THE DEMOCRATIC REPUBLIC OF TIMOR-LESTE
MINISTRY OF PUBLIC WORKS

PREPARATORY SURVEY ON THE PROJECT OF RIVER TRAINING FOR THE PROTECTION OF MOLA BRIDGE IN THE DEMOCRATIC REPUBLIC OF TIMOR-LESTE

FINAL REPORT

FEBRUARY, 2013

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

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PREFACE

Japan International Cooperation Agency (JICA) decided to conduct the preparatory survey and entrust the survey to Eight-Japan Engineering Consultants Inc.

The survey team held a series of discussion with the officials concerned of the Government of Timor-Leste, and conducted a field investigation. As a result of further studies in Japan, the present report was finalized.

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

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

February, 2013

Kazunori Miura
Director General
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Summary

1. Outline of the Recipient Country

The country of Timor-Leste is an island nation with a land area of approx. 1.49 million km^2 and a population of 1,120,000 (in 2012). Since its land is mostly steep mountainous terrain and geologically consists of brittle sedimentary layers, there frequently occur natural disasters such as landslides and floods in a rainy season. Its people are 99% Christian, mostly catholic. Its national language is Portuguese, but Indonesian, Tetum and English are spoken as practical languages.

Major industries of Timor-Leste are fishery and agriculture including coffee which is the only export agricultural product. According to the 2010 statistics, 64% of the working population is engaged in these industries. In contrast to this, agricultural production accounts for only 25.6% of the GDP. Low agricultural profitability being resulting in insufficient income in the agricultural villages, it is a major factor for poverty in this country. The GDP per capita is estimated to be $896 (in 2011 World Bank) and 41% of the population is estimated to live below the poverty line.

On the other hand, an economic growth rate of Timor-Leste dropped to the sub-zero levels in 2006 because of mayhems, but quickly recovered in 2007 and has maintained a high level since 2008. Setting its ultimate goal of building a sustainable economy within the next 20 years, the government of Timor-Leste aims to (1) break away from an economic structure dependent on oil revenue and realize a diversified economy, (2) switch from a government-led economic growth to a sustainable balanced one, and (3) increase the GDP per capita to $6,000 to transition from a low-income country to a middle-income one.

Politically, Timor-Leste became independent on May 20, 2002 after an interim administrative period by the UN Transitional Administration in East Timor (UNTAET) since the mayhems in 1999 and has been building its country under reconstruction assistance by an international society. Although there were mayhems because of political reasons in 2006, presidential and general elections were held in a peaceful manner to elect its president and prime minister in 2012.

2. Background and Brief Outline of the Project

Because Timor-Leste entirely depends on land transportation in commodity distribution and passenger transportation, the most significant issue for its economic development is to develop a transportation network, centering on roads. Marine transportation is also available in some regions, but has not become a major transportation facility because the number of ports is limited. Because the steep terrain and consists of brittle sedimentary layers, the roads in Timor-Leste are frequently subjected to landslides and floods in a rainy season. As a result, the transportation network is often cut off in many places, having a serious effect on social and economic development. For this reason, in its national development project targeting the year of 2020, Timor-Leste includes among its goals maintenance of access to important national roads and continual prevention of road erosion in order to inhibit damage on social capitals. Furthermore in 2010, Timor-Leste enacted a “Strategic Development Project (SDP) 2011-2030” targeting the year of 2030. One of the SDP goals is to secure a road transportation network.

The Mola Bridge is sitting on Route A02 and located about 9 km upstream from the mouth of the Mola River. An existing steel truss bridge (bridge length of 180 m) sits on the east bank side (hereinafter referred to as the left bank side) of the river which width is about 400 m. On the west bank side (hereinafter referred to as the right bank side), there had originally been an about 220 m-long causeway, but it was destructed by annual floods, forcing local people to cross the river by traveling on the river bed. Therefore, the validity of constructing a new bridge was recognized by the Japanese Government and was plan to be implemented from 2005 to 2007. However, due to building consensus with the local people by changing crossing route of the bridge and mayhems in Timor-Leste the construction was postponed. And thereafter, an Implementation Review Study was conducted in 2007 and the construction was commenced in March 2011, and completed in June 2011.

However, the Mola River banks near the new bridge were seriously damaged by abnormal rainfall and repeated floods in 2010. About 500 m upstream from the Mola Bridge, the embankment on the right bank was eroded over an extension of about 300 m, and the mortar masonry revetment on the left bank was also destroyed. Other nearby bridges were also destroyed or had their abutments eroded, resulting in emergency restoration work by the Government of Timor-Leste. It is their concern that the existing Mola Bridge may be also damaged by repeated large-scale floods in the future as with other bridges. In response to this, the government of Timor-Leste requested for a Grant Aid to Government of Japan concerning reinforcement works of the bridge piers, abutments of existing Mola bridge and Mola River banks.

In view of this, the Government of Japan decided to conduct a preparatory survey on the assumption that protection of the revetments of the Mola River and the piers and abutments of the existing Mola Bridge will be implemented by the Grant Aid for General Products.

3. Outline of the Survey Findings and Project Contents

Responding to this decision, JICA dispatched a preparatory survey team during a period of Mar. 21 to Apr. 4, 2012. In a field survey, the requests of the Government of Timor-Leste were reconfirmed through discussions with the government officials. As a result, both sides reached an agreement that as a reasonable development scale considering utilization of the peripheral land, the revetments should be developed for the existing ground, allowing for an overflow to some extent, not as a permanent measure to inhibit a flood against every swelling of the river.

Then, after sharing the information with those concerned as to the agreements in Japan, the second field survey was conducted during a period of Apr. 27 to Jun. 10, 2012. This field survey focused on the natural conditions (terrain and geological condition), investigation of the current state of destruction and analysis of the destruction cause, records of past floods, hydrological statistics documents, and procurement circumstances of construction machines and materials. Based on the results of the survey, discussion of the specifications of the piers, abutments and revetments to be protected, the specific protection methods and construction methods, and project cost estimation were conducted in Japan. After that, the survey team was dispatched during a period of Oct. 22 to Oct. 30, 2012 to explain and confirm the components of the outline design and obligations of both countries.

Protection of the object facilities was studied so as to reduce the burden of maintenance and management, while understanding a destruction occurrence mechanism and considering the maintenance and management capacity of the Government of Timor-Leste as well as the cost and appropriate scale. Specifically, the facilities were considered to ensure safety of the facilities even in cases of erosion and swollen river beyond expectation by preventing erosion around the piers by steel sheet piles, preventing erosion around the abutments by gabions and concrete blocks, building the concrete revetments, and installing the steel sheet piles under the footing.

The following gives an outline of the project finally proposed based on the results of the above-mentioned.

Table-1 Outline of the Structure

Target	Purpose	Protected Items
Existing Pier	Protection from scouring and erosion	• Place Metal Sheet Pile around the pier • Place concrete block in front of the sheet pile

Existing Abutment	Protection from scouring and erosion	• Place Gabion around the abutment • Place concrete block on and in front of the gabion
Revetment wall	Protection from scouring and erosion	• Place concrete retaining wall (height 5.0 to 6.7 m) • Place Metal Sheet Pile under the foundation of the retaining wall • Place concrete block in front of the retaining wall
	Secure current water use	• Place stairs at the revetment (totally 4 places)
		• Place an intake at the revetment

4. Project Duration and Estimated Project Cost

The project cost is estimated to be approx. ¥1,149,000,000 (¥1,106,000,000 to be borne by the Japanese side and ¥43,000,000 by the Timor-Leste side). An entire construction work period required for this project will be approx. 31 months including detailed design, bidding, and so on (8 months for detailed design and 23 months for construction).

5. Evaluation of the Project

(1) Validity (Project Evaluation)

Following table gives the validity of the implementation of this project.

Table 2 Validity of the Implementation of This Project

Item of Evaluation	Validity
1) Populations to be Benefited	The potential areas benefitted by securing stable road traffic environment are various areas within Covalima District containing Suai city, one of the southern major cities, which accounts for 5.4% (Population 60,000) of total land area of Timor-Leste.
2) Improvement of the Livelihood of Villagers	The goals for this project are to prevent adverse effects caused by erosion of the Mora River and to secure stable road traffic environment for National Route A02, which is an extremely important community road for the villagers. Implementation of this project will allow for stabilizing the infrastructure for livelihood of villagers in Zumalai (the local government around the Mora River) as well as stable transportation of supplies to the regions west of the Mora River. In addition, this will allow for, for example, stable transportation of harvested agricultural products to their consuming region, Dili, and thus great commitment to improving and stabilizing the livelihood of local residents.

3)	Compliance with the National Development Plan	Timor-Leste has a national development plan with a target year of 2030, whose objectives include placing between Suai and Betano as a keystone for agriculture development and development of oil industries in future. This project aims to enhance the stability of the Mola bridge where sitting on the middle of these cities, and therefore will make commitment to these objectives. Also, this project has a high necessity to implement expecting to have effectiveness for the development of southern area and traffic connection between the northern areas.
4)	Compliance with Japan's Grant Aid Policy	One of the Japan's grant aid policies for Timor-Leste is "Development of Infrastructure for Economic Revitalization". Implementation of this project provides a stable traffic environment to National Route A02, thereby complying with the policy.

(2) Effectiveness

1) **Quantitative Effect**

If this project is not implemented, it is presumed that erosion of the existing bridge will progress, losing stability of the bridge by scouring and erosion resulting from approx. 5-year probable rainfall and flood, and inundating the approach road on the right bank side. Because of this, it is expected that stability of the bridge will be lost as a quantitative result, forcing the vehicles to pass in the river channel. If this is the case, an impassable period due to elevated water surface by rainfall is 60 days/year according to a survey in 2007. Accordingly, the impassable period of 60 days/year can be prevented by protecting the piers and abutments through implementation of this project.

Table-3 Quantitative Effect

Index name	Reference value (2007)	Target value (2018)
Impassable days*	60 days/year	0 day/year

※ Assumes erosion damage by 5-year probable rainfall and flood.

Note) Direct factor to reduce the impassable days to Zero depends on the new Mola Bridge constructed in 2011. This index was adopted by considering the significance of this project lies in maintaining the functions of related infrastructure, including the existing Mola Bridge connected to the new bridge.

2) **Qualitative Effect**

- The revetments will have permanent durable structure, enabling them to withstand water impacts and scours during floods and to have more stability.

- Installation of revetments with permanent durable structure will result in preventing occurrence of riverbank erosion, increasing a sense of safety in everyday life of neighboring villagers, and avoiding the absence of a traffic function of the national route caused by erosion.
- Protection of the piers and abutments of the existing bridge will prevent the collapse of substructures due to scours, improving the safety of the existing bridge.
- Costs for maintenance management of the revetment (repair and renovation) will be significantly reduced.
- The frequency of national road's closure will be reduced, increasing the stability of traffic flow. These effects will contribute to developing social economies of not only villages around the Mora River, but also the entire area of Covalima District.

Judging from these benefits, the implementation of this project is expected to have a considerable validity and high effectiveness.

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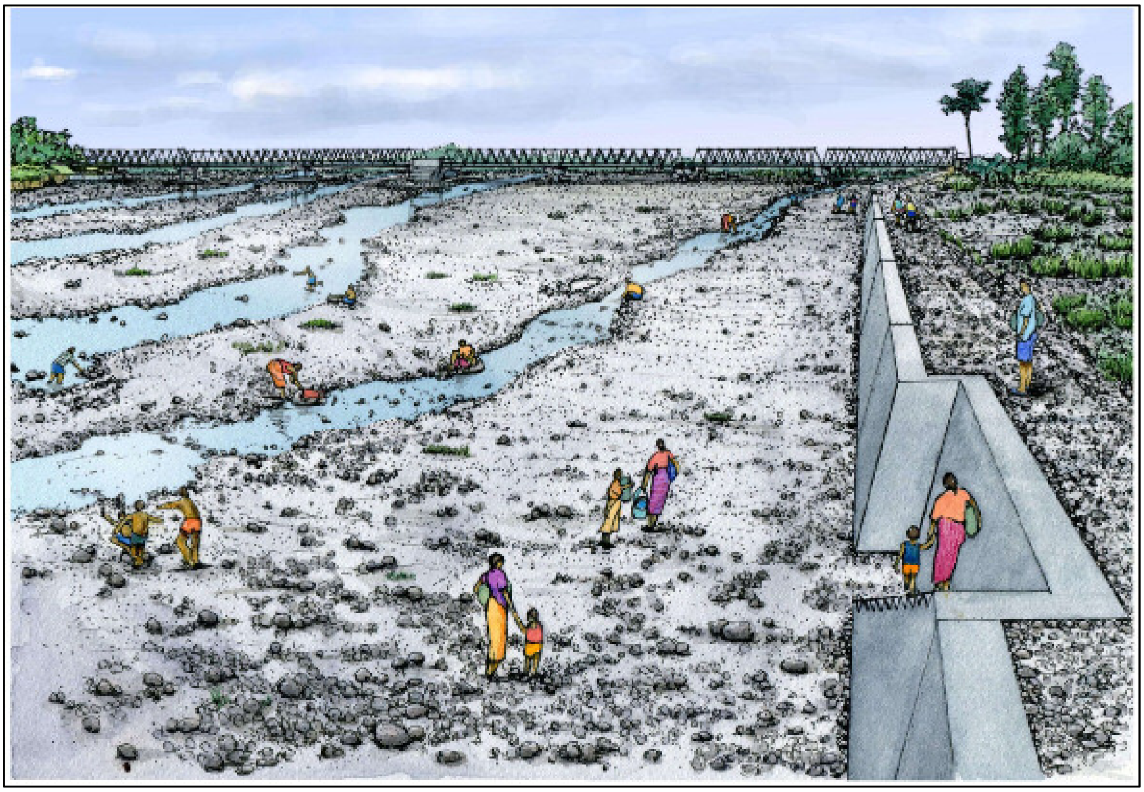

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ABBREVIATION

ALGIS	: Agriculture and Land use Geographic Information System
AIDS	: Acquired Immune Deficiency Syndrome
BGA	: Indonesian Agency for Metrology, Climatology and Geophysics
DRBFC	: Directorate for Road, Bridge and Flood Control
G/A	: General Agreement
GDP	: General Domestic Product
EIA	: Environment Impact Assessment
E/N	: Exchange of Notes
EU	: European Union
EMP	: Environment Management Plan
HIV	: Human Immunodeficiency Virus
IUCN	: International Union for Conversation of Nature
IEE	: Initial Environment Examination
JICA	: Japan International Cooperation Agency
MLIT	: Ministry of Land, Infrastructure, Transport and Tourism
MICE	: Ministry of Commerce, Industry and Environment
MOI	: Ministry of Infrastructure
MPW	: Ministry of Public Works
NDE	: National Directorate for Environment
PPP	: Purchasing Power Party
SPD	: Strategic Development Plan

Chapter 1 Background of the Project

1.1 Background of the Project

A road from Dili to Suai (about 180 km in total length) is a highway (Route A02) connecting between Dili, the capital, and Suai, a main city in a southern region serving as a stronghold for agricultural development, and a significant road as well from a viewpoint of national development program of Timor-Leste. Upon request for a Japanese Grant Aid concerning repair of the roads and bridges in the relevant section in Nov. 2002, road repair between Dili and Cassa, and bridge repair at a 60.3 km point were carried out from 2004 to 2006.

The Mola Bridge is sitting on the Route A02 located about 9 km upstream from the mouth of the Mola River. An existing steel truss bridge (bridge length of 180 m) sits on the east bank side (hereinafter referred to as the left bank side) of the river width of about 400 m. On the west bank side (hereinafter referred to as the right bank side), there had originally been an about 220 m-long causeway, but it was destructed by annual floods, forcing local people to cross the river by traveling on the river bed. Therefore, the validity of constructing a new bridge was recognized by the Japanese Government and was plan to be implemented from 2005 to 2007. However, due to building consensus with the local people by changing crossing route of the bridge and mayhems in Timor-Leste the construction was postponed. And thereafter, an Implementation Review Study was conducted in 2007 and the construction was commenced in March 2011, and completed in June 2011.

However, the Mola River banks near the new bridge were seriously damaged by abnormal rainfall and repeated floods in 2010. About 500 m upstream from the Mola Bridge, the embankment on the right bank was eroded over an extension of about 300 m, and the mortar masonry revetment on the left bank was also destroyed. Other nearby bridges were also destroyed or had their abutments eroded, resulting in emergency restoration work by the government of Timor-Leste It is their concern that the Mola Bridge may be also damaged by repeated large-scale floods in the future as with other bridges. In response to this, the government of Timor-Leste requested for a grant aid concerning reinforcement works of the bridge piers, abutments and Mola River banks. Table 1.1.1 lists the request items.

Table 1.1.1 Request Items of Requesting Government

Repair object	Damage status	Request
Bridge piers of existing Mola Bridge	Scouring exposed the concrete structure which seems to be a caisson at the base of the footing.	Protection of bridge piers
Abutments of existing Mola Bridge	Backfill soil was partly scoured.	Protection of abutments

Left-bank embankment of Mola River	Backfill soil of the mortar masonry revetment was washed out, causing settlement of the revetment itself.	Revetment embankment L=500m
Right-bank embankment of Mola River	A natural revetment was scoured (about 50 m wide, 300 m long), causing washout of houses, etc. Almost reached the road shoulder of the Route A2.	Revetment embankment L=500m

1.2 Natural Conditions

(1) Outline

Being an island country located to the southeast of the Malay Archipelago, Timor-Leste consists of the eastern half of the Timor Island located at the easternmost point of the Lesser Sunda Islands including Indonesia, Bali, etc., and the Atauro Island, Jaco Island, and an enclave, Oecussi, in West Timor (Indonesia). It faces the Savu Sea and Banda Sea in the north, and the Timor Sea in the south.

Belonging to an equatorial tropical region, the climate of Timor-Leste is clearly divided into rainy and dry seasons by the effects of monsoons. There is a difference in the rainy season and annual precipitation between the north and south sides of the Timor Island. In the northern region including Dili, the rainy season lasts 5 months from December to April and an annual average precipitation is 960 mm in Dili. In the southern region where Covalima District, an object area of this investigation, is located, the rainy season lasts 7 months from December to June and an annual average precipitation in a river basin at a Mola River crossing point (Moro Bridge) is 1,250 mm to 2,250 mm, which is higher than Dili in the northern region. In mountainous areas, serious soil erosion is caused in the rainy season.

(2) Temperature

For a temperature difference between the northern region where Dili is located, and the southern region where the object area of the investigation is located, the temperature in the northern region is about 2 to 3°C higher on the average throughout the year.

The lowest temperature in the object area of the investigation is about 22°C on the annual average; it drops to the coolest level of 20°C or less in several months during the dry season. The highest temperature is around 31 to 32°C throughout the year except a couple of months in the beginning of the dry season, reaching the hottest level of 33 to 34°C or more around December in the beginning of the rainy season. The daily average temperature is about 26°C on the annual average and tends to be higher around December in the beginning of the rainy season. A monthly temperature difference is 2 to 3°C throughout the year, which is not considerable. Table 1.2.1 lists the data at the Suai Observation Station which is the closest observation station to the object area of the investigation.

Table 1.2.1 Temperature Observation Data at Suai Observation Station

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual average
Average lowest	23.75	23.91	22.58	22.85	22.35	-	19.46	19.70	20.45	22.47	23.75	24.29	(22.32)
Average highest	34.11	33.67	32.04	32.46	30.80	-	29.34	30.02	31.53	32.34	33.67	33.59	(32.14)
Average temp.	28.00	28.01	26.46	27.52	25.85	-	24.01	24.68	26.02	27.42	28.52	28.14	(26.78)

(Note 1) Recording period: 2008 to 2011

(Note 2) Annual average: Average of 11 months except June

Table 1.2.2 Month Precipitation Record in Dili, Ainaro, Betano, Suai and Fohorem

Observation station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual total
Dili	110.3	156.8	141.5	128.1	62.6	29.7	21.8	8.2	8.7	30.6	87.9	170.8	957.0
Ainaro	2178.0	2008.8	3445.2	1766.4	2626.8	287.1	94.8	844.8	-	-	2442.0	3033.6	-
Betano	177.9	102.6	152.8	130.5	208.7	81.5	65.1	54.7	6.1	31.2	41.7	172.8	1225.6
Suai	998.4	838.0	1101.6	338.4	1303.2	-	203.4	139.2	17.2	245.4	404.8	1109.6	6699.2
Fohorem	170.8	192.3	182.1	191.3	318.8	55.2	174.7	73.2	98.7	110.3	224.0	352.4	2143.7

(Note 1) Recording period: Betano (2004 to 2011), Suai (2008 to 2011), Fohorem (2008 to 2011)

(Note 2) Annual total: Total of 11 months except June

(3) Precipitations and number of rainy days

Table 1.2.2 (previous page) lists monthly precipitations at each observation station.

When Betano located on the east side of the Mola River basin is compared with Suai and Fohorem located on the west side based on the monthly precipitation record, it is clearly indicated that Suai and Fohorem on the west side have higher precipitations throughout the year. When Suai and Fohorem are compared, Fohorem located closer to the mountains than Suai has more rain during the dry season.

In order to grasp the number of monthly rainy days, Table 1.2.3 lists the results of tallying the number of days having a daily precipitation of 0 mm or more and that having 10 mm or more at the Suai and Betano Observation Stations located on the east and west sides of the Mola Bridge.

At the respective observation stations, the annual ratio of the number of rainy days with 0 mm or more is 33.6% at Betano and 47.1% at Suai, and that for 10 mm or more is 10.7% and 20.3%, respectively. There is an annual difference of about 10 to 14% (35 to 50 days) in the number of rainy days between the eastern Betano area and western Suai area.

There is no supporting observation record, but it has been confirmed in hearings that there had been more than a few cases of sudden heavy rain which caused a rise of the river at the end of the rainy season and during the dry season in the immediate upstream area of the Mola Bridge in the past. Accordingly, it is necessary to carefully consider the measures in construction work to be carried out within the range of the river.

Table 1.2.3 Number of Monthly Rainy Days at Suai and Betano Observation Stations.

For daily precipitation of over 0.0 mm:

Observation station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual total
Betano	17	14	13	12	15	10	12	6	2	4	5	14	123
Suai	19	17	19	19	22	-	17	14	8	6	11	20	(172)

For daily precipitation of over 10.0 mm:

Observation station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual total
Betano	6	4	4	5	6	3	2	1	0	1	2	5	39
Suai	11	10	11	2	11	-	4	3	0	3	7	12	(74)

(Note 1) Recording period: Betano (2004 to 2011), Suai (2008 to 2011)

(Note 2) Annual total: Total of 11 months except June

1.3 Environment Impact Assessment (EIA)

1.3.1 EIA act in Timor-Leste

In Timor-Leste a new EIA act was enforced in Feb. 2011 and administrative instructions are being drawn up. This investigation confirms a schedule for classifying the categories associated with environmental impact assessment and acquiring an environmental license, and understands the current situations of natural and social environments of the project site and its surrounding areas, thereby supporting the MPW (Ministry of Public Works) [1]prepare the IEE (Initial Environment Examination) and EMP (Environment Management Plan).

1.3.2 Environment and Social Conditions

In order to confirm the environmental considerations in the project implementation phase, basic environmental and social conditions were grasped by a field investigation.

(1) Social Environment

a. Population

The total population in East Timor was approx1.12 million in 2012 and increased by 15.5% from that in 2004. The population change in Covalima where surveyed area is located is given in Table 1.3.1.In the surveyed area, there are about 40 households along Route A02. Multiplied by 5.8, the average population per household in East Timor, the population of the surveyed area is expected to be about 230.

[1] MOI has changed its name and organization to MPW (Ministry of Public Works) in the 5th Constitutional Cabinet.

Table 1.3.1 Population change in Covalima where surveyed area is located

District	Population	
	2004	2010
Covalima	53,063	60,063

Reference: http://timor-leste.gov.tl/

b. Land Use

In the surveyed area, most of the currently used land is occupied by the Mola River bed. The bank of Mola River has an existing protection and a village is located along Route A02 about 100m from the right-side levee. On the left side of the river in the surveyed area, there is the former camp yard used for the construction of Mola Bridge (built in 2011). There is also an old road on the right side of the river connecting Route A02 and the river bed. Small cultivated land is distributed on the both sides of the old road.

c. Owning Land

As a result of hearing to Ministry of Justice, representative of the local community and Maliana Office of MPW which was in charge of the construction of the current Mola Bridge and bank protection, it was confirmed that the river bed where the bridge footing and existing bank protection were located was all owned by the government. Although the former camp yard used for the construction of Mola Bridge (built in 2011) was owned by a private party, it was confirmed that the yard could be borrowed at no charge as done for the bridge construction.

d. Use of Water

As a result of the local survey, the major water utilization facilities in the surveyed area are the followings. These facilities use the surface stream water of Mola River as water resource and no water supply facility in the surveyed area uses underground water as water source. The outline of the water use is shown in Fig. 1.3.1.

- ✓ (Right bank) Simple water intake facility located 450m upstream from Mola Bridge (See Photo-④.)

  This is agricultural irrigation on the upstream side, but this water intake facility is not always used but only used as secondary facility. Water is corrected through a corrugated pipe of D1000mm, which penetrates the bank protection, and transferred to the downstream through an unlined channel behind the bank protection.
- ✓ Stairs on the bank protection on the right side (See Photo-⑤.)

  The top of the bank protection and the river bottom has a height difference of 2.5m. For the local residents to easily go to the river for collecting water, bathing and washing, there are two steep stairs (50-70cm wide) along the slope of the bank protection.

- ✓ (Right bank) Water intake facility located 720m upstream from Mola Bridge (See Photo-⑥.)

  This gate-type water intake facility was built in 1956 (Indonesia era). The facility cannot be used now due to the decline of the river bottom and the fall of a rock dam. Around the water intake, there remains a bank protection made of rocks, which was built when the water intake facility was constructed.

- ✓ (Right bank) Effluent outlet located 630m upstream from Mola Bridge (See Photo-⑦.)

  This is an effluent water channel located downstream from the water intake of the above ⑧. There remains a bank protection made of rocks in front.

- ✓ (Left bank) Water intake facility located 550m upstream from Mola Bridge (See Photo-⑨.)

  For water intake, a mound is made on the river to extract the river water. The water taken from the river is sent to the left and right channels used respectively for agriculture and household.

- ✓ (Left bank) Water channel located 450m upstream from Mola Bridge (See Photo-⑧.)

  This is a water channel for the water taken from the river in the above ⑩. It was located too close to the river and destroyed by the riverbank erosion. It was a rectangular water channel made of piled-up stones and mortar with the surface finished with mortar.

- ✓ (Left bank) Water intake facility located 400m downstream from Mola Bridge (See Photo-⑫.)

  For water intake, a mound is made on the river to extract the river water. The water taken from the river is sent to the downstream through an unlined channel to be used for agriculture and household.

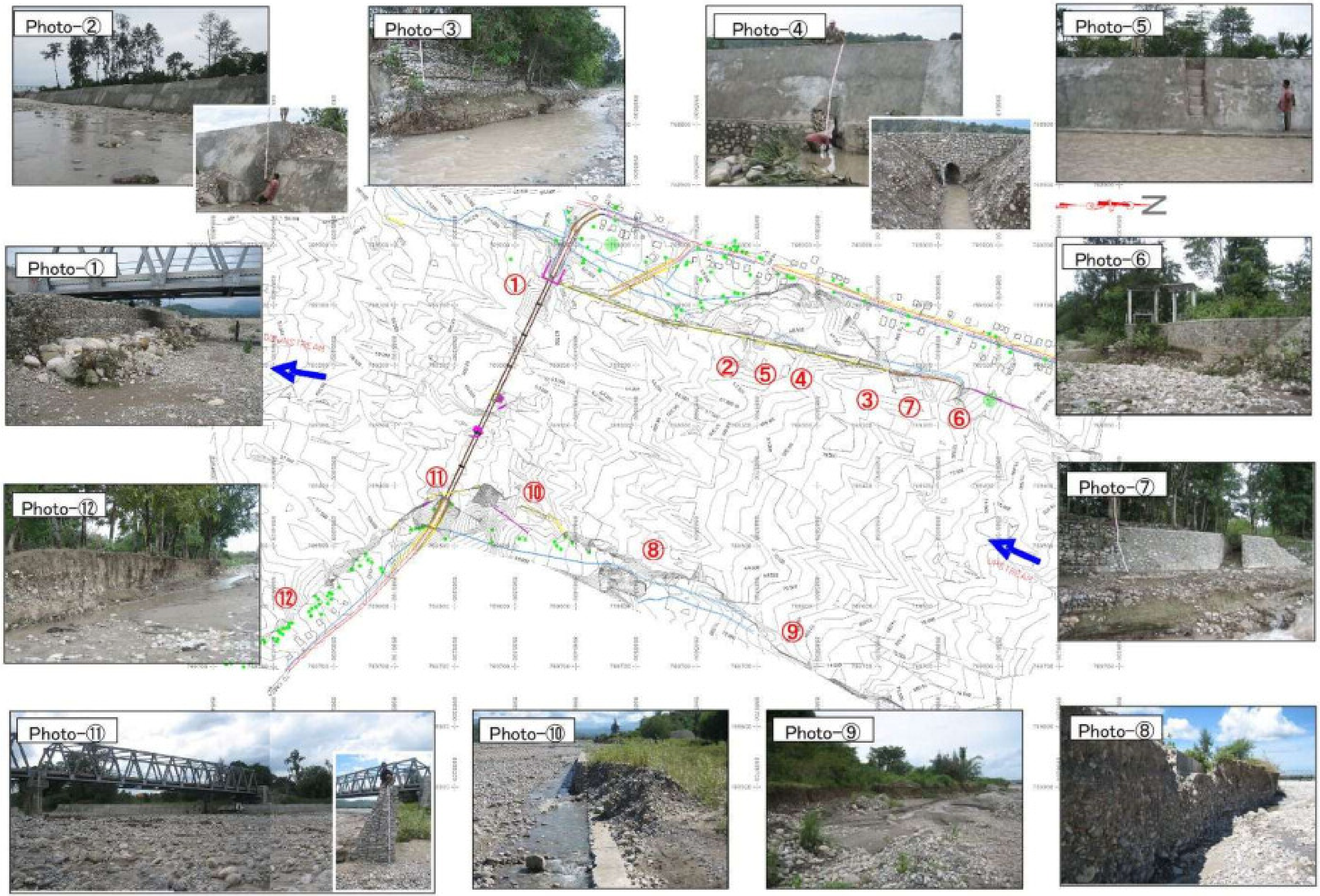


Fig. 1.3.1 Water utilization facilities at and around the project site

e. Minority race and Culture

East Timor has 17 languages of different origins and cultural exchanges among the races are closely related to these languages. As a result of hearing to local residents in the survey, no minority race was found in the surveyed area.

f. Education and Medical care

The literacy rate in East Timor is 50-60%. The literacy rate of youth is relatively high and in particular that of the age 15-24 exceeds 70%. The registration ratio of children in primary education is 60-70% in the period from 1999 to 2007 and the ratio of children in farming areas is a little lower than that of children in cities. With Basic Education Law established in 2008, children of the 17 or under can be educated at no charge.

The infant death rate in East Timor is about 10 % and the population ratio of qualified doctors per 1,000 people is less than 1. According to Ministry of Health, the population of HIV infected persons is kept low. The survey researches in 2004 and 2007 by WHO showed that the HIV infected persons occupied less than 1% of the total population. The local survey found no school or hospital in the surveyed area.

g. Cultural Asset

No cultural asset list is released in East Timor.

The local survey found no particular cultural building in the surveyed area. According to hearing to Ministry of Public Works, no particular cultural asset was found at the construction of Mola Bridge and bank protection.

h. Scenery

The current scenery in the surveyed area is made by the bed and water of Mola River, architectures such as Mola Bridge and existing bank protection, the village near Route A02, farming land and grass field behind the levee, and forest. However, the local survey found no facilities for viewing the scenery in the surveyed area.

(2) Natural Environment Condition

a. Climate and Whether

Refer to “1-2 Natural Condition”.

b. Topography and Geography

Refer to “2-2-2-2 Topographical and Geological Surveys”.

c. Wind speed

Table 1.3.2 gives the annual average wind speed in Suai and Benato. According the record, monthly average speed is around 1m/s. Annual average speed comes 1.15 m/s in Suiai and 1.02 m/s in Benato.

Table 1.3.2 Average Wind Speed at Suai and Betano Observation Stations

(m/s)

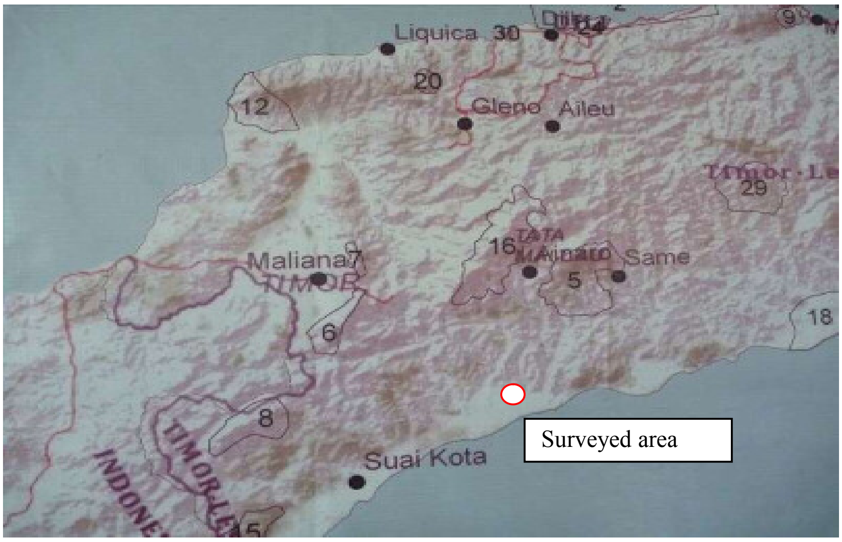
Observation station	Jan	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
Betano	1.00	0.95	0.99	0.99	1.00	1.08	1.02	1.00	1.03	1.02	1.09	1.02	1.02
Suai	0.85	2.30	1.03	1.26	0.85	0.93	0.92	1.16	1.17	1.19	1.23	0.97	1.15

(Note 1) Recording period: Betano (2008 to 2011), Suai (2008 to 2009)

d. Protected Area

East Timor currently has 30 natural reserves. The following Fig. 1.3.2 shows the distribution of the natural reserves on the west part of East Timor where the surveyed area is located. The natural reserves closest to the surveyed area are Mount of Cablaque and Lake of Welenas (5 in the figure) and Mount Tatamailau and Talobu/Laumeta (16 in the figure), which are both more than 30km distant from the surveyed area.

According to hearing to Ministry of Agriculture, it was currently examining additional protected areas in East Timor but not in the surveyed area.



Reference: PROTECTED AREAS MAP (11/2/11)

Fig 1.3.2 Distribution of natural reserves in the west part of East Timor

e. **Vegetation**

Most of the surveyed area is covered by the river bed of Mola River. Land around the river is mostly used by people as farming land, village, and former camp yard used for the construction of Mola Bridge (built in 2011). There is vegetation between the river and the village on the right side of the river. However this vegetation is quite small and a large mountain forest is located on the left side of the river 1km upstream from the surveyed area.

The plant distribution in the surveyed area was observed in the survey and almost no vegetation was found near the abutment and footing of Mola Bridge and the existing bank protection. Only pioneer grass plants, which could be found from place to place in the surveyed area, were sparsely distributed around the bridge.

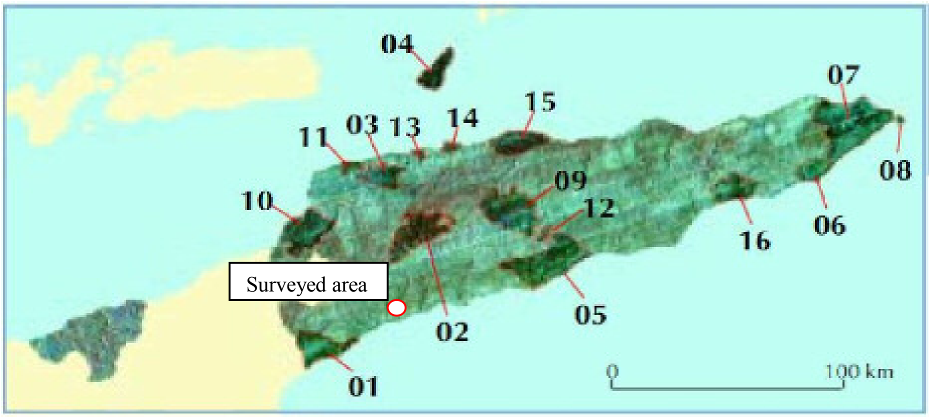
According to the hearing to Ministry of Agriculture, there is no rare vegetation reported around Mola Bridge.

f. Wild life and ecological system

Many rare species of birds listed in the International Union for Conservation of Nature (IUCN) Red List inhabit in East Timor and 15 important bird areas have been identified. These areas are shown in Fig. 1.3.3.

The bird areas closest to the surveyed area are Tilomar (01 in the figure), where Wetar Ground-dove and Pink-headed Imperial-pigeon inhabit, and Tata Mailau (02 in the figure), where Timor Imperial-pigeon and Olive-shouldered Parrot inhabit. These areas are both located more than 30km from the surveyed area and contain primeval forest and wetland.

The local survey found no primeval forest or wetland with wild animals and diversified ecological system within the surveyed area. According to the hearing to Ministry of Agriculture, the presence of rare animals around Mola Bridge was not specifically reported.



Source：IMPORTANT BIRD AREAS IN TIMOR-LESTE Key sites for conservation (BirdLife International)

Fig. 1.3.3 Location of Important Bird Areas in Timor-Leste

(3) Environment Pollution

a. Air

East Timor has no regulation standard for the air. No measurement of air contaminant is routinely conducted. As a result of hearing to local residents in the survey, the construction of Mola Bridge caused no particular air quality problem. The survey showed that there was no air contamination source in the surveyed area except Route A02 and that the air quality in the village seemed to be in a relatively good condition.

b. Water

East Timor has no regulation standard for water quality. No measurement of water quality is routinely conducted. As a result of hearing to local residents in the survey, the construction of Mola Bridge caused no particular water quality problem.

The survey showed that there was no water contamination source in the surveyed area except Route A02 and that the water quality of Mola River seemed to be in a relatively good condition except when the water sometimes became cloudy by rain.

c. Noise, Vibration

East Timor has no regulation standard for noise or vibration. No measurement of noise and vibration is routinely conducted. As a result of hearing to local residents in the survey, the noise or vibration due to the Mola Bridge construction caused no problem.

The current noise and vibration was measured in the survey. The measurement point in a village in the surveyed area close to the project site is shown in Fig. 1.3.4 and the measurement results in Table 1.3.3.

The noise level sometimes exceeded 60dB (A) when automobiles passed on Route A02 but the average level was 53dB (A), lower than the reference standard 55dB (A). The maximum and average vibration levels were both below 30dB, lower than the level 55dB above which ordinary people would feel vibration.

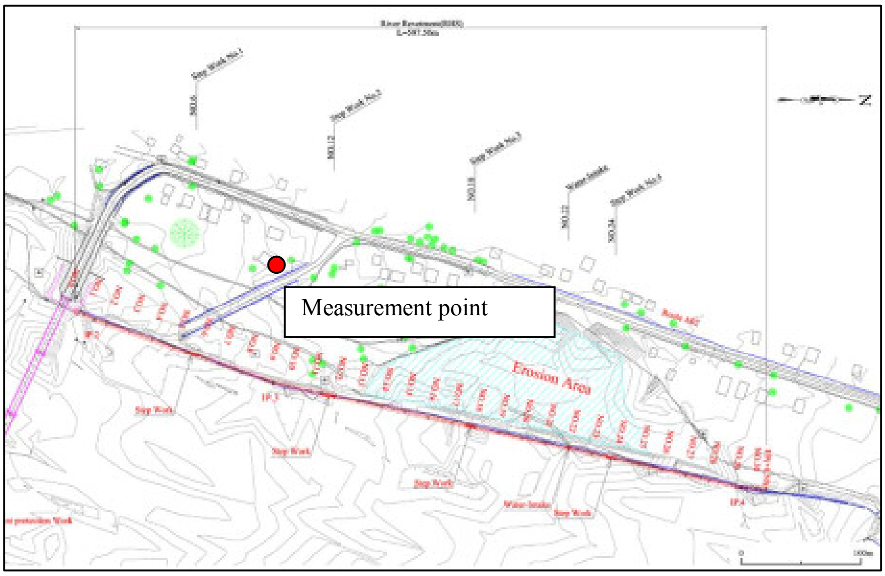


Fig. 1.3.4 Measurement point of noise and vibration

Table 1.3.3 Noise and Vibration Values in Surrounding Villages of Project Site

Item	Measurement date	Measurement device	Measurement period	Measurement result		Reference standard
				Average	Max	
Noise level	5/17/2012 (Daytime)	Noise meter NL21 (Rion)	10 minutes (3 times)	53 dB(A) [LAeq]	61 dB(A) [L_5]	55 dB(A)※
Vibration level		Vibration meter VM-53A (Rion)		< 30 dB [L_{50}]	< 30 dB [L_{10}]	55 dB※※

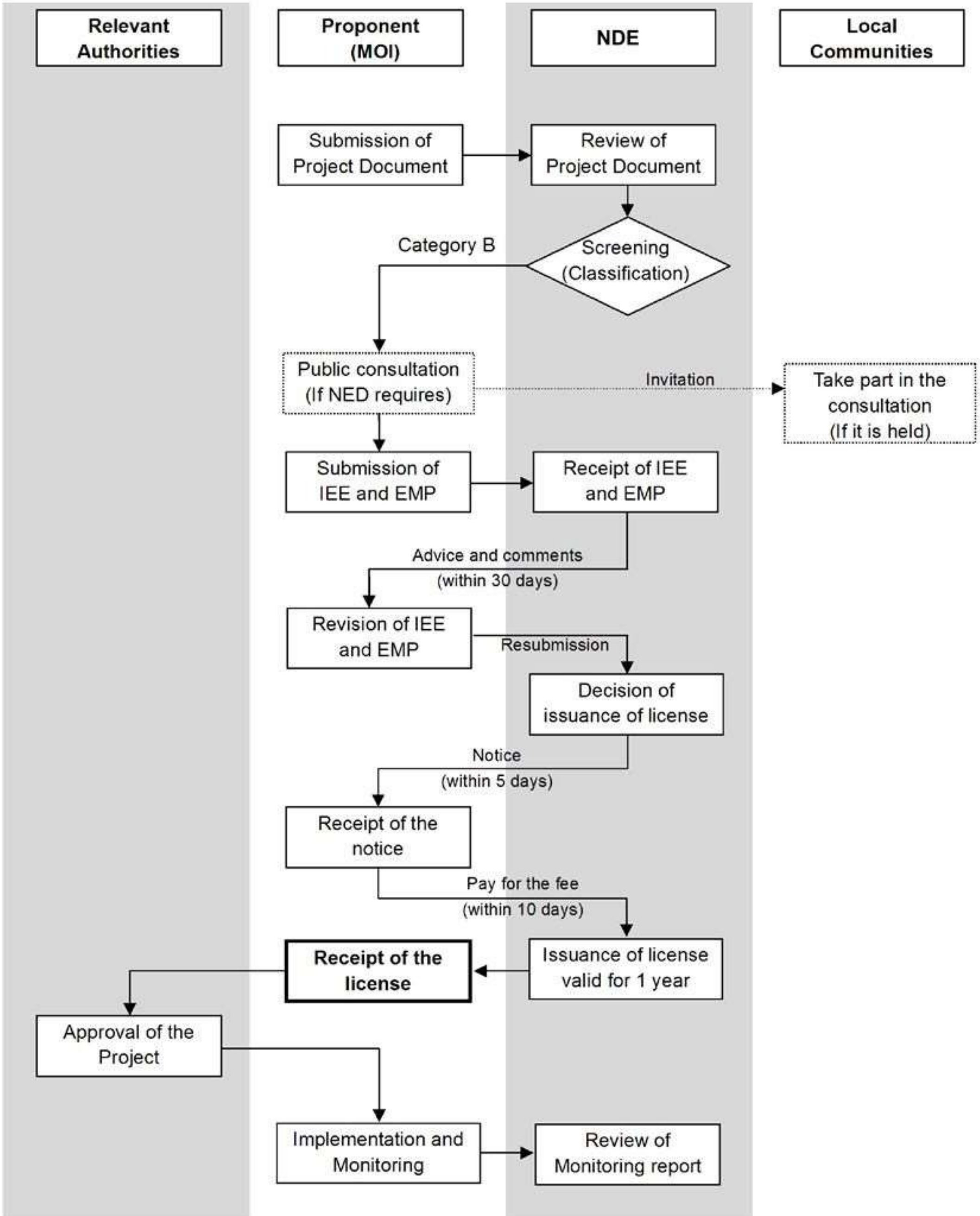
*Noise level suitable for house, school, and hospital according to International Finance Corporation (IFC) noise guideline (2007). (1 hour average in daytime)
**Level above which ordinary people can feel vibration.

Fig. 1.3.5 Instruments for noise and vibration measurement

1.3.3 Environment Impact

(1) EIA system

In Timor-Leste, National Directorate for Environment (NDE), Ministry of Commerce, Industry and Environment (MCIE) is in charge of EIA categorization and environment license publication. This survey confirmed NDE by hearing that the project site does not include a protected area and the Project categorizes to category-B. Fig. 1.3.6 gives the flowchart of the EIA procedure. As shown in this figure, there is no obligation in category-B to implement EIA but submission of IEE and EMP



Material: Based on Hearing Results with National Directorate Environment (NDE)

Fig. 1.3.6 EIA Procedure

(2) Environment Impact of the Project

Since aim of the Project is to protect the pier and abutment of the existing Mola Bridge and construction of concrete revetment which these structures are located within the river (public land), and there is neither land acquisition nor relocation of inhabitants, any irreversible environmental impacts are not expected. If the Project were not implemented, it could expect a damage to the Mola bridge by future flood occurrence. Therefore the implementation of the Project is adequate.

However, along with implementation of this project, it is determined that each pollution item will be slightly affected, but only temporary during construction work, and there will be no grave adverse effect as a whole. Details of environmental impacts of the project are presented in Table 1.3.4.

Table 1.3.4 Environmental Impacts resulting from Implementation of the Project

Category	No	Target of influence	Influence evaluation		Reason of influence evaluation result	Remarks
			Before and during construction	After construction		
Social environment	1	Displacement of residents	D	D	**Before construction:** The local survey showed that there was no house on the construction site and yard. The local residents therefore do not have to be displaced for the project. **After construction:** The local residents do not have to be displaced even when the bridge is in service.	The presence/absence of houses is checked on the local survey result.
	2	Local economy	B+	B+	**During construction:** Positive influence such as employment of local residents is expected during the construction. **After construction:** Positive influence can be expected since the transportation through Mola Bridge and hence access to the market will become stable.	-
	3	Use of land and resource	D	B+	**During construction:** This project aims at reinforcement of Mola Bridge and the land modification is limited to the existing bridge footing and levee. Since the camp yard and soil pit used for the construction of Mola Bridge and the old road extending from Route A02 to the river will be used, the land utilization plan for temporary installation of facilities would not be changed. Also, it is not necessary to use another land or another resource since the existing soil pit owned by MPW will be used. **After construction:** Positive influence such as stabilization of land use is expected since bank erosion around Mola Bridge will be stopped by the reinforcement of the existing levee.	-
	4	Local social organization	D	B+	**During construction:** The construction work will not block the traffic through Route A02 or Mola Bridge and hence the local social organization would not be split. **After construction:** Positive influence such as stable local community exchange is expected sine stable traffic route over Mola Bridge will be secured.	-

Category	No	Target of influence	Influence evaluation		Reason of influence evaluation result	Remarks
			Before and during construction	After construction		
	5	Existing infrastructure and service	D	B+	**During construction:** The existing levee in the surveyed area will be temporarily destroyed. However the construction will be made by introducing a makeshift levee in front, which can block flooding. **After construction:** Positive influence can be expected since the project aims at protection of Mola Bridge and reinforcement of the existing infrastructure.	-
	6	Rights of poor people, minority races, minority gender, and children	D or B+	B+	**Before construction:** The local survey did not find any minority race. Local residents do not have to be displaced for the construction. **During construction:** Positive influence such as employment of female for the construction work of the project is expected. **After construction:** Positive influence is expected since securing stable traffic through Mola Bridge allows poor people, female, and children to easily access schools, social services, and the market.	The presence of minority race is examined by hearing.
	7	Share of profit and disbenefit	B-	D	**During construction:** In the employment of local residents during construction, the profit could not be equally shared by the residents for a certain type of employment form. **After construction:** Unfair profit or disbenefit due to stable traffic through Mola Bridge is not expected.	-
	8	Cultural asset	D	D	**During construction:** No influence is expected since no cultural asset is found around the current Mola Bridge or the bank protection. **After construction:** No influence is expected as during the construction.	The presence of cultural asset is examined by hearing.
	9	Conflict in relevant persons	B-	D	**During construction:** Since local residents are employed for the construction, a conflict among local residents on the employment could occur. **After construction:** Conflict within the area is not expected since the traffic through Mola Bridge will become stable.	-
	10	Water usage, water use right	B-	D	**During construction:** There are six facilities of using the river in the surveyed area and it will be difficult to use two of them on the existing levee, i.e. water intake and stairs to Mola River. No influence on the stairs to Mola River is expected since the construction will proceed step by step. Also almost no influence on the water intake is expected since an open channel will be made for water flow. **After construction:** No influence is expected since it is planned in the project that stairs and water intake will be installed to the right-side levee.	The current water-use facilities were found in the local survey.
	11	Public health	B-	D	**During construction:** There could be a sanitary risk such as excrement in the camp yard. **After construction:** No influence due to the bridge abutment and footing and the bank protection is expected.	-
	12	HIV/AIDS and	B-	D	**During construction:** There could be a risk of HIV/AIDs or other infection since many construction	-

Category	No	Target of influence	Influence evaluation		Reason of influence evaluation result	Remarks
			Before and during construction	After construction		
		other infection			workers will be engaged in the work. **After construction:** No influence due to the bridge abutment and footing and the bank protection is expected.	
	13	Accident	B-	D	**During construction:** There is an accident risk during the construction as a village is located on the right side of Mola River. **After construction:** No influence due to the bridge abutment and footing and the bank protection is expected.	-
Natural environment	14	Landform and geological condition	D	B+	**During construction:** No influence is expected since the landform modification during the construction is limited to the existing abutment and footing of Mola Bridge and to the existing bank protection. **After construction:** The landform of the river bank will be stabilized by the reinforcement of the levee and hence positive influence is expected.	-
	15	Soil (Runoff, denudation)	D	B+	**During construction:** Soil outflow, erosion or other influences are not expected since the landform modification during the construction is limited to the existing abutment and footing of Mola Bridge and to the existing bank protection. **After construction:** Soil erosion of the river bank will be suppressed by the reinforcement of the levee and hence positive influence is expected.	-
	16	Underground water	D	D	**During construction:** The construction will be made by closing the river around the abutment and footing of Mola Bridge and around the existing bank protection and by pumping out leaking underground water. No influence is expected since the construction proceeds step by step and since there is no water supply facility that uses underground water around the construction site. **After construction:** No influence is expected since underground water is not pumped up when the bridge is in service.	The absence of water supply facility that uses underground water was checked in the local survey.
	17	River flow-rate, stream regime and water temperature	D	D	**During construction:** No influence is expected since the water channel construction during the construction is limited to the existing abutment and footing of Mola Bridge and to the existing bank protection. **After construction:** No influence is expected since the conditions of the abutment and footing of the bridge and the bank protection will not change.	-
	18	Seashore	D	D	**During construction:** No influence to the sea and shore is expected since Mola Bridge is located about 9km upstream from the estuary. **After construction:** No influence is expected as during the construction.	-
	19	Plant, animal, and ecological	D	D	**During construction:** There is no natural reserve in the project area or around. The land deformation during the construction will be limited to the abutment and footing of Mola Bridge and to the existing bank protection where	Based on the existing data, hearing to Ministry of

Category	No	Target of influence	Influence evaluation		Reason of influence evaluation result	Remarks
			Before and during construction	After construction		
		system			vegetation is only scarcely distributed and since there is no rare plant or animal around, no influence is expected. **After construction:** Since the height and length of new levee will be the same as those of the existing one, the new one would not suppress more the migratory activities of wild animals.	Agriculture, and local survey.
	20	Climate	D	D	**During construction:** No climate change is expected since the construction is limited to the abutment and footing of Molar Bridge and to the existing bank protection and since large-scale forest cutting or landform modification will not be performed. **After construction:** No influence due to the bridge abutment and footing and the bank protection is expected.	-
	21	Scenery	D	D	**During construction:** No influence is expected since there is no facility of viewing the scenery in the surveyed area. **After construction:** Since the height and length of new levee will be the same as those of the existing one, the new one would not worsen the scenery.	The absence of the facility of viewing the scenery is checked in the local survey
	22	Global warming	B-	D	**During construction:** CO_2 will be emitted from heavy machinery during the construction. **After construction:** No influence due to the bridge abutment and footing and the bank protection is expected.	-
Pollution	23	Air contamination	B-	D	**During construction:** Exhaust gas will be emitted from heavy machinery or construction vehicles during the construction. Dust will be generated in the working area of the heavy machinery or in the unpaved river bed where the construction vehicles run around. However the influence is expected to be relatively small since the construction site is about 70m distant from the closest village and the exhaust gas and dust will diffuse. Also, since the average wind speed is recorded approx...1 m/s at Suai and Forem where near the project site is, it is considered occurrence frequency comes above 5.5m/s is rare. 5.5m/s is a standard which Beaufort wind scale gives as a wind speed dust generates. **After construction:** No influence due to the bridge abutment and footing and the bank protection is expected.	The average wind speed is given from the previous observation record.
	24	Water contamination	B-	D	**During construction:** The water quality of Mola River is expected to receive influences from cloudy water due to river bed drilling, waste water from the batcher plant and by washing concrete mixer trucks, and human waste water from the camp yard. Other water contamination due to oil, etc. is not expected since the river flow channel is appropriately displaced and hence the heavy machinery or construction vehicles will not directly contact the river water. **After construction:** No influence due to the bridge abutment and footing and the bank protection is	-

Category	No	Target of influence	Influence evaluation		Reason of influence evaluation result	Remarks
			Before and during construction	After construction		
					expected.	
	25	Soil contamination	B-	D	**During construction:** Soil contamination could occur due to construction oils discharged from the camp yard or heavy machinery. **After construction:** No influence due to the bridge abutment and footing and the bank protection is expected.	-
	26	Waste	B-	D	**During construction:** Concrete pieces will be produced when the existing levee is removed and concrete frames, waste steel, and waste oil will be produced in the construction work. **After construction:** No influence due to the bridge abutment and footing and the bank protection is expected.	-
	27	Noise and vibration	B-	C	**During construction:** Noise and vibration will become largest when steel sheets are piled. According to estimation, the noise level (Laeq) will be about 106dB(A) in the vicinity of the noise source and 61dB(A) or lower in a house 70m distant from the source. The vibration level (L_{10}) is about 77dB in the vicinity of the noise source and 54dB in a house 70m distant from the source, which is lower than the level 54dB above which people can feel the vibration. **After construction:** No influence due to the bridge abutment and footing and the bank protection is expected.	-
	28	Land sinking	D	D	**During construction:** The construction will be made by closing the river around the abutment and footing of Mola Bridge and around the existing bank protection and by pumping out leaking underground water. No ground sinking is expected since the construction will proceed step by step and the ground is gravel base. **After construction:** No influence due to the bridge abutment and footing and the bank protection is expected.	-
	29	Bad odor	D	D	**During construction:** No bad odor due to the construction is expected to be generated. **After construction:** No influence due to the bridge abutment and footing and the bank protection is expected.	-
	30	Bottom sediment	D	D	**During construction:** No contamination of the bottom sediment due to the construction, other than water contamination, is expected. **After construction:** No influence due to the bridge abutment and footing and the bank protection is expected.	-

A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected.

(3) Environmental Mitigation

Details of the monitoring plan are presented in Table 1.3.5.

The Environmental Management Plan (EMP) presents the mitigation measures, the monitoring plan, and institutional arrangements for implementation of the river training for the protection of Mola Bridge. The particular sections of the EMP shall be appended to the Tender Documents for the Contractor's compliance. Most of the mitigation measures are fairly standard methods of minimizing disturbance, minimizing threats to the safety to population and enhancing the socio-economic benefits during construction to communities.

Table 1.3.5 Environmental Mitigation Plan（During construction:）

Item		Influence	Countermeasure	Implemented by	Frequency of implementation
Social environment	7. Share of profit and disbenefit	Unfair profit sharing in the employment of local residents	-Taking actions on the representative of the local community to prevent unfair profit sharing in the employment of local residents	Constructor	As needed when local residents are employed
	9. Conflict in relevant persons	Conflict within the local community caused by the employment of local residents	-Taking actions on the representative of the local community to prevent conflict within the local community caused by the employment of local residents	Constructor	As needed when local residents are employed
	10. Water usage, water use right	Temporal blocking of water flow at the water intake	-Securing water flow by making an open channel	Constructor	As needed when water intake construction is made
	11. Public health	Sanitary risk in e.g. excrement treatment	-Installation and maintenance of toilet and simple water purification system in the camp yard.	Constructor	Maintenance conducted once in every month
			-Monitoring of water quality of Mola River to which processed water is discharged.		Once in every month
	12. HIV/AIDS and other infection	Risk of HIV/AIDS or other infection due to inflow of construction worker	-Guidance, training, health control, and sanitary control of construction workers	Constructor	Once in every month
	13. Accident	Accident risk due to heavy machinery and construction vehicles	-Enclosing the construction site with barricade (preventing local residents to enter the site)	Constructor	As needed during construction
			-Guidance and training of construction workers -Suppression of traffic speed in the village -Compliance with appropriate load on trucks -Inspection and maintenance of heavy machinery and trucks		Once in every month

Item		Influence	Countermeasure	Implemented by	Frequency of implementation
	22. Green house gas	Emission of CO_2 from heavy machinery and construction vehicles	-Reduction of CO_2 by idling-stop practice of machinery and vehicles	Constructor	As needed during construction
			-Inspection and maintenance of heavy machinery and trucks		Once in every month
Pollution	23. Air contamination	Emission of exhaust gas from heavy machinery and construction vehicles	-Reduction of exhaust gas by idling-stop practice of machinery and vehicles	Constructor	As needed during construction
			-Inspection and maintenance of heavy machinery and trucks		Once in every month
		Emission of dust from heavy machinery and construction vehicles	-Suppression of traffic speed in the village		As needed during construction
			-Water sprinkling in the construction area		About twice a day depending on the dust generation status
			-Installation of tire washing equipment at the exit of the construction area to Route A02.		As needed during construction
			-Monitoring of dust		Once in every month
Pollution	24. Water contamination	Outflow of human waste water from camp yard	-Installation and maintenance of toilet and simple water purification system in the camp yard.	Constructor	Maintenance conducted once in every month
			-Monitoring of water quality of Mola River to which processed water is discharged.		Once in every month
		Outflow of cloudy water due to river bed drilling	-Installation of temporary fence and sump of the drilling site; Discharging of surface water	Constructor	As needed during construction
			-Monitoring of water quality of Mola River to which surface water is discharged.		Once in every month
		Concrete waste water discharging from batcher plant	-Installation and maintenance of waste water treatment facilities	Constructor	Maintenance conducted once in every month
			-Monitoring of water quality of Mola River to which waste water is discharged.		Once in every month
	25. Soil contamination	Outflow of construction oil from camp site or heavy machinery	-Installation of oil prevention fence to the construction oil storage area in the camp site; Storage of neutralizer.	Constructor	As needed during construction
			-Inspection and maintenance of heavy machinery and trucks		Once in every month
	26. Waste	Concrete pieces from the abolition work of the existing levee	-Reuse for the construction (to reduce waste)	Constructor	As needed during construction
		Concrete frame, waste steel, waste oil, etc. from the construction work	-Appropriate disposal to MPW-specified places	Constructor	As needed during construction

Item		Influence	Countermeasure	Implemented by	Frequency of implementation
	27. Noise and vibration	Noise and vibration by heavy machinery or construction vehicles	-Reduction of noise and vibration by idling-stop of machinery when it is not used. -Compliance with work hours (Work stop in the nighttime)	Constructor	As needed during construction
			-Inspection and maintenance of heavy machinery and trucks		Once in every month
			-Monitoring of noise and vibration		Once in every month

Remark: The mitigation measures during construction need to be reflected on the TOR (Terms Of Reference) for construction work.

(4) Environmental Monitoring

The environmental monitoring for the construction stage of the project is presented in Table 1.3.6.

The impact to the environment during the construction will be reduced by reflecting the contents of EMP to TOR.

However, since the dust comes from the construction vehicle passing national road A02, and noise and vibration generated from hammering the Steel Sheet Pile in ground is considered to have relatively large impact to people's life, environment monitoring shall be carried out. Necessary analysis of the cause and its countermeasure shall be taken immediately when significant impact was found from the environment monitoring.

Table 1.3.6 Environmental Monitoring Plan（During Construction:）

Item		Monitoring item	Method	Place	Standard and index	Monitoring frequency
Social environment	7. Share of profit and disbenefit	Status of employment of local residents	Arrangement of employment method and record	Project site	Consultation with representative of local community: Yes/No	As needed when local residents are employed
	9. Conflict in relevant persons	Status of employment of local residents	Arrangement of employment method and record	Project site	Consultation with representative of local community: Yes/No	As needed when local residents are employed
	10. Water usage, water use right	Check of water flow condition	Visual check	Project site	Check: Yes/No	As needed when water intake construction is made
	11. Public health	Status of installation of toilet or simple water purification system	Record and examination of installation status by taking photographs	Camp yard	Installation: Yes/No	Once when installed

Item		Monitoring item	Method	Place	Standard and index	Monitoring frequency
		Status of maintenance of simple water purification system	Check and arrangement of maintenance record	Camp yard	Maintenance: Yes/No	Once in every month
		Water quality (Typical index of organic contamination: BOD or COD)	Check by a simple method	Mola River after discharging the water (One place)	The maximum value before discharging the processed water shall be referred to.	Three times before discharging and once in every month after discharging
	12. HIV/AIDS and other infection	Status of guidance, training and health control for construction workers	Check and arrangement of implementation record	Project site	Implementation: Yes/No	Once in every month
	13. Accident	Status of installation of barricade around the construction site	Record and examination of installation status by taking photographs	Project site	Installation: Yes/No	Once in every month
		Status of guidance and training for construction workers	Check and arrangement of implementation record	Project site	Guidance and training: Yes/No	Once in every month
		Status of traffic speed reduction in the village	Check and record of traffic speed	Village around project site	30km/h or lower shall be referred to.	Once in every month
		Status of compliance with appropriate load on trucks	Check and record of load	Project site	Overload: Yes/No	Once in every month
		Status of inspection and maintenance of heavy machinery and trucks	Check and arrangement of inspection and maintenance records	Project site	Inspection and maintenance: Yes/No	Once in every month
	22. Green house gas	Status of implementation of idling-stop when the heavy machinery is not used.	Check and record of implementation status	Project site	Idling stop: Yes/No	Once in every month
		Status of inspection and maintenance of heavy machinery and trucks	Check and arrangement of inspection and maintenance records	Project site	Inspection and maintenance: Yes/No	Once in every month
Pollution	23. Air contamination	Status of implementation of idling-stop when the heavy machinery is not used.	Check and record of implementation status	Project site	Idling stop: Yes/No	Once in every month
		Status of inspection and maintenance of heavy machinery and trucks	Check and arrangement of inspection and maintenance records	Project site	Inspection and maintenance: Yes/No	Once in every month
		Status of suppressing traffic speed in the village	Check and record of traffic speed	Village around project site	30km/h or lower shall be referred to.	Once in every month

Item		Monitoring item	Method	Place	Standard and index	Monitoring frequency
		Status of water sprinkling in the construction area	Record and examination of implementation status by taking photographs	Project site	Water sprinkling: Yes/No	Once in every month
		Installation of tire washing facilities at the exit of the construction area to Route A02.	Record and examination of installation status by taking photographs	Project site	Installation: Yes/No	Once when installed
		Monitoring of dust	Visual check[note)]	Village around project site	Dust scattering : Yes/No	Once in every month
	24. Water contamination	Status of installation of toilet or water purification system	Record and examination of installation status by taking photographs	Camp yard	Toilet installation: Yes/No	Once when installed
		Status of maintenance of simple water purification system	Check and arrangement of maintenance record	Camp yard	Maintenance: Yes/No	Once in every month
		Quality of processed and discharged human waste water (Typical index of organic contamination: BOD or COD)	Simple measurement	Mola River (A place more than 100m upstream and a place more than 100m downstream from the discharged point)	The maximum value from the upstream shall be referred to.	Once in every month
		Status of installation of temporal closing fence and makeshift sand basin for drilling works and status of supplied water discharging	Record and examination of installation status by taking photographs	Camp yard	Installation: Yes/No	Once when installed
		Quality (transparency) of discharged water after cloudy water is processed	Measurement with transparency meter	Mola River (A place more than 100m upstream and a place more than 100m downstream from the discharged point)	The maximum value from the upstream shall be referred to.	Once in every month

Item		Monitoring item	Method	Place	Standard and index	Monitoring frequency
		Status of installation of waste water treatment facilities for batcher plant	Record and examination of installation status by taking photographs	Camp yard	Facility installation: Yes/No	Once when installed
		Status of maintenance of waste water treatment facilities for batcher plant	Check and arrangement of maintenance record	Camp yard	Maintenance: Yes/No	Once in every month
		Water quality (pH) of processed waste water from batcher plant	Measurement by pH meter	Mola River (A place more than 100m upstream and a place more than 100m downstream from the discharged point)	The maximum value from the upstream shall be referred to.	Once in every month
	25. Soil contamination	Status of installation of oil proof fence around the oil storage place for the construction	Record of the oil fence installation by taking photographs	Camp yard	Oil fence installation: Yes/No	Once when installed
		Status of inspection and maintenance of heavy machinery and trucks	Check of inspection and maintenance records	Project site	Inspection and maintenance: Yes/No	Once in every month
	26. Waste	Status of reuse of concrete pieces (to reduce waste)	Check of status of reuse	Project site	Reuse: Yes/No	As needed during construction
		Status of disposal of concrete frame, waste steel, waste oil, etc. from the construction work	Check of disposal	Project site	Appropriate disposal: Yes/No	As needed during construction
	27. Noise and vibration	Status of idling-stop practice when the machines or vehicles are not used.	Check and record of implementation status	Project site	Idling stop: Yes/No	Once in every month
		Status of compliance with work hours (work stop in the nighttime)	Check and record of implementation status	Project site	Compliance: Yes/No	Once in every month
		Status of inspection and maintenance of heavy machinery and trucks	Check of inspection and maintenance records	Project site	Inspection and maintenance: Yes/No	Once in every month

Item		Monitoring item	Method	Place	Standard and index	Monitoring frequency
		Noise and vibration level	Measurement with noise meter and vibration meter[note)]	A village near the project site	For noise, the maximum value (61dB (A)) in the current situation before construction shall be referred to. For vibration, the level of 55dB above which people can feel vibration shall be referred to.	Once in every month (when steel sheets are piled)

Note) the information (about complaints, etc.) is to be supplemented if necessary by the hearing to local residents.

(5) Stakeholders conference

In order to obtain a basic agreement to implementation of the project, a Stakeholders Conference was held to explain to the representatives of local districts and communities and compare notes with them. Table 1.3.7 outlines the stakeholders conference.

Table 1.3.7 Outline of Stakeholders Conference

Organized by	MPW (Ministry of Public Works), DRBFC (Directorate of Road, Bridge and Flood Control)
Purpose	To form a basic agreement to implementation of the project.
Attended by	Representatives of Zumalai district Representative of local communities MPW (Mariana Office) NDE (National Directorate for Environment) JICA investigation group
Venue	Zumalai district
Date	Jun. 1, 2012
Agenda	1. Outline of the project 2. Advantages of the project 3. Adverse effects on the environmental and social aspects 4. Exchange of opinions

The stakeholders conference was held by the MPW and attended by 7 persons, including the organizer. As a result of the conference, the attendees understood the significance of this project and agreed to implementation of the project. The following describes main opinions and requests of the attendees.

Fig. 1.3.7 Appearance of Stakeholders Conference

- For improvement of the revetments, install staircases for coming down from the current banks to the river, and water inlet ports for irrigation.
- In order to secure access to the downstream villages of the Mola Bridge, secure a passage for crossing to the national road from downstream of the right bank of the Mola Bridge.
- In addition to the surrounding area of the Mola Bridge, improve the embankments in its upstream and downstream areas. Particularly in the downstream area of the Mola Bridge, the Mola River expands in the direction different from the one leading to the sea, making an issue of decreasing agricultural land in the downstream villages.
- When hiring the workers at the time of construction work, consult the representatives of the local communities.
- The river is public land and there is no problem in using it for construction. The areas eroded by the river are also public land.
- The camp yard used during construction work of the Mola Bridge can be provided for this project free from charge. When starting construction work in the future, consult the representatives of the local communities.

1.3.2 Land Acquisition and Resettlement

The project site includes the bridge piers and abutments of the existing Mola Bridge, and the banks of the Mola River, basically within the river land. Accordingly, there will be no new land acquisition and resettlement. Because the old road and the areas eroded by the river are used as construction roads, no land acquisition and resettlement are required. The existing facility owned by the MPW is used as a borrow-pit, requiring no land acquisition and resettlement.

In addition, it is planned to use the camp yard used for construction of the Mola Bridge again. This camp yard is private land, but the MPW intends to obtain consent from a land owner during this preparatory investigation period.

Chapter 2 Contents of the Project

2-1 Basic Concept of the Project

(1) The Higher Goal and the Project Objectives

The Mola Bridge is located on the National Route A02, which connects Suai, a main city in the southern region, and Dili, the capital of Timor-Leste, and serves not only as an important community road for 200,000 roadside residents including those living in Suai, but also as a highway for transporting agricultural products. The bridge also serves as a section of an international highway that connects this country to Indonesia.

The Mola Bridge comprises two bridges－one is a new bridge built with Japanese grand aid in April 2011 and the other is an existing bridge constructed during the Indonesian period. The completion of this new bridge has allowed passengers and vehicle traffic to pass through the section that had been closed to traffic during the rainy season and thus allowed the Mola Bridge to pass over the Mola River, ensuring the safe passage of people and traffic under any climate conditions and dramatically improving traffic flow between Suai and Dili. This allows more easy access to both the southern region including Suai city and the northern region including Dili city and has made an economic and social contribution to the country.

To the contrary, repeated abnormal rainfalls and floods, including those occurred in 2010, resulted in many damages to the area, such as broken/washed-out revetments and severely scoured substructure of the existing bridge's pier. In response to the situation, the Government of Timor-Leste took emergency restoration measures to reinforce the damaged revetments. However, the structural problems could not make those measures permanent. If such situations continue, not only further river bank's erosion toward the national route but also scoring of the substructure will progress, expecting the washing away of the road and the collapse of the existing bridge to occur in the future. As a result, the road will be forced to close to traffic for long periods of time, thus having great impacts on the lives of residents as well as on the local economic and social activities. For these reasons, it is necessary to prevent the bridge scour and revetment erosion from occurring and to maintain road and traffic functions through reinforcement of the existing bridge and reconstruction of the surrounding revetments.

(2) The Outline of the Project

The existing Mola Bridge is a structure built at a time before the independence of Timor-Leste (during the Indonesian period) and must have been aged over 12 years. Regardless of that, the superstructure suffers only minor coating detachment and is kept in an extremely healthy condition, raising no particular problems. Therefore, most of problems with the bridge come down to the instability of the substructure caused by river scour.

For the substructure, due to the strong tractive force of the Mola River and flood erosion, scour progresses to a point where the lower part of the footing is exposed; unless appropriate measures are taken, it is apparent for the bridge to be seriously damaged (for example, to be tilted) in the future. The results of trail pit and Pile Integrity Test (PIT) revealed that it was a caisson structure and was supported by a combination of the ground reaction force in the bottom slab and the skin friction. Although the most effective resolution to such a scouring problem is both foot protection work and sheet pile driving, in this case, because the pier foundations are not anchored on solid bedrock, a suitable construction method has to be selected that minimizes the effects on the bearing capacity of the foundation.

The revetments, which had been repaired by Timor-Leste itself, have some structural problems and therefore, the reliability is insufficient in terms of their construction as a structure. Most causes of damage to the revetments repaired by the country are the overturning due to the scour of their front side and the breakage due to their insufficient structural strength. Hence, it is in need of securing an appropriate structure designed in full consideration of these causes.

The goal of this project is to reinforce the piers and abutments of the existing bridge against scour in consideration of the above findings and to reconstruct the concrete revetments in consideration of the tractive force of the river as well as flood flow impacts, so that the traffic function of the national route can be secured.

2-2 Outline Design of the Japanese Assistance

2-2-1 Design Policy

(1) Basic Policy

Initial requests from the local government are given in Table 2.2.1.

Table 2.2.1 Outline of the Requests

Damaged Part	Situation of the Damage	Request
Piers of the existing Mola Bridge	Scouring exposed the concrete structure which seems to be a caisson at the base of the footing.	Protection of the piers
Abutments of the existing Mola Bridge	Partly scoured backfill soil	Protection of the abutment
Left-bank levee of the Mola River	Settling of the revetment due to the outflow of backfill soil of the masonry revetment	Length of sheet-piled revetment: L=500m
Right-bank levee of the Mola River	Swept-away houses due to scouring of the natural revetment (W≒50m,L≒300m). Approaching the road shoulder of the National Route A02.	Length of sheet-piled revetment: L=500m

As a result of our survey results and consultations with the local government, the Japanese Government determined to implement this project based on the following basic policies.

1) The Piers of the Existing Mola Bridge

Three solutions to preventing further scours of the pier's substructure include protection with concrete blocks, enclosure with gravity-type retaining walls and enclosure by steel sheet piles. The "concrete block method" offers low costs but needs periodic maintenance and repair. In light of their maintenance/repair capability, such obligations seem to be too much for the Timor-Leste government. Although the "enclosure with gravity-type retaining walls" is such a common method that the necessary construction processes can be performed by the local government on its own; however, the effectiveness may not be maintained when more severe scours than expected occur. The "enclosure by steel sheet piles" method requires special equipment used for driving the sheet piles, but it can be adopted because the procurement of such equipment is surely available from Japan, whose effectiveness to handle more severe scours than expected can be maintained and furthermore, whose costs are lower than that of the gravity-type retaining wall method.

This project has a shortage of annual hydrological information about the Mola River, which makes it extremely difficult to determine the extent of scour that may occur in the future. Thus, it is highly anticipated there is a need for addressing the cases where unexpectedly severe scouring proceeds. For these reasons, it is concluded that, in this project, the damaged bridge piers are better to be protected using an enclosure by steel sheet piles.

2) The Abutments of the Existing Mola Bridge

Gabions are put in place around Abutment A2 (Suai side) of the existing bridge in order to prevent occurrence of scouring; regardless of that, it was found that erosion in the abutment proceeds at a rapid pace. Hence, the enclosing of the entire abutment is determined to be conducted to prevent further erosion. Although the three options as stated in 1) may be applicable for the enclosing works, after considering their economies and workability, protection by the concrete block method is the right choice to be used. The "enclosure with steel-sheet pile method" adopted in 1) is extremely effective for scour events, but it requires a larger self-standing height due to the topographical reasons, making it difficult to secure structural stability.

3) Left-bank Levee of the Mola River

The initial request for this project from Timor-Leste was reinforcement of the Mola River's revetment with sheet piles. However, since the site comprised a ground mixed with gravel and was unfit for sheet pile driving and therefore the application of the sheet pile method to this case was economically disadvantaged, the government of Timor-Leste agreed on altering the revetment to a concrete revetment. In addition, although the distance of a requested extension of the revetment is 500m, because, on the left bank side, there are no other villages/facilities to be especially protected than the bridge abutments, the concrete revetment is supposed to be built in the levee area with a distance of approximately 300m where the abutments are located.

When it comes to the structure of the left-bank levee, most causes of damage to the revetments repaired by Timor-Leste are the overturning due to the scour of their front side and the breakage due to their insufficient structural strength. Thus, in order to prevent the scour, after comparing the survey results obtained at this time with those obtained in the past, an appropriate value of the deepest riverbed level must be established based on the annual topographical changes. The insufficient structural strength of the field revetment is likely to be caused by the adoption of wet masonry. Therefore, the revetment must be of concrete construction and built based on suitable quality management practices.

The main focus in this project is on the prevention of bridge scour and the measures against erosion of revetments. Bearing this in mind, JICA and the local government confirmed that overflow protection measures were beyond the scope of the project. Hence, the levee height must be adjusted to the existing ground level.

4) Right-bank Levee of the Mola River

Structural requirements for the right bank levee are the same as those in the above Section 3). From the view of preventing erosion into the national route, the scope of the reconstruction is determined to be areas around the abutment and areas of up to about 500m in the upstream direction.

(2) Policies for Natural Environment Conditions

Data from all weather observatories near the project area is collected and used to perform a hydrological analysis. Most of those metrological observation data are statistical results obtained since 2003 or 2008 (after the independence of the Timor-Leste). In order to understand the secular weather changes for longer periods of time, missing data must be compensated for with the data compiled during the Indonesian period.

(3) Policies for Social and Economical Conditions

In Timor-Leste, river basins are regarded as a public land. Since the structures used in this project are to be constructed inside the river basin, it is not necessary for other new land to be purchased. According to public consultations with the local government, for a construction yard during the works, the same site as used during the construction of a newly installed bridge can be again utilized. In addition, MOI will negotiate with the local land owner and draw an agreement with him before the start of the construction. At implementation stages, it is necessary to check whether a negotiation with the land owner is surely undertaken.

(4) Policies for Constructional/Procurement Conditions

1) Design Standards

The river bed around the Mola Bridge, whose bed slope is very steep (about 1/60), is situated in an alluvial fan whereas the upper river basin is a degraded land where large-scale denuded lands are distributed. The Mola River can be classified as a so-called “wild river” where, everytime the flood comes, sediment deposit and the scour of river beds/river banks repeatedly occur. Under these field circumstances, it is valid for facilities in a river channel to be planned as a “SABO facility”.

In Timor-Leste, no specifications on SABO facilities have yet been established. Therefore, the following relevant standards in Japan are applied to the design. However, for any matter that is not described in the technical criteria for SABO facilities, the technical criteria for “River Structures” must be complied with.

- ✧ The Japanese Ministry of Land, Infrastructure, Transport and Tourism (MLIT) Technical Criteria for River Works (Draft) Practical Guide for Research (Japan River Association)
- ✧ The Japanese Ministry of Land, Infrastructure, Transport and Tourism (MLIT) Technical Criteria for River Works (Draft) Practical Guide for Design I and II (Japan River Association)
- ✧ The Japanese Ministry of Land, Infrastructure, Transport and Tourism (MLIT) Technical Criteria for River Works (Draft) Practical Guide for Planning (Japan River Association)
- ✧ A Dynamic Design Method for Revetments (Japan Institute of Construction Engineering)
- ✧ The Collection of SABO Design Formulae (Japan SABO Association)
- ✧ Road Earthwork. Retaining Wall Construction Guideline (Japan Road Association)
- ✧ Guidelines for Designing Disaster-relief Work (National Association of Disaster Prevention)
- ✧ And Other Relevant Criteria, Guidelines and Standards

2) Procurement of Materials and Equipment/Machinery

Primary construction materials used for this project include cement, aggregates, and steel-sheet piles. Among those materials, cement is necessary in large amounts and it is seemingly difficult to procure the required quantity in Timor-Leste; therefore, cement procurement must rely on the third country (Indonesia). Aggregates used in the project are boulders interspersed with gravels, which are collected from the surrounding river. Steel-sheet piles are difficult to be procured from both Timor-Leste and the third country. Therefore, their procurement must rely on our country.

Of construction equipment and machinery, transporter vehicles such as trucks and semi-trailers are in widespread use within Timor-Leste and thus locally procured. Machineries temporarily required for the project, such as graders, road rollers or other machinery used only in a temporary work, are locally procured. To the contrary, procurement from Japanese suppliers includes equipment and machinery required for concrete production and placement and for sheet pile driving.

3) Labor

A field supervisor is assigned from foreign staff members (including Japanese) and workers are employed from villages near the project site. Skilled works including reinforcement works, formwork, machine maintenance/repair works are all critical processes for the project and directly associated with the quality of workmanship. Hence, such skilled workmen are supposed to be assigned from Japanese staff members. The labor management plan must be in compliance with the Labor Standards Law of Timor-Leste and take into consideration the related information such as information about when the public holidays are, or how much labor unit costs are.

(5) Policies for Utilization of Local Traders

Basically, local construction companies in Timor-Leste have an extremely poor awareness of quality assurance; in other words, one is unable to find, among local construction companies with local interests, at least one trustworthy company. However, within the country, there are also several foreign construction companies, including an Australia-owned company, which have relatively high skilled workers and heavy machinery such as trucks and backhoes. Therefore, this project must receive a supply of not only workers who support individual operations under the instruction of skilled Japanese staff members, but also equipment/machineries to be locally procured.

(6) Policies for Operating, Maintenance and Management

The transport sector of Timor-Leste is involved in the National Development Plan whose target year is set for 2020. In that plan, the following three objectives are established in relation to maintenance and management.

a. To maintain existing road capitals through a long-term, sustainable maintenance management plan

b. To establish the system and improve the technological and management skills of Timorese staff members in order to perform the maintenance management and repair of channel networks

c. To implement a continuous strategy for maintenance and repair of local roads.

In spite of these objectives, regular maintenance management practices have not been implemented because of the limited budget of the MOI (responsible for such maintenance management) and the nature of their organization system. The current circumstances only allow for the temporary repair of a place where damages were found. In the Mola River, after a massive flood occurred in 2010, the revetments were repaired in the course of their emergency work. Regardless of these measures, the Mola Bridge suffered from overturning due to scour and damage due to water impacts during the flood and yet remains unrepaired. Maintenance management practices performed in the Mola River through the last year (2011) was a riverbed leveling work only.

Judging from these circumstances, it would be hard to expect the Timor-Leste government to undertake reliable maintenance management practices. Therefore, in order for the performance of river structures to be maintained even after reconstruction/repair took place, it is necessary to reduce obligations for Timor-Leste. For these reasons, this project must need to apply "maintenance-free" concept to those river structures; in other words, there is less need of maintenance and management once such structures have been reconstructed/repaired; practically, the following measures should be taken: (1) Adoption of concrete structures; (2) Erosion countermeasures by ensuring the sufficient depth of footing; and (3) Restriction of erosion with foot protection blocks.

(7) Policies for Setting Grades of Facilities

The goal of this project is to reinforce the existing bridge and revetments so that the traffic function of the national route can be secured. For the existing bridge, it was found that the area around the bridge pier suffered from severe scour caused by the More River and the bottom of the footing was exposed. If these situations continue, the bridge will be overturned anytime in the future. Hence, the enclosing of the area around the piers needs to be conducted to protect them. However, the project has a shortage of long-term hydrological information about the Mola River, which makes it difficult to assume the depth of scour that may occur in the future. Therefore, in this project, the damaged bridge piers were determined to be enclosed by steel sheet piles, which enable the construction to address cases where more severe scours than expected occurred. Besides, the abutments have been also similarly scoured; however, since the damaged area is relatively far from the abutment itself, after considering the economies and workability, protection by the use of gabions and concrete blocks was determined to be adopted. For the bridge piers, this project plans to install concrete blocks in front of the steel-sheet piles.

Most patterns of damage to the revetments are the overturning due to the scour of their front side and the breakage due to their insufficient structural strength. Bearing this in mind, through the use of Japanese standards as a reference, the footing depth must be, at least, 1m below the deepest riverbed level that was determined by the measured topographical map. Concrete construction allowed the river structure to ensure sufficient rigidity. The purpose of revetment repair/reconstruction in this project is to prevent further erosion toward the national route. Therefore, the occurrence of a certain level of overflow is acceptable in the project. In such a case, there is the possibility where piping may occur due to the water height difference between the front-side and back-side. Hence, a steel-sheet pile of 2m in length was determined to be installed below the revetment itself, in order to block the flow of seepage water. If the deepest riverbed level becomes lower than expected, the bottom of the revetment may possibly be scoured, leading to overturning the revetment. The steel-sheet pile is also expected to play a key role in preventing such unwanted events from occurring. Measures against scouring must be planned so that the progression of the scour can be restricted, for example, putting in place concrete blocks in front of the revetment.

Also, the existing revetments have stairs for descent into the river and river water inlets for irrigation. These are also planned to be repaired/reconstructed from the view point of securing their current functions.

(8) Policies for Construction Method/Procurement Method and Construction Schedule

In order to prevent the piers of the existing bridge from scouring, steel-sheet piles are installed around the footing. Since the site ground is interspersed with much cobbles and boulders, it is readily assumed to be difficult to put steel-sheet piles in place. Hence, a full-rotating excavator (φ1500mm class) is planned to be procured from Japan. The sheet pile installation is executed as follows: Excavate the ground where steel-sheet piles are to be put in place; displace the resulting soil with high quality sand; and then put the sheet piles into place. Placement of steel-sheet piles requires a power shovel (backhoe)-mounted vibro hammer. Placing joints are provided at two points where the clear headway is restricted or one point where the clear headway is not restricted.

The main work in the revetment construction is concrete casting. Although the construction work needs concrete of approximately 16,000 m^3, the project site and the surrounding areas have no plant that can provide ready-mixed concrete in such large quantities. For this reason, a concrete production plant (full-automatic, forced-mixing type 45 m^3/h) is planned to be procured from Japan. Similarly, for aggregates, an aggregate production plant (20t/h) is planned to be procured from Japan. Aggregates are produced by collecting and transporting boulders containing gravels from Himanu River, approximately 20km west from the Mola Bridge.

Timor-Leste experiences many heavy rainfall days (more than 800mm per month) during the rainy season (from December to May), swelling the Mola River. The main part of this project is instream construction works. Because it is critical to avoid any risk associated with the swollen river, execution of such instream construction works must be scheduled within the dry season (July to November). The successful completion of this project requires two different dry seasons, resulting in around two years of overall construction period.

2-2-2 Basic Plan (Construction Plan/Equipment Plan)

2-2-2-1 Hydrologic and Hydraulic Study

2-2-2-1-1 Meteorological Data

The periphery of the study area has five meteorological observatories (Dili, Betano, Fohorem, Suai, and Ainaro). This study collects and utilizes meteorological records from these observatories. Most of those data were obtained after the independence of Timore-Leste, in 2003 or later (partly obtained in 2008 or later). Therefore, regarding data that include observations taken before 2003, it is necessary to use the data owned by the Indonesian BMG (Meteorology & Geophysical Agency).

In the past grant aid projects for Timor-Leste, BMG data were utilized. Therefore, this study is determined to use the data of BMG for information before 2000 (before the independence of the country) and the data of such five stations for information on 2000 or later. Since missing data are frequently present in the rainfall records presented by the BMG and the five meteorological observatories, such missing data must be compensated for using as a reference the data correlation among those observatories. Compensation for missing data is an approach taken in the past grant aid programs; the effectiveness has been already demonstrated because the correlation parameters become 0.8 or higher.

2-2-2-1-2 Rainfall Analysis

(1) Mean Watershed Rainfall

The methods of determining mean watershed rainfall include Arithmetic Mean, Thiessen, and Isohyetal Methods. Regrettably, all of these options are not always the right choice because there is no weather observatory within the watershed area of the Mola River and four observatories around the area have insufficient rainfall records (having many missing data), possibly representing information different from that on the actual environment of the watershed area of the river. Thus, when determining the mean watershed rainfall of the watershed area, it is invalid to use the arithmetic mean method or Thiessen method.

In the meanwhile, ALGIS (Agriculture and Land Use Geographic Information System) , in collaboration with AusAID, had prepared the 2001 Annual Isohyetal Map (Fig. 2.2.1) based on the annual precipitation data from 56 nationwide observatories. Bearing this in mind, in this project, we determined to obtain a detailed annual isohyetal map from ALGIS that shows the watershed area around the Mola Bridge and to use the isohyetal method (averaging according to the area ratio) in order to calculate the mean watershed rainfall of the Mola River's watershed area. As a result, the mean watershed rainfall of the Mola River's watershed area, as shown in Table 2.2.2, was determined to be 2,041.3 mm/year.

Table 2.2.2 Calculation of the Mean Watershed Rainfall by Isohyetal Method

Division	Rainfall in the Division	Rainfall for Division Area (ｍｍ)	Division Area (%)
a-1	2,000mm~2,500mm	2,250	64.35
a-2	1,500mm~2,000mm	1,750	29.55
a-3	1,000mm~1,500mm	1,250	6.10
Total		2,041.3	100.00

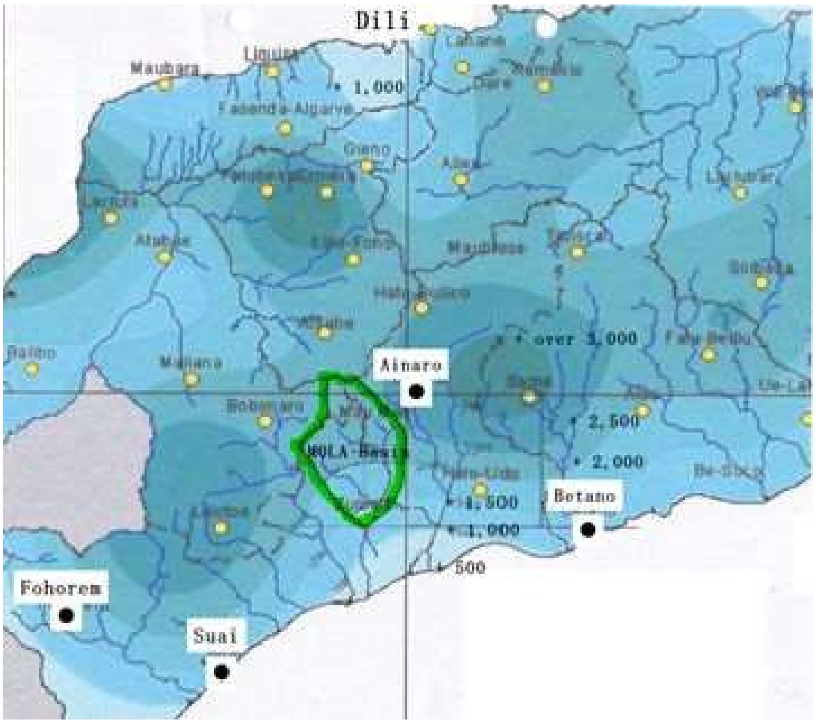


Fig 2.2.1 Isohyetal Map and Basin Divide Map of Mola River's Watershed Area (source: ALGIS)

(The difference in color tone represents the difference in rainfall; Rainfalls were calculated based on the ratio between two area values within the watershed area.)

For the evaluation of annual maximum daily rainfall long-term observation data is required. Therefore, the data from Dili observatory is positioned as a base sample for the evaluation and further, utilized for the data on the Mola River's watershed area based on statistical considerations. Dili observatory, a core meteorological station in Timor-Leste, has been continuing weather observations since the Indonesian period, and thus keeps the records made before 2000. Weather observations in the observatory, although temporarily halted during the time of independence, have recurred after 2003.

On the basis of the ratio of Dili station's annual rainfall(=960mm/year) to the mean watershed rainfall of upstream-side area of the Mola Bridge (=2,041.3mm/year) calculated by the isohyetal method, a modification factor of 2.13 was obtained that converts the Dili station's data into the mean watershed rainfall.

Consequently, the annual daily rainfall value used in this project is determined to be the result obtained by multiplying an annual daily rainfall calculated in Dili Observatory by 2.13. Table 2.2.3 shows the result.

Table 2.2.3 Annual Maximum Daily Rainfall (conversion of Dili data)

	Annual Maximum Daily Rainfall				Annual Maximum Daily Rainfall during Dry Season (June-November)			
	Station : Dili			Station : Mola Bridge (=Dili x 2.13)	Station: Dili			Station : Mola Bridge (=Dili x 2.13)
Year	Month	Date	Rainfall (mm)	Rainfall (mm)	Month	Date	Rainfall (mm)	Rainfall (mm)
1978	Mar	28	110.0	234.3	Oct	03	30.0	63.9
1979	Apr	16	60.0	127.8	Nov	27	21.0	44.7
1980	Jan	29	85.0	181.1	Jun	08	37.0	78.8
1981	Nov	25	80.0	170.4	Nov	25	80.0	170.4
1982	Jan	12	58.0	123.5	Aug	03	6.0	12.8
1983	Feb	13	77.0	164.0	Nov	21	39.0	83.1
1984	-	-	-	-	Sep	03	23.0	49.0
1985	-	-	-	-	-	-	-	-
1986	-	-	109.0	232.2	Jun	23	11.0	23.4
1987	-	-	136.6	291.0	Nov	19	34.0	72.4
1988	-	-	95.2	202.8	Oct	12	28.0	59.6
1989	Mar	6	57.0	121.4	-	-	-	-
1990	Mar	5	91.0	193.8	Nov	24	20.0	42.6
1991	Apr	8	74.0	157.6	-	-	-	-
1992	-	-	67.6	144.0	Aug	22	45.0	95.9
1993	Jan	21	158.0	336.5	Nov	29	32.0	68.2
1994	Jan	9	73.0	155.5	Jun	16	6.0	12.8
1995	Mar	28	99.0	210.9	Nov	20	99.0	210.9
1996	Feb	6	92.8	197.7	Nov	17	27.8	59.2
1997	Jan	2	84.6	180.2	Jun	12	29.2	62.2
1998	Nov	13	116.8	248.8	Nov	13	116.8	248.8
1999	Jan	11	121.0	257.7	Jun	10	70.0	149.1
2000	-	-	-	-	-	-	-	-
2001	-	-	-	-	-	-	-	-
2002	-	-	-	-	-	-	-	-
2003	Feb	03	54.2	115.4	Nov	09	9.4	20.0
2004	Fe	06	126.7	269.9	Jul	01	12.5	26.6
2005	Mar	29	113.4	241.5	Oct	20	60.2	128.2
2006	Dec	21	69.4	147.8	Oct	13	25.4	54.1
2007	Nov	22	69.4	147.8	Nov	22	69.4	147.8
2008	Feb	20	81.6	173.8	Jun	18	16.0	34.1
2009	Jan	23	34.6	73.7	Sep	09	18.8	40.0
2010	Dec	03	140	298.2	Jul	08	110.6	235.6
2011	Feb	05	84.6	180.2	Nov	06	39.5	84.1

1) 1977-1999: In 2003 JICA study, missing data was compensated for based on the rainfall records of BMG(Geophysical & Meteorology Agency, Indonesia).
2) 1977and 1984/1985: Records in these years have many missing data, resulting in no compensation
3) 1986/1987/1988 and 1992: Records in these years have many missing data, resulting in no compensation
4) 2003-2011: These data were obtained form Direcsa des Servisos da Meterologia e Geofica at Airport

(2) Probable Daily Rainfall

Regarding probable daily rainfall, two methods are compared: one is Log-Pearson Type III and the other is Gumbel method, both of which have been in widely used in the East Asia region. Data used are the annual maximum rainfall given in the previous page (Table 2.2.3). The probable daily rainfall calculated by both methods are provided in Table 2.2.4. According to the results, values obtained by Gumbel method tuned out to be on the safe side. Hence, in this study, the values calculated through Gumbel method is determined to be adopted.

Table 2.2.4 Probable Daily Rainfall Throughout the Year

Return Period	Log-Pearson Type III	Gumbel Method	Adopted Value (㎜/day)
2	182.7	183.2	183.2
3	207.0	212.5	212.5
5	242.1	245.1	245.1
10	280.5	286.1	286.1
50	363.2	376.3	376.3
100	397.8	414.4	414.4

In this project, a temporary coffer dam is planned to be installed during the dry season. Therefore, the values of probable daily rainfall during the dry season(June through November) are also calculated in the same manner. Bearing in mind that the coffer dam is a temporary structure, the probable daily rainfall was calculated for a return period of up to 5 years. As shown in Table 2.2.5, as with the throughout-the- year case, estimates by Gumbel method were determined to be used in the dry-season case.

Table 2.2.5 Probable Daily Rainfall During the Dry Season

Unit: mm/day

Return Period	Log-Pearson Type III	Gumbel Method	Adopted Value
2	63.5	75.1	75.1
3	85.8	106.6	106.6
5	125.2	141.6	141.6

2-2-2-1-3 Setting up of Flood Discharge

The Mola River is characterized by the following features. Therefore, it is valid for the calculation of flood discharge to use rational method. The rational method is a simple way to estimate peak flood discharges and widely used for a river that does not have to take into account water storage phenomenon, especially in a case where only the peak flood discharge is needed. The Mola River is:

- A river that does not have a plan of installation of flood control facilities such as dams
- A relatively small sized river with a watershed area of 150 km^2 (less than 200 km^2)
- A river that does not have to take into account watershed storage phenomena

$$Q = f \cdot r \cdot A/3.6$$

Q : Flood discharge (m3/s)

f : Runoff coefficient

r : Rainfall intensity within the time of flood concentration (mm/hr)

A : Catchment area (km2)

(1) Runoff Coefficient

The value of runoff coefficient needs to be set up in consideration of ground cover/vegetation conditions in the upstream area of the Mola Bridge as well as the catchment shape and development status. Since the soil during flood events seems to be in almost saturated condition, it is assumed that the flood water does not seep into the ground but rather runs off as surface water. For these reasons, in this case, the runoff coefficient is determined to be 0.9 using Table 2.2.6 as a reference.

Table 2.2.6 Runoff Coefficient of Rivers

River Conditions and Terrain Conditions	Range of Runoff Coefficients	Adopted Runoff Coefficient
Steep mountain	0.75~0.90	0.90
Mountains of tertiary deposit	0.70~0.80	
Hilly lands and forests	0.50~0.75	
Plain cultivated lands	0.45~0.60	
Irrigated paddy field	0.70~0.80	
Mountainous river	0.75~0.85	
Plain river	0.45~0.75	
Large river, more than half of the basin is plain	0.50~0.75	

Source: MLIT Technical Criteria for River Works (Draft) Practical Guide for Research

(2) Flood Concentration Time

Flood concentration time is expressed as the sum of a time taken to reach from the furthest upstream point to the river channel (inlet time) and a time taken to flow through the channel (flow time). The inlet time is difficult to be unambiguously determined because it may be affected by many factors such as the shape and area difference of the catchment close to a river channel, surface slope, cover condition, flow distance, rainfall intensity, etc. Therefore, in this case, the inlet time is determined to be 30min (Mountainous river basin) using the following values as a reference.

Table 2.2.7 Example of Average Inlet Time

River basin Conditions	Average Inlet Time
Mountainous river basin:	30mins
River basin with very steep slope :	20mins
Area with sewerage system :	30mins

Source: MLIT Technical Criteria for River Works (Draft) Practical Guide for Planning

Time of flow (t) is calculated with Rziha formula shown below. Rzhiha formula is an empirical formula that is expressed by a distance of the channel and elevation difference.

$$T = L / W$$

Where, W: Flood flow velocity (m/s)

L: Distance of the Channel = Approx. 1300m (judging from drawing)

$$W = 20 \times (H/L)^{0.6}$$

Where, H: Elevation difference=Approx. 1230m (judging from drawing)

Substitution of these values into the above formulae gives W=4.86 (m/s) and time of flow (t)=44.58min. Hence, addition of this value to the predetermined inlet time of 30min results in a flood concentration time of 74.58min.

(3)Rainfall Intensity within the Flood Concentration Time

Rainfall intensity within the flood concentration time is calculated with the "Monobe formula" below:

$$r = R24/24 \cdot (24/T)^{0.6}$$

Where, r: Rainfall intensity within the flood concentration time(mm/hr)

R24: probable daily rainfall (mm/day) (Tables 2.2.3 and 2.2.4)

T: Flood concentration time(hr) (1.243 hr from(2))

(4) Probable Flood Discharge

Table 2.2.8 provides probable flood discharges (throughout the year) calculated with Rational Method using Mononobe formula described in (3), whereas Table 2.2.9 shows probable flood discharges during the dry season when the construction of temporary coffer dams is scheduled.

Table 2.2.8 Probable Flood Discharge (Throughout the Year)

Return Period	Daily Rainfall (mm/d)	Rainfall Intensity(mm/hr)	Flood Discharge (m^3/s)
2	183.2	45.1	1,700
3	212.5	52.3	1,970
5	245.1	60.3	2,270
10	286.1	70.4	2,650
50	376.3	92.6	3,480
100	414.4	102.0	3,840

Table 2.2.9 Probable Flood Discharge(Dry Season)

Return Period	Daily Rainfall (mm/d)	Rainfall Intensity (mm/hr)	Flood Discharge (m^3/s)
2	75.1	18.5	700
3	106.6	26.2	990
5	141.6	34.9	1,320

(5) Evaluations for Rive Discharge Capacity

Using the assumption of water levels during the floods for the present case and the plan's case, discharge capacity of the river is evaluated. The water level is determined based on non-uniform flow calculations. Cross-sections are defined by assuming the centerline alignment, and then, water level, depth of water, and flow velocity are calculated for each cross-section (of 27cross-sections, at intervals of 50m, total length of 1,300m) . Calculation conditions are given below.

1) Roughness Coefficient

Judging from the Table 2.2.10, the coefficient of roughness is determined to adopt 0.04, a standard value for natural rivers.

Table 2.2.10 Standard Roughness Coefficient

River Conditions	Range of Manning's n(Roughness Coefficient)	Adopted Roughness Coefficient
Minor streams on plain with weeds, and shrubs	0.030 ~ 0.040	0.040
Minor streams on plain with more weeds and gravel bed	0.040 ~ 0.055	
Mountain streams with gravels and cobbles	0.030 ~ 0.050	
Mountain streams with cobbles and boulders	0.040 or more	
Major streams with gravel bed	0.025 ~ 0.040	

Source: MLIT Technical Criteria for River Works (Draft) Practical Guide for Planning

2) Starting Point Water Level

Non-uniform flow calculations are to be used for successively calculating the water level of a certain cross section from that of the previous cross-section; prior to starting the calculation, a water level at the starting point (Starting Point Water Level) needs to be given as a boundary condition. When a channel in the plan is of ordinary flow, a water level at the down-stream end must be given as a starting point water level whereas, when the channel is of jet flow, a water level at the upstream end.

As a result of a topographic survey, the Mola River was turned out to be an extremely steep river with a gradient of1/60. Therefore, a water flow around the Mola Bridge is assumed to be a jet flow. Hence, the calculations are to be made by giving a water level at the upstream end of the targeted reach, starting from the upstream end to the down-stream end.

3) Establishment of an Effective Range of River

Water level calculations based on non-uniform flow calculation method, in principle, exclude the following zones because such zones are not associated with water discharge and regarded as a "dead water" region:

- A zone where there is no water flow on the surface of a channel
- A zone where (if any) the water flow is deemed to be extremely low
- A zone where the water flow creates whirlpools(looped vortex)

Although the right-bank levee of the upstream side from the Mola Bridge has been severely eroded by the flood occurred in August 2010, a calculated water level varies depending on whether the area is deemed as a dead water region. Thus, in this project, the range of a channel (Effective Range of River) is determined to be: up to the top level of the existing revetment when the scale of the flood is such that it cannot overflow the existing revetment(equivalent to 1/2~1/50 of return period), or up to the level of the surface of National Route A02 when the scale of the flood is such that it may overflow the revetment (1/50 or more of return period), on the assumption that river water will inflow into an eroded area.

(6) Calculations for the Water Level of the Present River Channel and Evaluations for the Discharge Capacity

For the present river channel, its discharge capacity is evaluated in combination between the results of non-uniform flow calculations and those of interviews on the previous flood damage.

1) Results of Calculations for the Water Level of the Present Channel

On the basis of non-uniform flow calculation method, the water levels were calculated using the values of probable flood discharge shown in Tables 2.2.8 and 2.2.9. The results are provided in Table 2.2.11.

Table 2.2.11 Results of Calculations for the Water Level of the Present Channel

Survey Point	Height of the Ground Near the River Bank (in between the levees)		Height of the Revetment		Probable Flood Discharge (m3/s)					
					1700	1970	2270	2650	3480	3840
	Left-bank Side	Right-bank Side	Left-bank Side	Right-bank Side	T=1/2	T=1/3	T=1/5	T=1/10	T=1/50	T=1/100
0+000	54.365	58.450	54.365	58.450	56.046	56.222	56.475	56.758	57.358	57.478
0+050	56.194	59.871	56.194	59.871	57.155	57.400	57.650	57.833	58.169	58.289
0+100	57.283	60.714	57.283	60.714	58.467	58.626	58.783	58.932	59.216	59.290
0+150	58.815	62.685	58.815	61.385	59.063	59.214	59.357	59.502	59.803	59.906
0+200	60.791	63.904	60.791	62.984	60.471	60.555	60.638	60.731	60.935	61.004
0+250	62.806	65.123	62.806	64.152	61.193	61.318	61.427	61.549	61.773	61.864
0+300	66.894	65.456	63.024	65.371	62.437	62.590	62.712	62.842	63.136	63.246
0+350	64.292	66.299	64.292	66.299	63.419	63.542	63.672	63.823	64.019	64.103
0+400	66.993	66.696	66.993	65.827	63.960	64.095	64.239	64.412	64.763	64.906
0+450	65.315	67.308	64.889	67.238	64.276	64.423	64.597	64.890	65.252	65.457
0+500	65.924	67.164	65.051	67.108	65.211	65.327	65.433	65.561	65.819	65.950
0+550	67.347	68.328	67.347	67.455	65.915	66.051	66.188	66.353	66.690	66.828
0+600	72.934	69.076	72.934	69.076	66.506	66.613	66.727	66.864	67.151	67.278
0+650	71.950	69.723	69.478	68.254	67.464	67.592	67.726	67.888	68.282	68.410
0+700	69.892	70.326	69.892	69.305	68.193	68.299	68.396	68.513	68.758	68.864
0+750	70.530	70.507	70.530	69.914	68.887	69.017	69.155	69.323	69.664	69.933
0+800	71.946	70.377	71.946	70.377	69.312	69.410	69.514	69.645	69.914	70.048
0+850	72.885	71.353	72.885	71.238	70.502	70.607	70.727	70.875	71.300	71.414
0+900	73.562	72.041	73.562	71.819	71.395	71.510	71.631	71.778	72.165	72.267
0+950	74.160	72.677	74.160	72.474	72.104	72.192	72.288	72.424	72.781	72.880
1+000	74.150	73.580	74.150	72.689	72.893	73.032	73.155	73.263	73.476	73.634
1+050	77.647	74.354	77.647	74.354	73.580	73.683	73.824	74.009	74.401	74.496
1+100	78.543	74.778	78.543	74.778	74.522	74.639	74.820	74.900	75.110	75.182
1+150	79.141	75.798	76.354	75.798	75.302	75.409	75.522	75.661	75.976	76.064
1+200	77.186	76.352	77.186	76.352	76.220	76.416	76.524	76.653	76.918	77.023
1+250	79.211	76.858	77.963	76.858	76.997	77.099	77.207	77.328	77.575	77.676
1+300	81.284	77.382	81.284	77.382	77.563	77.671	77.775	77.901	78.178	78.275

Note) Green: A range where the water level becomes higher than that of the revetment in the left-bank side area. Yellow: A range where the water level becomes higher than that of the revetment in the right-bank side area.

2) Results of the Interview on Flood Damage Situations

At a private home along National Route A02 of the right-bank side (survey point: 0+800 or near it), interviews were made about the damage caused by the flood that occurred on August 2, 2010. The results of the interview are provided in the following:

- The entrance was 70cm above the ground surface. No water reached there.
- A few shrubs along the road flew away and also, a house and its agricultural land were washed out by the flood. The devastated area remains severely eroded.
- National Route A02 was submerged under approximately 30-50cm of water; however, the force of the water stream was not as strong as one can remember.
- Before the flood occurred in August, 2010, also in 2006, flood events took place, resulting in the erosion of the river bank only.

Further, interviews were also made with a staff member of MOI's Mariana Office who is responsible for the whole project area and with the representative of the district. The results are given below:

- During the flood in August 2010, submersion of National Route A02 took place. This is not caused by overflows due to the rise in the water level of the Mola River, but by the insufficient performance of an irrigation system and a feed canal (for daily-life water use) in the upstream-side area.
- In conclusion, the swollen river severely eroded its bank but did not cause the overflow.

Around 10 p.m. on May 25, 2012, when the field survey was underway, unexpected water level rise occurred on the Mola River. As a result, at the right-bank side of the river (survey point: 0+900 or near it), the base part of the revetment was scoured which had been repaired in the MPW's emergency repair work, and two locations of the revetment was damaged that encompassed a few tens of meters. After checking on the situation at a later date, the survey confirmed the occurrence of overflow in the upstream-side feed canal, whose range was limited. For these reasons, it is concluded that the flooding of National Route A02 resulted from the overflowing of the upstream-side feed canal, but not from the overflowing from the revetment.

3) Evaluations for the Discharge Capacity of the Present River Channel

On the basis of the above-mentioned water level calculation results and interview results, the discharge capacity of the present river channel is evaluated as follows:

- In the upstream area from a point around 1km upstream of the Mola Bridge, submersion/flooding is expected to occur at the right-bank side, when a 1/2 year probable flood discharge becomes 1,7000m3/s or more.
- The significantly eroded area in the right-bank side due to the flood occurred in August 2010, is deemed to be a water colliding front. Thus, it may be assumed that the exacerbated erosion of the area was not caused by washout/scouring due to overflow but caused by the overturning of the existing revetment due to shortage of its structural strength.

(5) Calculations for the Water Level of the Planned Channel

Confirmation is made on how high/low the water level of the channel will be when the revetment plan has been completed. The scope of the revetment plan is as follows:

- Left-bank side: Survey Point No.0+300~No.0+350 (2 cross-sections)
- Right-bank side: Survey Point No.0+350~No.0+950 (13 cross-sections)

Table 2.2.12 shows the results of calculated water levels for probable flood discharge with 1/50 return period and 1/100 return period. The results of the calculation tell us that the planned revetment will be located at the same vertical spatial position as that of the existing one; consequently, the both water levels become almost the same. Hence, it is considered the present discharge capacity is able to be firmly secured after the project has been completed.

Table 2.2.12 Results of Calculations for the Water Level of the Planned Channel after the Revetment Plan has been Completed

Survey Point	Height of the Ground Near the River Bank (in between the levees)		Top Height of the Planned Revetment		Probable Flood Discharge (m3/s)	
					3480	3840
	Left-bank Side	Right-bank Side	Left-bank Side	Right-bank Side	(T=1/50)	(T=1/100)
0+000	54.365	58.450	-	-	57.358	57.478
0+050	56.194	59.871	-	-	58.168	58.289
0+100	57.283	60.714	-	-	59.218	59.292
0+150	58.815	62.685	-	-	59.801	59.904
0+200	60.791	63.904	-	-	60.940	61.010
0+250	62.806	65.123	-	-	61.762	61.845
0+300	66.894	65.456	63.307	-	63.159	63.329
0+350	64.292	66.299	64.126	65.800	64.144	64.197
0+400	66.993	66.696	-	65.800	64.763	64.906
0+450	65.315	67.308	-	66.066	65.252	65.458
0+500	65.924	67.164	-	66.885	65.826	65.955
0+550	67.347	68.328	-	67.705	66.689	66.828
0+600	72.934	69.076	-	68.525	67.122	67.236
0+650	71.950	69.723	-	69.344	68.218	68.352
0+700	69.892	70.326	-	69.583	68.763	68.873
0+750	70.530	70.507	-	69.583	69.679	69.946
0+800	71.946	70.377	-	70.403	69.906	70.035
0+850	72.885	71.353	-	71.223	71.383	71.471
0+900	73.562	72.041	-	72.043	72.195	72.293
0+950	74.160	72.677	-	72.862	72.902	73.001
1+000	74.150	73.580	-	-	73.476	73.634
1+050	77.647	74.354	-	-	74.401	74.496
1+100	78.543	74.778	-	-	75.110	75.182
1+150	79.141	75.798	-	-	75.976	76.064
1+200	77.186	76.352	-	-	76.918	77.023
1+250	79.211	76.858	-	-	77.575	77.676
1+300	81.284	77.382	-	-	78.178	78.275

Note) Green: A range where the water level becomes higher than that of the revetment in the left-bank side area.
Yellow: A range where the water level becomes higher than that of the revetment in the right-bank side area.

(6) Calculations for the Water Level of the Present Channel during Construction

A temporary cofferdam is planned to be installed approximately 20m away from the top of the planned revetment. In order to determine the height of the top of the cofferdam, calculations are made for its water level during the dry season. Since this structure is to be temporarily built, the values of flood discharges with 1/2, 1/3, and 1/5 return periods need to be calculated. The following two cases are reviewed in consideration of the consecutive order of the construction work.

a. Left Bank: Present State＋Right Bank: Revetment Construction
b. Left Bank: Revetment Work＋Right Bank: Revetment Completion

The results of the calculation are provided in Table 2.2.13.

Table 2.2.13 Results of Calculations for the Water Level of the Planned Cofferdam

Height of the top of the planned revetment			Case a (Left bank: Present, Right bank: Under construction)			Case b (Left bank: Under Construction, Right bank: Construction completed)		
			Probable Water Discharge (m3/s)			Probable Water Discharge (m3/s)		
			700	990	1310	700	990	1310
Survey Point	Left-bank Side	Right-bank Side	(T=1/2)	(T=1/3)	(T=1/5)	(T=1/2)	(T=1/3)	(T=1/5)
0+000	-	-	55.152	55.601	55.849	55.152	55.601	55.849
0+050	-	-	56.330	56.684	56.901	56.330	56.684	56.901
0+100	-	-	57.668	57.913	58.195	57.668	57.913	58.195
0+150	-	-	58.272	58.470	58.764	58.249	58.468	58.764
0+200	-	-	59.540	59.972	60.211	59.614	59.978	60.211
0+250	-	-	60.664	60.820	61.025	60.600	60.779	60.973
0+300	63.307	-	61.475	61.812	62.169	61.581	62.003	62.267
0+350	64.126	65.800	62.585	62.887	63.153	62.742	63.008	63.253
0+400	-	65.800	63.315	63.557	63.764	63.311	63.549	63.751
0+450	-	66.066	63.598	63.880	64.046	63.598	63.886	64.062
0+500	-	66.885	64.434	64.672	64.978	64.435	64.683	64.981
0+550	-	67.705	65.271	65.482	65.691	65.273	65.487	65.697
0+600	-	68.525	65.982	66.154	66.312	66.011	66.179	66.331
0+650	-	69.344	66.943	67.128	67.311	66.912	67.092	67.269
0+700	-	69.583	67.679	67.868	68.045	67.651	67.837	68.008
0+750	-	69.583	68.327	68.538	68.732	68.298	68.501	68.691
0+800	-	70.403	68.912	69.082	69.215	68.830	69.002	69.145
0+850	-	71.223	70.098	70.286	70.462	70.038	70.219	70.393
0+900	-	72.043	70.955	71.120	71.285	70.907	71.067	71.227
0+950	-	72.862	71.648	71.849	72.011	71.587	71.792	71.958
1+000	-	-	72.315	72.515	72.695	72.315	72.515	72.695
1+050	-	-	73.087	73.299	73.441	73.087	73.299	73.441
1+100	-	-	73.847	74.131	74.320	73.847	74.131	74.320
1+150	-	-	74.749	75.000	75.153	74.749	75.000	75.153
1+200	-	-	75.675	75.863	76.033	75.675	75.863	76.033
1+250	-	-	76.347	76.562	76.759	76.347	76.562	76.759
1+300	-	-	76.811	77.024	77.393	76.811	77.024	77.393

2-2-2-2 Topographical and Geological Surveys

2-2-2-2-1 Topographical Survey

(1) Survey Practices

As shown in Table 2.2.14, topographical survey was undertaken.

Table 2.2.14 Items and Quantity in the Topographical Survey

Item	Quantity	Specification/Deliverables	Objective
Plane Survey	780,000 ㎡	Existing bridge (upstream-side 1,000m+downstream-side 300m)× width 600m (600m=average width 400m＋existing revetment 100m× both side) Deliverables : Planimetry drawing 1/1000 (digital) , contour line 0.5ｍ	Preparation of a topographic plan
Longitudinal Profile Survey	1,300m	Existing bridge's downstream side 300m＋upstream side 1,000m Deliverables: cross-sectional profile: width(1/100) and height(1/500)(digital)	Present bed slope
Cross-section Profile Survey	15,600m	50m pitch× 600m width (26 cross-sections) Deliverables: cross-sectional profile: 1/200(digital)	Present cross-section profile, present longitudinal profile
	10,500m	20m pitch×100m width(105 cross-sections) Deliverables: cross-sectional profile: 1/200(digital)	Present revetment's profile
	1,200m	Point of the Mola Bridge and points 30ｍ upstream/downstream from the bridge, 450m in width	Cross-sectional profile of channel at a point of the Mola Bridge and points in the upstream-side/downstream-side
Control Point Survey	43 points	Control points are set over an area of approx. 100m in circumference around each of the plane survey points. Deliverables: Records of control points	Establishing control points, Survey recurrence at the time of construction

In the longitudinal/cross-sectional profile survey, it was determined to use the same center line and cross sections as those used in the basic design implemented in 2003. This allows us to compare the results of this survey with the data of the 2003 basic design, and to understand changes in riverbed profile. The control point and benchmark were determined to use the same as those used in the scheme drawing for the newly-built Mola Bridge, to ensure the consistency in height between the two bridges. This allows for the same coordinate system and height as those of the newly-built Mola Bridge and thus for comparing between these two bridges. In order to ensure the integrity of control points and benchmarks even after the beginning of the construction, their pile was surrounded by a concrete enclosure and stamped, at its top, with the pile number, coordinate, and altitude.

(2) Appearance of the River Channel

Observations of the present river channel were made by a topographic survey. The results are presented below:

- With heavily weathered, steep mountains at the upstream side, the Mola River, a typical flashy stream in Timor-Leste, runs through a small alluvial fan out into the estuary.
- The area around the Mola Bridge is located at the top of an alluvial fan where sediment load is deposited. The Mola River is a so-called "wild river" where, everytime the flood comes, not only sediment deposit but also the scour and erosion of river beds/river banks repeatedly and actively occur.
- The width of the channel is approximately 500m in the upstream side of the Mola Bridge, narrowed to 400 m at the point of the bridge, and becomes broader in the downstream side as the river flows toward the right and left affluents. Hence, the width becomes narrowest at the Mola Bridge. The bed slope and curvature radius for this section are assumed to be 1/61 and R=2000m, respectively.
- In the downstream area from a point 200m upstream of the Mola Bridge, the left-bank side of the channel is lower than the right-bank side and, in the downstream area from the bridge, the channel broadens to the left-bank side. To the contrary, in the upstream area from the point 200m upstream of the Mola Bridge, the right-bank side of the channel becomes lower than the left-bank side. Although the position of water routes varies everytime floods occur, the main stream in the channel always flows from the right-bank side toward the point of the existing bridge in the left-bank side.
- According to the data for 2003, most of the water routes lay between Abutment 1(A1) and Pier 2(P2), whereas, present water routes shift to an area between Pier 2(P2) and Abutment 2(A2) of the existing bridge. Hence, neither degradation nor scouring of the riverbed is observed and the bed level (lowest bed height) has not significantly changed since 2003. Due to the shift of the water routes, the scoured area extends laterally, scouring the base of gabion cages around the abutments.
- Parts of the existing revetment in the upstream area of the right-bank side fell off due to the flood that occurred on May 22, 2012. The damaged area is identical to the area eroded by the flood that came in August 2010. This location seems to become a water colliding front during flood events. Thus, the zone where the exiting revetment has been already built may be regarded as valid for design considerations.

Fig. 2.2.2 Present Water Route in the Mola River (photographed on June 2, 2012)

(Upper: Overlooking the upstream side from the center of the Mola Bridge/ Lower: Overlooking the downstream side from the center of the Mola Bridge)

(3) Changes in Riverbed Level

Comparison of the survey results between 2003 and 2012 is made to calculate the difference in riverbed's area between these two years. The obtained difference is divided by the transverse width of riverbed to give an average change in riverbed width. The results are shown in Table 2.2.15 and Fig. 2.2.3 to Fig 2.2.6.

Table 2.2.15 Changes in Average Riverbed Level

(Comparison of data between 2003 and 2012)

Survey Point	Deepest Riverbed Level in 2003	Deepest Riverbed Level in 2012	Change in the Deepest Riverbed Level	Average Change in Riverbed Width	Deepest Riverbed Level based on Survey Results
0	55.59	55.12	-0.47	-0.12	53.23
50	56.48	56.18	-0.30	-0.12	54.21
100	56.63	56.88	0.25	-0.23	55.37
150	58.11	57.73	-0.38	-0.62	55.85
200	58.19	58.23	0.04	-0.11	57.49
250	58.66	59.00	0.34	-0.28	58.66
300	59.32	59.85	0.53	-0.31	59.32
350	59.85	60.08	0.23	-0.06	59.85

400	60.83	60.36	0.53	0.14	60.83
450	62.32	61.85	-0.47	-0.23	61.85
500	63.43	62.66	-0.77	-0.28	62.66
550	64.20	63.46	-0.74	-0.39	63.46
600		64.31			63.46
650		65.11			65.11
700		66.18			66.18
750		65.84			65.84
800		67.26			67.26
850		67.89			67.89
900		68.54			68.54
950		70.23			70.23
1000		69.99			69.99
1050		71.35			71.35
1100		72.02			72.05
1150		73.01			73.01
1200		73.72			73.72
1250		74.11			74.11
1300		74.60			74.60
				-0.24	

As shown in Table 2.2.15, the riverbed level in this year becomes lower by 0.24m than that in 2003. Average riverbed variation for nine years from 2003 is 0.24m, which is considered to be a relatively small value. Hence, in designing river structures such as the revetment, only meeting the standard value is sufficient for maintaining the intrinsic performance of the structure. In conclusion, it does not seem to need any particular construction that can be designed in consideration of more severe values than the standard value.

However, since the average value of riverbed variations in this study was calculated based on the data obtained from only two rounds of survey (in 2003 and 2012), it may be possible that a momentary degradation of riverbed took place during the 9 years inbetween 2003 and 2009. Therefore, in this project, in order to respond to more severe riverbed degradation than expected, a steel-sheet pile of 2m in length (that serves as measures to prevent soil piping) is determined to be installed under the base of the revetment. The quantity of the data obtained from two rounds of survey is too small to exactly understand what the riverbed variations of the Mola River are. Therefore, a continuous monitoring is recommended.

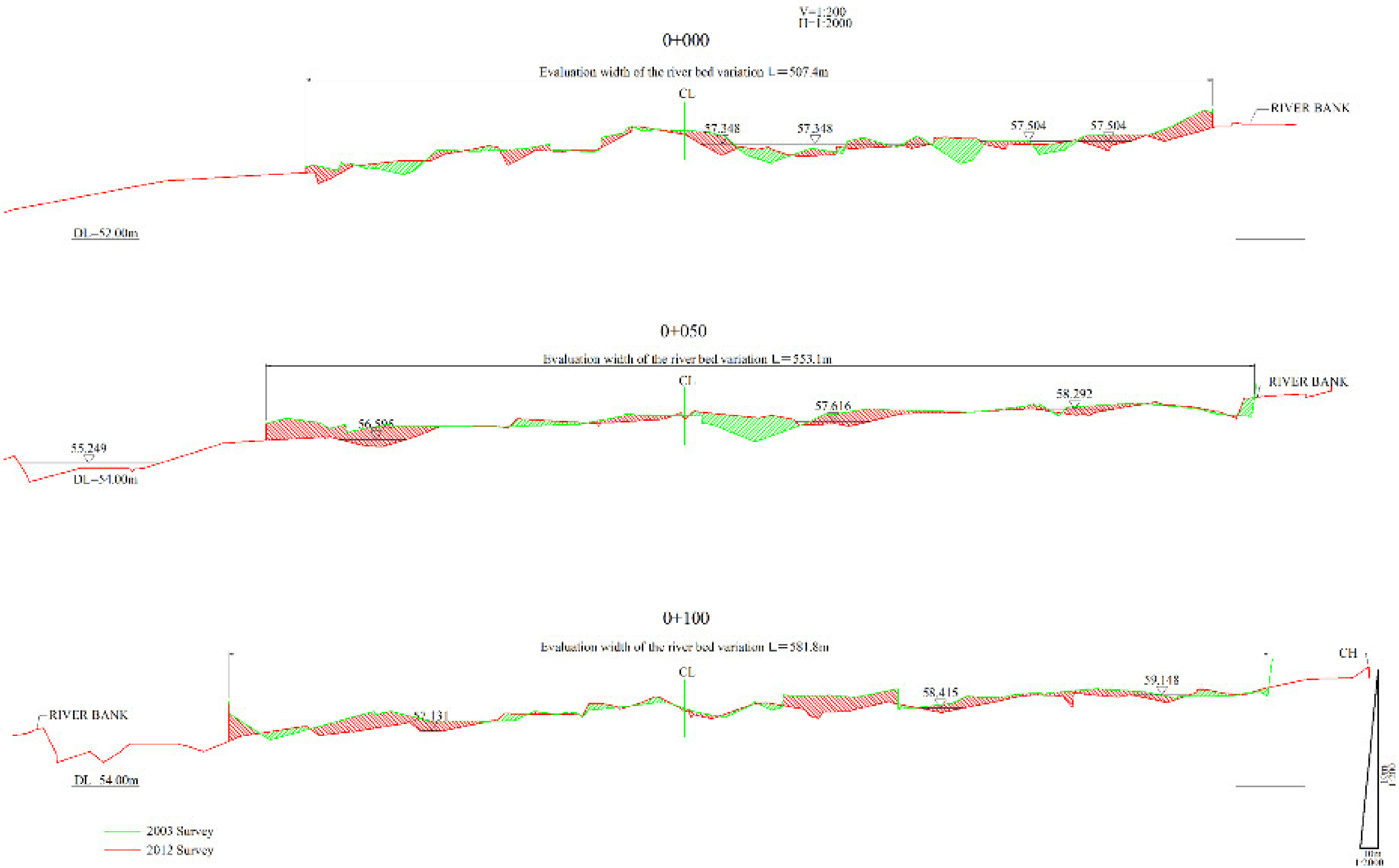


Fig. 2.2.3 Topographic Variations based on the Comparison of Cross-Sections (1/4)

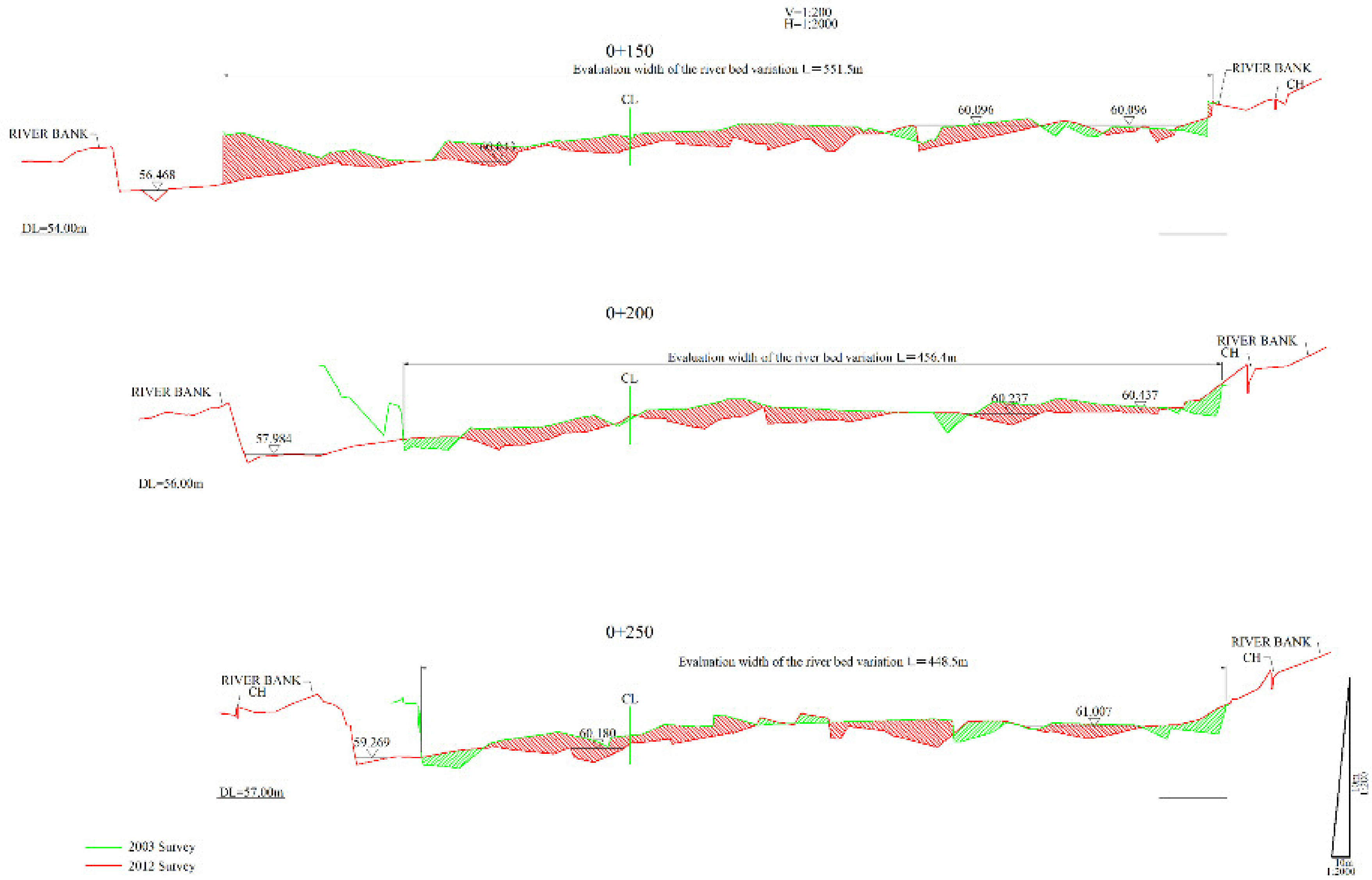


Fig. 2.2.4 Topographic Variations based on the Comparison of Cross-Sections (2/4)

Fig. 2.2.5 Topographic Variations based on the Comparison of Cross-Sections (3/4)

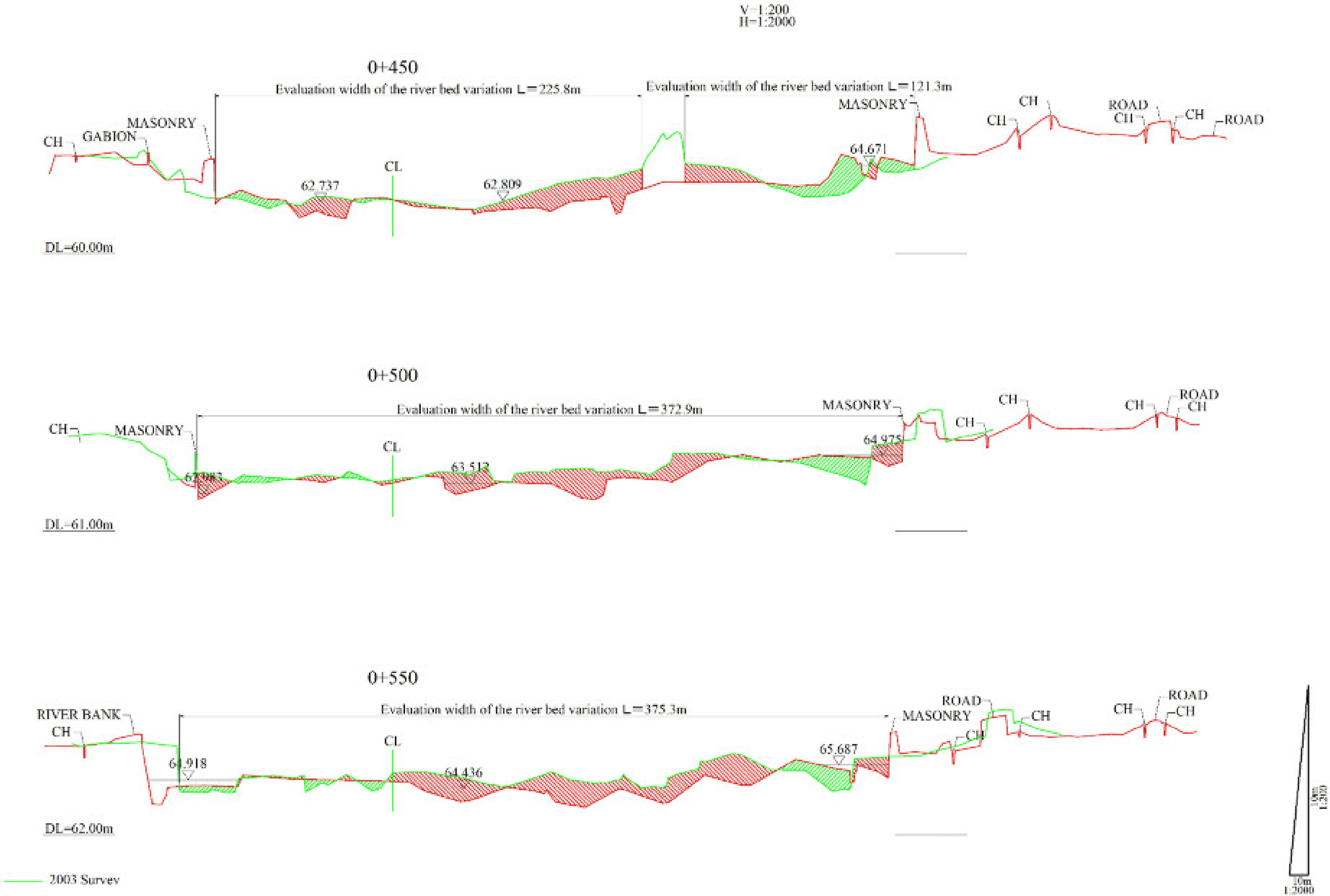


Fig. 2.2.6 Topographic Variations based on the Comparison of Cross-Sections (4/4)

(4) Deepest Riverbed Level

Changes in the deepest riverbed level as shown in Table 2.2.14 are given as a graph in Fig. 2.2.7.

Fig. 2.2.7 represents that riverbed levels in the range of a survey point between 100m and 400m are higher than those in the up-stream and down-stream side of the range. The riverbed levels in this range are considered to gradually go lower in the future due to the riverbed variations in the longitudinal direction. Design riverbed levels for revetment design need to be determined using an envelope created by connecting two deepest riverbed levels outside the range (i.e., points 100 and 450), thereby determining the required depth of footing.

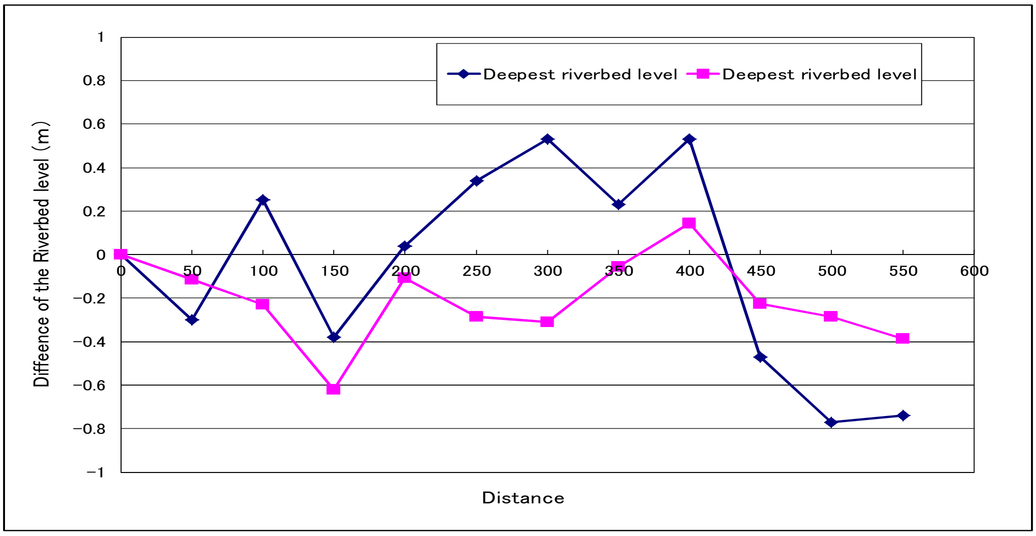


Fig 2.2.7 Changes in Deepest Riverbed Level and Average Riverbed Level

2-2-2-2-2 Geological Survey

(1) Summary

The Timor Island is a narrow long island (with a length of 500km and the maximum wide of 105km), which is located at the southeastern part of the Sunda Islands (also called the Indonesian Archipelago) that create an island arc and face the Indian Ocean. The eastern half of the island is the territory of Timor-Leste, whose topography is characterized by, at the center of the island, the central backbone range that runs from east-northeast to west-southeast direction and by hilly terrains that are steeply sloped down from the watershed of the backbone range to the north and south sides and coastal plains.

Rivers stemming from the watershed of the central backbone range to north and south sides, meander short channels and pour out into the Banda Sea and the Timor Sea. Although the profile of these rivers varies depending on the annual rainfall in the island, because the wide distribution of porous limestone strata allows water readily to pass through the riverbed layers, such rivers experience extremely low river flows during the dry season whereas, during the rainy season, they convey muddy stream flows with insufficient erosion and flooding control, which makes them turbulent rivers.

(2) Geography around the Mola Bridge

1) Contents of Geological Survey

The contents of geological surveys conducted for Mola Bridge's scour prevention work and for revetment work design are provided in Tables 2.2.16 and 2.2.17, and the implementation points in Fig. 2.2.8.

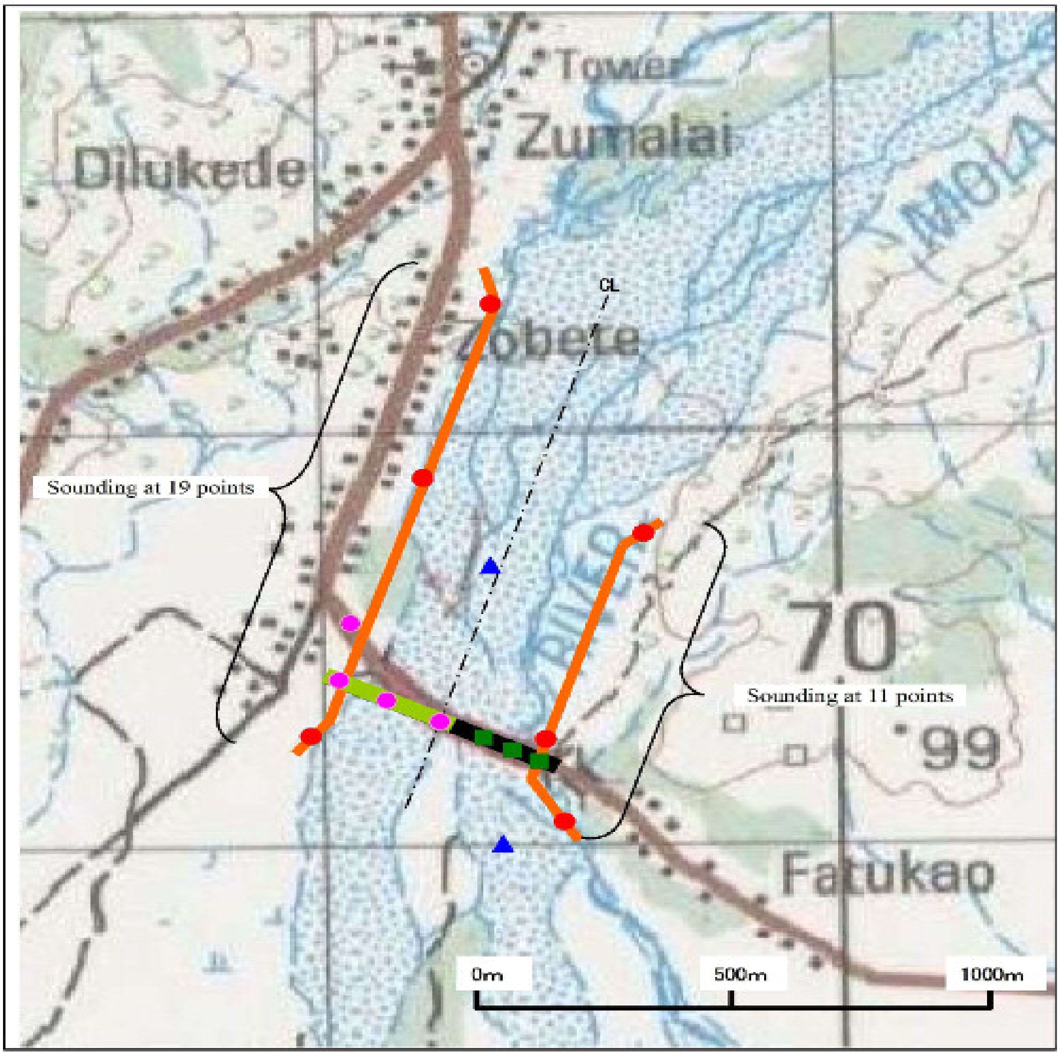
Table 2.2.16 Contents of Geological Survey

Item of Survey	Contents	Quantity of Implementation
Composition and Characteristics of Strata	Mechanical boring SPT	5points Total extension for survey 55m
	Lab. Test (grain size distribution, water content)	12 samples
Riverbed Survey	SPT (successive drives)	Left bank side: 11points Right bank side: 15points
	River deposit material, grain size distribution	1 point for up-stream and/or down-stream side
Survey on the type and depth of foundation	Trial excavation	P1,P2,A2 3points Non-destructive test 3 points

Table 2.2.17 Items for the Geological Survey and their Quantity

Item	Quantity	Specs./Deliverables	Objective
Boring	6 points	3 eroded points in the right bank side and 2 eroded points in the left bank side 1 point in the area of the downstream side where foot protection work is scheduled 10m/point×6 points=60m in total Deliverables: Geological longitudinal profile	Soil Composition
SPT(Standard Penetration Test)	60 points	Implemented at intervals of 1m layer for each boring Deliverables: Geological columnar section	Ground strength
Laboratory Test	60 points	10 materials for each boring hole Physical property test Deliverables: Results of each type test	Soil property values/characteristics
Material Test	9 materials	3 samples×3 materials Physical property test, single shear test Deliverables: Results of each type test	Quality of backfill material
Swedish Sounding Test	30 points	For the area with a total distance of 1,300m(1,000m(left bank)+300m(right	Strength of the existing revetment's

		bank)), tests were performed at 40m－50m pitch. Deliverables: Geological cross-section	base
Trial Excavation	5 points	Check on the substructure of the existing bridge: 3 points Check on river deposit materials: 2 points (including grain size test) Deliverables: Observation Report	Visual observation



- Boring: 6 points ● This time ● Existing
- Swedth Sounding: 30 points (19 on the right bank and 11 on the left bank)
- Sampling: 3 points (borrow pit)
- Foundation survey pit: 3 points ■
- Sediment survey pit: 2 points ▲

-Quantities are not fix and able to be amended due to site condition and other reasons

Fig. 2.2.8 Survey Point Map

2) Composition of Strata

The Mola River, whose channel width is 500m or longer at its broadest, is a braided river and creates an alluvial fan at which top is located around the Mola Bridge. The upstream side of this river has an extremely-weathered, steep mountainous topography and both an abundant sediment load from the upstream basin and the tractive force of the flashy stream reflect repeated sedimentation and scour.

According to the boring survey conducted in Basic Design Study for 2003, it is found that, both gravel layers, containing many cobbles and boulders, and relatively-well compacted silt layers (N value≥20), containing sand, are being alternately and laterally deposited.

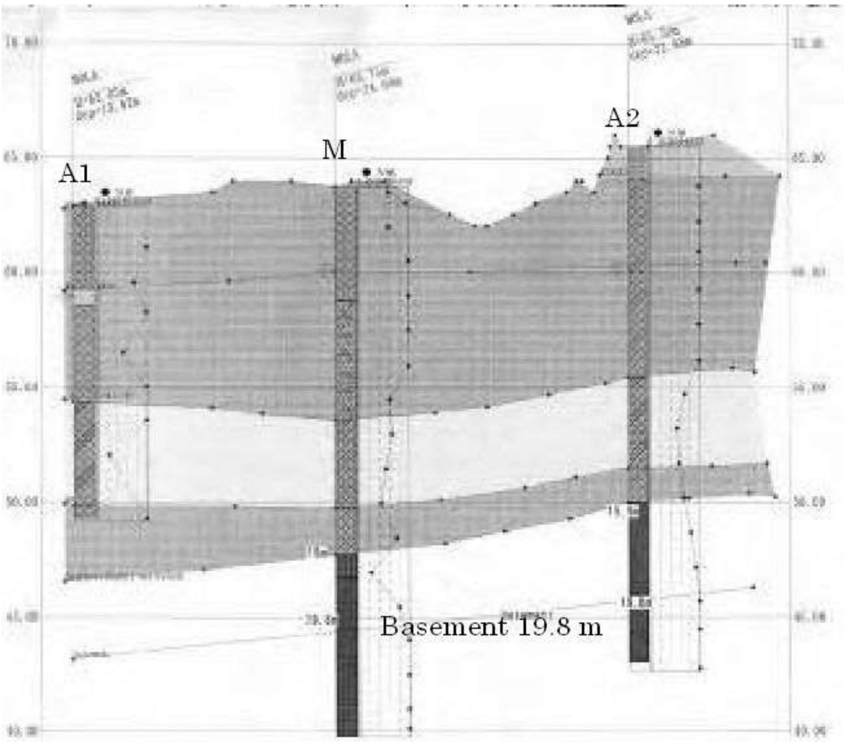


Fig-2.2.9 Expected Ground Composition at the Position of the Mola Bridge

(Source: Basic Design for 2003, JICA)

In this project, a pilot boring was conducted for revetments to be installed on the right/left-bank levees, in order to check on their geology that serves as basic data for the work. In light of the footing’ s installation depth, the boring depth is determined to be 10m below the riverbed surface.

- **Left-bank Side (Boring BH-No1 & No2)**

  Gravel layers containing many cobbles and boulders are deposited. In particular, at layers near the riverbed, the content of cobbles and boulders becomes high. The strata deeper than 5m are gravel layers with high silt content.

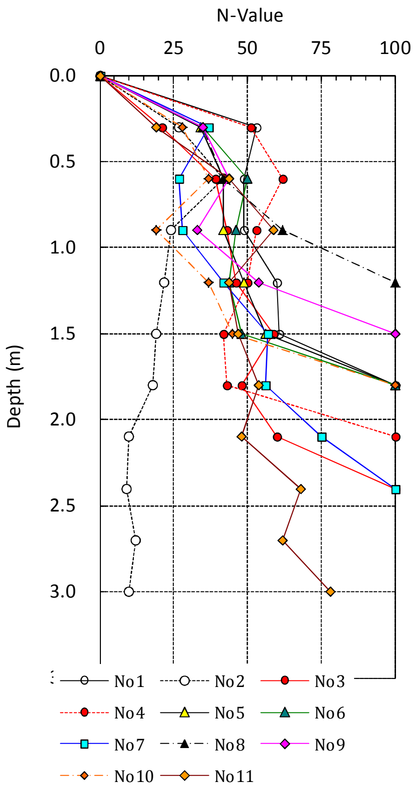
- **Right-bank Side(Boring BH-No3 & No4)**

  The profile is almost the same as that of the left-bank side. Layers near the bed have a particularly high content of cobbles and boulders and layers deeper than 5m are a well-compacted, sandy silt layer that has abundant content of sand and silt, with an average N value of 25 or more.

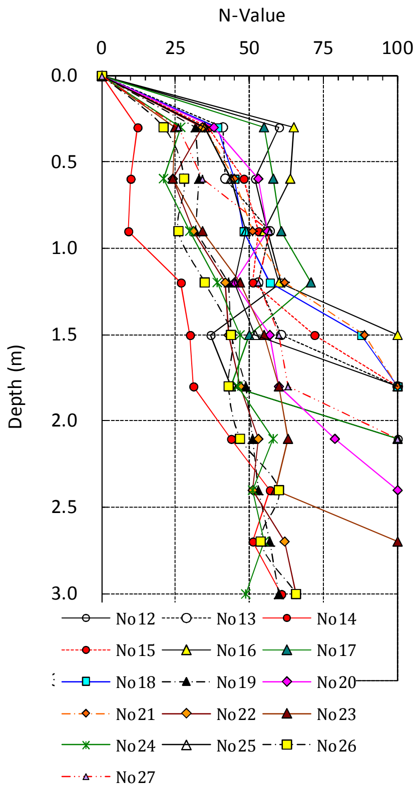
3) The Results of SPT (Standard Penetration Test)

In order to check on the properties of the riverbed ground in a wide range of areas near the revetment-planned site, the SPT (standard penetration test) blow was performed from the riverbed surface and then the blow counts of a heavy hammer were recorded per 30cm of penetration. The test results for the right-bank and left-bank sides are separately given in Fig.2.2.10. SPT blows are generally continued up to 50 counts; however, in Timor-Leste, driving a sampler is usually continued until the further advance of the sampler cannot be made. If 100 blow counts were insufficient to achieve 30cm penetration, the test was stopped.

Due to the presence of too many cobbles and boulders, many attempts of the test resulted in an N value of 50 in a layer shallower than 3m or experienced difficulty in further penetration. However, only one attempt for the left-bank side shows an N value of around 10 even at a depth of 3m. In this test hole, luckily, the sampler did not encounter any boulder. For these reasons, it may be considered that the sediment trapped between cobbles or boulders have a similar degree of compaction.



(a) Left-bank side



(b) Right-bank side

Fig. 2.2.10 The Results of SPT for the Riverbed Ground

4) Results of the Grain Size Survey for Riverbed

A grain size distribution curve for river deposit materials is given in Fig. 2.2.12. Since it is difficult to perform laboratory grain size tests on samples containing cobbles/boulders, firstly, as shown in Fig. 2.2.11, the separation of cobbles and boulders that are suited for grain size analysis was performed and then, the resultant soil samples underwent laboratory grain size tests. The results also took into consideration the volume of the separated cobbles and boulders, to give the grain size distribution curve.

(a) Collecting Riverbed Samples **(b) Bank Scouring and River Deposit Material**

Fig 2.2.11 Collecting Samples for Grain Size Curve (abundant cobbles seen on the bed)

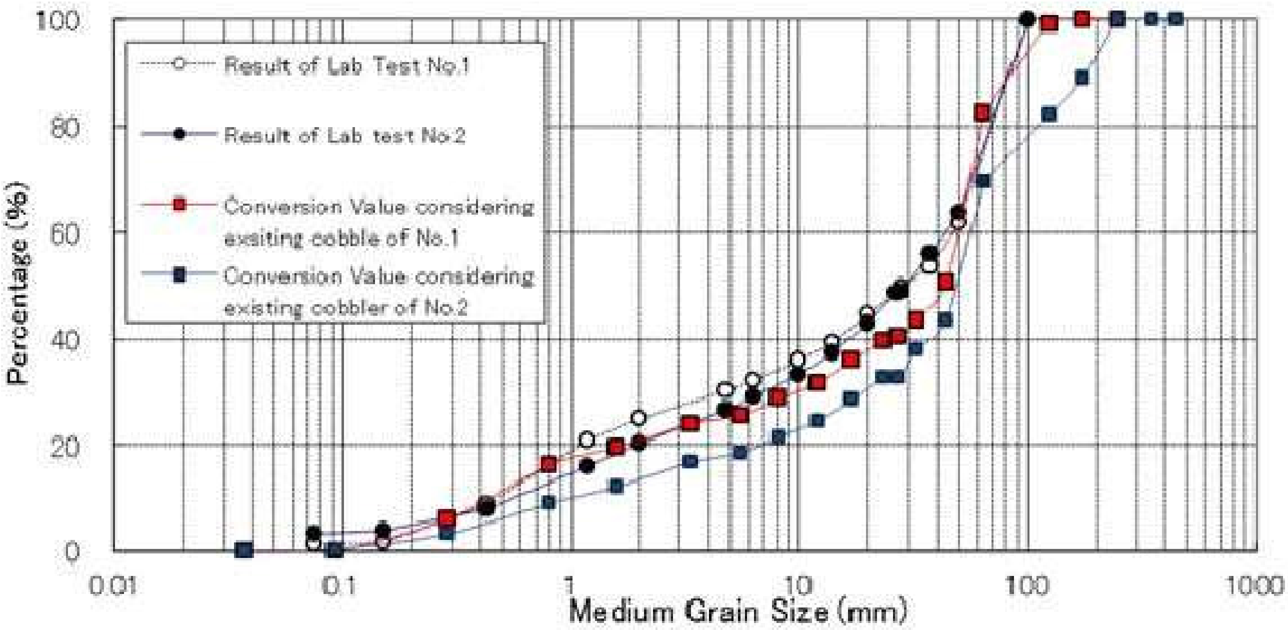


Fig. 2.2.12 Grain Size Distribution Curve

2-2-2-3 Bridge pier scouring prevention work

(1) Design ground level

Fig. 2.2.13 shows a river cross-section at a bridge pier position. After a survey in 2003, a water route has moved to the central side of the river, currently located between the P2 bridge pier and A2 abutment. In this section, there has been riverbed scouring of up to 2.5 m over a 9-year period from 2003. For the moment, the maximum riverbed height of the river cross-section is about EL. 60.0 m; it was much the same near the P1 bridge pier in 2003.

The riverbed height used for scouring preventive design is EL. 58.5 m at the No. 350 point of the planned riverbed height (maximum riverbed height envelope curve). It is positioned 1.5 m deeper in the river longitudinal direction shown in Fig. 2.2.13.

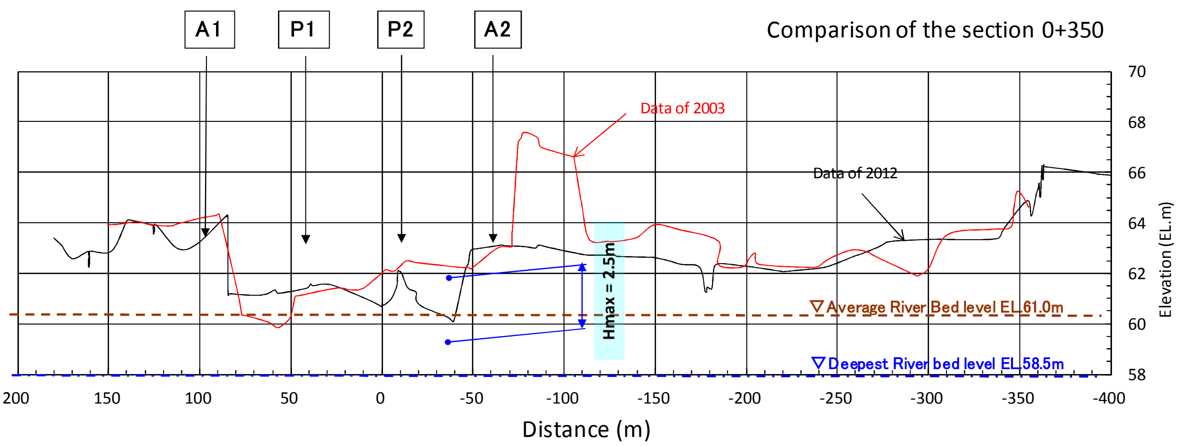


Fig. 2.2.13 River Cross-Section at Bridge Pier Position

(2) Area of the protection required ground

Based on the field investigation, it is estimated that bridge pier foundation work consist of two caissons of about ø4 m. As shown in Fig. 2.2.14, a caisson foundation bearing capacity has the following features.

- A vertical load is mainly supported at the base of the caisson (a friction resistance of the peripheral surface of the caisson is low).
- The ground resists to a horizontal load such as a flood. A ground resistance is more important in the upside of the foundation. Once the ground is increasingly washed out around the foundation, a horizontal resistance decreases and a large bending moment acts on the foundation, leading to inclination of substructure work and bending fracture of

foundation work.

In response to the above-mentioned features, this project prevents ground washout around the foundation and protects the peripheral ground within an area where you can expect a foundation horizontal resistance which the foundation is assumed to have originally had at the time of construction. In this case, the P1 bridge pier is 2.5 m from the end of footing and P2 bridge pier is 5.0 m, respectively, resulting in the area shown in Fig. 2.2.15.

Because a protection area projects from the riverbed, its landform is requested to reduce a resistance to running water as much as possible. Accordingly, paying attention to the shape of the existing footing and reducing extension of protection, an oval shape having curves in the upstream and downstream directions is employed in order to inhibit scouring by the occurrence of local turbulent flow. A crest surface is covered with cast-in-place concrete to prevent scouring by running water.

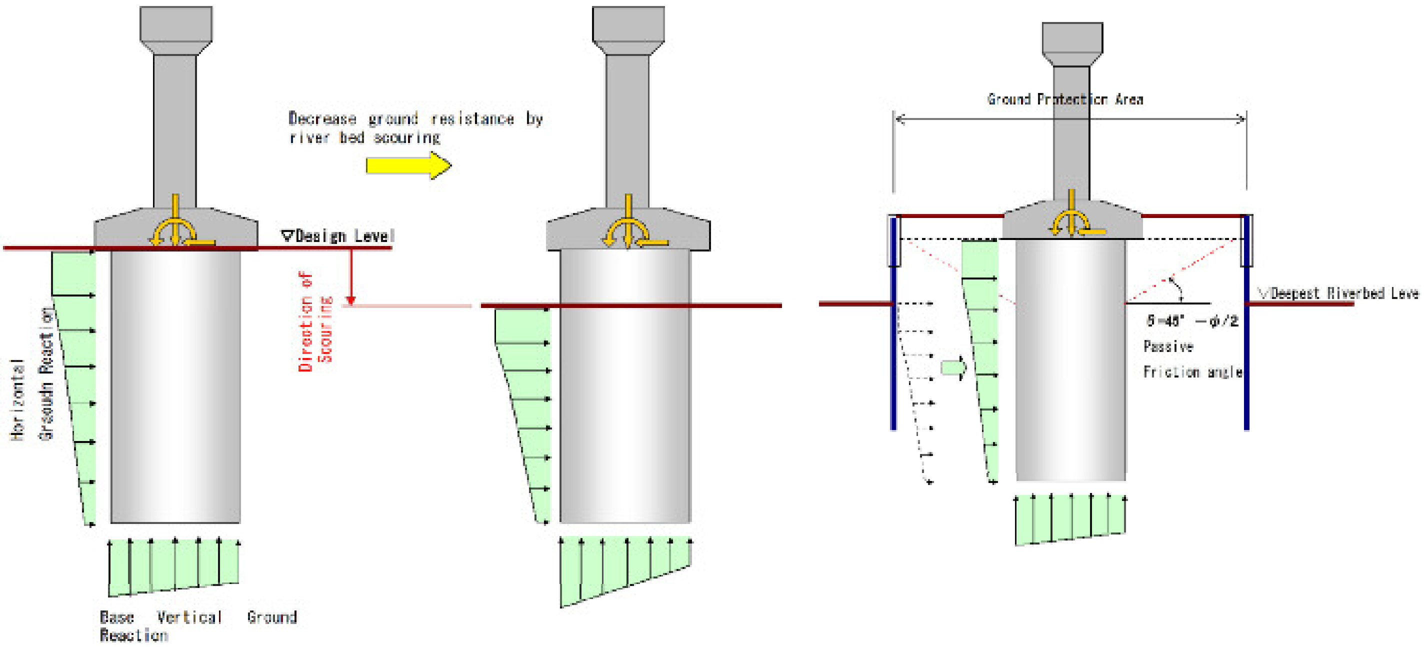


Fig. 2.2.14 Caisson Foundation Bearing Capacity Mechanism and Ground Protection Area

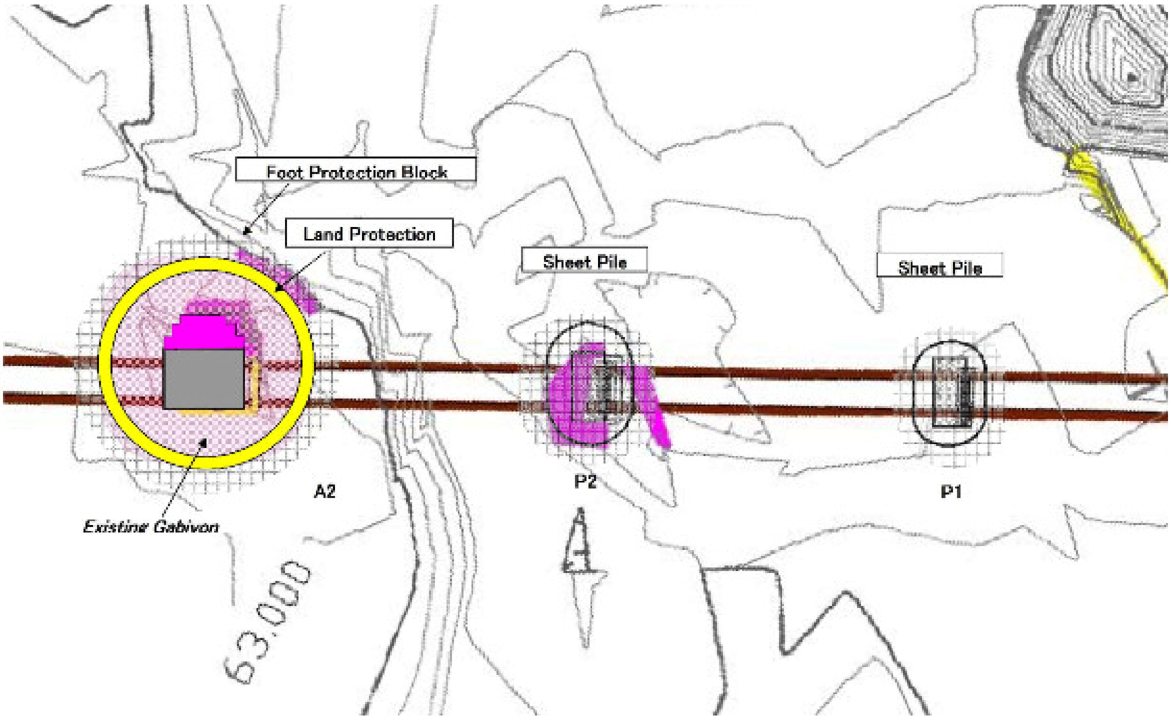


Fig. 2.2.15 Layout of Bridge Pier Foundation Protection Work against Scouring

(3) Comparison of bridge pier foundation scouring prevention work

As shown in Table 2.2.18, bridge pier foundation scouring prevention work is largely divided into foot protection work and protection work. Foot protection work is superior in bendability to rive bed variations, but maintenance is important for keeping resistivity to shifting and tearing off of blocks by running water. However, the Mola River is a flashy stream with a bed slope of about 1/60 and large river bed variations, and often overflows its banks. Prediction accuracy of river bed variations is low and maintenance is difficult. Because the P2 foundation projects greatly from the river bed and the P1 bridge pier foundation has been repeatedly subjected to scouring and sedimentation, it is necessary to select a method of construction capable of unfailingly protecting the bridge pier foundation against river bed scouring.

On the other hand, if a gravity type retaining wall enclosure method and a steel sheet pile enclosure method are compared as protection, the steel sheet pile enclosure method is employed, which is more reliable in economic efficiency, and structural stability and constraints of construction. The steel sheet pile enclosure method has problems of driving the steel sheet piles into a boulder layer and performing construction below the girder. Based on Japanese

Fig. 2.2.16 Existing gravel and deposition layer at riverside

domestic high responsive technology and abundant construction technology, however, it is determined that construction is fully possible.

According to the investigation conducted within the river, it takes 2.5 days to bore 10 m with a machine because of many boulders, and a massive accumulation layer of cobbles has been confirmed as shown in Fig. 2.2.16. As a sheet pile driving method, accordingly, it is necessary to select a method of construction capable of securely driving steel sheet piles within a limited period in the dry season in addition to construction below the girder where construction space is limited.

Table 2.2.19 lists a combination of methods responding to the above-mentioned construction conditions, and the number of construction days and estimated expenses for each method of construction. Although it takes some more construction days, we will select a combination of boulder layer pre-excavation by a full-swing all casing method and vibro-driving by an LHV method, because it allows construction within the dry season and is superior in economic efficiency.

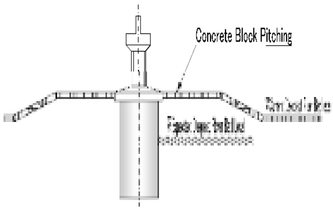
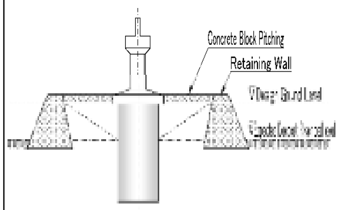
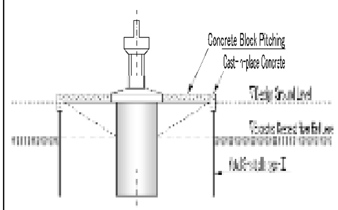
(4) Steel sheet piles used

The following shows the structural calculation results of the steel sheet piles:

P1 bridge pier, UII type, L = 8.0m	Pile head displacement 1.2 cm < 5.0 cm --- OK
	Stress intensity $\sigma = 34\ N/mm^2 < 180\ N/mm^2$ -- OK
P2 bridge pier, UIII type, L = 10.0m	Pile head displacement 4.6 cm < 5.0 cm --- OK
	Stress intensity $\sigma = 88\ N/mm^2 < 180\ N/mm^2$ -- OK

Table 2-2-18 Bridge Pier Foundation Scouring Prevention Measures

(Schematic Drawing for P2 Bridge Pier)

		Foot protection work	Protection work	
		Plan 1: Precast concrete armor units	Plan 2: Gravity type retaining wall enclosure	Plan 3: Steel sheet pile enclosure
Structural schematic drawing				
Outline		・ Rebuild the ground requiring foundation stability and protect with foot protection blocks an area for which scouring and stability of the peripheral river bed have been taken into consideration. ・ Resist to a hydrodynamic force and a scouring force with mutually connected concrete blocks（W=3tf）.	・Protect the ground required for foundation stability with the gravity type retaining wall against the maximum scouring depth. ・The retaining wall foundation base should be deeper than the deepest scoured river bed (depth of embedment of 1.0 m), and protect the base ground with foot protection blocks against local scouring.	・Protect a ground area required for foundation stability with steel sheet piles. ・ Design the steel sheet piles as self-supporting ones, taking the deepest river bed as the design ground. ・ Protect the base ground with foot protection blocks against local scouring.
Features	Merit	・ It is relatively easy to evacuate the construction machines located in the river from flush flood at the time of construction.	・ Special method of construction such as Plan 3 is not required, except for measures for effluent.	・ The steel sheet piles have high stability, ensuring secure protection of the ground around the foundation. ・No measures for spring water are required and structural stability is relatively high against flush flood at the time of construction.
	Demerit	・ Maintenance of combined reinforcing bars, etc. is required, and deformation from the end of the foot protection block cannot be perfectly prevented. ・ When degradation of the river bed is considerable, it is difficult to secure stability by foot protection blocks alone.	・ Deep excavation is required for building the retaining wall, and an underwater pump is necessary as a measure for effluent. (At construction time + EL 59m ⇔ Excavation base + EL 57.5 m) ・ Measures for softening of the ground around the foundation are required at excavation time. ・ There is no safety margin for scouring higher than expectation.	・ A special method of construction is required for driving the steel sheet piles into a cobble layer and under the bridge girder (construction height of about 7.5 m). No experience in Timor-Leste.
Applicability to this project (Challenge)		・The ground has been considerably scoured in the running water section around the bridge pier. Reliability is low for river bed variations and a higher hydrodynamic force.	・ Construction costs greatly differ depending on the measures for draining spring water caused by a lift (expected to be about 2 m) at excavation time. ・ Construction costs are higher	・ Conduct secondary comparison based on comparison of the steel sheet pile driving method into the cobble layer and below the girder. ・ Driving of the steel sheet

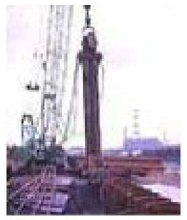
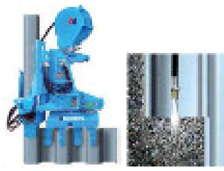
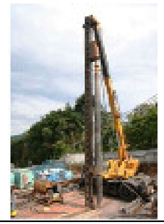
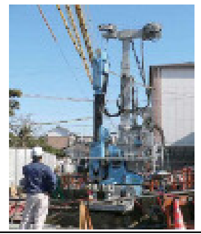
<table>
<tr><td></td><td>・ Maintenance is imperative for deformation of the foot protection blocks.</td><td>than Plan 3 because of measures for softening of the ground and drainage.</td><td>piles is regarded as a special method of construction because of the boulder layer and construction below girder, but it can be implemented by the domestically possessed technology in Japan. Economically efficient as well.</td></tr>
<tr><td>Evaluation</td><td>×</td><td>△</td><td>○ Adopted</td></tr>
</table>

Table 2.2.19 Combination of Possible Steel Sheet Pile Driving Methods and Comparison Results (For P2 Bridge Pier)

<table>
<tr><th rowspan="3">Basic principle for driving steel sheet piles</th><th colspan="2">Restriction on construction</th><th colspan="4">Comparison (Steel sheet pile material + Driving of steel sheet piles)</th></tr>
<tr><th rowspan="2">Measure for boulder layer</th><th rowspan="2">Construction below girder (H≦7.5m)</th><th colspan="2">Construction days</th><th colspan="2">Construction cost(in millions)</th></tr>
<tr><th>No restriction on girder</th><th>Construction below girder</th><th>No restriction on girder</th><th>Construction below girder</th></tr>
<tr><td rowspan="2">Vibro-hammer method</td><td rowspan="2">Pre-excavation by full-swing all casing method</td><td rowspan="2">LHV method</td><td>34</td><td>16</td><td>36.8</td><td>16.6</td></tr>
<tr><td colspan="2">50</td><td colspan="2">53.4</td></tr>
<tr><td rowspan="2">Hydraulic jacked pile method</td><td rowspan="2">Hard ground jacked pile method</td><td rowspan="2">Hard ground jacked pile method w/ auger handling system</td><td>29</td><td>14</td><td>25.5</td><td>45.3</td></tr>
<tr><td colspan="2">43</td><td colspan="2">70.8</td></tr>
<tr><td>Remark</td><td></td><td></td><td colspan="2">For operation rate of 100%</td><td colspan="2">Overhead assumed to be 50%</td></tr>
</table>

Comparison of construction method between no restriction and under girder construction is shown in Table 2.2.20.

Table 2.2.20 Steel Sheet Pile Driving Method in Accordance with Restrictions on Construction

		Vibro-hammer method			Hydraulic jacked pile method			
General ground	Construction condition							
	Construction principle	This method drives the sheet piles by vertical vibrations of the vibrator.			Allowing penetration reaction for the weight of the press-fitting machine and the driving sheet piles, this method press-fits the sheet piles, etc. by expansion and contraction of a hydraulic jack.			
	Feature	High vibration and noise levels. Quick construction. Least expensive.			Almost no vibrations and noise.			
	Applicable ground	Ground of N value ≤ 50 or so.			Ground of N value ≤ 25 or so.			
Hard ground cobble layer		Vibro-hammer combined with water jet	Vibro-hammer combined with pre-excavation method		Hydraulic jack integrated		Crane method	
			Rock auger or cast-in-place hammer	Full-swing all casing method	Jacked pile method combined with water jet	Hard ground jacked pile method	Jacked pile method combined with auger	Combined with rock auger or cast-in-place hammer
	Construction condition							
	Construction principle	This method removes the resistance of the steel sheet piles and the ground by high-pressure water jet and drives the piles by a vibro-hammer.	This method performs pre-excavation (pore wall protection by casing) by a rock auger and a cast-in-place hammer and drives the steel sheet piles by the vibro-hammer.	This method replaces with sand by the full-swing all casing method and drives the steel sheet piles by the vibro-hammer method.	This method removes the resistance of the steel sheet piles and the ground by high-pressure water jet and press-fits the piles.	After excavating the bedrock with a large-diameter auger head, this method removes it and press-fits the steel sheet piles, while excavating with a regular auger.	This method penetrates auger casing along the steel sheet piles and press-fits them, while running an auger machine.	After removing the internal auger and external casing, this method press-fits the steel sheet piles by adding a dead load or a supplemental load.
	Applicable ground	50 ≤ N value ≤ 180 Low cobble mixture rate	Hard bedrock, cobble layer	Hard bedrock, cobble layer	N value ≤ 50	Hard bedrock, cobble layer	N value ≤ 65	Hard bedrock, cobble layer
When construction space is limited		LHV method	CHV method		Low-space press-fitting machine	Hard ground jacked pile method		
	Construction condition							
	Feature	The capabilities of regular vibro-hammer method can be secured by the vibratory force of the vibro-hammer body and the pushing force of the base machine. Combined with the above-mentioned method designed for the hard ground and cobble layer.			Steel sheet pile driving method remodeled for low space.	Hard ground jacked pile method provided with an auger handling system for low space.		
	Applicable ground	Ground of N value ≤ 50 or so.			N value ≤ 25	Hard ground, cobble layer		
	Min. construction height	3.5m			3.5m	7.5m at minimum		

2-2-2-4 Abutment scouring prevention work

(1) Protection required ground area

As shown in Fig.2.2.17 and Fig. 2.2.18, the periphery of the abutment A2 of the old bridge and that of the abutment A1 of the new bridge located in the central part of the Mola River are protected by piled gabion works in order to protect the surrounding ground. When a survey was conducted in middle of May 2012, there was 18-m flat ground in the front of the abutment, but it has been quickly eroded since then and an area protected by the gabions has been reduced to about 11 m for the moment (June 2012). Scouring at the foot of the gabions has also progressed; some of them have been washed out on the upstream side and the river bed has been scoured, wrapping around the abutment. In order to prevent collapse and destruction of the currently installed gabions by river bed scouring, the relevant ground area is protected by entirely enclosing it, including the abutment of the new bridge.

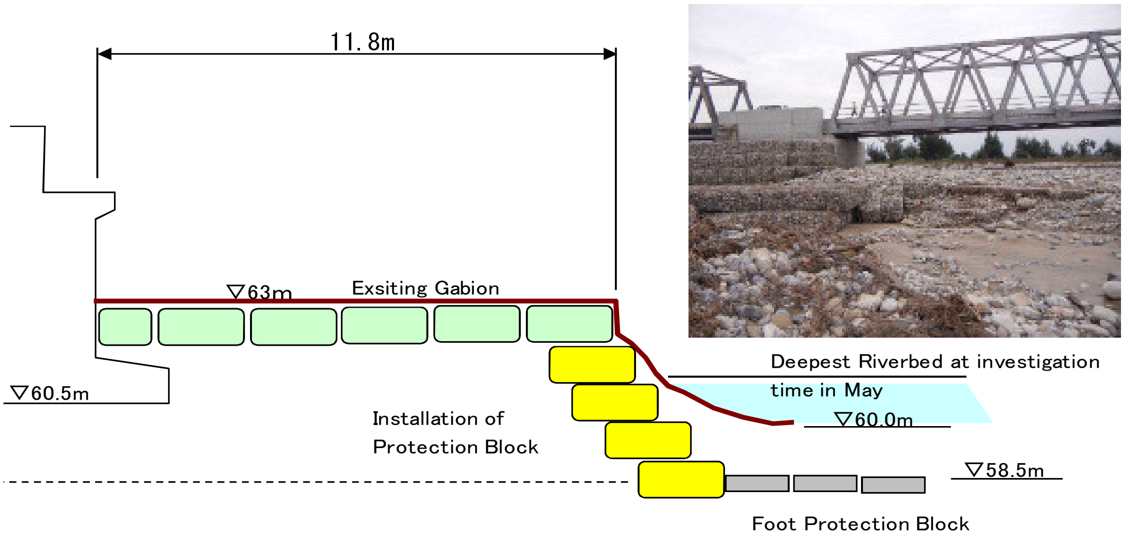


Fig. 2.2.17 Surrounding Ground Condition of Abutment A2

Photo 2.2.18 Current Situation of Bridge Pier Provided with Protection Work

(2) Foundation height

As with a revetment plan mentioned later, the foundation height refers to the position obtained by setting an inclusive straight line in the longitudinal direction from the minimum river bed height calculated for each cross-section and subtracting 1.0 m from it. Accordingly, the foundation height of the scouring preventive revetment for the abutment A2 will be EL. = 58.0 m which has secured the depth of embedment of 1.0 m from the minimum river bed height of EL. = 59.0 m at the No. 3 river channel survey point + 50, closest to the installation site.

(3) Crest elevation

The crest height of the existing gabions is EL. 63.0 m and will be EL. = 63.0 m according to the current situation.

(4) Type

A preferable type of revetment has high wear resistance because running water has a great effect. For this reason, the following 3 plans are compared.

- Plan 1: Gravity type concrete retaining wall
- Plan 2: Concrete block pitching (because there is no restriction on back land, different from the bank revetment, a revetment slope can be reduced)
- Plan 3: Steel sheet pile-based revetment

Of the above-mentioned, the steel sheet pile-based revetment is excluded because it has high self-supporting height (crest height (EL. 63.0) – minimum river bed height (EL. 59.0) = 4.0 m), failing to satisfy the stability conditions. On the other hand, the relevant project position is almost in the center of the river channel. Given safety along with an increased water level at construction time, it is preferable to choose a method of construction which requires a shorter construction period. When Plans 1 and 2 are compared, Plan 2 completes manufacturing on the land in advance, leaves only installation work as to river channel internal work, thus requiring a shorter construction period than Plan 1 which requires cast-in-place concrete work (formwork, concrete placement, curing). Accordingly, “concrete block pitching” is employed.

(5) Structural design

1) Slope gradient

“Dynamic Design Method for Revetments “describes the relations between revetment destruction factors and gradient as follows. Referring to this, the slope gradient of the planned revetment will be 1:1.5, the maximum gradient at which a hydrodynamic force becomes a main destruction factor.

When the slope gradient is lower than 1:1.5: The hydrodynamic force is a main destruction force. When the slope gradient is higher than 1:1.5: The earth pressure and water pressure are main cause of destruction. Source: Dynamic Design Method for Revetments

2) Size of the concrete blocks

For the size of the concrete blocks, the shape satisfying the formula mentioned in "Sabo Design Formulas "will be used. This project will use the blocks weighing 3 tons. Details of examination are described in 2-2-2-5 Revetment work.

3) Foundation concrete

Fig. 2.2.19 shows the dimension of foundation concrete which satisfies the stability conditions.

Table 2.2.21 Stability Calculation Results of Foundation Concrete

Item	Stability condition	Case 1 (At normal time)	Case 2 (At rainfall time)
Titling condition	$e \leq 0.128$	0.006	0.009
		OK	OK
Sliding condition	$n \geq 1.5$	1.714	1.629
		OK	OK
Bearing capacity condition	$\sigma u \leq 300kN/m^2$	21.8	12.8
		OK	OK
Stability evaluation result		OK	

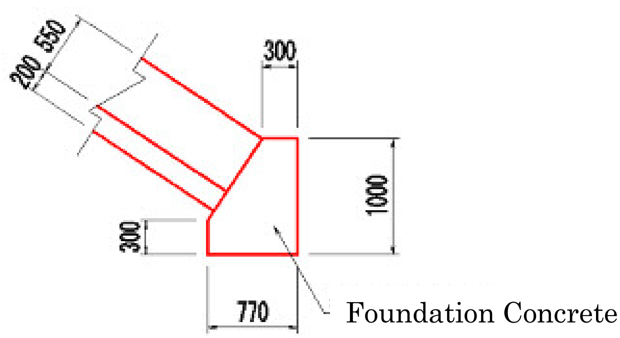


Fig. 2.2.19 Dimension of Foundation Concrete

(6) Foot protection work

In the front of protection work, 3-ton concrete blocks are installed 4 m wide or more in order to prevent scouring, as with the revetments planned on both sides of the Mola River. Stability calculation of the foot protection blocks is detailed in "2-2-2-5 Revetment work".

(7) Crest protection work

As with the face of slope, install 3-ton concrete blocks for the crest of concrete pitching in order to prevent scouring by running water.

(8) Treatment of the back face of slope

As with the current situation, the gabions are piled up to form the foundation of the face of slope of concrete block pitching. Porosity between the gabions and concrete blocks may be sucked out and flows out when a backfilling material is fine. If the backfilling material flows out, stability of the concrete blocks is damaged. Accordingly, a block installation surface is filled with locally available material equivalent to crushed stones. The minimum thickness of crushed stones will be 20 cm, with reference to the backfilling material thickness of the masonry retaining wall.

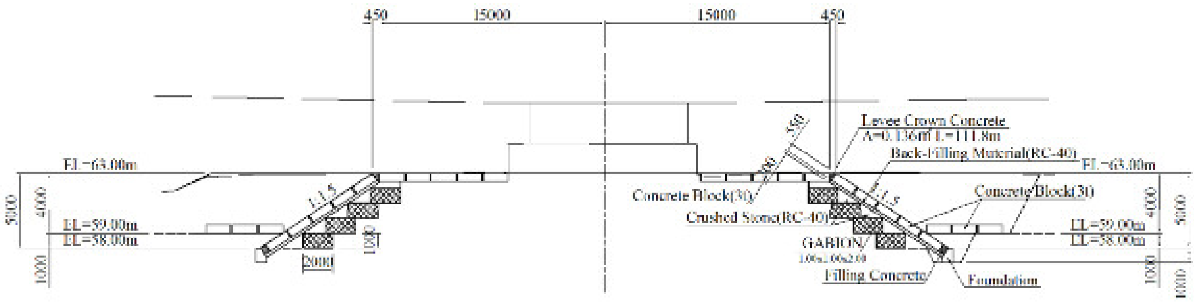


Fig. 2.2.20 Standard Cross-Section Image of Abutment A2 Protective Revetment

2-2-2-5 Revetment work

(1) Revetment arrangement plan

1) Scope of revetment installation on the right bank side

There is a mortar masonry revetment existing on the right bank side upstream of the Mola River, but this was improved in a short period from Nov. 2011 to Mar. 2012 by the Government of Timor-Leste as an emergency work because the right bank was eroded 300 m long and 100 m wide by a flood in Aug. 2010, closing in on the road shoulder of the Route A02. The wall height of the improved mortar masonry revetment is 4.3 to 4.6 m, extending 570 m in length.

On Mar 22, 2012, a year after construction, it collapsed at 2 spots on the upstream side by the swollen river. When the damaged revetment body was checked, it was found out that mortar had not been fully filled between stones, resulting in dry masonry. There occurred no overflowing because embankment in the hinterland remained without being washed out. Based on this, it is figured out that the revetment collapsed, being unable to resist the impact of a water flow because of insufficient strength of the structure.

The foundation has been embedded about 2 m deep from the current riverbed on the downstream side, but only 0.5 to 1 m on the upstream side. The foundation may lose stability particularly on the upstream side along with advance of foundation scouring.

It was confirmed that the actual collapsed spot of the revetment became a water colliding front even in case of small-scale swollen river. It is highly necessary to install a rigid revetment on the right bank side, including this part, to prevent erosion of the bank.

On the other hand, gabions have been installed around the abutment of the new Mola Bridge, completed in Nov. 2011 in order to prevent erosion of the abutment and road embankment. Because huge stones of around 1 m can be found on the river bed of the Mola River and in peripheral accumulation layers, however, it is presumed that the gabions consisting of wire cages filled with cobble stones cannot endure collisions with the huge stones flowing in running water. Based on this, it is considered difficult to secure the functions of the revetment for a long period.

In view of the above-mentioned, the revetment will be constructed in the following area of the right bank side in order to prevent scouring around the abutment of the new Mola Bridge and erosion of the banks, and secure the functions of the Route A02.

- The upstream end of the revetment will be the end of the gabion revetment located upstream of the existing revetment. Because the foundation of the gabions has been scoured, making them unstable, part of this will be incorporated. Fig. 2.2.21 shows the current situation of the end of the gabions (abutment of the newly constructed revetment).

- The downstream end of the revetment will be connected along the landform from the front of the abutment of the new Mola Bridge shown in Fig. 2.2.22 to the downstream side.

Fig. 2.2.21 Current Situation of Upstream End (Right Bank)

Fig.2.2.22 Current Situation of Down stream End (Right Bank)

2) Revetment installation area on the left bank side

On the left band side, there is a mortar masonry revetment near the abutment of the existing Mola Bridge, which was improved in 2009 in order to prevent scouring. It is about 5.5 m high and extends 90 m. Fig. 2.2.23 shows a photo of its current situation.

Since the upstream and downstream ends of the revetment are not closed to the landform and the side surfaces are released, rear backfill has been washed out, resulting in the unstable condition. The structure is the same mortar masonry as on the right bank. There is a problem in its strength because mortar has not been fully filled in. Since a large mainstream water route tends to be formed at the position where the revetment has been improved, it is highly likely to become a water colliding front, requiring installation of a rigid revetment. For this reason, a revetment will be improved over an extension of about 100 m in order to prevent scouring of the abutment foundation.



Fig. 2.2.23Revetment Condition on Left Bank Side of Mola Bridge

(2) Revetment normal line

A revetment normal line refers to a line connecting the center of the crest of the revetment in the direction of the stream-flow. The revetment normal line has been designed based on the following concept.

- In view of constrains of construction and economic efficiency accompanying demolition of the existing revetment, it is desirable to arrange a new revetment in the front of the existing revetment (river side). If arranged in the front, however, the current discharge capacity decreases. In order to avoid this, the existing revetment normal line will be followed as much as possible.
- Since a desirable alignment of the revetment normal line is a straight line in view of constraints of construction, a polygonal line will be avoided as much as possible except for connection to the current landform at the end.
- For the right bank, it is difficult to design the revetment normal line only with straight lines because it is segmental as a whole. In order to configure it with straight lines as much as possible while following the existing revetment normal line, however, the number of break points will be limited to only one, the No. 6 revetment survey point + 60.

(3) Revetment crest height

The revetment crest height will be lower than the current ground level at the revetment installation position so that the revetment crest will not continue to be higher than the current ground, in order to naturally drain running water from the hinterland into the river. If it inevitable becomes higher than the ground level, ensure that it does not continue to be higher. Also, the following will be observed so as to envelope the hinterland ground level except for spots where the hinterland ground is locally low.

- If the revetment crest height is set according to the hinterland ground for each cross-section, the revetment crest will longitudinally become uneven. Accordingly, design the revetment crest height on the right bank side so that it will have an approximately identical gradient in a channel profile. Fig. 2.2.27 shows the channel profile.

(4) Revetment foundation height

According to the "MLIT, Sabo Technical Standards (Draft), Design Volume II," the depth of embedment of the revetment at the sabo facilities is defined as follows:

> The cause of breaching of the revetment is scouring of the foundation in many cases. Because this action is particularly remarkable in a steep-gradient torrent, full depth of embedment is required. Whether the depth of embedment should be deepened or foot protection work should be employed to cope with scouring of the foundation will be decided safely and economically after properly understanding the field condition. When independently designing the revetment, the depth of embedment should be deeper than the deepest part of the current river bed. If a design river bed has been specified, the depth of embedment is preferably deeper than that by 1 m or more. Source: Ministry of Construction, Sabo Technical Standards (Draft), Design Volume II

"Sabo Design Formulas" technical standards for designing the sabo facilities, also provides that the depth of embedment of 1 m or more should be secured from the design bed height or minimum river bed height, as shown in Fig. 2.2.24. Accordingly, assuming that the depth of embedment for the revetment foundation is secured by "1.0 m or more from the design bed height or minimum river bed height," a comprehensive straight line was set in the longitudinal direction by connecting the minimum river bed height obtained for each cross-section, and the height of the straight line minus 1.0 m was taken as the foundation height of the revetment. Fig 2.2.25 shows the work plan and Fig. 2.2.26 shows a longitudinal profile of the revetment foundation height.

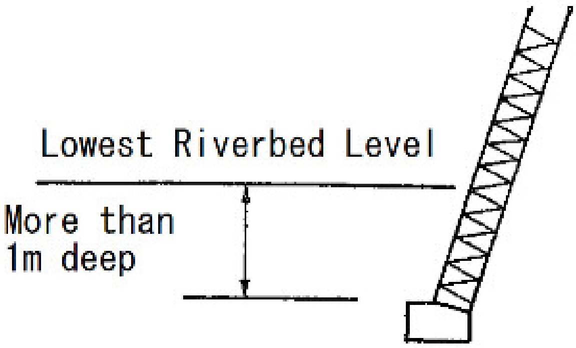
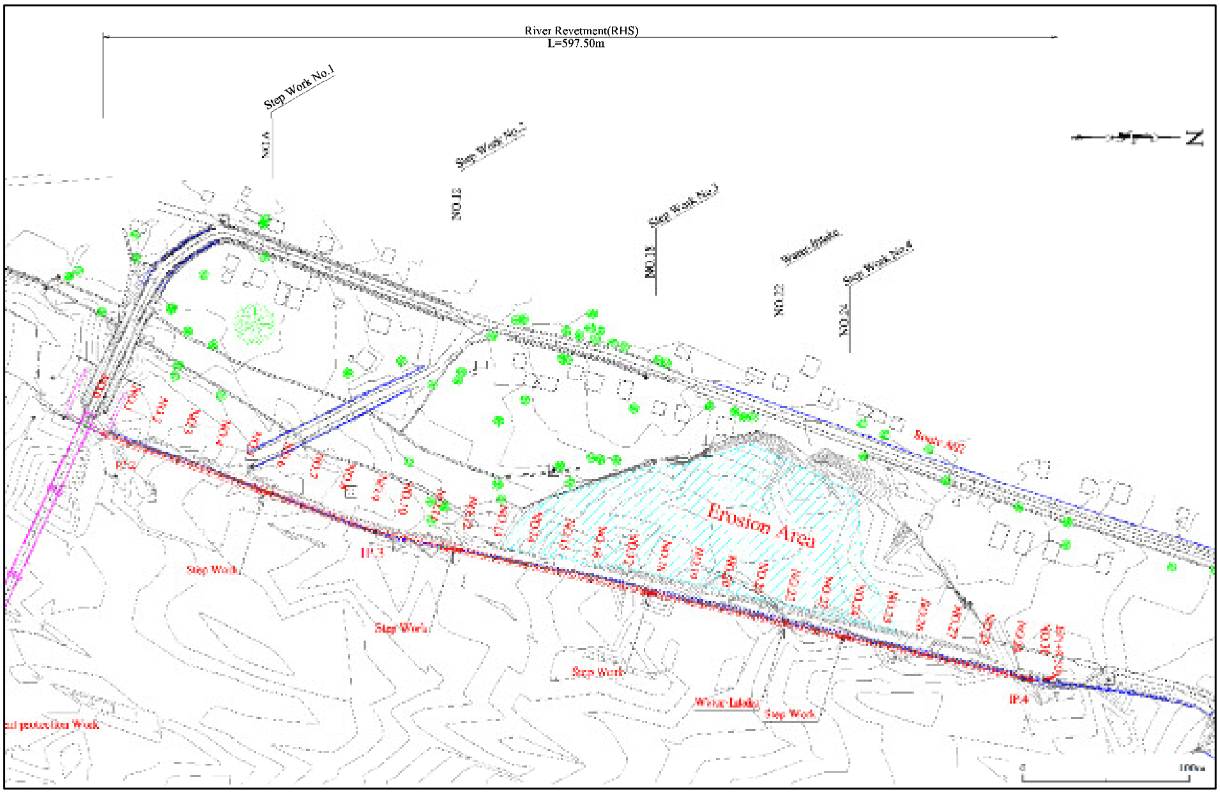


Fig. 2.2.24 Depth of Embedment for Revetment (Source: Sabo Design Formulas)



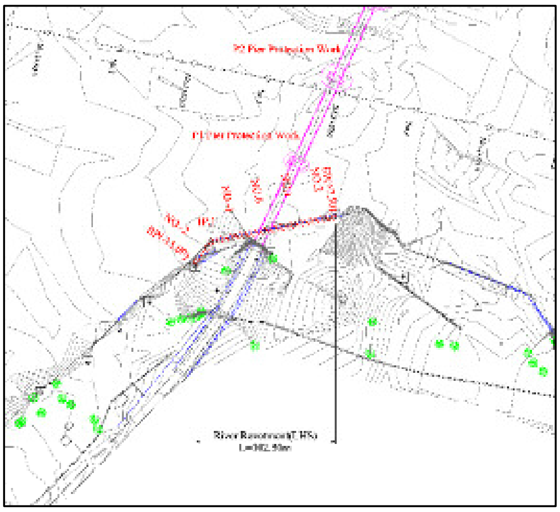
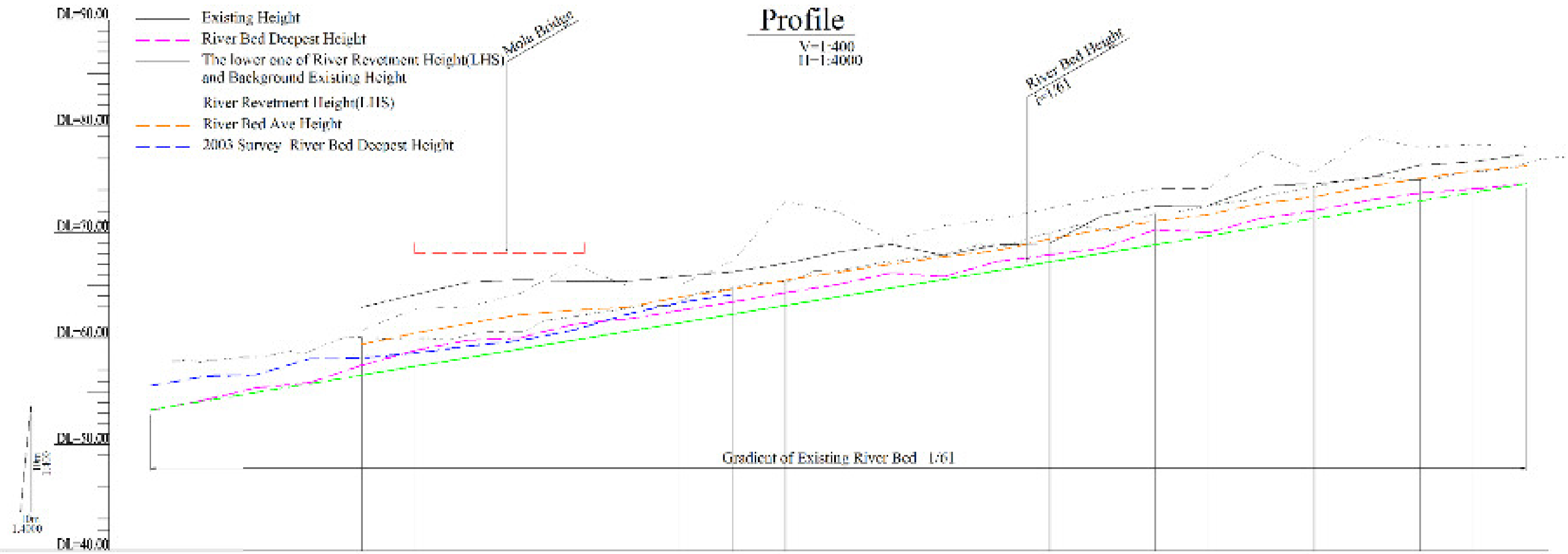


Fig. 2.2.25 Revetment Work Plan



Station	0	50	100	150	200	250	300	350	400	450	500	550	600
River Revetment Height(LHS)					60.79	62.81	63.02	64.29	66.99	65.01	65.05	67.31	72.95
Background Existing Height(RHS)					62.98	64.15	65.12	65.57	65.41	65.45	65.97	66.30	67.07
River Bed Ave Height					59.47	60.50	61.45	62.27	62.56	62.56	63.92	64.65	65.50
River Bed Deepest Height	53.23	54.21	53.37	55.85	57.45	58.88	59.85	60.08	61.36	61.85	62.66	63.46	64.31
Existing Heigh.	57.87	57.76	58.24	58.73	60.11	60.06	60.34	60.66	62.16	62.85	63.52	64.81	65.49
Accumulative Length	0	50	100	150	200	250	300	350	400	450	500	550	600
Distance	0.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00

Station	650	700	750	800	850	900	950	1,000	1,050	1,100	1,150	1,200	1,250	1,300
River Revetment Height(LHS)	71.95	69.25	70.66	71.26	72.28	73.30	74.16	74.15	77.65	75.68	79.04	77.98	78.32	78.10
Background Existing Height(RHS)	68.15	68.58	67.85	68.38	68.97	71.60	72.47	72.56	74.35	74.60	75.12	76.35	76.68	77.38
River Bed Ave Height	66.26	67.01	67.71	68.29	69.40	70.29	71.07	71.71	72.73	73.36	74.32	75.10	75.81	76.36
River Bed Deepest Height	65.11	66.18	65.84	67.36	67.80	68.54	70.23	69.96	71.15	72.05	73.01	73.72	74.11	74.60
Existing Heigh.	66.40	67.28	67.98	68.56	69.97	70.31	71.81	72.49	73.33	74.29	75.18	74.96	75.74	76.55
Accumulative Length	650	700	750	800	850	900	950	1,000	1,050	1,100	1,150	1,200	1,250	1,300
Distance	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00

Fig. 2.2.26 Revetment Work Longitudinal Profile

(5) Comparison of the types of revetment

Since the type of revetment needs to assume that rear earth may be lost by overflowing, and so on, it will be of self-supporting type, not leaning type. Possible self-supporting type revetments include a concrete gravity type revetment, concrete block masonry type revetment, steel sheet pile type revetment and improved existing mortar masonry revetment. The concrete gravity type revetment has three possible methods, cast-in-place concrete method, ISM method and INSEM method. The following compares 6 types of methods in total.

Table 2.2.22 Comparison of Methods of Construction

Type		Method of construction
New revetment	Self-supporting gravity type	(1) Concrete method
		(2) Large concrete block masonry method
		(3) ISM method (Sand and gravel and cement milk are stirred and mixed to build the structure)
		(4) INSEM method (Sand and gravel and cement milk are mixed, and roller-compacted by a bulldozer and vibration rollers to build the structure)
	Self-supporting sheet pile type	(5) Self-supporting sheet pile method
Existing revetment used		(6) Use of existing mortar masonry revetment + Addition of concrete thickness to the revetment body + Reinforcement of the foundation (self-supporting steel sheet piles)

Comparison was made on the items such as economic efficiency, constraints of construction and quality control. Table 2.2.23 and Table 2.2.24 list the results of comparison. As shown in the table, economic efficiency, constraints of construction (particularly a risk of flush flood in the dry season) and quality control were comprehensively judged to choose Plan 1, Concrete method as an optimum plan.

Table 2.2.23 Comparison of Types of Revetment (1/2)

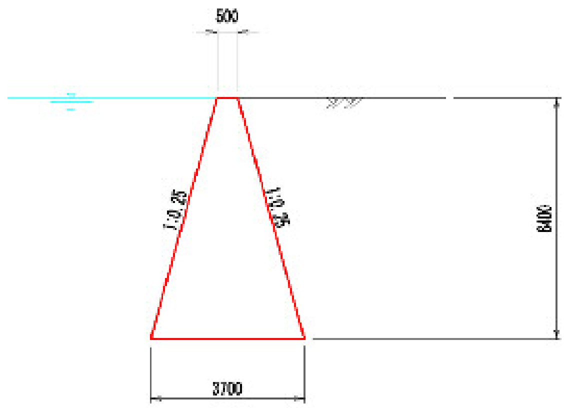
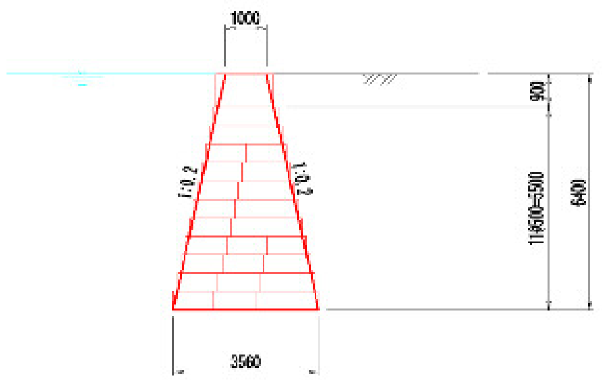
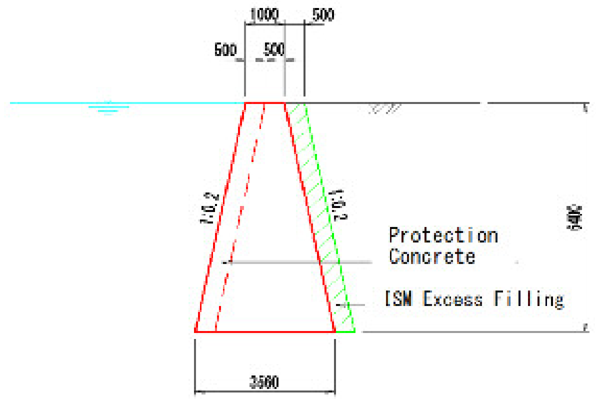
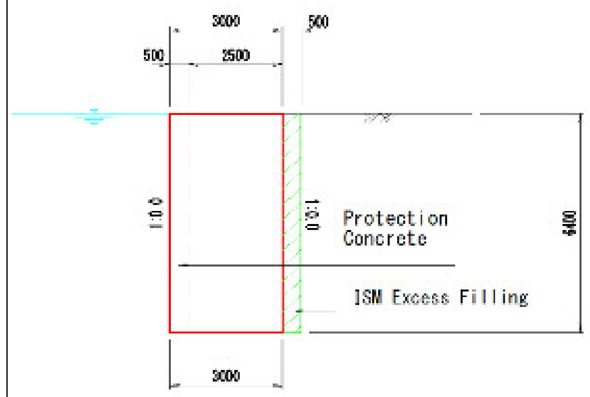
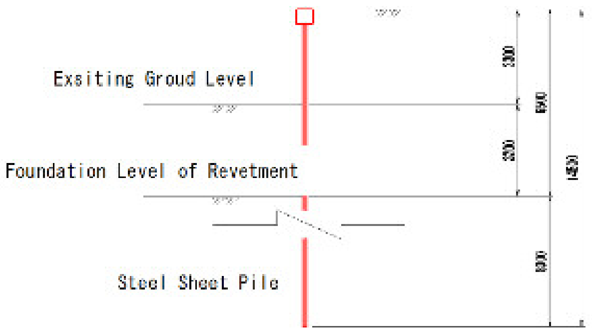
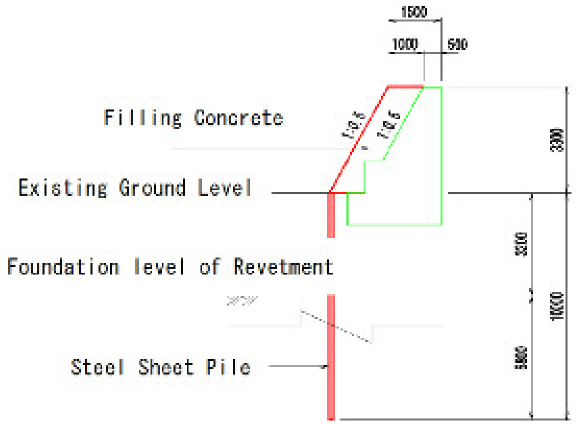
	Plan 1: Gravity type concrete	Plan 2: Concrete block	Plan 3: ISM method	Plan 4: INSEM method
Cross-section				
Outline	This method installs a concrete form at site in the form of satisfying the stability conditions and places fresh concrete.	Revetment made by piling up the concrete blocks which satisfy the stability conditions by themselves. This method transports the concrete blocks produced outside the river channel to the construction site and installs them by a crane.	This method stirs and mixes local cobble stones, river bed sand and gravel and cement milk, using a twin header attached to a backhoe. In order to secure durability, the front side is finished with concrete pitching and the rear side is finished with extra banking with 0.5-m ISM material.	This method mixes local river bed sand and gravel with water and cement, and lays and compacts the mixed material with a bulldozer and vibration rollers. In order to secure durability, the front side is finished with concrete pitching and the rear side is finished with extra banking with 0.5-m ISM material.
Crest width	0.5 m (from the existing revetment)	1.0 m (block shape satisfying the stability conditions)	1.0 m (from the construction conditions)	3.0 m (from the construction conditions)
Front slope gradient	1:0.25	1:0.2	1:0.2	1:0.0
Back slope gradient	1:0.25	1:0.2	1:0.2	1:0.0
Approx. qty. per extension of 10 m	Concrete: 134.4 m^3 Concrete form: 131.9 m^2 Scaffolding: 90.7 m^2	Concrete: 153.5 m^3 Concrete form: 394.7 m^2	ISM material: 145.9 m^3 Concrete: 32.0 m^3 Concrete form: 135.8 m^2 Scaffolding: 134.6 m^2	INSEM material: 92.0 m^3 Concrete: 32.0 m^3 Concrete form: 192.0 m^2 Scaffolding: 132.1 m^2
Top: Approx. construction cost Bottom: Approx. project cost per extension of 10 m (earthwork included)	¥4,730,000 ¥10,642,500	¥7,510,000 ¥16,897,500	¥5,740,000 ¥12,915,000	¥5,150,000 ¥11,587,500
	◎	△	△	○
Constrains of construction	It is not that the next block cannot be placed in order to secure a curing period because the crest length is long, but the construction period is the longest among the compared plans because a daily construction volume is the lowest.	Concrete blocks can be produced outside the river channel. Since it is possible to produce them in advance in the rainy season and install in the dry season, the construction period is the shortest.	The construction period is shorter than Plan 1. Compared with the concrete, however, the rainfall conditions are stricter. In a high-rainfall year, the number of construction days is limited, possibly resulting in the longer construction period.	The construction period is shorter than Plan 1. Compared with the concrete, however, the rainfall conditions are stricter. In a high-rainfall year, the number of construction days is limited, possibly resulting in the longer construction period.
	△	○	△	△
Quality	There is a long track record for cross dykes or road retaining walls. Highest quality among the compared plans.	There is no domestic track record of piling up rectangular concrete blocks. They do not properly interlock with each other. This is a method for piling up single blocks, falling short of integrity.	Domestic track record has been increasing. Compared with the concrete, however, the strength is lower, possibly subjected to damage, if directly hit by cobbles at the time flush flood. Compared with the INSEM method, the strength tends to be higher and close to the concrete.	Domestic track record has been increasing. Compared with the concrete, however, the strength is lower, possibly subjected to damage, if directly hit by cobbles at the time flush flood.
	◎	△	○	○
Overall evaluation	◎	△	△	○

Table 2.2.24 Comparison of Types of Revetment (2/2)

	Plan 5: Steel Sheet Pile-based Revetment	Plan 6: Use of Existing revetment		
Cross-section				
Outline	This plan press-fits the steel sheet piles, which satisfies the stability conditions, into the current ground without excavating.	This plan makes use of the existing revetment. The front side of the existing revetment is widened with concrete embankment, and a sheet pile-based revetment is installed at its lower part in order to secure stability against foundation scouring.		
Steel sheet pile standards	VI type	IVw type		
Steel sheet pile full length	14.5 m	10.0 m		
Depth of footing from current foundation surface	11.2 m	6.7 m		
Approx. qty. per extension of 10 m	Steel sheet piles, VI type: 25 pcs. (14.5 m) Concrete form: 394.7 m^2	Concrete: 30.59 m^3 Concrete form: 36.9 m^2 Reinforcing bar insertion work: 100 pcs./m^2 Steel sheet piles, IVw type: 17 pcs. (10.0 m)		
Top: Approx. construction cost Bottom: Approx. project cost per extension of 10 m	¥8,080,000 ¥18,180,000	¥5,700,000 ¥12,825,000		
	△	△		
Constrains of construction	The material of the relevant construction site is "cobble stones" and it is necessary to drive the steel sheet piles 10 m or more, extremely worsening the constraints of construction.	In order to treat the existing concrete joint surface, "chipping of the existing concrete" and "insertion of reinforcing bars" are required, taking more time and effort.		
	△	△		
Quality	Head displacement is 15 cm or more and does not satisfy "within 5.0 cm" described in "Design Procedures for Disaster Restoration." Low quality.	The safety for the quality of the existing revetment is low. Head displacement is 6 cm or more and does not satisfy "within 5.0 cm" described in "Design Procedures for Disaster Restoration," affecting the upper concrete.		
	△	△		
Overall evaluation	△	△		

(6) Structural design

1) Stability calculation method

It is determined reasonable to take the characteristics of the Mola River into account to design the revetment based on the design of the sabo facilities, but the "MLIT, Sabo Technical Standards (Draft)", general technical standards of the sabo facilities, do not include the concept of self-supporting revetment. For this reason, this project will design the revetment as a self-supporting retaining wall and use the "Guideline for Road Earthwork and Retaining Wall Work" (Japan Road Association) as its technical guideline.

2) Load conditions

The following table lists the loads to be considered in designing the revetment. This project takes a dead load, earth pressure, surcharge load, water pressure and buoyancy into account.

Table 2.2.25 Evaluation Results of Load Conditions

Type of load	Applicability	Evaluation
Dead load	Weight of the retaining wall itself and required to be considered.	○
Surcharge load	Required to be considered, based on the possibility of the construction vehicles passing in the rear during construction.	○
Earth pressure	Required to be considered because there is earth and sand in the rear of the revetment.	○
Effect of earthquake	The "Guideline for Road Earthwork and Retaining Wall Work" provides that regular 8-m or lower retaining walls may omit consideration of earthquake stability. This item is omitted because the design revetment height is 8 m or lower.	×
Water pressure and buoyancy	Required to be considered because this is a revetment and there is running water in the front.	○
Snow load	Not required to be considered because it does not snow.	×
Wind load	The "Guideline for Road Earthwork and Retaining Wall Work" provides that this item is required to be considered when a sound insulation wall is built on the crown of the retaining wall. No consideration is required because no sound insulation wall will be installed on the design revetment.	×
Collision load	The "Guideline for Road Earthwork and Retaining Wall Work" provides that this item is required to be considered when a vehicle guard is directly installed on the crown of the retaining wall. No consideration is required because no vehicle guard will be installed on the design revetment.	×

3) Stability calculation cases

Table 2.2.26 lists stability calculation cases to be considered.

Table 2.2.26 Stability Calculation Cases

Type of revetment	Case	Load to be considered
Self-supporting retaining wall	Case (1): Normal time	Dead load, earth pressure, surcharge load
	Case (2): In case of flood	Dead load, earth pressure, water pressure and buoyancy
	Case (3): In case of rainfall (squall)	Dead load, earth pressure, water pressure and buoyancy

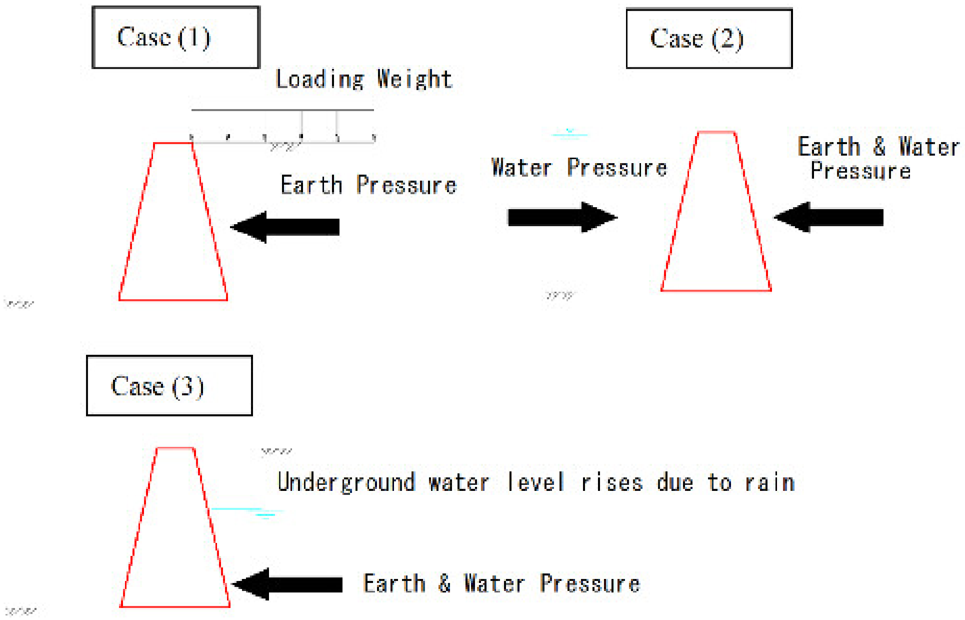


Fig. 2.2.27 Schematic Diagram of Consideration Cases of Self-Supporting Retaining Wall

4) Stability conditions

The following lists the stability conditions for the self-supporting retaining wall.

a. Stability against sliding

Resistance to sliding/sliding force ≥ 1.5

b. Stability against tilting

A resultant force working position must be within a range of 1/3 of the center of the bottom slab.

c. Stability against the bearing capacity of the supporting ground

The maximum stress of the bottom slab must be equal to or lower than the allowable bearing capacity of the supporting ground.

5) Physical properties used for stability calculation

a. Unit weight of rear earth and sand

Locally produced materials are scheduled to be used as rear earth and sand. The locally produced materials are river deposit materials widely distributed around the project area and mainly consist of pebbles and cobbles. For this reason, the unit weight will be 20 kN/m^3 based on the following table.

Table 2.2.27 Unit Weights of Soil

Ground	Soil nature	Loose soil	Dense soil
Natural ground	Sand and gravel	18	20
	Sandy soil	17	19
	Cohesive soil	14	18
Embankment	Sand and gravel	20	
	Sandy soil	19	
	Cohesive soil (wL<50%)	18	

Source: Guideline for Road Earthwork and Retaining Wall Work

b. Shearing resistance constant of backfilling earth

Based on the following table, the shearing resistance angle of backfilling earth will be ø = 35° and a cohesion C will be 0 kN/m^2.

Table2.2.28 Shearing Resistance Constant of Backfilling Earth

Type of backfilling earth	Shearing resistance angle (ø)	Cohesion (C)
Gravelly soil	35°	-
Sandy soil	30°	-
Cohesive soil (wL<50%)	25°	-

Source: Guideline for Road Earthwork and Retaining Wall Work,

c. Allowable bearing capacity of the supporting ground

Based on the following table, the allowable bearing capacity of the supporting ground will be 300 kN/m^2, a standard value for “Gravel layer (Not dense).”

Table 2.2.29 Allowable Bearing Capacity of Supporting Ground

Type of supporting ground		Allowable bearing capacity (kN/m^2)	Remarks	
			qu(kN/m^2)	N value
Bedrock	Uniform bedrock with fewer cracks	1000	100,000 or more	
	Bedrock with many cracks	600	10,000 or more	
	Soft rock, hardpan	300	1,000 or more	
Gravel	Dense	600	-	

layer	Not dense	300	-	
Sandy gravel ground	Dense	300	-	30 to 50
	Medium	200	-	20 to 30
Cohesive soil ground	Very rigid	200	200 to 400	15 to 30
	Rigid	100	100 to 200	10 to 15

Source: Guideline for Road Earthwork and Retaining Wall Work,

d. Friction coefficient and adhesion between the foundation base and ground

Based on the following table, a friction coefficient and an adhesion between the foundation base and the ground will be 0.6 and 0 kN/m^2, respectively.

Table 2.2.30 Friction Coefficient and Adhesion between Foundation Base and Ground

Shear surface condition	Type of supporting ground	Friction coefficient	Adhesion
Rocks and gravel and concrete	Bedrock	0.7	Not considered
	Gravel layer	0.6	Not considered
When broken stones or crushed stones are laid between the earth and the foundation concrete	0.6	0.7	Not considered
	0.5	0.6	Not considered

Source: Guideline for Road Earthwork and Retaining Wall Work,

e. Unit weight of concrete

The unit weight of concrete is defined as 22.56 kN/m^3 in the "MLIT, Sabo Technical Standards (Draft), Design Volume II" On the other hand, it is defined as 23 kN/m^3 in the "Guideline for Road Earthwork and Retaining Wall Work" The unit weight of concrete will be 22.56 kN/m^3 in consideration of safety.

f. Unit weight of running water

The unit weight of running water will be a general value of 9.81 kN/m^3.

g. Surcharge load

Based on the "Guideline for Road Earthwork and Retaining Wall Work" a surcharge load will be a general value of 10 kN/m^2.

h. Rear residual water level

The revetment is mainly designed to prevent erosion toward the national road and there still remains a possibility of overflowing at the time of flood. If the river overflows, a water level in the rear soil increases, an external force (residual water pressure) acts on the retaining wall, becoming an instability factor. For this reason, the "Dynamic Design

Methods for Revetments" states on Page 73 that it is necessary to install a backfilling material and weep holes so that the residual water pressure will not act. In this project, the weep holes are installed above the top surface (1.5 m from the foundation base) of the foot protection blocks to be laid in the front of the revetment. Accordingly, the residual water level will be 2.0 m from the foundation base of the revetment in consideration of clogging of the weep holes.

6) Cross-sectional shape

a. Crest width

The crest width of revetment work will be 50 cm in line with the current situation.

b. Slope gradient

In this project, it is also necessary to assume overflowing at the time of flood. If the river overflows, it is expected that the rear side of the revetment will be scoured, resulting in washout of the backfilling material or lowering of the ground. If this is the case, the revetment has to endure a stream impact and a water pressure without rear earth and sand. Based on this, the slope gradient of the revetment should be the same on the front and rear so that safety can be secured against the water pressure and stream impact from the front, even if a reaction force from the rear has been lost.

The following shows the stability calculation results. The revetment height on the right bank side is uniformly 5.0 m on the upstream side of the Mola River and 6.7 m at maximum on the downstream side. For the right bank side, since the revetment height on the left bank side is uniformly 6.1 m, the cross section at the height of 6.1 m is examined.

[Standard cross-section of the right-bank revetment (No. 7 + 50 downstream) (wall height of 6.7 m)]

Stability calculation was made on two cases of 1:0.20 and 1:0.25. As a result of calculation, it was found out that the stability conditions were satisfied at the slope gradient of 1:0.25. Accordingly, the crest width will be 0.5 m and the slope gradient will be 1:0.25 as to the cross-sectional shape of the revetment work. The following table lists the details of stability calculation.

Table 2.2.31 Stability Calculation Results (Wall Height: 6.7 m)

Front slope gradient	Rear slope gradient	Item	Stability condition	Case (1) (Normal time)	Case (2) (At flood)	Case (3) (At rainfall)
0.2	0.2	Tilting condition	e≦0.530	0.539	0.418	0.587
				×	○	×
		Sliding condition	n ≧1.5	1.607	1.800	1.443
				○	○	×
		Bearing capacity condition	σu≦300kN/m^2	237.760	122.606	221.350
				○	○	○
		Stability evaluation result		×		
0.25	0.25	Tilting condition	e≦0.642	0.392	0.351	0.450
				○	○	○
		Sliding condition	n ≧1.5	1.818	2.031	1.634
				○	○	○
		Bearing capacity condition	σu≦300kN/m^2	183.96	96.502	172.608
				○	○	○
		Stability evaluation result		○		

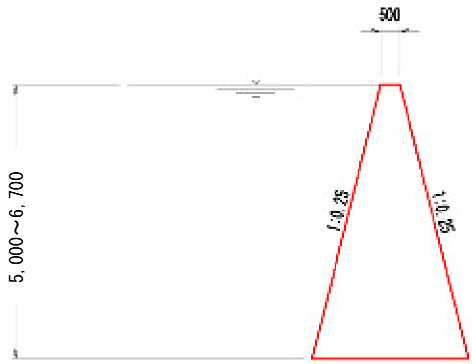


Fig. 2.2.28 Standard Cross-Section of Right-Bank Revetment (Wall Height: 5.0 m to 6.7 m)

[Standard cross-section of the right-bank revetment (No. 7 + 50 upstream) (wall height: 5.0 m)]

Stability calculation was made on two cases of slope gradient, 1:0.20 and 1:0.25. As a result of calculation, it was found out that the stability conditions were satisfied when the slope gradient is 1:0.25. Accordingly, the crest width will be 0.5 m and the slope gradient will be 1:0.25 as to the cross-sectional shape of revetment work. The following table lists the details of stability calculation.

Table 2.2.32 Stability Calculation Results (Wall Height: 5.0 m)

Front slope gradient	Rear slope gradient	Item	Stability condition	Case (1) (Normal time)	Case (2) (At flood)	Case (3) (At rainfall)
0.2	0.2	Tilting condition	e≤0.417	0.378	0.322	0.441
				○	○	×
		Sliding condition	n ≥1.5	1.641	1.928	1.384
				○	○	×
		Bearing capacity condition	σu≤300kN/m^2	172.667	86.392	1158.919
				○	○	○
		Stability evaluation result		×		
0.25	0.25	Tilting condition	e≤0.5	0.275	0.234	0.345
				○	○	○
		Sliding condition	n ≥1.5	1.832	2.154	1.557
				○	○	○
		Bearing capacity condition	σu≤300kN/m^2	136.004	69.400	126.008
				○	○	○
		Stability evaluation result		○		

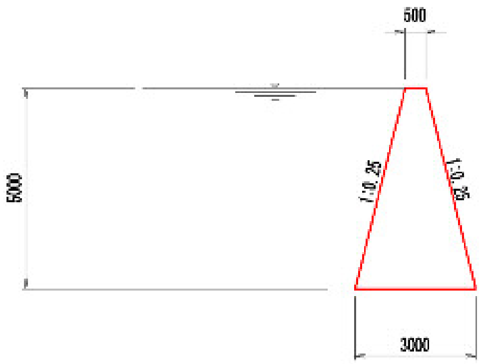


Fig. 2.2.29 Standard Cross-Section of Right-Bank Revetment (Wall Height: 5.0 m)

[Examination of the standard cross-section of the left-bank revetment (wall height:6.1 m)]

Stability calculation was made on two cases of slope gradient, 1:0.20 and1:0.25. As a result of calculation, it was found out that the stability conditions were satisfied when the slope gradient is 1:0.25. Accordingly, the crest width will be 0.5 m and the slope gradient will be 1:0.25 as to the cross-sectional shape of revetment work. The following table lists the details of stability calculation.

Table 2.2.33 Stability Calculation Results (Wall Height: 6.1 m)

Front slope gradient	Rear slope gradient	Item	Stability condition	Case (1) (Normal time)	Case (2) (At flood)	Case (3) (At rainfall)
0.2	0.2	Tilting condition	e≦0.490	0.484	0.424	0.533
				○	○	×
		Sliding condition	n ≧1.5	1.610	1.837	1.429
				○	○	×
		Bearing capacity condition	σu≦300kN/m^2	215.550	109.710	198.728
				○	○	○
		Stability evaluation result		×		
0.25	0.25	Tilting condition	e≦0.592	0.362	0.309	0.411
				○	○	○
		Sliding condition	n ≧1.5	1.817	2.067	1.614
				○	○	○
		Bearing capacity condition	σu≦300kN/m^2	167.407	86.866	155.837
				○	○	○
		Stability evaluation result		○		

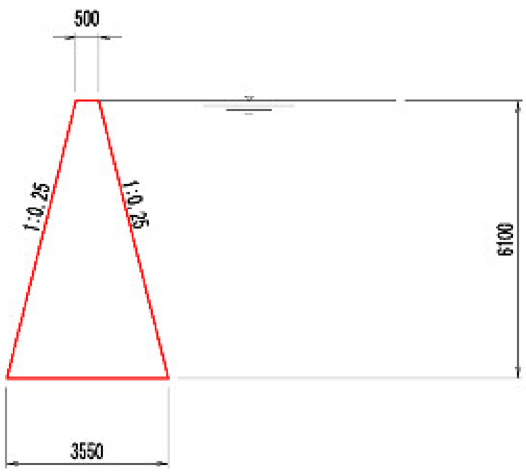


Fig.2.2.30 Standard Cross-Section of Left-Bank Revetment (Wall Height: 6.1 m)

(7) Crest width of the banking section

The revetment has a section (banking section) where the crest is higher than the ground level behind it. The crest width of the banking section will be 3 m as the minimum required width for maintenance (passage of administrative vehicles, repair space).

(8) Cutoff sheet piles

If water remains in the rear of the revetment due to rainfall and overflowing, piping will result from a water level difference between the river side and the rear side. Since the local ground consists of sand and gravel, underground seepage water runs easily, causing piping. Once piping occurs, the bearing capacity of the foundation is lost, allowing a possibility of collapse. For this reason, the occurrence of piping will be prevented by driving the cutoff sheet piles in a manner of shutting off a flow of the underground seepage water. For the length of the cutoff sheet piles, calculate it by "Bligh's formula" and "Lane's formula" based on the "Sabo Design Formulas," and choose whichever is greater.

[Bligh's formula]

$d = (Cc \times \Delta h - L)/2$

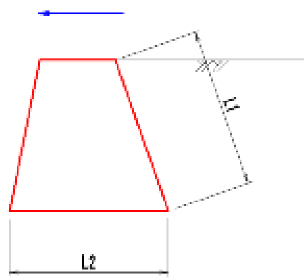
where;

d: Length of the cutoff sheet piles (m)

Cc: Creep ratio of the Bligh's formula. (Cc = 4.0. Since there is no evaluation value of the "cobble stones and gravel," the minimum value of "coarse gravel mixed with cobble stones" is used. See Table 2.2.34)

Δh: Water level difference between the upstream and downstream sides. (Δh = 2.0 m because the weep holes are installed up to the height of 2.0 m from the foundation base)

L: Total creep length. (L_1 + L_2 shown in the right figure).



[Lane's formula]

$D = (Cw \times \Delta h - L/3)/2$

where;

Cw: Load creep of Lane's formula.

(Cw = 2.5. See Table 2.2.34)

Table 2.2.34 Creep Ratio

Foundation component material	Cc	Cw	Foundation component material	Cc	Cw
Microsand or silt	18	8.5	Medium gravel	-	3.5
Fine sand	15	7.0	Mixture of sand and gravel	9.0	-
Medium sand	-	6.0	Gravel mixed with cobble stones	4.0～6.0	3.0
Coarse sand	12	5.0	Cobble stones and gravel	-	2.5
Fine gravel	-	4.0			

Source: Sabo Design Formulas

1) Length of the cutoff sheet piles

As a result of calculating the required length of the cutoff sheet piles by respective calculation methods, the length obtained by Lane's formula is employed because it is longer. The following table outlines the calculation results.

Table 2.2.35 Calculation Results of Cutoff Wall Length

Item		Unit	Right-bank side No. 7 + 50 downstream	Right-band side No. 7 + 50 upstream	Left-bank side
Revetment height examined		m	7.1	5.0	6.1
Input conditions	Total creep length	m	6.1	5.1	5.6
	Water level difference between upstream and downstream sides	m	2.0	2.0	2.0
	Creep ratio of Bligh's formula		4.0	4.0	4.0
	Load creep of Lane's formula		2.5	2.5	2.5
Calculation results	Length of cutoff sheet piles by Bligh's formula	m	1.0	1.5	1.2
	Length of cutoff sheet piles by Lane's formula	m	1.5	1.7	1.6
	Length of cutoff sheet piles (design value)	m	2.0	2.0	2.0

3) Type of the cutoff sheet piles

Possible types of the cutoff sheet piles include a cast-in-place concrete type and a steel sheet pile type. The cast-in-place concrete type requires measures for spring water because it is necessary to excavate deeper than the foundation of the revetment body. Furthermore, its construction period tends to be longer because it is necessary to secure a time for curing the concrete. Since this construction work has to be completed within a limited period in the dry season, the steel sheet pile type is appropriate, which does not require those measures.

4) Standards of the steel sheet piles

The "Design Procedures for Disaster Restoration Work" provides the standards of the steel sheet piles-based revetment as follows.

1. A tidal section will be of the standard Type II or above.
2. Non-tidal sections falling under one of the following categories will be of the standard Type II or above, and otherwise, they will be of the improved Type II or above.
    1) When the section has a possibility of scouring of the river bed.
    2) When the soil nature has relatively high penetration resistance.
    3) When using relatively long sheet piles.
    4) When corrosion is expected to be greater than general cases.
    5) When the section is determined to be particularly important from a view point of flood control.

Source: Design Procedures for Disaster Restoration Work

The relevant section is not a tidal one and located at a position deeper than the maximum river bed height, having a low possibility of scouring. Because an extension is short, the standards of the steel sheet piles will be the "improved Type II" or above. If the standard and improved (wider) versions of Type II are compared, the "improved version" (wider) requiring less construction time and effort is more economical. Accordingly, the standards of the steel sheet piles used will be the improved Type II (IIw type).

5) Installation position of the steel sheet piles

Because it is significant to join the steel sheet piles with the concrete revetment, they are installed at a position of 0.5 m in the direction of the revetment body from the front of the revetment foundation and penetrate into the body of the gravity type concrete revetment by 0.3 m.

(9) Foot protection work

Since the relevant river is subject to foundation scouring because of violent river bed vibrations, "foot protection work" is planned.

1) Foot protection work

Concrete blocks are used for foot protection work. Their size is designed based on the "Sabo Design Formulas." The following verification assumes that the weight of 3 tons is required.

[Safety for sliding]

$R/P \geq n$

$P = Cd \times Wo \times \varepsilon \times A \times V^2/(2g)$

$R = f \times Wb$

$Wb = (1 - Wo/Wc) \times W \times K$

[Stability for tilting]

$X \times Wb > Y \times P$

where;

P: Dynamic water pressure acting on the block (kN).

n: Safety facto (generally 1.0 to 1.5, but 1.2 is employed, which is the same as stability calculation of the revetment).

R: Resistance force of the block (kN).

[Block shape]

B:	Width (m).	B =	1.98	(m)
H:	Height (m).	H =	0.55	(m)

L:	Length (m).	L =	1.65	(m)
A:	Projection area (m^2) (entire width x height in case of colony).	A =	1.09	(m^2)
W:	Aerial weight (kN)	W =	27.54	(kN)
Wb:	Underwater weight (kN)	Wb =	13.17	(kN)
X:	Horizontal distance from the supporting point of the block to the center of gravity (m).	X =	0.990	(m)
Y:	Vertical distance from the supporting point of the block to the center of gravity (m).	Y =	0.275	(m)

[Physical properties]

Wo:	Unit weight of running water (kN/m^3)	Wo =	11.77	(kN/m^3)
Wc:	Aerial unit weight of the block (kN/m^3)	Wc =	22.56	(kN/m^3)
G:	Gravitational acceleration (m^2/s)	g =	9.80	(m^2/s)

[Calculation conditions]

Cd:	Dynamic water pressure coefficient (1.0 is generally used).	Cd =	1.00	
ε:	Sheltering coefficient (1.0 for a single piece and 0.35 to 0.40 for a colony. In this case, 0.4 because of expectation of "interlocking" and assuming the use of the equivalent of "stone block).	ε =	0.40	
V:	Flow velocity of running water (m/s)	V =	5.00	(m/s)
f:	Resistance coefficient (friction coefficient, generally 0.80).	f =	0.80	
k:	Number of blocks (right- and left-bank directions).	k =	1	(pcs.)

[Dynamic water pressure acting on the block: P (kN)]

$P = Co \times Wo \times \varepsilon \times A \times V^2/(2g)$

$= 1.00\times11.77\times0.4\times1.09\times5.0^2/(2\times9.8) = 6.54$ (kN)

[Resistance force of the block: R (kN)]

$R = f \times Wb = 0.8 \times 13.17 = 10.54$ (kN)

[Safety factor for sliding]

$n = R/P = 10.54/6.54 = 1.61 > 1.2$ OK

[Overturning moment]

$Y \times P = 0.275 \times 6.54 = 1.80$ (kN-m)

[Resisting moment]

$X \times Wb = 0.990 \times 13.17 = 13.04$ (kN-m)

[Stability for tilting]

$X \times Wb = 13.04 \geq Y \times P = 1.80$ OK

Furthermore, the "MLIT, Sabo Technical Standards (Draft), Design Volume I" states that there are generally more cases shown in Table 2.2.36 as to the weight of the concrete block.

Table 2.2.36 Weight of Precast Concrete Armor Units

	Cross-sectional mean velocity at flood time		
	Less than 2m/s	2 m/s to less than 4 m/s	4 m/s or more
Block weight	0.5 to 2 tons	1 to 4 tons	2 tons or more

Source: MLIT, Sabo Technical Standards (Draft), Design Volume I

In this project, the flow velocity of the Mola River near the Mola Bridge can be assumed to be 5.0 m/s or more on the average, and the weight of the concrete block can be considered to be 3 tons or more, upgrading the minimum weight. Since the above-mentioned stability calculation results are satisfied, the weight of foot protection work (concrete blocks) will be 3 tons.

2) Installation area of foot protection work

An installation area of foot protection work is considered based on the "MLIT, Sabo Technical Standards (Draft), Design Volume I."

$$B = Ln + \Delta Z/\sin\theta = 2.0 + 1.0/\sin 30° = 4.0 \text{ m}$$

where; B: Foot protection work laying width (m).

Ln: Planation width of the front of the revetment (2 m or more. In this case, minimum value of 2 m).

ΔZ: Elevation difference from the foot protection work laying height to the evaluation height of the maximum river bed height.
(In this case, 1.0 m on the assumption that the depth of embedment of 1.0 m will be secured).

θ: Underground repose angle of the river bed material (Generally30°).

The installation range of foot protection work will be 4.0 m or more based on the calculation result. Since the width of each foot protection work is 1.7 m, there will be 3 of them per row.

2-2-2-6 Ancillary work

The following facilities are considered as ancillary work.

a. Weep holes
b. Expansion joints
c. Stepladders
d. Simple intakes

(1) Weep holes

By lowering the rear water level of the gravity type concrete revetment, an external force applied to the revetment can be reduced, contributing to stability of the revetment. For this reason, a weep hole made of PVC pipe is installed for every 2 m^2 with reference to the “Pocketbook of Preventive Work for Sabo, Landslide, Slope Failure and Avalanche” The top surface of the foot protection block will be considered as an installation position at the height of 2.0 m or more from the foundation.

> When there is much spring water in the hinterland or in case of embankment, install weep holes to reduce an external force applied to the revetment. In case of mortar masonry or concrete block masonry, install at least one weep hole for every 2 m^2. Its diameter is 5 cm or more as a rule. Install them at a position which is always higher than the water level.
> Source: Pocketbook of Preventive Work for Sabo, Landslide, Slope Failure and Avalanche,

(2) Expansion joints

In order to absorb expansion of concrete, expansion joints are installed in the revetment. Each expansion joint is installed for every 20 m with reference to the “Pocketbook of Preventive Work for Sabo, Landslide, Slope Failure and Avalanche,”

> A temperature change and drying shrinkage may cause expansion and contraction, resulting in cracked concrete. In order to prevent them, each expansion joint is generally installed for about every 20 m of the revetment.
> Source: Pocketbook of Preventive Work for Sabo, Landslide, Slope Failure and Avalanche

(3) Consideration of the stepladders

The water of the Mola River is essential for the living of residents around the Mola Bridge in terms of washing, water drawing, and children’s playground. There is an about 2.5-m difference in level between the crest of the revetment and the river bed, and two stepladders have been installed so that you can go down to the dry river bed. For this reason, this project will install two additional stepladders in view of convenience to allow easier access to the dry river bed, totaling four of them.

The current stepladders have been installed along the face of slope direction of the revetment, but they are very steep at a gradient of 1:0.5 and as narrow as about 0.5 m. Because of this, they are determined problematic in safety and convenience, and the type of stepladders will be as follows.

a. Direction of the stepladders

With reference to the "Sabo Design Formulas" the stepladders are installed in parallel with the revetment and designed downward from upstream to downstream. Also, they are designed not to project from the revetment so that they will not be the water colliding front of running water. Furthermore, in order to eliminate a structural weakness, a revetment is installed behind them to make up for lost parts because of the stepladders.

When the stepladders and ramps are required, do not install them immediately upstream of a drop in order to prevent danger and install an intrusion preventive gate as required. When installed in parallel with the revetment, design them downward from upstream to downstream, avoiding a downward structure the other way around. Design carefully so that the stepladders will not become a weakness of the revetment and destroy it. Source: Sabo Design Formulas

b. Installation height of the stairs

If the current ground level is assumed to be the installation height of the stairs, they are highly likely to be scoured. Accordingly, the installation height is the top surface of the foot protection blocks in view of prevention of scouring.

c. Gradient of the stairs

In view of convenience, the gradient of the stairs is 1:2.0, the steepest gradient of the banks, in accordance with the MLIT, Sabo Technical Standards (Draft), Design Volume I,"

d. Height and width of each step

For the height (rise) and step of the stairs, the height of each step is 15 cm by rounding the minimum value of 5 cm and the width is 30 cm based on the gradient of stairs of 1:2.0 with reference to the Building Standards Act and considering convenience.

Table 2.2.37 Types of Stairs and Dimensions of Each Step

	Type of Stairs	Rise (cm)	Width (cm)
1	For grade school children.	16	26
2	For the students of junior and high schools and secondary education schools. Shops for the customers at the theaters, movie theaters, public halls, assembly halls, etc. (including the goods processing and repair businesses) and having a total floor area exceeding 1,500 m^2.	18	26
3	Stairs of the basements and underground structures where the total floor area of living rooms exceeds 100 m^2.	20	24
4	Stairs other than Items 1 to 3, and those for other than the houses.	22	21
5	Houses (except for common-use stairs of the apartment buildings)	23	15
6	Direct stairs among outdoor stairs.	Compliant with the values for Items 1 to 5.	
	Other stairs among outdoor stairs.		

Source: Building Standards Act, Japan

e. Width of the stairs and stair landing

The width of the stairs and that of the stair landing are 1.0 m, respectively, with reference to the Building Standards Act of Japan.

Table 2.2.38 Width of Stairs and Stair Landing

	Type of stairs	Width of stairs and stair landing (cm)
1	For grade school children.	140 or more
2	For the students of junior and high schools and secondary education schools. Shops for the customers at the theaters, movie theaters, public halls, assembly halls, etc. (including the goods processing and repair businesses) and having a total floor area exceeding 1,500 m^2.	140 or more
3	Stairs of the basements and underground structures where the total floor area of living rooms exceeds 100 m^2.	120 or more
4	Stairs other than Items 1 to 3, and those for other than the houses.	75 or more
5	Houses (except for common-use stairs of the apartment buildings).	75 or more
6	Direct stairs among outdoor stairs.	90 or more only for stairs
	Other stairs among outdoor stairs.	60 or more for only stairs

Source: Building Standards Act, Japan

Based on the above-mentioned, the basic shape of the stepladder is shown in Fig.2.2.31.

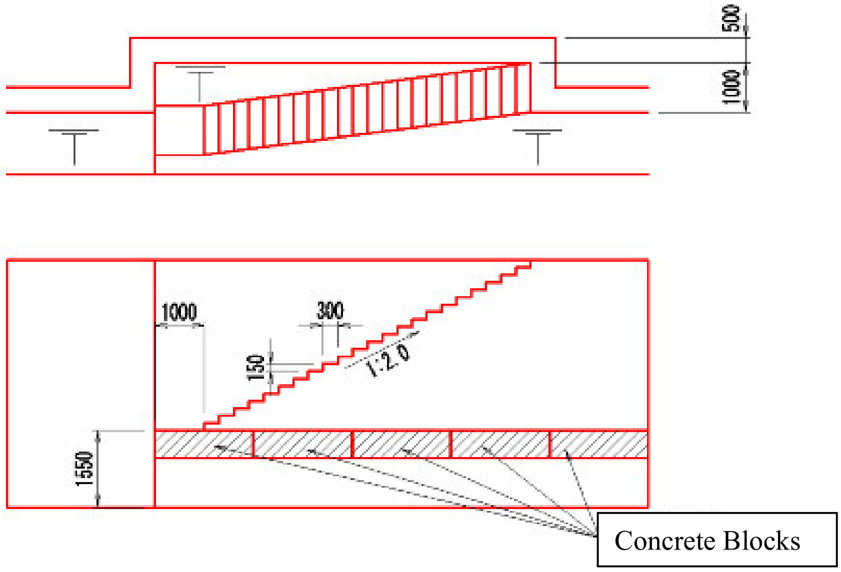


Fig.2.2.31 Basic Shape of Stepladder

(4) Intake

Intake facilities are installed in one place on the right bank side of the Mola River as an auxiliary water source for domestic water for the residents and irrigation water. River water is led to the rear side of the revetment through a ø1,000 mm corrugated pipe penetrating the existing masonry wall and flows to the farming land through a waterway excavated open channel. On the river side, the ground has been excavated 10 m wide and 0.5 to 1.0 m deep to build a weir by rubble works. This weir raises the water level to facilitate drawing of water. At the time of every flood, however, these rubble works have been washed out and repaired by the residents. The following shows the current situation.

(River side) **(Rear side)**

Fig. 2.2.32 Current Situation of Intake Facilities

From a viewpoint of restoring the current functions of the facilities, this project will improve the facilities almost at the same position and of the same shape as the current situation. Accordingly, a rectangular intake of 1.0 × 1.0 m is installed, and cutoff stop logs are also installed in order to prevent intrusion of water to the rear side at the time of swollen river. However, the weir by rubble works on the river side is not included. The following outlines the intake facilities.

a. Intake foundation height

The intake foundation height will be almost the same as the current situation and near the top surface of the foot protection concrete blocks to be laid in the front.

b. Operation platform and stop log height

The stop logs have to be manually operated. A platform required for manual operation is provided 1.0 m lower than the crest of the revetment, and the steps are installed in between to allow easy access to the platform. In this case, the stop log height is 2.45 m from the intake foundation height to the crest of the operation platform.

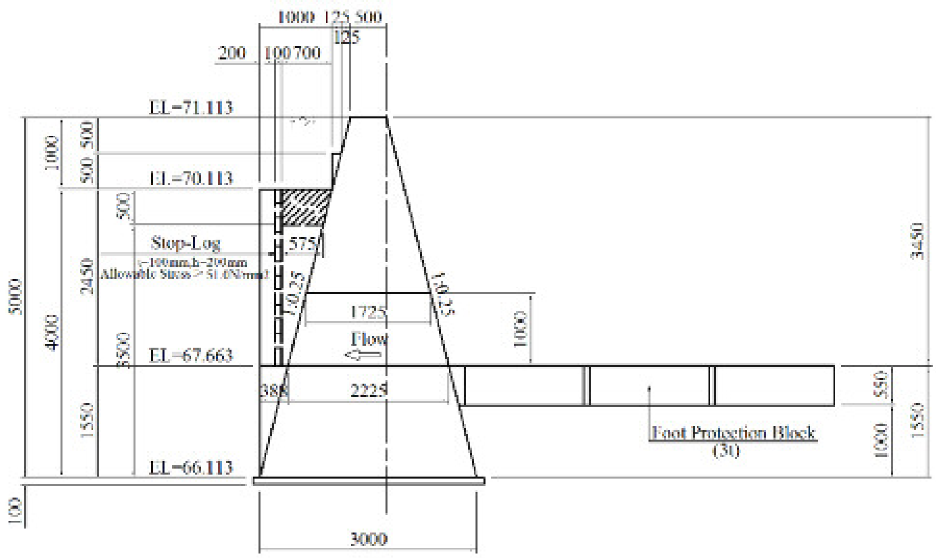


Fig. 2.2.33 Cross-Section of Stop Log Portion

c. Standards of the stop log material

Assuming that the stop logs are made of wood of 20 cm high, 10 cm wide and 1.0m long (25 cm high for only one piece), safety is verified by stress calculation.

<u>**Specifications of wood**</u>

○ Standards of wood: B 1,000 mm × H 200 mm × T 100 mm

○ Section modulus of wood: $Z = (b \times t^2/6) \times h$

$$= (1{,}000 \times 100^2/6) \times 200 = 333{,}333{,}333 \text{ mm}^3$$

Horizontal moment

Since the stop log foundation height is located at 3.45 m from the crest of the revetment, a horizontal moment acting on the stop logs is 16,905,000,000 N-mm by the following calculation.

$$M = Wo \times h \times B/2 = 9{,}800 \times 3{,}450 \times 1{,}000/2 = 16{,}905{,}000{,}000 \text{ N-mm}$$

Calculation of stress intensity and wood used

As a result of stress calculation, the material required is wood capable of securing allowable stress of 51.0 N/mm^2.

$$\sigma = M/Z = 16{,}905{,}000{,}000/333{,}333{,}333 = 50.7 \rightarrow 51.0 \text{ N/mm}^2$$

The allowable stress of wood generally has the relations shown in the following table. To satisfy 51.0 N/mm^2 (bending stress), it is necessary to have bending tolerance of 139 N/mm^2 or more. The following lists several types of wood and their intensity values for your reference.

Table 2.2.39 Relations between Wood Intensity and Allowable Stress Intensity

Intensity	Compression	Tension	Bending	Shear
Allowable stress for long sustained loading	1.1/3・Fe			
Allowable unit stress for temporary loading	2/3・Fe			
Material strength	Fe			

Table 2.2.40 Wood Strength (Example)

General name	Country of origin	Color	Specific gravity	Bending strength kg/cm^2	Compressive strength kg/cm^2	Knot	Durability	Price
Ulin	Indonesia	Yellow-Brown	0.96	1886	911	No	Extremely high	Medium
Ipen	Brazil	Yellow green-Brown	1.05	1950	905	No	Extremely high	Medium
Ipegrande (Cumaru)	South America	Yellow-Brown	1.08	1990	1050	No	Extremely high	Medium
Macaranduba	South America	Yellow-Brown	1.05	1550	936	No	Extremely high	Medium
Selangan Batu	Malaysia	Red-brown	0.96	1333	701	No	Extremely high	Medium
Itauba	South America	Yellow-brown	0.85	1240	620	No	Extremely high	Medium
Redwood	Africa	Red-brown	0.33	770	300	Yes	High	Medium
Western red cedar	North America	Red-brown	0.32	550	310	Yes	Medium to high	Low
Japanese cedar	Japan	Pale yellow-white	0.3	660	340	Yes	Medium	Low
Synthetic wood	Japan	Brownish		450-550	480-580	No	No decay	High

Source: http://www.d3.dion.ne.jp/~hojogumi/mokuzaikyoudosuuchihyou.html

d. Cross-sectional shape of the side wall

For the cross-sectional shape of the side wall, assuming that the height is 2.45 m, crest width is 0.5 m, and front slope gradient is vertical, calculate the rear slope gradient by a trial, which satisfies the stability conditions. Table 2.2.41 lists the stability calculation results when the rear gradient is 1:0.45 and 1:0.5. Since the stability conditions are satisfied when the rear gradient is 1:0.5, the cross-sectional shape of the side wall assumes that the crest width is 0.5 m, front slope gradient is vertical, and rear gradient is 1:0.5.

Table 2.2.41 Stability Calculation Results

Rear gradient	Item	Stability condition	Case 1 (Normal time)	Case 2 (At flood)	Case 3 (At rainfall)
0.45	Tilting condition	e≦0.267	0.250	0.250	0.270
			OK	OK	X
	Sliding condition	n ≥1.5	2.445	2.496	2.259
			OK	OK	OK
	Bearing capacity condition	σu≦300kN/m²	96.063	53.874	95.407
			OK	OK	OK
	Stability evaluation result		×		
0.50	Tilting condition	E≦0.287	0.246	0.246	0.267
			OK	OK	OK
	Sliding condition	n ≥1.5	2.566	2.618	2.373
			OK	OK	OK
	Bearing capacity condition	σu≦300kN/m²	91.531	51.373	90.954
			OK	OK	OK
	Stability evaluation result		OK		

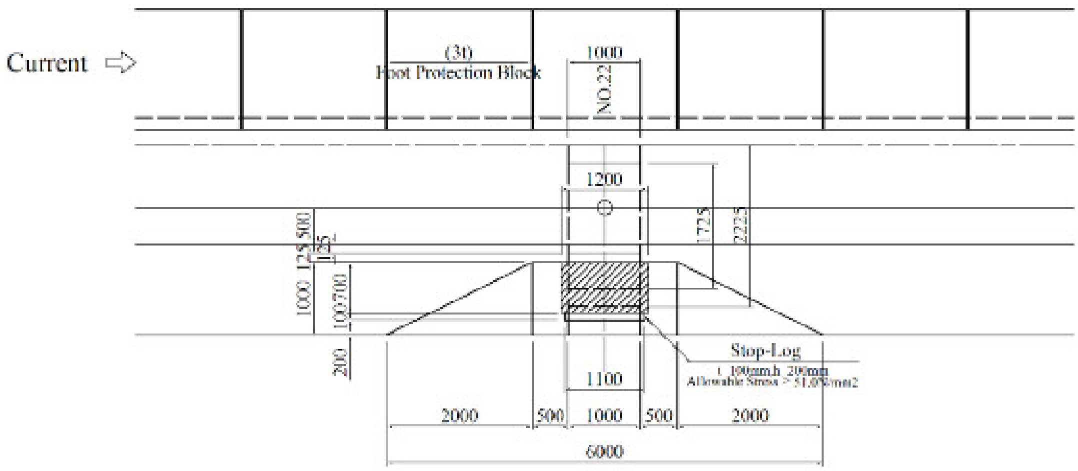
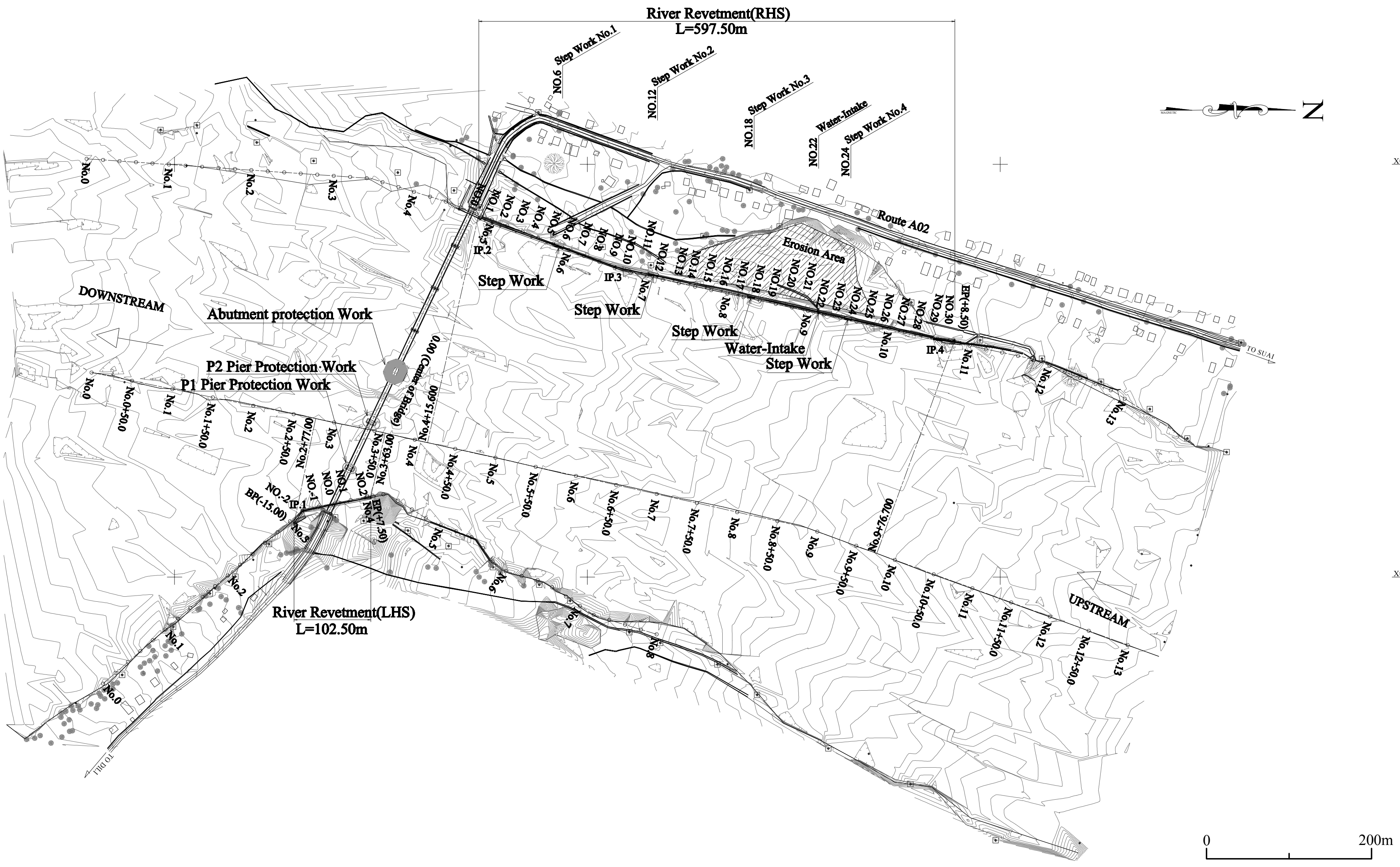


Fig.2.2.34 General Plan of Intake

2-2-3 Outline Design Drawing

General Plan

S=1:5000



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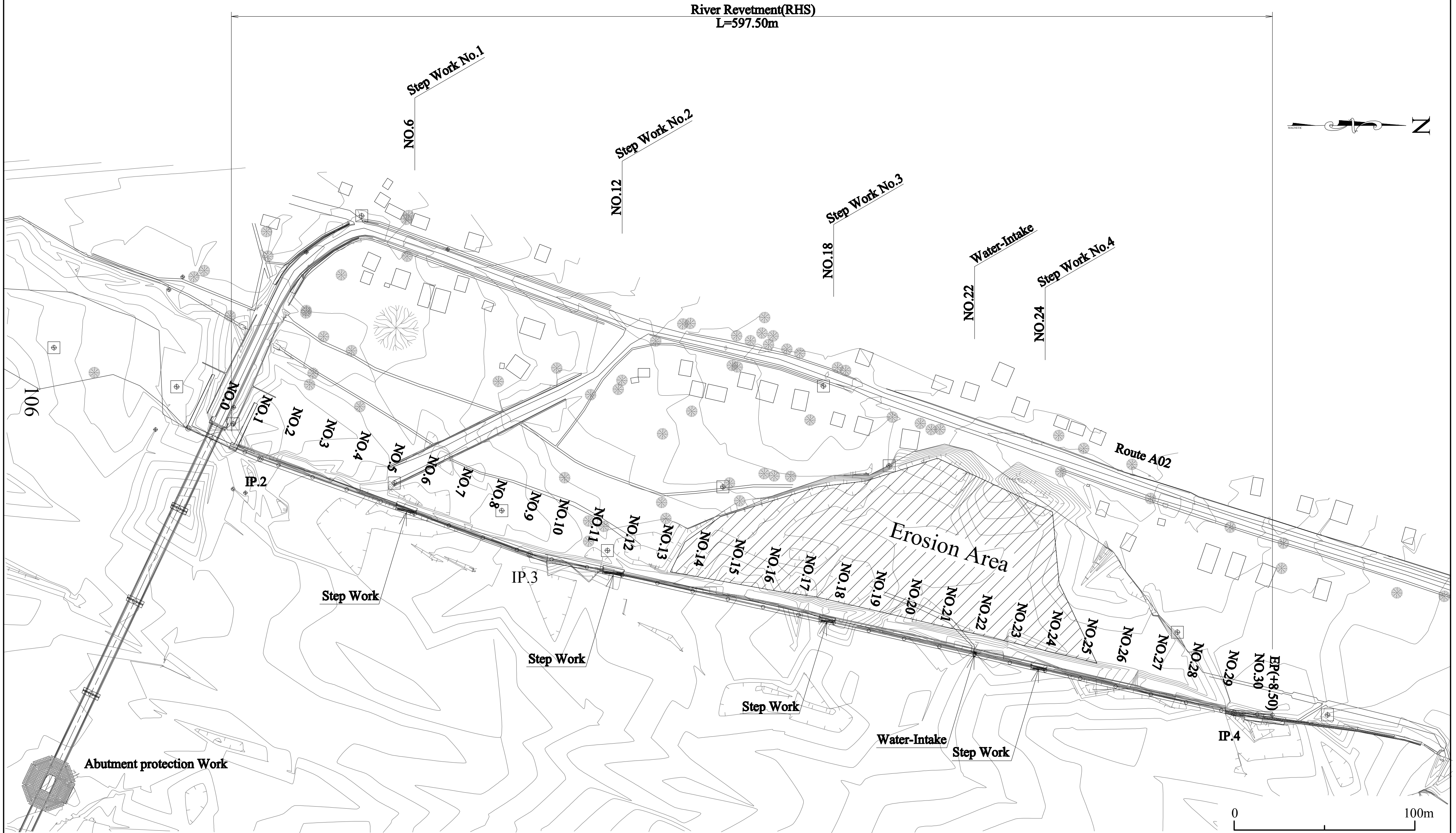
			General Plan	S=1:5000		Date		Date	January,2013	

Plan (River Revetment-RHS)

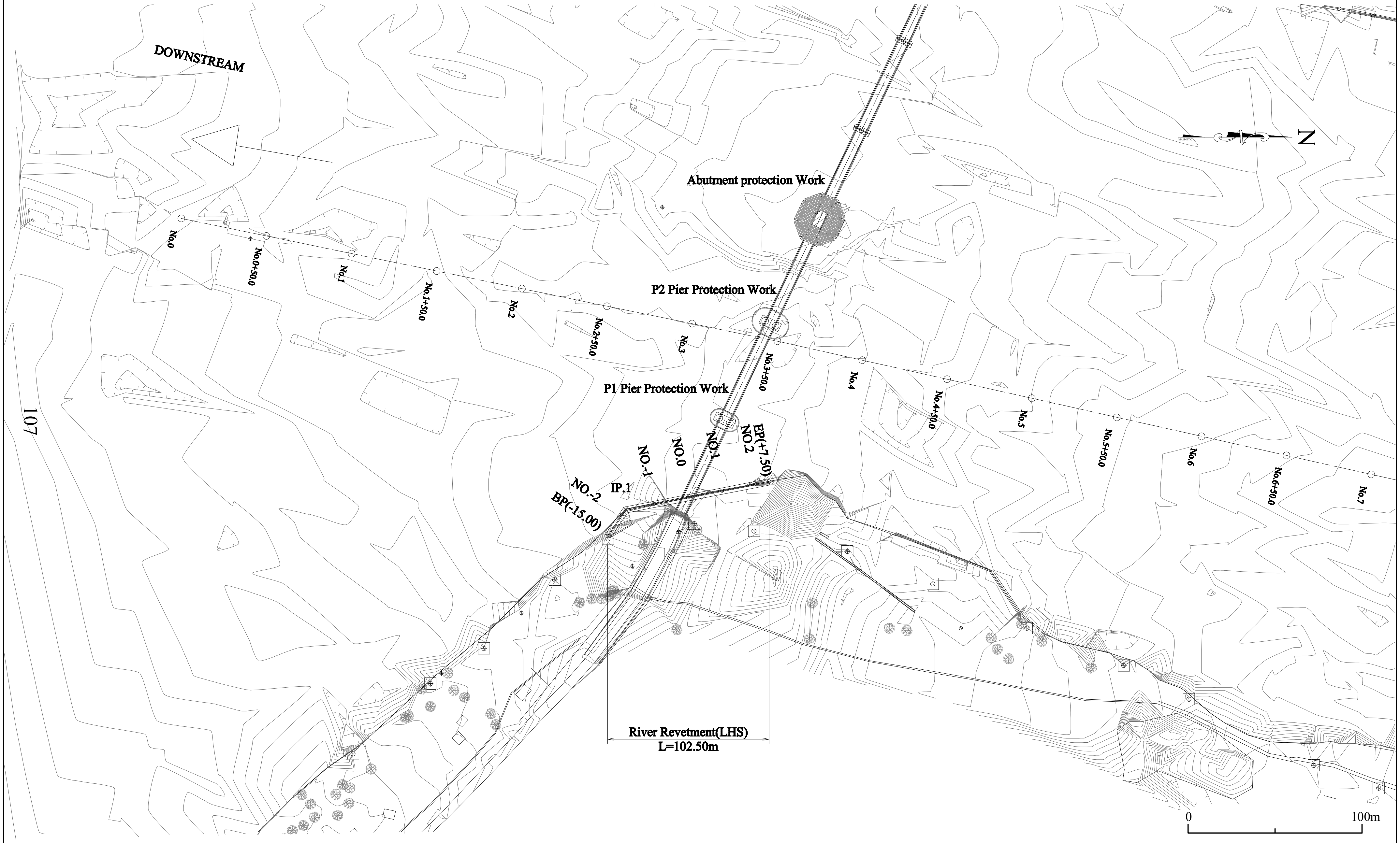
S=1:2000



Democratic Republic of Timor-Leste	The Preparatory Survey on the Project of River Training for the Protection of Mola Bridge in Timor-Leste	Eight-Japan Engineering Consultants Inc.	Drawing Title: Plan (River Revetment-RHS)	Scale: S=1:2000	Directorate of Road , Bridge and Flood Control (DRBFC) DemocraticRepublic of Timor-Leste	Approved by / Date	Eight-Japan Engineering Consultants Inc.	Checked by / Date	Date: January,2013	Sheet No.

Plan (River Revetment-LHS)

S=1:2000



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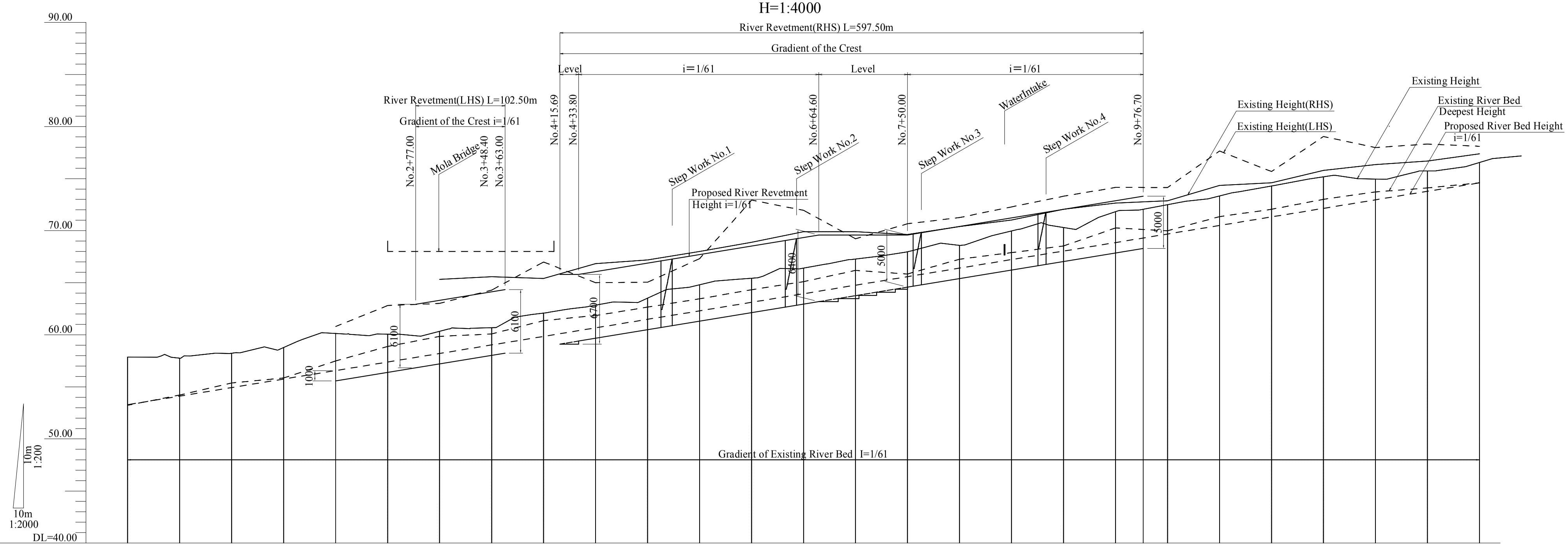
Profile

V=1:400
H=1:4000



Proposed River Bed Gradient: 56.57 (NO.2) — I=1/61.0, L=776.700m — 69.30 (+76.70)

Station	Distance	Accumulative Length	Existing Height	Existing River Bed Deepest Height	Existing River Bed Ave. Height	Proposed River Revetment Height(RHS)	Proposed River Revetment Height(LHS)	Proposed River Bed Height	Proposed River Bed Gradient
NO.0	0.00	0.00	57.87	53.23				53.29	
+50.00	50.00	50.00	57.76	54.21				54.11	
NO.1	50.00	100.00	58.24	55.37				54.93	
+50.00	50.00	150.00	58.78	55.85				55.75	
NO.2	50.00	200.00	60.13	57.49	59.47			56.57	56.57
+50.00	50.00	250.00	60.06	58.88	60.50			57.39	
NO.3	50.00	300.00	60.34	59.85	61.45		63.31	58.21	
+50.00	50.00	350.00	60.68	60.08	62.27	65.18	64.12	59.03	
NO.4	50.00	400.00	62.08	61.36	62.66	65.80		59.85	
+50.00	50.00	450.00	62.85	61.85	62.95	66.07		60.67	
NO.5	50.00	500.00	63.52	62.66	63.92	66.89		61.49	
+50.00	50.00	550.00	64.81	63.46	64.65	67.70		62.31	
NO.6	50.00	600.00	65.43	64.31	65.50	68.52		63.13	
+50.00	50.00	650.00	66.40	65.11	66.26	69.34		63.95	
NO.7	50.00	700.00	67.28	66.18	67.01	69.58		64.76	
+50.00	50.00	750.00	67.98	65.84	67.71	69.58		65.58	
NO.8	50.00	800.00	68.59	67.26	68.29	70.40		66.40	
+50.00	50.00	850.00	69.97	67.89	69.40	71.22		67.22	
NO.9	50.00	900.00	70.31	68.54	70.29	72.04		68.04	
+50.00	50.00	950.00	71.82	70.23	71.07	72.86		68.86	
+76.70	26.70	976.70							69.30
NO.10	23.30	1000.00	72.49	69.99	71.71			69.68	
+50.00	50.00	1050.00	73.33	71.35	72.73			70.50	
NO.11	50.00	1100.00	74.29	72.05	73.36			71.32	
+50.00	50.00	1150.00	75.18	73.01	74.32			72.14	
NO.12	50.00	1200.00	74.96	73.72	75.10			72.96	
+50.00	50.00	1250.00	75.74	74.11	75.81			73.78	
NO.13	50.00	1300.00	76.55	74.60	76.26			74.60	

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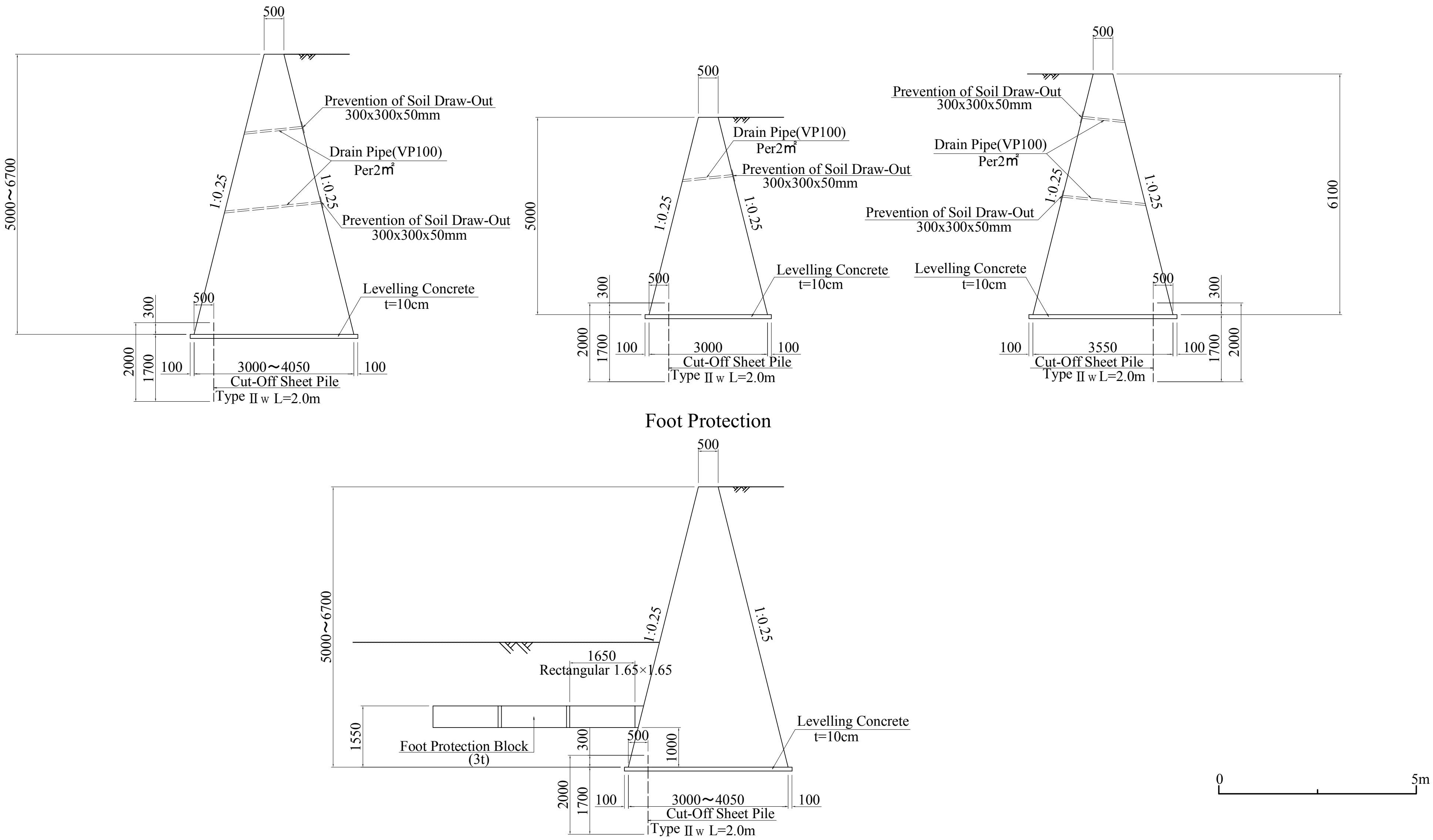
Typical Cross Section

S=1:100

River Revetment Down stream (RHS) From No.7+50 | River Revetment Up stream (RHS) From No.7+50 | River Revetment(LHS)



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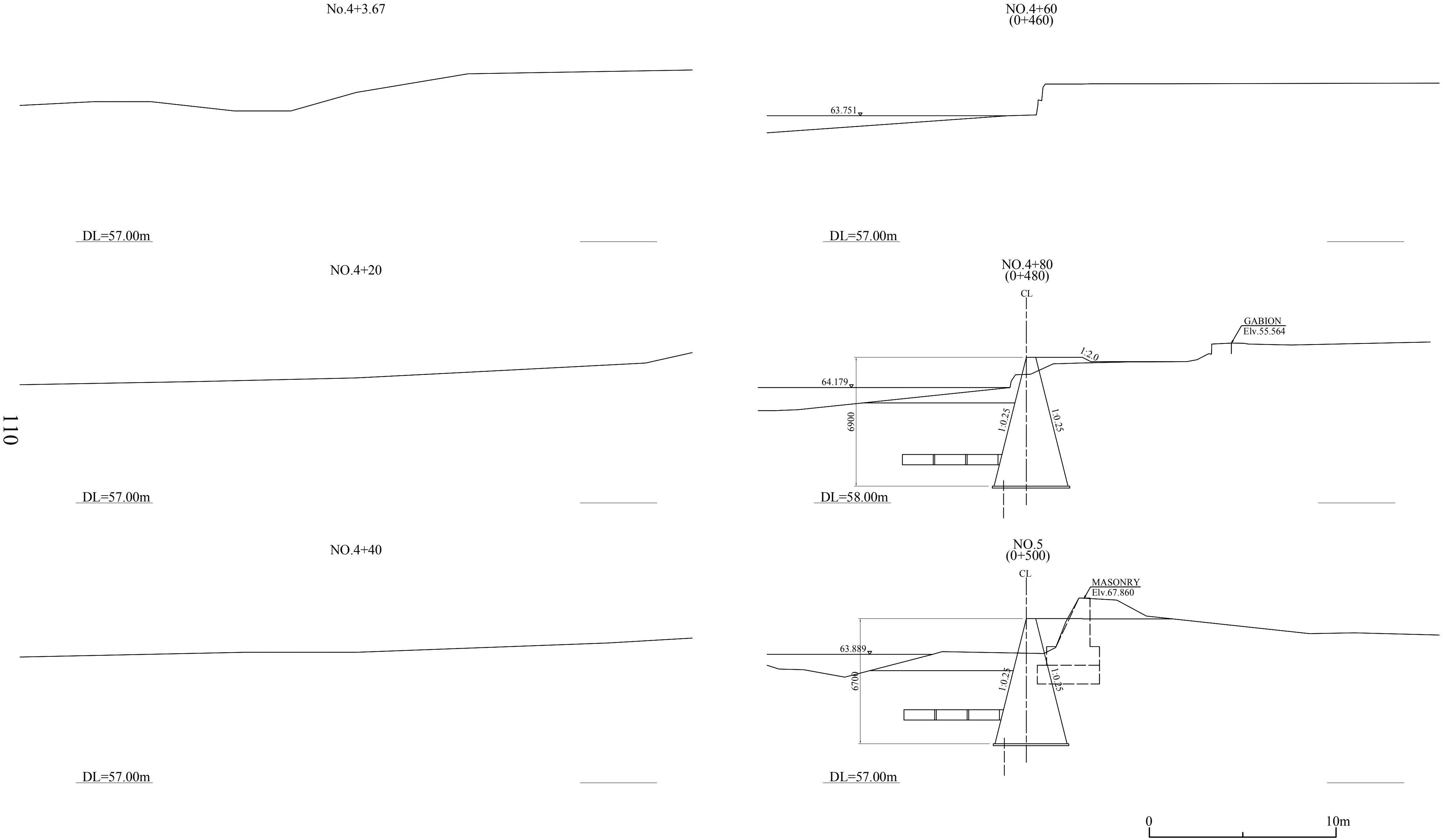
Cross Section (RHS) (1/6)

S=1:200



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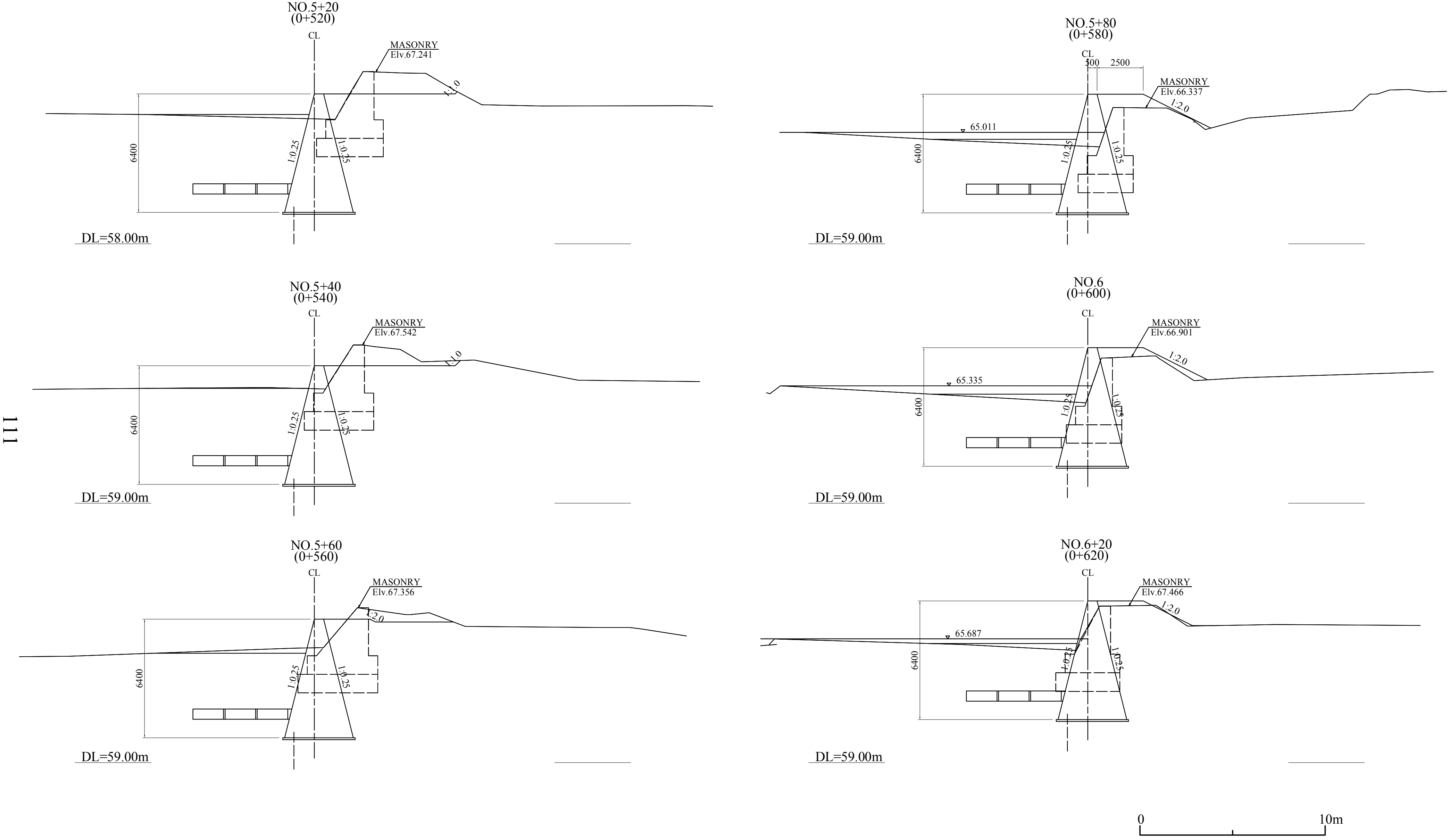
Cross Section (RHS) (2/6)

S=1:200



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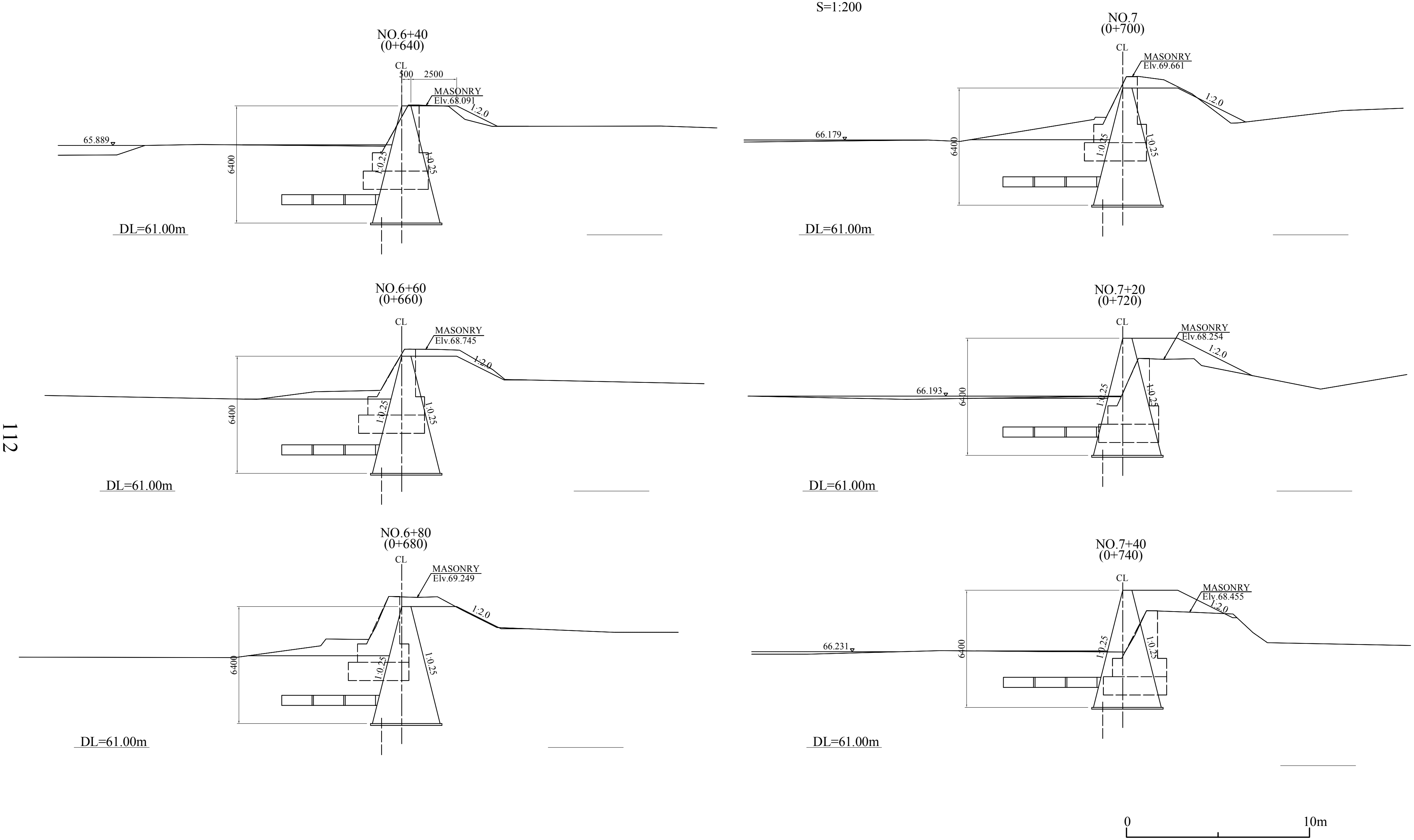
Cross Section (RHS) (3/6)

S=1:200



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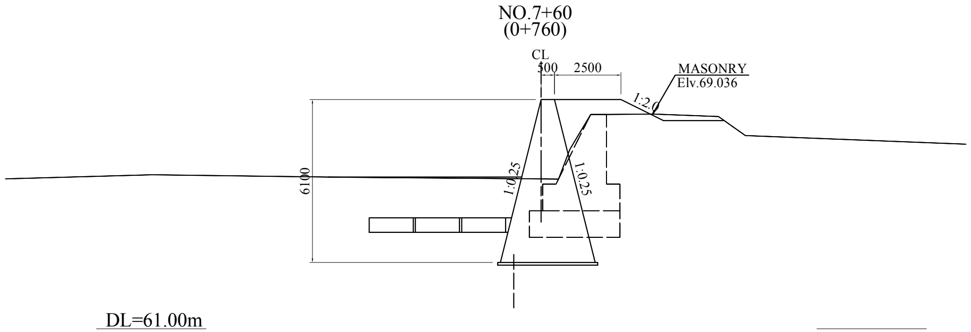
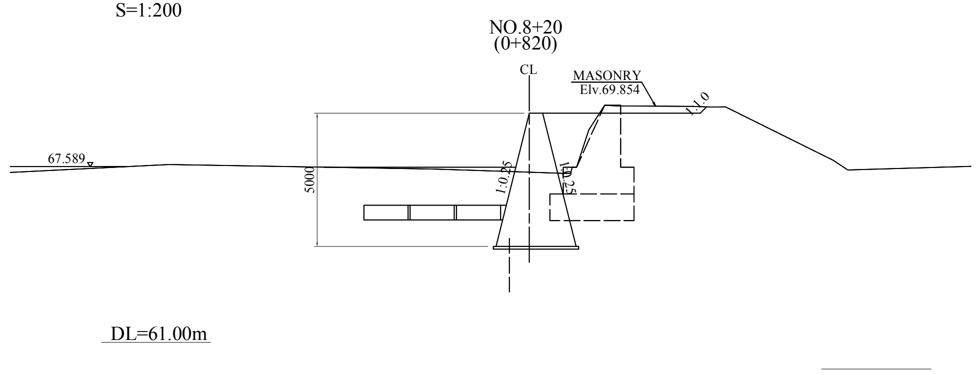
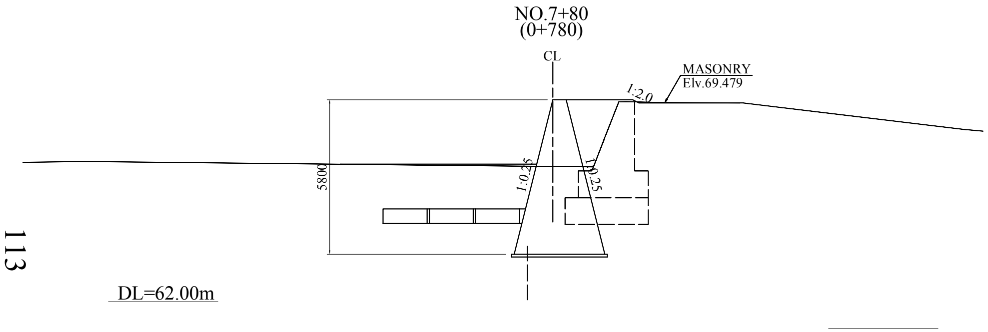
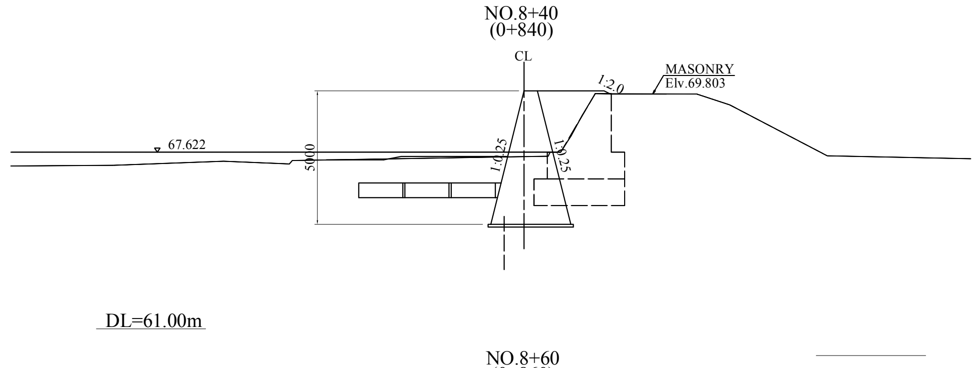
Cross Section (RHS) (4/6)

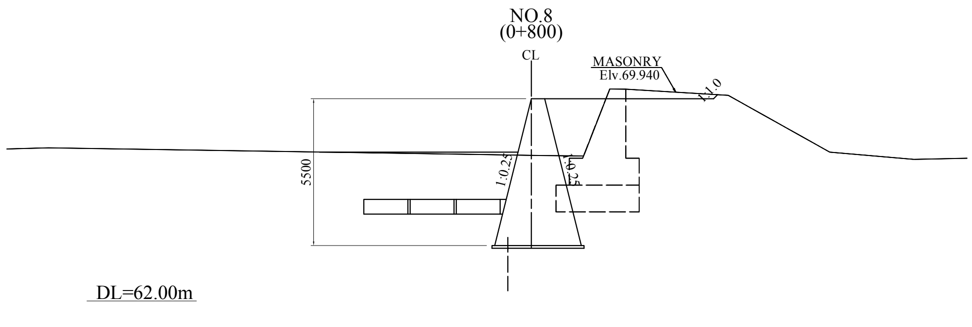
S=1:200

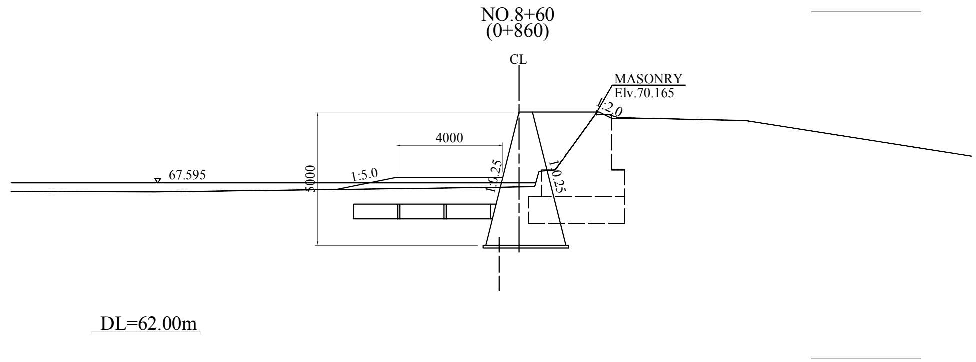












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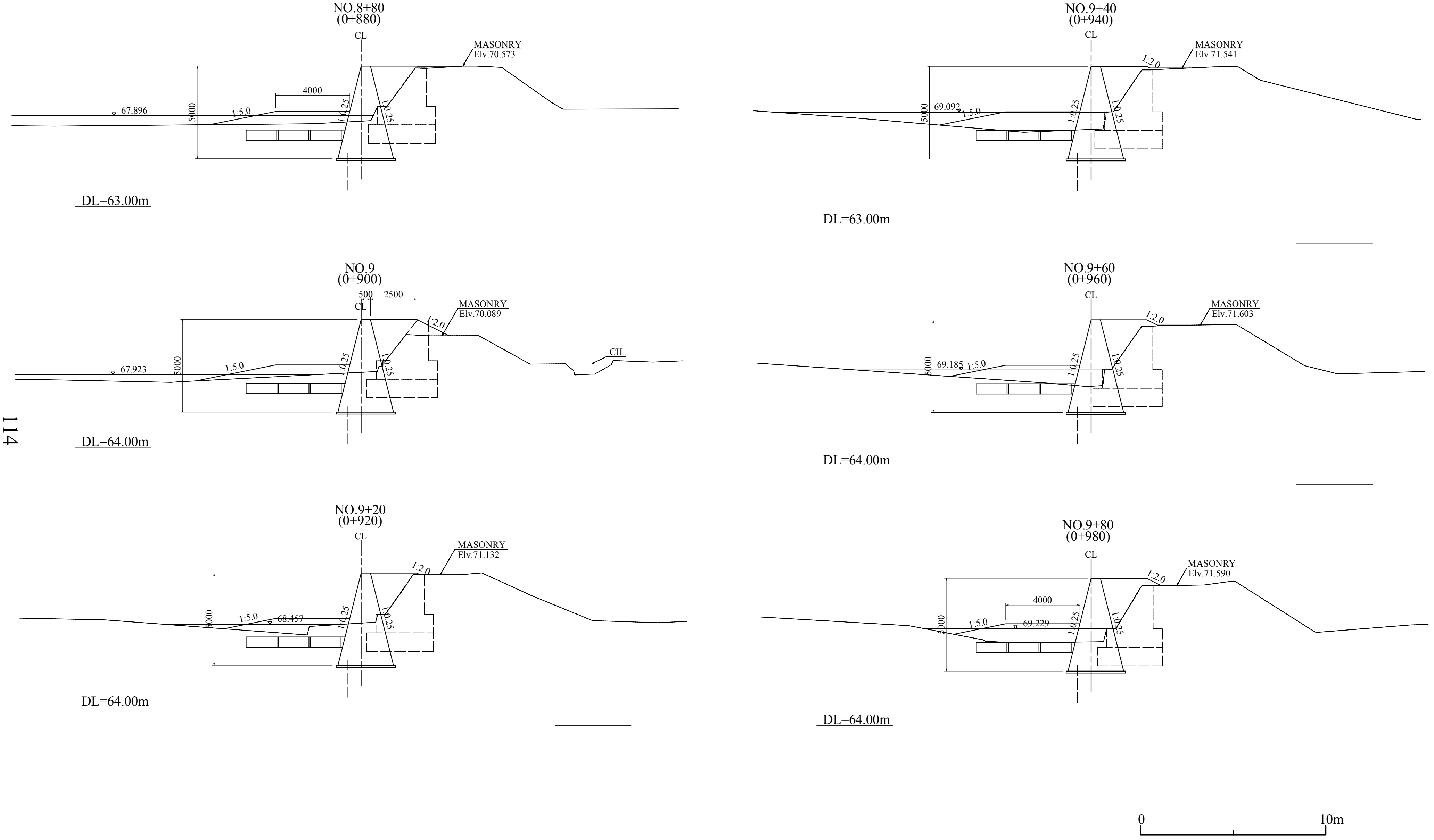
Cross Section (RHS) (5/6)

S=1:200



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Cross Section (RHS) (6/6)

S=1:200

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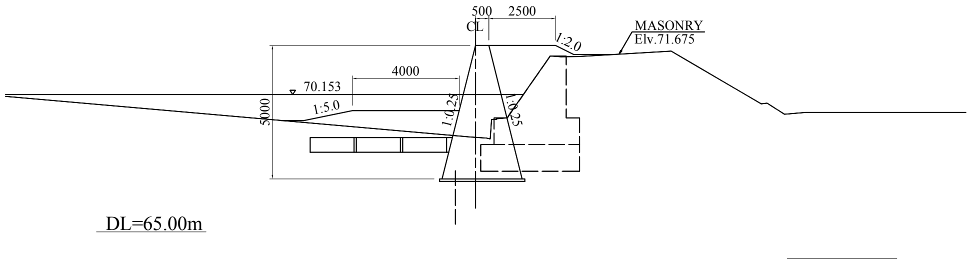
(1+000)



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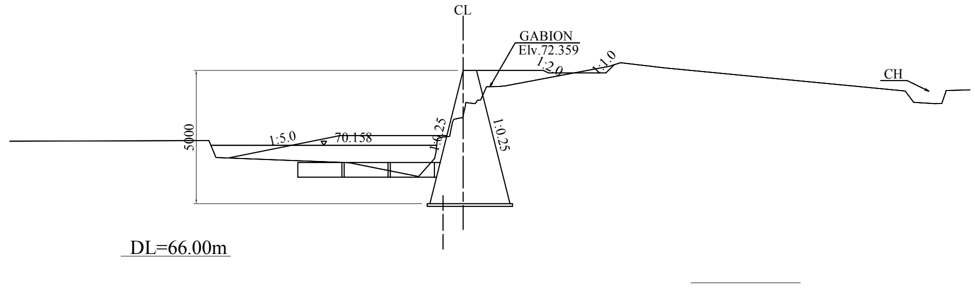

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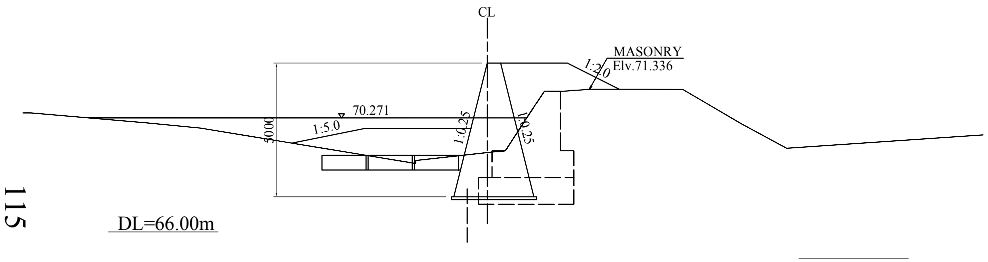

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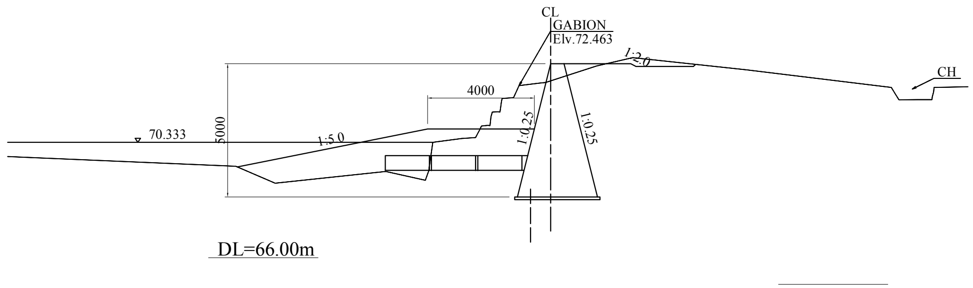

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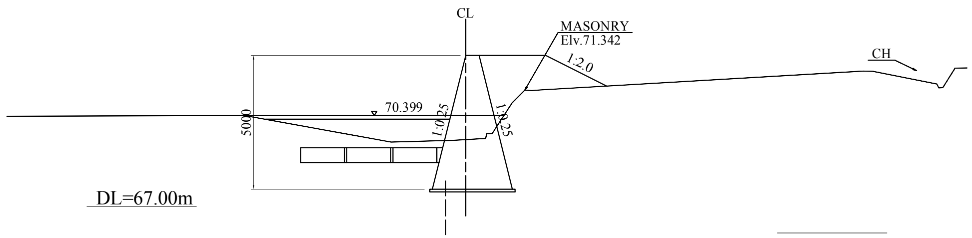
(1+040)



0 10m

Democratic Republic of Timor-Leste	The Preparatory Survey on the Project of River Training for the Protection of Mola Bridge in Timor-Leste	Eight-Japan Engineering Consultants Inc.	Drawing Title	Scale	Directorate of Road , Bridge and Flood Control (DRBFC) DemocraticRepublic of Timor-Leste	Approved by	Eight-Japan Engineering Consultants Inc.	Checked by	Date	Sheet No.
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Cross Section (LHS)

S=1:200

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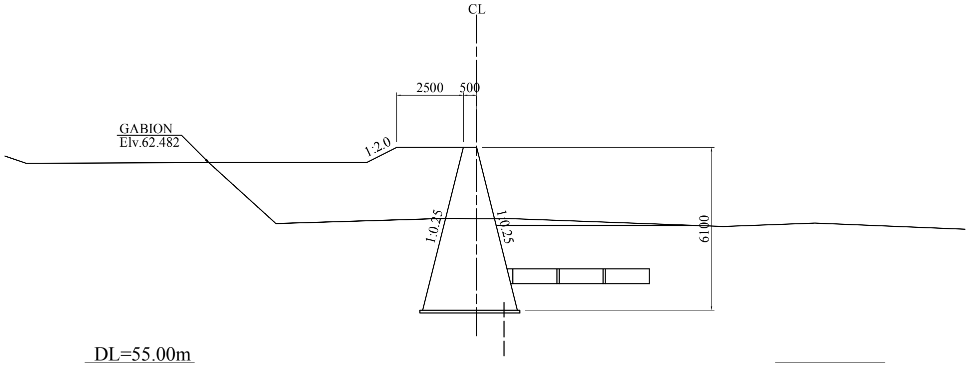
(0+320)



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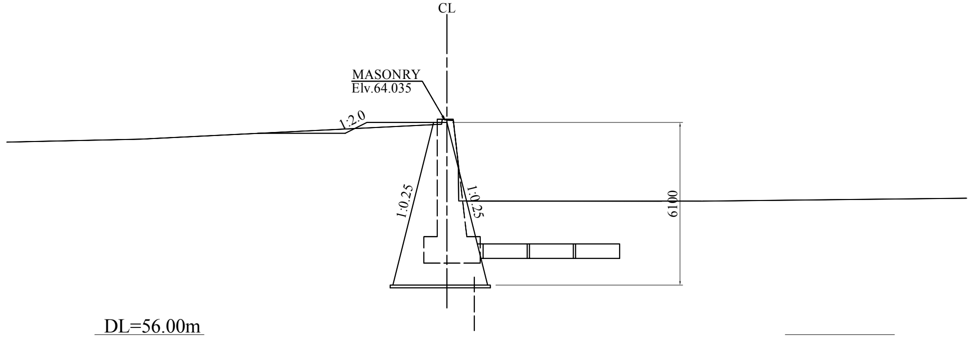

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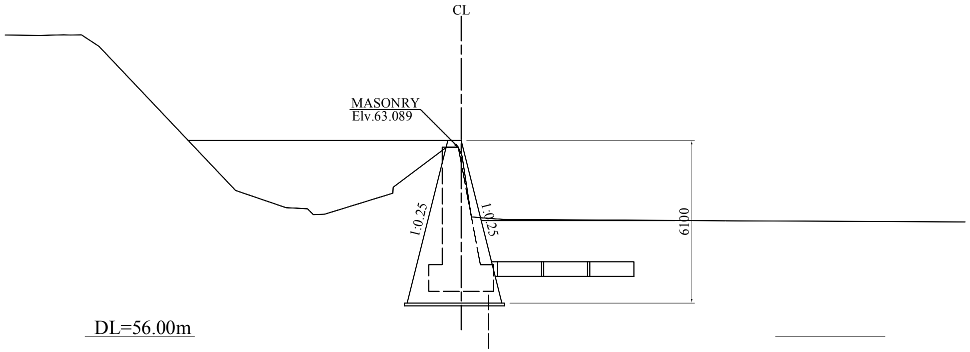

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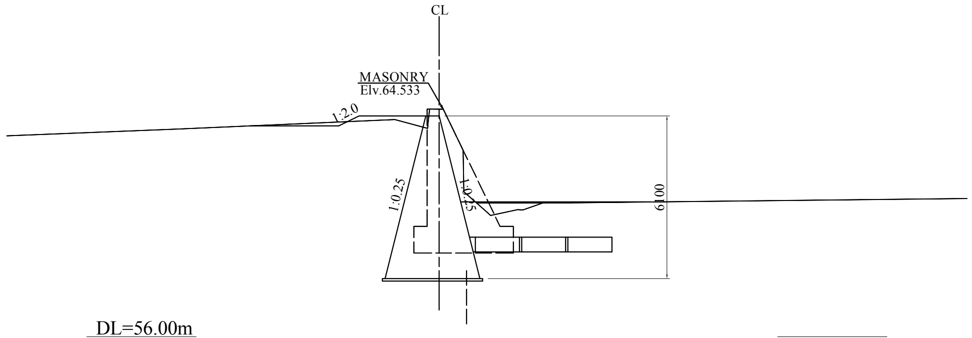

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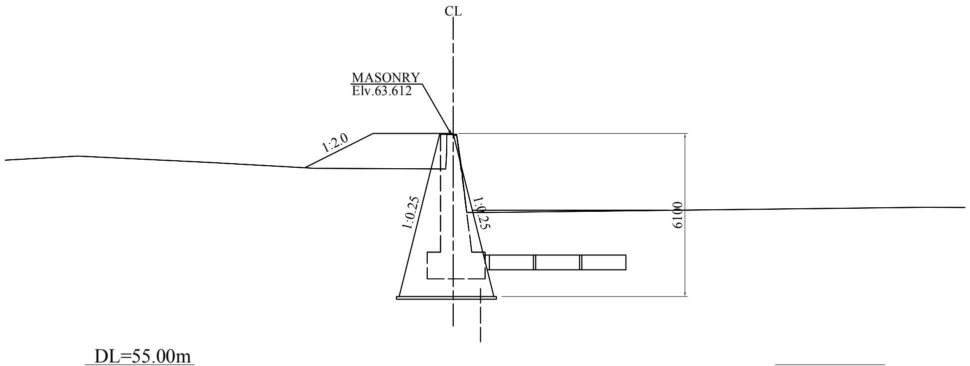
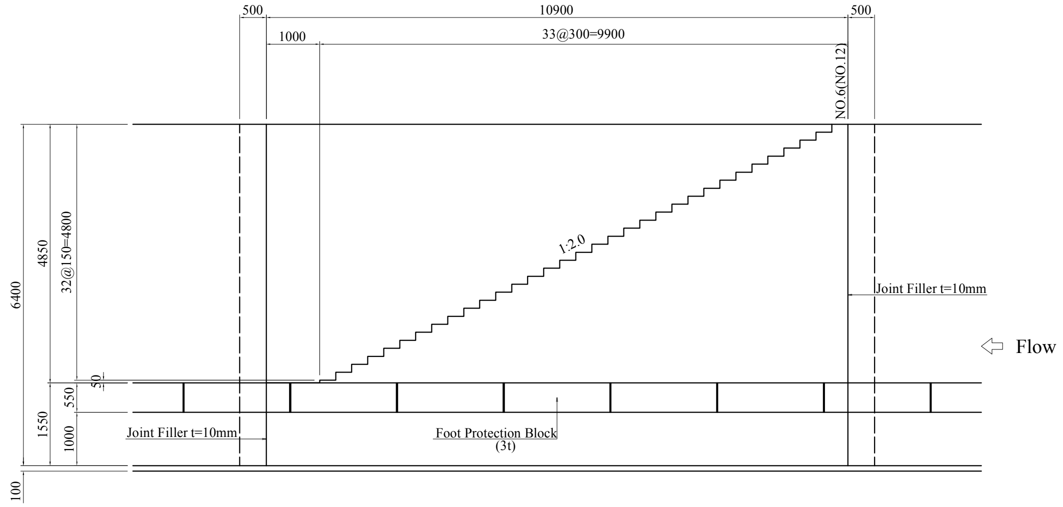


Democratic Republic of Timor-Leste	The Preparatory Survey on the Project of River Training for the Protection of Mola Bridge in Timor-Leste	Eight-Japan Engineering Consultants Inc.	Drawing Title	Scale	Directorate of Road , Bridge and Flood Control (DRBFC) DemocraticRepublic of Timor-Leste	Approved by	Eight-Japan Engineering Consultants Inc.	Checked by	Date	Sheet No.
			Cross Section (LHS)	S=1:200		Date		Date	January,2013	

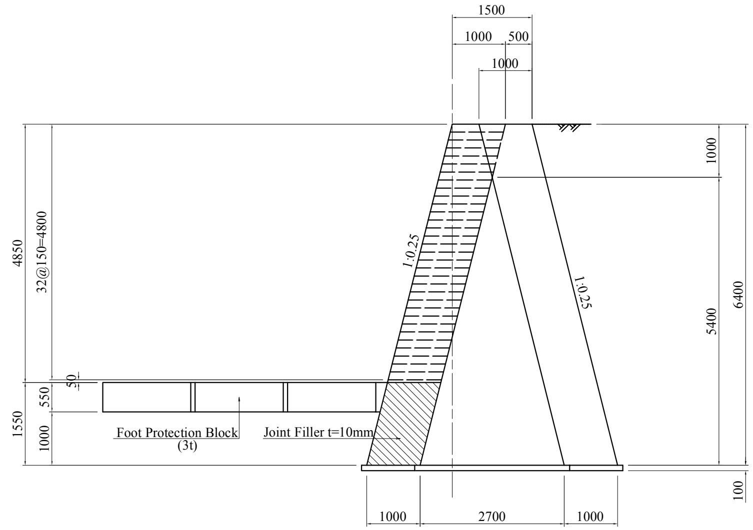
Step Work NO.1,NO.2

S=1:100

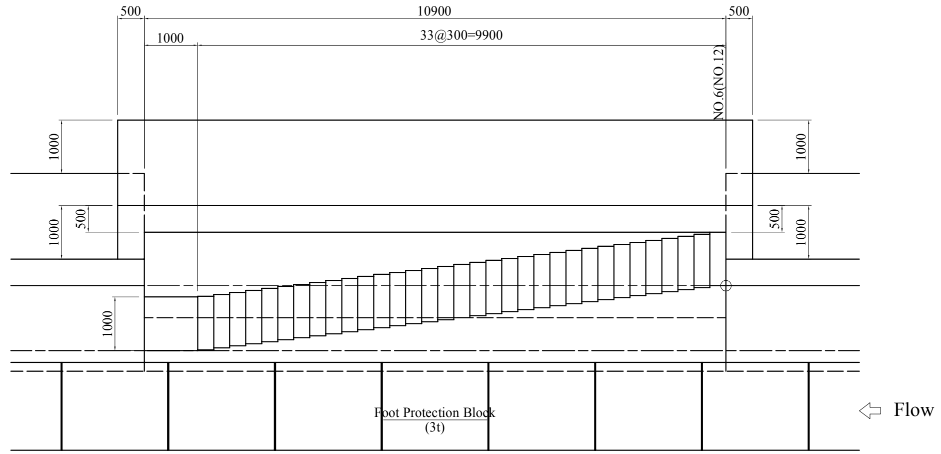
Side View

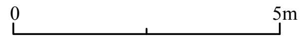


Section



Plan



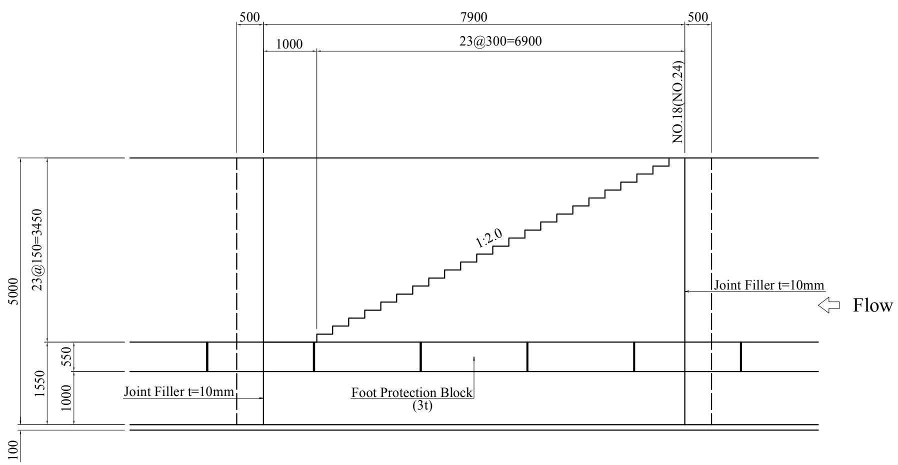


Democratic Republic of Timor-Leste	The Preparatory Survey on the Project of River Training for the Protection of Mola Bridge in Timor-Leste	Eight-Japan Engineering Consultants Inc.	Drawing Title	Scale	Directorate of Road , Bridge and Flood Control (DRBFC) DemocraticRepublic of Timor-Leste	Approved by	Eight-Japan Engineering Consultants Inc.	Checked by	Date	Sheet No.
			Step Work NO.1,NO.2	S=1:100		Date		Date	January,2013	

Step Work NO.3,NO.4

S=1:100

Side View



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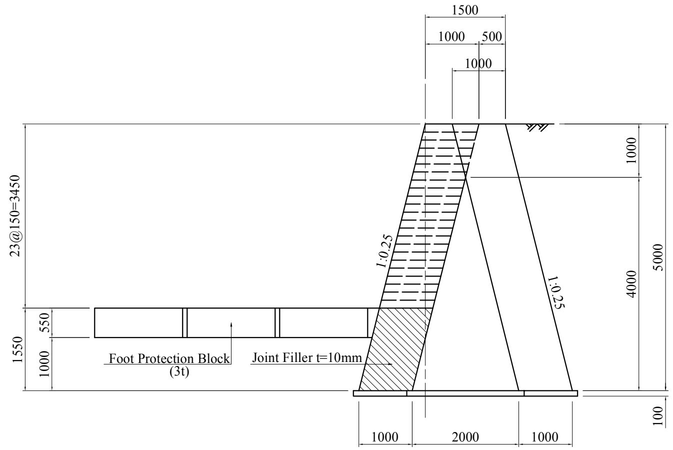

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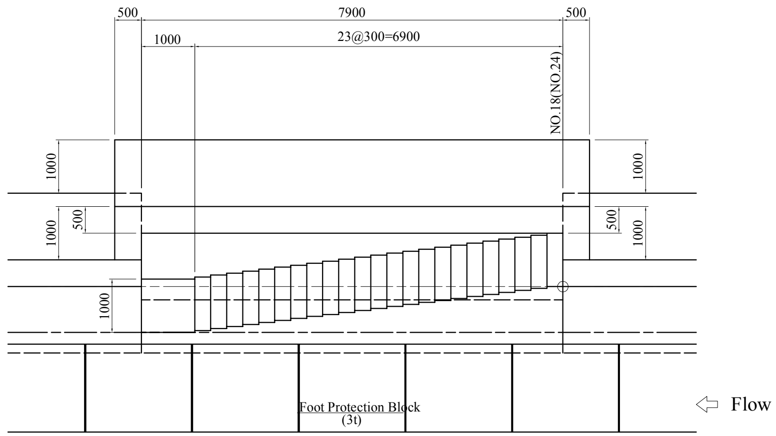
Plan



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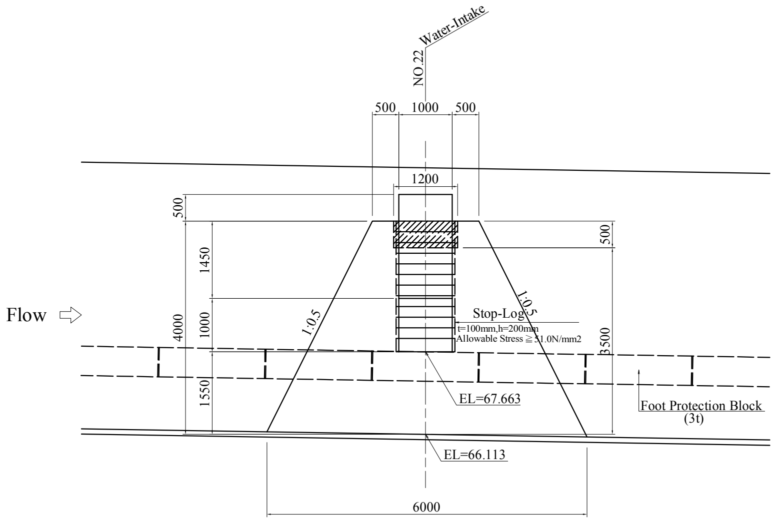
Water-Intake Details

S=1:100

Side View



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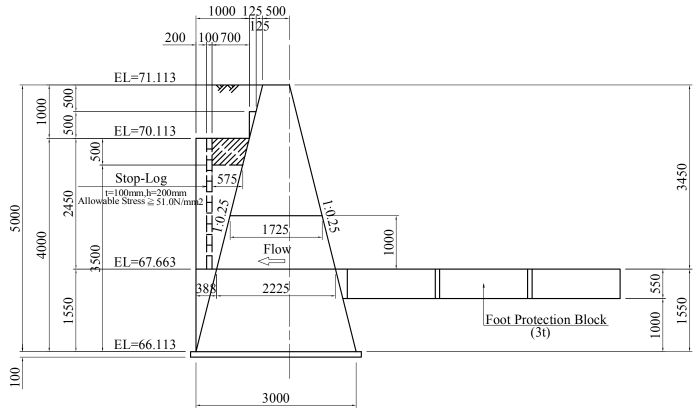

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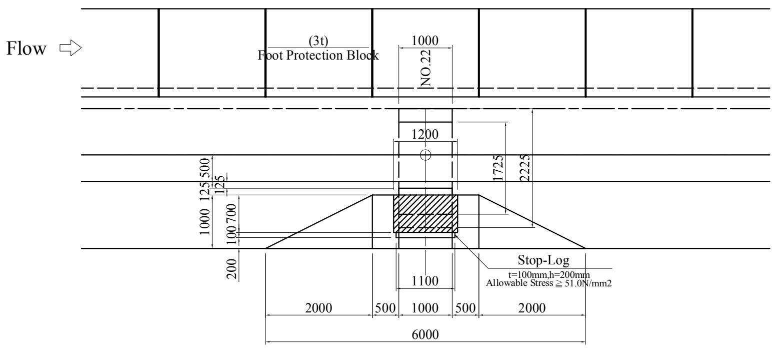

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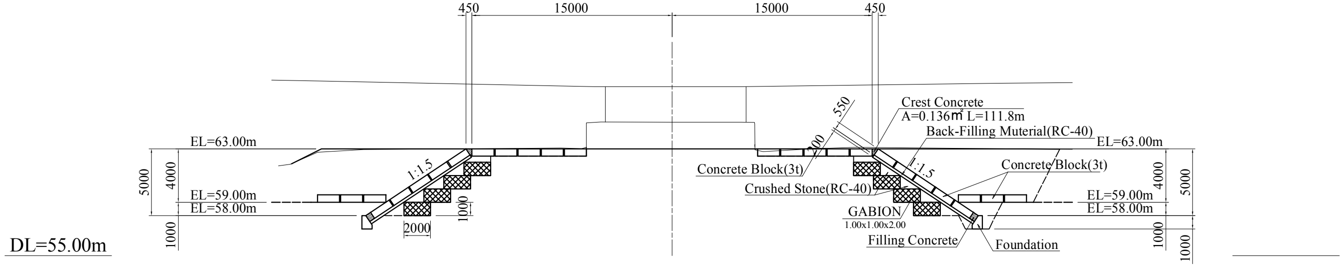
Democratic Republic of Timor-Leste	The Preparatory Survey on the Project of River Training for the Protection of Mola Bridge in Timor-Leste	Eight-Japan Engineering Consultants Inc.	Drawing Title	Scale	Directorate of Road , Bridge and Flood Control (DRBFC) DemocraticRepublic of Timor-Leste	Approved by	Eight-Japan Engineering Consultants Inc.	Checked by	Date	Sheet No.
			Water-Intake Details	S=1:100		Date		Date	January,2013	

Abutment Protection Work Details

Section

S=1:400



Plan

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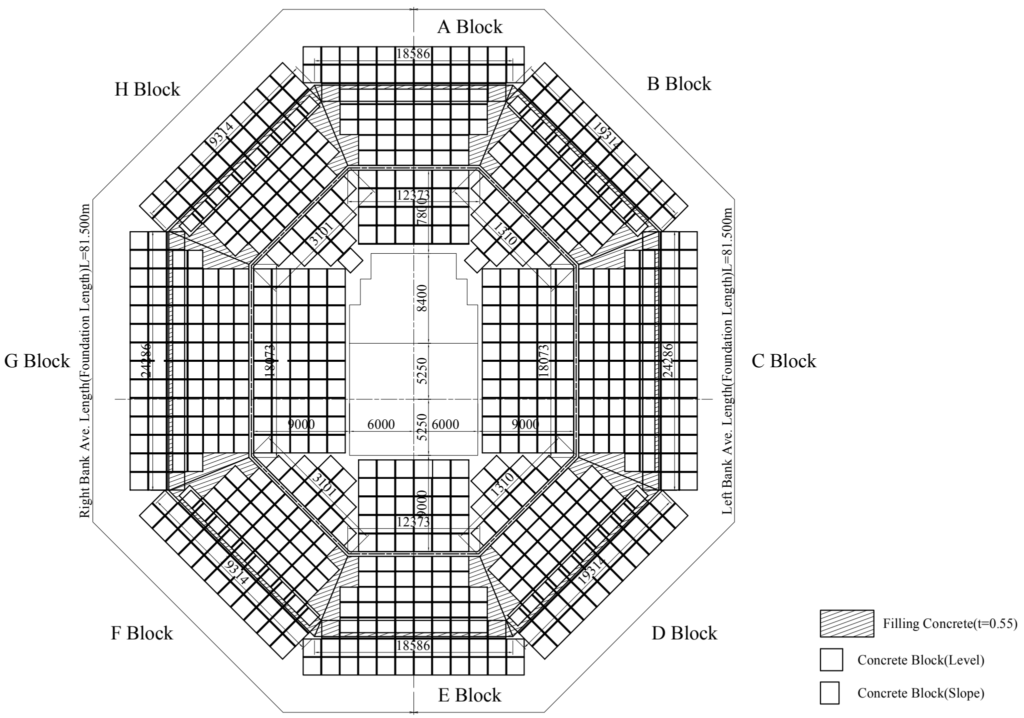
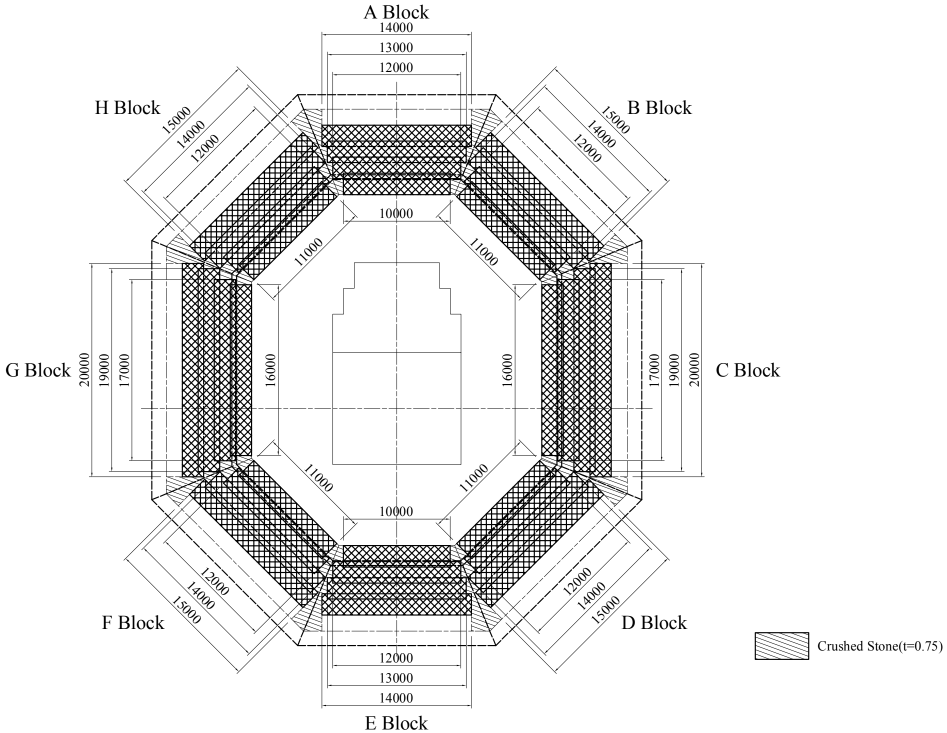
Concrete Block



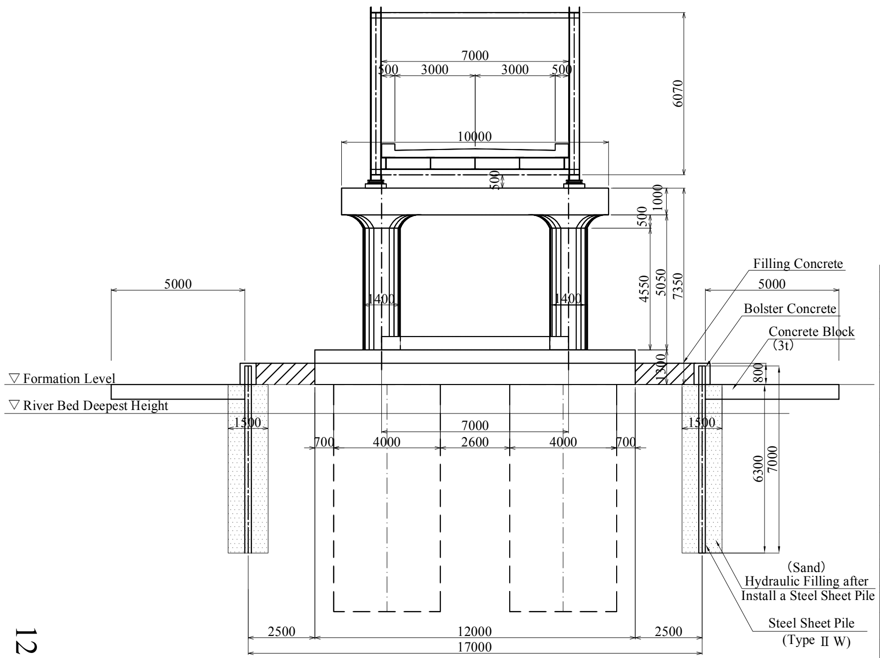
GABION

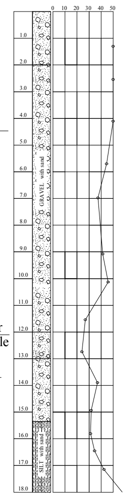


Democratic Republic of Timor-Leste	The Preparatory Survey on the Project of River Training for the Protection of Mola Bridge in Timor-Leste	Eight-Japan Engineering Consultants Inc.	Drawing Title: Abutment Protection Work Details	Scale: As Shown	Directorate of Road , Bridge and Flood Control (DRBFC) DemocraticRepublic of Timor-Leste	Approved by / Date	Eight-Japan Engineering Consultants Inc.	Checked by / Date	Date: January,2013	Sheet No.

P1 Pier Protection

Section S=1:200





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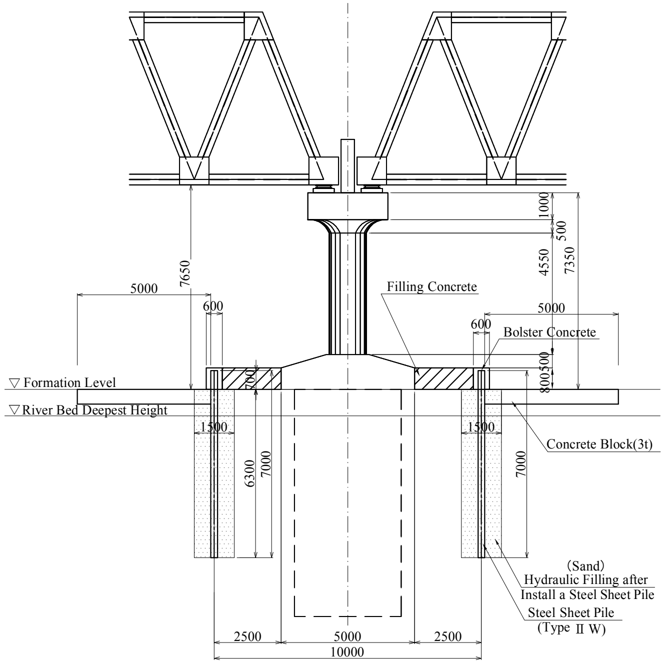

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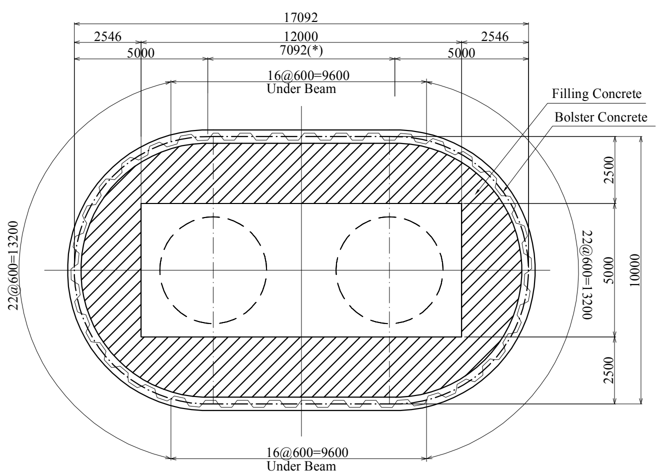
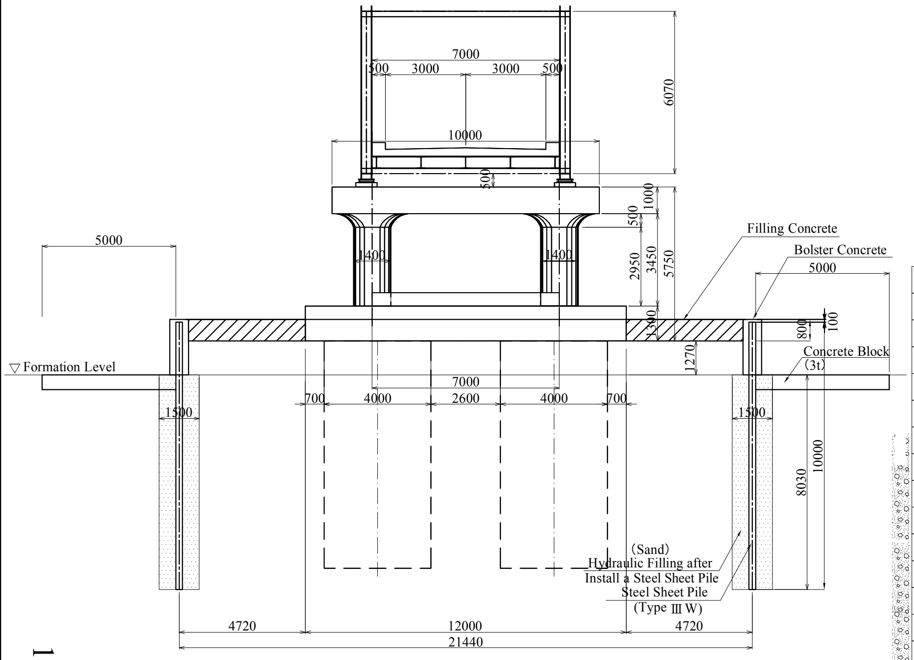
Plan S=1:200

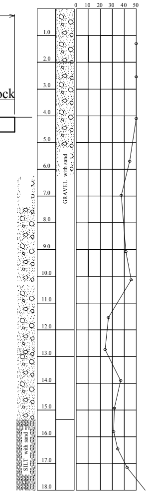


Democratic Republic of Timor-Leste	The Preparatory Survey on the Project of River Training for the Protection of Mola Bridge in Timor-Leste	Eight-Japan Engineering Consultants Inc.	Drawing Title	Scale	Directorate of Road , Bridge and Flood Control (DRBFC) DemocraticRepublic of Timor-Leste	Approved by	Eight-Japan Engineering Consultants Inc.	Checked by	Date	Sheet No.
			P1 Pier Protection	As Shown		Date		Date	January,2013	

P2 Pier Protection

Section S=1:200





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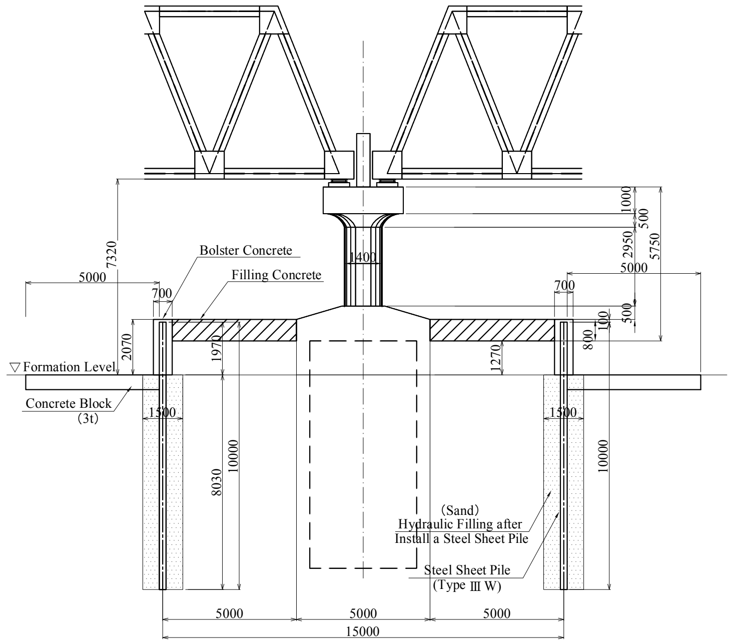

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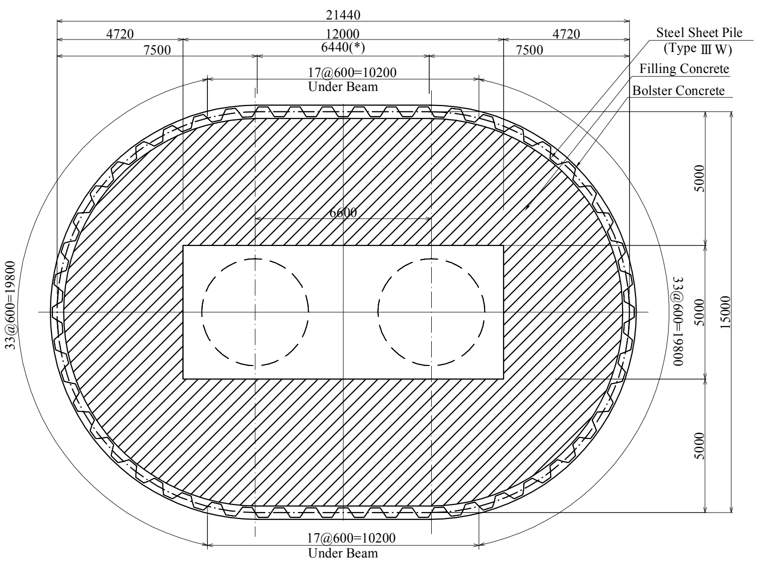
Plan S=1:200



Democratic Republic of Timor-Leste	The Preparatory Survey on the Project of River Training for the Protection of Mola Bridge in Timor-Leste	Eight-Japan Engineering Consultants Inc.	Drawing Title: P2 Pier Protection	Scale: As Shown	Directorate of Road , Bridge and Flood Control (DRBFC) DemocraticRepublic of Timor-Leste	Approved by / Date	Eight-Japan Engineering Consultants Inc.	Checked by / Date	Date: January,2013	Sheet No.

2-2-4 Implementation Plan

2-2-4-1 Implementation Policy

(1) Repair of Transportation Routes

Of equipment and materials in this work, those procured from both Japan and the third countries are unloaded on Dili Port and transported to the site by land. Equipment and machinery to be procured in Timor-Leste are to be procured mainly in Dili district and similarly transported by land. The transportation route by land is a narrow winding road that snakes through the steep geography; especially during the rainy season, slope failure or road surface subsidence frequently occurs, impairing the passage of heavy vehicles. Due to wheel ruts and erosion, the road surface is deeply depressed and there are many pints through which large-sized vehicles are had to pass. Moreover, the transportation route include the Bailey bridge (steel-made temporary bridge), whose wooden slab suffers from corrosion, thus increasing reduced structural stiffness of the bridge and possibly hindering the passage of heavy vehicles.

Although securing transportation routes is an affair for which the recipient country (Timor-Leste) should be responsible, judging from the current condition of the country, it is pretty impossible to expect them to perform appropriate repair of the road at the right time. In the previous Mola River construction project under the Japanese Grant Aid, the response by the Government of Timor-Leste was rather insufficient. Hence, the following repair works were determined to be included in this project to secure a safety transportation route.

- Repair of the fallen slope using Gabions
- Backfill with high quality soil and gravel pavement for depressed or recessed roadbeds and base course
- Installation of steel plate over the wooden slab of the Bailey Bridge

(2) Road for Construction/Operational Use

The following roads will become a frequent passage of vehicles and thus, undergo gravel pavement (in 4m width) so that they can serve as a construction road:

- An access road from the transportation road (National Route A02) to a concrete plant, gravel plant, and base camp
- An access road from each facility to the construction site
- An entry route from the revetment to a river area

- A road along the revetment (land side)

In addition, a service road is temporarily installed in the river areas to facilitate the revetment work in the river and the foundation protection work for piers and abutments. The service road with a width of 4.0m is built through dozing and spreading by 20t-class bulldozer.

(3) Cofferdam Work and Temporary Diversion Work

Since the main construction work is to be performed within the river channel, in order to prepare for unexpected freshets, an area under construction is surrounded with a cofferdam of large sand bags (Height: 1-3m). Leachate entering into the cofferdam is supposed to flow through a trench into a shallow sump (water sump) where a submerged pump (φ200mm, 7.5kw) discharges the water into the Mola River. For some minor water rise, the water is forced to flow through a diversion channel that is located away from the construction site, into the downstream side of the river.

(4) Earth Work

Operations associated with revetment work such as excavation, backfilling, compaction, waste soil disposal, etc. are, in principle, performed through the use of machinery. Excavations require a $0.8m^3$-class backhoe while the backfilling and compaction need to be performed in combination of backhoes, bulldozers, vibrating rollers, dumpers, etc. Resultant waste soil is dumped by a backhoe, into the depression on the right bank, resulting from river erosion.

(5) Demolition of Existing Retaining Walls

The existing retaining walls are of mortar masonry construction and thus have neither concrete nor reinforcing bars. For this reason, demolition of the walls is planned to be performed with a backhoe. Since the resulting scrap usually contains high quality cobbles and boulders, they will be reused as a coarse aggregate in the aggregate plant.

(6) Water Cut-off Work for Revetment Foundation

The ground used for the revetment foundation is composed of boulders containing gravels and a relatively hard layer that is expected to have sufficient soil bearing capacity. Therefore, a spread foundation is adopted for this revetment foundation. At the bottom slab of the foundation, a steel-sheet pile (2m in length) is supposed to be installed to prevent piping. Bearing in mind that the ground contains cobbles and boulders, the installation of steel sheet pile is planned to be made by a combination of a vibration hammer and water jet.

(7) Concrete Work

The project site and the surrounding areas have no plant that can provide ready-mixed concrete in large quantities. The construction work needs concrete of approximately 16,000m^3, In order for such large amount of high quality concrete to be stably supplied, a concrete production plant (full-automatic, forced-mixing type 45 m^3/h) is planned to be procured from Japan. Similarly, for aggregates, an aggregate production plant (20t/h) is procured from Japan. Coarse aggregates are produced by collecting and transporting boulders containing gravels from Himanu River, approximately 20km west from the construction site (toward Suai direction). Concrete is transported from the plant to the construction site and casted on site by a concrete pumping vehicle (boom type).

(8) Foot Protection Concrete Block Work

Steel forms required for preparing concrete blocks are procured from Japan. In the preparation yard either within the river zone or on land, 3tons concrete blocks are created. These concrete blocks, which serve as a foot protection, are installed around bridge piers and abutments and in front of the revetments. Concrete blocks prepared in the yard within the river zone are laterally transferred and installed by a 25 ton rough terrain crane. Concrete blocks prepared in the yard on land are put in place through successive processes, beginning from lateral transfer, loading, unloading to installation. The lateral transfer, loading, unloading and installation processes are performed by a 25 ton rough terrain crane, whereas the transportation by a 10 ton truck.

(9) Bridge Foundation Protection Work

In order to protect the piers of the existing bridge, steel-sheet piles are installed around the footing. Since the site ground is interspersed with much cobbles and boulders and also the clear headway is restricted due to the presence of bridge's girder, it is assumed to be difficult to install steel-sheet piles. Hence, a full-rotating excavator (φ1500mm class) is planned to be procured from Japan. After excavating the ground where steel-sheet piles are to be put in place and displacing the resulting soil with high quality sand, installation of the sheet piles starts. Placement of steel-sheet piles requires a power shovel (backhoe)-mounted vibro hammer. The types of the steel-sheet pile are U II w×8m for P1(Pier 1) and U III w×10m for P2(Pier 2). Placing joints are provided at one point where the clear headway is not restricted or two points where the clear headway is restricted.

2-2-4-2 Implementation Condition

(1) Securing of Local Work Force

Villagers around the site expect to have cash payment through wage labor employment for this project. From the point of view of employment promotion, villagers around the construction site need to be maximally used as labor force in this project. Because it is necessary to equalize the job opportunity, in-depth coordination with local heavyweights must be made. In addition, it is necessary to make full use of engineers who come from local contactors.

Timor-Leste's labor standard law titled "REGULATION No.2002/5 ON THE ESTABLISHMENT OF LABOUR CODE FOR TIMOR-LESTE" was enacted on May 1, 2002. And in April, 2012, this Law was revised to reflect to the remarkable economic development and change of the social environment, which contains the following requirements. Local employment must be provided in accordance with the labor rules of the country, lest any labor dispute should occur. In Timor-Leste, no social insurance system has been put in place.

- Work Time: 8 hours daily, 44 hours weekly
- Overtime Allowance: Weekday overtime(hourly wage×1.5), Work on holiday(hourly wage×2.0)
- Retirement Allowance:
  "1 month or more to less than 6 months" employee: half month payment
  "6 months or more to less than 1 year" employee: 1 month payment
  "1 year or more to less than 2 years" employee: 2 month payments
  "2 years or more to less than 3 years" employee: 3month payment
- Dismissal Notice Period:
  For "less than 2 years" employed workers, the notice shall be made at least 15 days prior to the expiration date.
  For "2 years or more" employed workers, at least 30 days prior.

(2) Execution System for the Contractors

Construction works are performed under the strict control of a Japanese construction company, with local construction companies who have appropriate technical skills and of manpower of inhabitants around the site. The contractor must plan to secure the following staff members:

- Project Manager: Overall management for the Project
- Clerical Account Manager: Accounting, labor management
- Civil Engineering Technician: Administration for the revetment work
- Civil Engineering Technician: Administration for bridge pier protection work

In addition, for the following reasons, both form work/reinforcement work and machine maintenance/repair works are planned to be performed by Japanese

- Skilled formwork/reinforcement work:
  Judging from the current conditions of Timor-Leste, the construction companies have an extremely poor awareness of quality assurance. Therefore, under thorough instructions by Japanese skilled workmen, the concrete forms must be properly assembled and installed to ensure a minimum quality assurance that meets the requirements in the grant aid program.

- Skilled machine maintenance/repair work:
  The work requires the dismantlement, assembly, and installation of an aggregate plant/concrete plant because of the introduction of such plants. Due to restrictions applied to the transportation route, these plants need to be disassembled, transported to the site, and then reassembled/installed on site. Also, since a large number of construction machineries have to be operated under severe conditions, their proper performances must continue to be maintained. Therefore, suitable inspections, repairs, and adjustments, etc. are required for those plants.

(3) Safety Measures against River’s Rise

The construction site in this project is mainly in an area inside the Mola River. Therefore, safety measures need to be taken to protect worker’s life from a sudden water rise and to prevent construction materials and equipment from being washed way/submerged by river floods. Practical measures include: understanding the rainfall in the river basin based on the meteorological information available on the internet; or directly understanding the condition of the river by stationing an observer/observers at a point in the up-stream side from the construction site. Any information on the water rise of the river must be caught as early as possible, thereafter, give the workers immediate directions to evacuate. An appropriate system needs to be established in preparation for unexpected floods.

(4) Maintenance of Aggregate/Concrete Plants

In this project, an aggregate plant and concrete plant are introduced and operated for on-site production. Both of these plants need to be assembled and installed; the former undergoes adjustment of a crushed stone sieve and grain size tests; the latter undergoes concrete laboratory tests and field tests. Adequate adjustment of those plants is required so that they themselves can be correctly operated.

(5)Work Schedule Plan

Although construction works within the channel cannot be performed during the rainy season, works on land (such as fabrication of concrete blocks) are able to be conducted. In consideration of operations that can be completed during the rainy season, effective and rational work schedule plans must be made.

(6) Establishing Lifeline at a Base Camp

Since the base camp has neither public water lines nor public power lines, it is necessary to install elevated water tanks, a well equipped with lift pumps, generators (20KVW, 2 units) in the yard, so that water and electricity can be supplied to the field office and the construction camp. Fuel supply issues are resolved by purchasing gas purchasing propane gas cylinders. Since Timor Telecom's communication antenna has been already in place, communication means can be secured only by signing up for cellar phone service and internet service.

(7) Safety Measures Taken During Construction

"No Trespass" signs are installed at the site as well as a construction guide board (1.8m×3.6m) is installed along the main road passing through neighboring villages so that villagers can understand what risk may be posed by the project, to ensure their safety and prevent injuries or troubles from occurring.

(8) Environmental and Social Considerations

In light of environmental impacts posed through the implementation of this project, the following points need be observed:

- Waste water and wastes generated from construction work must be properly treated and disposed of in order to reduce and alleviate the environmental impacts as much as possible.
- Due to the frequent passage of large-sized vehicles for transporting materials and equipment, both National Route A02 and service roads must have measures to reduce the generation of dusts, noise and vibration and also perform monthly monitoring so that the conditions are continuously monitored.

(9) Procurement of Materials and Equipment/Machinery

Primary construction materials used for this project include cement, aggregates, and steel-sheet piles. Among those materials, cement is necessary in large amounts and it is seemingly difficult to procure the required quantity in Timor-Leste; therefore, cement procurement must rely on the third country (Indonesia). Aggregates used in the project are boulders interspersed with gravels, which are collected from the surrounding river. Steel-sheet piles are difficult to be procured from both Timor-Leste and the third country. Therefore, their procurement must rely on Japan.

Of construction equipment and machinery, transporter vehicles such as trucks and semi-trailers are in widespread use within Timor-Leste and thus locally procured. Machineries temporarily required for the project, such as graders, road rollers or other machinery used only in a temporary work, are locally procured. To the contrary, procurement from Japanese suppliers includes equipment and machinery required for concrete production and placement and for sheet pile driving.

2-2-4-3 Scope of Works

The following provides the scope of works for the Japan side and the Timor-Leste side:

(1) The Scope of Work shared by the Japan side

1) Construction for bridge foundation protection work and revetment work
2) Ocean transportation of materials and equipments to Timor-Leste that are supposed to be procured from Japan and the third country
3) Inland transportation of the materials and equipment from the landing port to the construction site
4) Consultations (execution design, formulation of documents and drawings for bidding, support for bid-related business, and supervision of works)

(2) The Scope of Work Shared by the Timor-Leste side

1) Securing a land necessary for the base camp
2) Securing a land necessary for water-supply facilities
3) Smooth custom clearance and tax exemption at the port of disembarkation
4) Dispatching the person(s) in charge of this project and bearing the related costs and charges.

2-2-4-4 Consultant Supervision

(1) Consultants

Consulting services must be undertaken through the consultant agreement after the both countries signed E/N and G/A, that include execution design, formulation of documents and drawings for bidding, support for bid-related business, and supervision of works after conclusion of the contractor's contract. These consulting services are mainly composed of the following:

1) Execution Design and the Formulation of Documents and Drawings for Bidding

On the basis of the survey map, boring survey results and detailed field investigation that were obtained at the basic design stage, execution design's drawings must be prepared. Also, the Japan side must formulate documents necessary for bidding and consult with the Timor-Leste side about the documents to gain their approval.

2) Support of Bid-related Business

Bid announcement, preliminary eligibility examination, distribution of the documents/drawings for bidding, and the receipt, analysis and evaluation of Form of Bidding-With regard to these activities, the Japan side must support the Timor-Leste side and further, give some advice about the contract negotiation between the successful bidder and the Government of Timor-Leste. In addition, the Japan side must become a witness at the time of conclusion of construction contract between the both parties.

3) Supervision of Works

Main activities related to the supervision of works are given below:

- Progress report to the Government of Timor-Leste and discussion
- Instructions for the contractors associated with transportation of materials and equipment and their supervision
- Work schedule management and quality management associated with construction of facilities, and the approval of the related documents/drawings
- Submission of monthly report to the Government of Timor-Leste, progress report and discussion, etc.

(2) Implementation Systems

In order to facilitate the execution design and supervision of works, implementation systems must be established that are undertaken by personnel who familiarize themselves with the Grant Aid Scheme.

1) Implementation Systems in Execution Design

The following provides staff members who are involved in execution design, preparation of documents/drawings for bidding, and support for bid-related business and their roles:

(i) Operation Manager: Overall affairs related to the execution design and bidding

(ii) Structures Design 1: Execution design related to bridge abutment-/pier foundation-protection work

(iii) Structures Design 2: Execution design related to the revetment work

(iv) Quantity Survey: Survey on cost estimates as a result of ordering construction

(v) Documents/Drawings for Bidding: Preparation of documents/drawings related to the construction contract, preliminary examination, and support for bid-related business

2) Implementation Systems in the Supervision of Works

This project adopts full-time resident supervision in consideration of the contents and scale of the construction project. The supervisor dispatches civil engineers who have experiences with other grant aid projects. In addition, the supervisor also dispatches an operation manager at each work stage in order to understand the entire flow of the operations and to perform necessary operational coordination and give technical instructions. Further, the persons in charge of the execution design of pier protection work and revetment retaining walls are dispatched at the time of start of the work, and conduct tentative supervisions so as not to create technical discrepancy. The following provides staff members who are involved in supervision of works and their shared roles:

(i) Operation Manager: Coordinating and technological management activities to facilitate smooth operations

(ii) Full-time resident supervision: Daily management affairs and work schedule affairs

(iii) Tentative supervision 1: Explanations and instructions related to bridge pier work and bridge foundation protection work

(iv) Tentative supervision 2: Explanations and instructions related to revetment work

(v) Inspection on Completion of Work: Final inspection operations prior to handover, in the bridge pier work and bridge foundation protection work.

Aside from the above Japanese engineers, construction management engineers who help the full-time resident supervisor and an office boy who performs odd-jobs at the supervision office are supposed to be employed on site.

2-2-4-5 Quality Control Plan

Consultants must direct the contractors to conduct such analyses/tests as given in the table below and reflect those results on the quality control. For concrete tests, since there are neither companies nor institutions to whom we should commission the tests, the contractors bring the testing equipment on site. For the aggregate plant and concrete plant to be procured from Japan, inspections are supposed to take place at the plant, which allows for prior checking of their quality and performance, etc.

Table 2.2.42 Analysis and Test Methods Related to Quality Control

Type of Work	Item of the Test	Frequency of the Test	Note
1. Concrete Work			
(1) Trail Mixing	Fine aggregate gradation analysis	Once per mixing	Sieving method
	Coarse aggregate gradation analysis	Ditto	Sieving method
	Chloride concentration test	Ditto	Quantab method
	Compression strength test	Ditto	Strength after 7days and 28days
(2) On-site Placement	Slump test	Once per 50m^3	
	Chloride concentration test	Once per 2weeks	Quantab method
	Compression strength test	Once per 50m^3	Strength after 7days and 28days
2. Reinforcement Bar Work	-	Per receiving	Checking on mill sheet

2-2-4-6 Procurement Plan

(1) Plan for Procurement of Construction Materials

The following describes our plans for procurement of construction materials used in this project, both in the recipient country (Timor-Leste) and from Japan and the third country:

1) Cement

Cements used in this project are all imported products and are locally available because there are suppliers in Dili city. However, in this project, large amounts of cement are required. Apparently, it is difficult for them to ensure continuous supply of cement in required amounts. If supply of cement stops, this will affect the progress of work significantly. Hence, this project is determined to focus on proper transportation plans from the third country (Indonesia).

2) Aggregate

Aggregates used in this project are those collected from Himanu River, approximately 20km west from the construction site (toward Suai direction). Fine aggregates are purchased products that have been obtained as a result of sieving by suppliers. Boulders and gravels collected from Himanu River, will be used to produce coarse aggregates for this project. Such coarse aggregates are produced from them in an aggregate plant that is planned to be procured from Japan.

3) Reinforcing Bars

There are several suppliers in Dili city and therefore, stable supply in required amounts can be expected. Hence, reinforcing bars are locally procured.

4) Steel-Sheet Pile (U II w and U III w)

Steel-sheet piles are impossible to be procured locally. In addition, it is difficult to procure products with equivalent performance and quality from the third country. Hence, they need to be purchased from Japan.

5) Wood

Wood materials used for forms, etc. are planned to be procured from suppliers in Dili city.

6) Drainage Pipe

PVC pipes (φ100) used as a drainage pipe are planned to be procured from suppliers in Dili city.

7) Steel mesh used for Gabions

In Timor-Leste, steel mesh used for gabions made in Indonesia (the third country) is easily available and also, they have been adopted in many projects. Hence, the steel mesh used for gabions is planned to be procured from Indonesia.

8) Large Sand Bags

Large sand bags are difficult to be purchased both in Timor-Leste and from the third country. Hence, they are planned to be procured from Japan.

9) Expansion Joint Sealer, Water-Reducing Agent, etc.

It is difficult to procure products with equivalent quality to those made in Japan, either in Timor-Leste or from the third country. Hence, they need to be procured from Japan.

The results shown in Table2.2.43 are construction materials organized for each country.

Table 2.2.43 Where Construction Materials are To be Procured from

Construction Materials	Timor-Leste	Japan	Third Country	Remarks
Cement			○	
Aggregates	○			
Reinforcing bar	○			
Steel Sheet Pile U II w		○		
Steel Sheet Pile U III w		○		
Wood	○			
PVC Φ100	○			
Gabion Net			○	
Large Sand Bag		○		
Expansion Joint Sealer, Water-Reducing Agent		○		

(2) Procurement of Construction Machinery

For transporter vehicles including trucks, semi-trailers, dump trucks, sprinkler trucks, etc., are in widespread use within Timor-Leste and thus locally procured. Backhoes, bull dozers, crawler cranes, rough terrain crane, concrete pumping vehicles, compressors, generators, electric welders, and submerged pumps for construction use—these have the difficulty in their timely rental availability and their rental fees are relatively expensive. Hence, they are determined to be procured from Japan. Besides, temporarily required machinery, such as motor graders, road rollers, tire rollers and other machineries used in temporary work are also locally procured. Concrete pumping vehicles, aggregate production plants, concrete plants, full-rotation excavators (including their accessories), vibration hammers, water jet cutter, power shovel-mounted vibration hammers, large-size breakers and other special machineries are difficult to be procured from the recipient country and the third country and thus, determined to be procured from Japan.

The table below provides information on where construction machineries are to be procured.

Table 2.2.44 Countries where Construction Machinery are Procured from

Construction Machinery, etc.	Timor-Leste	Japan	Third Country	Remarks
Backhoe		○		
Bulldozer		○		
Crawler crane (50t)		○		
Motor grader	○			
Road roller	○			
Tire roller	○			
Rough terrain crane		○		
Truck crane, 4t capacity	○			
Truck 10t class	○			
Semi-trailer	○			
Dump truck	○			

Sprinkler truck 4,000L-class	○	○		
Concrete pumping vehicle		○		
Concrete plant		○		
Aggregate production plant		○		
Full-rotation excavator		○		
Vibro hammer		○		
Power shovel-mounted vibro hammer		○		
Large size breaker		○		
Vibrating roller		○		
Water jet cutter		○		
Compressor		○		
Generator		○		
Electric welder		○		
Submerged pump for construction use		○		

(3) Transportation Plan for Construction Materials and Equipment

1) Materials and Equipment to be Procured from Japan

Materials to be procured from Japan include: steel sheet piles, large sand bags, joint sealers, etc. Their transportation from Japan to Timor-Leste is by ship. Due to their considerably large amounts, these materials are supposed to be containerized for transportation. Self-propelled machineries such as a backhoe, bull dozer, crawler crane, rough terrain crane, concrete pumping vehicles, or full-rotation excavators are transported through non-containerized shipment. Non-self-propelled machineries such as an aggregate plant, concrete plant, vibro hammer, or generators are containerized and transported by ship.

The transportation route is from Japanese major ports to Dili Port, which is assumed to take around one month.

2) Materials to be Procured from the Third Country(Indonesia)

Materials to be procured from the third country include cement and steel mesh used for gabions. They are planned to be containerized and transported by ship. The transportation route is from Surabaya Port to Dili Port, which is assumed to take around 10 days.

3) Inland Transportation within Timor-Leste

The transportation route from Dili (landing port) to the construction site is a mountain road. Judging from the road conditions, the maximum superimposed load should be 20 tons. Therefore, heavy equipment of 20tons or heavier, after arrival to Dili Port, must be broken down to manageable sizes and then transported to the site. The transportation is assumed to take 3 days by a 10t -class truck or 4 days by a 20t-class semi trailer.

2-2-4-7 Implementation Schedule

In this project, since execution of instream constructions is restricted during the rainy season, bearing such a large volume of the project work in mind, it is assumed to require the entire construction period of around 31 months. Table 2.2.45 provides Project Implementation Schedule.

Table 2.2.45 Project Implementation Schedule (Proposed)

Year	2013												2014												2015										
			D/D				Procurement					Term-1				Term-2												Term-3							
Item	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11
E/N & G/A				▼					▼																										
Contract with Consultant				▼					▼																										
Detailed Design Stage					━	━	━	━																											
Tendering Procudure									━	━	━																								
Contract with Contractor												▼																							
Construction (Term-1)													━	━	━																				
Construction (Term-2)																━	━	━	━	━	━	━	━	━	━	━	━								
Construction (Term-3)																												━	━	━	━	━	━	━	━

2-3 Obligations of Recipient Country

If this project is put in place under Japan's Grant Aid, the "Timor-Leste" side must assume the following obligations, at the preliminary stage, during construction, and after completion of work:

1) Securing a land necessary for a yard for stockpiling materials/equipment and workplace
2) Securing a land necessary for building worker's camp, etc.
3) Securing a land necessary for building a facility that supplies daily life water for workers
4) Smooth custom clearance at the port of disembarkation of materials/equipment transported from Japan and the third country
5) Regarding the procurement of materials/equipment and supply of service by the Japanese people, exempting or bearing customs, domestic tax, and other surcharges imposed within Timor-Leste
6) Accommodating the Japanese people who will supply services for this project, especially when he/she is getting into, leaving and staying Timor-Leste for their work
7) Appropriately and effectively maintaining/operating the facility(or facilities) repaired in this project
8) Bearing the costs imposed on Timor-Leste side person(s) in charge of this project.

The above-stated obligations were assumed by Timor-Leste in the Mola Bridge's Construction Project under the Japan's Grant Aid. Therefore, these obligations are also expected to be undertaken by the recipient country in this project.

2-4 Project Operation Plan

The Directorate of Road, Bridge and Flood Control (DRBFC) of the Ministry of Infrastructure (MOI) is responsible for the maintenance and management of public facilities related to the management of the Mola River, the Mola Bridge, and National Route A02. Budget control, establishment of plans, design, order, and contracts, all of which are associated with the maintenance management, are undertaken by the Head Office of DRBFC whereas the related inspections and construction management are done by local offices. The project area is under the jurisdiction of Mariana Office; after repaired and reconstructed, the maintenance and management of the facilities are supposed to be implemented under this system.

The following shows maintenance/management operations required after the repair reconstruction of the facilities:

Table 2.4.1 Maintenance and Management Works for the Related Facilities

Classification	Frequency	Area to be Inspected	Contents of Work	Inspection Method
Management by Periodic Inspection	Twice Yearly（Before and after the rainy season）	Revetment	Scour and erosion in the front portion of revetment Deformation/displacement of the facility, cracks in the facility Movement of concrete blocks Sediment runoff from the backside	Visual Check
		Piers/Abutments	Deformation of the top part of steel-sheet pile Movement of concrete blocks	Visual Check

Since they are made of steel-sheet piles and concrete, the facilities themselves are basically maintenance-free. It is therefore sufficient that visual periodic inspections are conducted before and after the rainy season, checking is made on whether there occurs any of the events specified in Table 2.4.1 and, if needed, repairs is made for the facility.

2-5 Project Cost Estimation

2-5-1 Initial Cost Estimation

The total project cost required for implementation of this project is estimated to be approx.1, 106 million yen. Under the following estimation conditions, the breakdown of both side's costs based on the above-mentioned obligations for Japan and Timor-Leste is as follows. However, this amount does not indicate the Grant Aid Limit in the Exchange of Notes (E/N). The breakdown of the approximate project cost is given in Table 2.5.1.

【Estimation Conditions】

1) Start of Estimation: June, 2012
2) US Dollar Exchange Rate: 1US$＝80.52 yen（average value for the past 6 months till August 31, 2012）
   *) The US dollar is used in Timor-Leste; their local currency has not been set up.
3) Total Construction Period: 25 months
4) Others: This project is undertaken in accordance with Japanese Government's Grant Aid Guideline. The approximate project costs shown in Table 2.5.1 do not indicate the Grant Aid Limit in the Exchange of Notes (E/N) and is supposed to be reviewed by Japanese Government before the E/N.

Table 2.5.1 Breakdown of Approximate Project Cost

Classification of Project Costs		Approximate Project Cost (Million Japanese Yen)
(1) Construction Cost	Direct Construction Cost	594.1
	Temporary Works	97.5
	Site Management Cost	133.8
(2) General Administrative Expenses		71.5
(3) Detailed Design/Construction Supervision Fee		94.8
(4) Preliminary Cost (12%)		115.1
Total		1,106.4

2-5-2 Operational and Maintenance Cost

DRBFC's periodic control of the Mola River has not been substantially performed; namely, an emergency work was undertaken only when a specific damage was identified (for example, when a revetment had damaged). Thus, prior to start of the maintenance /management of the facilities, sufficient budget needs to be secured. Table 2.5.2 shows approximate costs required for the maintenance.

Table 2.5.2 Approximate Costs for Maintenance

Item of Operation	Frequency	Amount (US Dollar)
Management by Periodic Inspection	Twice Yearly	1,000

As shown in Table 2.5.3, an annual budget for DRBFC for the facility management in 2012 is approximately 25 million USD. From this, the above required maintenance cost is equivalent to 0.003% and understandable to allocate to the annual cost required for the Mola River.

Table 2.5.3 Budget for Maintenance

Unit: Thousand US$

	2010/2011	2011/12	2012/13
Personal Cost	525	488	544
Activity Cost	148	197	355
Procurement Cost	82	76	0
Facility Management Cost	43,502	25,825	25,675
Total	44,257	26,586	26,574

Source: State Budget 2012

Chapter 3 Project Evaluation

3-1 Preconditions

Preconditions for implementation of this project are shown below:

1) Environmental and Social Considerations

The procedures for Timor-Leste's EIA (Environment Impact Assessment) implementation are under the control of NDE (National Directorate for Environment) that is responsible for categorizing projects and issuing environmental licenses. For this reason, in this project's case, the project summary needs to be submitted from DRBFC (Directorate of Roads, Bridge and Flood control) (the Project Implementing Body) to NDE so that the NDE categorizes the project. Then, necessary responses will be made according to the category of this project.

Prior confirmation obtained from the NDE mentions that this project corresponds to Category B. Category B does not require EIA implementation but has to submit EMP (Environmental Management Plan). Since requirements for EMP can be almost covered by the information contained in this report, the duration of waiting for the completion of all procedures is expected to be around 3 months after submission of the report. Hence, we can expect all procedures necessary for environmental and social considerations to be completed before the start of this project.

2) Tax Exemption

The Ministry of Public Works (MPW) will bear the taxes and duties related to implementation of the Project.

3) Free Provision of Construction Yard

Regarding the free provision of the construction yard, the both parties held the stakeholder meeting where in-depth explanations were given to the persons who are in charge of political affairs and the local heavyweights and their agreement was gained. The person in charge of DRBFC also participated in this meeting where it was determined that detailed explanations would be provided to the land owner so that consents should be obtained from him before the agreement of the construction contract. In addition, since the construction yard is the same site as provided in the previous Grant Aid project for the Mora Bridge's Construction, we can expect to gain consent from the land owner. Hence, there is probably no problem with the free provision of the construction yard.

In light of the above, the preconditions for implementation of the project are deemed to be secured.

3-2 Necessary Inputs by the Recipient Country for Achieving the Overall Plan for the Project

Producing and continuing the effects of this project will require the inputs by the recipient country (Timor-Leste).

1) The Employer of this project will be the government of the recipient country. The recipient country's government is supposed to have a monthly progress report. However, from the view of ownership, it is desirable for engineers to be periodically dispatched to the project site in order to understand actual conditions during the construction period.
2) Facilities to be repaired/reconstructed in this project require continuous maintenance and management so that their performance can be properly maintained even after completion of the project. Such facilities, although designed to be maintenance-free, should be subject to periodic inspections at least twice a year, and, if needed, be properly repaired. Budgets for DRBFC's maintenance management, as described in Section 2.5.2 "Operational and Maintenance Cost", are deemed to be sufficiently secured.

The above-mentioned inputs are considered to be fully manageable for the government of the recipient country.

3-3 Important Assumptions

Producing and continuing the effects of this project will require satisfaction of the following external conditions:

1) Continuing the policy where major national routes can be adequately undertaken;
2) Continuing to perform adequate maintenance and management for a transportation route from Dili to the construction site and to facilitate transportation of materials/equipment and procurement of supplies;
3) Facilitating the provision of a construction yard and aggregates for concrete production; and
4) Undertaking appropriate maintenance and management of the construction yard and the aggregates even after they have been provided.

So far, the above external conditions have not been hindered by some factors and, therefore, can be considered to be fully satisfied.

3-4 Project Evaluation

3-4-1 Validity (Project Evaluation)

Table 3.4.1 shows the validity of the implementation of this project.

Table 3.4.1 Validity of the Implementation of This Project

Item of Evaluation	Validity
1) Populations to be Benefited	The potential areas benefitted by securing stable road traffic environment are various areas within Covalima District containing Suai city, one of the southern major cities, which accounts for 5.4% of total land area of Timor-Leste.
2) Improvement of the Livelihood of Villagers	The goals for this project are to prevent adverse effects caused by erosion of the Mora River and to secure stable road traffic environment for National Route A02, which is an extremely important community road for the villagers. Implementation of this project will allow for stabilizing the infrastructure for livelihood of villagers in Zumalai (a local government around the Mora River) as well as stable transportation of supplies to the regions west of the Mora River. In addition, this will allow for, for example, stable transportation of harvested agricultural products to their consuming region, Dili, and thus great commitment to improving and stabilizing the livelihood of local residents.
3) Compliance with the National Development Plan	Timor-Leste has a national development plan with a target year of 2030, whose objectives is to maintain the road capitals through the sustainable and long-term maintenance management plans. Also, in order to reduce the damage to social capital, continuous implementation of erosion protection measures has been called for. This project will make a commitment to these objectives.
4) Compliance with Japan's Grant Aid Policy	One of the Japan's grant aid policies for Timor-Leste is "Development of Infrastructure for Economic Revitalization". Implementation of this project provides a stable traffic environment to National Route A02, thereby complying with the policy.

3-4-2 Effectiveness

(1) Quantitative Effect

If this project is not implemented, it is presumed that erosion of the existing bridge will progress, losing stability of the bridge by scouring and erosion resulting from approx. 5-year probable rainfall and flood, and inundating the approach road on the right bank side. Because of this, it is expected that stability of the bridge will be lost as a quantitative result, forcing the vehicles to pass in the river channel. If this is the case, an impassable period due to elevated water surface by rainfall is 60 days/year according to a survey in 2007. Accordingly, the impassable period of 60 days/year can be prevented by protecting the piers and abutments through implementation of this project.

Table-3.4.2 Quantitative Effect

Index name	Reference value (2007)	Target value (2018)
Impassable days*	60 days/year	0 day/year

※ Assumes erosion damage by 5-year probable rainfall and flood.

Note) Direct factor to reduce the impassable days to Zero is the new Mola Bridge constructed in 2011. This index was adopted by considering the significance of this project lies in maintaining the functions of related infrastructure, including the existing Mola Bridge connected to the new bridge.

(2) Qualitative Effect

- The revetments will have permanent durable construction, enabling them to withstand water impacts and scours during floods and to have more stability.
- Installation of revetments with permanent durable construction will result in preventing occurrence of riverbank erosion, increasing a sense of safety in everyday life of neighboring villagers, and avoiding the absence of a traffic function of the national route caused by erosion.
- Protection of the piers and abutments of the existing bridge will prevent the collapse of substructures due to scours, improving the safety of the existing bridge.
- Costs for maintenance management of the revetment (repair and renovation) will be significantly reduced.
- The frequency of national road's closure will be reduced, increasing the stability of traffic flow. These effects will contribute to developing social economies of not only villages around the Mora River, but also the entire area of Covalima District.

Judging from these benefits, the implementation of this project is expected to have a considerable validity and high effectiveness.