

SECTOR B
CONSTRUCTION

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

**FINAL REPORT
VOLUME 3
-MANUAL FOR RIVERBANK PROTECTION-**

SECTOR B

CONSTRUCTION

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SECTOR B

CONSTRUCTION

1. INTRODUCTION

This construction manual is prepared to make Lao engineers implement Japanese traditional construction method through the execution of the pilot riverbank protection work (hereinafter referred to as “the Pilot Works”) at three (3) sites in and around Vientiane Municipality, conducted by the JICA Study Team and Laotian Counterpart Team.

The first design had established in 1st Work in Lao P.D.R. from December 2001 to March 2002. The serious flood occurred on August 2002, causing the severe bank erosion to the Pilot Work sites. Based on an additional survey and supplement design (refer to Volume 4 Supporting Report (Sector B: Preparatory Study for Pilot Works)), the tender document was prepared in December 2002.

The construction work started from January 2003. During JICA Study Team leaving for Japan, Laotian Counterpart Team has successfully supervised the construction site paying careful attention.

1.1. Outline

1.1.1 Bank Protection Type

The bank protection type at three (3) sites for the Pilot Works under the Study are mainly composing of the rubble deposition work used commonly in the Mekong and various Japanese traditional river works such as the wooden pile Groyne, Soda Mattress, log hurdle and cobble stone with willow branch.

The protection type for the Pilot works is summarized in Table 1.1.1

Table 1.1.1 Bank Protection Type of Pilot Works

Site Name	Ban Dongphosi	Wat Chom Cheng	Wat Sibounheuang
Foot Protection Work	Soda mattress work Riprup work	Type A: Soda mattress work Wooden pile groyne Type B: Wooden pile groyne	Soda mattress work Riprup work Log hurdle work
Slope Protection Work	Cobble stone with willow branch work	Wooden pile groyne	Cobble stone with willow branch work

1.1.2 Construction Site and Construction Profile

Three (3) construction sites, stockyards, and material procurement sites for the Pilot Works is shown in Figure.1.1.1.

Profile and dimension of Pilot work at each site is summarized in Table 1.1.2.

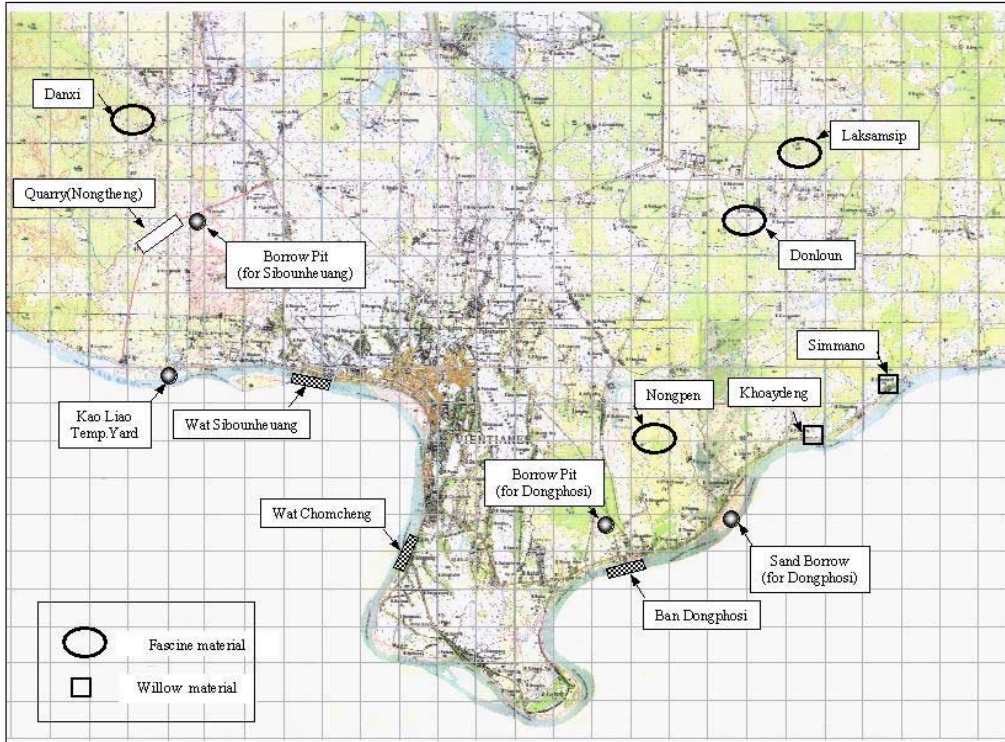


Figure 1.1.1 Pilot Work Construction Sites

Table 1.1.2 Profile and Dimension of Pilot Works

PILOT RIVERBANK PROTECTION WORKS	
Construction Site	Ban Dongphosi Wat Chom Cheng Wat Sibounheuang
Construction Period:	17, Jan., 2003 to 31, May, 2004
Main Construction Volume:	
Ban Dongphosi Site	Soda mattress work— 10.0 m*6.0m*66 sheet Foundation work— 17,370m ³ River sand embankment— 47,880m ³ 、 Cobble stone with willow branch work 12,540m ²
Wat Chom Cheng Site	Soda mattress work— 10.0 m*6.0m*9 sheet Wood pile groyne - Pile φ 200mm*4m~6m - 567Nos.) Riprap work in Slope-300m ²
Wat Sibounheuang Site	Soda mattress work – 10.0*6.0 *23 Sheets Riprap work for foundation & soda mattress – 2600 m ³ 、 Log hurdle work - 154m、 River sand embankment - 930m ³ 、 Cobble stone with willow branch work - 1,100 m ²

1.1.3 Picture Profile

The pictures of before and after the completion at three (3) sites are shown in Figure 1.1.2.

- **Ban Dongphosi Site**



Figure 1.1.2 (1/3) Picture of Pilot Works

- Wat Chom Cheng Site

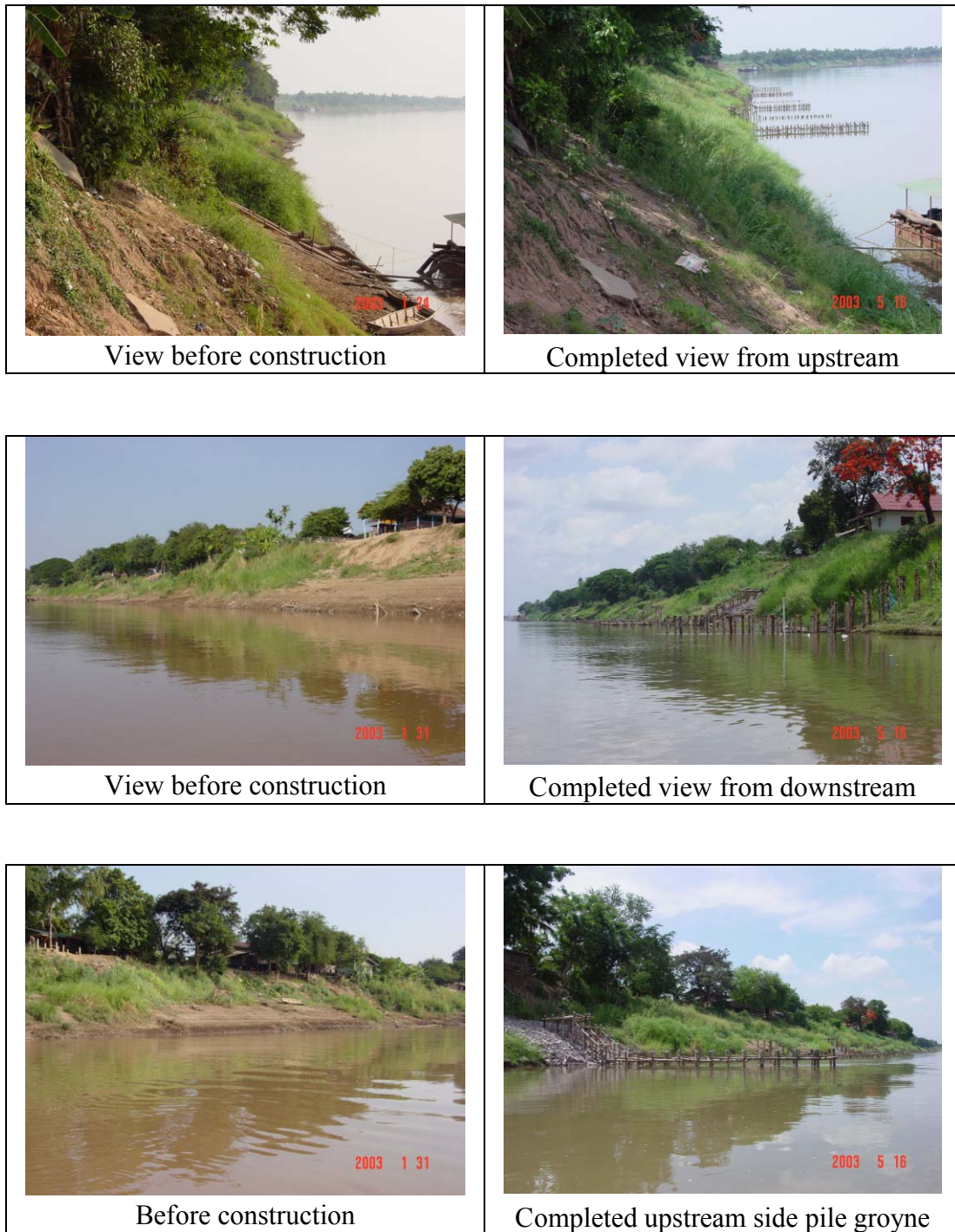


Figure 1.1.2 (2/3) Picture of Pilot Works

- Sibounheuang Site



Figure 1.1.2 (3/3) Picture of Pilot Works

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

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 (refer to Sector D (Execution of Pilot Works)). The outline of this pilot work is summarized as shown in Table 2.1.1.

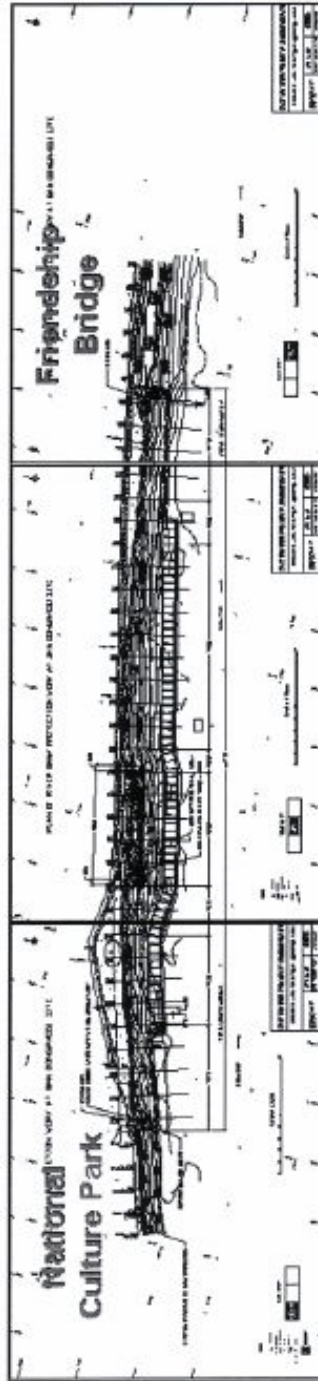
Table 2.1.1 Outline of Pilot Work at Ban Dongphosi Site

1. Total length of execution: 643 m
2. Riverbank type: <ul style="list-style-type: none"> 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: <ul style="list-style-type: none"> a) design flow velocity: 3.4 m/sec b) low water level with 5-year return period: 155.0 m, MSL
4. Construction type: <ul style="list-style-type: none"> 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: <ul style="list-style-type: none"> 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 <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> a) preparatory works <ul style="list-style-type: none"> • temporary works and facilities • collection and transportation of materials b) foundation riprap works c) foot protection works by Soda Mattress <ul style="list-style-type: none"> • assembling of mattress (66 sheets) • installation of mattress d) earth works (backfill by river sand) e) slope protection works <ul style="list-style-type: none"> • 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 Figure 2.2.1.



Plan

Figure 2.2.1 (1/2) Drawings of the bank protection work at Ban Dongphosi Site

2.3. Construction Schedule

The Pilot Work was executed according to the schedule as shown in Table 2.3.1 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).

Figure 2.3.1 Construction Schedule

Description	Q'ty	unit	Jan	Feb	Mar	Apr	May
Preparation Work							
Cleaning			—				
Temporary Road	650	m	—	—			
Foot Protection							
Placing (Blasted Stone)	12300	m ³		400m ³ /day	—		
Placing (River Stone)	1750	m ³		80m ³ /day	—		
Placing on Soda Mattress	5000	m ³			200m ³ /day		
Earth Work							
Filling Sand (< EL+1.57m)	4500	m ³			—	—	
Filling Sand (< EL+161.5m)	20700	m ³			600m ³ /day	—	
Filling Laterite	19500	m ³				600m ³ /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							
Placing Soda & willow	13710	m ²				200m ² /day (on Sand)	200m ² /day (on laterite)
Riprap (Cobble)	5550	m ³				100m ³ /day (on Sand)	100 m ³ /day

2.4. Construction Equipment and Materials

Main construction equipments and its working description utilized for the execution are listed in Table 2.4.1.

Table 2.4.1 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 2.4.2.

Table 2.4.2 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)		
River sand & Gravel	< ϕ 80 mm, Collected in Mekong	m ³
Laterite	Collected on Ban Dongphosi Borrow Site	m ³
Pebble / 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	M2
Tate Soda	L=3.0 m, S=0.7 m	Bundle
Cobble Stone with Willow Branch (Slope Protection Work)		
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 2.4.3 lists local name of fascine material for Soda Mattress Work and Cobble Stone with Willow Branch Work.

Table 2.4.3 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 Figure 2.5.1.



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 2.5.1 (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 2.5.1 (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 2.5.2 and 2.5.3). 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 2.5.2 and 2.5.3.

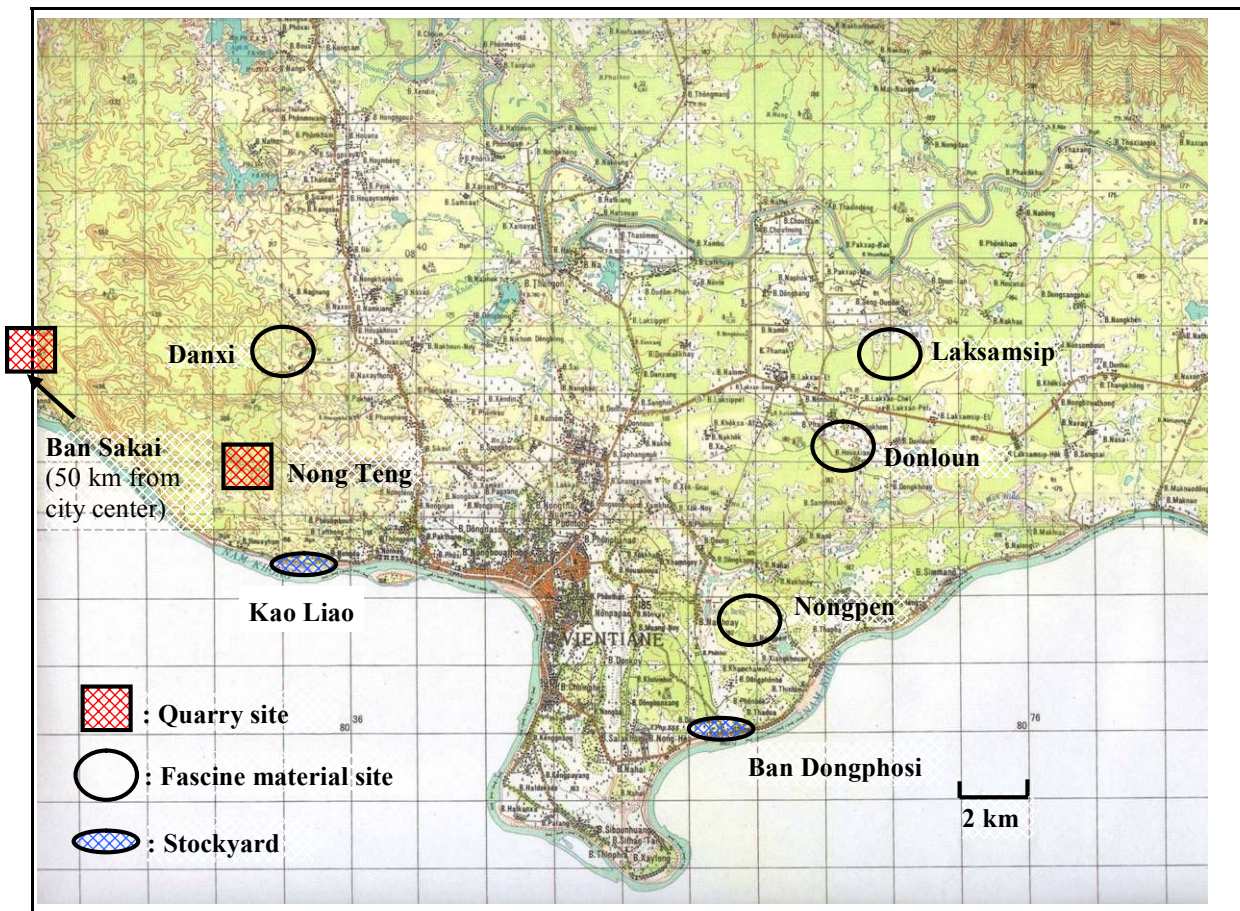


Figure 2.5.2 Location of Material Collection Sites



1) Stockpile at Nong Teng temporary quarry site



2) Ban Sakai quarry site



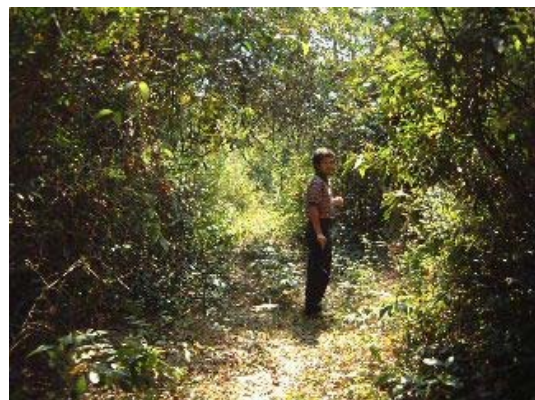
3) Borrow site of river sand and gravel at Xiangkhouan in the Mekong River



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 2.5.3 Condition of Material Collection Sites

2.5.2 Foundation Works

<p>1) General Outline</p> <ul style="list-style-type: none"> 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.
<p>2) Construction Method</p> <ul style="list-style-type: none"> Graded stones brought by dump trucks from the quarry site are put on the designed place by using Backhoe (refer to Figure 2.5.4).
<p>3) Specification of Materials</p> <ul style="list-style-type: none"> 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.
<p>4) Material Procurement</p> <ul style="list-style-type: none"> Main stones are collected at Nong Tehn temporary quarry site. Gravel and sand are purchased from market Bamboo net is purchased from market
<p>5) Equipment and Tool</p> <ul style="list-style-type: none"> Dump Truck Backhoe (0.7m³)
<p>6) Manpower Required</p> <ul style="list-style-type: none"> Operator of Backhoe Workers
<p>7) Quantity</p> <ul style="list-style-type: none"> Stone dike (Crushed stone of dia. 250mm-600mm): 12,300m³ Stone dike (gravel of dia. 50mm under): 1,800m³
<p>8) Production Rate (as of Mar.7, 2003)</p> <ul style="list-style-type: none"> Rip-rap placing: 170m³/day River gravel placing: 50m³/day
<p>9) Comment</p> <ul style="list-style-type: none"> 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 2.5.4 Workflow of Foundation Work

2.5.3 Foot Protection Works

(1) Assembling of Soda Mattress

<p>1) General Outline</p> <ul style="list-style-type: none"> 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. 	
<p>2) Construction Method (refer to Figure 2.5.5)</p> <ul style="list-style-type: none"> 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. 	
<p>3) Specification of Materials</p> <ul style="list-style-type: none"> 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 	
<p>4) Material Procurement</p> <ul style="list-style-type: none"> Soda materials are brought from Nongpen Village. Short piles, rope and wire are bought in market. 	
<p>5) Equipment and Tool</p> <ul style="list-style-type: none"> Rensai bundler (with frame) Pliers and wire fastener 	<ul style="list-style-type: none"> Wooden hammer(large) Crawler crane (50t) Clamshell for piling
<p>6) Manpower Required</p> <ul style="list-style-type: none"> Japanese instructor, Leader, Workers (10-15 for a group), operator for crane 	
<p>7) Quantity</p> <ul style="list-style-type: none"> Soda mattress of 10m x 6m x 0.9m(Length, width, height) : Total 66 sheets 	
<p>8) Production Rare</p> <ul style="list-style-type: none"> Rensai: 911m/day, Soda mattress: 1.8 sheet/day as date of Mar.5, 2003 	
<p>9) Comment</p> <ul style="list-style-type: none"> 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 2.5.5 (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 2.5.5 (2/2) Workflow of Assembling Soda Mattress

(2) Installation of Soda Mattress

<p>1) General Outline</p> <ul style="list-style-type: none"> Assembled Soda mattresses are transported to the setting location and submerged by putting rubble stones on them.
<p>2) Installation Method (refer to Figure 2.5.6)</p> <ul style="list-style-type: none"> 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.
<p>3) Equipment and Tool</p> <ul style="list-style-type: none"> Crawler crane (50t), wire straw-basket, backhoe Wooden hammer (large)
<p>4) Manpower Required</p> <ul style="list-style-type: none"> Operator of crawler crane, backhoe Staff and workers (approximately 10 persons)
<p>5) Quantity</p> <ul style="list-style-type: none"> Soda mattress (10m x 6m x 0.9m): Total 66 sheets
<p>6) Production Rate</p> <ul style="list-style-type: none"> 3 sheets/day as of Mar. 5, 2003
<p>7) Comment</p> <ul style="list-style-type: none"> 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) Temporarily placing for final setting



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



5) Piling of wooden short pile to the final depth



6) Connection of Soda mattress with up-stream one

Figure 2.5.6 (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 2.5.6 (2/2) Workflow of Installation of Soda Mattress

2.5.4 Earth Works

<p>1) General Outline</p> <ul style="list-style-type: none"> • 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.
<p>2) Construction Method (refer to Figure 2.5.7)</p> <ul style="list-style-type: none"> • 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
<p>3) Specification of Materials</p> <ul style="list-style-type: none"> • River sand collected in the Mekong River • Tate-soda, bamboo net
<p>4) Material Procurement</p> <ul style="list-style-type: none"> • River sand and bamboo net purchased in market, Tate Soda: directly collected from Nongpen.
<p>5) Equipment and Tool</p> <ul style="list-style-type: none"> • Dump truck, backhoe • Bulldozer, vibration roller (8t), generator, water pump
<p>6) Manpower Required</p> <ul style="list-style-type: none"> • Site manager, operator of backhoe, bulldozer and vibration roller • Skilled, semi-skilled and un-skilled laborers
<p>7) Quantity</p> <p>Embankment of sand and laterite ($V=45,000 \text{ m}^3$)</p>
<p>8) Production Rate</p> <ul style="list-style-type: none"> • Bulldozer ($500 \text{ m}^3/\text{day}$)
<p>9) Comment</p> <ul style="list-style-type: none"> • 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 2.5.7 Workflow of Earth Works

2.5.5 Slope Protection Works

(1) Cobble Stone with Willow Branch Works

<p>1) General Outline</p> <ul style="list-style-type: none"> 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.
<p>2) Construction Method (refer to Figure 2.5.8)</p> <ul style="list-style-type: none"> 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
<p>3) Specification of Materials</p> <ul style="list-style-type: none"> 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
<p>4) Material Procurement</p> <ul style="list-style-type: none"> 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
<p>5) Equipment and Tool</p> <ul style="list-style-type: none"> Dump truck, backhoe
<p>6) Manpower Required</p> <ul style="list-style-type: none"> Site manager, operator of backhoe, driver Semi-skilled and un-skilled laborers
<p>7) Quantity</p> <ul style="list-style-type: none"> Crushed cobble (about 4,200 m³) Siki soda, Taisya, Kogui, willow branch (Construction area=13,700 m²)
<p>8) Production Rate</p> <ul style="list-style-type: none"> Placing Soda & willow (200m²/day below El. 161.5m, 400 m² /day above El. 161.5m) Cobble placing (100m³/day)
<p>9) Comment</p> <ul style="list-style-type: none"> 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 2.5.8 Workflow of Cobble Stone with Willow Branch Works

(2) Partial Reinforcement by Stone Covering

<p>1) General Outline</p> <ul style="list-style-type: none"> • 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.
<p>2) Construction Method (refer to Figure 2.5.9)</p> <ul style="list-style-type: none"> • Transportation by dump truck • Placing by backhoe • Stone adjustment placing on the slope by man-power
<p>3) Specification of Materials</p> <ul style="list-style-type: none"> • Crushed stone (ϕ 150-400 mm)
<p>4) Material Procurement</p> <ul style="list-style-type: none"> • Production by the contractor at Nong Teng temporary quarry site
<p>5) Equipment and Tool</p> <ul style="list-style-type: none"> • Dump truck, backhoe
<p>6) Manpower Required</p> <ul style="list-style-type: none"> • Backhoe operator, engineer • Semi-skilled and un-skilled laborers
<p>7) Quantity</p> <ul style="list-style-type: none"> • Crushed stone ($V=1,400\text{m}^3$)
<p>8) Production Rate</p> <ul style="list-style-type: none"> • Placing of crushed stone: $100\text{ m}^3/\text{day}$
<p>9) Comment</p> <ul style="list-style-type: none"> • 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 2.5.9 Workflow of Partial Reinforcement by Stone Covering

3. EXECUTION OF PILOT WORK AT WAT CHOM CHENG SITE

This Chapter 3 describes the construction process of the execution of the pilot riverbank protection work at Wat Chom Cheng site conducted by the Study Team in 2nd and 3rd Works in Lao P.D.R. and completed in May 2003.

3.1. Outline

The pilot work was constructed based on the original design established in 1st Work in Lao P.D.R. (refer to Volume 4 Sector B (Preparatory Study for Pilot Works)). The outline of this pilot work is summarized as shown in Table 3.1.1

Table 3.1.1 Outline of Pilot Work at Wat Chom Cheng Site

1. Total length of execution: 240 m
2. Riverbank type: <ul style="list-style-type: none"> a) bank slope: 45 degree or less b) secondary deposits: loose sandy silt/silty sand
3. Design criteria: <ul style="list-style-type: none"> a) design flow velocity: 2.6 m/sec b) low water level with 5-year return period: 158.1 m, MSL
4. Construction type: <ul style="list-style-type: none"> a) Foot protection work (wooden pile groin work, Soda Mattress) b) Slope protection work (wooden pile groin work)
5. Main points to note: <ul style="list-style-type: none"> a) Number of groin: 6 (3 of them are reinforced by Soda Mattress) b) Spacing of groins: 40 m (upper stretch), 60 m (downstream stretch) c) Length of the groin: 20m d) 3 rows of wooden piles is arranged in a hound's tooth with spacing of 1m
6. Work items: <ul style="list-style-type: none"> a) preparatory works <ul style="list-style-type: none"> • temporary works and facilities • collection and transportation of materials b) groin works <ul style="list-style-type: none"> • log pilling • assembling of mattress (9 sheets) • installation of mattress c) finishing works, and d) inspection of completion by the Study Team
7. Construction period: January 2003 - May 2003

3.2. Drawings

Wooden Pile Groin Work applied for the bank protection in front of Wat Chom Cheng Site consists of sets of spaced groins. The interval of each groin is set as 40m in the upstream 120m range, and spacing of 60m in the downstream 120m range. Offshore length of the groin is 20m, considering the riverbed cross-section and an area to be protected. Spacing of groin is generally 2-3 times of the length of groin. Each groin consists of 3 rows of wooden piles arranged in a hound's tooth with spacing of 1m. Every other set of groin is protected by Soda mattress and rip-rap stones and connected each pile by tie-rod to avoid any damage due to possible local scouring around piles.

Drawings of the bank protection work at Wat Chom Cheng Site are as shown in Figure 3.2.1.

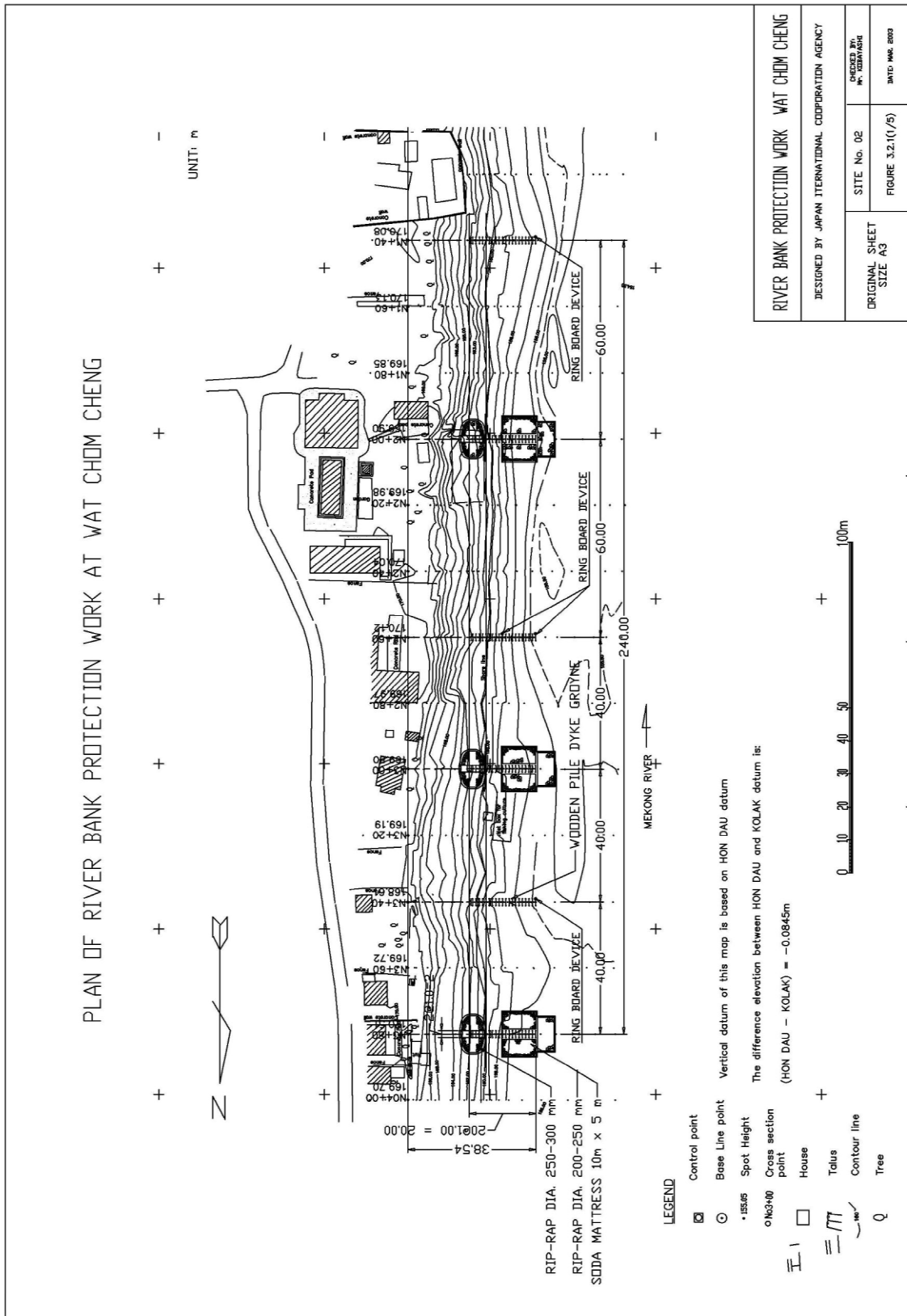


Figure 3.2.1(1/2) Drawings of the bank protection work at Wat Chom Cheng

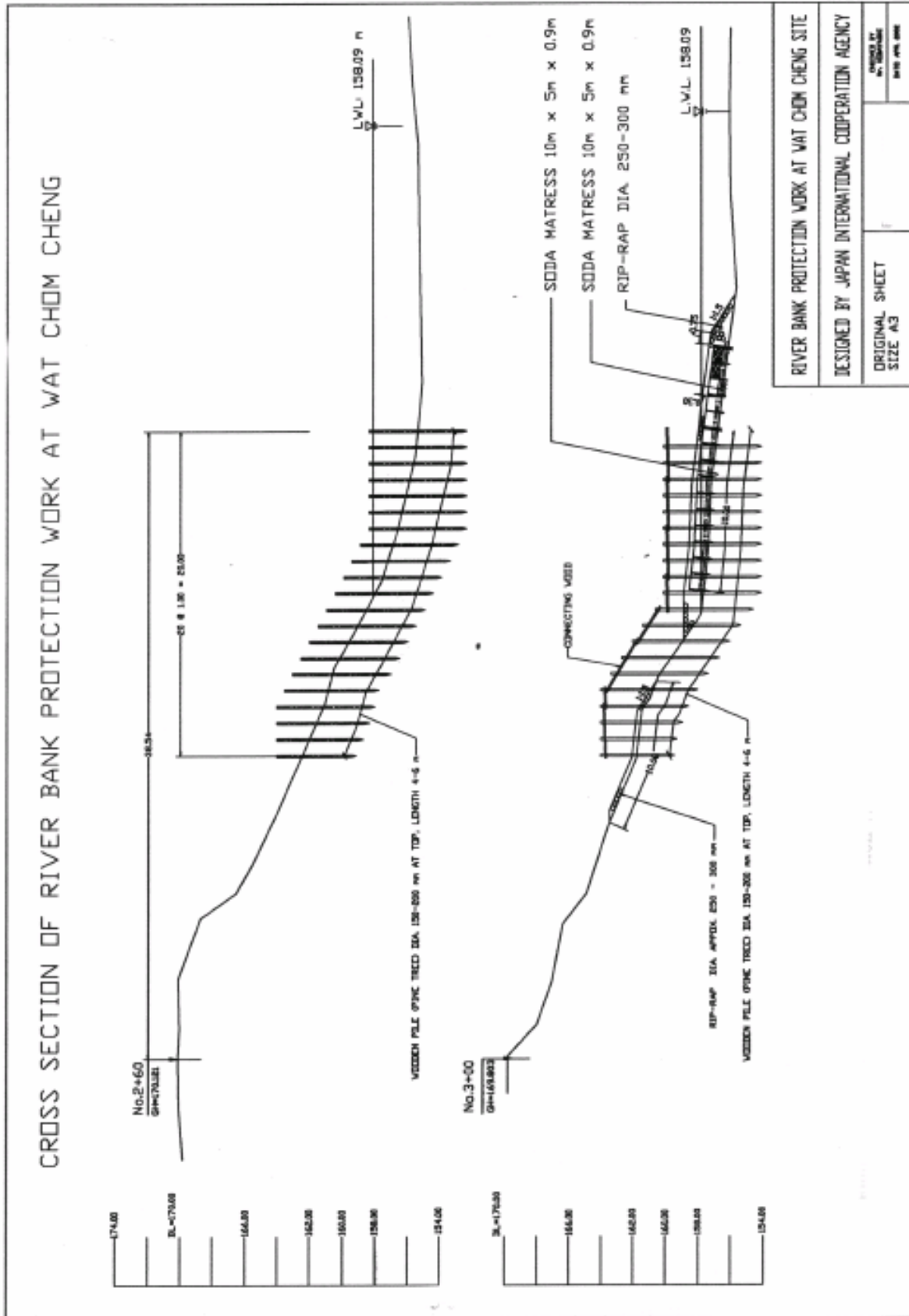


Figure 3.2.1(2/2) Drawings of the bank protection work at Wat Chom Cheng

3.3. Construction Schedule

The Pilot Work was executed according to the schedule as shown in Table 3.3.1 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 Wat Chom Cheng site are composed of foot protection work (Soda Mattress, Wooden pile groin work) and Slope protection work (Wooden pile groin work).

Table 3.3.1 Construction Schedule

Description	Q'ty	unit	Jan	Feb	Mar	Apr
Wooden Piling Work						
Wooden piling	378	nos			30nos/day	
Connecting Wooden Pile	360	m				
Stone Work						
Riprap for slope protection	100	m ³				
Riprap on Soda Mattress	560	m ³				120 m ³ /day
Soda Mattress Work						
Fabrication of Rensai	2,253	m		200 m/day		
Mattress Fabrication	9	nos		1no./day		
Setting Soda Mattress	9	nos				2 nos/day

3.4. Construction Equipment and Materials

With the consideration of construction period and actual performance of the various works, the main construction equipments are proposed and listed below.

Table 3.4.1 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 Truck	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 Contractor)

The main material used for the various work and its specification is summarized below. The local material supplied in the market should be fit to local standard or Japanese standard.

Table 3.4.2 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)		
River sand & Gravel	< ϕ 80 mm, Collected in Mekong	m ³
Laterite	Collected on Ban Dongphosi Borrow Site	m ³
Pebble / 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	M2
Tate Soda	L=3.0 m, S=0.7 m	Bundle
Cobble Stone with Willow Branch (Slope Protection Work)		
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 3.4.3 lists local name of fascine material for Soda Mattress Work.

Table 3.4.3 Fascine Material for Soda Mattress

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	○	○	

3.5. Construction Works

3.5.1 Preparatory Works

(1) Temporary Works and Temporary Facilities

All works were performed by a barge from the Mekong River. Workstation for the barge management, stockpile of material (logs and rocks), and fabrication of soda mattress were set up at Kao Liao site. (refer to Figure 3.5.1)



1) Stockpile in Kao Liao Stockyard



2) Barge and piling

Figure 3.5.1 Temporary Facility for Wat Chom Cheng Site

(2) Collection and Transportation of Materials

Wooden logs for groins were purchased in market. The logs were cut and sharpened as pile and stocked in Kao Liao stockyard. Fascine material (Soda, Taisha and Kogui etc.) for Soda Mattress work were collected by the local residents in Donloun and Laksamsip Villages. These materials were transported by the several trucks with the capacity of 6-10 t to Kao Liao yard. A flat barge transported wooden piles and soda mattresses fabricated at the Kao Liao yard to Wat Chom Cheng site.

3.5.2 Groin Works

(1) Log Piling

<p>1) General Outline</p> <ul style="list-style-type: none"> • Wooden pile groin work is one of permeable dyke groin to reduce river flow velocity and sifting current direction offshore-wards to protect riverbank between groins. • Typical of wooden piles consists of logs spaced in every 1.0-1.2m each other and arranged in more than two rows. Piles are tightened by tie beam laterally and longitudinally to connect each pile. • This work is usually applied in mild slope river. Although less construction cost, necessary attention to the conservation of forest with respect to environmental aspect should be paid.
<p>2) Construction Method (refer to Figure 3.5.2)</p> <ul style="list-style-type: none"> • Wooden pile is driven by backhoe • Wooden pile of every other groin is connected with tie-beam. • The joint is fixed by bolt. • Riprap is placed on the slope around connecting piles
<p>3) Specification of Materials</p> <ul style="list-style-type: none"> • Wooden material is hard enough against external force and deterioration: species is such as May Peuy, May Safang, May Tiou Nam, May Ankham, etc. • Wooden Pile : L=4-6m, tip-end > ϕ 15cm • Tie-beam : L=3.2m, tip-end dia.> ϕ 9cm • Bolt : L=30cm, ϕ 13mm
<p>4) Material Procurement</p> <ul style="list-style-type: none"> • Wooden logs are purchased in market. The log is cut and sharpened as pile. • Bolt is available in market.
<p>5) Equipment and Tool</p> <ul style="list-style-type: none"> • Barge and backhoe • Pile driving attachment
<p>6) Manpower Required</p> <ul style="list-style-type: none"> • Operator of barge and backhoe • Staff and workers
<p>7) Quantity</p> <ul style="list-style-type: none"> • Total number wooden logs are 378.
<p>8) Production Rate</p> <ul style="list-style-type: none"> • 20 piles/day in average
<p>9) Comment</p> <ul style="list-style-type: none"> • Due to slightly high water level of the Mekong River in February 2003, log-piling work was postponed in the middle of March 2003.



1) Preparation of wooden pile by sharpening tip of log



2) Transporting to the wooden piles to the planned location by barge



3) Piling work by backhoe (pushing down)



4) Piling work by backhoe with attachment to vibrate and hit a wooden log



5) Lateral view of piled wooden logs



6) Longitudinal view of piled wooden logs

Figure 3.5.2 (1/2) Workflow of Wooden Log Piling



7) Riprap on the slope around connecting piles



8) View of completed groin works

Figure 3.5.2 (2/2) Workflow of Wooden Log Piling

(2) Assembling of Soda Mattress

<p>1) General Outline</p> <ul style="list-style-type: none"> 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. 	
<p>2) Construction Method (refer to Figure 3.5.3)</p> <ul style="list-style-type: none"> 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. 	
<p>3) Specification of Materials</p> <ul style="list-style-type: none"> 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. Tayisha 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 5.5m 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 	
<p>4) Material Procurement</p> <ul style="list-style-type: none"> Soda materials are brought from Donloun village and Laksamsip village. Short piles, rope and wire are bought in market. 	
<p>5) Equipment and Tool</p> <ul style="list-style-type: none"> Rensai bundler (with frame) Pliers and wire fastener 	<ul style="list-style-type: none"> Wooden hammer(large) Crawler crane (50t) ClamShell for piling
<p>6) Manpower Required</p> <ul style="list-style-type: none"> Japanese instructor, Leader, Workers (10-15 for a group), operator for crane 	
<p>7) Quantity</p> <ul style="list-style-type: none"> Soda mattress of 10m x 6m x 0.9m(Length, width, height): Total 9 sheets 	
<p>8) Production Rate</p> <ul style="list-style-type: none"> Rensai: 205m/day, Soda mattress: 1.3 sheet/day 	
<p>9) Comment</p> <ul style="list-style-type: none"> Soda mattress assembling work technique has been well transferred Laotian staff and workers. 	



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 3.5.3 (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 3.5.3 (2/2) Workflow of Assembling Soda Mattress

(3) Installation of Soda Mattress

<p>1) General Outline</p> <ul style="list-style-type: none"> Assembled Soda mattresses are transported to the setting location and submerged by putting rubble stones on them. All the installation work is conducted on the water. No yard on the ground is required.
<p>2) Installation Method (refer to Figure 3.5.4)</p> <ul style="list-style-type: none"> Floating Soda mattress is towed by boat from Kao Liao stockyard into the site. Using the boat and manpower, the Soda mattress is placed on the surface of river water and fixed by anchors. The mattress is submerged by putting rubble stones on them by a backhoe on a barge
<p>3) Equipment and Tool</p> <ul style="list-style-type: none"> Backhoe, barge, boat Wooden hammer (large)
<p>4) Manpower Required</p> <ul style="list-style-type: none"> Operator of backhoe, barge and boat Staff and workers (approximately 10 persons)
<p>5) Quantity</p> <ul style="list-style-type: none"> Soda mattress (10m x 6m x 0.9m): Total 9 sheets
<p>6) Production Rate</p> <ul style="list-style-type: none"> 3 sheets/day
<p>7) Comment</p> <ul style="list-style-type: none"> Towing Soda mattress by boat is suitable transportation method to the site without yard on the riverbank like Sibounheuang.



1) Towing floating Soda mattress by boat from Kao Liao stockyard into the site



2) Placing Soda mattress at the planned position by boat and manpower



6) Putting rubble stones on mattress by backhoe on barge to submerge mattress

Figure 3.5.4 Workflow of Installation of Soda Mattress

4 EXECUTION OF PILOT WORK AT SIBOUNHEUANG SITE

This Chapter 4 describes the construction process of the execution of the pilot riverbank protection work at Sibounheuang site conducted by the Study Team in 2nd and 3rd Works in Lao P.D.R. and completed in April 2003.

4.1. Outline

The pilot work was constructed based on the original design established in 1st Work in Lao P.D.R. (refer to Volume 4 Sector B (Preparatory Study for Pilot Works)). The outline of this pilot work is summarized as shown in Table 4.1.1

Table 4.1.1 Outline of Pilot Work at Sibounheuang Site

1. Total length of execution: 156 m
2. Riverbank type: <ul style="list-style-type: none"> a) bank slope: 65~90 degree b) upper layer: pale reddish brown, stiff clay c) lower layer: gravel layer with loose sand where hollows are produced by scouring
3. Design criteria: <ul style="list-style-type: none"> a) design flow velocity: 2.6 m/sec b) low water level with 5-year return period: 158.9 m, MSL
4. Construction type: <ul style="list-style-type: none"> a) Foundation work (log hurdle work), b) Foot protection work (Soda Mattress work), and c) Slope protection work (earthwork, Cobble stone with willow branch work).
5. Main points to note: <ul style="list-style-type: none"> a) The principle design concept is the same as IDI Japan's test project, i.e., to protect the foot of slope by foot protection work b) The slope protection work is designed to cover the possible notch formation part to avoid undermining.
6. Work items: <ul style="list-style-type: none"> a) preparatory works <ul style="list-style-type: none"> • temporary works and facilities • collection and transportation of materials b) foundation work (log hurdle works) c) earth works (embankment) d) foot protection works (Soda Mattress: 23 sheets) <ul style="list-style-type: none"> • assembling of mattress • installation of mattress • toe rubble deposition e) slope protection works for lower bank (cobble stone with willow branch works) f) finishing works, and g) inspection of completion by the Study Team
7. Construction period: January 2003 - April 2003

4.2. Drawings

Considering that the site is just downstream of the test project of Soda mattress and gabion wall work, principle design concept is the same as that, i.e., to protect the foot of slope by foot protection work, that consists of Soda mattress work. The slope protection work is done by Cobble Stone with Willow Branch Work to avoid the possible notch formation, that undermines the slope to collapse, and is supported by foundation work consisting of log hurdle work.

Drawings of the bank protection work at Sibounheuang Site are as shown in Figure 4.2.1.

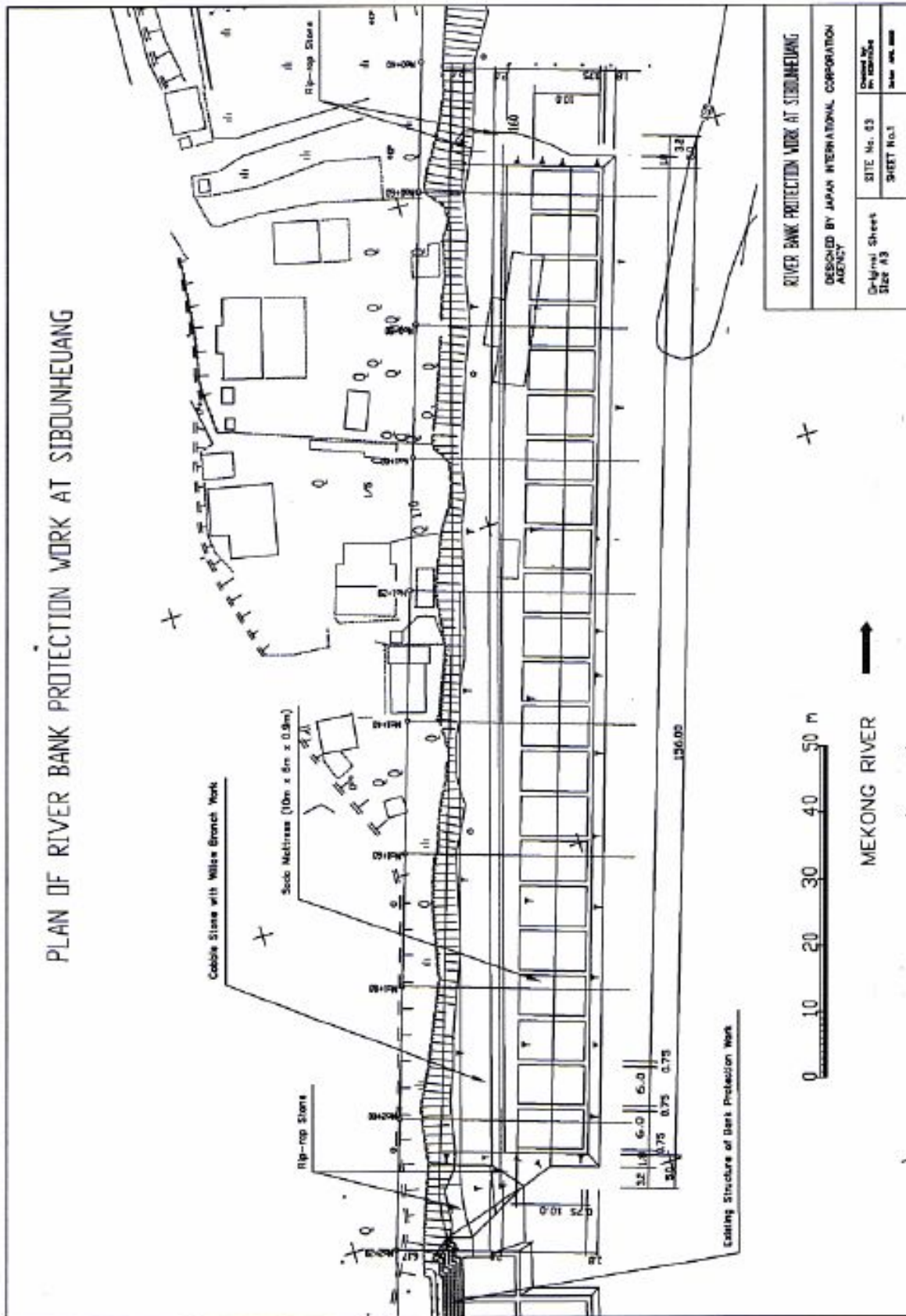


Figure 4.2.1(1/2) Drawings of the bank protection work at Sibounheuang Site

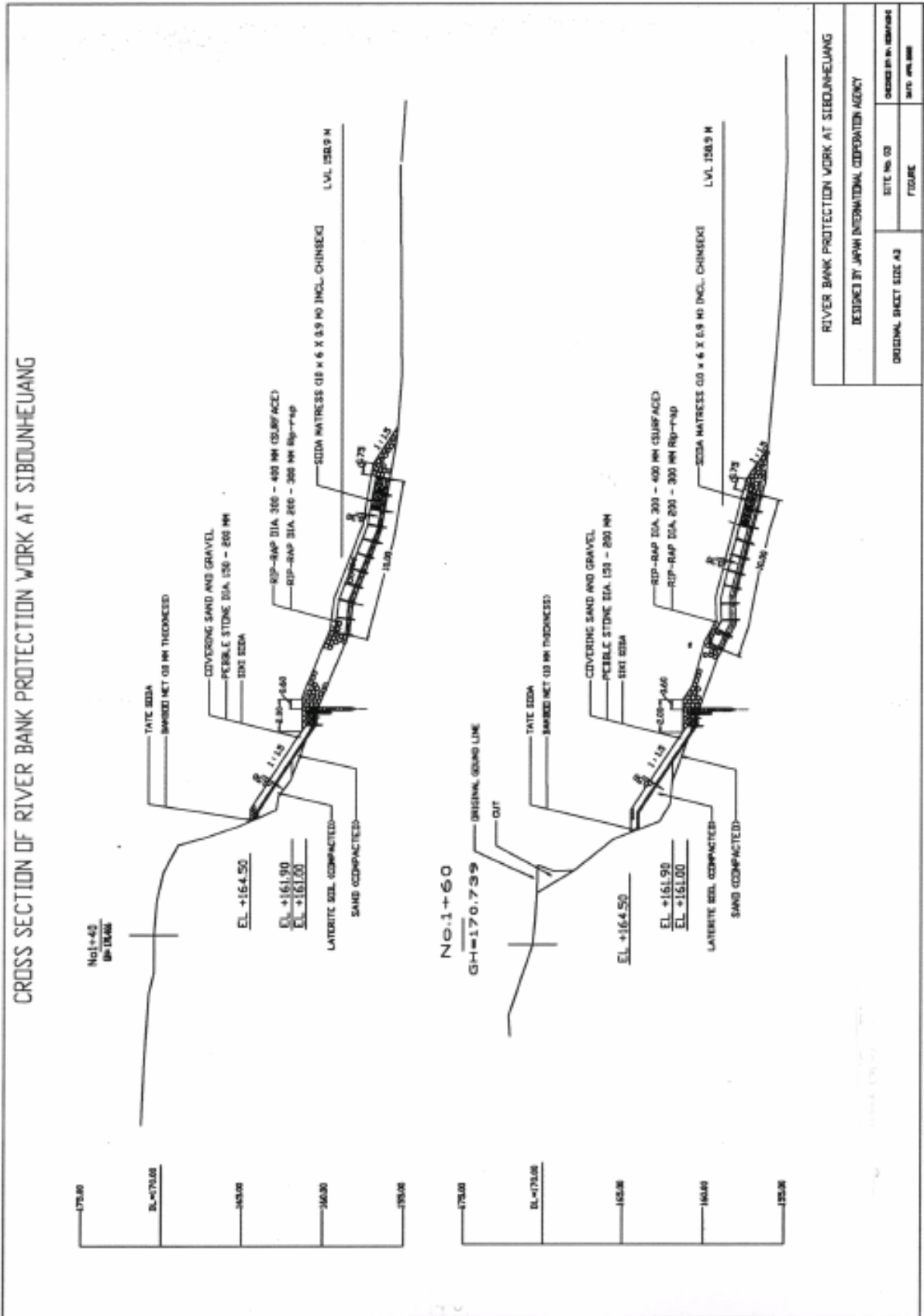


Figure 4.2.1(2/2) Drawings of the bank protection work at Sibounheuang Site

4.3. Construction Schedule

The Pilot Work was executed according to the schedule as shown in Table 4.3.1 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.

Table 4.3.1 Construction Schedule

Description	Q'ty	unit	Jan	Feb	Mar	Apr
Wooden Piling Work						
Log Hurdle (L=3m)	78	nos		20nos./day		
Log Hurdle (L=1.5m)	770	nos		100nos./day		
Earth Work						
Filling Sand	270	m3			200m3/day	
Filling Laterite	660	m3			200m3/day	
Slope Protection						
Protection with soda material	1100	m2			200m2/day	
Placing Riprap	200	m3			200m3/day	
Soda Mattress Work						
Fabrication of Rensai	6750	m		200m/day		
Mattress Fabrication	23	nos	1 set/day			2 set/day
Setting Soda Mattress	23	nos			4set/day	
Riprap on Soda Mattress	2400	m3			170m3/day	

Main works at Sibounheuang site are composed of Foot Protection Work (Soda Mattress System, Rubble Deposition) and Slope Protection Work (Log hurdle, earthwork, Cobble Stone with Willow Branch work). All works were performed from the Mekong River by using a barge.

4.4. Construction Equipment and Materials

With the consideration of construction period and actual performance of the various works, the main construction equipments are proposed and listed below.

Table 4.4.1 Construction Equipment

Item	Capacity	Working Description
Rensai Stand	2 lines	Rensai assembling
Backhoe	0.7 m3	Riprap, Earthwork, Piling
Truck	6-10 t	Transportation (Soda Material)
Dump Track	10 t	Transportation (stone, soil)
Clam shell	1.0 m3	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 m3/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 Contractor)

The main material used for the various work and its specification is summarized below. The local material supplied in the market should be fit to local standard or Japanese standard.

Table 4.4.2 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)		
River sand & Gravel	< ϕ 80 mm, Collected in Mekong	m ³
Laterite	Collected on Ban Dongphosi Borrow Site	m ³
Pebble / 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	M2
Tate Soda	L=3.0 m, S=0.7 m	Bundle
Cobble Stone with Willow Branch (Slope Protection Work)		
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 4.4.3 lists local name of fascine material for Soda Mattress Work and Cobble with Willow Branch Work.

Table 4.4.3 Fascine Material for Soda Mattress

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	○	○	

4.5. Construction Works

4.5.1 Preparatory Works

(1) Temporary Works and Temporary Facilities

The workstation for barge management, stockpile of material, and fabrication of soda mattress was set up at Kao Liao site located 6 km upstream of Sibounheuang Site.

From the main road to Ban Sakai and the quarry site at Nong Teng, access roads (l=250 m, width=6 m) were constructed to the stockyard.

Two (2) houses for local staffs and labors, a generator (60 KVA), Rensai assembling stand, and stockpile for fascine material, Rensai, Soda mattress, and log for piling were set in Kao Liao stockyard. Some portion of Soda mattresses for Ban Dongphosi site were fabricated and stock in this yard.

Figure. 4.5.1 shows the temporary facilities and works in Kao Liao stockyard.

(2) Collection and Transportation of Materials

Wooden logs for log hurdle works were purchased in market. The logs were cut and sharpened as pile and stocked in Kao Liao stockyard. Fascine material (Soda, Taisya and Kogui etc.) for Soda Mattress work and Willow Branch Work were collected by the local residents in Donloun and Laksamsip Villages. These materials were transported by the several trucks with the capacity of 6-10 t to Kao Liao yard. A flat barge transported wooden logs and Soda mattresses fabricated at the Kao Liao stockyard to Sibounheuang site for setting.

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.



1) Access Road from Main Road



2) Kao Liao Stockyard



3) Workstation and Labor House



4) Rensai Assembling Stand



5) Stockyard for fascine, Rensai, Mattress



6) Loading into Barge

Figure 4.5.1 Temporary Facilities and Works in Kao Liao Stockyard

4.5.2 Foundation Works

(1) Log Hurdle Work

<p>1) General Outline</p> <ul style="list-style-type: none"> • Log hurdle work as foundation work is composed of primary log piling, secondary (short) piling, connecting beam and cobbles placed behind log hurdle as back-fill. • Primarily log piling is set with interval of 2m and secondary pilings are with interval of 20cm between primary logs. Connecting beam by bolts connects primary log and secondary log.
<p>2) Construction Method (refer to Figure 4.5.2)</p> <ul style="list-style-type: none"> • Primary pile is driven by Backhoe set on Barge. • Secondary piling is done by manpower, and connecting beam setting is done by manpower. • Back-filling of cobble stones are done by Backhoe.
<p>3) Specification of Materials</p> <ul style="list-style-type: none"> • Wooden pile material is hard enough against external force and deterioration: species is such as May Peuy, May Safang, May Tiou Nam, May Ankham, etc. • Primary wooden pile : L=3m, tip-end > ϕ 20cm • Secondary wooden pile: L=1.52m, tip-end dia.> ϕ 10cm • Connection beam: L=4.2m, tip-end dia.> ϕ 10cm • Bolt : L=30cm, ϕ 13mm • Cobble stone : ϕ 150-50mm
<p>4) Material Procurement</p> <ul style="list-style-type: none"> • Wooden logs are purchased in market. The log is cut and sharpened as pile. • Bolt is available in market.
<p>5) Equipment and Tool</p> <ul style="list-style-type: none"> • Barge • Backhoe • Pile driving attachment
<p>6) Manpower Required</p> <ul style="list-style-type: none"> • Operator of Barge and Backhoe • Staff and workers
<p>7) Quantity</p> <ul style="list-style-type: none"> • Primarily log: total number 77, and secondary log: total number 760.
<p>8) Production Rate</p> <ul style="list-style-type: none"> • Primarily log: 9.6 piles/day. • Secondary log: 117 piles/day
<p>9) Comment</p> <ul style="list-style-type: none"> • This method is one of rather simple river protection work as foundation work.



1) Preparation of wooden pile by sharpening tip of log



2) Piling-up of shaped wooden logs.



3) Primary piling work by Backhoe mounted on Barge



4) Secondary piling work by manpower between primary piles.



5) Close view of pile arrangement



6) Longitudinal view of piled wooden logs

Figure 4.5.2 Workflow of Log Hurdle Work

4.5.3 Slope Protection Work

(1) Earth Work

<p>1) General Outline</p> <ul style="list-style-type: none"> • 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. • The material and construction equipment are transported by barges. • The compaction work is conducted from the backhoe on the barge.
<p>2) Construction Method (refer to Figure 4.5.3)</p> <ul style="list-style-type: none"> • Trimming of slope and clearance • Transportation of earth material by barges • Filling by backhoe • Moisture content arrangement • Compaction by vibration roller • Filling and slope compaction by backhoe
<p>3) Specification of Materials</p> <ul style="list-style-type: none"> • River sand collected in the Mekong River • Laterite from Ban Dongphosi borrow pit
<p>4) Material Procurement</p> <ul style="list-style-type: none"> • River sand purchased in market, Tate Soda: directly collected from Nongpen • Laterite: directly collected in the borrow pit
<p>5) Equipment and Tool</p> <ul style="list-style-type: none"> • Backhoe (1 No.) • Vibration roller (8t), generator, water pump • 2 barges for material transportation and backhoe operation
<p>6) Manpower Required</p> <ul style="list-style-type: none"> • Site manager, engineer, operator of barge and backhoe • Semi-skilled and un-skilled laborers
<p>7) Quantity</p> <ul style="list-style-type: none"> • River sand ($V=270 \text{ m}^3$), laterite ($V=660 \text{ m}^3$)
<p>8) Production Rate</p> <ul style="list-style-type: none"> • Sand filling: $200 \text{ m}^3/\text{day}$ • Laterite filling: $200 \text{ m}^3/\text{day}$
<p>9) Comment</p> <ul style="list-style-type: none"> • The filling work and slope compaction work were done by a backhoe on a barge with the greatest care for safety.



1) River sand filling and moisture arrangement



2) Overview of sand embankment level (EL 161.9 m)



3) Laterite loading by backhoe



4) Compaction by vibration rollers and slope compaction by a backhoe



5) Filling and slope compaction by backhoe on barge



6) Check of the compaction and finishing of the embankment level

Figure 4.5.3 Workflow of Earth Work

(2) Cobble Stone with Willow Branch Works

<p>1) General Outline</p> <ul style="list-style-type: none"> The structure consists of Siki soda on the slope of earth embankment, 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.
<p>2) Construction Method (refer to Figure 4.5.4)</p> <ul style="list-style-type: none"> 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
<p>3) Specification of Materials</p> <ul style="list-style-type: none"> Siki Soda (l=3.0m, S=0.7m), Taisya (l=3.0m), Kogui (l=1.2m, $\phi =4\text{cm}$), Willow (l=1.2m) Cobble ($\phi =150\text{-}200\text{mm}$), River sand and gravel from the Mekong
<p>4) Material Procurement</p> <ul style="list-style-type: none"> Wooden material (Siki soda, Taisya, Kogui, Willow) collected at Danxi and Nong Teng Cobble collected at Nong Teng temporary quarry site River sand and gravel purchased in the market
<p>5) Equipment and Tool</p> <ul style="list-style-type: none"> Dump truck, barge, backhoe
<p>6) Manpower Required</p> <ul style="list-style-type: none"> Site manager, operator of backhoe, driver Semi-skilled and un-skilled laborers
<p>7) Quantity</p> <ul style="list-style-type: none"> Crushed cobble ($V=200\text{m}^3$) Siki soda, Taisya, Kogui, willow branch ($A=1,100\text{m}^2$)
<p>8) Production Rate</p> <ul style="list-style-type: none"> Placing Soda & willow ($200\text{ m}^2/\text{day}$) Cobble placing ($20\text{ m}^3/\text{day}$)
<p>9) Comment</p> <ul style="list-style-type: none"> 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 of river sand



2) Frame using Taisya (Tie-twig)



3) Condition of sand and gravel placing in the frame (Taisya hurdle)



4) Cobble placing by backhoe on barge



5) Cobble adjustment by hands of local workers



6) Completed cobble stone with willow branch works

Figure 4.5.4 Workflow of Cobble Stone with Willow Branch Works

4.5.4 Foot Protection Works

(1) Assembling of Soda Mattress

<p>1) General Outline</p> <ul style="list-style-type: none"> 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. 	
<p>2) Construction Method (refer to Figure 4.5.5)</p> <ul style="list-style-type: none"> 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. 	
<p>3) Specification of Materials</p> <ul style="list-style-type: none"> 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 	
<p>4) Material Procurement</p> <ul style="list-style-type: none"> Soda materials are brought from Donloun village and Laksamsip village. Short piles, rope and wire are bought in market. 	
<p>5) Equipment and Tool</p> <ul style="list-style-type: none"> Rensai bundler (with frame) Pliers and wire fastener 	<ul style="list-style-type: none"> Wooden hammer(large) Crawler crane (50t) Clamshell for piling
<p>6) Manpower Required</p> <ul style="list-style-type: none"> Japanese instructor, Leader, Workers (10-15 for a group), operator for crane 	
<p>7) Quantity</p> <ul style="list-style-type: none"> Soda mattress of 10m x 6m x 0.9m(Length, width, height) : Total 23 sheets 	
<p>8) Production Rare</p> <ul style="list-style-type: none"> Rensai: 294m/day, Soda mattress: 0.6 sheet/day 	
<p>9) Comment</p> <ul style="list-style-type: none"> 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 4.5.5 (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 4.5.5 (2/2) Workflow of Assembling Soda Mattress

(2) Installation of Soda Mattress

<p>1) General Outline</p> <ul style="list-style-type: none"> Assembled Soda mattresses are transported to the setting location and submerged by putting rubble stones on them. All the installation work is conducted on the water. No yard on the ground is required.
<p>2) Installation Method (refer to Figure 4.5.6)</p> <ul style="list-style-type: none"> Floating Soda mattress is towed by boat from Kao Liao stockyard into the site before final setting. Using the boat and manpower, the Soda mattress is placed on the surface of river water and fixed by anchors. The mattress is submerged by putting rubble stones on them by a backhoe on a barge
<p>3) Equipment and Tool</p> <ul style="list-style-type: none"> Backhoe, barge, boat Wooden hammer (large)
<p>4) Manpower Required</p> <ul style="list-style-type: none"> Operator of backhoe, barge and boat Staff and workers (approximately 10 persons)
<p>5) Quantity</p> <ul style="list-style-type: none"> Soda mattress (10m x 6m x 0.9m): Total 23 sheets
<p>6) Production Rate</p> <ul style="list-style-type: none"> 3 sheets/day
<p>7) Comment</p> <ul style="list-style-type: none"> 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. Towing Soda mattress by boat is suitable transportation method to the site without yard on the riverbank like Sibounheuang.



1) Towing floating Soda mattress by boat from Kao Liao stockyard into the site



2) Placing floating Soda mattress at the planned position by boat



3) Making fine adjustment by manpower



4) Connecting Soda mattresses by manpower



5) Row of connected mattresses



6) Putting rubble stones on mattress by backhoe on barge to submerge mattress

Figure 4.5.6 Workflow of Installation of Soda Mattress

(3) Rubble Deposition

<p>1) General Outline</p> <ul style="list-style-type: none"> • This work is done around log hurdle work and conjunction to Soda mattress to reinforce stability of earth embankment. • In addition, this functions as continuous protection work including Soda mattress, log hurdle work and cobble stone with willow branch works.
<p>2) Construction Method (refer to Figure 4.5.7)</p> <ul style="list-style-type: none"> • Stone material and construction equipment transported by barges • Placing and filling the material by a backhoe on the barge • Stone adjustment by manpower on the ground and under the water surface
<p>3) Specification of Materials</p> <ul style="list-style-type: none"> • Crushed stone (ϕ 200-400 mm)
<p>4) Material Procurement</p> <ul style="list-style-type: none"> • Production by the contractor at Nong Teng temporary quarry site
<p>5) Equipment and Tool</p> <ul style="list-style-type: none"> • Barge, backhoe
<p>6) Manpower Required</p> <ul style="list-style-type: none"> • Site manager, engineer, operator of backhoe and barge • Semi-skilled and un-skilled laborers
<p>7) Quantity</p> <ul style="list-style-type: none"> • Crushed stone (V=2,400 m³, including riprap of Soda mattress)
<p>8) Production Rate</p> <ul style="list-style-type: none"> • Stone placing including the riprap on Soda mattress: 170 m³/day
<p>9) Comment</p> <ul style="list-style-type: none"> • Stone placing by a backhoe on a barge were done with the greatest care for safety. Placing adjustment as finishing work was done by hands under water around the conjunction to Soda mattress.



1) View of completed slope protection work



2) Stone transported from Kao Liao stockyard by barge and loaded by backhoe



3) Stone placing adjustment by hand around log hurdle work



4) Stone placing adjustment by hand under water around the conjunction to Soda mattress



5) Stone placing on Soda mattress from barge



6) Completed toe rubble deposition

Figure 4.5.7 Workflow of Toe Rubble Deposition

5 CONSTRUCTION DATA

This Chapter describes the relation of work item and its construction rate obtained from the execution of the Pilot Works. These data is prepared to estimate unit price and construction schedule on the similar work by Laotian engineers themselves.

5.1. Construction Work Progress

The construction work completed in 31 May, 2003, the appointed date of the contract.

Some work progress was slightly different from the original schedule because that the material procurement of wood and crushed stone from temporary new quarry site depended on the market and site. In addition, the size of soda mattress was also changed from 10 m*10 m*0.9 m to 10 m*6 m*0.9 m due to the capacity of crane available in Lao PDR.

The construction progress performed at three (3) site is summarized in Table 5.1.1.

Table 5.1.1 Construction Work Progress

Description	Qty	unit	Jan-03	Feb-03	Mar-03	Apr-03	May-03
BAN DONGPHOSI							
Preparation Work							
Mobilization - Cleaning, Stripping	1	LS	█				
Temporary Road	1	LS	█				
Reintegration of Existing Dike	2,200	m3					█
Stone Work for foot protection							
Bank for foot protection (Blasted Stone)	12,275	m3		█			
Bank for foot protection (River Stone)	1,736	m3			█		
Placing stone on Soda Mattress	5,094	m3				█	
Earth Work							
Filling Sand (up to EL+157m)	7,500	m3			█		
Filling Sand (up to EL+161.5m)	29,840	m3				█	
Filling Sand (up to Final EL)	16,990	m3					█
Soda Mattress Work							
Fabrication of Rensai	19,140	m	█				
Mattress Fabrication (10m x 6m)	66	nos		█			
Setting Soda Mattress (10mx6m)	66	nos			█		
Slope Protection							
Fabrication protection with Willow branch	12,328	m2				█	
Riprap Placing	5,370	m3				█	
Wat Chom Cheng							
Wooden Piling Work							
Wooden piling	378	nos		█			
Connecting Wooden Pile	360	m				█	
Stone Work							
Riprap for slope protection	90	m3					█
Riprap on Soda Mattress	560	m3				█	
Soda Mattress Work							
Fabrication of Rensai	2,253	m	█				
Mattress Fabrication	9	nos		█			
Setting Soda Mattress	9	nos				█	
Sihounhuang							
Wooden Piling Work							
Log Hurdle (L=3m)	77	nos		█			
Log Hurdle (L=1.5m)	760	nos			█		
Earth Work							
Filling Sand	272	m3			█		
Filling Laterite	657	m3				█	
Slope Protection							
Fabrication protection with Willow branch	1,100	m2				█	
Placing Riprap	275	m3				█	
Soda Mattress Work							
Fabrication of Rensai	6,750	m	█				
Mattress Fabrication	23	nos		█			
Setting Soda Mattress	23	nos				█	
Riprap on Soda Mattress	2,570	m3				█	
Quarry Operation							
Supply Stone (Existing Stone)	2,030	m3	█				
Supply Stone (Drilling/ Blasting / Loading)	23,824	m3		█			
Total Progress (end of month)		%	1.0%	12.6%	51.9%	81.5%	100.0%

5.2. Construction Rate

Table 5.2.1 lists up the construction rate of manpower and construction equipment performance on various work of the Pilot Works at three (3) sites.

Specially, the contract company of the Pilot Works had the first experience on Soda mattress Work in IDI, Japan project at Sibounheuang site. The construction rates on Soda mattress work are better than those of the construction company without the experience.

Table 5.2.1 (1/3) Construction Rate of Manpower and Equipment

Site	Work Item	Specification	Estimated Volume (Design)	Actual Volume (Construction)	Working Days	Rate		Notes
						Average	Unit	
Dongphosi	Foundation Work	Crushed Stone 250~600mm	12275 m ³	14208 m ³		213.11	m ³ /Day	0.7m ³ Backhoe, Bulldozer – 1 unit
	Soda Mattress Work				23			
	Rensai Assembling	φ 15cm x 10.5m φ 15cm x 6.5m	19140 m	19140 m	21	23.84	m/Pers.	Rensai Stand 6 sets
	Chinsyo Assembling	10m x 6m	66 Shts	66 Shts	38	11.90	Pers./Sht	35t Rough Terrain Crane (RT-Crane) 1 unit
	Soda Install	10m x 6m	66 Shts	66 Shts	16	2.32	Pers./Sht	50t Crawler Crane, 35t RT-Crane, 25t Trailer – 1 unit
	Rubble Deposition	Crushed Stone 250~600mm	5094 m ³	5219 m ³	21	202.14	m ³ /Day	50t Crawler Crane, Backhoe – 1 unit
	Embankment	River Sand	47881 m ³	58678 m ³	66	604.17	m ³ /Day	Long arm Backhoe, 7t Roller 0.7m ³ Backhoe, Bulldozer – 1 unit
	Cobble Stone with Willow Branch							
	Frame Assembling	Soda, Willow Branch	12540 m ²	12540 m ²	43	15.10	m ² /Per	
	Riprap	Crushed Stone 150~400mm	12540 m ²	12540 m ²	44	6.20	m ² /Per	Long arm Backhoe, 0.7m ³ Backhoe, 50t Crawler Crane – 1 unit

Table 5.2.1 (2/3) Construction Rate of Manpower and Equipment

Site	Work Item	Specification	Estimated Volume (Design)	Actual Volume (Construction)	Working Days	Rate		Notes
						Average	Unit	
Wat Chom Cheng	Wooden Pile Work							
	Piling	Log ϕ 15~20cm, L=4~6m	378 Nos.	378 Nos.	18	2.58	No./Pers	Braker Backhoe, 150t Flat Barge – 1 Unit
	Pile Connecting	ϕ 10cm Log	360 m	360 m	8	6.00	m./Pers.	Power Drill
	Soda Mattress Work							
	Rensai Assembling	ϕ 15cm x 10.5m ϕ 15cm x 5.5m	2412 m	2412 m	8	20.94	m./Pers.	Rensai Stand 2 sets
	Chinsyo Assembling	10m x 5m	9 Shts	9 Shts	8	12.06	Pers./Sht	50t Crawler Crane – 1 unit
	Soda Install	10m x 5m	9 Shts	9 Shts	3	6.48	Pers./Sht	Tag-Boat, 35t RT-Crane – 1 unit
	Rubble Deposition	Crushed Stone 250~300mm	650 m ³	670 m ³	9	60.19	m ³ /Pers.	Long arm Backhoe, 0.7m ³ Backhoe – 1 units, Barge(Flat, Ship) – 2 units

Table 5.2.1 (3/3) Construction Rate of Manpower and Equipment

Site	Work Item	Specification	Estimated Volume (Design)	Actual Volume (Construction)	Working Days	Rate		Notes
						Average	Unit	
Sibounheuang	Log Hurdle Work	Log ϕ 20cm L=3.0m/L=1.5m	151.25 m	152 m	27	0.73	m/Pers.	Braker Backhoe, 150t Flat Berge - 1 Unit
	Embankment	Lateelite, River Sand	929 m ³	1073 m ³	18	43.01	m ³ /Day	Long arm Backhoe, 0.7m ³ Backhoe - 1 units, Berge(Flat, Ship) - 2 units
	Cobble Stone with Willow Branch							
	Frame Assembling	Soda, Willow Branch	1100 m ²	1100 m ²	6	13.48	m ² /Pers.	
	Riprap	Crushed Stone 150~400mm	1100 m ²	1100 m ²	9	5.09	m ² /Pers.	Long arm Backhoe, 0.7m ³ Backhoe - 1 units, Berge(Flat, Ship) - 2 units
	Soda Mattress Work							
	Rensai Assembling	ϕ 15cm x 10.5m ϕ 15cm x 6.5m	6670 m	6670 m	16	17.37	m/Pers.	Rensai Stand 2 sets
	Chinsyo Assembling	10m x 6m	23 Shts	23 Shts	19	12.78	Pers./Sht	50t Crawler Crane - 1 unit
	Soda Install	10m x 6m	23 Shts	23 Shts	8	3.71	Pers./Sht	Tag-Boat, 35t RT-Crane - 1 unit
	Rubble Deposition	Crushed Stone 200~400mm	2570 m ³	2,632 m ³	27	79.32	m ³ /Day	0.7m ³ Backhoe, Berge(Flat, Ship) - 2 units
	Product. Transport	Sand Stone	25854 m ³	28905 m ³	100	215.45	m ³ /Day	0.7~1.2m ³ Backhoe-4, 10~15tDump-1, Braker backhoe, Crawler drill-3