No.

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR
RECONSTRUCTION OF BRIDGES (PHASE II)
IN
THE KINGDOM OF BHUTAN

DECEMBER 2004

JAPAN INTERNATIONAL COOPERATION AGENCY

PACIFIC CONSULTANTS INTERNATIONAL

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PREFACE

In response to a request from the Royal Government of Bhutan, the Government of Japan decided to conduct a basic design study on the Project for Reconstruction of Bridges (Phase II) and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Bhutan a study team from June 18 to July 24, 2004.

The team held discussions with the officials concerned of the Government of Bhutan, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Bhutan in order to discuss a draft basic design, and as this result, 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.

I wish to express my sincere appreciation to the officials concerned of the Royal Government of Bhutan for their close cooperation extended to the teams.

December 2004

Seiji Kojima
Vice-President
Japan International Cooperation Agency

December 2004

Letter of Transmittal

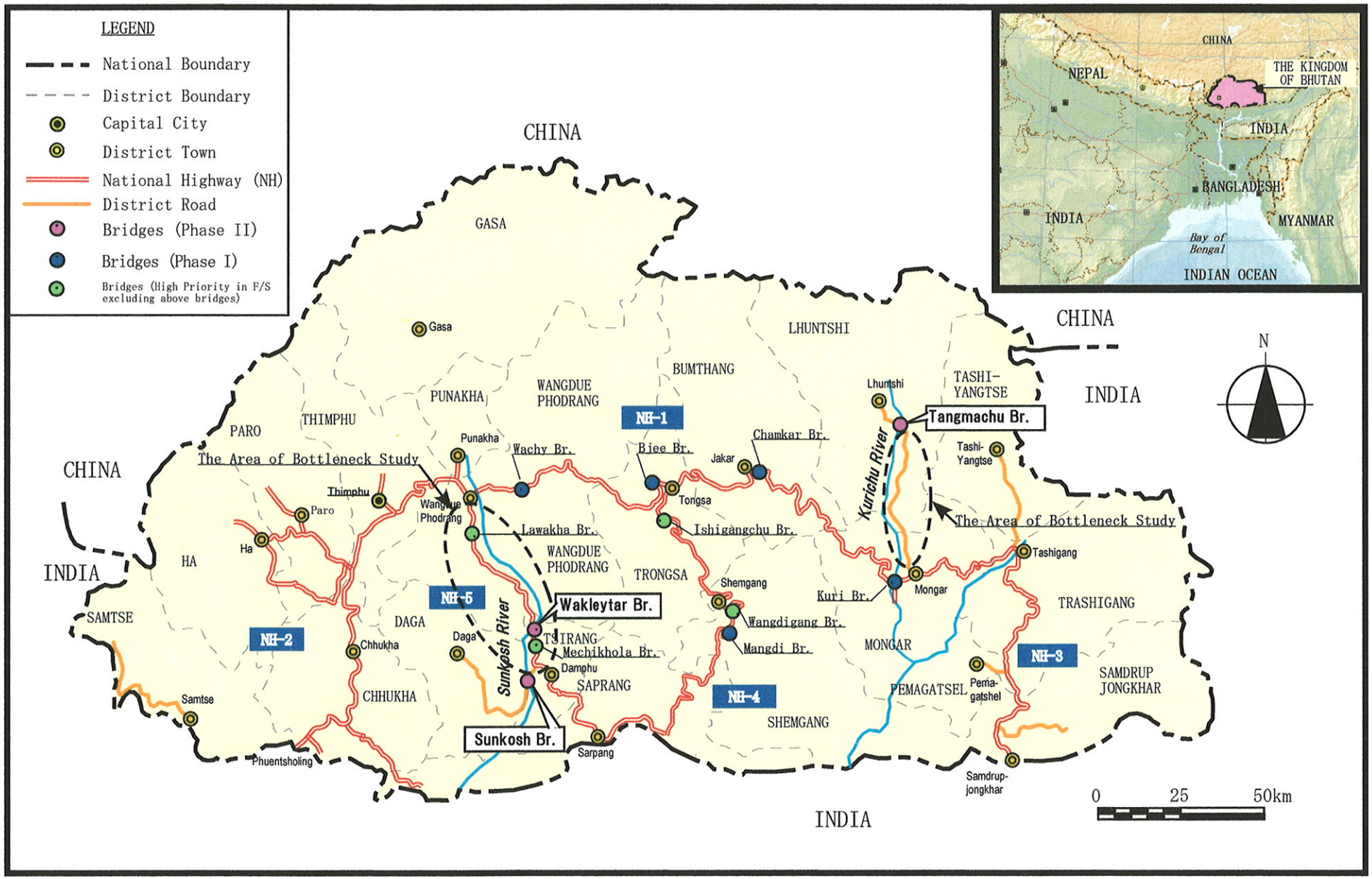
We are pleased to submit to you the basic design study report on the Project for Reconstruction of Bridges (Phase II) in the Kingdom of Bhutan.

This study was conducted by Pacific Consultants International, under a contract to JICA, during the period from June 2004 to December 2004. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Bhutan and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

Finally, we hope that this report will contribute to further promotion of the Project.

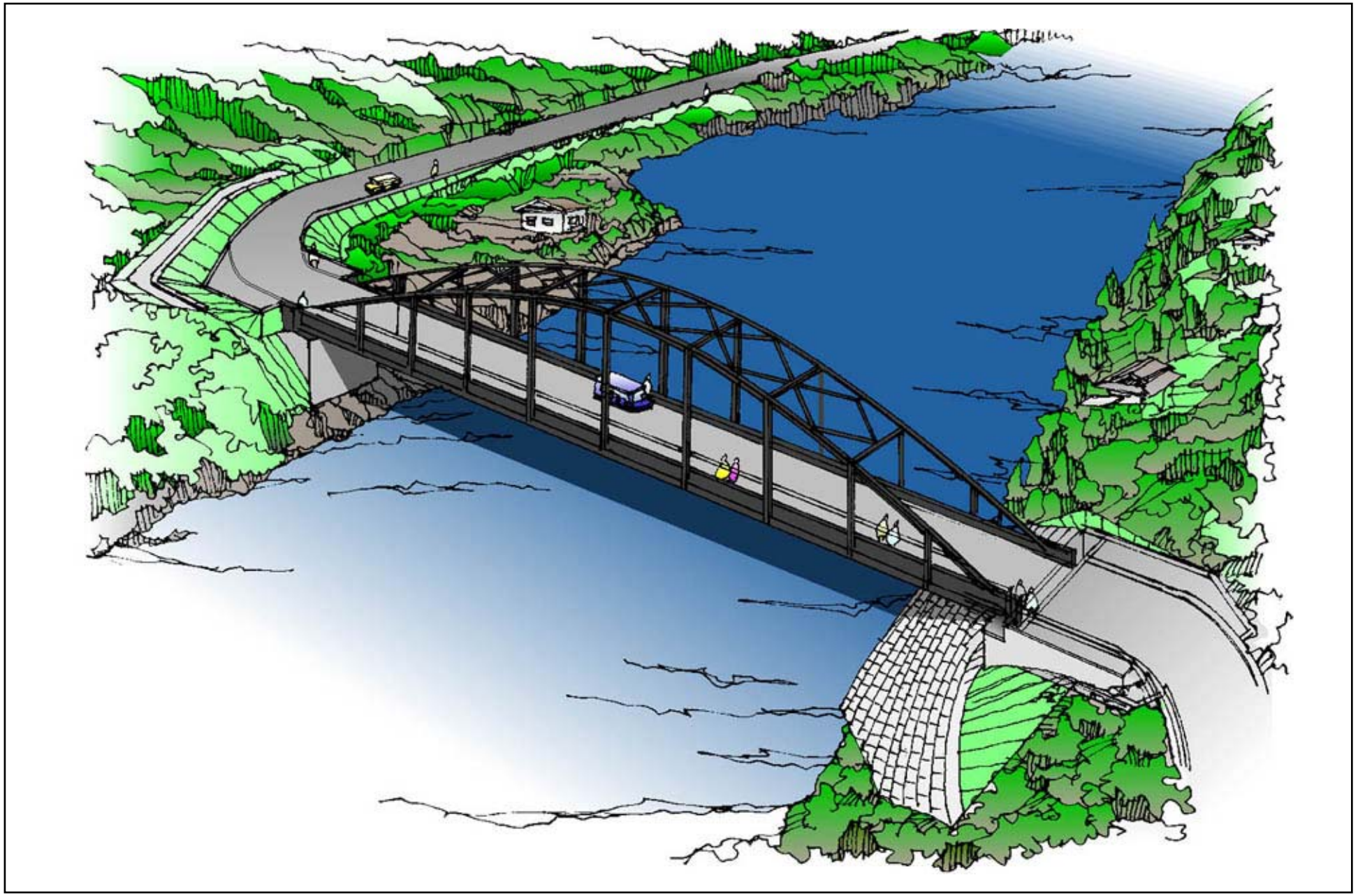
Very truly yours,

Hideki Yoneyama
Chief Consultant,
Basic design study team on the Project for Reconstruction of Bridges (Phase II)
Pacific Consultants International

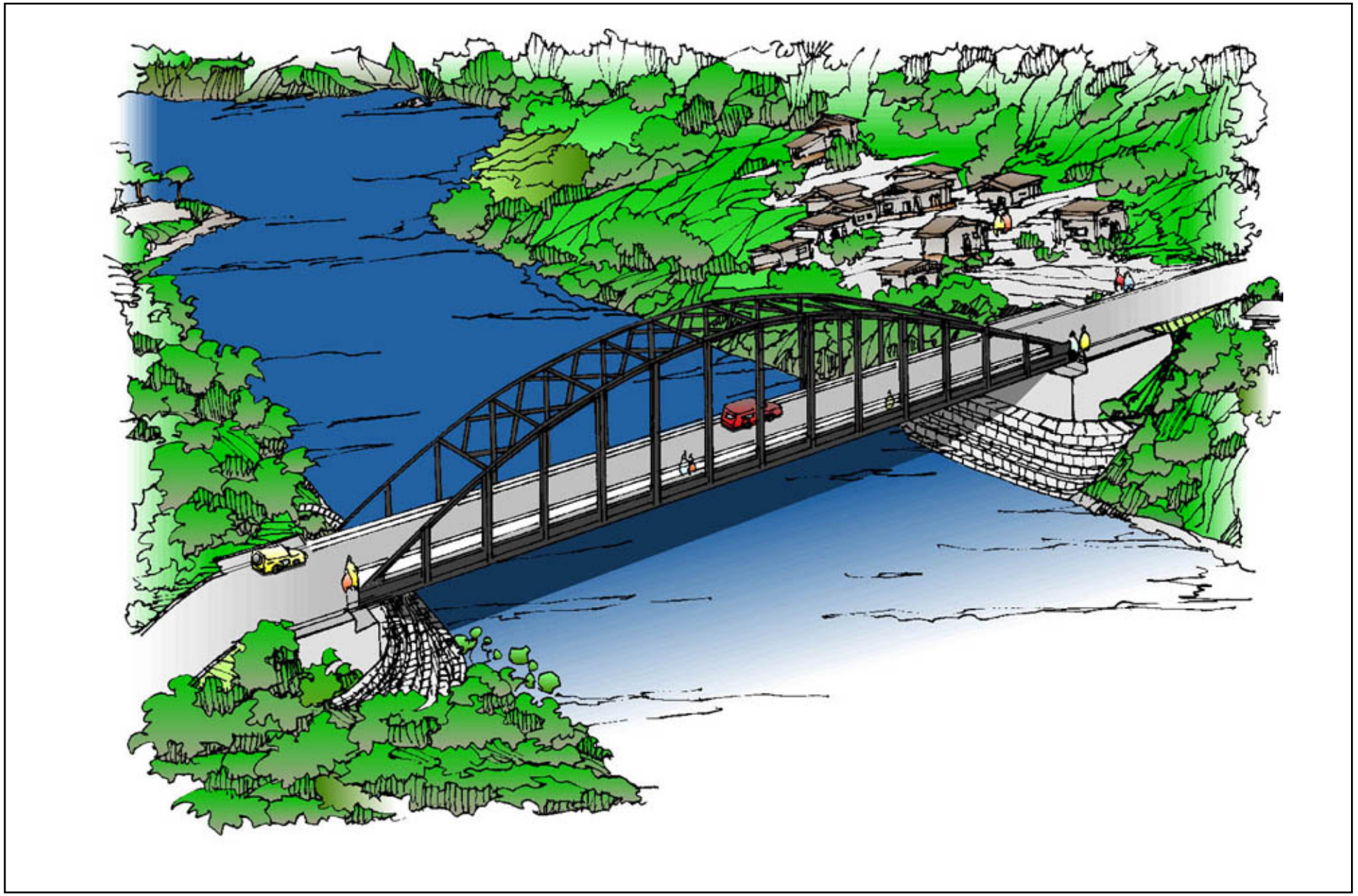


Location Map

Wakleytar Bridge



Tangmachu Bridge



Sunkosh Bridge

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ABBREVIATIONS

ADB	Asian Development Bank
A/P	Authorization to Pay
B/A	Bank Arrangement
B/D	Basic Design
DANTAK	Indian Corps of Engineers
D/D	Detailed Design
DoE	Department of Energy
DoR	Department of Roads
EC	Environmental Clearance
EIA	Environmental Impact Assessment
E/N	Exchange of Notes
F/S	Feasibility Study
GDP	Gross Domestic Product
GLOF	Glacial Lake Outburst Flood
GNI	Gross National Income
GNP	Gross National Product
GOI	Government of India
GOJ	Government of Japan
HWL	High Water Level
IEE	Initial Environmental Examination
IRC	The Indian Roads Congress
JICA	Japan International Cooperation Agency
MoWHS	Ministry of Works and Human Settlement
NEC	National Environmental Commission
Nu.	Bhutanese Currency or Ngultrum
PC	Prestressed Concrete
RC	Reinforced Concrete
RGoB	Royal Government of Bhutan
SQCA	Standards and Quality Control Authority
TOR	Terms of Reference
UN	United Nations
UNDP	United Nations Development Programme
US$	US Dollar
WB	World Bank

Summary

The Kingdom of Bhutan is situated between 27～28 degrees North Latitude and 89～92 degrees East Longitude. Bhutan is a landlocked country located between Tibet (southwest China) and Assam (northeast India). There are some peaks of the Himalaya Mountains, higher than 7,000 m, located between northern part of Bhutan and southern part of Tibet. Some rivers originate from the peaks in the northern part flow south and down to the plain less than 100 m elevation in Assam and then into the Brahmaputra river. The area of Bhutan is 46,500 km^2, a little bit larger than Kyushu, and the population was about 700,000 in 2001.

The main road network of Bhutan consists of East-West Highway (National Road No.1) and four North-South Highway (National Road No.2～No.5). Department of Roads (DoR), Ministry of Works and Human Settlement, manages these national roads except the National Roads No.2 and No.3 which the Indian Government is taking care of. Since Bhutanese transportation mostly relies on these Highways throughout the mountainous country, establishing an efficient and safe road network is essential to renovate social and economic situation.

However, implementing road improvement projects by the Bhutanese Government solely is difficult because of lack of expertise to cope with the construction required under severe topological and natural conditions. There are many Bailey bridges (temporary steel bridges), most of those were constructed before 1980's and have reached their expected life, on the trunk roads maintained by DoR. Replacement of these damaged or deteriorated bridges was being executed so slowly, that it has become one of the main problems in this country.

Under these circumstances, as a part of the 8th Five Year Plan started in 1997, the Royal Government of Bhutan has the plan to implement a feasibility study of replacement of 22 bridges on the trunk roads maintained by DoR. Responding the request, the Government of Japan implemented the study on National Highway Bridge Replacement Project for the requested 22 bridges and recommended 12 bridges should be replaced urgently. In October 2003, the most urgent 5 bridges among the recommended 12 bridges had been replaced with the assistance of Japanese Grant Aid.

In the 9th Five Year Plan, replacement of the remaining bridges is given high priority again in the road sector. In August 2003, The Royal Government of Bhutan requested replacement of 3 bridges out of the 12 bridges as "The Project for Reconstruction of Bridges (Phase-II)".

Responding this request, the Government of Japan decided to execute a basic design study and directed the Japan International Cooperation Agency (JICA) to send a study team from

June 18 to July 24, 2004 for site survey. The study team discussed with the execution agency, DoR, about the intent of this request, and studied their capability for project implementation and maintenance. Then, the team investigated the site and collected reference materials about this project and the projects with the other donors.

Based on this site survey, the team studied the scope of the grant aid, type and size of the facilities, and the cost of the project. The results of the study were compiled into the Draft Report. JICA sent a team to Bhutan for explanation of this report and for discussion about the basic design from October 10 to 16, 2004. The Royal Government of Bhutan basically agreed with Japanese side about the results of the basic design.

The contents of the basic design agreed upon by both parties are shown in the following table. In this project, atmospheric corrosion resistant steel (weathering steel), which facilitates bridge maintenance works compared to the usual steel, was selected as the bridge material. The implementation period including detail design phase is to be 32.5 months.

Content of the Basic Design

Br. No.	Bridge Name	District Name	Type of Road	Bridge length (m)	Span length (m)	Carriage-way width (m)	Bridge type	Note
1	Wakleytar	Wangdue Phodrang ～Tsirang	National Highway	86.0	84.6	6.0	Steel Langer Arch	Weathering Steel
2	Tangmachu	Lhuntse	District Road	70.0	68.6	5.5	Steel Langer Arch	Weathering Steel
3	Sunkosh	Dagana	District Road	95.2	93.8	5.5	Steel Langer Arch	Weathering Steel

The construction work for approach roads is responsibility of the Bhutanese side for the following reasons:

① Some of the approach roads must be constructed after the completion of the new bridge and removal of the existing bridge to avoid interference on the existing bridge (cable and anchorage for the suspension bridge).

② The Bhutanese side has adequate capability to construct approach roads especially after the procurement of construction equipment under Japanese Grant Aid as "the Project for Improvement of Equipment for Road Construction and Maintenance".

For the implementation of "the Project for Reconstruction of Bridges (Phase II)" under the Grant Aid of Japan, the rough estimated cost is about 1,364 million yen (1,349 million yen

from the Japanese side, and 15 million yen from the Bhutanese side), although this cost estimate is provisional and will be further examined by the Government of Japan for the approval of the Grant. The cost borne by Bhutanese side is only 0.4% of the road sector budget in 2003 (1,600 million Nu or 3,680 million yen), therefore it is concluded that the Bhutanese side has adequate capability for implementing this project.

The following benefits are expected from the implementation of the project:

Direct Benefits

- The allowable load for the Wakleytar Bridge, Tangmachu Bridge and Sunkosh Bridge will be increased to 40t, whereas present allowable load are only 18t, 8t, 12t respectively.
- As for transportation of heavy cargo such as construction equipment, the required time to cross the river will be reduced to less than one minute at the three bridge sites whereas it presently takes 2 days to dismantle and re-assemble large equipment, and 30 minutes for alighting and reboarding for self-propelled equipment.
- Regarding heavy vehicle traffic, more than three axle trucks and trailers will be able to pass over the three bridges whereas only two axle trucks with the loading capacity less than 8t can now pass (presently, average traffic volume at the sites are 26 cars/day at Wkleytar Bridge, 9cars/day at Tangmachu Bridge and 13 cars/day at Sunkosh Bridge).

Indirect Benefits

- Local economic activity will be promoted by permitting heavy vehicle transportation on the trunk roads, which will allow prompt shipping of agricultural and livestock products from the district and promoting the regional development plan in the district.
- Economic disparity between the districts, connected solely by the bridges which are bottlenecks, will be reduced by upgrading the bridges. This will promote economic self-reliance of the districts being connected by the more reliable roads.
- Through reconstructing of the requested bridges into permanent bridges and upgrading other bottleneck bridges on the same roads, accessibility to markets, schools and hospitals will become easier, and consequently, living standards of the people in the districts will rise.

The above will be more effective if the other smaller bottleneck bridges are resolved at the same time. The Bhutanese side proposed to resolve problems at these bridges at their own cost by the end of the project (March 2008a) including temporary upgrading of the bottleneck bridges.

To resolve all the bottleneck bridges on the trunk roads will facilitate transportation of material, equipment and product in the country, and then, in medium to long range, it will promote economic and industrial development not only in the object districts of the requested bridges, but also in the surrounding districts. As a result, this project will correct economic disparity among all the districts and contribute to more balanced growth in the country. Therefore, the number of benefited population of this project is about 700,000 people, all the residents in this country.

In spite of these benefits, it is technically and financially difficult for the Bhutanese Government to replace the requested bridges because the bridges have long span (more than 70 m) and the Bhutanese Government has never had experience to replace temporary Bailey bridges with such long span permanent bridges. Therefore, it is appropriate to replace the request bridges under the assistance of Japanese Grant Aid.

Furthermore, in this project, construction works of approach roads are obligation of the Bhutanese side, and the works resolving other bottleneck bridges by the Bhutanese side are a condition of this project. Therefore, it is important for the Japanese side to monitor the progress for the Bhutanese side to allocate the budget for those works and to execute them properly.

Kingdom of Bhutan
The Project for Reconstruction of Bridges (Phase II)

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CHAPTER 1 BACKGROUND OF THE PROJECT

1-1 Background of the Request

The Kingdom of Bhutan is situated between 27～28 degrees North Latitude and 89～92 degrees East Longitude. Bhutan is a landlocked country located between Tibet (southwest China) and Assam (northeast India). There are some peaks of the Himalaya Mountains, higher than 7,000 m, located between northern part of Bhutan and southern part of Tibet. Some rivers originate from the peaks in the northern part flow south and down to the plain less than 100 m elevation in Assam and then into the Brahmaputra river. The area of Bhutan is 46,500 km^2, a little bit larger than Kyushu, and the population was about 700,000 in 2001.

The main road network of Bhutan consists of East-West Highway (National Road No.1) and four North-South Highway (National Road No.2～No.5). Department of Roads (DoR), Ministry of Works and Human Settlement, manages these national roads except the National Roads No.2 and No.3 which the Indian Government is taking care of. Since Bhutanese transportation mostly relies on these Highways throughout the mountainous country, establishing an efficient and safe road network is essential to renovate social and economic situation.

However, implementing road improvement projects by the Bhutanese Government solely is difficult because of lack of expertise to cope with the construction required under severe topological and natural conditions. There are many Bailey bridges (temporary steel bridges), most of those were constructed before 1980's and have reached their expected life, on the trunk roads maintained by DoR. Replacement of these damaged or deteriorated bridges was being executed so slowly, that it has become one of the main problems in this country.

Under these circumstances, as a part of the 8th Five Year Plan started in 1997, the Royal Government of Bhutan has the plan to implement a feasibility study of replacement of 22 bridges on the trunk roads maintained by DoR. Responding the request, the Government of Japan implemented the study on National Highway Bridge Replacement Project for the requested 22 bridges and recommended 12 bridges should be replaced urgently. In October 2003, the most urgent 5 bridges among the recommended 12 bridges had been replaced with the assistance of Japanese Grant Aid.

In the 9th Five Year Plan, replacement of the remaining bridges is given high priority again in the road sector. In August 2003, The Royal Government of Bhutan

requested replacement of 3 bridges out of the 12 bridges as "the Project for Reconstruction of Bridges (Phase-II)".

Responding this request, the Government of Japan decided to execute a basic design study and directed the Japan International Cooperation Agency (JICA) to send a study team from June 17 to July 25, 2004 for site survey. The study team discussed with the execution agency, DoR, about the intent of this request, and studied their capability for project implementation and maintenance. Then, the team investigated the site and collected reference materials about this project and the projects with the other donors.

1-2 Request Components

According to the request form, "Project for Reconstruction of Bridges (Phase-II), 1st August, 2003" by DoR, the requested components to the Government of Japan are reconstruction of following three existing bridges:

- No.1 Walleytar Bridge over Sunkosh River in Tsirang Dzongkhag (District)
- No.2 Tangmachu Bridge over Kuri River in Lhuntse Dongkhag (District)
- No.3 Sunkosh Bridge over Sunkosh River in Dagana Dzongkag (District)

The existing Wakleytar Bridge has 73.2 m span on National Highway Route 5, the existing Tangmachu Bridge has 85.2 m span on the Mongar to Lhuntshi District Road, and the existing Sunkosh Brisge has 85.2 m span on the Tsirang to Dagana District Road. All three existing bridges are Bailey suspension bridges and their carriage widths are about 3.3 m.

Regarding construction work of the new approach roads, the Japanese side proposed to treat the work as the responsibility of the Bhutanese side for the following reasons:

① Some of the approach roads must be constructed after the completion of the new bridge and removal of the existing bridge to avoid interference on the existing bridge (cable and anchorage for the suspension bridge).

② The Bhutanese side has adequate capability to construct approach roads especially after the procurement of construction equipment under Japanese Grant Aid as "the Project for Improvement of Equipment for Road Construction and Maintenance".

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2-1 Basic Concept of the Project

2-1-1 Objective of the Project

"The Project for Reconstruction of Bridges (Phase II)" forms part of the Road Network Establishment Projects implemented by the Ministry of Works and Human Settlement, the Royal Government of Bhutan, in the 9th Five Year Plan which consists of widening national highways, construction of local roads, operation/maintenance of existing roads and bridges, and reconstruction of existing bridges. According to the sector program of the 9th Five Year Plan, the Overall Goal of these projects is as follows:

① Improved quality of life of rural population through better access to socio-economic facilities, etc.
② Reduced dependency on Indian Highways for transport between towns and cities in Bhutan.
③ More reliable and safer road transport system through reducing travel time and cost.

This project is to reconstruct three deteriorated bridges on trunk roads and follows the successful reconstruction of five bridges under Japanese Grant Aid.

The allowable loads for Wakleytar Bridge, Tangmachu Bridge and Sunkosh Bridge do not meet the 40 ton capacity specified for trunk roads, since they are 18 tons, 8 tons and 12 tons respectively. This is a hindrance to development in the area, particularly for currently planned infrastructure development projects.

Furthermore, there are no possible alternative routes and if a bridge becomes impassable and many communities would be isolated.

The Project Purpose is to remove the bottleneck bridges which restrict progress of rural development.

2-1-2 Basic Concept

To achieve the Project Purpose, three bridges are to be reconstructed through Japanese Grant Aid. The Government of Bhutan will carry out land acquisition, removal of existing bridges and construction of approach roads. Construction work is expected to make use of construction equipment provided to the Department of Roads (DoR) under

a related Japanese Grant Aid Project "The Project for Improvement of Equipment for Road Construction and Maintenance". The equipment will be leased to companies carrying out the work.

Through this project, it is expected that the deteriorated three bridges with inadequate load capacity are to be reconstructed as proper grade bridges suitable for present social and economic needs. In this project, the Requested Japanese Assistance is construction of substructures, revetments and fabrication and installation of superstructures of Wakleytar Bridge, Tangmachu Bridge and Sunkosh Bridge.

2-2 Basic Design of Requested Japanese Assistance

2-2-1 Design Policy

(1) Basic Policy

The requested three bridges (Wakleytar Bridge, Tangmachu Bridge and Sunkosh Bridge) are among the 22 bridges investigated and recommended for replacement in the "Study on National Highway Bridge Construction in the Kingdom of Bhutan" prepared by JICA in 1997. Of the 22 bridges, the five with highest priority have already been constructed under Japanese Grant Aid. The three bridges that are the subject of this report are numbered 9, 11 and 12 in the list of prioritized bridges.

The process followed by the Study Team in examining the justification for replacement of the bridges is illustrated in Figure 2-2-1-1.

Firstly the Study Team confirmed with DoR the reasons for selection of these bridges, even though they are not the highest prioritized bridges remaining from the 1997 JICA study.

It was understood that the bridges are relatively long span structures over main rivers, with no clear means of creating a temporary diversion, and are considered relatively difficult to reconstruct. Other bridges are shorter and temporary diversion roads can be built to allow bridge reconstruction. As a short term solution, there is also scope for propping of the shorter bridges to allow passage of trucks carrying exceptionally heavy loads, whereas for the longer bridges this is not possible. Based on these discussions and field inspection of the bridges, the Study Team concluded that selection of the three bridges was appropriate.

Secondly, the Study Team considered the validity of design for 40 ton capacity. Other bridges on the route from Thimphu to the bridge sites still have lower capacities, and it was necessary to check the impact of these bottlenecks to passage of trucks.

In particular, various development projects are underway or planned in the region including hydropower projects that require transport of heavy trucks carrying construction materials, and large equipment such as transformers. Design live loads for permanent bridges should be Class A (IRC Standard) in Bhutan, and allowable loads 40 tons. The DoR plans to upgrade all the bridges on trunk roads over time, but in the short term measures such as propping are used to strengthen shorter bridges.

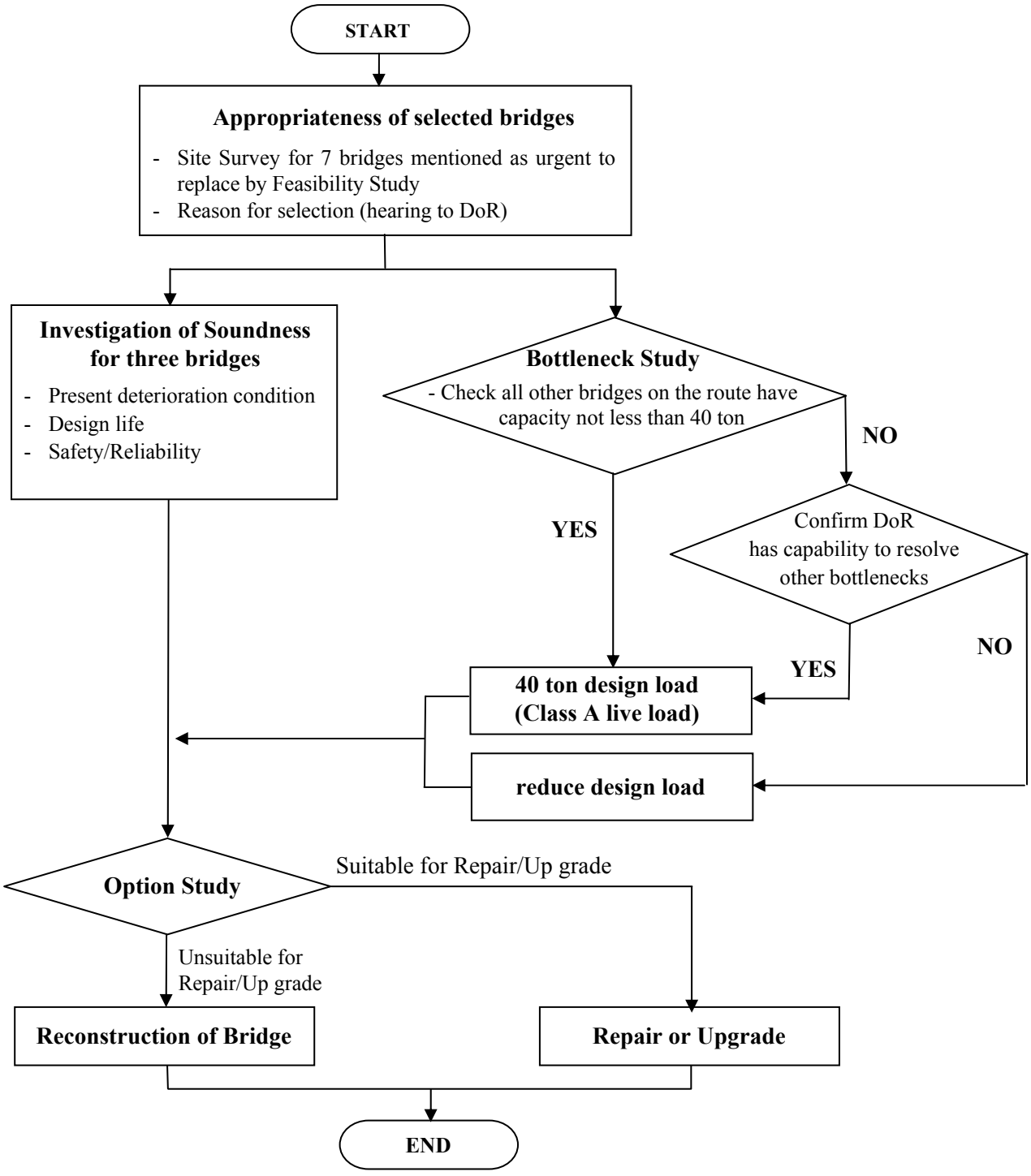


Figure 2-2-1-1 Flow Chart for Justifying Reconstruction of Bridges

Since propping is not possible for the longer bridges, DoR strongly requested reconstruction of the three bridges to 40 ton capacity, and this was accepted by the Study Team.

Thirdly, the Study Team looked at options for repair, upgrading, or replacement of the bridges, and carried out detailed field inspection. Since the bridges were constructed with allowable loads of 24 tons, repair was ruled out as an option since even if restored to new condition the capacity would be inadequate.

Upgrading was considered; however, there are a number of severe constraints to this option. The bridges were constructed as bailey bridges with cable suspension support. These are lightweight structures using relatively thin steel members that are easy to transport and to construct. The use of lightweight members means that design life is limited to 20-25 years, and the present structures, although fairly well maintained and in fair condition, are nearly expired. It was felt that upgrading the structures with additional trusses, cross-beams, and stronger suspension towers/cables would at most produce structures with serviceable life of 10-20 years, and such a short design life is not appropriate for Japanese Grant Aid projects.

Accordingly, it was resolved to reconstruct new bridges with allowable load capacities of 40 tons.

In order that the investment in the 40 ton capacity bridges is fully utilized, it is noted by the Study Team that DoR should continue its programme of bridge upgrading of other inadequate bridges along the routes from Thimphu in order to eliminate load capacity bottlenecks.

The design policies when the bridges are to be reconstructed are follows:

(2) Policies Based on Natural Conditions

1) Meteorological conditions

In Bhutan, the rainy season (June to Sept.) and dry season (Oct. to May) can be classified clearly and rainfall is concentrated during the monsoon (rainy) season. Due to landslides, debris flow etc, roads (including the national highways) get totally blocked frequently during the rainy season. Further, road surfaces sometimes freeze in winter where the height above sea level is more than 3,000 m. Such meteorological conditions should be reflected in the process planning of transportation of the equipment and materials.

2) Hydrological conditions

For the design of the bridges such as position, span, structure, bank protection works, the results of the hydrological and hydraulic analyses should be adequately taken into account. The design high water level is to be determined based on the comparative analysis on the maximum discharge in the past, 50 years period discharge and flood marks. Moreover, river current speed during the rainy season is also supposed to be measured at each bridge site in order to perform a brief analysis on possibility of installation of an intermediate pier of bridge.

There exist many glacier lakes in the upstream regions of the existing bridges. It is understood that the glacier lakes might burst which may exert severe flood damage in the downstream regions due to global warming or an earthquake. Therefore, the high water level in consideration of the influence of the glacier lake outburst should be considered.

3) Topographical conditions

At the sites with steep slopes, it is to be considered not to increase earthwork incurred by approach road design. The most economical installation method suitable to topology of the site shall be chosen as a bridge installation plan. Safety net to protect falling rock shall be provided at the sites of steep slopes with rocks.

4) Geological conditions

Location and foundation size of abutments and thickness of approach road shall be determined based on the result of geological survey. The concrete arch bridge as well as steel bridge is to be studied for especially Wakleytar site where rock formation can be observed on both sides of the river.

5) Seismic conditions

As the seismic conditions of Bhutan, IRC Standard (Standard Specifications and Code of Practice for Roads Bridges; Section II Loads and Stress; The Indian Road Congress) is to be applied. Although the seismic zone map does not include Bhutan, it is assumed to be seismic zone V from the zone of Assam area in India adjacent to Bhutan.

(3) Policies Regarding Socio-economical Conditions

The bridge locations are selected to avoid resettlement as much as possible. It is considered in the approach road plan and bridge installation plan to maintain traffic flow on the roads even during construction of new bridges because the bridges are located on trunk roads of each Dzongkhag (prefecture) and there is no diversion route.

(4) Policies Regarding Situation of Construction, Procurement and Business

Construction materials and equipment are to be procured in the Bhutan as much as possible. However, most items are not produced in Bhutan but imported from India such as re-bar, fuel and asphalt. Therefore the project cost is estimated based on the prices and the distance from Phuentsholing, border town adjacent to India.

If the superstructure of a bridge is made of cement concrete, most of main materials except re-bar can be procured in Bhutan such as cement, sand and aggregate, the same as the substructure. However if the superstructure is made of steel, it should be procured from Japan or any other third countries because there is no mill and bridge fabricator in Bhutan. The study team assumed that the third country could be Thailand where some Thai-Japanese joint enterprises with bridge fabrication experience are located. For this project, Indian bridge fabricators are eliminated from presumable suppliers of steel bridge because of difficulty of quality assurance with no mill sheet and difficulty of keeping schedule (except imported re-bar from India where its quality can be confirmed by testing tensile strength in Thimphu).

As for construction equipment, DoR agreed to lease construction equipment procured through Japanese Grant Aid "the Project for Improvement of Equipment for Road Construction and Maintenance" with first priority. In the implementation plan, the study team counts on the equipment for reducing project cost.

(5) Policies Regarding the Use of Local Contractors

Local contractors are registered and classified as A, B, C and D (petty) depending on the corporate size. 52 Class A contractors employing engineers, superintendents, skilled labors can procure not only labors but also subcontractors and equipment for this project.

To facilitate local contractor's entering in this project, the Bhutanese way of retaining wall design will be adopted and also Bhutanese way of asphalt paving will be adopted in the implementation plan.

(6) Policies Regarding Maintenance Capabilities of the Administering Agency

DoR operates and maintains all the bridges on trunk roads except the bridges on National Highway No.1 and No.5 which are operated and maintained by Indian government (Dantak). The requested three bridges are also operated and maintained by DoR.

In Bhutan, almost all bridges of 10 to 30 m span are the Bailey type temporary bridges, and many bridges less than 10 m span are concrete slab bridges. Most of experience of DoR for maintenance work covers repair, upgrade and reconstruction of temporary bridges, and only a little experience for permanent bridges. However, for atmospheric corrosion resistant steel (weathering steel) bridges, DoR has fair experience because five bridges are constructed under the Phase I project with that kind of steel and maintained under instructions of bridge expert from JICA. Therefore DoR will not need additional management effort, and has an adequate level of maintenance skill if the weathering steel bridges are selected.

(7) Policies Regarding the Grade of Bridge Construction

1) Design live load

The other bottleneck bridges between Thimphu and the sites were studied in this basic design study to fix design live load. As a result of the bottleneck study, it was confirmed that following bridges are bottlenecks.

① route: Thimphu～Wangdue-Phodrang～Wakleytar Bridge～Sunkosh Bridge

10 bridges: Hesothangkha, Lawakha, Basochu, Rurichu, Baychu, Kamichu, Nyarachu, Necheychu (Mechekola), Burichu, Chachey

② route: Thimphu～Limithang～Tangmachu Bridge

5 bridges: No.4 Bridge, Rewanchu, Phawan, Karma Shangshong, Rongmanchu

The design load may be reduced if DoR has not enough capability of resolving these 15 bottleneck bridges. Through discussion with DoR, the study team confirmed that the following measures of resolving bottlenecks were proposed by DoR.

① Bottleneck bridge which is less than 10 m will be replaced with a concrete slab bridge (Class A load) within 1 to 2 years.

② Bottleneck bridge which is from 10 to 20 m will be replaced into a concrete bridge (Class A load) following the replacement of shorter bridges. This bridge will be reinforced by additional bailey panel, or provided detour until the concrete bridge is constructed.

③ To replace bailey bridge more than 20 m with permanent bridge is technically and financially difficult for DoR for the scheduled completion of three requested bridges. Therefore reinforcing or repairing existing bridge will be applied as a tentative measure.

DoR keeps Standard Design Manual for RC bridges of less than 20 m, and assumes they themselves have technical capability for such bridges. As for financing of replacement of bridges, DoR proposed the following measures:

① British Company offers soft loan to replace temporary bailey bridges with galvanized steel modular bridges with 75 years life span. DOR is trying to get approval from Ministry of Finance for this loan.

② Project fund for Punatsangchu hydroelectric project may be utilized to replace bottleneck bridges on the National Highway No.5.

As stated above, DoR mentioned a specific way of resolving bottleneck bridges and also preparing the finance of this project. Therefore the study team concluded that to apply Class A design live load (IRC Standard) is suitable for the new bridges.

2) Procurement from third country for steel bridge

To reduce project cost, fabrication of superstructure for steel bridges in Thailand was considered in this basic design study. In Thailand, some companies have experience to fabricate steel bridges in joint enterprise with a Japanese fabricator. However, no company has experience to fabricate Langer type steel bridge in Thailand. Therefore the study team will only allow fabrication of Langer bridge in third country (assumed as Thailand) under the condition of dispatching Japanese engineers required to keep adequate level of quality the same as Japanese products.

3) Policies regarding atmospheric corrosion resistant steel (weathering steel)

Painted steel bridge and unpainted atmospheric corrosion resistant steel (weathering steel) bridge are compared regarding initial cost and life cycle cost under the condition of fabricating in Thailand.

As for initial cost, the cost of unpainted weathering steel bridge is almost the same as the cost of painted bridge. As for life cycle maintenance cost, the cost of unpainted bridge is negligible because of utilization of weathering steel, although the cost of painted bridge is about 70% of initial cost which shall be funded by Bhutanese Government.

The study team recommends the unpainted weathering steel bridge because it drastically reduces maintenance cost of the recipient country, although the initial cost is almost same as painted bridge, thus satisfying the following limitations for weathering steel bridge by Japan Highway Public Corporation.

Limit of application:

- In saline environment: free from saline environment in Bhutan
- Effect of anti-freeze: no freezing of surface for three bridges even in winter because the elevation of the bridges are between less than 400 m (Wakleytar, Sunkosh) and 1,100 m (Tangmachu).
- Environmental issue: unpainted weathering steel bridges constructed in phase I are accepted by Bhutanese people with no claim so far, and dense rust layer is growing properly.

(8) Policies Regarding Construction/Procurement Methods, and Schedule

Comparing various ways of bridge erection such as truck crane and bent method, extruding method and cable erection method, the study team will select the most economical and suitable method regarding the topology of the site. As mentioned above, although atmospheric corrosion resistant steel will be procured from Japan, it will be allowed to fabricate steel superstructure of the bridge in third country.

The rainy season, from June to September, will be considered for implementation plan. Especially the first dry season, from October 2005 to May 2006, when it is important to start Tangmachu Bridge which is the most urgent to replace. Therefore the detail design should be started early in 2005.

2-2-2 Basic Plan

2-2-2-1 Design Condition

(1) Road Design Standard

1) Road design standard in Bhutan

For the road design standard in Bhutan, the relationship between the road function including design speed and traffic volume component are indicated in the Table 2-2-2-1. At this study area, the design speed will be at the maximum 60 km/h. However, the design speed for each approach road in this study is to be 20 km/h for the following reasons:

- There are bluffs that make it difficult to setback approach road at the bank of each site.
- It is possible to maintain present traffic volume, even if the design speed is as low as 20 km/h.

The Bhutanese road geometric design standards, which depend on each design speed, are almost same as the "Road Structure Ordinance" in Japan.

Table 2-2-2-1 Road Design Criteria in Bhutan

Road Class (Design traffic volume)			Design Speed km/h
			Up to 60
National Highway	Class AA Two Lanes (>200)	Pavement (m)	6.0
		Shoulder (m)	1.0
		Formation (m)	8.0
	Class A One Lane (100 - 200)	Pavement (m)	3.5
		Shoulder (m)	1.5
		Formation (m)	6.5
District Road	Class B One Lane (50 - 100)	Pavement (m)	3.5
		Shoulder (m)	1.0
		Formation (m)	5.5
Feeder Road	Class C One Lane (<50)	Pavement (m)	3.0
		Shoulder (m)	0.75
		Formation (m)	4.5

Source: Road Design Manual, Public Works Department, Ministry of Social Service, Royal Government of Bhutan

2) Minimum curve radius

In the study on "National Highway Bridge Construction in the Kingdom of Bhutan (Feasibility Study in 1997)", the minimum curve radius of 6.0 m for the horizontal

alignments was adopted considering the largest trucks (w = 2.5 m, L = 8.2 m) at that time and reducing earthwork of steep slope just behind the approach roads.

However, during the phase I study, the study team found that heavy vehicles like a semi-trailer (w = 2.5 m, L = 14.8 m) were usually used in order to transport the machinery and materials for the construction of hydraulic power stations such as Tala, Kurichu and Basochu. In addition to the hydraulic power stations, the study team presumed that utilization of heavy vehicles must increase for future reconstruction projects of Puna-Tsangchhu and Geylegphug bridges on national highway. Therefore, the minimum curve radius of 15.0 m for the horizontal alignments was adopted considering the semi-trailer for the phase I bridges.

During this (the phase II) study, the study team also confirmed some projects are on going near the objective three bridges, such as Punatsangchu Hydropower Project financed by India, Construction of Feeder Roads project financed by World Bank and Road Network Expansion Project financed by ADB. Considering the actual size of semi-trailer (w = 2.5 m, L = 13.5 m) owned by DoR, the minimum curve radius of 12.5 m for the horizontal alignments was adopted for the phase II bridges as requested by Bhutanese side.

3) Horizontal and vertical alignment

According to the design speed of approach roads (20 km/h), the study team sets geometric design such as horizontal alignment and sight distance for the approach roads. Vertical grade for approach road shall be less than 8% and minimum vertical grade of bridge surface is 0.5 % for drainage.

4) Carriageway width

According to the result of traffic survey the carriageway width of Tangmachu and Sunkosh Bridges is to be 5.5 m as proposed in the Feasibility Study in 1997. This width will remain the space for a vehicle to pass the bridge even a large size car such as a buss or a truck with 2.5m width stopping on the bridge.

However, DoR requested the carriageway width of 6.0 m for Wakleytal bridge because the bridge is located on the national road that is planned to be widen to 2 lane 6 m width road. According to the result of traffic survey, the present traffic volume at the bridge is as small as 18~29 (vehicles/12 hours). However, the traffic volume of large size vehicle will increase drastically at the completion time of Wakleytar Bridge (in 2007) thanks to "Punatsangchhu Hydro-Electric project".

This width will remain the space for a large size vehicle to pass the bridge even one such as a bus or a truck with 2.5 m width stopping on the bridge or passing on the other lane.

(2) Bridge Design Standard

1) Design criteria

"Standard Specification and Code of Practice for Road Bridges, The Indian Roads Congress (IRC)" shall be applied according to the result of technical meeting with Bhutanese government.

2) Live load

Class A live load of the IRC-Code has been applied to permanent bridges (mostly RC or PC bridges) in Bhutan because previously all the bridges were constructed by Indian Government. As mentioned in the section 2-2-1 (1) "Basic Policy", application of Class A live load to the three bridges is valid under the condition for dissolution of bottleneck bridges by Bhutanese Government.

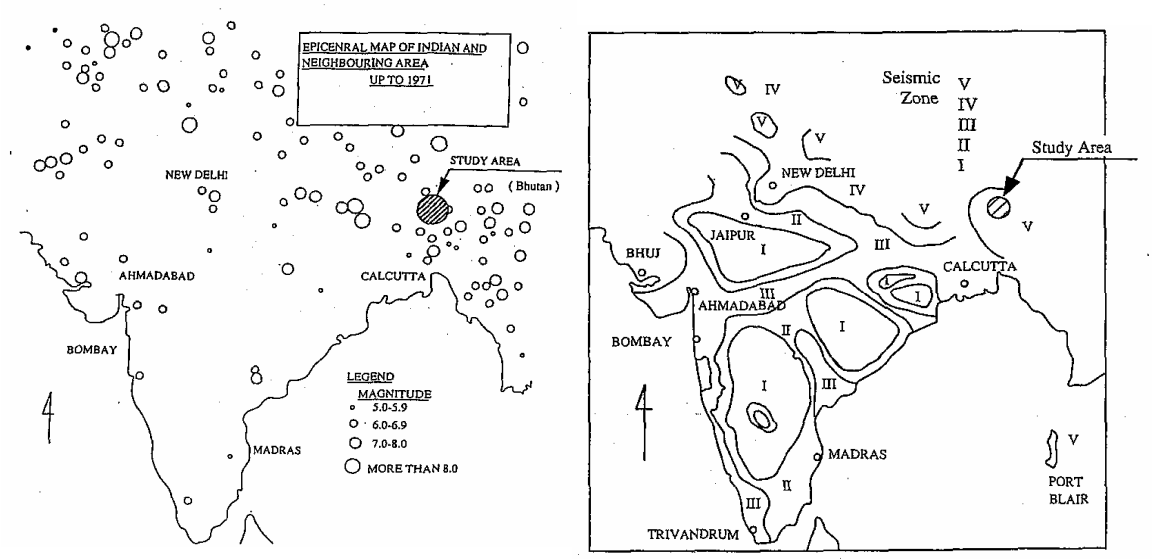
3) Horizontal seismic coefficient

Seismic zone map of the IRC-Code is shown to Figure 2-2-2-1. Bhutan is not included in the Figure 2-2-1-1. However, the figure shows that Assam district of India, adjacent to the South and East border of Bhutan, is identified "Zone V" where the seismic effect shall be the largest. Therefore, it is reasonable to assume "Zone V" for Bhutan. Horizontal seismic coefficient for this zone is 0.12 from the following formula:

α_h (Horizontal Seismic Coefficient) $= \beta \times I \times \alpha_0 = 1.0 \times 1.5 \times 0.08 = 0.12$

where β : Geological Factor
I : Important Factor
α_0 : Area Factor

If there are any Seismic design items not mentioned in the IRC-Code, the "Specifications for Highway Bridges" by Japan Road Association will be applied.



Source : "Elements of Earthquake Engineering" A.R. Chandrasekaran , Professor, School of Research & Training in Earthquake, Engineering University of Roorkee, Roorkee, India , 1976

Figure 2-2-2-1 Seismic Zone Map of India and Neighboring Area

4) Pavement for bridges

The following types are studied for bridge pavement:

a) Asphalt concrete pavement
b) Cement concrete pavement

a) Asphalt concrete

Since there is no asphalt mixing plant in Bhutan, hot mix asphalt concrete is usually produced at road construction sites. Therefore, the quality control is the critical issue when the asphalt concrete pavement is applied.

b) Cement concrete

Cement concrete pavements have been used for bridges constructed by Indian Government. To avoid instant cracks of the cement concrete pavement, those pavements must be placed on bridge deck slab concrete at the same time. Most of the case, a waterproof layer between the bridge deck and the pavement is usually omitted because of difficulty of setting. Consequently, water might easily permeate into the deck slab if cracks appear on the pavement concrete in future. Therefore, preventing water permeating into the deck slab concrete is critical issue.

Judging from facilitating of Bhutanese maintenance work, asphalt concrete pavement is selected for the three bridges with appropriate quality control during construction.

Thickness of asphalt cement pavement shall be 60 mm referred to the specification of Japan Road Associations.

5) Design criteria of other structures

IRC Standard shall be applied to other structures such as retaining walls and drainages. The specification of Japan Road Associations are applied for design items which are not mentioned in the IRC Standard.

6) Strength of concrete

a) Sub-structure

Strength of concrete is 21 N/mm^2 as same as phase I, because target structure is abutment where bending moment will not occur.

b) Superstructure (Concrete for deck slab)

Rich cement concrete is preferable to avoid cracks on the deck causing water permeation and deterioration. Therefore, strength of 24 N/mm^2 shall be applied for superstructures.

7) Hydrological and hydraulic conditions

In Bhutan, 2,700 glacial lakes are recognized and 24 glacial lakes are nominated as dangerous[1]. There are 13 dangerous glacial lakes out of 929 in the upstream regions of Wakleytar Bridge and Sunkosh Bridge. There is at least 1 dangerous glacial lake out of 179 in the upstream regions of Tangmachu Bridge; however, the conditions of the glacial lakes in the further upstream region in China are still unknown.

For the analysis of high water levels, the influences of glacier lake outbursts flood (GLOF) are taken into account. Table 2-2-2-2 shows the results of the analysis around the three bridges (Wakleytar Bridge, Tangmachu Bridge and Sunkosh Bridge).

[1] Inventory of Glaciers, Glacial Lakes and Glacial Lake Outburst Floods, International Centre for Integrated Mountain Department (ICMOD), 2001

Table 2-2-2-2 Results of the Analyses on High Water Level

Name of Bridge	HWL including GLOF influence	HWL for 50 year period discharge	HWL for the max flood level in the past based on the hearing investigation and flood marks investigation	HWL for annual flood level based on the hearing investigation and flood marks investigation
Wakleytar Bridge	386.914 m	382.475 m	379.653 m	379.253 m
Tangmachu Bridge	1,119.852 m	1,113.459 m	1,112.463 m	1,110.963 m
Sunkosh Bridge	348.923 m	344.571 m	341.732 m	341.232 m

The high water level (HWL) including GLOF influence means the water level with the 50-year flood discharge including the discharge in the event of GLOF. This is the considerable highest water level. The HWL including GLOF can be possible during the service period of the bridges; however, it is quite difficult to predict it from the existing data. Moreover, the possibility in which the glacier lake outburst and the 50-year flood event happen at one time is thought to be very small. This means that the bridge design is quite uneconomical based on such high water level. Therefore, HWL for 50-year period discharge shall be used for the bridge design except for the lower level of the superstructures of three bridges.

For the design of the appropriate level of the superstructures, the discharge 5,800 - 7,500 m^3/s (including GLOF influence) with 1.5 m clearance should be applied in order to avoid the damage due to the collision of driftwood and boulders.

2-2-2-2 Design Concept

(1) Selection of Bridge Location

1) Wakleytar Bridge

2 points upstream from existing bridge and 1 point downstream from existing bridge are studied as new bridge location. Details are as follows:

a) 100 m upstream from existing bridge

- There is a bending point of river at the left bank. Because the flow velocity at the point is very high, there is a high risk of scouring at the abutment.
- If new approach road is constructed at left bank, it is necessary to cut the steep slope.
- There is a high risk of slope collapse in rainy season, because of the steep slope.
- There is a difference of ground level between left bank and right bank.

Therefore, to connect both banks by new road, it is necessary to cut the slope and to make an embankment.

This location isn't suitable because of the above-mentioned reasons.

b) 15 m upstream from existing bridge

- There is a bending point of river at the left bank. Because the flow velocity at the point is very high, there is a high risk of scouring at the abutment.
- If new approach road is constructed at left bank, it is necessary to cut the steep slope.

This location isn't suitable because of the above-mentioned reasons.

c) 30 m downstream at right bank and 100 m downstream at left bank from existing bridge

- There is a bending point of river at the right bank and the flow velocity at the point is very high. However the abutment of the right bank is placed on rock foundation, so there is no risk of scouring.

- At this pint a new approach road at the right bank is necessary. However the grade of slope at the right bank is not so steep as that of the left bank. Therefore, the volume of cutting slope and embankment at this point will be smaller than the other point.

This location is suitable because of the above-mentioned reasons. Although the bridge at this location shall be skewed to the river for keeping alignment of approach road, structurally, the bridge does not need to be skewed.

2) Tangmachu Bridge

An upstream point and a downstream point from existing bridge are studied as a new bridge location. Details are as follows:

a) Upstream point from existing bridge

- It is possible to reduce the bridge length (L = 70 m).
- It is possible to minimize land acquisition of private land.
- Flow of the river is straight and stable.
- It is not necessary to change vertical alignment of the approach road.
- Its not necessary to demolish the private house locating downstream of the right bank.

This location is suitable because of the above-mentioned reasons. Distance between the new bridge and the existing bridge shall be 15 m. The reasons are as follows:

- If the distance is more than 15 m, the width of the river is getting larger and the bridge is getting longer.
- If the distance is less than 15 m, construction work of the new bridge might affect on the existing bridge.

b) Downstream point from existing bridge

- The bridge length at this point can be shorter than the length at the above point and it might be easier to construct the approach roads. However the area of land acquisition at the right bank will be larger than the area at the left bank. In addition, a private house located at downstream of the right bank should be demolished during the construction stage. In this case, it is going to be impossible to reconstruct demolished houses according to the latest regulation related to land acquisition which established in July 2004.

From these reasons, downstream point isn't suitable for a new bridge location.

3) Sunkosh Bridge

Downstream from existing bridge is not suitable for a new bridge location because the left bank is scoured and the width of river is larger than upstream. In addition, it is necessary to demolish some private houses at the right bank. Therefore, upstream points from the existing bridge are studied as a new bridge location. Details are as follows:

a) 300 m upstream from the existing bridge

- The difference of ground level between right and left bank is more than 6 m at this pint. The volume of earthwork such as cutting slope and embankment for approach road shall be relatively big.

This location isn't suitable because of the above-mentioned reason.

b) 100 m upstream from existing bridge

- Although there are some private houses at the right bank, Bhutanese Government has restricted to build houses at the prospected area for the new bridge. Therefore, no private house shall be demolished at this point even if the land acquisition procedure shall be taken.

- The difference of ground level between right and left bank is very small at this point. Therefore, it is possible to make a new approach road without big volume of earthwork.

From the above reasons, this location shall be selected as the new bridge location.

(2) Selection of Bridge Type

1) Policy for selection of bridge type

a) The points from the site investigation

- At each site, river flow is very fast and quantity of the flow is also big. In addition, the depth of the river is more than 4~5 m. Therefore, it is difficult to make a bypath for the river by making embankment.
- It is difficult to install sheet piles at each site because all the riverbeds consist of not only sand, but also gravel and boulders.
- Rock layer is observed at both bank surfaces of Wakleytar Bridge. On the other hand, rock layer isn't observed at any bank surfaces of Tangmachu Bridge and Sunkosh Bridge.

b) Policies from the site investigation

- Continuous bridge type cannot be applied to these three bridges because it is very difficult and costly to construct a pier in the middle of the river despite the points described above. Consequently the single span bridge shall be applied for three bridges.
- The range of bridge length is 70~95 m for three bridges. In this range, Truss, Langer arch and Lohse arch are suitable type of steel bridges. Only arch type bridge may be suitable for a concrete bridge.

c) Procedure of selection

- Firstly, the best type of both steel bridge and concrete bridge will be selected by "Preliminary Comparison". Then, "Secondary Comparison" study shall be executed for Wakleytar Bridge which have rock layer at the both bank surfaces as bearing stratum and is suitable for arch type bridge. Based on the result of this comparison study, bridge type of Tangmachu and Sunkosh shall be studied.

2) Preliminary comparison of bridge type

a) Steel bridge

Deck bridge type, half through bridge type and through bridge type are to be considered as steel Truss or Arch bridges. Based on the following reasons, through bridge type shall be applied for steel bridges.

- Considering the flood by glacier lake outburst, it is difficult to keep adequate space between superstructure and water level if deck bridge type or half through bridge type is applied.
- Considering the water level of 50-year probable rain, it is possible to keep adequate space between superstructure and water level even if deck bridge type or half through bridge type is applied. However, for the steel bridges, the risk is too high to neglect the damage by collision of logs and boulders which might happen at the time of glacier lake outburst because the stiffness of section for steel bridge is usually smaller than that of concrete bridge.

Furthermore, it should be considered that each member of the bridge must be smaller than usual because only short and small trucks or trailers can travel the narrow and winding Bhutanese road.

Taking the above into consideration, preliminary comparison for superstructure type (steel bridge) is shown in Table 2-2-2-3. The main points of the comparison table are follows:

- The Lohse arch is not suitable for this project because the arch member is too large to transport on the Bhutanese roads.
- Although there is little problem for transportation of Truss type small members, Truss type requires more steel in total weight than Langer type, especially for the long span bridge such as Wakleytar Bridge and Sunkosh Bridge.

Therefore, if steel bridge is applied, the most suitable type for each bridge is as follows:

Wakleytar Bridge	(Bridge Length = 86 m)	Langer Arch
Tangmachu Bridge	(Bridge Length = 70 m)	Truss or Langer Arch
Sunkosh Bridge	(Bridge Length = 95 m)	Langer Arch

As for Tangmachu Bridge, the measure of bridge erection shall be cable erection method because of the topography. Longer arch is better selection for Tangmachu Bridge because it is difficult to erect Truss bridge by cable erection method.

b) Concrete bridge

The river flows very fast and abundant at each bridge site, even in dry season. Therefore, it is difficult to set support from the riverbed for concreting.

Therefore, "Composite Arch Erection Method", which requires no support from the riverbed for concreting, is considered as construction method.

Taking the above into consideration, preliminary comparison for superstructure type (concrete bridge) is shown in Table 2-2-2-4.

- In case of deck bridge type, steel arch members of "Composite Arch Erection Method" are considered as a temporary bridge to support deck slab concrete firmly.

  On the contrary, in case of half through bridge type and through bridge type, steel arch members of "Composite Arch Erection Method" can not work as a temporary bridge to support deck slab, so another firm support from riverbed is required. Because of difficulty of setting support from the riverbed, these types of bridges should not be selected for this project.

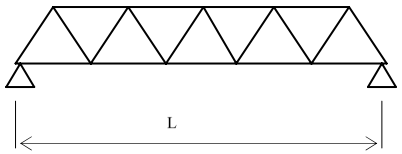
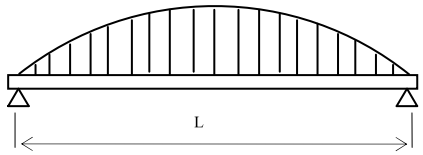
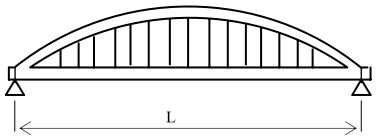
- In case of deck bridge type, huge horizontal force will be introduced to foundation by arch action. Therefore, strong bearing layer is preferable to avoid excessive mass of sub-structure supporting concrete arch. From this point of view, Wakleytar Bridge, where rock layer appears on both bank surfaces, has higher priority to adopt concrete arch than other two bridges.

Therefore, if concrete bridge is applied, the most suitable type is as follows:

Wakleytar Bridge	(Bridge Length = 86 m)	RC deck slab by "Composite Arch Erection Method"

Table 2-2-2-3 Preliminary Comparison for Superstructure Type (Steel Bridge・Span Length = 70~95m)

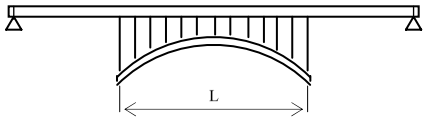
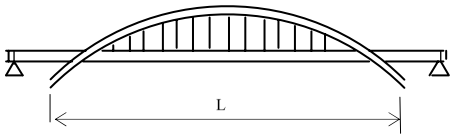
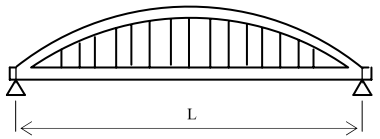
Restrict Condition for this Project: Roads in Bhutan are narrow and winding sharp. The length of trucks and trailers must be short to travel the roads. Using small and short trucks or trailers, it is difficult to transport long and heavy members.

	Sketch	Structural Property	Validity for application	Evaluation
Truss		• All loads are modified to axial force and resisted by all members. • Suitable span length is 55~85 m.	• Size of truss member can be small. So, transportation will be easier than other arch type structure. • Wakleytar Bridge (Bridge length = 86 m) is upper limit of applicable span length. However, from 70 m or so, weight and cost of truss bridge is getting bigger than other type.	△ (○)*
Langer		• Arch member can bear axial force only. • Appearance of arch member is more slender and smaller than that of Lohse type.	• Size of arch member will be smaller than that of Lohse type. Therefore, transportation is easier than Lohse type.	◎
Lohse		• arch member and lower cords member can bear both axial force and bending moment . • Size of arch member and lower cords member shall be same.	• Size of arch members are bigger than the other types. Therefore, the arch materials must be cut into small part.	△

*: Evaluation for Tangmachu Bridge (The shortest bridge)

Table 2-2-2-4 Preliminary Comparison for Superstructure Type (Concrete bridge・Span length = 70~95 m)

Restrict Condition for this Project: The river flows very fast and abundantly, even in dry season. Therefore, it is difficult to set support from the riverbed for concreting.

	Sketch	Structural Property	Validity for application	Evaluation
Deck Bridge		• This structure is statically indeterminate structure. Big horizontal force will be introduced to arch member.	• Applying composite structure to arch member, this bridge requires no support from riverbed for concreting deck slab.	△ (◎)*
Half Through Bridge		• This structure is statically indeterminate structure. Big horizontal force will be introduced to arch member.	• If the arch is on higher position than the deck slab, it is necessary to support deck slab concrete from riverbed. However, because of the river condition, it is difficult to set support from the riverbed even in the dry season. Therefore, this type is not suitable for the project.	△
Through Bridge		• This structure is statically determinate structure. Therefore, behavior is same as an usual girder bridge.	• It is necessary to support deck slab concrete from riverbed. However, because of the river condition, it is difficult to set support from the riverbed even in the dry season. Therefore, this type is not suitable for the project.	△

*: Evaluation for Wakleytar Bridge, where bed rock to bear horizontal force is available.

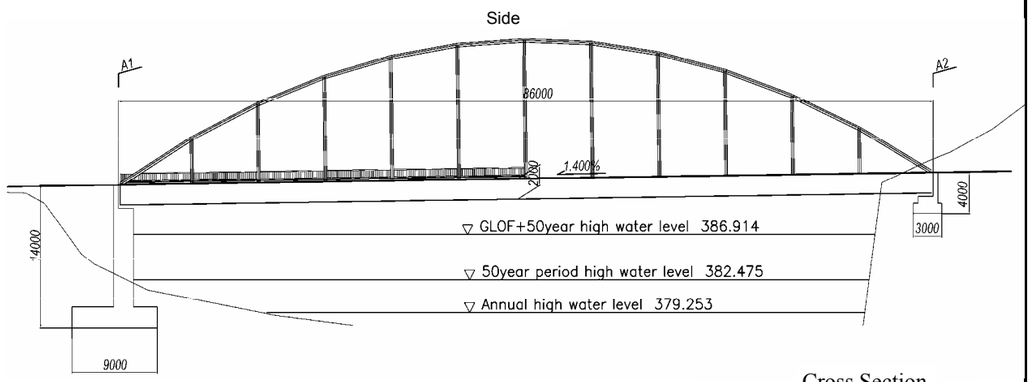
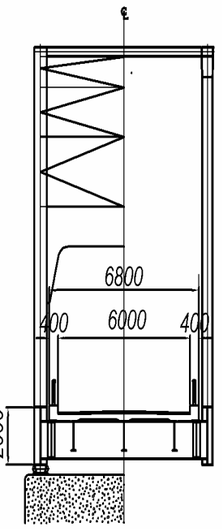
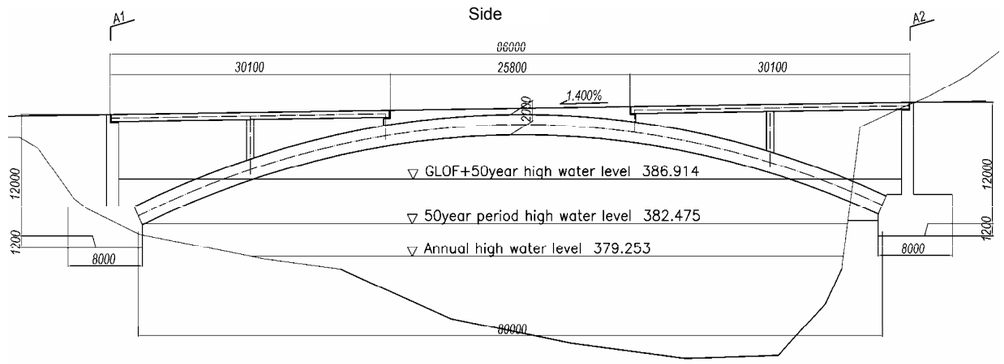
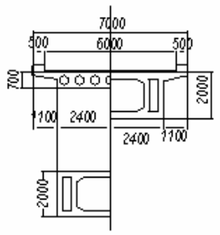
3) Secondary comparison of bridge type

Secondary comparison of bridge type for Wakleytar Bridge is shown in Table 2-2-2-5. From the result of comparison, it is confirmed that there is no significant difference of cost and construction period between steel bridge and concrete bridge. However, it should be noted that the risk of getting damage from collision of logs and boulders caused by glacier lake outburst cannot be measured but it is assumed not to be negligible for deck type concrete bridge.

Therefore, Steel Langer bridge is preferable for Wakleytar Bridge.

Bearing layer of Tangmachu Bridge and Sunkosh Bridge is not bedrock, but sand and gravel layer. Therefore, it is necessary to provide bigger substructure than Wakleytar Bridge to resist strong horizontal force from arch action. Compared to the steel bridge, the construction cost of concrete bridge will become bigger than the case of Wakleytar Bridge. Therefore, Steel Langer type is also applied to Tangmachu and Sunkosh Bridge.

Table 2-2-2-5 Secondary Comparison for Superstructure Type

	Steel Langer Arch	Concrete Arch
Sketch	Side  Cross Section  	Side   Cross Section 
Structure	- Bridge Length = 86 m - Arch Rise = 13.5 m, Rise Ratio = 1/6.4 - Arch = Box Section, Lower codes = I Section - RC Deck Slab - Substructure = RC Inverted T-type - Foundation = Direct Foundation (Bearing layer is rock) - Clearance from HWL is 10 m.	- Bridge Length = 86 m, RC Arch - Arch Rise = 9 m, Rise Ratio = 1/9.6 - Deck slab is PC hollow slab, and connected to arch members at arch crown rigidly. - Substructure = RC Inverted T-type - Foundation = Direct Foundation (Bearing layer is rock) - Clearance from HWL is 10 m. - The road level shall be 1m higher than the level of steel bridge to keep appropriate arch rise.
Construction	- Launching method is applicable for bridge erection	- Steel square-pipe arch will be erected by cable crane from both banks. After that, the square-pipe will be filled by concrete. Then, RC structure will be composed surrounding of the arch by casting concrete with a special equipment.
Maintenance	- Weathering steel may reduce maintenance work drastically, although, minimum periodical inspection will be required. - Re-painting, which is necessary for normal steel every 5 years or so, can be eliminated by using weathering steel.	- A concrete bridge is usually maintenance free, although, minimum periodical inspection will be required.
Quality Control	- Quality of the bridge will be reliable because of factory fabrication. However, it is necessary to pay attention to transportation and storage of the bridge from the factory to the site.	- Quality control is important because of in-situ concrete works.
Appearance	- This arch type bridge has good appearance as a monument in the mountainous region.	- This arch type bridge has good appearance as a monument in the mountainous region.
Disaster	- This type of bridge will be safe against glacial lake outburst because the superstructure is above the high water level including GLOF (Glacial Lake Outburst Flood) influence.	- This type of bridge will have some risks from glacial lake outburst because part of the arch is under the high water level including GLOF (glacial lake outburst Flood) influence.
	- It is difficult to predict timing and scale of glacial lake outburst. However, considering global warming in recent years, the risk of GLOF cannot be negligible. To avoid this unpredictable risk, the best way to be taken is to place the whole superstructure of the bridge above the high water level of 50 year period discharge including GLOF influence.	
Term and Cost for construction	- Direct Cost : (to be 1.00) - Term of Construction = Superstructure : 7 Months, Substructure : 7 Months - Project Cost (including indirect cost) : (1.485)	- Direct Cost : (0.97) - Term of Construction = Superstructure : 10 Months, Substructure : 7 Months - Project Cost (including indirect cost) : (1.494)
Evaluation	◎	○

(3) Superstructure

Bridge Length, Span Length, Road Width and Superstructure type are shown in Table 2-2-2-6.

Table 2-2-2-6 Summary of Superstructure

Bridge Name	Bridge Length [m]	Span Length [m]	Carriageway Width [m]	Superstructure Type
Wakleytar	86.0	84.6	6.0	Steel Langer Arch
Tangmachu	70.0	68.6	5.5	Steel Langer Arch
Sunkosh	95.2	93.8	5.5	Steel Langer Arch

To facilitate maintenance work after completion of the bridges, atmospheric corrosion resistant steel (weathering steel) is used for bridge members. Cross-section, length and weight of members shall be determined depending on the condition of transportation and the erection method. For this project, maximum length of member shall be 8 m.

(4) Revetment

Revetment of gabion is applied with the following conditions:

- Foundation of abutment is under HWL
- Bearing layer is other than bedrock

If bearing layer is bedrock, wing wall will be embedded to ground. The type of each revetment is shown in Table 2-2-2-7.

Table 2-2-2-7 Type of Revetment

Bridge Name	Abutment No.	Revetment	Remarks
Wakleytar	A1	Wing Wall	Rock Layer
	A2	-	Under HWL
Tangmachu	A1	-	Under HWL
	A2	Gabion	Sand and Gravel Layer
Sunkosh	A1	Gabion	Sand and Gravel Layer
	A2	Gabion	Sand and Gravel Layer

(5) Approach Road

Construction of permanent approach road is the obligation of the Bhutanese Government. In order to keep traffic, roads for construction work at the sites will be

used as temporary approach roads until completion of the permanent approach roads. Therefore two types of approach roads are designed namely "Temporary approach road" and "Permanent approach road".

Summary of design for approach road are shown in Tables 2-2-2-8 and 2-2-2-9.

Table 2-2-2-8 Summary of "Permanent Approach Road"

	Wakleytar	Tangmaxhu	Sunkosh
Horizontal Alignment	R=8⇒R=15m⇒R=8⇒R=40m⇒R=8	R=8⇒R=15m⇒R=8⇒R=15m⇒R=8	R=8⇒R=15m⇒R=8⇒R=15m⇒R=8⇒R=50m
Vertical Alignment	8.0%⇒3.0%⇒LEVEL ⇒8.0%⇒15.0%	0.311%⇒5.0%⇒8.0%	5.15%⇒0.5%⇒0.5% ⇒3.3%⇒8.0%
Carriageway Width	6.0 m	6.0 m	6.0 m
Pavement	Asphalt	Asphalt	Asphalt
Length of Approach Road (Beginning side)	43.0 m	81.3 m	96.4 m
(End side)	101 m	58.7 m	141.4 m

Table 2-2-2-9 Summary of "Temporary Approach Road"

	Wakleytar	Tangmaxhu	Sunkosh
Horizontal Alignment	R=15m⇒R=8⇒R=20m⇒R=8⇒R=15m	R=15m⇒R=8⇒R=15m	R=8⇒R=15m⇒R=8⇒R=15m⇒R=8
Vertical Alignment	3.0%⇒LEVEL⇒13.0%	2.08%⇒1.5%⇒14.5%	9.823%⇒0.5%⇒0.5% ⇒0.8%
Carriageway Width	6.0 m (Beginning side) 4.0 m (End side)	6.0 m	6.0 m (Beginning side) 4.0 m (End side)
Pavement	Temporary Pavement by gravel	Temporary Pavement by gravel	Temporary Pavement by gravel
Length of Approach Road (Beginning side)	22.97 m	26.3 m	96.4 m
(End side)	59.65 m	29.3 m	141.4 m

(6) Summary of Bridge Design

Results of the basic design for the bridges including length of approach road are summarized in Table 2-2-2-10.

Table 2-2-2-10 Summary for Bridges Design

	Wakleytar Bridge	Tangmachu Bridge	Sunkosh Bridge
Horizontal alignment	R=8	R=8	R=8
Vertical alignment	3.0% ◄	1.5% ►	0.5% ◄ 0.5% ►
Bridge length	86.0 m	70.0 m	95.2 m
Carriageway width	6.0 m	5.5 m	5.5 m
Superstructure type	Langer Arch	Langer Arch	Langer Arch
Substructure type	RC inverted T-type (Faulting Footing)	RC inverted T-type	RC inverted T-type
Height of A1 abutment	15.0 m	8.0 m	15.0 m
Height of A2 abutment	4.0 m	10.5 m	15.0 m
Length of approach road (Beginning point)	43.0 m	81.3 m	96.4 m
(End point)	101.0 m	58.7 m	141.4 m

2-2-3 Basic Design Drawings

Basic design drawings are attached in the following order for each bridge:

- General view of bridge
- General Plan
- Profile
- Cross Section for Approach Road

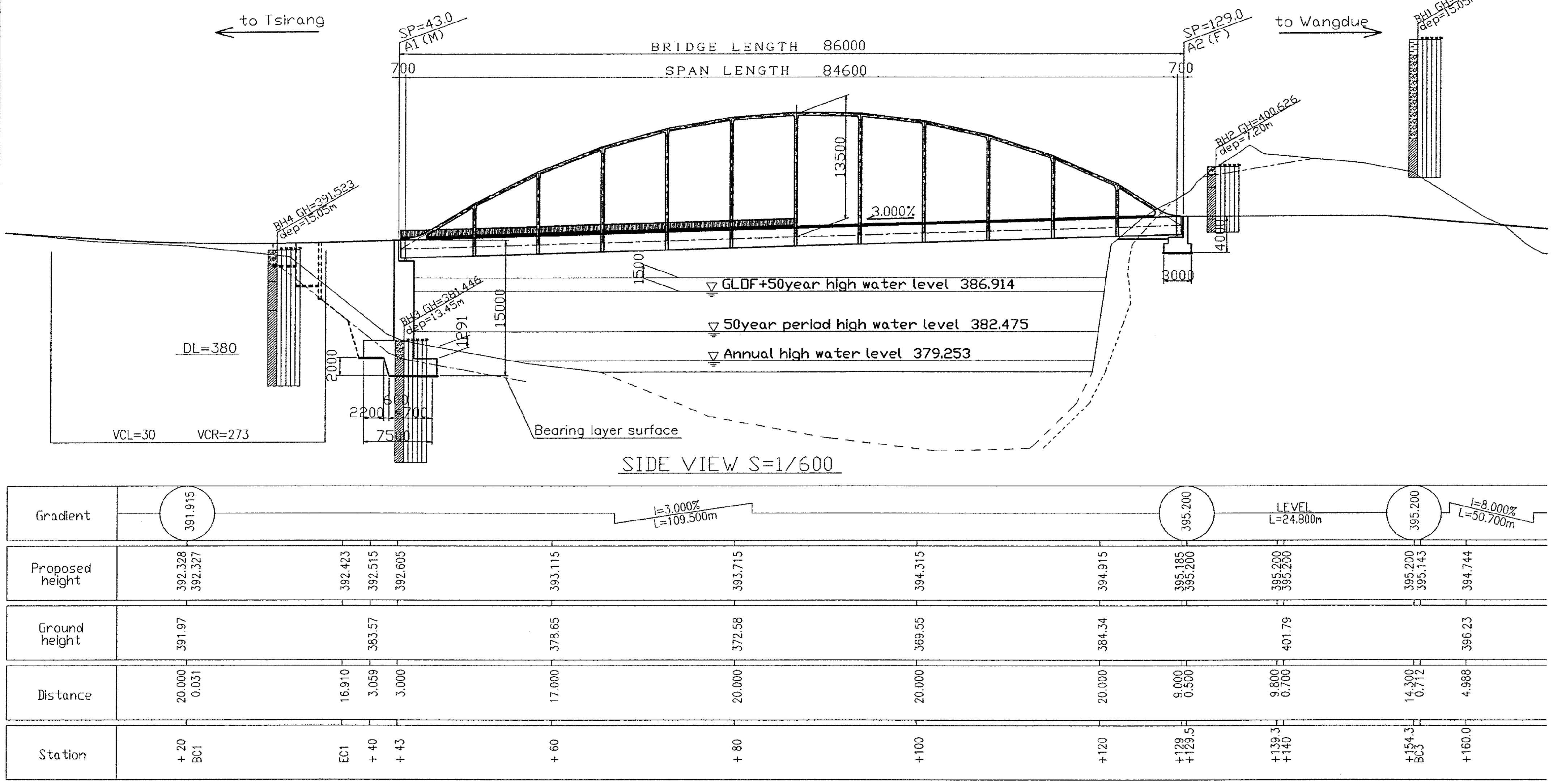
The drawings of permanent approach roads which are obligation of the Bhutanese side are attached in item "(4) Reference".

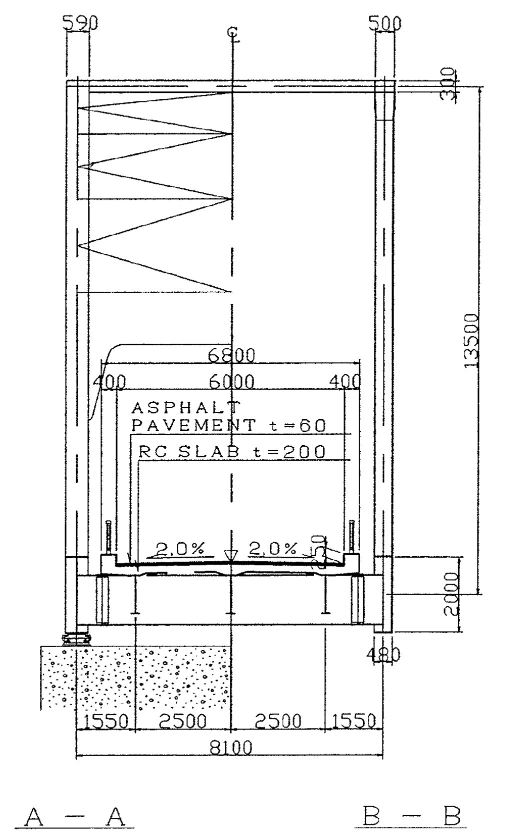
ROYAL GOVERNMENT OF BHUTAN DEPARTMENT OF ROADS, MINISTRY OF WORKS & HUMAN SETTLEMENT				
PROJECT	THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN THE KINGDOM OF BHUTAN (PHASE II)			
CONSULTANT	PACIFIC CONSULTANTS INTERNATIONAL			
	DESIGNED BY	CHECKED BY	APPROVED BY	
NAME	S. KOBAYASHI	H. YONEYAMA	PHUNTSHO WANGDI	
SIGNATURE				
DATE				

GENERAL VIEW OF WAKLEYTAR BRIDGE

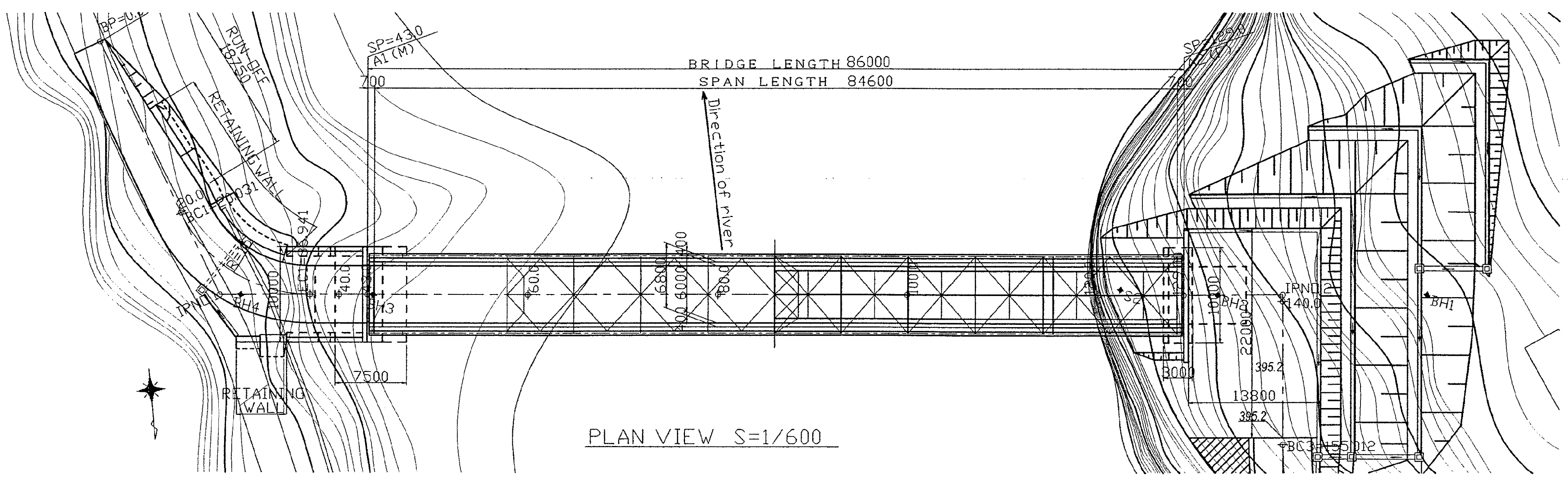
SECTION	SCALE	DRAWING NO.	SHEET NO.
	1/200 ,1/600		1 OF 1
DRAWING TITLE	GENERAL VIEW OF WAKLEYTAR BRIDGE		
REV.NO.	DATE	DESCRIPTION	SIGNATURE

(1) Wakleytar Bridge





CROSS SECTION S=1/200



PLAN VIEW S=1/600

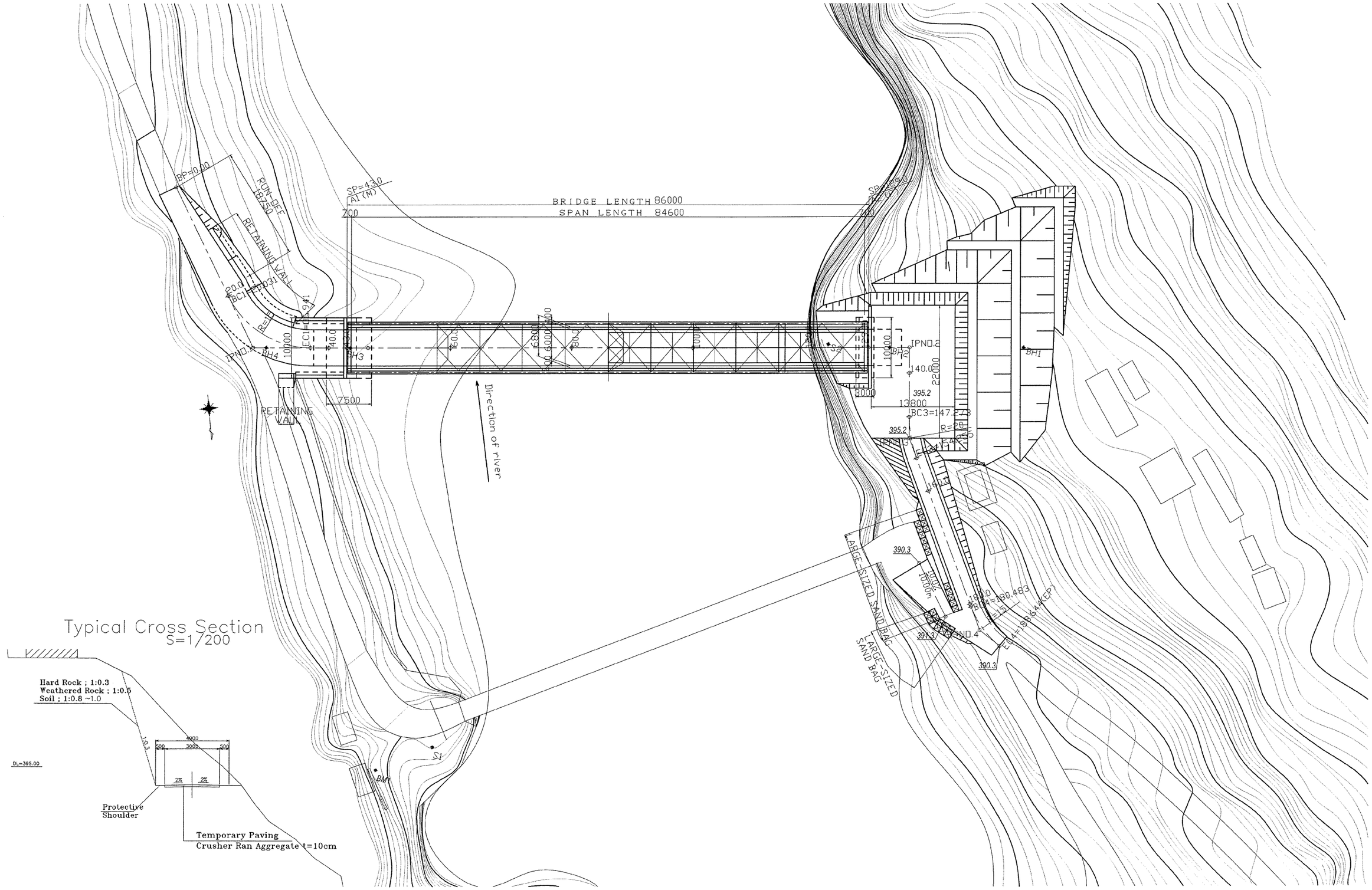
The Terms Of Design

Bridge Order			Second Order Bridge
Bridge Length			86.000 m
Span Length			84.600 m
Road Width			6.000 m
Live Road			IRC Class A
Design Seismic Scale			K_H=0.12 K_v=0
Super structure	Form		Langer
	Material Strength	Concrete	δck =24 N/mm²
		Reinforcing Bar	Cold Twisted Steel Reinforcement
		Steel	σla=210N/mm²(SMA490W) σta=140N/mm²(SMA490W)
Sub structure	Form	Structure	Inverted T Type Abutment
		Foundation	Spread Foundation
	Material Strength	Concrete	δck =21 N/mm²
		Reinforcing Bar	Cold Twisted Steel Reinforcement

ROYAL GOVERNMENT OF BHUTAN DEPARTMENT OF ROADS, MINISTRY OF WORKS & HUMAN SETTLEMENT				
PROJECT	THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN THE KINGDOM OF BHUTAN (PHASE II)			
CONSULTANT	PACIFIC CONSULTANTS INTERNATIONAL			
	DESIGNED BY	CHECKED BY	APPROVED BY	
NAME	S. KOBAYASHI	H. YONEYAMA	PHUNTSHO WANGDI	
SIGNATURE				
DATE				

SECTION	SCALE	DRAWING NO.	SHEET NO.
	1/600		1 OF 1
DRAWING TITLE	PLAN (WAKLEYTAR BRIDGE : DURING CONSTRUCTION)		
REV.NO.	DATE	DESCRIPTION	SIGNATURE

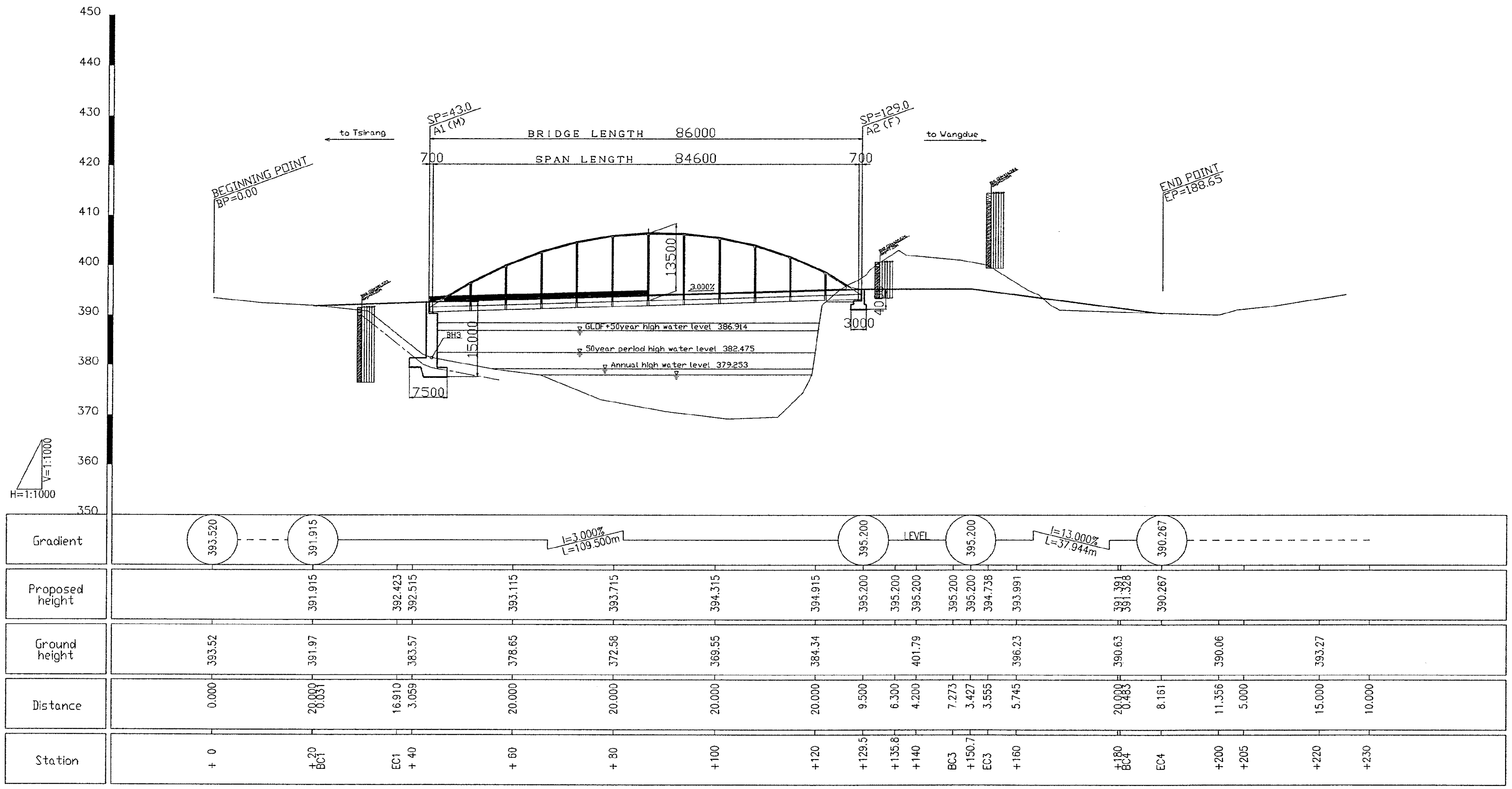
PLAN S=1/600
(WAKLEYTAR BRIDGE : DURING CONSTRUCTION)



ROYAL GOVERNMENT OF BHUTAN DEPARTMENT OF ROADS, MINISTRY OF WORKS & HUMAN SETTLEMENT				
PROJECT	THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN THE KINGDOM OF BHUTAN (PHASE II)			
CONSULTANT	PACIFIC CONSULTANTS INTERNATIONAL			
	DESIGNED BY	CHECKED BY	APPROVED BY	
NAME	S. KOBAYASHI	H. YONEYAMA	PHUNTSHO WANGDI	
SIGNATURE				
DATE				

PROFILE
(WAKLEYTAR BRIDGE:DURING CONSTRUCTION)

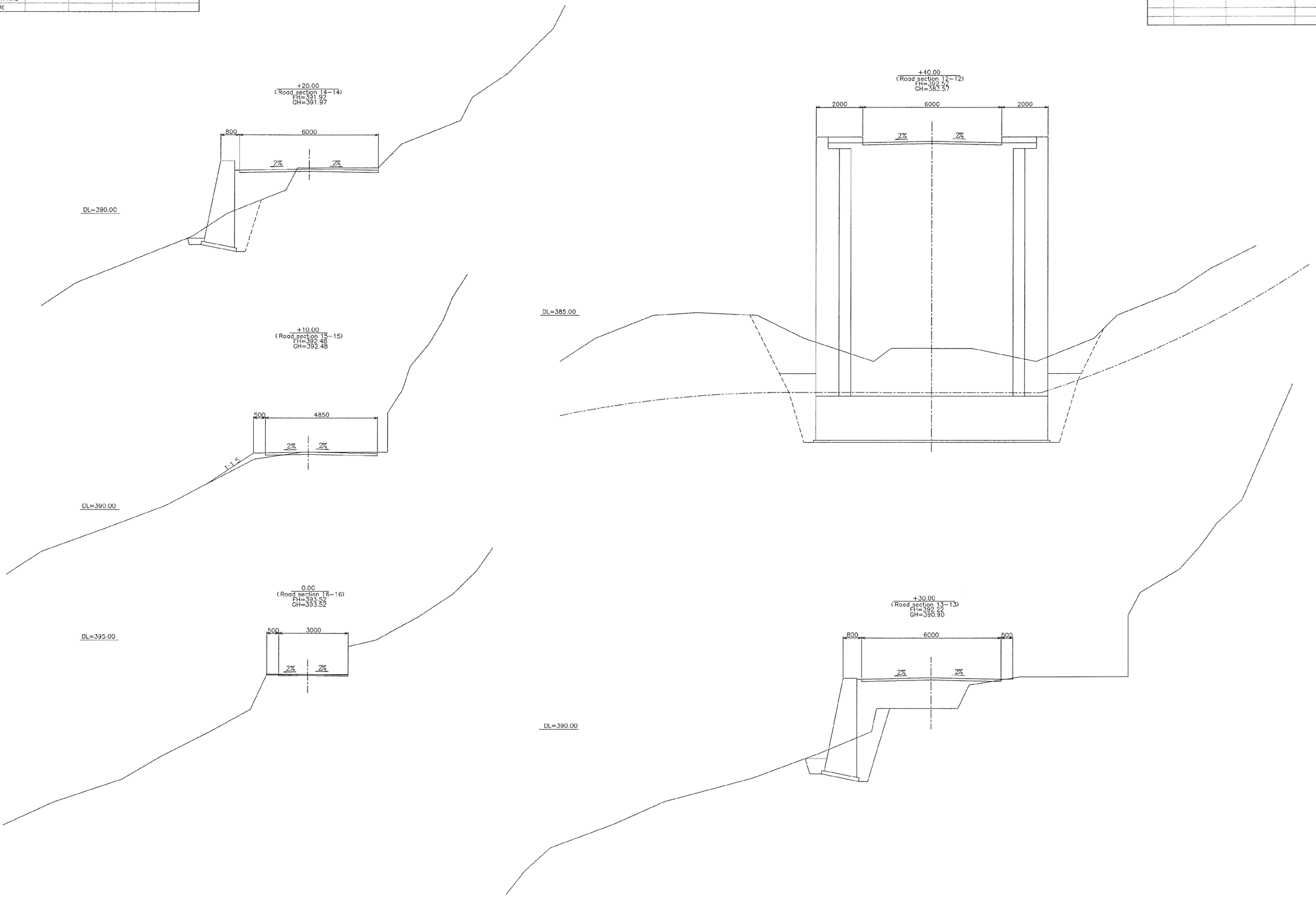
SECTION	SCALE	DRAWING NO.	SHEET NO.
	V:1/1000 H:1/1000		1 OF 1
DRAWING TITLE	PROFILE (WAKLEYTAR BRIDGE:DURING CONSTRUCTION)		
REV.NO.	DATE	DESCRIPTION	SIGNATURE



ROYAL GOVERNMENT OF BHUTAN DEPARTMENT OF ROADS, MINISTRY OF WORKS & HUMAN SETTLEMENT			
PROJECT	THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN THE KINGDOM OF BHUTAN (PHASE II)		
CONSULTANT	PACIFIC CONSULTANTS INTERNATIONAL		
	DESIGNED BY	CHECKED BY	APPROVED BY
NAME	S. KOBAYASHI	H. YONEYAMA	PHUNTSHO WANGDI
SIGNATURE			
DATE			

SECTION	SCALE	DRAWING NO.	SHEET NO.
	1/150		1 OF 2
DRAWING TITLE	CROSS SECTION1 (WAKLEYTAR BRIDGE:DURING CONSTRUCTION)		
REV.NO.	DATE	DESCRIPTION	SIGNATURE

CROSS SECTION1
(WAKLEYTAR BRIDGE:DURING CONSTRUCTION)

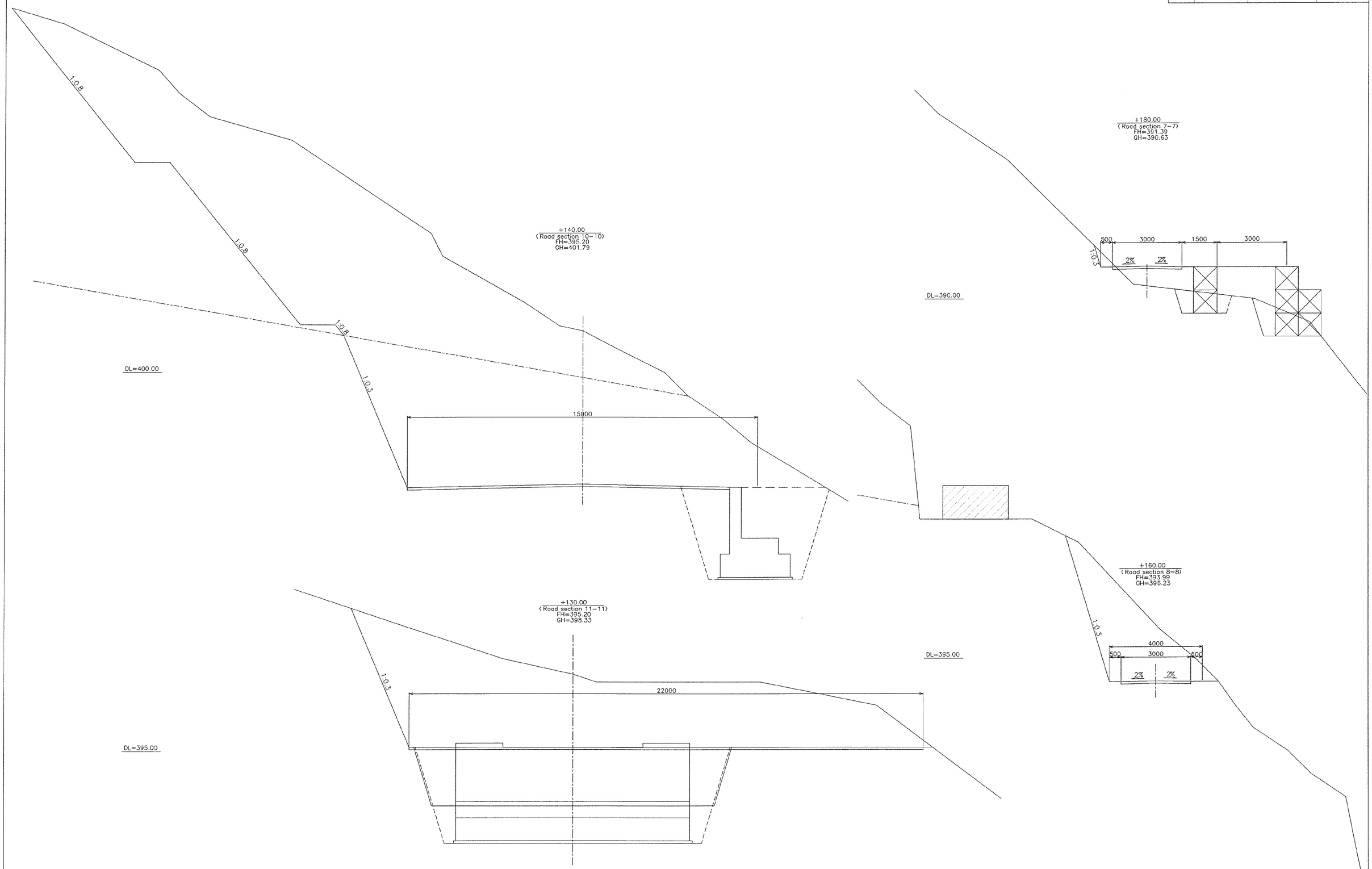


ROYAL GOVERNMENT OF BHUTAN DEPARTMENT OF ROADS, MINISTRY OF WORKS & HUMAN SETTLEMENT				
PROJECT	THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN THE KINGDOM OF BHUTAN (PHASE II)			
CONSULTANT	PACIFIC CONSULTANTS INTERNATIONAL			
	DESIGNED BY	CHECKED BY	APPROVED BY	
NAME	S. KOBAYASHI	H. YONEYAMA	PHUNTSHO WANGDI	
SIGNATURE				
DATE				

SECTION	SCALE	DRAWING NO.	SHEET NO.
	1/150		2 OF 2
DRAWING TITLE	CROSS SECTION2 (WAKLEYTAR BRIDGE:DURING CONSTRUCTION)		

REV.NO.	DATE	DESCRIPTION	SIGNATURE

CROSS SECTION2
(WAKLEYTAR BRIDGE:DURING CONSTRUCTION)

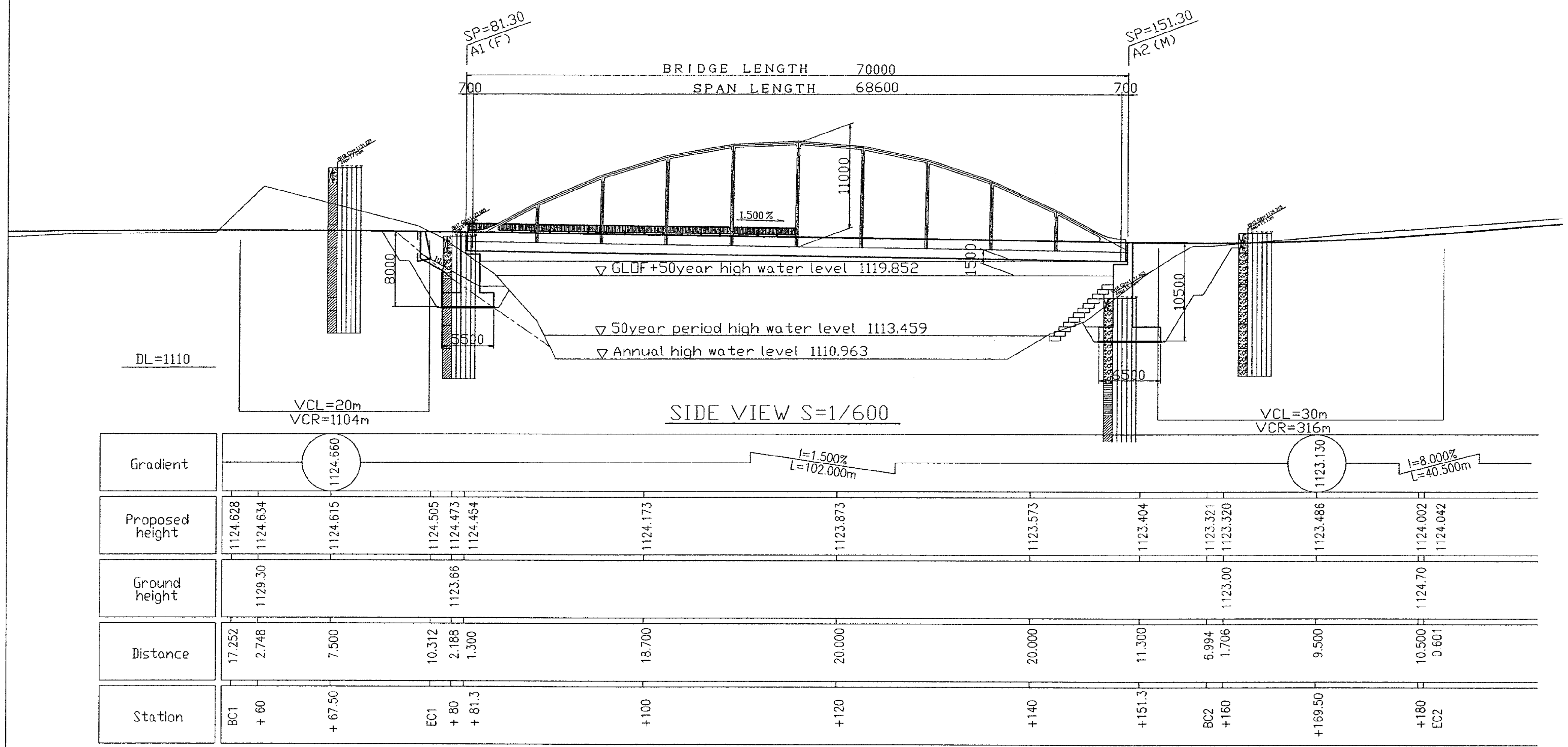


ROYAL GOVERNMENT OF BHUTAN DEPARTMENT OF ROADS, MINISTRY OF WORKS & HUMAN SETTLEMENT				
PROJECT	THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN THE KINGDOM OF BHUTAN (PHASE II)			
CONSULTANT	PACIFIC CONSULTANTS INTERNATIONAL			
	DESIGNED BY	CHECKED BY	APPROVED BY	
NAME	S. KOBAYASHI	H. YONEYAMA	PHUNTSHO WANGDI	
SIGNATURE				
DATE				

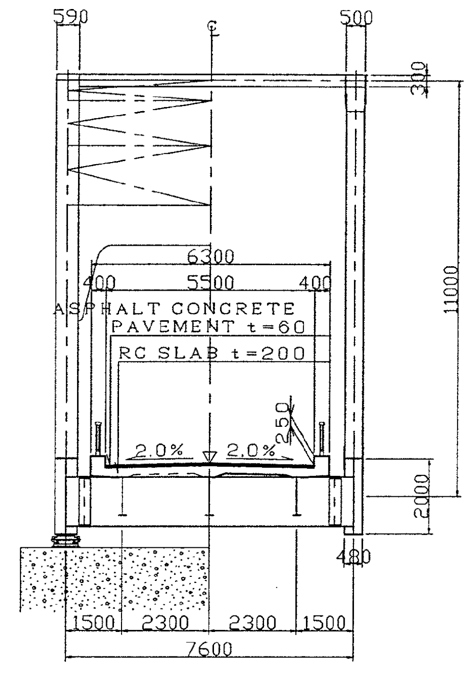
GENERAL VIEW OF TANGMACHU BRIDGE

(2) Tangmachu Bridge

SECTION	SCALE	DRAWING NO.	SHEET NO.
	1/200 ,1/600		1 OF 1
DRAWING TITLE	GENERAL VIEW OF TANGMACHU BRIDGE		
REV.NO.	DATE	DESCRIPTION	SIGNATURE

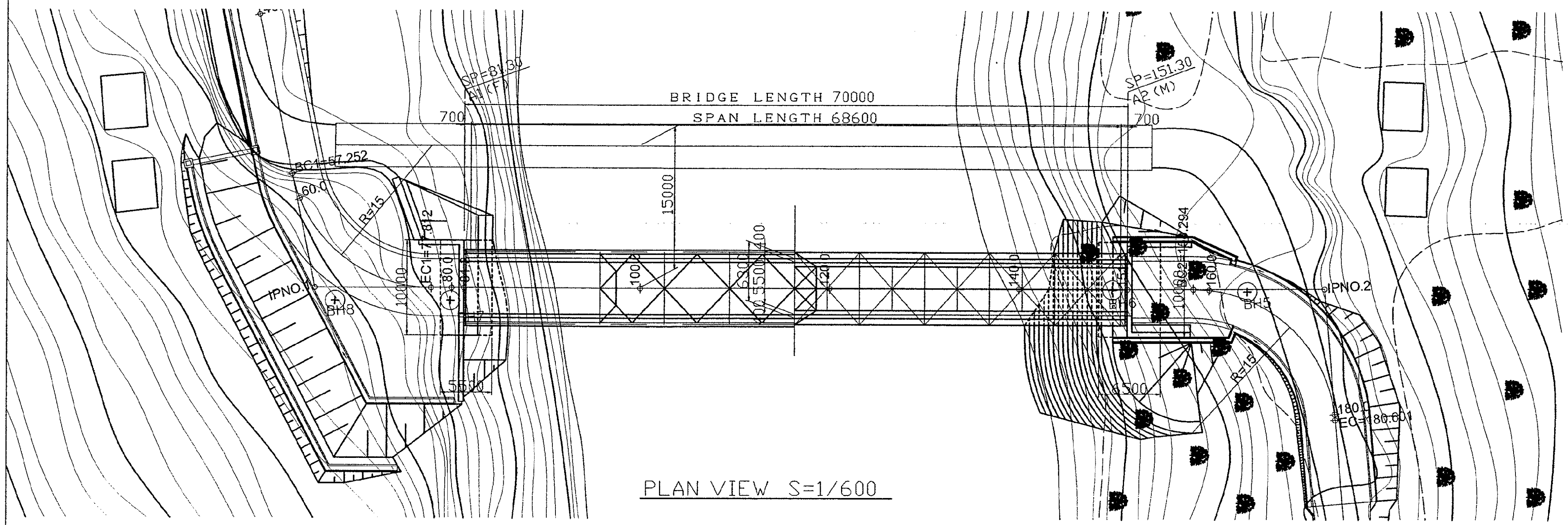


SIDE VIEW S=1/600



A — A B — B

CROSS SECTION S=1/200



PLAN VIEW S=1/600

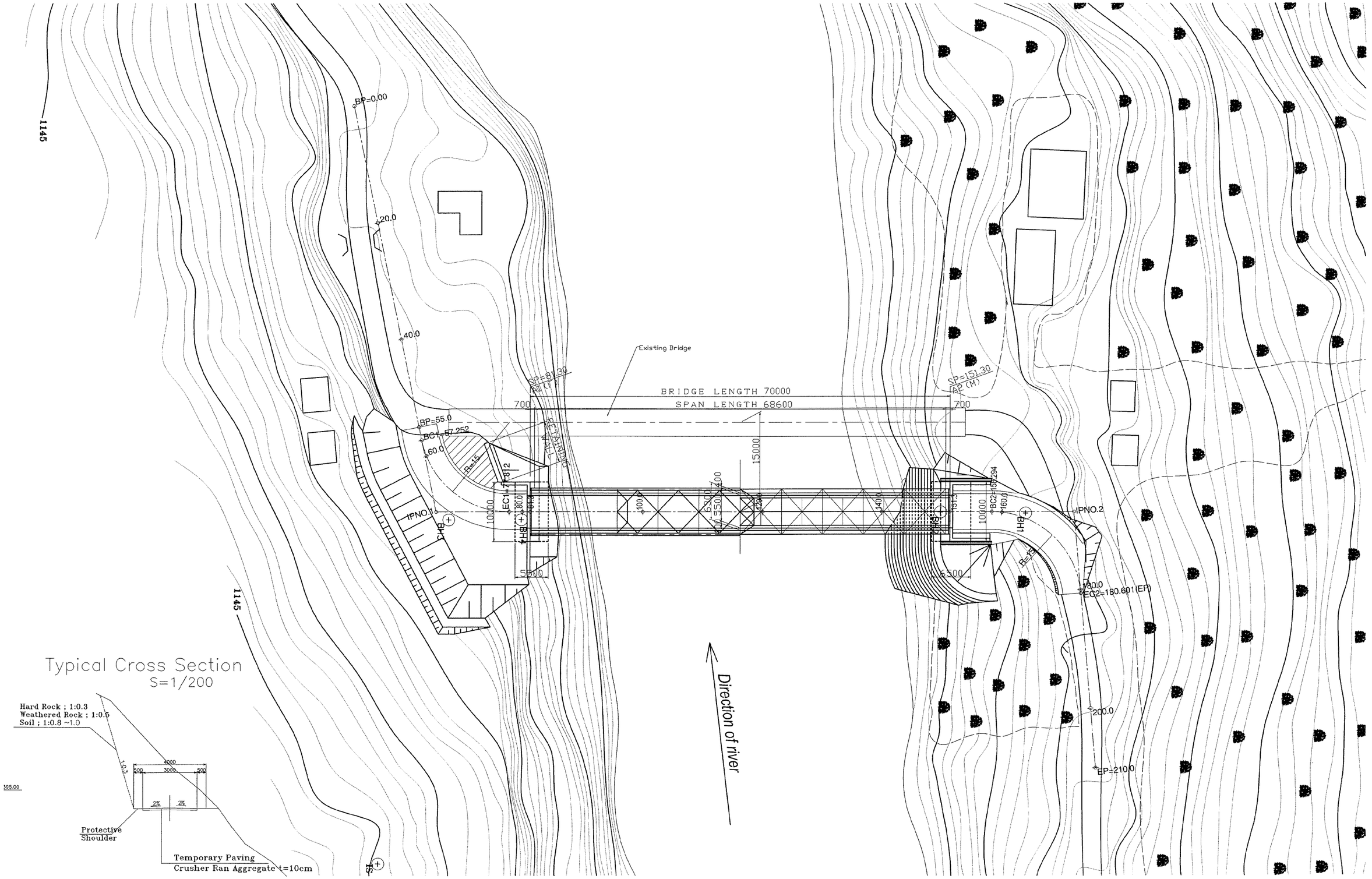
The Terms Of Design

Bridge Order			Second Order Bridge
Bridge Length			70.000 m
Span Length			68.600 m
Road Width			5.500 m
Live Road			IRC Class A
Design Seismic Scale			K_H=0.12 K_v=0
Super structure	Form		Langer
	Material Strength	Concrete	σck =24 N/mm²
		Reinforcing Bar	Cold Twisted Steel Reinforcement
		Steel	σla=210N/mm²(SMA490W) σta=140N/mm²(SMA490W)
Sub structure	Form	Structure	Inverted T Type Abutment
		Foundation	Spread Foundation
	Material Strength	Concrete	σck =21 N/mm²
		Reinforcing Bar	Cold Twisted Steel Reinforcement

ROYAL GOVERNMENT OF BHUTAN DEPARTMENT OF ROADS, MINISTRY OF WORKS & HUMAN SETTLEMENT				
PROJECT	THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN THE KINGDOM OF BHUTAN (PHASE II)			
CONSULTANT	PACIFIC CONSULTANTS INTERNATIONAL			
	DESIGNED BY	CHECKED BY	APPROVED BY	
NAME	S. KOBAYASHI	H. YONEYAMA	PHUNTSHO WANGDI	
SIGNATURE				
DATE				

SECTION	SCALE	DRAWING NO.	SHEET NO.
	1/600		1 OF 1
DRAWING TITLE	PLAN (TANGMACHU BRIDGE : DURING CONSTRUCTION)		
REV NO.	DATE	DESCRIPTION	SIGNATURE

PLAN S=1/600
(TANGMACHU BRIDGE : DURING CONSTRUCTION)

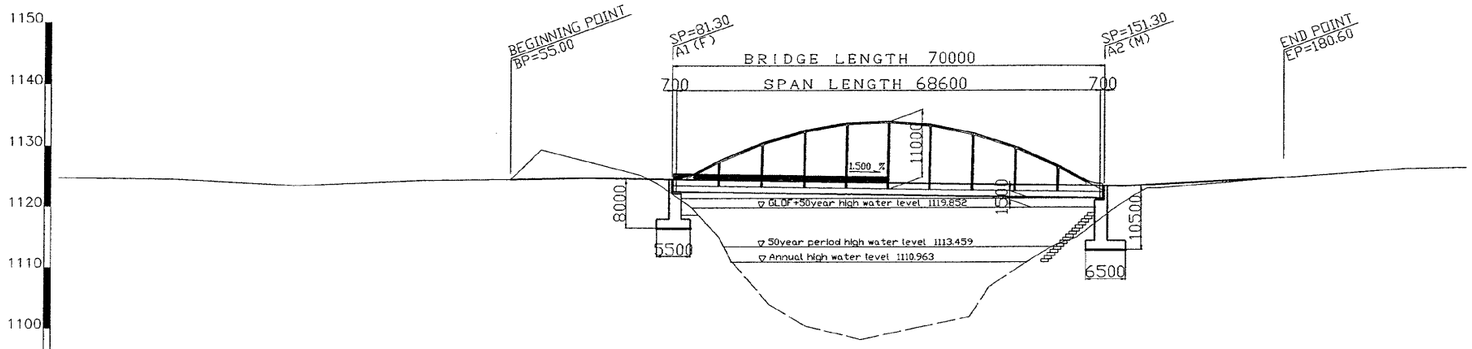


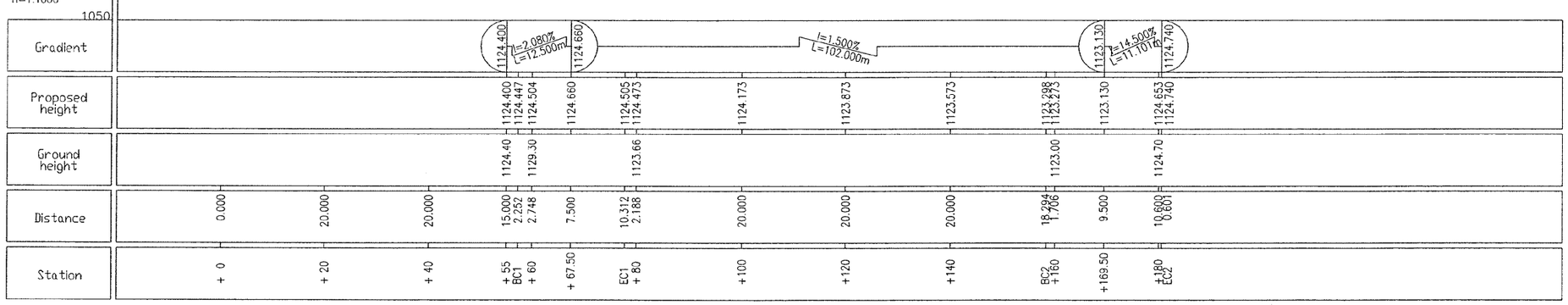
ROYAL GOVERNMENT OF BHUTAN DEPARTMENT OF ROADS, MINISTRY OF WORKS & HUMAN SETTLEMENT				
PROJECT	THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN THE KINGDOM OF BHUTAN (PHASE II)			
CONSULTANT	PACIFIC CONSULTANTS INTERNATIONAL			
	DESIGNED BY	CHECKED BY	APPROVED BY	
NAME	S. KOBAYASHI	H. YONEYAMA	PHUNTSHO WANGDI	
SIGNATURE				
DATE				

SECTION	SCALE	DRAWING NO.	SHEET NO.
	V.1/1000 H:1/1000		1 OF 1
DRAWING TITLE	PROFILE (TANGMACHU BRIDGE:DURING CONSTRUCTION)		

REV.NO.	DATE	DESCRIPTION	SIGNATURE

PROFILE
(TANGMACHU BRIDGE: DURING CONSTRUCTION)

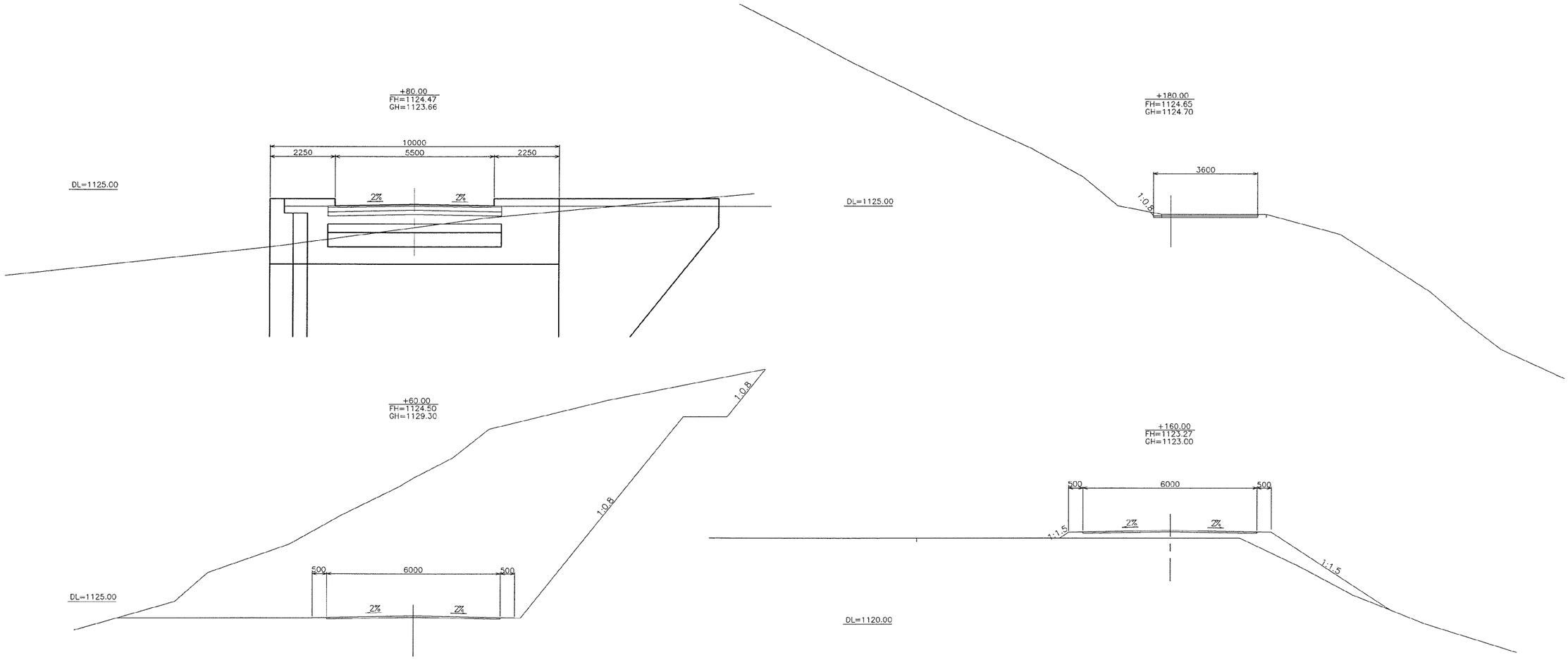




ROYAL GOVERNMENT OF BHUTAN DEPARTMENT OF ROADS, MINISTRY OF WORKS & HUMAN SETTLEMENT				
PROJECT	THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN THE KINGDOM OF BHUTAN (PHASE II)			
CONSULTANT	PACIFIC CONSULTANTS INTERNATIONAL			
	DESIGNED BY	CHECKED BY	APPROVED BY	
NAME	S. KOBAYASHI	H. YONEYAMA	PHUNTSHO WANGDI	
SIGNATURE				
DATE				

SECTION	SCALE	DRAWING NO.	SHEET NO.
	1/150		1 OF 1
DRAWING TITLE	CROSS SECTION1 (TANGMACHU BRIDGE:DURING CONSTRUCTION)		
REV.NO.	DATE	DESCRIPTION	SIGNATURE

CROSS SECTION1
(TANGMACHU BRIDGE:DURING CONSTRUCTION)

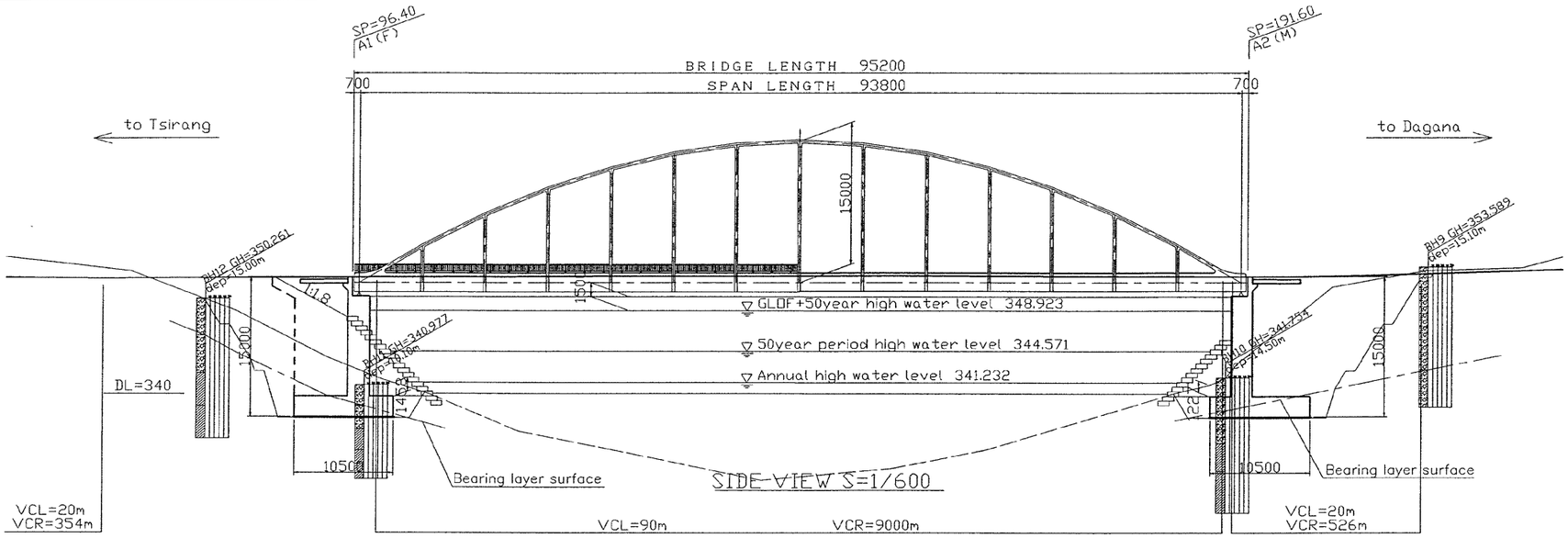


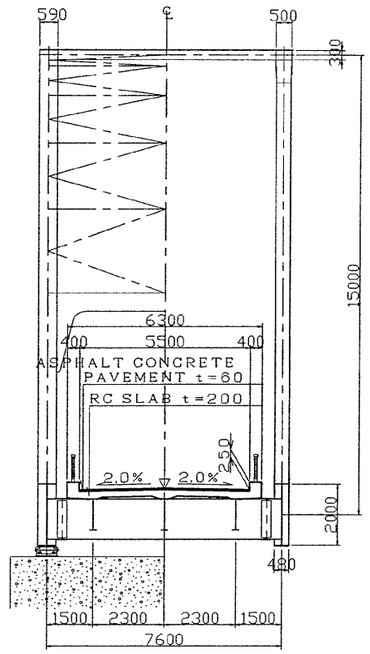
ROYAL GOVERNMENT OF BHUTAN DEPARTMENT OF ROADS, MINISTRY OF WORKS & HUMAN SETTLEMENT				
PROJECT	THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN THE KINGDOM OF BHUTAN (PHASE II)			
CONSULTANT	PACIFIC CONSULTANTS INTERNATIONAL			
	DESIGNED BY	CHECKED BY	APPROVED BY	
NAME	S. KOBAYASHI	H. YONEYAMA	PHUNTSHO WANGDI	
SIGNATURE				
DATE				

SECTION	SCALE	DRAWING NO.	SHEET NO.
	1/200 , 1/500		1 OF 1
DRAWING TITLE	GENERAL VIEW OF SUNKOSH BRIDGE		
REV.NO.	DATE	DESCRIPTION	SIGNATURE

GENERAL VIEW OF SUNKOSH BRIDGE

(3) Sunkosh Bridge

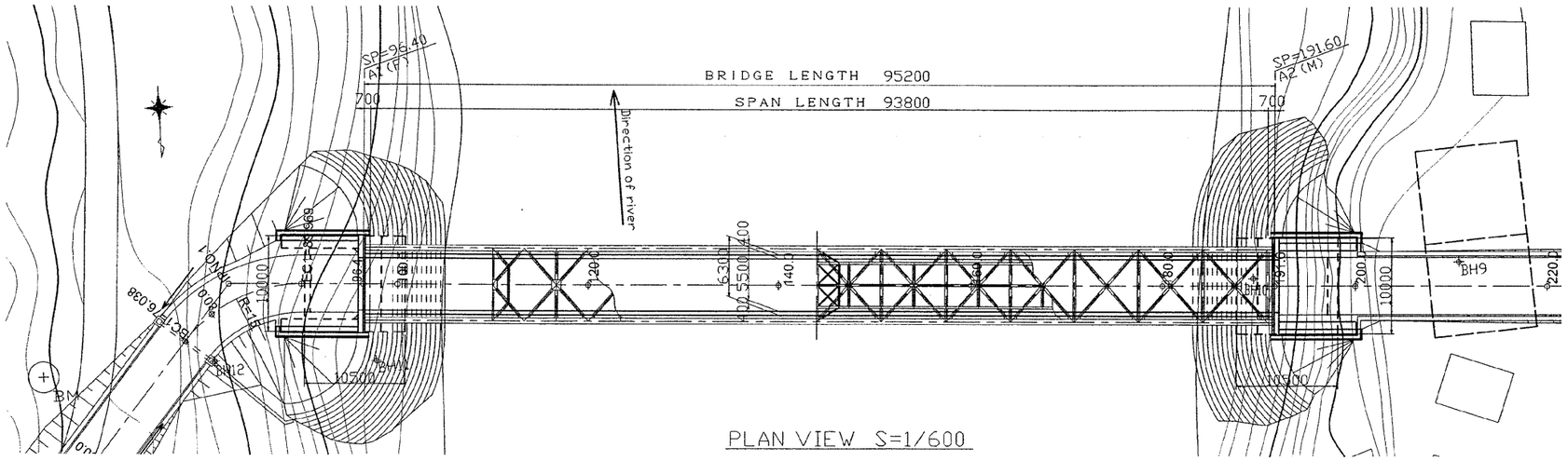




A – A B – B

CROSS SECTION S=1/200

Gradient			l=0.500% L=84.000m / 352.800 / l=0.500% L=56.000m / 352.520 / l=3.300% L=40.000m
Proposed height	352.460	352.480	352.530 352.562 352.580 352.656 352.687 352.688 352.673 352.616 352.562 352.615 353.180
Ground height		350.55	341.47 351.04 353.48
Distance	16.038	3.962	9.969 6.431 3.600 20.000 20.000 4.000 16.000 20.000 11.600 8.400 20.000
Station	BC1	+80	EC1 +96.40 +100 +120 +140 +144.0 +160 +180 +191.60 +200 +220



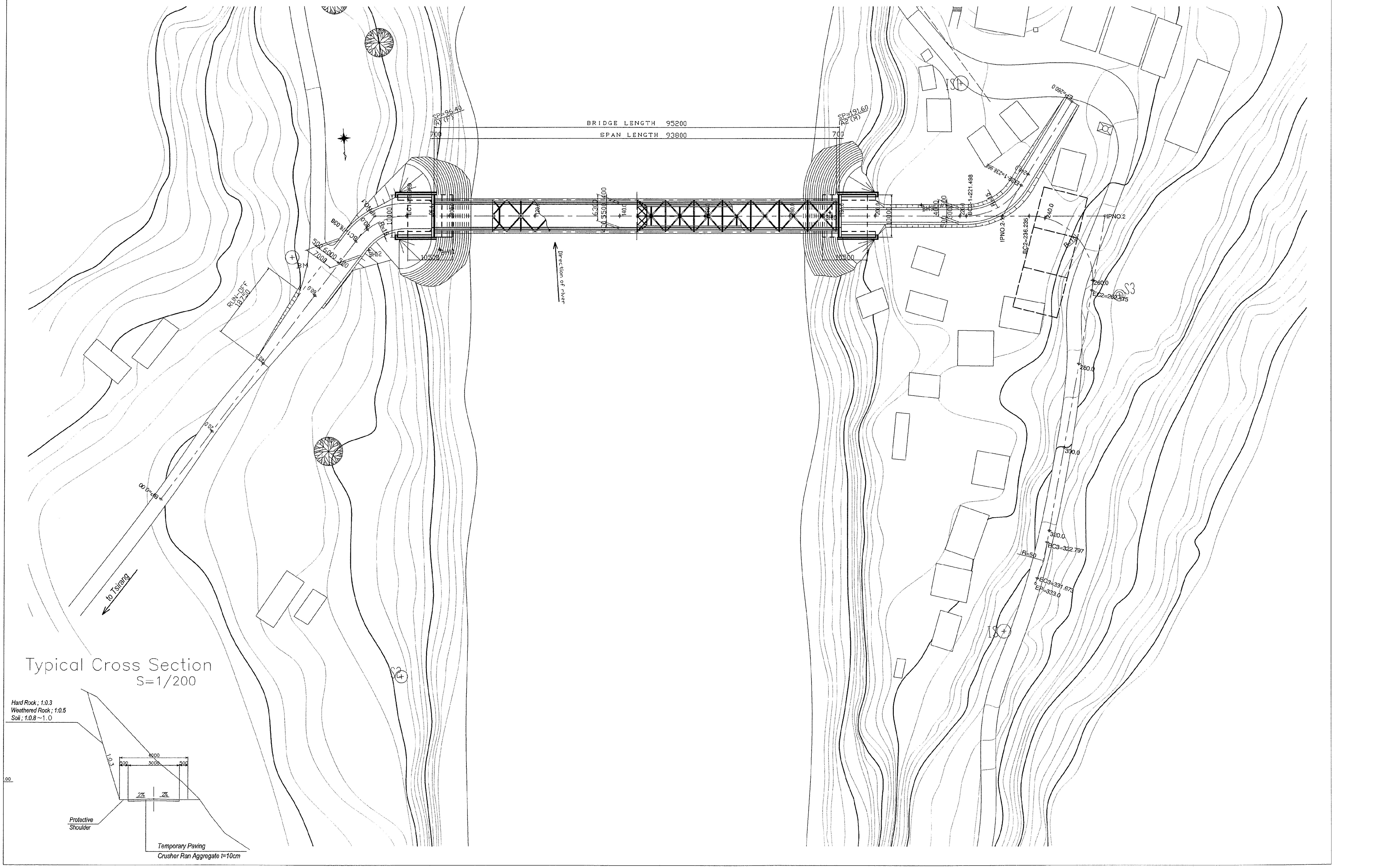
The Terms Of Design

Bridge Order			Second Order Bridge
Bridge Length			95.200 m
Span Length			93.800 m
Road Width			5.500 m
Live Road			IRC Class A
Design Seismic Scale			K_h=0.12 K_v=0
Super structure	Form		Langer
	Material Strength	Concrete	σck =24 N/mm²
		Reinforcing Bar	Cold Twisted Steel Reinforcement
		Steel	σta=210N/mm²(SMA490W) σta=140N/mm²(SMA490W)
Sub structure	Form	Structure	Inverted T Type Abutment
		Foundation	Spread Foundation
	Material Strength	Concrete	σck =21 N/mm²
		Reinforcing Bar	Cold Twisted Steel Reinforcement

ROYAL GOVERNMENT OF BHUTAN DEPARTMENT OF ROADS, MINISTRY OF WORKS & HUMAN SETTLEMENT			
PROJECT	THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN THE KINGDOM OF BHUTAN (PHASE II)		
CONSULTANT	PACIFIC CONSULTANTS INTERNATIONAL		
	DESIGNED BY	CHECKED BY	APPROVED BY
NAME	S. KOBAYASHI	H. YONEYAMA	PHUNTSHO WANGDI
SIGNATURE			
DATE			

PLAN S=1/800
(SUNKOSH BRIDGE : DURING CONSTRUCTION)

SECTION	SCALE	DRAWING NO.	SHEET NO.
	1/800		1 OF 1
DRAWING TITLE	PLAN (SUNKOSH BRIDGE : DURING CONSTRUCTION)		
REV.NO.	DATE	DESCRIPTION	SIGNATURE

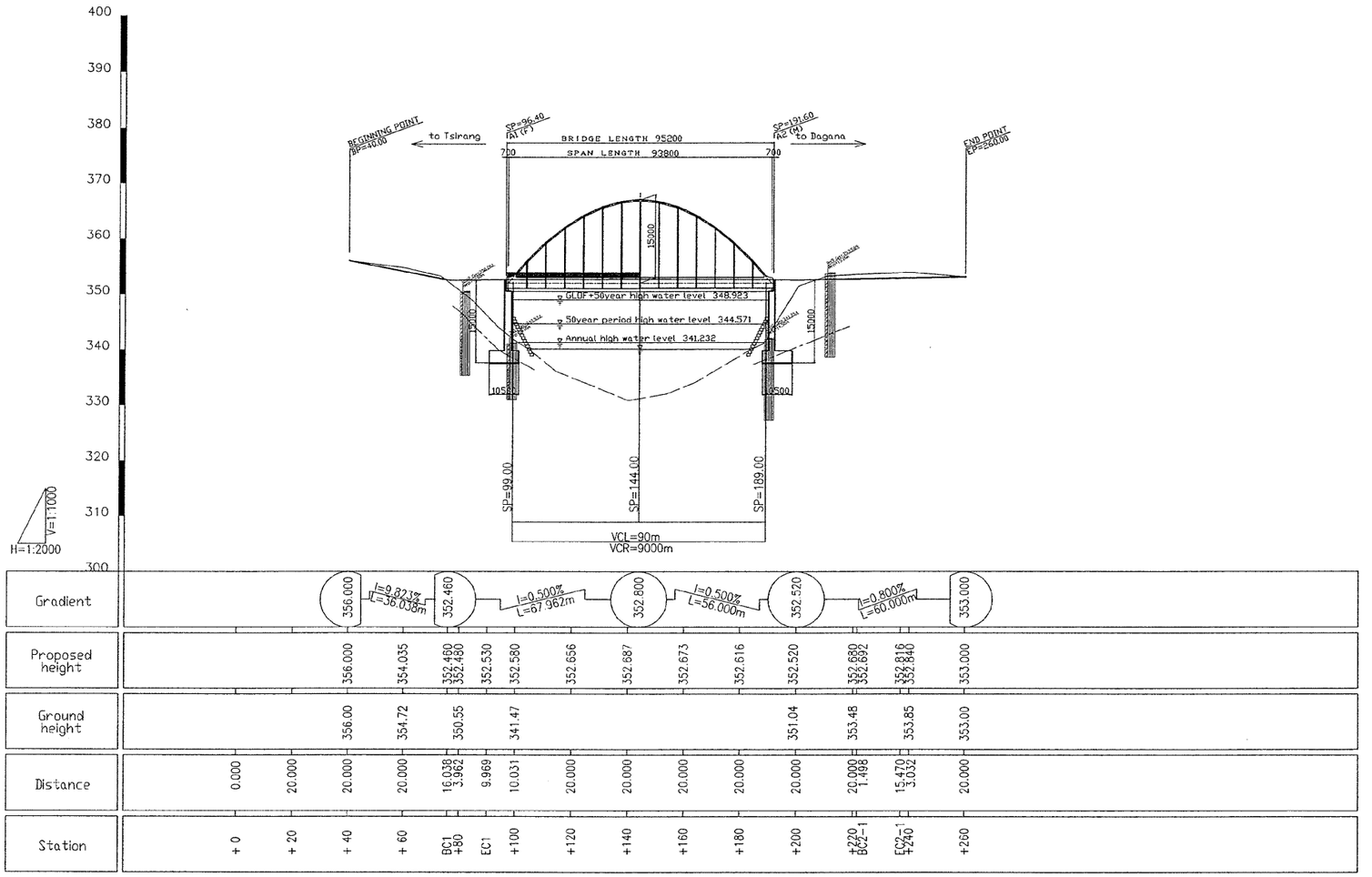


ROYAL GOVERNMENT OF BHUTAN DEPARTMENT OF ROADS, MINISTRY OF WORKS & HUMAN SETTLEMENT				
PROJECT	THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN THE KINGDOM OF BHUTAN (PHASE II)			
CONSULTANT	PACIFIC CONSULTANTS INTERNATIONAL			
	DESIGNED BY	CHECKED BY	APPROVED BY	
NAME	S. KOBAYASHI	H. YONEYAMA	PHUNTSHO WANGDI	
SIGNATURE				
DATE				

SECTION	SCALE	DRAWING NO.	SHEET NO.
	V:1/1000 H:1/2000		1 OF 1
DRAWING TITLE	PROFILE (SUNKOSH BRIDGE : DURING CONSTRUCTION)		

REV.NO.	DATE	DESCRIPTION	SIGNATURE

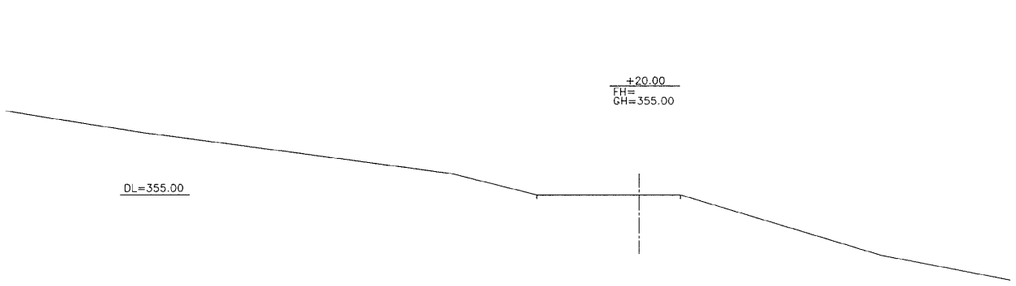
PROFILE
(SUNKOSH BRIDGE : DURING CONSTRUCTION)

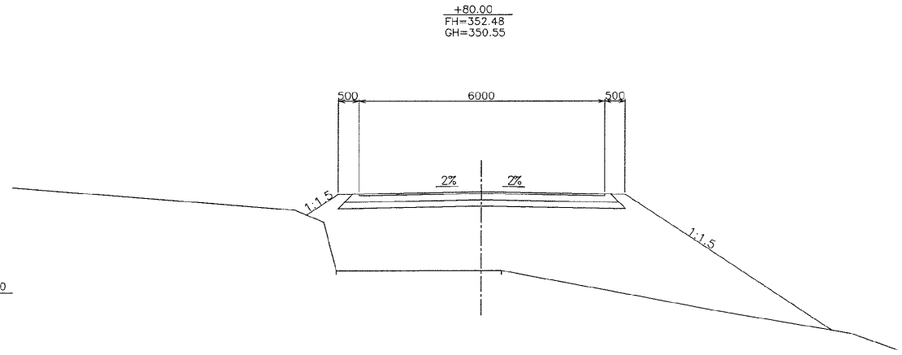


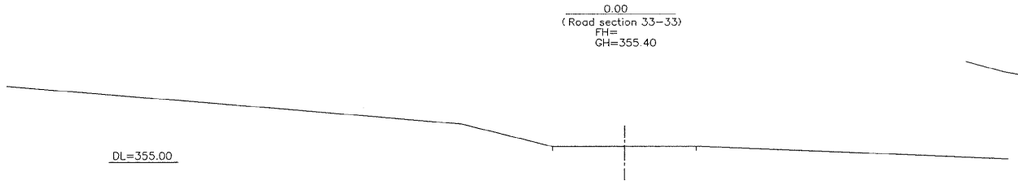
ROYAL GOVERNMENT OF BHUTAN DEPARTMENT OF ROADS, MINISTRY OF WORKS & HUMAN SETTLEMENT				
PROJECT	THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN THE KINGDOM OF BHUTAN (PHASE II)			
CONSULTANT	PACIFIC CONSULTANTS INTERNATIONAL			
	DESIGNED BY	CHECKED BY	APPROVED BY	
NAME	S. KOBAYASHI	H. YONEYAMA	PHUNTSHO WANGDI	
SIGNATURE				
DATE				

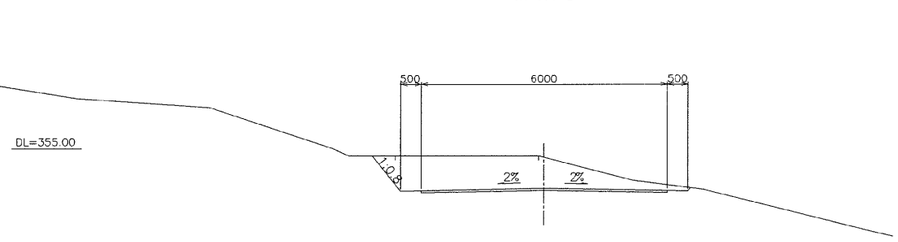
CROSS SECTION1
(SUNKOSH BRIDGE:DURING CONSTRUCTION)

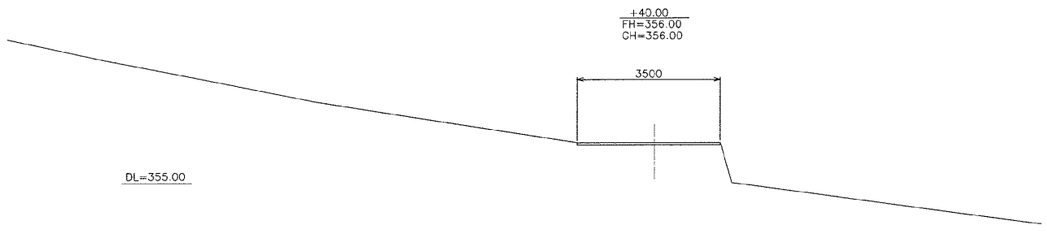
SECTION	SCALE	DRAWING NO.	SHEET NO.
	1/150		1 OF 2
DRAWING TITLE	CROSS SECTION1 (SUNKOSH BRIDGE:DURING CONSTRUCTION)		
REV.NO.	DATE	DESCRIPTION	SIGNATURE









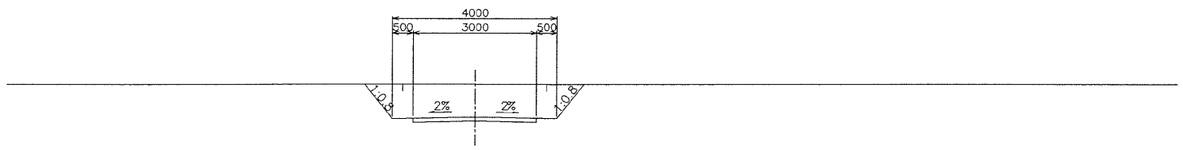


ROYAL GOVERNMENT OF BHUTAN DEPARTMENT OF ROADS, MINISTRY OF WORKS & HUMAN SETTLEMENT				
PROJECT	THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN THE KINGDOM OF BHUTAN (PHASE II)			
CONSULTANT	PACIFIC CONSULTANTS INTERNATIONAL			
	DESIGNED BY	CHECKED BY	APPROVED BY	
NAME	S. KOBAYASHI	H. YONEYAMA	PHUNTSHO WANGDI	
SIGNATURE				
DATE				

SECTION	SCALE	DRAWING NO.	SHEET NO.
	1/150		2 OF 2
DRAWING TITLE	CROSS SECTION2 (SUNKOSH BRIDGE:DURING CONSTRUCTION)		
REV.NO.	DATE	DESCRIPTION	SIGNATURE

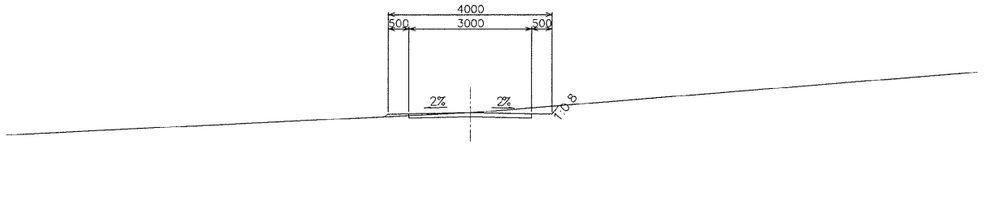
CROSS SECTION2
(SUNKOSH BRIDGE:DURING CONSTRUCTION)

+220.00
FH=352.68
GH=353.48



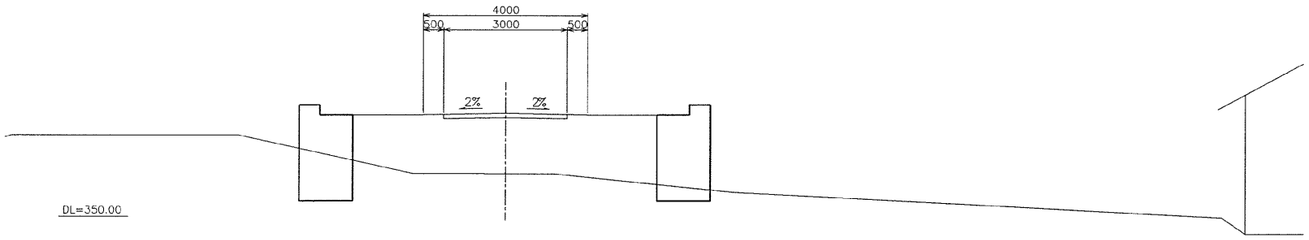
DL=350.00

+260.00
FH=353.00
GH=353.00



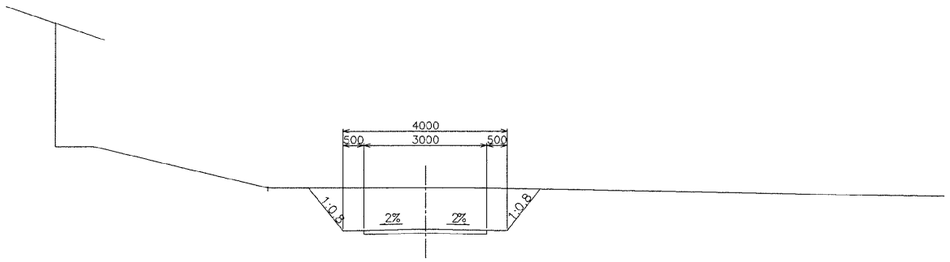
DL=350.00

+200.00
FH=352.52
GH=351.04



DL=350.00

+240.00
FH=352.84
GH=353.85



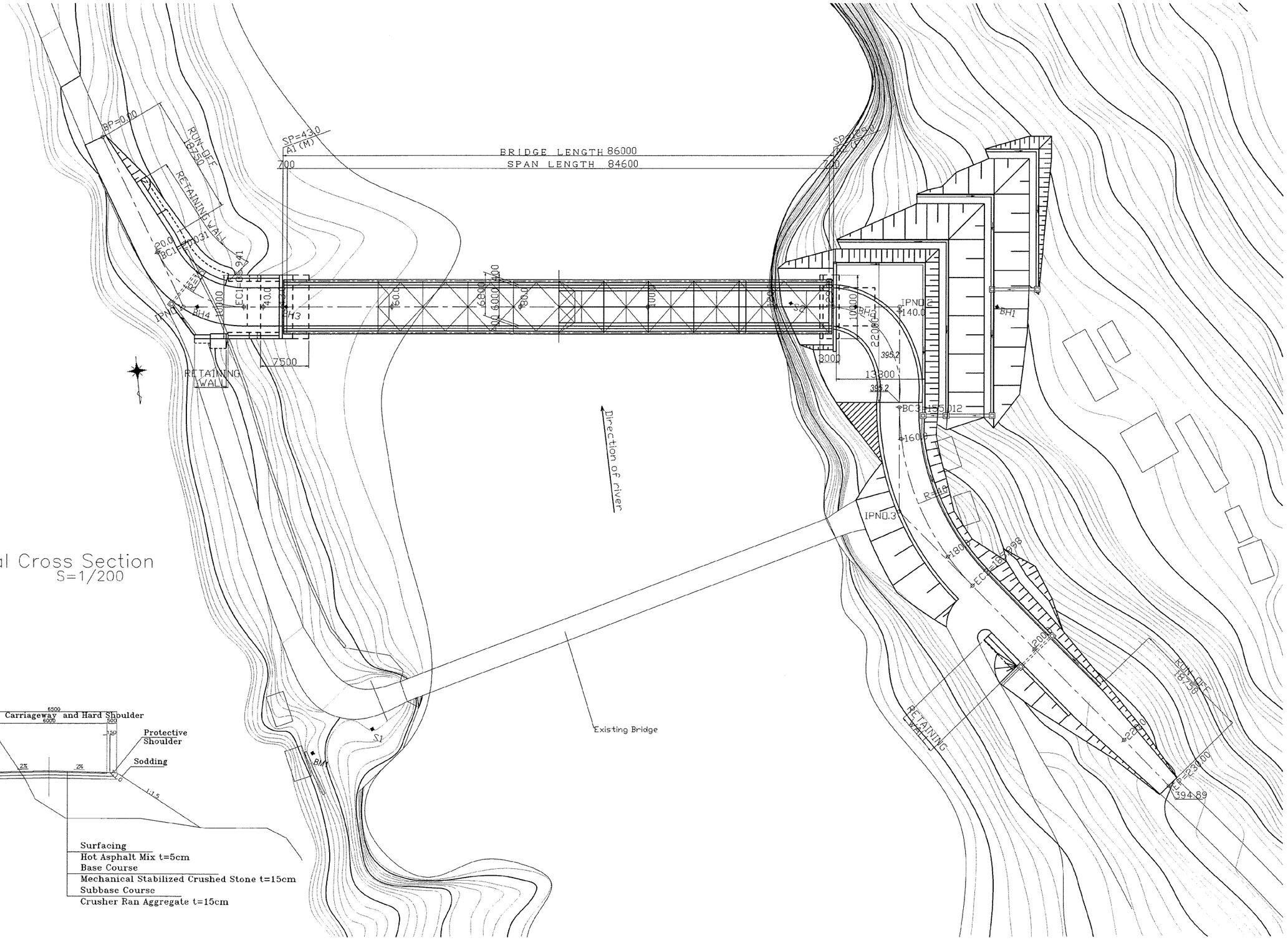
DL=350.00

ROYAL GOVERNMENT OF BHUTAN DEPARTMENT OF ROADS, MINISTRY OF WORKS & HUMAN SETTLEMENT				
PROJECT	THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN THE KINGDOM OF BHUTAN (PHASE II)			
CONSULTANT	PACIFIC CONSULTANTS INTERNATIONAL			
	DESIGNED BY	CHECKED BY	APPROVED BY	
NAME	S. KOBAYASHI	H. YONEYAMA	PHUNTSHO WANGDI	
SIGNATURE				
DATE				

SECTION	SCALE	DRAWING NO.	SHEET NO.
	1/600		1 OF 1
DRAWING TITLE	PLAN (WAKLEYTAR BRIDGE)		
REV.NO.	DATE	DESCRIPTION	SIGNATURE

(4) Reference Drawings

PLAN S=1/600
(WAKLEYTAR BRIDGE)



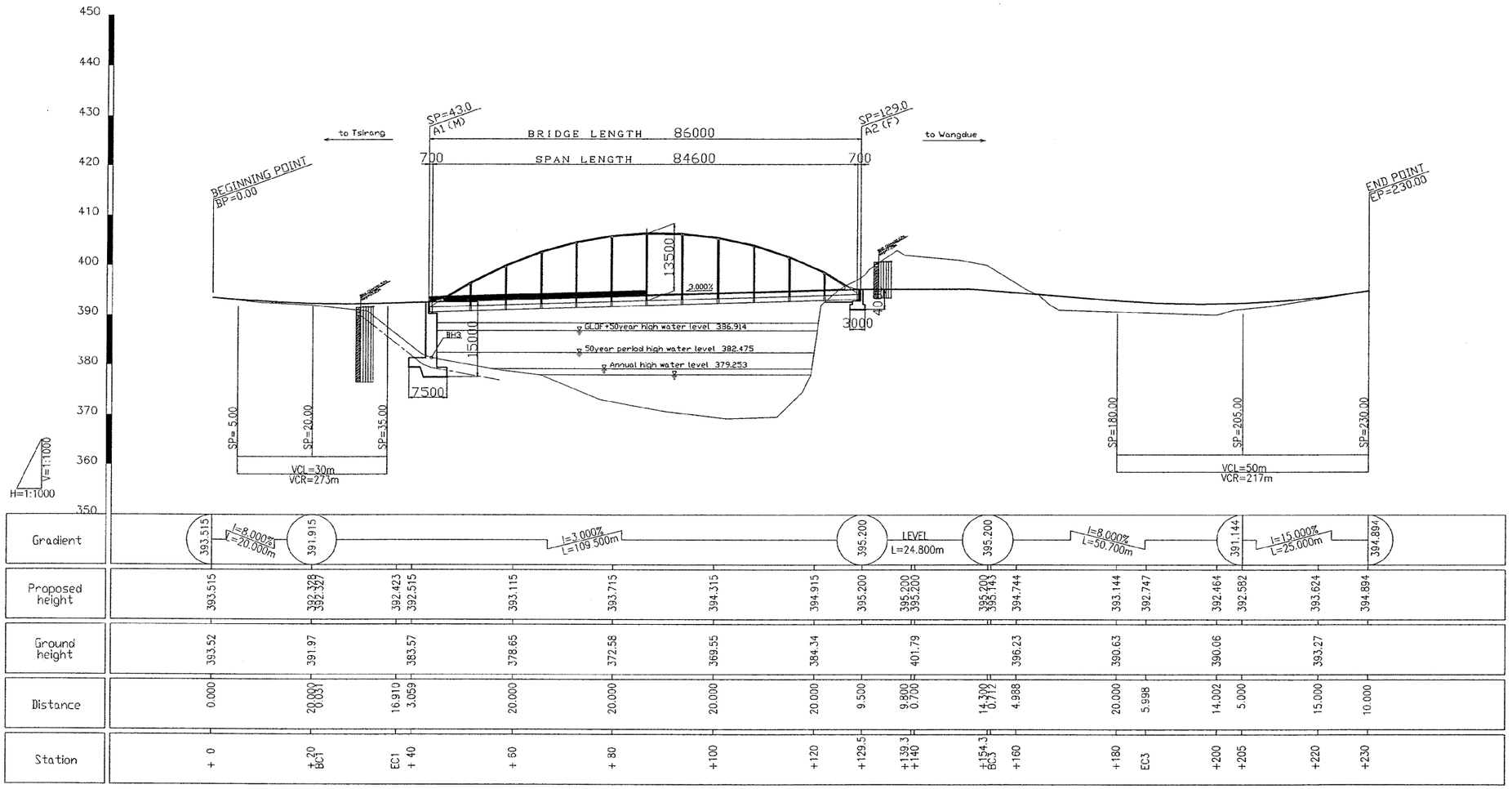
Typical Cross Section
S=1/200

ROYAL GOVERNMENT OF BHUTAN DEPARTMENT OF ROADS, MINISTRY OF WORKS & HUMAN SETTLEMENT				
PROJECT	THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN THE KINGDOM OF BHUTAN (PHASE II)			
CONSULTANT	PACIFIC CONSULTANTS INTERNATIONAL			
	DESIGNED BY	CHECKED BY	APPROVED BY	
NAME	S. KOBAYASHI	H. YONEYAMA	PHUNTSHO WANGDI	
SIGNATURE				
DATE				

SECTION	SCALE	DRAWING NO.	SHEET NO.
	V:1/1000 H:1/1000		1 OF 1
DRAWING TITLE	PROFILE (WAKLEYTAR BRIDGE)		

REV.NO.	DATE	DESCRIPTION	SIGNATURE

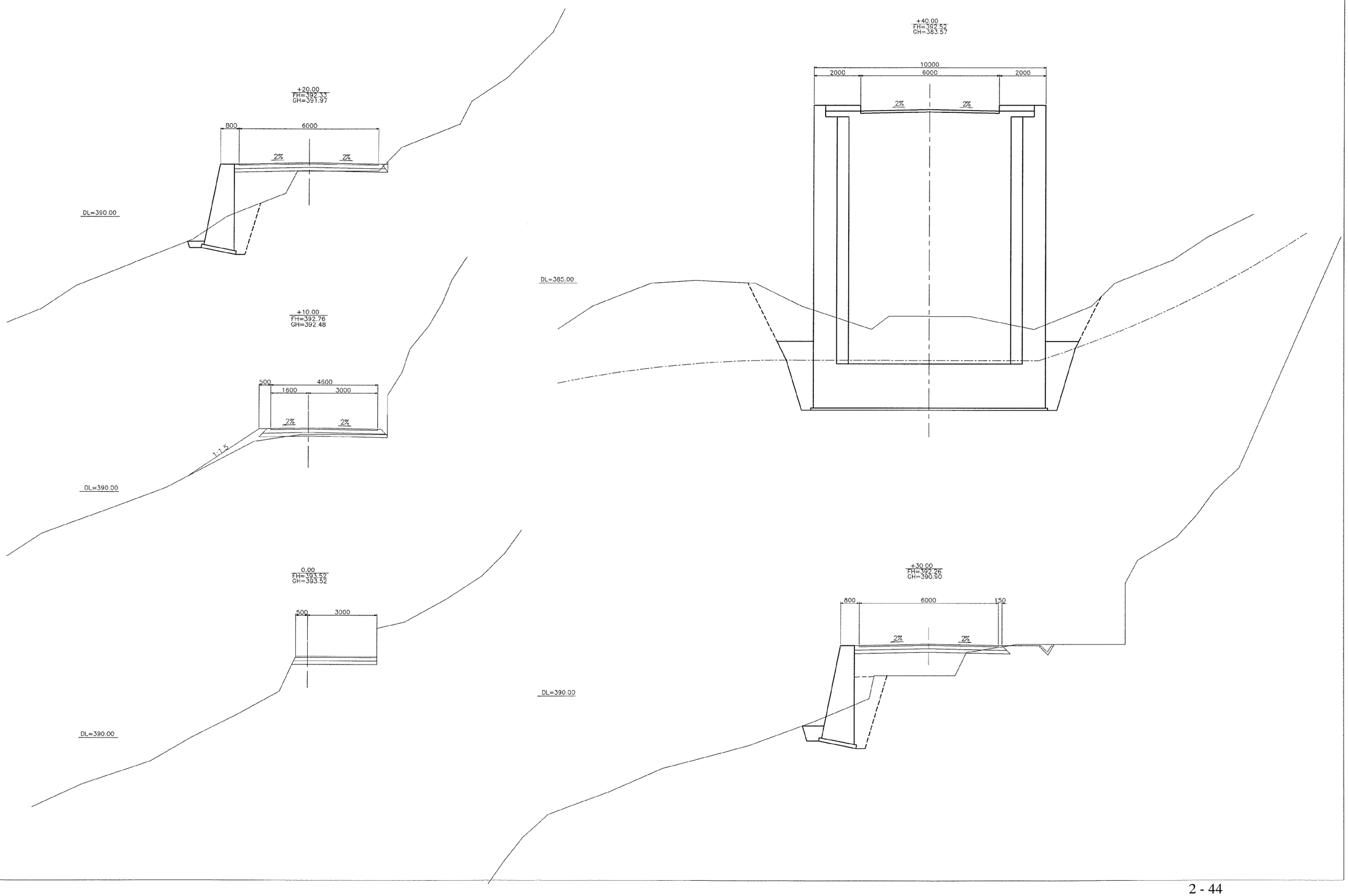
PROFILE
(WAKLEYTAR BRIDGE)



ROYAL GOVERNMENT OF BHUTAN DEPARTMENT OF ROADS, MINISTRY OF WORKS & HUMAN SETTLEMENT			
PROJECT	THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN THE KINGDOM OF BHUTAN (PHASE II)		
CONSULTANT	PACIFIC CONSULTANTS INTERNATIONAL		
	DESIGNED BY	CHECKED BY	APPROVED BY
NAME	S. KOBAYASHI	H. YONEYAMA	PHUNTSHO WANGDI
SIGNATURE			
DATE			

SECTION	SCALE	DRAWING NO.	SHEET NO.
	1/150		1 OF 3
DRAWING TITLE	CROSS SECTION1 (WAKLEYTAR BRIDGE)		
REV.NO.	DATE	DESCRIPTION	SIGNATURE

CROSS SECTION1
(WAKLEYTAR BRIDGE)

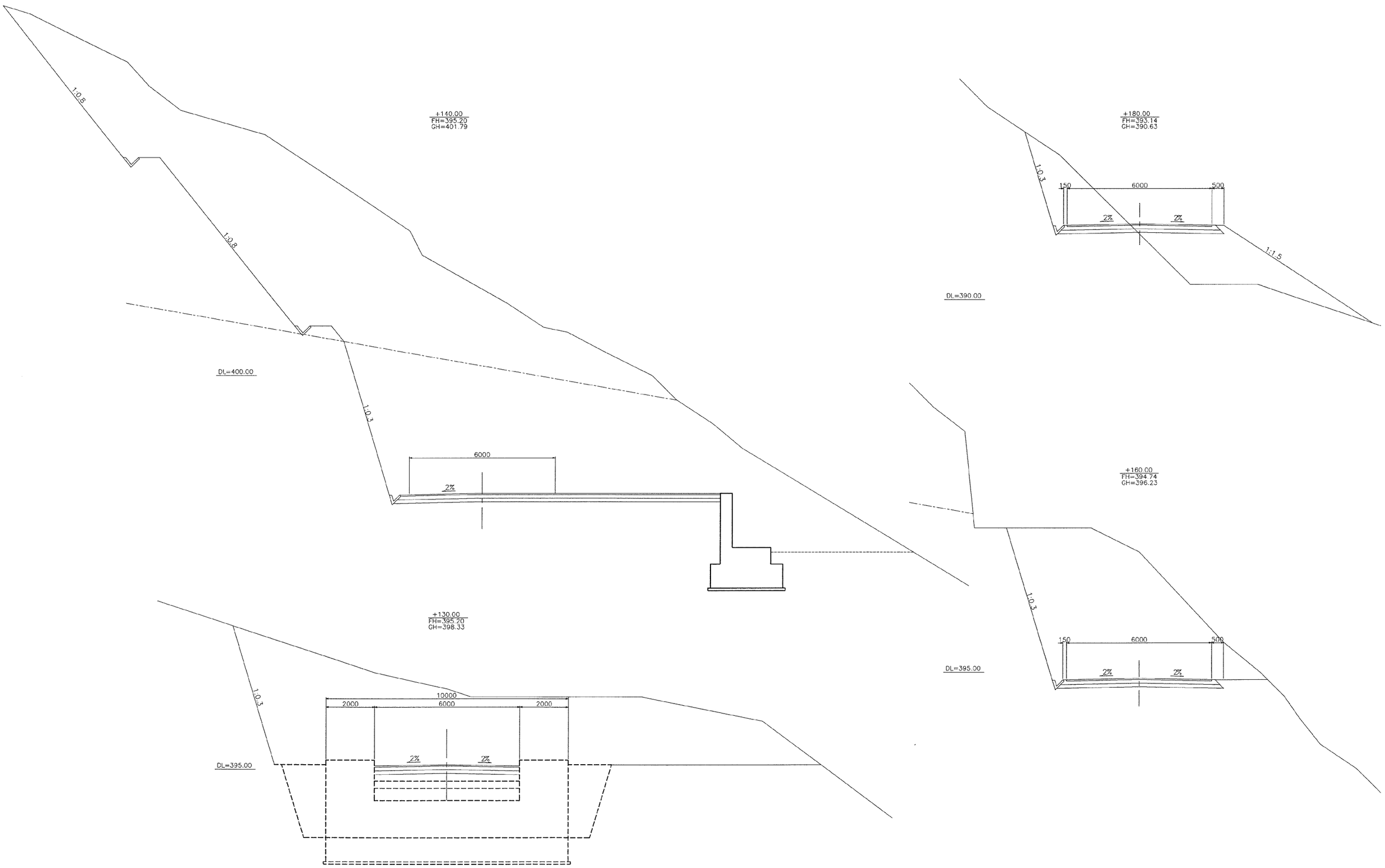


ROYAL GOVERNMENT OF BHUTAN DEPARTMENT OF ROADS, MINISTRY OF WORKS & HUMAN SETTLEMENT				
PROJECT	THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN THE KINGDOM OF BHUTAN (PHASE II)			
CONSULTANT	PACIFIC CONSULTANTS INTERNATIONAL			
	DESIGNED BY	CHECKED BY	APPROVED BY	
NAME	S. KOBAYASHI	H. YONEYAMA	PHUNTSHO WANGDI	
SIGNATURE				
DATE				

SECTION	SCALE	DRAWING NO.	SHEET NO.
	1/150		2 OF 3
DRAWING TITLE	CROSS SECTION2 (WAKLEYTAR BRIDGE)		

REV.NO.	DATE	DESCRIPTION	SIGNATURE

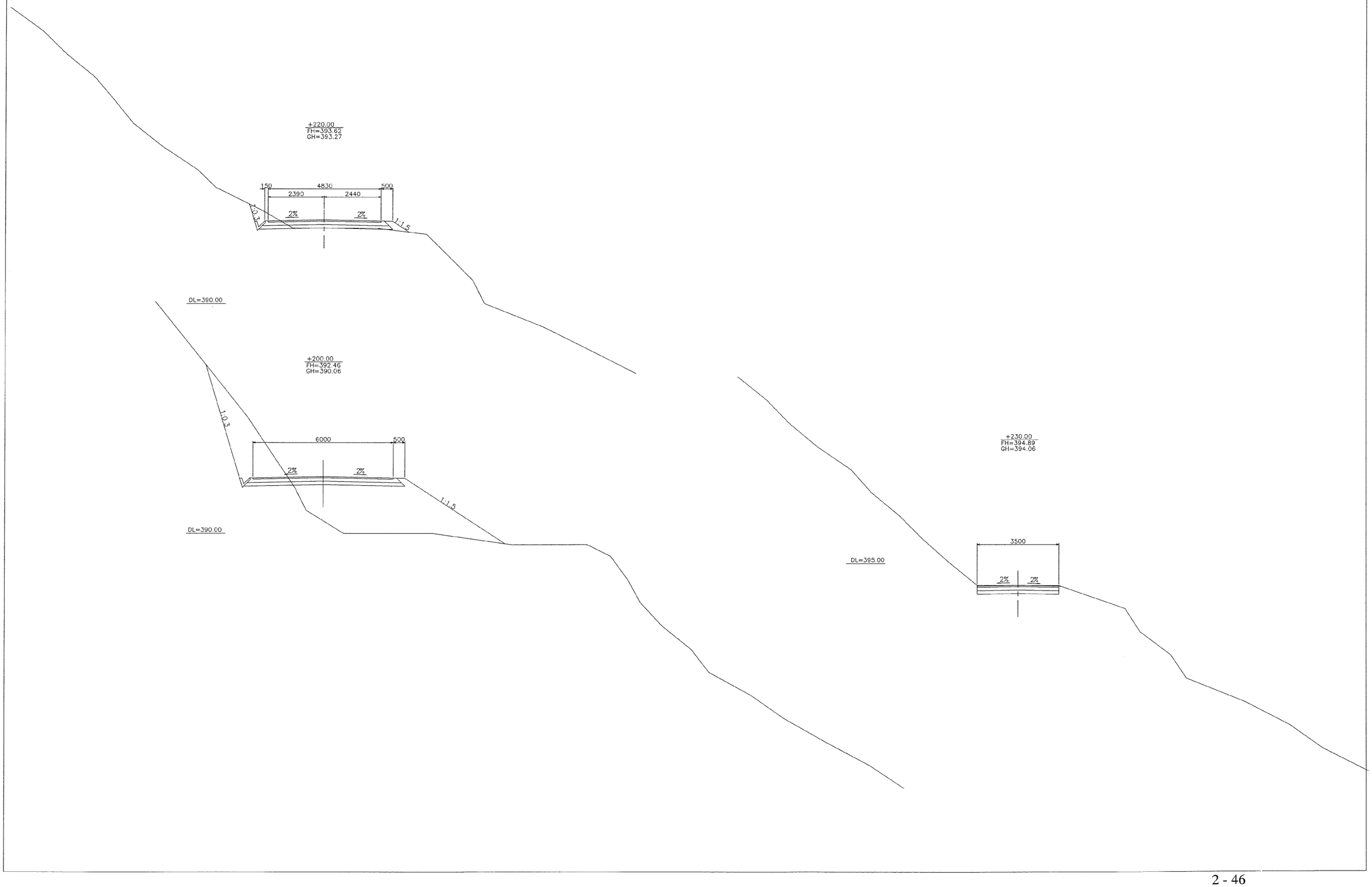
CROSS SECTION2
(WAKLEYTAR BRIDGE)



ROYAL GOVERNMENT OF BHUTAN DEPARTMENT OF ROADS, MINISTRY OF WORKS & HUMAN SETTLEMENT			
PROJECT	THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN THE KINGDOM OF BHUTAN (PHASE II)		
CONSULTANT	PACIFIC CONSULTANTS INTERNATIONAL		
	DESIGNED BY	CHECKED BY	APPROVED BY
NAME	S. KOBAYASHI	H. YONEYAMA	PHUNTSHO WANGDI
SIGNATURE			
DATE			

CROSS SECTION3
(WAKLEYTAR BRIDGE)

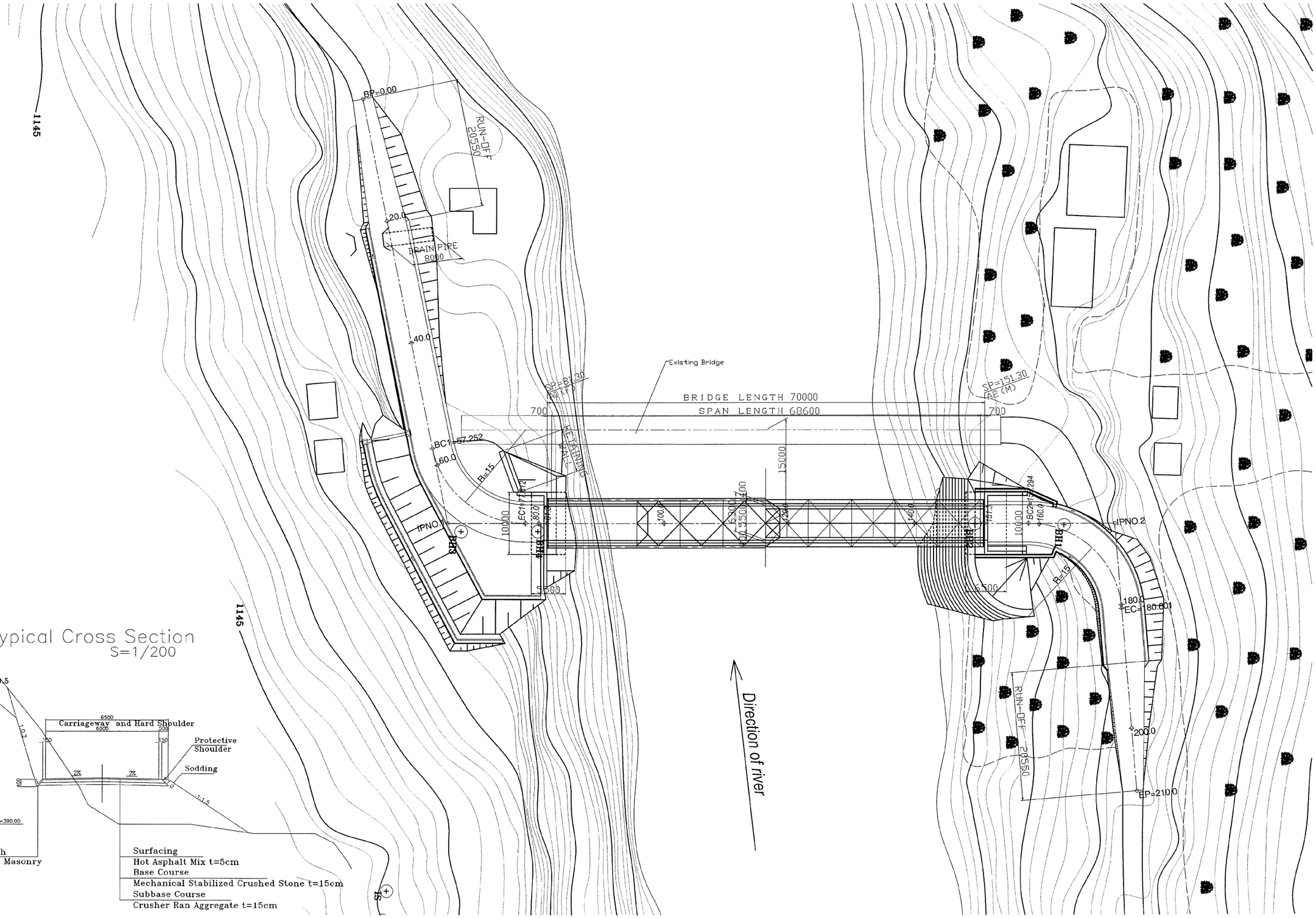
SECTION	SCALE	DRAWING NO.	SHEET NO.
	1/150		3 OF 3
DRAWING TITLE	CROSS SECTION3 (WAKLEYTAR BRIDGE)		
REV.NO.	DATE	DESCRIPTION	SIGNATURE



ROYAL GOVERNMENT OF BHUTAN DEPARTMENT OF ROADS, MINISTRY OF WORKS & HUMAN SETTLEMENT				
PROJECT	THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN THE KINGDOM OF BHUTAN (PHASE II)			
CONSULTANT	PACIFIC CONSULTANTS INTERNATIONAL			
	DESIGNED BY	CHECKED BY	APPROVED BY	
NAME	S. KOBAYASHI	M. YONEYAMA	PHUNTSHO WANGDI	
SIGNATURE				
DATE				

SECTION	SCALE	DRAWING NO.	SHEET NO.
	1/600		1 OF 1
DRAWING TITLE	PLAN (TANGMACHU BRIDGE)		
REV.NO.	DATE	DESCRIPTION	SIGNATURE

PLAN S=1/600
(TANGMACHU BRIDGE)



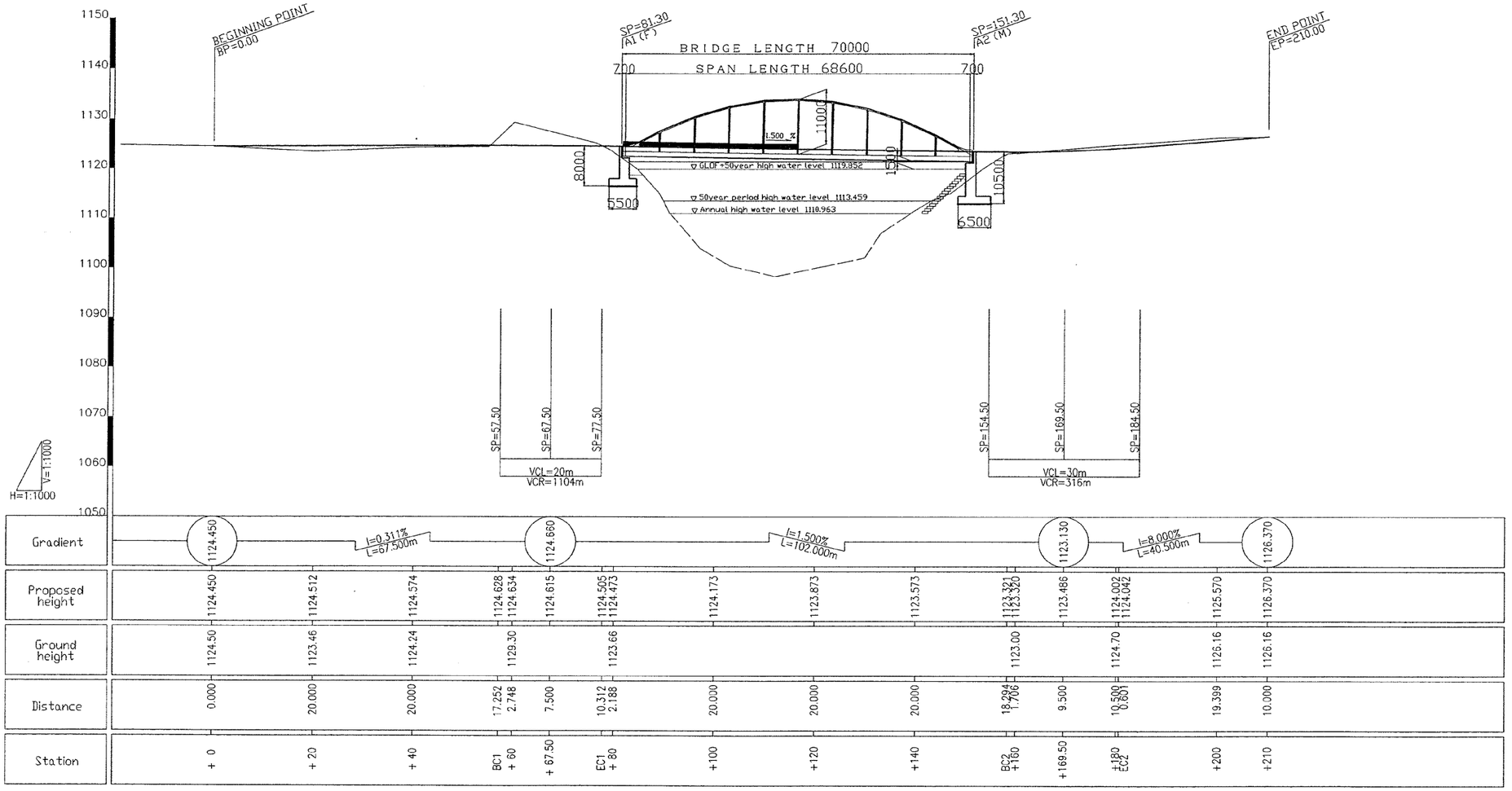
Typical Cross Section
S=1/200

ROYAL GOVERNMENT OF BHUTAN DEPARTMENT OF ROADS, MINISTRY OF WORKS & HUMAN SETTLEMENT				
PROJECT	THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN THE KINGDOM OF BHUTAN (PHASE II)			
CONSULTANT	PACIFIC CONSULTANTS INTERNATIONAL			
	DESIGNED BY	CHECKED BY	APPROVED BY	
NAME	S. KOBAYASHI	H. YONEYAMA	PHUNTSHO WANGDI	
SIGNATURE				
DATE				

SECTION	SCALE	DRAWING NO.	SHEET NO.
	V:1/1000 H:1/1000		1 OF 1
DRAWING TITLE	PROFILE (TANGMACHU BRIDGE)		

REV.NO.	DATE	DESCRIPTION	SIGNATURE

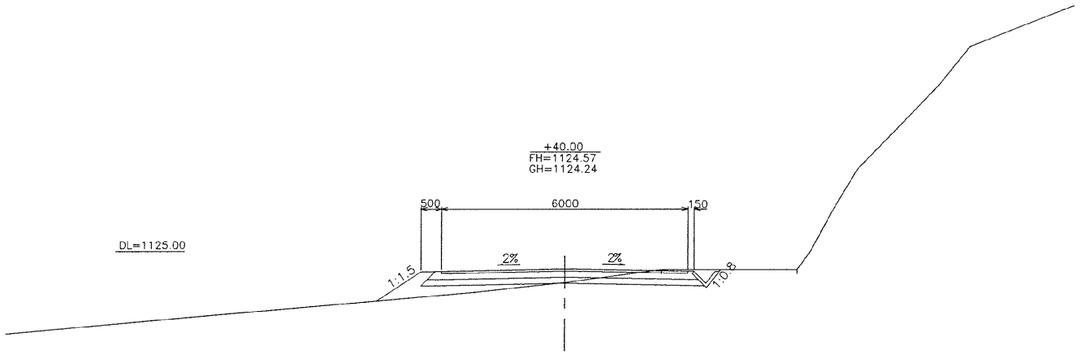
PROFILE
(TANGMACHU BRIDGE)

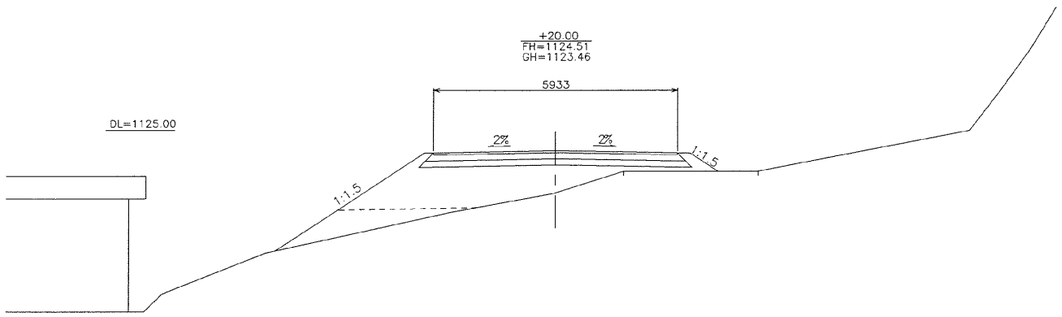


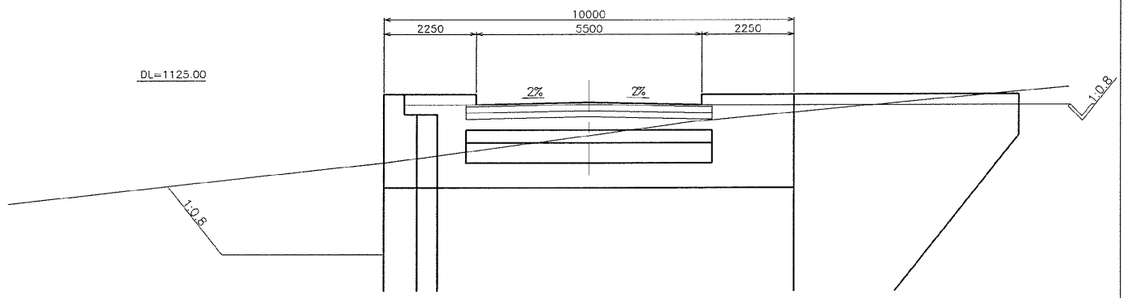
ROYAL GOVERNMENT OF BHUTAN DEPARTMENT OF ROADS, MINISTRY OF WORKS & HUMAN SETTLEMENT				
PROJECT	THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN THE KINGDOM OF BHUTAN (PHASE II)			
CONSULTANT	PACIFIC CONSULTANTS INTERNATIONAL			
	DESIGNED BY	CHECKED BY	APPROVED BY	
NAME	S. KOBAYASHI	H. YONEYAMA	PHUNTSHO WANGDI	
SIGNATURE				
DATE				

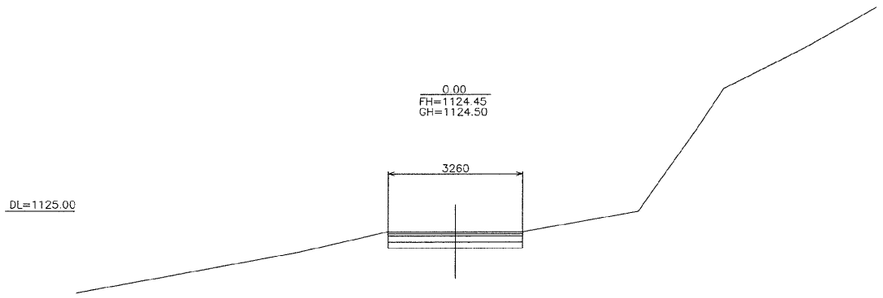
SECTION	SCALE	DRAWING NO.	SHEET NO.
	1/150		1 OF 2
DRAWING TITLE	CROSS SECTION1 (TANGMACHU BRIDGE)		
REV.NO.	DATE	DESCRIPTION	SIGNATURE

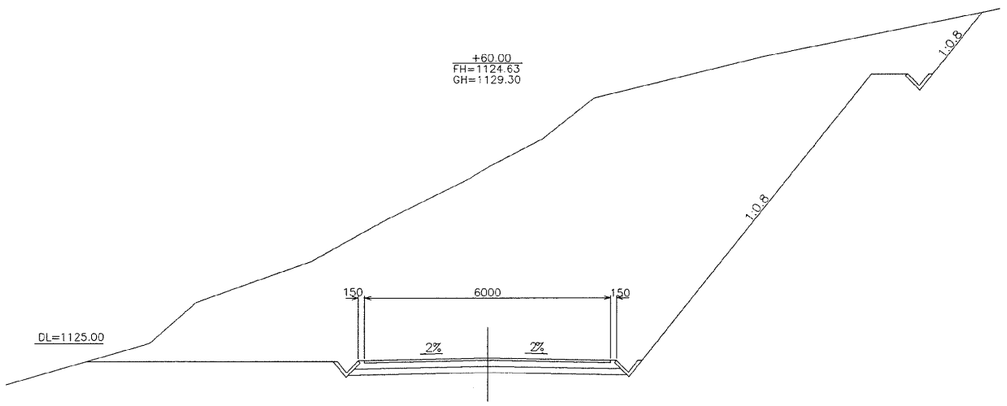
CROSS SECTION1
(TANGMACHU BRIDGE)







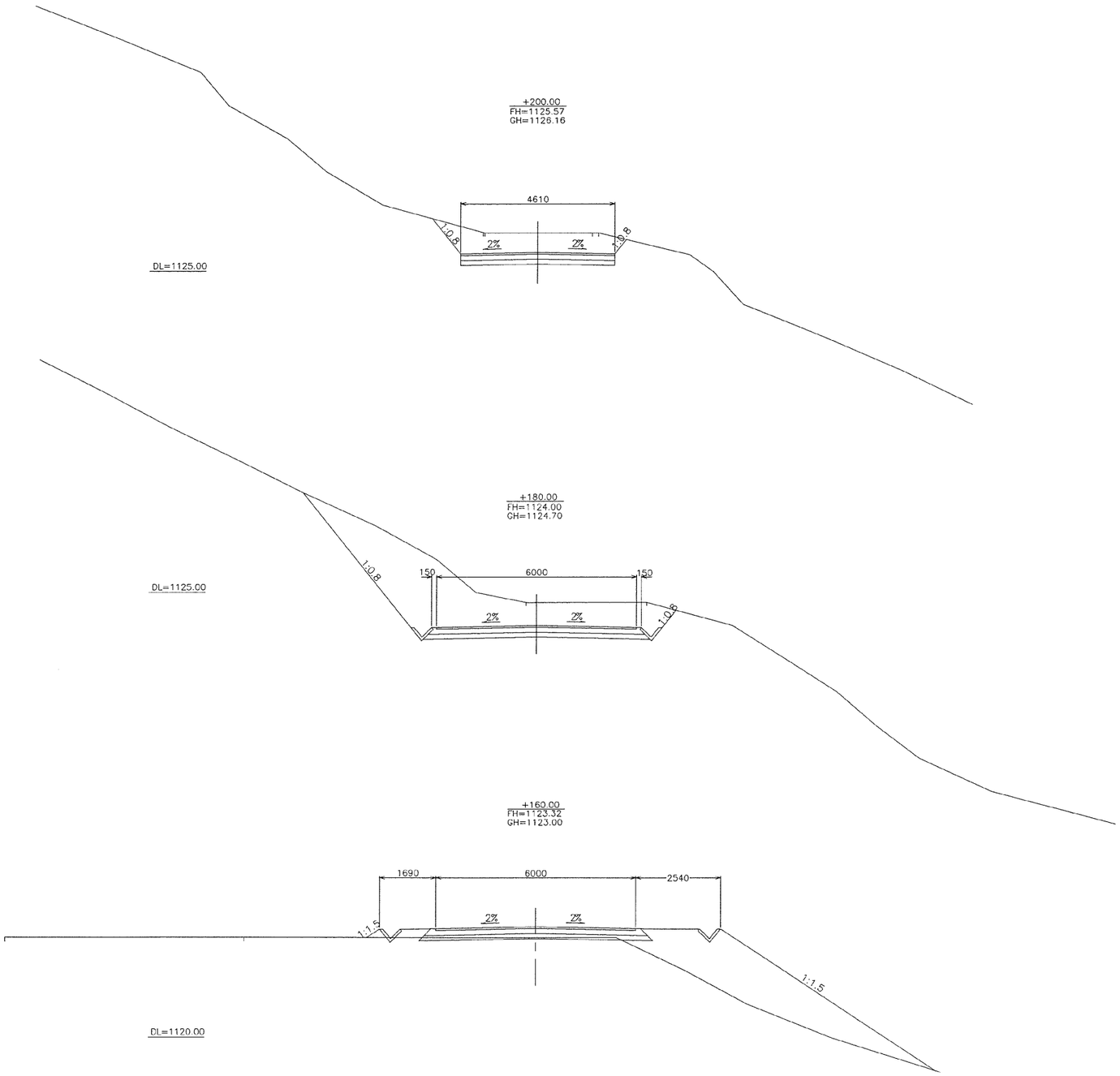




ROYAL GOVERNMENT OF BHUTAN DEPARTMENT OF ROADS, MINISTRY OF WORKS & HUMAN SETTLEMENT				
PROJECT	THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN THE KINGDOM OF BHUTAN (PHASE I)			
CONSULTANT	PACIFIC CONSULTANTS INTERNATIONAL			
	DESIGNED BY	CHECKED BY	APPROVED BY	
NAME	S. KOBAYASHI	H. YONEYAMA	PHUNTSHO WANGDI	
SIGNATURE				
DATE				

SECTION	SCALE	DRAWING NO.	SHEET NO.
	1/150		2 OF 2
DRAWING TITLE	CROSS SECTION2 (TANGMACHU BRIDGE)		
REV.NO.	DATE	DESCRIPTION	SIGNATURE

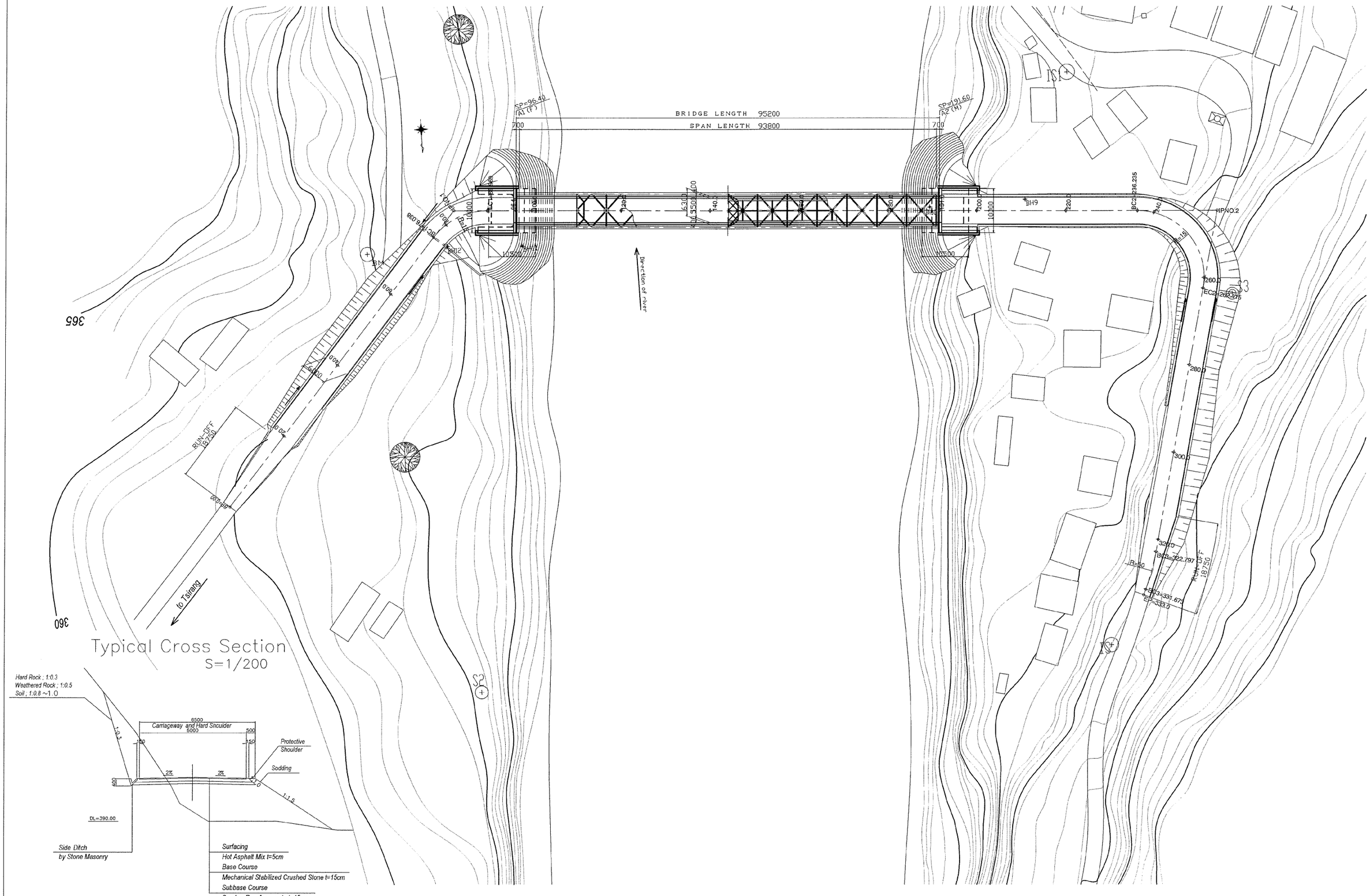
CROSS SECTION2
(TANGMACHU BRIDGE)



ROYAL GOVERNMENT OF BHUTAN DEPARTMENT OF ROADS, MINISTRY OF WORKS & HUMAN SETTLEMENT				
PROJECT	THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN THE KINGDOM OF BHUTAN (PHASE II)			
CONSULTANT	PACIFIC CONSULTANTS INTERNATIONAL			
	DESIGNED BY	CHECKED BY	APPROVED BY	
NAME	S. KOBAYASHI	H. YONEYAMA	PHUNTSHO WANGDI	
SIGNATURE				
DATE				

SECTION	SCALE	DRAWING NO.	SHEET NO.
	1/800		1 OF 1
DRAWING TITLE	PLAN (SUNKOSH BRIDGE)		
REV.NO.	DATE	DESCRIPTION	SIGNATURE

PLAN S=1/800
(SUNKOSH BRIDGE)

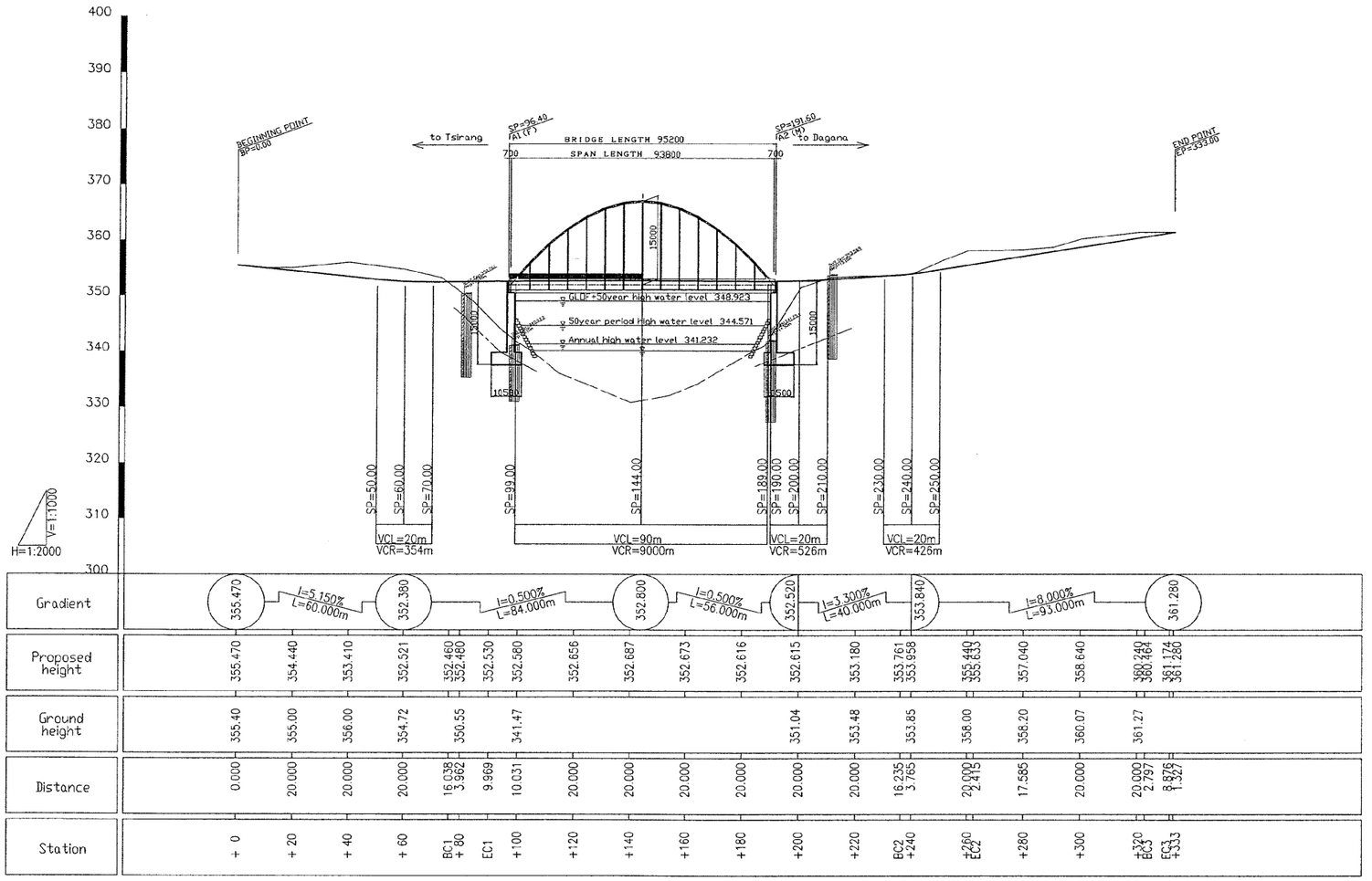


Typical Cross Section
S=1/200

ROYAL GOVERNMENT OF BHUTAN DEPARTMENT OF ROADS, MINISTRY OF WORKS & HUMAN SETTLEMENT				
PROJECT	THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN THE KINGDOM OF BHUTAN (PHASE II)			
CONSULTANT	PACIFIC CONSULTANTS INTERNATIONAL			
	DESIGNED BY	CHECKED BY	APPROVED BY	
NAME	S. KOBAYASHI	H. YONEYAMA	PHUNTSHO WANGDI	
SIGNATURE				
DATE				

SECTION	SCALE	DRAWING NO.	SHEET NO.
	V:1/1000 H:1/2000		1 OF 1
DRAWING TITLE	PROFILE (SUNKOSH BRIDGE)		
REV.NO.	DATE	DESCRIPTION	SIGNATURE

PROFILE
(SUNKOSH BRIDGE)

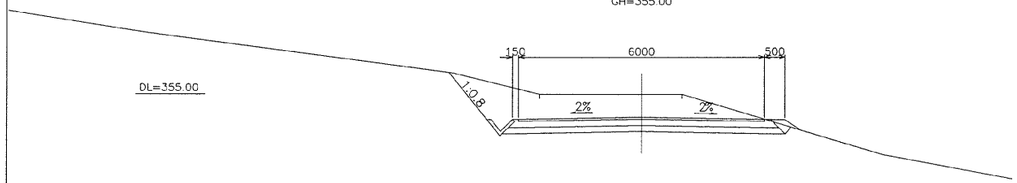


ROYAL GOVERNMENT OF BHUTAN DEPARTMENT OF ROADS, MINISTRY OF WORKS & HUMAN SETTLEMENT				
PROJECT	THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN THE KINGDOM OF BHUTAN (PHASE II)			
CONSULTANT	PACIFIC CONSULTANTS INTERNATIONAL			
	DESIGNED BY	CHECKED BY	APPROVED BY	
NAME	S. KOBAYASHI	H. YONEYAMA	PHUNTSHO WANGDI	
SIGNATURE				
DATE				

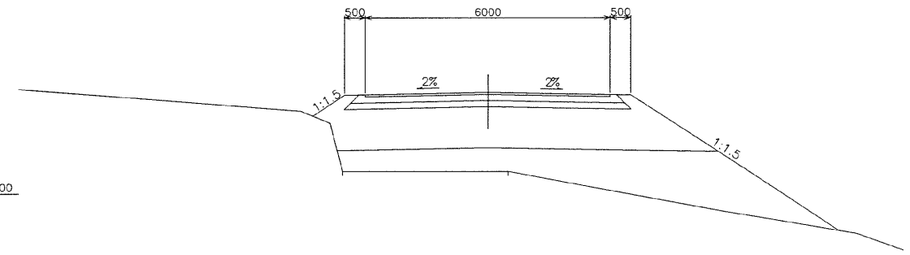
CROSS SECTION1
(SUNKOSH BRIDGE)

SECTION	SCALE	DRAWING NO.	SHEET NO.
	1/150		1 OF 3
DRAWING TITLE	CROSS SECTION1 (SUNKOSH BRIDGE)		
REV.NO.	DATE	DESCRIPTION	SIGNATURE

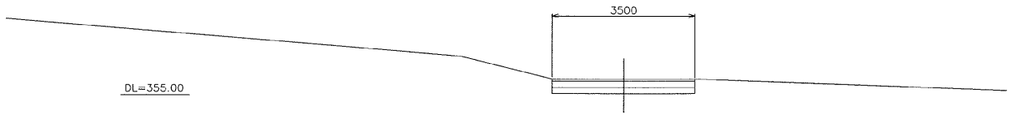
+20.00
FH=354.44
GH=355.00



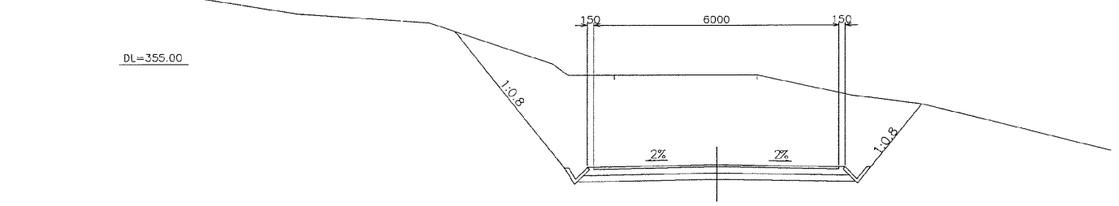
+80.00
FH=352.48
GH=350.55



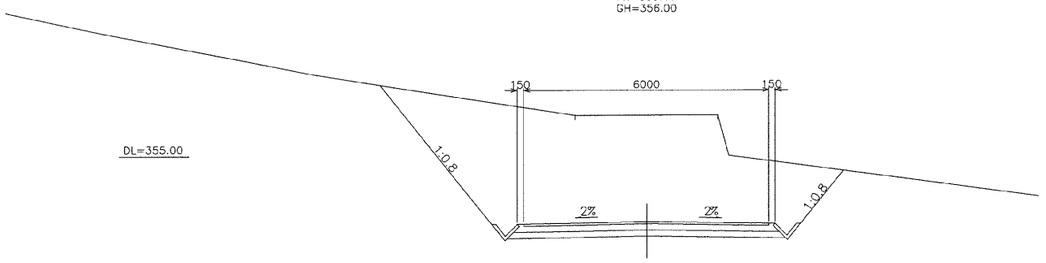
0.00
FH=355.47
GH=355.40



+60.00
FH=352.52
GH=354.72



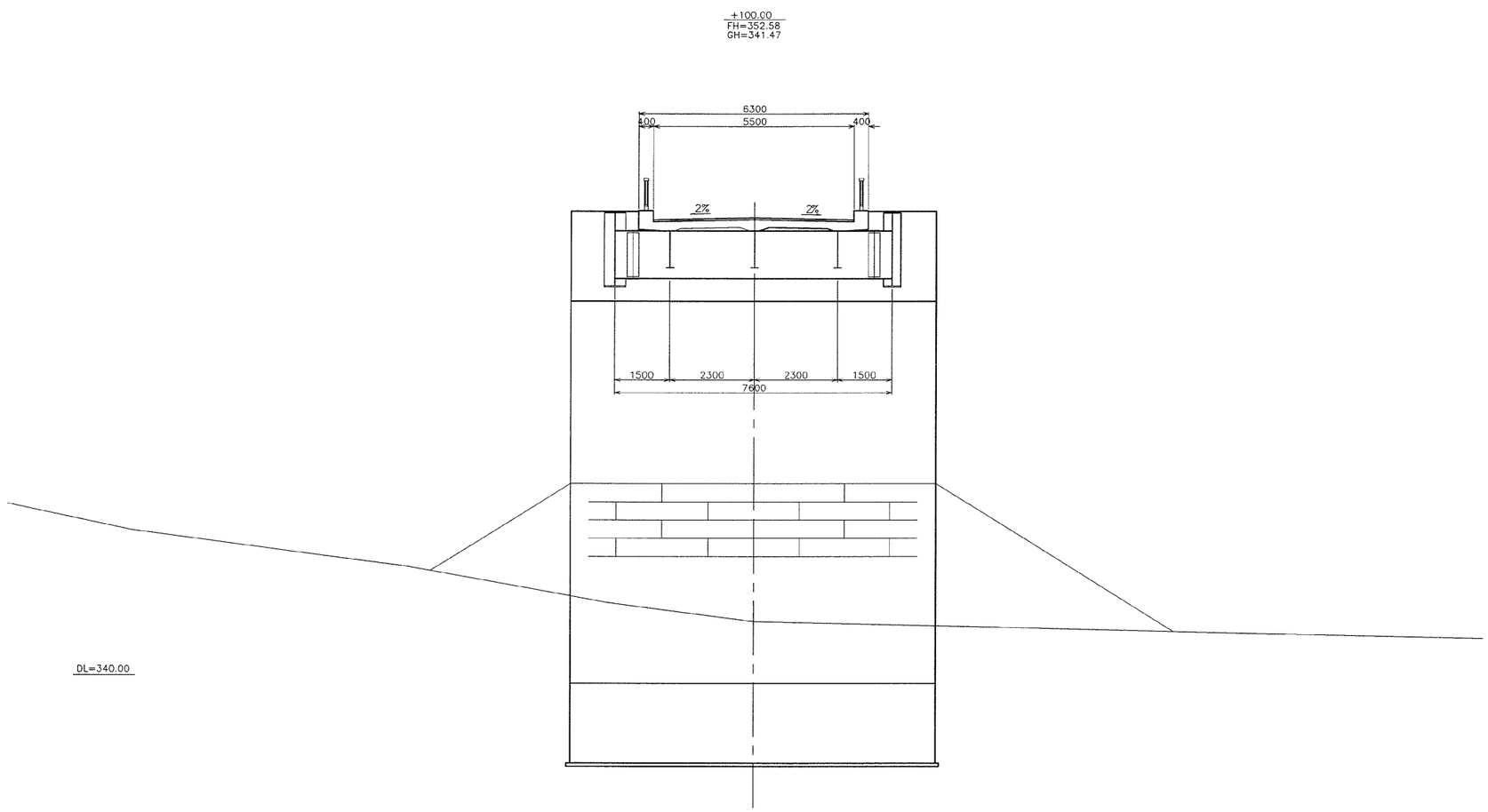
+40.00
FH=353.41
GH=356.00



ROYAL GOVERNMENT OF BHUTAN DEPARTMENT OF ROADS, MINISTRY OF WORKS & HUMAN SETTLEMENT				
PROJECT	THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN THE KINGDOM OF BHUTAN (PHASE II)			
CONSULTANT	PACIFIC CONSULTANTS INTERNATIONAL			
	DESIGNED BY	CHECKED BY	APPROVED BY	
NAME	S. KOBAYASHI	H. YONEYAMA	PHUNTSHO WANGDI	
SIGNATURE				
DATE				

SECTION	SCALE	DRAWING NO.	SHEET NO.
	1/150		2 OF 3
DRAWING TITLE	CROSS SECTION2 (SUNKOSH BRIDGE)		
REV.NO.	DATE	DESCRIPTION	SIGNATURE

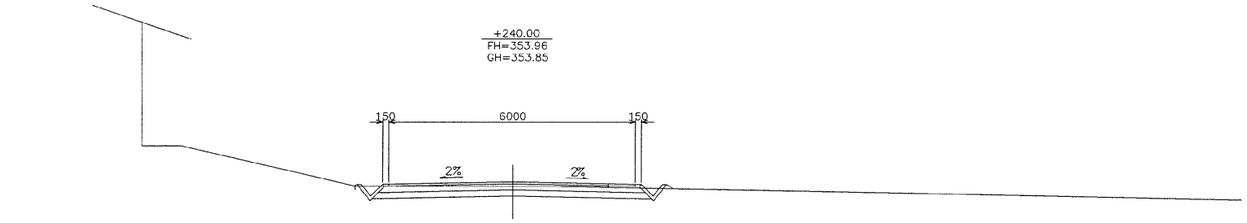
CROSS SECTION2
(SUNKOSH BRIDGE)

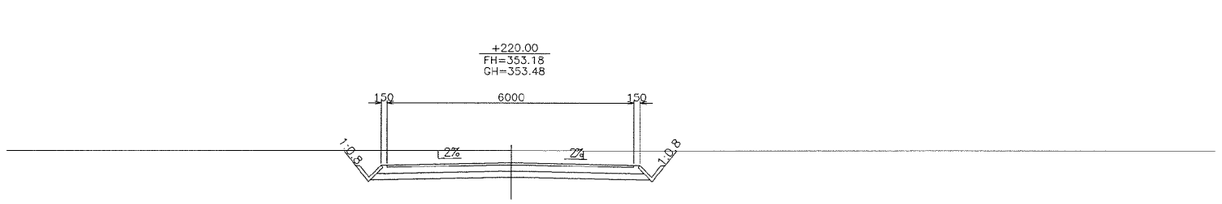


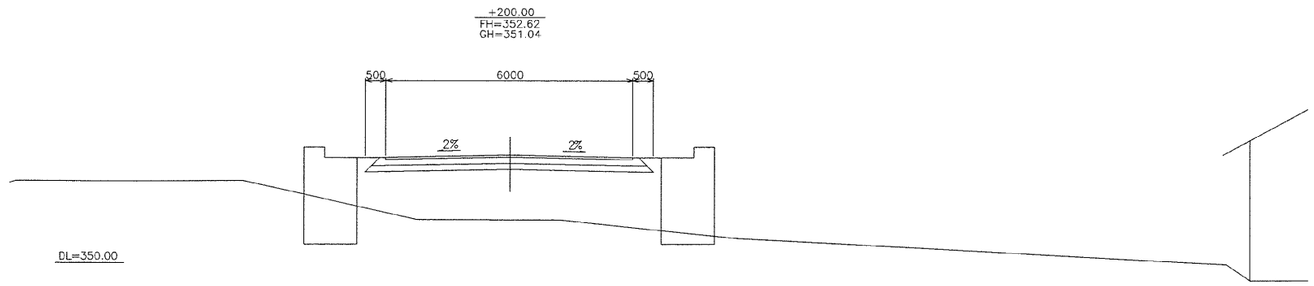
ROYAL GOVERNMENT OF BHUTAN DEPARTMENT OF ROADS, MINISTRY OF WORKS & HUMAN SETTLEMENT				
PROJECT	THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN THE KINGDOM OF BHUTAN (PHASE II)			
CONSULTANT	PACIFIC CONSULTANTS INTERNATIONAL			
	DESIGNED BY	CHECKED BY	APPROVED BY	
NAME	S. KOBAYASHI	H. YONEYAMA	PHUNTSHO WANGDI	
SIGNATURE				
DATE				

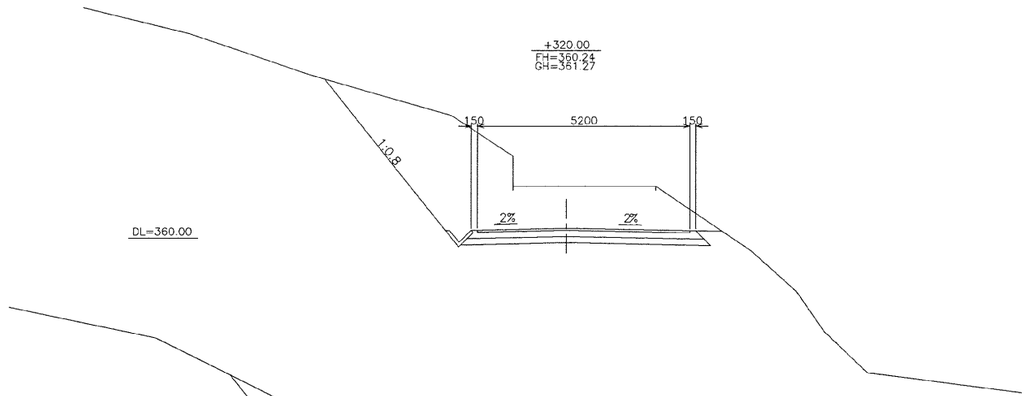
CROSS SECTION3
(SUNKOSH BRIDGE)

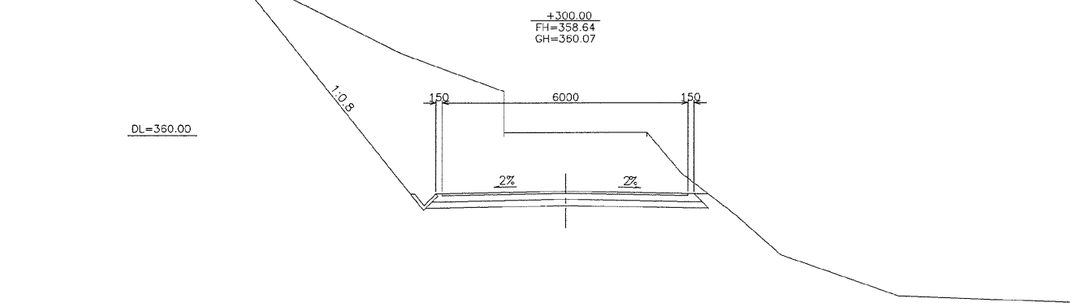
SECTION	SCALE	DRAWING NO.	SHEET NO.
	1/150		3 OF 3
DRAWING TITLE	CROSS SECTION3 (SUNKOSH BRIDGE)		
REV.NO.	DATE	DESCRIPTION	SIGNATURE

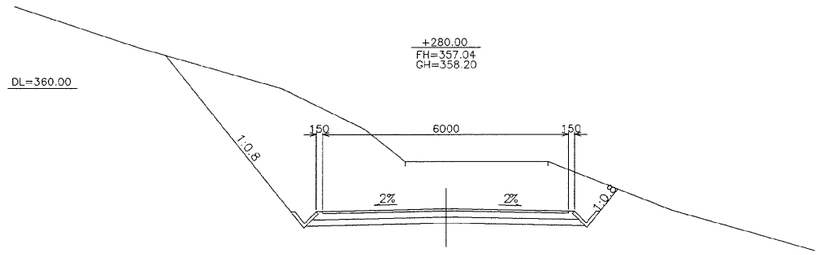


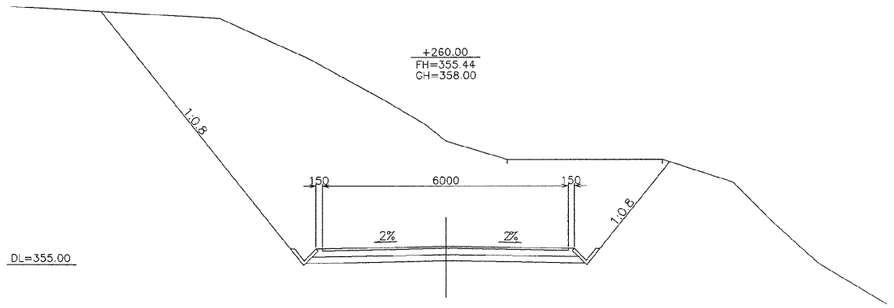












2-2-4 Implementation Plan

2-2-4-1 Implementation Policy

Counterpart of the Bhutanese side for this project is Department of Roads (DoR). DoR consists of several divisions. Bridge division will be the direct counterpart, Mechanical Division will take charge of leasing construction equipment, and Road Division will take charge of construction for approach roads.

Basic implementation policies of this project under the Japanese Grant Aid are as follows:

① To reduce the project cost, it is considered desirable to fabricate superstructures in Thailand. Japanese expert of steel bridge fabrication will be sent to support the fabricator in Thailand to maintain adequate level of quantity.

② In Bhutan, there are only a few contractors who have experience of permanent steel bridge erection because almost all steel bridges in Bhutan are temporary Bailey Bridges. Therefore Japanese expert of steel bridge erection will be sent to Bhutan for safety and smooth erection of the bridges and technical transfer to Bhutanese.

③ Generally, Mechanical division of DoR will lease the construction equipment procured under the Japanese Grant Aid not only to any Government agency, but also to any private contractors. Regarding the utilization of Bhutanese resources, the Japanese contractor will use the equipment for construction work of this project. Bhutanese construction methods of retaining wall and revetment will be adopted for the design to make participation in this project easier for Bhutanese contractors.

2-2-4-2 Implementation Conditions

(1) Distance between Two Sites

Construction sites for this project are divided into two regions: North-East region where Tangmachu Bridge is located and South-West region where Wakleytar Bridge and Sunkosh Bridge are located. Travel to the site takes 2 days in the dry season, but it takes a few days to a few weeks in rainy season because of roadblocks caused by landslides. These conditions will be taken into account for planning of general administration and implementation.

(2) Access from Phuntsholing

All imported materials and equipment will come through the border town, Phuntsholing. From there to the sites, there are some dangerous zones, and passes higher than 3,000 m even to the nearest bridge, Wakleytar. In the dangerous zones, the road will be slippery in winter and sometimes blocked by landslide in rainy season. Therefore, transportation of materials and equipment must be restricted in those seasons. Especially transportation to the North-East region, to the site of Tangmachu Bridge, must be prohibited in winter and rainy season, because of high risk.

(3) Transportation of Heavy Cargo through Existing Tangmachu Bridge

Allowable load of existing Tangmachu Bridge is 8t. It is assumed that there is some difficulty to transport equipment and materials to the other bank with the small allowable load. Therefore, reinforcement of existing Tangmachu Bridge shall be executed before commencement of construction work for the new Tangmachu Bridge.

2-2-4-3 Scope of Works

For the implementation of the project under the Japanese Grant Aid, the share of works to be undertaken by the Government of Japan and the Royal Government of Bhutan is described hereafter.

(1) The Share to be Borne by the Government of Japan

① Transportation of equipment and materials from Japan or any third countries to the sites
② Inland transportation from port in India (Kolkata) to the sites
③ Construction of the bridges, revetment and temporary approach road (construction road). Refer to Section 2-2-3 Basic Design Drawings (1)～(3) (p.2-28～p.2-41)
④ Construction and removal of camp yards and construction yards
⑤ Procurement of the materials, equipment and labor required for the above construction works
⑥ Field management costs for the above construction works
⑦ The consultant services, which are necessary to implement the works

(2) The Share to be Borne by the Royal Government of Bhutan

① Land acquisitions of the construction sites.
② Clearing and grabbing before construction and putting up a fence if necessary.
③ Notice of A/P to Japanese Bank, and pay commission.

④ The exemption of tax on the materials and equipment imported for the project, and the expeditious proceeding of custom procedures.
⑤ Expedient procedures for the Japanese to procure equipment and materials and to transport it to Bhutan.
⑥ The exemption of taxes and custom fees for the Japanese and the third national parties entering Bhutan to work on the project.
⑦ To establish the necessary facilities such as electricity, water, and so on, at each site.
⑧ To lease the construction equipment to be procured by Japanese Grant Aid "the Project for Improvement of Equipment for Road Construction and Maintenance", with first priority for this project.
⑨ Removal of existing three bridges after completion of construction work covered by Japanese Grant Aid.
⑩ To construct permanent approach roads mentioned in section "2-2-3 Basic Design Drawings (4) Reference (p.2-42～p.2-55)". To remove pavements of temporary approach roads before commencement of permanent approach road work, if necessary. To remove temporary approach roads after the completion of the permanent approach roads.
⑪ Proper treatment and maintenance to the bridges constructed under this Grant Aid program.
⑫ To pay necessary cost for this project excluding the cost of items supplied by the Japanese Grant Aid.

2-2-4-4 Consultant Supervision

(1) Basic Policy of Detailed Design

The basic policy of the detailed design is as follows:

- Field studies during the detailed design will conduct reconfirmation of the site, supplementary studies related to the construction/estimation and additional survey based upon the basic design. Final discussion shall be held with the Royal Government of Bhutan on confirmation items related to the detailed design.

- After the completion of detailed design, the context of the detailed design shall be explained to the Bhutanese authorities, and discussions will be held.

(2) Basic Policy of Consultant Supervision

The basic policy of the consultant supervision will be as follows:

- This project is concerned with the replacement work of three (3) bridges located at two different regions of the country and these bridges are scheduled to be constructed almost simultaneously. The construction supervisory team, including locals shall be under "select-few" principle.

- The construction supervision engineers shall endeavor to perform the construction supervision operations as smoothly as possible. Furthermore, it is necessary to establish a backup system for this project in Japan.

- The launching method and cable erection method of steel bridges applied to this project are not a familiar method for Bhutanese engineers. Therefore, the Japanese supervisors with the cooperation of the contractors will carry out technical transfer about these bridge erection works to the engineers of the Royal Government of Bhutan.

(3) Consultant Supervision

The supervisors dispatched to the sites will perform the following construction supervision works:

- Approval of the construction schedule and construction drawings
  Supervisors will inspect and approve the construction schedule and shop drawings submitted by the contractor, in conformity with the contract document, contract drawings, specifications and others.

- Schedule control
  Supervisors will receive the progress reports from the contractor, and give adequate and essential instructions necessary for the timely completion of the project.

- Quality control
  Supervisor will examine and approve the quality of construction materials and construction methods, in conformity with the contract drawings and specifications.

- Inspection of completed construction works
  Through the inspection of the final sections, plans, figures and others, supervisors will confirm the completed construction works to the control criteria and certify the quantities.

- Issuing of certification
  Supervisors will issue the certificates for the payment of the contractor, such as the completion of the construction and the expiration of warranty terms, etc.

- Submittal of reports
  Supervisor will inspect the monthly reports, final pictures prepared by the contractor and submit them to the Bhutanese authorities, JICA and others. Furthermore, the supervisors will prepare the final report after the completion of the construction and submit it to JICA.

(4) Procurement

Method of transportation might affect on the atmospheric corrosion resistant steel (weathering steel) for occurrence of stable rust. Therefore, contractor shall prepare the plan of transportation and issue it to consultants to get approval.

2-2-4-5 Quality Control Plan

Bhutanese specifications and IRC-Codes are to be applied for this project, and Japanese specification is also to be applied if there is no related design rule in Bhutanese specifications and IRC codes. Items for quality control of embankment and concrete are shown in Tables 2-2-4-1 and 2-2-4-2.

Table 2-2-4-1 Items and Frequency of Quality Control for Embankment

Target	Contents	Frequency
Embankment	Density test Water content test Liquid and plastic test CBR test Compaction test	Once a 50,000 m^3, or Once a construction point
Sub-grade		Once a 10,000 m^3, or Once a construction point
Back filling		Once a 10,000 m^3, or Once a construction point

Table 2-2-4-2 Items and Frequency of Quality Control for Concrete

Target	Contents	Frequency
Substructure	Compression test	Followed specification in IRC-21-1987 (SECTION III CEMENTCONCRETE)
Superstructure (Deck slab)		

2-2-4-6 Procurement Plan

(1) Materials

1) Basic policy

As a general rule, materials essential for the construction shall be procured from local sources if possible. Imported materials easily available in Bhutan are considered as local materials and shall be procured locally, unless materials lack in quality, or if there is difficulty in the procurement process within a required period

of time. In such cases, the material will be obtained from Japan or from a neighboring third country, namely India.

2) Present procurement conditions of materials

The present procurement conditions of the major construction materials required for this project are shown as below.

a. Cement

The cement manufactured in Bhutan is mostly ordinary Portland cement. As the manufactured amount exceeds that of domestic demand, the balance is mostly exported to India. Import of cement from other country is prohibited due to the national policy of Bhutan. Table 2-2-4-3 shows cement manufacturers and their production capacities.

Table 2-2-4-3 Cement Manufactures and Capacities

Manufacturers	Location	Capacity (ton / day)	Remarks
Penden	Gomtu, Samchi	1,000	Increased from May 2002, 80% of product for domestic supply
Lhaki	Gomtu, Samchi	150	From 1995, 30% of product for domestic supply
Druck	Paska, Phunthsoling	100	Established in 2001
Yangzom	Tashijong, Samchi	20～30	-

Penden cement is used in general. The cost of cement varies in each region due to the differences of transportation cost. The following table shows cement cost in various cities.

Table 2-2-4-4 Regional Price Indices

Cities	Price Indices	Cities	Price Indices	Cities	Price Indices
Gomutu	1.000	Haa	1.352	Trongsa	1.591
Samtse	1.050	Pemagatsel	1.378	Trashigang	1.631
P/Ling	1.057	Damphu	1.383	T/Yangtse	1.688
Gelephu	1.233	W/Phodrang	1.399	Jakar	1.703
S/Jongkhar	1.252	Punakha	1.404	Mongar	1.738
Sarpang	1.263	Zhemgang	1.472	Lhuntse	1.872
Thimphu	1.310	Dagana	1.537	Gasa	-
Paro	1.310				

Note 1) Penden Cement Authority Ltd. 2004.7.17
Note 2) There is no transportation route to Gasa

b. Sand and aggregate

Sand is collected from rivers either in the adjacent regions to the plains of India or from the rivers in valleys where rapid flow of the river becomes moderate. However, the sand collection areas are limited due to the swollen rivers in the rainy-seasons. Therefore, it is necessary to prepare stockpile during dry-seasons. On the other hand, crashed stones are widely used as aggregates. Due to the lack of a large-scale quarry plant that utilizes boulders and mountain rocks, manpower crushing boulder into aggregates besides of roads will supplement with an insufficient supply of aggregates. However, recent large-scale road pavement project financed by ADB provides temporary crushing plants at each section. The following table shows sources of aggregate in this project.

Table 2-2-4-5 Sources of Sand and Aggregates

Bridge Name	Source of Supply	
	Sand	Aggregate
Wakleytar Bridge	River sand collection area at W/Phodrang (54 km from the site)	Existing crushing plant adjacent to national highway at W/Phodrang (30 km from the site, nearby Baychu Bridge)
Tangmachu Bridge	River sand collection area adjacent to district road (33 km downstream from site, nearby Rewanchu Bridge)	Existing crushing plant adjacent to national highway, 60 km from Mongar to Tashigang (120 km from the site)
Sunkosh Bridge	River sand collection area at W/Phodrang (73 km from the site)	Existing crushing plant adjacent to national highway, at W/Phodrang (49 km from the site, nearby Baychu Bridge)

c. Reinforcing steel bar, structural steel

- Reinforcing steel bar (re-bar)

  The reinforcing steel bar, which is imported from India, can be procured from domestic market. These are mild steel bars with yield strength of 250 MPa and cold twisted deform bars with yield strength of 415 MPa. The available size of re-bars are 6, 8, 10, 16, 20 22, 25, 28, 30 and 32 mm in diameter and 12 m in length. Re-bars are delivered to site bended as half-length and usually it has rust. Because the bended portion of the re-bar cannot be utilized, the actual length to be utilized becomes shorter. In general, quality certification (mill sheets) regarding yield strength is not attached to steel products from India. However, the tensile strength test for re-bars became available at the laboratory of MoWHS (Ministry of Works & Human Settlement) in Thimphu recently.

Therefore, it is considered to use re-bars imported from India with proper quality assurance test in Bhutan. Recently, the cost of re-bar has been increasing world-wide: actually 15% increase during a half year, from December 2003 to June 2004.

- Structural steel
  Structural steels such as angles, channels and H/I sections are also supplied from India because they are used for temporary works.

- Steel bridges
  Fabricators in India and Thailand were investigated to reduce the project cost although Japanese fabricators have advantage of quality assurance and firm delivery period.

  For example, even a large scale fabricator in India has experience for mainly wagons and bailey bridges, and has no experience of fabricating permanent steel bridge as planned for this project. Therefore, there are some apprehensions of quality and delivery period about Indian fabricators.

  In Thailand, two fabricators in the suburb of Bangkok were investigated. Main products of both fabricators were facilities of power plants and oil refinery plants, and they have only one experience of plate girder fabrication. However, considering their own facilities and equipment, it was judged that they have capability to fabricate the steel Langer type bridge.
  Taking into account the above investigation results, it is possible to fabricate Langer bridges in Thailand although the material, weathering steel, must be procured from Japan. In this case, some Japanese expert of steel fabrication shall be dispatched to Thailand and supervise the fabricator in Thailand, due to lack of adequate experience for steel bridge fabrication.

d. Materials for concrete forms and scaffolding

- Formwork material
  The plywood, imported formwork material from India, is available in the Bhutanese market. However, reusability of the Indian plywood is very low, usually only two times according to the previous project, due to low quality. On the other hand, in Bhutan, the metal form is used for only building projects and not used for civil work projects. The separators and form ties are also not used for civil works in Bhutan, but re-bars are used as substitute for separators.

- Scaffolding

  Bamboo materials are generally used as scaffolding materials. However, in recent years, steel pipes and pipe supports are used at bridge construction projects and a big hotel construction project in Thimphu. In Bhutan, steel pipes are often delivered with rusty condition, so at least, procuring accessories such as clamps from Japan is preferable.

e. Ready mixed concrete / Asphalt mixture

- Concrete batching plant and Asphalt mixing plant

  In Bhutan, the concrete is normally produced by means of barrel mixers at site although, for a large-scale project such as power plant, a concrete batching plant may be established.

  Regarding asphalt mixing plant, DoR owns an Indian mobile small-size plant; however, it has been hardly used and manpower hot mix asphalt is usually used at site. Even DANTAK (Indian army engineer corps) applies the manpower hot mix asphalt.

- Concrete mix design

  Concrete mix design at site shall be generally conformity with the "Guideline for Construction Site Management" issued by MoWHS. The following table shows the mix:

Table 2-2-4-6 General Concrete Mix Design in Bhutan

Class	Minimum 28 days strength (Kg / cm^2)	Mix Ratio (Volume)			Applicable for
		Cement (Bag)	Sand (Bag)	Aggregate (Bag)	
M10	100	1	3	6	-
M15	150	1	2	4	Lean Concrete
M20	200	1	1.5	3	RC Concrete
M25	250	1	1	2	Important RC Concrete

In this project, the concrete strength applies σ_{ck} = 21 N/mm^2 and σ_{ck} = 24 N/mm^2 for substructures and bridge deck for superstructures respectively. The following table shows mix design for σ_{ck} = 21 N/mm^2 of phase I as reference.

Table 2-2-4-7 Concrete Mix Design (σ_{ck}=21N/mm^2, Kuri Bridge)

Minimum size of Course Aggregate (mm)	W/C (%)	s/a (%)	W (kg/m^3)	C (kg/m^3)	S (kg/m^3)	G (kg/m^3)	Water Reducing Agent (Lit./m^3)	Air Entraining Agent (Lit./m^3)
40	45.0	39.0	180	400	628	1041	1.30	0.035

f. Fuel

Generally, fuel such as petrol and diesel oil is imported from India, and is available at petrol stations from agents (i.e. Bhutan Oil Distributors, Druk Petroleum Co., Ltd, Damchen Petroleum Distributors) located in major cities. Like other materials such as cement, the cost of fuel varies depending on region. It should be reflected into the cost estimation that fuel cost jumped up three times in this year.

g. Others

- Embankment material
  Good borrow materials are available almost from anywhere, because inappropriate places such as soft ground scarcely exist in Bhutan. Therefore, any mountain area except rocky zone can be used as a borrow pit if Department of Forestry Services, Ministry of Agriculture, approves. Although only a small volume is necessary for embankment of this project, quality of backfill material is important especially for the material behind abutments. The material is assumed to be available from slope area within 10 km of each bridge site.

- Explosives
  Dynamite, imported from India, is generally used to excavate outcrop rocks in Bhutan. However, it is understood that fragments will roll into rivers and give damage to adjacent bridges and houses, if this method is applied for the project. Therefore, breaker attached to an excavator will be basically used instead of explosive.

- Water
  Water for concrete mixing cannot be supplied from a river especially in rainy season because of the mud dissolved in river water. In this project, the water shall be taken from neighboring streams and stored in water tanks at construction yards. Drinking water shall be purchased.

3) Procurement plan of materials

Considering the present procurement conditions mentioned above, the procurement plan of major construction materials is shown in Table 2-2-4-8.

Table 2-2-4-8 Procurement Plan of Materials

Materials	Standard	Supply Source			Remarks
		Bhutan	Japan	Third Country	
Embankment Material		○			Within 5 km from site
Asphalt	Site manpower mixing			India	Purchase in Bhutan
Asphalt Emulsions				India	Purchase in Bhutan
Base Course	Crush Stone	○			
Cement	Ordinal Portland Cement	○			
Admixtures	Water Reducing Agent		○		
Fine Aggregate	Sand	○			
Course Aggregate	Crush Stone	○			
Quarry Stone	20～25 cm	○			
Re-Bar				India	
Steel Superstructure	Atmospheric Corrosion Resistant Steel		(○)	Thailand	Weathering Steel is procured from Japan
Bridge Railing	Steel made			India	
Metal Shoe	With Accessory		○		
Expansion Joints			○		
Surface Catch Basin	With Vertical Drain Pipe		○		
Gabion				India	
Plywood for Formwork				India	
Support	Steel Pile			India	
Scaffolding	Scaffold planks, separator	○	(○)		Separator is procured from Japan
Wood	Formwork, Temporary yard	○			
Sand Bag	Temporary use			India	Purchase in Bhutan
Fuel				India	Purchase in Bhutan

(2) Construction Equipment

1) Basic policy

As for construction equipment, DoR agreed to lease construction equipment procured through the Japanese Grant Aid "the Project for Improvement of Equipment for Road Construction and Maintenance" to the Japanese contractor with first priority. In the implementation plan, the study team counts on the equipment for reducing project cost. However special machines, such as a takedown type of rough terrain crane, will basically be brought from Japan because of no availability from inside of Bhutan or neighboring countries.

2) Present procurement conditions of construction equipment

The Royal Government of Bhutan is promoting mechanization of construction in order to supplement the insufficiency of skilled and expert construction workers.

DoR and other large construction companies own some kind of construction equipment used for transportation, earth works, road works and concrete works. Among the equipment, most of vehicles and machine parts are manufactured in India, whereas most of the special vehicles (heavy vehicles) are manufactured in Japan. The equipment belonging to DoR is given preference to be used at their own works. Therefore it is difficult to hire the equipment for Japanese contractor except those machines to be procured under the Japanese Grant Aid "the Project for Improvement of Equipment for Road Construction and Maintenance".

3) Procurement plan of construction equipment

Considering the present procurement conditions mentioned above, the procurement plan of major construction equipment is shown in Table 2-2-4-9.

Table 2-2-4-9 Procurement Plan of Construction Equipment

Equipment	Capacity	Supply Source			Remarks
		Bhutan	Japan	Third Country	
Backhoe	0.8 m^3	○			Earthwork
Big Breaker	1,300 kg class	○			Earthwork
Rough-Terrain Crane	20 ton		○		Substructure, Superstructure
Vibration Roller	0.8～1.1 ton	○			Earthwork, Pavement work
Tamper	60 to 100 kg	○			Earthwork, Pavement work
Air Compressor	0.5 m^3/min.	○			Earthwork
Concrete Breaker	20 kg class	○			Earthwork
Engine Welder	250 A		○		Temporary work
Generator	20 kVA			India	Camp yard
Generator	45 kVA			India	Superstructure (launching girder)
Generator	200 kVA		○		Superstructure (cable erection)
Concrete Mixer	0.5 m^3			India	Concrete work
Water Pump	φ100 mm	○			Drainage work
bulldozer	15 ton	○			Earthwork
Wheel Loader	1.2 m^3	○			Transportation
Tire Roller	8 to20 ton	○			Earthwork, Pavement work
Road Roller	10 to12 ton	○			Earthwork, Pavement work
Road Sprinkler	10 m^3	○			Earthwork, Pavement work
Truck	8 ton	○			Earthwork, Transportation
Temporary Support	Bent		○		Superstructure
Launching Apparatus	Erection Nose		○		Superstructure
Cable Erection Apparatus			○		Superstructure

(3) Transport Plan of Materials and Construction Equipment

The place of delivery of the construction equipment and materials, which are locally procured, are usually at material production area, warehouse or regional workshop. The following is the transportation plan regarding construction equipment and materials, which are mainly supplied from overseas.

1) Customs procedure

Trading companies located in Thimphu, Phuentsholing and Kolkata, and several transportation companies engage in overseas cargoes clearance. The period of time required for customs procedure is described below:

- From India : 1 to 2 days at Phuentsholing (for custom clearance)
- From other countries : 6 to 9 days at Kolkata port (for waiting, unloading and temporary custom clearance) and, 1 to 2 days at Phuentsholing (for regular custom clearance)

2) Transportation between Kolkata and Phuentsholing

The construction equipment and materials procured from overseas excluding India will be transported from Kolkata port to Phuentsholing (754 km) by means of vehicles described below. Time required for this transportation will be 5 to 7 days.

Table 2-2-4-10 Vehicle for Transportation (Kolkata～Phuentsholing)

Vehicle type	Loading Dimension (m)			Max. Loading (t)
	length	width	height	
Tata Truck	5	2.1	2.1	13
STD Trailer	12	2.4	2.4	24
Low Bed Trailer	6	3	3	30
Special Low Bed Trailer	8	3.75	3.75	40

3) Transportation between Phuentsholing and each site

① Transportation route and time

The materials and equipment procured from overseas including India are transported to each bridge construction site through Phuentsholing. Time required to transship at Phuentsholing is 3 to 5 days.

Transportation route avoiding the area with security problem (the area near the south border) are described in the following table.

Table 2-2-4-11 Transportation Route and Period

Bridge Site	Wakleytar Bridge	Tangmachu Bridge	Sunkosh Bridge
Transportation Route	Phuentsholing → 166 km (NH 2)→ Semtoka → 65 km (NH 1) → W/Phodrang → 54 km (NH 5) → Site	Phuentsholing →166 km (Route 2) → Semtoka → 65 km (NH 1) → W/Phodrang → 133 km (NH 1) → Trongsa → 66 km (NH 1) → Jakar → 180 km (NH 1) → → 50 km (District Rd)→ Site	Phuentsholing → 166 km (Route 2) → Semtoka → 65 km (NH 1) → W/Phodrang → 72 km (NH 5) → → 2 km (District Rd)→ Site
Distance	287 km	660 km	307 km
Tata Truck	2 days	4～5 days	2～3 days
Trailer	3～4 days	7 days	3～4 days

There are dangerous points in the above-mentioned transportation route. These points are indicated in the Table 2-2-4-12 and Figure 2-2-4-1. Therefore, the following special attention shall be paid for transportation of construction materials and equipment.

- Large-scale transportation such as imported bridge members shall not be planned during rainy-season, due to increasing risk of road closure caused by slope collapse.
- Additional time is necessary to allocate for transportation in winter, due to road closure caused by clearing snow.
- The allowable loads for existing Tangmachu Bridge, Sunkosh Bridge and Namlingchu Bridge were less than 18 ton. Unloading and reloading is required when vehicles pass these bridges.

Table 2-2-4-12 Road Conditions of Transportation Routes

Spot No.	Location (km)	Existing Road condition	Countermeasures
1-1	154	Large landslide at both side of stream due to heavy rain in July 2000	Completion of temporary bridge in 2004
1-2	166	Namling : Dangerous zone for landslide	Under construction of by-pass road
1-3	192-209	Thrumshigla pass : Snow / Freeze, bad road at Mongar side	Clearing snow / Sprinkling salt
1-4	226-232	Wanthonla pass : Snow / Freeze	Clearing snow / Sprinkling salt
1-5	246-253	Sheytangla pass : Snow / Freeze	Clearing snow / Sprinkling salt
1-6	291-297	Pass : Snow / Freeze	Clearing snow / Sprinkling salt
1-7	322-330	Yutongla pass : Snow / Freeze & landslide	Clearing snow / Sprinkling salt
1-8	387-390	Pass : Snow / Freeze	Clearing snow / Sprinkling salt
1-9	420-428	Pelela pass : Snow / Freeze	By-pass road was opened
1-10	529-534	Dochula pass : Snow / Freeze	Clearing snow / Sprinkling salt
2-1	20	Sorchen : Dangerous zone for landslide	*
2-2	43	Jumja : Dangerous zone for landslide	*
	* Under construction of by-pass road at Pasakha～Monitar between Kharbandi and Gedu		
2-3	121	The highest point in national highway route 2 : Snow / Freeze	Clearing snow / Sprinkling salt
5-1	W-77	Chackey : Dangerous zone for landslide	Under design of by-pass road
5-2	W-54	Wakleytar Bridge : Load limit 18 ton	Subject to replace
D-1	2	Sunkosh Bridge : Load limit 12 ton	Subject to replace
L-1	14	Rewan : Dangerous zone for landslide	
L-2	50	Tangmachu Bridge : Load limit 8 ton	Subject to replace

Note) The location of Spot Nos. are shown in Fig. 2-2-4-1.

② Transportation vehicles and load limit

Considering the road condition of Bhutan (hairpin curves, load limits on bridges), the vehicles listed in Table 2-2-4-13 will be used for transportation.

Table 2-2-4-13 Vehicle for Transportation (Phuentsholing～Sites)

Vehicle Type	Load Dimension (m)			Load Limits (t)
	Length	Width	Height	
Tata Truck	4.2	2.1	2.1	8
Trailer (Ten Wheelers)	7	2.5	2.7	8

Note) Trailers are low bed trucks with single-axle in the front and double-axle in the rear

The maximum length of materials in the above-mentioned trailer is 9 m, due to the interrelation of length and load. In accordance with road regulation of Bhutan, the maximum loading is 8 ton, stick out length is less than 2.5 m, and stick out width is less than 1 m.

4) Transportation route and period for procurement from Japan

There are a large number of container ships sailing from the port of Japan to the port of Kolkata. However, scheduled ships are limited to about once a month. The transportation period from the factories in Japan to sites are assumed as mentioned below.

Warehouse/Factories～Nearest Port in Japan	:	7 days
Deport～Singapore Port～Chittagaon Port～Kolkata Port	:	30 days
Waiting and unloading at Kolkata Port	:	5～7 days
Temporary custom clearance at Kolkata	:	1～2 days
Inland transportation from Kolkata to Phuentsholing	:	5～7 days
Custom clearance at Phuentsholing	:	1～2 days
Loading into Trucks at Phuentsholing	:	2～3 days
Phuentsholing～Sites	:	3～7 days

Total Period: 54～65 days = 2 months

5) Estimate condition regarding transportation

In accordance with the above mentioned transportation plan, conditions for the estimation are described below.

- Transportation period for equipment and materials procured from Japan is around two months, and the period from India is three to seven days.
- Bulk transportation is allowed in India; however, only transportation with small quantities is allowed in Bhutan.
- Materials and equipment shall be divided and transported, if the total weight is beyond the allowable load on the bridge.
- Steel superstructures shall be transported for each bridge and shall not be transported in rainy-season.

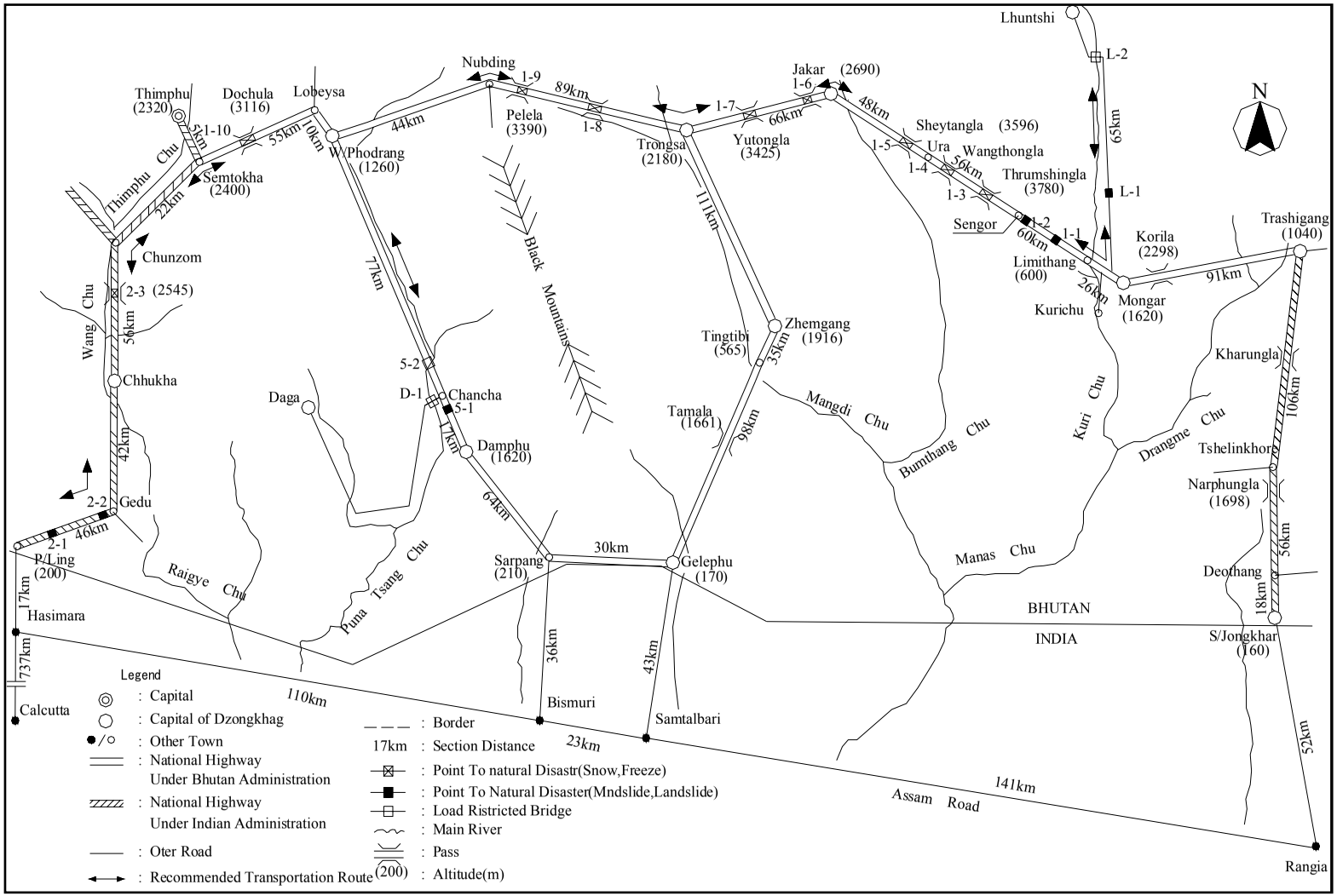


Figure 2-2-4-1 Road Condition of Transportation Route

2-2-4-7 Implementation Schedule

Implementation schedule consists of Detail Design stage, Tender Stage, and Construction/Supervision Stage.

(1) Detailed Design

The Consultant contracted with the Bhutanese Government will execute the following detailed design works:

- Detailed design for three bridges (field investigation, design calculations, preparing drawings)
- Construction cost estimate, preparing tender documents including technical specification

(2) Tender

The consultant for Bhutanese Government in Japan will perform tenders for the project. The details are as follows:

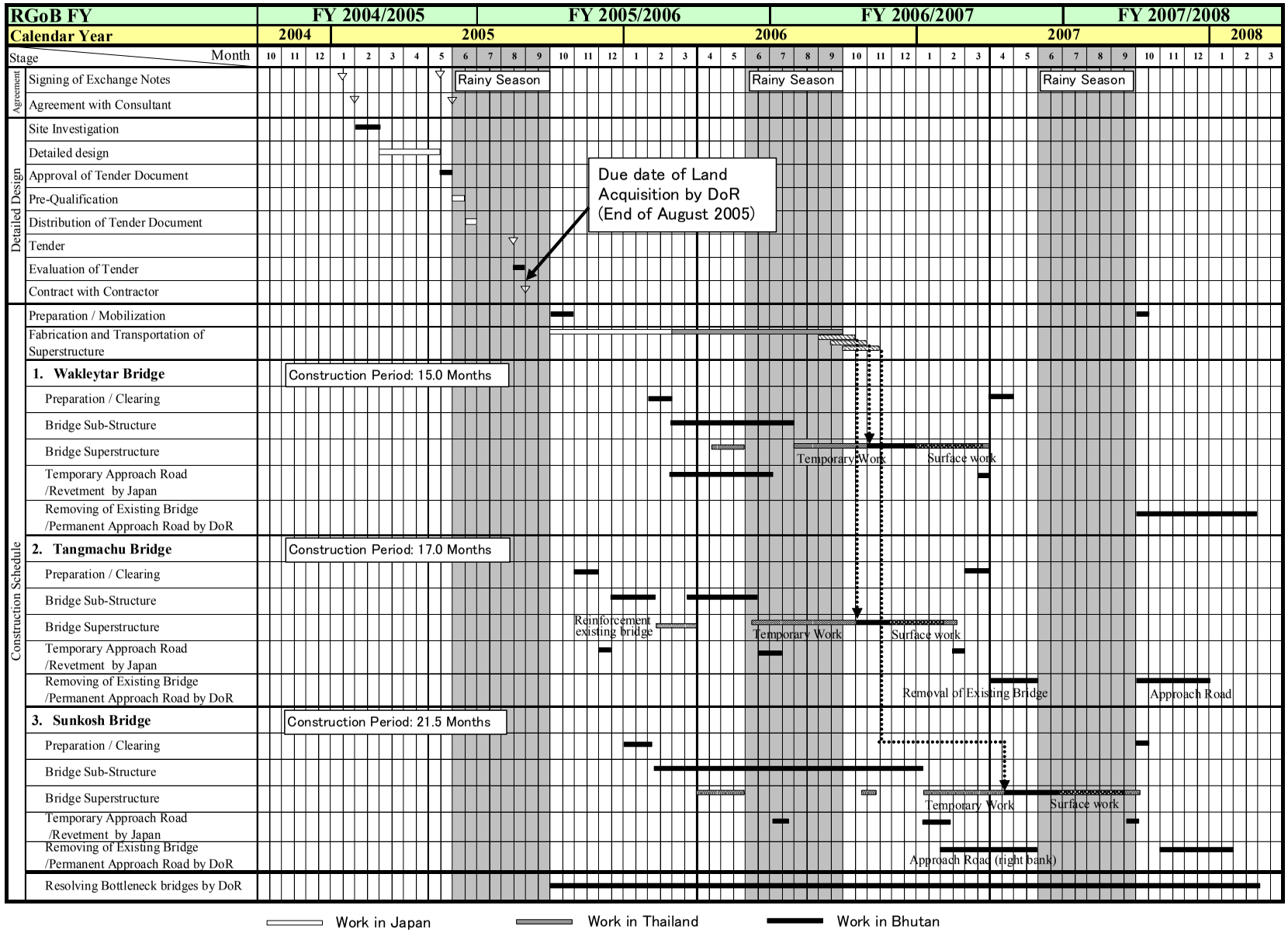
- Receipt of pre-qualification documents from contractors
- Evaluation of pre-qualification documents
- Conducting of briefing and provide question and answer session
- Receipt, opening and evaluation of tenders
- Evaluation meeting, award of contract and notification to the successful contractor

(3) Construction / Construction Supervision

The construction operation will consist of preparation of the construction sites, temporary works, bridge substructure works, bridge superstructure works, approach road works, revetment works and cleaning and clearing works. Although the construction period for each bridge varies, the total construction period will be assumed to be 25.5 months. The consultant will perform the services described in section 2-2-4-4 "Consultant Supervision" throughout the period of construction. The implementation schedule for this project is composed of the detailed design, tendering, construction / construction supervision as described below. The summarized schedule for implementation is shown in Table 2-2-4-14.

- The materials and heavy equipment are to be transported to each site, avoiding road closures caused by landslides and blockage by debris of National Highway.
- The river water level rises rapidly during the rainy seasons. Therefore, substructure and other work inside rivers shall be avoided in the rainy seasons.

Table 2-2-4-14 Project Implementation Schedule



2-3 Obligations of the Recipient Country

The following items are the obligations of the recipient country:

(1) General Matters

① To set up project Banking Arrangement (B/A).

② To advise commission of Authorization to Payment (A/P) and make payment for the commission.

(2) Implementation Matters

① To secure land necessary for the sites of the project, to compensate for resettlement, and to remove/relocate obstructions of utilities.

② To clear, level and reclaim the land, and to construct fences in and around the site prior to commencement of the construction, if necessary.

③ To secure all the expenses and prompt execution of customs clearance at the port of disembarkation for unloading products purchased under the Grant Aid.

④ To accord work permits to Japanese nationals whose services may be required in connection with supply of the products and the services under the verified contracts.

⑤ To exempt Japanese nationals from customs duties, internal taxes and other fiscal levies which may be imposed in the recipient country with respect to the supply of the products and services under the verified contracts.

⑥ To provide electricity, water supply, drainage and other incidental facilities to the vicinities of the site.

⑦ To lease the construction equipment to be procured by Japanese Grant Aid "the Project for Improvement of Equipment for Road Construction and Maintenance", with first priority.

⑧ To remove existing three bridges after completion of construction work covered by Japanese Grant Aid.

⑨ To construct permanent approach roads. To remove pavements of temporary approach roads before commencement of permanent approach road work, if

necessary. To remove temporary approach roads after the completion of the permanent approach roads.

⑩ To maintain and use properly and effectively the facilities constructed under the Grant Aid.

⑪ To bear all the expenses, other than those to be borne by the Grant Aid, necessary for construction of the facilities.

(3) Others

① To secure the budget for land acquisition, compensation and the construction works covered by the recipient country.

② To contract with a Japanese consulting firm for detailed design (D/D) and construction supervision.

③ To contract with a Japanese construction firm.

④ To implement reconstruction and reinforcement work promptly for the bottleneck bridges existing between Thimphu and the sites.

2-4 Project Operation Plan

(1) Operation and Maintenance System

After completion of the bridges, large-scale repair works will not be necessary until 20 to 30 years later if operation and maintenance methods in Table 4-1 are applied properly, unless the main structure members will be deformed and damaged by a vehicle collision. Although replacement of expansion joints will be necessary in the future depending on the damages by increasing traffic volume, re-painting which is mandatory for usual painted bridges every 10 to 20 years will not be necessary in the future since the atmospheric corrosion resistant steel (weathering steel) will be used for the superstructures of the bridges. Therefore, without establishing new administrative organization, operation and maintenance for the bridges can be carried out by the present system of Department of Road (DoR) under Ministry of Works and Human Settlement.

(2) Operation and Maintenance Method

1) Periodical inspection and maintenance

Although the main objective of this project is the construction of three bridges, the approach roads are also considered as the objectives of the operation and

maintenance. A standard schedule of periodical inspection and maintenance for the bridges is shown in Table 2-4-1.

Table 2-4-1 Schedule of Periodical Inspection and Maintenance

Facility		Maintenance and Repairing Works	Inspection Period
Bridges	Drainage pipe	Cleaning of sediments	3 months
	Expansion joint	Repair of damaged members	3 months
	Handrail	Repairing damages by traffic accidents	3 months
	Bearings	Removal of earth deposit	6 months
	RC slab and Curb	Repair of crack and stripping	1 year
	Asphalt pavement	Repair of crack and potholes	1 year
	Main structure, Floor system, Lateral bracing	Repair of damaged members	1 year
	Substructure	Repair of crack and stripping	1 year
	Revetment	Repair of scours	1 year
Roads	Road surface	Patching and smoothing	1 month
	Shoulder and Slope	Surface treatment, vegetation, additional embankment	1 month
	Sid drainage	Removal of earth deposit	1 month
	Marking	Repainting	1 month
	Guard rail	Repainting and replacement	6 months
	Retaining wall	Repair of crack and stripping	1 year

It is important to keep records (date of inspection, location of inspection, result of inspection, name of inspector) of periodic checking in the road register and to grasp the condition of damage in order to establish the repair schedule and its scale. Therefore, the periodic checking system must be established at the early stage.

2) Maintenance of asphalt pavement

The following repairing works for pavement wearing will be required once in 10 years as well as minor maintenance works (patching, leveling).

- Bridge surface : Reconstruction of pavement
- Approach road : overlay

2-5 Rough Estimated Cost for the Project

2-5-1 Project Cost Estimation

For the implementation of the project under the Grant Aid of Japan, the rough estimated cost including Bhutanese side will be about 1,364 million yen. Based on the share of the works described in section 2-2-4-3, the cost covered by the Japanese side and the cost borne by the Bhutanese side are as follows:

(1) Cost Covered by the Japanese Side

This cost estimate is provisional and will be further examined by the Government of Japan for the approval of the Grant Aid.

①	Construction of three bridges	: 1,221 million yen
	No.1 Wakleytar Bridge	: (440 million yen)
	No.2 Tangmachu Bridge	: (301 million yen)
	No.3 Sunkosh Bridge	: (480 million yen)
②	Consultant fee	: 128 million yen
	TOTAL (①+②)	: 1,349 million yen

(2) Cost Borne by the Bhutanese Side

①	Land acquisition for three bridges	: 0.65 million yen	(0.285 million Nu)
②	Leasing of land for camps and construction yards	: 0.74 million yen	(0.324 million Nu)
③	Removal of existing three bridges	: 6.84 million yen	(3.000 million Nu)
④	Construction cost for permanent approach road	: 7.04 million yen	(3.090 million Nu)
	TOTAL (①+②+③+④)	: 15.27 million yen	(6.699 million Nu)

(3) Condition of Cost Estimation

1) Exchange rate : 1US$ = 110.08 yen
1Nu = 2.28 yen

2) Implementation period : 7 months for detail design and tendering, 25.5 months for construction of three bridges as shown in Table 2-2-4-14.

3) Others : This project will be implemented in accordance with the Japanese Grant Aid system.

2-5-2 Operation and Maintenance Cost

(1) Periodic Inspection and Maintenance

The periodic inspection, and minor repairing/maintenance will be carried out under direct management of DoR. The normal annual cost for operation and maintenance is estimated as shown below.

Personnel expenses (engineer, worker):	1,000 Nu/month × 12 months × 3 bridges =	36,000 Nu
Miscellaneous materials cost :	Lump-sum (labor cost × 150%) =	54,000 Nu
Vehicle hire charge :	2,500 Nu/month × 12 months × 3 bridges=	90,000 Nu
TOTAL		180,000 Nu

(2) Maintenance of Asphalt Pavement

The maintenance of asphalt pavement will be entrusted to the local construction company and estimated cost for each bridge is as shown in Table 2-5-2-1.

Table 2-5-2-1 Maintenance Cost of Asphalt Pavement

Bridge No.	Bridge Name	Bridge Surface Area (m^2)	Road Overlay Area (m^2)	Maintenance Cost (x 1,000 Nu)
No.1	Wakleytar	516	600	346
No.2	Tangmachu	385	303	213
No.3	Sunkosh	524	682	374
TOTAL		1,425	1,585	933

CHAPTER 3

PROJECT EVALUATION AND RECOMMENDATIONS

CHAPTER 3 PROJECT EVALUATION AND RECOMMENDATIONS

3-1 Project Effect

The following benefits are expected from the implementation of the project:

Direct Benefits

- The allowable load for the Wakleytar Bridge, Tangmachu Bridge and Sunkosh Bridge will be increased to 40t, whereas present allowable load are only 18t, 8t, 12t respectively.

- As for transportation of heavy cargo such as construction equipment, the required time to cross the river will be reduced to less than one minute at the three bridge sites whereas it presently takes 2 days to dismantle and re-assemble large equipment, and 30 minutes for alighting and re-boarding for self-propelled equipment.

- Regarding heavy vehicle traffic, more than three axle trucks and trailers will be able to pass over the three bridges whereas only two axle trucks with the loading capacity less than 8t can now pass (presently, average traffic volume at the sites are 26 cars/day at Wkleytar Bridge, 9 cars/day at Tangmachu Bridge and 13 cars/day at Sunkosh Bridge).

Indirect Benefits

- Local economic activity will be promoted by permitting heavy vehicle transportation on the trunk roads, which will allow prompt shipping of agricultural and livestock products from the district and promoting the regional development plan in the district.

- Economic disparity between the districts, connected solely by the bridges which are bottlenecks, will be reduced by upgrading the bridges. This will promote economic self-reliance of the districts being connected by the more reliable roads.

- Through reconstructing of the requested bridges into permanent bridges and upgrading other bottleneck bridges on the same roads, accessibility to markets, schools and hospitals will become easier, and consequently, living standards of the people in the districts will rise.

3-2 Recommendations

The above will be more effective if the other smaller bottleneck bridges are resolved at the same time. The Bhutanese side proposed to resolve problems at these bridges at their own cost by the end of the project (March 2008) including temporary upgrading of the bottleneck bridges.

To resolve all the bottleneck bridges on the trunk roads will facilitate transportation of material, equipment and product in the country, and then, in medium to long range, it will promote economic and industrial development not only in the object districts of the requested bridges, but also in the surrounding districts. As a result, this project will correct economic disparity among all the districts and contribute to more balanced growth in the country. Therefore, the number of benefited population of this project is about 700,000 people, all the residents in this country.

In spite of these benefits, it is technically and financially difficult for the Bhutanese Government to replace the requested bridges because the bridges have long span (more than 70 m) and the Bhutanese Government has never had experience to replace temporary Bailey bridges with such long span permanent bridges. Therefore, it is appropriate to replace the request bridges under the assistance of Japanese Grant Aid.

Furthermore, in this project, construction works of approach roads are obligation of the Bhutanese side, and the works resolving other bottleneck bridges by the Bhutanese side are a condition of this project. Therefore, it is important for the Japanese side to monitor the progress for the Bhutanese side to allocate the budget for those works and to execute them properly.

APPENDICES

【Appendix 1: Member List of the Study Team】

(1) Basic Design Study Team

Assignment	Name and Authority/Firm
Leader	**Mr. Kazuhisa Arai** Chief, Living Conditions Improvement Team, Project Management Group II, Grant Aid Department, JICA
Project Coordinator	**Mr. Shigehiko Sugita** Officer, Traffic Infrastructure Team, Project Management Group II, Grant Aid Department, JICA
Chief Consultant/ Road Maintenance Planner	**Mr. Hideki Yoneyama** Pacific Consultants International
Bridge Designer I	**Mr. kobayashi Shigeru** Pacific Consultants International
Bridge Designer II	**Mr. Yukio Murakami** Pacific Consultants International
Natural Condition Surveyor I (Geography)/Environmental and Social Considerations Analyst	**Mr. Takenobu Suzuki** Pacific Consultants International
Natural Condition Surveyor II (Hydrology)	**Mr. Kenichiro Kato** Pacific Consultants International
Construction Planner/Cost Estimator	**Mr. Kazuo Mizukoshi** Pacific Consultants International

(2) Draft Report Explanation Team

Assignment	Name and Authority/Firm
Leader	**Mr. Mitsukuni Sugimoto** Resident Representative, JICA Bhutan
Chief Consultant/ Road Maintenance Planner	**Mr. Hideki Yoneyama** Pacific Consultants International
Bridge Designer I	**Mr. kobayashi Shigeru** Pacific Consultants International

【Appendix 2: Study Schedule】

(1) Basic Design Field Study

No.	Date			Officials	Consultants					
				JICA Members	Chief Consultant/ Operation and Maintenance Planner	Bridge Designer(I)	Natural Condition Surveyor I (Geography)/ Environmental and Social Consideration Analyst	Natural Condition Surveyor II (Hydrology)	Bridge Designer (II)	Construction Planner/ Cost Estimator
				ARAI Kazuhisa						
				SUGITA Shigehiko	YONEYAMA Hideki	KOBAYASHI Shigeru	SUZUKI Takenobu	KATO Kenichiro	MURAKAMI Yukio	MIZUKOSI Kazuo
1	June	17	Thu	Narita11:00 - Bangkok15:30 TG641						
2		18	Fri	Bangkok06:50 - Paro11:10, Courtesy Call to JICA, MoWHS						
3		19	Sat	Site Survey (Thimphu→Wakleytar Bridge)						
4		20	Sun	(Sunkosh Bridge→Thimpu)						
5		21	Mon	Discussion with MoWHS						
6		22	Tue	Discussion with MoWHS, Site Survey (Babaesa Highway)						
7		23	Wed	Signing on M/D, Report to JICA			Preparation of Contracts for Topo. and Geo. Survey			
8		24	Thu	Wachy Bridge	Data Collection					
9		25	Fri	Paro - Bangkok -	(Thimpu→Sunkosh Bridge)					
10		26	Sat	- Narita	Site Survey (Jakar→Tangmachu Bridge→Jakar)				Narita - Bangkok	
11		27	Sun		Discussion among Study Team at Wangdue Phodrang				Bangkok - Paro	
12		28	Mon		(Wangdue Phodrang→Jakar)					
13		29	Tue		Site Survey (Tangmachu Bridge)					
14		30	Wed		Site Survey (Jakar→Tangmachu Bridge)					
15	July	1	Thu		(Kuri→Jakar)					Narita - Bangkok
16		2	Fri		(Jakar→Thimphu)					Bangkok - Paro
17		3	Sat		Discussion with Related Agencies, Data Collection・Arrangement					
18		4	Sun		Discussion among Study Team					
19		5	Mon		Site Survey (Sunkosh Bridge)		Technical Study, Data Collection and Arrangement		Bottleneck Survey: Wangdigang Br., Ishigangchu Br.	Sunkosh Bridge
20		6	Tue		Technical Study, Data Collection and Arrangement	Bottleneck Survey: Lawakha Br., Mechikhola Br.				Wakleytar Bridge
21		7	Wed						(→Jakar)	(→Jakar)
22		8	Thu			Technical Study, Data Collection and Arrangement			(Jakar→Tangmachu)	
23		9	Fri						Site Survey (Tangmachu Bridge)	
24		10	Sat						(Kuri→Jakar)	
25		11	Sun						(Jakar→Thimpu)	
26		12	Mon		Discussion with DoR, Technical Study					
27		13	Tue							
28		14	Wed		Report to JICA					
29		15	Thu		Technical Study, Data Collection and Arrangement	Paro - Bangkok -	Technical Study, Data Collection and Arrangement	Paro - Bangkok -		Technical Study, Data Collection and Arrangement
30		16	Fri			- Narita		- Narita		
31		17	Sat							
32		18	Sun		discussion among Study Team		discussion among Study Team			discussion among Study Team
33		19	Mon		Data Collection・ Arrangement		Data Collection・ Arrangement			Data Collection・ Arrangement
34		20	Tue							
35		21	Wed							
36		22	Thu							
37		23	Fri		Discussion with DoR/ Report to JICA		Discussion with DoR/ Report to JICA			Paro - Bangkok - Study on steel bridge fabricator
38		24	Sat		Paro - Bangkok -		Paro - Bangkok -			- Bangkok-
39		25	Sun		- Narita		- Narita			- Narita

(2) Draft Report Explanation Study

No.	Date			Officials	Consultants	
				JICA Members	Chief Consultant/Operation and Maintenance Planner	Bridge Designer (I)
				SUGIMOTO Mitsukuni	YONEYAMA Hideki	KOBAYASHI Shigeru
1	Oct.	9	Sat		Narita 16:55 - Bangkok 21:25 TG677	
2		10	Sun		Bangkok 06:50 - Paro 11:10 KB121	
3		11	Mon		Courtesy Call to JICA, MoWHS, Explanation of Draft Report	
4		12	Tue		Discussion with MoWHS DoR	
5		13	Wed		Site Survey (Wakleytar Bridge, Sunkosh Bridge)	
6		14	Thu	Discussion with MoWHS		
7		15	Fri	Signing on M/D, Report to JICA		
8		16	Sat		Paro 07:00 - Bangkok 12:30 KB120, Bangkok 23:10	
9		17	Sun		Narita 07:30 TG642	

【Appendix 3: List of Parties Concerned in the Recipient Country】

List of Parties Concerned in the Recipient Country

(1) Bhutanese		
Ministry of Works & Human Settlement (MoWHS)		
Kinzang Dorji	Minister	
Tshering Dorji	Secretary	
Ministry of Works & Human Settlement (MoWHS) Department of Roads (DoR)		
Phuntsho Wangdi	Director	-
Kunzang Wangji	Superintending Engineer	Survey & Design Division
M. N. Lamichaney	Superintending Engineer	Bridge Division
Sonam K. Tshering	Executive Engineer	Road Bridge Section, Bridge Division
Karma Tenzin	Assistant Engineer	Road Bridge Section
Jigme Dorji	Executive Engineer	Field Division, Lingmethang
Sonam Dorji	Joint Director	Mechanical Division
Phuba Gyelsshen	Exectutive Engineer	Mechanical Division
Masatoshi Sasaki	JICA Expert	Bridge Division
Kazumasa Suzuki	JICA Senior Volunteer	Geo-Tech Unit, Survey & Design Division
Ministry of Trade & Industry (MTI) Department of Energy (DoE)		
Tashi Dorji	Executive Engineer	Planning & Coordination Division (PCD)
Ajay Pradhan	Computer Programmer	Hydrology Services
Kinga Sonam	Techinical Officer	Meteorology Services
Puspati Sharma	Assistant Engineer	Hydrology Section
J.B. Basnet	Assistant Scientific Officer	Hydrology Section, Hydromet Services Division
Ministry of Trade & Industry (MTI) Department of Geology and Mines		
Karma	Junior Geologist	Division of Geological Survey
National Environment Commission (NEC) Autonomous Agencies, Bhutan		
Yeshey Penjor	Environmental Assessment Officer	National Environment Commission
(2) Japanese		
Masatoshi Sasaki	JICA Expert	Bridge Division
Kazumasa Suzuki	JICA Senior Volunteer	Geo-Tech Unit, Survey & Design Division
Yuzaburo Yamaga	JICA Senior Volunteer	-

【Appendix 4: Minutes of Discussions】

(1) Basic Design Field Study (June 23, 2004)

Minutes of Discussions
on the Basic Design Study
on the Project for Reconstruction of Bridges (Phase II)
in the Kingdom of Bhutan

In response to the request from the Royal Government of Bhutan (hereinafter referred to as "Bhutan"), the Government of Japan decided to conduct a Basic Design Study on the Project for Reconstruction of Bridges (Phase II) (hereinafter referred to as "the Project") and entrusted the study to the Japan International Cooperation Agency (hereinafter referred to as "JICA").

JICA sent to Bhutan the Basic Design Study Team (hereinafter referred to as "the Team"), headed by Mr. Kazuhisa Arai, Chief, Living Conditions Improvement Team, Project Management Group II, the Grant Aid Management Department, JICA, and is scheduled to stay in the country from June 18 to July 24, 2004.

The Team held discussions with the concerned officials of the Royal Government of Bhutan. In the course of the discussions, both sides have confirmed the main items described in the attached sheets. The Team will continue to carry out further works and prepare the Basic Design Study Report.

Thimphu, June 23, 2004

新井和久

Kazuhisa Arai
Leader
Basic Design Study Team
Japan International Cooperation Agency

Phuntsho Wangdi 23/6/2004
Director
Department of Roads
Ministry of Works and Human Settlement
Royal Government of Bhutan

ATTACHMENT

1. Objective of the Project

The objective of the Project is to secure smooth traffic by the improvement / replacement of bridges on the national road or the district road to connect rural areas in the Kingdom of Bhutan.

2. Project Site

The Project site is in Tsirang, Daga, Wangdue Phodrang and Lhuntshi District, shown in Annex-1.

3. Responsible and Implementing Organizations

The responsible organization is the Ministry of Works and Human Settlement.

The implementing organization is the Department of Road.

- The organization chart of the implementing organization is shown in Annex-2.

4. Items Requested by the Royal Government of Bhutan

After discussions with the Team, requested bridges by the Bhutanese side were confirmed as below:

1. Wakleytar Bridge
2. Sunkosh Bridge
3. Tangmachu Bridge

JICA will assess the appropriateness of the request and will report to the Government of Japan.

5. Japan's Grant Aid Scheme

(1) The Bhutanese side understood the Japan's Grant Aid scheme and the necessary measures to be taken by the Royal Government of Bhutan explained by the Team as described in Annex-3.

(2) The Bhutanese side promised to take necessary measures, as described in Annex-4, for smooth implementation of the Project as a condition for the Japan's Grant Aid to be implemented.

6. Schedule of the study

(1) The consultants will continue to carry out further studies in Bhutan until July 24, 2004.

(2) JICA will prepare the draft report in English and dispatch a mission to Bhutan in order to explain its contents in October 2004.

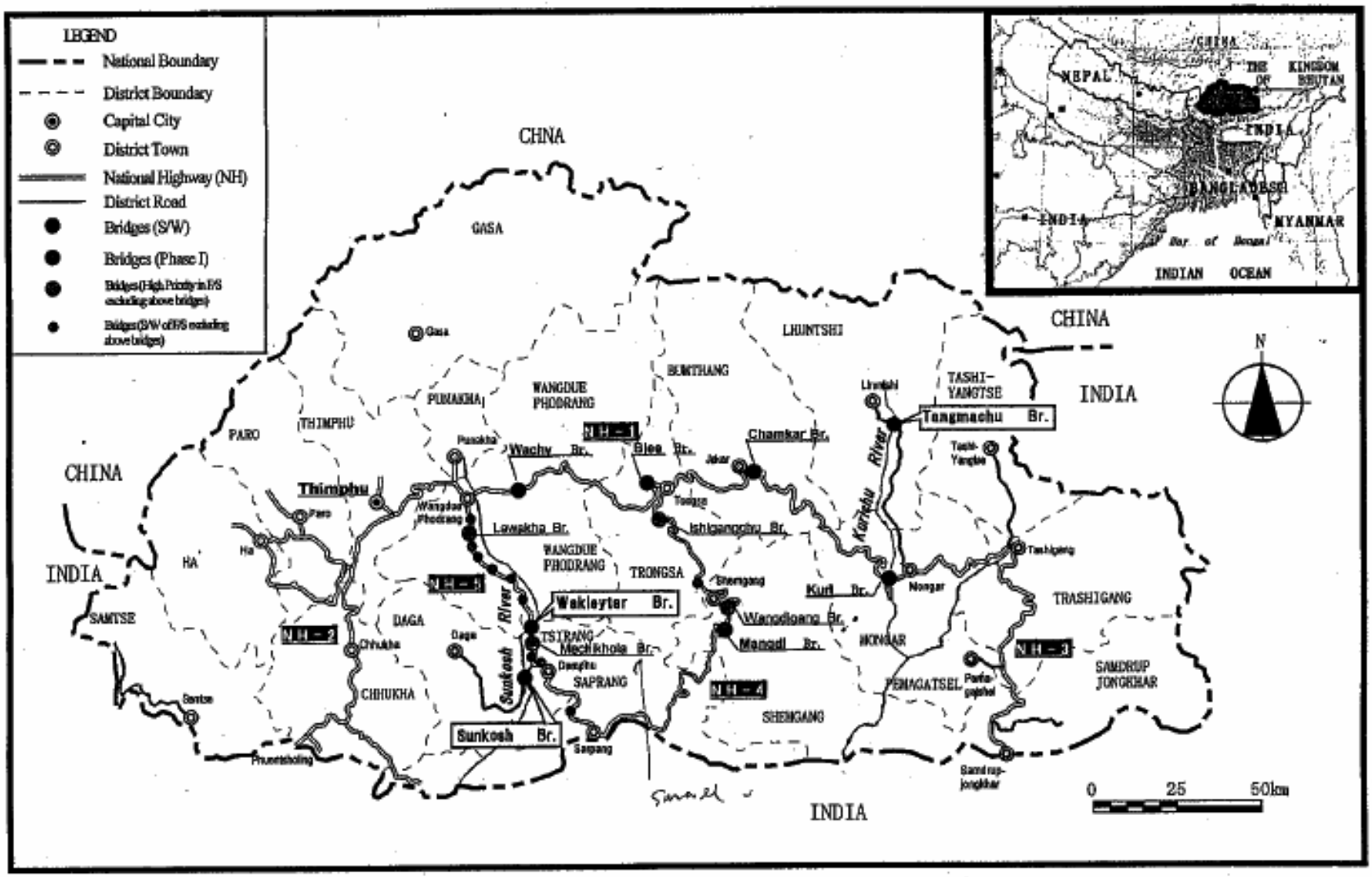
(3) In case that the contents of the report is accepted in principle by the Royal Government of Bhutan, JICA will complete the final report and send it to the Royal Government of Bhutan by January 2005.

7. Other Relevant Issues

(1) The Bhutanese side shall allocate the budget for undertakings to be done by the Bhutanese side, which were shown in Annex-4 within the financial year of 2004 to 2005.

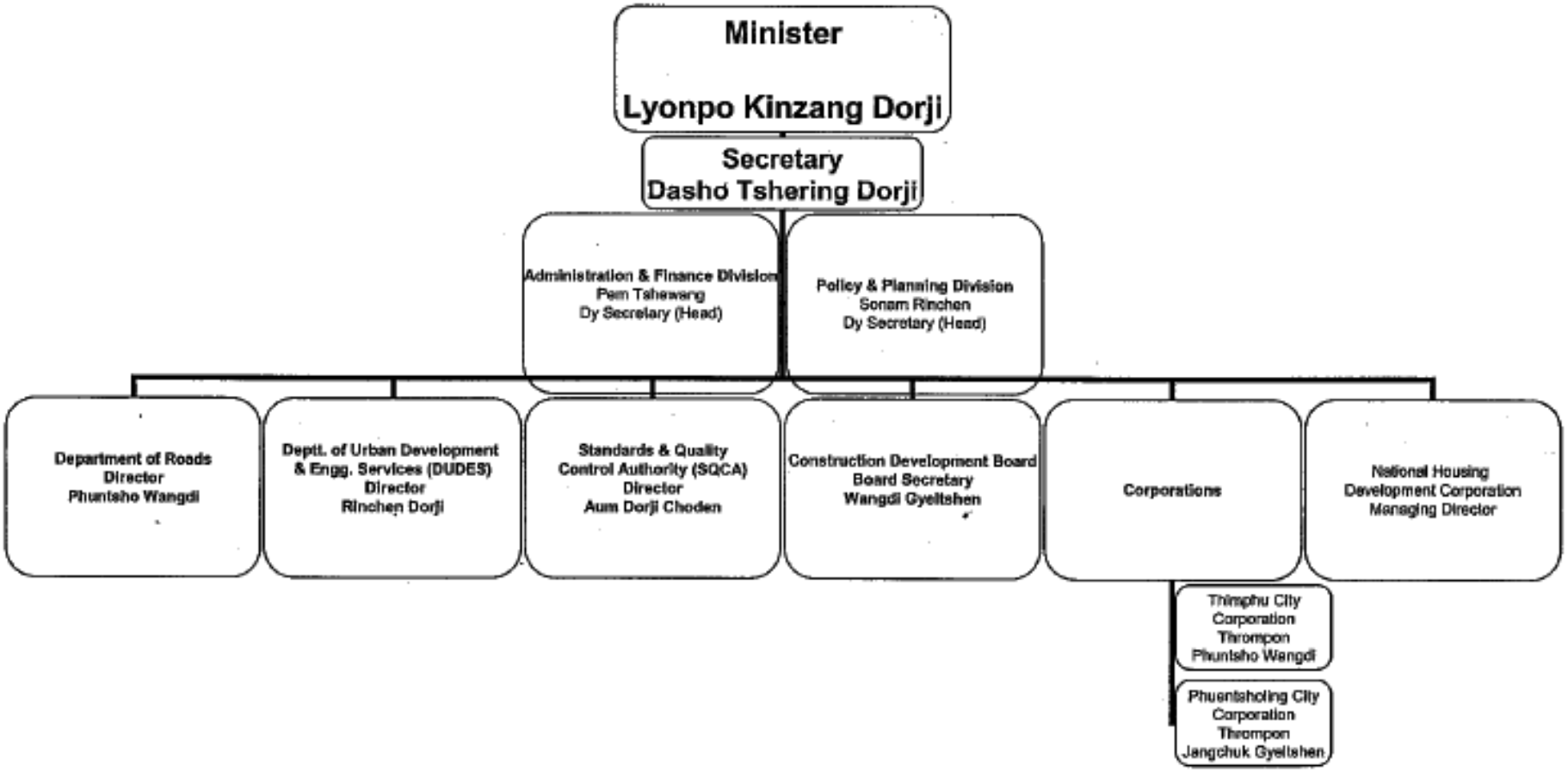
(2) The Bhutanese side understood that the applicable bridge design will be determined based on the results of further study of traffic volume, live load, river characteristics, etc.

(3) The Bhutanese side shall construct the approach roads at each bridge site at their own expense with Japanese technical assistance.
(4) The Bhutanese side shall demolish the existing bridge after completion of new bridge at their own expense.
(5) The Bhutanese side shall hire a part of equipment procured by Japan's Grant Aid under "the Project for Improvement of Equipment for Road Construction and Maintenance" for this project on priorities.
(6) The Team explained the outline of the JICA Environmental and Social Considerations Guidelines (hereinafter referred to as "the JICA Guidelines") to the Bhutanese side. The Bhutanese side took the JICA Guideline into consideration, and shall complete the necessary procedures. The Bhutanese side shall get an approval for IEE (Initial Environmental Examination) from the National Environmental Commission by the end of September 2004, and if EIA (Environmental Impact Assessment) is required, the Bhutanese side shall get an approval of either simple EIA or full EIA by the end of November 2004.
(7) The Bhutanese side shall obtain the basic agreement for the Project and relocation from the households in concerned area by September 2004.
(8) The Bhutanese side shall submit answers to the Questionnaire, which the Team handed to the Bhutanese side, by June 23, 2004.
(9) The Bhutanese side shall provide necessary number(s) of counterpart personnel to the Team during the period of their studies in Bhutan.
(10) The Bhutanese side requested the training of Department of Roads engineers in the design of bridges and the implementation of works.
(11) The Bhutanese side requested for involvement of Bhutanese contractors during implementation of works.

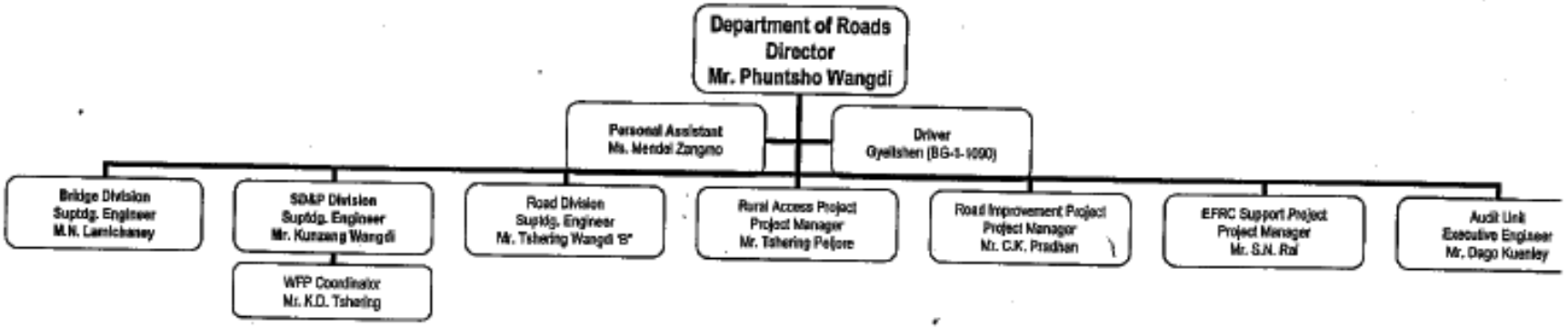


Location Map

MoWHS Organogram



DoR Organogram



JAPAN'S GRANT AID

The Grant Aid Scheme provides a recipient country with non-reimbursable funds to procure the facilities, equipment and services (engineering services and transportation of the products, etc.) for economic and social development of the country under principles in accordance with the relevant laws and regulations of Japan. The Grant Aid is not supplied through the donation of materials as such.

1. Grant Aid Procedures

Japan's Grant Aid Scheme is executed through the following procedures.

Application	(Request made by the recipient country)
Study	(Basic Design Study conducted by JICA)
Appraisal &Approval	(Appraisal by the Government of Japan and Approval by the Cabinet)
Determination of Implementation	(The Note exchanged between the Governments of Japan and recipient country)

Firstly, the application or request for a Grant Aid project submitted by a recipient country is examined by the Government of Japan (the Ministry of Foreign Affairs) to determine whether or not it is eligible for Grant Aid. If the request is deemed appropriate, the Government of Japan assigns JICA (Japan International Cooperation Agency) to conduct a study on the request.

Secondly, JICA conducts the study (Basic Design Study) using (a) Japanese consulting firm(s).

Thirdly, the Government of Japan appraises the project to see whether or not it is suitable for Japan's Grant Aid Scheme, based on the Basic Design Study report prepared by JICA, and the results are then submitted to the Cabinet for approval.

Fourthly, the project, once approved by the Cabinet, becomes official with the Exchange of Notes (E/N) signed by the Governments of Japan and the recipient country.

Finally, for the implementation of the project, JICA assists the recipient country in such matters as preparing tenders, contracts and so on.

2. Basic Design Study

(1) Contents of the study

The aim of the Basic Design Study (hereafter referred to as "the Study") conducted by JICA on a requested project (hereafter referred to as "the Project") is to provide a basic document necessary for the appraisal of the Project by the Government of Japan. The contents of the Study are as follows:

- Confirmation of the background, objectives, and benefits of the Project and also institutional capacity of agencies concerned of the recipient country necessary for the Project's implementation.
- Evaluation of the appropriateness of the Project to be implemented under the Grant Aid Scheme from a technical, social and economic point of view.
- Confirmation of items agreed on by both parties concerning the basic concept of the Project.
- Preparation of a basic design of the Project.
- Estimation of costs of the Project.

The contents of the original request are not necessarily approved in their initial form as the contents of the Grant Aid project. The Basic Design of the Project is confirmed considering the guidelines of the Japan's Grant Aid Scheme.

The Government of Japan requests the Government of the recipient country to take whatever measures are necessary to ensure its self-reliance in the implementation of the Project. Such measures must be guaranteed even though they may fall outside of the jurisdiction of the organization in the recipient country actually implementing the Project. Therefore, the implementation of the Project is confirmed by all relevant organizations of the recipient country through the Minutes of Discussions.

(2) Selection of Consultants

For smooth implementation of the Study, JICA uses (a) registered consulting firm(s). JICA selects (a) firm(s) based on proposals submitted by interested firms. The firm(s) selected carry(ies) out a Basic Design Study and write(s) a report, based upon terms of reference set by JICA. The consultant firm(s) used for the Study is (are) recommended by JICA to the recipient country to also work on the Project's implementation after the Exchange of Notes, in order to maintain technical consistency.

3. Japan's Grant Aid Scheme

(1) Exchange of Notes (E/N)

Japan's Grant Aid is extended in accordance with the Notes exchanged by the two Governments concerned, in which the objectives of the Project, period of execution, conditions and amount of the Grant Aid, etc., are confirmed.

(2) "The period of the Grant Aid" means the one fiscal year, which the Cabinet approves, the Project for. Within the fiscal year, all procedures such as exchanging of the Notes, concluding contracts with (a) consultant firm(s) and (a) contractor(s) and final payment to them must be completed. However, in case of delays in delivery, installation or construction due to unforeseen factors such as national disaster, the period of the Grant Aid can be further extended for a maximum of one fiscal year at most by mutual agreement between the two Governments.

(3) Under the Grant Aid, in principle, Japanese products and services including transport or those of the recipient country are to be purchased. When the two Governments deem it necessary, the Grant Aid may be used for the purchase of the products or services of a third country. However, the prime contractors, namely, consulting, constructing and procurement firms, are limited to "Japanese nationals". (The term "Japanese nationals" means persons of Japanese nationality or Japanese corporations controlled by persons of Japanese nationality.)

(4) Necessity of "Verification"

The Government of recipient country or its designated authority will conclude contracts denominated in Japanese yen with Japanese nationals. Those contracts shall be verified by the Government of Japan. This "Verification" is deemed necessary to secure accountability to Japanese taxpayers.

(5) Undertakings required of the Government of the Recipient Country

In the implementation of the Grant Aid Project, the recipient country is required to undertake such necessary measures as the following:

a) To secure land necessary for the sites of the Project and to clear, level and reclaim the land prior to commencement of the construction,

b) To provide facilities for the distribution of electricity, water supply and drainage and other incidental facilities in and around the sites,

c) To secure buildings prior to the procurement in case the installation of the equipment,

d) To ensure all the expenses and prompt excursion for unloading, customs clearance at the port of disembarkation and internal transportation of the products purchased under the Grant Aid,

e) To exempt Japanese nationals from customs duties, internal taxes and other fiscal levies which will be imposed in the recipient country with respect to the supply of the products and services under the Verified Contracts,

f) To accord Japanese nationals, whose services may be required in connection with the supply of the products and services under the Verified contracts, such facilities as may be necessary for their entry into the recipient country and stay therein for the performance of their work.

(6) "Proper Use"

The recipient country is required to maintain and use the facilities constructed and the equipment purchased under the Grant Aid properly and effectively and to assign staff necessary for this operation and maintenance as well as to bear all the expenses other than those covered by the Grant Aid.

(7) "Re-export"

The products purchased under the Grant Aid should not be re-exported from the recipient country.

(8) Banking Arrangements (B/A)

a) The Government of the recipient country or its designated authority should open an account in the name of the Government of the recipient country in a bank in Japan (hereinafter referred to as "the Bank"). The Government of Japan will execute the Grant Aid by making payments in Japanese yen to cover the obligations incurred by the Government of the recipient country or its designated authority under the Verified Contracts.

b) The payments will be made when payment requests are presented by the Bank to the Government of Japan under an Authorization to Pay (A/P) issued by the Government of the recipient country or its designated authority.

(9) Authorization to Pay (A/P)

The Government of the recipient country should bear an advising commission of an Authorization to Pay and payment commissions to the Bank.

(End)

Major Undertakings to be taken by Each Government

No.	Items	To be covered by Grant Aid	To be covered by Recipient Side
1	To secure land		●
2	To clear, level and reclaim the site when needed		●
3	To construct gates and fences in and around the site		●
4	To construct the parking lot	●	
5	To construct temporary roads		
	1) Within the site	●	
	2) Outside the site		●
6	To construct the buildings	●	
7	To provide facilities for the distribution of electricity, water supply, drainage and other incidental facilities		
	1) Electricity		
	a. The distributing line to the site		●
	b. The drop wiring and internal wiring within the site	●	
	c. The main circuit breaker and transformer	●	
	2) Water Supply		
	a. The city water distribution main to the site		●
	b. The supply system within the site (receiving and elevated tanks)	●	
	3) Drainage		
	a. The city drainage main (for storm, sewer and others to the site) to the site		●
	b. The drainage system (for toilet sewer, ordinary waste, storm drainage and others) within the site	●	
	4) Gas Supply		
	a. The city gas main to the site		●
	b. The gas supply system within the site	●	
	5) Telephone System		
	a. The telephone trunk line to the main distribution frame/panel (MDF) of the building		●
	b. The MDF and the extension after the frame/panel	●	
	6) Furniture and Equipment		
	a. General furniture		●
	b. Project equipment	●	
8	To bear the following commissions to the Japanese bank for banking services based upon the B/A		
	1) Advising commission of A/P		●
	2) Payment commission		●
9	To ensure unloading and customs clearance at port of disembarkation in recipient country		
	1) Marine (Air) transportation of the products from Japan to the recipient country	●	
	2) Tax exemption and custom clearance of the products at the port of disembarkation		●
	3) Internal transportation from the port of disembarkation to the project site	●	
10	To accord Japanese nationals whose service may be required in connection with the supply of the products and the services under the verified contact, such facilities as may be necessary for their entry into the recipient country and stay therein for the performance of their work.		●
11	To exempt Japanese nationals from customs duties, internal taxes and other fiscal levies which may be imposed in the recipient country with respect to the supply of the products and services under the verified contracts		●
12	To maintain and use properly and effectively the facilities constructed and equipment provided under the Grant Aid		●
13	To bear all the expenses, other than those to be borne by the Grant Aid, necessary for construction of the facilities as well as for the transportation and installation of the equipment		●

(B/A: Banking Arrangement, A/P: Authorization to Pay, N/A: Not Applicable)

(2) Draft Report Explaination Study (October 15, 2004)

Minutes of Discussions
on the Basic Design Study
on the Project for Reconstruction of Bridges (Phase II)
in the Kingdom of Bhutan
(Explanation on the Draft Report)

In June 2004, the Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched the Basic Design Study Team on the Project for Reconstruction of Bridges (Phase II) (hereinafter referred to as "the Project") to the Kingdom of Bhutan (hereinafter referred to as "Bhutan"), and through discussions, field survey and technical examination of the results in Japan, JICA prepared a draft report of the study.

In order to explain and to consult with the officials concerned of the Government of Bhutan on the components of the draft report, JICA sent to Bhutan the Basic Design Explanation Team (hereinafter referred to as "the Team"), headed by Mr. Mitsukuni Sugimoto, Resident Representative of the JICA Bhutan Office, from October 10 to 16, 2004.

In the course of the discussions, both sides confirmed the main items described in the attached sheets.

Thimphu, October 15, 2004

Mitsukuni Sugimoto
Leader
Basic Design Explanation Team
Japan International Cooperation Agency

Tshering Dorji
Secretary
Ministry of Works and Human Settlement
Royal Government of Bhutan

ATTACHMENT

1. Contents of the Draft Report

The Bhutanese side agreed and accepted in principle the contents of the Draft Report explained by the Team.

2. Japan's Grant Aid Scheme

The Bhutanese side reconfirmed the Japan's Grant Aid scheme and the necessary measures to be taken by the Royal Government of Bhutan explained by the Team as described in Annex-3 and Annex-4 of the Minutes of Discussions (M/D) signed by both sides on June 23, 2004.

3. Schedule of the Study

JICA will complete the Final Report in accordance with the confirmed items and send it to the Bhutanese side by January 2005.

4. Other Relevant Issues

(1) The Bhutanese side shall allocate the budget from the fiscal year 2005/06 onwards for undertakings to be done in a timely manner by the Bhutanese side, which were shown in Annex-4 of the M/D signed by both sides on June 23, 2004. Tentative Project Implementation Schedule is shown in Annex-3.

(2) The Bhutanese side shall make the construction machineries as shown in Annex-1 available on hire, which will be procured through the Project for Improvement of Equipment for Road Construction and Maintenance, on priority to the contractor of this Project during the implementation of the Project.

(3) The Bhutanese side shall remove the existing bridges after completion of new bridges.

(4) The Bhutanese side shall construct the approach roads at each bridge site. If removal of low cost pavement or crushed aggregate pavement, which shall be constructed by the Japanese side, is required, the Bhutanese side shall remove it.

(5) The Bhutanese side shall remove temporary roads after completion of the approach roads at each bridge site.

(6) The Bhutanese side shall replace/strengthen the small and medium scale bottleneck bridges located on the roads which lead to the target bridges of the Project to facilitate implementation of the project. The list of the bottleneck bridges and agreed measure for replacing/strengthening are shown in Annex-2.

(7) Bhutanese side requested training of two Bhutanese engineers during detailed design of bridges in Japan.

Technical Memorandum

Both parties agreed as follows;

1. Equipment to be leased by DoR

According to "ATTACHMENT 4. Other Relevant Issues (2), the construction machineries to be leased by DoR on priority to the contractor of this project are follows.

Equipment Type	Model	Hire Charge for Private (Nu/hour)	Idle Charge (Nu/hour)	Duration (Tentative)
Excavator (20ton)	KOBELCO SK 200-6E	1,575	227	Oct.2005 - Oct. 2007
Dump Truck (4x2, 8t)	ISUZU FVR33G-21	530	68	Oct.2005 - Oct. 2007
Motor Grader (130~140HP)	CASE CNH 845	1,134	175	Oct.2005 - Oct. 2007
Pay Loader (125~135HP)	KAWASAKI 65ZIV	1,029	152	Oct.2005 - Oct. 2007
Road Roller (6.5~8ton)	SAKAI SW 651	1,60	160	Oct.2005 - Oct. 2007
Fuel Tanker (6,000litr.)	ISUZU FSR33F-01	529	75	Oct.2005 - Oct. 2007
Self Loading Short Body Truck	ISUZU CXZ 81Q-01	1,814	280	Oct.2005 - Oct. 2007
Breaker Attachment for Excavator (140~150HP)	OKADA TOP 200	130	16	Oct.2005 - Oct. 2007

All machineries are subject to be procured through Japanese Grant Aid "the Project for Improvement of Equipment for Road Construction and Maintenance".

2. Bottleneck bridges to be replaced / strengthen by DoR

According to "ATTACHMENT 4.Other Relevant Issues (6), the bottleneck bridges to be replaced/strengthen by DoR are follows.

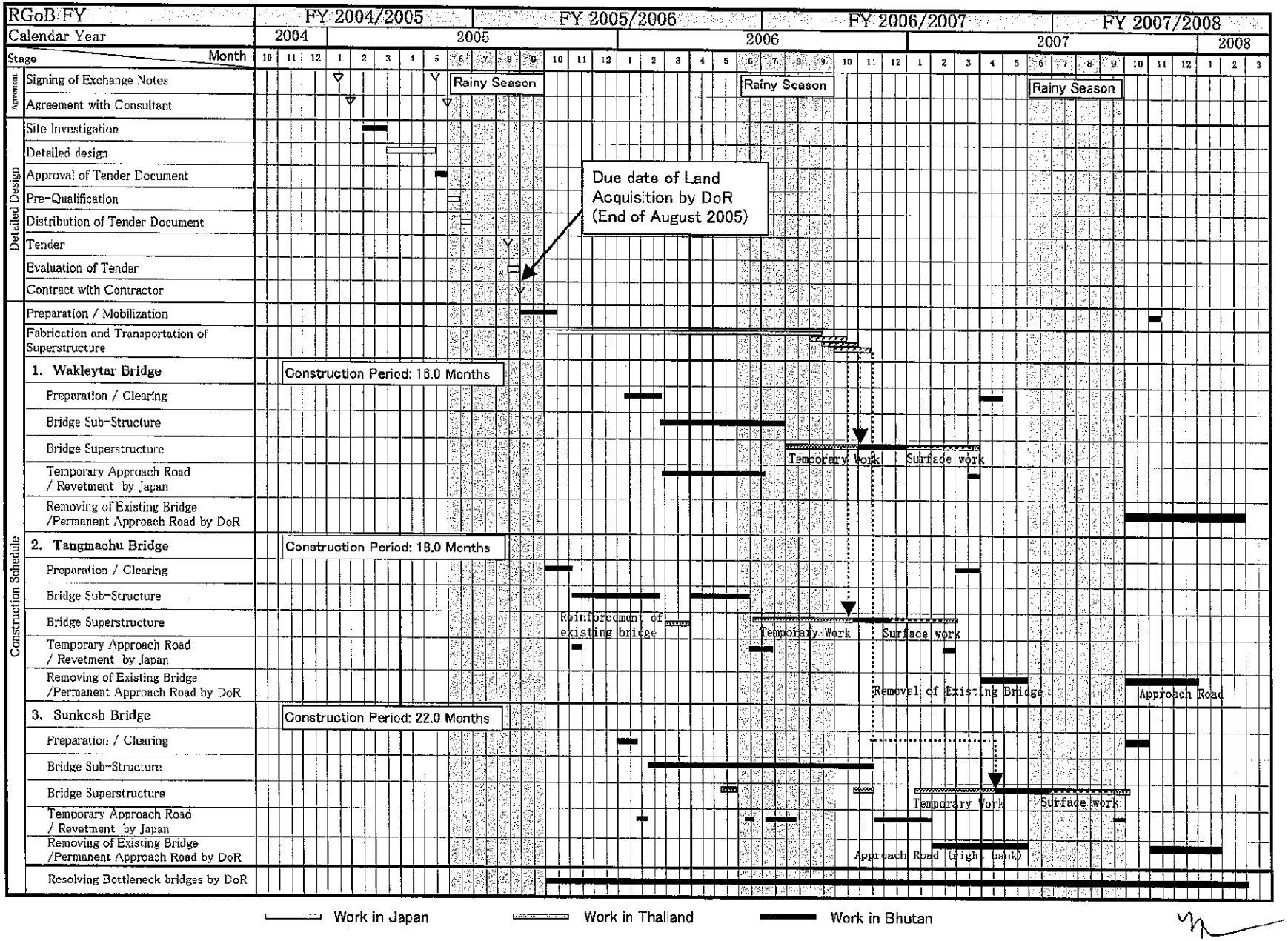
(1) Thimphu~Wangdue-Phodrang~Wakleytar Bridge~Sunkosh Bridge

SN	Bridge Name	Bridge Type	Length (m)	Allowable Load (t)	Proposal by DoR
1	Hesothangkha	Bailey	9.3	24	Budget proposal will be made in FY 2005/2006 for replacement of this bridge with a permanent RCC bridge.
2	Lawakha	Bailey	30.5	24	The bypass can be used when required to transport heavy machinery & equipment.
3	Basochu	Bailey	18.0	30	DoR will strengthen the existing bailey bridge with additional bailey bridge parts & propping during Phase 2
4	Rurichu	Bailey	15.4	30	DoR will strengthen the existing bailey bridge with additional bailey bridge parts & propping during Phase 2
5	Baychu	Bailey	15.0	24	DoR will strengthen the existing bailey bridge with additional bailey bridge parts & propping during Phase 2
6	Kamichu	Bailey	18.0	18	DoR will strengthen the existing bailey bridge with additional bailey bridge parts & propping during Phase 2
7	Nyarachu	Bailey	30.5	18	DoR will strengthen the existing bailey bridge with additional bailey bridge parts & propping during Phase 2
8	Necheychu (Mechekola)	Bailey	18.0	24	DoR will strengthen the existing bailey bridge with additional bailey bridge parts & propping during Phase 2
9	Burichu	Bailey	27.0	24	DoR will strengthen the existing bailey bridge with additional bailey bridge parts & propping during Phase 2
10	Chachey	Bailey	39.6	12	DoR will strengthen the existing bailey bridge with additional bailey bridge parts & propping during Phase 2

(2) Thimphu~Limithang~Tangmachu Bridge

SN	Bridge Name	Bridge Type	Length (m)	Allowable Load (t)	Proposal by DoR
1	No.4 Bridge	Bailey	9.0	24	Budget proposal will be made in FY 2005/2006 for replacement of this bridge with a permanent RCC bridge.
2	Rewanchu	Bailey	15.0	24	DoR proposes to replace the existing bailey bridge in FY 2005/2006. The design & drawings for a 20 mtr RCC T-beam bridge has been prepared.
3	Phawan	Bailey	9.0	24	Budget proposal will be made in FY 2006/2007 for replacement of this bridge with a permanent RCC bridge.
4	Karma Shangshong	Bailey	21.0	24	DoR will strengthen the existing bailey bridge with additional bailey bridge parts & propping in FY 2006/2007
5	Rongmanchu	Bailey	18.0	24	DoR will strengthen the existing bailey bridge with additional bailey bridge parts & propping in FY 2006/2007

Tentative Project Implementation Schedule



【Appendix 5: Cost Estimation Borne by the Recipient Country】

དཔལ་ལྡན་འབྲུག་གཞུང་། ཞབས་ཏོག་ལྷན་ལག། ལམ་སེལ་ལས་ཁང་།

ROYAL GOVERNMENT OF BHUTAN

Ministry of Works & Human Settlement

Department of Roads

Bridge Division, Road Bridge Section

DoR/BD/RBS/27.2/2004-2005/ 735 Dated: 21/9/04

To
The Project Manager
Pacific Consultant International
Tokyo: Japan

Subject: Cost estimate to be borne by Royal Government of Bhutan (RGoB)

Sir,

As desired vide your e-mail of dated 10th September 2004, we have the pleasure to submit herewith the tentative cost estimates to be borne by RGoB for the following works:

1. Acquisition of the construction site for three bridges----------Nu.0.285 million
2. Leasing of land for the camp and construction for three bridges----Nu.0.324 million
3. Removal of the existing three bridges ----------Nu.3.000 million
4. Construction of the approach roads for the three bridges----------Nu.3.090 million

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Grand Total----------Nu. 6.699 million

The above cost estimate has been prepared based on the drawings and bill of quantities supplied by your good self. We hope that this information will be quite useful during your first draft presentation to be made on 5th October at JICA, Head Office, Tokyo.

Thanking You.

Yours Faithfully

Karma Tenzin
Counterpart Engineer

Copy to:

1. The Director, DoR Thimphu for kind information please as reported to Dasho on 21st September 2004 regarding the above cost estimate.
2. The S.E (Bridges) , DoR, Thimphu for kind information please.
3. The EE (RBS) for kind information and necessary action please.

P.O. Box No. 143, Thimphu : Bhutan Tel: (+975 2) 322 086/ 321 259 Fax: (+975 2) 321 434/ 324 472
E-mail: dorbd@druknet.bt

【Appendix 6: References】

No.	Title	Year	Size	Publisher	Source
1	Preliminary Study on Southwestern Region Flood Mitigation Plan	2001	A4	Ministry of Land, Infrastructure and Transport & Infrastructure Development Institute - Japan	Masatoshi Sasaki (JICA Expert) @ DoR
2	Water Resources Management Plan and Update of the Power System Master Plan, Bhutan Volume A - Executive Summery and National Thematic Maps, Draft Final Report	2003	A4	Norconsult, Norway	Hydrology Section, Hydromet Services Division, Department of Energy Ministry of Trade & Industry, Bhutan
3	Water Resources Management Plan and Update of the Power System Master Plan, Bhutan THE 2003 - 2022 POWER SYSTEM MASTER PLAN FINAL REPORT - EXECUTIVE SUMMARY	2004	A4	Norconsult, Norway	Hydrology Section, Hydromet Services Division, Department of Energy Ministry of Trade & Industry, Bhutan
4	Water Resources Management Plan and Update of the Power System Master Plan, Bhutan THE 2003 - 2022 POWER SYSTEM MASTER PLAN FINAL REPORT - MAIN VOLUME	2004	A4	Norconsult, Norway	Hydrology Section, Hydromet Services Division, Department of Energy Ministry of Trade & Industry, Bhutan
5	Water Resources Management Plan and Update of the Power System Master Plan, Bhutan THE 2003 - 2022 POWER SYSTEM MASTER PLAN FINAL REPORT - APPENDICES	2004	A4	Norconsult, Norway	Hydrology Section, Hydromet Services Division, Department of Energy Ministry of Trade & Industry, Bhutan
6	Final Report of the GLACIER LAKE OUTBURST FLOOD (GLOF) MITIGATION PROJECT PHO CHHU - EASTERN BRANCH	2002	A4	Institute of Geology, University of Vienna, Austria & Department of Geology and Mines, Bhutan	Department of Geology and Mines, Bhutan
7	Water Resources Management Plan and Update of the Power System Master Plan, Bhutan Water Resources Management Plan - Draft Final Report, Volume D-5 Appendix D-13 Atlas of Glaciers and Glacial Lakes in Bhutan to Be Monitored (GLOF Risk Atlas)	2003	A4	Norconsult, Norway	Hydrology Section, Hydromet Services Division, Department of Energy Ministry of Trade & Industry, Bhutan
8	Water Resources Management Plan and Update of the Power System Master Plan, Bhutan WATER RESOURCES MANAGEMENT PLAN - FINAL REPORT, Volume D3 Appendix D-11: Atlas of Glaciers and Glacial Lakes in Bhutan to Be Monitored (GLOF Risk Atlas)	2003	A4	Norconsult, Norway	Hydrology Section, Hydromet Services Division, Department of Energy Ministry of Trade & Industry, Bhutan
9	Water Resources Management Plan and Update of the Power System Master Plan, Bhutan Water Resources Management Plan - Final Report, Volume C2 - River Basin II - Water Resources Characteristics and Development	2003	A4	Norconsult, Norway	Hydrology Section, Hydromet Services Division, Department of Energy Ministry of Trade & Industry, Bhutan
10	Water Resources Management Plan and Update of the Power System Master Plan, Bhutan Water Resources Management Plan - Final Report, Volume C2 - River Basin II - Water Resources Characteristics and Development	2003	A4	Norconsult, Norway	Hydrology Section, Hydromet Services Division, Department of Energy Ministry of Trade & Industry, Bhutan
11	Report of Japan-Bhutan Joint Research 1998 on the assessment of Glacier Lake Outburst Flood (GLOF) in Bhutan	1999	A4	Institute for Hydrospheric-Atomosheric Sciences, Nagoya University, Department of Geography of Tokyo Metropolitan University & Geological Survey of Bhutan	Department of Geology and Mines, Bhutan
12	Report of Japan-Bhutan Joint Research 2002 on the assessment of Glacier Lake Outburst Flood (GLOF) in Bhutan	2003	A4	Institute of Low Temperature Science of Hokkaido University, Graduate School of Environmental Studies of Nagoya University & Geological Survey of Bhutan	Department of Geology and Mines, Bhutan
13	Report of Japan-Bhutan Joint Research 2003 on the assessment of Glacier Lake Outburst Flood (GLOF) in Bhutan	2004	A4	Graduate School of Environmental Studies of Nagoya University, Graduate School of Bioscience & Biotechnology of Tokyo Institute of Technology & Geological Survey of Bhutan	Department of Geology and Mines, Bhutan

No.	Title	Year	Size	Publisher	Source
14	Inventory of Glaciers, Glacial Lakes and Glacial Lake Outburst Floods	2001	A4	International Centre for Integrated Mountain Development (ICIMOD)	Department of Geology and Mines, Bhutan
15	JICA Feasibility Study on the Development of Punatsangchhu hydropower Project in the Kingdom of Bhutan Final Report - Summary	2001	A4	Electric Power Development Co., Ltd., Japan	Hydrology Section, Hydromet Services Division, Department of Energy Ministry of Trade & Industry, Bhutan
16	Meteorology Data Book 1990-2002 Data Book Vol. 1	2000	A4	Meteorology Section, Hydromet Services Division, Department of Energy Ministry of Trade & Industry, Bhutan	Hydrology Section, Hydromet Services Division, Department of Energy Ministry of Trade & Industry, Bhutan
17	Digitized Meteorological Data	-	-	Meteorology Section, Hydromet Services Division, Department of Energy Ministry of Trade & Industry, Bhutan	Hydrology Section, Hydromet Services Division, Department of Energy Ministry of Trade & Industry, Bhutan
18	Closed Secondary River Gauging Station	-	A4	Hydrology Section, Hydromet Services Division, Department of Energy Ministry of Trade & Industry, Bhutan	Hydrology Section, Hydromet Services Division, Department of Energy Ministry of Trade & Industry, Bhutan
19	Secondary Hydrological Data Book	2003	A4	Hydrology Section, Hydromet Services Division, Department of Energy Ministry of Trade & Industry, Bhutan	Hydrology Section, Hydromet Services Division, Department of Energy Ministry of Trade & Industry, Bhutan
20	Hydrological Data Book 1991-2002	2003	A4	Hydrology Section, Hydromet Services Division, Department of Energy Ministry of Trade & Industry, Bhutan	Hydrology Section, Hydromet Services Division, Department of Energy Ministry of Trade & Industry, Bhutan
21	Digitized Hydrological Data	-	-	Hydrology Section, Hydromet Services Division, Department of Energy Ministry of Trade & Industry, Bhutan	Hydrology Section, Hydromet Services Division, Department of Energy Ministry of Trade & Industry, Bhutan
22	Digitized Sedimentation Data	-	-	Hydrology Section, Hydromet Services Division, Department of Energy Ministry of Trade & Industry, Bhutan	Hydrology Section, Hydromet Services Division, Department of Energy Ministry of Trade & Industry, Bhutan
23	Cross Section of the Rivers in Bhutan		A3	Hydrology Section, Hydromet Services Division, Department of Energy Ministry of Trade & Industry, Bhutan	Hydrology Section, Hydromet Services Division, Department of Energy Ministry of Trade & Industry, Bhutan
24	Statistical Yearbook of Bhutan 2003	2004	B5	National Statistical Bureau, Bhutan	Mr. Karma Tenzin @ DoR
25	Bhutan's National Newspaper "KUENSEL", July 3, 2004	2004	A3	KUENSEL Corporation, Bhutan	-
26	Bhutan Road Network	2003	A1	Department of Roads, Ministry of Roads, Bhutan	DoR
27	Environmental Assessment Act, 2000	2000	A4	National Environment Commission, Bhutan	Mr. Sughimoto JICA Bhutan Office
28	Layout Plan around Sunkosh Bridge	2000	A3	Department of Urban Development & Housing, Bhutan	DoR
29	The Middle Path - National Environment Strategy for Bhutan	1998	A4	National Environment Commission, Bhutan	Mr. Sughimoto JICA Bhutan Office
30	Bhutan 2020 - A Vision for Peace, Prosperity and Happiness	1999	A4	Planning Commission, Bhutan	Mr. Karma Tenzin @ DoR
31	Institutionalizing and Strengthening of the Environmental Assessment Process in Bhutan - Reference Document	1999	A4	National Environment Commission, Bhutan	Mr. Sughimoto JICA Bhutan Office
32	Environmental Assessment Process Manual	1999	A4	National Environment Commission, Bhutan	Mr. Sughimoto JICA Bhutan Office
33	Strategic Environmental Assessment - Bhutanese Environmental Assessment Sectorial Guidelines	1999	A4	National Environment Commission, Bhutan	Mr. Sughimoto JICA Bhutan Office
34	Highways and Roads - Bhutanese Environmental Assessment Sectoral Guidelines	1999	A4	National Environment Commission, Bhutan	Mr. Sughimoto JICA Bhutan Office
35	Bhutan Schedule of Rates - 2001 (Civil)	2001	A4	Standard & Quality Control Division, Ministry of Communications, Bhutan	DoR
36	Manual (March 2001), Revision	2001	A4	Construction development board, Ministry of Communications, Bhutan	DoR

No.	Title	Year	Size	Publisher	Source
37	Revised Land Compensation Rate	1996	A4	-	DoR
38	DoR Hire Rate for Construction Equipment	-	A4	-	DoR
39	DoR, Field Division Organization Chart	-	A3	-	DoR
40	DoR Budget Data	-	A4	-	DoR
41	Map of Bhutan showing approximate locations of the bridge sites	-	A4、A3	-	DoR
42	Meteorology Data Book 1990-2002 Data Book Vol. 1	2004	A4	Meteorology Section, Hydromet Services Division, Department of Energy, Ministry of Trade & Industry, Bhutan	Hydrology Section, Hydromet Services Division, Department of Energy, Ministry of Trade & Industry, Bhutan
43	Meteorology Data Book Data Book Vol. 2	2004	A4	Meteorology Section, Hydromet Services Division, Department of Energy, Ministry of Trade & Industry, Bhutan	Hydrology Section, Hydromet Services Division, Department of Energy, Ministry of Trade & Industry, Bhutan
44	Meteorology Data Book 1990-2002 Data Book Vol. 3	2004	A4	Meteorology Section, Hydromet Services Division, Department of Energy, Ministry of Trade & Industry, Bhutan	Hydrology Section, Hydromet Services Division, Department of Energy, Ministry of Trade & Industry, Bhutan
45	Hydrological Data Book 1991-2002	2003	A4	Meteorology Section, Hydromet Services Division, Department of Energy, Ministry of Trade & Industry, Bhutan	Hydrology Section, Hydromet Services Division, Department of Energy, Ministry of Trade & Industry, Bhutan
46	Secondary Hydrological Data Book	2003	A4	Meteorology Section, Hydromet Services Division, Department of Energy, Ministry of Trade & Industry, Bhutan	Hydrology Section, Hydromet Services Division, Department of Energy, Ministry of Trade & Industry, Bhutan
47	Closed Secondary River Gauging Station	-	A4	Meteorology Section, Hydromet Services Division, Department of Energy, Ministry of Trade & Industry, Bhutan	Hydrology Section, Hydromet Services Division, Department of Energy, Ministry of Trade & Industry, Bhutan
48	Sediment Data Book	2003	A4	Meteorology Section, Hydromet Services Division, Department of Energy, Ministry of Trade & Industry, Bhutan	Hydrology Section, Hydromet Services Division, Department of Energy, Ministry of Trade & Industry, Bhutan
49	Lhuentse Dzongkhang Ninth Plan [2002-2007]	2002	A4	Royal Government of Bhutan	Department of Roads, Bhutan
50	Dagana Dzongkhang Ninth Plan [2002-2007]	2002	A4	Royal Government of Bhutan	Department of Roads, Bhutan
51	Standard Formation of Roads in Bhutan	-	A4	Department of Roads, Bhutan	M.N. Lamichaney, Department of Roads, Bhutan
52	JICA Feasibility Study on the Development of Punatsangchhu hydropower Project in the Kingdom of Bhutan Final Report - Vol.1 Main Report	2001	A4	Electric Power Development Co., Ltd., Japan	Mr. Karma Tenzin @ DoR
53	Project Docutment for Road Bridge Unit & Puna Tsang Chhu Bridge Project, Phase II	1999	A4	Helvetas Bhutan	DoR
54	ADB Road Network Expansion Project in Bhutan	2004	A4	Intercontinental Consultants and Technocrats Pvt. Ltd.	DoR
55	Specifications for Building & Road Works - 2001	2001	A4	Standard & Quality Control Division, Ministry of Communications, Bhutan	DoR
56	Urban Roads Standard 2002	2002	A4	Standard & Quality Control Authority, Ministry of Works & Human Settlement, Bhutan	DoR
57	Basic Field Tests for Building & Road Works 2003, Construction Quality Series, Manual No. 3	2003	A4	National Authority for Construction Standards & Quality Control	DoR
58	Indian Standard Specification and Code of Practice for Road Bridge, Section Ⅱ Roads and Stress(1997) and Others 2	1997	A4	The Indian Roads Congress, Jamnagar House, Shahjahan Road, New Delhi-110011,1997	DoR
59	IRC, Section Ⅲ Standard Plain and Reinforced Concrete Code of Practice (Fourth Edition) 1997	1997	A3	The Indian Roads Congress, Jamnagar House, Shahjahan Road, New Delhi-110011,1997	DoR
60	Indian Standard Specification and Code of Practice for Road Bridge, Section Ⅵ Composit Construction(1997)	1991	A4	The Indian Roads Congress, Jamnagar House, Shahjahan Road, New Delhi-110011,1991	DoR
61	Indian Standard Specification and Code of Practice for Road Bridge, Section Ⅶ Foundation and Substructure(1994)	1994	A4	The Indian Roads Congress, Jamnagar House, Shahjahan Road, New Delhi-110011,1994	DoR
62	Indian Standard Specification and Code of Practice for Road Bridge, Section Ⅸ Bearings Part Ⅱ:Elastometric Bearings(1996)	1996	A4	The Indian Roads Congress, Jamnagar House, Shahjahan Road, New Delhi-110011,1996	DoR
63	Design Criteria for Prestressed Concrete Road Bridges (Post-tensioned Concrete) 1997	1994	A4	The Indian Roads Congress, Jamnagar House, Shahjahan Road, New Delhi-110011,1997	DoR
64	Public Works Department Ministry of Social Services Royal Government of Bhutan Road Design Manual	-	A4	Snowy Mountains Engineering Corporation under Asian Development Bank Technical Assistance	DoR