SECTOR D

EXECUTION OF PILOT WORKS

THE STUDY ON MEKONG RIVERBANK PROTECTION AROUND VIENTIANE MUNICIPALITY IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC

FINAL REPORT
VOLUME 4
-SUPPORTING REPORT-

SECTOR D

EXECUTION OF PILOT WORKS

CONTENTS

LIST OF TABLES

LIST OF FIGURES

SECTOR D

EXECUTION OF PILOT WORKS

This Sector D compiles the result of the execution of riverbank protection pilot works (hereinafter referred to as "the Pilot Works") as a component of the Study. The construction sequence is also compiled in Volume 3 "Manual for Riverbank Protection (Sector B Construction)".

1 INTRODUCTION

1.1 General

The Pilot Works at three (3) sites, namely, Ban Dongphosi, Wat Chom Cheng and Sibounheuang Sites were completed by the Study Team in May 2003. The locations are as shown in Figure 1.1 and the photos of completed works are as shown in Figure 1.2 to 1.4. Outline of the work is as follows:

1. Scheme of execution: Sublet contract with the Study Team for JICA Development Study (Not JICA Grant Aid Project scheme)
2. Design & Supervision: JICA Study Team (in full cooperation with MCTPC/ DCTPC)
3. Contractor: Obayashi Corporation (selected by competitive bidding including local contractors)
4. Construction Period: January 2003 - May 2003 (5 months)
5. Construction Cost (engineering estimate): US$ 1,259,000 in total
   i. Ban Dongphosi Site US$ 1,088,000 (approx. US$ 1,690/m)
   ii. Wat Chom Cheng Site US$ 49,000 (approx. US$ 200/m)
   iii. Sibounheuang Site US$ 122,000 (approx. US$ 810/m)

As described in succeeding Section 1.2, the pilot work at Ban Dongphosi site was executed based on the facility design upgraded after August 2002 historical big flood to cope with the severe erosion caused by the flood.

Figure 1.1 Location of 3 Pilot Work Sites

After Construction (May 2003)

Before Construction (October 2002)

Figure 1.2 (1/3) Completed Pilot Work at Ban Dongphosi Site

Upstream Side (1)

Upstream Side (2)

Figure 1.2 (2/3) Completed Pilot Work at Ban Dongphosi Site

Downstream Side

Figure 1.2 (3/3) Completed Pilot Work at Ban Dongphosi Site

After Construction (May 2003)

Before Construction (February 2002)

Figure 1.3 (1/2) Completed Pilot Work at Wat Chom Cheng Site

Upstream Side from Wat Chom Cheng

Wooden Pile Groyne and Riprap on Slope

Figure 1.3 (2/2) Completed Pilot Work at Wat Chom Cheng Site

After Construction (May 2003)

Before Construction (December 2001)

Figure 1.4 (1/2) Completed Pilot Work at Sibounheuang Site

Downstream Side from Wat Sibounheuang

Upstream Side

Figure 1.4 (2/2) Completed Pilot Work at Sibounheuang Site

1.2 Upgrading of Specification of Pilot Work at Ban Dongphosi Site

1.2.1 Riverbank Erosion at Pilot Work Sites by August 2002 Flood

On August 2002, a historical big Mekong flood caused severe riverbank erosion in many stretches around Vientiane City. The flood is the second biggest (H max =170.64 m, MSL in August 21) since the biggest flood in 1966 (H max = 170.75 m, MSL). On October 2002, at the beginning of 2nd Work in Lao P.D.R., the Study Team urgently investigated the damaged condition of eroded banks at three pilot works sites.

(1) General Outline of August 2002 Flood

1. There was no serious inundation like that in 1966 flood in the urban area of Vientiane City because embankment had been constructed and the flood fighting activity by the local residents' organizations worked very effectively.
2. The highest water level at Ban Dongphosi site was 166.9 m, MSL just 1 m below the ground elevation and fortunately there was no overflow. The condition at Sibounheuang was nearly the same as that in Ban Dongphosi. At Wat Chom Cheng, the temple was inundated around 0.3 m.
3. Residents inhabited along the Mekong continued to live as usual during the flood without evacuation.
4. The flood caused great damage by bank erosion at many stretches forming natural riverbank without bank protection. Emergent measures by sandbag were found in many sites like Bo-O and Sibounheuang.
5. Little damage was found on existing bank protection works adjacent to Ban Dongphosi site, that is, National Cultural Park (upstream side) and Friendship Bridge (downstream side).

(2) Progress of Erosion at Pilot Work Sites

Figures 1.5 to 1.7 are prepared to compare the riverbank condition before and after August 2002 flood at pilot work sites. The Study Team conducted urgent check topographical survey by local surveyor at Ban Dongphosi and Sibounheuang sites to grasp the amount of change in riverbank alignment. The condition at each site is as follows:

1. Ban Dongphosi: The whole riverbank was severely eroded by August 2002 flood. The shortest distance between oil tank and eroded bank is only 15 m at most critical portion. The average setback width eroded by the flood is around 2.3 m, while the average setback width in ordinary year is estimated around 0.5 m. The extent of erosion becomes severe as going down and the average width is as follows:
   a) Upstream reaches (220 m) :1.2 m
   b) Along oil stockpiling base (100 m) :2.2 m
   c) Downstream reaches (330 m) :2.9 m
2. Wat Chom Cheng: The riverbank was not eroded so much by the flood.
3. Sibounheuang: The riverbank was not eroded so much generally because of the harder bank soil than that at Ban Dongphosi, even though, several points were eroded with the width of 3-5 m locally.

February 5, 2002
<Upstream Side>

October 5, 2002

February 5, 2002
<Downstream Side>

October 5, 2002

February 5, 2002
<In front of State Fuel Company>

October 5, 2002

Figure 1.5 (1/3) Condition at Ban Dongphosi Site

December 29, 2001
<View from Friendship Bridge>

October 8, 2002

October 5, 2002
<Critical Portion>

October 5, 2002
<Distance from tank to fence = 15m>

October 5, 2002
<View from National Cultural Park>

Figure 1.5 (2/3)
Condition at Ban Dongphosi Site

December 2001

August 2002

August 15, 2002

August 26, 2002

August 15, 2002

August 26, 2002

Figure 1.5 (3/3) Condition at Ban Dongphosi Site

December 20, 2001
<Upstream Side>

October 5, 2002

February 5, 2002
<Downstream Side>

October 5, 2002

Figure 1.6 Condition at Wat Chom Cheng Site

December 15, 2001
<Upstream Side>

October 5, 2002

February 5, 2002
<Downstream Side>

October 5, 2002

October 5, 2002

October 5, 2002

Figure 1.7 Condition at Sibounheuang Site

1.2.2 Upgrading of Specification

As a result of discussing the drastic progress of erosion by August 2002 flood, JICA judged that it is essential to upgrade original facility design of pilot work at Ban Dongphosi site taking into account the importance of oil stockpiling base of Lao State Fuel Company located extremely close to the eroded vertical cliffs. Consequently, the specification was modified as follows, even though the work is originally planned to be executed as a test work in JICA Development Study, not as Japan's Grant Aid Project.

1. Additional backfill corresponding to the riverbank setback eroded by the flood with an average width of 2.3 m, and
2. Partial reinforcement by stone covering at the front of oil stockpiling base (L=100 m).

The stone covering covers completed slope protection works by expendable riprap. The function of the stone covering is 1) to prevent Soda material to drying by accelerating the sedimentation on the slope, 2) to strengthen the slope protection works by accelerating the growth of willow as a result of 1), and 3) to work as buffer zone against erosion.

The pilot works at Wat Chom Cheng and Sibounheuang sites are executed according to the original design, since the erosion by August 2002 flood is not serious at both sites.

The implementation schedule of the pilot works has been rescheduled as shown below because of a series of careful discussion in JICA on the treatment of Ban Dongphosi site and on the upgrade of the specification:

1. Original schedule :November 2002 – March 2003 (5 months)
2. Present schedule: :January 2003 – May 2003 (5 months)

1.3 Inspection of Pilot Works

Each completed pilot works was inspected by the Study Team in May 2003 in full cooperation with MCTPC. The final Inspection was carried out by the Study Team in June 2003. The Study Team confirmed that all the completed pilot works achieved the required level of quality.

2 EXECUTION OF PILOT WORK AT BAN DONGPHOSI SITE

This Chapter 2 describes the construction process of the execution of the pilot riverbank protection work at Ban Dongphosi site conducted by the Study Team in 2nd and 3rd Works in Lao P.D.R. and completed in May 2003. After completion, willows will grow and will cover the surface of the slope.

2.1 Outline of this Pilot Work

The pilot work was constructed based on the concept of facility design and construction plan established in 1st Work in Lao P.D.R., and the revised facility design upgraded in 2nd Work in Lao P.D.R. to cope with the severe erosion caused by August 2002 flood as discussed in Chapter 1 (refer to Sector B (Preparatory Study for Pilot Works)). The outline of this pilot work is summarized as shown in Table 2.1.

Table 2.1 Outline of Pilot Work at Ban Dongphosi Site

1. Total length of execution: 643 m
2. Riverbank type: a) upper steep portion: pale gray silty clay, moderate stiff b) lower gentle: gravel layer (Vientiane gravel), rather strong resistance against erosion
3. Design criteria: a) design flow velocity: 3.4 m/sec b) low water level with 5-year return period: 155.0 m, MSL
4. Construction type: a) Foundation work (rubble deposition) b) Foot protection work (Soda Mattress work) c) Slope protection work (Cobble stone with willow branch work)
5. Main points to note: a) Much amount of backfill is introduced to protect important properties, especially around the oil stockpiling base of Lao State Fuel Company. b) The slope protection work for peripheral part of the Company is designed to protect the foot of the steep cliff to avoid further setback due to undermining of the slope and to establish naturally stable slope with vegetation. c) The following upgrading of facility design is newly introduced after August 2002 flood • additional backfill corresponding to the riverbank setback eroded by the flood with an average width of 2.3 m • partial reinforcement by stone covering at the front of oil stockpiling base (L=100 m) d) After completion, willows will grow and will cover the surface of the slope.
6. Work items: a) preparatory works • temporary works and facilities • collection and transportation of materials b) foundation riprap works c) foot protection works by Soda Mattress • assembling of mattress (66 sheets) • installation of mattress d) earth works (backfill by river sand) e) slope protection works • cobble stone with willow branch works • partial reinforcement by stone covering (L=100 m) f) finishing works, and g) inspection of completion by the Study Team
7. Construction period: January 2003 - May 2003

2.2 Drawings

Cobble Stone with Willow Branch Work is arranged to protect the upper slope of river bank at Ban Dongphosi Site. The lower slope consists of the foundation work made of rip-rap stones and the Soda mattress as a foot protection work. The Cobble Stone with Willow Branch Work is one of Japanese traditional river works for bank protection work. After completion, willows will grow and will cover the surface of the slope.

Drawings of the bank protection work at Ban Dongphosi Site are as shown in Sector B (Preparatory Study for Pilot Works).

2.3 Construction Schedule

The Pilot Work was executed according to the schedule as shown in Table 2.2 from January to May 2003.

After the contract dated on 17th January 2003, the construction schedule was discussed based on the procurement of construction equipment, land rental, staff arrangement and the various approval of action from the Government related agencies.

Main works at Ban Dongphosi site are composed of Foot Protection Work (Soda Mattress System, Rubble Deposition) and Slope Protection Work (Earthwork, Cobble Stone with Willow Branch Work).

Table 2.2 Construction Schedule

Description	Q'ty	unit	Jan	Feb	Mar	Apr	May
Preparation Work							
Cleaning							
Temporary Road	650	m					
Foot Protection							
Placing (Blasted Stone)	12300	m3		400m3/day			
Placing (River Stone)	1750	m3		80m3/day			
Placing on Soda Mattress	5000	m3			200m3/day		
Earth Work							
Filling Sand (<EL+157m)	4500	m3					
Filling Sand (< EL+161.5m)	20700	m3				600m3/day	
Filling Laterite	19500	m3				600m3/day	
Soda Mattress Work							
Fabrication of Rensai	19140	m		400m/day			
Mattress Fabrication	66	nos				3 nos./day	
Setting Soda Mattress	66	nos				6 nos/day	
Slope Protection							200m2/day(on laterite)
Placing Soda & willow	13710	m2				200m2/day(on Sand)	
Riprap (Cobble)	5550	m3				100m3/day(on Sand)	100 m3/day

2.4 Construction Equipment and Materials

Main construction equipments and its working description utilized for the execution are listed in Table 2.3.

Table 2.3 Construction Equipment

Item	Capacity	Working Description
Rensai Stand	2 lines	Rensai assembling
Backhoe	0.7 m^3	Riprap, Earthwork, Piling
Truck	6-10 t	Transportation (Soda Material)
Dump Track	10 t	Transportation (stone, soil)
Clam shell	1.0 m^3	Riprap, Depositing
Bulldozer	D5-D20	Earthwork
Rough Terrain Crane	30 t	Fabrication (Soda Mattress)
Crawler Crane	50 t	Setting Soda Mattress
Vibration Roller	8 t	Earthwork
Air Compressor	18 m^3/min	Blasting
Drilling Machine	100 PS	Blasting (Quarry Site)
Flat Barge	150-250 t	Transportation in River
Generator	10-60 KVA	Electricity Supply

(Source: Method Statement by the Contractor)

Main material used for the various work for the Pilot Works and its specification is summarized in Table 2.4.

Table 2.4 Main Material

Item	Specification	Unit
Soda Mattress (Foot Protection Work)		
Soda	Length: 2.7m, 45cm rise peripheral 60cm 200cm rise peripheral…55cm	bundle
Taisya	Length:2.7m, ϕ 2～3cm at butt end ϕ 1.0cm at 2.7m rise 25 twigs per bundle	bundle
Kogui	Length: 1.2m, ϕ 3～5cm at butt end	Pieces
Rubble stones	ϕ 600～250 mm ϕ 100～50 mm (Inside)	m^3
Straw rope	ϕ 10 mm	m
Zinc-coated whip	#10	m
Zinc-coated whip	#12	m
Embankment (Slope Protection Work)		**Unit**
River sand & Gravel	< ϕ 80 mm, Collected in Mekong	m^3
Laterite	Collected on Ban Dongphosi Borrow Site	m^3
Cobble / Cobble	ϕ 80～10 mm	m^3
Rubble (Rip rapping)	ϕ 200～150 mm	m^3
Rubble (Deposition)	ϕ 600～250 mm	m^3
Rubble (Covering)	ϕ 400～300 mm	m^3
Bamboo net	B=2.5 m L=2.5 m	m^2
Tate Soda	L=3.0 m, S=0.7 m	Bundle
Cobble Stone with Willow Branch (Slope Protection Work)		**Unit**
Siki Soda	L=3.0 m, S=0.7 m	Bundle
Taisya	L=3.0 m, 1 bundle =25 unit	Bundle
Kogui (Short Pile)	L=1.2 m ϕ =4 cm	Unit
Willow	L=1.2 m, S=0.9 m	Bundle
Cobble	ϕ =150 – 200 mm	m^3

Table 2.5 lists local name of fascine material for Soda Mattress Work and Cobble Stone with Willow Branch Work.

Table 2.5 Fascine Material Name

Lao Name	Description		
	Soda	Taisya	Pile
May Mouk	○		○
May Kadouk	○		
May Mikhon	○		
May Nang Dam	○		
May Tiou Nam	○	○	○
May Mahamek / xalot	○		
May Khilekpa	○		
May Pohou	○		
May Khom Som	○		
May Tun Pet	○		
May Meuat	○	○	○
May Khe Pa	○		
May Pao	○		
May Khap	○		
May Te Ho	○		○
May Ham Ao	○		
May Chik	○		○
May Xeuak	○	○	
May Thom	○	○	
May Koung	○	○	

2.5 Construction Works

2.5.1 Preparatory Works

(1) Temporary Works and Facilities

Two (2) access roads (8 m wide) to the site from National Road were temporary constructed for the construction work. Temporary road for the foot protection work and embankment work was connected to the riverine.

The stockyard for fascine and soda mattress fabrication was set up beside No. 1 access road. Another stockyard at Kao Liao was set up for fascine of willow branch work and Rensai assembling. A temporary office and two (2) worker houses are also mobilized on the site.

Condition of the temporary works and facilities is shown in Figures 2.1.

1) Generator

2) Rensai Stockyard: Fascine material is transported from Nongpen.

3) Soda Mattress stockyard on the bank

4) Space for working and workstation Flame making for transportation of Soda Mattress

5) Stockpile of bamboo net

6) Technical guidance by the Study Team member: Demonstration of Cobble Stone with Willow Branch Work

Figure 2.1 (1/2) Temporary Works and Facilities in Ban Dongphosi Site

1) Access road from No. 1 National Road

2) Temporary road near riverbed

3) Soda Mattress under assembling

4) Model of Cobble Stone with Willow Branch Work demonstrated by the Study Team

5) Situation along oil stockpiling

6) Temporary road to riverbed

Figure 2.1 (2/2) Temporary Works and Facilities in Ban Dongphosi Site

(2) Collection and Transportation of Materials

Stones were collected at Nong Teng temporary quarry site and Ban Sakai quarry site. Gravel and sand were collected from the borrow site at Xiangkhouan in the Mekong River. Laterite was directly collected in the borrow pit located near Ban Dongphosi site.

Fascine material (Soda, Taisha and Kogui etc.) for Soda Mattress Work and Cobble Stone with Willow Branch Work were collected by the local residents in Nongpen Village (refer to Figures 2.2 and 2.3). These materials were transported by the several trucks with the capacity of 6-10 t to two (2) stockyards on the site. In addition, soda mattresses fabricated in Kao Liao stockyard were also transported to this site. Bamboo nets were purchased from market.

Willow fascine is much available at the sandbar near Thintom Village downstream of Lao-Thai Friendship Bridge. Willow branches were cut by manpower and transported by trucks to the site.

Location of major material collection sites and the condition of the sites is shown in Figures 2.2 and 2.3.

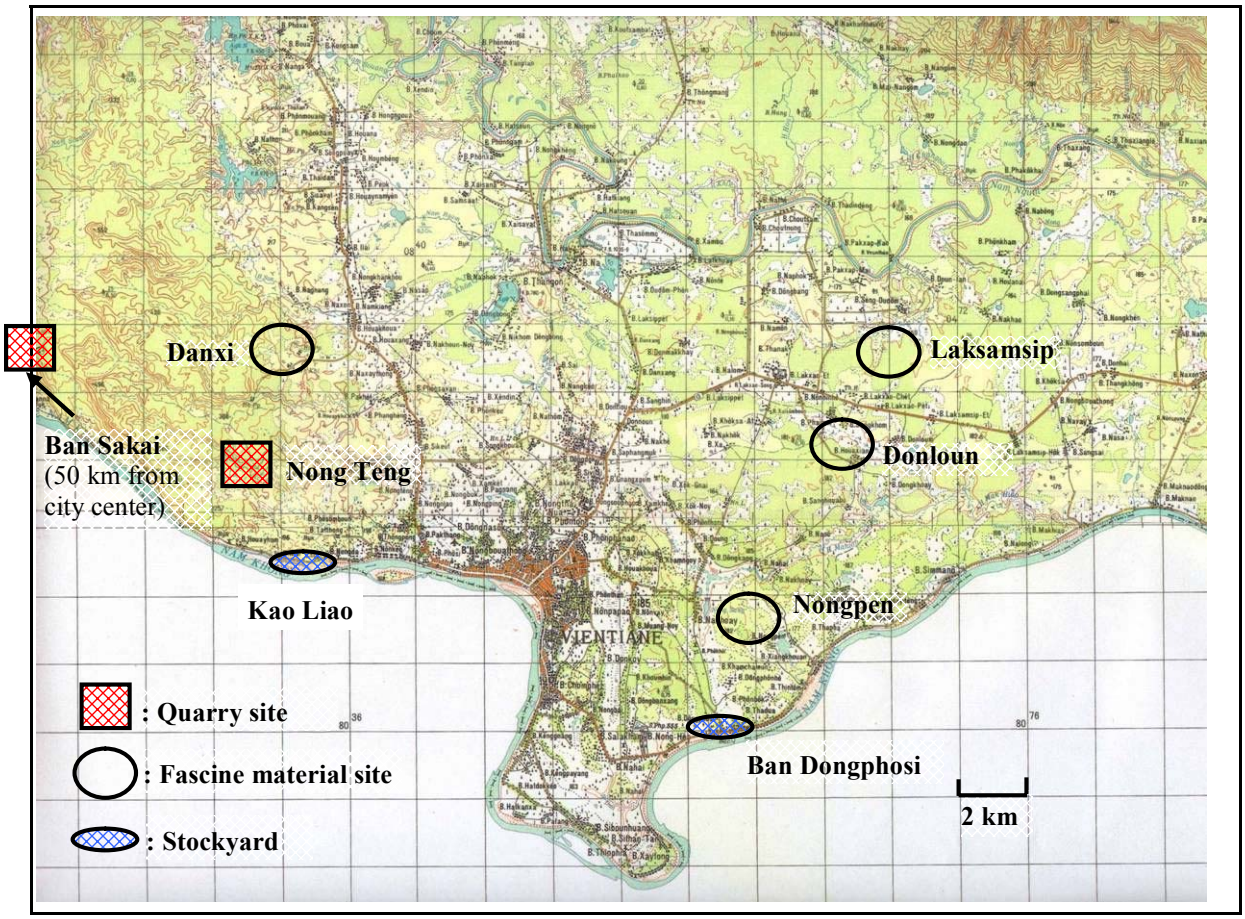

Figure 2.2 Location of Material Collection Sites

1) Stockpile at Nong Teng temporary quarry site

2) Ban Sakai quarry site

3) Borrow site of river sand and gravel at Xiangkhouan in the Mekong River

4) Gravel (river stone) for Cobble Stone with Willow Branch Work

5) Fascine material site at Nongpen Village (1)

6) Fascine material site at Nongpen Village (2)

Figure 2.3 Condition of Material Collection Sites

2.5.2 Foundation Works

1) General Outline • Riprap work is a foundation of the slope to support the upper structure to avoid any failure of the slope. Surface riprap is to protect the foundation against river flood flow and inner one is to be placed to support the external load and to avoid flushing out against backpressure.
2) Construction Method • Graded stones brought by dump trucks from the quarry site are put on the designed place by using Backhoe (refer to Figure 2.4).
3) Specification of Materials • Size of riprap is 400mm – 600mm on the surface. • Size of riprap is 250mm – 300mm at sub-surface. • Specific gravity of the stone shall be more than 2.5 and water absorption rate shall be less than 3%. • Gravel size is 10mm-15mm(inner), and 50mm-80mm(outer) • Bamboo-net is about 10mm thick.
4) Material Procurement • Main stones are collected at Nong Tehn temporary quarry site. • Gravel and sand are purchased from market • Bamboo net is purchased from market
5) Equipment and Tool • Dump Truck • Backhoe ($0.7m^3$)
6) Manpower Required • Operator of Backhoe • Workers
7) Quantity • Stone dike (Crushed stone of dia. 250mm-600mm): $12,300m^3$ • Stone dike (gravel of dia. 50mm under): $1,800m^3$
8) Production Rate (as of Mar.7, 2003) • Rip-rap placing: $170m^3$/day • River gravel placing: $50m^3$/day
9) Comment • Foundation work is used as construction road for setting Soda mattress during construction

1) Starting filling stones for the foundation work

2) Extending the foundation work by Backhoe

3) Supplying stones by Dump Truck

4) Placing crushed stone

5) Placing gravels behind the rip-rap

6) Placing bamboo net and sand behind gravel layer

Figure 2.4 Workflow of Foundation Work

2.5.3 Foot Protection Works

(1) Assembling of Soda Mattress

1) General Outline

- Soda Mattress consists of Soda(fascine), Rensai(bunch of fascine), Siki-Soda(fascine flooring), Sigara(hurdle work), and Chinseki(rubble stone). On the lower lattice structure of Rensai with grid space of 1m(Sitagoshi: lower lattice), three layers of Siki-Soda with each layer having perpendicular to the other, in approx. 15 cm in thickness is put on. Upper lattice with the similar structure is put on the lower lattice and bound with rope and wooden pile driven at each node of the lattice to fix the structure. Tie-twig hurdle work is made on it. Almost all materials are produced locally.

2) Construction Method (refer to Figure 2.5)

- Soda mattress assembling system consists of: i) Preparation of Soda bundle, ii) Rensai manufacturing, iii) Lower lattice structure, iv) Temporally short piling, v) Flooring Soda (3-layers: each layer crosses perpendicular to others), vi) Upper lattice structure, vii) Secondary short piling, viii) Hurdling work by using 'Taisha'
- Most works are done by using manpower and tools as 'Rensai bundler', pliers, large wooden hammer, etc.

3) Specification of Materials

- Soda (fascine) is twigs of broad-leaved trees such as May Mak Ngeo, May Mon Khai, May Tiou, May Pey Kho, etc. Soda bundle; L=2.7m, peripheral length of 45cm at height of 60cm and 55cm at 200cm height.
- Taisha is flexible twigs such as May Nang Dam, May Mon Khai, etc. Taisha bundle: L=2.7m, ϕ 2-3cm at but end and 1cm at 2.7m height. 25 twigs per bundle.
- Rensai: L=10.5m and 6.5m for Soda mattress of 10m x 6m size, dia.15cm, bundled by wire in every 20cm interval
- Short wooden pile consists of May Gut Sa, May Mak Fai, May Mak Keua, etc. and L=1.2m, ϕ 3cm-5cm at but end.
- Wire is #12 for Rensai bundling and #10 for Rensai lattice connection.
- Rope made of coconut tissue : ϕ 10mm

4) Material Procurement

- Soda materials are brought from Nongpen Village.
- Short piles, rope and wire are bought in market.

5) Equipment and Tool

- Rensai bundler (with frame)
- Pliers and wire fastener
- Wooden hammer(large)
- Crawler crane (50t) Clamshell for piling

6) Manpower Required

- Japanese instructor, Leader, Workers (10-15 for a group), operator for crane

7) Quantity

- Soda mattress of 10m x 6m x 0.9m(Length, width, height) : Total 66 sheets

8) Production Rare

- Rensai: 911m/day, Soda mattress: 1.8 sheet/day as date of Mar.5, 2003

9) Comment

- Soda mattress assembling work technique has been well transferred.

1) Preparation of Soda bundles

2) Making 'Rensai' (connection beam made of fascine)

3) Making 'Rensai' by Japanese traditional way

4) Piling up of 'Rensai'

5) Arrangement of lower lattice structure by using 'Rensai'.

6) Fixing node of Rensai lattice

Figure 2.5 (1/2) Workflow of Assembling Soda Mattress

7) Flooring 'Siki-Soda' work

8) Arranging higher lattice beam

9) Piling short wooden piles to combine upper and lower lattice structures and for hurdling work

10) Preparation of 'Taisha', flexible tie-twigs

11) Hurdling work by using 'Taisha'

12) Piling-up of completed Soda mattresses

Figure 2.5 (2/2) Workflow of Assembling Soda Mattress

(2) Installation of Soda Mattress

1) General Outline • Assembled Soda mattresses are transported to the setting location and submerged by putting rubble stones on them.
2) Installation Method (refer to Figure 2.6) • Soda mattress is transported by crawler crane to the riverbank before final setting. • Using crawler crane, the mattress is placed on the river and fixed by anchors. • Putting rubble stones on the mattress by wire straw-basket and/or backhoe to submerge it.
3) Equipment and Tool • Crawler crane (50t),wire straw-basket, backhoe • Wooden hammer (large)
4) Manpower Required • Operator of crawler crane, backhoe • Staff and workers (approximately 10 persons)
5) Quantity • Soda mattress (10m x 6m x 0.9m): Total 66 sheets
6) Production Rate • 3 sheets/day as of Mar. 5, 2003
7) Comment • Upper most Soda mattress is to be submerged after positioned by putting weight/ rubble stone to avoid any destruction or displacement of connected ones due to river flow.

1) Hanging Soda mattress from the stored location

2) Lowering Soda mattress to the bank slope

3) Temporally placing for final setting

4) Placing Soda mattress at the planed position by Crawler crane

5) Piling of wooden short pile to the final depth

6) Connection of Soda mattress with up-stream one

Figure 2.6 (1/2) Workflow of Installation of Soda Mattress

7-1) Row of connected mattresses

7-2) Row of connected mattresses

8-1) Putting rubble stones on mattress by wire straw-basket to submerge mattress

8-2) Putting rubble stones on mattress by backhoe to submerge mattress

Figure 2.6 (2/2) Workflow of Installation of Soda Mattress

2.5.4 Earth Works

1) General Outline • Earth works is the fundamental work to prevent bank failure and to establish cobble stone with willow branch work as slope protection work. • The filling work consists of the construction of embankment by furnishing, placing, compacting and shaping suitable earth material.
2) Construction Method (refer to Figure 2.7) • Access road and temporary road construction • Trimming of slope and clearance • Transportation of earth material by dump truck • Siki soda and bamboo net arrangement on foundation riprap • Filling by backhoe and bulldozer • Moisture content arrangement • Compaction by bulldozer and vibration roller
3) Specification of Materials • River sand collected in the Mekong River • Tate-soda, bamboo net
4) Material Procurement • River sand and bamboo net purchased in market, Tate Soda: directly collected from Nongpen.
5) Equipment and Tool • Dump truck, backhoe • Bulldozer, vibration roller (8t), generator, water pump
6) Manpower Required • Site manager, operator of backhoe, bulldozer and vibration roller • Skilled, semi-skilled and un-skilled laborers
7) Quantity Embankment of sand and laterite (V=45,000 m^3)
8) Production Rate • Bulldozer (500 m^3/day)
9) Comment • The embankment material above El. 161.5 m changed from laterite to sand due to be completed in desired period.

1) Trimming of the slope by backhoe

2) Tate-soda and bamboo net setting

3) Filling of river sand below El. 161.5m

4) Moisture content arrangement by pumping water and compaction by roller

5) Spreading and compaction by Bulldozer above El. 161.5m

6) Gravel spreading and compaction for the restoration at temporary access road

Figure 2.7 Workflow of Earth Works

2.5.5 Slope Protection Works

(1) Cobble Stone with Willow Branch Works

1) General Outline • The structure on the slope of earth embankment consists of Siki soda, Taisya (tie-twig) hurdle work, willow branch placing, river sand & gravel placing and cobble stone placing. • Riverbank covered by vegetation to create favorable natural environment shall be realized.
2) Construction Method (refer to Figure 2.8) • Compaction and furnishing of slope • Piling Kogui • Laying Taisya for frame fence • Pounding & placing of river sand, gravel and willow branch in the frame • Placing cobble stone in the frame
3) Specification of Materials • Siki Soda (l=3.0m, S=0.7m), Taisya (l=3.0m), Kogui (l=1.2m, ϕ =4cm), Willow (l=1.2m) • Cobble (ϕ =150-200mm), river sand and gravel from the Mekong
4) Material Procurement • Wooden material (Siki soda, Taisya, Kogui, Willow) collected at Nongpen • Cobble collected at Nong Teng temporary quarry site • River sand and gravel purchased in market
5) Equipment and Tool • Dump truck, backhoe
6) Manpower Required • Site manager, operator of backhoe, driver • Semi-skilled and un-skilled laborers
7) Quantity • Crushed cobble (about 4,200 m^3) • Siki soda, Taisya, Kogui, willow branch (Construction area=13,700 m^2)
8) Production Rate • Placing Soda & willow (200m^2/day below El. 161.5m, 400 m^2 /day above El. 161.5m) • Cobble placing (100m^3/day)
9) Comment • Actual volume of cobble was more than that in the specification, since the work was conducted in accordance with the demonstration model work of cobble stone with willow branch works conducted by a Soda technique expert of the Study Team.

1) Embankment work by bulldozer

2) Compaction of slope and Kogui piling

3) Hurdle work using 'Taisya' and Siki-soda placing

4) Sand and gravel placing in Taisya hurdle (T=20cm)

5) Cobble placing by manpower

6) Finishing work of slope: Adjusting cobble placing

Figure 2.8 Workflow of Cobble Stone with Willow Branch Works

(2) Partial Reinforcement by Stone Covering

1) General Outline • Additional covering riprap is executed to reinforce completed cobble stone with willow branch works taking into account the importance of oil tanks. • The slope gradient is 1:1.9 with a length of 100 m.
2) Construction Method (refer to Figure 2.9) • Transportation by dump truck • Placing by backhoe • Stone adjustment placing on the slope by man-power
3) Specification of Materials • Crushed stone (ϕ 150-400 mm)
4) Material Procurement • Production by the contractor at Nong Teng temporary quarry site
5) Equipment and Tool • Dump truck, backhoe
6) Manpower Required • Backhoe operator, engineer • Semi-skilled and un-skilled laborers
7) Quantity • Crushed stone (V=1,400m^3)
8) Production Rate • Placing of crushed stone: 100 m^3/day
9) Comment • The stone covering is specified against the scale of August 2002 flood.

1) Crushed stone temporary stocked on the dike after transportation from the quarry site

2) Stone loading by backhoe on the cat-walk level (El 161.5 m) of the lower slope

3) Stone placing by backhoe on the slope of cobble stone with willow branch work

4) Stone arrangement by manpower

5) Completed stone covering slope

6) Overview of completed pilot works and the stone covering in front of oil tanks

Figure 2.9 Workflow of Partial Reinforcement by Stone Covering