
After concluding the Exchange of Notes (E/N) pertaining to the implementation design of the project, the consultant will sign a consultant agreement with the Government of Cambodia to begin the implementation design work for this project as a Japanese grant aid project. After operations are begun, the consultant will implement a field survey for the implementation design for approximately two weeks, after which the detailed design and tendering documents will be created in Japan.

Subsequently, after concluding the Exchange of Notes (E/N) pertaining to tendering assistance work, construction supervision work, and the main construction, the consultant will prepare tendering documents, and assist in work related to prequalifying contractors, tendering, contractor selection, and construction contract tendering as a part of the tendering assistance services to be provided to the Government of Cambodia.

After tendering, the construction contractor will enter into a construction agreement with the Government of Cambodia. After the construction agreeement is certified by the Government of Japan, the construction contractor will begin work upon receiving written orders issued by the consultant.

The implementation schedule described above is shown in Table2-2-37 below.

Table2-2-37 Work Implementation Schedule



2-3 Summary of Responsibilities of Recipient Country

The following items are to be undertaken by the Government of Cambodia for the implementation of the project.

2-3-1 General Items for Japanese Grant Aid Projects

- To provide the data and information necessary for project implementation.
- To secure the land necessary for the implementation of the project (land for roads, work, camp yards, and material/equipment storage).
- Each construction site will be cleared prior to the start of construction.
- To open an account with a bank in Japan in the name of the Government of Cambodia as the account holder; to issue authorization to pay (A/P).
- To ensure prompt unloading work at the port of disembarkation in Cambodia, implement tax exemption measures and customs duty exemptions.
- To accord Japanese nationals or companies whose services may be required in connection with the supply of the products and services for the certified contract exemption from customs duties, internal taxes, and other fiscal levies which may be imposed in Cambodia.
- To accord project personnel entry into Cambodia and stay therein for the performance of their work, based on the approved contract and pertaining to the supply of their services.
- To accord permissions and other authority for project implementation as needed.
- To ensure that the facilities built under the project be maintained, managed, and protected in a proper and effective manner.
- To bear all expenses, other than those covered by Japanese grant aid, within the scope of project operations.

2-3-2 Project-Specific Items

- To remove facilities impacted by the construction.
- To secure additional land needed for the project, other than the land used for existing roads.
- To provide and clear a temporary yard.
- To provide a site to dispose of waste and soil.

(Before the PQ public notice)

- To monitor the entire construction area during the construction work period.
- Cambodian Government officials are to oversee operations during the period of construction.

2-4 Operation and Maintenance Plan for the Project

Cambodia will manage the operation and maintenance plan of this project. Maintenance management after construction of the Chroy Changwar Bridge will implemented by the MPWT and the RID. Everyday maintenance management will be conducted by the Department of Public Works and Transport (DPWT) in Phnom Penh, where the bridge is located.

Maintenance management work after the project is completed will be broadly divided into tasks to be performed annually and those performed every certain number of years. The work items shown below must be conducted for the project.

(1) Inspections and Maintenance Required Annually

The inspections and maintenance needed annually are as shown below.

- Cleaning and removal of sand and debris accumulated in the drainage pipes and ditches on the bridge surface
- Cleaning and removal of debris around expansion joints and bearings
- Traffic safety structure maintenance including repainting of road surface markings
- Weed removal on road shoulders and slopes
- Pavement patching
- Inspection/repairs of revetments after flooding
- Removal of washed up rocks and trees after flooding

(2) Maintenance Performed in Multiple-Year Units

The maintenance to be conducted approximately once per five years is shown below.

- Pavement overlaying on bridge surface and access roads
- Inspection, repainting, and repair of railings
- Inspection/repairs of revetments
- Inspection, repainting, and repair of railings

2-5 Estimated Costs for the Project

2-5-1 Estimated Grant Aid Project Costs

2-5-1-1 Cost Born by the Government of Japan

The project will be implemented in accordance with the Japan's Grant Aid scheme and the cost will be determined before concluding the Exchange of Note for the project.

2-5-1-2 Expenses Borne by the Cambodian Side

Table 2-5-1 Expenses Borne by the Cambodian Side

Item	Amount (1,000 USD)	Converted amount (million yen)
(1) Land acquisition cost	379.7	45.50
(2) House compensation cost	31.8	3.80
(3) Resettlement cost	1.3	0.20
(4) House demolishment cost	0.1	0.01
(5) Land leasing cost	345.0	41.30
(6) Other mitigation cost	8.0	0.96
(7) Cost of relocating utilities, etc.	850.0	101.80
(8) Construction of detour road	42.2	5.10
(9) Bank handling fees	26.7	3.20
Total	1,684.8	201.87

2-5-1-3 Calculation Conditions

- Time of calculation: March 2015
- USD exchange rate: US$1.0= 119.79 JP¥ (average of three months immediately prior to February 28, 2015)
- Cambodian Riel exchange rate: KHR1.0= 0.029 JP¥ (average of three months immediately prior to February 28, 2015)
- Period of construction work: 21 months
- Other: This project will be implemented following the guidelines for Japanese grant aid. The estimated project cost above can be revised by the Government of Japan before the E/N.

2-5-2 Operation and Maintenance Costs

The maintenance management of the new bridge built under the project, the existing steel bridge after repairs are made, and the access roads will be the responsibility of the MPWT, RID, and the DPWT. The primary maintenance work that must be done after construction of the Chroy Changwar bridge consists of the everyday inspections, cleaning, and repairs shown in Table 2-5-2. The maintenance management cost (converted to annual average) is estimated to be UD$ 59,700. This maintenance cost is 0.12% of the MPWT's maintenance budget of US$ 50 million (FY 2014), making it possible to implement sufficient maintenance management.

Table 2-5-2 Primary Maintenance Management Items and Costs

Category	Frequency	Inspection area	Content of work	Estimated cost (1,000 USD)		Remarks
				Per occurrence	Per year (yearly average)	
Maintenance and management of drainage ditch	Twice per year	Bridge surface drainage ditch	Removal of accumulated sand	18.8	37.6	
Maintenance and management of traffic safety structures	Once per year	Road markings	Repainting	9.3	9.3	Estimated at 10% of direct construction cost
Road maintenance	Twice per year	Road shoulder and slopes	Weed removal	2.4	4.8	
Pavement maintenance repair	Once per 5 years	Pavement surface	Repair of overlay, pavement cracks, potholes	19.1	3.8	Estimated at 10% of direct construction cost
Inspection and repair of revetments	After flooding (estimated at once per 2 years)	Revetment, bed	Repair of damaged areas	8.4	4.2	Estimated at 2% of direct construction cost
Annual converted amount of maintenance fees above					59.7	

Note: Indirect costs are estimated at 40% of direct construction costs.

Chapter 3 Project Evaluation

Chapter 3 Project Evaluation

3-1 Preconditions for Project Implementation

Major preconditions for project implementation are as follows.

① While relocation of water supply pipes, high-voltage lines, fiber optic cables, communications cables, etc. is needed in relation to the removal and construction of PC approach bridge parts, these relocation must be completed before the public announcement of PQ.

② While resettlement of up to 84 inhabitants in 21 households is needed in relation to the removal and construction of the PC approach bridge part on the Chroy Changwar side, these resettlement and removal must be completed before the public announcement of PQ.

③ While the project requires land leasing of 1,400 m2 on the Phnom Penh side and land acquisition of 348.84 m2 and leasing of 10,900 m2 on the Chroy Changwar side, these acquisition and leasing must be completed before the public announcement of PQ.

④ Approval of environmental impact assessment (EIA) must be obtained in relation to bridge construction

⑤ While temporary yards and stock yards are needed for bridge rehabilitation, these places must be determined before the public announcement of PQ.

⑥ While muck disposal yards and waste disposal yards are needed for bridge rehabilitation, these places must be determined before the public announcement of PQ.

⑦ While closure of traffic is needed in relation to bridge rehabilitation, measures to mitigate traffic congestion must be formulated before the public announcement of PQ.

3-2 Necessary Inputs by Recipient Country for Fulfilment of the Overall Project Plan

The matters that should be performed by the recipient country to realize and maintain project effects are as follows.

① Budget must be secured in advance to cover the matters described in “2-5-1-2 Costs to Be Borne by the Cambodian Side” in this report to ensure the smooth implementation of this project.

② Among the matters listed above, it is necessary to complete the removal and relocatio of obstacles and the provision of leased land for work yards, stock yards, etc. before the beginning of work without fail.

③ To ensure the permanent functioning of the bridge and approach roads rehabilitated in this project, it is necessary to perform the maitenance works described in “2-4 Project Operation and Maintenance Plans” in this report, and necessary personnel and funds must be secured.

3-3 External Conditions

The external conditions needed for the realization and maintenance of project effects are listed below.

① Although the new bridge and the approach roads are designed with the design load covering trailer loads (43 tons), prohibition of overloading, prosecution of offenders, and other measures must be exercised to ensure the longevity of service life.

3-4 Project Evaluation

3-4-1 Relevance

For the following reasons, it is considered relevant to implement the cooperation project under Japanese grant aid.

① The beneficiaries of the project are a large number of general citizens in the nine northeastern provinces including Phnom Penh city and the northern suburbs of the city (directly 1.33 million citizens of Phnom Penh and indirectly 4.92 million inhabitants of the nine northeastern provinces).

② The bridge requires prompt actions in view of the urgency of needs, since it has been severely damaged from deteriorating and the increase in traffic volume, and there is a concern about bridge collapse due to a lack of sufficient durability for the passage of large vehicles.

③ Operation and maintenance after completion can be conducted by the Cambodian side using its own personnel and technologies, without requiring excessively advanced technologies.

④ This project has been positioned as a concrete strategy in the National Strategic Development Plan (NSDP 2014-2018) of Cambodia, and is included in the improvement program for National Road 6A, which is one of the most important trunk roads in Cambodia.

⑤ While this project involves relocation of inhabitants and businesses, there will be no particular problems, as approval and understanding concerning the project have been obtained from those affected.

⑥ The project can be implemented without particular difficulty using the grant aid scheme of Japan.

⑦ Because the bridge is a long PC bridge with the length of 85.2 m (4 @ 21.3 m) on the Phnom Penh side and 77.2 m (4 @ 19.3 m) on the Chroy Changwar side, it is difficult to design and construct using the technologies available in Cambodia, and the use of Japanese technologies is supported by necessity and advantage.

3-4-2 Effectiveness

(1) Quantitative Effects

The quantitative effects expected from the implementation of this project are as follows.

Table 3-4-1 Quantitative Effects

Indicator	Baseline value (actual in 2015)	Target value (2021) 【3 years after project completion】
Increase in mean travel speed (km/h)	26.8	40.0
Increase in the use by large vehicles (vehicles/day)	0 (*)	1,278

(*) Because restriction is imposed on the passage of large vehicles.

(2) Qualitative Effects

The qualitative effects expected from the implementation of this project are as follows.

① While the existing bridge has been severely damaged from deteriorating and the increase in traffic volume, and a risk of bridge collapse has been pointed out, replacement with a new bridge will eliminate the risk of bridge collapse and ensure stable physical distribution and movement of people.

② For the inhabitants in the northern part of Phnom Penh, this project will help improvement of the basic human needs (BHN) through the improvement of access to schools, hospitals, and workplaces in the city.

③ This project will help vitalization of local economic activities through stable transport of agricultural and forestry products from the nine northeastern provinces of Cambodia to Phnom Penh city.

Based on the above, this project is considered highly relevant and expected to be effective.