2.2.3 Basic Design Drawings

2.2.3.1 Bridge Outline

Based on the examination, each bridge is outlined in Table 2-8 and 2-9.

Table 2-8 Bridge Outline (1)

Bridge Name	Lawakha Bridge	Basochu Bridge	Nyarachu Bridge
Bridge Type	Simple composite steel I girder bridge	PC box girder bridge	PC box girder bridge
Bridge Length	45.0m	40.0m	40.0m
Span Length	44.0m	39.0m	39.0m
Girder Height	2.2m×3 main girders	2.2m	2.2m
Width	6.0m (2-lane)	6.0m (2-lane)	6.0m (2-lane)
Foundation	Spread foundation (A1 abutment) Caisson type pile foundation (φ2.0m、A2 abutment)	Spread foundation (A1, A2 abutment)	Spread foundation (A1, A2 abutment)
Major Materials	Steel material (SMA490, SMA400 : using weathering steel) Concrete σ_{ck}=21N/mm^2(abutment) σ_{ck}=24N/mm^2(Caisson type pile foundation) σ_{ck}=30N/mm^2(Superstructure deck slab)	Main girder concrete (σ_{ck}=30N/mm^2) Concrete (σ_{ck}=21N/mm^2)	Main girder concrete (σ_{ck}=30N/mm^2) Concrete (σ_{ck}=21N/mm^2(abutment))
Superstructure Construction	Launching method using temporary vent (2 units)	Stationary scaffolding using columns ＋ river cutaway	Stationary scaffolding using columns ＋ river cutaway
Earth Retaining Method	Earth retaining wall for earthwork of A2 abutment using soldier piles and lagging method	Earth retaining wall for earthwork of A1 and A2 abutment using soldier piles and lagging method	Earth retaining wall for earthwork of A2 abutment using soldier piles and lagging method
Remarks	➢ Necessary to relocate the existing bridge ➢ Retaining wall for the approach road at Punatsangchu Dam and junction with the national highway are scheduled in the vicinity of A1 abutment.	➢ Well point drainage of spring water at the excavation for abutments using a submerged pump	➢ Well point drainage is jointly applied using cut-off wall by chemical injection and a submerged pump for good permeability on ground to be load bearing layer for bridge abutments ➢ Due to high road height of the bridge, traffic should be restricted for smoothing the existing national highway.

Table 2-9 Bridge Outline (2)

Bridge Name	Burichu Bridge	Chanchey Bridge	Loring Bridge
Bridge Type	PC box girder bridge	PC box girder bridge	Simple steel Langer bridge
Bridge Length	50.0m	45.0m	70.0m
Span Length	48.9m	43.9m	68.6m
Girder Height	2.8m	2.5m	11.0m
Width	6.0m (2-lane)	6.0m (2-lane)	6.0m (2-lane)
Foundation	Spread foundation (A1、A2 abutment)	Caisson type pile foundation (φ3.0m, A1・A2 abutment)	Spread foundation (A1 abutment) Caisson type pile foundation (φ3.0m、A2 abutment)
Major Materials	Main girder concrete (σ_{ck}=30N/mm^2) Concrete (σ_{ck}=21N/mm^2(abutment))	Main girder concrete (σ_{ck}=30N/mm^2) Concrete σ_{ck}=21N/mm^2(abutment) σ_{ck}=24N/mm^2 Caisson type pile foundation, superstructure deck slab)	Steel material (SMA490, SMA400 : using weathering steel) Concrete σ_{ck}=21N/mm^2(abutment) σ_{ck}=24N/mm^2(Caisson type pile foundation, superstructure deck slab)
Superstructure Construction	Stationary scaffolding using columns ＋ river bypath	Stationary scaffolding using pickets ＋ river bypath	Cable erection ＋ vertical hanging method
Earth Retaining Method	Earth retaining wall for earthwork of A 1 and A2 abutment using soldier piles and lagging method	Earth retaining wall for earthwork of A1 abutment using soldier piles and lagging method	Earth retaining wall for earthwork of A2 abutment using soldier piles and lagging method
Remarks	-	-	-

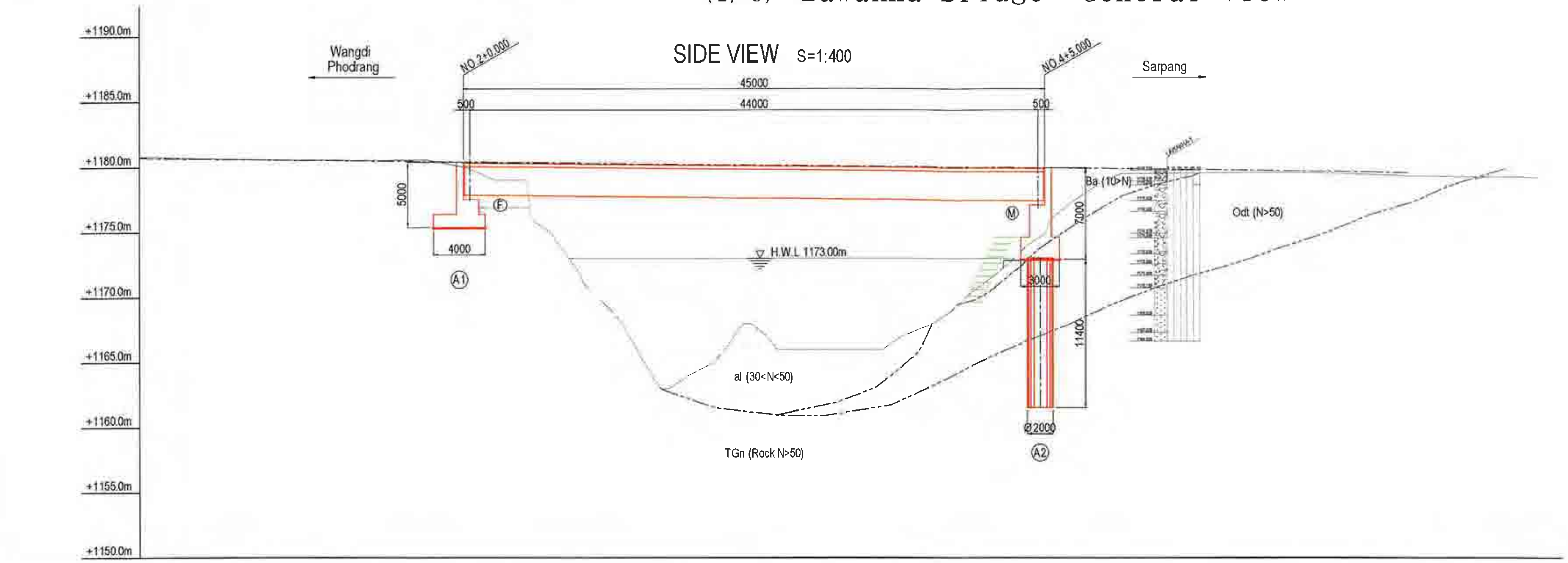
2.2.3.2 Basic Design Drawings

General basic design drawings for the proposed bridges are shown on the following pages.

Table 2-10 List of Basic Design Drawings

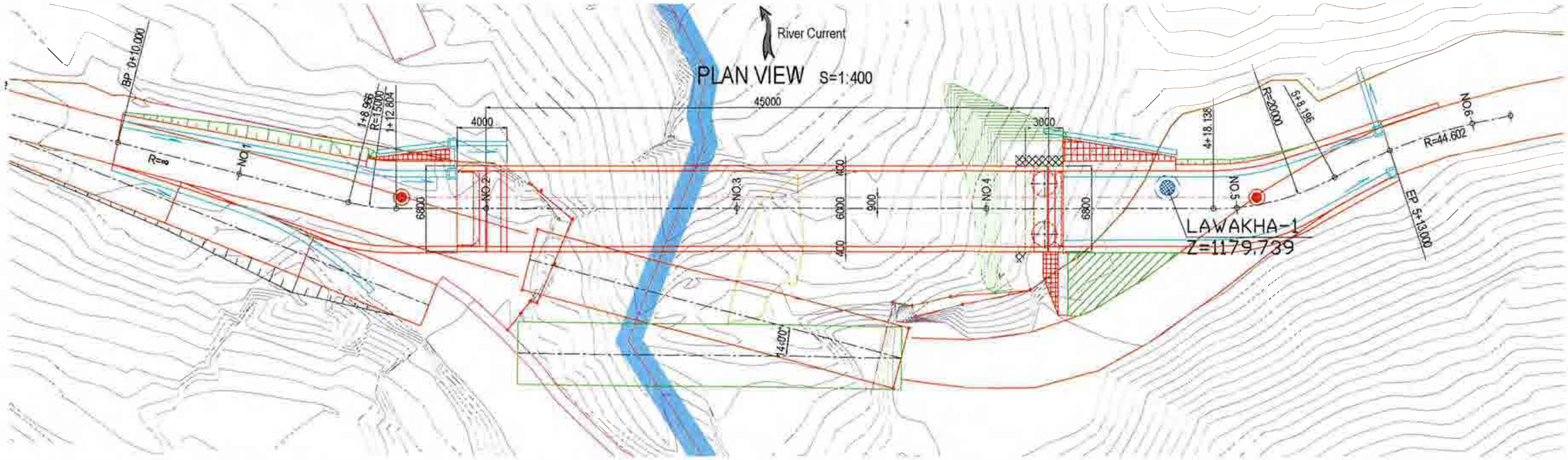
Drawing No.	Description	No. of Drawings
1/6	Lawakha Bridge General View	1
2/6	Basochu Bridge General View	1
3/6	Nyarachu Bridge General View	1
4/6	Burichu Bridge General View	1
5/6	Chanchey Bridge General View	1
6/6	Loring Bridge General View	1

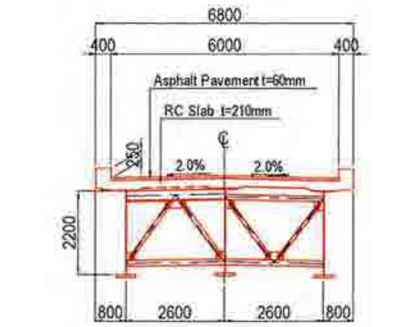
(1/6) Lawakha Bridge General View

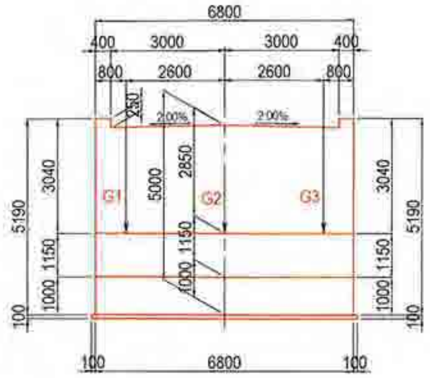


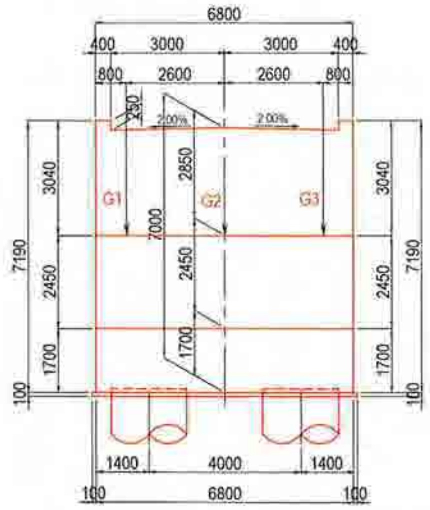
Gradient: i=1.250% L=20.000m; (1180.650) VCL=20.00m VCR=8000m; i=1.500% L=70.000m; VCL=20.00m VCR=17000m (1179.600); i=1.615% L=13.000m; (1179.390)

Station	NO.1	+8.966	+10.000	+12.804	A1 NO.2	NO.3	NO.4	A2 +5.000	+18.138	NO.5	+8.196	+13.000	NO.6
Proposed Height	1180.775	1180.658	1180.644	1180.605	1180.500	1180.200	1179.900	1179.825	1179.626	1179.597	1179.468	1179.390	
Ground height	1180.67	1180.55	1180.54	1180.50	1180.02	1165.78	1170.91	1174.87	1179.53	1179.55	1179.49	1179.39	1179.28
Distance	10.000	8.966	1.034	2.804	7.196	20.000	20.000	5.000	13.138	1.862	8.196	4.804	7.000









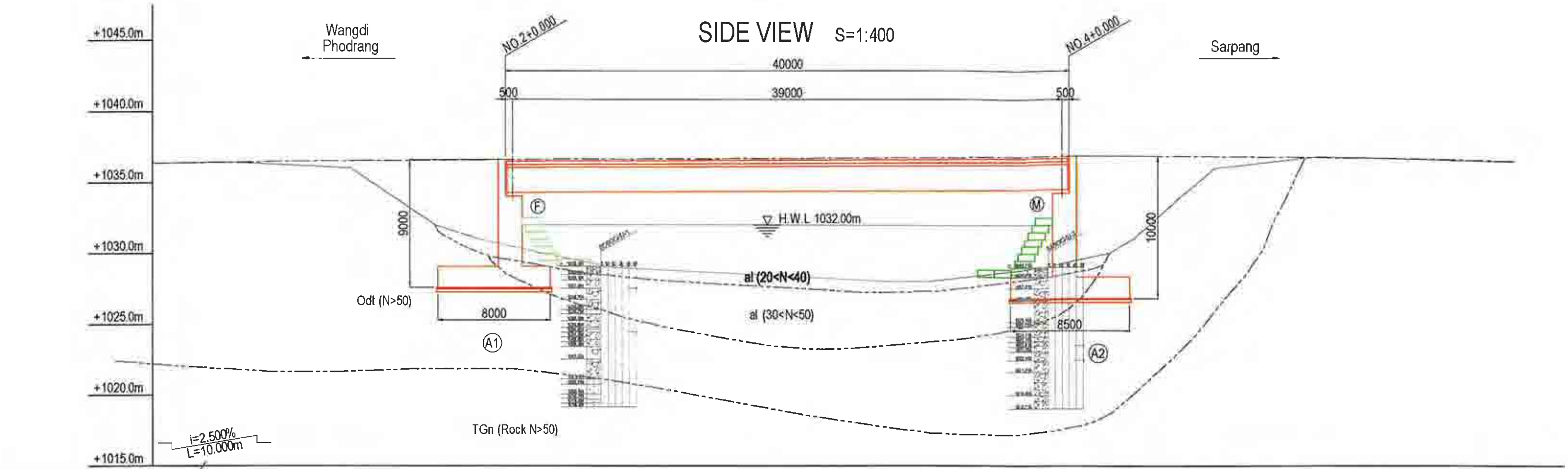
The Terms Of Design

Bridge Order			First Order Bridge
Bridge Length			45.000m
Span Length			44.000m
Road Width			6.000m
Live Load			IRC Class A
Design Seismic Scale			KH=0.22 KV=0.00
Super structure	Form		Composite Simple Steel I Girder
	Material strength	Concrete	σck=30 N/mm ^{2}
		Reinforcig Bar	SD295
		Steel	σta=210N/mm ^{2} (SMA490W) σta=140N/mm ^{2} (SMA400W)
Sub structure	Form	Structure	Inverted Type Abutment
		Foundation	Spread Foundation
	Material strength	Concrete	σck=21 N/mm ^{2}
		Reinforcig Bar	SD295

MINISTRY OF WORKS AND HUMAN SETTLEMENT DEPARTMENT OF ROADS	THE PROJECT FOR RECONSTRUCTION OF BRIDGES (PHASE III) IN KINGDOM OF BHUTAN	JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	TITLE	SCALE	DATE	DRAWING NO
			1_LAWAKHA-BRIDGE	1:400		

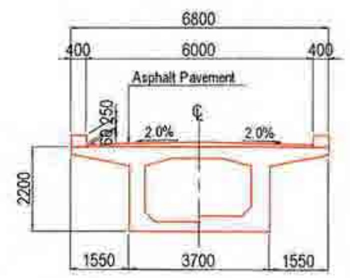
(2/6) Basochu Bridge General View

SIDE VIEW S=1:400

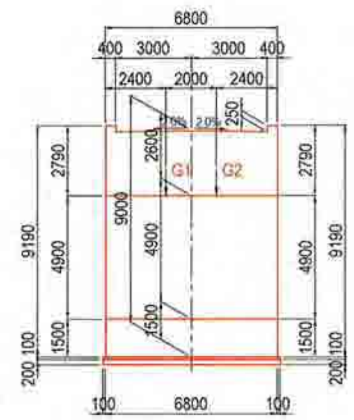


Gradient	1036.480			VCL=20.00m VCR=1100m / i=0.600% L=70.000m	VCL=20.00m VCR=800m	1036.900	i=1.900% L=10.000m / 1036.710		
Proposed Height	1036.432	1036.510	1036.600	1036.720	1036.840 1036.843	1036.837	1036.71		
Ground height	1036.44	1036.14	1030.60	1028.35	1029.39 1029.50	1035.72	1036.71	1036.54	1036.41
Distance	6.061	6.121	13.879	20.000	20.000 0.491	9.509	10.000	5.916	5.584
Station	NO.1	+6.121	A1 NO.2	NO.3	A2 NO.4 +0.500	+10.000	NO.5	+5.926	+11.500

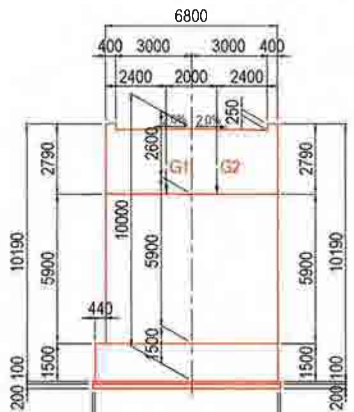
CROSS SECTION S=1:200

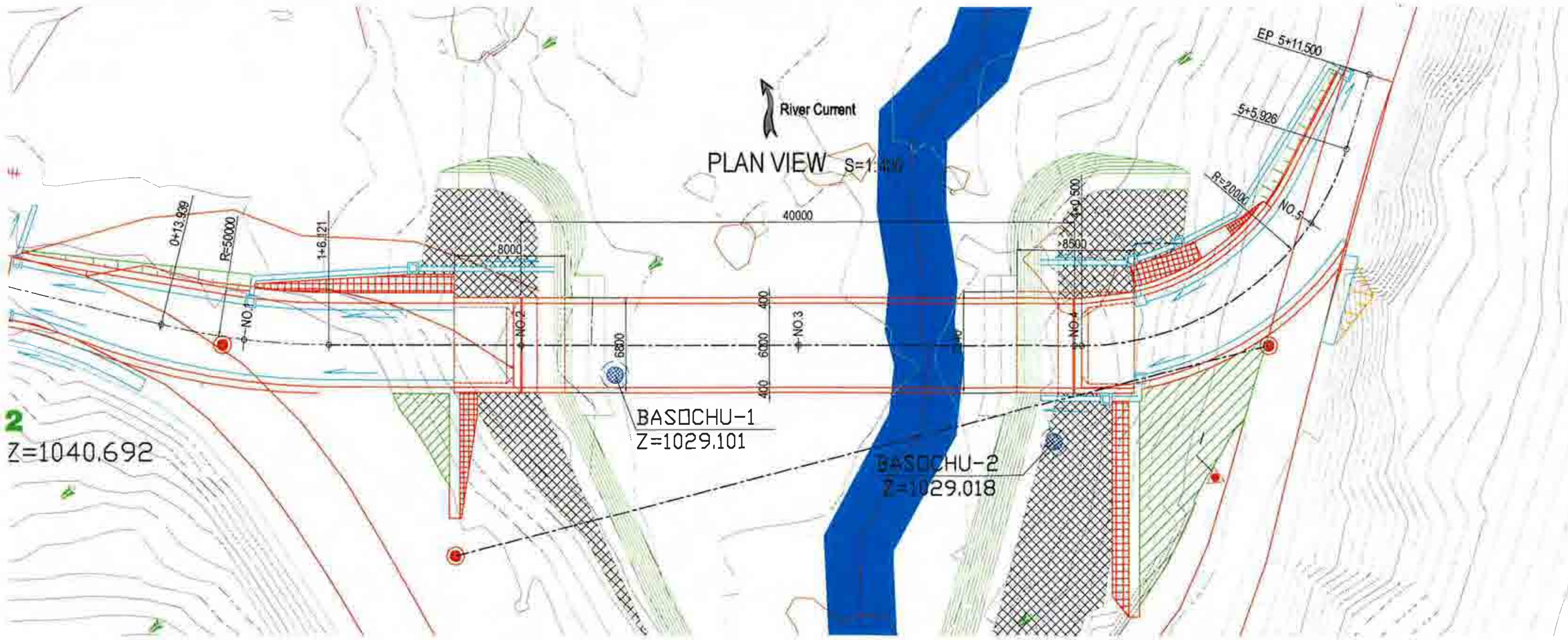


A1-ABUT S=1:300



A2-ABUT S=1:300





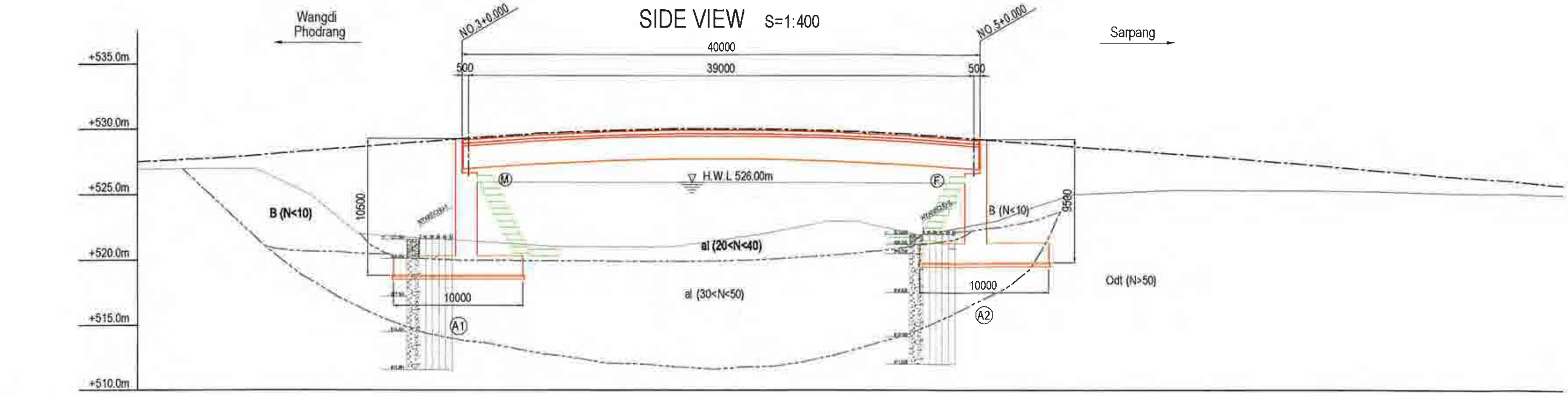
The Terms Of Design

Bridge Order			First Order Bridge
Bridge Length			40.000m
Span Length			39.000m
Road Width			6.000m
Live Load			IRC Class A
Design Seismic Scale			KH=0.22 KV=0.00
Super structure	Form		Pre-stress Concrete box Girder
	Material strength	Concrete	σck=30 N/mm ^{2}
		Reinforcig Bar	SD295
		Tendon	12S12.7mm
Sub structure	Form	Structure	Inverted Type Abutment
		Foundation	Spread Foundation
	Material strength	Concrete	σck=21 N/mm ^{2}
		Reinforcig Bar	SD295

MINISTRY OF WORKS AND HUMAN SETTLEMENT DEPARTMENT OF ROADS	THE PROJECT FOR RECONSTRUCTION OF BRIDGES (PHASE III) IN KINGDOM OF BHUTAN	JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	TITLE	SCALE	DATE	DRAWING NO.
			2_BASOCHU-BRIDGE	1:400		

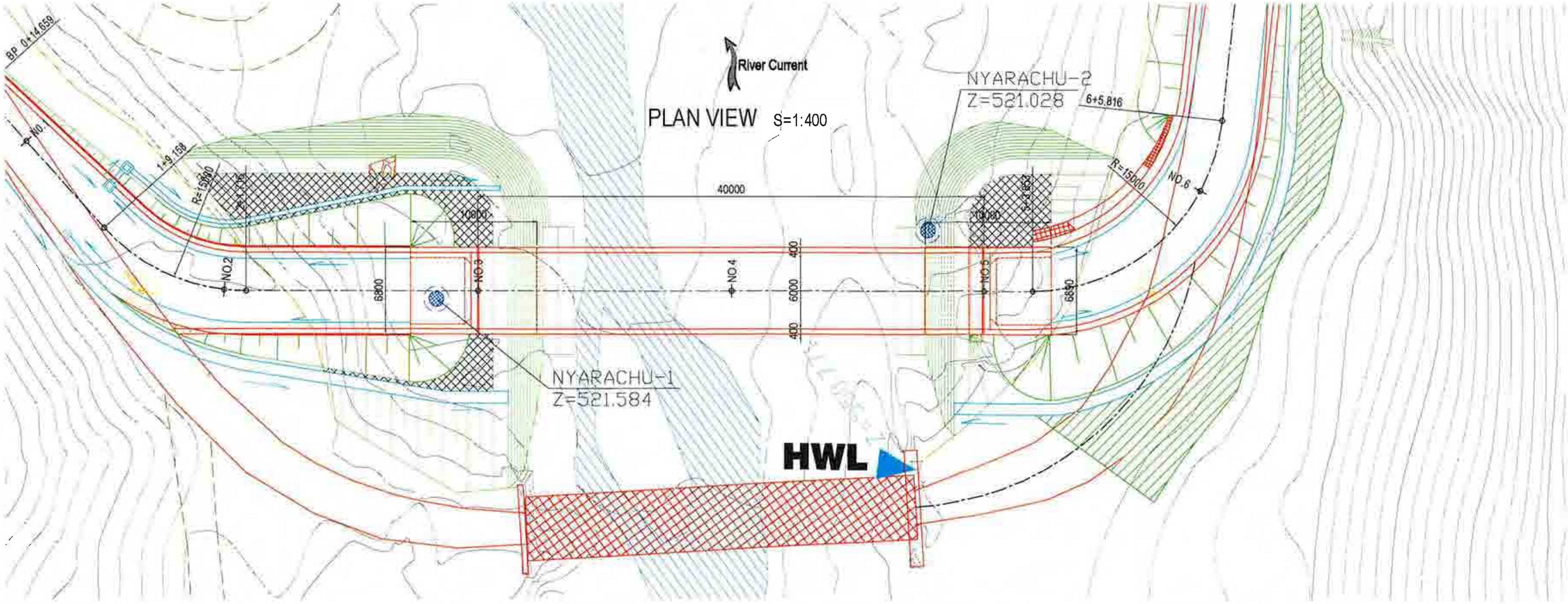
(3/6) Nyarachu Bridge General View

SIDE VIEW S=1:400

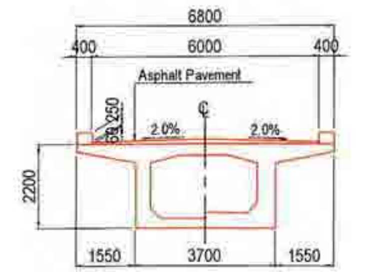


Gradient	i=8.000% L=48.275m			VCL=40.00m 530.900 VCR=250m			i=8.000% L=77.000m		
Proposed Height	527.708	527.837	529.300	530.100	529.300	528.992	527.700	527.235	526.100
Ground height	526.98	526.99	521.48	521.56	522.77	523.94	525.31	525.30	525.05
Distance	8.275	1.716	18.284	20.000	20.000	3.853	16.147	5.816	14.184
Station	NO.2	+1.716	A1 NO.3	NO.4	A2 NO.5	+3.853	NO.6	+5.816	NO.7

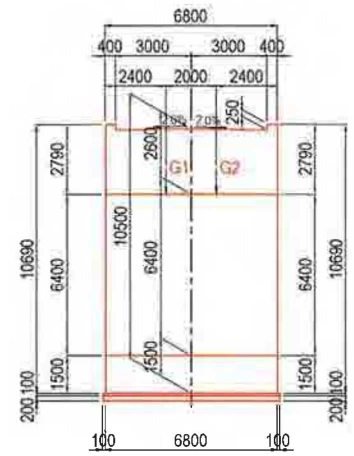
PLAN VIEW S=1:400



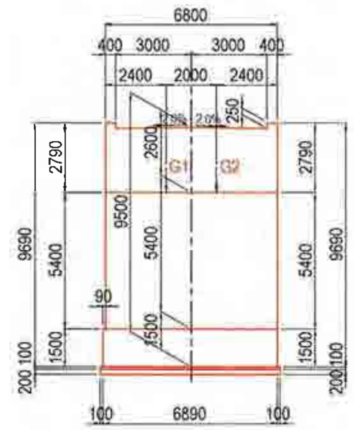
CROSS SECTION S=1:200



A1-ABUT S=1:300



A2-ABUT S=1:300

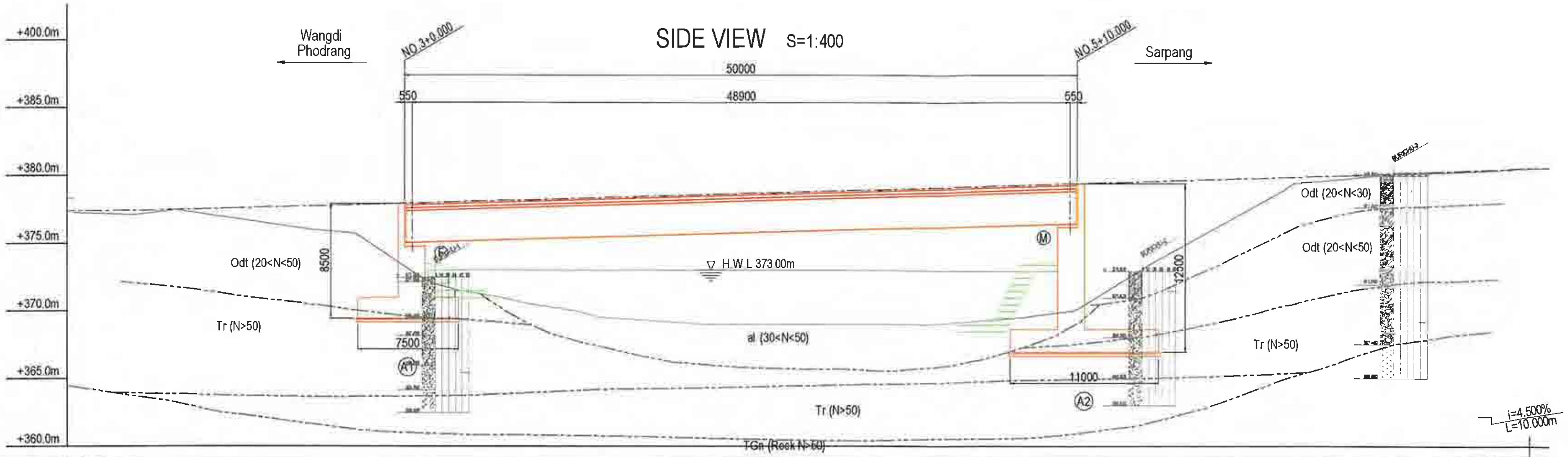


The Terms Of Design

Bridge Order			First Order Bridge
Bridge Length			40.000m
Span Length			39.000m
Road Width			6.000m
Live Load			IRC Class A
Design Seismic Scale			KH=0.22 KV=0.00
Super structure	Form		Pre-stress Concrete box Girder
	Material strength	Concrete	σck=30 N/mm ^{2}
		Reinforcig Bar	SD295
		Tendon	12S12.7mm
Sub structure	Form	Structure	Inverted Type Abutment
		Foundation	Spread Foundation
	Material strength	Concrete	σck=21 N/mm ^{2}
		Reinforcig Bar	SD295

MINISTRY OF WORKS AND HUMAN SETTLEMENT DEPARTMENT OF ROADS	THE PROJECT FOR RECONSTRUCTION OF BRIDGES (PHASE III) IN KINGDOM OF BHUTAN	JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	TITLE	SCALE	DATE	DRAWING NO.
			3_NYARACHU BRIDGH	1:400		

(4/6) Burichu Bridge General View

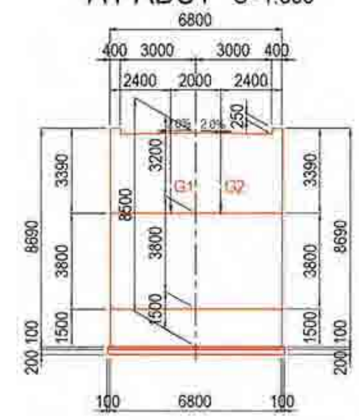


SIDE VIEW S=1:400

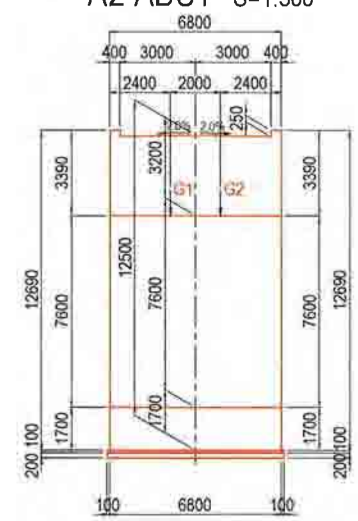
Gradient: 377.260 VCL=20.00m VCR=400m; i=3.000% L=103.000m; VCL=20.00m VCR=1300m 380.350

Station	+15.765	+17.000	NO.2	A1 NO.3	NO.4	NO.5	A2 +10.000	NO.6	+10.000	NO.7	+1.286
Proposed Height	377.381	377.385	377.411	377.950	378.550	379.150	379.450	379.750	380.050	380.387	380.436
Ground height	377.26	377.21	377.10	373.26	369.14	369.08	370.14	376.05	379.80	380.33	380.38
Distance	8.765	1.235	3.000	20.000	20.000	20.000	10.000	10.000	10.000	10.000	1.286

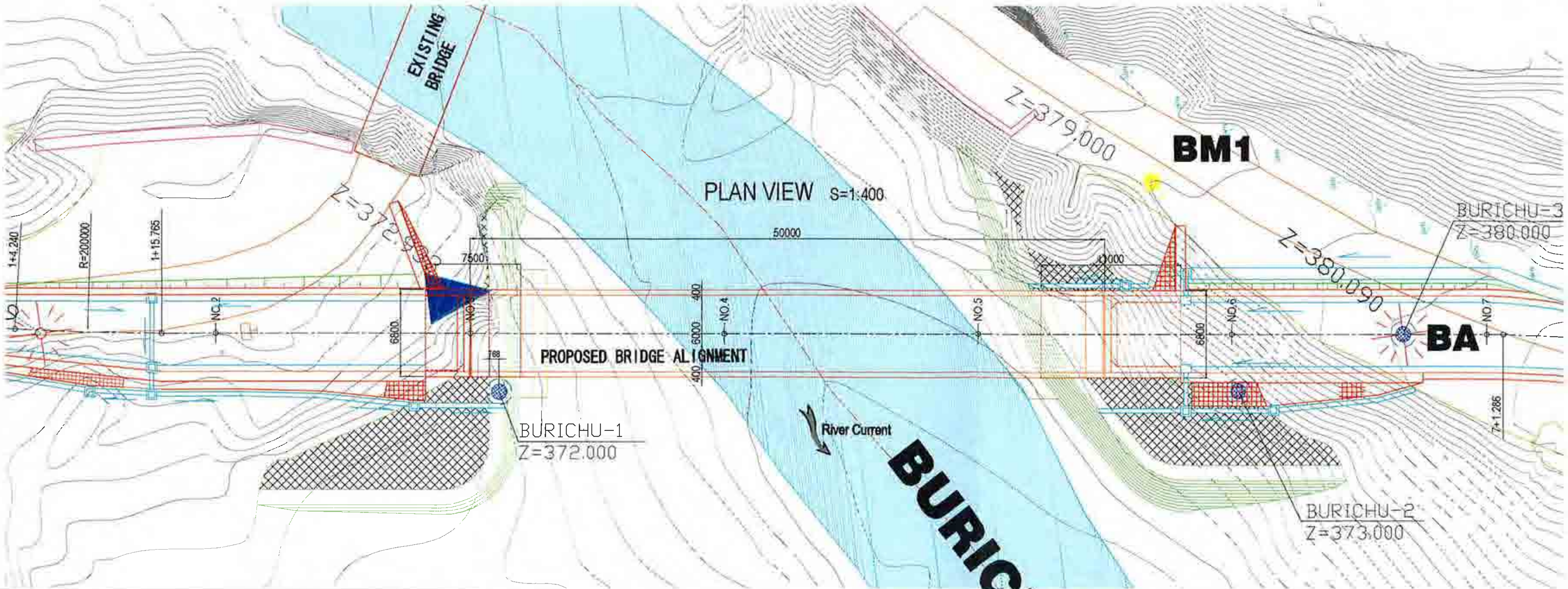
CROSS SECTION S=1:200



A1-ABUT S=1:300



A2-ABUT S=1:300



PLAN VIEW S=1:400

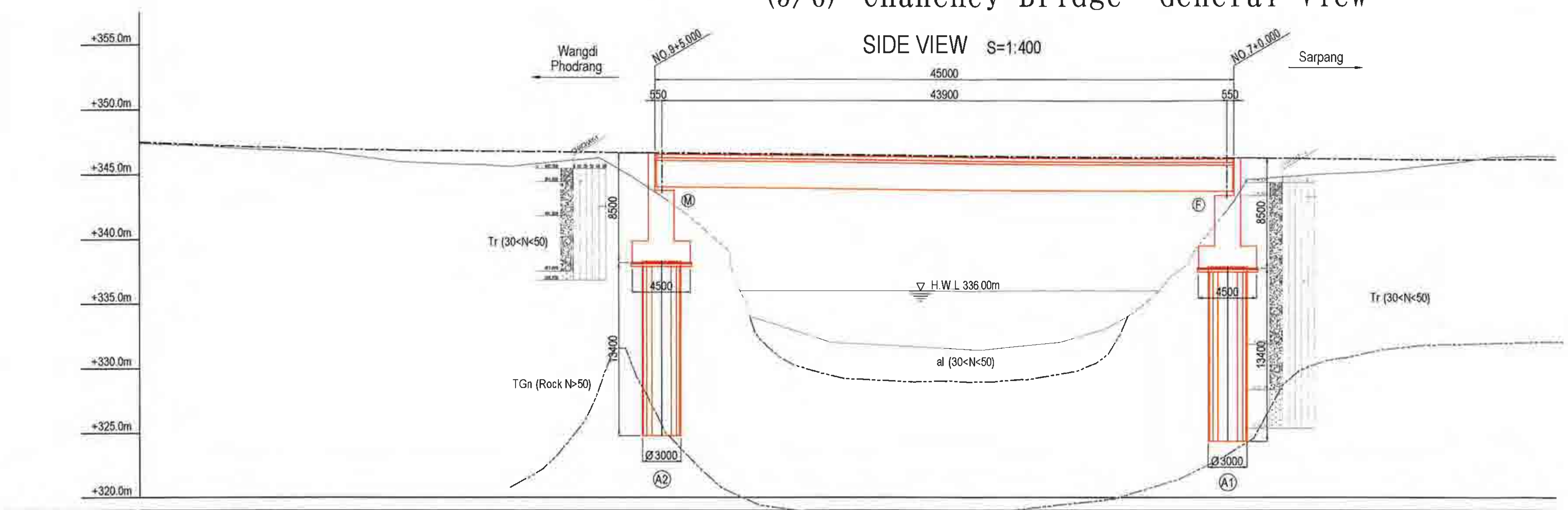
The Terms Of Design

Bridge Order			First Order Bridge
Bridge Length			50.000m
Span Length			48.900m
Road Width			6.000m
Live Load			IRC Class A
Design Seismic Scale			KH=0.22 KV=0.00
Super structure	Form		Pre-stress Concrete box Girder
	Material strength	Concrete	σck=30 N/mm 2
		Reinforcig Bar	SD295
		Tendon	12S12.7mm
Sub structure	Form	Structure	Inverted Type Abutment
		Foundation	Spread Foundation
	Material strength	Concrete	σck=21 N/mm 2
		Reinforcig Bar	SD295

MINISTRY OF WORKS AND HUMAN SETTLEMENT DEPARTMENT OF ROADS	THE PROJECT FOR RECONSTRUCTION OF BRIDGES (PHASE III) IN KINGDOM OF BHUTAN	JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	TITLE	SCALE	DATE	DRAWING NO
			4_BURICHU-BRIDGE	1:400		

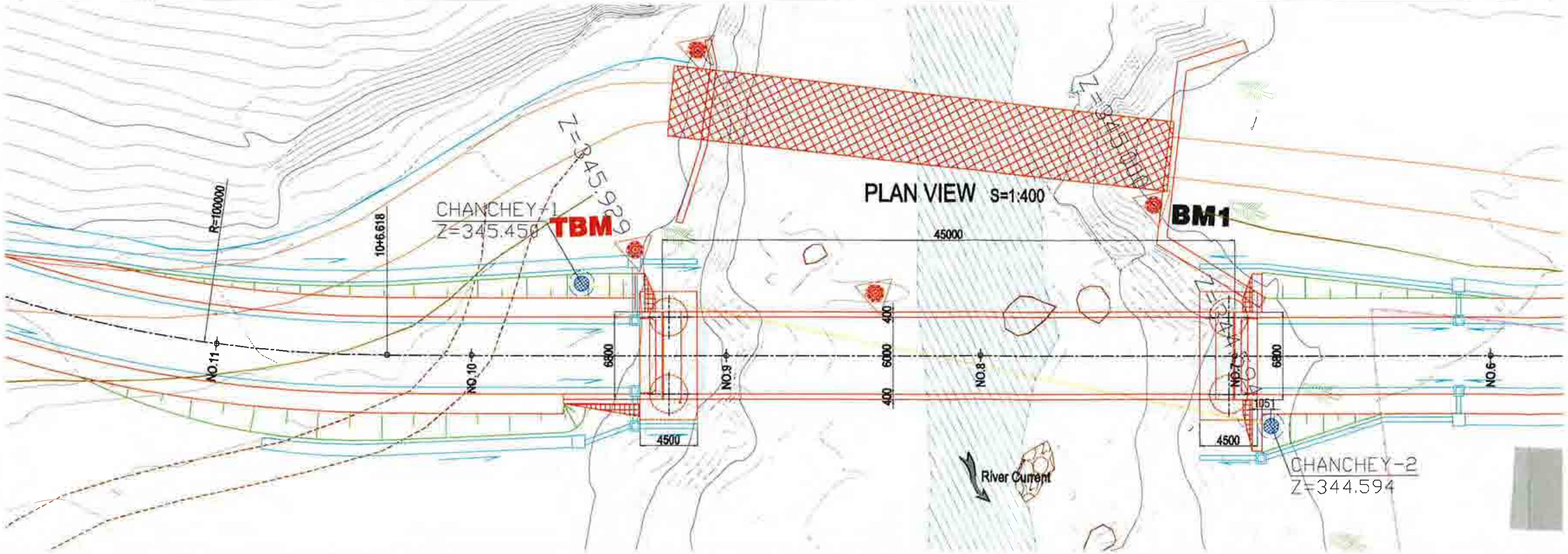
(5/6) Chanchey Bridge General View

SIDE VIEW S=1:400

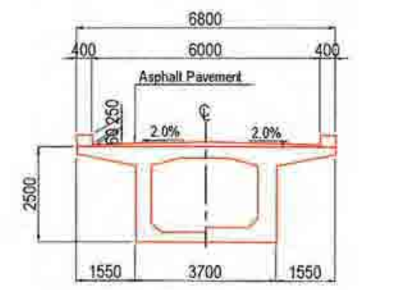


Gradient	i=5.218% L=44.844m	347.000	VCL=20.00m VCR=470m				i=1.000% L=90.000m	VCL=20.00m VCR=1200m	346.100	i=0.600% L=45.000m
Proposed Height	347.287	347.105	346.919	346.850	346.700	346.650	346.450	346.250	346140	346 140
Ground height	347.20	346.92	346.22	345.80	343.68	339.74	331.40	342.90	345.65	346.30
Distance	5.000	8.382	6.618	15.000	5.000	20.000	20.000	15.000	5.000	20.000
Station	NO.11	+15.000	+6.618	NO.10	A2 +5.000	NO.9	NO.8	A1 NO.7	+5.000	NO.6

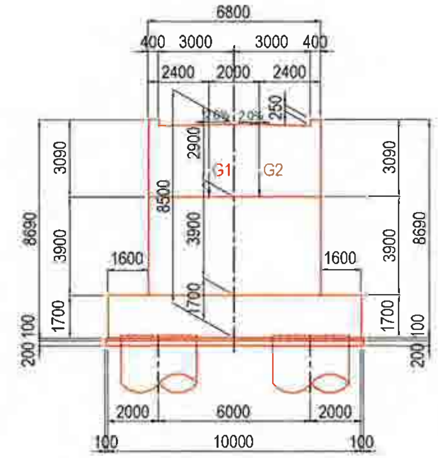
PLAN VIEW S=1:400



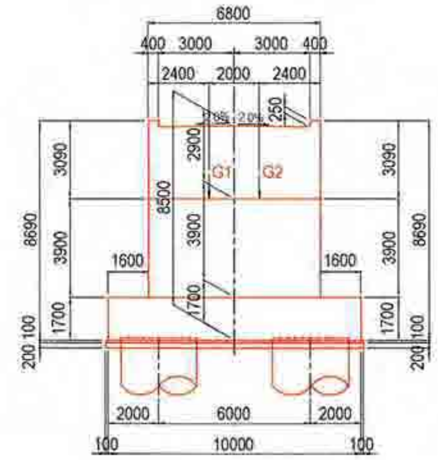
CROSS SECTION S=1:200



A1-ABUT S=1:300



A2-ABUT S=1:300



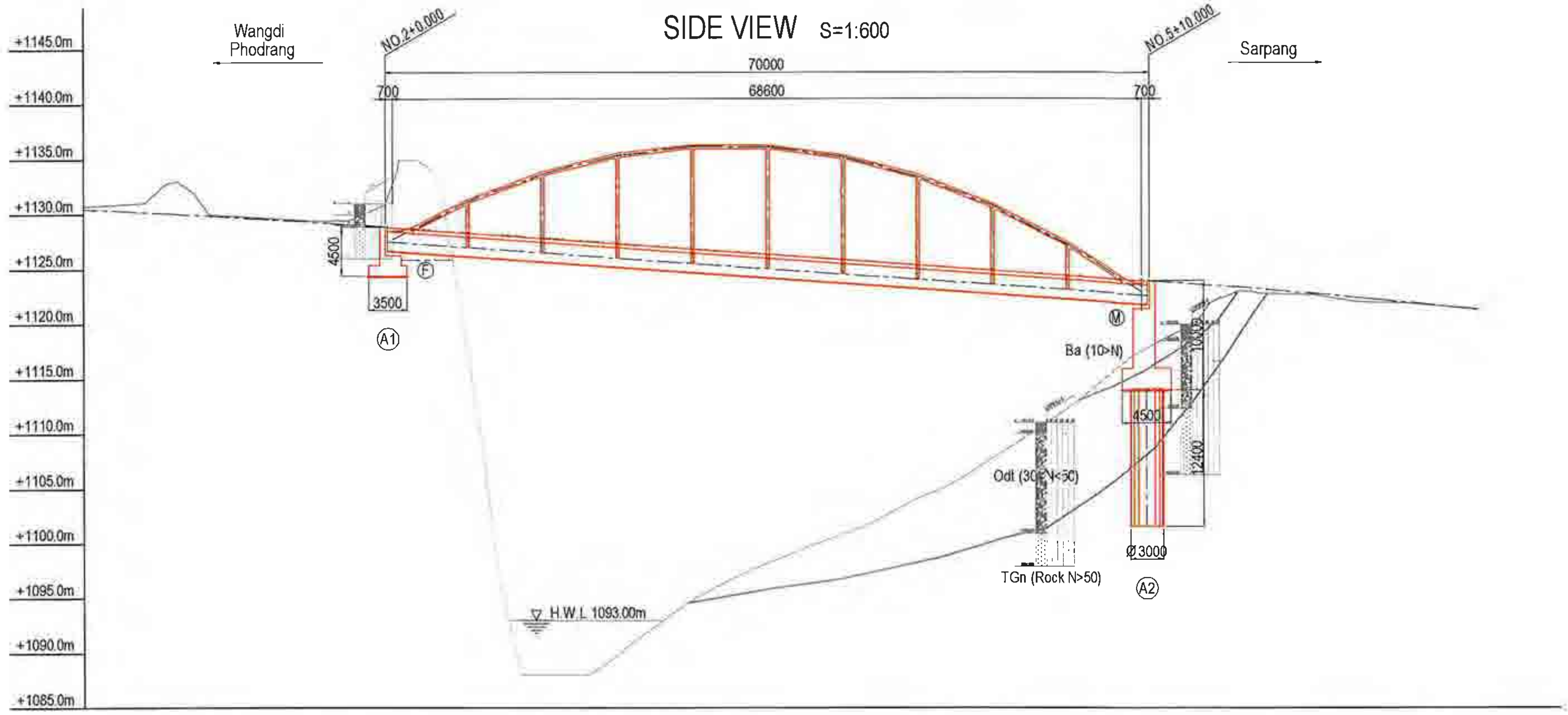
The Terms Of Design

Bridge Order			First Order Bridge
Bridge Length			45 000m
Span Length			43 900m
Road Width			6 000m
Live Load			IRC Class A
Design Seismic Scale			KH=0 22 KV=0 00
Super structure	Form		Pre-stress Concrete box Girder
	Material strength	Concrete	σck=30 N/mm ^{2}
		Reinforcig Bar	SD295
		Tendon	12S12 7mm
Sub structure	Form	Structure	Inverted Type Abutment
		Foundation	Spread Foundation
	Material strength	Concrete	σck=21 N/mm ^{2}
		Reinforcig Bar	SD295

MINISTRY OF WORKS AND HUMAN SETTLEMENT DEPARTMENT OF ROADS	THE PROJECT FOR RECONSTRUCTION OF BRIDGES (PHASE III) IN KINGDOM OF BHUTAN	JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	TITLE	SCALE	DATE	DRAWING NO
			5_CHACHAY BRIDGE	1:400		

(6/6) Loring Bridge General View

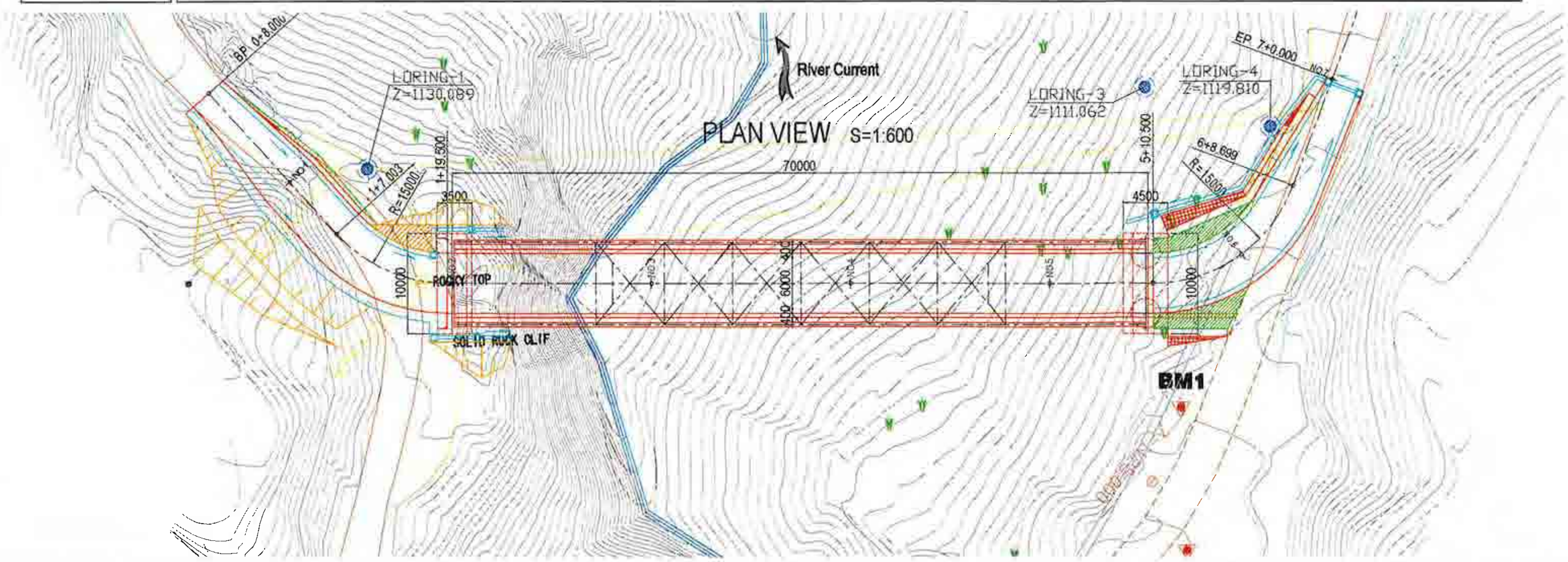
SIDE VIEW S=1:600



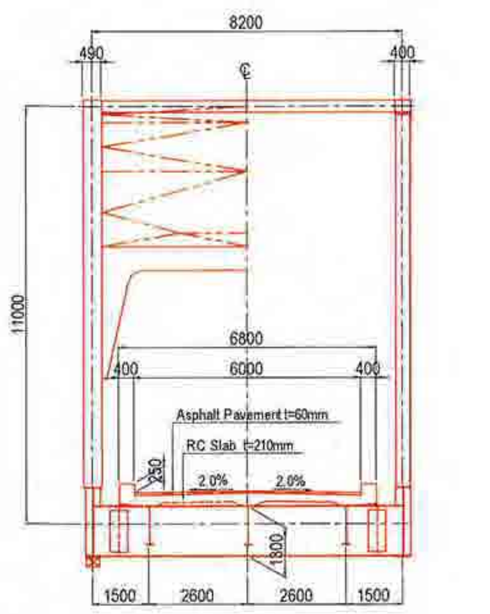
Gradient: i=5.000% L=20.000m — (1129.600) — VCL=20.00m VCR=1000m — i=7.000% L=90.000m — VCL=20.00m VCR=670m — (1123.300) — i=10.000% L=20.000m — (1121.300)

Station	Proposed Height	Ground height	Distance
NO.1	1130.100	1132.80	10.000
+7.003	1129.725	1129.79	7.003
+10.000	1129.550	1129.60	2.997
+19.500	1128.935	1130.68	9.500
NO.2 A1	1128.900	1130.90	0.500
NO.3	1127.500	1088.92	20.000
NO.4	1126.100	1100.20	20.000
NO.5	1124.700	1110.68	20.000
A2 +10.000	1124.000	1117.92	10.000
+10.500	1123.965	1118.19	0.500
NO.6	1123.225	1122.80	9.500
+8.699	1122.429	1122.05	8.699
NO.7	1121.300	1121.30	11.301

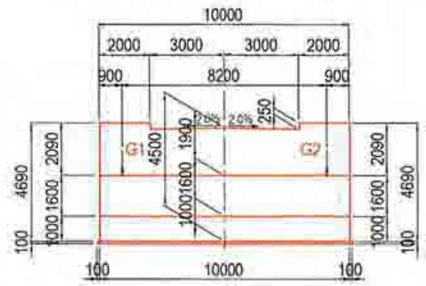
PLAN VIEW S=1:600



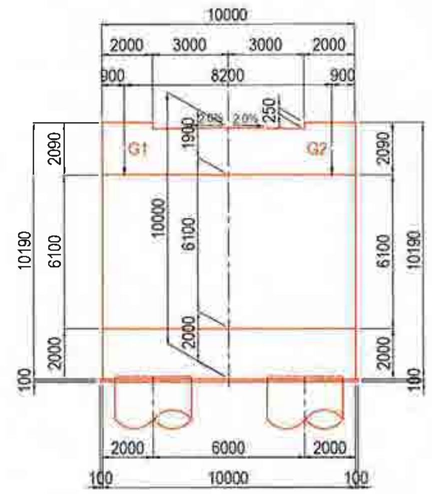
CROSS SECTION S=1:200



A1-ABUT S=1:300



A2-ABUT S=1:300



The Terms Of Design

Bridge Order			First Order Bridge
Bridge Length			70.000m
Span Length			68.600m
Road Width			6.000m
Live Load			IRC Class A
Design Seismic Scale			KH=0.22 KV=0.00
Super structure	Form		Simple Steel Langer
	Material strength	Concrete	σck=24 N/mm ^{2}
		Reinforcig Bar	SD295
		Steel	σta=210N/mm ^{2} (SMA490W) σta=140N/mm ^{2} (SMA400W)
Sub structure	Form	Structure	Inverted Type Abutment
		Foundation	Spread Foundation
	Material strength	Concrete	σck=21 N/mm ^{2}
		Reinforcig Bar	SD295

MINISTRY OF WORKS AND HUMAN SETTLEMENT DEPARTMENT OF ROADS	THE PROJECT FOR RECONSTRUCTION OF BRIDGES (PHASE III) IN KINGDOM OF BHUTAN	JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	TITLE	SCALE	DATE	DRAWING NO.
			6_LORING BRIDGE	1:600		

2.2.4 Implementation Plan

2.2.4.1 Implementation Policy

The following implementation policies were taken into account when implementing the Project as a Japanese Grant Aid Scheme.

- To maximize the use of local engineers, workers, construction materials and equipment so as to contribute to creating employment opportunities, to promote technology transfer and to revitalize the regional economy.
- To create a close liaison system with Bhutanese implementing agencies, the consultant and contractors.
- To draw up a plan on the implementation of substructure and PC superstructures during the dry season (between October and May) when the river water level is low.
- To draw up a realistic implementation plan in due consideration of local rainfall patterns, the time required for materials and equipment procurement and application of appropriate construction methods, etc.
- To draw up an implementation plan and onsite work-in-process without hindering the present traffic conditions and inconveniencing the public as much as possible.

2.2.4.2 Implementation Conditions

Special considerations for the project implementation are described as follows.

(1) Compliance with labor standards

The contractor shall observe the present construction-related legislation in Bhutan and prevent any conflicts with workers by respecting appropriate labor conditions or customs associated with employment.

(2) Environmental conservation during the construction period

Instructions and supervision shall be provided in due consideration of the environmental aspects as a prerequisite for a permission when receiving a “building permit” prior to the commencement of the construction work.

In particular, attention is given to dust and muddy water discharged due to disposal of scrap wood, removal of surplus soil, land banking and pavement construction, and the impact on wild animals through noise resulting from the utilization of explosives.

(3) Necessity of communication means at the sites

Since the infrastructure of telephone communications including cellular phones has not been established at the project sites, the minimal necessary communications system shall be taken into account for work supervision and safety control of construction-related personnel in order to ensure communication between sites by installing satellite phones at each construction site.

(4) Respect of local practices

On drawing up an implementation plan, a work scheduled shall be made taking into account the local traditional events such as the Tsechu Festival or religious holidays.

(5) Security of traffic safety

In order to carry out the construction work while opening traffic to public, traffic safety shall be sufficiently taken into account. When necessary, the construction work shall be carried out by requesting traffic direction from the Bhutan police for smooth traffic management in order to prevent schedule delays.

(6) Schedule adjustment

Progress of the work undertaken by the Bhutanese side shall be properly confirmed and adjusted.

(7) Customs clearance and road conditions

An implementation plan shall be drawn up, considering imports and unloading, the required number of days for customs clearance and road conditions during the rainy and winter seasons.

2.2.4.3 Scope of Work

In implementing the Project, the scope of work to be undertaken by the Japanese and Bhutanese sides is outlined as follows.

(1) Work undertaken by the Japanese side

1) Reconstruction of Proposed Six Bridges

- Superstructure work, substructure work, deck face work, incidental bridge work, approach road work, retaining wall work, drainage work and necessary temporary work
- Establishment of temporary facilities (such as base camps, offices, lodging houses and warehouses)
- Shifting the existing Lawakha Bridge

2) Materials and equipment procurement

Procurement of construction materials and machinery necessary for the facility construction described in “2.2.4.6 Procurement Plan”

3) Safety measures

Safety control pertaining to the implementation of construction work

4) Consultancy services

A detailed design, preparation of tender documents and contract, assistance for tendering procedures, and construction supervision described in the “2.2.4.4 Consultant Supervision”

(2) Work undertaken by the Bhutanese side

1) Issuance of construction permits

Prior to commencement of the construction work, the acquisition of construction permits pertaining to the Project by the implementing agency of Bhutan

2) Customs clearance and tax exemption

Facilitating customs clearance in Bhutan for imports and exports of construction materials and equipment, tax exemption conveniences

3) Land acquisition

Acquisition of lands for the bridge construction under the Project, lots necessary for temporary yards such as offices, laboratories and plants, waste and surplus soil disposal sites, described in the Implementation Plan.

4) Relocation of obstacles

Relocation of obstacles such as water pipes or electric lines, when necessary

5) Others

- Provision of quarries and borrow pits necessary for construction work
- Facilitating of entry and stay of Japanese and third-country persons engaged in the Project
- Exemption of taxes and other public surcharges such as custom duties and domestic taxes imposed by Bhutan.
- Appointment of the counterpart (C/P) and provision of transportation means and expenses for the personnel

2.2.4.4 Consultant Supervision

(1) Operating schedule of consultancy services

In the case of implementing the Project, the Exchange of Notes (E/N) for a detailed design under the Japanese Grant Aid Scheme for the Project shall be signed between both Governments of Japan and Bhutan as a prerequisite, and then the Grant Agreement (G/A) shall be made between JICA and the Government of Bhutan. After the signing of the E/N and G/A, the consultant shall conclude a Consultancy Agreement with the Department of Roads (DoR), Ministry of Works and Human Settlement, which is the implementing agency in Bhutan, in accordance with the scope and procedures of the Japanese Grant Aid Scheme based on a written recommendation issued by JICA. Following the conclusion of the agreement, the consultant shall prepare the detailed design and receive an approval for tender documents to be prepared and then the Consultancy Agreement will be completed. After that, the E/N and the G/A for tendering assistance services, construction supervision and construction work shall be concluded between both countries. Based on these, the Consultancy Agreement and Contract for the construction work shall be concluded with DoR. The major services including the consultancy agreement are described as follows.

1) Stage of tender document preparation (Detailed design stage)

In conformity with the results of the Basic Design Study Report, a detailed design for each facility and tender documents will be prepared. These documents as follows will be approved by DoR;

- Design reports
- Design drawings
- Tender documents

2) Tender stage

The DoR will select a contractor of Japanese nationality by means of competitive bidding with the assistance of the consultant. Representatives from the Government of Bhutan shall have the authority to approve related contracts and who are able to judge technical matters. The tender assisting services of the consultant at the tender stage are described as follow.

- Public announcement of P/Q (pre-qualification)
- Pre-qualification
- Bidding and evaluation of bids
- Contract with contractor

3) Work supervision stage

After receiving a verification of construction contract from JICA, the consultant will issue the commencement of work to the contractor and begin construction supervision. During the construction supervision, the consultant shall report on the construction progress to DoR, and provide services to the contractor on work progress, quality, safety and payments, remedies and suggestions on construction work.

In addition, the consultant shall conduct a defect inspection one year later after the completion of the construction supervision, after which the consultancy services will be completed.

(2) Implementation organization

The personnel arrangements and duties of the consultant at each stage of the detailed design, tendering and construction supervision are described as follows.

1) Preparation of detailed design and tender documents

A design team organized by the chief consultant shall make detailed designs. In addition, this work will include preparation of tender documents. In due consideration of the Project to be implemented under the Japanese Grant Aid Scheme, the following points shall be taken into account in preparing tender documents.

- Forms for instruction to tenderers and contracts, etc. shall conform to the guidelines of the Japanese Grant Aid Scheme.
- Technical specifications shall be prepared in due consideration of the “Road Survey and Design Manual (1st Edition, June 2005) compiled by the Department of Roads, Thimphu, Ministry of Works and Human Settlement, Royal Government of Bhutan” and “Standard Specifications and Code of Practice for Road Bridge, the Indian Roads Congress (IRC standard)” so as to sufficiently ensure quality.
- Personnel who are fully familiar with design contents of the Basic Design Study and detailed designs shall take the initiative in preparing the tender documents.

2) Implementation system for tender assistance

The necessary personnel and their roles as an implementation system for assistance of tender procedures are described as follows.

- Chief consultant : General supervision of all matters to ensure that the tendering progresses smoothly
- Tender documents preparation : Checking of tender documents, duties pertaining to the

construction work, tender opening and the evaluation

3) Implementation system for construction supervision

The required engineers and their roles as an implementation system for construction supervision are described as follows.

- Chief supervisor : In addition to on-site witnessing at the commencement of the Project, at the midway point and at the time of completion, and at the time of a completion inspection, coordination so that duties are carried out smoothly, management of stationed work supervisors and generalization of work supervision services.
- Stationed work supervisor : By being stationed at the project site, the supervisor will carry out safety control, construction schedule control, completed work amount and quality control. Since the sites are far from each other and there are many bridges, work supervision will be conducted by dividing responsibility into north and south areas. The work supervisor responsible for the south will be a stationed supervisor of overall local work supervision services, and will also take charge of Burichu, Chanchey and Loring Bridges in the south. The stationed supervisor responsible for the north will supervise Lawakha, Basochu and Nyarachu Bridges.
- Superstructure engineer : As superstructure construction will be carried out for steel and PC bridges, one steel bridge and one PC bridge engineer will be arranged during the superstructure construction period.
- Work supervision (pavement) : By posting an engineer at the sites from the commencement of pavement work (roadbed and asphalt pavement) for approach roads to the completion of trial asphalting, various tests with respect to pavement will be witnessed, and construction and work progress will be controlled.
- Inspector of outsourcing work (steel bridge fabrication): Quality will be controlled by witnessing the inspection of full-scale drafting, material test and a temporary assembly at a steel bridge manufacturing plant for steel bridges

outsourced by the contractor.

2.2.4.5 Quality Control Plan

The quality of construction materials and products and precision of bridge structure will be controlled on fabrication and erection. The Table 2-11 lists the control items and the frequency.

Table 2-11 Quality Control Schedule

Classification	Item	Description	Frequency
Material Inspection	Aggregate	Grading, specific gravity, hardness, soundness	Every production district, every 50m^3
	Cement	Grading, specific gravity, intensity	Every manufacturer
	Reinforcing bar	Intensity, bending workability	Every diameter, every lot
	PC steel	Intensity	Every lot
	Asphalt	Viscosity, penetration degree, softening point	Every lot
	Landfill material	Grading, specific gravity, moisture content, plasticity, liquidity, compaction, CBR	Every production district, every 500m^3
Product Inspection	Freshly concrete	Temperature, slump, air content	Every 10m^3 at the construction site
	Hardened concrete	Intensity, unit weight	Every 30m^3, test piece for intensity was prepared on 7/28
	Hot mix asphalt	Temperature, OAC	Every 30 tonnage at construction site
	Banking roadbed	Field density	2 locations at each bridge (every approach road)
	Pile load bearing layer	Position, bearing capacity	All positions, 1 location for a group of piles for load bearing layer
	Girders	Dimension, linearity	All number of items
	Piles	Dimension, linearity	All number of items
	Foundation work substructure	Dimension, position, height	All number of items
	Superstructure	Dimension, position, height	Every 5m in the direction of road
	Asphalt pavement	Thickness, surface smoothness, height	Every 100m^2 for thickness Every 5m for surface smoothness and height in the direction of road

2.2.4.6 Procurement Plan

(1) Construction materials

The policy concerning procurement of construction materials is described as follows.

① Locally available materials shall be procured in principle.

② If local material have quality problems or difficult to procure locally due to insufficient distribution volume within a certain period, then they shall be procured from Japan or a third country (India).

Procurement sources for major materials to be utilized for the construction work are shown in Table 2-12 following table.

Table 2-12 Procurement Sources for Major Construction Materials

Item	Procurement Source			Remarks
	Bhutan	Japan	Third Country	
Landfill materials	○			
Asphalt (for mixing in place construction)	○			
Asphalt emulsion	○			
Base course material (crushed stones)	○			
Cement (ordinary Portland cement)	○			
Admixture (water reducing agent)		○		
Fine aggregate (sand)	○			
Coarse aggregate (crushed stones)	○			
Triangular pole stone (20 to 25cm)	○			
Liner plate (circular 2m, 3m)		○		
Reinforcing bar (Fe-415)			○	India
PC steel wire			○	India
Sheath			○	
Steel bridge (weather proofing)		○	○	Steel materials procured from Japan, manufacturing in Indonesia
Balustrade (steelwork)			○	India
Bearing (with bearing accessories)		○		
Expansion devices		○		
Bridge deck catch basin (with longitudinal discharge pipe)		○		
Gabion			○	India
Form plywood			○	India
Timbering materials (H-type steel, tube pipe, etc.)			○	India
Scaffolding materials (scaffolding board, separator, etc.)	○	○		Separators, etc. procured from Japan, scaffolding boards locally procured
Lumber (fro formwork, temporary work, etc.)	○			
Sand bags (for bridge election)	○			
Fuel	○			

(2) Construction machinery

The policy concerning procurement of construction machinery is described as follows.

① Universal-use machinery shall be procured locally or from India.

② If large machinery or special machinery is broken down or impossible to use it may have a significant impact on the construction schedule. Therefore, it shall be procured from Japan.

From the findings of the field survey, the procurement sources for major machinery to be utilized for the construction work shall be scheduled in Table 2-13.

Table 2-13 Procurement Sources for Major Construction Machinery

Item	Procurement Source			Remarks
	Bhutan	Japan	Third Country	
Bulldozers (15, 21 ton)	○			
Back hoes (0.8 m^3)	○			
Clamshells (0.4 m^3)		○		
Large-sized breakers (1,300 kg class)	○			
Wheel loaders (1.4 m^3)	○			
Dump trucks (10 ton)	○			
Trucks (4 to 4.5 ton)	○			
Rafter cranes (16, 25 ton)		○		
Grout mixers		○		
Grout pumps		○		
Chemical feeding system		○		
Core drills (55 kW)		○		
Down the hole hammers (508 to 762)		○		
Motorized graders (3.1m)	○			
Road rollers (10 to 21t)	○			
Tire rollers ()8 to 12t			○	India
Vibration rollers (0.8 to 11t)			○	India
Tampering machines (60 to 100kg)	○			
Concrete mixers (0.5m^3)			○	India
Road sprinklers (10m^3)	○			
Air compressors (5m^3/min.)			○	India
Air compressors (18 to 19m^3/min.)		○		
Generators (Not more than 75 kva)			○	India
Generators (125, 200 kva)		○		
Vent material machinery ()		○		
Launching machinery ()		○		
Cable erection machinery ()		○		

(3) Transportation of construction materials / machinery

The place of delivery for construction materials / machinery which are locally procured is usually a materials production area, warehouse, or motor pool.

The transportation plan for construction materials / machinery which are mainly supplied from overseas is described as follows.

1) Customs procedures

The number of days required for customs procedures at the source of importation is as follows.

- India : Two days at Phuentsholing (regular customs clearance)
- Other countries : Eight days at the Kolkata Port (for waiting at the offing, unloading and temporary customs clearance) and two days at Phuentsholing (regular customs clearance)

2) Transportation between Kolkata and Phuentsholing

Construction materials / machinery which are procured from overseas other than India will be transported via transport vehicles shown in Table 2-14 from Kolkata Port to Phuentsholing (785km) and the number of days for transportation will be four to five days.

Table 2-14 Transport Vehicles (Kolkata to Phuentsholing)

Vehicle Type	Loading Dimension (m)			Maximum Loading (MT)
	Length	Width	Height	
Trucks	5	2.1	2.1	13
Trailers	12	2.4	2.4	24
Low bed trailers	6	3	3	30
Special low bed trailers	8	3.75	3.75	40

3) Transportation between Phuentsholing and each bridge site

Details for transportation between Phuentsholing which is located on the border with India and each bridge site are described as follows.

① Transport vehicle and loading limit

- The maximum length of materials will be 9m.
- The maximum load will be 8 tons.

② Transportation route and time

Generally speaking, roads in Bhutan will be utilized as transportation routes between Phuentsholing and each bridge site. However, in special cases when passing is dangerous, for example, when transporting superstructure steel elements through the mudslide district halfway to Loring Bridge, roads in Assam in India will be taken.

In due consideration of the above-mentioned situations, the transportation routes and time to each bridge site are shown in Table 2-15.

Table 2-15 Transportation Routes and Time

Bridge Name	Transportation Route	Conveyance Distance (km)	Required Time (day)
Lawakha Bridge	Phuentsholing to Bhutan to site	241	2
Basochu Bridge	Phuentsholing to Bhutan to site	245	2
Nyarachu Bridge	Phuentsholing to Bhutan to site	282	2
Burichu Bridge	Phuentsholing to Bhutan to site	294	2
Chanchey Bridge	Phuentsholing to Bhutan to site	301	2
Loring Bridge (general materials and equipment)	Phuentsholing to Bhutan to site	359	2
Loring Bridge (such as steel girders)	Phuentsholing to via India to Bhutan to site	259	2

4) Transportation routes and time for procurement from Japan

Although there are many container freighters operating between Japan and Calcutta Port, a conventional ship is operated about once a month. The number of days required for transporting materials from the warehouse and plants in Japan to each project site is as follows.

Warehouse/Plant to a Japanese port	:	7 days
Port departure to Singapore Port, Chittagong Port, Calcutta Port	:	30 days
Waiting in the offing at Calcutta and unloading	:	5 to 7 days
Temporary customs clearance at Calcutta	:	1 to 2 days
Calcutta to Phuentsholing via inland transportation	:	5 to 7 days
Regular customs clearance at Phuentsholing	:	1 to 2 days
Reloading at Phuentsholing into trucks in Bhutan	:	2 to 3 days
at Phuentsholing to project site	:	3 to 7 days
Total		54 to 65 days = 2 months

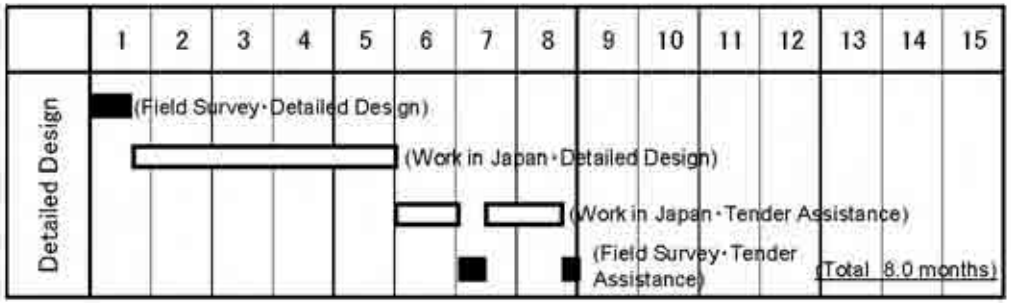
2.2.4.7 Implementation Schedule

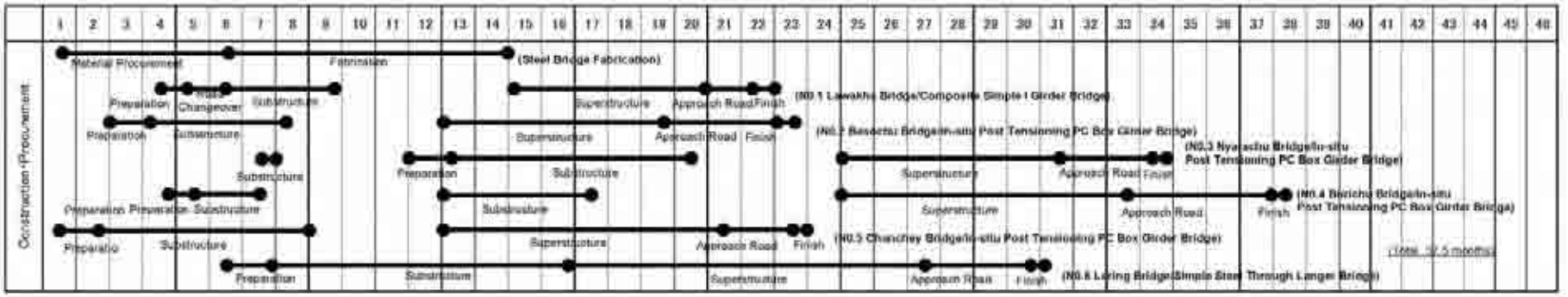
The project implementation schedule table prepared in accordance with the procedures of the Japanese Grant Aid Scheme is shown in Table 2-16.

In the Project, factors considered in the case of deciding construction work schedules are listed as follows.

- Base camps are assumed to be established at Wangdi Phodrang and Damphu.
- With respect to the five bridges aside from the Loring Bridge, both superstructure and substructure will be constructed during the dry season when it will not be affected by the river conditions.
- With respect to Loring Bridge, due to the deep valley and low water level, the substructure can be constructed even during the rainy season and subsequently after the dry season. Since a cable erection method is scheduled for the superstructure, once again it will not be affected by the river water level. Therefore substructure construction will continue even during the rainy season.

Table 2-16 Project Implementation Schedule





2.3 Obligations of the Recipient Country

2.3.1 General Requirements for the Japanese Grant Aid Project

The general requirements to be undertaken by Bhutan which were already agreed on between both governments and confirmed in the Minutes of Discussions (M/D) are described as follows.

① Land required for implementing the Project shall be secured prior to the commencement of construction work.

② Electric power and water supply and a drainage system and other incidental facilities, etc. shall be completely equipped.

③ Customs duties, internal taxes and other public surcharges which will be imposed in the recipient country with respect to the supply of products and services under the verified contracts shall be exempted.

④ Japanese nationals and third-country nationals whose services may be required in connection with the supply of products and services under verified contracts and such facilities as may be necessary for their entry into the recipient country and stay therein in the performance of their work shall be accorded.

2.3.2 Specific Requirements for the Project

Specific requirements for the Project other than general requirements requested under the Grant Aid Scheme are described as follows.

(1) Removal of existing proposed bridges

The existing bridges will be promptly removed by the Bhutanese side immediately after the completion of the proposed bridges.

(2) Reconstruction or improvement of other bridges

Of the six bridges other than those under the Project on National Highway No.5, reconstruction of Wakleytar Bridge was completed under the Phase II Project. In addition, it has been between 18 to 23 years since the other five bridges were constructed (1985 to 1990), and since the load limit are only 8 to 18t and the width is a narrow 3.27m, Bhutan should reconstruct or improve the five bridges at an appropriate time in order to ensure the effects of the Project.

Table 2-17 Overview of Five Bridges Other than Proposed

Bridge Name	Distance in kilometers (km)	Bridge Length (m)	Effective Span (m)	Effective Width (m)	Load Capacity (ton)	Year Constructed
Hesothangkha Bridge	2.4	9.55	9.3	3.27	18	1985
Rurichu Bridge	18.5	16.0	15.0	3.27	18	1987
Baichu Bridge	23.6	16.0	15.0	3.27	18	1985
Kamichu Bridge	31.5	19.0	18.0	3.27	15	1986
Mechiikora Bridge	53.9	19.0	18.0	3.27	8	1990

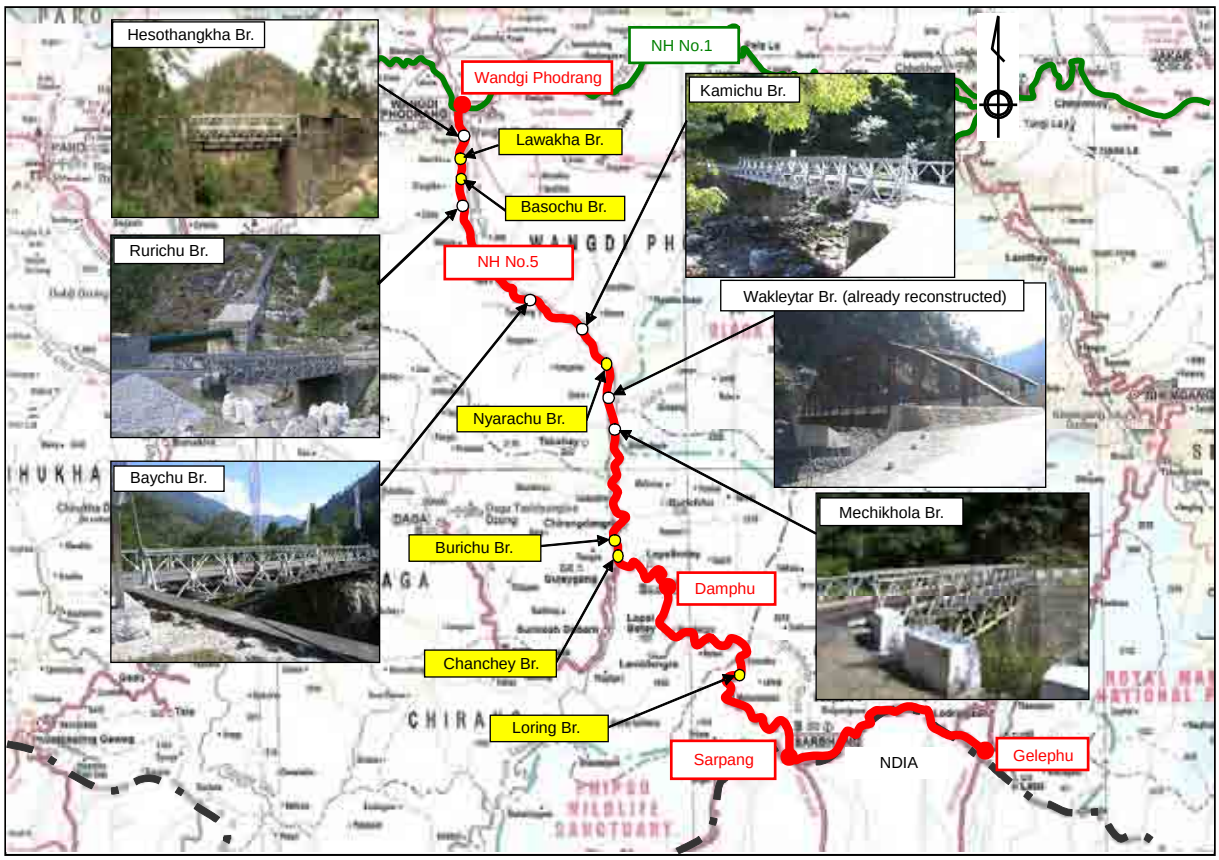


Fig. 2-16 Locations of Five Bridges Other than Proposed

(3) Removal and Relocation of Existing Utilities for Project-related Construction

With respect to Land Acquisition, it is unnecessary to secure a new lot at the present time. The following existing objects will be removed or relocated by the Bhutanese side.

① Relocation of the existing utilities (such as electricity and water supply) at project sites

② Relocation of the forest administration office located in the vicinity of Chanchey Bride (on the side of Damphu)

(4) Temporary Yard Acquisition

The following yards should be secured during the construction period as temporary yards for contractors.

① Vacant (unoccupied) land located in the roadside of Basochu Bridge (on the side of Wangdi Phodrang)

② Vacant land located in the roadside of Nyarachu Bridge (on the side of Wangdi Phodrang)

③ Vacant land located in the roadside of Burichu Bridge (on the side of Wangdi Phodrang)

④ Lot after the relocation of the forest administration office located in the roadside of Chanchey Bridge (on the side of Damphu)

⑤ For Loring Bridge, a lot on the side of Sarpang 3km from Loring Bridge to be used as a temporary yard and vacant land on the side of Sarpang 17 km away for steel elements storage

(5) Arrangement on aggregate or gravel

It is requested to arrange an exemption for mining rights for aggregate or gravel, to secure its rights, and to provide free of change with or to help secure borrow pits and dumping grounds. The following locations on the excavation of aggregate or gravel are scheduled.

① Aggregate : Stone pit in the vicinity of Nyarachu Bridge
② Gravels : Collected sand from Sunkosh and Gelephu Rivers in Wangdi Phodrang

2.4 Project Operation and Maintenance Plan

2.4.1 Maintenance Work Description

Superstructures of two bridges are of weathering steel, and the other four are of PC. All the substructures are of reinforced concrete.

Although maintenance items are necessary yearly and every five years, large-scale maintenance work such as repainting will be unnecessary. In addition to bridge maintenance, approach roads and revetment will be maintained.

Table 2-18 Contents of Maintenance

Item		Contents
Annual maintenance	① Inspection and cleaning of drainage systems:	By inspecting catch basins on the bridges, gutters and pipes of approach roads, to remove and clean any sediment.
	② Inspection and cleaning of expansion joints:	Although a surface drainage system is installed on expansion joints on the bridge surface, to inspect and if necessary remove and clean mud or sand accumulated in joint gaps.
	③ Inspection and repair of bridge face:	By inspecting conditions of bridge pavement, to repair cracks, etc.
	④ Inspection and cleaning of bearings:	To inspect, clean and remove mud accumulated around bearings below girders if necessary.
	⑤ Inspection and repair of approach road pavement:	To inspect and repair pot holes on asphalt pavement.
	⑥ Inspection and cleaning of approach road gutters:	To remove mud accumulated in gutters.
Maintenance every five years	① Repair of steel handrails:	To partially repair handrails damaged by vehicle collisions.
	② Repair of revetments:	To inspect and replace gabions if necessary.
	③ Re-painting of road markings:	To periodically repaint road markings.

2.4.2 Other Maintenance Items

It is important to preserve good bridge conditions and to improve the durability of the facilities by sufficiently carrying out maintenance in order to sustain the effects of the Project. Therefore, the following items should be taken into account.

① By periodically inspecting, to constantly grasp the facility conditions.
② To inspect and clean the drainage system before the rainy season.
③ To secure maintenance budget based on a maintenance plan.

2.5 Project Cost Estimation

2.5.1 Cost Estimation under the Project

(1) Expenses to be borne by 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) Expenses to be borne by Bhutan

Project items to be undertaken by Bhutan, the implementing time and estimated project cost are shown in the following table.

Table 2-19 Project Description undertaken by Bhutan, Implementing Time and Estimated Project Cost

No.	Project Description	Implementing Time	Project Cost (Nu.)	Project Cost (yen conversion)
1	Remove 6 proposed bridges	After opening bridges to traffic under the Project	2,119,000	6,081,530
2	Relocate check posts of 6 proposed bridges	After opening bridges to traffic under the Project	450,000	1,291,500
3	Reconstruct 5 bridges other than proposed bridges	To be confirmed through discussions	30,356,000	87,121,720
4	Service charges for A/P and B/A procedures		6,822,000	19,579,140
		Total	39,747,000	114,073,890

Nu. = Ngultrum

(3) Estimation Conditions

① Estimation Time : May 2008

② Exchange rate : $1 US = ¥107.97, 1 Nu = ¥2.87 (mean value between November 1, 2007 and April 30, 2008)

③ Implementation period : The Project will be implemented as construction work through A national bond. The time required for detailed designs and construction work will be 8.0 months and 37.5 months respectively as shown in the implementation schedule.

④ Other : The cost was estimated with the accuracy of the Grant Aid Scheme of the Government of Japan.

2.5.2 Operation and Maintenance Cost

The maintenance cost was calculated in Table 2-20 in accordance with the maintenance plan for the Project as described earlier.

Table 2-20 Major O/M Items and Cost

(Exchange rate : 1Nu .= ¥2.87)

Cycle	Object	Location subject to inspection	Maintenance Description	Unit	Unit Cost	Workload	Maintenance Cost (Nu)
Annual	Bridge	Drainage system	Cleaning of catch basins, conduit pipes	spot	100	50	5,000
		Expansion joints	Cleaning, shield rubber repair	spot	500	12	6,000
		Bridge decks	Minor repair of pavement	㎡	220	174	38,000
		Bearings	Cleaning on abutments	spot	100	12	1,000
	Road	Road surfaces	Pavement repair	spot	620	143	88,000
		Gutters	Removal of sediment	m	50	950	48,000
	①Subtotal						186,000
Five-year	Bridge	Handrails	Repair of damage due to collisions	m	1,000	29	29,000
		Revetment	Inspection, repair of gabions	m	1,800	144	259,000
	Road	Marking	Re-painting	m	30	290	9,000
	②Subtotal						297,000
	③Average amount of each year (②/5-year)						59,000
Total amount for each year (①＋③)							245,000
					Japanese yen conversion amount /year ＝¥703,000		

2.6 Other Relevant Issues

In order to sufficiently display the project effects through the smooth implementation of the requested Japanese assistance, the Bhutanese side is required to take the following matters into account.

① Information on the possibility of impact in the implementation of the Project, for example, the approach road for the Phase 1 Punatsangchu Hydropower Plant Project which is under construction in the vicinity of Lawakha Bridge should be sufficiently shared with the Japanese side. In addition, information on the Phase 2 to Phase 4 Punatsangchu Hydropower Plant Project or Sunkosh Hydropower Plant Project should be sufficiently shared in the similar manner and it should be requested in order for the bridges to be reconstructed through the implementation of the hydropower construction projects not to be buried in water.

② Although the reconstruction of the five other bridges on National Highway No. 5 is essential in displaying the project effects, it should be adjusted so as not to interfere with the Project during the construction work period.

③ In order to alleviate traffic congestion during construction work and to avoid unnecessary troubles with local residents, advanced notice for motorists and local residents should be thorough through the initiatives of DoR.

④ DoR should carry out periodic monitoring in accordance with the Environmental Codes of Practice (ECoP).

CHAPTER 3

PROJECT EVALUATION AND RECOMMENDATIONS

CHAPTER 3 PROJECT EVALUATION AND RECOMMENDATIONS

3.1 Project Effects

The stable transportation of people and goods on National Highway No. 5 will be secured by reconstructing bridges on National Highway No.5 through the implementation of the Project. Accordingly, approximately 120,000 residents in four districts (Wangdue Phodrang, Dagana, Tsirang and Sarpang dzongkhags) along National Highway No. 5 are expected to benefit.

The project effects are shown in Table 3-1.

Table 3-1 Project Effects

Current Situation and Problems	Remedial Measures under the Requested Japanese Assistance	Direct Effects and Degree of Improvement	Indirect Effects and Degree of Improvement
The present temporary Bailey bridges on National Highway No. 5 show remarkable damage or deterioration; in addition, the load capacity on many bridges is less than 18t, so they cannot withstand large vehicles. Consequently, larger vehicles are unable to utilize the route so that vehicles larger than 18t must utilize National Highway No. 2, which is a route passing through India, in order to access to cities in the south. The restriction of transportation hinders socio-economic development.	・ The temporary bridges on National Highway No. 5 will be reconstructed as permanent bridges.	① The load capacity of all six bridges will increase from 18t (minimum value for the proposed six bridges) to 40t. Consequently, the weight limit of passing vehicles can be substantially eased, in particular, traffic of large-sized vehicles will be revitalized. ② The travel distance for large-sized vehicles between Gelephu, the center of the development in the south which is regarded as a priority development district in the 10th Five Year Plan and Thimphu, the capital of Bhutan will decrease sharply. Specifically, since the load capacity of the existing bridges along National Highway No. 5 is 18t, larger vehicles are unable to utilize the route. Accordingly, large-sized vehicles over 18t in both cities must utilize National Highway No. 2 at a distance of approximately 380km (passing through India). After the completion of the Project, since the route from Thimphu to Gelephu will be converted to approximately 260km passing through National Highways No. 1 and No.5, the travel distance will decrease approximately by 120km and double transit across the border can be prevented.	① Two-way traffic on the existing bridges is impossible, so vehicles must slow down when crossing. This leads to a bottleneck for traffic. In addition, it also invites the possibility of traffic accidents since the width of the bridge section is narrower. By reconstructing the bridges, not only will load capacity increase but also road width. The drivability and safety of bridges will therefore be improved. ② As the project site relies on road traffic and National Highway No. 5 is the only trunk road, improvement in drivability along National Highway No. 5 through the rebuilding of bridges will promote the distribution of people and commodities and in turn regional economic development. ③ Since there are development programs along National Highway No. 5 and in the southern district (Punatsangchu Hydropower Project, Industrial Estate Construction Project, New Airport Construction Project and 2nd East-West Highway Construction Project), the reconstruction of bridges will support the transportation of materials and equipment for the implementation of these development projects.

3.2 Recommendations

3.2.1 Undertakings to be Taken by the Recipient Side

(1) Implementation of Responsibilities Undertaken by the Bhutanese Side

The Bhutanese side is required ensure security of necessary lots for reconstructing the bridges, temporary yards, such as offices and plants, as described in “Implementation Plan”, disposal yard for waste and surplus soil disposal related to construction work, relocation of obstacles, provision of quarry and borrow pits without any hindrance to the project implementation.

(2) Reconstruction of Other Five Bridges

The remaining five Bailey bridges on National Highway No. 5 should be reconstructed by the Bhutanese side in line with the project implementation.

3.2.2 Technical Cooperation and Coordination with Other Donors

By dispatching bridge experts to DoR as Technical Cooperation Project, design, soundness survey and evaluation on superstructure (PCT girder bridge and plate girder bridge), substructure (abutment and bridge pier) were instructed. As the result, Bhutan has independently designed concrete and steel bridges up to 30m long and conducted soundness evaluation on domestic bridges. In addition, design and work supervision has been taken up to about 50m long Bailey brides without any problems.

Bridges over 30m long are designed by India and Thailand, whereas, construction work is conducted by India or by joint ventures of builders between India and Bhutan. In the design and construction work, troubles on delay of a construction period or quality arise, so they cannot catch up with the past bridge construction conducted through Japanese Grant Aid.

Through the implementation of the Project, with respect to knowledge and skills that the Bhutanese engineers obtained from the technical cooperation, the further skills are considered to be settled through the implementation of on-site observation.